वार्षिक प्रतिवेदन

ANNUAL REPORT

राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली

National Physical Laboratory (CSIR), New Delhi

Contents

प्राक्कथन

राष्ट्रीय भौतिक प्रयोगशाला (एनपीएल) की वर्ष 2009-2010 की वार्षिक रिपोर्ट प्रस्तुत करते हुए मुझे हर्ष का अनुभव हो रहा है। एनपीएल जो कि भारत की प्रमुख शोध प्रयोगशाला है, में भौतिकी के मुख्य क्षेत्रों में उन्नत अनुसंधान किए जाते हैं। एनपीएल ने मुख्य रूप से राष्ट्रीय मानकों, पदार्थ विज्ञान और वायुमण्डलीय भौतिकी के क्षेत्रों में उल्लेखनीय आधारभूत (मूल) और व्यावहारिक परिणाम दिए हैं। प्रयोगशाला ने मानक, इंजीनियरिंग पदार्थ, इलैक्ट्रॉनिक पदार्थ, फोटो वोल्टीयता, पालिमरिक एवं मृदु पदार्थ, पदार्थ अभिलक्षणन्, रेडियो एवं अंतरिक्ष भौतिकी, जलवायु परिवर्तन और पर्यावरणीय अध्ययन, निम्न ताप भौतिकी, क्वांटम आप्टिक्स, फ्रीक्वेंसी स्टैण्डर्ड और बायो मैडीकल इंस्ट्रूमेंटेशन में गहन क्षमता विकसित की है।

यह प्रयोगशाला भारत की राष्ट्रीय मापिकी संस्थान (NMI) है और मापन के राष्ट्रीय मानकों की संरक्षक भी है। यह आर्थिक और सुरक्षा सम्बन्धी संगठनों के सभी क्षेत्रों के उपभोक्ताओं को उच्च स्तर का अंशांकन उपलब्ध कराती है। यह सेवा देश में हुए मापनों को अन्तर्राष्ट्रीय माप एवं तोल समिति (CIPM)/अन्तर्राष्ट्रीय माप एवं तोल ब्यूरो (BIPM) और एशिया पेसिफिक मापिकी कार्यक्रम (APMP) से ट्रेसीब्लिटी प्रदान करवाती है।

राष्ट्रीय मानकों का अनुरक्षण एवं उन्नयन (अपग्रेडेशन) राष्ट्रीय भौतिक प्रयोगशाला का एक संवैधानिक दायित्व है (मानक तोल एवं माप अधिनियम 1956 एवं 1976 तथा मानक तोल तथा माप अधिनियम 1976 के लिए 1988 के नियमों के अन्तर्गत अधिदेशाधीन), तदापि, भौतिकी के अग्रणी क्षेत्रों में गहन अनुसंधान एवं विकास कार्य भी किया जाता है जो कि विभिन्न बाह्य रूप से फण्डेड तथा इन-हाउस परियोजनाओं के माध्यम से निष्पादित होते हैं। सीएसआईआर की नेटवर्क परियोजनाओं के सूत्रपात के साथ-साथ, एनपीएल इन परियोजनाओं में से कई परियोजनाओं में महत्वपूर्ण भूमिका निभा रही है, जिन्हें इस रिपोर्ट में प्रस्तुत गतिविधियों में देखा जा सकता है।

वर्ष 2009-2010 के दौरान सातों अनुसंधान विभागों यथा भौतिक यांत्रिक मानक, विद्युत तथा इलैक्ट्रॉनिक मानक, इंजीनियरिंग पदार्थ, इलैक्ट्रॉनिक पदार्थ, पदार्थ अभिलक्षणन, रेडियो एवं वायुमण्डलीय विज्ञान, अतिचालकता एवं क्रायोजेनिक्स द्वारा अनुसंधान के सभी क्षेत्रों में महत्त्वपूर्ण योगदान दिया गया है।

भौतिक-यांत्रिक मानक विभाग की महत्त्वपूर्ण शोध एवं विकासात्मक (R&D) गतिविधियों में आटोकोलीमेटर के रेसोल्युशन में वृद्धि, शुद्ध धातु थर्मोकपल के उच्च ताप का अध्ययन, फाइनाइट एलीमेंट प्रक्रिया (FEM) द्वारा संबद्ध फोटोन मापिकी और बलाघात विश्लेषण शामिल है। अन्तर्राष्ट्रीय स्तर पर एनपीएल की बढ़ी हुई क्षमताओं को पहचाना गया है। यूरोपियन (EURAMET) और अमेरिकन (SIM) मापिकी संस्थान ने बहुत से मुख्य आंकड़ों को स्वीकृति दी है और उन्हें BIPM वेब-साइट के की कंपेरिजन डेटा बेस (KCDB) में प्रकाशित किया है। इनमें जो अत्यन्त महत्वपूर्ण थे वे हैं - अंशांकन मापन क्षमताएं (CMC) दाब एवं निर्वात मानक और ध्वानिकी मानक के आंकड़े जिनका पूर्व वर्षों में अन्तर्राष्ट्रीय विशेषज्ञों द्वारा पीअर रिव्यु किया गया था। दो निर्णायक परामर्शी समिति (CC)/प्रादेशिक मापिकी (APMP) की कंपेरिजन डेटा भी प्रकाशित किए गए थे। विधिक मापिकी अधिनियम-2009 को प्रकाशित करने के लिए विधिक मापिकी विभाग, भारत सरकार की सहायता की गयी। अन्तर्राष्ट्रीय विशेषज्ञों द्वारा विवेचनात्मक पीअर रिव्यु और तीन अन्तर्राष्ट्रीय 'की कंपेरिजन' में सहभागिता की गयी। इंडो-यूएस विज्ञान एवं प्रौद्योगिकी फोरम के वित्तीय सहयोग से NIST (USA) के साथ मेरीलेंड, यूएसए में एक पांच दिवसीय रिसर्च वर्कशाप का आयोजन किया गया।

विद्युत एवं इलैक्ट्रॉनिक्स मानक विभाग में, भारतीय क्षेत्रीय नेवीगेशन प्रणाली (IRNSS) हेतु Rb परमाणु घड़ी के विकास के लिए अंतरिक्ष अनुप्रयोग केन्द्र (SAC) एवं एनपीएल की संयुक्त परियोजना के अन्तर्गत रूबीडियम Rb परमाणु

घड़ी की एक फिजिक्स पैकेज को सफलतापूर्वक विकसित किया गया। सीजियम (Cs) फाउण्टेन क्लाक को विकसित करने हेतु चलाए जा रहे कार्यक्रम के लिए ट्रैप्ड Cs एटोमिक क्लाउड सहित एक चुंबकीय- प्रकाशिक ट्रैप को सफलतापूर्वक प्रदर्शित किया गया। प्रो. समीर के ब्रहमचारी, महानिदेशक, सीएसआईआर ने औपचारिक रूप से 28 जुलाई, 2009 को सार्वजनिक उपयोग के लिए टेलीफोन नेटवर्क का उपयेाग करके टेलीफोन रिसीवर के नए संस्करण (Version) का उद्घाटन किया और इसकी जानकारी (Know-how) उद्योग जगत को हस्तांतरित की। एंटीना गेन : 6 to 10 dB एवं VSWR≤1.6 वाले फीचर सहित एक TEM हार्न एंटीना का फ्रीक्वेंसी रेंज : 1 to 18 GHz के लिए डिजाइन व निर्माण किया। वेवगाइड सिस्टम में VNA पर आधारित प्रतिबाधा माप सुविधा के संस्थापन के लिए Ka-band में (26.5 से 40 GHz) और Q-band (33 से 50 GHz) फ्रीक्वेंसी रेंज में परिशुद्धता वेवगाइड सैक्शनस् को स्वदेश में ही विकसित किया गया।

इंजीनियरिंग पदार्थ विभाग में मुख्यत: उन्नत पदार्थों, कंपोनेन्टस, डिवाइसेज, सेंसर्स और सिस्टमस् की डिजाइनिंग के लिए प्रक्रियाओं और प्रौद्योगिकियों को विकसित करने का कार्य किया जाता है। इसमें बहुत से शोध समूह हैं यथा : धातु एवं मिश्र धातु, उन्नत कार्बन पदार्थ, पालिमरिक व साफ्ट मैटीरियल्स, फेरोइलैक्ट्रिक द्रव क्रिस्टल और बायो-मोलक्यूलर इलैक्ट्रानिक्स एवं सुचालक पालीमर्स। उल्लेखनीय आर एण्ड डी आऊटपुट में एयरो स्पेस मैटेलिक डिवाइसेज़, सामरिक महत्व के नए कार्बन उत्पाद, आर्गेनिक फोटोवोल्टीय डिवाइसेज़ और विभिन्न चालक पालीमर्स व बायो सेंसर्स को विकसित करना शामिल है। कई विकासशील परियोजनाओं को जैसे सीएसआईआर. नेटवर्क, प्रायोजित, सहायता अनुदान (ग्रांट इन एड) सहयोगी एवं परामर्शी परियोजनाओं को विभिन्न आर एण्ड डी संस्थानों जो सरकारी और निजी क्षेत्र दोनों के हैं, सफलतापूर्वक लागू/पूरा किया जा चुका है।

इलैक्ट्रॉनिक पदार्थ विभाग में पदार्थ भौतिकी और रसायन के विभिन्न क्षेत्रों यथा इलैक्ट्रो संदीप्तिशील और फोटो वोल्टीय पदार्थ, नैनो संरचना पदार्थ, नैनो सम्मिश्र पदार्थ, उच्च ताप अतिचालकीय पदार्थ, उन्नत सिरेमिक पदार्थ और पालिमेरिक पदार्थ में अनुसंधान एवं विकास कार्य किया जाता है। इन पदार्थों में पतली और मोटी फिल्म फार्म के साथ-साथ बल्क फार्म को शामिल करते हुए डिवाइसेज को इस उद्देश्य के साथ विकसित करने के प्रयास किए गए जिससे कि इन विकसित प्रौद्योगिकियों को सफलतापूर्वक इंडस्ट्री को हस्तांतरित किया जा सके। सतहों और नैनो संरचना का अध्ययन और अभिलक्षणन् यहां की एक महत्त्वपूर्ण गतिविधि रही है।

पदार्थ अभिलक्षणन् विभाग ने उच्च स्तरीय परिष्कृत विश्लेषणात्मक उपकरणों का प्रयोग करते हुए अर्द्धचालक, धातु एवं मिश्र धातु, विभिन्न प्रकार के कम्पोजिट (सम्मिश्र) कुचालकों, फेरो-फ्लुइड्स, पालिमर्स और तरह-तरह के नैनो पदार्थों जैसे अतिविशिष्ट पदार्थों के मूल अभिलक्षणन् और अन्वेषण किए। इससे मुख्यत: उनके विकास और संश्लेषित पैरामीटर्स के आप्टिमाइज़ेशन में मदद मिलती है अन्य आर एण्ड डी संस्थानों के समन्वय से प्रमाणित निर्देशक पदार्थों के निर्माण और प्रौद्योगिक रूप से महत्वपूर्ण पदार्थों का विकास विभाग की अन्य उपलब्धियां हैं। इसके अतिरिक्त विभाग ने उद्योगों और अन्य आर एण्ड डी संस्थानों की उनके उत्पादों का अभिलक्षण करके उनकी गुणवत्ता को सुधारने में सहायता की है। इसके अलावा विभाग ने वर्साइल्स प्रोजेक्ट ऑन एडवांस्ड मैटीरियल्स एण्ड स्टैण्डर्डस् (VAMAS) पर 35 वीं स्टीयरिंग कमेटी मीटिंग का आयोजन किया। एशिया में पहली बार होना इसकी विशिष्टता थी। इसके उपरांत 'इंजीनियरिंग पदार्थों और प्रौद्योगिकियों के लिए मापन की आवश्यकता' पर एक कार्यशाला भी आयोजित की गयी।

रेडियो एवं वायुमण्डलीय विज्ञान विभाग में आयन मण्डलीय एवं ट्रोपोस्फेरिक संप्रेषण के विभिन्न पक्षों का अध्ययन किया जाता है। अन्तर्राष्ट्रीय सुविधा के रूप में अंतरिक्ष मौसम प्रादेशिक चेतावनी केन्द्र परिचालित है। वायु मण्डलीय ट्रेस गैस, एयरोसोल, सौर विकिरण और परिवर्तन के सन्दर्भ में परिवर्तनशील वायुमण्डलीय पर्यावरण और इसके प्रभाव के अभिलक्षण को सम्पादित किया गया। आर्कटिक और अंटार्कटिका के ऊपर ध्रुवीय आयनमण्डल और पर्यावरण से सम्बन्धित अध्ययन किए जा रहे हैं।

अतिचालकता विभाग हाल ही में खोजे गए विविध अतिचालकों पर कार्य कर रहा है। विवेचनात्मक पैरामीटर्स जैसे H_{c2}, H_{irr} और J_c (H) की वृद्धि की गणना करने के लिए $MgB_{2-x}C_x$ नमूनों पर विस्तृत चुंबकीय अध्ययन किया गया। क्षीण एवं प्रबल युग्मित MgB_2 सिस्टम में फ्लक्स लाइन्स की गतिकी का अवकलन किया गया। आक्सी-निक्टाइड सिस्टम जैसे $SmFe_{0.9}Co_{0.1}AsO$ और $NdFeAsO_{0.8}Fe_{0.2}$ को तैयार करने के लिए विभिन्न रूटीन्स विकसित किए गए।

एनपीएल ने मानव संसाधन विकास में विश्वविद्यालयों और अन्य शैक्षणिक संस्थानों के विद्यार्थियों को परियोजना कार्य और प्रशिक्षण के लिए सुविधाएं उपलब्ध कराने में भी योगदान दिया है। विभिन्न संस्थानों से लगभग 302 विद्यार्थियों ने जोकि M.Sc., M.E./M.Tech., M.C.A., B.E./B.Tech. कोर्सेज कर रहे हैं, अल्पकालीन व दीर्घकालीन प्रशिक्षण प्राप्त किया। इस वर्ष 27 शोध छात्रों को एनपीएल में काम करने के लिए प्रेरित किया गया और इस प्रकार यह संख्या बढ़कर 87 हो गयी। स्कूलों के प्रतिभावान बच्चों को विज्ञान और विज्ञान में कैरियर बनाने की ओर प्रेरित करने व प्रेरणा देने के उद्देश्य से सीएसआईआर प्रोग्राम आन यूथ फॉर लीडरशिप इन साइंस (CPYLS) 2009 के अन्तर्गत 42 युवा विद्यार्थियों को एनपीएल का दौरा कराया गया और उन्होंने एनपीएल के वैज्ञानिकों के साथ पूरे दिन पारस्परिक विचारों का आदान-प्रदान किया।

मापन विज्ञान, पदार्थ एवं पर्यावरण विज्ञान जैसे अग्रणी क्षेत्रों और 'बायोमोलक्युलर इलैक्ट्रॉनिक्स एण्ड आर्गेनिक नैनो टैक्नोलॉजी फॉर एनवायरमेंटल प्रिजर्वेशन' पर तीन अन्तर्राष्ट्रीय संगोष्ठियां/कार्यशालाएं आयोजित की गयी जिसमें इंडो-जापान वर्कशाप भी शामिल है। मापिकी के क्षेत्र में विभिन्न विषयों पर 15 प्रशिक्षण कार्यक्रम कराए गए जिसमें विभिन्न राष्ट्रीय एवं अन्तर्राष्ट्रीय संस्थानों ने भाग लिया। इसके अतिरिक्त पन्द्रह संस्थानों से 542 आगन्तुकों (विज़िटर्स) ने एनपीएल का दौरा किया।

वर्ष के दौरान लगभग 303 वैज्ञानिक एवं तकनीकी पेपर्स SCI जरनलस् में प्रकाशित हुए और 214 पेपर्स विभिन्न राष्ट्रीय एवं अन्तर्राष्ट्रीय सम्मेलनों में प्रस्तुत किए गए। भारत में 10 और विदेशों में 13 पेटेण्ट फाइल किए गए। पूर्व के वर्षों में फाइल किए गए 6 अन्तर्राष्ट्रीय पेटेण्ट और एक भारतीय पेटेण्ट को वर्ष 2009-10 में स्वीकृति मिली। 20 नई परियोजनाएं (प्रायोजित एवं परामर्शी) प्राप्त हुई और 2843 अंशांकन रिपोर्ट जारी की गयी जिनसे लगभग 435 लाख का ECF प्राप्त हुआ।

यह बहुत ही गर्व का विषय है कि एनपीएल में 27-29 दिसम्बर, 2009 के दौरान 41वां शांति स्वरूप भटनागर स्मारक (आऊटडोर) 4th जोनल टूर्नामेंट का आयोजन किया गया। यह सीएसआईआर का एक प्रतिष्ठित टूर्नामेंट है जो सीएसआईआर के प्रत्येक व्यक्ति में खेल भावना को विकसित करता है। मैं एनपीएल टीम को इतने बड़े आयोजन को बेहतरीन टीम भावना से सफलतापूर्वक आयोजित करने के लिए बधाई देता हूं।

मैं एनपीएल के सभी स्टाफ सदस्यों, वैज्ञानिकों और प्रशासन के साथ-साथ सपोर्टिंग स्टाफ के प्रत्येक सदस्यों द्वारा पूरे दिल से दिए गए सहयोग और योगदान के प्रति अपना आभार व्यक्त करता हूं जिन्होंने एनपीएल को इतना जीवंत कार्यस्थल बनाया है। मैं सीएसआईआर मुख्यालय और हमारे रिसर्च काउंसिल और प्रबन्ध काउंसिल, बाह्य विशेषज्ञों जिन्होंने वर्ष के दौरान एनपीएल का दौरा किया और हमारे शोधकर्त्ताओं को जहां कही आवश्यकता हुई प्रोत्साहित किया, के प्रति भी अपना आभार व्यक्त करता हूं।

अंत में मैं प्रकाशन समिति के अध्यक्ष डा. वीरेन्द्र शंकर तथा संबंधित समिति के सदस्यों का विशेष आभारी हूं जिन्होंने इस रिपोर्ट को तैयार करने में अपना अमूल्य योगदान दिया है। श्री प्रेम चन्द, श्री एन के वधवा, श्रीमती अनीता शर्मा, श्रीमती सरोज उपाध्याय और श्री सुभाष चन्द्र का विशेष प्रयास भी सराहनीय है।

(आर.सी. बुधानी)
निदेशक

Foreword

It is my pleasure and privilege to present the Annual Report of National Physical Laboratory (NPL) for the year 2009-10.

NPL, a premier research laboratory of India, conducts advanced research in important areas of Physics. It has delivered outstanding results at various stages, from basic to applied, primarily in the areas of National Standards, Materials Science and Atmospheric Physics. It has developed core competencies in standards, engineering materials, electronic materials, photovoltaics, polymeric & soft materials, materials characterization, radio and space physics, global change & environmental studies, low temperature physics, quantum optics, frequency standards and biomedical instrumentation.

The laboratory is also the National Metrological Institute (NMI) of India and is the custodian of the national standards of measurement. It provides apex level calibration to users in all sectors of economy and security related organizations. This service ensures stability to measurements made in the country to the international committee for weights & Measurements (CIPM)/ International Bureau of Weights & Measures (BIPM) as well as the Asia Pacific Metrology Programme (APMP).

While maintenance and up-gradation of National Standards of Measurements remains the statutory responsibility of NPL (as mandated by the standards of weights and measures Act 1956 and 1976 and under the rules of 1988 for the standards of weights and measures Act 1976), intensive R&D in frontier areas of physics is carried out under several externally funded and in-house projects. With the initiation of Network-projects programme of CSIR, NPL has been playing a crucial role in many of these projects as can be seen by the activities presented in the report.

During 2009-10, significant contributions were made in all the areas of research carried out under the Divisional Structure comprising of seven research divisions namely Physico-Mechanical Standards, Electrical and Electronic Standards, Engineering Materials, Electronic Materials, Materials Characterization, Radio & Atmospheric Sciences and Superconductivity & Cryogenics.

The significant R&D activities of Physico-Mechanical Standards Division included enhancement of the resolution of autocollimator, high temperature studies of pure metal thermocouple, correlated photon metrology and stress analysis by Finite Element Method (FEM). The enhanced capabilities of NPL were recognized internationally. Many important data were accepted by European (EURAMET) and American (SIM) metrology organization and published in the Key Comparison Data Base (KCDB) of BIPM website. Most important were calibration measurement capabilities (CMC) data of Pressure & Vacuum standards and Acoustics standards which had been peer reviewed by international experts in the previous year. Two crucial Consultative Committee (CC)/ Regional Metrology (APMP) key comparison data were also published. Legal Metrology Department, Government of India was helped to publish Legal Metrology Act-2009. There was participation in three international key comparisons and critical peer review by international experts. A research workshop of five days duration was organized at Maryland, USA along with NIST (USA) under the financial support of Indo-US Science and Technology Forum.

In Electrical and Electronic Standards Division, a Physics Package of rubidium (Rb) atomic clock was successfully developed under the Space Application Center (SAC)-NPL joint project on the development of Rb Atomic clock for Indian Regional Navigation System (IRNSS). For the ongoing development

programme of a Cesium (Cs) fountain clock, a magneto-optic trap was effectively demonstrated with a trapped Cs atomic cloud. The new Version of Teleclock Receiver using mobile telephone network was formally launched for public use by Prof. Samir K. Brahmchari, DG CSIR, on 28 July 2009, and the know–how was transferred to the industry. A TEM horn antenna was designed and fabricated for the frequency range 1 to 18 GHz with the features of antenna gain: 6-10 dB and VSWR $\leq$ 1.6. Precision waveguide sections and flush shorts in Ka-band (26.5 to 40 GHz) and Q-band (33 to 50 GHz) frequency range were indigenously developed for the establishment of VNA-based impedance measurement facility in waveguide system.

The Division of Engineering Materials worked with the sole objective of development of advanced materials, processes and technologies for designing components, devices, sensors and systems. It has a wide range of research groups, namely, Metals & Alloys, Advanced Carbon Products, Polymeric & Soft Materials, Ferroelectric Liquid Crystals and Bio-molecular Electronics & Conducting Polymer. The major R & D output included development of aerospace metallic devices, new carbon products of strategic importance, organic photovoltaic devices and a variety of conducting polymers & biosensors. Several developmental projects, such as CSIR network, sponsored, grant-in-aid, collaborative and consultancy were successfully implemented / completed for different R & D organizations, both in the public and private sectors.

In the Division of Electronic Materials, R&D was carried out on several areas of materials physics and chemistry such as electroluminescent and photovoltaic materials, nanostructured materials, nanocomposite materials, high temperature superconducting materials, advanced ceramic materials and polymeric materials. Efforts were made to develop devices involving these materials, in thin and thick film form as well as in bulk form, with the objective of transferring successfully developed technologies to industry. The study and characterization of surfaces and nanostructures had been a major activity.

Materials Characterization Division, with highly sophisticated analytical instruments, remained devoted to the basic characterization and investigation of different key materials related to semiconductors, metals and alloys, composites of various kinds, insulators, ferro-fluids, polymers and variety of nanomaterials. This essentially helped optimization of their growth and synthesis parameters. Preparation of certified reference materials in coordination with other R&D organizations and development of technologically important materials had been other accomplishments. Besides, industries and other R&D organizations were supported by characterizing their products towards improvement in their product quality. In addition, the Division organized the 35th Steering Committee (SC) meeting of the Versailles Project on Advanced Materials and Standards (VAMAS) which had the distinction of being first time in Asia. This was followed by a workshop on "Measurement needs for Engineering Materials and Technologies".

Radio and Atmospheric Sciences Division carried out studies on various aspects of ionospheric and troposopheric communication. A space weather regional warning center, as a part of International facility, is in operation. Characterization of changing atmospheric environment and its impact in respect of atmospheric trace gases, aerosols, solar radiation and climate change was done. The studies related to Polar ionosphere and environment over Arctic and Antarctica are continuing.

The Superconductivity Division continued with the preparation of variety of recently discovered superconductors. Exhaustive magnetic studies on $MgB_{2-x}C_x$ samples were carried out to figure out enhancement of critical parameters like H_{c2}, H_{irr} and J_c.(H). The dynamics of flux lines in weakly and strongly coupled MgB_2 systems was differentiated. Various routines were developed to prepare oxy-pnictide systems, e.g., $S_mFe_{0.9}Co_{0.1}AsO$ and $NdFeAsO_{0.8}Fe_{0.2.}$

NPL has also been contributing in the human resource development by providing facilities to students from universities and other educational institutes for project work and training. About 302 students pursuing M.Sc., M.E./ M.Tech., M.C.A., B.E./ B.Tech. courses from various institutes underwent short and long term training. Twenty seven fresh research fellows were motivated to join NPL during the year, making a total strength of 87. To inspire and motivate the talented school children towards science and scientific carrier, 42 bright young school students visited NPL and had full day interactive sessions with NPL scientists, under CSIR Programme on Youth for Leadership in Science (CPYLS)-2009.

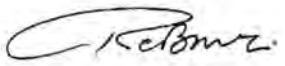
Three international conferences/workshops were organized covering pioneer areas of Measurement Science, Materials and Environmental Science including Indo-Japan workshop on "Biomolecular Electronics and Organic Nanotechnology for Environmental Preservation". Fifteen training courses on diverse topics in the field of metrology were held where persons from various national and international organizations participated. Besides, fifteen institutional visits to NPL were organized involving 542 visitors.

During the year, about 303 scientific and technical papers were published in SCI and 214 papers were presented at various national and international conferences. Ten patents were filed in India and thirteen were filed abroad. Six international patents and one Indian patent filed in previous years were granted during 2009-10. Twenty new projects (sponsored and consultancy) were undertaken and 2843 calibration reports were issued, which contributed to generation of an ECF of about 435 lakhs.

It was an honour for NPL to hold XXXXI Shanti Swarup Bhatanagar Memorial (Outdoor) 4th Zonal Tournament during December 27-29, 2009. This is a prestigious tournament of CSIR meant for fostering sportsperson's spirit among every individual and CSIR as a whole. I would like to congratulate Team NPL for successfully organizing the grand event with excellent team spirit.

The wholehearted support and cooperation of each and every member of NPL staff; scientists, supporting as well as administrative, that has made NPL a lively place to work, is duly acknowledged. I also wish to acknowledge the support received from CSIR Head Quarters and our Research Council and Management Council. External experts who visited NPL during the year continued to provide desired impetus to our researchers. I, earnestly, feel grateful to them.

I would also like to acknowledge the contribution of the Publication Committee Chairman Dr. Virendra Shanker and associated team members in bringing out this report. Special efforts made by Sh Prem Chand, Sh. N.K. Wadhwa, Ms Anita Sharma, Ms Saroj Upadhyay and Sh Subhash Chandra are also appreciated.



(R. C. Budhani)
Director

Preamble

National Physical Laboratory is one of the first National laboratories set-up under CSIR. Its foundation stone was laid by the first Prime Minister of India, late Pandit Jawahar Lal Nehru on 4th January 1947. Late Dr. K.S. Krishnan, FRS, was the first Director of the laboratory. The main building was opened by the then Deputy Prime Minister, late Sardar Vallabhbhai Patel on 21st January 1950.

CHARTER

The main objectives of NPL have been a) to establish, maintain and improve National Standards of Measurements and to realize the Units based on International system, b) to identify and conduct research in areas of Physics, which are most appropriate to the needs of the Nation and for the advancement of the field, c) to assist industries, national and other agencies in their developmental tasks by precision measurements, calibration, development of devices, processes and other allied problems related to physics and d) to keep itself informed of and study critically the status of physics.

CUSTODIAN OF NATIONAL STANDARDS OF MEASUREMENT

National Physical Laboratory has the responsibility of realizing the units of physical measurements based on the International System (SI units) under the subordinate legislations of Weights & Measures Act 1956 (reissued in 1988 under the 1976 Act). NPL also has the statutory obligation to establish, maintain and update the national standards of measurement & calibration facilities for different parameters. The Seven SI base units are metre, kilogramme, second, kelvin, ampere, candela, mole (mol) and the SI supplementary units are radian (rad) & steradian (sr). The other derived units for physical measurement, that the laboratory currently maintains, are: force, pressure, vacuum, luminous flux, sound pressure, ultrasonic power; ac voltage; current and power; low frequency voltage; impedance and power; high frequency voltage; power; impedance; attenuation and noise; microwave power; frequency; impedance; attenuation and noise.

NATIONAL APEX BODY FOR CALIBRATION

The laboratory provides apex level calibration services in the country, offering National Accreditation Board for Testing and Calibration (NABL), the national accreditation body in the country (i) its qualified assessors as needed for establishing best measurement capability of the applicant laboratory; (ii) its technical input to enable NABL to decide the suitability of the applicant laboratory for accreditation, and (iii) its faculty to train testing laboratories for estimation of uncertainty in their measurements.

Besides, the laboratory is engaged in development of Certified Reference Materials to ensure high quality measurement and traceability of analytical measurements to national/international measurement system (SI unit) in order to fulfill the mandatory requirement of quality systems (ISO/IEC-17025) and of the NABL.

MAJOR ACHIEVEMENTS

National Physical Laboratory has to its credit innumerable number of achievements, a few major achievements are: a) Introduction of Metric system of measurements in India, b) Development of Indelible ink-the indelible contribution to Indian democracy, c) Estimation of methane gas emission from India-a nationwide measurement campaign giving countrywide advantage in environment protection, d) Setting up a pilot plant for development of Electronic components (ferrites), which led to setting up a public sector Unit called Central Electronics Ltd. (CEL) in 1973, e) Development of know-how of the Electrostatic Photocopying machine using indigenous materials and f) Indian Standard Time.

The major thrust areas of R & D are

(A) Metrology

- Calibration & Testing Services to Industries
- Electrical & Electronic Standards
- Physico - Mechanical Standards
- Metrology in Chemistry
- Nano Metrology
- Primary Standards
- Realization of SI units

(B) Materials

- Light weight, high strength metallic materials
- Bulk Nano metallic and Nanocomposite materials
- Carbon & Carbon composites
- Plasma Processed Materials
- Organic and Inorganic Photovoltaics
- Luminescent Materials
- Organic Light Emitting Diodes
- Conduction Polymers & Composites
- Superconducting materials and Superconductivity
- Fuel cells
- Sensors (based on Bio, Gas, Chemicals, MEMS)
- Advanced Characterization Techniques

(C) Radio and Atmospheric Sciences

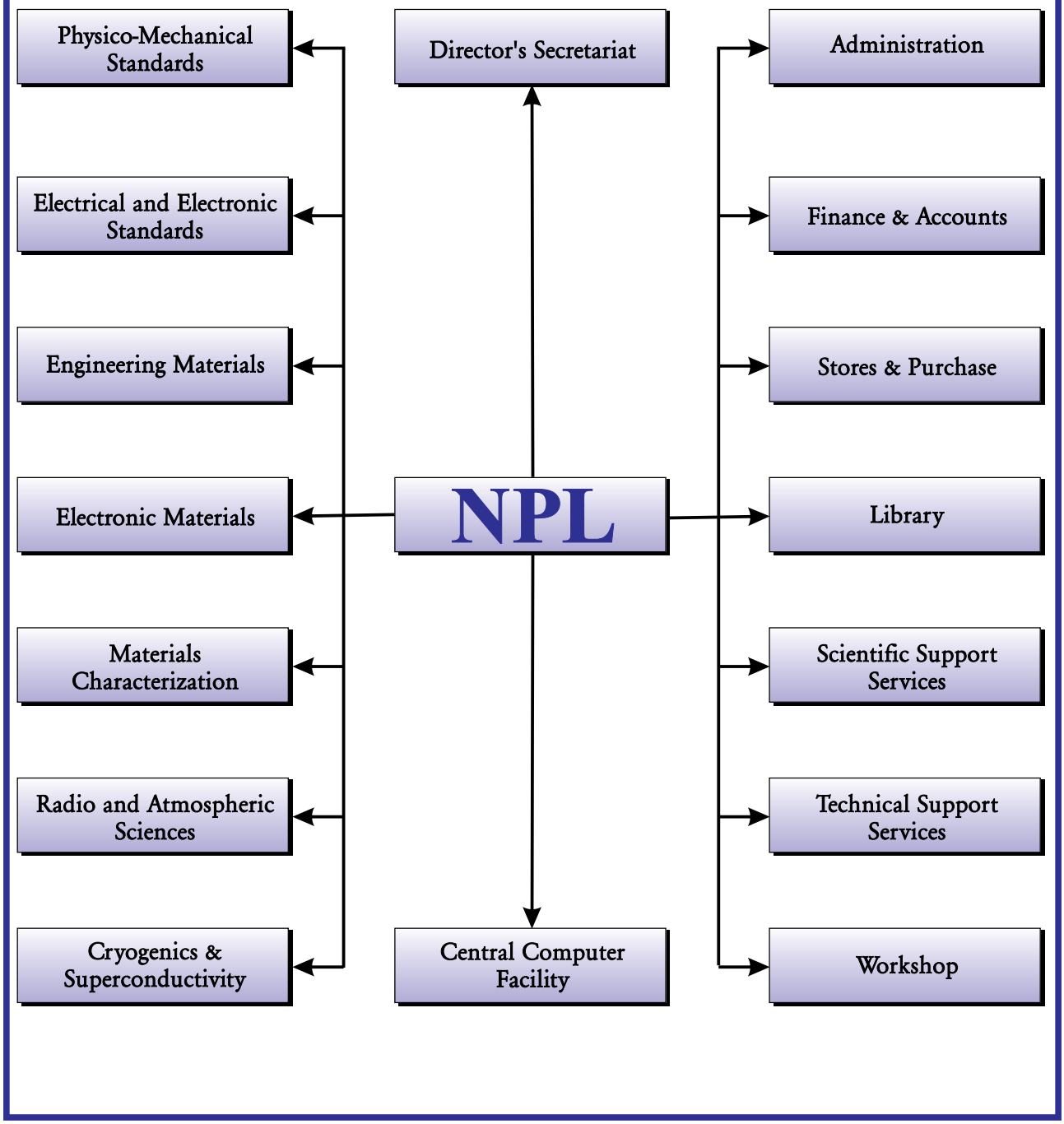
- Ionosphere & Troposphere
- Atomospheric Environment
- Global Climate change
- Antarctica and Arctic studies
- Radio- Propagation
- Communications (Fixed, mobile and marine)

ORGANIZATION AND MANAGEMENT

The laboratory has structured its total activities under seven scientific decision units. These are: (i) Physico-Mechanical Standards, (ii) Electrical and Electronic Standards, (iii) Engineering Materials, (iv) Electronic Materials, (v) Materials Characterization, (vi) Radio and Atmospheric Sciences and (vii) Cryogenics and Superconductivity.

In addition, it has set-up nine support units for its organization and management. These are (i) Director's Secretariat (ii) Administration (iii) Finance & Accounts, (iv) Store & Purchase, (v) Library, (vi) Scientific Support Services, (vii) Technical Support Services, (viii) Workshop and (ix) Central Computer Facility.

R & D GROUPS & MANAGEMENT



Photographs of Important Events

Prithvi Divas-Radio avam Paryavaran Vigyan Rashtriya Sangosthi-2009, April 22-23, 2009

National Technology Day and World Metrology Day Celebrations, May 20, 2009

Technology Transfer of Mobile Teleclock Receiver: an improved version of Teleclock receiver utilizing mobile network to M/s Bihar Communications Pvt. Ltd., Patna, July 07, 2009

Technology Transfer of Humidity Portable Relative Humidity Generator to M/s Belz Instruments Pvt. Ltd., July 20, 2009

CSIR Programme for Youth Leadership in Science (CPYLS-2009) December 1-2, 2009

Indo Japan Workshop on Biomedical Electronics & Organic Nanotechnology for Environmental Preservation (IJWBME, 2009) December 17-20, 2009

Signing of Agreement with M/s Bharti Automation Pvt. Ltd., New Delhi for Prototype Development of an Automatic Compact Fluid Flow Calibration System February 18, 2010.

35th Steering Committee Meeting on Versailles Project on Advanced Materials & Standards and Workshop on Measurement needs for Engineering Materials & Technologies March 3-5, 2010.

CSIR Foundation Day

CSIR Foundation Day Celebrations
September 26, 2009

Sports

Shanti Swarup Bhatnagar Memorial Tournament (Outdoor-Zonal)
December 27-29, 2009

भौतिक-यांत्रिक मानक

PHYSICO-MECHANICAL STANDARDS

भौतिक यांत्रिक मानक

शीर्ष स्तर मानक एवं औद्योगिक मापिकी विभाग में भौतिक, यांत्रिक, प्रकाशीय और थर्मल मापन गतिविधियों सम्बन्धी कार्य किए जाते हैं। इस विभाग में निम्नलिखित 9 उप–विभाग हैं :–

डी पी संख्या	डी पी का नाम
1.01	द्रव्यमान मानक
1.02	लम्बाई और आयाम (विभा) मानक
1.03	तापमान और आद्रता मानक
1.04	प्रकाशीय विकिरण मानक
1.05	बल और कठोरता मानक
1.06	दाब और निर्वात मानक
1.07	ध्वनिक और पराश्रव्य मानक
1.08	तरल बहाव मानक
1.09	आघात और कंपन मानक

शीर्ष स्तर मानक एवं औद्योगिक मापिकी के ये उप–विभाग मापन के राष्ट्रीय मानकों को स्थापित, रख–रखाव और निरन्तर उन्नयन के लिए उत्तरदायी है। इस विभाग द्वारा देश के उद्योगों और संस्थानों को उच्च स्तरीय अंशांकन उपलब्ध कराया जाता है, जिससे उन पैरामीटर्स के आधार पर किए गए मापन का अनुरेखण किया जा सके। अंशांकन मापन क्षमताओं की विश्व के अग्रणी राष्ट्रीय मापन संस्थानों (NMI) के तकनीकी विशेषज्ञों द्वारा समीक्षा की गयी है। सी.एस.आई.आर. नेट वर्क परियोजना (NWP-45) के माध्यम से इस विभाग की गतिविधियों को फंड मिलता है। इस परियोजना के अन्तर्गत बहुत सी नई गतिविधियों को आरम्भ किया गया है।

विभाग की मुख्य विशेषताएं

(1) मौलिक अनुसंधान और विकास

(क) बहुपरावर्त्ती तकनीक का इस्तेमाल करते हुए इसकी परिशुद्धता खोए बिना स्वचालित समांतरित्र के विभाजन का संवर्धन (डीपी 1.02)

(ख) उच्च ताप रेंज में मानक थर्मोकपल का प्रयोग करते हुए इसके निष्पादन का अध्ययन करने के लिए तुलनात्मक पद्धति द्वारा 800^{0}C से 1300^{0}C के रेंज में और जिंक के निश्चित प्वाइंट (419.527) का पैलेडियम (Pt/Pd) कांबिनेशन वर्सेज प्लेटिनम के उच्च ताप शुद्ध धातु थर्मोकपल पर अध्ययन किया गया (डीपी 1.03)

(ग) सह सम्बन्धित फोटोन मापिकी प्रयोगात्मक सैट–अप संस्थापित किया गया (डीपी 1.04)

(घ) नियंत्रित अन्तर दाब तुला (CCPG) के अभिलक्षणन के लिए परिमित तत्व परिकलन विधि (डीपी 1.06)

(2) इस अवधि के दौरान सृजित नई सुविधाएं :–

(क) रांगा (टिन) और जस्ता (जिंक) युक्त प्वाइंट सैल्स सहित त्रय जोन फरनेस और उच्च ताप मानक प्लेटिनम रेसिस्टेंस थर्मोमीटर।

(ख) श्रव्य विश्लेषक और द्वितीयक कंपन अंशांकन पद्धति

(ग) 10 MPa तक गैस आधारित स्वचालित भारण प्राथमिक दाब मानक

(घ) श्यानता (विस्कोसिटी) मापन हेतु परिशुद्ध ताप बाथ

(3) BIPM KCDB वेब साइट [http://kcdb. bipm.org/ appendixC/] पर एशिया पेसिफिक प्रोग्राम (APMP) में अंशांकन मापन क्षमताओं (CMCs) का प्रकाशन

(क) 12 अक्टूबर, 2009 को विभाग द्वारा निर्वात एवं दाब मानक के उप–विभाग के अंशांकन मापन क्षमताओं (CMCs) के सैट को अद्यतन किया गया (डीपी1.06)

(ख) 24 अक्टूबर, 2009 को ध्वनिक मानक उप–विभाग के अंशांकन मापन क्षमताओं (CMCs) के सेट का प्रकाशन किया गया (डीपी 1.07)

(4) BIPM KCDB वेब साइट [http://kcdb.bipm.org/appendix B/] पर एशिया पेसिफिक मैट्रोलॉजी प्रोग्राम (APMP)/ के माध्यम से कराए गए मुख्य तुलनाओं के ब्यौरों का प्रकाशन

(क) 24 जुलाई, 2009 - ABMP.L-K 1.1 – व्यतिकरणमिति (इंटरफेरोमीटरी) द्वारा मापन किए गए स्टील गॉज ब्लाक की मुख्य तुलना का प्रकाशन (डीपी 1.02)

(ख) 6 अक्टूबर, 2009 – APMP.M.M-K2 - CCM.M-K2 से संबद्ध APMP.M.M-K2 परिणामों का प्रकाशन। ये किलोग्राम के बहुगुणक, उपबहुगुणक की मुख्य तुलनाएं (डीपी 1.01)

(ग) 28 अक्टूबर, 2009 – $3x10^{-6}\dot{P}$ से $9x10^{-4}$Pa तक गैस आधारित (CCM.P-K3) पूर्ण दाब मापन की प्रतिवेदन का प्रकाशन (डीपी 1.06)

(5) विभाग द्वारा अन्तर्राष्ट्रीय मुख्य तुलनाओं में भाग लेना

विभाग ने विभिन्न समूहों में तीन अन्तर्राष्ट्रीय मुख्य तुलनाओं में भाग लिया। जो द्रव्यमान मानक APMP.M.D-K4 (डीपी 1.01) और निर्वात एवं दाब मानक CCM.P-K12 और CCM.P-K13 (डीपी1.06) हैं। इनमें से सभी सफलतापूर्वक पूरे किए गए और अश्मोपकरण (Artifacts) वापस भेजे गए।

(6) विभाग का तकनीकी पीअर–रिव्यु

क्रमांक	गतिविधि	दिनांक	तकनीकी विशेषज्ञ	CMCs
1.	लम्बाई और आयाम मानक (डी पी 1.02)	11–13 नवम्बर, 2009	डा. तोशीयुकी ताकासूजी राष्ट्रीय मापिकी संस्थान (NMI), जापान	22
2.	बल और कठोरता मानक (डी पी 1.05)	16–18 नवम्बर, 2009	डा. कोनरेड हरमन पी टी बी, (PTB), जर्मनी	12
3.	ताप एवं आद्रता मानक (डी पी 1.03)	2–4 मार्च, 2010	डा. जार्ज बोनियर एल एन ई (LNE), फ्रांस	24

(7) तकनीकी व्यवस्थापन के समर्थन में मापिकी, मानक और स्थायी निर्धारण व उनके प्रयोग पर यू एस – इंडिया कार्यशाला स्थल : नेशनल इंस्टीट्यूट ऑफ स्टैण्डर्डस् एण्ड टैक्नोलॉजी (NIST), MSEL कांफ्रेंस रूम NIST बिल्डिंग 223 रूम बी 307, गैथर्स बर्ग, मैरीलेण्ड, यू एस ए, दिनांक 1–4 जून, 2009

विभाग ने दो देशों भारत और अमेरिका में मापन विज्ञान और उच्च स्तर मानक पद्धति का अवलोकन करने के लिए संयुक्त रूप से एक संगोष्ठी का आयोजन किया। संगोष्ठी में विशेष रूप से अमेरिका और भारत में मानकों (डोक्यूमेंटरी और मापन दोनों में), स्थायी निर्धारण और माप पद्धति व सपोर्ट तकनीकी व्यवस्थापन में उनके प्रयोग पर विचार किया गया। कार्यशाला के शिष्ट मण्डल ने NIST की विभिन्न प्रयोगशालाओं (यथा नैनो, कैमिकल, बायो, मैन्युफैक्चरिंग इंजीनियरिंग आदि) का दौरा किया। इस वर्कशाप की अवधि चार दिन 1–4 जून, 2009 की थी। इस कार्यशाला में शिष्ट मण्डल के सदस्य सिर्फ एन पी एल (NPL) से ही नहीं वरन् सी एस आई आर (CSIR) की अन्य प्रयोगशालाओं जैसे आई आई पी (IIP) (देहरादून), सी बी आर आई, (CBRI)(रूड़की) एस ई सी आर आई (SECRI) (चैन्नई), सी एफ टी आर आई (CFTRI)(मैसूर), आई आई सी टी (IICT) (हैदराबाद), से भी शामिल हुए थे। बी आई एस (BIS), एन ए बी एल (NABL), क्यू सी आई (QCI), सी आई आई (CII), एफ आई सी सी आई (FICCI) आदि संस्थानों के सदस्यों ने भी 20 सदस्यों वाले प्रतिनिधिमण्डल में भाग लिया।

(8) पुरस्कार एवं सम्मान

1. वर्ष 2009 में, डा. एच सी काण्डपाल का इंडियन नैशनल साइंस अकादमी, इलाहाबाद के फैलो के रूप में चयन किया गया।
2. डा. ए के बंधोपाध्याय को मास एण्ड रिलेटिड क्वांन्टिटीज़ के क्षेत्र में उनके विशिष्ट योगदान के लिए वर्ष 2009 का APMP तकनीकी पुरस्कार प्रदान किया गया।

PHYSICO-MECHANICAL STANDARDS

The division of Physico-Mechanical Standards (PMS) constitutes of Physical, Mechanical, Optical and Thermal measurement activities involving nine groups –

DP No.	Name of the DP
1.01	Mass Standards
1.02	Length and Dimension Standards
1.03	Temperature and Humidity Standards
1.04	Optical Radiation Standards
1.05	Force and Hardness Standards
1.06	Pressure and Vacuum Standards
1.07	Acoustics and Ultrasonic Standards
1.08	Fluid Flow Standards
1.09	Shock and Vibration Standards

The PMS division is responsible to establish, maintain and continually upgrade the National Standards of Measurements of the above mentioned DPs. It provides apex level calibration services to the industry and institutions of the country and thus ensures the traceability of measurements made by these parameters. The calibration and measurement capabilities (CMCs) have been peer-reviewed by Technical experts of leading National Metrology Institutes (NMI) of the world. The activities of PMS have been funded through a CSIR Net Work Project (NWP-45). A lot of new activities have been initiated under the project.

Highlights of the Division:

A) Basic Research and developments carried out during the period:

i) Enhancement of the resolution of autocollimator without loosing its accuracy using multi reflection techniques (DP 1.02).

ii) Study of high temperature pure metal thermocouple of platinum versus palladium (Pt/Pd) combination has been carried out at fixed point of zinc (419.527 °C) and also in the range 800 ºC to 1300 °C by comparison method in order to study its performance to be used as standard thermocouple in the high temperature range (DP 1.03).

iii) Correlated photon metrology experimental set-up was established (DP 1.04).

iv) Finite Element Calculation Method (FEM) for the characterization of a Controlled Clearance Piston Gauge (CCPG) (DP 1.06).

B) New Facilities created during this period :

i) Three zone furnace with Tin & Zinc fixed point cells and High temperature standard platinum resistance thermometer.

ii) Audio Analyser and Secondary Vibration calibration System.

iii) Primary Pressure standard-Automatic loading Pneumatic Dead weight tester upto 10 MPa.

iv) Precision Temperature baths for viscosity measurements.

C) Publication of Calibration Measurement Capabilities (CMCs) in the BIPM KCDB web site via Asia Pacific Metrology Program (APMP) [http://kcdb.bipm.org/appendixC/]

i) 12th October 2009- Update of the set of CMCs of the Pressure and Vacuum Standards from the Division (DP 1.06)

ii) 24th October 2009 - Publication of the set of CMCs of the Acoustics Standards from the Division (DP 1.07)

D) Publication of Key comparison in the BIPM KCDB web site via Asia Pacific Metrology Program (APMP) [http://kcdb.bipm.org/appendixB/]

i) 24th July 2009- APMP.L-K1.1 - Publication of key comparison of steel gauge blocks measured by interferometry (DP 1.02).

ii) 6th October 2009 - APMP.M.M-K2 - Publication of APMP.M.M-K2 results, linked to those of CCM.M-K2. These are key comparisons of multiples and submultiples of the kilogram (DP 1.01)

iii) 28th October 2009 – Publication of CCM.P-K3 absolute pressure measurements in gas from $3x10^{-6}$ Pa to $9x10^{-4}$ Pa (DP 1.06).

E) Participation in the International Key comparisons from the Division:

The division has participated in three international key comparisons in the various groups. They are from Mass standards APMP.M.D-K4 (DP 1.01) and Pressure and Vacuum Standards CCM.P-K12 and CCM.P-K13 (DP1.06) . All of them successfully completed and the artifacts were sent back.

F) Technical Peer review of the Division:

S. No.	Activity	Dates	Technical Expert	CMCs
1.	Length & Dimension Standards (DP 1.02)	11 - 13 Nov. 2009	Dr. Toshiyuki Takatsuji, National Metrology Institute, Japan	22
2.	Force & Hardness Standards (DP 1.05)	16 - 18 Nov. 2009	Dr. Konrad Herrmann, PTB, Germany	12
3.	Temperature & Humidity Standards (DP 1.03)	2 - 4 March 2010	Dr. George Bonnier, LNE, France	24

G) US-India Workshop on Metrology, Standards, and Conformity Assessment and Their Use in Support of Technical Regulations Venue: National Institute of Standards and Technology (NIST), MSEL Conference Room NIST Bldg 223 Room B307, Gaithersburg, Maryland USA, Date: June 1-4, 2009

The division organized a joint symposium to overview the measurement sciences and the apex level standards system in the two countries India and the US. The symposium specifically dealt with the standards (both documentary and measurement), conformity assessment and metrology systems and their applications to support technical regulations in the United States and India. It examined the role that these system components play in enhancing global trade and spurring innovation; and explore opportunities for future collaboration. The Laboratory tours to specific NIST laboratories (e.g., nano, Chemical, bio, manufacturing engineering etc.) were also organized. This workshop was of four days duration from 1st to 4th June, 2009. The delegates of this workshop were not only from NPL but also from other CSIR laboratories like IIP (Dehradun), CBRI (Roorkee), SECRI (Chennai), CFTRI (Mysore), IICT (Hyderabad). Other delegates from the institutions like BIS, NABL, QCI, CII, FICCI etc. have also joined the 20 members delegation.

H) Honours and Awards

i) Dr. H.C. Kandpal was elected as Fellow of Indian National Science Academy, Allahabad, India in the year 2009.

ii) Dr. A.K. Bandyopadhyay was awarded APMP Technical Award - 2009 for his outstanding contribution in the field of Mass and related quantities

Figure 1.1: Group photo of Indian delegates with Drs. Claire M. Saundry and Maria Uhle, Office of International Affairs of NIST (USA) under the famous Newton Apple Tree of NIST.

Mass Standards

Major Achievements :

(1) APMP-M-M-K2 Inter-comparison on Mass Measurement

This comparison was piloted by NPL, India during July 2004 to March 2007. The National Metrology Institutes (NMIs) of eleven countries participated in this comparison. A set of five weights (10 kg, 500 g, 20 g, 2 g and 100 mg) of E1 class were used as traveling standards.

Final report of this comparison was published named as "APMP comparison of mass standards APMP.M.M-K2 : (Sub)multiples mass key comparison" in Metrologia, 2009, 46, Tech. Suppl., 07014.

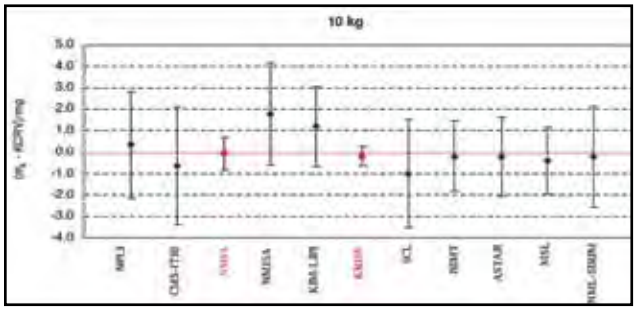


Fig. 1.2

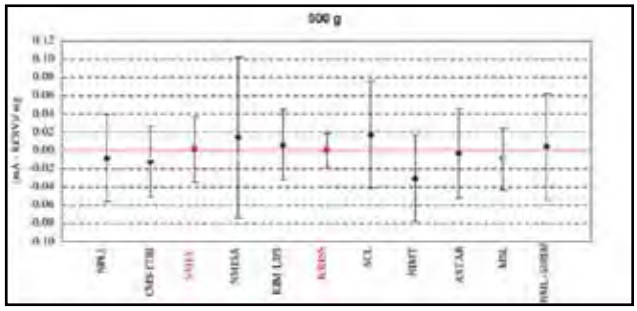


Fig. 1.3

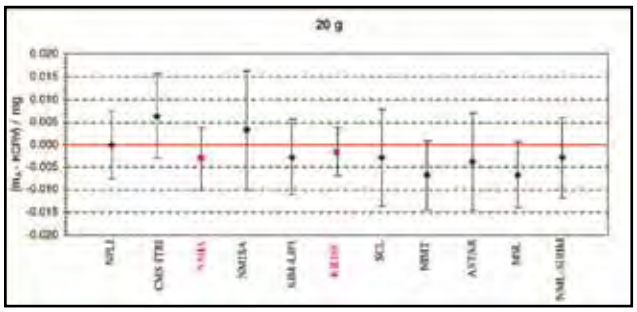


Fig. 1.4

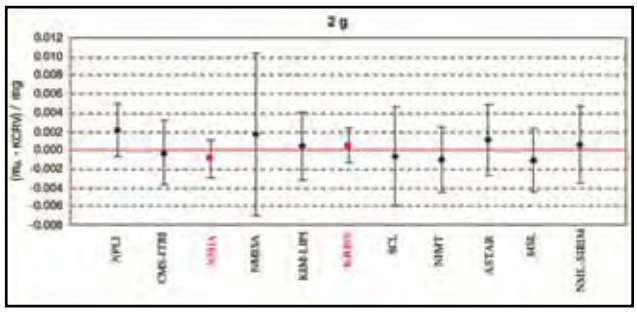


Fig. 1.5

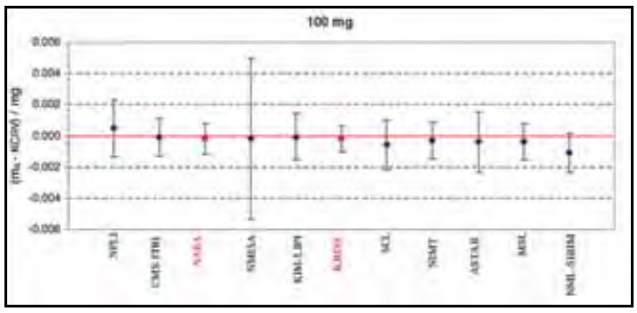


Fig. 1.6

Fig. 1.2 to 1.6 : The graphs indicate the difference between each participant's mass value (m_A) and the key comparison reference value (KCRV) of CCM.M-K2 with bars representing expanded uncertainties U (k=2). Link laboratories to CCM.M-K2 are shown by the rectangular pink marker.

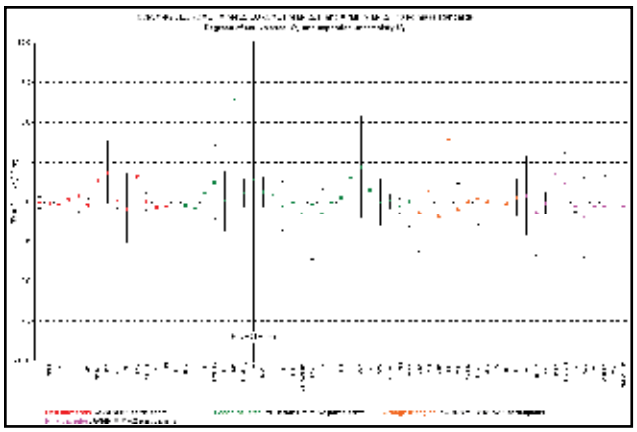


Fig. 1.7 : Results of 10 kg mass standard for all participants and linking with the corresponding CCM key comparison

(2) CCM-M-K5 Inter-comparison on Mass Measurement

Draft B report is the final report which was sent by the NMIJ, Japan (Pilot laboratory) for verification and as per report, all the results of NPL, India are within the agreement. NPL, India participated in this comparison in 2002.

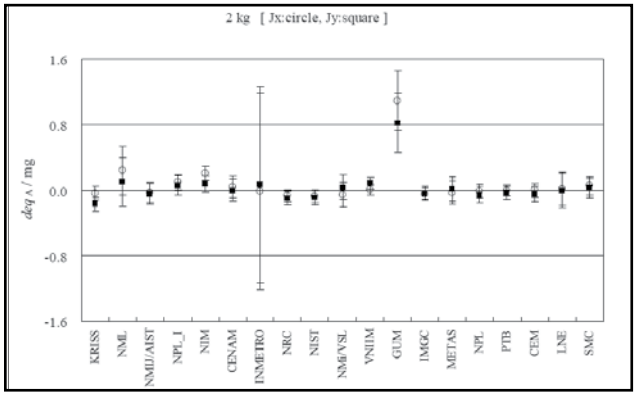


Fig. 1.8 : Results of 2 kg mass standard for all participants. The zero line represents the median. Circle and solid square points represent J_x and J_y standard mass respectively. Error bars show the expanded uncertainty $U_{95(meqA)}$ of each point. Uncertainties of the median are 0.037 mg for J_x, 0.048 mg for J_y.

(3) SAARC-PTB Technical Cooperation Program and APMP-M-M-S1 Inter-comparison on Mass Measurement

Phase-I is completed covering the countries like Nepal, Sri Lanka and Bangladesh. We have imparted on-site training to the staff of Mass Metrology of Bangladesh Standard and Testing Institution (BSTI) in December 2009. Same trainings for staff of Mass Metrology of NMIs of Pakistan, Bhutan and Maldives are to be organized in Phase-II.

(4) APMP-M-D-K4 Inter-comparison on Density Measurement

An international inter-comparison on Density Standards is being carried out among eleven NMIs named as NMIA (Australia), CSIR (South Africa), NML-SIRIM (Malaysia), IRL (New Zealand), NML (Philippine), NMIJ (Japan), NIM (China), NIMT (Thailand), NPL (India), KIM LIPI (Indonesia) and KRISS (Korea)

The KRISS, Korea is coordinating this comparison. The NMIJ, Japan has been provided technical help to the pilot Laboratory with setting up this Technical Protocol. This comparison is intended to be a regional key comparison according to the Mutual Recognition Arrangement (MRA). It should also support provisional entries for the CMC tables in this sub-field.

The aim of the APMP.M.D-K4 is to establish the degree of equivalence of NMIs for hydrometer calibration in the density range between 640 kg/m^3 and 1320 kg/m^3 at 20 °C. For the comparison, three glass hydrometers ranging of (640 to 660) kg/m^3, (980 to 1000) kg/m^3 and (1300 to 1320) kg/m^3 were used as travelling standards.

As per protocol of the program, NPL Scientist visited NIM, China in November 2009 to hand over the artifacts.

The NPL, India participated in this comparison during September-October 2009 using Hydrostatic weighing Method.

Fig. 1.9 : Traveling bag

Fig. 1.10 : Traveling boxes

Fig. 1.11 : Traveling standards inside the boxes

Fig. 1.12 : Traveling standards and boxes

Other Significant Achievement

1. Actively participated in organizing National Workshop on Mass, Temperature and Dimensional Metrology from 16th to 18th September 2009.
2. Technical protocol for NPL-NABL proficiency testing [PT] program [NPL-NABL/M/1/2010] on Mass Measurement has been prepared. Also a list of participants has been prepared and sent to PT coordinator.
3. Imparted training on Mass and related parameters to the participants from Govt. & Private organizations, industries etc. from 8th to 12th June 2009 and from 22nd to 26th February 2010.
4. Provided consultancy to the MSME, New Delhi (Project code : CNP 080832) and the ERTL(N), New Delhi (Project code : CNP 090132) in the area of Pressure Standards jointly with Pressure and Vacuum Standards Group.

5. One dead weights machine was made by the Force & Hardness Standards, NPL for RRSL, Bangalore (ministry of Food and Consumer Affairs) and all the dead weights used in this project were characterized by the Mass Standards Group.

6. Provided traceability to the following Standards Activities of NPL :
   i. Force and Hardness Standards
   ii. Pressure and Vacuum Standards
   iii. Fluid Flow Measurement
   iv. Chemical Metrology
   v. Nano-Magnetic Fluid

7. Provided apex level calibration facilities in Mass, Volume, Density and Viscosity Measurements to the Legal Metrology, Pharmaceutical Industries, weights manufactures, weighing instruments manufactures, petroleum industries, paint industries and NABL accredited laboratories. Mass group has issued certificates of 493 nos. (452 nos. for external and 41 nos. for notional) and earned Rs. 75.97 lakhs (Rs. 69.04 lakhs from external and Rs. 6.93 lakhs from notional).

Fig. 1.13 : Hardness Tester Machine

8. On-site calibration of Hardness Tester Machine using NPL Mass Standards for Ordnance Equipment Factory, Kanpur (Fig.1.13).

9. NPL has unique facility for calibration of the weights upto 2500 kg in the premises of Fluid Flow Measurement. We have taken a special work for ISRO, Bangalore for calibration of their weights for 1000 kg and 2000 kg (Fig.1.14).

Fig.1.14 : Calibration set-up of 2000 kg weight of ISRO, Bangalore

Length and Dimension Standards

1. Enhancement of the resolution of autocollimator without loosing its accuracy using multi reflection techniques

In the field of angle metrology, tilting table, sine bar and rotary table are the angle generating instruments and the electronic engineering level, precision spirit level, autocollimator are angle measuring instruments. An autocollimator along with reflector is used for calibrating these instruments. In principle, the reflector is mounted on angle generating instrument and the autocollimator is aligned such that it's optical beam falls perpendicularly onto the reflector. The

collimated optical beam emitted from reference standard autocollimator is reflected back by the reflector on to the target of reference standard autocollimator. When an angle generating instrument generates the predetermined angular displacements, the reflector deflects the incident beam by the same angle. Theoretically, the angle between emitted beam and reflected beam is twice the angular displacement of reflector. The autocollimator determine the angle generated by the angle generating instrument. In this way, we achieved the resolution of four times. Based on the above theory, we are developing a patentable technology (proposad invention) which can enhance resolution of reference autocollimator used for the calibration. Several mirrors are assembled in a patterned fashion to realise multiple reflection technique of optical beam and to achieve the improved uncertainty of measurement in this work.

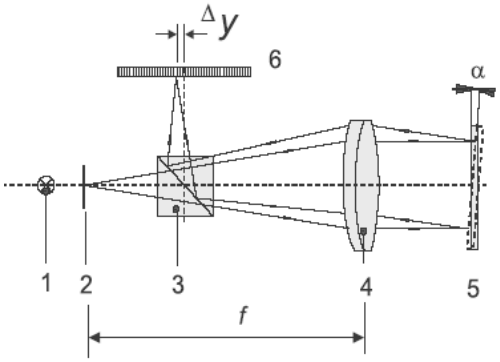


Fig.1. 15 : Diagrammatic sketch of an electronic autocollimator, (1) illumination unit; (2) slit; (3) beam splitter; (4) collimator objectives; (5) plane mirror; (6) CCD arrey

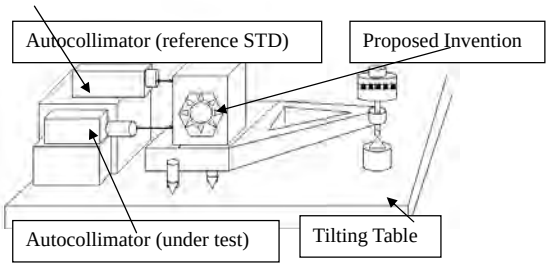


Figure 1.16 Calibration setup for autocollimator

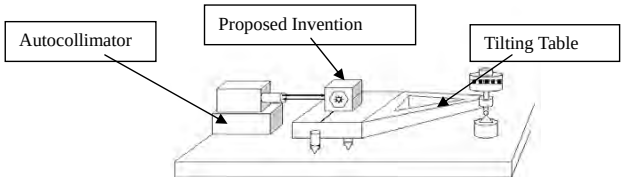


Figure 1.17 Calibration setup for tilting table

2. Precision traceable measurements and certification of complex Masters for cylinder heads for automobile industries .

Complex parameters of the cylinder heads are measured using 3D Coordinate Measuring Machine with an uncertainty of measurement of 0.5 micrometer at k=2 using substitution and comparison method. Earlier these were being measured at Italy till recently. We have carried out this challenging job for the first time in India and created expertise to deal such jobs in future.

Figure 1.18 : Master cylinder head 1 under evaluation

Figure 1.19 : Master cylinder head 2 under evaluation

3. Participated in APMPL-K8 international intercomparison for roughness and groove depth standard in October, 2009. Project was coordinated by NMI, Australia. Total 18 labs participated in this intercomparison, including NIST USA and NPL UK. The measurements are in process and hopefully it will be completed by the end of this year.

Temperature & Humidity Standards

1. R&D work carried out on new Pt/Pd Thermocouple Temperature Standards:

Research work on the development and study of high temperature pure metal thermocouple of platinum versus palladium (Pt/Pd) combination has been carried out at fixed point of zinc (419.527 °C) and also in the range 800 ºC to 1300 °C by comparison method in order to study its performance to be used as standard thermocouple in the high temperature range. The results of the performance have been shown below.

Fig.1.20 Set-up for Zn-point Calibration and Non-contact Comparison for Pt/Pd Thermocouple

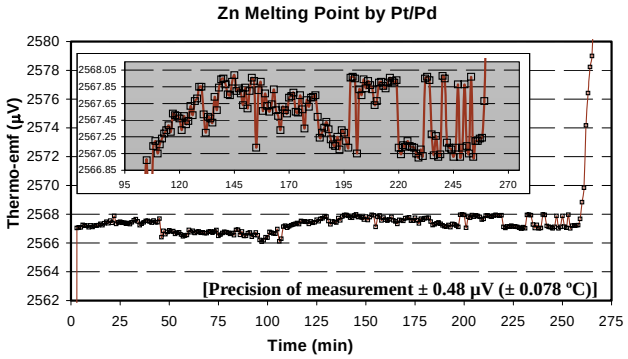


Fig. 1.21 Measurement at Melting Point of Zn (419.527 °C) by Pt/Pd Thermocouple

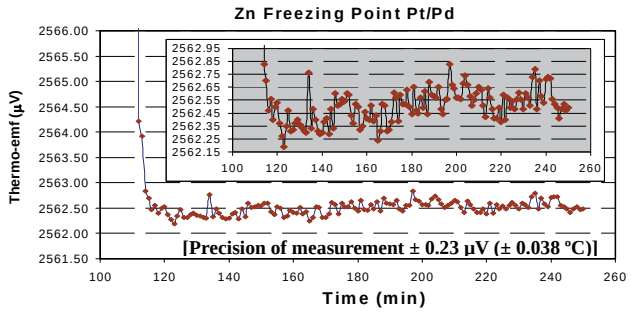


Fig.1.22 Measurement at Freezing Point of Zn (419.527 °C) by Pt/Pd Thermocouple

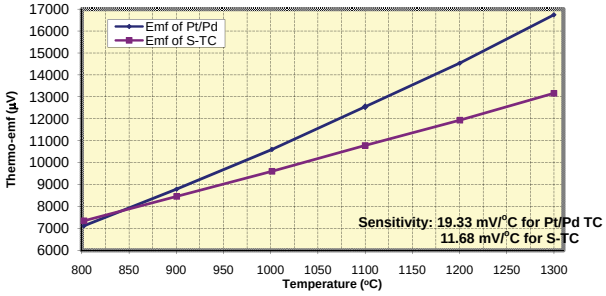


Fig.1.23 Comparison of Pt/Pd TC with Type-S Thermocouple in the range 800-1300°C

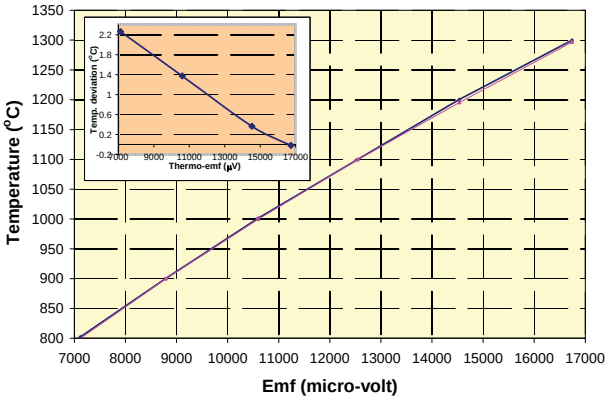


Fig-1.24 Temperature deviation measured by Contact (S-TC) and Non-contact (Spectral pyrometer) Comparison for Pt/Pd thermocouple in the Range 800-1300 °C

The results on the performance of Pt/Pd thermocouple as shown in Fig.1.21 to Fig.1.22, depict that the Pt/Pd TC can be used with the precision of ±0.038°C at Zn freezing point. Further the Pt/Pd evaluation by contact and non-contact method (Fig.1.23 & 1.24) shows that the temperature deviations are minimum in the higher temperature range and hence its performance is better as compared to standard type-S thermocouple. Various NMIs are also examining on the Pt/Pd TC in order to authenticate its performance.

2. International Peer Review

The activities of Temperature & Humidity Standards group have been peer-reviewed second time by an international auditor Dr. Georges Bonnier of LNE, France during March 2-4, 2010. Our activity comprising of Liquid-in-glass thermometry, Platmum Resistance Thermometry, Thermocouples, and Radiation pyrometry has been successfully audited without any non-compliance. Total of 32-CMCs were claimed by Temperature and Humidity Standards Division.These CMCs are being reviewed at APMP region.

3. SAARC-PTB Technical Cooperation Program in Temperature Metrology

Phase-I of SAARC-PTB Project has been completed. Beginning with the preparatory workshop of the program held at NPSL Pakistan in 2006, training workshops have been organized in temperature metrology at NPL, India during 2007-09 for participants from Pakistan, Sri Lanka, Nepal, Bangladesh, Bhutan and Maldives. On-site training in temperature metrology has also been imparted to the staff of NMIs of the SAARC member countries including MUSSD Sri Lanka, NBSM Nepal and BSTI Bangladesh at their respective laboratories during year 2007-09. Similar training in temperature metrology is required to be organized for NMIs of Pakistan, Bhutan and Maldives in Phase-II.

4. Other Significant Achievements

1. Fabrication of Standard Platinum Resistance Thermometers: One SPRT was fabricated & stabilized at triple point of water by annealing at temperature of 670^0 C and 450^0 C. Calibrated the SPRT at triple point of water, melting point of gallium, freezing points of tin, zinc & aluminum. Introduced in quality system as standard for the comparison calibration of SPRTs, RTDs etc.
2. Design and Developmental work has been initiated to fabricate Co-C (1324°C) and Fe-C (1154°C) eutectic fixed point cells to use them in International Key comparison to be held in 2011-12 among the following participating NMIs i.e. KRISS Korea, NMIA Australia, NMIJ Japan, NIM China and NPL India. An experimental study was undertaken to evaluate stability and uniformity parameters of a liquid temperature bath at 5-90 °C range. This can be utilized as a procedure for determining these parameters for any liquid temperature source in the calibration process.
3. A three days national training workshop was organized jointly in the areas of Mass, Temperature and Dimension Metrology held at NPL, New Delhi during 16-18th September 2009.
4. Two Nos. of Technical Protocols for NPL-NABL proficiency testing program on temperature metrology (LIGT, 0-300°C, NABL-T-TEMP-005) and (TC, 0-1200°C, NABL-T-TEMP-006) have been prepared to conduct PT among the participating laboratories.

5. Imparted training in temperature metrology (LIGT) to the nine participants from Govt. & private organizations, user industries during 4-5th December 2009.

6. Maintained the reference humidity standards (an aspirated psychrometer using two precise quartz thermometers) for calibrating RH instruments/hygrometers, in the RH range 15 % to 95 % RH with an uncertainty of ±1 % RH. Regular maintenance and overhauling of the existing humidity oven (Gallen Kamp) twice in a year.

7. Developed two (2 Nos.) prototype Compact RH Generator based on two pressure technique for humidity calibration to meet the industries requirement in the range of 15 to 95 % RH, with □1 % RH stability. These devices were tested in the whole range for its satisfactory performance and these were sold to M/s. Adcon Instruments Pvt. Ltd., Gurgaon (Haryana), and M/s Gatrad Engineering Corporation, Ahmedabad for `1,45,000/- (Rupees One Lakh Forty Five Thousand) through CFCT Section. Two days training were also provided for their Personnel's/ Engineers.

8. Developed one Portable Relative Humidity (RH) generator in the range of 15% RH to 95 % RH with □1 % RH stability and hand over to M/s Belz Instruments Pvt. Ltd. Faridabad (Haryana) for Technology Know-how transfer.

9. Provided traceability in temperature metrology to the following standards Activities of NPL, India.
   i. Pressure & Vacuum Standards
   ii. Chemical Metrology
   iii. Electrical & Electronics Standards
   iv. Length & Dimensional Standards
   v. Mass Standards
   vi. Material Characterization Group

10. Provided apex level calibration in the temperature metrology to the govt. & public sectors departments like ERTL, ETDC, BHEL, NTPC, HAL and ARAI, private manufacturers, user industries and NABL accredited laboratories. The TTP Group of Temperature & Humidity Standards has issued 142 Nos. calibration certificates (112 Nos. to external and 30 Nos. for notional) and earned Rs.18.65 (Rs.15.1 Lakh for external and Rs.3.55 Lakh for notional).

11. Technical assessment of nine NABL accredited laboratories in the area of thermal calibration has been performed Under the NPL-NABL collaboration.

Optical Radiation Standards

Source based primary standard of spectral radiance and calibration work

To maintain the traceability of the spectral radiance scale the temperature stability of the black body was measured and the radiance uniformity was estimated across the aperture of the blackbody. The calibration of primary reference standards in the form of strip filament lamps for spectral radiance was done. These lamps will be used for disseminating the unit to the other levels of measurement. Calibration facilities for the photometric parameters were extended to various lamp and lighting industries, R and D institutions etc. Calibration and Measurement facilities in air UV spectral region and IR spectral region were maintained and extended to user industries and institutions.

A number of Polystyrene films were calibrated for different pharmaceutical industries and R & D organizations using Fourier transform infrared spectrophotometer. Further FT-IR and FT-Raman Spectroscopic testing facilities were provided to various groups of NPL and outside agencies.

Basic research

Correlated photon metrology experimental setup was established and some fundamental work on sub-wavelength interference with pseudo thermal light was done. This will pave path for establishing quantum base for the classical standards of optical radiation. The phenomena of interference and polarization were studied in both space-time domain and space-frequency domain. Some more experiments were done for the first time to verify electromagnetic interference law. Basic research on optical coherence for its application on encoding and information processing was pursued further. Important results obtained were published.

The potential of Raman spectroscopy was assessed to determine the stability of different antiretroviral and anticancer drugs under different stress conditions defined by ICH guidelines. Raman spectra of the drugs before and after exposure to different stress conditions as heat, photo radiations, acidic hydrolysis, basic hydrolysis and oxidative condition were acquired using a Fourier transform Raman spectrophotometer. The spectra show that the drugs undergo degradation under different conditions. The degradation products may be identified using the Raman spectra. Differential scanning calorimetry (DSC), Thermogravimetric analysis (TGA), X-ray diffraction (XRD) analysis and high performance liquid chromatography (HPLC) were carried out simultaneously to confirm and support the results of Raman spectroscopy.

DNA, famously known as blueprint of life, carries genetic information in a cell. It is the major target for drug interaction as it is the origin point of most important cellular processes of replication, transcription and translation. Small ligand molecules bind to DNA and artificially modulate and/or inhibit the functioning of DNA. These small ligand molecules act as drug when modulation or inhibition of DNA function is required to cure or control a disease. We studied the binding of two anticancer drugs carboplatin and vincristine with DNA. Interaction of platinum containing anti-cancer drug, carboplatin with DNA was carried out using Fourier transform infrared and circular dichroism spectroscopy to understand the binding modes of carboplatin with DNA and its effect on DNA conformation. The results show that carboplatin binds to DNA through direct interaction of platin-DNA bases with a small perturbation of phosphate group of DNA backbone. Various changes in the double helical structure of DNA after addition of vincristine have been examined using FTIR and UV-visible spectroscopy. Analysis of vincristine interaction with DNA indicates towards intercalation and external binding mode of interaction.

Externally Funded Projects

Funded by DBT, New Delhi

On-line approach to non-contact IR sensor technique for estimation of sugars and its byproducts

Nutritional quality of fruit juices during storage has become increasingly important problem to be addressed. The loss of some nutrients as organic acids and vitamins is an important factor for the shelf life of juices. Organic acid is an important parameter of fruit juice quality and freshness as they are widely distributed in

fruits and fruit juices. Tartness and flavour of fruit juices are also determined by their organic acid composition. The nature and amount of the organic acids may also affect the microbiological growth of fruit juices.

The aim of the work is to determine organic acids degradation in two commercially packed fruit juices (Real brand and Tropicana brand) over 72 hours at room temperature. The concentrations of different organic acids (oxalic, tartaric, malic, ascorbic and citric acid) are observed for 0, 24, 48 and 72 hours using reverse phase high-performance liquid chromatography (RP-HPLC). The organic acids concentration primarily decreased in most of the commercial fruit juices under study during the storage span of 72 hours. The lowest stability of all organic acids was detected in real orange fruit juice during storage. It is observed that the degradation of organic acids in all tropicana juices is less in comparison to real juices. Among the fruit juices of tropicana brand, orange and mixed fruit juice exhibit more degradation than pineapple, grapes and apple fruit juice. The ascorbic acid is most rapidly and highly degraded organic acid followed by malic and citric acid in commercial fruit juices. The variation in the content of organic acids of same fruit juice of two distinct brands might be due to different amount and kind of preservatives added in the juices. Present organic acid degradation study may be helpful in the development of future commercial juices to target specific consumer requirements. This project was completed in March 2010.

Funded by DST, New Delhi

Infrared spectroscopic study for tumor diagnosis

Ovarian cancer is the second most common cancer among women and the leading cause of death among gynecologic malignancies. Number of samples of ovarian cancer tissues and their normal counter parts were collected from Dharamshila hospital, Vasundhra, New Delhi. These samples were analyzed using Fourier Transform Infrared spectrophotometer. The results of the present study have shown that remarkable differences exist between the IR spectra of normal and malignant tissue in terms of absorption frequencies and intensities of prominent absorption bands of cellular biomolecules. The differences observed in the spectra of normal and malignant tissue reflect changes in the content of nucleic acid and lipids. Protein absorption bands indicate towards the presence of new proteins as well as changes in their conformation and composition. Spectral absorption patterns observed for major biomolecules, nucleic acid, proteins and lipids can be viewed as IR spectral signatures which can be used for distinguishing malignant ovarian tissue from the normal tissue. Based on this, we can compare the infrared spectrum of malignant tissue with its corresponding normal tissue, and establish a new way to diagnose malignant tumors. Prospectively, in conjunction with other markers this technique could be useful in diagnosis of ovarian cancer (stage I and stage II).

Sponsored Project

Based on the successful completion of previous project, 'Development of Calibration-Validation (CAL-VAL) site at Kavaratti Island' another project entitled 'Validation of OCM-II Geo-physical products (Optical instrument calibration)' was sponsored by SAC, Ahmedabad in November 2008. This project is on-going now and a facility for calibration of spectral radiance and spectral irradiance on the surface of ocean in the Lakshyadweep and Minicoy Islands will be set up at Space Applications Centre Ahmedabad

to compare the results obtained on site at Kavaratti Island (Lakshyadweep and Minicoy Islands) and the data transmitted to SAC Ahmedabad by the satellite.

Force and Hardness Standards

A torque primary standard machine of capacity 2000 Nm (Fig.1.25) developed under the consultancy projects funded from the Department of Weights and Measures, Ministry of Consumer Affairs, food and Public distribution was fabricated for establishing it at Regional Reference Standard Laboratories at Bangalore and Faridabad. The performance evaluation of the low cost machine is in progress. The estimated machine uncertainty is ± 0.05%, which will be used to calibrate reference torque transducers for the secondary torque standard machines RRSLs at Bhubaneshwar, Ahmedabad and Guwahati, and also for other customers from industry.

Fig.1.25. Torque primary standard machine developed for RRSL, Bangalore

Three comparator type secondary torque standard machines of capacity 2000 Nm developed under the consultancy projects funded from the Department of Weights and Measures, Ministry of Consumer Affairs, food and Public distribution were fabricated, evaluated and established at Regional Reference Standard Laboratories at Guwahati, Bhubaneshwar and Ahmedabad. These machines, fitted with the necessary reference torque transducers of capacities 20, 200 and 2000 Nm, were calibrated using torque transfer standards and the bmc of the machines was evaluated to be within ± 0.5% at k=2 (Fig.1.26).

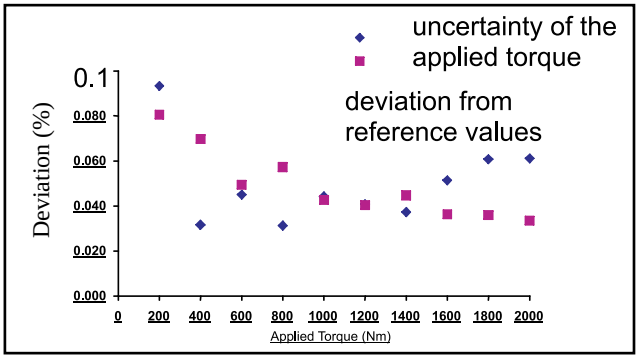


Fig.1.26 Metrological performance of secondary torque standard machine supplied to RRSLs

Establishment of 1 MN Force National Standard having an expanded uncertainty in the force realized less than ± 20 ppm upto 100 kN and less than ± 90 ppm above 100 kN to 1000 kN, has been a major initiative taken during last year to enable class '00' calibration of force transducers as per latest standards ISO 376-2004, IS 4169-1988, ASTM E-74 2006 and participation in CCM or APMP key comparisons. Two scientists from the group visited the works of the manufacturer, M/s GTM at Prague, to inspect and evaluate the performance of the machine. The machine has been delivered at NPL. The necessary infrastructure work for installation of the machine, including environmental conditions, is in progress.

Second BIPM peer review of the force activity was held 16 to 18 Nov. 2009 after five years of the first peer review. In addition to the previous 8 CMCs for force and torque parameters, CMCs for hardness parameter for Vickers and Rockwell scales were also submitted. In all 17 CMCs were reviewed by the technical expert

Dr Konrad Herrmann, Head of Hardness Metrology at PTB, Germany. The experts without any non-conformances cleared all CMCs along with the quality management system of the activity. The comments of the APMP technical expert on the peer review report, received subsequently have been satisfactorily responded. It is expected that the existing/ new CMCs of NPL in force, torque and hardness parameters would appear on BIPM website appendix 'C' in due course of time.

Fig.1.27 Brinell hardness primary standard machine

A special job of Load testing of the cargo lifting cables, used for helicopter operations, was taken up on request of the Indian Air-Force. A hydraulic draw bench was rigged for subjecting the cables, up to 20 m long and 28 mm diameter, to the required force up to 15 T using a calibrated 200 kN force transducer in series. Test reports were issued to the Air force as per their requirement.

The Brinell hardness primary standard machine was commissioned (Fig.1.27). The performance evaluation of the hardness standard machine for uncertainty of the realised force, measuring system and repeatability were found to be within the prescribed limits as per ISO 6506-2005. With the establishment of this facility, NPL is fully equipped to provide traceability in all the three dominant hardness scales in industry, i.e. Rockwell, Vickers and Brinell.

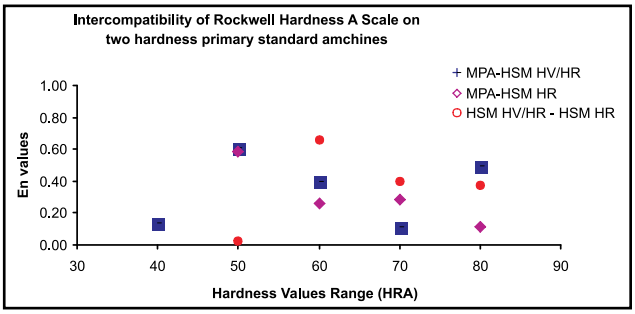


Fig.1.28. Normalized deviation of hardness scale A on two hardness primary standard machines

Inter-compatibility of Rockwell hardness A scale on two hardness primary standard machine was established. The two primary standards used different measurement systems, viz. laser interferometer and microscope respectively. The measurement results show the normalized deviation between the two machines less than unity (Fig.1.28).

The ECF realized by providing national traceability in force, torque and hardness (Rockwell and Vickers scales) parameters was approximately Rs 61 lakh. More than 550 calibration reports were issued to different users during the year including site calibration at FIE Research Institute at Ichalakaranji (M.S.). This is 10% more than previous year.

Pressure and Vacuum Standards

1. Improvement of the uncertainty in measurements in the calibration and

measurement capabilities (CMCs) of the entire range of pressure and vacuum standards:

After the Feb 23-24, 2009 Peer Review, CMCs of the group have been re-established through a continuous chain of traceability from very low pressures starting with the use of ultrasonic interferometer manometer (UIM) to piston gauges upto a pressure 1000 MPa. The lower range piston gauge was characterized using Ultrasonic Interferometer Manometer (UIM), the Primary Pressure Standard, whose expanded measurement uncertainty evaluated as Q (0.0092 Pa, 0.00072% of reading). However, further traceability is established through cross-floating the low range piston with next higher range piston. Table 1.1 shows the improved and peer reviewed CMCs which were notified in Appendix- C of BIPM data base in October, 2009. A comparison is shown of our earlier CMCs, so that the improvement is clearly visible.

Table 1.1: Improvement of the CMCs in comparison to the previous data (2003-08)

Sr. No	Class	Minimum value	Maximum value	Units	Measurement Uncertainty (2009-2014) (at k=2)	Measurement Uncertainty (2003-2008) (at k=2)
1.	Absolute Pressure, Gas Medium	0.001	130	kPa	$[(9.2E\text{-}03)^2 + (7.2E\text{-}06p)^2]^{½}$, *p* Pressure in Pa	$[(9.2E\text{-}03)^2 + (7.2E\text{-}06p)^2]^{½}$, *p* Pressure in Pa
2.	Gauge Pressure, Gas Medium	0.001	130	kPa	$[(9.2E\text{-}03)^2 + (7.2E\text{-}06p)^2]^{½}$, *p* Pressure in Pa	-
3.	Absolute Pressure, Gas Medium	6.5	360	kPa	$[(1.4E\text{-}01)^2 + (12E\text{-}06p)^2]^{½}$, *p* Pressure in Pa	-
4.	Gauge Pressure, Gas Medium	20	360	kPa	12E-06p, *p* Pressure in Pa	-
5.	Gauge pressure gas medium	0.036	4	MPa	22E-06p, *p* in MPa	52E-06p, *p* in MPa
7.	Gauge pressure gas medium	8	12	MPa	32E-06p, *p* in MPa	
8.	Gauge pressure gas medium	12	20	MPa	33E-06p, *p* in MPa	-
10.	Gauge pressure gas medium	20	40	MPa	36E-06p, *p* in MPa	-
11.	Differential pressure (Dp), gas medium	30	150	kPa	$[(10)^2+(2.5E\text{-}06*Pl)^2 +(2.9E\text{-}05*Dp)^2]^{1/2}$, where p_l in Pa and Dp in Pa.	1E-04*p*, *p* in kPa
12.	Gauge pressure, liquid medium	500	1000	MPa	250E-06*p*, *p* in MPa	-

13.	Gauge pressure, liquid medium	200	500	MPa	135E-06*p*, *p* in MPa	
14.	Gauge pressure liquid medium	100	200	MPa	50E-06*p*, *p* in MPa	133E-06*p*, *p* in MPa
15.	Gauge pressure liquid medium	50	100	MPa	48E-06*p*, *p* in MPa	
16.	Gauge pressure liquid medium	0.1	50	MPa	45E-06*p*, *p* in MPa	
17.	Absolute pressure, gas medium, vacuum	0.05	10	Pa	4E-03*p*, *p* pressure in Pa	4E-03*p*, *p* pressure in Pa
18.	Absolute pressure, gas medium, vacuum	3.00E-06	0.1	Pa	2E-02*p*, *p* pressure in Pa	2E-02*p*, *p* pressure in Pa

2. Draft B of key comparison CCM.P-K3 absolute pressure measurements in gas from $3x10^{-6}$ Pa to $9x10^{-4}$ Pa

Draft B of key comparison CCM.P-K3 absolute pressure measurements in gas from $3x10^{-6}$ to $9x10^{-4}$ Pa, was circulated by Dr. Doug Olson, NIST, USA to the participants on 28 Oct. 2009 for comments and for agreement on Key Comparison reference value, the discussion and the conclusions made. The draft was examined and a reply was sent on 1.12.2009. After the review, the final report has been published in the Metrologia Tech. Supplement and the KCDB of BIPM.

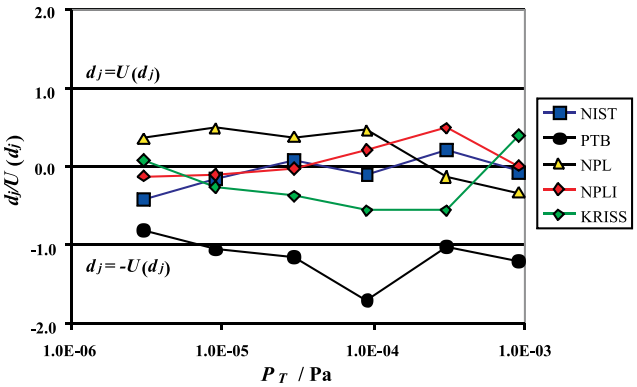


Figure 1.29 Summary of results for the degree of equivalence for each NMI with respect to the key comparison reference value, expressed as $d_j/U(d_j)$. When $|d_j/U(d_j)| \leq 1.0$ there is equivalence at k=2 expanded uncertainty.

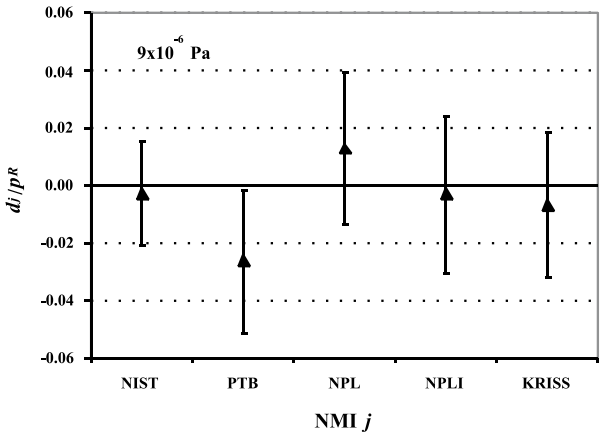


Figure 1.30 :Degree of equivalence at $9x10^{-6}$ Pa for each NMI. Plotted is relative difference (d_j/p_R) of corrected mean gauge pressure reading (p_j) from reference value (p_R), with expanded (k=2) uncertainty in relative difference shown as error bars. When error bars cross x-axis, there is equivalence to the reference value.

3. Participation in CCM.P-K13: 500MPa key comparison

At the CCM High Pressure Working Group (HPWG) meeting on 21 April 2008 it was decided to start a new CCM 500 MPa key comparison (KC). PTB (Germany) agreed to act as a pilot

laboratory. The protocol of the international comparison was prepared in consultation with the participating laboratories. Eight NMIs, namely PTB (Germany), NIST (USA), LNE (France), NIM (Japan), NPL (India), NIM (China), CENAM (Mexico) and KRISS (Korea) would participate in the key comparison. The artifact of the comparison arrived at NPL (India) under ATA CARNET from CENAM (Mexico) on 25th April 2009. After experimentation for four weeks up to 25th May, 2009, it was sent to NIM (China). The data is under preparation and would be shortly sent to PTB (Germany) for evaluation.

4. Supplementary comparison with NIST (USA) (70 Pa – 1000 Pa) SIM.M.P-S1

The preliminary analysis of the NIST-NPLI SES comparison data provided by Dr. Jay Hendricks has been examined during this period. A very good agreement has been obtained between the NPLI SES and the NIST UIM and it has been agreed by the two laboratories to proceed with the publication of the report. Measurements for this comparison were carried out using the transfer standard supplied by the pilot laboratory NIST, USA, in the range 70 Pa to 1000 Pa on our Static Expansion Primary Vacuum Standard in the year 2007

5. Proficiency Testing Program in Barometric Pressure Region

A Proficiency Testing Program in the Barometric Pressure Region was got approved under the NPL-NAL Project CLP003732. An artifact consisting of inbuilt sensors that can cover three barometric pressure ranges; (i) -1000hPa to 0 hPa (g), 0 hPa to +1000 hPa (g) and (iii) 0 hPa to 2000 hPa (abs) has been ordered. At the initial survey for identification of potential participants in this program, 243 labs (having NABL Certification in Mechanical Discipline) in India, were identified, and with consultation of the NABL Doc # 500, letters were dispatched asking for their willingness on May 11, 2010.

6. Big diameter piston gauge for primary standard

For the upgradation of our primary pressure standard facility a big diameter piston gauge with automatic mass loading as well as state of the art data acquisition software has recently been procured and installed. This new system would replace our old controlled clearance piston gauge as our primary standard. The special features of the instrument are : Integrated Auto Mass Handling up to 100 kg with a mass resolution of 0.1 kg, Pressure range 1 MPa and 10 MPa Uncertainties in the effective area 10-16 ppm and pressure 13-20 ppm. The equipment was installed in Oct. 2009 and extensively tested for operation through the remote terminal as well as through the software for automatic mass-loading, pressure generation etc. The full range of both the pc assemblies i.e. 1 MPa and 10 MPa were tested.

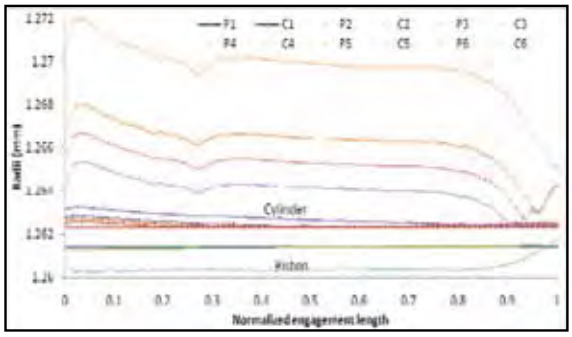
Figure 1.31 : Primary Pressure standard-Automatic loading Pneumatic Dead weight tester upto 10 MPa

7. Coordinated Gravity Measurements At NPLI

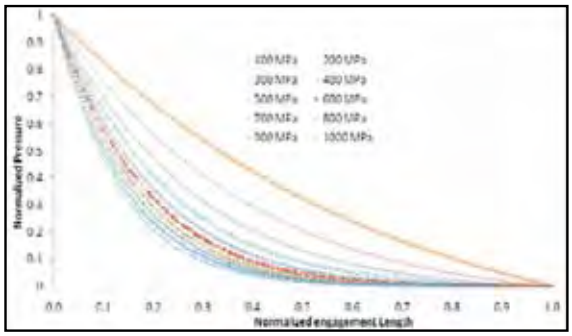
The accurate and precise measurement of acceleration of gravity (g) plays a vital role in the measurement of mass related quantities e.g. mass, force, pressure and vacuum, etc. A small variation in 'g' value affects the parametric values drastically. In this connection, a project for the measurement of absolute and relative gravity values at several locations in NPL was undertaken with the Gravity and Magnetic Studies Group of National Geophysical Research Institute (NGRI), Hyderabad. The project was initiated during May 2009 and completed during Dec. 2009. There were total 15 locations in NPL at which measurements were carried out with the precision of a few µgal. The absolute measurements were performed on a pillar of the Force Standards Building. The relative measurements with respect to the measured absolute value were made at 8 locations in TEC Building (7 in Pressure and Vacuum Standards Laboratory and 1 in the TEC Reception Hall), 3 locations in Force Building and 3 locations in Main Building (2 in Mass and Viscosity Metrology Laboratories and in Reception Hall). The measured 'g' values were handed over to the concerned scientists.

8. Finite Element Calculation Method (FEM) For the Characterisation of a Controlled Clearance Piston Gauge (CCPG)

The effect of gap profile between piston and cylinder of CCPG was studied under the influence of applied pressure (p) from 100 MPa to 1000 MPa, on the pressure distortion coefficient (λ) of the assembly using FEM modeling. A two dimensional model of the p-c assembly was considered assuming p-c assembly as axially symmetric. The gap profile was also studied at different applied jacket pressure (pj) such that pj/p varied from 0.3, 0.4 and 0.5. The di 2-ethylhexyl sebacate was used as pressure transmitting fluid. FEM analysis showed that the clearance h between piston and cylinder decreased as pj increased. The gap width increased with increase in the applied pressure p both in FDM and CCM. The radial clearance gap was always higher than the undistorted value. The change in gap width also increased along the engagement length from top to bottom due to the increase in pressure distribution in the gap profile. Though the pressure distortion coefficient, λ was independent of applied pressure but, the values of λ are much higher in FDM in comparison to CCM. The pressure distortion



(a)



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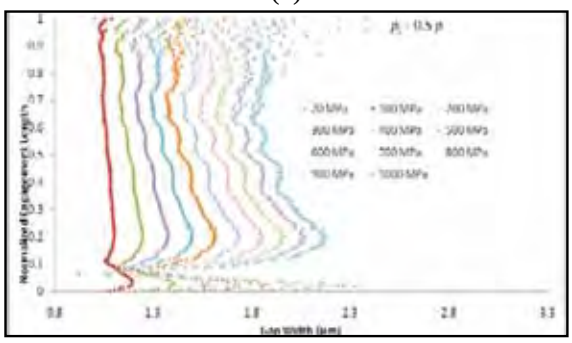

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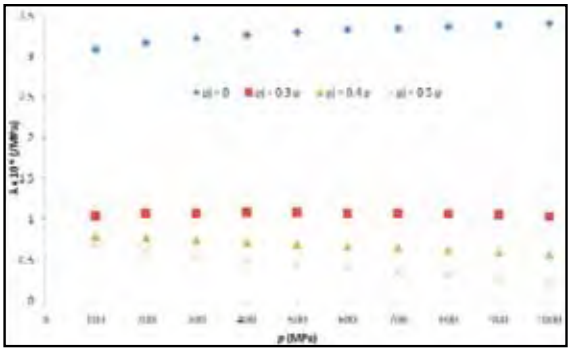


(d)

Fig. 1.32: (a) Radii of piston and cylinder along the engagement length, both in FDM and CCM to show the radial distortions (P1 is at p = 0 and pj = 0 for piston, C1 is at p = 0 and pj = 0 for cylinder, P2, P3, P4 and P5 are at p = 100 MPa and pj = 30 MPa, 40 MPa, 50 MPa and 0 pressure, respectively for piston, C2, C3, C4 and C5 are at p = 100 MPa and pj = 30 MPa, 40 MPa, 50 MPa and 0 pressure, respectively for cylinder. Similarly, P6, P7, P8 and P9 are at p = 1000 MPa and pj = 300 MPa, 400 MPa, 500 MPa and 0 pressure, respectively for piston, C6, C7, C8 and C9 are at p = 1000 MPa and pj = 300 MPa, 400 MPa, 500 MPa and 0 pressure, respectively for cylinder), (b) Normalized pressure distributions in the clearance as a function of normalized engagement length for different applied pressures,(c) The difference of gap width between FDM and CCM as a function of applied pj along the engagement length (d) □ determined as a function of applied pressures p with pj/p varying as 0 in FDM and 0.3, 0.4 and 0.5in CCM.

coefficient λ was not much affected by applied pressure p but it is greatly affected by jacket pressure pj. Consequently, the values of λ were larger in the free deformation mode in comparison to controlled clearance mode.

9. Coordination of NABL sponsored proficiency testing in the hydraulic pressure measurements up to 70 MPa

NABL-Pressure-PT004: This PT was started during March 2008 for the laboratories having measurement capabilities better than 0.05 % of full scale using dead weight tester as an artifact in the pressure range 7 – 70 MPa. A total number of 9 laboratories participated in the PT. During the period under report, all the laboratories completed the measurements and submitted their results. The characterization of the artifact after completion of the loop was carried out twice once in Jan, 2009 and second time in April, 2009. Results have been analyzed. The interim report has been prepared and submitted to NABL for further action to this effect. After receiving the feedback from the participants, the final report would be prepared incorporating their appropriate corrective actions, suggestions and remark.

10. DST Sponsored project : "High Pressure Raman studies on rare earth sesquioxides",

Pressure induced anomalous phase transformation in nano-crystalline Dysprosium sesquioxide

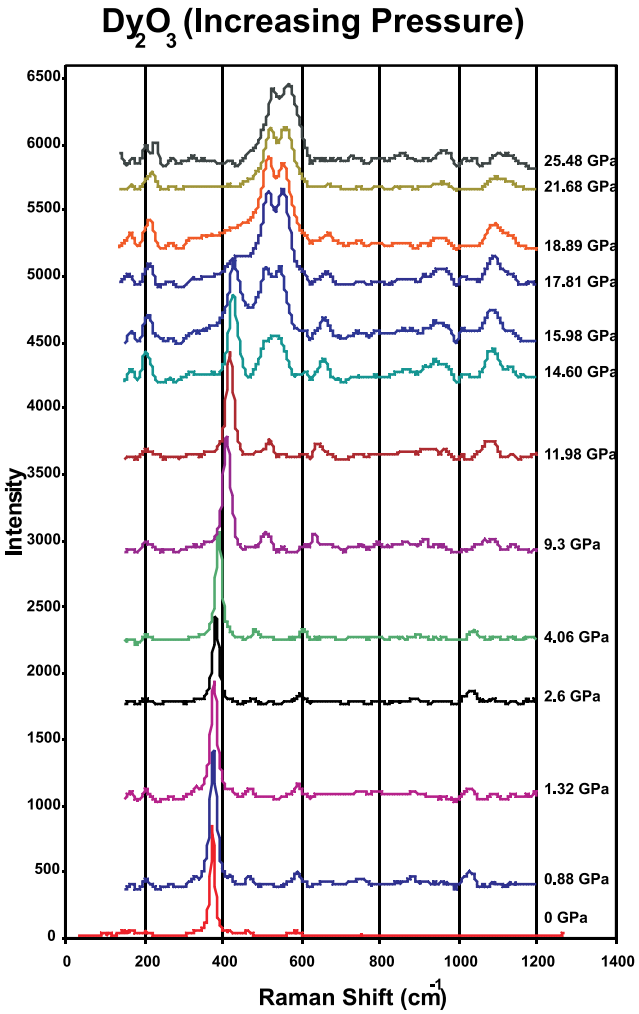


Fig. 1.33 : Raman Spectroscopic data of Dy_2O_3 at different pressures.

Under ambient conditions the Raman spectrum of the Dy_2O_3 showed a predominant cubic phase peak at 373 cm^{-1}, identified as F_g mode. With increase in the applied pressure this band steadily shifts to higher wavenumbers. However, around a pressure of about 14.6 GPa, another broad band is seen to be developing around 542 cm-1 which splits into two distinct peaks as the pressure is further increased. In addition, the cubic phase peak also starts losing intensity significantly and above a pressure of 17.81 GPa, this peak almost completely disappears and is replaced by two strong peaks at about 520 and 558 cm^{-1}. These peaks have been identified as occurring due to the development of hexagonal phase at the expense of cubic phase. Further increase in pressure upto about 25.5 GPa does not lead to any new peaks apart from slight shifting of the hexagonal phase peaks to higher wavenumbers. With release of the applied pressure, these peaks shift to lower wavenumbers and lose their doublet nature. However, the starting cubic phase is not recovered at total release indicating that the transition may be irreversible. The factors contributing to this anomalous phase evolution were identified and included a significant contribution from the fact that the material was nano-crystalline in nature.

Acoustical and Ultrasonic Standards

1. A DC converter has been successfully designed and fabricated for the measurement of RF voltage in terms of DC voltage. This will help in the measurement of applied voltage to the ultrasonic transducer while carrying out the power measurement. It will bring down the uncertainty from 4% to 0.5% in RF voltage measurement.
2. The nicrobalance method of ultrasonic power measurement has been modified for greater accuracies in many ways. Using the new setup, the ultrasonic power has been measured using both the absorbing target and the reflecting target at various frequencies in the range of 1 to 10 MHz and at various voltage inputs. Results have been compared for two methods. Frequency responses of the ultrasonic transducers have also been studied.
3. An ultrasonic technique has been developed for the evaluation of flatness of small diameter flat bottom holes. Measurements have been taken using both direct contact as well as immersion technique on various blocks with FBH diameter 1.2, 2.0, 1.8 and 3.25 mm using 4 MHz and 10 MHz frequencies.
4. Electromagnetic acoustic transducer (EMAT) system has been set up for ultrasonic non-destructive evaluation. It is capable of sending and receiving shear waves perpendicular to the scanning surface of the material. The method has the potential to characterise the bulk properties of materials at a faster rate.
5. Approval of APMP.AUV.6-2009, NPLI Acoustics CMCs in Intra RMO review and published in BIPM, Key comparison Date base (KCDB website).
6. Regional Supplementary Key comparison APMP.AUV.A-S1, Determination of Sound pressure level, frequency and total distortion of Multifunction Acoustic Calibrators was completed successfully.
7. Inter comparison APMP.AUV.V-K1.2, Sinusoidal linear acceleration sensitivity of standard accelerometer successfully completed with Degree of Equivalence (DoE) at 160 Hz for Single ended

accelerometer as 4.6 × 10^{-4} pC/ms^{-2} and for Back to Back accelerometer at 160 Hz as 4.2× 10^{-4} pC/ms^{-2} as compared to NIM China.

8. Research studies on Acoustic induced vibration in diffuse field and free field conditions for completion of consultancy project sponsored by Aracheological Survey of India, Chennai Circle entitled "Investigation on the effect of Sound and Light show at Brihadisawara temple, Thanjavur.

9. Establishment of Secondary Vibration calibration facility at NPL with an uncertainty of ± 1.5 % is at a coverage factor k=2 and 95 % for a normal distribution

10. Sponsored Testing assignment by M/s Star Track fasteners, Faridabad for Noise emissions reduction of Delhi metro trains due to track lubrication. The work has led to an interesting conclusion that gauge face lubrication doesn't have a significant effect on the A-weighted noise generated by the train transit system (paper accepted in IJPAP).

11. A presentation entitled "Vibration impact of proposed Bangalore Metro corridor (BMRCL) on Historical monuments (Tipus palace and Tipus Fort) was delivered at ASI Head Quarters, Janpath on request of BMRCL that has led to clearance of ASI to BMRCL for moving ahead.

Fig. 1.34: Electromagnetic acoustic transducer facility at NPL

Service to the Nation : Societal Benefits

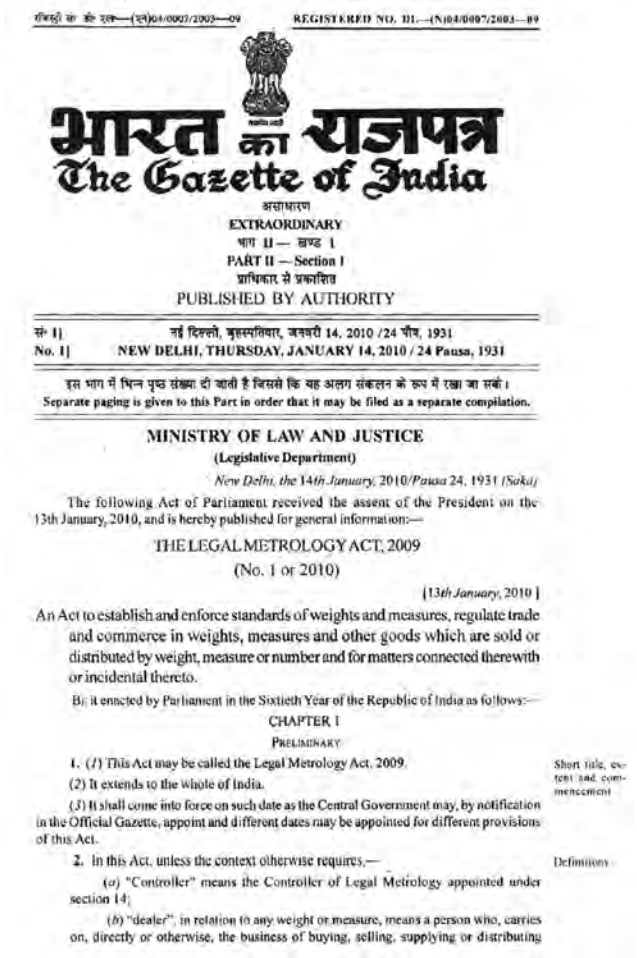
Legal Metrology :

The division is working very closely with the other stake holders of the National Metrology Institute of India – it helps the department of Legal metrology under the Ministry of of Consumer Affairs, Krishi Bhavan, New Delhi for the publication of the Legal Metrology Act – 2009. This act of Parliament received the assent of the President of India on 13th January, 2010. During the formal inauguration of the implementation of this act to common public, Department of Legal Metrology organized an All India Conference on Legal Metrology at National Agricultural Science Center - 24th February, 2010. Prof. K. V. Thomas, Hon'ble Minister of State for Agriculture and Consumer Affairs, Food and Public Distribution mentioned, specially mentioned " We need to have more coordination with the institutions like the National Physical Laboratory, in the coming days. States and centre need to be in constant conversation with them also. I wish we can display excellent models in synergy and operational impact of the programme which must become a model one".

Benefits of the CIPM MRA for the National Physical Laboratory of India (published in the KCDB Newsletter No 13 at BIPM.org)

a) Mass Standards

M/s Fresenius Kabi Oncology Ltd. (FKOL), Solan, India, is a pharmaceutical company that exports drugs and other pharmaceutical products to the USA and countries around the world. Recently, the U.S. Food and Drug Administration (USFDA) audited the company. Usually, FKOL calibrated



रजिस्ट्री सं. डी.एल.—(एन)04/0007/2003—09 REGISTERED NO. DL.—(N)04/0007/2003—09

भारत का राजपत्र
The Gazette of India

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इस भाग में भिन्न पृष्ठ संख्या दी जाती है जिससे कि यह अलग संकलन के रूप में रखा जा सके।
Separate paging is given to this Part in order that it may be filed as a separate compilation.

MINISTRY OF LAW AND JUSTICE
(Legislative Department)

New Delhi, the 14th January, 2010/Pausa 24, 1931 (Saka)

The following Act of Parliament received the assent of the President on the 13th January, 2010, and is hereby published for general information:—

THE LEGAL METROLOGY ACT, 2009
(No. 1 OF 2010)

[*13th January, 2010*]

An Act to establish and enforce standards of weights and measures, regulate trade and commerce in weights, measures and other goods which are sold or distributed by weight, measure or number and for matters connected therewith or incidental thereto.

BE it enacted by Parliament in the Sixtieth Year of the Republic of India as follows:—

CHAPTER I

PRELIMINARY

1. (*1*) This Act may be called the Legal Metrology Act, 2009. Short title, extent and commencement

(*2*) It extends to the whole of India.

(*3*) It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint and different dates may be appointed for different provisions of this Act.

2. In this Act, unless the context otherwise requires,— Definitions

(*a*) "Controller" means the Controller of Legal Metrology appointed under section 14;

(*b*) "dealer", in relation to any weight or measure, means a person who, carries on, directly or otherwise, the business of buying, selling, supplying or distributing

Fig. 1.35: a) legal Metrology Act 2009 and b) Prof. K. V. Thomas, Hon'ble Minister of State for Agriculture and Consumer Affairs, Food and Public Distribution inauguration speech.

its mass standard artifacts against the National Physical Laboratory of India (NPLI) standards, and NPLI provided them with the corresponding certificates as per the CIPM MRA. FKOL later informed NPLI that they had been successfully qualified in their USFDA audit. India is slowly becoming a hub for the global pharmaceutical industry and this success is being attributed to the benefit of the CIPM MRA – making it unnecessary to send instruments overseas for calibration. Tested once, accepted every where!

b) Force Standards

Simultaneous measurement of longitudinal and bending strains in bolts used in wind turbines – M/s Suzlon Energy outsourcing calibration work to NPLI. Specialized work for calibration of the bolts used in wind turbines was carried out by NPLI for M/s Suzlon Energy, The Netherlands, a company that has started operating in India as M/s Suzlon Energy (India). This calibration work was outsourced by the company to NPLI, which was a direct benefit gained by NPLI as a signatory of the CIPM MRA.

c) Acoustics and ultrasonic standards

Construction of the Delhi Metro, which is operated by the Delhi Metro Railway Corporation (DMRC), was a project of national importance in India. The construction and engineering work complied with all the international standards for a project of its type and many internationally recognized companies participated in the venture. NPLI, a signatory of the CIPM MRA, was entrusted with studying the noise and vibration generated by the Delhi Metro and its impact on the surrounding environment, in particular the barrier design for DMRC. The project was completed successfully and on schedule and this has allowed NPLI to go on and undertake other noise and vibration impact studies, including the Bangalore Metro and also for other Historical Monuments in India.

विद्युत तथा इलेक्ट्रानिक मानक

ELECTRICAL AND ELECTRONIC STANDARDS

इलेक्ट्रिकल तथा इलेक्ट्रानिक मानक

विद्युत और इलैक्ट्रॉनिक मानक विभाग विभिन्न विद्युत, इलैक्ट्रॉनिक और चुम्बकीय प्राचलों के प्राथमिक और सैकेण्डरी स्टैण्डर्ड, एस आई यूनिट को ज्ञात करने, स्थापन, अनुरक्षण और विस्तारण में सक्रिय रूप से सलंग्न है। विभाग विभिन्न उद्योगों, अनुसंधानों और विकसित प्रयोगशालाओं, रक्षा प्रयोगशालाओं तथा भारतीय अंतरिक्ष अनुसंधान संगठन इत्यादि को अनुमार्गणीयता प्रदान करता है। यह विभाग अन्तर्राष्ट्रीय अंतर्तुलनाओं, द्विपक्षी और निपुणता परीक्षण कार्यक्रमों में भी सक्रिय रूप से संलग्न है। इस अवधि में विभाग की कुछ महत्त्वपूर्ण उपलब्धियां हैं जो निम्नलिखित हैं।

i. भारतीय प्रादेशिक नेवीगेशन सिस्टम (IRNSS) के लिए Rb परमाणु घड़ी को विकसित करने के लिए SAC-NPL संयुक्त परियोजना के अन्तर्गत राष्ट्रीय भौतिक प्रयोगशाला में Rb परमाणु घड़ी के फिज़िक्स पैकेज़ सफलतापूर्वक विकसित किया गया है।

ii. हम Cs फाउण्टेन क्लॉक को एन पी एल भारत में विकसित कर रहे हैं। हाल में ही ट्रैप्ड Cs एटोमिक क्लाउड सहित एक मैग्नेटो–आप्टिक ट्रैप का सफलतापूर्वक प्रदर्शन किया गया है।

iii. मोबाइल टेलीफोन नेटवर्क का प्रयोग करते हुए टेली क्लॉक रिसीवर के नए प्रारूप (Version) का विकास किया गया है और यह तकनीकी जानकारी एक उद्योग/संगठन को हस्तांतरित कर दी गयी है। प्रो. समीर के ब्रहमचारी, महा निदेशक सी एस आई आर ने 28 जुलाई, 2009 को जन सामान्य के इस्तेमाल के लिए इस नए प्रारूप का औपचारिक रूप से उद्घाटन किया।

iv. 3X600 वोल्टस और 3X120 Amps के लिए एक नई बहु स्थान (मल्टी पोजिशन) पावर एवं ऊर्जा मीटर अंशांकन/परीक्षण बेंच को प्रतिस्थापित किया गया है।

v. निम्न मंद वोल्टेजों पर AC-DC ट्रांसफर मानक की मुख्य तुलना EUROMET EM-EII की अंतिम रिपोर्ट से पता चलता है कि एन पी एल आई अन्तर्तुलना के लिए आरंभिक प्रयोगशाला द्वारा लिए गए तुलना सन्दर्भ मान के काफी करीब है।

vi. 11 और 12 मार्च, 2010 को DC उच्च वोल्टेज पर दूसरा पीअर पुनरीक्षण कराया गया था। विद्यमान तीन CMCs में संशोधन किया गया और DC उच्च धारा के लिए पांच नए CMCs का KRISS कोरिया के अन्तर्राष्ट्रीय ख्याति प्राप्त तकनीकी विशेषज्ञों द्वारा अनुमोदन किया गया।

vii. एंटीना वृद्धि : 6.10 dB व VSWR $\leq$ 1-6 फीचर सहित 1 से 18 GHz की आवृत्ति सीमा के लिए एक TEM हॉर्न एंटिना की युक्ति तथा निर्माण किया गया।

viii. तरंगपथक प्रणाली में VNA.आधारित प्रतिबाधा मापन सुविधा (इंपीडेंस मेजरमेंट फेसिलिटी) के संस्थापन के लिए Ka-band (26.5 to 40 GHz) और Q-band (33 to 50 GHz) फ्रीक्वेंसी रेंज में परिशुद्ध वेवगाइड खण्डों और फ्लश शार्टस् को स्वदेश में ही विकसित किया गया है।

ELECTRICAL AND ELECTRONIC STANDARDS

The electrical and electronics standards division is actively involved in the realization, establishment, maintenance and dissemination of SI unit, primary and secondary standards of various electrical, electronic and magnetic parameters. This division provides traceability to the various industries, R & D laboratories, defence labs and ISRO etc. The division is also actively involved in the international intercomparison, bilateral and proficiency testing programmes.

Some of the important achievements of the division during this period are listed below:

i. A Physics Package of Rb atomic clock has been successfully developed at National Physical Laboratory under the SAC-NPL joint project on the development of Rb Atomic clock for Indian Regional Navigation System (IRNSS).

ii. We have been developing a Cs fountain clock at NPL India. A magneto-optic trap has been successfully demonstrated with a trapped Cs atomic cloud recently.

iii. New Version of Teleclock Receiver using mobile telephone network has been developed and know –how has been transferred to one company. This new version has formally been launched for public use by Prof. Samir K. Brahmchari, DG CSIR on 28 July 2009.

iv. A new Multi position power and energy meter calibration/test bench has been installed for 3X600 Volts and 3X120 Amps.

v. The final report on the "Key Comparison EUROMET.EM- K11 on AC-DC transfer standards at low voltages", shows that the results of NPLI are very close to the comparison reference value taken by the pilot laboratory for the intercomparison.

vi. 2nd peer review of DC High Voltage was conducted on 11th and 12th March 2010. Exsiting three CMCs were improved and five new CMCs for DC high current were approved by international renowned technical expert from KRISS Korea.

vii. A TEM horn antenna has been designed and fabricated for the frequency range 1 to 18 GHz with the features of antenna gain: 6-10 dB and VSWR $\leq$ 1.6.

viii. Precision waveguide sections and flush shorts in Ka-band (26.5 to 40 GHz) and Q-band (33 to 50 GHz) frequency range have been indigenously developed for the establishment of VNA-based impedance measurement facility in waveguide system.

Time and Frequency Standards

A Physics Package of Rb atomic clock has been successfully developed at National Physical Laboratory under the SAC-NPL joint project on the development of Rb Atomic clock for Indian Regional Navigation System (IRNSS). A MoU has also been signed with the Russian company for developing Rb bulbs and cells of high quality which can withstand vibration, shock, radiation and other stringent tests, making them worthy of use in high pressure and vacuum conditions in space. The vacuum system for developing Rb isotopic cells and bulbs at NPL is under development.

Fig. 2.1 Current Status of Physics package of Rb clock (SAC-NPL Project)

Fig. 2.2 MOT setup of Laser Cooled Cs Fountain Project

We have been developing a Cs fountain clock at NPL India. A magneto-optic trap has been successfully demonstrated with a trapped Cs atomic cloud recently. Once the cloud is formed, measurements are done to characterize the cloud in terms of size of atomic cloud, number of atoms in the cloud, and the temperature of the cloud.

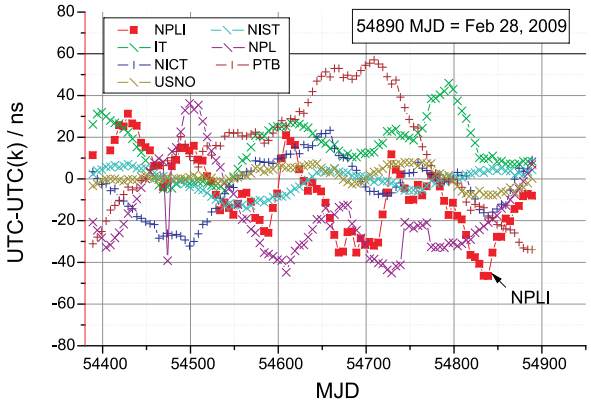


Fig. 2.3 Status of Time Scale UTC(NPLI) maintained by NPL

NPL maintains national time scale with the help of Cesium Atomic clock. This time is traceable to BIPM through GPS network. NPL has improved its performance by identifying the sources of contributing noise and by reducing them by suitable remedial measures. The performance of time scale of NPL has been now comparable with all the leading timing labs of the world.

Automatic measurement system for the generation of better time scale ensembling several atomic clocks has been completed. This involves deign and development of selector switching system and development of software to automate the system. Channel delay of the switching system has been measured and found to be stable within few tens of picoseconds.

Teleclock service - the time service via telephone network is in use extensively in India and abroad. New Version of Teleclock Receiver using mobile telephone network has been

developed and know -how has been transferred to one company. This new version has formally been launched for public use by Prof. Samir K. Brahmchari, DG CSIR on 28 July 2009.

Fig. 2.4 New Version of Teleclock Receiver

Fig 2.5. Launching of Mobile Teleclock by Prof. Samir K. Brahmchari DG, CSIR

Josephson Voltage Standard and DC Current, Voltage

The JVS and DC Standard group realizes the JSAVS at 10V and 1.018V and. maintains 'National Standard' of DC Voltage, DC Current & DC Resistance.

The Software for Automation in calibration of DMM & Calibrator was prepared and tested in LabVIEW platform. There is provision of doing Calibration of a number of DMM and Calibrator in Auto mode.

The new calibration points have been incorporated in the control chart to see the trend of voltage drift of Zener Reference Standard (732B and 7000N series). The drift is being utilized in the calculation of expanded uncertainty while doing calibration of the Zener Reference Standards.

Carried out calibration work of other standards groups for the implementation of "Quality System" in standards divisions of the laboratory.

Internal Audit of the Group was successfully completed in the month of December.

Under DIT sponsored project ("Generic development of Nano-metrology for Nano-technology at NPL (I)"), precision calibration of Nano-ampere and pico ampere range traceable to primary DC standards and precision calibration of Nano-volt range traceable to Josephson Voltage Series Array Standard has been carried out. The high precision Automatic DCC Bridge was procured and installed. Further uncertainty evaluation in different ranges is under process.

DC High Voltage Standards

This group is providing calibration facility for High Voltage DC equipments ie. DC High Voltage probe, DC High Voltage divider, DC High Voltage Power Supplies and DC Volt meter, upto 100 kV. Primary standard of DC High Voltage is the Resistive Divider, which is traceble to Josephson voltage standard.

2nd peer review of DC High Voltage was conducted on 11th and 12th March 2010. Exsiting three CMCs were improved and five new CMCs for DC high current were approved by international renowned technical expert from KRISS Korea.

AC Power and Energy Standard

AC Power & Energy Standard maintains national standard of AC Power & Energy and is actively involved in the dissemination of traceability throughout the country.

Peer Review for the activity was held in Feb. 2009 and improvement in measurement uncertainty was sent to APMP. All the proposed CMC's have been cleared by QS reviewer and APMP TC chair of EM has informed that the Intra Regional review of CMC's is nearly completion and will be submitted to JCRB for Inter regional review in early September 2010.

Various clauses for testing of AC/DC abnormal magnetic influences have been included in IS specifications with a view to control energy theft.

A new Multi position power and energy meter calibration/test bench has been installed for 3X600 Volts and 3X120 Amps.

Disputed energy meters were received from court of law/Electricity boards.

These were tested and analysed for tampering and energy theft.

AC High Current and High Voltage Standards

This section is maintaining National Standards of AC High Current and High Voltage Ratios at power frequencies (50Hz) by using Reference Standard Current Transformers and Reference Standard High Voltage Ratio Measuring System. Calibration services were provided for the calibration of Current Transformers, Current Transformer Testing Sets, Clamp Meters, CT Burdens and for Voltage Transformers, Voltage Transformer Testing Sets, HV Probes, Electrostatic Voltmeters (ESVMs), HV Break Down Test Sets and Voltage Transformer Burdens etc. As many as 80 Calibration Certificates were issued to the electrical manufacturers and utilities.

The National Standard of AC High Current Ratio Measuring System upto 5000A/1A, 5A is shown in Fig. 2.6.

Fig. 2.6 The National Standard of AC High Current Ratio Measuring System upto 5000A/1A, 5A

Fig. 2.7 The National Standard of AC High Voltage Ratio up to 100kV/100V comprising of the Compressed Gas Capacitor, Air Capacitor & the Electronic Voltage Divider (EVD)

The National Standard of AC High Voltage Ratio up to 100kV/100V comprising of the Compressed Gas Capacitor, Air Capacitor & the Electronic Voltage Divider (EVD) is shown in Fig.2.7.

LF and HF Impedance Standards

This group of electrical and electronic standards is disseminating the traceability for measurement of capacitance, inductance and AC resistance at low and high frequency to calibration laboratories and R & D organizations. The traceability starts from primary standards of capacitance, Calculable Cross Capacitance, based on Lampard-Thompson theorem and traceable to base unit length. The unit of resistance, Ohm, is also realized from capacitance using Quadrature Bridge and other precision AC bridges. The unit of inductance, Henry, is realized from capacitance and AC resistance using Maxwell-Wien Bridge. A set of high precision coaxial reference air lines with traceability to calculable cross capacitor is used as primary standards of HF impedance

The group had earlier used the setup based on difference voltage measurement (Method I) to measure change in inductance and thus determine temperature coefficient of standard inductors at 1 kHz. The group has currently re-determined the temperature coefficient of these inductors by measuring the change in resistance with respect to temperature (Method II), as manufacturer suggest.

These inductors were kept in a commercial air bath, whose temperature stability is ±0.05ºC. The air bath temperature was set at a particular temperature for about 24 hours and resistance of the inductor was measured by using Fluke make 8846 A, 6½ digits precision multimeter. Measurements were taken at an interval of 30 minutes. Process was repeated for 1 ºC and 2.54 ºC temperature change.

Table 2.1

Sr. No.	Temperature Coefficient (in ppm) with deviation	
	Method I	Method II
18892	46±5	26±5
18577	42±5	29±5
19570	47±5	31±5

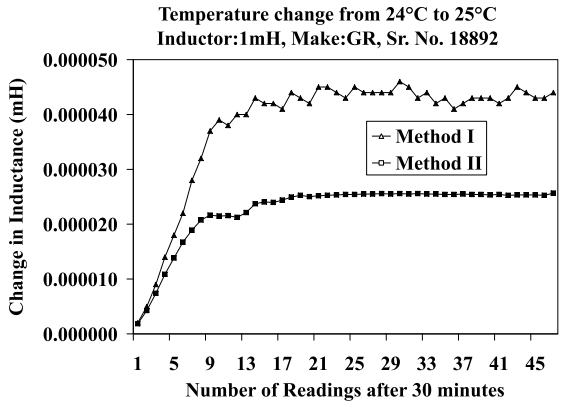


Fig.2.8 Change in Inductance for 1ºC temperature change

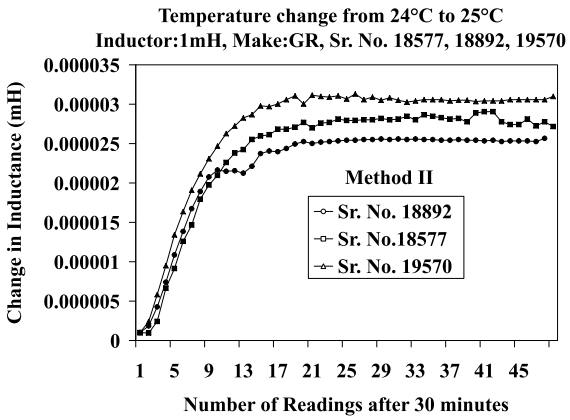


Fig.2.9 Change in Inductance for 1ºC temperature change

It is clear from both the methods that inductors take 10 to 12 hours to stabilize against change in temperature and the temperature coefficient is different for different inductors of same make, model and nominal value. This study will be utilized in inter comparison and proficiency testing programme.

Work is also initiated to evaluate 4 terminal pair capacitors of nominal value from 1 pF to

1000 pF to be used as high frequency impedance standards.

LF and HF Voltage, Current and RF Power Standards

Traceability of thermal voltage converters covering voltage range from 250 mV to 1000 V & frequency from 10 Hz to 1 MHz has been re-established to the primary standard of LF voltage. Traceability of thermal current converters covering the current range from 1 mA to 20 A has been re-established to the primary standard of LF current in the frequency range 10 Hz to 10 kHz.

RF Power Standards:

Successfully installed the new thermopile in the coaxial line of the microcalorimeter. To evaluate coaxial microcalorimeter correction factors, designed and developed RF short and open using an old coaxial thermistor mount.

Coaxial microcalorimeter lines losses have been evaluated which gave the attenuation factor of the calorimeter line. With all these results we have calculate the correction factors of the calorimeter by practically estimating 'eL', which is an additional thermopile e.m.f for an N type coaxial thermistor mount due to RF losses.

RF Voltage Standards:

Traceability of high frequency thermal converters against the primary standard of HF voltage based on calorimetric principles has been re-established in the voltage range 1V to 50 Volt upto 1000 MHz.

Intercomparison:

The final report on the "Key Comparison EUROMET.EM- K11 on AC-DC transfer standards at low voltages", shows that the results of NPLI are very close to the comparison reference value taken by the pilot laboratory for the intercomparison as shown in the fig.2.10

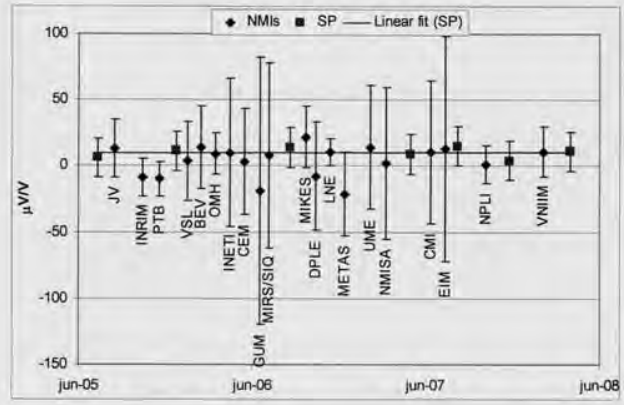


Fig 2.10: Results of the intercomparison

Automation Softwares:

Submitted three softwares for copyright to IPMD, CSIR New Delhi vide NPL ref no. NPL/IPRM/CR/3/2009 dated 17/09/2009. Two softwares are for LF Voltage & Current, one for assigning AC-DC transfer difference to thermal voltage & current converters and micro potentiometers using thermal devices and other for calibrating precision AC calibrator.

Third software measures the resistivity of the superconducting materials in the temperature range of 12 K to 325 K for Superconductivity and Cryogenics DU#7.

Establishment of free space dielectric measurement technique

Free space dielectric measurement technique has been established for RF characterization of material sheets in 8.2 to 12.4 GHz range. The technique broadly comprises of a vector network analyzer Wiltron 37247B, two X-band horn antennas and the material sheet holder.

Fig.2.11 X-band horn antennas with turn tables

The technique has been verified with Teflon dielectric sheet and used to characterize Plaster of Paris ($CaSO_4 \cdot H_2O$), white rigid Polyethylene foam and yellow flexible Polyurethane foam. The calculated dielectric properties along with their uncertainties are given in Table 2.2.

Development of Ka- and Q-band waveguide standards

Precision waveguide sections and flush shorts in Ka-band (26.5 to 40 GHz) and Q-band (33 to 50 GHz) frequency range have been indigenously developed for the establishment of VNA-based impedance measurement facility in waveguide system. These precision sections and flush shorts will be used as standards of VNA calibration kit for the calibration of waveguide components in the above frequency range which will be traceable to Dimensional metrology.

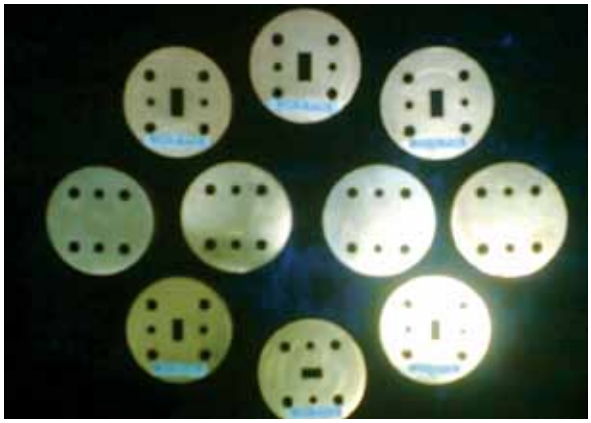


Fig.2.12 Ka- and Q-band waveguide standards

Design and development of TEM horn antenna

A TEM horn antenna has been designed and fabricated for the frequency range 1 to 18 GHz with the features of antenna gain: 6-10 dB and VSWR $\leq$ 1.6. This is developed for the wide applications in Broad-band communication systems, electromagnetic compatibility (EMC) measurement, detection systems.

Table 2.2 - Dielectric properties in the X-band frequency range

Parameter / Material		Dielectric constant ε′		Dielectric Loss ε″		Loss tangent tanδ	
		Range	Uncertainty	Range	Uncertainty	Range	Uncertainty
Teflon		2.055 1.882	0.055 0.048	0.098 0.004	0.002 1.72E-04	0.051 0.002	1.14E-04 4.78E-07
Plaster of Paris	Max Min	2.088 1.869	0.036 0.031	0.099 6.38E-04	0.002 1.54E-04	0.051 3.18E-04	8.25E-05 3.26E-08
White Foam	Max Min	1.032 1.004	0.014 0.014	0.028 3.70E-04	3.84E-04 2.79E-05	0.028 3.65E-04	2.14E-05 1.19E-08
Yellow Foam	Max Min	1.075 1.011	0.014 0.014	0.040 0.003	0.001 6.25E-05	0.040 0.002	4.18E-07 2.1E-07

Fig.2.13 The TEM horn antenna

Extension of the attenuation measurement range:

A frequency converter model 8852 and an existing attenuator & signal calibrator model VM-7 through the software are under installation to enhance the dynamic range and uncertainty of attenuation parameter. This will enable the attenuation calibration facility upto more than 100 dB with uncertainty ± 0.02dB/10dB in comparison to the existing 60 dB with uncertainty ± 0.02 dB/10 dB in the range of 10 MHz to 18 GHz.

Magnetic Standards

Preparation and properties of new multiferroic Hexaferrite $Sr_3Co_2Fe_{24}O_{41}$

Multiferroics with sufficient magnetoelectric coupling at room temperature and low magnetic fields are very important for various spintronics as well as sensor applications. Recently a Z-type hexaferrite ($Sr_3Co_2Fe_{24}O_{41}$) is reported to be one of such important multiferroic materials. In the present work we have prepared $Sr_3Co_2Fe_{24}O_{41}$ compounds at various sintering temperatures and measured its structural magnetic and dielectric properties. The samples were prepared using solid state reaction route and sol-gel route. Extra phases of some different ferrite phases (Y-type & others) were also detected in some of the prepared samples. We have further planned to study the effect of additives Bi_2O_3, CuO and metallic silver on the preparation of these hexaferrite samples. The synthesis and the measurements on these samples are in progress.

इंजीनियरिंग पदार्थ

ENGINEERING MATERIALS

इंजीनियरिंग पदार्थ

इंजीनियरिंग पदार्थ विभाग में मुख्यतः धातु और मिश्र धातु, उन्नत कार्बन उत्पाद, बहुलक तथा मृदु पदार्थ, फैरोइलैक्ट्रिक द्रव क्रिस्टल; जैव आण्विक इलैक्ट्रॉनिक्स और चालक बहुलक शोध ग्रुप शामिल है। इस विभाग का उद्देश्य उक्त क्षेत्रों में घटकों के लिए पदार्थों, प्रक्रिया और प्रौद्योगिकियों, डिवाइसेज़, सेंसर्स और प्रणाली को विकसित करना है। इस विभाग के आर एण्ड डी कार्यक्रम में एयरोस्पेस मैटेलिक डिवाइसेज़, सामरिक महत्त्व के नए कार्बन उत्पाद, जो देश में उपलब्ध नहीं है, आर्गेनिक फोटोवोल्टीय डिवाइसेज और कई प्रकार के चालक बहुलक और बायोसेंसर्स का विकास शामिल है। प्रत्येक ग्रुप द्वारा किए गए शोध का विवरण निम्नवत् है :–

धातु एवं मिश्र धातु ग्रुप

शोध एवं विकास कार्य मुख्य रूप से यांत्रिक गुण धर्मों में संशोधन के लिए स्प्रे–फार्मिंग, उष्ण निष्कासन और पाउडरधातु–कर्म संसाधन तकनीक का इस्तेमाल करते हुए Mg, Al व उनकी मिश्र धातु व यौगिकों की हल्की धातु के प्राथमिक, सैकेण्डरी संसाधन और अभिलक्षणन् पर केन्द्रित है। सी.एस.आई.आर. नेटवर्क परियोजना के अन्तर्गत नैनो क्रिस्टेलाइन Al मिश्र धातु प्रबलन के बल्क कंपोजिट को सिरेमिक नैनो पार्टिकल्स नियोजित क्रायो माइलिंग व स्पार्क प्लाज़्मा सिंटरिंग तकनीक के साथ विकसित करने का कार्य भी आरंभ किया गया।

उन्नत कार्बन उत्पाद

ग्रुप, 12000 सेल्शियस तक संशोधित यांत्रिक बल और दृढ़ता के साथ कार्बन–सिरेमिक कंपोजिट, एयरोस्पेस अनुप्रयोगों के लिए कार्बो–ग्रेफाइट पदार्थ, उच्च निष्पादित कार्बन फाइबर्स के लिए मध्य प्रावस्था पिच, इलैक्ट्रान ट्यूब्स के बहुचरणी (multi stage) अवनत संग्रहण के लिए उच्च घनत्व ग्रेफाइट और कार्बन नैनो ट्यूब्स के साथ नैनो SiC सहित विभिन्न कंपोजिट प्रबलन को विकसित करने में सक्रिय है। यांत्रिक अनुप्रयोगों के लिए नोवल कार्बन उत्पाद, निम्न एवं उच्च थर्मल चालकता का कार्बन फोम, PME फ्यूल सैल में प्रयुक्त होने वाले CNT ग्रेफाइट कंपोजिट बाई पोलर को विकसित करने का कार्य भी सफलतापूर्वक किया गया।

फैरो इलैक्ट्रिक द्रव क्रिस्टल शोध समूह

गोल्ड नैनो पार्टिकल्स (GNP) डोप्ड फैरो इलैक्ट्रिक द्रव क्रिस्टल पदार्थ में संदीप्ति प्रबलता की वृद्धि देखी गयी। दूसरे, सूक्ष्म प्रवाही क्रय विन्यास का इस्तेमाल कार्डिएक बायो–मार्कर विशेषकर सी–रिएक्टिव प्रोटीन (CRP) और मायो ग्लोबिन प्रोटीन के निदान में किया जाता है।

आर्गेनिक फोटो वोल्टीय शोध समूह

आने वाली पीढ़ी के लिए स्वच्छ और कम लागत वाली ऊर्जा को ध्यान में रखते हुए आर्गेनिक सोलर सैल्स बहुत महत्त्वपूर्ण हैं। हमने आर्गेनिक सोलर सैल्स को व्यापारिक दृष्टिकोण से विकसित करने में पहल कर दी है। उपरोक्त लक्ष्य को प्राप्त करने के लिए परिवहन और डिवाइसेज़ की माडेलिंग और निष्पादन के लिए आधारभूत और व्यावहारिक अनुसंधान किए जा रहे है।

चालक पालीमर समूह

विभिन्न औद्योगिक अनुप्रयोगों के लिए इस्तेमाल करने हेतु बेरियम फेराइट पार्टिक्ल्स और टाइटेनियम डाइआक्साइड सहित पोली एथलीन डाईआक्सी थियोफीन (PEDOT) के नैनो कम्पोजिट को इमल्शन पालीमराइजेशन द्वारा संश्लेषित किया गया। यह देखने के लिए कि किस प्रकार ग्रेफीन मैट्रिक्स में फेराइट कणों का समावेशन विद्युत चालकता और कंपोजिट के शील्डिंग इफैक्टिवनेस को प्रभावित करता है। HRTEM ने नैनो फेराइट कणों से जड़ित ग्रेफीन का संश्लेषण व अभिलक्षणन किया।

बायोमोलक्यूलर इलैक्ट्रॉनिक्स और चालक पालीमर शोध समूह

विज्ञान एवं प्रौद्योगिकी केन्द्र विभाग, बायोमोलक्यूलर इलैक्ट्रॉनिक्स कई प्रकार के बायो सेंसर्स को विकसित कर रहा है जिससे कि उन्हें कोलेस्ट्राल, लो डेन्सिटी लिपो प्रोटीन, ट्रिगली सीराइड, ग्लूकोज, यूरिया, पैथोजन्स (E. coli, M.tuberculosis, Neisseria ghonorhea), आहार जीव–विष (food toxin) और अपेक्षित परीक्षण नमूनों में पेस्टीसाइडस का अनुमान लगाने में प्रयुक्त किया जा सके।

स्वतः निशान लगाने के लिए अमिट स्याही सूत्रीकरण

चुनावों में वोटिंग में धोखा धड़ी रोकने के लिए वोटर की उंगली पर अमिट स्याही का निशान लगाने के लिए एक पद्धति विकसित की गयी। उंगली पर स्याही का निशान लगाते ही गहरे काले रंग का अर्द्ध–स्थायी धब्बा आ जाता है जो त्वचा में तुरन्त समा जाता है और उसे किसी रसायन या यांत्रिक चालाकी से भी खत्म नहीं किया जा सकता है। यह नव–विकसित इंक अपने आप में एक पूर्ण उपयोगी उत्पाद है जिससे देश में प्रत्येक वर्ष चुनावों में लगभग 4–5 करोड़ रूपए की एक बड़ी राशि की बचत होती है।

ENGINEERING MATERIALS

The Division of Engineering Materials mainly comprises of Metals & Alloys, Advanced Carbon Products, Polymeric & Soft Materials, Ferroelectric Liquid Crystals and Biomolecular Electronics & Conducting Polymer research groups. The objective of this division is to develop materials, processes and technologies for components, devices, sensors and systems in the above mentioned areas. The R & D output of this division includes the development of aerospace metallic devices, new carbon products which hold strategic importance and are not available to the country at any cost, organic photovoltaic devices and a variety of conducting polymers & biosensors. The summary of the research work done by each group is mentioned below:

Metals & Alloys Group

The R&D work was mainly focused on primary, secondary processing and characterization of light metals of Mg, Al and their alloys and composites using spray-forming, hot extrusion and powder metallurgy processing techniques with the main idea to improve the mechanical properties. The development work of bulk nanocomposites of nanocrystalline Al alloys reinforced with ceramic nanoparticles employing cryomilling and spark plasma sintering techniques was also initiated under a new CSIR Net - work project.

Advanced Carbon Products

The group is actively involved in the development of carbon-ceramic composites with improved mechanical strength and stability up to 1200 ºC, carbo-graphite material for aerospace applications, mesophase pitch for high performance carbon fibres, high density graphite for multistage depressed collection of electron tubes and a variety of composites reinforced with carbon nanotubes as well as nano-SiC. Developmental work on novel carbon products for mechanical application, carbon foam of low and high thermal conductivity, CNT graphite composite bipolar plate used in a PME fuel cell was also carried out successfully.

Ferroelectric Liquid Crystals Research Group

The enhancement of luminescence intensity in gold nano particles (GNP) doped ferroelectric liquid crystal material has been observed. Secondly, the microfludic arrays are being used to diagnose the cardiac biomarker, particularly C-reactive protein (CRP) and myoglobin protein.

Organic Photovoltaic Research Group

From generation of long term, clean and cost effective energy point of view, Organic Solar Cells (OSCs) are very important. We have undertaken the initiatives to develop OSCs and to make them commercially viable. To achieve the above objectives fundamental and applied investigations have been carried out in organic materials and solar cells with regard to charge transport, modeling and performance of the devices.

Conducting Polymer Group

Nanocomposites of poly ethylene dioxy thiophene (PEDOT) with barium ferrite particles and titanium dioxide used for various industrial applications were synthesized via in-situ emulsion polymerization. In order to see how incorporation of ferrite particles in graphene matrix affects the electrical conductivity and shielding effectiveness of composites, graphene embedded with nano ferrite particles were synthesized and characterized by HRTEM.

Biomolecular Electronics and Conducting Polymer Research Group

The Department of Science & Technology Centre on Biomolecular Electronics has been actively engaged towards the development of various biosensors that can be utilized for estimation of various analytes like cholesterol, low density lipo protein, triglyceride, glucose, urea, pathogens (E.Coli, M.tuberculosis, Neisseria ghonorhea), food toxins and pesticides in desired test specimens.

Indelible ink formulation for spontaneous marking

A method was developed for ready to use novel formulation of indelible ink for marking the finger of a voter in the elections to prohibit fraudulent voting. The formulation marks the finger spontaneously to leave a semi-permanent highly visible black stain which is impregnating into skin instantaneously and cannot be wiped out by chemical and mechanical manipulations. This newly developed ink is a complete utility product in itself which will save a huge amount of silver costing about 4-5 crores of rupees per year for elections in the country.

Metals & Alloys Group

Work was mainly focused on primary, secondary processing and characterization of light metals of Magnesium, Aluminium, their alloys and composites. Spray-forming and powder metallurgy material processing techniques were employed to synthesize these high performance alloys and composites with improved metallurgical and mechanical properties. Hot extrusion was used as a secondary processing technique to process these alloys to refine the microstructure leading to improved mechanical properties. This year work on a new CSIR Network project entitled, "Development of bulk nanocomposites of nanocrystalline aluminium alloys reinforced with ceramic nanoparticles employing cryomilling and spark plasma sintering", was initiated. R & D work on other ongoing sponsored & network projects was continued to achieve the specified objectives and targets.

Magnesium alloys

General Motors sponsored project entitled, "To understand the mechanism of recrystallization and grain refinement during extrusion of Magnesium-Rare Earth alloys"

The main objectives of this project are (i) investigation into the mechanisms of dynamic recystallization, grain refinement and ductility enhancement in Mg-Ce binary alloy system subjected to hot extrusion and Severe Plastic Deformation (SPD) employing Equal Channel Angular Pressing (ECAP) (ii) study of the effect of rare earth (Ce, etc) addition on the microstructure and mechanical behaviour of AM30 and AZ31 alloys extruded under different process conditions (temperature, strain rate, die design etc) (iii) understanding deformation mechanisms, effect of intermetallics and texture behaviour of extruded Mg-Ce, Mg-Al-Mn-Ce and Mg-Zn-Mn-Ce alloy systems. Under this project several Mg-alloys such as, Mg-0.2Ce, Mg-0.5Ce, Mg-1.5%Gd, Mg-1% Gd, Mg-1.25Zn, AM30, AZ31, Mg-4Zn-0.2Ce and Mg-2Zn-0.2Ce (in the form of cast billets) have been extruded and characterized extensively. These alloys have been hot extruded in different forms of circular rods (dia 15 mm and 25 mm), rectangular strips and square rods (16 mm side). Photograph of the volume of the hot extruded Mg alloy products are shown as Fig.3.1.

Fig. 3.1 : Extruded products of different Mg-alloys

Under this project, square section hot extruded rods of different alloy systems have been subjected to severe Plastic Deformation (SPD) employing Equal Channel Angular Pressing (ECAP) for which a die having 90° channel angle has been designed and developed at NPL. The ECAP has been conducted at temperature of 400°C. Different extruded billets of square section (15 X15 sq.mm) having initial grain size ~50 μm have been ECAPed upto four passes and the grain size could be refined upto 10 μm after multiple passes. It was found that the unique design of the die developed for ECAP at NPL was working successfully at elevated temperature; however, ECAP at lower temperatures was not

possible to be conducted. In order to achieve significant grain refinement, ECAP requires to be conducted at slightly lower temperatures, which requires modifications in the ECAP die. Based on these findings, a new design for the ECAP dies & tooling was worked out. Fabrication and procurement of the modified tooling for ECAP is currently under progress.

CSIR Network Project entitled, "Development of light-weight Al and Mg wrought products using secondary processing employing extrusion technique"

Mg-Al-Zn cast alloy ingots were processed by hot extrusion and all the processing parameters were optimized in order to obtain defect-free products. Two different alloys, namely AZ91 (Mg-9Al-1Zn) and AZ31 (Mg-3Al-1Zn), which are widely used for commercial applications, were taken up for hot extrusion. These cast alloy billets were homogenized followed by hot extrusion in the form of solid rods at different extrusion ratios. The homogenized and extruded rod products exhibited uniform equiaxed grain structure with fine intermetallic Mg17Al12 precipitates located preferably at the grain boundaries, in AZ31 as well as AZ91 alloys (Fig.3.2). The mechanical properties (tensile strength and ductility) of pure Mg as well as cast Mg alloys were poor, which were significantly improved after hot extrusion (Table 3.1), due to refinement in the microstructure. After extrusion, the tensile strength of AZ91 and AZ31 alloys increased to 298 MPa and 276 MPa, respectively, as compared to around 150 MPa for both their cast alloy counterparts.

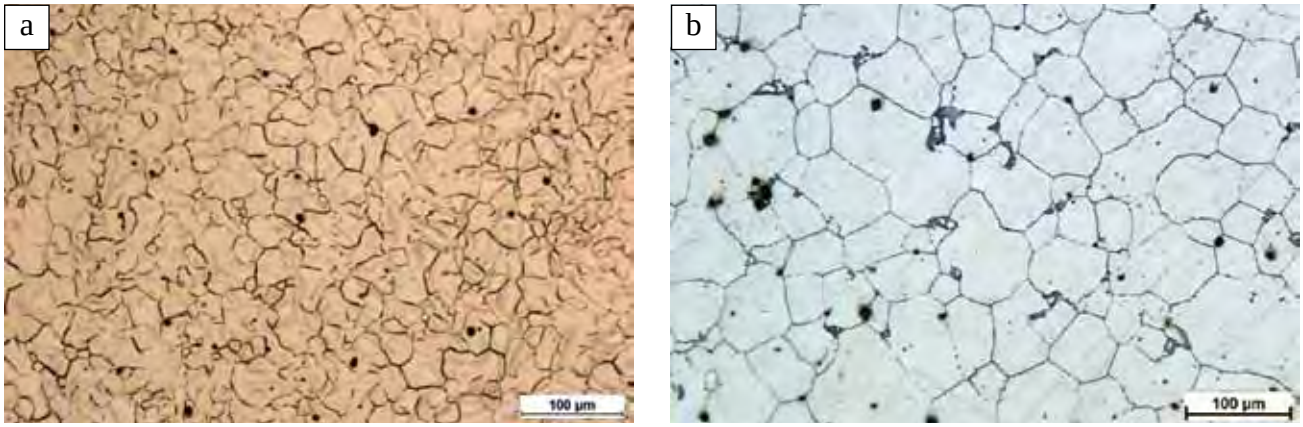


Fig. 3.2 : Optical micrographs of hot extruded Mg alloys having uniform equiaxed grains and fine intermetallic precipitates (a) AZ31 (25 µm) and (b) AZ91 alloy (60 µm).

Table 3.1 : Mechanical properties of Extruded products

Material/Alloy Composition	Condition (Extrusion Ratio)	Mechanical Properties		
		Vickers Microhardness (HV_{300})	Tensile Strength (MPa)	% Elongation
Pure Mg	Extruded rod (ER: 9:1)	32±4	181	8
AZ91 (Mg-9Al-1Zn)	Cast	60±4	150	6
	Extruded rod (ER: 25:1)	67±6	298	16
AZ31 (Mg-3Al-1Zn)	Extruded rod (ER: 9:1)	64±3	262	16
	Extruded rod (ER: 25:1)	70±3	276	16

In-house project entitled, "Synthesis of Mg alloys using rapid solidification and employing spray forming"

Magnesium alloys due to their light weight and high strength have gained momentum for applications in aerospace and automobile industry. Generally, Mg-alloys are synthesized using casting route but these are also being synthesized through rapid solidification process employing spray-forming, as it improves the mechanical and metallurgical properties of these alloys. Under this project, Mg-alloy AZ31 (Mg-3Al-1Zn) has been spray-formed and the effect of different processing parameters (nozzle diameter, flight distance, melt temperature) on the microstructural characteristics of the alloy has been investigated. It was observed that after the optimization of process parameters, the spray-formed deposits with fine and equiaxed microstructure were obtained leading to improved mechanical properties. Spray-forming experiments were carried out by reducing the spraying nozzle diameter from 4 mm to 2.5 mm (keeping other parameters constant) which indicated that the grains were refined from about 25 µm to 6 µm by reducing the nozzle diameter size. The flight distance of spray-forming was varied from 400 mm to 350 mm. It was observed that at 400 mm flight distance the grain size of the sample was about 40 µm but as the flight distance was reduced to 375 mm the grain size reduced to about 6 µm and when flight distance was further reduced to 350 mm grain size increased to 15 µm. Experiments were also carried out by varying the melt temperature which indicated that at 830°C, fine grains of size about 8 µm were obtained and at reduced temperature of 820°C the grain size increased to 25 µm and at melt temperature of 840°C the grain size further increased to about 70 µm. The mechanical testing of the spray-formed Mg-alloy samples indicated that the tensile strength of spray-formed coarse grained samples was 190-200 MPa but with fine grained samples the tensile strength increased to 225-230 MPa.

Aluminium alloys

"CSIR Network project entitled, "Development of bulk nanocomposites of nanocrystalline aluminium alloys reinforced with ceramic nanopaticles employing cryomilling and spark plasma sintering"

The main objective of this project is the optimization of process parameters to synthesize Al-alloy/SiC nanocomposites with near-theoretical density while maintaining the nanoscale features post-sintering and development of Al-alloy/SiC nanocomposite cylindrical product (Φ10mm x 15mm, up scaling to Φ30mm x 30mm) employing cryomilling followed by spark plasma sintering.

Experiments were carried out on the nanpowder synthesis of Al5083 alloy using cryomilling (Union Process, USA). Typically, a stainless-steel vessel, impeller, and grinding balls were used, with a ball-to-powder mass ratio of 20:1 with an impeller speed of 240 rpm. To prevent excessive welding, process control agent stearic acid added to the milling slurry. Detailed characterization of cryomilled nanopowder was carried out. Average crystallite sizes were calculated using X-ray diffraction employing Williamson-Hall method. The SEM investigations indicated that the cryomilled nanoalloy powder particle consists of numerous nanocrystalline grains. The minimum crystallite size observed was 25nm for 16hrs of cryomilling, as determined from XRD peak broadening. The particle morphology of cryomilled nanoalloy powders (Fig.3. 3) reveals that the metal particles

tend to flatten as time of milling is increased due to agglomeration and the particle size decreased with milling time period and was observed to be 30µm after 12 hrs of cryomilling.

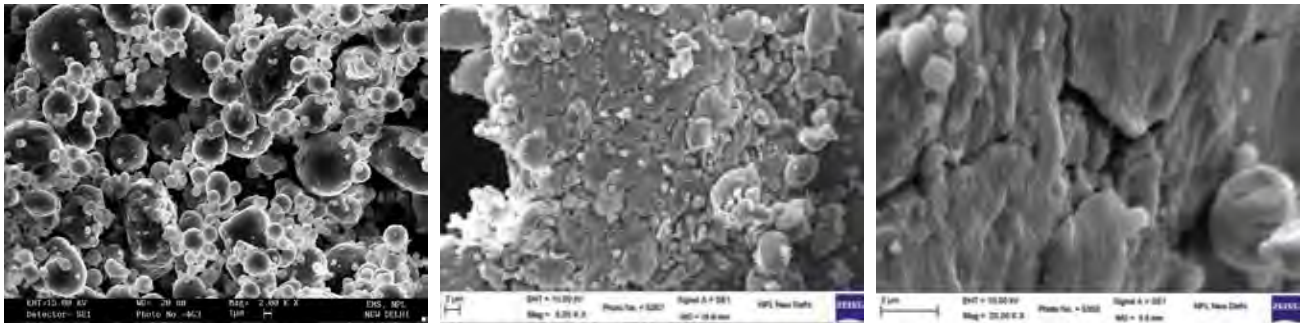


Fig. 3.3: SEM of Al5083 powder (a) As received, (b) After 12 hrs of cryomilling (c) After 12 hrs of cryomilling at higher magnification

TEM investigations of the 16 hrs cryomilled Al5083 nanoalloy powders show (bimodal) two types of representative microstructures. Grains most frequently observed were equiaxed (larger grains), with a completely random distribution of fine grains. These cryomilled nanoalloy powders will be consolidated into cylindrical bulk products using Spark Plasma Sintering with near-theoretical density and avoiding grain growth leading to high mechanical properties. The purchase order for procuring the Spark Plasma Sintering unit has already been placed.

Non-network project entitled, "Centre for Nanoscience & Nanotechnology"

This aim of this work was to synthesize Al-30Si nanocomposites using high energy mechanical ball milling followed by high temperature consolidation to obtain nanocomposites with superior mechanical and tribological properties.

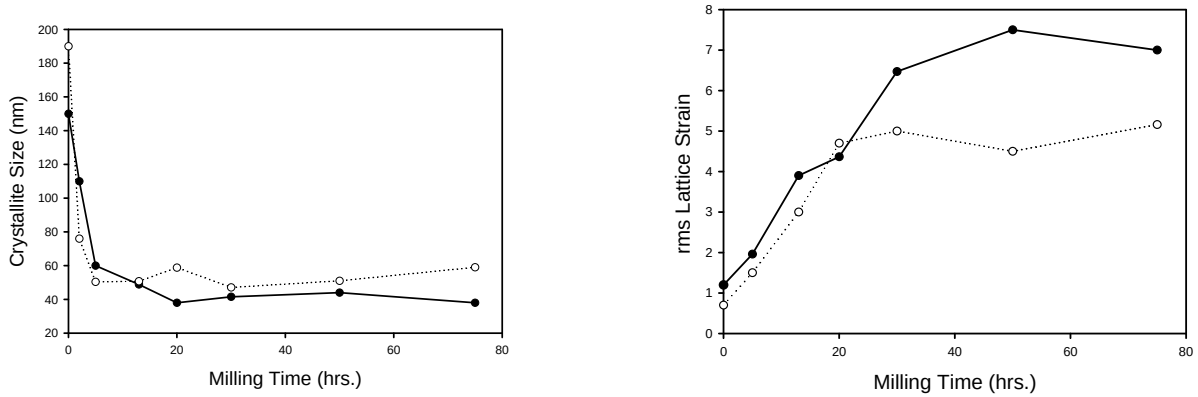


Fig. 3.4 : Crystallite size and rms lattice strain of Al-30Si milled nanocomposite powders as a function of milling time of (• Al and ○ Si)

Table 3.2 : Processing conditions and mechanical properties of Al-30Si nanocomposites

Sample	Sintering Temp.(°C)	Micro-Hardness (HV100)	Fracture Toughness (MPa.m1/2)	Compressive Strength (GPa)	Grain Growth
Micro-compacts	500	93	2.4	0.4	---
Nano-compacts	500	372	4.7	1.4	N
Nano-compacts	600	238	3.2	0.8	Y

Al and Si elemental powders (both ~ 100 μm) were ball milled for extended time periods at high speeds under controlled Argon gas atmosphere, in a Fritsch-make high-energy ball mill (model pulverisette – 4). The ball-milling process parameters, such as, ball diameter, ball-to-powder weight ratio, bowl speed, transmission ratio, milling time and milling cycle were optimized to obtain unagglomerated nanocomposite powders. The powder X-ray diffraction employing FWHM (Full Width at Half Maxima) analysis of these nanosized Al-30Si powders indicated average crystallite size as : Al ~ 15 nm & Si ~ 22 nm. It was found that with increasing milling time the crystallite size decreased sharply initially and finally became nearly constant at high milling periods (Fig.3.4). These nanopowders were cold compacted and the green nanocomposite disc was then consolidated using rapid sintering at high pressure employing a belt-type high pressure assembly on a 500-ton hydraulic press, with an aim to achieve near-theoretical density and avoid grain growth in these nanocomposites. The high pressure sintering temperature and heating rate were optimized so that the grain growth in these nanocomposites was avoided, which was confirmed by XRD analysis. The consolidated nanocomposites show substantially higher mechanical properties (compressive strength, fracture toughness and microhardness) as compared to their counterpart microcomposites, consolidated at identical conditions (Table 3.2).

Advanced Carbon Products

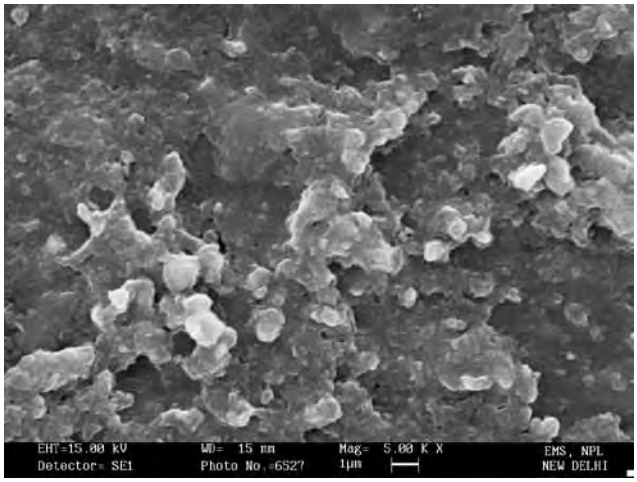
A leading centre in India dedicated to research in both pure and applied science of carbon with three principal motives i) to develop the process technology of newer carbon products which hold strategic importance and are not available to the country at any cost, ii) to develop products which can be made cost-effective by innovative process suitable to available infrastructure, expertise and resources in India, iii) to promote overall growth of carbon science and technology in the country through sustained R&D, research publications, patents, technology transfer, consultancy to industry, national & international conferences and refresher courses etc.

1. Development of carbon-ceramic composites and influence of oxidation at elevated temperatures

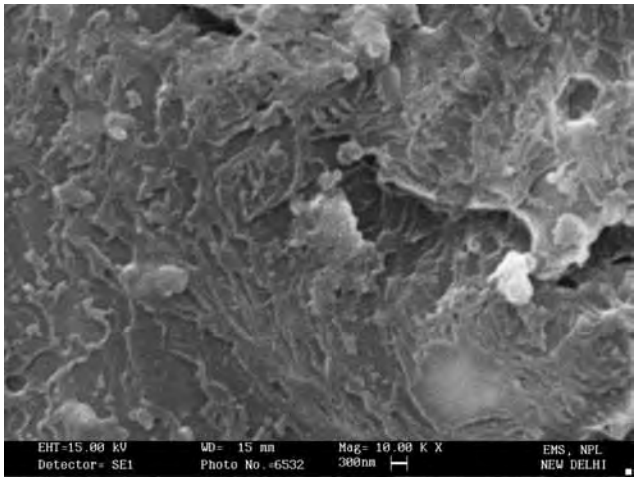
This project is sponsored by Department of Science & Technology (DST), New Delhi. Carbon based materials like graphite and carbon-carbon composites have many potential high temperature applications up to 3000°C in an inert atmosphere. However, these materials suffer from a serious drawback that they get oxidized at temperatures as low as 450°C and are completely lost / oxidized at 800°C in one hour. The development of carbon-ceramic composites is a solution to this serious problem.

The carbon-ceramic composites were developed through various routes namely; in-situ formation of silicon carbide (SiC) or using SiC particulates or coated silicon along with boron carbide (B_4C) and coal tar pitch derived green coke taken in definite proportions. The composites heat treated to 1400°C were studied for their physical including microstructure (Fig. 3.5a), mechanical and oxidation resistant properties in the temperature range of 800-1200°C for extended hours. It was observed that the presence of silicon (used as SiC forming precursor) in the base mixtures for the development of carbon-ceramic composites results in high bending strength

(around 110-160MPa) as compared to those developed with SiC particulates (55-91MPa). The coating of silicon with a suitable pitch material in the precursor significantly increases the bending strength of the composites from a value of 110 to 155MPa. All the composites developed under the project through different routes exhibited oxidation resistance in the temperature range of 800-1200°C for periods up to 20 hours. The influence of oxidation on the properties of carbon-ceramic composites was studied and it was found that the electrical resistivity and bulk density of all the composites after oxidation at 800-1200°C increases marginally which is attributed to the formation of glassy boron oxide at 800°C (Fig.3.5 b), silica at 1000°C (Fig.3.5 c) and borosilicate layer at 1200°C (Fig.3.5 d). The bending strength of all the composites batches increases after oxidation at 800°C up to 5 hours. The bending strength values of carbon-ceramic composites were found to increase after oxidation at 1000-1200°C for 5 hours and it then decreases as the exposure time in air is increased up to 20 hours. The project has been completed and the final technical report is being written for onward submission to DST, New Delhi.



(a)



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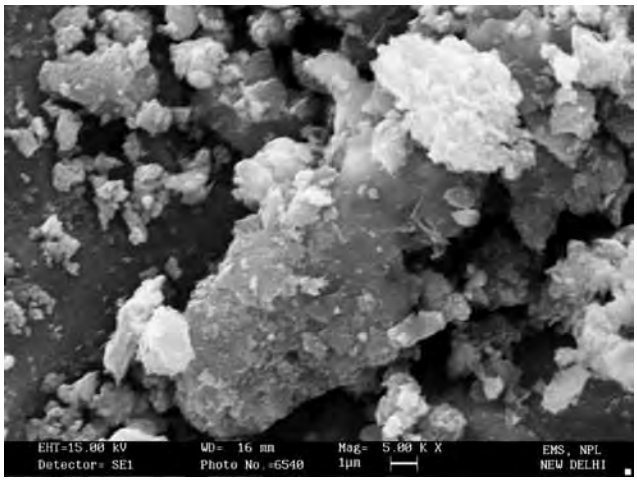

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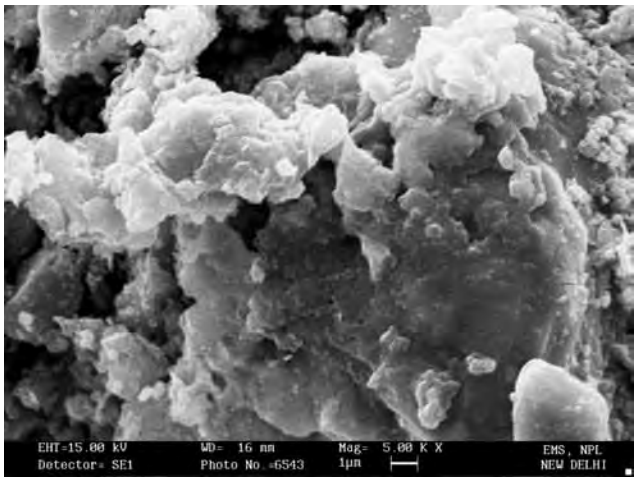


(d)

Fig. 3.5: Scanning electron micrographs of carbon-ceramic composite developed thorugh in-situ formation of SiC (HTT 1400°C) (a) as such (b) oxidized at 800°C for 20 hours (c) oxidized at 1000°C for 20 hours (d) oxidized at 1200°C for 20 hours in air

2. Development of carbo-graphite material for aeronautical application

This project is sponsored by Defence Materials and Stores Research & Development Establishment (DMSRDE), Kanpur. The carbo-graphite material is a high quality graphite product which possesses a density of more than 1.8 g/cm^3, hardness of 85 on shore scale, high compressive strength of ~ 1500 kgcm^{-2}, besides being stable in air at 650°C. This material is to be used as a seal for the Kaveri Engine of the LCA aircraft. High density carbon/graphite samples were made from four types of in-house prepared green coke / modified green cokes (GC-1 to GC-4) at a heat treatment temperature (HTT) of 1400°C and up to 2500°C. These samples were then impregnated using a high pressure-high temperature impregnation assembly (designed and fabricated) with some boron, phosphorus and other salts, baked to 650°C and tested for thermal stability at 650°C in air.

Table : 3.3 Oxidation resistance of impregnated carbo-graphite at 650°C in air

Batch	Weight loss (%) after heating at 650°C for		
	1hr	5hr	10hr
GC-1	0.016	0.44	0.68
GC-2	0.002	0.32	0.57
GC-3	0.024	0.30	0.35
GC-4	0.260	0.41	0.69

It was observed that carbographite prepared showed excellent thermal stability at 650°C in air. Further work is in progress to prepare and supply isostatically moulded samples of carbo-graphite.

3. Development of mesophase pitch for high performance carbon fibres

This project is also sponsored by a defence laboratory, namely Defence Materials and Stores Research & Development Establishment (DMSRDE), Kanpur. Carbon fibres are a special class of materials which are stronger than steel, stiffer than titanium and lighter than aluminium and are used in fabricating light weight fibre based composite materials.

The objective of this project was to develop mesophase (liquid crystalline) pitch of low softening point (250-280°C), high coking value (80%) and high spinnability for spinning it into high performance carbon fibres. Besides this, mesophase pitch can also be used for the development of carbon-carbon composites and other high tech applications. The mesophase (liquid crystalline) pitch of desired specifications was successfully developed by suitable thermal / controlled treatment of coal tar pitch, petroleum pitch and their mixtures. Few mesophase pitch samples were supplied to DMSRDE, Kanpur and used for spinning into fibres at NPL and DMSRDE. The project has been successfully completed and final technical report was submitted to DMSRDE in July 2009. Efforts are continuing to develop some useful products from this novel pitch.

4. Development of high density graphite for multistage depressed collection of electron tubes

This is a part of the XI Plan CSIR sponsored network project on "Design and fabrication/ capabilities for very high power microwave tubes" with CEERI, Pilani as the nodal agency. The objective in the project is to develop two types of graphite (imported graphite procured from USA by CEERI, Pilani) with stringent specifications i.e. (i) high density graphite, (ii) copper reinforced graphite suitable for multistage depressed collector of electron tubes viz. traveling wave tubes useful for space applications. Such types of graphite are not produced or available in the country.

High density graphite samples were prepared from suitable/modified self sintering green coke powders developed in-house by heat treatment of suitable coal tar pitch which were ground into fine powder using planetary ball mill, and molded into rectangular plates/blocks and carbonized to 1000°C, 1400°C and then up to 2500°C in an inert atmosphere to obtain high density graphite. A high density of 1.9 g/cm^3, electrical resistivity of 1.5 mΩcm and bending strength of 90 MPa were obtained at a HTT of 2500°C. The graphite samples developed at NPL exhibit properties which are close to the required values. The samples of this graphite are being prepared and will be supplied to CEERI, Pilani for testing and use in the traveling wave tubes.

Extensive work has been carried out to develop copper reinforced graphite by mixing coated copper in different amounts with green coke / modified green coke powders having copper to carbon (Cu:C) weight ratio from 1.0 to 1.5. These were molded, carbonized up to 1200°C and characterized for various properties. The bulk density values of 3.0-3.2 g/cm^3, electrical resistivity as low as 0.5-1.0 mΩcm, bending strength of 118-135MPa and shore hardness of 85-90 were achieved at a HTT of 1200°C. In comparison, the electrical resistivity of coated copper reinforced carbon composites (Cu:C =1.3:1), in the presence of suitable additive was found to decrease significantly to the value of 0.26 mΩcm at HTT of 1100°C which may be attributed to low temperature graphitization of carbon material. Most of the specifications of the copper reinforced graphite were found to be close to the targeted values desired in the project. Electroless coating of various carbon precursors namely, green coke, natural graphite and synthetic graphite was also done and used in the preparation of copper reinforced graphite composites. The X-ray powder pattern of electrolesss copper coated natural graphite (Fig.3.6) shows characteristics peaks of copper (Cu) at 2θ = 43.29°, 50.43° and 74.13° besides a graphite (C) peaks at 2θ = 26° and 54.5°. The experimental parameters are being optimized for this process. An interim technical report was prepared and submitted. Further work is in progress.

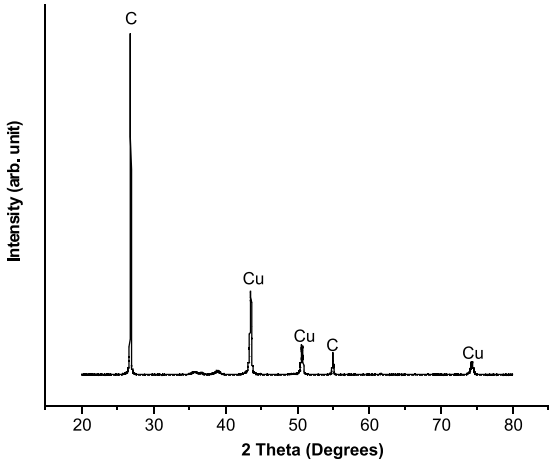


Fig. 3.6 : X-ray pattern of electroless copper coated natural graphite

5. Development and demonstration of Polymer Electrolyte Fuel cell (PEFC) stacks for stationary applications

This is an Inter institutional project involving NPL, NCL, CECRI and Reliance Industries (as an Industrial partner) with an objective to develop PEM fuel cell as a clean source of energy in the country using all indigenous components. The goal is to demonstrate a 5 kW fuel cell stack using the carbon developed at NPL. During the last year Porous conducting carbon paper and Carbon composite bipolar plates were developed and their performance was matched with the best commercially produced product marketed by the International companies.

About 100 numbers of carbon paper and bipolar plate samples conforming to the standard

specifications were prepared and characterized at NPL. These were sent to CECRI for assembling fuel the cell stacks. A 350 W fuel cell stack using NPL components was demonstrated live at "International symposium and exhibition on Fuel cell technologies- FUCETECH-2009, organized by NMRL (DRDO) in Mumbai from 11-13 Nov. 2009. Another 350 W stack was also demonstrated to Honorable minister of science and technology during his visit to NCL, Pune on 30th January'2010. Efforts are continuing to develop these components to develop fuel cell stacks up to 5 kW capacity, based on indigenous components. The result is a big boost to the NPL technology for both the components and the programme goal to develop PEMFC using indigenous components.

Further R&D is being carried out to improve the quality and the production rate of the samples to meet the demand in the present phase of the project.

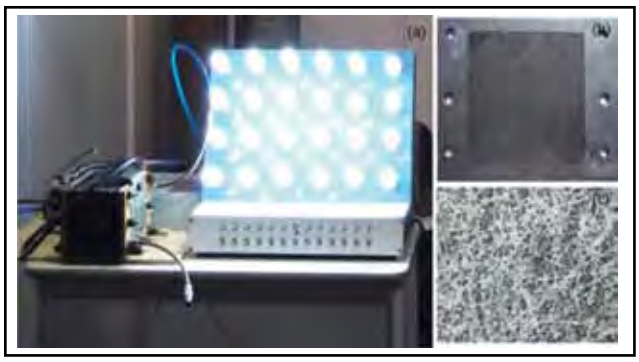


Fig. 3.7: (a) PEM fuel cell stack of 350W using all indigenous components: NPL (b)Bipolar plate and (c) porous conducting carbon paper.

6. CNT Nanostructuring effect on properties of Graphite Composite Bipolar Plate

Bipolar plate is one of the important components of PEM fuel cell, which account as much as 70 % of stack weight and 40 % of its total cost. Development of a suitable low density material for use as bipolar plate is scientifically and technically important due to the need to maintain high electrical conductivity, good mechanical properties and low cost. Therefore, the present work Intents to improve the thermal and electrical properties of graphite-polymer composite bipolar plate by nanostructuring. This involves the incorporation of different vol. % of multi walled carbon nanotubes (MWNTs) in graphite-polymer composite bipolar plate. It is found that, inclusion of 1vol. % of MWNTs in graphite composite plate increases its electrical and thermal conductivity by 100%. The through plane & in plane thermal conductivities of nano composite plate increases from 1 W/m.K to 13 W/m.K and from 25 W/m.K to 50 W/m.K respectively at 1 vol. % of CNTs loadings. This significant enhancement is due to the orientation of CNTs in all directions of composite, positive synergistic effect of CNTs and heat transfer along the axes direction. Bending strength of nanocomposite increases by 25 % and maximum augmentation in case of 1 vol. % of CNTs. The improvement in conductivity of nanocomposite plate is due to the increase in the electron transfer ability and hence, enhances the I-V performance of the fuel cell. These observations confirm that the optimal content of CNTs is 1vol. %., in graphite-polymer composite.

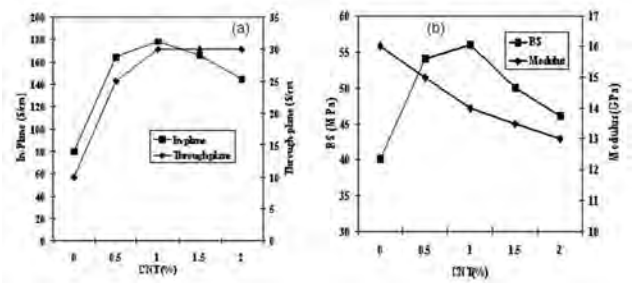


Fig. 3.8: Effect of CNT nanostructuring effect on (a) electrical conductivity and (b) mechanical properties of composites bipolar plate.

7. Dispersion and Alignment of Carbon Nano Tubes and Development of CNT Reinforced Composites

The project has been initiated as a consortium approach between the laboratories in DRDO, NCL and NPL to develop strong composites for future missile and aircraft structures.

Some of the significant achievements during the period are

- Optimization of the dispersion conditions of CNTs in epoxy resin. Different functionalized nanotubes were dispersed in epoxy resin. Fig. 3.9 shows dispersion of the amine functionalized 1% MWNTs in epoxy matrix. Insert in Fig.3.9 shows the SEM micrograph at higher magnification in which individual CNTs are well dispersed.
- The degree of dispersion of different wt % of CNTs was monitored by UV-Vis technique. With increasing the dispersion of CNTs in epoxy resin, the area under the absorption curve increase.
- Making CNT-epoxy composites with different functionalized CNTs received from NCL, Pune after different chemical treatments from time to time.

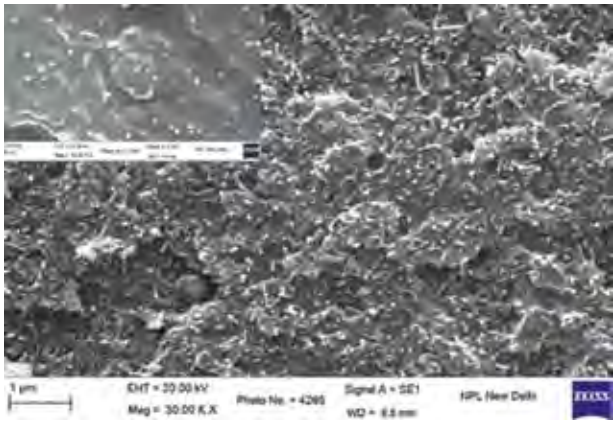


Fig. 3.9: Dispersion of amine functionalized MNTs in epoxy matrix.

- Developed CNT reinforced pitch based carbon-carbon composites. The thermal conductivity value of these composites with only 10 vol% of CNT were found to be in the range of 100 W/mK which is quite high for a composite of 1.5 g/cc density only. Further experiments are in progress to produced CNT based high thermal conductivity c/c composites which may ultimately find application as first wall material in fusion reactors.

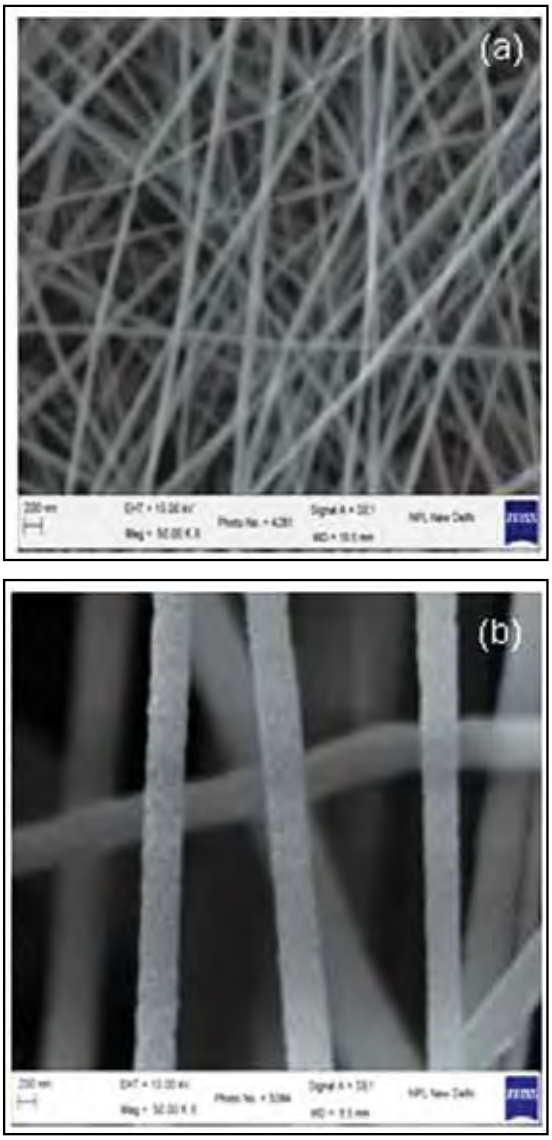


Fig. 3.10: (a) Electrospun PAN nanofibers, (b) aligned 5 wt % MWNTs of in PAN polymer.

- Electrospun PAN nanofibers are produced from different weight percentage of PAN by controlling solution condition and processing parameters. It is found that, with increasing the PAN content, polymer nanofibers diameter increases, the minimum diameter 200 nm is of 5 wt % of PAN in the DMF solution. However, with 7.5 and 10 wt % fiber diameter varies from 300-1000 nanometer.
- To realize the full potential properties of CNTs in composites, alignment of CNT in particular direction is necessary to achieve maximum properties in the composite. In this direction MWNTs- polyacrilonitrile nanofibers composite containing aligned MWNTs with concentration 1 to 5% are produced. It is found that, with 5 % of MWNTs, nanotubes are aligned in the fiber direction uniformly as compared to 1 % of CNTs which is revealed by the surface morphology of fibers.

8. Non Network Projects

8A. Development of nano composites using nano-SiC

The nano- silicon carbide has been prepared by the reaction between silicon and carbon black as well as silicon and resin based carbon at temperature of 1400^{0}C which was characterized using XRD, SEM and TEM. The self sintering pitch precursor was used as such and also mixed with nano silicon carbide (5-15 weight %), molded into plates and carbonized to 1400^{o}C to obtain carbon monolith and carbon-nano silicon carbide composites respectively. Significant improvement has been observed in the properties of C-nanoSiC composites such as bulk density (from 1.84 to 1.91g/cm^3), bending strength (from 120 to 155 MPa) and shore hardness (90 to 110) respectively by the incorporation of 15% nano SiC particles, as compared to those of carbon monolith. These C-nano SiC composites can be used as advanced seals, bearings etc for high temperature / specialized applications. It is worth while to mention here that the process know-how for the preparation of novel pitch based precursor for producing monolithic carbon was transferred to carbon industry in March 2010.

Experiments have also been carried out on the development of carbon-nanoSiC-B_4C composites using green coke, nano silicon carbide particulates (developed using carbon black and silicon as nano-SiC precursor) and B_4C at a HTT of 1400^{0}C. The composites were characterized for

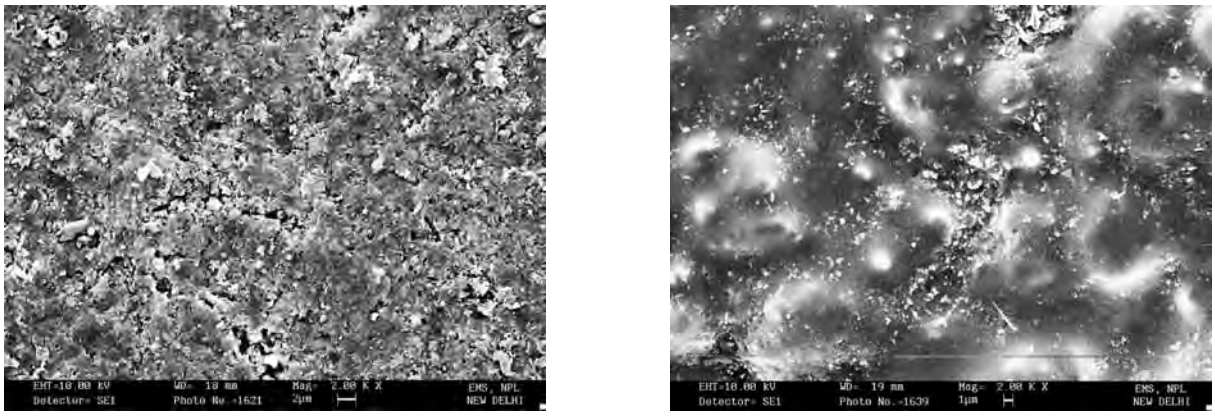


Fig. 3.11: Scanning electron micrographs of (a) C-nanoSiC-B_4C composites developed using nanoSiC particulates (HTT 1400°C) (b) C–nanoSiC–B_4C oxidized at 800°C for 20 h

various properties including oxidation resistance. These composites exhibited oxidation resistance in the temperature range of 800-1200°C for periods up to 20 hours. Further, it is was observed that the C-nanoSiC-B_4C composites developed by in-situ (within the composite) formation of nanoSiC using carbon black and silicon as SiC precursor exhibited inferior properties as compared to those developed by using nanoSiC particulates.

8B. Development of novel carbon Product for mechanical applications

A suitable self sintering material is prepared from coal tar pitch by controlled heat treatment in presence of carbonaceous additives which is then ball milled to a fine powder in a high speed planetary ball mill and molded in the form of plates, blocks or cylindrical rings and carbonized at of 1000°C or higher to produce a novel carbon product possessing a bulk density of more than 1.7g/cm^3, bending strength of more than 50 MPa, shore hardness of more than 60 along with a homogeneous and fine microstructure. Its potential applications include bearings, seals and other jigs for mechanical applications.

8C. Development of Carbon foam of low and high thermal conductivity

Carbon foam of low thermal conductivity are useful for high temperature thermal insulation in inert atmospheres while the foam of high thermal conductivity finds potential applications in heat sinks, lithium ion battery electrodes, catalyst supports and filters, etc. This is because of its low and varied density (0.2-0.8g/cm^3), high temperature tolerance up to 3000°C in inert medium, large specific surface with open cell structure and adjustable thermal and electrical conductivity. Low thermal conductivity carbon foams of various densities (in the range of 0.2-0.6 g/cm^3) have been developed from phenol-formaldehyde resin using template method. The foam so produced was carbonized at 1400°C. The foam has been characterized by SEM and characterization by other techniques is under progress.

Similarly the high thermal conductivity carbon foams of various densities (0.15-0.5g/cm^3) have been developed by mesophase pitch developed in-house in different concentrations using template method and then carbonizing the same at 1000°C followed by graphitization at 2400 / 2500°C. Microstructure has been observed by SEM and characterization by other techniques is under progress.

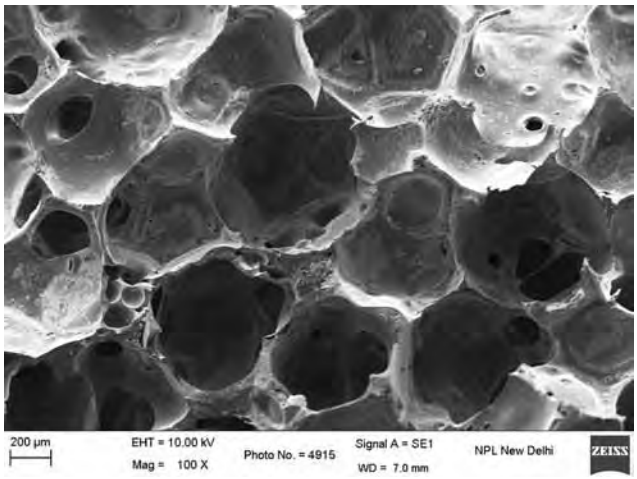


Fig. 3.12: SEM of In-house developed mesophase pitch impregnating carbon foam (HTT = 1400°C)

8D. Development of SiC based susceptor material for Microwave absorption for high emperature applications

The application of microwave energy has become most popular in recent years with new and innovative applications in material science, nanotechnology, polymer chemistry etc. This technique has distinctive advantages in reducing processing time and temperature, enhancing material property and yields over those reported

for conventional methods. SiC carbide based dense (r=2.6 g/cm^3) ceramic composite material has been developed which increases in temperature upon exposure to microwave radiation resulting in rapid heating up to 1100° C in 3 minutes. Desired specific resistance >103 Ωcm is achieved by adding suitable ingredients having high melting points >1500°C such as Al_2O_3, ZrO_2, B_4C, TiO_2 maintaining higher specific resistance even at high temperatures. Different processing techniques including cold and hot molding and different heat treatments were tried to achieve optimum processing conditions. The detailed characterization of the material is under progress. This material is not produced in India and is quite expensive if procured from abroad. A project proposal has been submitted to DST, New Delhi.

8E. Development of Al-MWNT composites

A new activity was started during 2009-10 on the development of Al composites reinforced with multi-walled carbon nanotubes (MWNT) using powder metallurgy process. These composites are found to posses superior mechanical properties than those of pure Al composites and are used in aerospace and automobile industries for manufacturing different components. MWNT were used as the reinforcement materials for these composites because of its outstanding properties including high tensile strength, Young's modulus and low density. These MWNT were synthesized in the laboratory from the decomposition of a hydrocarbon in the presence of Fe catalyst. Of the various processes available, powder metallurgy (PM) process was used at NPL because of its easy processing. However, one of the major problems in fabricating these composites is the homogeneous dispersion of MWNT in Al powder because of strong van der Waals force of attraction between the tubes because of which the MWNT tend to agglomerate rather than disperse in Al powder. It must be mentioned that many researchers all over the world are trying to fabricate Al-MWNT composites using a variety of methods, the problem of dispersion of MWNT in Al powder has not yet been solved to a satisfactory level, and, therefore, a lot of research work in this direction is still required. At the NPL, during the year 2009-10, we tried to disperse MWNT in Al powder using high energy ball milling of Al and MWNT (taken in different weight percentage). Our exploratory results in this direction are very encouraging. Al-MWNT composites of rectangular shape and size 13 x 7 x 2 mm were fabricated by cold pressing a powdered mixture of Al and MWNT followed by sintering near the melting temperature of Al (660 ºC), both in an inert atmosphere as well as under vacuum. Fig. 3.13 shows a SEM image of the fractured surface of Al composite loaded with 1.5 wt.% MWNT.

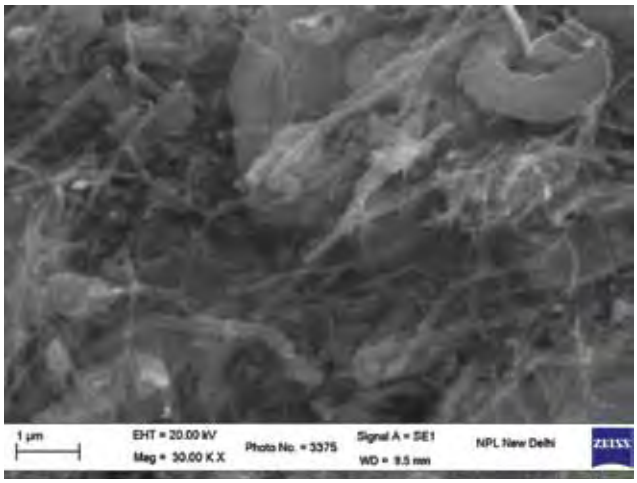


Fig.3.13: SEM micrograph showing fractured surface of Al-MWNT composite

The microhardness of these composites was found to increase from about 40 kg/mm^2 observed for pure Al composites to about 104 kg/mm^2 and the compressive strength was found to increase by 200%.

Ferroelectric Liquid Crystals

Liquid Crystal and Self-assembled Monolayer Section

(A) Ferroelectric Liquid Crystals:

It has long been appreciated that liquid crystals (LCs) are the most promising materials for display as well as non-display (optical devices based on LC) applications in modern technology. The liquid crystal based display devices have some problem of low brightness and low energy efficiency due to the use of polarizers and absorbing colour filters. The use of luminescent LC materials or photo-luminescent sheets as active color filters has emerged as a fascinating approach towards the fabrication of luminescent LCD using pure liquid crystal materials as they emit less intense light in the visible region of the electromagnetic spectrum.

Recently, we at NPL have characterized a new type of LC material called deformed helix ferroelectric liquid crystal (DHFLC) material and found the enhancement of luminescence intensity in gold nano-particle (GNP) doped DHFLC LAHS 19 (Trade name) material. It has also been found that the luminescence (PL) intensity of GNP doped DHFLC material can be tuned by varying the concentration of GNPs. A newly characterized DHFLC material (LAHS 19) has fast response and large intrinsic PL intensity. A nine fold enhancement in the PL intensity of the GNPs doped LAHS 19 material has been observed as shown in Fig. 3.14.

It has been demonstrated that generation of large electromagnetic fields near the GNPs surfaces enhances the PL intensity of GNPs doped LAHS 19 material. The enhancement in the PL intensity of GNPs doped LC material opens up an important way in realization of

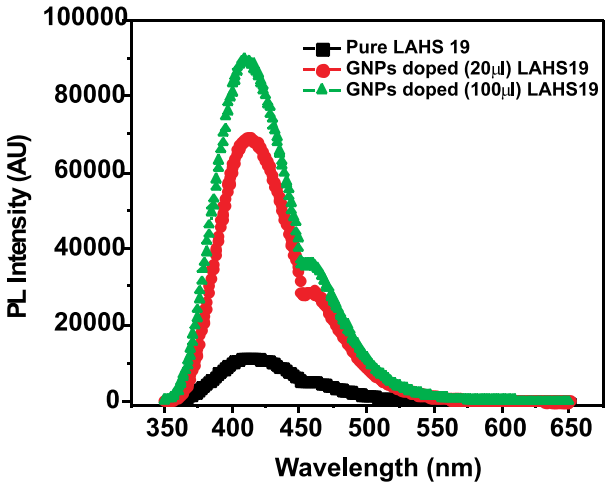


Fig. 3.14

photo-luminescent LCDs. The LCDs based on the underlying phenomenon would have enhanced brightness, high contrast, large view angle, and used in exceeding power efficiency of current LCDs, enhancing multiplexing in passive LCDs and providing large screen direct view displays.

(B) Microfludic and SAM based techniques for biomarkers:

C-reactive protein (CRP) and Myoglobin proteins are being extensively used as diagnostic markers of acute myocardial infarction (AMI). As a cardiac biomarker, myoglobin is used in conjunction with troponin to help diagnose or rule out a heart attack in human blood. New biochemical diagnostic methods for AMI are being investigated in response to the requirement for superior diagnostic accuracy and rapidity, and for improvements in the management of patients with chest discomfort. High sensitivity and selectivity nature of the recognition between antigen (Ag) and antibody (Ab) makes the immunoassays very useful in widespread applications in environmental monitoring, processing quality control and clinical diagnosis. The concept of direct label-free immunosensors has advantages

with respect to speed and simplicity in which the immune interaction between antibody and antigen is directly monitored. A person is at an average risk of cardiovascular disease when the CRP level in blood is between 1-3 mg/L. A CRP level above 3 mg/L predicts a high risk and below 1 mg/L is an indication of low risk of cardiovascular disease. CRP is diagnosed with tests like enzyme linked immunoassay, nephelometric and turbidimetric assays. Recently, we have reported a label-free electrochemical impedance immunosensor by immobilizing protein antibody, aCRP-Ab, through a self assembled monolayer (SAM) of 3-aminopropyltriethoxysilane (APTES) using a cross linker, Bis[sulfosuccinimidyl] suberate (BS3), on indium tin oxide (ITO) coated glass electrode. The scheme illustration of surface modification on ITO glass plate and immobilization of protein antibody together with antibodies-antigens interaction at the immunosensor surface is shown in Fig. 3.15. The immunosensor (aCRP-Ab/BS3/ APTES/ITOglass) was characterized by scanning electron microscopy (SEM), atomic force microscopy (AFM) and electrochemical techniques. The electrochemical performance of the immunosensor was studied by electrochemical impedance spectroscopy. The results showed an increasing electron-transfer resistance with the immobilization of CRP antibody (aCRP-Ab) on the modified ITO coated glass electrode surface and on their coupling with protein CRP antigen (aCRP-Ag) at the immunosensor surface in the presence of [Fe (CN) 6]3-/4- as redox probe, as shown in Fig 3.16.

Due to small size of 17.8 kDa of Myoglobin, a non-enzymatic cardiac protein, it is released into plasma in a significant amount within 3 hrs of the onset of AMI while the plasma concentrations usually return to normal within 24 hrs. Normal serum myoglobin levels range from 30 to 90 ng/ml. After 1 hour of the onset of myocardial infarction, serum myoglobin level

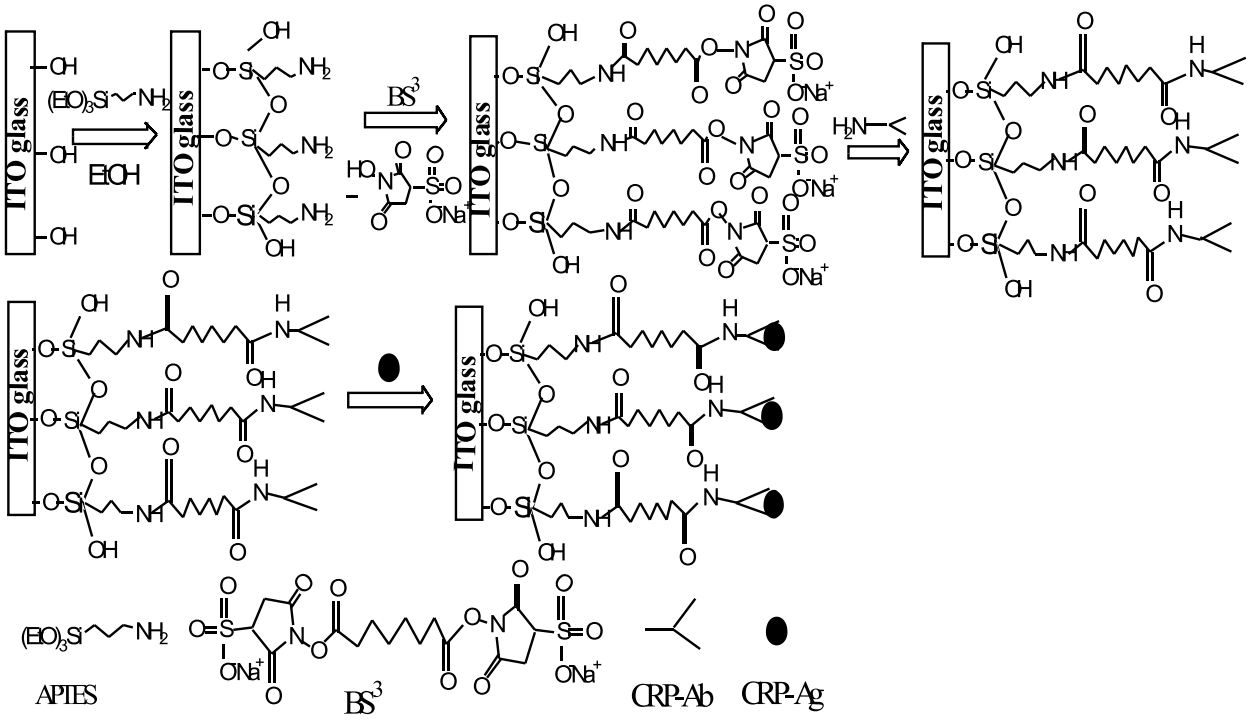


Fig. 3.15

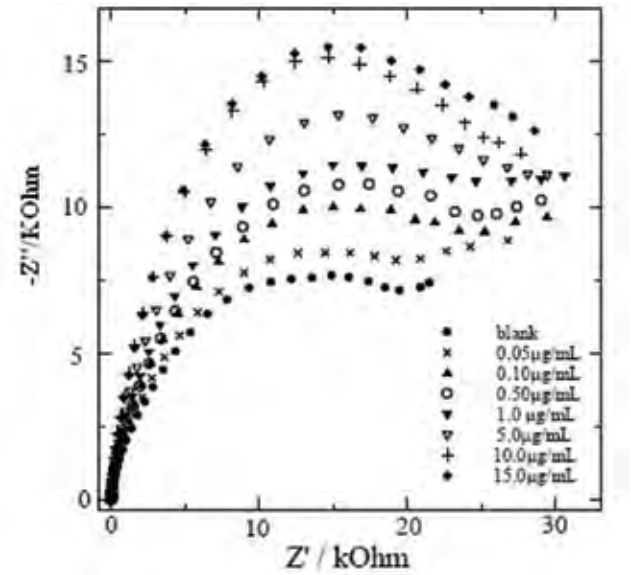


Fig. 3.16

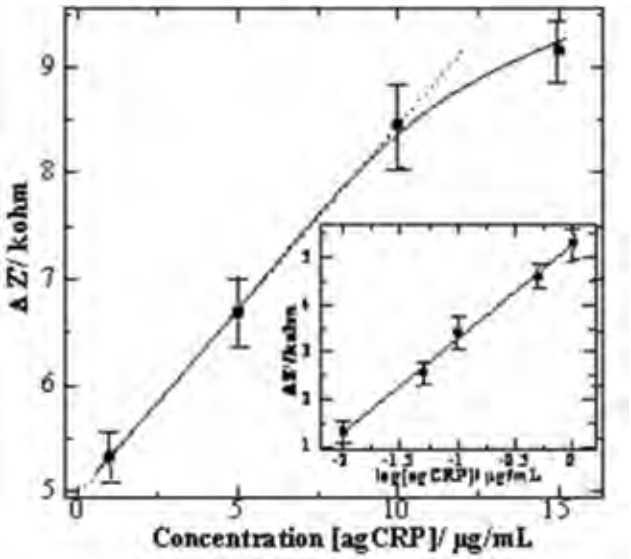


Fig. 3.17: The immunosensor exhibits an electrochemical impedance response to antigen, aCRP-Ab, concentrations in a linear range from 8.5 ng to 9.12 µg mL-1 with a lowest detection limit of 3.5 ng mL-1 antigen, as shown in Fig.3.17

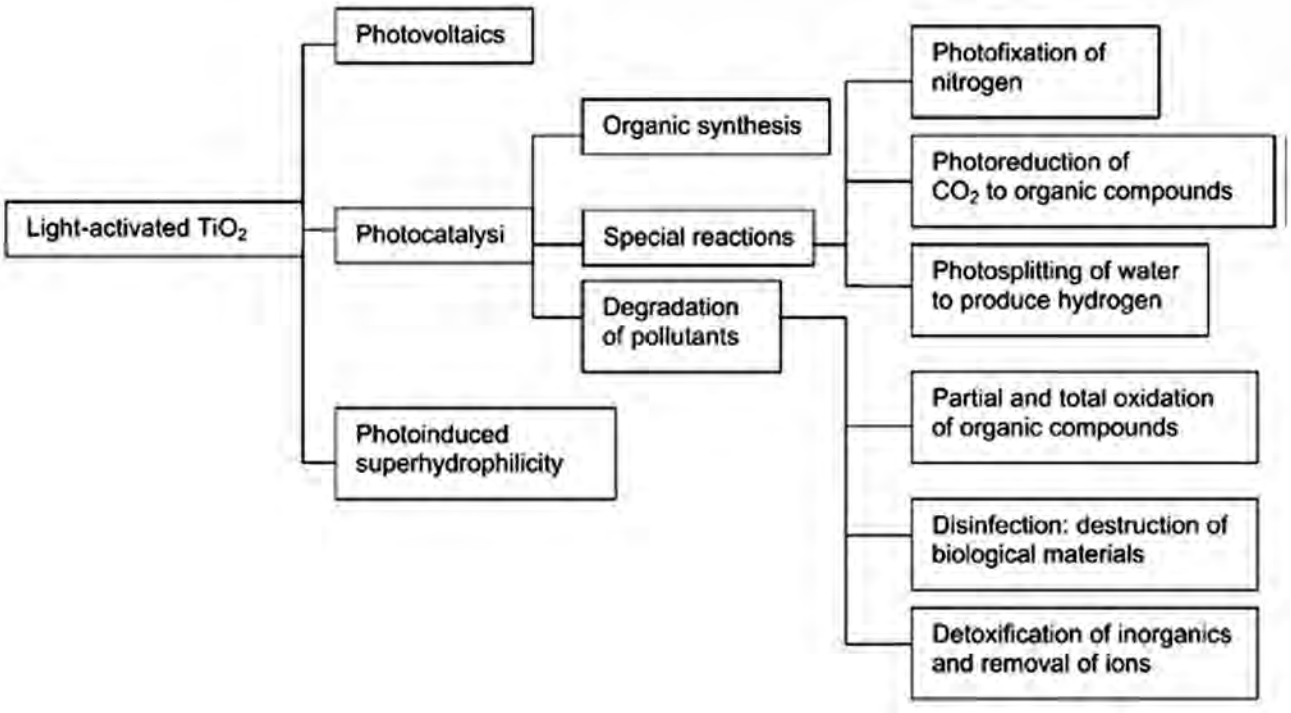
can elevate to 200 ng/ml or even higher. During the peak hour, myoglobin level can be as high as 900 ng/ml.

Recently, We at NPL have carried out a surface modification of thin flat gold wire electrode with self assembled monolayer (SAM) of 11-mercaptoundecanoic acid (MUA) and 3-mercapto propionic acid (MPA) for making an electrochemical immunosensor for the quantitative detection of Myoglobin in aqueous solution. The protein antibody, ab-Mb, was covalently immobilized on a Au electrode through a SAM of 11-mercaptoundecanoic acid (MUA) and 3-mercapto propionic acid (MPA) via carbodiimide coupling reaction using N-(3-dimethylaminopropyl)-N'-ethyl carbodiimide hydrochloride (EDC) and N-Hydroxy Succinamide (NHS). The immunosensor (ab-Mb/MUA-MPA/Au) was characterized by scanning electron microscopy (SEM), and electrochemical techniques. The electrochemical performance of the immunosensor was studied by electrochemical impedance spectroscopy. The modified Au electrode immunosensor exhibits an electrochemical impedance response to antigen, ag-Mb concentrations in a linear range from 10 ng to 650 ng mL-1 with a lowest detection limit of 5.2 ng mL-1. The work is being carried out for other cardiac biomarker also such as troponin.

(C) Titanium Dioxide for electronic applications:

We are also working on Titanium Dioxide based solar cells. The utilization of solar irradiation to supply energy or to initiate chemical reactions is already an established idea. If a wide-band gap semiconductor like titanium dioxide (TiO_2) is irradiated with light, excited electron–hole pairs created that can be applied in solar cells to generate electricity or in chemical processes to create or degrade specific compounds. Following chart list the different photoinduced processes in TiO_2.

Injection of photo-electron from semiconductor nano-particles into the bandgap of TiO_2 is being carried out: Nanoparticles of



bismuth sulphide are synthesized by chemical route and a layer of these particles is settled onto the TiO_2 film on FTO glass by electrochemical techniques. These samples are being studied for injection of photoelectron from the BiS nano-particle into the TiO_2 film.

Biomolecular Electronics And Conducting Polymer Research Group

I. TECHNICAL DEVELOPMENT OF CHOLESTEROL BIOSENSORS

(a) POLYANILINE (PANI) – CARBOXYMETHYL CELLULOSE (CMC) NANOCOMPOSITE FOR CHOLESTEROL DETECTION

Preparation of Polyaniline–Carboxymethylcellulose nanocomposites

180 µl of aniline (1 M) monomer and 5µl of Carboxymethyl Cellulose (CMC) are dissolved in 10 ml of 1 M hydrochloric acid and sonicated for about 10 minutes. Prior to polymerization of aniline and CMC film, indium-tin-oxide (ITO) coated glass plate is cleaned with a solution comprising of water, hydrogen peroxide and ammonium hydroxide (5:2:2) and is then rinsed thoroughly with deionized water. Electrochemically polymerization of aniline and CMC onto ITO electrode has been carried out at 150 µA for about 10 min at a scan rate of 50 mV/s using a three electrode (ITO) as working, platinum foil as counter and Ag/AgCl as a reference electrode cell. These PANI–CMC/ITO nanocomposite films are rinsed with distilled water to remove any oligomers and dried at room temperature for 24 hrs.

Immobilization of Cholesterol Oxidase (ChOx) on PANI–CMC/ITO Electrodes

The PANI–CMC/ITO nanocomposite electrode is modified with glutaraldehyde by spreading 0.1% of glutaraldehyde on PANI–CMC/ITO electrode for about 2 h, after which it is washed with deionized water a number of times. 10µL solution of ChOx (1.0 mg/mL, in PB,

50 mM, pH 7.0) is immobilized onto modified PANI–CMC/ITO electrode. Prior to being used, ChOx/PANI–CMC/ITO bioelectrode is allowed to dry overnight under desiccated conditions and is then washed with phosphate buffer saline (PBS, 50 mM, pH 7.0, 0.9% NaCl) to remove any unbound ChOx and is stored in a refrigerator at 25 ºC when not in use.

Electrochemical response studies of ChOx/ PANI– CMC/ITO bioelectrode

The electrochemical response of ChOx/ PANI–CMC/ITO bioelectrodes has been investigated using cyclic voltammetry as a function of cholesterol concentration (0.5–22 mM) in phosphate buffer (50 mM, pH 7.0, 0.9% NaCl) at scan rate of 30 mV/s. It has been found that magnitude of current response increases on addition of cholesterol concentration (Fig. 3.18). The response time of the ChOx/PANI–CMC/ITO bioelectrode found to be about 10 s is attributed to faster electron communication feature of PANI–CMC nanocomposite. ChOx/PANI–CMC/ITO bioelectrode can be used to estimate cholesterol from 0.5 to 22 mM (inset, Fig.3.18).

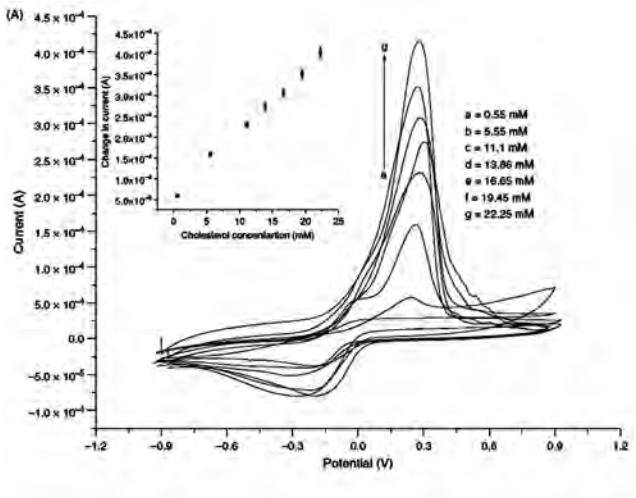


Fig. 3.18: Electrochemical response studies of ChOx/ PANI– CMC/ITO bioelectrode

(b) NANOSTRUCTURED IRON OXIDE PLATFORM FOR IMPEDIMETRIC CHOLESTEROL DETECTION

The super-paramagnetic Iron oxide (Fe_3O_4) nanoparticles have been prepared using co-precipitation method. Nanostructured iron oxide ($NanoFe_3O_4$) film is fabricated by dispersing 10 µL solution of Fe_3O_4 nanoparticles (1mg/ml in ethanol) onto hydrolyzed ITO coated glass plate placed on a simple magnet with magnetic field of 0.2 gauss and was applied perpendicular to the $NanoFe_3O_4$/ITO electrode. The film is allowed to dry at 200^{O}C for about 6 h in a controlled environment and is then washed with deionized water to remove any unbound nanoparticles. 10 µL solution of freshly prepared ChOx (1mg/ dL of 24 U/ml in 10% Triton X-100) is spread onto the $NanoFe_3O_4$/ITO electrode. The ChOx/ $NanoFe_3O_4$/ITO bioelectrode is kept undisturbed for about 12 h at 40C. Figure 3.19 shows the working of ChOx/$NanoFe_3O_4$/ITO bioelectrode.

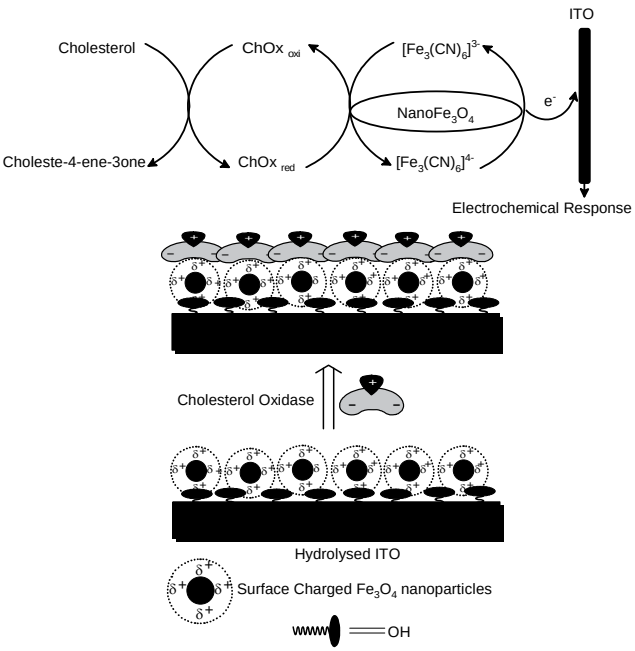


Fig. 3.19: Schematic overview of the working of ChOx/ $NanoFe_3O_4$/ITO bioelectrode.

The electrochemical impedance spectroscopic (EIS) response of the ChOx/NanoFe$_3$O$_4$/ITO bioelectrode has been investigated as a function of cholesterol concentration (100 µL of 2.5 - 400 mg dL-1) using electrochemical impedimetric studies at bias potential of 0.06V with incubation time of 25s. The relative change in surface charge transfer resistance (RCT) is observed at different cholesterol concentrations. This can be attributed to the formation of NanoFe$_3$O$_4$/ChOx bioconjugate that accepts electrons during re-oxidation of ChOx and transfer these to electrode. In a biochemical reaction, ChOx catalyses oxidation and isomerisation of 3βhydroxysteroidsm having trans double bond of the steroid ring yielding ketosteroid and hydrogen peroxide via the utilization of FAD (Flavin adenin dinucleotide). The oxidized FAD is a primary acceptor of hydride from cholesterol and reduced FAD is then transferred the generated electron to NanoFe$_3$O$_4$ results in enhanced charge transfer rate leading to decreased RCT value. Thus ChOx/NanoFe$_3$O$_4$/ITO bioelectrode surface acts as electron transfer-accelerating layer for transfer of electrons revealing that interaction of cholesterol and ChOx significantly changes RCT and other impedance parameters. A linear calibration curve has been fitted between RCT and logarithm of cholesterol concentration revealing linearity from 2.5 to 400 mg dL^{-1} with a correlation coefficient of 0.997. It has been shown that ChOx/NanoFe$_3$O$_4$/ITO biosensor shows characteristics such as low detection limit (2.5 mg/dL), fast response time (25 s), high sensitivity.

II. ELECTROPHORETICALLY DEPOSITED PANI FILMS FOR CHOLESTEROL DETECTION

(a) PREPARATION, CHARACTERIZATION AND APPLICATION OF POLYANILINE NANOSPHERES (PANI-NS) TO BIOSENSOR

Polyaniline nanospheres (PANI-NS) prepared by morphological transformation of micelle polymerized camphorsulphonic acid (CSA) doped polyaniline nanotubes (PANI-NT)

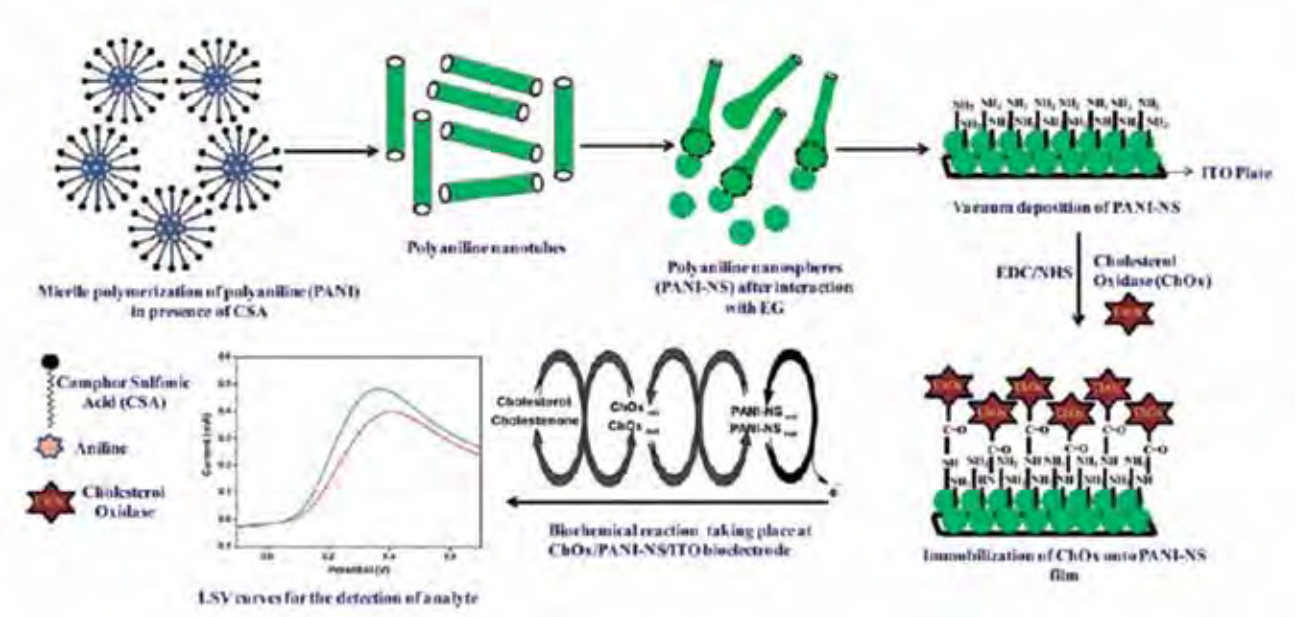


Fig. 3.20: Pictorial representation of morphological transformation of PANI-NT to PANI-NS, immobilization of ChOx and the biochemical reactions involved in cholesterol sensing.

in presence of ethylene glycol (EG) have been characterized by X-ray diffraction, atomic force microscopy, transmission electron microscopy, scanning electron microscopy, Fourier transform infra-red and UV-Visible spectroscopy. PANI-NS (60-80nm) film deposited onto indium-tin-oxide (ITO) coated glass plate by solution casting method has been utilized for covalent immobilization of biomolecule (ChOx) via N-ethyl-N′-(3-dimethylaminopropyl) carbodiimide (EDC) and N-hydroxysuccinimide (NHS) chemistry for fabrication of cholesterol biosensor. The ChOx/PANI-NS/ITO bioelectrode detect cholesterol in the concentration range of 25 to 500 mgdL^{-1} with sensitivity as 1.3 x 10^{-3} mAmg^{-1}dL and regression coefficient as 0.98. Further, this PANI-NS based bioelectrode shows fast response time (10s), low Michaelis-Menten constant (2.5 mM) and shelf-life of 12 weeks. The spherical nanostructure observed in the final morphology of the PANI-NS film is attributed to hydrogen bonding interactions between PANI-NT and EG. Figure 3.20 shows the schematic overview of the formation of nanospheres and its immobilization.

III. IMMUNOSENSORS FOR LIPOPROTEIN DETECTION

a) ANTIBODY IMMOBILIZED SELF-ASSEMBLED MONOLAYE R OF 4-AMINOTHIOPHENOL (ATP)

Human plasma low density lipoprotein (LDL) immunosensor based on surface plasmon resonance (SPR) and quartz crystal microbalance (QCM) was fabricated by immobilizing antiapolipoprotein B (AAB) onto self assembled monolayer (SAM) of 4-aminothiophenol (ATP). The AAB/ATP/Au immunosensor can detect LDL up to 0.252 µM (84 mg/dL) and 0.360 µM (120 mg/dL) with QCM and SPR, respectively. The SPR and QCM measurements were further utilized to study the reaction kinetics of the AAB-LDL interaction. Kinetic, thermodynamic, and sticking probability studies disclosed that desorption of the water molecules from the active sites of AAB and LDL plays a key role in the interaction process and increase in temperature favours binding of LDL with the AAB/ATP/Au immunosensor.

AAB was immobilized onto the ATP/Au surface using EDC-NHS chemistry in which EDC works as a coupling agent and NHS works as an activator. EDC-NHS activates the -COOH group of antiapolipoprotein B which subsequently reacts with the -NH2 group of ATP to produce a stable amide bond. For immobilization of AAB, the ATP/Au plate was incubated in the 1 mg/mL solution of AAB containing 0.2 M EDC and 0.05 M NHS for 4 h followed by washing with PBS containing 0.05% tween-20 to remove any unbound AAB. The prepared AAB/ATP/Au immunosensor was immersed in Bovine serum albumin (BSA) for 1 h to block the nonspecific sites for LDL adsorption.

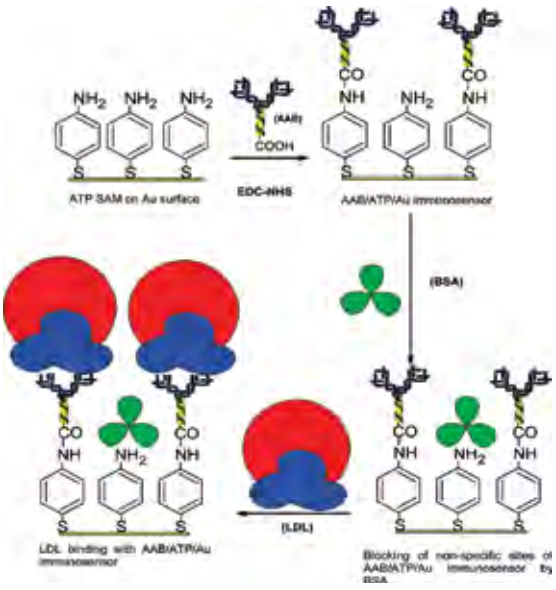


Fig. 3.21: Schematic Showing Stepwise Preparation of AAB/ATP/Au Immunosensor and LDL Binding

Response Studies of AAB/ATP/Au Immunosensor

The SPR immunosensor toward LDL in the range 0.072 µM (24 mg/dL) to 0.360 µM (120 mg/dL) with regression coefficient (R) of 0.999 and standard deviation (SD) as 2.45. The change in the SPR angle was found to increase even beyond 0.360 µM. Thus the prepared AAB/ATP/Au immunosensor can be used to quantify LDL in the physiological range (<129 mg/dL). The sensitivity calculated from the calibration curve for the AAB/ATP/Au immunosensor was found to be 977.96 m° µM-1.

IV. FABRICATION OF DNA SENSORS FOR M.TUBERCULOSIS DETECTION

(a) ZIRCONIA BASED NUCLEIC ACID SENSOR FABRICATION OF ZIRCONIA FILM

Zirconia films were deposited onto bare gold electrode in an aqueous electrolyte of 5.0 mmol L−1 $ZrOCl_2$ and 0.1 mol L−1 KCl by cycling the potential between (1.5 to and0.7 V) versus Ag/AgCl at a scan rate of 20 mV s^{-1} for ten consecutive scans. The electro synthesis helps in accumulation of the colloidal particles at the electrode surface resulting in formation of the ZrO_2 film.

Figure 3.22 exhibits results of Differential Pulse Voltametric studies of DNA-ZrO_2 /Au bioelectrode on hybridization with Genomic DNA of Mycobacterium tuberculosis. With increasing Genomic DNA concentration (1–150 ng/L), methyline blue oxidation current decreases, indicating increased number of DNA duplexes formed at the ZrO_2 surface. The lower detection limit of ss-DNA/ZrO_2 /Au electrode with genomic DNA is found to be 1 ng/L

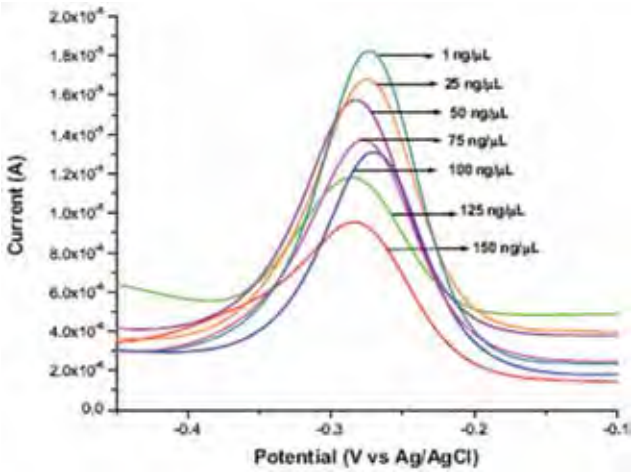


Fig. 3.22: DPV response studies of DPV studies of DNA-ZrO_2 /Au bioelectrode on hybridization with Genomic DNA of Mycobacterium tuberculosis

(b) SELF-ASSEMBLED MONOLAYERS OF (2-AMINOETHYL) 3-AMINOPROPYLTRIMETHOXYSILANE

Preparation of N-(2-aminoethyl) 3aminopropyltrimethoxysilane self- assembled monolayer (AEAPTS-SAM)

Self assembled monolayers of N-(2-aminoethyl)-3-aminopropyltrimethoxysilane (AEAPTS) have been prepared on hydrolyzed ITO substrates. ITO plates are first immersed in a solution of 1:1:5 (v/v) H_2O_2: NH_4OH: H_2O for about 30 min at 80°C for hydrolysis after which they are rinsed thoroughly with de-ionized water and dried. Then hydrolyzed ITO plates are immersed in 1% (v/v) solution of AEAPTS in toluene overnight at room temperature for silanization. After the coupling reaction, the electrodes are rinsed with toluene and water to remove the physically adsorbed silanes from the ITO surface. AEAPTS/ITO electrodes are then dried under a stream of nitrogen.

The AEAPTS/ITO electrode surface is treated with activated avidin (2µl, 1 mg/

ml,) followed by covalent immobilization biotinylated probe sequence containing 21-bases. These functionalized DNA-AEAPTS/ITO electrodes have been characterized using Fourier transform infrared spectroscopy, contact angle measurements, cyclic voltammetry (CV), differential pulse voltammetry (DPV), and electrochemical impedance spectroscopy (EIS), respectively.

The results of DPV studies of DNA-AEAPTS/ITO bioelectrode on hybridization with single stranded M.Tuberculosis genomic DNA (5 min) shows that with increasing M.Tuberculosis genomic DNA concentration (1×10^{-13} M to 1×10^{-7} M), MB oxidation current (Igenomic, A) decreases, indicating increased number of DNA duplexes formed at the AEAPTS surface. No DNA duplex is formed for M.Tuberculosis genomic DNA concentration < 1×10^{-13} M indicating it as the detection limit. It may be noted that we have observed changes in the MB peak height due to hybridization up to 1×10^{-12} M concentration indicating detection limit as 1×10^{-12} M. This nucleic acid electrode has been found to be stable at least for about 6 months.

V. BIOSENSORS FOR FOOD TOXIN DETECTION

(a) CERIUM OXIDE-CHITOSAN BASED NANOBIOCOMPOSITE FOR OCHRATOXIN-A

Fabrication of nanocomposite film

The nanocomposite films are fabricated by uniformly spreading 10 µl solution of CH-$NanoCeO_2$ nanobiocomposite onto an ITO surface and dried at room temperature for about 12 h and then washed with deionized water to remove any unbound particles. OTA (Aspergillus ochraceus) solution is prepared in phosphate buffer (PB, 50 mM, pH 7.0) with 10% methanol. Solution of r-IgGs is prepared in PB. The immobilization of r-IgG has been carried out by spreading 10µ l solution onto the CH-$NanoCeO_2$ nanobiocomposite electrode. BSA (98%) dissolved in PB is used as the blocking agent for nonspecific binding sites. Both the solutions containing 0.015M NaN_3 as a preservative are aliquoated and stored at −20 °C.

The presence of $NanoCeO_2$ in nanobiocomposite results in improved electronic and ionic transport due to uniformly distributed $NanoCeO_2$ within CH matrix rather than clustered matrix (SEM analysis) resulting in three-dimensional electron conductive network extended throughout the ion-conductive matrix of CH. The surface concentration of redox species onto CH-$NanoCeO_2$/ITO electrode is higher than that of CH/ITO suggesting that incorporation of $NanoCeO_2$ increases electroactive surface area for diffusion of electrons resulting in high electrocatalytic properties of nanobiocomposite that may be responsible for improved sensing characteristics due to high loading of rabbit immunoglobulin antibodies (r-IgGs). DPV

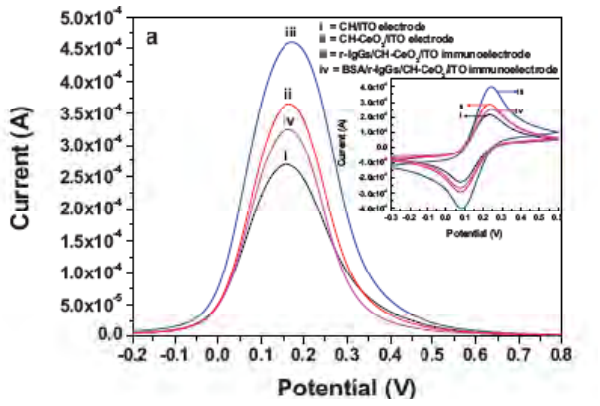


Fig.3.23: DPV studies of CH/ITO electrode (curve i), CH-$NanoCeO_2$/ITO electrode (curve ii), r-IgGs/CH-$NanoCeO_2$/ITO immunoelectrode (curve iii), and BSA/ r-IgGs/CH-Nano-CeO_2/ITO immunoelectrode (curve iv) Inset: CV studies of the stepwise formation of BSA/ r-IgGs/CH-$NanoCeO_2$ /ITO immunoelectrode.

studies of CH/ITO electrode, CH-NanoCeO_2 /ITO electrode, r-IgGs/CH-NanoCeO/ITO immunoelectrode, and BSA/ r-IgGs/CH-Nano-CeO_2 /ITO immunoelectrode are shown in Figure 3.23.

(b) NANOSTRUCTURED ZINC OXIDE PLATFORM FOR OCHRATOXIN-A DETECTION

1 g of zinc acetate dihydrate [Zn $(CH_3COO)_2$ $2H_2O$] is dissolved in 10 ml ethanol. Then 3 ml (1 M) solution of ammonium hydroxide (NH_4OH) is added drop wise to this solution with constant stirring at room temperature to maintain pH=9–10. A white milky precipitate of $Zn(OH)_2$ thus obtained is centrifuged and is followed by washing with deionized water until neutral pH is achieved. Subsequently, this precipitate is dispersed in distilled water and dilute HNO_3 (1 M) in ambient conditions for peptization. A transparent viscous solution is obtained for film fabrication on ITO coated glass plate via dip-coating technique. To achieve uniform coating onto a desired ITO electrode, 2 wt. % TritonX-100 is added to the resulting solution. These films are then allowed to dry at 400 °C for about 1 h.

Fabrication of immunoelectrode

A solution of rabbit immunoglobulin antibodies (r-IgGs) is prepared in phosphate buffer (PB, 50 mM, pH =7.0). Bovine serum albumin (BSA, 98%) dissolved in PB solution has been used as the blocking agent for non-specific binding sites. Both the solutions containing 0.15 M NaN_3 as a preservative are aliquoated and are stored at −20 °C. Immobilization of r-IgGs has been carried out by spreading 10 µL solution onto the sol–gel derived Nano-ZnO/ITO electrode. Both r-IgGs and BSA are immobilized onto the Nano-ZnO/ITO electrode under similar conditions to delineate the role of Nano-ZnO film and synergy between the various components. Figure 3.24 shows stepwise fabrication of the BSA/r-IgGs/Nano-ZnO/ITO immunosensor along with the biochemical reaction of r-IgGs with OTA on the Nano-ZnO surface. Ochratoxin-A (A. ochraceus; OTA) solution is prepared in phosphate buffer (50 mM, pH=7.0) with 10% methanol.

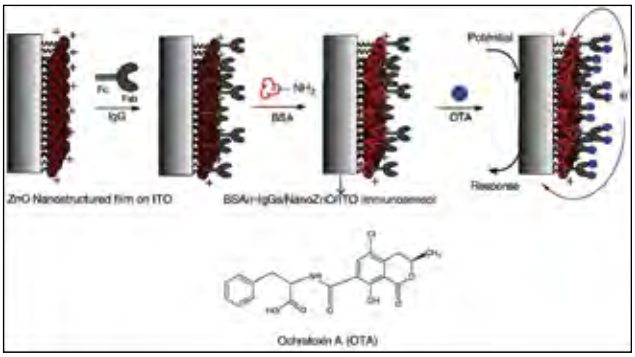


Fig. 3.24: Schematic of fabrication of BSA/r-IgGs/Nano-ZnO/ITO immunosensor along with the biochemical reaction between OTA and immunosensor.

Impedimetric response studies

Dependence of the electron transfer resistance, RCT, on the OTA concentration for the BSA/r-IgCs/Nano-ZnO/ITO immunosensor in 10 mL phosphate buffer (50 mM, pH =7.0 an 0.9% NaCl) containing $[Fe(CN)_6]_3^{-/4-}$ and subsequent addition of OTA concentration (1–6 ng/dL) is stirred for 30 s using impedimetric technique in triplet set. The interaction of OTA with IgGs on the electrode surface results in significant changes in impedimetric parameters (RCT, Cdl, Rs and Zw). Figure 3.25 shows the linear curve between the RCT values obtained during EIS response of the BSA/r-IgGs/Nano-ZnO/ITO immunoelectrode as a function of OTA (mycotoxin) concentration. The value of RCT increases on addition of OTA concentration. This may be attributed to the increased number of OTA molecules bound to the immobilized antibodies that perhaps provide

a kinetic barrier for the electron transfer. BSA/r-IgGs/Nano-ZnO/ITO immunoelectrode exhibits improved sensing characteristics such as linearity as 0.006–0.01 nM/ dm3, detection limit as 0.006 nM/dm, short response time of 25 s, and long term stability (45days), sensitivity of 189Ω/nM/dm^{3}cm, reproducibility and the regression coefficient of 0.997. It may be noted that conformational changes are known to affect a biological reaction that in turn may be influenced by the nature of immobilization matrix and its surface morphology. The increased activity of r-IgGs due to favourable conformational changes results in enhanced interaction between the Nano-ZnO/ITO electrode and the active site of r-IgGs as indicated by the observed high value of stability constant (Ka, 7.6×1011L/m) revealing high affinity of r-IgGs towards OTA due to prevalent electrostatic interactions. This may be attributed to favourable conformation of r-IgGs and increased loading of r-IgGs provided by the microenvironment of sol–gel derived Nano-ZnO film.

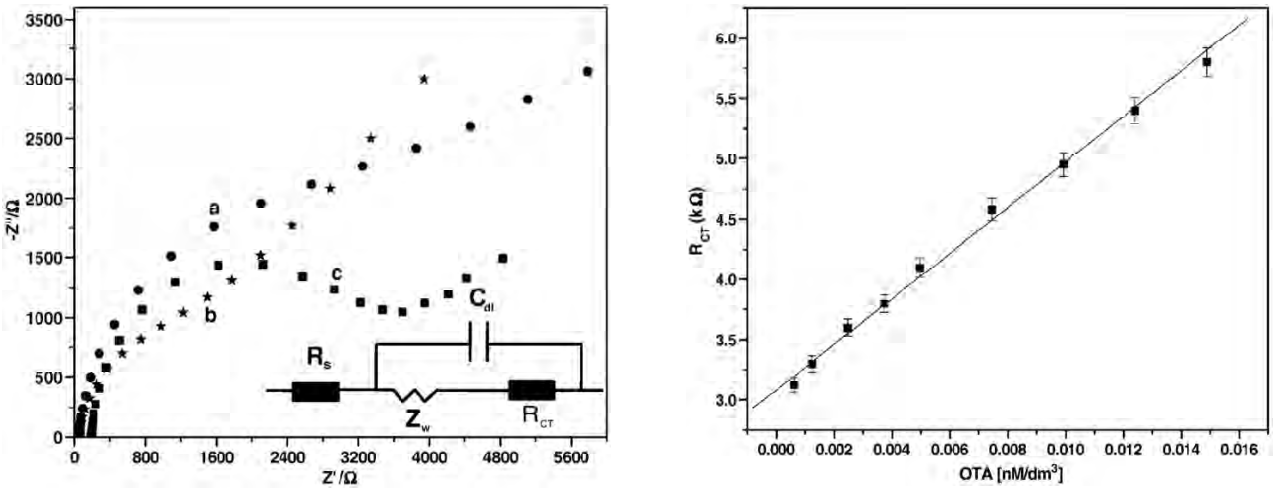


Fig. 3.25: (a) Electrochemical Impedance spectra of sol–gel derived Nano-ZnO electrode (a), r-IgGs/Nano-ZnO/ITO electrode (b) and BSA/r-IgGs/Nano-ZnO/ITO electrode (c) in PBS solution (50 mM, pH =7.0, 0.9% NaCl) containing 5 mM [Fe(CN|6]3−/4−, inset: diagram of electronic circuit. (b) Linear response curve of BSA/r-IgGs/Nano-ZnO/ITO immunosensor obtained between OTA concentration and RCT value

VI. BIOSENSOR FOR UREA DETECTION

(a) NANOSTRUCTURED ZINC OXIDE FILM FOR UREA SENSOR

Nanostructured zinc oxide (Nano-ZnO) film has been electrochemically deposited onto indium-tin-oxide (ITO) coated glass plate to co-immobilized urease (Urs) and glutamate dehydrogenase (GLDH) for urea detection. The observed reflection planes corresponding to wurtzite ZnO nanoparticles (~25 nm) in X-Ray diffraction pattern and UVvisible absorption band at 338 nm reveal the formation of Nano-ZnO. Urs-GLDH/Nano-ZnO/ITO bioelectrode shows high sensitivity for urea detection within 10–80 mg/dL and limit of detection as 13.5 mg/dL with regression coefficient as 0.994 and Michaelis–Menten constant (Km, 6.1 mg/dL) indicating good affinity of Urs-GLDH to urea.

The results of CV studies (Figure 3.26) conducted on the Urs-GLDH/Nano-ZnO/ITO bioelectrode as a function of scan rate (10–100 mV/s) reveal that the magnitude of current response and potential are linearly dependent on the scan rate. This suggests the controlled diffusion

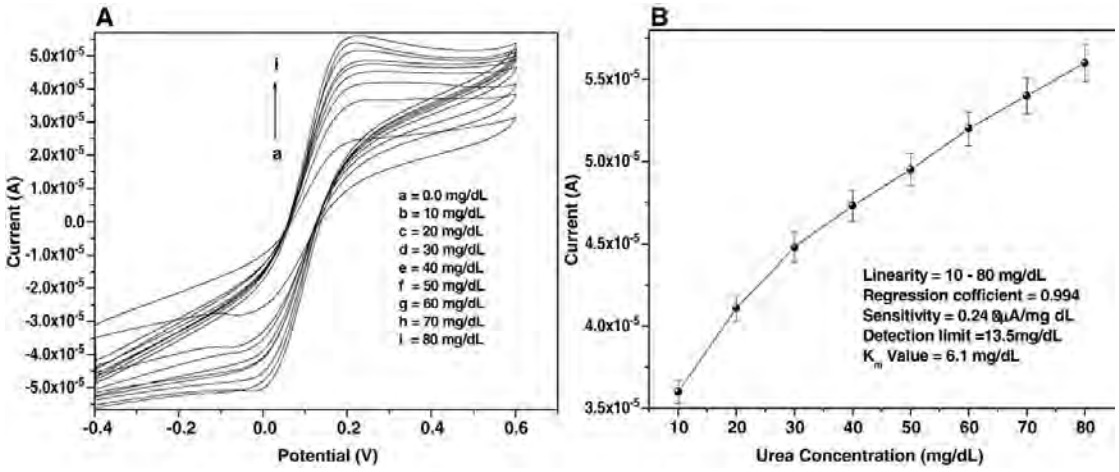


Fig. 3.26: Electrochemical response of Urs-GLDH/Nano-ZnO/ITO bioelectrode as a function of urea concentration, B) Calibration curve between urea concentrations (10–80 mg/dL) and magnitude of current response for Urs-GLDH/Nano-ZnO/ITO bioelectrode

process with facile charge transfer kinetics. The maximum magnitude of current for Urs-GLDH/Nano-ZnO/ITO bioelectrode is obtained at pH 7. This suggests that Urs-GLDH/Nano-ZnO/ITO bioelectrode shows maximum activity at pH 7 at which Urs retains its natural structure and is responsible for low detection limit and high sensitivity for urea detection.

VII. DNA BIOSENSOR FOR NEISSERIA GONORRHOEAE DETECTION

(a) POLYANILINE/CARBON NANOTUBES (PANI/CNT) PLATFORM FOR SEXUALLY TRANSMITTED DISEASE DETECTION

Fabrication of amino labeled DNA functionalized PANI/CNT composite films

PANI/CNT composite films have been prepared on an ITO coated glass plate (0.25 cm^2) by electro polymerization of aniline (0.2 M, 3 g, 12.91 nmol) and acid treated MWCNT (1 mg) in water. The polymerization has been performed chronopotentiometrically at 150mA for 600 s (via intermittent washing using autoclaved Millipore water after every 300 s of polymerization). The resulting composite films have been washed with the background electrolyte solution to exclude any residual monomer from the electrode. After electro deposition, amino labeled DNA (aDNA) is immobilized onto PANI/CNT electrode using glutaraldehyde as cross-linker under optimized conditions. For this purpose, firstly the electrode is dipped in 0.5% glutaraldehyde for 4 h followed by treatment with 2 ml of aDNA in a humid chamber.

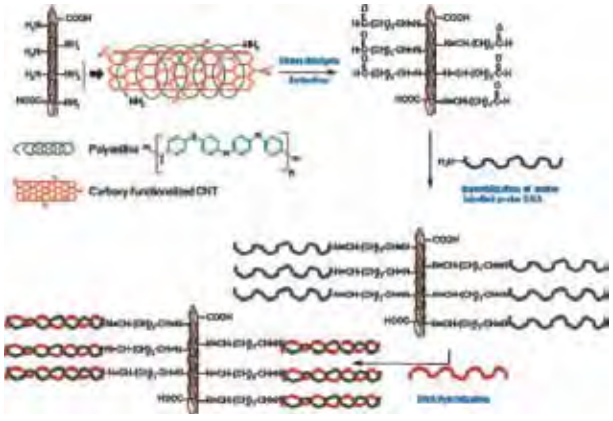


Fig. 3.27: Fabrication of PANI/CNT composite based DNA sensor: aDNA immobilization onto PANI/CNT/ITO using glutaraldehyde as a cross-linker for DNA hybridization detection

Detection of Neisseria gonorrhoeae in patient samples and sensor validation using control bacterial strains.

The Figure 3.28 shows response of the aDNA-Glu-PANI-CNT/ITO electrode to detect presence of the complementary target DNA sequence in different samples viz Neisseria gonorrhoeae spiked pus sample, patient sample, culture isolate, and non-complementary target DNA sequence in other non-Neisseria gonorrhoeae Neisseria species (NgNs) as well as other gram negative bacteria (GNB). Panels of well-characterized bacterial strains have been tested to validate the species specificity of the STD chip using detector- probe of Neisseria gonorrhoeae. As expected, detector probe is positive for the Neisseria gonorrhoeae and negative for E. coli, P.aeruginosa, S. aureus, N. sicca, and K. pneumonia.

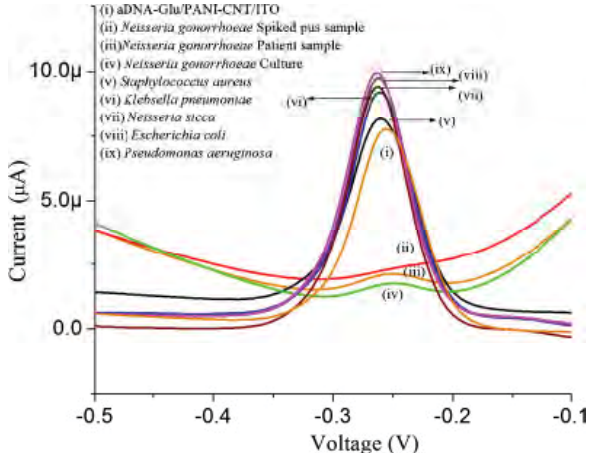


Fig. 3.28: Fabrication of PANI/CNT composite based DNA sensor: aDNA immobilization onto PANI/CNT/ITO using glutaraldehyde as a cross-linker for DNA hybridization detection

VIII. DNA SENSOR FOR E.COLI DETECTION

(a) FABRICATION OF DNA BIOSENSOR BASED ON MODIFIED OCTADECANETHIOL (ODT) SELF-ASSEMBLED MONOLAYER (SAM)

The electrochemical DNA biosensor based on 1-fluoro-2-nitro-4azidobenzene (FNAB) modified octadecanethiol (ODT) self-assembled monolayer (SAM) has been fabricated for Escherichia coli detection. The results of electrochemical response studies investigated using methylene blue (MB) as redox indicator reveal that this nucleic acid sensor can detect target DNA concentration in the range of 1×10^{-6} M to 0.5×10^{-18} M within 60s of hybridization time. The studies on interference of other water borne pathogens such as Klebsiella pneumonia, Salmonella typhimurium and other gram negative bacterial samples indicate that the sensor is highly specific to E. coli and stable for about four months with the reusability of at least ten times. Figure 3.29 shows the response studies of DNA/FNAB/ODT/Au as a function of target DNA concentration.

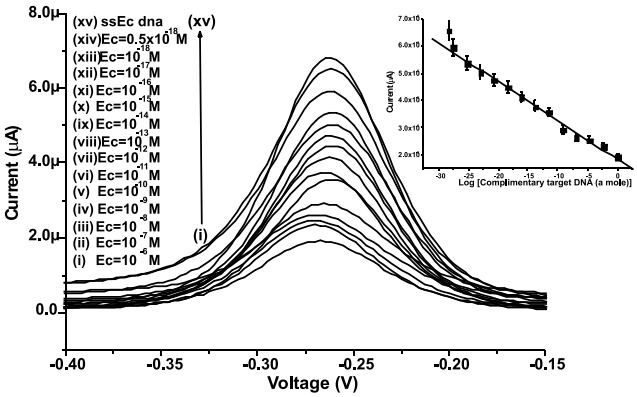


Fig. 3.29: Sensing characteristics of DNA/FNAB/ODT/Au as a function of target DNA concentration.

Organic Photovoltaic devices

Organic solar cells are very important towards the generation of energy at very low cost. This technology is quite environmental friendly and the devices can even be prepared on flexible substrates like plastic, paper and cloth. The importance of organic solar cells has now been well recognized by the scientific community and efforts are being made to develop these devices all over the world. National Physical Laboratory, New Delhi has undertaken to develop these devices to make them commercially viable. In

the year of 2009-2010 intensive work has been carried out at NPL on the basic and applied aspects of materials and devices to improve the performance of organic solar cells. Emphasis has been on the understanding of device physics and device demonstration. We have presented a model to explain the behaviour of organic solar cells in different environmental conditions. We observed that contrary to the Si solar cells the forward bias current in OPV devices under illumination intersects the dark current and becomes more than the dark current. The most interesting observation is that all the illuminated characteristics intersect the dark current at a single point. We have presented a model where it has been shown that this intersection point corresponds to the built in voltage Vbi in the sample. It is observed experimentally that Vbi shifts to higher values as the temperature is reduced. The theoretical interpretation has been presented to support the variation of Vbi with temperature. We have also investigated the effect of active layer thickness on the Voc in organic solar cells. Voc has been found to vary nonlinearly with the active layer thickness even with the same donor/acceptor materials. We present a model which gives a nonlinear variation of Vbi with the active layer thickness. The nonlinear variation of Voc with active layer thickness has been attributed to the variation of Vbi in the samples. The investigations reported here suggest that Vbi controls the Voc in organic solar cells.

Current-voltage (J-V) characteristics of an organic bulk heterojunction solar cell have been modeled and compared with the measured characteristics of solar cell based on the blend of poly(3-hexylethiophene) (P3HT) and phenyl [6,6] C61 butyric acid methyl ester (PCBM). We have employed various device design and treatments to organic solar cells to improve the efficiency. Organic solar cells have been fabricated using both the small molecular and polymeric systems. The devices have been fabricated in bilayer as well as bulk-heterojunction configurations. Almost 2.0 % efficiency has been demonstrated. Efforts are being made to improve further the performance of these devices. We have fabricated a 2" X 2" organic solar panel and demonstrated the direct operation of an electronic device using the same panel. Fig. 3.30 shows the direct operation of the electronic device using organic solar panel.

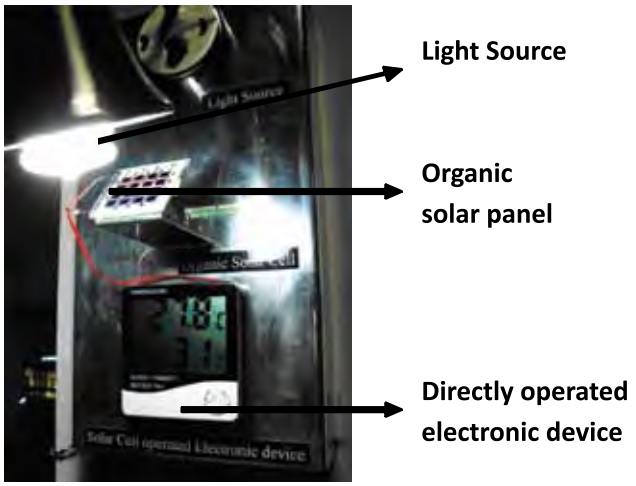


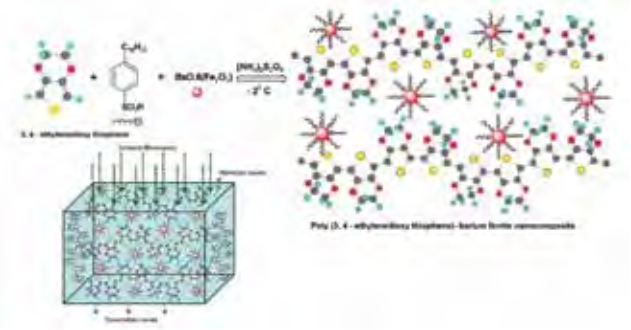
Fig. 3.30: Direct demonstration of the operation of an electronic device using organic solar panel fabricated at NPL, New Delhi.

Conducting Polymers

Insitu polymerization of PEDOT in the presence of nano ferrite and TiO_2 particles

Nanocomposites of poly (ethylene dioxy thiophene) (PEDOT) with barium ferrite particles and titanium dioxide (TiO_2) are synthesized via insitu emulsion polymerization. TEM and HRTEM results shows the formation of array of nanoparticles encapsulated with in the polymer chains during the synthesis process. The high value of microwave absorption results from the combined effect of the nano particles and

the polymer matrix. The amount of barium ferrite has the profound effect on permittivity (ε), permeability (μ) and microwave absorption of the nanocomposite. The contribution to the absorption value comes mainly due the magnetic losses (μ″) in barium ferrite and dielectric losses (ε″) in TiO_2 and polyaniline.



Scheme 1: Mechanism of TiO_2 and Barium ferrite particles entrapped in polymer matrix

Microwave absorption properties of conducting polyaniline composite with TiO_2 and barium ferrite nanoparticles in 12.4-18 GHz

Fig 3.31a clearly shows that when the nano particles of TiO_2 & barium ferrite are polymerized along with aniline they form a core shell type of morphology. The nano particle serves as a nucleation center while the polymer forms the shell in the composite. From the fig it is also observed that an array of nano particles is formed during the insitu polymerization process and directly indicates that the particles are separated by the polymer matrix. HRTEM images of PBT21 (Fig 3.31c) and PBT12 (Fig. 3.31d) confirms the core-shell morphology in the nano composite. The shell of the particle gives an impression of an amorphous layer as no fringes were observed at the shell while the d-spacing of the particle confirms the presence of TiO_2 nano particle. The presence of other elements is confirmed by the spot EDAX pattern (Fig 3.31b).

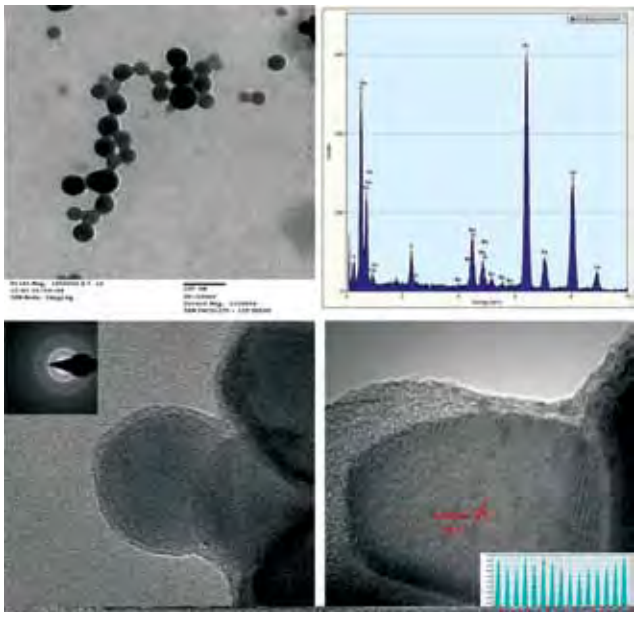


Fig. 3.31: TEM & HRTEM images of the PBT nano composite

Fig. 3.32 shows the variation of the SE with frequency in the 12.4-18 GHz range. It is observed that the shielding effectiveness increases with the increase in ferrite concentration and with the increase of frequency. The maximum shielding effectiveness of 58 dB has been achieved for the sample PBT12 having the polymer to TiO_2/ferrite ratio of 1:1:2.

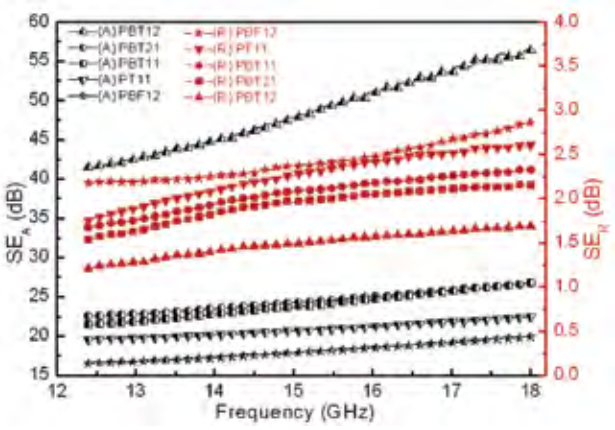
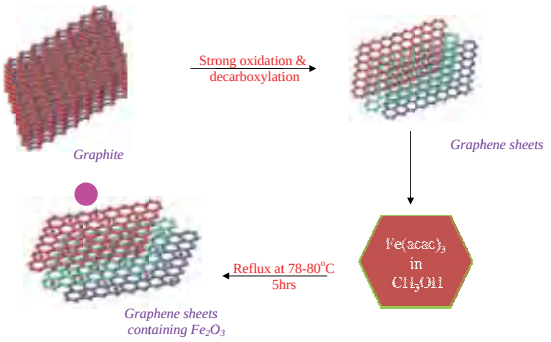


Fig. 3.32: Shielding Effectiveness of Conducting polymer-TiO_2 and barium ferrite composites in the frequency range 12.4-18 GHz

Synthesis of Graphene with ferrite particles:

In order to see how incorporation of ferrite particles in graphene matrix affects the electrical conductivity and shielding effectiveness of composites, graphene embedded with nano ferrite particles were synthesized and its HRTEM was recorded (Fig. 3.33). HRTEM data shows entrapment of ferrite particles in graphene matrix.



TEM & HRTEM of Graphene embedded with Ferrite particles

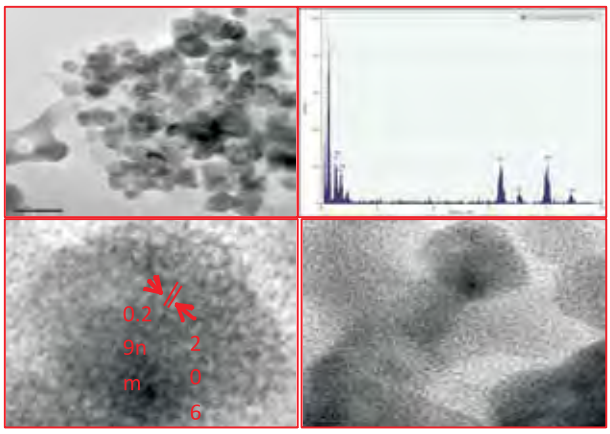


Fig. 3.33: The dispersion of γ- Fe_2O_3 particles in the graphene matrix.

The lattice fringes of γ- Fe_2O_3 with lattice spacing 0.29nm corresponding to (206) plane were matched with the XRD pattern of the ferrite particles.

A facile synthetic method was developed to produce 4-[(3,4-ethylenedioxy)thien-2-yl] aniline monomers by making use of palladium complex through Stille reaction protocol in reasonable yields. The presence of electron rich 3,4-ethylenedioxythiophene (EDOT) and aniline moiety results in a new -conjugated polymeric materials with a donor-donor (D-D) type system. The electrochemical polymerization of 4-[(3,4-ethylenedioxy)thien-2-yl]aniline was carried out at 0.85 V on ITO electrode vs. Ag/AgCl reference electrode. The polymer growth was studied by cycling the potential between -0.20 V to 0.85 V on ITO electrode at a scan rate of 20 mV/sec. Prior to polymerization, the solution was deoxygenated by passing argon gas through the reaction solution for 30 minutes. The oxidation peak appears at 0.4V against a standard Ag/AgCl electrode at a scan rate of 20mV/s. The peak current decreases in successive cycles but when the electrochemical deposition was carried out in 50% methanol solution in acidic medium, the oxidation start at 0.37V. In the consecutive cycles, the current increases with repeated scan, indicating the deposition of polymer film. The electrochemical growth behaviour of the film is shown in the Fig. 3.34.

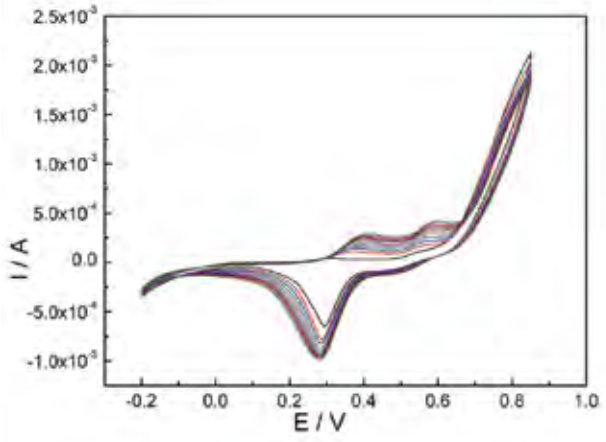


Fig. 3.34: Electrochemical growth behaviour of 4-[(3, 4-ethylenedioxy)thien-2-yl)]aniline in acidic medium on cycling the potential between -0.2 V to 0.85 V, taking eight successive scans, on ITO electrode vs. Ag/AgCl at a scan rate of 20 mV/sec.

Nanowires of copolymers film based on aniline and 1-amino-2-naphthol-4-sulphonic acid were electrochemically synthesized on the iron electrode by cyclic voltammetry using oxalic acid as a supporting electrolyte. Protective properties of copolymer film on the iron surface in 1.0 M HCl solution was investigated by chronoamperometry, potentiodynamic polarization technique and electrochemical impedance spectroscopy (EIS). The results showed that the copolymer film showed the significant shifting in the corrosion potential and greater charge transfer resistance. Moreover, the copolymer showed the larger degree of surface coverage onto the iron surface, reflecting the higher protection for corrosion of the iron in acidic medium. In addition, the film constitute a physical as well as a chemical barrier layer due to the presence of –OH and –NH groups in ANSA unit, which provides passivity protection in polymer coatings. The mechanism of corrosion protection of iron by these copolymers was investigated by surface morphology (Fig. 3.35) and Tafel polarization techniques (Fig. 3.36). In addition, by using scanning electron microscopy,

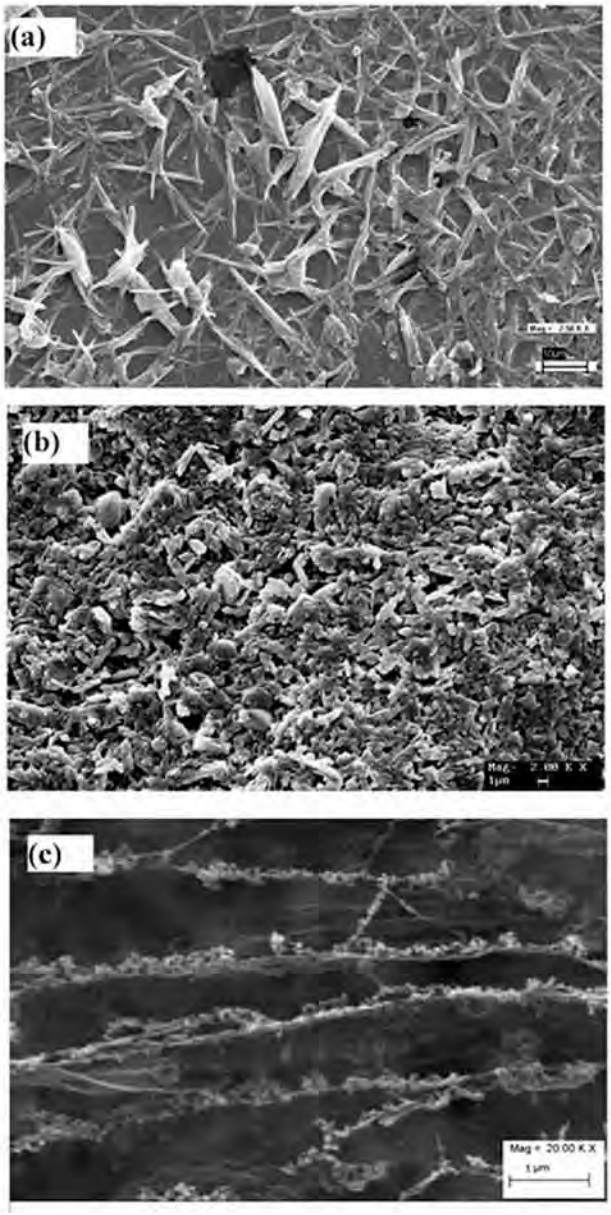


Fig. 3.35: SEM images of; (a) iron sample polarized with 0.3 M oxalic acid solution, (b) PANI coated iron sample and (c) poly(AN-co-ANSA) coated iron sample.

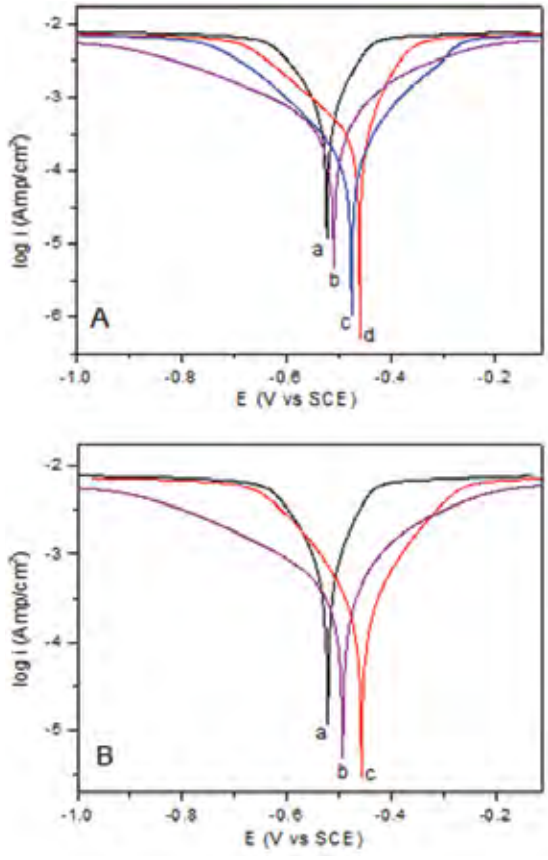


Fig. 3.36: Potentiodynamic polarization behaviour of iron in 1.0 M HCl (Immersion time 0 hr) (a) bare iron and poly (AN-co-ANSA) coated iron sample with different deposition time (b) 10 cycles, (c) 20 cycles and (d) 30 cycles

the effect of morphology of copolymer on corrosion protection of metal was investigated.

Indelible Ink Formulation For Spontaneous Marking

We have developed ready to use novel formulation of Indelible ink for marking the finger of a voter in the elections to prohibit fraudulent votings. The formulation mark the finger spontaneously to leave a semi-permanent highly visible black stain which is impregnating into skin and cannot be wiped out by chemical and mechanical manipulations.

Fraudulent voting during the elections have always been a matter of great concern during elections because, the indelible ink marked on the voter finger which helps the voting monitoring committee to identify that the person has casted his vote and can be erased by unfair means.

Majority of Governments and Civic agencies around the world strive hard to avoid the illegal votes by marking the fingers with an indelible ink prior or after the voting which should impart a non-erasable, black, high contrast stain. The stain should appear on the finger within a minute, should persist for few days and should not be removable by bleaching powder solution, light detergent, trichloroethylene, petroleum hydrocarbon, mild acid, organic solvents etc. i.e. by chemical and mechanical manipulations.

The present invention is a single step and definite process to mark the finger spontaneously. The coloration of the indelible ink appears on the finger in three steps. The first impression on the skin comes from the dye in the solution which also ensures that the vote has been casted. The second intermediate impression of the blue-violet color appears on the finger in 5-10 minutes. The third impression comes from the Ag^{1+} present in the ink which reduces the silver giving the dark brown black stain on the finger in 10-20 minutes in ambient light and in about one minute in sunlight. The indelible ink composition is optimized such that it diffuses/penetrates into the skin spontaneously to give a definite marking which is resistible to chemical manipulations.

The indelible inks presently being used worldwide to prohibit fraudulent voting's in election are i) premixed solution of silver nitrate, violet dye, potassium bromide and alcohol in water, ii) solution of ninhydrin in water and iii) solution of ninhydrin and silver nitrate in water and iv) the two formulations process of marking the finger instantaneously first with an activator and then with the stainer.

The indelible inks prepared by the methods i) take a longer time to impart a semi-permanent black stain ii) the stain comes out by bleaching powder solution, mild acids, organic solvents, common detergents, vim powder etc. iii) the contrast is very poor on a person with dark complexion iv) the shelf life is limited and v) shipping transportation is dangerous because of use of organic solvent such as alcohol. In the novel formulation (iv) of marking the finger instantaneously, the two solutions are used to mark the finger.

The presently developed indelible ink single formulation has the immense resistance to chemical and mechanical manipulations and overcome the drawbacks of conventional indelible inks being used and offer the following advantages.

1. **Mark spontaneously** The indelible ink mark fully dries in less than five seconds and satisfy the election official that the voter has been exposed to the staining compound which

will bind strongly to the skin residue proteins, spontaneously.

2. **Penetrating** The developed ink penetrates/ impregnate into skin spontaneously which cannot be removed by organic solvents, detergents, mild acid (1% HCl), bleaching powder suspension i.e. by chemical manipulations.

Moreover the penetration of the ink on the palm side of the finger is more as compared to on the backside because of the more porosity and thickness of the skin on palm side. The contrast of the stain is also more because the complexion of the palm side of every human being is fairer as compared to back of the hand.

3. **Re-appearing** However, if in any case the stain has been removed by rigorous use of chemical and by mechanical means or by other unfair means in few minutes after the application of stainer, the stain appears again in 10-20 minutes by itself in room light or in one minute with the exposure of sun light. This is because the stainer compound has impregnated/ penetrated/ diffused into the skin.

Efficient And Economical The formulated Indelible ink with a suitable viscosity can be applied on a voter's finger by use of an applicator dispenser/ marker to dispense about 100 nL of the compound (<200 µ gm) to delineate an exact mark in a precise and controlled way on a voter's finger. The amount dispense is sufficient to ingress an impression and definite marking which will save about 40 – 50 % of the existing cost compared to that of an ink used by EC. The application and drying time of the ink is about five seconds in each case.

Thus an improved Indelible ink has been developed which is a novel formulation for a definite spontaneous marking which is economical, easy to handle, controlled marking, inhibits erasure by chemical and mechanical manipulations, easily portable just about anywhere in the world and has a great societal impact. This newly developed ink a complete utility product in itself which will save a huge amount of silver costing about 4-5 crores of rupees per year for elections in the country.

इलेक्ट्रानिक पदार्थ

ELECTRONIC MATERIALS

इलैक्ट्रॉनिक पदार्थ

इलैक्ट्रॉनिक पदार्थ विभाग में पदार्थ भौतिकी और रसायन के विभिन्न क्षेत्रों यथा विद्युत संदीप्ति शील और प्रकाश वोल्टीय पदार्थ, नैनो संरचित पदार्थ, नैनो कंपोजिट पदार्थ, उच्च ताप अतिचालक पदार्थ, उन्नत सिरेमिक पदार्थ और पालिमेरिक पदार्थ पर कार्य किया जाता है। इन पदार्थों में पतली और मोटी फिल्म के साथ–साथ बल्क फार्म का इस्तेमाल करते हुए डिवाइसेज को विकसित करने का भी प्रयास किया गया जिसका उद्देश्य इण्डस्ट्री को विकसित प्रौद्योगिकी को सफलतापूर्वक हस्तांतरित करना है। इसके अतिरिक्त इस विभाग की मुख्य गतिविधियां सतह और नैनो संरचना का अभिलक्षणन और अध्ययन है। इस विभाग में निम्नलिखित ग्रुप है :–

संदीप्तिशील पदार्थ और डिवाइस ग्रुप :–

सोलर सैल और प्रदर्शित अनुप्रयोगों के लिए बढ़ी हुई उच्च रूपांतरण संदीप्त क्षमता सहित नैनो फास्फर्स का विकास। नेक्सट जनेरेशन प्लाज्मा डिस्प्ले पैनल टैक्नोलॉजी (औद्योगिक पार्टनर SAMTEL के साथ एन पी एल का सहयोग) को विकसित करने के लिए प्लाज़्मा डिस्प्ले पैनल (PDP) के लिए फास्फर्स का संश्लेषण। 'संदीप्तिशील सिक्यूरिटी इंक' अनुप्रयोगों के लिए विकसित सूक्ष्म आकार वर्गीकरण और उच्च संदीप्त क्षमता सहित अति परिष्कृत नैनो फास्फर। नैनो क्रिस्टलाइन ZnO पर आधारित क्वांटम डाट्स (QD's) को विकसित किया गया।

प्लाज्मा संसाधित पदार्थ, डिवाइसेज और सिस्टम ग्रुप :–

100 cm^2 सब्सट्रेट एरिया पर अक्रिस्टलीय और माइक्रो/नैनो क्रिस्टलाइन सिलिकान फिल्मों के निक्षेपण के लिए माइक्रोवेव/VHF PECVD सिस्टम का विकास। इंपीडेंस प्रोब का इस्तेमाल करके ऐसीटिलीन प्लाज्मा डिस्चार्ज का अन्वेषण। धातु समावेशित डायमण्ड जैसे कार्बन (DLC) फिल्म और उनके बहुपरत वाली संरचना का निक्षेपण और अन्वेषण। थिन फिल्म नैनो–हार्डनेस और प्रत्यस्थ मापांक मापन के लिए नैनो – इंडेटर। फिल्टरित कैथोडिक वैक्यूम आर्क तकनीक द्वारा निक्षेपित अंतःस्थापित सूक्ष्म कणों युक्त डोप्ड व अनडोप्ड चतुष्फलकीय अक्रिस्टलीय कार्बन का अध्ययन।

सिलिकॉन एवं सिलिकॉन डिवाइसेज़ ग्रुप :–

इंपीडेंस स्पैक्ट्रोस्कोपी द्वारा सिलिकॉन वेफर में उत्पादन और पुनः संयोजित जीवन काल का निर्धारण। सोलर सैल अनुप्रयोगों के लिए सिलिकॉन नैनो वायर्स के विस्तृत क्षेत्र वृद्धि के लिए नोवल रूम तापमान प्रक्रिया का विकास। सोलर सैल निष्पादन और उनके अभिलक्षणन का मापन, माइनारिटी कैरियर लाइफटाइम मापन पद्धति का स्थापन, सतह फोटो वोल्टेज तकनीक, प्रकाश किरण प्रेरित धारा मानचित्रण तकनीक, स्पैक्ट्रल प्रतिसंवेदी मापन सुविधा और शीघ्रगामी थर्मल प्रोसेसिंग पद्धति।

नैनो संरचित पदार्थ एवं डिवाइसेज व सतह अध्ययन :–

हाईब्रिड पॉलीमर : $CdSe/TiO_2$ क्वांटम डॉट कम्पेजिट का चार्ज ट्रांसफर अध्ययन। नैनो संरचित धातु आक्साइड गैस सेंसर विन्यास का विकास। धातु आक्साइड/MWCNT कंपोजिट के लिए संश्लेषित और गैस सेंसिंग अध्ययन। विभिन्न पालीमर फिल्मस् में चार्ज ट्रांसपोर्ट के मैकेनिज्म (यंत्र विन्यास) और डी सी वैद्युत चालकता का स्त्रोत और डाइइलैक्ट्रिकल रिलैक्सेशन का अध्ययन।

उच्च ताप अतिचालकता पदार्थ एवं डिवाइसेज़ उन्नत सिरेमिक (मृत्तिका शिल्प) और प्रकाशिक थिन फिल्मस् :–

उच्च धारा वाहक के लिए (Bi-2223) लंबी बहुतन्तुक टेप (मल्टी फिलामेंट्री) के निष्पादन का आप्टिमाइजेशन (दृष्टतमीकरण)। Bi-2223 अतिचालकता प्रणाली में प्रभावी पिनिंग केन्द्र की खोज में युग्मन और पिनिंग की प्रवृत्ति को समझने के लिए अध्ययन किया गया। सोल–जैल तकनीक द्वारा कैल्शियम–कॉपर–टाइटेनेट का संश्लेषण और पार्टिकल साइज व परावैद्युत गुण धर्मों पर काल प्रभाव का विस्तृत अध्ययन। PECVD द्वारा शुद्ध ऐनाटेस टाइटेनिया नैनो क्रिस्टल और टाइटेनिया नैनो रॉड का संश्लेषण। थिन–फिल्म की मोटाई और प्रतिबल मापन के लिए सुई आधारित सतह प्रोफाइलर का संस्थापन, थिन–फिल्म की व्यापक प्रकाशिक अभिलक्षणन और माडलिंग के लिए परिवर्तनशील कोण स्पैक्ट्रोस्कोपिक एलिप्सोमीटर, विभिन्न फिल्मों की थिन–फिल्मों के कण रंजन (Sputter) निक्षेपण के लिए बहुलक्ष्य कण रंजन निक्षेपण प्रणाली।

ELECTRONIC MATERIALS

The Division of Electronic Materials has been working on several areas of materials physics and chemistry: electroluminescent and photovoltaic materials, nanostructured materials, nanocomposite materials, high temperature superconducting materials, advanced ceramic materials and polymeric materials. Efforts have also been made to develop devices involving these materials, in thin and thick film form as well as in bulk form, with the objective of transferring successfully developed technologies to industry. Besides, the study and characterization of surfaces and nanostructures is a major activity in this division. The division includes the following groups:

Luminescent Materials and Devices Group

Development of nanophosphors with enhanced upconversion luminescence efficiency for solar cells and display applications. Synthesis of phosphors for Plasma Display Panels (PDP) for the development of Next Generation Plasma Display Panel Technology [NPL collaboration with industrial partner SAMTEL]. Ultra-fine nanophosphor with a narrow size distribution and high luminescence efficiency developed for "Luminescent Security Ink" applications. Quantum Dots (QD's) based on nanocrystalline ZnO developed.

Plasma Processed Materials, Devices and Systems Group

Development of microwave/VHF PECVD system for deposition of amorphous and micro/nano crystalline silicon films over 100 cm^2 substrate area. Investigation of acetylene plasma discharge using impedance probe. Deposition and investigations on metal-incorporated diamond like carbon (DLC) films and their multilayer structures. Nano-indentor for thin film nano-hardness and elastic modulus measurements. Studies on doped and undoped tetrahedral amorphous carbon films with embedded nanoparticles, deposited by filtered cathodic vacuum arc technique.

Silicon and Silicon Devices Group

Determination of generation and recombination lifetimes in silicon wafer by impedance spectroscopy. Development of novel room temperature process for large area growth of silicon nanowires for solar cell applications. For measurements of solar cell performance and their characterization, establishment of minority carrier lifetime measurement system, surface photovoltage technique, light beam induced current mapping technique, spectral responsivity measurement facility and rapid thermal processing system.

Nanostructured Materials and Devices and Surface Studies

Charge transfer studies of hybrid polymer:CdSe/TiO_2 Quantum Dot composites. Development of nanostructured metal oxide gas sensor arrays. Synthesis and gas sensing studies for metal oxide / MWCNT composite. Studies on mechanism of charge transport and the origin of DC electrical conduction and dielectric relaxation in various polymeric films.

High Temperature Superconducting Materials & Devices, Advanced Ceramics and Optical Thin Films

Optimization of performance of [Bi-2223] long length multifilamentary tapes for high current transport. Studies to understand the nature of pairing and pinning, in search of effective pinning centers in the Bi-2223 superconducting system. Synthesis of calcium-copper-titanate by sol-gel technique and detailed studies of the effect of ageing time on particle size and dielectric properties. Synthesis of pure anatase titania nanocrystals and titania nanorods by PECVD. Establishment of Stylus-based Surface Profiler for thin film thickness and stress measurements; Variable Angle Spectroscopic Ellipsometer for extensive optical characterization and modeling of thin films; Multi-target Sputter Deposition System for sputter-deposition of a variety of thin films.

LUMINESCENT MATERIALS AND DEVICES

Nanophosphors of the type YOCl:Yb,Er and core-shell nanophosphor of the form $NaYF_4$:Er,Yb/$NaYF_4$ with enhanced upconversion luminescence efficiency have been prepared for use as solar cell phosphor for utilizing IR part of solar spectrum towards enhancement of solar cell efficiency and other potential applications and displays.

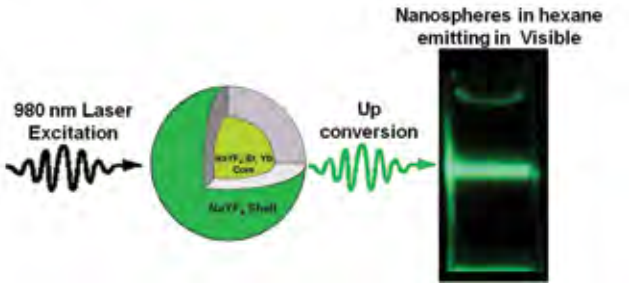


Fig. 4.1 Schematic of the core shell structure of nanophosphor and measured upconversion luminescence under irradiation of 980 nm laser

ZnO, being a potential host material for LED, Spin LED and Spintronics, was further investigated in nanocrystalline form. It was doped with different group of elements to achieve n-type conductivity (ZnO:Al), p-type conductivity (ZnO:Li/Na), dilute ferromagnetism (ZnO:Li/Na) at room temperature and tunable luminescence.

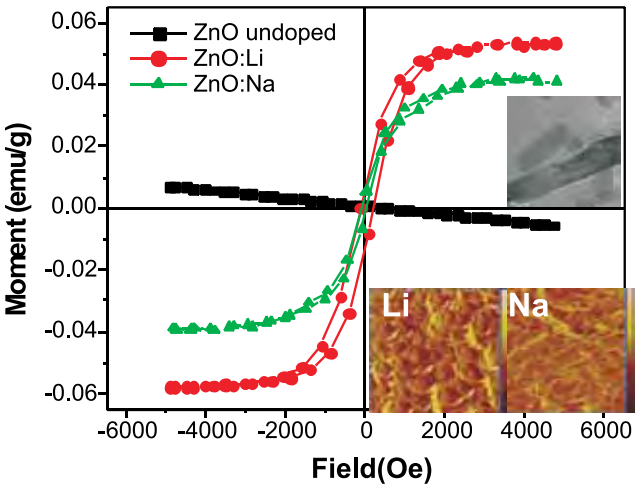


Fig. 4.2 M-H curve of p-type ZnO:Li/Na ferromagnetic nanorods. Inset shows the nanorod and magnetic domain structure (J. Appl. Phys. 106 (2009) 113923)

NMITLI Project on "Development of Next Generation Plasma Display Panel Technology" in which NPL part was "Synthesis of phosphors for Plasma Display Panels (PDP)", in collaboration with industrial partner M/s SAMTEL India Ltd, Gaziabad, has been successfully completed. Under this project, Red, Green and Blue (RGB) PDP phosphors excitable by VUV radiation 147 nm (resonant Xe*) and 172 nm (Xe_2* excimer band) excitation with improved characteristics have been developed. NPL developed phosphors have high luminescence quantum efficiency, shorter decay time, negligible degradation due to baking process and suitable particle size of 1-2 µm for screen printing of PDP panels. Red phosphor has improved monochromatic red luminescence, better colour coordinates and shorter decay time as compared to commercial red PDP phosphor. The results have been published in Optics Express (17, 22023–22030 (2009)). NPL phosphors have been accepted by SAMTEL for PDP panel preparation.

Ultra-fine Y_2O_3:Eu^{3+} nanophosphor with a narrow size distribution (<10 nm) and high luminescence efficiency has been developed for *"Luminescent Security Ink"* applications. Stable, transparent and non-toxic luminescent nanophosphor colloids in aqueous medium can have numerous applications involving optoelectronic devices, biological fluorescence labeling, luminescent paints and inks for security codes and many more. The transparent (>85% in the visible region) colloid showed a very strong red (611 nm) photoluminescence emission and short decay time (~1 ms) as well as superior crystal quality and minimum lattice fringe distortions, needed for applications in security codes and biological fluorescence labeling.

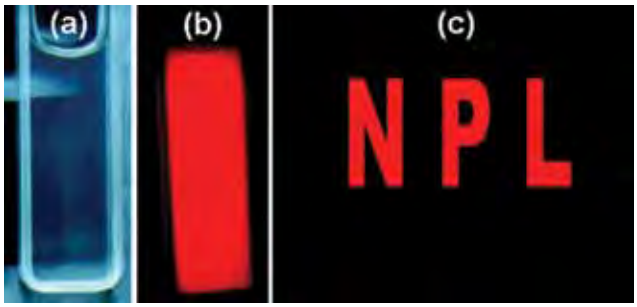


Fig. 4.3 A transparent Eu^{3+} -doped Y_2O_3 nanophosphor colloid under (a) room light, (b) UV (250 nm) radiation and (c) bright red emission from screen printed alphabets useful for security ink applications. (Nanotechnology, 21 (2010) 055607)

Quantum dots (QDs) are a new class of semiconducting nanocrystals containing microscopic amounts of the semiconductor material. The LMD group at NPL made such QDs with surface adsorbed anionic species of acetate ions and nitrate ions using ZnO. Both acetate and nitrate adsorbed ZnO QDs show antibacterial activity against *Escherichia coli (E-coli)*. However, the acetate adsorbed QDs were found to be more efficient. This could be attributed to the inherent ability of acetate ions to generate reactive oxygen species. In other words, the QDs when bound to negatively charged ions have potential application for bactericidal effects. This work opens up a new avenue in combating bacterial infections.

ZnO QDs were also prepared successfully using quantum confinement (QC) atom method that shows exceptionally high PL brightness. It is known that QC effects are strongly dependent on size of the nanocrystals (exciton Bohr radius, r_B, for bulk ZnO is 1.8 nm). Hence, it was observed that ZnO QDs having sizes <3.6 nm experience strong QC effects in all the dimensions; whereas, the sizes ≥3.6 nm did show weak/medium QC effects respectively. For the first time we observed and reported the strong, weak and medium QC effects for ZnO QD liquid, agglomerated nanocrystal (NC) powder and re-dispersed NCs in ethanol, respectively.

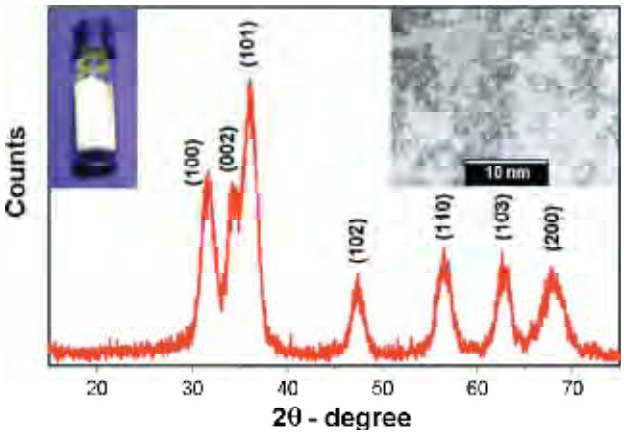


Fig. 4.4 Powder XRD pattern of ZnO:Na NC's. Insets show the TEM micrograph and a vial containing ZnO:Na NC powder irradiated under UV (350 nm) light. (Appl. Phys. Lett. 96 (2010) 123102)

Two of our research articles published this year have received global appreciations and the details are here under:

1. Nature-India had cited and appreciated our article published in J. Nanosci. Nanotechnol. 9 (2009) 6427 as a Research Highlight and named our quantum dots as "*Antibiotic Dots*". The Nature-article (doi:10.1038/nindia.2009.339; published online on Nov. 24, 2009) is available free at: http://www.nature.com/nindia/2009/091124/full/nindia.2009.339.html

2. Nature-India had cited and appreciated our article published in the journal Nanotechnology 21 (2010) 055607 as a Research Highlight and named our transparent colloid as "*Security Ink*". The Nature-article (doi:10.1038/nindia.2010.8; published online on Feb. 05, 2010) is available free at: http://www.nature.com/nindia/2010/100205/full/nindia.2010.8.html

PLASMA PROCESSED MATERIALS, DEVICES & SYSTEMS

1. R&D on amorphous/micro(nano) crystalline silicon thin films

During 2009-2010 a microwave/VHF PECVD system has been developed for the deposition of amorphous and micro/nano crystalline silicon films over substrate area of 100 cm^2 as shown in Fig 4.5. A ladder shaped VHF electrode custom designed and got fabricated and integrated into the system which has perforated hole to introduce gas or gaseous mixture in the process chamber. Large numbers of amorphous and micro/nano crystalline silicon films have been deposited using the said VHF electrode assembly. It is observed that the deposition rate of these films was higher compared to conventional rf PECVD process. It is also revealed that conductivities of these films were higher than a-Si:H films, which also confirmed the micro-crystallinity of these films. Fig. 4.6 and 4.7 show the typical AFM images and conductivities of microcrystalline silicon films deposited using only VHF and microwave coupled VHF power. Optimization of process parameters are in progress to deposit both doped and undoped silicon thin films for making p-i-n amorphous/ microcrystalline silicon solar cells.

Fig 4.5 Microwave/VHF PECVD system for the deposition of amorphous and micro/nano crystalline silicon films

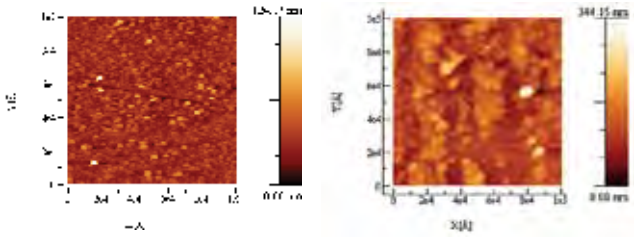


Fig 4.6 AFM image of micro/nano-crystalline silicon thin film deposited at (a) VHF (40W) and (b) Microwave/VHF (5 W/ 25 W) silane plasma.

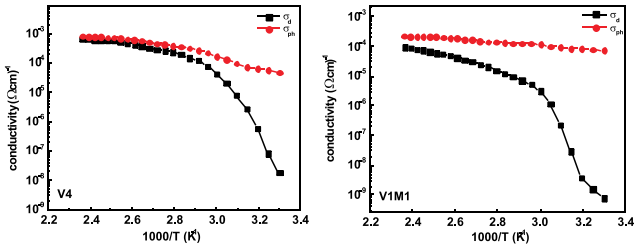


Fig 4.7 Dark and photo-conductivities of micro/nano-crystalline silicon thin film deposited at (a) VHF (40W) and (b) Microwave/VHF (5 W/ 25 W) silane plasma.

2. R&D on Diamond like carbon coatings

Investigation of acetylene plasma discharge using impedance probe (also called VI probe) was carried out to identify the condition of growth for Diamond like carbon (DLC) coating. Plasma parameters of gaseous mixture of argon and acetylene plasma discharge as a function of self bias and pressure were measured; simultaneously DLC films were deposited under same plasma conditions.

Deposition and investigations were carried out on metal incorporated diamond like carbon (DLC) and their various multilayer structures, such as;

(i) Copper incorporated diamond like carbon (Cu-DLC) films.

(ii) Copper / hydrogenated amorphous carbon (Cu / a-C:H) multilayer structure.

(iii) Titanium / hydrogenated amorphous carbon (Ti / a-C:H) multilayer structure.

(iv) Copper / diamond like carbon (Cu / DLC) bilayer structure.

(v) Titanium / diamond like carbon (Ti / DLC) bilayer structure etc.

Measurement of mechanical properties of large number of diamond like coatings such as nano hardness (H) and elastic modulus (E) using newly procured IBIS nano indentation (M/s Fischer-Cripps Laboratories Pty. Limited, Australia). Photograph of equipment is depicted in Fig 4.8)

Fig 4.8 IBIS nanoindenter installed at NPL

As a typical example; hardness of 38 GPa and elastic modulus of 462 GPa, were measured for a DLC bilayer structure at 10 mN load which is shown in Fig 4.9

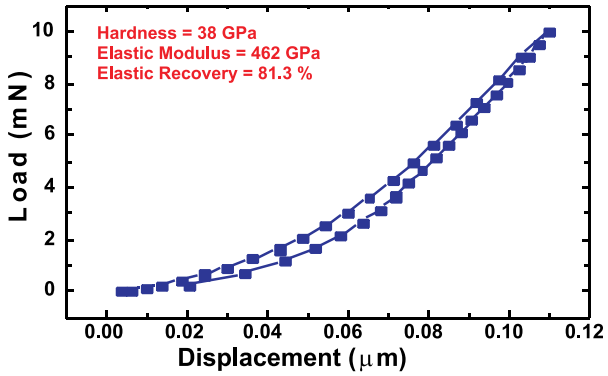


Fig.4.9 A representative load – displacement curve for one of DLC film.

3. R& D on undoped and doped tetrahedral amorphous carbon (ta-C) and amorphous carbon thin films with embedded nanoparticles

(i) A physical vapour deposition technique known as "filtered cathodic vacuum arc" (FCVA) was set up and a system for the same was custom designed and indigenously developed in the laboratory. The system consists of (a) water cooled cathode and anode (b) S bend magnetic filter on 6 inch duct to remove the macro particles and neutrals generated in the arc and (c) an 8 inch S.S. Cross deposition chamber with a provision of biasing and heating the substrate. The system is evacuated by two turbo molecular pumps backed by two rotary pumps. The magnetic filters are energized using different D.C. power supplies. A mechanical striker using a DC / pulsed arc supply capable of delivering up to 200 A current initiates the arc.

The FCVA system has been modified (Fig.4.10). An additional water cooled cathode and anode with linear magnetic filter has been added to the one side of SS cross deposition chamber. One gate valve is added between the deposition chamber and S bend magnetic filter with continuous copper winding and another gate valve is added between the deposition chamber and new water cooled cathode and anode assembly. A gas manifold for He and N_2 gases has been made. A separate pumping line consisting of root and rotary pump has been made to operate the system at high pressure. The vacuum arc deposition method has modified by creating a He or N_2

jet in the vicinity of carbon arc. Depending on whether the gas is injected through the cathode or the anode, the techniques will either be termed as "cathodic jet carbon arc" (CJCA) or "anodic jet carbon arc" (AJCA) techniques. Both these techniques have been custom designed and indigenously developed and integrated into the existing FCVA system which are being used to grow undoped and doped amorphous carbon thin films embedded with nanoparticles. A vacuum ~ 4 x 10^{-6} mbar has been achieved inside the modified FCVA system.

Fig. 4.10 Modified FCVA system integrated with CJCA and AJCA techniques

Fig. 4.11 Field emission measurement set up.

(ii) Fig. 4.11 shows the photograph of a Field emission measurement facility which has also been set up in the laboratory. This consists of a (i) custom designed SS chamber with glass window and various ports, (ii) turbo pump backed by rotary pump, (iii) a High voltage source meter, (iv) software for I-V measurement and a PC. All the procured parts have been integrated to make an ultrahigh vacuum (UHV) system mounted on a suitable frame locally made. A vacuum >3x10^{-7} mbar has been achieved inside the chamber.

(iii) The effect of substrate bias and hydrogenation and nitrogenation on density of states ($N(E_F)$), field emission threshold ($E_{turn\text{-}ON}$) and emission current density (J) in ta-C films have been studied. The value of $N(E_F)$ and $E_{turn\text{-}ON}$ decreases and J increases with the increase of substrate bias up to -200 V and beyond -200 V there is a reversal in the trend. Hydrogen and nitrogen incorporation in ta-C films reduced the values of $N(E_F)$ and $E_{turn\text{-}ON}$ and enhanced J which is corroborated with the increase of sp^3 content in the film. Large value of J and low $E_{turn\text{-}ON}$ are obtained in those films that have low $N(E_F)$ and high sp^3 content. The effect of varying boron and phosphorous in ta-C films have been studied by electrical conductivity, optical band gap, stress, hardness, XPS, XAES, Raman, AFM and field emission. It is observed that both boron and phosphorous content increased the value of conductivity, $E_{turn\text{-}ON}$ and reduces the activation energy, J and sp^3 content.

SILICON & SILICON DEVICES

Determination of generation and recombination lifetimes in silicon wafer by impedance spectroscopy

Impedance spectroscopy is used to study the effect of surface passivation on minority carrier lifetimes. The technique allows measurement of generation and recombination lifetimes separately. Induced p+-p-n structures are prepared by depositing semitransparent layers of high and low work function metals Pd and Al, respectively on the two sides of silicon wafers. Hydrogen adsorption property of Pd surface has been utilized for passivation. The generation lifetimes remain almost unaffected but recombination lifetimes enhance many folds after passivations which are in agreement with values obtained by microwave photoconductive decay technique after chemical passivation. Variations are analyzed for estimation of bulk recombination lifetime.

Silicon Nanowires for Solar Cells Applications

A novel room temperature process for large area growth of silicon nanowires (SiNW) arrays of controlled length via selective wet chemical etching of silicon process was developed. Less than 2% reflectivity in the spectral range (300-1000 nm) with SiNW arrays was achieved. This is the best reported value of reflectivity (without anti reflection coating) in silicon therefore SiNW arrays have potential application in silicon solar cells. A prototype of SiNW arrays based "black silicon" solar cells employing the low reflective property of the SiNW arrays was demonstrated. An improved process for SiNW arrays based solar cells was developed wherein ~10-15% efficiency improvement in SiNW arrays based solar cells relative to the control reference cell was found.

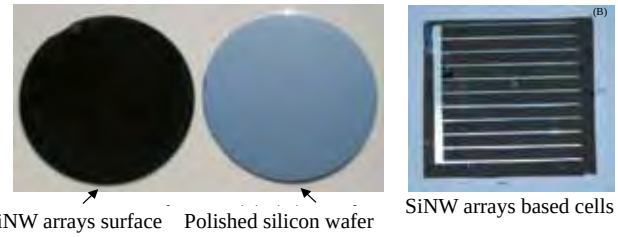


Fig. 4.12 Silicon Nanowires for Solar Cells Applications

Facilities at NPL for Materials and solar cells characterization:

1. Non-contact methods for measurement and mapping of minority carrier lifetime/diffusion length, defects etc. in semiconductors:
   - Minority carrier lifetime system: Microwave induced photoconductive decay (μ-PCD) for minority carrier lifetime mapping. This technique employs a pulsed laser source to generate electron hole pairs that changes the conductivity of the material. The reflected microwave from the surface which in turn is related with the change in the electrical conductivity of the material is correlated with the minority carrier lifetime. The measured lifetime is its effective value which has contributions both from the bulk and the surface. Effective surface passivation is desirable for the measurement of bulk lifetime of the material.
   - Surface Photo voltage (SPV) technique: Minority carrier lifetime and diffusion length mapping.

     Diffusion length is a property of a bulk semiconductor material, telling how long an excess carrier travels, on average, before recombining to achieve equilibrium carrier concentration. The diffusion length of a semiconductor with a perfect crystal lattice and no contamination will be long, and any imperfections

in the semiconductor material or contamination will reduce the diffusion length. Amongst the various methods for measuring diffusion length surface photo voltage is an established method where the SPV response of multiple wavelengths is used to calculate diffusion length. This measurement technique works well in semiconductor grade silicon where the wafer thickness is greater than 3 times the diffusion length.

- Light Beam Induced Current (LBIC): mapping of solar cells device performance and defects etc.

2. Solar cells Performance testing facility

- I-V and spectral response measurement system:

  The Silicon & Silicon Devices Group uses I-V system to measure performance of individual solar cells (Model CEP-25HS-50). Xenon arc lamp is used to illuminate solar cells of size 5cm × 5cm at 1-sun (AM1.5 Global reference spectrum, Class A solar simulator meeting JIS standard).

- Spectral responsivity (SR) measurement is an important part of the photovoltaic (PV) device performance assessment process. Spectral responsivity systems measure how a device responds to selected narrow (spectral) bands of irradiance. Responsivity is measured in units of amperes per watt versus wavelength and reported in terms of quantum efficiency (QE)-a measure of how efficiently a device converts incoming photons to charge carriers in an external circuit.

  CEP-25HS-50 SR system is a grating based system with typical minimum beam size of 5cm × 5cm, making it ideal for absolute spectral responsivity measurements. The system is used for solar cells SR measurements of size 5cm x 5cm in a wavelength range of 300 to 1200 nm with wavelength interval of as low as 1 nm.

3. Rapid Thermal Processing (RTP) System (Annealsys AS-One-150, France)

   RTP system for annealing/sintering of metal contacts (Ti/Pd/Ag/Al) has been installed. It can be operated up to max temperature of 1200 ˚C and is capable of accommodating samples of up to 6” diameter.

SURFACE STUDIES AND NANOSTRUCTURES

Charge Transfer Studies of Hybrid Polymer:CdSe/TiO_2 Quantum Dot Composites

The role of varied sized CdSe quantum dots on the transient absorption properties of hybrid organic (MEH-PPV/P3HT)-inorganic (CdSe) nanocomposites has been investigated. Efficient charge transfer for MEH-PPV/P3HT :CdSe composites corresponding to smaller CdSe nanocrystallite (~ 5 nm) was realized as elucidated by transient absorption measurements respectively. However, for larger-sized CdSe nanocrystallites (size ~ 14 nm), charge transfer between polymer:CdSe composites was hindered owing to the presence of defects because of agglomeration/phase segregation effects which act as recombination centers particularly for

P3HT:CdSe composites. Signatures of CdSe-* radical upon acceptance of charge from MEH-PPV/P3HT can be readily monitored within visible region. These studies provide an insight into the charge separation, charge accumulation and/or trapping of charge carriers for the better understanding of hybrid organic-inorganic photovoltaics.

A selection of an appropriate solvent and the linker ensures complete coverage of the CdSe QD's on the TiO_2 surface and consequently improvement in the photocatalytic behaviour of CdSe-TiO_2 nano-composite. It was observed that direct adsorption does not occur when the TOPO/ TOP-capped CdSe QD's are dispersed in toluene. However, the bifunctional linker molecules particularly for ethanol solvent facilitate binding of CdSe QD's to TiO_2. As TiO_2 particles are relatively larger (size ~ 20 nm) than CdSe QD's, such large particle surface enables linking of several small CdSe particles (~ 5nm) to a single TiO_2 particle and consequently, interparticle electron transfer is thus facilitated. Linker plays a key role in anchoring CdSe QDs to TiO_2 surface. The above factors help in an efficient charge transfer between CdSe and TiO_2 which result in higher PL quenching. It has been found that TiO_2(w) nanocrystals prepared by sol-gel method as compared with the corresponding one's prepared by simple hydrolysis method TiO_2(t) show (a) better steric stability against coagulation, homogeneity and thus imparting photostability to their respective TiO_2/MEH-PPV composites and (b) high value of Stern-Volmer quenching constant calculated from photoluminescence (PL) quenching studies and (c) more decrease in lifetime values indicating efficient charge transfer across TiO_2/MEH-PPV interface.

Nanostructured metal oxide gas sensor array

Different sensor arrays were prepared and tested for their utility as selective detection of the presence of small concentrations of harmful gases in the local environment. The sensor array consisted of eight differently doped metal oxide sensors. Different metal oxides such as SnO_2, ZnO, WO_3, TiO_2 etc. were synthesized using chemical routes to prepare nanocrystalline powders. Materials were characterized and gas sensitivities of these materials were investigated for bulk as well as thin films.

Synthesis and gas sensing studies for metal oxide / MWCNT composite

Composite films based on tin or tungsten oxide and carbon nanotubes/ graphene have been investigated as new gas sensitive materials with improved sensitivity. Composites containing carbon nanotubes/graphene exhibit cooperative or synergetic effects between the metal oxide and carbon nanotube, and useful for many applications. A sol-gel processing route was used to prepare composite films. Films were studied by X-ray diffraction, scanning electron microscopy (SEM). Sensing properties of the prepared composites have been tested with respect to NO_2 gas. A high surface area and small crystallites present in the sol-gel synthesized composite films were attributed to high sensitivityand fast response characteristics. Low concentrations of NO_2 could be detected even at room temperature using these composite films which was not possible without CNT/graphene addition.

Project : Nanostructured metal oxide gas sensor array for detection of chemical warfare agents, DRDO: duration 2 years, 14.12 lakhs, Start date: 1-4-08, end date: 31-3-2010

Mechanism of charge transport in poly(2,5-dimethoxyaniline)

Poly (2,5-dimethoxyaniline) (PDMA) has been synthesized by chemical oxidative polymerization technique using varying ratio of oxidants; ferric chloride ($FeCl_3$) and ammonium persulfate (APS) ($(NH_4)_2S_2O_8$), in an inert atmosphere at low temperature ~278 K. The synthesized samples of PDMA have been characterized by Fourier transform infrared (FT-IR) spectroscopy, scanning electron microscopy (SEM) and by measuring its dc conductivity (σdc). The temperature dependence of dc conductivity of PDMA samples has been examined in the wide temperature range 6-303 K. The analysis of dc conductivity data reveals that in the temperature range ~100-303 K, the dc conductivity is predominantly governed by Mott's 3-dimensional variable range hopping (3D-VRH), however, below 100 K tunneling seems to dominate. Different Mott's parameters such as characteristic temperature (T0), density of states at the Fermi level ($N(E_F)$), the average hopping distance (R), and the average hopping energy (W) have been estimated for all the PDMA samples and are in good agreement with the values reported earlier for other conjugated polymers.

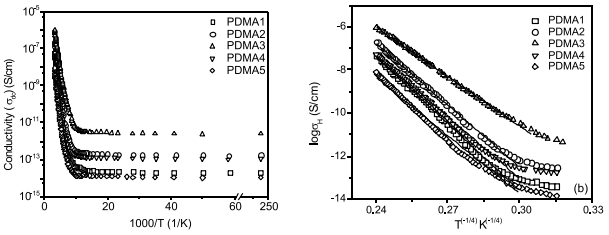


Fig. 4.13. Variation of dc conductivity (σdc) as a function of reciprocal temperature in the range 6-303 K for different PDMA samples. (b) The hopping conductivity (σH) plotted as functions of T-1/4 in the temperature range 100-303 K.

The Origin of DC Electrical Conduction and Dielectric Relaxation in Pristine and Doped Poly(3-hexylthiophene) Films

We present here the evidence for the origin of dc electrical conduction and dielectric relaxation in pristine and doped poly(3-hexylthiophene) (P3HT) films. P3HT has been synthesized and purified to obtain pristine P3HT polymer films. P3HT films are chemically doped to make conducting P3HT films with different conductivity level. Temperature (77-350 K) dependent dc conductivity (σ_{dc}) and dielectric constant έ(ω) measurements on pristine and doped P3HT films have been conducted to evaluate dc and ac electrical conduction parameters. The relaxation frequency (f_R) and static dielectric constant ε_0 have been estimated from dielectric constant measurements. A correlation between dc electrical conduction and dielectric relaxation data indicates that both dc and ac electrical conductions originate from the same hopping process in this system.

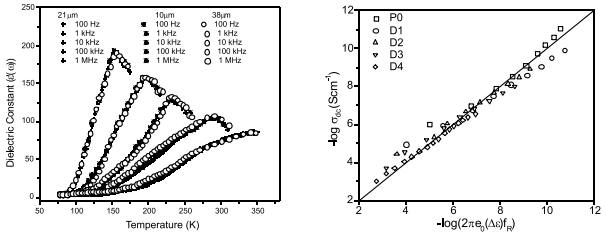


Fig. 4.14. Variation of dielectric constant έ (ω) as a function of temperature (77-350 K) at five fixed frequencies (0.1, 1, 10, 100 kHz and 1 MHz) for D2 (doped) P3HT film (thick. ~ 10,21,38 μm) and Plot of log σ_{dc} versus log($2\pi e_0(\Delta\varepsilon)fR$) for P0 (pristine); D1, D2, D3, D4 (doped) P3HT films

High Temperature Superconducting Materials and Devices, Advanced Ceramics & Optical Thin Films

HIGH TEMPERATURE SUPERCONDUCTING MATERIALS AND DEVICES

Knowing the key role of long length multi-filamentary HTS (Bi-2223) tape and tube/rod conductors in HTS devices and other applications, NPL has indigenously developed > 75m long Bi-

2223 multi-filamentary tapes with comparable Jc ~104 A/cm^2 at 77K. The optimization of the same needed some fabrication and testing facilities. The group has acquired groove rolling machine with nearly 0% ellipticity, two box furnaces (9x9x12″; 8x8x12″ constant temperature zone) programmable furnace for calcination of 1Kg powder and intermediate annealing of wire/tapes. A highly sophisticated furnace (Lenton, UK) having 1.8m long constant temperature zone for sintering of long length (100m) wires/tapes and multi-joint tube assembly (1 to 1.5m long) was also made operative at optimum conditions. In optimization of joint tube assembly (Fig 4.15) this group has come a long way and now the reproducibility of the joint system is >80% and can individually carry 500 to 1000 A at 4.2K and the whole system with loss at joints can carry 200-300A. Apart from these studies, to understand the nature of pairing and pinning in search of effective pinning centers, superconducting properties of Bi-2223 system with addition of Yb (0 to 0.1M%) have been investigated. The values of T_c and J_c decreased with increase in Yb addition. XRD and SEM studies of these samples showed that Yb degrades (i) the formation of Bi-2223 phase, and (ii) the surface morphology and intergrain connectivity in comparison with undoped sample, respectively. CESR studies of these samples are in progress.

Fig. 4.15. Joint Tube Assembly

ADVANCED CERAMICS

Advanced Ceramics section has synthesized calcium-copper-titanate (CCTO) were prepared by sol-gel method. Sol was prepared from nitrate salts of calcium and copper and Titanium isopropyl orthotitanate (TTIP) by refluxing in ethanol. The effect of ageing time on particle size and dielectric properties of CCTO was investigated. Samples for this study were prepared by aging the sols for 24, 48 and 72 hours, followed by the same drying and calcinations conditions. Fine Powders with good crystalline were obtained Calcinations at 650°C. They are uniaxially pressed and sintered at 1000°C. The average grain size (d_G) of 1.57, 1.64 and 1.86 µm for samples derived from sol aged for 24, 48 and 72 hours respectively (Fig. 4.16). The absolute permittivity of CCTO is enhanced with an increase in aging time. The Cole-Cole plots of CCTO reveal intra grain polarization is affected with increase in aging time. They have

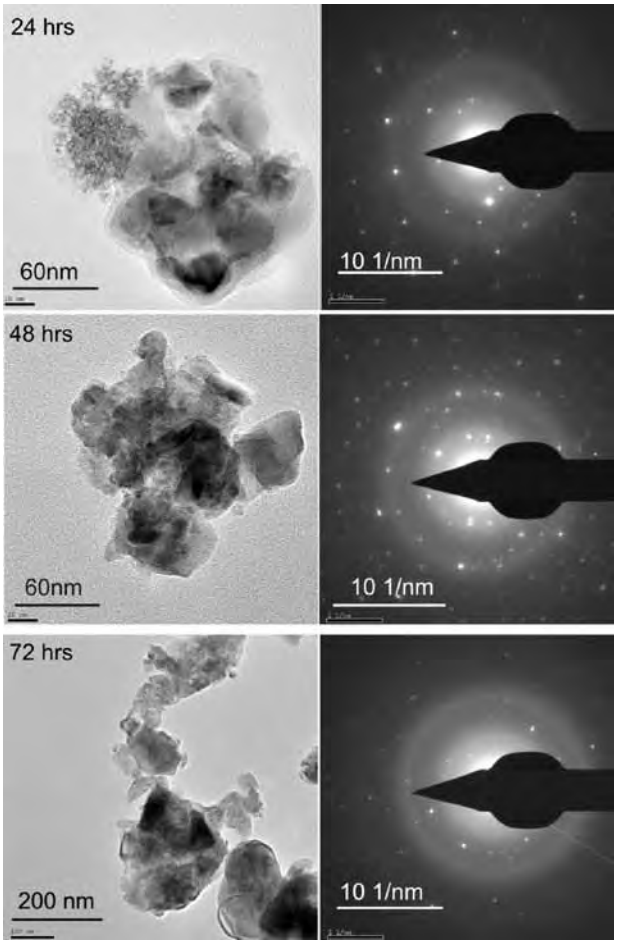


Fig. 4.16 Effect of CCTO particle size on ageing

also synthesized yttrium oxide nanopowders by microwave combustion synthesis and its sinterability under microwave radiation. First, nano-powder of yttria was synthesized from hexa-hydrate Yttrium Nitrate [$Y(NO_3)_3.6H_2O$] powder and different fuels (urea, urea along with oxalic acid and urea along with tartaric acid) through microwave combustion technique. Calcinations of foam were carried out at three different temperatures (1000^{O}C, 1100^{O}C and 1200^{O}C). XRD results revealed that the powders obtained were phase pure polycrystalline cubic yttrium oxide. Particle size was tailored from 55 to 300 nm with addition of reducing agents. HRTEM image of the powders clearly indicates the interfacial spacing of 0.30 nm corresponding to (222) plane of cubic yttria. Microwave sinterability of these powders was studied in the temperature range of 1550 to 1750^{O}C. Homogeneous 3-7 µm grain sized samples with negligible porosity were obtained for the pellets sintered at 1650°C for 20 minutes.

OPTICAL THIN FILMS

Pure anatase titania has been synthesized at room temperature by Plasma Enhanced Chemical Vapour Deposition (PECVD) technique. The deposition was carried out on silicon (100) substrates, under an applied substrate DC bias using titanium tetra-isopropoxide $Ti(OC_3H_7)_4$ (TTIP) vapour, and argon and oxygen mixtures. The X-ray Diffraction (XRD) analysis for the as-deposited titania has confirmed its crystallinity and phase as anatase titania. Pure anatase titania was observed to be formed under substrate DC bias of -150 V. The broadening of XRD peaks and morphology in the Scanning Electron Microscope (SEM) micrographs indicated the formation of large size agglomerates of anatase titania crystallites. The largest size of agglomerate is about 1300 nm x 500 nm, and the average crystallite size was determined as 58nm. In addition, titania nano structures, nanoparticles, and nanorods have also been synthesized at room temperature on silicon (100) substrates. The XRD spectrum has confirmed the crystallinity and phase as anatase titania. SEM micrograph shows the morphology of the nanoparticles with average dimension of 50nm and 100nm, and nanorods of different dimensions about1 nm length with 50nm dia. and about 4 micrometer length and about 200nm dia. at two deposition pressures of 0.5 mbar and 0.8 mbar respectively, keeping other process parameters constant. It is reported that anatase nanoparticles display superior photocatalytic properties as compared to rutile phase.

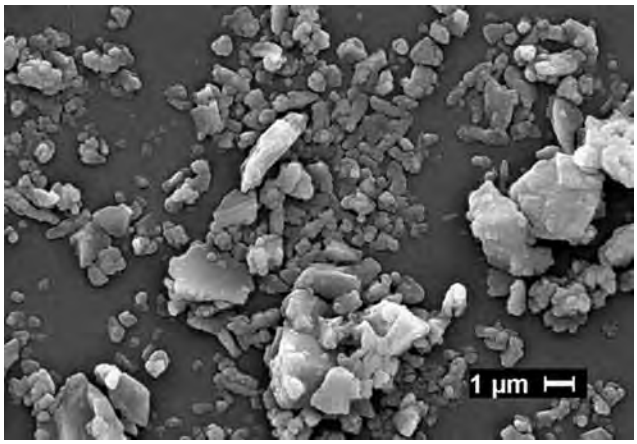


Fig. 4.17 SEM Morphology of Anatase Titania

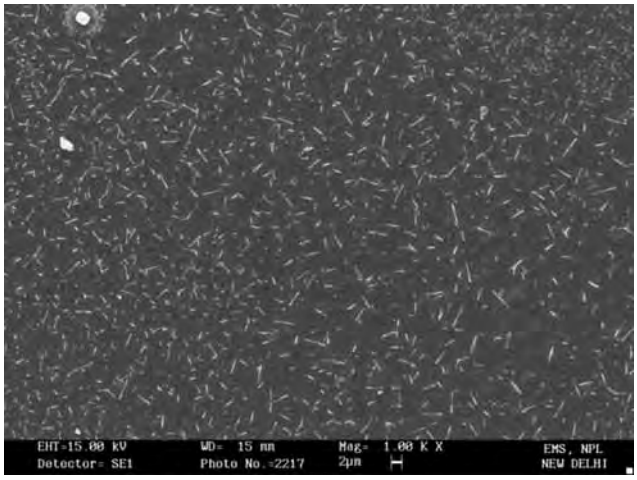


Fig. 4.18 SEM Morphology of Titania Nanorods

Three major thin film characterization and deposition facilities have been established in NPL: **STYLUS BASED SURFACE PROFILER** from M/s Ambios, USA (model XP-200). This can be used to measure the thickness of a thin film deposited on a flat substrate with a sharp step (50 nm to 5 microns). It can also scan a surface over a 150 x 178 mm area and provide a 3-D plot of the surface profile. Thin film stress measurements are also possible.

SPECTROSCOPIC ELLIPSOMETER from M/s J A Woollam, USA (model V-VASE). It can provide ellipsometric as well as reflectance and transmittance scans over the range 200 - 1700 nm, with automated angle of incidence (15 - 90°), vertical sample stage, automated sample translation (150 x 150 mm), etc. It has extremely user-friendly and versatile software for data acquisition and analysis, capable of analyzing thin film optical constants and thicknesses, surface roughness, inter-facial layers, graded and mixed composition films, multi-layer structures, simulation as function of 2-3 parameters, sensitivity calculations, surface mapping and generation of 3-D graphs, etc.

MULTI-TARGET SPUTTER DEPOSITION SYSTEM from M/s Milman Thin Film Systems, Pune. The deposition chamber (about 400 mm dimensions) is pumped down by a dry scroll pump and a turbopump to a base vacuum of about 10^{-6} mbar. There are 3 nos of 2" (50 mm) diameter magnetron sputtering targets, mounted in a confocal arrangement to carry out sputter-down deposition on substrates of up to 3" (75 mm) diameter, from one target as well as co-sputtering from 2 targets. Two targets have provision for RF sputtering (600 W max @ 13.56 MHz) and one for DC sputtering (1500 W max). Two targets have magnetrons for non-magnetic material targets and one for magnetic material targets. The substrate can be rotated (0 - 20 rpm), heated (up to 300°C) or cooled. A quartz crystal monitor measures the deposited film thickness. A Kaufman ion source can be used for pre-cleaning the substrates. The system is provided with an array of safety interlocks and can be operated in manual mode as well as PLC-PC based fully automatic mode. A new air compressor and a closed-cycle chilled water system have also been installed for the operation of this sputtering plant.

पदार्थ अभिलक्षणन

MATERIAL CHARACTERIZATION

पदार्थ अभिलक्षणन

राष्ट्रीय भौतिक प्रयोगशाला में कई प्रकार के उपकरणों में अनुप्रयुक्त होने वाले विभिन्न प्रकार के विकसित पदार्थों जैसे ऊर्जा उत्पादन संरक्षण, निम्न ताप अति चालक पदार्थ, जेवे संवदेक, चालन बहुलक आदि का इस प्रभाग में उनके संघटन, लेश अशुद्धियों, स्फटिक संरचना, स्फटिक–आदर्शिता, पृष्ठीय एवं अन्तरापृष्ठीय अभिलक्षण किया गया है। ये पदार्थ तनु परतों (Thin films), नैनो नलिकाओं (Nano tubes), नैनो दंडिकाओं (Nano rods), नैनो तारों (Nano wires), नैनो चूर्ण (Nano Powders), आयतन पट्टिकाओं (Bulk Pallets), आदि के रूप में होते हैं। प्रभाग प्रयोगशाला के शोध प्रयोजनों के साथ समस्वरित होते हुए, स्वयं के निश्चित लक्ष्यों के लिए विभिन्न शोध एवं विकास कार्यों में भी लिप्त है। प्रभाग के इस वर्ष के कुछ महत्त्वपूर्ण शोध और विकास कार्य नीचे सूचित किए गए हैं

(1) रासायनिक मापिकी और प्रमाणित निर्देशक पदार्थ क्रियाकलाप जानकारी बढ़ाने, प्रशिक्षण उपलब्ध कराने और क्षमता निर्माण, रासायनिक मापिकी के विभिन्न चुनौतीपूर्ण क्षेत्रों में शोध और विकास, CCQM और APMP अंतर्राष्ट्रीय मुख्य तुलनाओं में प्रतिभागन, मार्गदर्शी अध्ययनों, NABL के साथ राष्ट्रीय पारंगता परीक्षण (PT) कार्यक्रम का संगठन और प्रमाणित निर्देशक द्रव्यों (CRM's) या भारतीय निर्देशक द्रव्यों (BND) का (NPL) राष्ट्रीय भौतिक प्रयोगशाला द्वारा इसके MiC परिपथ साथियों के साथ रासायनिक मापनों में SI अनुरेखण प्रदान कराने और उनकी अंतर्राष्ट्रीय तुलनात्मकता को बनाए रखने आदि के लिए केन्द्रित किए गए हैं। इसके साथ राष्ट्रीय भौतिक प्रयोगशाला की घरेलू शोध कार्य की रासायनिक अभिलक्षणन आवश्यकताओं, सरकारी एजेंसियों और विभिन्न प्रकार के पदार्थों का अभिलक्षणन जैसे दिल्ली जल बोर्ड (DJB); भारतीय निर्वाचन आयोग से निर्वाचन उद्देश्य के लिए अलोप्य स्याही; VVIP सुरक्षा के लिए गैस मिश्रण अभिलक्षणन आदि कुछ महत्वपूर्ण सेवाएं हैं।

(2) EPR अनुभाग में a State of art इलेक्ट्रोन स्पिन स्पेक्ट्रोमीटर स्थापित किया गया है, जिसका उपयोग राष्ट्रीय भौतिक प्रयोगशाला के विभिन्न समूहों मे विकसित किए गए चुम्बकीय पदार्थों के अभिलक्षणन में किया जाता है। $Ni_x Zn_{1-x} Fe_2 O_3$ (x=0.1, 0.3 और 0.4) नैनो कम्पोजिट के लिए EPR स्पेक्ट्रा परिवेश ताप पर अभिलिखित किए गए हैं। स्पिन सांद्रता की गणना तुलनात्मक विधि द्वारा की गयी जिसमें DPPH मानक सन्दर्भ पदार्थ के रूप में उपयोग किया गया, लाइन विड्थ (Line width) की तरह स्पिन सांद्रता भी समान रूप से अनुसरण करती है, अर्थात् $Ni_{0.3} Zn_{0.1} Fe_2 O_3$ नमूने में यह बढ़ती है और फिर $Ni_{0.5} Zn_{0.5} Fe_2 O_3$ में घटती है । यह $Ni_{0.5} Zn_{0.5} Fe_2 O_3$ नैनो कणों में उपस्थित ऑक्सीजन आयनों द्वारा घनायनों के मध्य प्रबल अति–विनिमय अन्योन्य क्रियाएं सूचित करती है। स्पिन विश्रान्त प्रक्रिया एक समय नियतांक द्वारा प्रदर्शित की जाती है और चुम्बकीय क्षेत्र का फलन है। यह उस दर पर निर्भर करता है, जिस पर सूक्ष्मतरंग ऊर्जा अवशोषित की जा सकती है और वातावरण की स्पिनों को उत्सर्जित की जाती है।

(3) लीथियम फ्लोराइड (LiF: मात्रामापी और X-किरण एकवणित के लिए एक अत्युत्तम उम्मीदवार) के वृहद एकल क्रिस्टल का विकासन गृह निर्मित चोक्रालस्की (Czochralski) क्रिस्टल पुलर द्वारा किया गया। विकसित क्रिस्टलकी की स्फटिक पूर्णता का निर्धारण बाउल की लम्बाई के समकक्ष भिन्न–भिन्न खण्डों पर उच्च विभेदन X-किरण विवर्तन मापी का प्रयोग करके किया गया, जिससे यह पाया गया कि – बीज क्रिस्टल में विद्यमान रेणु परिसीमाएं क्रमिक रूप से मध्य–कृशन (Necking) विधि द्वारा वृहद क्रिस्टल में पहुंचने से रोकी गयी।

सभी पूर्व संस्थापन व्यवस्थाओं के बाद नया प्राप्त किया रिगाकू (Rigaku) ZSX Prim us XRF उपकरण सफलतापूर्वक संस्थापित किया गया। ठोस के अतिरिक्त द्रव पदार्थों का प्रमाणित निर्देशक द्रव्यों का उपयोग करके परीक्षण किया गया, जिसका प्रतिवेदन भी जमा किया जा चुका है। BSO (विस्मथ सिलिकॉन आक्साइड) और Zn.डोप्ड लीथिम नियोबेट ($LiNbO_3$) क्रिस्टल का विकासन चो–क्राल्स्की विधि द्वारा उन्नति पर है। क्रूसिबल व्यवस्थापन में आवश्यक ताप प्रवणता परिवर्तन को सुधारने का कार्य किया गया है।

(4) TEM और HRTEM का उपयोग करके विभिन्न विधियों द्वारा निर्मित कार्बन नैनो ट्यूब नमूनों का अभिलक्षणन किया गया है। बिस्मथ टेल्युराइड; कैडमियम टेल्युराइड और SnO_2 की तनुपरतें (Thin Films) थर्मल इवापोरेशन विधि द्वारा निर्मित की गयी थी। Ag नैनो कण, Al/Si अपमिश्र, विभिन्न ताप पर निस्तापित Y_2O_3 चूर्ण, भिन्न विधियों से निर्मित लीथियम फेराइट, ग्रेफीन पर A_4 कोबाल्ट फेराइट चूर्ण, क्रायो–मिल्ड (Cryo-milled) Al चूर्ण, PVP आच्छेदित ZnS और SiO_2 आदि; कई पदार्थ जैसे कि Zn+ ग्रेफेटाइज्ड कार्बन चूर्ण, नति विलेपर विधि से निर्मित Si सबस्ट्रेट पर सिल्वर के साथ ग्रेफीन शीट, विभिन्न स्थानों से प्राप्त Particulate द्रव्य/फिल्टर पेपर, Au फिल्म/ITO,?एन्जाइम के साथ गोल्ड कण और पाइरॉल के साथ गोल्ड कण, Al, Al_2O_3, Al+A_2O_3 चूर्ण एल्कलाइन और अम्ल गठित सूक्ष्म मणिक सिलिकॉन, एन्जाइम के साथ और इन्जाइम के बिना गोड नैनो कण, उच्च Tc अतिचालक Bi 2223 नमूने, Mg फेराइट और Li-Mg फेराइट आदि नमूने SEM सुविधा द्वारा अभिलक्षित किए गए हैं।

(5) A State of art Time of Flight Secondary Ion Mass Spectro-meter (TOF-SIMS)

(मॉडल–TOF-SIMS 5-100) M/S IONTOF GmbH जर्मनी से प्राप्त किया गया और नवनिर्मित सेन्टर फॉर नैनो स्केल साइन्स (CNS) में संस्थापित किया गया। अधिक मात्रा में नमूनों जैसे :–

(1) Cu-Cr-Fe अपमिश्र, (2) Si पटलिका (Wafer) पर Au, (3) टेफ्लॉन, (4) Si में डेल्टा डोप्ड B, (5) B इम्प्लान्टेड (Implanted) Si का परीक्षण, प्रशिक्षण के दौरान और बाद में स्टॉफ सदस्यों द्वारा उपकरण को मानकीकृत करने के लिए किया गया। तदनोपरान्त कुछ और नमूनों का परीक्षण किया गया। जैसे :–

(1) टेक्सटाइल नमूनों का 2 D इमेजिंग (2) बहुस्तरीय TMR नमूनों (CoFe/MgO/ NiFe/Si) का गहराई परिच्छेदन (Depth profile); (3) कुछ LED संरचनाएं (Mg doped GaN/Sapphire) और (4) Nb अतिचालक पर उपस्थित विभिन्न अशुद्धियों का गहराई परिच्छेदन द्वारा अध्ययन।

MATERIAL CHARACTERIZATION

Different types of materials which are being developed at NPL for application in various types of devices like energy generation or preservation, low temperature superconducting materials, bio sensors, conducting polymers etc. are being characterized at this division for their composition, trace impurities, crystalline structure, crystalline perfection, surfaces & interfaces. These materials are in the form of thin films, nano tubes, nano rods, nano wires, composite materials, nano powders, bulk pellets etc. The division is also engaged in different R & D activities of its own with definite targets in tune with the research plan of the laboratory as a whole. Some of the important R & D activities of the division pursued during this period are listed below:

1) The Chemical Metrology and Certified Reference Materials (CRM) activities have been focusing to create awareness, provide training & build capacity, doing R&D in various Metrology in Chemistry (MiC) challenging areas, participating in CCQM & APMP international key comparisons, pilot studies, organization of national proficiency testing (PT) program with NABL and includes preparation & dissemination of certified reference materials (CRMs) or Bhartiya Nirdeshak Dravyas (BND) for providing SI traceability in chemical measurements by NPL with its MiC network partners and maintain their international comparability.In addition, the chemical characterization needs of NPL in-house research work, government agencies and institutions for characterization of a variety of materials like Delhi Jal Board; indelible ink for election purpose from Election Commission of India; gas mixtures characterization for VVIP security, are some of the important services rendered.

2) A State of the art Electron Spin Spectrometer has been established in the EPR section and are used for characterizing magnetic materials developed at various groups of NPL. The EPR spectra of $Ni_xZn_{1-x}Fe_2O_4$ (x=0.1,0.3 and 0.5) nano composites were recorded at ambient temperature.The spin concentration is calculated by the comparison method where DPPH is used as a standard reference material. Spin concentration also follows the same trend like line width, i.e. it increases in $Ni_{0.3}Zn_{0.7}Fe_2O_4$ sample and then decreases in $Ni_{0.5}Zn_{0.5}Fe_2O_4$ sample. This indicates the strong super exchange interactions among the cations through oxygen ions present in $Ni_{0.5}Zn_{0.5}Fe_2O_4$ nanoparticles. The spin relaxation process is represented by a time constant and is a function of magnetic field. It depends upon the rate at which microwave energy can be absorbed and emitted to the surrounding spins

3) The bulk single crystal of Lithium Fluoride (LiF; a excellent candidate for dosimeters and X-ray monochromators) was grown by homemade Czochralski crystal puller. The effect of necking has been studied. The crystalline perfection of the grown crystal was assessed along the length of the boule at different parts using high-resolution X-ray diffractometer and found that the grain boundaries which were present in the seed crystal were stopped gradually from propagating in to the bulk crystal by necking.

After all necessary pre-installation arrangements the newly procured Rigaku ZSX Primus XRF system has been installed successfully. After testing for solid as well as liquid materials using certified reference materials, the test report has also been submitted.

Crystal growth of BSO (bismuth silicon oxide) and Zn-doped lithium niobate by Czochralski technique is in progress. The necessary modifications for the crucible setup for the improvement of temperature gradient have been done.

4) Some of the samples which were characterized by using TEM and HRTEM are carbon nanotubes prepared by different methods, Thin films of bismuth telluride, cadmium telluride and SnO_2 prepared by thermal evaporation technique. Ag nano particles, Al/Si alloy, Y_2O_3 powder calcinated at different temperatures, Lithium ferrites prepared by different routes, Gold on grapheme, cobalt ferrite powder, Cryo-milled Al powder, ZnS capped with PVP and SiO_2 etz.

Materials like Zn + Graphitized carbon powder grown by thermal heating, ,Grapheen sheets with silver on silicon substrate by dip coating method, Particulate matter/filter paper collected from different locations, Au film/ITO, gold nanoparticles with enzyme and gold nanoparticles with pyrol, Al, Al_2O_3, $Al+Al_2O_3$ powders ball milled, Alkaline and acid texturised micro crystalline Silicon, Gold nanoparticles with and without enzymes, High Tc Superconducting Bi2223 samples , Mg ferrite and Li-Mg Ferrite samples etc have been characterized by the SEM facility.

5) A state of the art time of flight Secondary Ion Mass Spectrometer (TOF-SIMS) was procured (Model TOF.SIMS 5-100) from M/S IONTOF GmbH, Germany, and installed at the newly created Centre for Nano-scale Science (CNS). A good number of samples viz. 1) Cu-Cr-Fe alloy grid, 2) Au on Si wafer, 3) Teflon, 4) Delta doped B in Si, 5) B implanted Si were tested during the on-site training period and also later by the staff to standardize the equipment. Thereafter studies of some more samples were also carried out like 1) 2D Imaging of textile samples, 2) Depth profiles of multilayer TMR materials (CoFe/MgO/NiFe/Si), 3) some LED structures (Mg doped GaN/Sapphire) , and 4) Study of various impurities present on the Nb superconductor by depth profiling.

Chemical Metrology

Under the Metrology in Chemistry (MiC) and Certified Reference Materials (CRM) activities of the section, focus has been given to create awareness, provide training & build capacity, doing R&D in various MiC challenging areas, participating in CCQM & APMP international key comparisons, pilot studies, organization of national proficiency testing (PT) program with NABL and includes preparation & dissemination of certified reference materials (CRMs) or Bhartiya Nirdeshak Dravyas (BND) for providing SI traceability in chemical measurements by NPL with its MiC network partners and maintain their international comparability. These activities are major thrust under the 'Advances in Metrology' CSIR Network project. In addition, the chemical characterization needs of NPL in-house research work, government agencies and institutions for characterization of a variety of materials viz. poly aluminum chloride and Alumina Ferric Grade-II used for treatment of water by Delhi Jal Board; indelible ink for election purpose from Election Commission of India; gas mixtures characterization for VVIP security, metal impurities in NPL grown crystals, water & waste water etc. are some of the important services rendered during this period. The major facilities utilized for trace metal analysis are FAAS/ GFAAS/ ICP-AES/ UV-Vis Spectrophotometer and Gas Chromatography (GC) for gas analysis & Green House Gases (GHGs) studies.

Figure-5.1: MiC training workshop, January 11-15, 2010, Lucknow UP.

Two sponsored projects for second national communication (NATCOM-SNC) for GHG QA/QC and traceability are being implemented for Ministry of Environment & Forests. NABL sponsored proficiency testing (PT) project in chemical discipline (code PT-44) for the NABL accredited 67 laboratories has been completed during this year for Phase-II for ten elements (viz. Cu, Fe, Zn, Pb, Cd, Ni, Cr, Ag, As and K) in water. Data analysis have been carried out for studies under ISRO-GBP special observational programme (ICARB) in Delhi, by the group for suspended particulate matter (SPM) and its chemical composition apart from aerosol size and mass distribution by Anderson cascade impactor and quartz crystal microbalance (QCM); apart from the trace gas & aerosol measurements from residue burning in Patiala district of Punjab in collaboration of Thapar University, the under such field campaign. A new low cost and highly effective nano material has been prepared for the removal of arsenic and chromium from contaminated water and a patent entitled "a process for the removal of arsenic and chromium from contaminated water" has been filed to Delhi patent office [0578-DEL 2010; 12th March 2010]. The aerosol particles collected at NPL on day and night-time basis analyzed for different chemical species had indicated that the fraction of water-soluble organic carbon (WSOC) in organic carbon (OC) is higher in day-time aerosols than in night-time aerosols. Further, more-WSOC fraction in total WSOC is higher in day-time than

in nighttime (Figure 5.2). This suggests for the local photochemical production of WSOC. Study revealed that the aerosols in Delhi are mostly from local sources and that the contribution of long-range transported particles is not that significant during the study period.

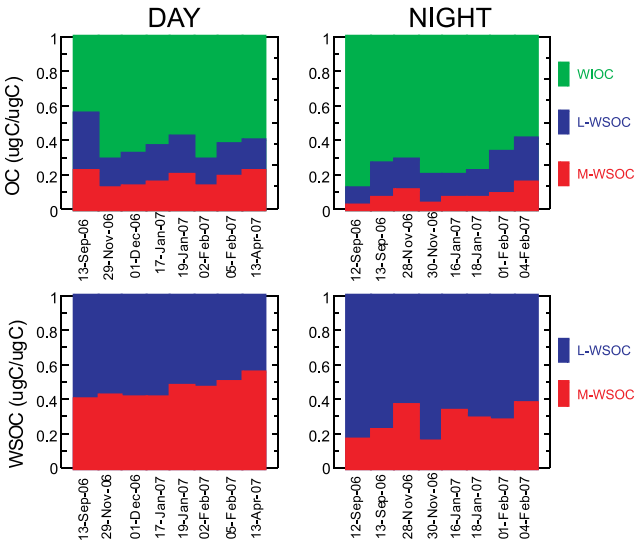


Figure 5.2 Day- and night-time distribution of water-soluble organic carbon (WSOC) fractions in organic carbon (OC)

Participation in international inter-comparison viz. APMP QM-P15 Pesticides in Tea and international PT in this area being organized by APMP-TCQM-DEC, has been assured from our network partners IITR Lucknow, IHBT Palampur, CFTRI Mysore, IICT Hyderabad, and IARI Delhi. Participated in international inter-comparison viz. CCQM-K-51 (CO in nitrogen) and CCQM-K76 (SO_2 in nitrogen), coordinated and conducted by NMISA South Africa and NIST USA respectively. Four new CRMs of mono [BND-2105.01 Potassium, BND 501 & BND 505 Silver] and multi elemental [BND-2301.01 Lead, Cadmium & Nickel] solutions have been prepared, validated and ready to release. NPL, CFTRI, IITR had participated in APMP.QM-K24 and P-12 comparison of cadmium content in rice powder. Helping MiC partners participation in international PT (Arsenic, Cadmium and Lead in Seafood) and key (APMP.QM-P19 Malamine in milk powder; APMP.QM-K89 & P-18 Trace and essential elements in herb) comparisons.

Figure-5.3: MiC Training workshop and Discussion meeting (Measurement Uncertainty and Traceability), 01-03 July 2009, IHBT, Palampur, H.P.

EPR & IR Spectroscopy

Ferrofluids are the novel and technologically advanced colloidal dispersion of nanosize (2-20 nm) ferro-ferri magnetic particles in some suitable liquid medium. A true magnetic fluid is homogeneous through their volume and stable over time. These fluid move as whole in the direction of applied magnetic field up and down and all around the obstacles. Therefore ferrofluid acts as intelligent and smart material. The application potential of these fluids in the technological and medical field have been already explored and now it has gained technical importance in everyday life. Ferrofluids display (bulk-scale) paramagnetism and are often referred as superparamagnetic due to their large magnetic susceptibility.Keeping this in view we have developed nano NiZn ferrite for the preparation of ferrofluid.

Nanocrystalline nickel zinc magnetic particles have drawn considerable attention of researchers due to their wide range of potential applications such as high-density information storage devices, microwave devices, transformer cores, NEM/MEMs, magnetic fluids, etc. The surface to volume ratio of these nano-magnetic materials is very large as compared to the bulk due to which they exhibit unique properties such as spin canting, surface anisotropy, superparamagnetism, etc. Nickel and zinc are known to have strong preference for the tetrahedral and octahedral sites, respectively, making nickel ferrite a model inverse ferrite and zinc ferrite a model normal ferrite.

Nickel zinc ferrite nanoparticles $Ni_xZn_{1-x}Fe_2O_4$ (x=0.1,0.3,0.5) have been synthesized by a chemical co-precipitation method. The samples were characterized by X-ray diffraction, Fourier transform infrared spectroscopy, electron paramagnetic resonance, dc magnetization and ac susceptibility measurements. The X-ray diffraction patterns confirm the synthesis of single crystalline $Ni_xZn_{1-x}Fe_2O_4$ nanoparticles shown in Fig.5.4.

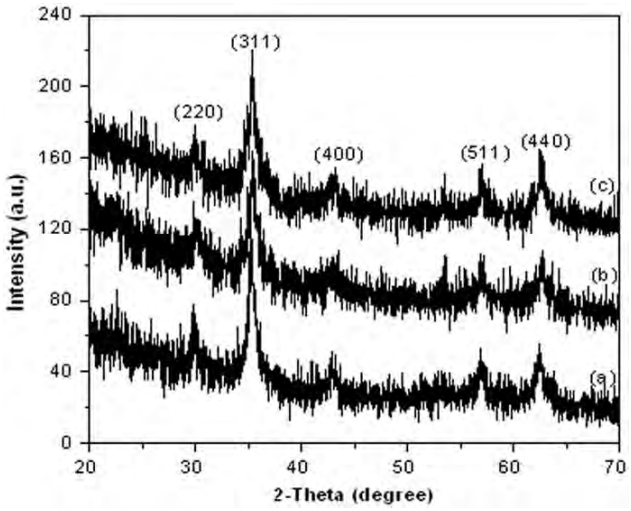


Fig.5.4. X-ray diffractograms of $Ni_xZn_{1-x}Fe_2O_4$ samples: (a) x=0.1,(b) x=0.3and (c) x=0.5

The lattice parameter decreases with increase in Ni content resulting in a reduction in lattice strain. Similarly crystallite size increases with the concentration of Ni. The magnetic measurements show the superparamagnetic nature of the samples for x=0.1 and 0.3 whereas for x=0.5 the material is ferromagnetic. The saturation magnetization is 23.95emu/g and increases with increase in Ni content. The superparamagnetic nature of the samples is supported by the EPR and ac susceptibility measurement studies.

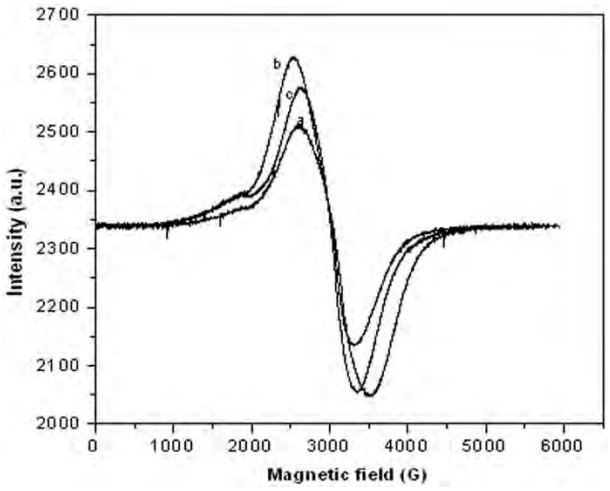


Fig. 5.5 EPR spectra for $Ni_xZn_{1-x}Fe_2O_4$ samples: (a) x=0.1,(b) x=0.3and(c) x=0.5

The EPR spectra of $Ni_xZn_{1-x}Fe_2O_4$ (x=0.1,0.3 and 0.5) nano composites were recorded atambient temperature and are shown in Fig. 5.5. The spin concentration is calculated by the comparison method where DPPH isused as a standard reference material. Spin concentration also follows the same trend like linewidth, i.e. it increases in $Ni_{0.3}Zn_{0.7}Fe_2O_4$ sample and then decreases in $Ni_{0.5}Zn_{0.5}Fe_2O_4$ sample. This indicates the strong superexchange interactions among the cations through oxygen ions present in $Ni_{0.5}Zn_{0.5}Fe_2O_4$ nanoparticles. The spin relaxation process is represented by a time constant and is a function of magnetic field. It depends upon the rate at which microwave energy can be absorbed

and emitted to the surrounding spins. The spin–spin relaxation time constant is determined from the following equation:

$$1/T_2 = (g5\beta\Delta H1/2)$$

$$and\ \Delta H_{1/2} = (3)1/2\Delta H_{pp}$$

where g is g-value, b is Bohr magnetron, ΔH1/2 is the line width at half of the absorption peak and is a constant.

It is observed that the relaxation time decreases with increase in nickel content. The superparamagnetic relaxation at the surface of nanoparticles in the $Ni_{0.1}Zn_{0.9}Fe_2O_4$ sample causes an increase of relaxation time for smaller particles. The pronounced change is observed in $Ni_{0.3}Zn_{0.7}Fe_2O_4$ sample. The change in spin–spin relaxation time is attributed to the decrease in electron motion in $Ni_{0.3}Zn_{0.7}Fe_2O_4$ sample and weakening of super exchange interaction in lattice. While in $Ni_{0.5}Zn_{0.5}Fe_2O_4$ sample, the relaxation time further improved due to enhancement of super exchange interaction among magnetic ions through oxygen. These studies revealed that magnetic dipole interactions among nanoparticles and super exchange interaction between magnetic ions with oxygen ion are the two main factors that determine EPR resonance parameters. Strong dipole interactions give a large peak-to-peak line width and g-value while strong super exchange interaction produces small value of peak-to-peak line width and g-value. The increase in nickel concentration causes increase in motion of electrons, which results in stronger super exchange interaction among cations via oxygen ions and decreases peak-to- peak line width and g-value.

Magnetic measurements were carried out on these samples at room temperature using these arch coil method. From these measurements saturation magnetization(Ms), remanence(Mr) and coercivity(Hc) were evaluated. The magnetization curves demonstrate a typical superparamagnetic behaviour of the as-prepared $Ni_{0.1}Zn_{0.9}Fe_2O_4$ and $Ni_{0.3}Zn_{0.7}Fe_2O_4$ nanoparticles with zero remanence and coercivity. The superparamagnetism of these nano particles can be attributed to their fine crystalline size, which makes it easier for them to be thermally activated to overcome the magnetic anisotropy. For $Ni_{0.5}Zn_{0.5}Fe_2O_4$ sample a small hysteresisis observed, indicating the ferromagnetic nature of the material at room temperature. This can be attributed to the comparatively larger crystallite size of the sample.

It is seen that saturation magnetization for $Ni_{0.1}Zn_{0.9}Fe_2O_4$ is 23.95 emu/g and increases with increase in nickel content. The smaller value of saturation magnetization may be due to lattice defects and random orientation of spin on the surface of the nanoparticles. Measurements of temperature dependence of ac susceptibility give information on possible phase transition. The temperature dependence of ac susceptibility of these samples measured in the 77–300 K temperature range. It is seen that $Ni_{0.1}Zn_{0.9}Fe_2O_4$ sample shows a sharp transition starting at T=87K. As the Ni content increases the on set of transition shifts towards higher temperature and is found to beat 138 K for $Ni_{0.3}Zn_{0.7}Fe_2O_4$ samples. For $Ni_{0.5}Zn_{0.5}Fe_2O_4$ sample no such transition is observed in the studied temperature region (77–300 K). This can be attributed to the ferromagnetic nature of $Ni_{0.5}Zn_{0.5}Fe_2O_4$ sample at room temperature as observed from magnetization studies. The blocking temperature (TB) was determined by taking the derivative of the Δχ–T data. From the measured data it is seen that the blocking temperature increases

with increase in nickel content. The increase in blocking temperature with increase in nickel content is due to strengthening of superexchange interactions and can be attributed to the decrease in the distance between the moments of A and B sites, which is confirmed by the decrease in the lattice parameter with increase in nickel content.

Crystal Growth and Crystallography

Growth and characterization of strategic and technologically important nonlinear optical (NLO) and dosimeter crystals

Crystalline state is the most stable state of the solids and the properties can be well predicted in this state. One can realize the various properties of the single crystals with full efficiency only when the crystals are perfect. Crystalline perfection becomes more stringent in the modern devices due to miniaturization. Continuous efforts are going on to improve the crystalline quality. High-resolution X-ray diffraction (HRXRD) methods play an important role to evaluate the crystalline perfection of single crystals or epitaxial layers because of their non-destructive and convenient nature with good accuracy. Various properties of single crystals depend on their crystallographic structure and the impurities or intentionally introduced dopants. For these studies powder X-ray diffractometry and X-ray florescence (XRF) spectroscopy are the well-established techniques. Due to potential applications of nonlinear optical (NLO) materials in laser and photonics industry, growth and characterization of NLO materials is also an important activity. Radiation detection is also an important task. For obvious advantages related to semiconductor industry and the special advantages of nanocrystals / nanocomposites growth and characterization single crystals as well as nanocrystals of II-VI and III-V semiconductors is also an important R&D activity. In view of the above facts, various NLO single crystals, LiF single crystals (for dosimeters) and single crystals and nanocrystals of II-VI and III-V semiconductors have been grown and characterized by powder XRD, XRD and HRXRD methods. Various device properties like optical transmittance, photoluminescence, second harmonic generation, dielectric, piezoelectric and ferroelectric properties have been characterized.

Some of the important R&D achievements (which were published in 21 SCI journals) obtained during this year are as follows: (i) Synthesis, growth, optical, dielectric and thermal studies of lithium hydrogen phthalate dihydrate crystals (ii) Growth and characterization of glycine picrate, (iii) Growth and characterization of organic non-linear optical crystal 4-hydoroxy benzaldehyde-N-methyl 4-stilbazolium tosylate (HBST), (iv) Synthesis and growth of nearly perfect single crystal of l-histidine bromide (LHB) and its structural, optical and electrical characterizations, (v) Growth and characterization of a new NLO material: l-Glutamic acid hydro bromide [l-GluHBr], (vi) Nucleation studies and characterization of potassium thiocyanate added KDP crystals grown by seed rotation technique, (vii) Growth of LiF Single Crystal and its Characterization by HRXRD, UV-Vis., Photoluminescence and Impedance Analyzer, (viii) Effect of alkaline earth and transition metals doping on the properties and crystalline perfection of potassium hydrogen phthalate (KHP) crystals, (ix) Synthesis, growth, spectral, thermal, mechanical and optical properties of 4-chloro 4_dimethylamino-benzylidene aniline crystal: A third order nonlinear optical material (x) Investigations of structural, dielectric and optical properties on silicon ion irradiated

glycine monophosphate single crystals, (xi) Effect of ammonium malate on growth rate, crystalline perfection, structural, optical, thermal, mechanical, dielectric and NLO behaviour of ammonium dihydrogen phosphate crystals, (xii) Characterization of ZnSe nanoparticles synthesized by microwave heating process, (xiii) Studies on L-valinium Picrate Single Crystal: A Promising NLO Crystal having 60 times SHG efficiency than that of standard KDP , (ix) Growth of Fe-doped $LiNbO_3$ Single Crystals and its Characterization by HRXRD and UV-Vis. studies, (x) Dielectric behaviour and ac electrical conductivity analysis of ZnSe chalcogenide nanoparticle, (xi) Rare earth cerium doping effects in nonlinear optical materials: Potassium hydrogen phthalate (KHP) and tris(thiourea)zinc(II) sulfate (ZTS), (xii) Growth, structural, optical, thermal and mechanical studies of novel semi-organic NLO active single crystal: Heptaaqua-p-nitrophenolato strontium (I) nitrophenol (xiii) Enhancement of SHG efficiency by urea doping in ZTS single crystals and its correlation with crystalline perfection as revealed by Kurtz powder and high-resolution X-ray diffraction methods and (iv) Optical characterization of ferroelectric glycinium phosphite single crystals. Two of these studies are described briefly (as typical examples) in the following.

The enhancement of second-harmonic generation (SHG) efficiency by urea doping in tristhioureazinc(II) sulfate (ZTS) single crystals and its correlation with crystalline perfection have been investigated Fig. 5.6. ZTS is a potential semiorganic nonlinear optical material. Pure and urea-doped single crystals of ZTS have been successfully grown by the slow evaporation solution technique. The presence of dopant has been confirmed and analysed by Fourier

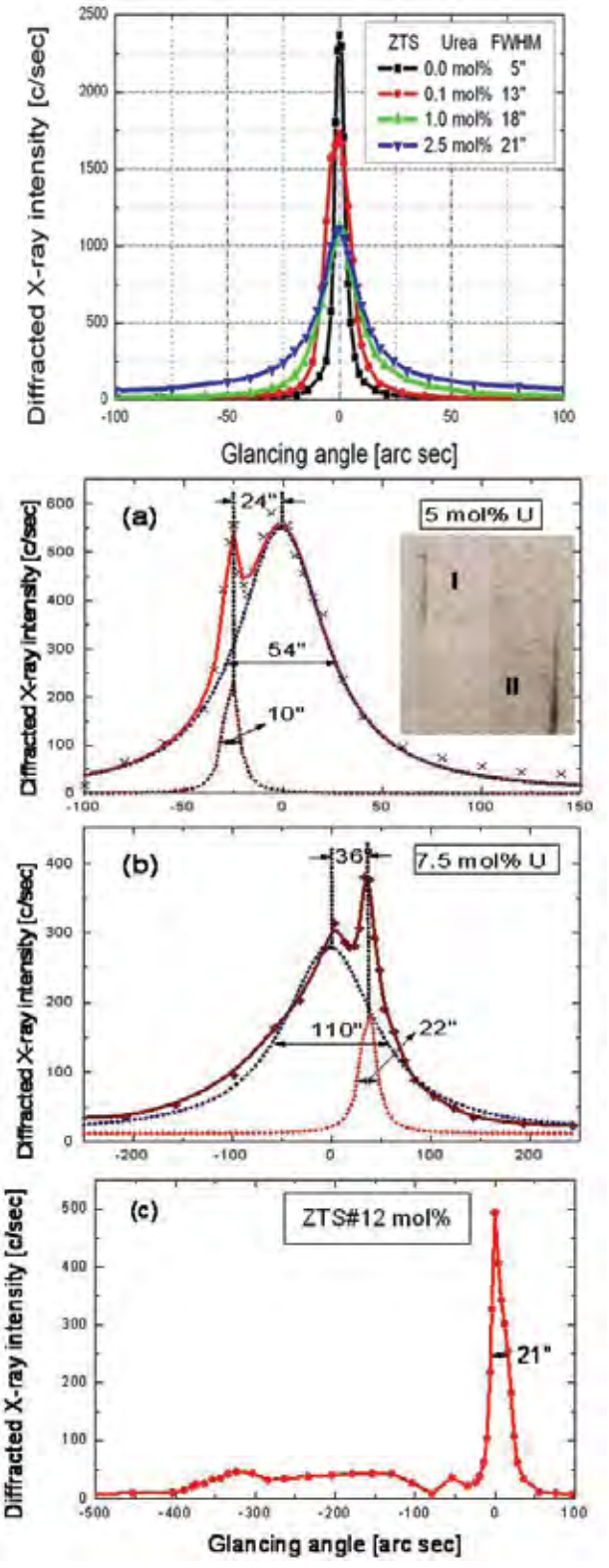


Fig.5.6 Effect of urea doping on crystalline perfection in ZTS.

transform infrared spectrometry. The influence of urea doping at different concentrations on crystalline perfection has been thoroughly assessed by high-resolution X-ray diffractometry (HRXRD). HRXRD studies revealed that the ZTS crystals could accommodate urea up to a critical concentration without any deterioration in crystalline perfection. Above this concentration, very low angle structural grain boundaries developed and it seems the excess urea above the critical concentration was segregated along the grain boundaries. At very high doping concentrations, the crystals were found to contain mosaic blocks. The SHG efficiency has been studied using the Kurtz powder technique. The relative SHG efficiency of the crystals was found to increase substantially with the increase in urea concentration. The correlation found between crystalline perfection and SHG efficiency is discussed [J. Appl. Cryst. (2010). 43, 154-162].

The bulk single crystal of Lithium Fluoride (LiF; a excellent candidate for dosimeters and X-ray monochromators) was grown by homemade Czochralski crystal puller. The effect of necking has been studied. The crystalline perfection of the grown crystal was assessed along the length of the boule at different parts as indicated by the numbers from #1 to 5 using high-resolution X-ray diffractometer and found that the grain boundaries which were present in the seed crystal (region #1) were stopped gradually from propagating in to the bulk crystal by necking. After two times necking, the regions #3, 4 and 5 are free from grain boundaries. Region #4 was found to be the best region with full width at half maximum of 60 arc s. However, the region #3 contains a few interstitial defects and #5 contains vacancy defects which could be due to deficiency of Li due to prolonged heating. The UV-Vis

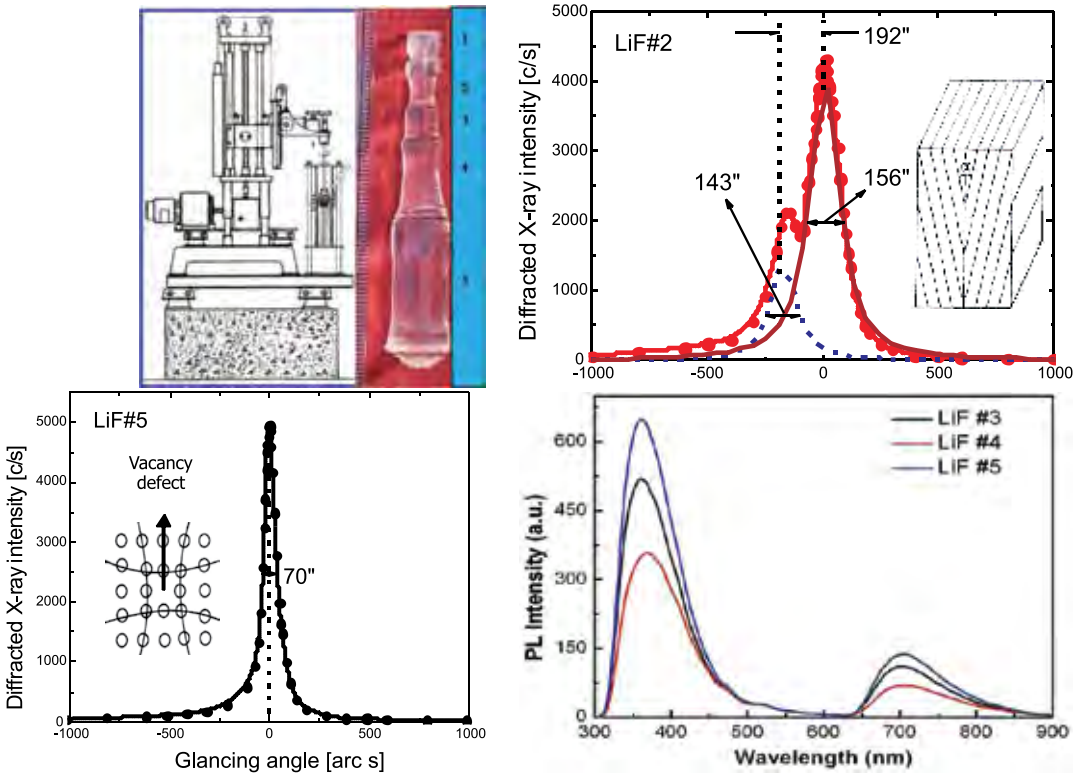


Fig.5.7 LiF crystal along with the in-house developed CZ-crystal puller, high-resolution diffraction curves and photoluminescence spectra.

transparency of the defect free region found to be slightly higher. Photoluminescence (PL) spectra recorded for specimens for regions #3, 4 and 5 shows that the PL is maximum for the specimen (#5) due to color centers associated with the observed vacancy defects. The dielectric studies have also been carried out over a wide range of frequency. The investigated optical transparency, photoluminescence and dielectric properties are in coherence with the crystalline perfection which are in turn found to be governed by the process of necking (for more details please see, Proceedings of XVth IWPSD-2009, Pg. 384-388).

Development of Certified Reference Materials for Powder X-ray Diffraction

Under the Network Project (NWP-045) on Planning, Preparation, Certification and Dissemination of Certified Reference Materials being coordinated by National Physical Laboratory, work is being carried out for development of certified reference materials for powder X-ray diffraction. At present, lanthanum hexaboride is being developed as certified reference material (CRM) or Bhartiya Nirdeshak Dravya (BND) for powder X-ray diffraction (XRD) line positions. Commercially purchased LaB_6 were characterized and found to be good. To improve the crystalline perfection of this polycrystalline powder, annealing experiments are in progress for which the furnace has been developed and calibrated.

Synthesis and Characterization of Nanocrystalline Zinc oxide

In continuation of our work on investigation of growth and characteristics of zinc oxide, pure and doped (Mn and Mg doped) samples were prepared by wet-chemical method under different conditions. The samples were investigated for crystalline phase, crystallite size, morphology, luminescence and vibrational characteristics by XRD, SEM, PL and FTIR-Raman techniques. Effect of growth conditions and doping on the above characteristics were examined.

R&D Collaborations: This group is also actively involved in helping or collaborating various R&D projects from other groups of NPL and various outside laboratories and educational institutes by characterizing variety of single crystal samples, epitaxial films and powder samples by in-house developed multicrystal X-ray diffractometer and Bruker AXS D8 Advance Powder X-ray Diffractometer. Around 120 single crystal samples to study the crystalline perfection or to study the effect of dopants or functional groups added to the semi-organic materials have been characterized by high-resolution X-ray diffractometry. Around 440 powder/film samples of oxides, ceramics, semiconductors, alloys, carbon and carbon composites, carbon nanotubes, ferrites, superconductors, conducting polymers, non linear materials etc have been characterized for structural studies and phase analysis for various projects at NPL on materials development using powder XRD.

Implementation of quality system is going on. The PXRD and the XRF labs were renovated to meet the quality system requirements. The internal audit of the Powder X-ray Diffraction Laboratory was done and most of the NC's were closed by the Quality Manager after suitable action was taken. Traceability and uncertainty issues are to be dealt.

The important technical achievements are: (i) After all necessary pre-installation arrangements like installation of existing chilling plant, preparation of room for electrical, civil and

plumbing work etc. the newly procured Rigaku ZSX Primus XRF system has been installed successfully. After testing for solid as well as liquid materials using certified reference materials, the test report has also been submitted. (ii) For the above XRF system, a 20 kVA UPS was indented with necessary approval for funds. (iii) Crystal growth of BSO (bismuth silicon oxide) and Zn-doped lithium niobate by Czochralski technique is in progress. The necessary modifications for the crucible setup for the improvement of temperature gradient have been done.

Electron Microscopy

Electron microscopy facilities are being utilized at NPL as the central facility for the characterization of materials. This group is equipped with state of the art and most modern equipments such as SEM, TEM and high resolution TEM with EDS and STEM attachements. Different types of samples in the form of thin films, powders, and composites prepared by various techniques have been received from different groups of NPL working on the development of new and advanced materials. These samples have been characterized for their particles shape, size, distribution of particles, phase identification and crystallographic structure etc., using these facilities.

Many industrial units and other scientific organizations have also made use of this facility for different type of materials characterization and testing for quality improvement of their products, which has resulted in generation of considerable ECF to the laboratory. Responsibilities included maintenance, up gradation and operation of the microscopes together with carrying out studies and investigations of new trends in the field of nano-materials have been the major work of the group. Electron microscopy group is doing basic research towards shape and size control of nanostructures as well as their synthesis using different methods: chemical as well as physical routes. Collaboration with some very prominent groups in the field of nano-science in NPL, user industries and other research institutions has been another activity of the group.

Development of resolution standard for Transmission Electron Microscope and HRTEM under CSIR Network Project NWP-0045 through chemical route and using thermal evaporation technique is also in progress.

Recently new Variable Pressure SEM (VPSEM) along with EDS attachment has been procured and installed in Centre for Nano Scale Science at the HEPP Building. The system is functional and open for material characterization work of the laboratory. The new Variable Pressure SEM is capable of characterizing insulating samples i.e without coating gold thin layer on them.

Some of the samples which were characterized by using TEM and HRTEM are carbon nanotubes prepared by different methods, Thin films of bismuth telluride, cadmium telluride and SnO_2 prepared by thermal evaporation

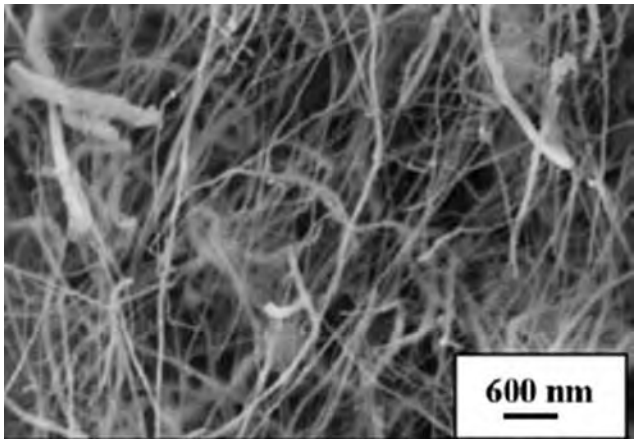


Fig.5.8(a) Scanning electron microscope (SEM) image of a cluster of Boron Nitride Nanotubes

technique. Ag nano particles, Al/Si alloy, Y_2O_3 powder calcinated at different temperatures, Lithium ferrites prepared by different routes, Gold on grapheme, cobalt ferrite powder, Cryo-milled Al powder, ZnS capped with PVP and SiO_2 etz. Some of the results obtained by using SEM and HRTEM is shown below in Fig.5.8 (a) and (b)

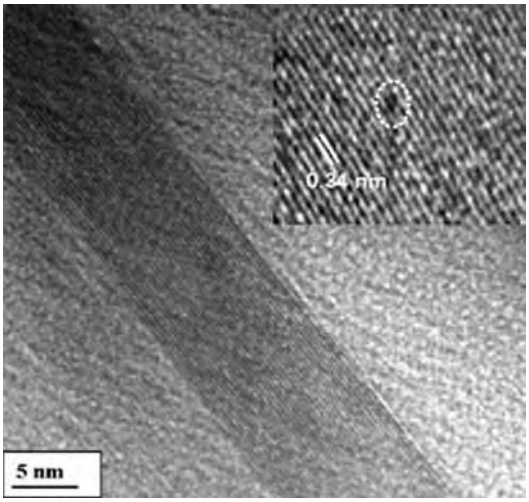


Fig.5.8(b) High – resolution transmission electron microscope (HR-TEM) image showing multiwalled structure of Boron Nitride Nanotubes. Inset shows an interlayer separation of 0.34 nm. A defect structure is also marked in the inset. These nanotubes are prepared at Engineering Materials Division of NPL.

About 90 samples were received from the various groups of NPL working on the development of new and advanced materials and have been examined by TEM and HRTEM for particle size, shape, microstructure and electron diffraction and phase identification. This facility was also extended to various industries

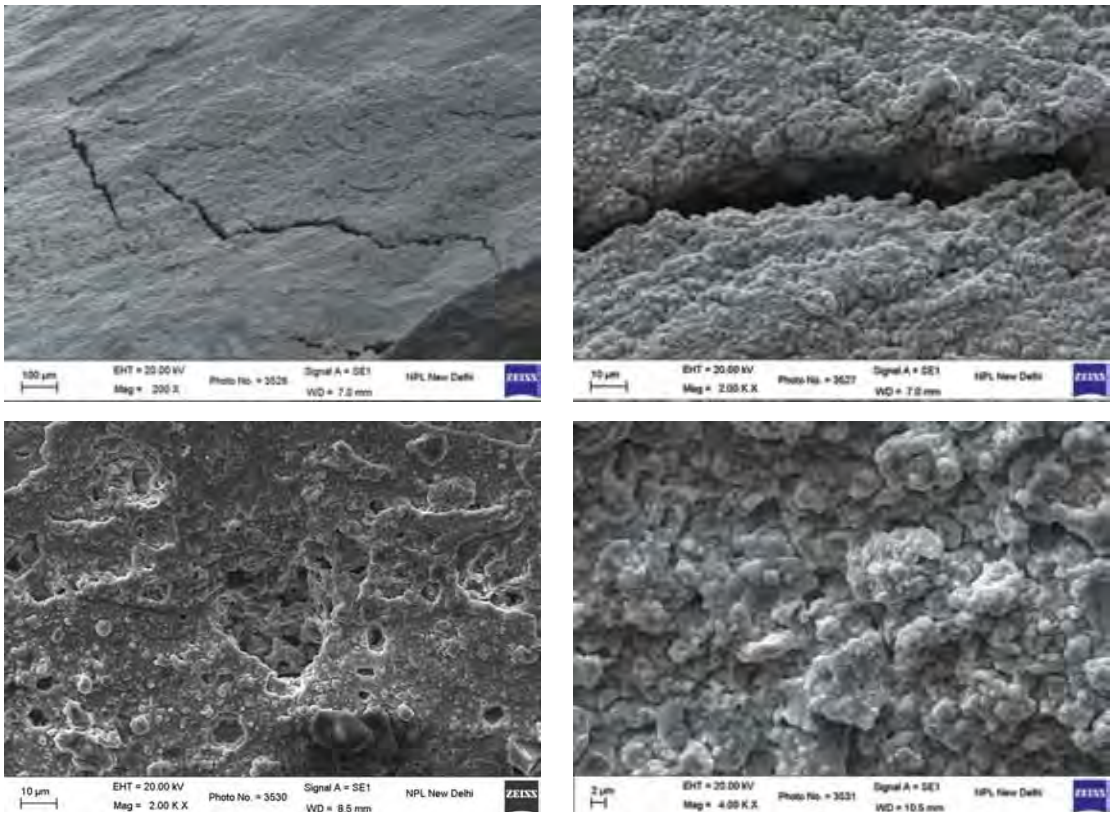
Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) is another central facility of the laboratory which is extensively used by various R & D groups of NPL, other scientific R & D institutes and Industrial organizations for characterization of materials for surface microstructure and chemical compositional measurement. Some of the materials characterized by using SEM are Zn + Graphitized carbon powder grown by thermal heating, ,Grapheen sheets with silver on silicon substrate by dip coating method, Particulate matter/filter paper collected from different locations, Au film/ITO, gold nanoparticles with enzyme and gold nanoparticles with pyrol, Al, Al_2O_3, $Al+Al_2O_3$ powders ball milled, Alkaline and acid texturised micro crystalline Silicon, Porus Silicon samples, WO_3-PEDOT thin films/ CTO glass deposited by electro-deposition, Porous Silicon grown in micro channels /Si, Gold nanoparticles with and without enzymes, High Tc Superconducting Bi2223 samples, Mg ferrite and Li-Mg Ferrite samples.

A total of more than 1300 samples have been examined by SEM and EDS for surface microstructure and compositional analysis of materials for different R&D groups of NPL.

SEM and EDS facility is also used by the industry for carrying out different type of testing and analysis work. During the period different samples were received from industry for particle size, shape, surface structure, fracture analysis, thickness and chemical compositional analysis. Some of the industries for which SEM/EDS analysis were carried out are M/s. Moserbaer India Ltd., Noida, UP, M/s. Samtel Color Ltd.,Ghaziabad, UP, M/s. Global Autotech, New Delhi, M/s.Moserbaer Photovoltaic Ltd., Noida, M/s.Ranbaxy Res. Labs. Ltd. Gurgaon, M/s. AGC Chemicals Ltd., New Delhi, M/s.NeoTech consultants, Morena, MP, M/s. Bry Air (Asia) Pvt. Ltd., Gurgaon, M/s. NTPC Ltd., Noida

Fig. 5.9 shows the SEM micrographs of the copper contact wire sample supplied by the M/s Delhi Metro Rail Corporation depicting micro cracks developed on the periphery of the contact wire.

ABB DMRC (FRACTURED PIECE)



DELHI METRO COPPER CONTACT WIRE SHOWING
CRACK INITIATION FROM THE PERIPHERY AND PITS

Fig. 5.9 Shows the SEM micrographs of the copper contact wire sample supplied by the M/s Delhi Metro Rail Corporation

Secondary Ion Mass Spectroscopy

A state of the art time of flight Secondary Ion Mass Spectrometer (TOF-SIMS) was procured (Model TOF.SIMS 5-100) from M/S IONTOF GmbH, Germany, and installed at the newly created Centre for Nano-scale Science (CNS) (Fig.5.10). The machine is equipped with a Bismuth liquid metal ion gun (LMIG) for main secondary ion creation and detection while two other ion sources are attached as electron impact guns (Cs & oxygen) for sputtering purposes. The mass spectrometer is of Time-of-Flight type with a one meter long vertical coloumn with a mass resolution > 10,000 at 29 a.m.u. The lateral resolution for the Bi source is ~ 100nm for 2-D & 3-D chemical imaging and a depth resolution of ~1nm can be achieved in this equipment.

There are three modes of operation in the TOF – SIMS at NPL, New Delhi; Surface spectroscopy, Surface imaging and Depth profiling. The technique has ultra-high sensitivity to surface layers, and detection of atomic concentrations as low as 10 ppm. Surface layers of insulating materials, polymers, organics, inorganics and biological materials, can be analyzed readily. Using this technique, one can study the depth distribution of elements or molecules, which is called depth profiling (Profile depths from a few nm to several microns). Imaging is also very interesting and unique technique of TOF – SIMS for mapping of elements or molecules present on

the sample surface (2D Imaging) or with respect to depth (3D Imaging).

A good number of samples viz. 1) Cu-Cr-Fe alloy grid, 2) Au on Si wafer, 3) Teflon, 4) Delta doped B in Si, 5) B implanted Si were tested during the on-site training period and also later by the staff to standardize the equipment. Thereafter studies of some more samples were also carried out like 1) 2D Imaging of textile samples, 2) Depth profiles of multilayer TMR materials (CoFe/MgO/NiFe/Si), 3) some LED structures (Mg doped GaN/Sapphire) , and 4) Study of various impurities present on the Nb superconductor by depth profiling.

Fig. 5.10 Model TOF.SIMS 5-100 at the Centre for Nano Scale Science

Infrared and Raman Spectroscopy

Fourier Transform Infrared and Raman studies were carried out on carbon and silicon nano materials. Carbon and silicon are two elements available abundantly in nature and their nano materials have many useful applications. Whereas carbon nano tubes (CNT) have applications in the electrical, optical and biomedical fields, nano-crystalline silicon (nc-Si) have applications in photovoltaic and optoelectronics and is economical material for high efficiency solar cells. Nano carbon tubes and nano crystalline silicon have been characterized by Fourier Transform Infrared and Raman spectroscopy in the spectral regions of 4000-400 cm^{-1} and 3500-100 cm^{-1} respectively. Raman spectra of nano tubes have shown two new predominant peaks at 2572 cm^{-1} and 2060 cm^{-1} which have not been reported so far in literature and these peaks have been analyzed. Further, angular infrared reflectance and transmittance spectra of nano crystalline silicon were also investigated in the spectral region 4000-400 cm^{-1} and their results were compared with that of bulk Single crystal silicon. The developmental work related to IR spectrophotometric standards of specular and diffuse reflectance and transmittance at near normal and oblique angles of incidence was continued. These standards are useful for the calibrations of spectrophotometers and IR systems which have many applications in industry, defense, health and research areas. Calibration of Thermovision Camera from Power Grid Corporation of India, Hyderabad (A.P) was done. This camera remotely check the temperature of various processing units of power grid and also provide their imaging. This work helps various industries and government agencies.

Role of modified active surfaces sites of magnesium ferrite for humidity sensing was investigated. Raman studies of different samples were done to analyze the defective structure of spinal compound. This work has been done in collaboration with magnetic standards group. Advanced materials' characterization was done with specialized infrared techniques based upon specular reflection and regular transmittance at oblique angles of incidence. Angular reflection and transmittance measurements on various materials such as metals, semiconductors, dielectrics (insulators); in film and bulk form; in single, poly-crystalline, amorphous and nano states have been carried out. This work has open new areas in infrared and Raman spectroscopic techniques.

रेडियो तथा वायुमण्डलीय विज्ञान

RADIO AND ATMOSPHERIC SCIENCES

रेडियो एवं वायुमण्डलीय विज्ञान

रेडियो एवं वायुमण्डलीय विज्ञान प्रभाग की गतिविधियों में दो प्रमुख परियोजनाएं है। पहली परियोजना रेडियो भौतिकी और उसकी अनुप्रयोग परतें। इसमें आयनमण्डलीय एवं ट्रोपोस्फेरिक संप्रेषण के लिए रेडियो पर्यावरण और उससे सम्बन्धित दूसरे अनुप्रयोग हैं। आयनमण्डलीय संप्रेषण के लिए विशेष तौर पर अंतरिक्ष भौतिकी, उच्च आवृत्ति संप्रेषण, नेवीगेशनल अनुप्रयोग शामिल हैं जबकि ट्रोपोस्फेरिक संप्रेषण में रेडियो आवृत्तियों का स्थलीय एवं पृथ्वी के स्पेस पर फैलाव का अध्ययन किया जाता है। यह बहुत उच्च आवृत्ति से लेकर कई गीगा आवृति तक है। अंतरिक्ष भौतिकी के अंतर्गत अलग–अलग वायुमण्डलीय पैरामीटर का मापन, आयनोसोन्दे जीपीएस और CRABEX रिसीवर के द्वारा विभिन्न भारतीय स्थानों एवं एंटार्कटिका पर किया जाता है। इससे प्राप्त परिणामों का विश्लेषण करके आयनमण्डलीय चलाय मानक एवं आयनमंण्डलीय माडलस का प्रतिस्थापन किया जाता है। इसमें आने वाली सोलर चक्र 24, टोटल इलेक्ट्रॉन सांद्रता की भविष्यवाणी संबन्धित आंकड़े प्रस्तुत किया गए हैं। भारतीय एंटार्कटिका स्टेशन पर एल बैण्ड प्रस्फुरण (सिनटिलेशन) का आगमन, सूर्य ग्रहण का आयनमण्डलीय घटकों पर प्रभाव, भारतीय भूमध्यीय एवं निम्न अक्षांश क्षेत्र पर इसके प्रभाव का अध्ययन किया जाता है। सौर प्रदीप्ति (सोलर फ्लेयर) का मंगल के आयन मण्डल पर प्रभाव एवं फिक्सड व मोबाइल कम्युनिकेशनस् की माडलिंग का अध्ययन भी किया जाता है। अन्य विषयों पर जैसे ग्रीन हाउस गैसों का प्रभाव एवं उसका गुणात्मक अध्ययन, कोहरे में व्याप्त जल वाष्प एवं पानी की मात्रा का अध्ययन भी किया जाता है।

दूसरी परियोजना वायुमण्डलीय पर्यावरण और जलवायु परिवर्तन विषय पर है। इसमें प्रमुख है बंगाल की खाड़ी के ऊपर मैरीन बाउन्ड्री परतों में एरोसोल और इसकी प्रारंभिक गैसों का वितरण में, सूर्य ग्रहण का सतहीय ओजोन, नाइट्रस आक्साइड, नाईट्रिक आक्साइड, अमोनिया, कार्बनमोनो आक्साइड और उनका मिक्सिंग अनुपात और सल्फरडाई आक्साइड का दिल्ली पर बदलाव आदि। ट्रॉपिकल स्ट्रेटोस्पेरिक ओजोन का लंबे अंतराल में बदलाव, अलग–अलग प्रकार के ऐरोसोल जैसे PM_{10} वायमुण्डलीय ऐरोसोल की रसायन शास्त्र इत्यादि। ऐरोसोल की आप्टिकल गुणों का अध्ययन लिडार द्वारा मापन करके किया जाता है। सूर्यग्रहण के समय ओजोन कालम (Column) की मात्रा में बदलाव, ओजोन डिपलीशन जैसी घटनाओं का भारतीय आर्कटिक क्षेत्र हिमाद्री में मापन जोकि 2010 की बसंत ऋतु में किया गया। ग्रीष्म, वर्षा मौसम के अत्यंत कम कोल्ड प्वांइट ट्रोपोपॉस का अध्ययन वायुमण्डलीय प्रदूषण पूर्वगामी (Precursor) विधि का अध्ययन भारतीय महानगरों पर इसकी माडलिंग और हीट स्ट्रेस का मानवीय स्वास्थ्य पर इसके प्रभाव का अध्ययन किया गया है। इन सबसे मानवीय स्वास्थ्य पर किस प्रकार की अनुकूल नीति अपनाई जाए इसका भी विस्तृत विवरण किया गया है।

RADIO AND ATMOSPHERIC SCIENCES

The activities of the Radio and Atmospheric Sciences Division comprise with two major projects of the laboratory. The first project is related to "Radio Physics and Applications". It deals with the characterization of radio environment for ionospheric and tropospheric communication and other applications related work. For ionospheric communication , the contributions are mainly on space physics, HF communication and navigational application while for tropospheric communication, it includes all aspects of radio wave propagation over both terrestrial and earth space paths covering the frequency range from VHF up to many giga hertz. Under the area of space physics, different ionospheric parameters are measured from Ionosondes, GPS and CRABEX receivers over different Indian locations and Antarctica to deduce results on ionospheric dynamics as well as to develop and validate the ionospheric models. A detailed investigation has been presented regarding the prediction of forthcoming Solar Cycle 24, GPS derived total electron content variations, occurrence of L-band scintillation over Indian Antarctica station, solar eclipse effects on ionospheric parameters over the Indian equatorial and low-latitude region as well as solar flare effects in the ionosphere of Mars. Radio channel measurements and modeling for fixed and mobile communications, development of a software for Phased Array Acoustic Wind Profiler and quantitative estimation of the greenhouse effects due to water vapour and liquid water in radiation fog also have been reported.

The second project is entitled "Atmospheric Environment and Global Change". The main achievements in this project are the distribution of aerosol and its precursor gases in the marine boundary layer over Bay of Bengal, effects of the solar eclipse on the surface O_3, NO, NO_2, NH_3, CO mixing ratio, ambient ammonia distribution and variation of ambient SO_2 over Delhi. Long term variation in tropical stratospheric ozone and its temporal variations, studies on various aspects of aerosols such as chemistry of PM_{10} atmospheric aerosols and Lidar measurements of optical properties of aerosol as well as fluctuation in ozone column during the solar eclipse, ozone depletion events observed at Indian Arctic station Himadri, during spring of 2010, occurrence of extremely low cold point tropopause temperature during summer monsoon season, atmospheric pollution precursor process modeling over mega cities and assessment of impacts of heat stress on human health and adaptation strategies have been presented in detail.

Radio Physics and Applications

Prediction of Solar Cycle 24 Using Geomagnetic Precursors: Validation and Update

Solar activity forecasting is an important topic for various scientific and technological areas, like space activities related to operations of low-Earth orbiting satellites, electric power transmission lines, high frequency radio communications and geophysical applications. The particles and electromagnetic radiations flowing from solar activity outbursts are also important for long term climate variations and thus it is very important to know in advance the phase and amplitude of the next solar and geomagnetic cycles. Solar cycle 24 has already commenced in December 2008. The maximum amplitude of solar cycle 24 might occur in mid-to-late 2012 as shown in Fig.6.1. Since, the current solar cycle 24 has already started and the observed monthly sunspots are available therefore in Fig. 6.1 the predicted along with the previous solar cycle 23 and the observed monthly sun spot numbers of sunspot cycle 24 are also shown for comparison.

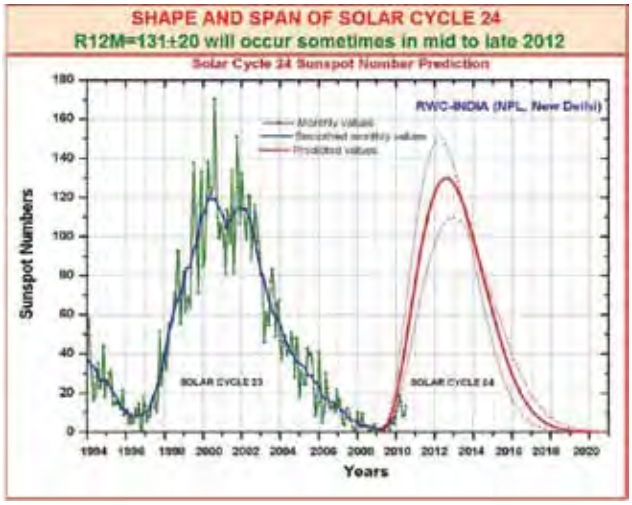


Fig. 6.1 For comparison, the predicted cycle 24 along with the previous solar cycle 23 and the observed monthly sun spot numbers of sunspot cycles 23 and 24 are shown.

GPS derived Total Electron Content (TEC) variations and the occurrence of L-band scintillation over Indian Antarctica station, Maitri

The ionospheric scintillation and TEC monitor receivers (GISTM) collect the TEC and scintillation data at every minute from the Indian Antarctic stations. Each GISTM can track up to 11 GPS signals at 1.575 GHz and 1.2 GHz and from which the slant TEC (STEC) for each of the satellites is derived and converted into vertical TEC (VTEC). The VTEC data thus obtained is processed for each of the satellite passes with an elevation mask angle greater than 30° in order to avoid the effects of low elevation angles, such as tropospheric, water vapour scattering and multi path effects. Figure 6.2 illustrates the latitudinal coverage area of GPS satellites over Maitri with an elevation mask angle of 30°. Therefore the TEC observations are restricted to a latitude grid of ±3° and longitude grid of ±3° from the observing sites.

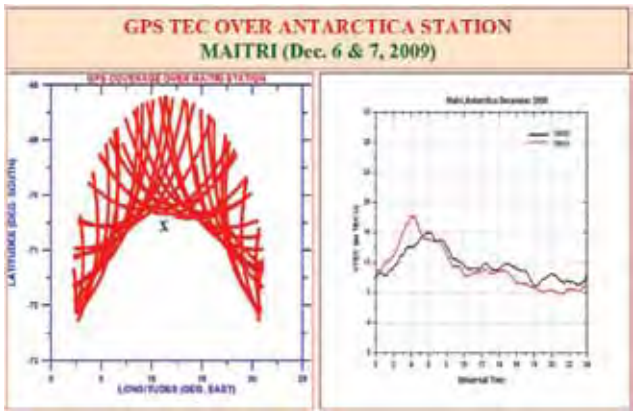


Fig. 6.2: The first panel shows the sub-ionospheric coverage of GPS over Maitri with an elevation mask angle of 30°. The second panel shows the diurnal variation of VTEC data at Maitri for December 6-7, 2009.

A total of one year of GPS-TEC data have been processed for Indian permanent station Maitri, Antarctica measured during the year of 2008.

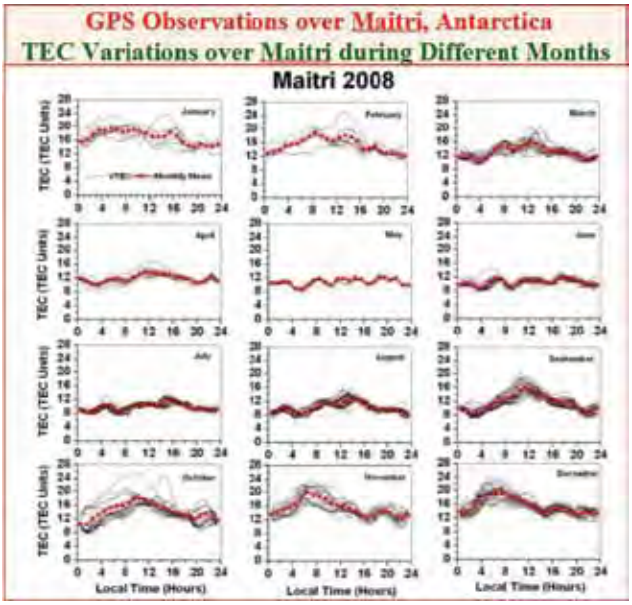


Fig. 6.3 Mass plot of diurnal variation of vertical TEC at Maitri from January 2008 to December 2008.

During the month of January TEC fluctuated between the ranges of 10 to 22 TECU. This type of behaviour of TEC in polar region depends on solar zenith angles. Figure 6.3 shows 12 month TEC behaviour in all months.

The L-band scintillations and the associated irregularities, about one year observations are carried our over Indian Antarctica Station by using dual frequency GPS receiver. Season wise (as noted from Figure 6.4), their maximum

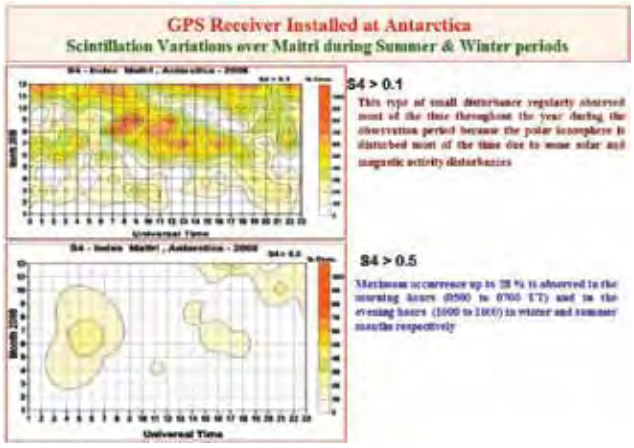


Fig. 6.4. Occurrence of scintillations during different months.

percentage occurrence is observed in winter season i.e. polar night periods from May to August 2008 as compared to summer and equinox seasons.

F-region parameters (foF2 and h'F) using Ionosonde measurements over Indian Antarctica station, Maitri

The interaction of solar-wind and sun blown high energetic particle with polar ionosphere is higher because of the almost vertical geomagnetic field lines. By using the Ionosonde system we monitor the bottom side ionospheric parameters in real time basis.

Figure 6.5 shows the diurnal pattern of foF2 and h'F variation during the month of November, July and September 2009 representing Summer, winter and Equinox.Fig.6.5 shows the mass plot of observed foF2 and h'F observations during these months along with the median values. It is seen that the maximum number of observation are available during the polar summer time, which is due to the fact that the source of ionization i.e. sun is available through out 24 hours. While, minimum number of observation are seen during polar winter month i.e. on the month of July, when the sun is not visible through out 24 hours. The results indicate that during polar winter Ionospheric F-layer nearly collapsed. Since the observations are during the low solar activity period i.e. for the year 2010, therefore the observed values of foF2 are few. The observations revel that the maximum foF2 was observed between 4 – 7 MHz, 3 - 4 MHz and 4 - 5 MHz during November (Summer), July (Winter) and September (Equinox) respectively.

Figure 6.6 shows the preliminary results of polar region ionospheric responses during the space weather event occurred on 10th March.2009. The results reveal that even a

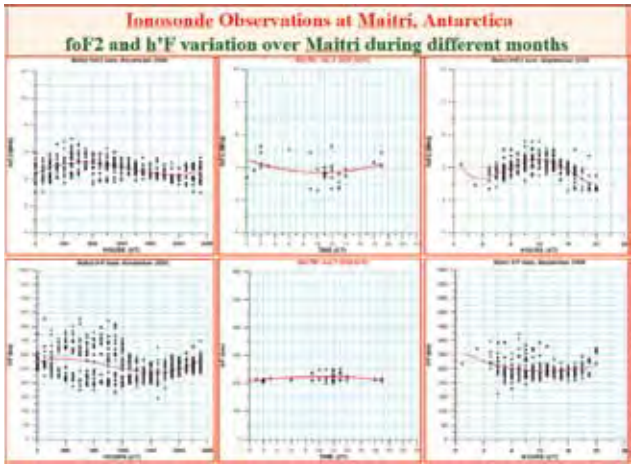


Fig. 6.5: Diurnal variation of foF2 over Maitri, Antarctica during the month of November, July and September 2009 representing summer, winter and equinox.

minor change in space-weather affects the polar region ionosphere. This is due to the fact that the earth's magnetic field lines are almost open at this region and allow the soft high energetic particles to penetrate and precipitate into polar region ionosphere.

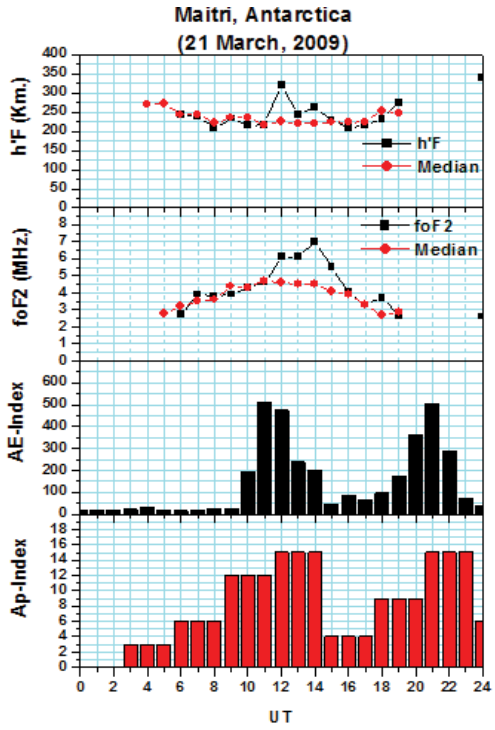


Fig.6.6 Variation of base height & critical frequency parameters of F-layer during the space weather event of March 21, 2009.

Ionospheric responses to the solar eclipse of July 22, 2009 and January 15, 2010 over the equatorial and low-latitude region of the Indian zone

Two solar eclipse events, July 22, 2009 and January 15, 2010 occurred with their paths of obscuration passing over northern and southern part of the Indian region. These two events are unique as the eclipse of July 22, 2009 was the total solar eclipse (TSE) and January 15, 2010 governed the longest annular solar eclipse (ASE) of the millennium. The maximum obscuration of TSE occurs during the dawn hours over the equatorial ionization anomaly (EIA) crest region while that of ASE occurs during the noon time hours over the equatorial region.

Ionospheric responses to the TSE of July 22, 2009:

Results show that in response to the total solar eclipse of July, 22 2009 over the EIA crest region, the TEC data does not show any variation. However, significant solar eclipse induced effect has been observed at the bottom side ionosphere during the dawn hours as shown is shown in Figs. 6.7 and 6.8. The notation B, E and T stands for the beginning, end and totality period of the solar eclipse respectively. The increase in the base height of the ionosphere (h'F) is seen just after the maximum occultation period. The depletion of foF2 appears jointly with increasing h'F during occultation and opposite is true as the de-occultation begins. Considerable decrease (of about 26 %) is seen in the critical frequency of the F2 region (foF2) during the maximum occultation period in comparison to reference day values.

The temporal variation of the bottom side electron density shows the dominant changes in the peak electron density during the solar eclipse.

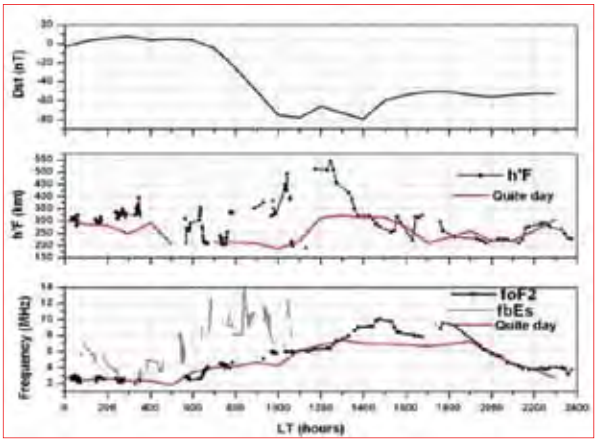


Fig. 6.7 shows diurnal variation of critical frequency (foF2) and base height (h'F) of F2 layer for the TSE day.

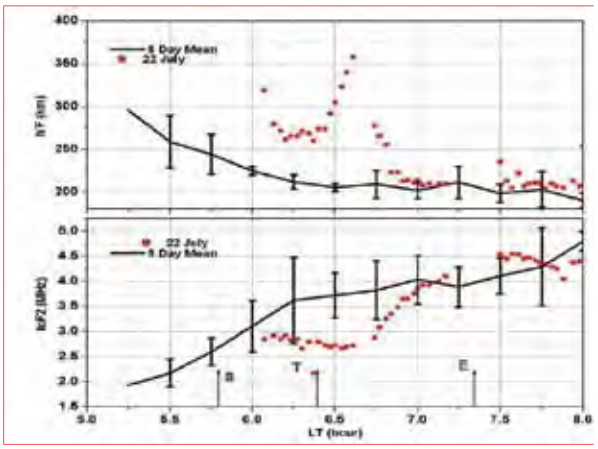


Fig. 6.8: shows variation of critical frequency (foF2) and base height (h'F) of F2 layer for the TSE day during the time interval 0500-0800 LT. The four day mean and the upper and lower bound of inter-quartile range are also plotted.

Thus, the electron density and foF2 follows the variations of local solar radiation flux and the maximum decrease in both the parameters is observed around the maximum solar occultation period. Thus, results suggest that during the dawn period photochemical process plays a significant role in the F2 region. The appearance of elevated and widespread sporadic-E layer was also one of the interesting features of the total solar eclipse event. The appearance of intense sporadic-E could be ascribed to the wind shearing introduced by the solar eclipse induced gravity wave.

Ionospheric response to the Annual Solar Eclipse of 15 January, 2010

The event of January 15, 2010 provided an opportunity to study the response of equatorial ionospheric to the longest annular solar eclipse. The Indian equatorial station, Trivandrum was also in the path solar eclipse. At Trivandrum the first contact (beginning) occurred at 11:04 LT and the last contact (end) occurred at 15:05 LT with a maximum obscuration between 13:10 to 13:17 LT. The study of solar eclipse induced effect over Trivandrum is performed by using the GPS derived total electron content (TEC) measurements. Study reveals the existence of trough like depression in the diurnal variability of TEC (Fig.6.9). The effect of the eclipse was detected more distinctly in the variations of TEC along individual satellite passes (Fig.6.10). The maximum depression of about 6 TECU is observed after the time of maximum occultation and the decreased values of TEC are seen up to the twilight hours i.e. after the 3 hours of the last contact of eclipse. It can also be inferred from the present results that the eclipse induced effect appears evidently during the noontime ionosphere in comparison to the daytime ionosphere.

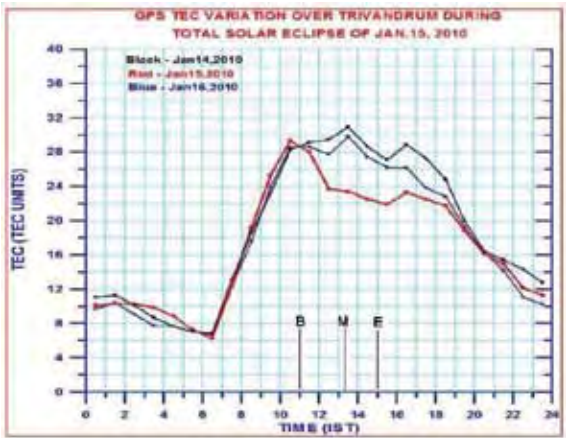


Fig. 6.9: shows the diurnal variation of TEC for the ASE day along with the reference days i.e. the pre-eclipse day and post-eclipse day.

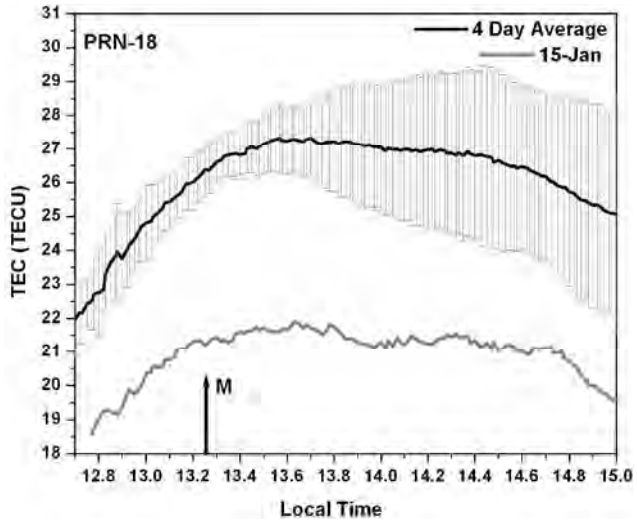


Fig. 6.10 The variation of TEC for the ASE day for PRN 12 along with the four day mean and the upper and lower bound of inter-quartile range.

IRI-2007 model model against TEC observations over Indian sector

Total Electron Content (TEC) is the most important parameter, since it provides overall description of the ionosphere and also is the key parameter for earth space telecommunications, satellite navigation systems etc. At present, one of the widely used models for the ionospheric predictions is the International Reference Ionosphere (IRI-2007). TEC observations over Indian obtained using ATS-6 geostationary satellite for sector covering stations from magnetic equator to beyond northern crest of the equatorial anomaly during low solar activity, are used to assess the IRI-2007 model as compared to IRI-2001. As an example Figure 6.11 given below illustrates the comparison of IRI 2007 and IRI 2001 estimated latitudinal variation of TEC as a function of local time for the months of January 1976 with the observed one using ATS-6 Geostationary Satellite. It is evident from the figure that at all locations, in general, the TEC predicted by the IRI-2007 model, show much better agreement with the observed monthly average TEC values as compared to those generated by IRI-2001 one. The IRI-2001 highly overestimates the observed TEC at all local times for all the stations. The results are same in the cases of other months as well.

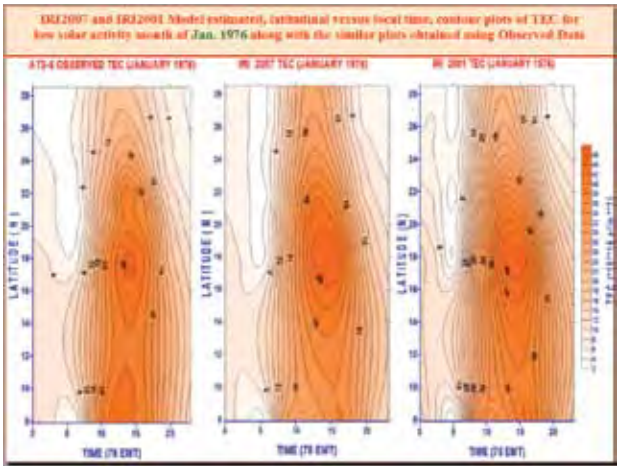


Fig. 6.11 Comparison of IRI 2007 and IRI 2001 estimated latitudinal variation of TEC as a function of local time for the months of January 1976 with the observed one using ATS-6 Geostationary Satellite

Planetary Studies

Some aeronomically important solar flare effects in the ionosphere of Mars have been studied from the analysis of electron density profiles recorded aboard Mars Global Surveyor (MGS) (Figure 6.12). All flares result in the formation of a well defined E layer peak, not always seen on other days. Further, while majority of flares result in elevated electron densities in the E region alone, some flares affect both the E and F1 layers. These altitude related effects can provide vital information on the relative enhancement of photon fluxes in the various wavelength bands during solar flares.

By studying the dayside electron density profile, the magnetised ionospheres of Venus, the "top" moves down to altitudes near 200 km and the ionopause layers with steep altitude gradients

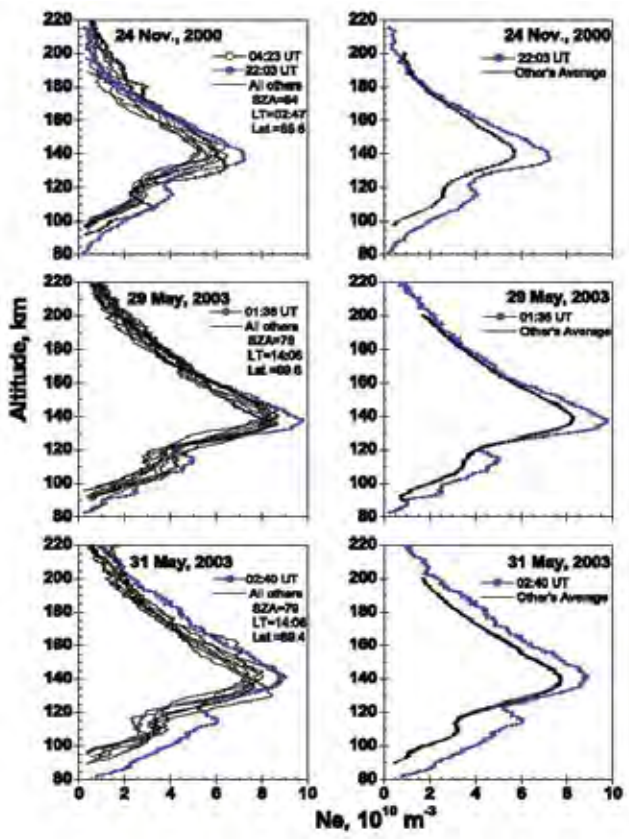


Figure 6.12: Electron density profiles observed by the MGS on each of the three flare days (left panel). Elevated electron densities through out the Martian ionosphere can be noted for all the three flare-time profiles. (right) Flare-time profile is also compared with the average of non-flare profiles for the respective day (along with one standard deviation). Well formed E peaks can be noted in all the flare-time profiles. These peaks are not always seen in the non-flare profiles.

in Ne (Electron density) and Te (Electron temperature) start above this altitude (Figure 6.13).

Radio channel measurements and modeling for fixed and mobile communications

The design of future generation mobile communication systems depend critically on the suitability of path loss prediction methods and their suitability to various regions. Development of new models helps to design new mobile communication systems, evaluate the

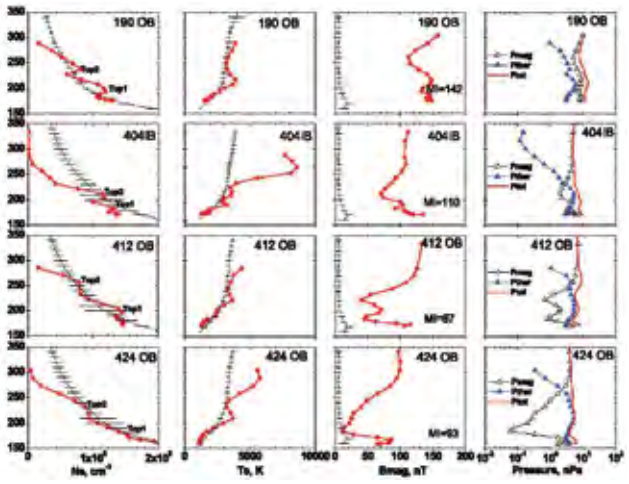


Fig. 6.13: Some sample Ne and Te profiles for un-magnetized ionospheres (dashed line) and for the magnetised ionospheres (solid line with circles) which exhibit two ionopause layers. It can be noted that Ne and Te are not significantly affected at ionospheric regions contained between the two ionopause layers. This region extends to altitudes up to 250 km in some cases.

performance of existing systems and to minimize the interference potential of other systems. To investigate the radio channel behaviour as an aid to design future generation mobile communication systems in the urban and suburban regions of India, experimental measurements in 1.8GHz band have been conducted with the help of user agencies and cellular operators. This is part of our continuing endeavour to generate new data base/sets in order to compare the existing models and to generate new models over these regions. The base stations used in the present study are 1. Inner circle 2. Arunachal building 3. Indra prastha extension 4. Onkar nagar sector-1 5. Onkar nagar sector-26. Trinagar. The transmitting powers of all the station are +43 dBm. All the six paths are situated in dense urban environment. The six GSM base station data collected in the dense urban region of New Delhi have been analyzed. Path loss exponents and break point distances have been deduced and observed losses have been compared with various prediction

methods. Measured regression line exhibited lowest standard deviation followed by roof top propagation method compared with COST 231 Hata and COST 231 Walfisch-Ikegami methods. Variation of observed results have been explained in terms of vertical and horizontal propagation mechanisms which is the novelty of this study. A typical figure of the above exponent variation for Inner circle base station is shown in Fig.6.14 In general at distances close to the transmitter exponents of the order of 7 are observed and then they fall steeply up to a value of 4 around 400 m and remains steady for the remaining distances. Another typical Fig.6.15 showing the comparison of observed path losses with those of predicted from COST 231WI (Walfisch-Ikegami) method for street widths of 20, 30 and 40 m and building heights of 15 and 18 m and COST231 Hata method is also presented. In this case close to transmitter, high path losses of 150 to 170 dB have been observed. The estimated measurement r.m.s. error is around 1.5 dB. Walfisch-Ikegami method with heights of 18 m passes through majority of dense cluster of observed points at all distances. The same method with heights of 15 m shows the predicted loss less than that of 18 m and passes through some of the points. As the street width increases path loss decreases for a given building height. COST 231 Hata method under estimates the values by 10 to 20 dB. The variation in path loss for a given street width of 30m when building height changes from 15 to 18 m is 5.5 dB. This figure also has regression line plotted with its coefficients. Similarly for all the remaining five base stations the deduction of path loss exponents as a function of distance and comparison of observed values with predicted values has been carried out. The break point also has been deduced as the distance at which the slope of the curve (the path loss exponent vs distance)changes. In Fig.6.14 it changes at 200 m.. In the case of other base stations same approach has been followed and the values are shown in Table 6.1.

Table 6.1. Break point distances observed from data.

Base station	Height of ant(m)	Observed break point(m)
1 Inner circle	22	200
2. Arunachal	32	400
3. IP extension	27	-
4.Onkarnagar sec-1	24	200
5.Onkarnagar sec-1	24	400
6. Trinagar	24	300

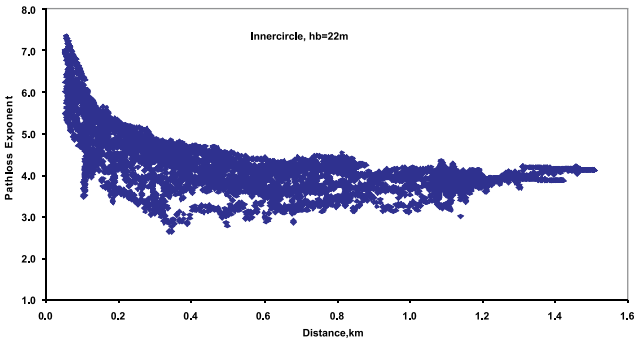


Fig 6.14 Variation of observed path loss exponent with distance for Inner circle base station

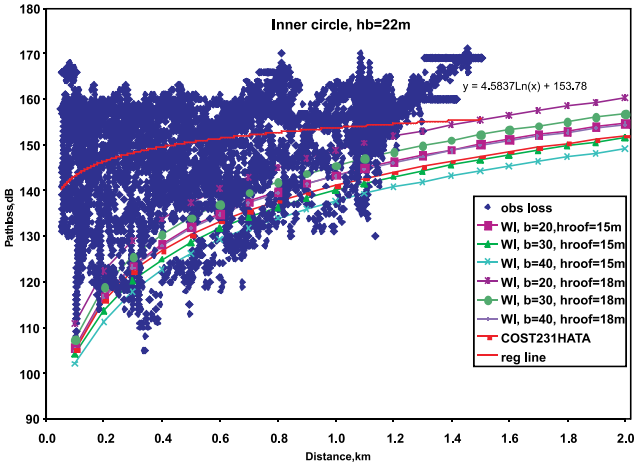


Fig 6.15 Comparison of observed path losses with COST 231 Walfish-Ikegami and COST 231 Hata

Development of Software for Phased Array Acoustic Wind Profiler in LabVIEW

A Phased Array Acoustic Wind Profiler is in operation for continuous wind measurements up to an altitude of 500 m. The profiler operates with sound waves at 2150 Hz. The antenna transmits the sound waves sequentially in three vertical directions, viz., one beam pointing towards zenith and two other beams, both tilted by 19^{O} each towards north and west respectively, from the zenith. The beam tilting is done electronically by a phase steering mechanism. The antenna is an array of 104 piezoelectric elements. The software for control and signal processing was initially developed in C-language. Now a new software has been developed in LabVIEW for control and signal processing. This software has got more improved features than the C – based one.

Green house effects in radiation fog

Quantitative estimation of the greenhouse effects due to water vapour and liquid water in radiation fog have been made from the measurements of temperature, relative humidity, wind speed, long-wave net radiation flux (all at 2 m height) and soil temperature (5 cm below ground) by using the NPL (National Physical Laboratory) Meteorological Tower. On a dense fog night, an enhancement of ~5 W m^{-2} in the net radiation flux has been observed before the onset of fog, due to the greenhouse effect of near saturated water vapour. Once fog forms abruptly in a period about an hour to two hours, the long-wave net radiation energy fluxes are observed to enhance from the pre-to post-fog formation hours, due to the trapping of the latent heat of condensation of the excessive water vapour into liquid water in fog. The energy flux due to the release of the latent heat of condensation varies from ~30 W m^{-2} to over 60 W m^{-2} under the light to dense fog conditions. Corresponding liquid water path in the fog column is estimated to vary between 0.06 kg m^{-2} and 0.17 kg m^{-2}. These liquid water paths would correspond to liquid water contents of 0.6 g m^{-3} to 1.7 g m^{-3}, for a fog layer thickness of 100 m. Sodar data have been used to obtain the fog layer thicknesses in actual cases. Thus it is possible to estimate the fog liquid water content through the use of 'real-time' routine ground-based measurements, when the fog is in the process of being formed or has just set in. Liquid water content is an essential parameter for forecast models to forecast the local time of clearance of fog by solar radiation.

Atmospheric Environment and Global Change

Effects of the solar eclipse on the surface O_3, NO, NO_2, NH_3, CO mixing ratio and the meteorological parameters on 15 January 2010 at Thiruvanathapuram, India

During the annular solar eclipse on 15 January 2010, the measurement of surface O_3, NO, NO_2, NH_3, CO mixing ratio and meteorological parameters (temperature, relative humidity, wind speed and solar radiation) have been performed at the National Institute of Interdisciplinary Science and Technology (NIIST), Thiruvanthapuram to explore the effect of solar eclipse. The experimental data has demonstrated that the solar eclipse phenomenon has affected the mixing ratio of surface ozone, nitric oxide, nitrogen dioxide, ammonia as well as temperature, relative humidity, wind speed and solar radiation near the ground. The decrease in mixing ratio of surface O_3 (Fig. 6.16) and NO_2 is observed after the beginning of the solar eclipse events and lasted for four hours, probably due to

decreased efficiency of the photochemical ozone formation, whereas, the increase in mixing ratio of NO and NH_3 might have followed the night time chemistry. As expected, the ambient temperature has decreased, relative humidity has increased and the wind speed has decreased. After the end of the solar eclipse period, all the above mentioned parameters exhibited a tendency to re-gain their earlier pattern on the same day.

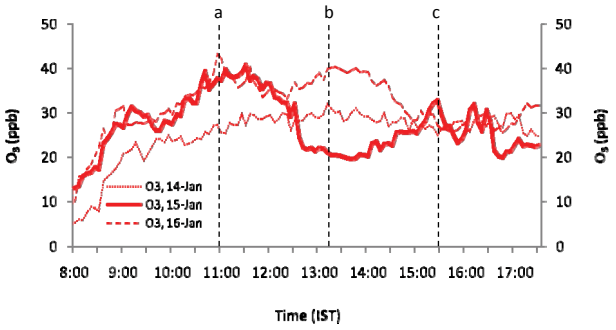


Fig. 6.16: Surface O_3 measured before, during and after the total solar eclipse occurred on 15 January, 2010 at Thiruvananthapuram, India, (a) beginning of the solar eclipse, (b) solar eclipse maximum, (c) end of the solar eclipse along with a day before and a day after of the solar eclipse.

Ambient ammonia distribution over National Capital Region of Delhi

Ammonia (NH_3) is an important atmospheric pollutant that plays an important role in several air pollution problems and affects the soil, water system as well as climate change. It is a highly reactive gas that has important effects on atmospheric chemistry and sensitive terrestrial or aquatic ecosystems arises from both natural and anthropogenic sources. Mixing ratios of atmospheric ammonia (NH_3 and NH_4^+) were estimated during February to April 2010 at various locations of National Capital Region (NCR) of Delhi to study the distribution and day-to-day variation of atmospheric NH_3 and its role of formation of secondary aerosol. NH_3 mixing ratio was measured using NH_3-Analyzer operating based on chemiluminescence's method whereas water soluble ionic species of PM10 were estimated using chromatography techniques.

The average mixing ratio of atmospheric NH_3 was recorded as 32.5 ± 2.1, 33.8 ± 3.0, 29.7 ± 0.7, 24.2 ± 1.4, 22.9 ± 1.3, 16.4 ± 3.2 and 15.6 ± 0.7 ppb at Indian Agricultural Research Institute, Research Farm; Naraina Industrial Area, Naraina; Central Road Research Institute (CRRI), Mathura road; National Physical Laboratory, New Delhi; Indra Prastha University, Delhi; Delhi University, Delhi and NCMRWF, Noida, UP respectively. The minimum average mixing ratio 9.4 ± 1.2 ppb was recorded at HRDC Ghaziabad, UP which is a rural area. The average mixing ratio of ambient NH_3 over NCR was estimated as 23.06 ± 1.7 ppb. Figure 6.17 shows the diurnal variation of NH_3 over CRRI, Mathura road and Naraina Industrial Area of NCR of Delhi.

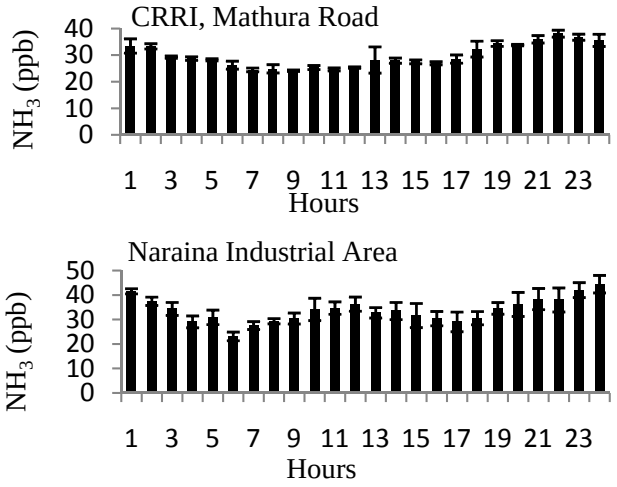


Fig. 6.17 : Average diurnal variations of mixing ratio of atmospheric NH_3.

Variation of ambient SO_2 over Delhi, India

The spatiotemporal variation of ambient SO_2 and the chemical composition of particulate matter (PM10 and PM2.5) at National Physical Laboratory (NPL), Delhi and other sites of Delhi were studied during 2008 (Fig.6.18). Ambient

SO_2 is significantly high (2.55 to 17.43 ppb) at air quality monitoring sites of Delhi particularly over industrial areas (15.00 to 17.43 ppb) during winter. There is no significant difference in SO_2 mixing ratio during monsoon; however, it was recorded significantly high over industrial sites during summer. The study establishes that transport sector may not be the major source of the SO_2 in the ambient atmosphere of Delhi, as there is no significant difference of ambient SO_2 mixing ratio recorded among residential and commercial sites. SO_2/SO_4^{-2} ($PM_{2.5}$) ratio suggests during winter the SO_4^{-2} over Delhi might be transported from long distance sources; whereas, during summer it might be from local sources. Wind pattern at NPL site suggests that during winter the wind blows from west and northwest directions. Coal used in thermal power plants at Panipat and Faridabad (about 200 km in the northwestern side of NPL) may be contributing to the higher SO_4^{-2} during winter. However, other thermal power plants situated at Pragati (Rajghat), Indraprastha and Badarpur (southeastern part of Delhi) may contribute during summer as a local source.

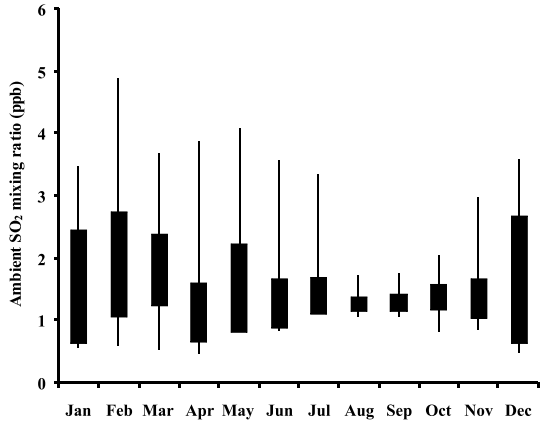


Fig. 6.18: Monthly variation of SO_2 mixing ratio at NPL

Distribution of aerosol and its precursor gases in the marine boundary layer over Bay of Bengal

Aerosol (PM_{10}) samples were collected and its precursor gases i.e., NH_3, NO, NO_2, SO_2 measured over Bay of Bengal during 28 December, 2008 to 25 January, 2009 to study their distribution and role in formation of inorganic aerosols under Integrated Campaign on Aerosols and Radiation (ICARB). NH_3 was monitored precisely and continuously over Bay of Bengal based on chemiluminescence method. Average ambient concentration of NH_3, NO, NO_2, SO_2 and NH_4^+, SO_4^{2-}, NO_3^-, Cl^- were recorded as 4.78 ± 1.68, 1.89 ± 1.26, 0.31 ± 0.14, 0.80 ± 0.30 µg/m^3 (Table 6.2) and 1.96 ± 1.66, 8.68 ± 3.75, 1.92 ± 1.75, 2.48 ± 0.78 µg/m^3 respectively. Higher $SO_4^{2-}/(SO^2 + SO_4^{2-})$ equivalent molar ratio during the campaign indicates gas-to-particle conversion with great efficiency over the study region. A good correlation of SO_4^{2-} and NO_3^- with NH_4^+ (NH_4^+ vs. SO_4^{2-}, $r^2 = 0.408$; NH_4^+ vs. NO_3^-, $r^2 = 0.867$) and NH_3 (NH_3 vs. SO_4^{2-}, $r^2 = 0.353$; NH_3 vs. NO_3^-, $r^2 = 0.537$) indicates the aerosol formation.

Table 6.2: Average concentration of NH_3, NO, NO_2 and SO_2 (µg/m^3) over Bay of Bengal.

	Concentration			
	Average	Day	Night	D/N
NH_3	4.78 ± 1.68	4.85 ± 1.91	4.70 ± 1.44	1.03
NO	1.89 ± 1.26	1.87 ± 1.24	1.90 ± 1.27	0.98
NO_2	0.31 ± 0.14	0.27 ± 0.12	0.34 ± 0.16	0.79
SO_2	0.80 ± 0.30	0.86 ± 0.33	0.75 ± 0.27	1.15

± standard deviation

Long term variation in tropical stratospheric ozone

The Stratospheric ozone which is about 90% of total ozone column protects the Earth's biota from potentially damaging short wavelength UV radiation. It also controls the temperature in the stratosphere. The studies of temporal and spatial variations in ozone help in the exploration of the processes governing ozone concentration and the interaction between

ozone and climate. Zonal monthly average SBUV data in 10^{O} latitude bands over 20^{O} S to 20^{O} N for the period Nov. 1978 to Dec. 2008 has been analyzed to find latitude-range and height-layer wise trend in ozone in the stratosphere. The data are integrated from Umkehr layers 2 to 4 (20-30 km) as representative for lower stratospheric ozone layer (LSOC) and from layers 5 to 13 (above 30 km) as upper stratospheric ozone layer (USOC) and from 20 km to top of stratosphere as total stratospheric column ozone (TSOC). The observed ozone as shown in Fig. 6.19 indicates the existence of Turning Points (TPs) in linear trend for low latitudes.

It is found that the values of piecewise trend during the periods 1994-99 and 1999-2003 are quite significant and have significant height-wise variations. If height-wise trend is considered, the directions of trend (downward/ upward) are opposite to each other in upper (> 30 km) and lower (20 km–30km) stratosphere over tropics and more specifically in 1999, the trend in lower stratosphere is decreasing in contrast to increasing in upper stratosphere (Figure 6.19).

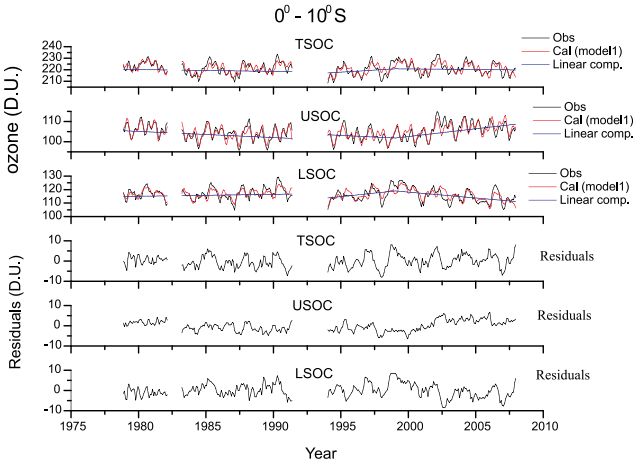


Fig. 6.19 Values of ozone - observed (black), calculated (red), piecewise linear component (blue) and, residuals for TSOC, USOC, LSOC for latitude range 0^{O} to 10^{O} S.

Temporal variations of stratospheric ozone and water vapour over Pune

The temporal variations of stratospheric ozone and water vapour over Pune (18N, 73E) are studied by analyzing ozone data from satellite based SBUV as well as ground based Umkehr and water vapour data from HALOE. The analysis of SBUV data for the period 1978-03 gives indications to the existence of three turning points (TPs) namely June 91, January 94 and January 99 at which the slope of the trend line changes. The data for two years following the volcanic eruptions at El-Chichon and Pinatubo are excluded from the analysis. The seasonal and annual trends in ozone from SBUV data have significant negative values during 1993-99 and positive values during the period 1999-03 at Umkehr layers 6-8. However, Umkehr data being sparse and having large deviations do not give definite indications of the TPs but do not contradict the existence of TPs. Because of the TPs where the slope of trend lines changes, analysis is done for the periods 1978-91 and 1994-99 separately. The annual trends in ozone from Umkehr data have significant negative values at layer 6 and 7 during 1994-99. Because of the change in ozone trend line at the TP of January 1999, a TP of January 1999 is also assumed in the analysis of water vapour data from HALOE for the period 1994-03. An increase in water vapour from 1994-99 and decrease from 1999-03 at pressure level 3-10 hPa corresponding to layers 6 and 7 is seen suggesting an anti-correlation between water vapour and ozone. This decrease in water vapour from 1999 found over tropical station Pune is about 3 years earlier in contrast to the year 2001 found over mid-latitudes. The 3 years lag at mid-latitudes may be because of the time taken in the transportation of air from tropics to mid latitudes.

Effect of Equivalent Effective Stratospheric Chlorine (EESC) on ozone over tropical stratosphere

Zonal monthly average SBUV data in 10^{O} latitude bands over 20^{O} S to 20^{O} N for the period Nov. 1978 to Dec. 2008 is considered to find the existence of the cause–effect relationship, if any, between ozone and Equivalent Effective Stratospheric Chlorine (EESC). The representative ozone column values for lower stratosphere from 20 to 30 km, upper stratosphere above 30 km and total stratosphere are obtained by integrating ozone values from layers 2 to 4, 5 to 13 and 2 to 13 respectively. The contributions from season, known natural explanatory variables QBO (quasi biennial oscillation) , solar activity and other unknown factors in ozone are obtained by fitting a regressive model to observations. The sum of contributions from other unknown factors and random error is called residual. Anthropogenic condition caused by EESC may be one of the unknown factors. It is found that the variation of residual with time does not follow variation of EESC over tropics though it follows EESC to some extent over mid-latitudes. If the residual part in the model is replaced by a regressive term with EESC as a regressive variable plus error, it is found that the contribution from EESC as compared to contributions from other regressive variables is insignificant over tropics though having some significance over mid-latitudes. Thus EESC has insignificant effect on ozone over tropics.

Studies on aerosols

The monthly average Single Scattering Albedo (SSA) over Delhi has been estimated using Optical Properties of Aerosol and Cloud (OPAC) model along with the measured Aerosol Optical Depth (AOD) and Black Carbon (BC) concentration. It is in the range 0.70 to 0.89 which is largely affected by the BC concentration that lies in the range 4 – 15 $\mu g/m^3$ (as monthly average during daytime). When the dust concentration was highest (May-June) the SSA increased with wavelength however when dust concentration was low the SSA decreased with the wavelength (Fig.6.20).

Figure 6.21 shows the monthly averaged clear-sky Direct Aerosol Radiative Forcing (DARF) at the surface that varied in the range –45 W/m^2 to –110 W/m^2 throughout the year. The value of monthly DARF at (TOA) top-of-atmosphere (TOA) was found to be in the range -1 to 21 W/m^2 and in the atmosphere it was in the range 46 W/m^2 to 115 W/m^2 throughout the year

The impact of long range transported dust aerosols, originating from the Thar Desert region, to a high-altitude station in the central Himalayas

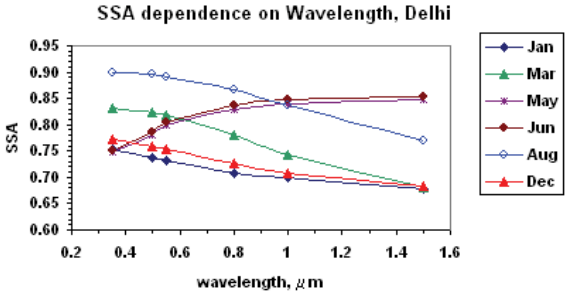


Fig. 6.20 Variation of Single Scattering Albedo (SSA) with wavelength during different months of the season

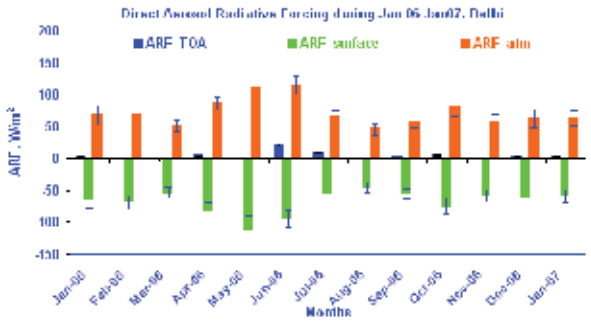


Fig. 6.21: Monthly average aerosol radiation forcing over Delhi

was studied with the help of micro-pulse lidar observations at Manora Peak, Nainital. The aerosol radiative forcing was also estimated using the Santa Barbara DISORT Atmospheric Radiative Transfer (SBDART) model in conjunction with Optical Properties of Aerosol and Cloud (OPAC) model. It showed a value of about -30, -45, and +15 W/m^2, respectively at top-of-atmosphere (TOA), surface and in the atmosphere on dust day. The positive atmosphere forcing caused an estimated heating of the lower atmosphere by ~0.4 K day^{-1}.

The chemical characterization of aerosols over Delhi for water soluble ionic components revealed that the $PM_{2.5}$ are mainly made up of secondary inorganic aerosols (26.15 μgm^{-3}, 27.1%), salt aerosols (22.48 μgm^{-3}, 23.3%) and mineral matter (8.41 μgm^{-3}, 8.7%) with undetermined fractions (39.46 μgm^{-3}, 40.9%) as shown in Fig. 6.22 The contribution of the ionic species in coarse fractions ($PM_{10-2.5}$) was obtained as the difference between analyzed fractions in PM_{10} and those in $PM_{2.5}$. The analyzed coarse fractions ($PM_{10-2.5}$) mainly composed of secondary inorganic aerosols species (16.0 μgm^{-3}, 13.07%), mineral matter (12.32 μgm^{-3}, 10.06%) and salt particles (4.92 μgm^{-3}, 4.02%). The relatively high percentage of nitrate and sulfate in $PM_{10-2.5}$ indicates their association with other coarse components.

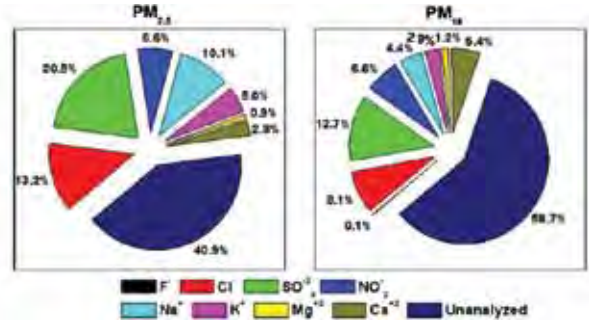


Fig. 6.22 Percentage contribution of water-soluble ionic species in $PM_{2.5}$ and PM_{10} sample over Delhi

Chemistry of PM_{10} atmospheric aerosols

A total of five heavy metals were analyzed in PM_{10} (particulate matter of size ten micron and below) aerosol samples which were collected at the site of National Physical Laboratory during the year 2009. The concentration order of these metals has been found to be Zn>Fe >Cu>Mn>Cd (Fig.6.23). These metals are contributed by different anthropogenic sources into the atmosphere.

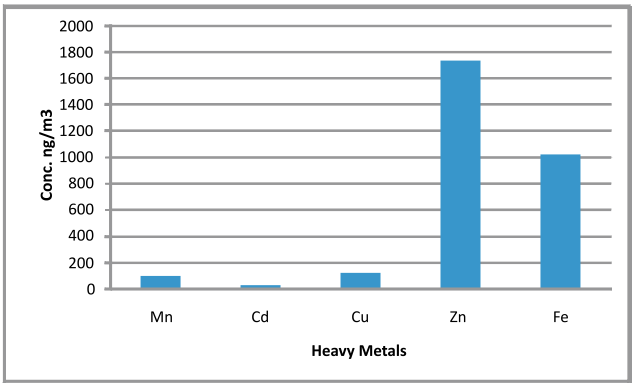


Fig. 6.23 Concentration (ng/m^3) of metal aerosols at NPL, New Delhi

The sources of Cd are of anthropogenic in nature. Cd is mainly used in making alloys, stabilizers in polyvinyl plastics, Ni-Cd batteries, electroplating industries. Cd exposure may result in many respiratory and heart related diseases. Iron comes from natural as well as anthropogenic sources. The natural source of iron is of crustal origin while anthropogenic sources include iron and steel manufacturing units, weathering of iron in contact with moisture and air. Lethal exposure to iron may affect the enzymatic activities in human beings. Cu is emitted by copper alloy industries in Delhi. There are several units installed in and around Delhi. The main sources of Zn are casting of different metals, rubber and chemical industries. The vehicles running on roads also contribute zinc metal. Mn is also used as an additive in unleaded gasoline.

Morphological study of PM_{10} Aerosols

Figure 6.24 shows the SEM (scanning electron microscope) analysis of a blank Quartz microfiber filter. The scan micrograph clearly shows that there is no deposition on filter before taking the sample. The fibrous structures are of micro fibers of quartz filter.

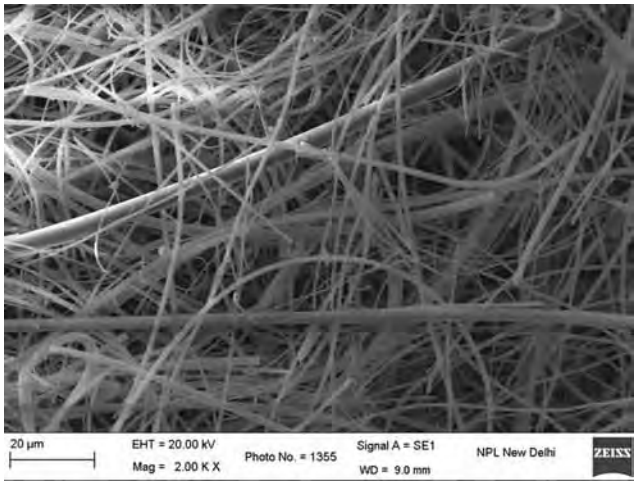


Fig. 6.24. SEM micrograph of blank quartz microfiber filter

Figure 6.25 shows the scan micrograph of aerosol sample collected on the quartz microfiber filter. After collecting the sample on the filter, the heavy loading of aerosols on the filter can be seen clearly.

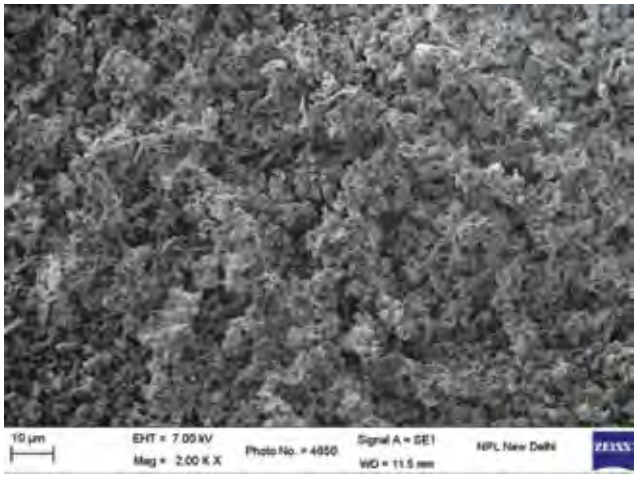


Fig. 6.25. SEM micrograph of aerosol sample collected on quartz microfiber filter

In Figure 6.26, the scan micrograph shows spherical shapes which may possibly be carbon soot particles.

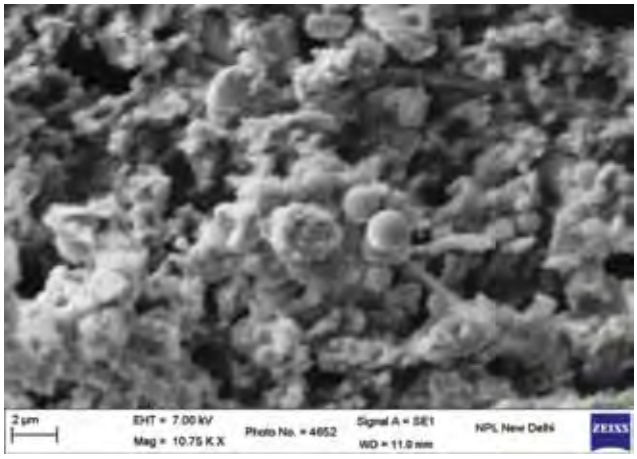


Fig. 6.26 SEM micrograph of aerosol sample collected on quartz microfiber filter

Figure 6.27 shows the mixture of different shapes which may belong to different compounds. The smaller irregular shaped particles may belong to crustal components.

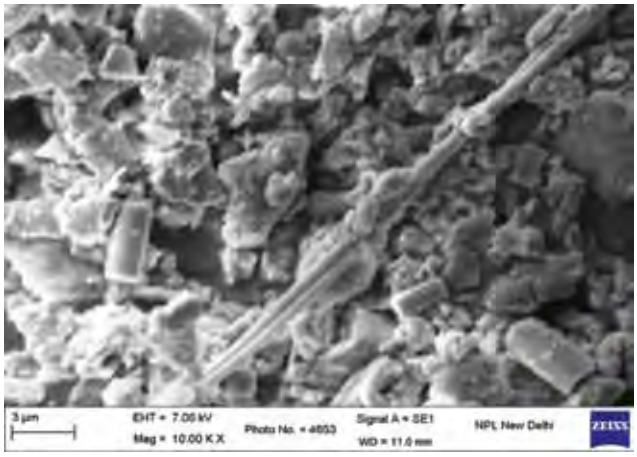


Fig. 6.27. SEM micrograph of aerosol sample collected on quartz microfiber filter

It was further confirmed by Energy Dispersive X-ray (EDX) analysis in more details that the smaller irregular particles may be soil dust particles as these had more percentage of Ca and other crustal components. The spherical shaped particles contained more percentage of carbon suggesting that these may be carbonaceous aerosols.

Lidar Measurements of Optical Properties of Aerosol:

Lidar measurements of optical properties of aerosols is being measured by EZ Aerosol Lidar over New Delhi. The laser transmits a wavelength of 355 nm short duration light pulses of 10 ns pulse width into the receiver field of view. The height dependence of the Lidar ratio indicates layers of different aerosol types. Average profile of backscatter, extinction coefficient and Lidar ratio measured on10th August, 2009 and 15th September, 2009 are given in the Figs. 6.28 and 6.29. The lidar ratio was found to be a useful quantity to track back different pollution sources and identify light absorbing particles. Lidar ratio > 60-70 sr indicates light absorbing particles. Lidar ratio 30 sr to 60 sr are typically found for anthropogenic non-absorbing ammonium sulphate like particle. Large lidar ratio implies the presence of absorbing soot like particle in pollution plume. Figure 6.29 shows the mean lidar role at 355 nm for Aug 10, 09 and 15 Sept., 09. The lidar ratio was found about 70 sr above 400m to 1.2 km, height on 10August,09 and more than 75 sr around 400 m height indicating the presence of light absorbing soot particles. The mean lidar ratio profile on 15th Sept. shows presence of several types of aerosol layers. Below 1000 km the lidar ratio varies between 45sr to 55sr and above 1 km to 1.3 km the lidar ratio increased to 56 sr indicating another aerosol layer. The extinction values measured were high ranging from 0.25 km^{-1} to 0.3 Km^{-1} up to the height of 1.2 km. as compared to 15th September, 09 values.

Fluctuation in Ozone column during the solar eclipse

The Solar eclipse occurred over Thiruvanthapuram on 15 January 2010 started

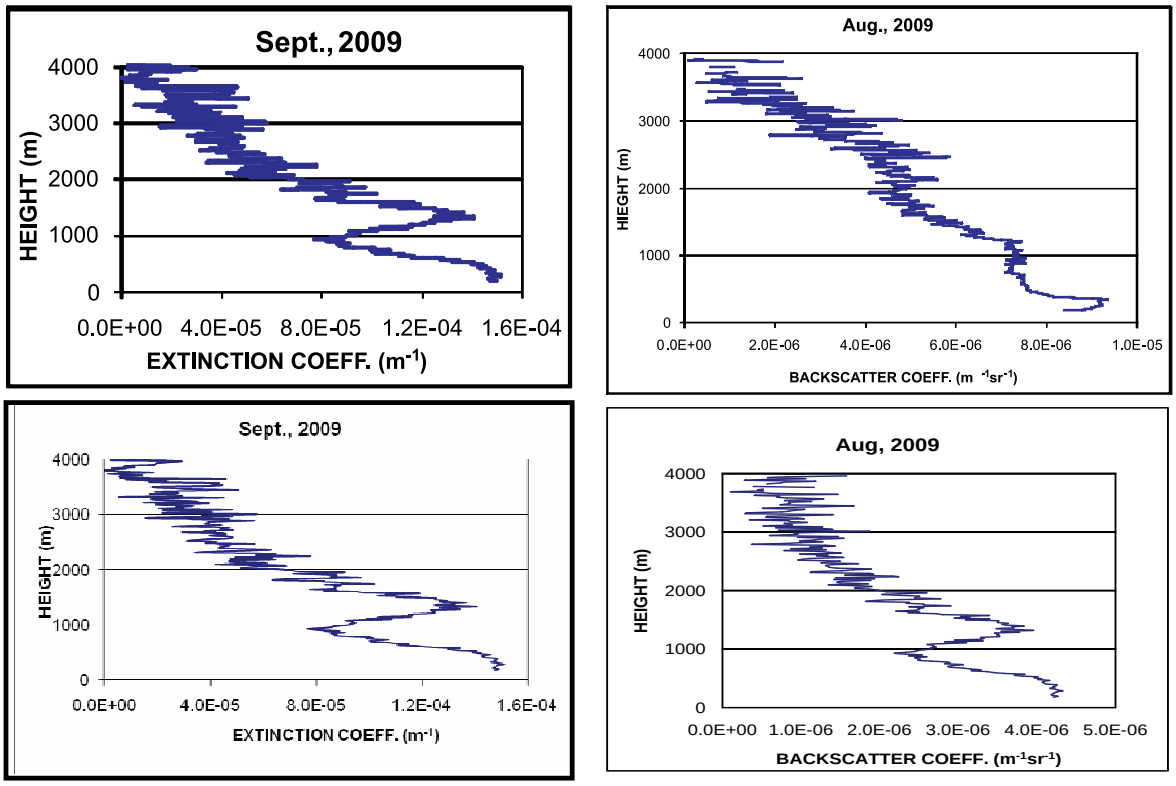


Fig. 6.28: Average profile of Backscatter and Extinction coefficient on 10th August, 2009 and 15th September, 2009 at NPL, New Delhi.

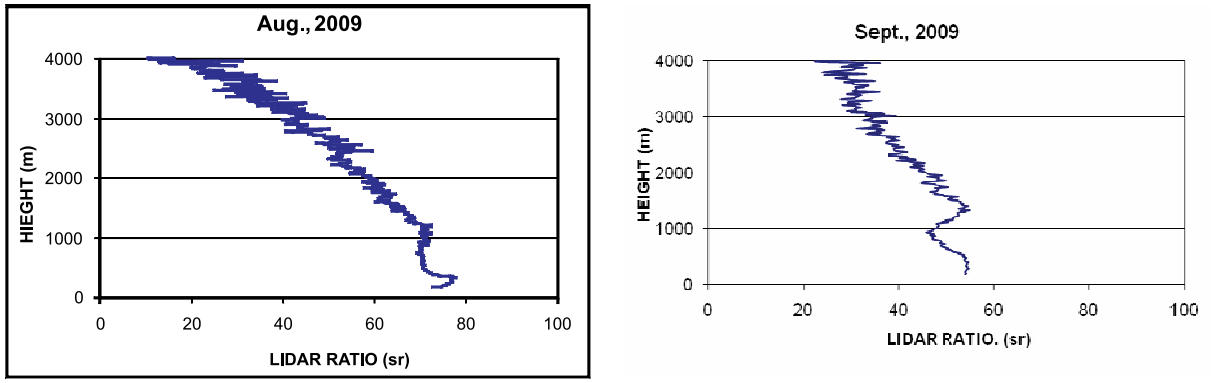


Fig. 6.29 Average profile of Lidar ratio on10th August, 2009 and 15th September, 2009 at NPL, New Delhi.

at 11.15 (IST), the maximum obscuration of the sun was 91.9% which occurred at 13.20 (IST) and the eclipse ended at 15.30 (IST). It was the longest annular solar eclipse of millennium with maximum length of 10 minutes 4 seconds. The column abundance of ozone during this event using hand held sun photometer (Microtop) with filters centered at 300, 305, 312, 940 and 1020 nm was measured. The first three UV wavelengths are used for total ozone measurements and 940 nm and 1020 nm are used for total water vapour measurements. For the period between 10.00 (IST) to 16.00, the total ozone column was changed on the day before the eclipse from 278 DU to 260 DU and on the day of eclipse it was varying from 285 DU to 262 DU (Fig. 6.30).

During the course of the eclipse a gradual decrease in the total ozone was observed before the maximum obscuration of the sun and followed by increase just after maximum obscuration. Visual inspection of observations shows a possible fluctuation in ozone column before the maximum obscuration occur. To determine the possible oscillations the data from 10:00 hrs to 14:00 hrs were subjected to Spectral Fourier Analysis (Fig. 6.31). The power spectrum of total ozone reveals significant oscillations. The principle fluctuation with a period of 15 to 20 minutes followed by a number of fluctuations of different periods of reduced amplitude were seen.

Ozone Depletion Events observed at Indian Arctic Station Himadri, during spring of 2010

Episodes of very low ozone concentrations are a common features at Arctic

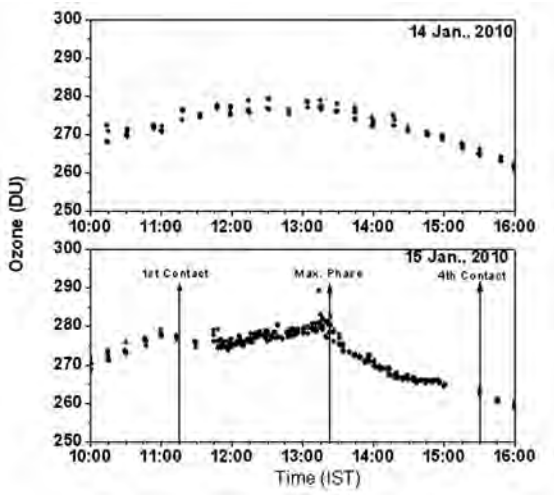


Fig. 6.30: Diurnal variation of total ozone on 14th Jan. and 15th Jan. 2010.

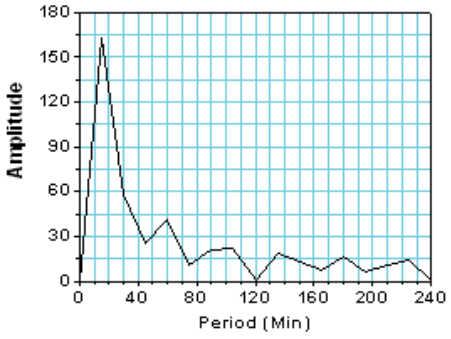


Fig. 6.31 Spectral Fourier analyses of Data

during spring. The low ozone episodes were observed from late March to the beginning of June. The events have been attributed to the dominant role of reactive halogen species chemistry in tropospheric ozone depletion. The time series measurements of surface ozone and carbon-monoxide taken during second phase of winter expedition from 28th, March to 14th, April is depicted in the Fig. 6.32 The ozone depletion event occurred on 30-03-2010 at 03:00 hrs and lasted up to 40 hours and ozone was depleted from (45 – 54 ppb) to 24 ppb is just one day. In another event on 12-04-2010 the ozone depletion was also observed and ozone depleted from 54 ppb to 32 ppb and this event lasted for 2 days, till 14-04-2010. Trajectory analysis shows that the observed low ozone events were closely linked to the transport direction. The episodes occurred when the air mass were transported from N or NE directions indicating the region of ice covered Arctic Ocean. The depletion could be explained by the advection of previously ozone depleted air mass from oceanic region the lower graph shows the depletion event at Zeppelin Mountain station which is about 2 km away from Indian station and is at the top of hill, 474 m.a.s.l. The carbon monoxide varied from 200 ppb to 250 ppb during observation periods.

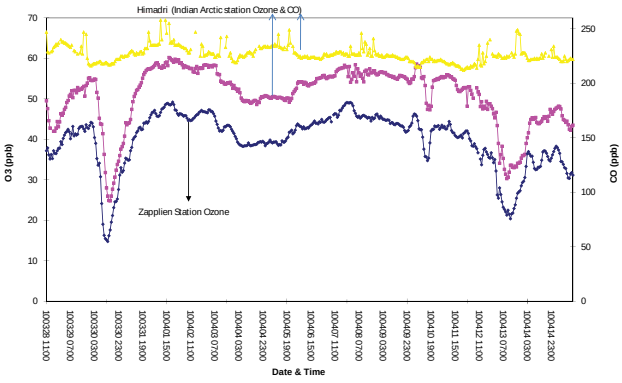


Fig. 6.32: Time series measurement of surface ozone and carbon monoxide concentration at Indian Arctic Station Himadri.

Occurrence of extremely low cold point tropopause temperature during summer monsoon season: ARMEX campaign and CHAMP / COSMIC satellite observations

Extreme low cold point tropopause (CPT) temperatures (T ≤ 191 K) are often observed during the monsoon season over the Bay of Bengal (BOB) and adjoining areas. Frequent occurrences of extreme low CPT temperature over Arabian Sea (AS) and adjoining areas using radiosonde observations during the Arabian Sea Monsoon Experiment (ARMEX) from 24 June to 15 August 2002. Day-to-day variations in temperature at and CPT and at 100 hPa level observed during ARMEX campaign show modulation by the wave activity with a period of ~15 days and it is observed to be closely associated with Tropical Easterly Jet (TEJ). Spatial and temporal distribution of low CPT temperature over a wide scale is examined using CHAMP and COSMIC satellite temperature data. These observations show occurrences of low CPT temperatures during the early period of the monsoon season over BOB, AS, and adjoining areas which often extends to the Africa's Horn region. An enhanced low CPT temperature occurrence during the early part of the monsoon season appears to be due to the modulation of outgoing long wave radiation (OLR), CPT temperature and height by intraseasonal oscillation. Modulation of CPT by intraseasonal oscillation suggests that this oscillation could contribute to dehydration of upper troposphere and lower stratosphere (UTLS). In addition a close association is noted between the seasonal variations of the latitude of low CPT temperature and low OLR. This is similar to the anticipated seasonal movement of Inter tropical convergence zone (ITCZ).

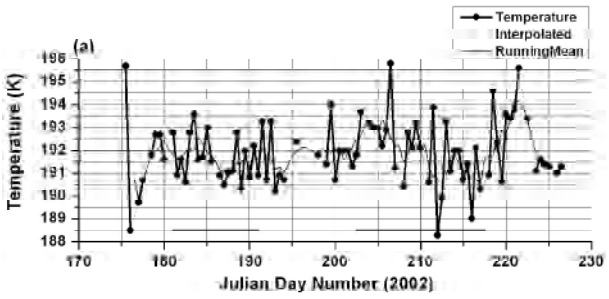


Fig. 6.33 Plots of time series of C P T Ttemperature measurements on board ORV Sagar Kanya. Data gap points are joined by dashed lines. The smoothed points of time series, after 5 day running mean, are joined by thin solid line.

Mega-city atmospheric pollution precursor process modelling

The air quality in urban areas has become an important issue having direct bearings on the human health and climate change. The increased anthropogenic activities associated with the urbanization are responsible for the deteriorating air quality. It is therefore important to quantify the urban emissions and investigate their impacts on ambient air quality through modelling which could be verified through ambient air quality measurement. During the 2009-10, emission inventory for the pollutants' emissions of CO_2, CH_4, N_2O, CO, NO_x and NMVOC (Non methane volatile organic carbon) from transport sector in Delhi for the period 2000 to 2007 have been generated and shown in Figs.6.34 (a to f).

These mega-city level emission inventory is being converted to grid-based inventory for incorporation of atmospheric models like WRF-CHEM to develop air-quality forecast at city level.

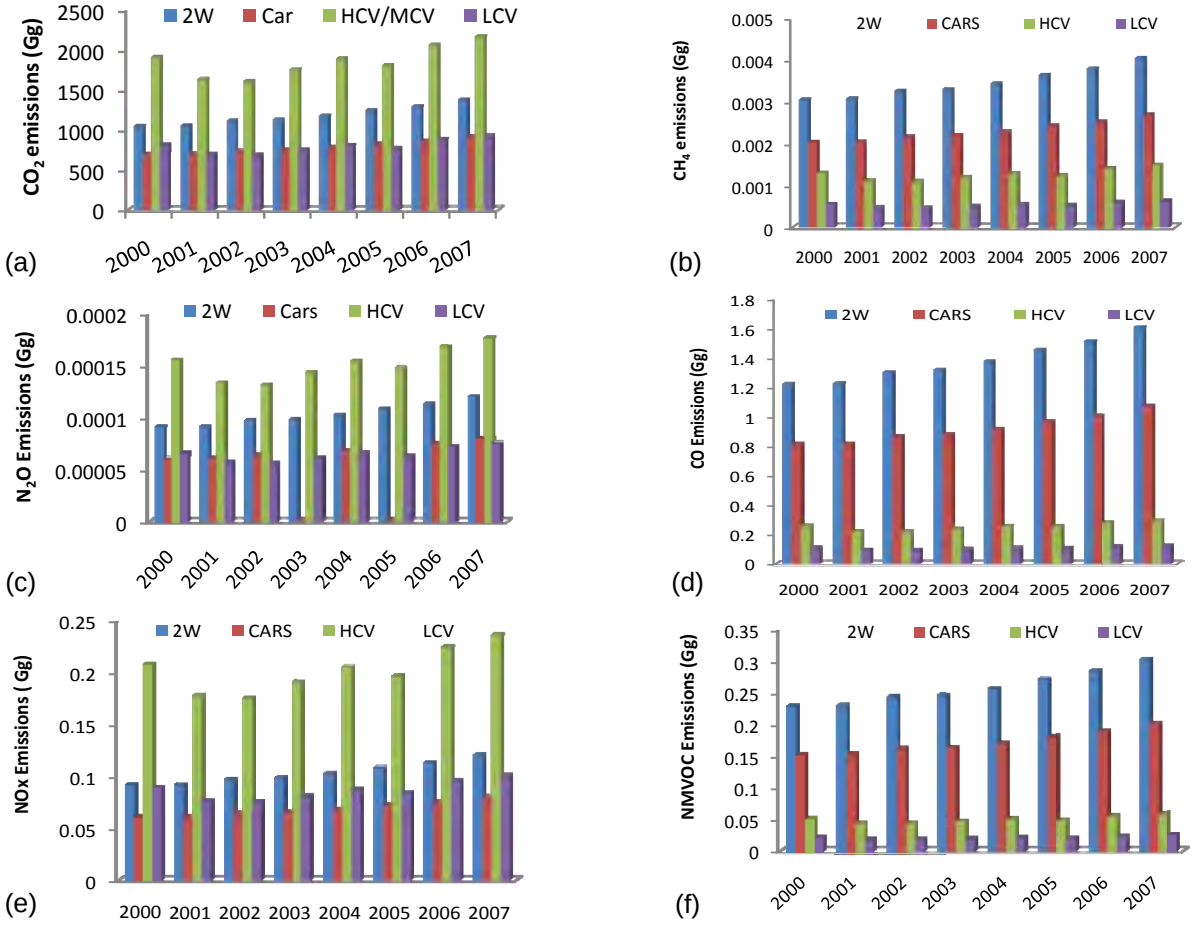


Fig. 6.34 (a-f). Pollutants Emission estimation from different types of vehicle

Assessment of impacts of heat stress on human health and adaptation strategies'

Climate change currently contributes to the global burden of disease and premature deaths. Globally the hot days, hot nights and heat-waves have become more frequent which are associated with marked short-term increases in mortality. Heat waves are normally associated with the high average temperature and the number of consecutive hot days. Heat stress-related mortality has been reported and evaluated mostly for mid-latitude countries and cities, but also in the hot subtropical and cold high-latitude environments. In India, eighteen heat-waves have been reported during the period between 1980 and 1998, with a heat-wave in 1988 affecting ten states and causing 1,300 deaths. Efforts are being made to assess the impacts of future climate change on heat stress in India. The future climate scenarios for India generated by Indian Institute of Tropical Meteorology (IITM), Pune by PRECIS climate change model for A2 & B2 Scenarios have been used to assess the likelihood of heat-wave conditions in different districts of seven most vulnerable states namely Andhra Pradesh, Gujarat, Orissa, Uttar Pradesh, Rajasthan, Bihar and West Bengal. Using the model outputs, the events of consequent three days of high temperature events in the months of April through June have been assessed. The results show the vulnerability of these regions for heat stress condition in future climate regimes. eg. in Andhra Pradesh, more than of half of its districts show high temperatures in the range of 450 to 500C for more than 15 days even in the month of April of 2071, 2080, 2090 & 2100 (Figure 6.35). The darker colours show the increasing number of high temperature events in different districts of Andhra Pradesh.

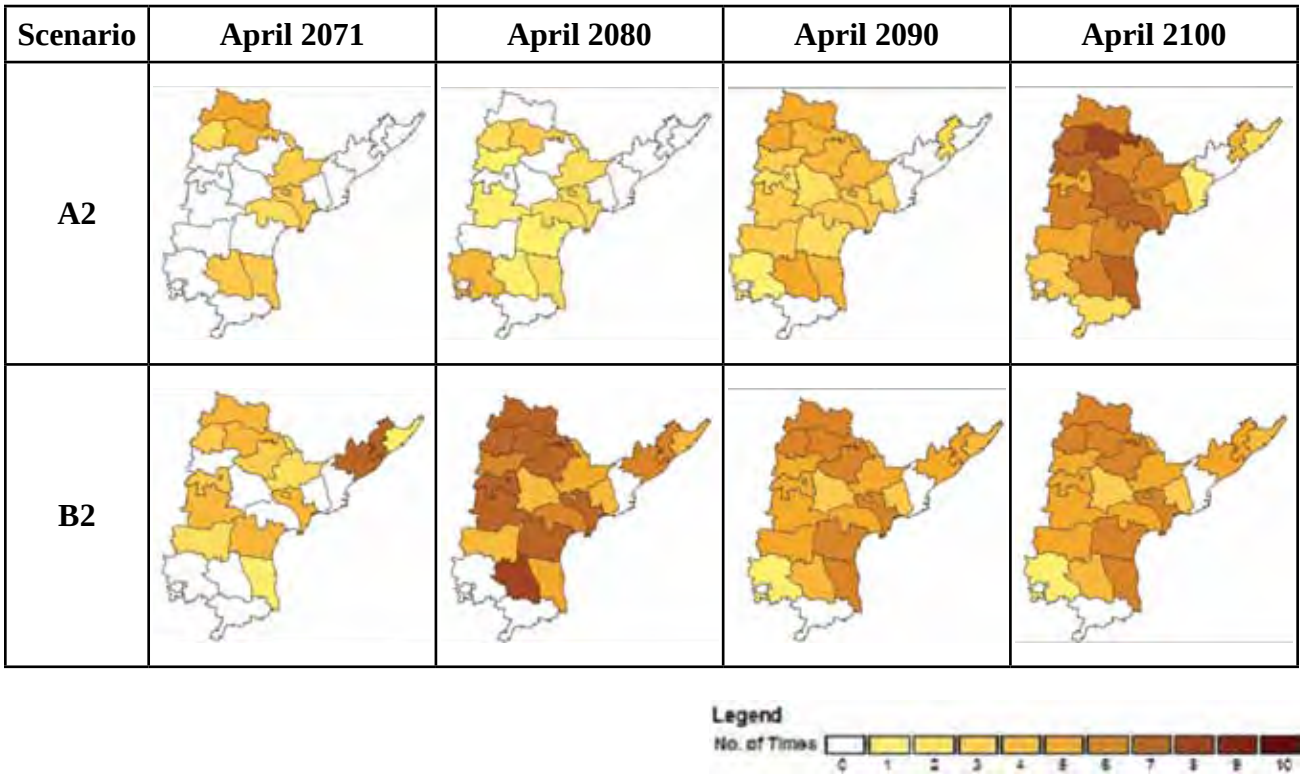


Fig. 6.35 Heat Stress Vulnerability of Andhra Pradesh due to continuous high temperatures ranging between 45^0-50^0C in the month of April of 2071, 2080, 2090 & 2100

अतिचालकता तथा निम्नतापिकी विज्ञान

SUPERCONDUCTIVITY AND CRYOGENICS

अतिचालकता एवं निम्न तापिकी

अतिचालकता समूह अभिलक्षणन की विविधता एवं अतिचालक पदार्थों की सुविस्तृत श्रृंखला के निर्माण में व्यस्त रहा है। Bi_2 Sr_2 Ca Cu_2 O_8 (Bio-2212) तंत्र का विभिन्न परिस्थितियों जैसे गलन शामिल (मेल्ट क्वेंच्ड), N_2^-.तापानुशीतन एवं O_2^-तापानुशीतन द्वारा संश्लेषण किया गया, नमूने में होल सान्द्रता की विभिन्नता आकर्षक तापशक्ति परिणाम दिखाती है। $MgB_{2-x}(nC)_x$ नमूनों की बड़ी श्रृंखलाओं में क्रांतिक अतिचालक प्राचलों के निर्धारण के लिए उच्च क्षेत्र चुम्बकन एवं चुम्बकीय परिवहन मापन का निष्पादन किया गया, विशुद्ध MgB_2 नमूनों की तुलना में नेनो कार्बन (nC) अपमिश्रण (डोपिंग) ने क्रांतिक प्राचलों जैसे H_{c2}, H_{irr} एवं $J_c(H)$ में संतोषजनक वृद्धि के परिणाम दिए हैं। स्थूल MgB_2 एक्स–सीटू नमूनों की श्रेणी, 5% तक आधिक्य में Mg मिलाकर तैयार की गयी जिसमें दुर्बलतः – युग्मित कणीय प्रकृति में सुव्यवस्थित अंतर देखा गया। विविध नमूनों में सामान्य अवस्था में आकलित धारावाही अनुप्रस्थ परिच्छेद का अतिचालक अवस्था गुणों जैसे Jc एवं Tc_o से कोई सहसबंध नहीं देखा गया।

अतिचालक आइरन आक्सिय्निक्टाइड्स जैसे $SmFe_{o.9}$ $Co_{o.1}$ AsO एवं Nd Fe $AsO_{0.8}$ $Fe_{0.2}$ नए संश्लेषण मार्ग द्वारा सफलतापूर्वक अनुकरण किए गए।

SUPERCONDUCTIVITY AND CRYOGENICS

The superconductivity group has been engaged in preparing an exhaustive range of superconducting materials and variety of characterizations. The $Bi_2Sr_2CaCu_2O_8$ (Bi-2212) system was synthesized under different conditions of melt quenched, N_2-annealed and O_2-annealed. The hole concentration variation in the samples led to interesting thermopower results. The high field magnetization and magneto transport measurements were carried out to determine the critical superconducting parameters in a large range of $MgB_{2-x}(nC)_x$ samples. The nano carbon (nC) doping resulted in substantial enhancement of critical parameters like H_{c2}, H_{irr} and $J_c(H)$ in comparison to the pure MgB_2 sample. Series of ex-situ samples of bulk MgB_2 were prepared with addition of excess Mg up to 5% that showed systematic difference in the weakly coupled particle nature. The estimated current carrying cross sections in normal state were found to show no correlation with the superconducting state properties like Jc and T_{co} in various samples. New synthesis routes to prepare superconducting iron oxypnictides, e.g., $SmFe_{0.9}Co_{0.1}AsO$ and $NdFeAsO_{0.8}F_{0.2}$ were successfully attempted.

Superconductivity and Cryogenics

We reported the temperature dependence of thermoelectric power *S(T)* of three differently processed $Bi_2Sr_2CaCu_2O_8$ (Bi2212) samples, viz. as-processed melt quenched (Bi2212-MQ), 600^{0}C N_2-annealed (Bi2212-N_2) and 800^{0}C O_2-annealed (Bi2212-O_2). All the samples possess single-phase character and their superconducting transition temperatures ($Tc^{R=0}$) are 85 K, 90 K and 72 K respectively for Bi2212-MQ, Bi2212-N_2 and Bi2212-O_2, see Figure.7.1. Though the Bi2212-MQ and Bi2212-N_2 samples are in near optimum doping regime, the Bi2212-O_2 is an over-doped sample. $Tc^{S=0}$ values obtained through *S(T)* data are also in line with those determined from the temperature dependence of resistance ($Tc^{R=0}$) and DC magnetization (Tc^{dia}). Interestingly, *S(T)* behaviour of the optimally-doped Bi2212-MQ and Bi2212-N_2 samples is seen to be positive in whole temperature range, the same is found negative for the over-doped Bi2212-O_2 sample above $Tc^{S=0}$, see Figure7.2. This anomalous *S(T)* behaviour is seen in the light of the recent band structure calculations and the ensuing split

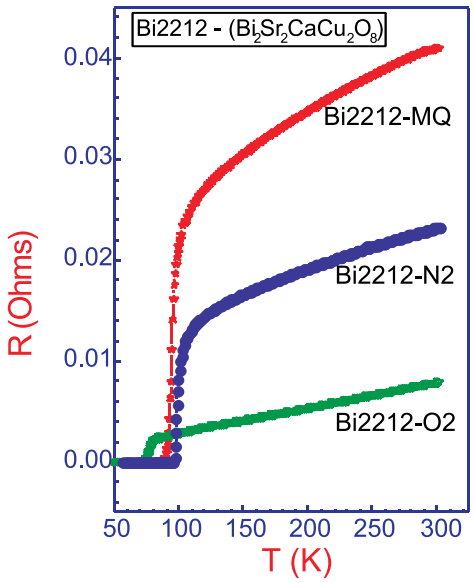


Fig. 7.1 R(T) of various Bi-2212 samples

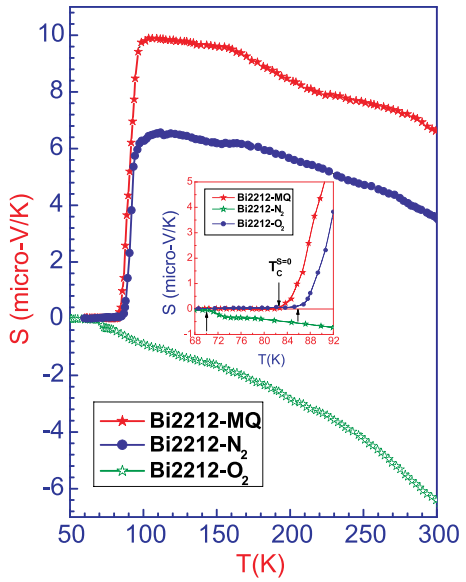


Fig. 7.2 S(T) of various Bi-2212 samples

Fermi surface as determined by angle-resolved photoelectron spectroscopy (ARPES).

The high field magnetization and magneto transport measurements are carried out to determine the critical superconducting parameters of $MgB_{2-x}C_x$ system. The synthesized samples are pure phase and the lattice parameters evaluation is carried out using the Rietveld refinement. The R-T(H) measurements are done up to a field of 140 kOe. The upper critical field values, H_{c2} are obtained from this data based upon the criterion of 90% of normal resistivity i.e. H_{c2}=H at which ρ=90%ρN; where ρN is the normal resistivity i.e., resistivity at about 40 K in our case, see Figure 7.3. The Werthamer-Helfand-Hohenberg (WHH) prediction of $H_{c2}(0)$ underestimates the critical field value even below than the field up to which measurement is carried out. After this the model, the Ginzburg Landau theory (GL equation) is applied to the R-T(H) data which not only calculates the $H_{c2}(0)$ value but also determines the dependence of H_{c2} on temperature in the low temperature high field region. The estimated $H_{c2}(0)$=157.2 kOe for pure MgB_2 is profoundly

enhanced to 297.5 kOe for the x=0.15 sample in $MgB_{2-x}C_x$ series, see Figure 7.4. Magnetization measurements are done up to 120 kOe at different temperatures and the other parameters

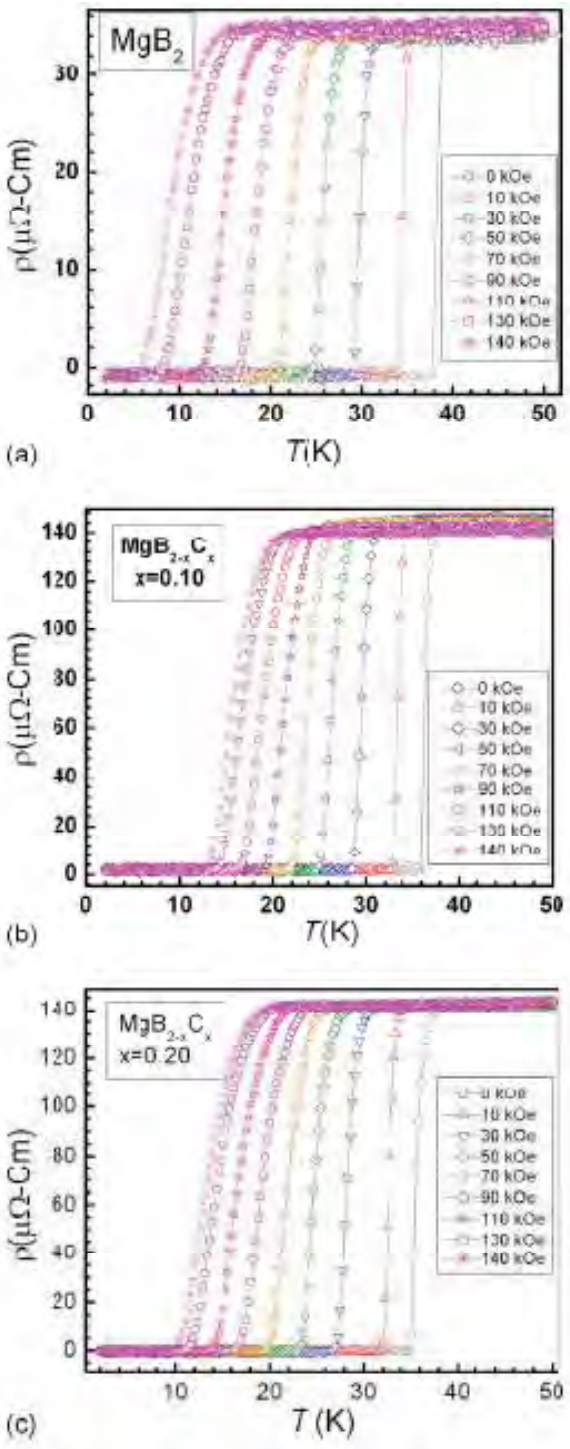


Fig.7.3: R(T,H) of $MgB_{2-x}C_x$

like irreversibility field, H_{irr} and critical current density Jc(H) are also calculated. The nano carbon doping results in substantial enhancement

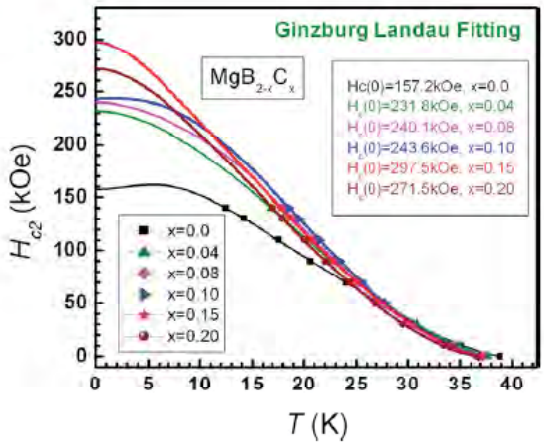


Fig. 7.4: $H_{c2}(T)$ for $MgB_{2-x}C_x$

of critical parameters like H_{c2}, H_{irr} and Jc(H) in comparison to the pure MgB_2 sample.

Series of ex-situ samples of bulk MgB_2 were prepared with addition of excess Mg up to 5% and varying sintering temperatures between 700°C to 950°C. All the samples were subjected to XRD and SEM characterization as well as thermoelectric power S(T), resistivity ρ(T) and magnetization M(B) measurements at 4.2 and 20 K and applied fields B=0 - 8 T. Various normal and superconducting state properties show weakly coupled particles in the samples. The samples typically show high values of ρ(300 K) that varies between 0.12 and 254 mΩcm. And the critical current density Jc(4.2 K, 1 T) show low values that varies between $1.8x10^7$ to $1.7x10^8$ A/m^2. The temperature dependence of resistivity in the normal state scales perfectly among the samples, to within a multiplication factor. Following Rowell's analysis, this indicates a difference in normal state connectivity, i.e., effective current carrying cross section (A_F), which is found to vary from 0.02% to 7% in different samples.

Surprisingly, no correlation between the Jc and T_{co} as a function of AF is found in our samples (Fig.7.5). However, Jc(B) of all the samples can be scaled within a multiplication factor at both 4.2 and 20 K until cross over fields $B_{cr} \sim 2$ and 1.3 T, respectively. The Jc(B) of the samples follow a B^{-1} dependence until Bcr, at both T=4.2 and 20 K, beyond which it decreases rapidly towards zero with increasing B. The superconducting transition measured resistively in the presence of B shows an enhanced broadening. We further attempt to delineate the role of the intra-particle and inter-particle regions in determining the Jc(B)

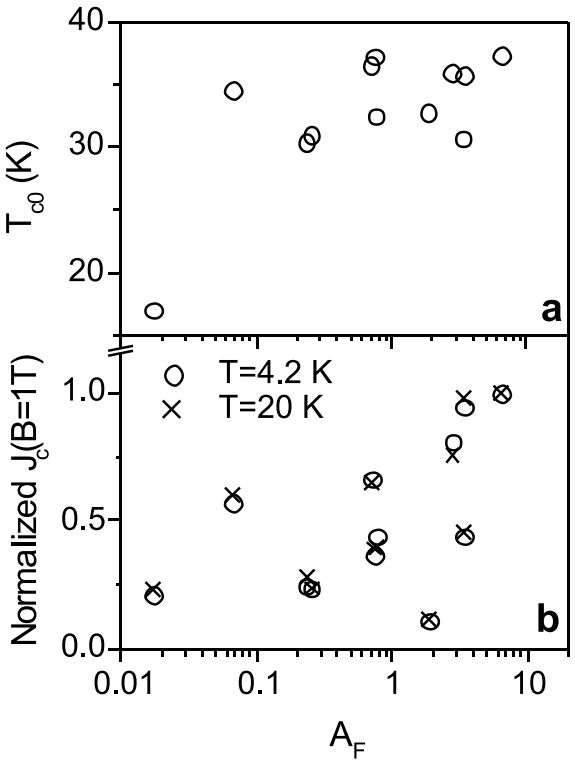


Fig.7.5. Variation of (a) T_{c0} and (b) Normalized J_c (B=1T) at T = 4.2 and 20 K as a function of A_F for different MgB_2 samples.

and ρ(T,B) properties of our weakly coupled samples.

We reported superconductivity in the $SmFe_{0.9}Co_{0.1}AsO$ system being prepared by most easy and versatile single step solid-state reaction route. The parent compound SmFeAsO is non-superconducting but shows the spin density wave (SDW) like antiferromagnetic ordering at around 140K. To destroy the antiferromagnetic ordering and to induce the superconductivity in the parent system, the Fe^{2+} is partially substituted by Co^{3+}. Superconductivity appears in $SmFe_{0.9}Co_{0.1}AsO$ system at around 14K. The Co doping suppresses the SDW anomaly in the parent compound and induces the superconductivity. Magnetization measurements show clearly the onset of superconductivity with Tc^{dia} at 14K, see Figure 6. The isothermal magnetization measurements exhibit the lower critical fields (H_{c1}) to be around 200Oe at 2 K. The bulk superconductivity of the studied $SmFe_{0.9}Co_{0.1}AsO$ sample is further established by open diamagnetic M(H) loops at 2, and 5K, see inset Figure 7.6. Normal state (above Tc) linear isothermal magnetization M(H) plots excluded presence of any ordered magnetic impurity in the studied compound.

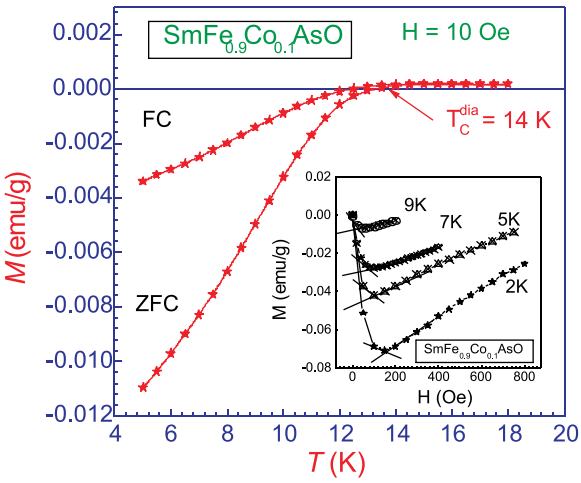


Fig. 7.6 M(T) and M(H) of $SmFe_{0.9}Co_{0.1}AsO$ system

सहायक सेवाएं
SUPPORT SERVICES

Planning, Monitoring and Evaluation Group (PME)

Contract R & D Projects, as Sponsored, Collaborative and Grant-in-Aid Projects are undertaken by the Laboratory with funding from External Agencies. Before submission of the project proposals to the outside agencies they are evaluated by the Group based on various criteria and conditions. Monitoring and developing of complete database for report generation on projects are done and project files are created and maintained. Similarly Major Laboratory Projects and other In-house Projects funded by CSIR & NPL, undertaken in NPL, are also monitored. Fund allocation and processing of indents is an important activity undertaken by this group. The report on completed projects and refund of unspent balance to the funding agencies at the end of project are made by the group.

PME prepares Annual Plan and Five Year Plan for NPL. It organizes Research Council meetings and coordinates the Management Council meetings, organized by administration. Time to time PME disseminates information on projects, performance reports and ECF reports to CSIR. PME is also involved in monitoring of Networking Projects. PME developed manpower data and maintains staff positions and disseminates the information to various authorities. The group also maintains and regulates the appointments of project staff under various externally funded projects.

PME has the additional responsibility of getting feedback on degree of customer satisfaction in a prescribed format from funding agencies who are funding the different contract research projects in NPL. The process is done at the end of each project. This function has been initiated by CSIR under the supervision of Customer Satisfaction Evaluation Unit (CSEU) at CSIR Headquarter, Rafi Marg, New Delhi – 110 001. The feed-back received from the funding agencies are sent to CSEU, CSIR.

PME prepares many types of reports on Manpower in different formats as required from time-to-time and also does different type of Analysis for manpower planning of the laboratory.

Publication of Annual Report is another important activity of PME. On receiving inputs from various DUs', DPs' & other concerned groups, Text and Apendices of Annual Report are compiled, corrected and published in the form of Annual Report each year.

Industrial Liaison Group (ILG)

This group undertakes two major areas viz marketing of developed technologies and consultancy and technical services. Besides this, the group is responsible for all matters connected with business development, open day function, wherein few thousand school and college students with their teachers are invited to see the various activities at NPL. Students are shown a film on NPL activities too. A technology day function is also observed where all licencees are invited to deliberate with concerned PI of the technology, for any suggestions. This group is also responsible for the dissemination of science through publication in CSIR news and in CSIR annual report, business and industrial magazines and their websites and through advertisements in news papers, conferences, symposiums, various other events and their souvenirs and also through participation in exhibitions. Processing of applications for the awards pertaining to

technology or consultancy services rendered. Informs industries and licencees for any new schemes. This group also takes care in the management of S & T outputs with other funding agencies viz. DST, CSIR, NRDC, AIMA, CDC, etc.. This group has recently initiated its efforts in setting-up an Incubation Centre and possible knowledge Alliance with Moser Baer Photovoltaic Limited in Solar Energy area.

Human Rsource Development Activities

The Human Resource Development (HRD) Group of NPL is a central group of the laboratory providing a wide range of HRD services not only to NPL but also to other organizations of the country, and quite often to other countries of the world also. It undertakes several activities such as organization of Industrial Training in Metrology / Standards, Students' Training / Project work for M.Tech./ MCA / M.Sc./ B.Tech and other equivalent degrees, Institutional Visits, Deputation of NPL staff members to attend conferences, etc. All these activities eventually lead to the generation of the trained S&T manpower.

International Science and Technology Affairs Group (ISTAG)

International visits play an important part of scientific R & D. Processing of application of the laboratory scientists pertaining to international visits, bilateral exchange programmes, sabbatical leave /study leave for deputations abroad are handled by this group. It also arranges important lectures and invited talks. Arranging training programmes for international candidates is also the job of this group. It also organizes the visit of foreign delegations at NPL. International collaborative projects, Bilateral International cooperation porgrammes & MoUs of NPL are also the areas of this group.

Knowledge Resource Center

NPL Knowledge Resource Center (KRC) has been providing library and information support to scientists for R & D pursuits.

Over the years, it has developed a rich collection of scholarly books and journals for the purpose, specially in the field of physics and related sciences.

During the current year, KRC subscribed to 99 scholarly journals (77 foreign journals and 22 Indian journals) and added 90 S & T books, 18 Hindi books. KRC serves the NPL community with services like Reprographic service, Electronic Document Delivery service, Inter Library Loan service, Reference service, Literature Search service etc.

NPL KRC offers online access to more than 6000+ full text journals under the e-consortium project of CSIR. The project facilitate access to electronic content from various publishers such as Elsevier, Springer, AIP (American Institute of Physics), APS (American Physical Society), Wiley - Blackwell, Oxford University Press, Royal Society of Chemistry, American Chemical Society etc as well as the archives of few publishers on concession rates.

This Service was made operational in NPL on 31st July 2002 with the access to Science Direct (Elsevier) group of journals and others w.e.f. February 2005 onwards.

Since 2002, the KRC has started providing access to intranet edition of Indian Standards.

With the installation of improved routers in the KRC there was a shift in the technology i.e. from 802.11G to 802.11N. This technology transfer resulted in increasing the bandwidth and wi-fi connectivity range within the KRC. Moreover, the practice offers freedom to the scientists/researchers to use their personal laptops in the KRC premises and thus helps in optimizing the use of entitled e-resources. Also, four out of seven desktops installed in the reading hall of the KRC are presently wi-fi enabled.

On continuous basis, KRC maintains its site on the NPL intranet to provide latest information on its activities such as additions to its collection, current subscribed journals, new journals received during the week, links to electronic libraries, publishing houses, and papers published by NPL scientists.

NPL KRC also maintains NPL website (http://www.nplindia.org) on Internet to inform others about the activities of NPL such as its role towards the society; thrust area of research, facilities, services and achievements.

Central Workshop

In Central Workshop more than 1032 jobs have been completed including their designing, fabrication and development. Out of the above, a large number of highly sophisticated components were produced notably of Cesium Fountain Clock, Rubidium Atomic Clock –a joint project of NPL and Space Application Centre, Ahmedabad, Helmotz Coil, technology development for Sensors, fabrication of LED devices & systems for Solid State Lighting applications etc.

During this period, the total output of the Central Workshop of the works done (Total Job Cards completed-1032) in the monetary terms was Rs. 1,44,41000/- (Rupees One crore forty four lacs forty one thousand only). In addition to the above, a large number of drawings & design work was also undertaken at the Mechanical Drawing & Design Section.

During this period workshop helped to develop and transfer a technology entitled "Piezoelectric Accelerometer – Shear Mode". This technology was transferred to M/s Powercon Engineers Pvt. Ltd., Ahmedabad on 02/02/2009. It was the effort of a team comprising Mr. S.K.Singhal, Mr. S.S.Verma, Mr. P.Srinivasan, Mr. Bhim Singh & Mr. Brijesh Kumar Sharma.

In our Cryogenic Plants & Facilities Section, a total quantity of 1326 liters of Liquid Helium from our old Linde Helium Liquefier (total market value of this production is approx. Rs. 10,34000/- (Rupees ten lacs thirty four thousand only) was produced. In addition to this, a total of 1981.04 liters of Liquid Helium from outside agencies was also procured. In addition to LHe, we have produced approximately 54600 liters of Liquid Nitrogen for R&D requirements of NPL (Market value being approximately Rs. 11.00 Lacs only).

In Glass Technology Unit a total of 233 jobs of different sections of NPL and 15 jobs from outside agencies like Indian Oil Corporation, IIT Delhi, IARI etc. were completed and earned a total of Rs. 66000/- (Rupees sixty six thousand only).

Due to the strict preventive maintenance schedules, most of our Workshop machines including CNC machines, equipments, Glass & Quartz working machines and Cryogenic Plants (Liquid Helium Plant & Liquid Nitrogen Plant) are working satisfactorily.

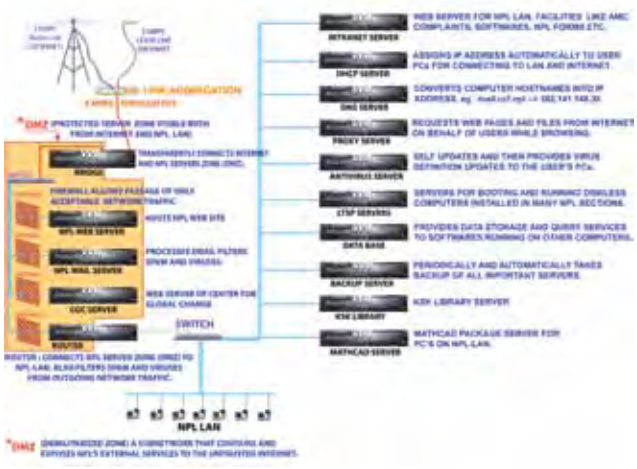
The Central Computer Facility

The Central Computer Facility (CCF) (a) offers several network, computing and user-support facilities to NPL scientists and staff, (b) is involved in software development for use at NPL and development of biomedical instruments, and (c) conducts research in the areas of pattern formation and nonlinear physics and evolving networks and (d) provides consultancy to other instutions and industry in the area of IT infrastructure and networking and automation and instrumentation.

IT Infrastructure and Facilities

A campus LAN (Local Area Network) has been set which connects together approximately 850 computers spread over the NPL campus. The network utilises a mixture of optical fibre, UTP cables and switches. The internet access is provided through a gateway to the external world via a 2 Mbps radio link and 2 Mbps leased line to the ERNET at the department of Electronics. Email and Internet services are thus brought to the user's desktops.

CCF has established and is actively maintaining various servers namely Mail, Web, LTSP, Intranet, DHCP, DNS, Router, Bridge, Anti-virus, Backup, Database and Other Dept. servers for providing networking, mailing and backup services. A schematic of the set up is shown in the figure below.



CCF has started the initiative to establish a new Data Center facility. Migration to improved infrastructure, with new servers to improve of the quality of service has been already completed. Multi-layered firewall, anti-spam engine, antivirus solution have been implemented to enhance the overall network security.

Developmental Activities

Development of Personnel Inventory System (PIR) to enable the employees to retrieve their PIR records. Its purpose is to help staff of NPL store for maintaining and updating the PIR records online.

CCF has developed the NPL intranet site (http://nplnet.ccf.npl) and is maintaining the same for providing information about latest circulars, notices, announcements etc. User friendly interfaces are also provided on the site for lodging PC/printer AMC related complaints and checking the status, to browse through the list of experts, personal inventory records, telephone directory, commonly used forms and open source softwares etc.

Research and Educational Activities

Development of biomedical instruments like blood oxygenation monitor, ECG machine and brain oxymeter. Experimental, theoretical, and computer simulation research on formation of patterns in a layer of a solid at the melting transition. Research on models for prebiotic evolution using numerical methods.

राजभाषा कार्यान्वयन

RAJBHASHA

राष्ट्रीय संगोष्ठी – 2009

विज्ञान प्रौद्योगिकी के क्षेत्र में हिन्दी के बढ़ते प्रयोग ने यह सिद्ध कर दिया है कि हिन्दी केवल साहित्यकारों की ही नहीं वरन् भारत के प्रबुद्ध वर्ग और जनसाधारण की भाषा है। आज हमारे देश के वैज्ञानिक हिन्दी में शोध–पत्र लेख और पुस्तकें लिख रहे हैं तथा हिन्दी के माध्यम से विज्ञान के प्रयोग और प्रसार कार्यों में संलिप्त हैं। प्रयोगशाला में 22–23 अप्रैल, 2009 को 'रेडियो एवं पर्यावरण विज्ञान' विषय पर राजभाषा हिन्दी में दो दिवसीय राष्ट्रीय संगोष्ठी का आयोजन किया गया। रेडियो विज्ञान, बेतार संचार व्यवस्था, पर्यावरण परिवर्तन एवं दूर संवेदन जैसे क्षेत्र आधुनिक युग में मानव जाति के विकास के लिए अत्यंत महत्वपूर्ण हैं। जन सुरक्षा, प्राकृतिक आपदा प्रबंधन एवं अन्य आपात कालीन परिस्थितियों में रेडियो संचार व्यवस्था का परिदृश्य बड़ी तेजी से बदल रहा है। पृथ्वी के पर्यावरण परिवर्तन में प्राकृतिक कारणों के बजाय मानवीय क्रिया–कलाप का प्रभाव ज्यादा है। 22 अप्रैल, 2009 को 'पृथ्वी दिवस' के रूप में मनाने के उद्देश्य से प्रयोगशाला में विभिन्न पाठशालाओं से 150 विद्यार्थियों को इस संगोष्ठी में शामिल होने के लिए आमंत्रित किया गया। उनमें पृथ्वी एवं पर्यावरण के प्रति जागरूकता उत्पन्न करने के लिए एक पेटिंग प्रतियोगिता का आयोजन किया गया जिसमें विजेता प्रतिभागियों को पुरस्कृत करने का प्रावधान किया गया।

इस संगोष्ठी का शुभारंभ डा. विक्रम कुमार, निदेशक, एन.पी.एल. के स्वागत भाषण से हुआ। निदेशक महोदय ने स्वागत भाषण में विभिन्न संस्थाओं से जुड़े प्रतिनिधियों, रेडियो विज्ञान से जुड़े वैज्ञानिकों तथा संगोष्ठी में उपस्थित सभी प्रतिभागियों को संदेश दिया कि पर्यावरण के प्रति सजग रहने में हमारी महत्वपूर्ण भूमिका होनी चाहिए। आधुनिक युग में सम्पूर्ण मानव जाति के विकास के लिए पर्यावरण परिवर्तन के प्रति कदम उठाना अतिआवश्यक है। तत्पश्चात् रेडियो विज्ञान विभाग के प्रमुख डा. स्वरूप कुमार सरकार ने कार्यशाला की भूमिका के बारे में बताया कि संगोष्ठी में 68 लेख सम्मिलित किए गए हैं जिसमें 3 मौखिक हैं और 31 पोस्टर सत्र में शामिल किए गए हैं। तीन पेपर अहिन्दी भाषी क्षेत्र – मैसूर, सिक्किम और कोलकाता से हैं।

पृथ्वी दिवस व रेडियो एवं पर्यावरण विज्ञान : राष्ट्रीय संगोष्ठी–2009 के अवसर पर मंच पर आसीन गणमान्य व्यक्ति

संगोष्ठी के उद्घाटन में आर्यभट्ट प्रेक्षण विज्ञान शोध संस्थान, नैनीताल के निदेशक डा. राम सागर जी को मुख्य अतिथि के लिए आमंत्रित किया गया। मुख्य अतिथि का परिचय राजभाषा यूनिट इंचार्ज डा. (श्रीमती) एस. शर्मा ने दिया। तत्पश्चात् मुख्य अतिथि ने अभिभाषण प्रस्तुत किया जिसमें उन्होंने हिन्दी के प्रति अपनी रूचि प्रदर्शित करते हुए सभी प्रतिभागियों का स्वागत किया। अपने मुख्य अभिभाषण में उन्होंने वायुमण्डल में बढ़ती प्रदूषण की मात्रा जिससे मानव के स्वास्थ्य पर काफी प्रतिकूल प्रभाव पड़ता है, के बारे में चर्चा करते हुए रेडियो विज्ञान, बेतार संचार व्यवस्था एवं दूर संवेदन क्षेत्र के बारे में जानकारी दी। उद्घाटन समारोह के अंत में कार्यशाला के संयोजक श्री देव राज नाकरा ने सबका आभार व्यक्त करते हुए धन्यवाद प्रस्तुत किया।

इस दो दिवसीय संगोष्ठी को छः सत्रों में विभक्त किया गया। ग्यारह आमंत्रित वार्ताएं प्रस्तुत की गयी। अंत में युवा वैज्ञानिकों को पुरस्कार प्रदान किए गए। इस प्रकार संगोष्ठी का आयोजन पूर्ण रूप से सफल रहा।

हिन्दी पखवाड़ा रिपोर्ट 2009

निदेशक महोदय की अध्यक्षता में हुई तिमाही बैठक में निर्णय लिया गया था कि हिन्दी दिवस के दौरान आयोजित किए जाने वाले कार्यक्रमों को केवल उसी माह तक सीमित न रखकर पूरे वर्ष भर आयोजित किया जाए, जिससे कि स्टाफ सदस्यों में हिन्दी

के प्रति जागरूकता बढ़े और वे अपना अधिकांश कार्य हिन्दी में ही करने के लिए प्रेरित हो सकें।

इस सन्दर्भ में प्रयोगशाला में दिनांक 1–14 सितम्बर, 2009 के दौरान हिन्दी पखवाड़ा मनाया गया। पखवाड़े एवं वर्ष के दौरान जो प्रतियोगिताएं आयेाजित की गयी वे इस प्रकार हैं :– साइंस क्विज़ प्रतियोगिता, निबन्ध प्रतियोगिता, टंकण प्रतियोगिता एवं डिक्टेशन प्रतियोगिता जो क्रमशः दिनांक 18.06.2009, 22.07.2009, 03.09.2009, 04.09.2009 को आयेाजित की गयी। उनका क्रमवार विवरण इस प्रकार हैं :–

1. प्रयोगशाला में दिनांक 18.06.2009 को साइंस क्विज़ प्रतियोगिता का आयोजन डा. जी. भगवन्नारायण, वैज्ञानिक–जी के सहयोग से किया गया। इस प्रतियोगिता में भाग लेने वाले प्रतिभागियों को चार ग्रुपों में बांटा गया था। प्रत्येक ग्रुप में चार प्रतिभागी शामिल किए गए थे। प्रत्येक ग्रुप को 10 प्रश्नों के उत्तर देने थे। इस प्रकार इन चार ग्रुपों में से दो ग्रुपों को विजेता घोषित किया गया जो क्रमशः प्रथम व द्वितीय रहे। इन्हें हिन्दी दिवस समापन समारोह के समय निदेशक महोदय द्वारा नकद पुरस्कार प्रदान किए गए।

2. प्रयोगशाला में दिनांक 22.07.2009 को निबंध प्रतियोगिता का आयोजन किया गया जिसमें 25 प्रतिभागियों ने भाग लिया। इनमें से 11 प्रतिभागियों को विजेता घोषित किया गया, जिन्हें क्रमशः प्रथम (2), द्वितीय (2), तृतीय (2) और प्रोत्साहन पुरस्कार (5) प्रदान किए गए।

3. प्रयोगशाला में दिनांक 04.08..2009 को टंकण प्रतियोगिता का आयोजन किया गया था। जिसमें प्रयोगशाला के 8 प्रतिभागियों को क्रमशः प्रथम (1), द्वितीय (1), तृतीय (3), और प्रोत्साहन पुरस्कार (3) से पुरस्कृत किया गया।

4. प्रयोगशाला के सभागार में दिनांक 03.09.2009 को काव्य पाठ प्रतियोगिता का आयोजन किया गया जिसमें प्रयोगशाला के 23 अधिकारियों/कर्मचारियों ने उत्साहपूर्वक भाग लिया। काव्य पाठ प्रतियोगिता में बाहर से दो सम्माननीय कवियों को बुलाया गया था जिनके निर्णयानुसार 13 प्रतिभागियों को विजेता घोषित किया गया। जिनमें प्रथम (2), द्वितीय (2), तृतीय (2), और प्रोत्साहन पुरस्कार (7) प्रदान किए गए।

हिन्दी दिवस समारोह में कार्यक्रम का शुभारंभ करते हुए
डा. पी. बनर्जी (कार्यकारी निदेशक)

5. प्रयोगशाला में दिनांक 04.09.2009 को टिप्पण एवं प्रारूप लेखन प्रतियोगिता का आयोजन किया गया जिसमें वर्ष के दौरान हिन्दी में किए गए कार्य का विवरण स्टाफ सदस्यों से मांगा गया। इस प्रतियोगिता में प्रशासन के स्टाफ सदस्यों के अतिरिक्त वैज्ञानिक भी भाग लेते हैं और वे वर्ष के दौरान हिन्दी में किए गए कार्यों का विवरण प्रस्तुत करते हैं। इस आधार पर प्रतियोगिता को दो भागों में विभक्त किया गया। प्रथम वैज्ञानिक/तकनीकी राजपत्रित और इसी में वैज्ञानिक/तकनीकी अराजपत्रित स्टाफ सदस्यों को शामिल किया गया व द्वितीय में प्रशासनिक राजपत्रित और प्रशासनिक अराजपत्रित अधिकारियों को शामिल किया गया है। इस प्रकार वैज्ञानिक/तकनीकी राजपत्रित अधिकारियों को पांच पुरस्कार जिसमें प्रथम (2) व द्वितीय (3) पुरस्कार दिए गए और तकनीकी अराजपत्रित स्टाफ सदस्यों को 11 पुरस्कार जिसमें प्रथम (2), द्वितीय (3), तृतीय (3) और प्रोत्साहन पुरस्कार (3) दिए गए। इसी प्रकार दूसरे भाग में प्रशासनिक राजपत्रित अधिकारियों को प्रथम (2) व द्वितीय (1) कुल तीन पुरस्कार दिए गए हैं।

इसी में प्रशासनिक अराजपत्रित स्टाफ सदस्यों में प्रथम (2), द्वितीय (3), तृतीय (5) और प्रोत्साहन पुरस्कार (4) कुल 14 पुरस्कार प्रदान किए गए। डिक्टेशन प्रतियोगिता में प्रथम पुरस्कार डा. मुकेश कुमार मित्तल, वैज्ञानिक–जी को दिया गया।

इस प्रकार 14 सितम्बर, 2009 को प्रयोगशाला के सभागार में हिन्दी दिवस समापन समारोह 11.00 बजे (प्रातः) मनाया गया। इस अवसर पर कवयित्री डा. प्रभा किरण जैन को मुख्य अतिथि के रूप में बुलाया गया। उन्होंने समसामयिक विषयों पर अपनी सुमधुर कविताएं सुनाकर सभागार में उपस्थित श्रोतागणों को भाव–विभोर कर दिया। तत्पश्चात् कार्यकारी निदेशक, डा. पी बनर्जी ने विजेता प्रतिभागियों को पुरस्कार प्रदान किए। अंत में डा. वी. एन. ओझा ने धन्यवाद प्रस्ताव प्रस्तुत किया।

प्रशासनिक कार्यशाला

प्रयोगशाला में राजभाषा नीति के प्रचार–प्रसार हेतु दिनांक 14 मई, 2009 को प्रशासनिक स्टाफ सदस्यों के लिए एक दिन की कार्यशाला का आयोजन किया गया। कार्यशाला में संसदीय समिति के उपसचिव श्री कृष्ण कुमार ग्रोवर जी को आमंत्रित किया गया जिसमें उन्होंने 'राजभाषा हिन्दी के प्रयोग में आने वाली कठिनाईयां और समाधान' विषय पर अपना व्याख्यान प्रस्तुत किया। उन्होंने कार्यशाला में उपस्थित अधिकारियों की समस्याओं को सुना और बताया कि किस तरह से अंग्रेजी के शब्दों को भी हम ज्यों का त्यों हिन्दी में लिख कर भी राजभाषा हिन्दी (देवनागरी लिपि) में काम को बढ़ोत्तरी दे सकते हैं। कर्मचारी यदि सही मायने में हिन्दी में काम करना चाहता है तो उसे झिझक नहीं लानी है। जो भाषा हम बोलचाल में इस्तेमाल करते हैं उसे ही प्रयोग में लाना है। कार्यशाला में अधिकारियों/कर्मचारियों के लिए एक प्रतियोगिता का आयोजन भी किया गया जिसमें भाग लेने वाले अधिकारियों को प्रथम, द्वितीय तृतीय तथा प्रोत्साहन पुरस्कारों की घोषणा की गयी। प्रयोगशाला के अधिकाारियों ने कार्यशाला में उत्साहपूर्वक भाग लिया व इस प्रकार उनका योगदान सराहनीय रहा।

प्रशासनिक कार्यशाला
में भाग लेने वाले सभी प्रतिभागी

कार्यशाला

इसी क्रम में प्रयोगशाला के वैज्ञानिक/तकनीकी अधिकारियों को एलटीसी नियमों/सीसीएस नियमों की जानकारी देने के लिए दिनांक 4 नवम्बर, 2009 को एक इंटरनल कार्यशाला का आयोजन किया गया। इस कार्यशाला में सीसीएस नियमों व एलटीसी नियमों की जानकारी देने के लिए श्री के. एस. कुमार संयुक्त निदेशक, आईएसटीएम एवं प्रयोगशाला के प्रशासन नियंत्रक श्री आर. पी. शर्मा को आमंत्रित किया गया था।

सीसीएस नियमों के विशेषज्ञ होने के कारण श्री कुमार ने सरल हिन्दी का प्रयोग करते हुए प्रतिभागियों को नियमों की विस्तार से जानकारी दी। एलटीसी नियमों पर चर्चा करते हुए श्री आर.पी. शर्मा ने प्रतिभागियों द्वारा बीच–बीच में पूछे गए प्रश्नों का उत्तर देकर व्याप्त भ्रान्तियों को दूर किया। इस कार्यशाला में प्रयोगशाला के लगभग 90 प्रतिभागियों ने भाग लिया। इस प्रकार यह कार्यशाला अपने मूल उद्देश्य में सफल रही।

व्याख्यान

प्रयोगशाला में व्याख्यानों की श्रृंखला के अंतर्गत दिनांक 24 जून, 2009 को श्री पंकज हांडा ने 'भारतीय प्रबंधकों की जीवन शैली की गुणवत्ता और जॉब में भागीदारी–संबंध और परिणाम' विषय पर व्याख्यान प्रस्तुत किया। इस व्याख्यान का शुभारंभ प्रयोगशाला के वरिष्ठ वैज्ञानिक डा. जी. भगवन्नारायण ने मुख्य वक्ता का परिचय देते हुए किया। इस व्याख्यान में श्री पंकज हांडा ने 'जीवन शैली की

गुणवत्ता को दर्शाने के लिए बहुआयामी जीवन शैली की गुणवत्ता के साथ महत्वपूर्ण संबंधों का उल्लेख किया। उन्होंने आगे बताया कि ऊंचे जॉब में भागीदारी रखने वाले प्रबंधकों की अपेक्षा उच्च जीवन शैली पसंद करने वाले प्रबंधक जिन बातों पर अधिक महत्त्व देते हैं, वे हैं – संतुलित जॉब में भागीदारी, मिलने वाले अवसरों का लाभ उठाना, अपने जीवन में चुने हुए लक्ष्यों में सुधार करना और उनको स्वयं नियंत्रित करना'। श्री हांडा जी ने अपने व्याख्यान को अत्यंत रोचक ढंग से प्रस्तुत किया। उपस्थित श्रोताओं द्वारा कुछेक प्रश्न भी किए गए जिसका उन्होंने समाधान किया।

व्याख्यान

प्रयोगशाला में पिछले कई वर्षों से राजभाषा हिन्दी के प्रयोग को बढ़ावा देने के लिए प्रशासन के साथ–साथ विज्ञान एवं तकनीकी क्षेत्रों में भी हिन्दी को और अधिक प्रसारित करने के उद्देश्य से समय–समय पर विज्ञान विषयों पर आधारित व्याख्यानों का आयोजन किया जाता है। इसी क्रम में 30 नवम्बर, 2009 को प्रयोगशाला के वैज्ञानिकों के लिए एक व्याख्यान का आयोजन किया गया। व्याख्यान देने के लिए प्रो. पी. रामासामी, पूर्व उप–कुलपति, अलगप्पा यूनिवर्सिटी को विशेष रूप से आमंत्रित किया गया। प्रो. रामासामी ने 'शंकरनारायणन–रामासामी पद्धति द्वारा घोल से बल्क एकल क्रिस्टल का एक दिशीय निर्माण' (Undirectional Growth of Bulk Single Crystals from Solution by Sankaranarayanan-Ramasamy Method) पर अपना व्याख्यान प्रस्तुत किया। प्रो रामासामी ने उपस्थित वैज्ञानिकों को क्रिस्टल के निर्माण के बारे में सूक्ष्मता से जानकारी उपलब्ध करायी। इस व्याख्यान की सबसे बड़ी विशेषता यह रही कि प्रो. रामासामी ने दक्षिण भारतीय होते हुए भी हिन्दी के बहुत ही सुन्दर व सरल शब्दों का प्रयोग करते हुए अपना व्याख्यान प्रस्तुत किया। इस प्रकार यह व्याख्यान ज्ञानवर्धक व अत्यन्त रोचक रहा।

APPENDIX - 1

PUBLICATIONS

Papers Published by NPL Researchers in SCI Indexed Journals During April 2009 - March 2010

1. Agarwal, A.; Sheoran, A.; Sanghi, S.; Bhatnagar, V.; Gupta, S. K.; and Arora, M. "Structural investigation and electron paramagnetic resonance of vanadyl doped alkali niobium borate glasses." Spectrochimica Acta Part a-Molecular and Biomolecular Spectroscopy 75 (Mar 2010): 964-969.
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201. Devinder Gupta, Development of IR Spectrophotometric Standards of Specular Reflectance at Near and Oblique Incidence International Conference on Advances in Metrology (AdMeT-2009), NPL, New Delhi.

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203. Synthesis and characterization of ZnO tetrapods by thermal evaporation J.S. Tawale, K.K. Dey, R. Pasricha, K.N. Sood and A.K. Srivastava India-Japan Workshop on Biomolecular Electronics & Organic Nanotechnology for Environment Preservation (IJWBME 2009), 17-20 Dec. 2009 at NPL, New Delhi.

204. Growth and Characterization of Silica Nanowires and Nanospheres Sanjay K. Srivastava*, P. K. Singh, Vikas Sareen, K. N. Sood, and Vikram Kumar (Proc. IWPSD- 2009)

205. Microstructural Features and Optical Studies of CdTe Bulk and its Thin Films Sukhvir Singh, Kamlesh Chandekar K.N. Sood and Shailesh N. Sharma (Proc. IWPSD- 2009) page 1197-1199

206. Effect of processing conditions on microstructure and dielectric properties of ZrO_2 doped CCTO($CaCu_3Ti_4O_{12}$) ceramics Gurvinder Singh, K.N.Sood, T.D.Senguttuvan (Abstract Book, International Conference on Electroceramics, ICE2009)

207. Growth and characterization of PbTe bulk compounds and its nanostructured thin films deposited by thermal evaporation technique Rajeev Kumar, K.N.Sood, A.G. Vedeshwar, Sukhvir Singh International Conference on Electroceramics, ICE2009)

208. Effect of green forming pressure on dielectric properties of Cr_2O_3 doped CCTO ($CaCu_3Ti_4O_{12}$) ceramics Monika Mishra, K.N.Sood, T.D. Senguttuvan, International Conference on Electroceramics, ICE2009)

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214. N. Bahadur, A. K. Srivastava, R.Gakhar, K. Jain, G.Gupta. Microsructural, optical and photocatalytic property correlation of silver-doped and nikel-doped TiO_2 powders, International conference Nanotech Europe-2009, Berlin Germany, September 28-30, 2009.

APPENDIX - 2

PATENTS

01-04-2009 - 31-03-2010

Patents Filed in India

Sr. No.	Title	Application No.	Filing Date	Inventors
1	Nucleic Acid Primers and Sequence for Detection of Neisseria Gonorrhoeae	1391DEL2009	07/07/2009 (prov.) 31/05/2010 (complete)	Sood Seema, Rachna, Singh Renu, Gajjala Sumana, Manju Bala, Sumantaray Jyotish Chandra, Pandey Manoj Kumar, Malhotra Bansi Dhar
2	Improved Teleclock Receiver Utilizing Mobile Telephone Network	1390DEL2009	07/07/2009	Banerjee Parameswar, Thorat Pranalee P, Suri Anil Kumar
3	Conducting polymer paints and coating composition for the corrosion protection of iron	0537DEL2010	09/03/2010	S K Dhawan, S Sathiyanarayanan, S Azim, Praveen Saini, S Radhakrishnan
4	A Process for growing an electron injection layer to improve the efficiency of organic light emitting diodes	0780DEL2010	31/03/2010	M N Kamalasanan, Ritu Srivastava, Amit Kumar, Ishwar Singh, S K Dhawan, S S Bawa
5	A Process for the Removal of Arsenic and Chromium from Water	0578DEL2010	12/03/2010	Nahar Singh, Rashmi, Sukhvir Singh,Daya Soni, Renu Pasricha and Prabhat K. Gupta
6	A process for the preparation of low-density multicomponent graphite composite bipolar plates	0766DEL2010	31/03/2010	Mathur Rakesh Behari,Dhakate Sanjay Rangnath, Sharma Shaveta, Dhami Tarsem Lal
7	A Long Durration Optical Memory Device Based on Deformed Helix Ferroelectric Liquid Crystal Material and Method for the Development thereof	0625DEL2009	18/11/2009	Jai Prakash, Ajay Kumar, Choudhary Amit, Malik Anu, Coondoo Indrani, Biradar Ashok Manikrao

Patents Granted in India

Sr. No.	Title	Grant Date	Patent No.	Inventors
1	A Compact Dew Point Generator	23/06/2009	195191	Hari Kishan, Shyam Kishore Agarwal, Rajan Babu Saxena, Bhikham Singh, Shiv Dutt Sharma

Patents Filed Abroad

Sr. No.	Title	Filing Date	Application No.	Country	Inventors
1	Conducting Organic Ferrimagnets:a Process for the Preparation thereof	04/05/2009	12/434753	USA	Sundeep Kumar Dhawan, Kuldeep Singh, Nikhil Sobti, Anil Ohlan, Parveen Saini, Beena Gupta, Rajendra Prasad Pant, Ravinder Kumar Kotnala, Hari Kishan, Prafulla Chandra Kothari
2	Large Area Electrochemically Stable Electrochromic Device Preferably for Window Applications	06/05/2009	12/436624	USA	Shahzada Ahmad, SA Agnihotri, M Deepa
3	A Novel Method for Joining Oxide-Superconducting Tubes With a Superconducting Joint	29/07/2009	12/525026	USA	Ekbote Shrikant Narayan, Padam Gursharan Kaur, Arora Narendra Kumar, Sharma Mukul, Sethi Ramesh
4	A Novel Method for Joining Oxide-Superconducting Tubes With a Superconducting Joint	31/08/2009	1020097018209	Korea	Ekbote Shrikant Narayan, Padam Gursharan Kaur, Arora Narendra Kumar, Sharma Mukul, Sethi Ramesh
5	Improved Version of Teleclock Receiver Utilizing Mobile Telephone Network	04/12/2009	PCT/IB2009/ 07602	WIPO, Geneva	Banerjee Parameswar, Thorat Pranalee Premdas, Suri Anil Kumar
6	A Novel Method for Joining Oxide-Superconducting Tubes With A Superconducting Joint	31/07/2009	112007003312.6	Germany	Ekbote Shrikant Narayan, Padam Gursharan Kaur, Arora Narendra Kumar, Sharma Mukul, Sethi Ramesh
7	A Novel Method for Joining Oxide-Superconducting Tubes With a Superconducting Joint	31/07/2009	2009-547813	Japan	Ekbote Shrikant Narayan, Padam Gursharan Kaur, Arora Narendra Kumar, Sharma Mukul, Sethi Ramesh
8	An Improved Process to Deposit Diamond Like Carbon as Protective Coating on Inner Surface of Bottles	27/01/2010	PCT/IB2010/ 000133	WIPO, Geneva	Kumar Sushil, Dixit Prakash Narain, Rauthan Chandra Mohan Singh
9	A Compact ECG Monitoring Device with a Filter for Impulse and Channel Switching ADC Noise and Error Correction for Sequential Sampling of ECG Leads	09/03/2010	PCT/IN2010/ 000134	WIPO, Geneva	Mehrotra Ravi, Mohd. Ansari Imran, Ranjan Ashish, Chadha Deepti, Sharma Anjali

Sr. No.	Title	Comp Filing Date	Application No.	Country	Inventors
10	A Compact ECG Monitoring Device with a Filter for Impulse and Channel Switching ADC Noise and Error Correction for Sequential Sampling of ECG Leads	09/03/2010	99106719	Taiwan	Mehrotra Ravi, Mohd. Ansari Imran, Ranjan Ashish, Chadha Deepti, Sharma Anjali
11	A Long Durration Optical Memory Device Based on Deformed Helix Ferroelectric Liquid Crystal Material and a Method for the Development thereof	26/03/2010	PCT/IB2010/ 000683	WIPO, Geneva	Jai Prakash, Ajay Kumar, Choudhary Amit, Malik Anu, Coondoo Indrani, Biradar Ashok Manikrao

Patents Granted Abroad

Sr. No.	Title	Grant Date	Patent No.	Country	Inventors
1	An Improved Process for the Preparation of Doped Lead Iron Tungstate Relaxor Material for Wide Range Pressure Measurement and a Capacitive Pressure Transducer Made thereby	13/10/2009	2480285	Canada	Jain; Kamlesh Kumar, Kumer; Vinay, Kesayap SC
2	Reusable Heat Pack, Method of Manufacture thereof, Mixture for Use in a Reusable Heatpack and Process tor the Preparation thereof	05/11/2009	287136	Slovakia	Sharma CP, Sharma RK, Kant C, Sarkar AK
3	Monoclinic Cetio2o6 Thin Film and a Sol-Gel Process for the Preparation thereof	16/03/2010	7678413	US	Verma Amita, Agnihotry Suhasini Avinash, Bakhshi Ashok Kumar
4	A Lactate Bio Sensing Strip.	30/03/2010	2512281	Canada	Pandey MK, Chaubey A, Pande KK, Sharma RK,, Saini KK, Malhotra BD and Rajesh
5	A Process for the Preparation of Novel Sol-Gel Based Enzyme Electrode Useful for Estimation of Cholesterol in Aqueous Medium.	27/04/2010	2512282	Canada	Kumar A, Malhotra BD and Rajesh

APPENDIX - 3

TECHNOLOGIES MARKETED

Sr. No.	Technology Developed	Licensee	Date of Tranfer
1.	Portable Relative Humidity (RH) Generator	M/s Belz Instrument Pvt Ltd, Faridabad – 121 004	20/07/09
2.	Mobile Teleclock Receiver- An improved version of Teleclock Receiver utilizing mobile network	M/s Bihar Communicaiton Pvt Ltd, Patna - 800001	27/07/09
3.	Preparation of Novel Based Precursor Material	M/s Neotech Consultants & Engineers (P) Ltd, Gwalior-474004	23/03/10

APPENDIX - 4

R & D COLLABORATIONS

Collaborating Institute	Area
IISc,Bangalore and Dharamshila Cancer Hospital,Delhi	Infrared Spectroscopic study of tumor pathology
National Institute of Standard and Technology (NIST) USA.	Pressure Standards
National Institute of Standard and Technology (NIST) USA.	Vacuum Standards
High Pressure Laboratory, Department of Physics, University of Jaipur, Jaipur	Raman Spectroscopy
Department of Physics, Barakatullah Vishwavidyalaya, Bhopal, MP	Raman Spectroscopy
S.N. Bose Institute, Kolkata	Raman Spectroscopy
Delhi University, Delhi	Organic Semiconductors
Allahabad university, Allahabad	Organic-Inorganic hybrid solar cells
Kyushu Institute of Technology (KIT) Japan	Biomolecular Electronics
Centre for Nano Bioengineering & Spintronics,Chungnam National University,Daejeon,Korea	Nanosensors
Department of Biotechnology, Guru Gobind Singh Indraprastha University,Delhi.	Nanobiotechnology
Institute of Microbial Technology, Chandigarh	Enzymatic biosensors for environmental applications
Department of Biomedical Eengineering, Indian Institute of Technology, Delhi, New Delhi	DNA Sensors
Department of Chemistry, Jamia Millia Islamia,New Delhi	Biosensors
Department of Physical Electronics,Tokyo Institute of Technology , Tokyo, Japan	Molecular electronics
DMSRDE, Kanpur	Caro-graphite seals for Aeronautical Applications
DMSRDE,Kanpur	Mesophase carbon fibres
CEERI, CSIO	High density graphite, Copper reinforced high density graphite
Raipur Tar Products Raipur	High coking value & QI-free pitch
SAMTEL Colour Lab. (NMITLI Project)	Synthesis of Phosphor for High Definition Plasma Display Panel (HD PDP) TV
Phys. Dept., Anna University, Chennai	Crystal Growth and Characterization
Crystal Growth Centre, SNN College of Engg., Chennai	Crystal Growth and Characterization
Physics Department, Jamia Millia Islamia	Crystal Growth and Characterization

Institute of Experimental Physics, Academy of Science, Kosice, Slovak	Nanomagnetic fluids
NML, Jamshedpur	Ferrofluid
CEERI, Pilani	Ferrofluid
Bhavnagar University, Bhavnagar	Ferrofluid
Thapar University, Patiala	ZnS nano particles
The Pennsylvania State University, USA	Surface & Interface study by SIMS
Thaper University, Patiala	Aerosols & Health
Hokkaido University, Sapporo, Japan	Aerosol Chemistry
PTB Braunschweig/ BAM Berlin, Germany	Metrology in Chemistry

APPENDIX - 5

SPONSORED/SUPPORTED R & D PROJECTS

(Rs. in lakhs)

Sr. No.	Title	Agency/Client	Amount Received
New Projects			
1	Studies on Double Perovskite CMR Thin Films for Magnetic Sensor Applications	Defence Research & Development Organization, (DRDO)	9.77
2	Study of distributing and sources of ambient Ammonia Over National Capital Region (NCR)	Department of Science & Technology (DST)	4.07
3	Investigation of pure and substituted rutheno-cuprate magneto superconductors in bulk and thin film at low temperature and high magnetic field	Department of Science & Technology (DST)	28.50
4	Nano-metrology: surface roughness	Department of Science & Technology (DST)	3.11
5	Innovative Product Development Center	Department of Science & Technology (DST)	14.81
6	Development of biosensors for detection of pathogens (under SERC FAST Track Scheme)	Department of Science & Technology (DST)	5.50
7	Multi centric collaborative study on the impact of global warming and ultra violet radiation (UVR) exposure on ocular health in India	Indian Council of Medical Research (ICMR, Min. of Health & Family Welfare)	58.00
8	Feasibility Study for the use of infrasoni sensors of predict Tsunami	National Institute of Ocean Technology, NIOT, Ministry of Earth Science	4.50
9	Development of Acoustic Equipment for object detection for divers	National Institute of Ocean Technology, NIOT, Ministry of Earth Science	25.20
10	Strengthening the quality infrastructure in Environmental analytics	PTB-Germany (Under NPL-PTB Coopr. Proj)	20.47
		Total	173.93

CSIR NETWORK PROJECTS

Sr. No.	Name of the Project	Project Code	Nodal Officer	Name of the Laboratory
1	R&D on Photovoltaics and other Solar Energy Applications (Supra-Institutional Project)	SIP 0017	Dr P K Singh	NPL
2	Development of Advance Light Weight Metallic Materials for Engineering Applications	NWP 0028	Dr Anil Kumar Gupta/ Dr R C Anandani	AMPRI. Bhopal
3	Conducting Polymer paints and coatings for corrosion protection and shielding of concrete structures in strategic areas	NWP 0012	Dr S K Dhawan	NPL as Nodal Lab (Since Dec'2008)
4	Technology for Assessment and Refurbishment of Engineering Materials and Components	NWP 0027	Dr Sushil Kumar/ Dr Ashok Kumar	NML, Jamshedpur
5	Fabrication of LED Devices and Systems for Solid State Lighting Applications	NWP 0025	Dr S T Lakshmikumar	NPL
6	Advancement in Metrology	NWP 0045	Dr P Banerjee	NPL
7	Surface analysis of Dispensor Cathodes for High Power MWT	NWP 0024 NPL - II	Dr Mahesh Kumar	NPL as Partner Lab CEERI, Pilani as Nodal Lab
8	Design and Fabrication Capabilities for very High Power Microwave Tubes	NWP 0024 NPL - I	Dr G Bhatia	CEERI, Pilani
9	Mega-city atmospheric pollution precursor process modeling	NWP 0017	Dr M K Tiwari / Dr C Sharma	IITR, Lucknow

APPENDIX - 6

CONSULTANCY PROJECTS

(Rs. in Lakhs)

Sr. No.	Client	Title	Contact Value	Amount Received 2009-10
NEW				
1	Raipur Tar Product, Raipur, Chhattisgarh,MP	General Consultancy relating to reduction of QI From high QI Coal Tar Pitch	0.98	0.98
2	Archaeologigical Survey of India, Chennai Circle, Chennai, TN	Investigation of induced vibrations due to acoustic excitation from sound show at Brihadisvara Temple Thanjavur (TN)	4.49	4.49
3	Archaeologigical Survey of India, Chennai Circle, Chennai, TN	Investigation on effect of Light show at Brihadisvara Temple, Thanjavur (Project B)	4.47	4.47
4	Assam Tourism Dev. Corp. Ltd, Guwahati, Assam	Investigation of induced vibrations due to acoustic excitation from sound show at Talatal Ghar, at Shiv Sagar, Assam	4.49	4.49
5	Assam Tourism Dev. Corp. Ltd, Guwahati, Assam	Investigation on effect of Light show at Talatal Ghar, at Shiv Sagar, Assam (Project B)	4.47	4.47
NEW AND COMPLETED				
1	Electronic Regional Test Laboratory, (North), New Delhi	Metrological Characterization of Dual Range Piston Gauge	3.27	3.27
2	Maple Consultants Gurgaon, Haryana	Noise and Vibration Impact Study for proposed Taj Hotel in Dwarka,New Delhi	2.02	2.02
3	Moser Baer Photo Voltaic Ltd, Greater Noida, UP	Measurement of Minority Carrier Life Time in multicrystalline silcon vapours	4.25	3.82
COMPLETED				
1	Coal Chem,Bhilai	QI free coal tar pitch from coal tar	0.80	0.00
2	DMRCL, Delhi	Consultancy services for studying noise impact of Delhi Metro Operation	5.33	0.00
3	ERTL,New Delhi	Characterization of dead weight tester	2.47	0.00
4	RRSL, Bhubaneswar	Design and fabrication of the transfer standards of 100 kg, 200 kg and 500 kg full scale confirming to class A over the range 20-100 % at RRSL, Bhubaneswar	2.23	0.00
5	Aparna Carbon Pvt Ltd, Kolkatta	General consultancy to improve the QI free coal tar-pitch	2.00	0.00
6	Urban Waste Management Ltd,New Delhi	Performance checking of high pressure hose	0.34	0.00
7	Jindal Steel & Power Ltd, Raigarh (MP)	Ultrasonic response from hall and notches in reference test rails and theirs correlation with dimensions	5.46	0.00

Sr. No.	Client	Title	Contact Value	Amount Received 2009-10
8	UP Samaj, Kalyan Nagar Nigam Ltd, Lucknow	Acoustic of multipurpose hall at Bhagdari, Bhawan, Gomati Nagar, Lucknow	1.73	0.00
9	Vijay Electrical Ltd, Hyderabad	Feasibility study of transformer noise abatement	0.49	0.00
10	Suzlan Pvt. Ltd,Vadodara	The strain gauge measurement to determine stress in tension and bending moment on given 3Nos mettallic bolts used in wind mill energy upto 450N and 16N respectively	4.75	0.00
11	Yantrika Instrument Pvt Ltd, New Delhi	Characterization of Yantrika dead weight tester Model YW1307HBO/04 Sr No T8M311	3.48	0.0
12	CPCB, Agra, Lucknow Zone	Inversion/mixing height studies at CPCB, Agra	9.99	0.00
13	MN Datur & Co. Ltd, Kolkatta	Mixing height determination at Paradeep, Orissa	2.76	0.00
14	MN Dastur & Co., Kolkatta	Mixing height determination at Keonjhar, Orissa	5.90	0.00
15	TATA STEEL, Jamshedpur	Inversion study for Tata Steel Plant at Jamshedpur	4.10	0.00
CONTINUING				
1	CSIO, Chandigarh (sister concern. Total consultancy fee waived off, as per CSIR guidelines)	Quality System implementation in Geoseimic and medical instrumentation in accordance with ISO/IEC 17025 : 2005	0.00	0.00
2	RRSL Guwahati	Setting up of torque standard machine at RRSL, Guwahati	14.29	0.00
3	RRSL,Faridabad	Design, fabrication and installation of primary torque measurement machine at RRSL, Faridabad	31.00	0.00
4	Bangalore Metro Rail Corporation Ltd (BMRCL), Bangalore	Noise and vibration study in and around proposed Bangalore metro trains/stations near histroric monuments	11.24	0.00
5	Aeronautical Development Agency (ADA), Bangalore	Certification of reference blocks of various materials as per 1,2mm FBH standards of ASTME 127-PV3/PV5 (59/704)	9.36	3.51
6	RRSL, Bangalore	Design, develop and fabricate torque primary standards from 2 Nm-200 Nm within uncertainity of 0.05 %	31.00	0.00
7	RRSL,Bangalore	Design,erection and commissioning of dead weight force machine at RRSL,Bangalore	101.25	0.00
8	RRSL,Ahmadabad	Design, primary and secondary torque measuring facility at RRSL, Ahmadabad	14.29	0.00

Sr. No.	Client	Title	Contact Value	Amount Received 2009-10
9	RRSL,Bhubaneswar	Supply of one number of secondary torque measureent facility at RRSL, Bhubaneswar	14.29	0.00
10	General Motors India Ltd, Bangalore	Recrystallization and grain refinement mechanism during extrusion of magnesium alloys	65.97	19.8
11	RRSL,Ahmedabad	Design, develop & fabricate secondary force stds upto 50 kN by comparison of 0.05 %	22.29	0.00
12	RRSL,Bhubaneswar	Design, develop & fabricate secondary force stds upto 50 kN by comparison of 0.05 %	22.29	11.14
13	RRSL,Guwahati	Design, develop & fabricate secondary force stds upto 50 kN by comparison of 0.05 %	22.29	0.00
14	RRSL,Faridabad	Design, develop & fabricate secondary force stds upto 50 kN by comparison of 0.05 %	22.29	11.14
		Total	**462.12**	**73.60**

APPENDIX - 7

EARNING FROM CALIBRATION & TESTING

Physico Mechanical Standards

S.No.	Activity	DP No.	Calibration Charges (In Lacs.)	Total No. of Reports
1	Mass	1.01	69.94	477
2	Length & Dimension	1.02	49.75	377
3	Temp. & Humidity	1.03A	9.38	76
4	Temp. & Humidity	1.03B	9.54	103
5	Temp. & Humidity	1.03C	4.34	72
6	Optical Radiation	1.04	102.21	434
7	Force & Hardness	1.05	68.83	517
8	Pressure & Vacuum	1.06	29.41	134
9	Acoustics	1.07 A	13.64	116
10	Fluid Flow	1.08	1.15	3
11	Ultrasonic	1.07B	2.39	18
12	Shock & Vibration	1.11	0.21	7
		Total (A)	**360.79**	**2334**

Electrical & Electronic Standards

S.No.	Activity	DP No.	Calibration Charges (In Lacs.)	Total No. of Reports
1	Time & Frequency	2.01	2.53	26
2	Josephson Voltage Std. DCI, V & R	2.03	6.21	91
3	DC High Voltage	2.04	1.19	19
4	AC Power & Energy	2.05	14.70	82
5	AC High Current & High Voltage (CT/PT)	2.06	24.78	79
6	LF & HF Impedance	2.07	3.36	38
7	LF & HF Voltage, Current & RF Power	2.08	5.55	27
8	RF Attenuation & Impedance	2.09	3.48	10
9	Magnetic	2.10	2.07	32
		Total (B)	**63.87**	**404**

Engineering Materials

S.No.	Activity	DP No.	Calibration Charges (In Lacs.)	Total No. of Reports
1	Metal & Alloys	3.01	0.48	7
2	Advanced Carbon Product	3.02	1.80	3
		Total(C)	**2.28**	**10**

Electronic Materials

S.No.	Activity	DP No.	Calibration Charges (In Lacs.)	Total No. of Reports
1	Thin Film	4.04	0.00	0
2	ENOP/Thin Film & Devices Stds.	4.05	0.02	1
3	Surface Physics & Nanostructured Devices	4.06	0.30	6
		Total(D)	**0.32**	**7**

Materials Characterisation

S.No.	Activity	DP No.	Calibration Charges (In Lacs.)	Total No. of Reports
1	Chemical Analysis	5.01	4.83	51
2	EPR & Spectrometry	5.02	0.00	0
3	Crystal Growth & Crystallography	5.03	0.00	0
4	Electron Microscopy	5.04	3.09	37
5	Sims	5.07	0.00	0
		Total(E)	**7.92**	**88**

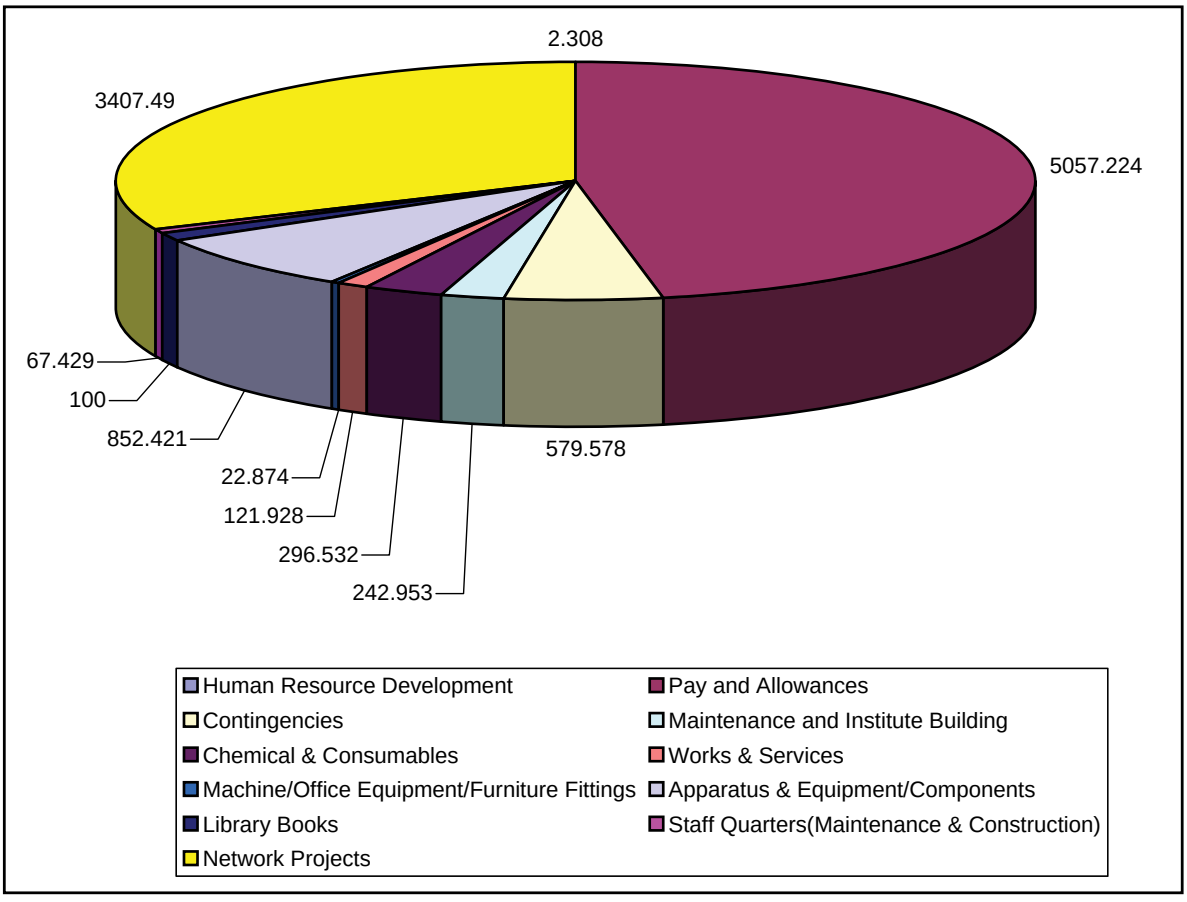
Grand Total (A+B+C+D+E)		**435.18**	**2843**

APPENDIX - 8

ACTUAL EXPENDITURE 2009-2010

(Rs. in Lakhs)

Sr No.	Budget Heads	Expenditure
1	Pay and Allowances	5057.224
2	Contingencies	579.578
3	Human Resource Development	2.308
4	Maintenance and Institute Building	242.953
5	Chemicals & Consumables	296.532
6	Works & Services	121.928
7	Apparatus & Equipment/Computers	852.421
8	Machine/Office Equipment/Furniture & Fittings	22.874
9	Library Books & Journals	100.000
10	Staff Quarters (Maintenance & Construction)	67.429
11	Network Projects	3407.490
	Total	**10750.737**



APPENDIX - 9

RECOGNITIONS, HONOURS AND AWARDS

Dr. H C Kandpal
Elected as fellow of Indian National Science Academy, Allahabad,India.

Dr. A K Bandyopadhyay
Awarded APMP Technical Award-2009 for his outstanding contribution in the field of Mass and related qualities.

Dr. H C Kandpal
Appointed as Topical Editor for the SCI Journal MAPAN-Journal of Metrology Society of India,Issue on "Optical Metrology" Volume 24(3) 2009 and Volume 25(1) 2010.

Dr. Ranjana Mehrotra
Appointed the Editorial Board Member of Journal 'Pharmaceutica Analytica Acta.

Dr. R. S. Dabas
Member of "International Space Environment Services (ISES)" of URSI which runs 14 Regional warning Centers (RWCs) all over the Globe for providing Space Weather services to the local users and one of them (RWC-India) is operated by NPL since last more than 30 years.

Dr. S.K. Dhawan
Scientist of the Year 2009

Ms.Renu Singh, Ms.Zimple Matharu and **Ms.Maumita Das** received the Best Poster award in IJWBME 2009

Ms. Chetna Dhand (SRF) won the Best Poster award on the eve of Science Day

Dr. B.D.Malhotra has been designated as the Visiting Professor to Centre for nano Bioengineering & Spintronics, Chungnam National University, Korea

Dr. G. Bhatia was awarded, jointly with Dr. P.K. Jain, Scientist, ARCI, Hyderabad, B.D. Bangur Award, 2009 instituted by M/s Graphite India Ltd., Bangalore/ Kolkatta/Nasik and Indian Carbon Society, at the First Asian Carbon Conference 2009, held at India Habitat Center, New Delhi, during 25-27 November 2009 in recognition of outstanding contribution made in the field of carbon science and technology and for the growth of carbon technology in India. The award consists of a cash amount of Rs. 50,000/-, a medal and a scroll.

Dr. G. Bhatia and his team were awarded certificates of merit and cash prize of Rs. 5000/- by Director, NPL on Technology Day in lieu of technology transfer to M/s Neotech Consultants and Engineers (P) Ltd., Gwalior/ Varanasi, on 23.03.2010.

Dr. Bipin Kumar Gupta
Aarya Bhat Samman-2009" has been awarded by "Vigyan Bhaarati for research work on "Europium doped Y_2O_3 : Eu^{3+}A potential nanophosphor" in 2nd National conference on Innovations in Indian Science, Engineering & Technology "July 17-19, 2009 at National Physical Laboratory, New Delhi.

Dr. Bipin Kumar Gupta
Indo-US fellowship award 2010, awarded on 15th March 2010 by Indo-US technology forum, fullbright house, New Delhi

Dr. G. Bhagavannarayana, Recipient of Prof. P. Ramasamy National Award for Crystal Growth

Dr. Sukhvir Singh
Awarded the "Life Fellow" of Metrology Society of India.

Dr. B.R.Chakraborty
Awarded the "Most Eminent Mass Spectroscopist of the year 2009" by Indian Society for Mass Spectroscopy (ISMAS).

Dr. A.K. Srivastava
INSA fellowship (2009-2010): International bilateral exchange programme award.

Dr. Prabhat K. Gupta
Member, Consultative Committee on Amount of Substance (CCQM): Metrology in Chemistry.
Member, Gas Analysis Working Group (GAWG) of Consultative Committee on Amount of Substance (CCQM): Metrology in Chemistry (CCQM).
Member, Cooperation on International Traceability in Analytical Chemistry (CITAC).
Co-Chaired the Technical Session on 'Analytical Techniques and Standards' at International Conference on "New Frontiers in Biofuels", 19 Jan. 2010, IHC, New Delhi.
Dr. V.P.S. Awana: Materials Research Society of India (MRSI) MEDAL - Year 2010

Dr. P. Banerjee Chairman, Technical Commission A (Electromagnetic Metrology), International Union of Radio Science

Dr. P. Banerjee Member, Editorial Board of International Journal of Metrology and Quality Engineering, France

Dr. P. Banerjee Technical Expert for assessment of Time & Frequency Activities of NMISA, South Africa, January, 2010

Dr. P. Banerjee Chairman, Horology Sectional Committee, BIS

Dr. P. Banerjee Member, Developing Economic Committee (DEC), APMP

Dr. P. Banerjee Member, Accreditation Steering Committee, NABL

Dr. P. Banerjee Regular Reviewer of papers of Ins. Meas. Tr. IEEE & Journal of Measurement Science and Technology

Dr. A. K. Saxena Member of Technical Programme Committee of "Conference on Precision Electromagnetic Measurement (CPEM 2010)" held at KRISS, South Korea

Dr. A. K. Saxena Chairman of Measuring Equipment for Basic Electrical Quantities, Sectional Committee ET 12 of BIS

APPENDIX - 10

VISITS ABROAD
(2009-2010)

Sr. No.	Name & Designation	Country Visited	Duration	Purpose
1	Dr. P. K. Singh, Sci. F	Germany & Switzerland	31.01.2009-04.04.2009	To visit Fraunhofer Institute Solare Energie system, LC Division, BU structure solution, Merck KGaA, Darmstadt, Germany & Oerlikon Blazers Ltd, Liechtenstein, Switzerland.
2	Dr. M. Deepa, Sci. C	Germany & Switzerland	31.01.2009-04.04.2009	To visit Fraunhofer Institute Solare Energie system, LC Division, BU structure solution, Merck KGaA, Darmstadt, Germany & Oerlikon Blazers Ltd, Liechtenstein, Switzerland.
3	Dr. V P S Awana, Sci. E-I	Japan	04.04.2009-04.05.2009	As a Short Term visiting Scientist on Sabbatical Leave to Work on use of HP HT Machine & PPMS/MPMS
4	Dr. P.K.Gupta Sci. G	France	19.04.2009-24.04.2009	1. 24th Cooperation on International Traceablity in Analytical Chemistry Members Meeting (CITAC) meeting on April 19, 2009. 2.Consultative Committee for Amount of Substance-Gas Analysis working Group (CCQM-GAWG) meeting from April 20-21, 2009. 3. 15th Consultative Committee for Amount of Substance (CCQM) from April 22-24, 2009 .
5	Ms. P.P.Thorat, Sci.B	France	20.04.2009-24.04.2009	To attend EFTF-IFCS-09 European Frequency and Time & Frequency
6	Dr. P. Banerjee Sci. G	France	20.04.2009-24.04.2009	To attend EFTF-IFCS-09 European Frequency and Time & Frequency
7	Dr. (Ms) Daya Soni Sci. B	Nepal	26.04.2009-01.05.2009	To attend APMP Workshop on Measurement Uncerntainity “Train the Trainer” (TCQM-DEC) jointly organized by PTB, Germany
8	Dr. Vikram Kumar, Director	Nepal	02.05.2009-06.05.2009	As a member of Executive Council of APMP and Chairman of Developing Economies Committee for attending the (i) Economies Committee (EC) meeting, (ii) Developing Economies Committee (DEC) Meeting & (iii) Symposium and TCQS-DEC Workshop.
9	Dr. A.K. Bandyopadhyay Sci. G	Nepal	05.05.2009-07.05.2009	To present the TCM report to APMP and also to present the Country Status at the TCCM-EC-TCCC-DCC Meeting.
10	Dr. A.K. Hanjura, Sci. G	Nepal	05.05.2009-07.05.2009	To attend the 4th APMP-TCQS-DEC Workshop as a Resource Person.

Appendix - 10, Visits Abroad

Sr. No.	Name & Designation	Country Visited	Duration	Purpose
11	Dr. B.R. Chakraborty, Sci. G	U.K.	13.05.2009-15.05.2009	To attend 34th Steering Committee Meeting of VAMAS Project as a Member Nominee/ Representative from NPL
12	Dr (Ms) Monika Kulshrestha, Sci E-I	Sweden	15.05.2009-18.06.2009	To participate in the Int. Training Prog. "Air Pollution Management- India"
13	Mr. Khem Singh, TOA	Malaysia	18.05.2009-22.05.2009	To attend 7th Workshop on " New Development in Gas Metrology at NML-SIRIM".
14	Dr. (Ms) Ritu Srivastva, Sci. C	Singapore	28.06.2009-03.07.2009	To attend the International Conference on Materials for Advanced Technologies for Poster Presentation
15	Dr. Vikram Kumar, Director	USA	01.06.2009-04.06.2009	As a Leader of the Delegation for attending the the US-India Workshop on "Metrology, Standards, and Conformity Assessment and their use in support of Technical Regulations" at National Institute of Standards and Technology (NIST), Maryland, USA.
16	Dr. A.K. Bandyopadhyay, Sci.G	USA	01.06.2009-04.06.2009	To attend US-India Workshop on "Metrology, Standards, and Conformity Assessment and their use in Support Regulations at National Institute of Standards and Technology (NIST), Maryland, USA.
17	Dr. P. Banerjee, Sci. G	USA	01.06.2009-04.06.2009	To attend US-India Workshop on "Metrology, Standards, and Conformity Assessment and their use in Support Regulations at National Institute of Standards and Technology (NIST), Maryland, USA.
18	Dr. V.N. Ojha, Sci. G	USA	01.06.2009-12.06.2009	As a Member of the Delegation to attend the IUSSTF Workshop and to Participate in the 8th Meeting of ISO/TC-229-IEC/TC 113- Nanotechnologies as an Expert of JWG1 Terminology and Nomenclature during 8-12 June, 2009 at Seattle, USA
19	Dr. P.K. Gupta, Sci G.	USA	21.06.2009-24.06.2009	As a Member of the Delegation to attend the IUSSTF Workshop.
20	Dr. A.K. Srivastava, Sci.E-I	NIST,USA Seattle, USA	01.06.2009-04.06.2009 07.06.2009-13.06.2009	1.To participate in "US Workshop on Metrology, Standards and Conformity Assessment and Their use in Support of Technical Regulations", NIST,USA. 2. To participate in ISO, Nanotechnology Meeting, Seattle, USA.
21	Sh. Anil Kumar, Sci.F	USA	01.06.2009-05.06.2009	For taking Equipment Training at Harwood Engineering Company

Appendix - 10, Visits Abroad

Sr. No.	Name & Designation	Country Visited	Duration	Purpose
22	Dr. Sanjay Kr. Srivastva, Sci. B	USA	07.06.2009-12.06.2009	To attend 34th IEEE Photovoltaics Specialist Conference
23	Dr.K.P.Chaudhary, Sci. G	France	08.06.2009-10.06.2009	To Participate in the 14th Working Group of Dimensional Metrology
24	Dr. R.B. Mathur, Sci. G	France	14.06.2009-19.06.2009	for Oral Presentation Entitled "Growth of Carbon Nanotubes on Carbon Fiber Cloth and their Application in Epoxy Composites for Enhanced Thermal and Mechanical Properties" at the Annual World Conference on Carbon 'CARBON-2009'to be held at Biarritz , France
25	Dr. Suresh Chand, Sci. G	U.K.	15.06.2009-19.06.2009	To attend the International Conference on Organic Electronics-2009(ICOE-2009) for Oral Presentation to be held at University of Liverpool , UK during 15-17th June, 2009 and to visit Cavendish Laboratory, Cambridge, UK
26	Dr. B.D. Malhotra, Sci. G	Korea	17.06.2009-20.06.2009	To Participate at the Symposium on "Next Generation Bioassay Technology" at the Research Center for Magnetic Materials, Chungnam National University, Daejon, Korea and for discussions related to India-Korea proposal on Biosensors.
27	Dr. R.K. Kotnala, Sci. F	Italy	06.07.2009-10.07.2009	1.To deliver a Lecture on Multiferroic Materials-their properties and their application to generic transducers . 2. To evaluate possible future joint research initiatives. 3. To perform experiments in the laboratory
28	Dr. ChhemendraSharma, Sci.EII	Sri Lanka	27.07.2009, 28.07.2009	To participate in the " APN 1st South Asia Sub -Regional Cooperation Meeting" (SA–SRCom) held in Colombo, Sri Lanka..
29	Dr (Ms) Anjana Dogra, Sci.C	Switzerland Italy	01.08.2009-07.08.2009 09.08.2009 13.08.2009	1.To attend the 8th PSI, Summer School on condensed matter research, Switzerland 2.To visit TASC INFM-CNRM laboratory, Trieste, Italy
30	Dr. B.D. Malhotra, Sci.G	Korea	01.08.2009-14.08.2009, 11.09.2009-08.10.2009, 20.10.2009-30.10.2009, 15.11.2009-20.11.2009	To take up Short Term Assignment on Leave Due & Admissible as a Young Professor at CNU under KOSEF
31	Dr. A.K. Srivastava, Sci.EI	Korea	03.08.2009-02.10.2009	Under INSA-KOSEF Exchange of Scientist Program for the year 2009-2010

Appendix - 10, Visits Abroad

Sr. No.	Name & Designation	Country Visited	Duration	Purpose
32	Dr. Nirmal Karar, Sci. C	USA	16.08.2009-15.05.2010	To visit USA for Nine Months from 16th Aug. 2009 to 15th May, 2010 on Leave Due & Admissible to avail INDO-US Research Fellowship Awarded by Indo-US Science &Technology Forum (IUSSTF) for the year 2009 to Work at University of Delaware , Department of Science & Engineering for conducting advanced research in the Area of Physical Sciences.
33	Dr. B.R. Chakroborty, Sci. G	Japan	17.08.2009-01.09.2009	To carry out Experiment
34	Dr. (Ms) Nita Dilawar Sharma, Sci. C	USA	24.08.2009-26.08.2009	To attend Equipment Training
35	Sh. Om Prakash, T.O.C	USA	24.07.2009-26.08.2009	To attend Equipment Training
36	Dr. S.S.K Titus . Sci.E-I	Portugal	06.09.2009-11.09.2009	To attend the XIX IMEKO World Congress
37	Mr. K.B. Ravat, T.O.E-I	USA	15.09.2009-23.09.2009	To take Equipment Training at M/S Ohm-Labs, Pittursburgh & visit to KEMA & NIST
38	Mr. Khem Singh, Sci.T.O.A	Germany	21.09.2009-16.10.2009	To attend the "Hands on Training on the Establishment of Primary Measurement System at NPL in the field of Gas Metrology" within the Frame of the Project entitled "Strengthening the Quality Infrastructure in Environmental Analysis" at BAM in Berlin, Germany.
39	Dr. P. Banerjee, Acting Director	France	07.10.2009-09.10.2009	To attend Meeting of Director's of National Institute of Metre Convention & 10th Anniversary of CIPM MRA
40	Dr. (Ms.) Prabha Johri, Sci C	Germany	11.10.2009-30.11.2009	To attend the "Hands on Training on the Establishment of Primary Measurement System at NPL in the Field of Gas Metrology "Within the Frame of the Project entitled "Strengthening the Quality Infrastructure in Environmental Analysis" at BAM in Berlin, Germany.
41	Dr. Chemmendra Sharma, Sci.E-II	Germany	14.10.2009-16.10.2009	To participate in the CHG Training Seminar for Inventory as a Review Expert of country's Representative Nominated by the Ministry of Environment & Forest, Govt. of India.
42	Dr. Govind, Sci. C	USA	30.11.2009-04.12.2009	To attend the International Conference on the 2009 Materials Research Society (MRS) Meeting
43	Mr. Naveen Garg, Sci. C	Thailand	11.10.2009-21.11.2009	To attend the 3rd Country Training Programme on "Strengthening on Measurements Standards Institute. of Asia Pacific Countries" conducted by JICA , Min. of Foreign Affairs & JICA, Japan

Appendix - 10, Visits Abroad

Sr. No.	Name & Designation	Country Visited	Duration	Purpose
44	Dr. Prabhat Kr. Gupta, Sci. G	Germany	18.10.2009-23.10.2009	To visit PTB under Technical Cooperation prog. Entitled "Strengthening the Quality Infrastructure in Environmental Analytics" Organized by the Government of the Federal Republic of Germany.
45	Dr. H.C. Kandpal, Sci. G	Hong Kong	28.10.2009-29.10.2009	To participate in the upcoming " Forum to Facilitate Asian Participation and Influence in International Electro-Technical Commission (IEC) Standards Development for Lighting" .
46	Dr. S.K. Singhal, Sci. G	Malaysia	11.11.2009-12.11.2009	To attend International Advisory Committee Meeting for the 3rd "International Conference on Underwater System Technology" Theory and Applications (USYS10).
47	Mr. Mukul Sharma, T.O, E-I	Korea (South)	09.11.2009-13.11.2009	To present the paper in the 19th International Photovoltaic Science and Engineering Conference and Exhibition
48	Dr. Shankar Gopala Aggarwal, Sci. E-I (Ad- hoc)	Bangkok, Thailand	24.11.2009-27.11.2009	To attend the Asian Aerosol Conference 2009 (AAC 2009)
49	Dr.V.P.S.Awana, Sci. EI	Japan	04.12.2009-06.01.2010	To visit National Institute of Material Science (NIMS), Japan under DST funded Project
50	Mr. Harish Kumar, Sci. B	Czech Republic	30.11.2009-04.12.2009	To visit GTM,Czech Republic for Pre-Dispatch Inspection and Performance checking of 1 MN Force Standard Machine purchased from M/s GTM, Germany
51	Dr. S.K. Jain, Sci. G	Czech Republic & Germany	30.11.2009-04.12.2009, 07.12.2009 11.12.2009	(i) For Pre-Dispatch Inspection and Performance of the 1 Meganewton (MN) Force Standard Machine in Czech Republic, Prague during 30th Nov. to 4th Dec., 2009 (ii)To Calibrate the 5 Meganewton (MN) Force Transfer Standard at PTB , Braunschweig, Germany and to visit Force, Torque and Hardness Facility at PTB to apprise about Latest Development and discussion on Future directions of Research and Co-Operation in these areas during 7-11 Dec., 2009
52	Dr. A.K. Bandyopadhyay Sci.G	Malaysia	10.12.2009-18.12.2009	To take part in the 25th General Assembly of APMP and to represent NPL at various Technical Committee Meeting.
53	Dr. P.K. Gupta, Sci.G	Malaysia	11.12.2009-16.12.2009	To take part in the 25th General Assembly of APMP and to represent NPL at various Technical Committee Meeting.
54	Dr. P. Banerjee, Acting Director	Malaysia	11-12-2009-18.12.2009	To attend 25th APMP General Assembly including Technical Committee (TCTF) and Developing Economics Committee (DEC) Meeting at Kuala Lampur, Malaysia.

Appendix - 10, Visits Abroad

Sr. No.	Name & Designation	Country Visited	Duration	Purpose
55	Dr. Y.P. Singh, Sci.F	Bangladesh	20-12-2009-24.12.2009	For providing Training to Scientists in the Area of Temperature Metrology at Bangladesh Standards Testing Institute (BSTI) under SAARC-NPL-PTB Technical Cooperation Programme
56	Mr. T. Lal, Ex Sci.G	Bangladesh	20-12-2009-24.12.2009	For providing Training to Scientists in the Area of Temperature Metrology at Bangladesh Standards Testing Institute (BSTI) under SAARC-NPL-PTB Technical Cooperation Programme
57	Dr. K.P.Chaudhary, Sci.G	Bangladesh	20.12.2009-24.12.2009	For providing Training to Scientists in the Area of Mass Metrology at Bangladesh Standards Testing institute(BSTI) under SAARC- NPL-PTB Technical Cooperation Programme
58	Dr. Chhemendra Sharma, Sci.EII	Taiwan	19.01.2010-22.01.2010	To participate and give an oral Presentation in the MAIRS Mega-City Workshop to be held at Research Center for Environmental Charges, Academia Sinica, Taipei, Taiwan.
59	Dr. P. Banerjee, Sci.G	South Africa	26.01.2010-28.01.2010	To participate as a Technical Expert during the Assessment of the National Metrology Institute of South Africa (NMISA) Time & Frequency Laboratory
60	Dr. A.K. Srivastava, Sci.E-I	USA	14.02.2010-20.02.2010	To participate in TMS (The Minerals, Metals, & Materials Society) Meeting at Seattle (14-18 Feb. 2010) and To meet Prof. Hameed Naseen of University of Arkansas, for Research Discussion.
61	Dr. P.K. Singh, Sci.G	Japan	21.02.2010-26.02.2010	As a visiting Researcher under NEDO Sponsored Joint Project (NPL-SEC-AIST) to Review and Discussed the outcome of the Project
62	Dr. Vandana, Sci. C	Japan	21.02.2010-26.02.2010	To visit Silicon & Silicon Devices group at Tsukuba, Japan as a visiting researcher under NEDO Sponsored Joint Project (NPL-SEC-AIST) on the invitation of Dr. Michio Kondo, Director, Research Center for Photovoltaics , AIST
63	Ms. Pooja Sharma, Technical Assistant	Japan	21.02.2010-26.02.2010	To visit Silicon & Silicon Devices group at Tsukuba, Japan as a visiting researcher under NEDO Sponsored Joint Project (NPL-SEC-AIST) on the invitation of Dr. Michio Kondo, Director, Research Center for Photovoltaics , AIST
64	Dr. G.M. Saxena, Sci F	Russia	20.03.2010-25.03.2010	For discussions with Dr. Selivanov, Director, M/s Ruknar J.S.Company Osharskaya, St.Russiafor discussions on Rb Atomic Clock and Test Bench Technical Details and visit to the Rb Atomic Lab
65	Dr. P. Banerjee, Sci G	France	25.03.2010-27.03.2010	Participated in the Workshop on the Redefinition of the Kilogram and also participated in the 12th meeting of the Consultative Committee for Mass and Related Quantities (CCM)

APPENDIX - 11

PhDs BASED ON THE RESEARCH WORK DONE AT NPL

Sr. No.	Title	Awardee	University/ Institute	Guide(s)
1	Vibrational spectroscopic studies to evaluate the stability of some antiretroviral and anticancer drugs	Parul Singh	Delhi University Delhi	Dr. Ranjana Mehrotra (NPL) Prof. A.K Bakshi (DU)
2	Organic and Inorganic nanocrystalline films for catalysis and sensor applications	R.R. Pandey	Delhi University, Delhi	Dr. K.K. Saini (NPL) Dr. Mansingh (DU)
3	Development of Conducting polymer based nucleic acid biosensors	Nirmal Prabhakar	Indian Institute of Technology (Submitted)	Dr. B.D.Malhotra Dr. Harpal Singh
4	Synthesis and Characterization of Ferrofluids for Various Device Applications	Vinod Kumar	Deptt. of Physics, Kurukshetra University, Kurukshetra, Haryana	Dr.M.S.Yadav (KurukshetraUniv.,Haryana) Dr. R.P. Pant (NPL, New Delhi)
5	Trace gases emission from field burning of crop residues	Shivraj Sahai	DCE, Delhi University	Dr. Prabhat K. Gupta (NPL) Dr. S.K. Singh (DCE)
6	Study of Carrier Lifetime and Related Parameters in Silicon Wafers and Solar Cells using Impedance Spectroscopy	Sanjai Kumar	Delhi University, Delhi	Dr. P.K. Singh, (NPL) Dr. G.S. Chilana, (DU)

APPENDIX - 12

HUMAN RESOURCE DEVELOPMENT ACTIVITIES

The Human Resource Development (HRD) Group of NPL is a central group of the laboratory providing a wide range of HRD services not only to NPL but also to other organisations of the country, and quite often to other countries of the world also. All these activities eventually lead to the generation of the trained S&T manpower. The various activities of the Group are as follows :

1. Organisation of External Training Courses

An important activity of the HRD group is to organize Training Courses on various physical parameters in the area of Metrology/Standards, as well as on other specialized topics. These courses are primarily meant for the personnel belonging to various industries, Testing & Calibration laboratories and other S & T organizations. However, the NPL staff members are also encouraged to attend these courses, wherever found fit.

The Training Courses consist of theory lectures on various scientific & technical aspects of the training course, followed by practical demonstration and hands-on training on the related instruments/apparatus/ machines.

Fifteen (15) Training Courses on diverse topics of 'Pressure & Vacuum Metrology', 'Temperature Metrology', 'Dimensional Metrology', 'Mass Metrology', 'Noise Measurement of DG Sets', etc., were organised by NPL during 2009-10, which were attended by a large number of personnel belonging to various national & international organisations, including many from NPL also.

This activity led to an ECF generation of Rs. 11.0 Lacs.

2. Formulation and Organisation of Internal Training Programmes

Besides the external training courses, the HRD Group also organizes the formulation and execution of special training programmes for the exclusive benefit and welfare of the NPL staff members. The basic objective is to provide the staff members knowledge and expertise in the area of relevance to their duties, so that they could perform in a more competent, productive and useful manner. Two training courses, 'Workshop on Material Characterization Technique' and 'Training Course on First Aid' were organised exclusively for the benefit of the NPL staff members.

3. Dissemination of HRD-Related Information to NPL Staff Members

Dissemination of HRD-related information to the NPL staff members is another important task performed by the HRD Group. The information generally refers to conferences/symposia/workshops, or special training programmes conducted by DST, HRDC (Ghaziabad) or other such organisation, or awards instituted by various agencies.

More than 250 different types of HRD-related papers were displayed at 4-5 prominent places of the laboratory each, during the year 2009-2010.

4. Deputation of NPL Staff Members to Attend Conferences

NPL encourages and supports its staff members, including the floating members like JRFs, SRFs, PAs, RIs, RAs, SRAs, etc., to attend and present papers at national/international conferences/symposia/seminars/ workshops, organised by different agencies in areas relevant to research activities being carried out at NPL. This is primarily meant to enable the staff members to put forward their views and research results before the leading national/international experts and interact with them on the latest developments in their research areas.

Besides the conferences/similar events, NPL also deputes its staff members to attend special training programmes organised by the DST, HRDC-Ghaziabad or other such organisation. These programmes are aimed at enhancing the knowledge and expertise of the participants so that they could prove to be more competent, productive and useful to their organisations.

A large number of NPL scientists and other staff members (399 cases) were deputed to participate in various conferences/similar events and different

Training Courses held across the country during the year 2009-10.

5. Placement, Ph.D. Registration and Other Support to Research Fellows

One of the most prominent activities of the HRD Group is to provide help and support to Research Fellows (JRFs/SRFs), starting from the time they join NPL till the time they leave NPL. This includes their placement in a suitable Division/Group and helping them in getting Hostel accommodation, if required. This also includes their Ph.D. registration, assessment for continuance/ upgradation, deputation to attend conferences, etc. Many a times, the help to the Research Fellows starts even before they join NPL. This refers to the cases wherein they are invited and inspired to join NPL for their Ph.D. programme.

Twenty Seven (27) fresh Research Fellows (JRFs/ SRFs) were inspired and motivated to join NPL during the year 2009-2010, making a total strength of JRFs+SRFs to be 87 as on March 31, 2010.

6. Organisation of Students' Training at NPL

NPL provides both Short Term and Long Term training to students pursuing M.Sc./B.Tech./M.Tech./MCA or their equivalent degree programmes, at different educational institutions spread across the country, in the areas of research activities being carried out at NPL. This training is extremely important to these students as it is oriented towards the fulfillment of their academic degree requirements. The basic objective is to provide the students an exposure of the NPL's research activities and motivate them towards scientific research, and thus contribute towards the generation of trained S&T manpower in the country.

During the year 2009-2010, 302 students were provided training at NPL in different areas of research, under the guidance of senior scientists of the laboratory.

This activity led to an ECF generation of Rs. 4.74 lacs.

7. Organisation of Institutional Visits to NPL

Organization of institutional visits involving students/ teachers/faculty members/personnel belonging to schools/colleges/universities/technical institutes/ S&T organisations is an important activity of the HRD Group. The basic objective is to provide the visitors a glimpse of the NPL activities and achievements, and thus enhance NPL's visibility in the society.

During the period from 1st April 2009 to 31st March 2010, Fifteen (15) institutional visits were organised by NPL, which involved more then 542 visitors and included prestigious institutions like IIT-Delhi, Amity University-Noida, IILM-Ranchi etc.

8. Placement of Newly-Recruited Scientists 'B'/'C'

Co-ordination was done towards the placement of newly-recruited Scientists 'B'/'C' in a particular Division/Section. These scientists were made to undergo a 2-week Orientation Programme consisting of meeting senior scientists, including all DU/DP Leaders, and interacting with them on their research activities. The basic aim of the Orientation Programme is to provide the freshly-inducted scientists an opportunity to have a glimpse of all the research activities being carried out at NPL, right in the very beginning of joining the NPL. This awareness could be very helpful in their proper placement by the authorities as well as in their pursuit of research activities in the future.

9. Formulation of NPL Training Calendar 2010-2011

The formulation of 'NPL Training Calendar' and its communication to the prospective industries/ laboratories/scientific institutions is the very first step towards the organization of Training Courses by the NPL. The NPL Training Calendar for the year 2010-2011 was formulated by the HRD Group in consultation with the concerned DU/DP Leaders, and sent to all the relevant parties. The 'Training Calendar' was also uploaded on NPL website for convenience of the participating organizations. These training courses, while benefiting the concerned personnel and thus contributing towards the generation of trained S&T manpower in the country, are beneficial to NPL also in terms of its image / visibility enhancement and ECF generation.

10. Formulation of DU-DP-wise Directory of NPL's Manpower

Efforts were initiated towards the formulation of a DU-DP-wise Directory of NPL's Manpower, seeing its immense usefulness in the execution of various HRD activities.

11. Organisation of CSIR Programme on Youth for Leadership in Science (CPYLS-2009)

The CPYLS programme for the year 2009 was organised by NPL at its campus on 01-02 December

2009 and was attended by 42 bright young school children, specially chosen by the CSIR for this programme. The programme involved a very fascinating inaugural lecture, entitled, 'Why Do We Measure' by Dr. S.T. Lakshmikumar, Chairman, NPL Academic Committee, besides two other lectures on different topics, namely, 'Organic Photovoltaics' and 'Atmospheric Aerosols' by the senior scientists of NPL. The programme also involved visits of the school children to various Research Groups of NPL involving different R&D activities, namely, Metals & Alloys, Carbon Fibers & Nanotubes, Organic Light Emitting Diodes, Luminescent Materials & Devices, Liquid Crystals, Optical Thin Films, etc. Beside this, the children were made to visit the Standards Groups also, such as, Time & Frequency Standards, Pressure & Vacuum Standards, Optical Radiation Standards, Force & Hardness Standards, etc., in addition to Scanning Electron Microscopy and Gas Chromatography Groups of the Materials Characterization Division.

The basic objective behind the whole programme was to inspire and motivate the talented school children towards Science and Scientific Research as the Career.

12. Organisation of National Science Day-2010 (Poster Presentation Symposium)

The National Science Day - 2010 was celebrated by NPL on 24th February 2010 in the form of a Poster Presentation Symposium, involving presentation of the work by the Research Fellows (JRFs+SRFs) of NPL and the students of the Delhi Technological University (DTU). The Inaugural Lecture at this occasion was delivered by Prof. P.B. Sharma, Vice Chancellor of the DTU, who was invited by NPL to be the Chief Guest at the celebration function. The symposium was kept open to all the NPL scientists and some of the senior staff members of the DTU, so that there could be a very useful and productive interaction between the students and the staff of the NPL and the DTU. To make the symposium lively and attractive, it was decided to give five (05) Best Poster Presentation Awards to the students selected by a jury, specially constituted for this purpose by the DNPL. Three (03) Research Fellows of the NPL and two (02) Students of the DTU were selected by this jury for this special award.

13. CSIR Foundation Day Celebrations-2009 (NPL Open Day)

Efforts were made towards the updation and publication of NPL Brochures (NPL at a Glance) at the occasion of CSIR Foundation Day Celebrations - 2009 in the form of NPL Open Day on September 26, 2009.

14. Other Miscellaneous Activities

Besides the above activities, the HRD Group also undertakes other assignments, singly or jointly with other groups of NPL, from time to time, where the basic objective behind the activities is to make the Human Resource more informed and knowledgeable so that it can prove to be better competent, productive and useful to the country.

APPENDIX - 13

CONFERENCES, SYMPOSIA, WORKSHOPS AND EVENTS ORGANISED BY NPL

May 20, 2009
World Metrology Day Celebration

June 08, 2009
Training course on Mass Metrology

June 12, 2009
NPL Strategic Visioning Workshop

July 13, 2009
Work Shop on Material Characterisation Technology

July 13, 2009
NABL Training Programme

July 17, 2009
National Conference on Innovation in Indian Science, Engineering and Technology

August 15, 2009
Independence Day celebration

August 24, 2009
Training Programme on Dimensional Metrology

September 24, 2009
CSIR Foundation Day Celebration

October 05, 2009
Training Programme on Photometry and Calorimetry

October 20, 2009
Training Programme on Time and Frequency Dissemination and Calibration

November 10, 2009
Training Programme on Pressure and Vacuum

December 01, 2009
CPYLS Program

December 17, 2009
Indo-Japan Work Shop on Bimolecular Electronics and Organic Nanotechnology Environment Preservation

January 15, 2010
Launch of CSIR Transformation Campaign & ICT Project

February 24, 2010
National Science Day Celebration

March 03, 2010
Workshop on Measurement needs for emerging Materials & Technologies

March 17, 2010
Invited talk by Dr. T. Ramaswamy, Secretary of DST

APPENDIX - 14

LECTURES ORGANIZED UNDER NPL SEMINAR SERIES

S.No.	Date	Speaker	Affiliation	Title of the talk
01	15-09-09	Biswapriya Deb	Research Scientist (Industry) Institute for the Advanced Materials and Renewable Energy University of Louisville, Louisville, KY-40292, USA	Chemical Vapour Deposition of Nanomaterials and Their Applications
02	17-11-09	Shin Toyoda	Okayama University of Science, Okayama, Japan	Formation and decay of the E1' center and oxygen vacancies in crystalline quartz
03	27-11-09	S. T. Lakshmikumar	National Physical Laboratory, Dr. K. S. Krishnan Road, New Delhi-110 012	Nobel Prizes (2009) in Science An Appreciation
04	4-01-10	Yinon Rudich	Chief Science Adviser, National Physical Laboratory, UK	Laboratory studies on the properties and processes of complex organic aerosols
05	10-03-10	B. Jeckelmann	METAS, Switzerland	Towards the new defintion of kilogram based on the fundamental constant
06	16-03-10	Ramesh Dhere	National Renewable Energy Laboratory (NREL), 1617 Cole Blvd., Golden, CO 80401	Overview of the present status and research opportunities for CdTe thin-film solar cells
07	23-03-10	Jürgen Rödel	Technische Universität Darmstadt, Germany	Mechanical properties of ferroelectrics

APPENDIX - 15

INVITED TALKS, LECTURES BY NPL SCIENTISTS

S.No.	Speaker's Name		Topic	Event and Venue
1	K P Chaudhary	i	"Repair and maintenance of Laser systems used in Biomedical Instrumentation"	Management development programme on operation, maintenance and repair of Bio-medical equipment' sponsored by Ministry of External affairs, Govt. of India, New Delhi under ITEC/SCAAP programme at SCIO, S&M Centre, New Delhi & Chandigarh from September 16, 2009 to November 10, 2009.
		ii	"Lasers in ophthalmology and their repair and maintenance"	Management development programme on operation, maintenance and repair of Bio-medical equipment' sponsored by Ministry of External affairs, Govt. of India, New Delhi under ITEC/SCAAP programme at CSIO, S&M Centre, New Delhi & Chandigarh from Decemberr 16, 2009 to February 9, 2010.
		iii	Uncertainty evaluation and calibration	Invited talk delivered at BIS Noida for the participants from South Asia regions on December 2, 2009
2	Y.P. Singh	i	"Basic concepts in temperature metrology: formulation and importance of the international temperature scales (ITS-90)"	Workshop on Metrology, Quality Assurance, Conformity Assessment and Proficiency Testing organized by NPL, MSI, NABL and QCI, held at the National Test House, Kolkata during 20-21 November, 2009.
3	A.K. Bandyopadhyay	i	Principle of Measurements in Pressure and Vacuum Standards,	Training course organized on Pressure and Vacuum Standards at NPL, New Delhi during Nov. 10-13, 2009.
		ii	"Experience upon nominating/ approving on-site peer reviewers"	Joint APMP-SIM Workshop on Peer Review of Quality Management Systems on the basis of CIPM MRA , Malaysia2009
4	D.R Sharma	i	Calibration Facilities using Ultrasonic Interferomenter Manometer near atmospheric pressure: Uncertainty in measurement	Training course organized on Pressure and Vacuum Standards at NPL, New Delhi during Nov. 10-13, 2009.
5	Pardeep Mohan	i	Vacuum measurements by some primary standards	Training course organized on Pressure and Vacuum Standards at NPL, New Delhi during Nov. 10-13, 2009.
6	D. Arun Vijayakumar	i	Barometric pressure measurements; Devices methods, corrections and measurement of uncertainty	Training course organized on Pressure and Vacuum Standards at NPL, New Delhi during Nov. 10-13, 2009.

S.No.	Speaker's Name		Topic	Event and Venue
7	Sanjay Yadav	i	Pressure Balance: Theory, Practice, Calibration, Technical and Metrological Requirements and Evaluation of Measurement Uncertainty	Training course organized on Pressure and Vacuum Standards at NPL, New Delhi during Nov. 10-13, 2009.
		ii	Recently Concluded PT in Hydraulic Pressure Region	Training course organized on Pressure and Vacuum Standards at NPL, New Delhi during Nov. 10-13, 2009.
8	Nita Dilawar Sharma	i	Pneumatic pressure measurement and Estimation of measurement uncertainty-A Simplified Overview	Training course organized on Pressure and Vacuum Standards at NPL, New Delhi during Nov. 10-13, 2009.
9	Harish Kumar	i	Calibration Procedure for Dial gauges, pirani gauges, penning gauges etc. in the range of 100 kPa to 10^{-3} Pa by direct comparison method,	Training course organized on Pressure and Vacuum Standards at NPL, New Delhi during Nov. 10-13, 2009
10	Om Parkash	i	Calibration procedure for Pneumatic pressure measuring instruments,	Training course organized on Pressure and Vacuum Standards at NPL, New Delhi during Nov. 10-13, 2009.
11	G. Bhatia	i	Studies on the development of high density graphite and copper reinforced graphite for multistage depressed collector of electron tubes"	IVSNS 2009 Symposium , CEERI, Pilani Nov. 11-13, 2009
		ii	R & D studies on Carbons – A family of versatile materials	B.D. Bangur Award Lecture during FACC 2009, November 25-27, 2009
12	Pankaj Kumar	i	Organic semiconductors and devices	Structured Workshop on New Electronic Devices, Department of Physics, University of Delhi, Delhi, June 1-15, 2009
13	R.B. Mathur	i	Growth of Carbon Nanotubes on Carbon Fiber Cloth and their Epoxy Composites with enhanced Mechanical Properties	International conference cum Workshop on Nano-Science and technology (2009 AIT NANO-2009) Ansal Institute of Technology, Gurgaon October 12-16, 2009
		ii	Carbon nanotubes – their Synthesis and Applications	National Symposium On Nano-Science: Theory and Applications (NASTA-MAP-2009) November 6-7, 2009
		iii	An improved process for making Porous Conducting Carbon Paper as electrode for Fuel Cells	First Asian Carbon Conference (FACC-2009).November 25-27, 2009, New-Delhi

S.No.	Speaker's Name		Topic	Event and Venue
		iv	Carbon Nanotubes – their Synthesis, Characterization and Applications Workshop on Nanomaterials : Recent techniques and Applications	Workshop on Nanomaterials: Recent techniques and Applications Institute of Engineering and technology, Shobit Univ. Meerut, March 27, 2010
14	S. R. Dhakate	i	Emerging trend in carbon materials	Emerging trend in material Science, (ETMS09), Mohta Science college, Nagpur, August 22, 2009.
		ii	Development of advanced carbon materials and their applications	National conference on Advanced material and technology (NCAMT09), Shri Shivaji Science College Congress Nagar, Nagpur, December 29- 30, 2009.
15	B.D. Malhotra	i	Fundamentals and Applications of Biosensors,	India-Brazil – South Africa Collaboration in Nanotechnology, Indira Gandhi Centre on Atomic Research ,February 23-27, 2010.
		ii	Nanomaterials based biosensors	Department of Physics, Panjab University, Chandigarh, September 3, 2009,
		iii	Introduction of Biosensors	Centre for Nano Bioengineering & Spintronics (nBEST), Chungnam National University, Deajeon, Korea, September 18, 2009.
		iv	Prospects of nanomaterials based biosensors	CNU Engineering Fair, Daejeon, Korea, October 26, 2009.
		v	Opportunities in nanostructured metal oxides based biosensors for clinical diagnostics	IIT Kanpur, Conference on Environmental and Technology Health, March 17, 2010.
		vi	Fundamentals and Applications of Biosensors, Prospects of Nanostructured metal	9th Refresher Course in Physics at JNU, New Delhi, JNU, 8, February 2010
16	Virendra Shanker	i	R & D of electroluminescent materials and devices for advanced display applications	National Seminar on Display Phosphors and Applications (NSDPA-2009) held at Vivekananda Degree College, Bangalore October 22-23, 2009
		ii	Development of Nanophosphors at National Physical Laboratory (CSIR), India	Indo-Russian Workshop on Nanotechnology and Laser Induced Plasma (IRNANO-2009) held at University of Delhi, Delhi during Nov. 24-26, 2009

S.No.	Speaker's Name		Topic	Event and Venue
17	Santa Chawla	i	Role of dopant in photoluminescence, electronic conduction and magnetic properties of ZnO nanocrystals	ICNM-2009. Kottayam, April, 2009
		ii	Development of Phosphors for solid state lighting and display	NWPAL 2009, Bhilai, December, 2009
		iii	Photoluminescence, TL and FTIR studies on Quartz from varied provenances	APLED 2, PRL, Ahmedabad, November, 12-14, 2009
		iv	Development of some technologically important luminescent material	Synthesis, Characterization and Applications of Technologically Important Materials (SCATIM 2010), BHU, Varanasi, December 5-6, 2010
18	D. Haranath	i	Synthesis and Characterization of Luminescent Magnetic Nanoparticles for Target Drug Delivery Applications	National Seminar on Display Phosphors and Applications (NSDPA-2009) held at Vivekananda Degree College, Bangalore during Oct.22-23, 2009
		ii	Advantages of Nanotechnology (Focus on Optoelectronic Materials)	Dr. Bhabha's Birth Centenary Guest Lecture held at Sevadal Mahila Mahavidyalaya, Nagpur during Oct. 31, 2009.
		iii	Multifunctional Fluorescent and Magnetic Nanoparticles for Bio-related Applications	Indo-Russian Workshop on Nanotechnology and Laser Induced Plasma (IRNANO-2009) held at University of Delhi, Delhi during Nov. 24-26, 2009
19	Bipin Kumar Gupta	i	Photoluminescence studies of new exotic spring-like carbon nanofibers	Indo-Russian Workshop on Nanotechnology and Laser Induced Plasma (IRNANO-2009) held at University of Delhi, Delhi during Nov. 24-26, 2009
		ii	Future prospects of nano-technology and nano-materials	National conference on application in material science in service of the society-second series at Department of chemistry, C.M.P. degree college, Allahabad, September 12-13, 2009
20	P.K. Singh	i	R&D on Silicon Solar Cell and Materials at NPL	Indo Australia Solar Energy Workshop at Amity University, Noida, February 9-10, 2010
		ii	Challenges and Opportunities in Silicon Solar Cell and R&D at NPL	National Institute of Advanced Industrial Science and Technology (AIST), Japan, February 24, 2010.

S.No.	Speaker's Name		Topic	Event and Venue
21	Sanjay K. Srivastava,	i	Synthesis and characterization of carbon and silicon nanostructures	Interaction Programme for M.Tech. (Nanotechnology) projects 2009; Department of Physics, Jamia Millia Islamia, New Delhi, May 23, 2009.
22	T.D.Senguttuvan	i	Advanced Ceramics research at NPL	Interaction Programme for M.Tech. (Nanotechnology) projects 2009; Department of Physics, Jamia Millia Islamia, New Delhi, May 23, 2009
23	O. S. Panwar	i	"Novel Filtered Cathodic Vacuum Arc Technique for the Deposition of Tetrahedral Amorphous Carbon Films".	inaugural lecture as Chief Guest in Department of Chemistry of Daulat Ram College, University of Delhi in their annual function, December 7, 2009.
24	Sushil Kumar	i	Innovations in Solar cells	Centre for Innovation Incubation and Entrepreneurship (CIIE) of IIM, Ahmedabad" at NPL , July 10, 2009
		ii	"Influence of process parameters on the growth and properties of micro/ nano-crystalline silicon thin film"	ASSCP-BHEL, Gurgaon, March 19, 2010.
25	N. Vijayan, G. Bhagavannarayana and K. K. Maurya	i	Growth and characterization analysis of some semi-organic single crystals for nonlinear applications	National conference on recent trends in crystal growth, thin films and nano-structured materials, Aditanar college of arts and sciences, Tiruchendur, Tamil Nadu, August 5-6, 2009.
26	T. Uma Devi,N. Lawrence, R. Ramesh babu, K. Ramamurthi, G. Bhagavannarayana	i	Studies on L-valinium picrate single crystal: a promosing NLO crystal	National conference on recent trends in crystal growth, thin films and nano-structured materials, Aditanar college of arts and sciences, Tiruchendur, Tamil Nadu, August 5-6, 2009.
27	G. Bhagavannarayana	i	A series of four lectures on the topic entitled Characterization of thin films and quantum wells by X-ray reflectometry, high-resolution and grazing-incidence diffractometry	GaN Journal Club, National Physical Laboratory, New Delhi, May and June 2009.
		ii	Characterization of Single Crystals and Thin Films by HRXRD, DXS, XRT, XRR, GI-XRD and RAMAN	Invited talk organized by Phys. Dept., Madurai Kamaraj University, Madurai,Tamilnadu under their UGC DRS programme, August 3, 2009.

S.No.	Speaker's Name		Topic	Event and Venue
		iii	Characterization of $Si_{1-x}Ge_x$/Si epitaxial films and the HBTs based on these layers by high-resolution XRD, Raman line shift and diffuse X-ray scattering measurement techniques	National conference on crystal growth, thin films and nano-structured materials-Crystal-NANO-2009 held at Department of Physics, Aditanar College of Arts and Science, Tiruchendur-628216, Tamil Nadu, August 5-6, 2009.
		iv	An introduction to Crystal Growth and Evaluation of Crystal Structure and Perfection by X-ray Diffraction/ Scattering methods Established at NPL.	National conference on recent trends in crystal growth, thin films and nano-structured materials, Aditanar college of arts and sciences, Tiruchendur, Tamil Nadu, August 5-6, 2009.
		v	Characterization of epitaxial films and thin films based nano structures/ devices by high-resolution X-ray diffraction and in-plane or grazing incidence X-ray diffraction techniques.	Invited talk organized by Chemistry Dept., ADM College for Women at Nagapattanam, Tamilnadu, October 8, 2009
		vi	An introduction to Crystal Growth, Evaluation of Crystal Structure and Perfection by powder XRD and High-resolution XRD	National conference on Materials Science, Annamalai University, Annamalai Nagar, Oct. 9-10, 2009.
		vi	Characterization of device-grade single crystals by various methods based on high-resolution X-ray diffraction/ diffuse scattering	Jamia Millia Islamia on a special invitation October 21, 2009
		vii	Characterization of $Si_{1-x}Ge_x$/Si epitaxial films and the HBTs based on these layers by high-resolution XRD, Raman line shift and diffuse X-ray scattering measurement techniques.	National symposium on Growth of Detector grade single crystal (NSGDSC-2009), held at Bhabha Atomic Research Centre, November 19-21, 2009.
		viii	In house developed Multicrystal X-ray diffractometer and its role in crystal growth activity in India.	XVth International workshop on The physics of semiconductor devices at Jamia Millia Islamia, December 15-19, 2009
28	K.K.Maurya, Mohd. Shakir, B. Riscob,V. Ganesh, M.A. Wahab, G. Bhagavannarayana	i	A centrosymmetric crystal with SHG efficiency : transition metal doped Bis thiourea Zinc(II) chloride crystals	14th National seminar on Crystal Growth, School of advanced sciences, VIT University, Vellore, March 10-12, 2010
29	S. Meenakshisundaram, G. Bhagavannarayana, B. Karthikeyan, K. Muthu, K. Nithya	i	Growth of Cadmium zinc telluride single crystal by Bridgeman oscillation (BRO) and Vertical Gradient Freezing (VGF) techniques and its characterization analysis	14th National seminar on Crystal Growth, School of advanced sciences, VIT University, Vellore, March 10-12, 2010.

S.No.	Speaker's Name		Topic	Event and Venue
30	N. Vijayan,E. Dieguez, V. carcelen, K.K. Maurya, G. Bhagavannarayana	i	CdS/potassium hydrogen phthalate-A short wave length filter to reduce eye damage	14th National seminar on Crystal Growth, School of advanced sciences, VIT University, Vellore, March 10-12, 2010.
31	T.Prem Kumar, G.Bhagavannarayana, K.Sankarnarayanan	i	Synthesis, growth, spectral, thermal, mechanical andoptical properties of 4-choloro, 4-dimethylamino bendydilene aniline crystals: A third order nonlinear optical material	14th National seminar on Crystal Growth, School of advanced sciences, VIT University, Vellore, March 10-12, 2010,
32	S. Leela, K. Ramamurthi, G. Bhagavannarayana	i	Unidirectional KAP-substrates-fabrication and its characterization	14th National seminar on Crystal Growth, School of advanced sciences, VIT University, Vellore, March 10-12, 2010,
33	T. Prem Kumar, G.Bhagavannarayana, K. Sankarnarayanan	i	Crystal growth and its Applications	14th National seminar on Crystal Growth, School of advanced sciences, VIT University, Vellore, March 10-12, 2010.
34	N. Vijayan	i	Crystal growth and its Applications	Association Meeting held at Govt. Arts and Science College, Ariyalur, Tamilnadu, March 15, 2010.
35	R. P. Pant	i	Nanotechnology of ferrofluid Materials	Nanocenter, Jamia Milia Islamia, New Delhi
36	Devender Gupta	i	Advanced Materials' Characterization by Infrared and Raman spectroscopic Techniques"	UGC Sponsored National Conference on Recent Trends in Material Sciences, Post Graduate DAV college, Guru Nanak Dev University, AMRITSAR, 2009.
		ii	IR and Raman Spectroscopy	Users Awareness Programme on Materials Characterization Techniques, NPL, New Delhi.
37	Sukhvir Singh	i	Characterizationh of materials using Transmission electron microscopy technique	Workshop on material Characterization technique WMCT-2009 in July 2009
		ii	Characterization of nano-materials using Electron microscopy	A conference on structured materials at Department of Physics North Campus Delhi University, May 2009
38	B.R. Chakraborty	i	Characterization of Nano-materials	2nd National conf. On Nano materials & Nanotechnology, Lucknow Univ
		ii	Secondary Ion Mass Spectroscopy: A Chronology	11th TRICON Conf. On Mass Spectrometry, Hyderabad

S.No.	Speaker's Name		Topic	Event and Venue
		iii	Secondary Ion Mass Spectroscopy: A Chronology	6 lecture series at the UGC center for college teachers, Gauhati Univ.,Gauhati
		iv	Secondary Ion Mass Spectroscopy: A Chronology	3 lecture series at the UGC center for college teachers, JNU, Delhi
39	A.K. Srivastava,	i	Oxide Nanostructures: Synthesis, Characterization and Properties Evaluation, Symposium on Functional and Structural Nanomaterials: Fabrication, Properties, Applications and Implications,	The Mineral, Metals and Materials Society (TMS), Seattle, USA.
		ii	Nano dimensional imaging,	University of Arkansas, Arkansas, USA,
		iii	Nano-materials: growth, characterization and properties evaluation,	Bhopal University, Silver Jubilee Program, Plenary Talk, Bhopal.
		iv	Characterization of nanomaterials employing electron microscopy, spectroscopy and diffractometry	Advance Materials Processing Research Institute, Bhopal.
		v	Electron microscopy and spectroscopy: Basics and applications,	Pohang University of Science and Technology, South Korea
		vi	Nano – dimensional Imaging with Analytical Measurements employing Electron Microscopy, Spectroscopy and Diffractometry	Pohang University of Science and Technology, South Korea.
		vii	Initiatives in Materials Science and Engineering, Indian research priorities with an emphasis to nanomaterials,	National Institute of Standards and Technology
40	Shankar Gopala Aggarwal	i	Recent Advances in Aerosol Measurement Techniques and the Importance of Aerosol Metrology	Urban Air Toxic Workshop (organized by EPA_Thailand and NIM_Thailand), Bangkok, Thailand, November 27, 2009.
		ii	Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP-AES)	Workshop on the Role of Analytical Techniques in Industries,KM College, DU, Delhi, January 21, 2010.
		iii	A simplify approach to calculate the percentage water content of atmospheric aerosols under ambient humidity conditions by operating two SMPS systems in parallel	Goldschmidt 2009 Conference, Davos, Switzerland, June 21-26, 2009
		iv	Recent Advances in Aerosol Analytical Techniques: Implication for Better Understanding toward Atmospheric Chemistry	Analytical Sciences in Energy and Environment, IIP, Dehradun, Nov. 19-20, 2009

S.No.	Speaker's Name		Topic	Event and Venue
		v	Winter-Time Long-Term Observations on Aerosol Loading in New Delhi: Implications for Local Source Changes	Asian Aerosol Conference, Bangkok, Thailand, Nov. 24-27, 2009
		vi	Determination of Aerosol Water Content Under Near Ambient Humidity Condition	Asian Aerosol Conference, Bangkok, Thailand, Nov. 24-27, 2009
41	Prabhat K. Gupta	i	Traceability in GHG measurements	MoEF National Work Shop, IITM, Pune, May 18-19, 2009
		ii	Status of MiC in India	NPL-NIST WS, USA June 3, 2009
		iii	Indian priorities in chemical metrology: Recent initiatives by NPL India	NPL-NIST WS, USA June 4, 2009
		iv	MiC training workshop and discussions on national PT scheme planning: Pesticides in tea	Un Trg WS IHBT, Palampur, H.P., July 1, 2009
		v	Metrology in Chemistry in India	WMCT-2009, NPL, July 17, 09
		vi	IOC & NPL New Delhi initiatives for CNG standards	CNG Planning Meeting, NPL 21 July 2009
		vii	Determination of Country Specific Emission Factor for Methane (CH_4) from Landfills in Mega cities	NATCOM WS, IHC, Delhi, October 13, 2009
		viii	GHG Emission from Waste Sector: Country Specific EF & Data QA/ QC	NATCOM CC WS, Delhi, October 14, 2009
		ix	Metrology in chemistry and environmental issues	CSIR PYLS Students Training at NPL, December 2, 2009
		x	Status of MiC in India	APMP2009-MiC WS, Malaysia, December 11, 2009
		xi	Awareness raising activities in setting up national MiC infrastructure in India	APMP2009-MiC WS, Malaysia, December 12, 2009
		xii	Metrology in Chemistry (MiC): Recent initiatives by NPL & its partners in India	MiC Trg. course, Lucknow, UP, January 11, 2010
		xiii	Measurement and Metrology Challenges in Agricultural and Climate Change	BHU Refreshar Course, Varanasi, January 23, 2010
		xiv	Metrology Challenges in Agricultural and Climate	Technia Instt., Rohini, Delhi, January 30, 2010
		xv	MiC: Dissemination of SI Traceability through PT & CRMs for Environmental Measurements	MiC Seminar, CPCB New Delhi, March 5, 2010
		xvi	Metrology in Chemistry: Traceability in Air Pollution Measurements	SERC School, NPL, March 16, 2010

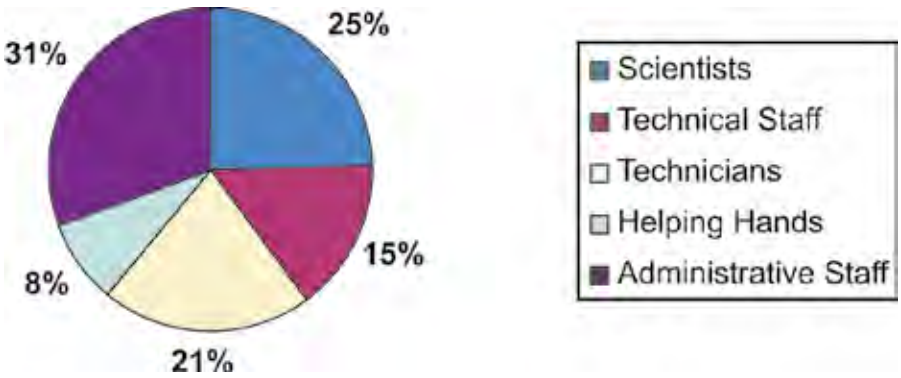
S.No.	Speaker's Name		Topic	Event and Venue
42	C. Sharma	i	Invited talk entitled 'Shahari Vatavaran Mei Karbon Ke Padchinh' in RASD	Hindi seminar on *"Radio Avom Paryavarn Vigyan: Rashtriya Sangosthi 2009"* held during April 22-23, 2009
		ii	Invited talk entitled 'Harnessing Energy from Municipal Waste'	CMS Environment Workshop on "Confronting Climate Change – Towards Carbon Neutral Indian Cities" held during 29-30 October 2009 at IHC, New Delhi.
		iii	Invited talk entitled `Road Transport & Climate Change	ITS Conference & Exhibition on "ITS for Mobility & Safety Management" organized during 1-2 December 2009 by Delhi Technological University (DTU).
		iv	Key note lecture entitled `Global Warming and Impacts' in 'Global warming, Human Factors and Environment: Perspectives form Anthropology"	Department of Anthropology, Panjab University, Chandigarh during 16th and 17th February, 2010.
		v	Invited talk entitled 'IPCC Methodologies for Preparation of Emission Inventories of Greenhouse Gases from Energy Sector'	SERC School on "Atmospheric Chemistry and Air Pollution' organized by RASD during 2-22 March 2010 at NPL, New Delhi
		vi	Invited talk entitled `Trace Gas Emissions from Energy and Waste Sectors in India' in 'Environmental Pollution and Mitigation Strategies	Centre of Advanced Faculty Training, Department of soils, Punjab Agriculture University, Ludhiana during 9-29 March 2010.
43	S. K. Sarkar	i	Invited Resource Person, INSPIRE programme DST Sponsored	Tripura University, Agartala, 14-15 March 2010
		ii	Invited lecture entitled "Recent advances in radio environment for radio communication	CODEC-2009, 15 December 2009, Kolkata
44	P. Banerjee	i	GPS and Time Keeping: Current Status & Challenging Issues	Tripura University, Agartala, April 3-4, 2009
		ii	Emerging trend in carbon materials	Emerging trend in material Science,(ETMS09),Mohta Science college, Nagpur, August 22, 2009.
		iii	Recent Progress and Challenges in Time Keeping and Time Transfer	4th SERC, NERTU Hyderabad, June 20, 2009
		iv	Relevance of Accurate Time	NTH, Kolkata November 19-20, 2009.
		v	Current status and future plan of Electrical and Electronics Standard Activities of NPLI	US-India Workshop in Washington, USA, June 1-4, 2009

S.No.	Speaker's Name		Topic	Event and Venue
45	V.N. Ojha	i	Quantum Metrology and nanometrology Activities of NPLI	US-India Workshop in Washington, USA, June 1-4, 2009
46	V.N. Ojha and Rina Sharma	i	Role of Nano metrology for Nano technology	National Conference On Emerging technologies & application, ETA-2010, Jaipur, February 6, 2010.
		ii	Nanometrology for Nanotechnology	National Conference on Advances ion materials and devices for renewable energy sources ETA-2010, Jaipur, February 25-27, 2010.

APPENDIX - 16

HUMAN RESOURCE
As on March 31, 2010

GROUP IV			**GROUP II**	**Sub-Total :**	**174**
Director		1			
Scientist G		39	**GROUP I**	**Sub-Total :**	**68**
Scientist F		43			
Scientist EII		22	ADMN-A		6
Scientist EI		27	ADMN-B		81
Scientist C		39	ADMN-C		49
Scientist B		28	ADMN-C (Cafeteria Staff)		8
	Sub-Total :	**199**	ADMN-D		96
			ADMN-D (Cafeteria Staff)		8
GROUP III				**Sub-Total :**	**248**
TO (EII)		7		**GRAND TOTAL :**	**815**
TO (EI)		24			
Engg.		3			
TO (C)		25			
TO (B)		6			
TO (A)		12			
STA		4			
Tech. Asst. VIII		44			
Junior Engg.		1			
	Sub-Total :	**126**			



SCIENTISTS AND OFFICERS AS ON 31.03.2010

Director

Prof R C Budhani

Name	Designation
Physico Mechanical Standards **Head : Dr Ashis Kumar Bandyopadhyay**	
Dr Ashis Kumar Bandyopadhyay	Scientist G
Dr Ashok Kumar	Scientist G
Dr Hem Chandra Kandpal	Scientist G
Dr Sushil Kumar Jain	Scientist G
Dr Pardeep Mohan	Scientist G
Dr K P Chaudhary	Scientist G
Sh Subodh Kumar Singhal	Scientist G
Sh Omkar Sharma	Scientist G
Dr Yesh Pal Singh	Scientist G
Dr Desh Raj Sharma	Scientist F
Sh B V Kumaraswamy	Scientist F
Dr Rakesh Kumar Garg	Scientist F
Sh Anil Kumar	Scientist F
Dr (Ms) Ranjana Mehrotra	Scientist F
Dr (Ms) Rina Sharma	Scientist EII
Dr Mahavir Singh	Scientist EII
Sh D Arun Vijayakumar	Scientist EII
Dr Sanjeev Sinha	Scientist EI
Dr Sanjay Yadav	Scientist EI
Dr (Ms)Nita Dilawar	Scientist EI
Dr S Seela Kumar Titus	Scientist EI
Sh Rajesh Kumar	Scientist EI
Sh Shiv Kumar Jaiswal	Scientist C
Sh Goutam Mandal	Scientist C

Name	Designation
Sh Naveen Garg	Scientist C
Sh Virendra Kumar Jaiswal	Scientist C
Sh Dilip Dhondiram Shivagan	Scientist C
Sh Gopan C K	Scientist B
Dr Parag Sharma	Scientist B
Sh Harish Kumar	Scientist B
Ms Girja Moona	Scientist B
Ms Susan George K	Scientist B
Sh Virendra Babu	Tech Ofcr (EII)
Sh Ravi Khanna	Tech Ofcr (EII)
Sh Jagdish Kumar Gupta	Tech Ofcr (EII)
Sh Gurbir Singh	Tech Ofcr (EI)
Ms Reeta Gupta	Tech Ofcr (EI)
Dr Yudhisther Kumar Yadav	Tech Ofcr (EI)
Sh Gurcharanjit Singh	Tech Ofcr (EI)
Sh V K Ojha	Tech Ofcr (EI)
Sh Ishwar Singh Taak	Tech Ofcr (C)
Sh Gurdeep Singh Lamba	Tech Ofcr (C)
Sh Bhikham Singh	Tech Ofcr (C)
Sh Mukesh Kumar	Tech Ofcr (C)
Sh Om Prakash	Tech Ofcr (C)
Sh K N Basavaraju	Tech Ofcr (C)
Sh Sudama	Tech Ofcr (B)
Sh Mahargha Baran Das	Tech Ofcr (B)
Ms Usha kiran	Tech Ofcr (B)
Sh Bharat Kumar Yadav	Tech Ofcr (A)
Sh Harish Kumar	Tech Ofcr (A)
Sh Rasik Behari Sibal	Tech Ofcr (A)
Sh Virendra Kumar Gupta	Tech Ofcr (A)

Electrical & Electronic Standards
Head : Dr P Banerjee

Name	Designation
Dr P Banerjee	Scientist G
Dr Amitava Sengupta	Scientist G
Dr Vijay Narain Ojha	Scientist G
Dr Sita Ram Gupta	Scientist G
Sh Anil Kumar Govil	Scientist G
Sh Mukesh Kumar Mittal	Scientist G
Dr G M Saxena	Scientist F
Sh Anil Kishore Saxena	Scientist F
Dr R K Kotnala	Scientist F
Sh H R Singh	Scientist F
Sh Pramendra Singh Negi	Scientist F
Sh M P Singh	Scientist EII
Mrs Arundhati Chatterjee	Scientist EII
Sh Kavindra Pant	Scientist EII
Sh Joges Chandra Biswas	Scientist EII
Sh Ajeet Singh	Scientist EI
Sh Rajbeer Singh	Scientist EI
Sh M A Ansari	Scientist EI
Dr Hari Krishna Singh	Scientist EI
Ms Manju Singh	Scientist EI
Dr Ashish Agarwal	Scientist C
Dr Aloysius R P	Scientist C
Sh Saood Ahmed	Scientist C
Sh Kamlesh Kumar Patel	Scientist C
Dr (Ms) Poonam Arora	Scientist C
Ms Priyanka Jain	Scientist C
Ms Pranalee Premdas Thorat	Scientist B

Name	Designation
Ms Santhya Malikar Patel	Scientist B
Sh Satish	Scientist B
Sh Anil Kumar Suri	Tech Ofcr (EII)
Sh Kul Bhushan Ravat	Tech Ofcr (EI)
Sh Mohammad Saleem	Tech Ofcr (EI)
Sh Avdhesh Kumar Goel	Tech Ofcr (C)
Sh Bijendra Pal	Tech Ofcr (C)
Sh Sridhar Lingam	Tech Ofcr (A)
Ms Poonam Sethi Bist	Tech Ofcr (A)
Sh Anoop Singh Yadav	Tech Ofcr (A)

Engineering Materials
Head : Dr Sukhwant Singh Bawa

Name	Designation
Dr Sukhwant Singh Bawa	Scientist G
Dr Gopal Bhatia	Scientist G
Dr Rakesh Behari Mathur	Scientist G
Dr M N Kamalasanan	Scientist G
Dr Bansi Dhar Malhotra	Scientist G
Dr Ashok Manikrao Biradar	Scientist G
Dr Suresh Chand	Scientist G
Dr Tarsem Lal Dhami	Scientist G
Sh Ramesh Chandra Anandani	Scientist F
Dr Sunil Kumar Singhal	Scientist F
Dr Chhotey Lal	Scientist F
Dr Tushya Kumar Saxena	Scientist F
Dr Krishan Kumar Saini	Scientist F
Dr S K Dhawan	Scientist F
Dr Ajay Dhar	Scientist F
Sh Sudhanshu Dwivedi	Scientist EII

Name	Designation
Sh Sanjay Rangnate Dhakate	Scientist EII
Dr Rajesh	Scientist EI
Dr (Ms) Ritu Srivastava	Scientist C
Sh Vipin Jain	Scientist C
Dr Surendra Pal Singh	Scientist C
Dr (Ms) G Sumana Gajala	Scientist C
Sh. Bhanu Pratap Singh	Scientist C
Sh.Parveen Saini	Scientist C
Dr (Ms) Nidhi Singh	Scientist C
Dr Vinay Gupta	Scientist C
Dr Ved Varun Agrawal	Scientist C
Sh Pankaj Kumar	Scientist B
Sh Bathula Sivaiah	Scientist B
Sh M Saravanan	Scientist B
Dr (Ms) Priyanka Heda Maheshwari	Scientist B
Dr (Ms) Saroj Kumari	Scientist B
Sh Rajiv Sikand	Tech Ofcr (EII)
Sh Pinaki Ranjan Sengupta	Tech Ofcr (EI)
Sh Gauri Datt Sharma	Tech Ofcr (EI)
Sh Chander Kant	Tech Ofcr (EI)
Sh Rakesh Khanna	Tech Ofcr (C)
Sh Rajesh Kumar Seth	Tech Ofcr (C)
Sh Vinod Kumar Tanwar	Tech Ofcr (A)

Electronic Materials
Head : Dr S T Lakshmikumar

Name	Designation
Dr S T Lakshmikumar	Scientist G
Dr Virendra Shanker	Scientist G
Dr Amitabha Basu	Scientist G
Dr Parakram Kumar Singh	Scientist G

Name	Designation
Dr Omvir Singh Panwar	Scientist G
Dr S M Shivaprasad	Scientist F
Dr Sher Singh Rajput	Scientist F
Dr (Ms) Kiran Jain	Scientist F
Dr (Ms) Santa Chawla	Scientist F
Dr Abdul Mobin	Scientist EII
Dr (Ms) Meenakshi Kar	Scientist EII
Sh C M S Rauthan	Scientist EII
Dr K M K Srivatsa	Scientist EII
Dr Narinder Kumar Arora	Scientist EI
Dr T D Senguttuvan	Scientist EI
Dr (Ms) Gurusharan Kaur Padam	Scientist EI
Dr Shailesh Narayan Sharma	Scientist EI
Dr Sushil Kumar	Scientist EI
Dr Amish G Joshi	Scientist EI
Dr Divi Haranath	Scientist EI
Ms Santosh Singh Golia	Scientist EI
Dr Govind	Scientist C
Ms Vandana	Scientist C
Dr Muthusamy Senthil Kumar	Scientist C
Sh Chockalingam Sreekumar	Scientist B
Dr Mahesh Kumar	Scientist B
Sh Sanjay Kumar Srivastava	Scientist B
Dr Bipin Kumar Gupta	Scientist B
Sh Rajiv Kr. Singh	Scientist B
Dr Praveen Kumar Siwach	Scientist B
Sh Ravi Kumar	Tech Ofcr (EII)
Sh Tarun Kumar Chakraborty	Tech Ofcr (EI)
Sh Mukul Sharma	Tech Ofcr (EI)
Dr V K Hans	Tech Ofcr (EI)
Sh Murari Lal Sharma	Tech Ofcr (C)
Sh Jagdish Chand	Tech Ofcr (B)

Materials Characterization
Head : Dr Bibhash Ranjan Chakraborty

Name	Designation
Dr Bibhash Ranjan Chakraborty	Scientist G
Dr Godavarthi Bhagavannarayana	Scientist G
Sh Prabhat Kumar Gupta	Scientist G
Dr (Ms) Rashmi	Scientist F
Dr Rajendra Prasad Pant	Scientist F
Dr Devinder Gupta	Scientist EII
Dr Sukhvir Singh	Scientist EII
Dr (Ms) Renu Pasricha	Scientist EII
Dr Avanish K Srivastava	Scientist EI
Dr Kamlesh Kumar Maurya	Scientist EI
Dr (Ms) Prabha Johri	Scientist C
Dr Nahar Singh	Scientist C
Dr Nirmalya Karar	Scientist C
Dr Narayanaswamy Vijayan	Scientist C
Dr Sushree Swarupa Tripathy	Scientist B
Dr (Ms) Daya Soni	Scientist B
Sh Manas kumar Dalai	Scientist B
Sh Niranjan Singh	Tech Ofcr (EI)
Dr (Ms) Manju Arora	Tech Ofcr (EI)
Sh Kedar Nath Sood	Tech Ofcr (EI)
Sh Rajiv Kumar Saxena	Tech Ofcr (C)
Ms Abha Bhatnagar	Tech Ofcr (C)
Sh Khem Singh	Tech Ofcr (A)

Radio & Atmospheric Sciences
Head : Dr Swapan Kumar Sarkar

Name	Designation
Dr Swapan Kumar Sarkar	Scientist G
Dr Raj Singh Dabas	Scientist G
Dr Bhuwan Chandra Arya	Scientist G

Name	Designation
Dr M V S N Prasad	Scientist G
Dr M K Tiwari	Scientist F
Dr Pradeep Kumar Pasricha	Scientist F
Dr Mahendra Kumar Goel	Scientist F
Sh Pattamatta Subrahmanyam	Scientist F
Ms Madhu Bahl	Scientist F
Sh Narendra Kumar Sethi	Scientist F
Sh H K Maini	Scientist F
Sh Thomas John	Scientist F
Sh Deo Raj Nakra	Scientist F
Dr (Ms)Meena Jain	Scientist EII
Dr Chhemendra Sharma	Scientist EII
Ms Anuradha Sengar	Scientist EI
Sh Randhir Singh Tanwar	Scientist EI
Dr Tuhin Mandal	Scientist EI
Dr Sachidanand Singh	Scientist EI
Dr Arun Kumar Upadhyay	Scientist C
Dr (Ms)Monika J. Kulshrestha	Scientist C
Sh Rupesh M Das	Scientist C
Sh Sumit Kumar Mishra	Scientist C
Dr (Ms) Kirti Soni	Scientist B
Dr Sudhir Kumar Sharma	Scientist B
Sh Arun Kumar Ghoghar	Tech Ofcr (EI)
Sh Shambhu Nath	Tech Ofcr (EI)
Ms Shiv Kumari Bhatia	Tech Ofcr (EI)
Ms Beena Gupta	Tech Ofcr (C)
Sh Vinod Kumar Sharma	Tech Ofcr (C)
Sh Man Mohan Gupta	Tech Ofcr (C)
Sh Alok Mukherjee	Tech Ofcr (A)

Superconductivity & Cryogenics
Head : Dr Hari Kishan

Name	Designation
Dr Hari Kishan	Scientist G
Dr Ratan Lal	Scientist EII
Dr. Vijay Kumar (Gumber)	Scientist EII
Dr (Ms) P L Upadhyay	Scientist EII
Dr Anurag Gupta	Scientist EI
Dr Veerpal Singh Awana	Scientist EI
Sh Man Mohan Krishna	Scientist C
Sh Rajendra Singh Meena	Scientist C
Dr (Ms) Anjana Dogra	Scientist C
Sh Ashok Kumar	Scientist B
Sh S B Samanta	Tech Ofcr (EII)

Director's Office
Head : Prof R C Budhani

Name	Designation
Prof R C Budhani	Director
Dr A.K. Hanjura	Scientist G

Library
Head : Sh Deepak Kumar Tewari

Name	Designation
Sh Deepak Kumar Tewari	Scientist F
Sh N K Wadhwa	Scientist EII
Sh Abhishek Sharma	Scientist B
Sh Jagdish Prasad	Tech Ofcr (EI)
Sh Rajpal Zamaji Walke	Tech Ofcr (B)
Ms Neetu Chandra	Tech Ofcr (A)

Scientific Support Services
Head : Dr Virendra Shanker

Name	Designation
Dr Virendra Shanker	Scientist G
Dr R K Aggarwal	Scientist G

Name	Designation
Sh S Uma Maheshwar Rao	Scientist F
Sh T Raghavendra	Scientist F
Dr Rajeev Chopra	Scientist F
Ms Shikha Mandal	Scientist F
Dr (Ms) Jyoti Lata Pandey	Scientist F
Dr D P Bhatt	Scientist F
Sh Sushil Kumar Sharma	Scientist F
Sh Ganga Prasad	Scientist F
Ms Indra Tiwari	Scientist F
Dr R G Mathur	Scientist B
Sh V D Arora	Tech Ofcr (EI)
Sh S K Rastogi	Tech Ofcr (EI)
Sh Ashwani Kumar Suri	Tech Ofcr (EI)
Ms Shashi Lekha Bhatnagar	Tech Ofcr (C)
Ms Anita Sharma	Tech Ofcr (A)

Technical Support Services
Head : Dr Jagdish Chandra Sharma

Name	Designation
Dr Jagdish Chandra Sharma	Scientist F
Sh K P S Yadav	Sr. Supt. Engnr.(Elect)
Sh A K Sabarwal	Supt. Engnr.
Sh Deepak Bansal	Tech Ofcr (EI)
Sh Prabhu Shankar Tripathi	Tech Ofcr (C)
Sh Mohan Chandra Singh	Tech Ofcr (C)
Sh Rambir Singh	Asstt. Engineer

Workshop, GTU & Cryogenic Infrastructure
Head : Sh Surendra Singh Verma

Name	Designation
Sh Surendra Singh Verma	Scientist G
Sh Srinivasan P	Scientist C
Sh Jai Pal Singh	Tech Ofcr (C)
Sh Amar Singh	Tech Ofcr (B)

Central Computer Facility
Head : Dr Ravi Mehrotra

Name	Designation
Dr Ravi Mehrotra	Scientist G
Ms Deepti Chaddha	Scientist C
Sh Ashish Ranjan	Scientist C
Sh Nitin Sharma	Scientist C
Ms Anjali Sharma	Scientist C
Sh Trilok Bhardwaj	Scientist B
Sh Ashok Kumar	Tech Ofcr (C)
Sh Kanwaljit Singh	Tech Ofcr (C)
Sh Vijay Sharma	Tech Ofcr (C)

Administration
Head : Sh T V Joshua

Name	Designation
Sh T V Joshua	COA
Ms Veena Jain	Admn. Ofcr
Sh Vijay Kumar	Sr Security Ofcr
Sh Jagan Nath Prasad	Tech Ofcr (C)
Sh Jokhan Ram	Tech Ofcr (C)
Sh M C Meena	S O(G)
Sh Rajiv Sharma	S O(G)
Sh Vikram Singh	S O(G)
Ms Bhawna Guglani	S O(G)
Sh Umesh Gupta	S O(G)
Sh Mange Ram	PS
Ms. Paramjit Kaur	PS
Sh Amar Singh	PS
Sh Ram Gopal Meena	PS
Ms S K Bajwa	PS

Finance & Accounts

Head : Sh S K Mehta

Name	Designation
Sh S K Mehta	CO (F & A)
Sh Sudipto Chaterjee	F&AO
Sh Ajay Kumar	S O (F&A)
Sh S K Thakur	S O (F&A)

Stores & Purchase

Head : Sh Mukesh Khanna

Name	Designation
Sh Mukesh Khanna	SPO
Sh S S Chaudhary	S O (Str & Pur)
Sh Surendra Kumar	S O (Str & Pur)
Sh Bhag Singh	S O (Str & Pur)

Retired Persons

Sh V P Sharma, Gr II(4)
Sh Jai Bhagwan, Tech Ofcr (EI)
Sh Inder Jeet Taneja, PS
Sh Parvinder Pal Singh, Gr II(4)
Sh Kishan Lal, Gr II(4)
Sh J L Chhabra, Gr II(4)
Sh Gian Chand, Asstt Halwai(ACP)
Mrs Gulshan Arora, PS
Sh P L Pundora, Gr II(4)
Dr Dharam Pal Singh, Tech Ofcr (EI)
Sh Rajan Babu Saxena, Scientist G
Dr (Ms) Shakuntala Sharma, Sr Hindi Officer
Ms Parvati Chopra, Scientist EII
Sh Shiv Datt Sharma, Gr II(4)
Sh Prem Singh, SPO
Dr Vikram Kumar, Director
Sh D D Saklani, Gr II(4)
Sh Daleep Singh, Gr II(4)
Sh Sukhbir Singh, Security Ofcr
Sh T K Parameshwaran, Tech Ofcr (C)
Sh Deepak Mukerjee, Asst. (G) Grade II
Sh Tripurari Lal, Scientist F
Sh Pritam Singh, Gr II(4)
Dr (Ms) S Niranjana N Goswami, Scientist EII
Sh Ritander Aggarwal, Scientist EII
Sh Om Prakash, Gr II(4)
Sh Mohinder Singh, Jr Sec Grd (ACP)
Sh T K Bhattacharya, Tech Ofcr (C)
Sh Ranbir Singh, Gr II(4)
Sh Bishan Swarup, Workshop Asstt VII
Sh Satish Kumar, Gr II(4)
Dr Bhim Sain Gera, Scientist G
Sh Ram Phal, Record Keeper
Sh D P Bahuguna, Gr II(4)
Sh Joginder Pal, Gr II(4)
Sh Chhotey Lal, Workshop Asstt VII
Dr Ashok Kumar Hanjura, Scientist G
Sh Tulsi Ram, Jr Sec Grd (ACP)

Obituaries

Sh Dinesh Singh Negi, Asst (G) Grade III
Sh Ram Deen, Mali (Gr.I)
Sh B C Joshi, Tea/Coffee Maker(Canteen))

Sh Hakam Singh, Workshop Asstt II

Scientists Fellow & Emeritus Scientists

Dr A K Aggarwal, Consultant
Dr K K Jain, Consultant
Prof Vikram Kumar, Consultant
Dr Harish Chandra, Emeritus Sci.
Dr Ashok Kumar Gupta, Emeritus Sci.
Dr P K Ghosh, Emeritus Sci.
Dr U N Sinha, Emeritus Sci.
Dr Subhash Chandra, Emeritus Sci.
Sh S C Garg, Emeritus Sci.
Dr R Bhattachryya, Emeritus Sci.
Dr S L Jain, Emeritus Sci.
Dr Lakha Singh, Emeritus Sci.
Dr Vinod Kumar Jain, Emeritus Sci.
Dr V Mohanan, Emeritus Sci.
Dr S N Singh, Emeritus Sci.
Dr S K Aggarwal, Emeritus Sci.
Dr S K Haldar, Emeritus Sci.
Dr C P Sharma, Emeritus Sci.
Dr O P Bahl, Emeritus Sci./co-ordinator
Dr K K Mahajan, INSA Honorary Sci
Dr Krishan Lal, INSA Sr. Sci.
Dr.Preeti Bijlani, Part time Medical Officer
Dr S K Joshi, Platinum Jub. Emr. Sci
Dr (Ms) V Raman, Project Adviser
Sh R B Saxena, Project Adviser
Dr Vikram Soni, Research Sci C

Research Fellows/Associates/Interns

Sh Ranjit Kumar, JRF (CSIR)
Sh Rajeev Kumar, JRF (CSIR)
Sh Anveer, JRF (CSIR, NPL)
Ms Khushboo Agarwal, JRF (NPL)
Sh Anoop Kumar S, JRF (UGC)
Sh Veeresh Kumar, JRF (UGC)
Sh Ajay Kumar, JRF (UGC-NPL)
Sh Tilak Joshi, JRF (UGC-NPL)
Ms Charu Sharma, JRF (UGC-NPL)
Sh Shiva Kumar Singh, JRF(CSIR)
Ms Anu Malik, JRF(CSIR)
Sh Anand Pal, JRF(CSIR)
Ms Rakhi Grover, JRF(CSIR)
Sh Amit Kumar, JRF(CSIR)
Ms Omwati, JRF(CSIR)
Sh Manoj Kumar Srivastava, JRF(CSIR)
Sh Saurabh Srivastava, JRF(CSIR)
Sh Ravinder Kumar, JRF(CSIR)
Sh Gaurav Kumar, JRF(CSIR)
Sh Amit Kumar Chauhan, JRF(CSIR)
Sh Sandeep Kumar Pundir, JRF(CSIR)
Sh Mohan Lal, JRF(CSIR)
Sh Suraj Singh Saini, JRF(CSIR)
Sh Surjeet Kumar Mishra, JRF(CSIR)
Ms Aditya Sharma, JRF(CSIR)
Sh Kajal Kumar Dey, JRF(CSIR)
Ms Aneeta Kharkwal, JRF(CSIR)
Sh Sandeep Kumar, JRF(CSIR)
Sh Manish Verma, JRF(CSIR)
Sh Ajay Shankar, JRF(CSIR)
Sh Parveen, JRF(NET)-CSIR
Sh Jagdish kumar, JRF(NET)-CSIR
Sh Ashok Kumar, JRF(NET)-CSIR
Sh Yogendra Kumar Yadav, JRF(NET)-CSIR
Sh Rajeev Sehrawat, JRF(NET)-CSIR
Ms Daisy Verma, JRF(UGC)
Sh G R Krishna Yaddanapudi, JRF(UGC)
Dr R P singhal, P.I.
Dr Pratima R Solanki, P.I.
Dr Ashutosh Tiwari, P.I. Young Scientist
Sh Sunil Dutta Sharma, P.I. Young Scientist
Dr (Mrs) Nupur Bahadur, P.I. Young Scientist
Dr Shilaja Pande, P.I.(WOS-A)
Ms Suman Sharma, RA
Ms Indrani Coondoo, RA
Sh Premshankar K. Dubey, RA
Sh Arindam Datta, RA
Ms Seema Kumari, RA
Sh Sameer S D Mishra, RA
Dr (Ms) Renu Maurya, RA (CSIR)
Sh Dalip Sharma, Res. Intern
Sh Mahesh Chand, Res. Intern
Ms Vasudha Agarwal, Res. Intern

Ms Anubha Sharma, Res. Intern
Ms Gunjan Mittal, Res. Intern
Ms Tanvi Vats, Res. Intern
Ms Monika Mishra, Res. Intern
Sh Neeraj Kumar, Res. Intern
Km Shivani Joshi, Res. Intern
Sh Ramesh Bhatt, Res. Intern
Ms Namita Gandhi, Res. Intern
Ms Maneesha Gupta, Res. Intern
Ms Neha Gupta, Res. Intern
Ms Anuushka Pal, Res. Intern
Sh Dharam Pal Singh, RGN-SRF
Dr Manoj Kumar Srivastava, Sr. Res. Assoc.
Sh Sameer Suwan Dutt Mishra, Sr. Res. Assoc.
Dr (Ms) Punita Singh, Sr. Res. Assoc.
Ms Jhuma Gope, SRF (CSIR)
Ms. Gaytri Chauhan, SRF (CSIR)
Ms. Taranuum Bano, SRF (CSIR)
Mrs. K Jayanti, SRF (CSIR)
Sh Monojit Chakraborty, SRF (CSIR)
Sh Vinod Kumar Chahar, SRF (CSIRL)
Sh Firoz Khan, SRF (CSIR-UGC)
Sh Dinesh Kumar, SRF (CSIR-UGC)
Ms Sweta Bhandari, SRF (CSIR-UGC)
Ms Zimple Matharu, SRF (CSIR-UGC)
Ms Chetna Dhand, SRF (CSIR-UGC)
Sh Praveen Kumar, SRF (CSIR-UGC)
Sh Ravi Kant Prashad, SRF (CSIR-UGC)
Ms Arpita Vajpayee, SRF (CSIR-UGC)
Sh Vivek Kumar Varma, SRF (CSIR-UGC)
Ms Hema Bhandari, SRF (CSIR-UGC)
Sh Umesh kumar, SRF (CSIR-UGC)
Sh Vikram Sen, SRF (Extnd), NPL
Sh Deepak Kumar Jangir, SRF (ICMR)
Sh Amit Choudhary, SRF (NET)-CSIR
Sh Anil Ohlan, SRF (NET)-CSIR
Sh Vibhav Pandey, SRF (NET)-CSIR
Ms Monika, SRF (NET)-CSIR
Sh Ayushman Prashar, SRF (NRE)
Ms Prachi Joshi, SRF(CSIR)
Ms Manisha Bajpai, SRF(CSIR)
Sh Anuj Kumar, SRF(CSIR)
Sh Hemant Kumar, SRF(CSIR)
Sh Arunandan Kumar, SRF(CSIR)
Sh Mohd Taukheer Khan, SRF(CSIR)
Sh Kuldeep Singh, SRF(CSIR)
Sh Nandan Singh, SRF(CSIR)
Ms Swati Raman, SRF(CSIR)
Sh Rajesh Kumar, SRF(CSIR)
Sh Amitava Bandhyopadhyay, SRF(CSIR)
Sh Ajeet Kumar Kaushik, SRF(CSIR)
Ms Shalini Singh, SRF(CSIR)
Sh Atif Khan, SRF(CSIR)
Mr. Johny C.J., SRF(CSIR)
Ms Jyoti Shah, SRF(CSIR)
Sh Ashok Kr. Sharma, SRF(CSIR)
Ms Moumita Das, SRF(CSIR)
Sh Vivek Panwar, SRF(CSIR)
Sh Abhay D Deshmukh, SRF(EXTD.)
Sh Bhaskar Gahtori, SRF(EXTD.)
Ms Kavita Sharma, SRF(Extnd.)/CSIR
Ms Nirmal Prabhakar, SRF(Extnd.)/CSIR
Sh Bhaskar Kanseri, SRF(NET)-CSIR
Ms Parul Singh, SRF(NPL)
Sh Trailokya Saud, SRF(NPL)
Ms Monu Dahiya, SRF(NPL)
Sh Purushottam Bhawre, SRF(NPL)
Sh Rahul Tripathi, SRF-UGC

APPENDIX - 17

RESEARCH AND MANAGEMENT COUNCILS
Research Council
(01.04.2009-31.03.2010)

01 Prof Ajay Kumar Sood, ...Chairman
Chairman
Division of Physical and Mathematical Sciences,
Department of Physics,
Indian Institute of Science,
BANGALORE - 560 012

02 Prof S S Jha..... ....Member
Distinguished Professor (External)
Department of Physics
Indian Institute of Technology
Powai
MUMBAI – 400 076

03 Dr V C Sahni... ....Member
Director
Raja Ramanna Centre for Advanced Technology
Department of Atomic Energy
Govt. of India
INDORE – 452 013
And
Director
Physics Group
Bhabha Atomic Research Centre (BARC)
MUMBAI – 400 085

04 Prof G K Mehta ....Member
Distinguished Honorary Professor IIT-K
Inter University Accelerator Centre,
Aruna Asaf Ali Marg,
NEW DELHI - 110 067

05 Prof B M Arora ....Member
Professor
Tata Institute of Fundamental Research (TIFR)
Homi Bhabha Road, Colaba
MUMBAI - 400 005

06 Dr U C Mohanty ..... Member
Professor
Centre for Atmospheric Sciences
Indian Institute of Technology
Hauz Khas
NEW DELHI – 110 016

07 Dr M J Zarabi.. ..... Member
C – 28, Pamposh Enclave
NEW DELHI - 110 048

08 Dr B Hari Gopal ..... Member
Director (Agency Representative)
National Accrediation Board for Testing
Calibration Laboratories
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14, Satsang Vihar Marg
New Mehrauli Road
New Delhi – 110 067

09 Dr S K Bhadra. ..... Member
Scientist (DG's Nominee)
Central Glass and Ceramic Research Institute (CGCRI)
196, Raja S C Mullick Road
Kolkata – 700 032

10 Dr Chandrashekhar .. .. Member
Director (Sister Laboratory)
Central Electronics Engineering Research Institute (CEERI)
Pilani – 333 031

11 Head. ..... Member
Projects Performance Division (PPD), (Permanent Invitee)
Council of Scientific & Industrial Research,
Anusandhan Bhawan,
2 Rafi Marg,
NEW DELHI - 110 001

12 Prof R C Budhani.... ..... Member
Director
National Physical Laboratory
Dr K S Krishnan Marg
NEW DELHI - 110 012

13 Sh T Raghavendra... ..... .Non-Member
Head, Planning Monitoring & Evaluation Group Secretary
National Physical Laboratory
Dr K S Krishnan Marg
NEW DELHI - 110 012

Management Council

01.	Prof. R.C. Budhani, Director	…	…	…	Chairman
02.	Dr. S. Gangopadhyay, Director, CRRI	…	…	…	Member
03.	Dr. M. Senthil Kumar, Gr V(2)	…	…	…	Member
04.	Dr. (Ms) Nita Dilawar, Gr IV(3)	…	…	…	Member
05.	Dr. Ajay Dhar, Gr IV(5) …	…	…	…	Member
06.	Dr. A. Sen Gupta, Gr IV(6)	…	…	…	Member
07.	Sh. Ravi Khanna, Gr.III(7)	…	…	…	Member
08.	Sh. T. Raghavendra, Head, PME	…	…	…	Member
09.	Sh. S.K. Mehta, CFA	…	…	…	Member
10.	Sh. T.V. Joshua, COA	…	…	…	Member Secretary