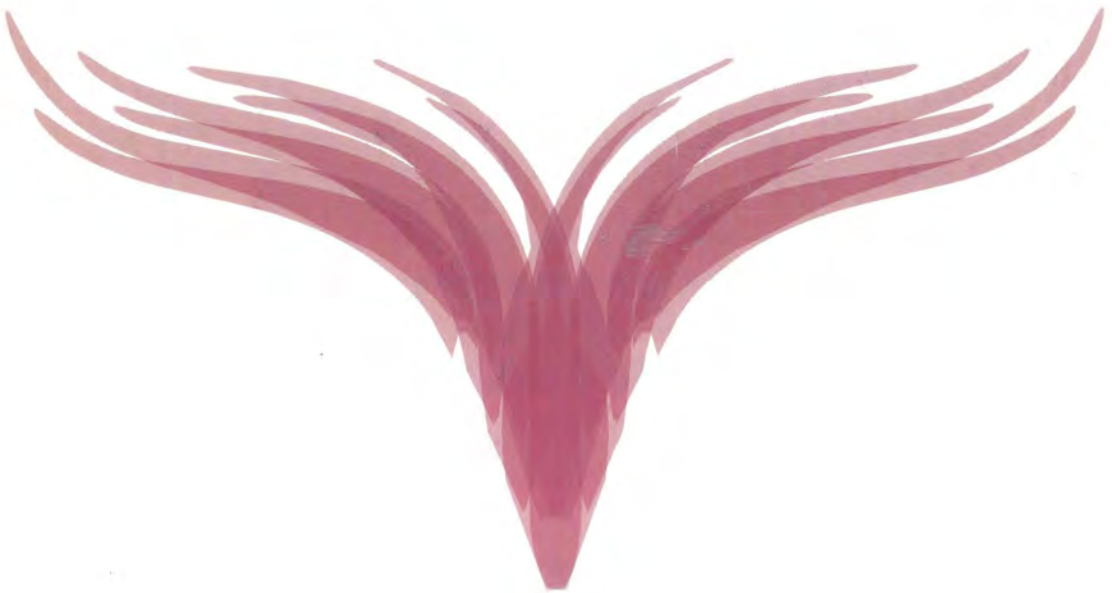
वार्षिक प्रतिवेदन
annual report
2001-2002



राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली
NATIONAL PHYSICAL LABORATORY, NEW DELHI

वार्षिक प्रतिवेदन

Annual Report
2001-2002

राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली – 110 012

National Physical Laboratory

Dr. K.S. Krishnan Marg, New Delhi - 110 012

प्राक्कथन

प्रयोगशाला की वर्ष 2001–02 की वार्षिक रिपोर्ट प्रस्तुत करते हुए मुझे आपार हर्ष का अनुभव हो रहा है।

इसमें प्रस्तुत की गई गति विधियाँ मेरे कार्यभार ग्रहण करने से पहले की है जब प्रयोगशाला के निदेशक डा. कृष्ण लाल थे। मैने इस प्रयोगशाला में 2 जून 2003 को निदेशक के रूप में कार्यभार ग्रहण किया।

मापन के राष्ट्रीय मानकों को बनाये रखना इस प्रयोगशाला का मुख्य उत्तरदायित्व है। यह अर्थ तथा सुरक्षा क्षेत्र से सम्बन्धित सभी प्रकार के संस्थानों को शीर्ष स्तर की अंशशोधन सेवाएं प्रदान करती है। राष्ट्रीय मानकों की स्थापना (या प्रतिष्ठा), विकास और रख–रखाव के लिए अनुसंधान एवम् विकास कार्यो के साथ–साथ प्रयोगशाला अन्तर्राष्ट्रीय समकक्षता बनाये रखने के लिए अन्तर्राष्ट्रीय माप एवम् तोल ब्यूरो (बी.आई.पी.एम.) तथा एशिया पैसिफिक मापिकी कार्यक्रम (ए.पी.एम.पी.) द्वारा आयोजित मुख्य अन्तर्राष्ट्रीय अन्तर्तुलनात्मक कार्यक्रमों तथा अन्य द्विपक्षीय अन्तर्तुलनाओं में प्रतिभागिता करती है।

यह प्रयोगशाला मानकों, इंजीनियरी पदार्थ, इलेक्ट्रॉनिकी पदार्थ, पदार्थ अभिलक्षणन, रोडियो तथा वायुमण्डलीय विज्ञान, अतिचालकता तथा निम्नतापिकी के क्षेत्रों में उन्नत अनुसंधान एवम् विकास परियोजनाओं का संचालन भी करती है। आन्तरिक परियोजनाओं के साथ–साथ प्रयोगशाला प्रायोजित परियोजनाओं, परामर्श समनुदेशन कार्यो तथा अनुबन्धित शोध कार्यों पर भी कार्य करती है।

वर्ष 2001–2002 में अनुसंधान एवम् विकास गतिविधियां सात प्रभागों (निर्णायक इकाईयों) में आयोजित की गई। ये है:–

(1) भौतिक यान्त्रिक मानक (2) विद्युत तथा इलेक्ट्रानिक मानक (3) इंजिनियरी पदार्थ (4) इलेक्ट्रानिकी पदार्थ (5) पदार्थ अभिलक्षणन (6) रेडियो तथा वायुमण्डलीय विज्ञान (7) अतिचालकता एवम् निम्नतापिकी।

वर्ष के दौरान प्रयोगशाला ने डीसी वोल्टेज अनुपात (सी.सी.ई.एम–8, जिसमें 14 देशों ने भाग लिया) तथा ए सी वोल्टेज अनुपात (सी सी ई एम–7) जैसी अन्तर्तुलनाओं तथा पराश्रव्यिकी के क्षेत्र में बी.आई.पी.एम. द्वारा आयोजित मुख्य अन्तर्तुलना में भाग लिया। राष्ट्रीय भौतिक प्रयोगशाला उन 31 प्रयोगशालाओं में से एक है जिन्होंने पराश्रव्यिकी की महत्वपूर्ण अंतर्तुलना में सबसे पहले भाग लिया। दो अन्य मुख्य अन्तर्तुलनाएं, जिसमें एन. पी. एल. ने प्रतिभागिता की थी वे इस प्रकार है: आई एम ई पी–12 (संदर्भ पदार्थ तथा मापन संस्थान, बेल्जियम) तथा ए.पी.एम.पी., क्यू.एम.पी 2 (QMP2) (राष्ट्रीय प्रयोगशाला, आस्ट्रेलिया)। प्रयोगशाला ने उद्योगों, निजी तथा सार्वजनिक क्षेत्रों की परीक्षण प्रयोगशालाओ और सरकारी संस्थानों को अंशशोधन परीक्षण तथा परामर्श समनुदेशन सेवाएं भी प्रदान कीं। इसने उद्योगों तथा प्रगतिशील देशों के प्रतिनिधियों के लिए अंशशोधन तथा मापन की अनिश्चितता विषय में प्रशिक्षण कार्यक्रम आयोजित किए। राष्ट्र की शीर्ष प्रयोगशाला के रूप में– रा॰ भौ॰ प्र॰ ने एन. ए. बी. एल प्रत्यायित प्रयोगशालाओं के लिए, लम्बाई, ताप, संधारिता तथा प्रत्यावर्त्तीधारा प्रतिरोध आदि के क्षेत्र में, छः प्रवीणता परीक्षण कार्यक्रमों का संचालन किया।

प्रयोगशाला द्वारा किये गये कुछ मुख्य विकास इस प्रकार थे:– (1) समस्थितिक रूप से मोल्डिड (Isostatically moulded) उच्च तापीय चालकता ग्रेफाईट का विकास (2) कार्बनिक प्रकाश उत्सर्जक डायोड (3) उन्नत हल्के हेलीकाप्टर के अवतरण (स्किड लैण्डिंग) गीअर के लिए एल्यूमिनियम की सम्मिश्र धातु की अवश्यकता अनुसार मोड़ी गई झुर्रियों से मुक्त (Suitably bent and wrinkle free) अंडाकार नली। (4) पांच नए भारतीय निर्देशक द्रव्य पदार्थों का विकास (5) थैलीसीमीया की फार्मुलेशन के लिए 9 देशों में पेटेंट की प्राप्ति। अति चालकता के क्षेत्र में उच्च T_c अतिचालक Ag clad Bi (Pb) Sr Ca CuO के उच्च चुम्बकीय क्षेत्र में अनुप्रयोगों के लिए लम्बी बहु–फिलामेण्ट पट्टियों, चालक का विकास किया। रेडियों तथा वायुमण्डलीय विज्ञान के क्षेत्रों में प्रयोगशाला ने दिल्ली में कोहरे के होने में प्रदूषकों के महत्व, दिल्ली व

कोलकाता में ग्रीन हाऊस गैसों की मानीटरिंग (गणना) के कार्य किये। वर्ष 2001–02 के दौरान प्रयोगशाला ने निम्नलिखित नई शोध सुविधाओं की स्थापना की:–

(1) ब्रूकर AXS D8 उन्नत पाऊडर X–किरण विवर्तनमापी

(2) एब्साल्यूट (निरपेक्ष) तथा अवक्लन मोड में कार्य करने वाले 5 kpa से 360 kpa के वायु पिस्टन गेज

(3) पी.टी.बी से अनुमार्गणीय खोजी कुण्डलियों (सर्च कौयल) के सापेक्ष खोजी कुण्डलियों की अंशशोधन की सुविधा।

प्रयोगशाला ने कुल 138 शोध पत्रों का प्रकाशन किया जिनमें से 98 विज्ञान साईटेशन इन्डेक्स (एस.सी.आई.) जर्नलों में थे। इसके अतिरिक्त 88 शोध पत्र कान्फ्रेंस प्रोसिडिगों में प्रकाशित हुए तथा 220 पत्र विभिन्न राष्ट्रीय तथा अन्तर्राष्ट्रीय सम्मेलनों में प्रस्तुत किए गये। कुल मिलाकर 15 पेटेंट भारत तथा विदेशों में फाइल किये गए। इस वर्ष 4 पेटेंट प्रदान किये गए जो गत वर्षों में भारत में फाइल किये गये थे। एन. पी. एल. द्वारा विकसित पांच तकनीकें विभिन्न भारतीय कम्पनियों को बेची (हस्तांतरित) गईं। प्रयोगशाला में 17 प्रायोजित परियोजनायें ली गई तथा परामर्श समनुदेशन से 42.312 लाख रु. अर्जित किये गये। अंशशोधन एवं परीक्षण से होने वाली आय 252 लाख रु. तक पहुंची।

एन. पी. एल. के वैज्ञानिकों व इंजीनियरों, प्रशासन वित्त तथा लेखा, भण्डार तथा क्रय अनुभाग और सहयोगी कार्मिकों तथा सेवाओं की प्रमुख उपलब्धियाँ मैं सहर्ष स्वीकार करता हूं।

मैं इस रिपोर्ट को प्रकाशित करने के लिए प्रकाशन समिति तथा प्रकाशन विभाग के योगदान की भी सहर्ष सराहना करता हूं– विशेष रूप से डॉ. एस. एम. धवन, श्री एस. के. चकलादर, डॉ. एम. के. गोयल, डॉ. वी. एन. ओझा, डॉ. (कु.) पी. एल. उपाध्याय, डॉ. टी. डी. सेनगुट्टुवन, डॉ. (श्रीमती) रीना शर्मा, डॉ. (श्रीमती) एस. शर्मा तथा श्री एन. के. वधवा के द्वारा किये गये प्रयासों की मैं सराहना करता हूं।

विक्रम कुमार

(विक्रम कुमार)
निदेशक

FOREWORD

I have great pleasure in presenting the annual report of the laboratory for 2001-02. The activities reported in this document pertain to the period prior to my joining when Dr Krishan Lal was the Director of the laboratory. I have joined the laboratory as Director, NPL on 2nd June 2003.

The laboratory has the prime responsibility of maintaining the national standards of measurements. It provides apex level calibration to users in all sectors of economy and security related organizations. Besides undertaking R&D activities in the establishment, development and maintenance of national standards, the laboratory also participates in international inter-comparisons organized by the BIPM (International Bureau for Weights & Measures) and the Asia Pacific Metrology Programme (APMP) as well as in the bi-lateral inter-comparison programmes for establishing international traceability. The laboratory also conducts advance research and development in standards, engineering materials, electronic materials, materials characterization, radio and atmospheric sciences, and superconductivity and cryogenics. In addition to in-house projects, the laboratory undertakes sponsored projects, consultancy assignments and contract research.

During 2001-02 the R&D activities were organized in seven divisions (Decision Units): (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) Superconductivity and Cryogenics.

During the year, the laboratory participated in key inter-comparisons like the CCEM-K8 (for DC voltage ratios in which 14 countries participated), CCEM K-7 (for AC voltage ratio), and BIPM inter-comparison in the area of Ultra-sonics in which NPL was one of the 9 laboratories to participate in this first ever key-comparison. The two other key comparisons in which NPL participated were: IMEP-12 (Institute for Reference Materials and Measurements, Belgium) and APMP QM-P2 (National Analytical Reference Laboratory, Australia). The laboratory also provided calibration, testing & consultancy services to industries, calibration/testing laboratories in public & private sector and government organizations. It organized training programmes for calibration and uncertainty in measurements for industries as well as for delegates from developing nations. As pilot laboratory in the country, the NPL conducted six Proficiency testing (PT) programmes for NABL accredited laboratories for length, temperature, capacitance and AC resistance etc.

Some of the noteworthy developments of the laboratory were : (i) development of isostatically-moulded high thermal conductivity graphite, (ii) organic light emitting diodes, (iii) suitably bent and wrinkle free oval-shaped Al alloy tubes for use as skid landing gear for advanced light helicopter, (iv) development of 5 new certified reference materials (CRM), and (v) a patent for a Thalassemia formulation granted in 9 countries. In the area of superconductivity, it fabricated long-length multi-filamentary tape-conductors of Ag-clad Bi(Pb)SrCaCuO high Tc superconductor for high magnetic field applications. In radio and atmospheric sciences studies it made a conscious effort in understanding the role of pollutants in fog occurrences in Delhi and in budgeting greenhouse gases in Delhi and Kolkata, and monitoring greenhouse gases in Antarctica during the 21st Antarctic Expedition.

The laboratory set up following new research facilities during 2001-02:

1) Bruker AXS D8 Advance Powder X-ray Diffractometer,
2) An Air-piston Gauge (5 kPa to 360 kPa) working in absolute as well as differential mode,
3) Facility for calibration of search-coils against standard search-coils traceable to PTB.

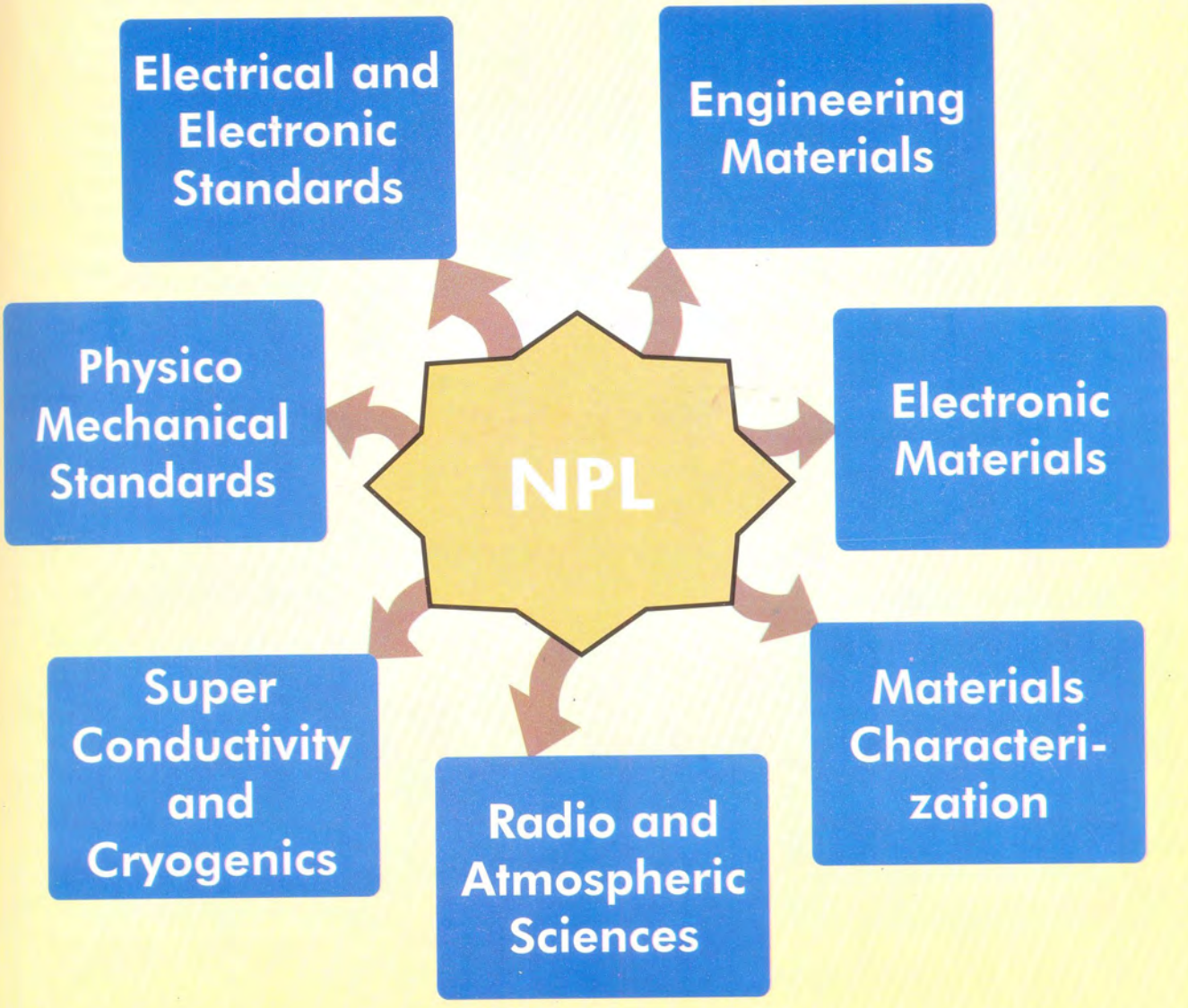
The laboratory published a total of 138 papers, of which 98 were in SCI-indexed journals. Besides, 88 papers were published in conference proceedings, and 220 papers presented at various national and international conferences. A total of 15 patents were filed in India and abroad. Four patents filed abroad during previous years were granted in 2001-02 and four patents were granted in India. It marketed five technologies developed at NPL to different companies in India. The laboratory took up 17 new sponsored projects and generated a sum of Rs 42.312 lakh by providing consultancy and technical services to different agencies. Earnings from calibration and testing reached Rs.252 lakh.

It gives me pleasure to acknowledge the contributions of NPL scientists and engineers, administration, finance and accounts, stores and purchase, supporting staff and infrastructure services for making several notable achievements.

I also acknowledge with great pleasure the contributions of the publication committee and the publication group in bringing out this document. In particular the efforts made by Dr S.M. Dhawan, Sh S.K. Chakladar, Dr M.K. Goel, Dr V.N. Ojha, Dr (Ms) P.L. Upadhyaya, Dr T.D. Senguttuvan, Dr (Mrs) Rina Sharma, Dr (Mrs.) S. Sharma and Sh N.K. Wadhwa are highly appreciated.

(Vikram Kumar)
Director

R & D Groups


Electrical and Electronic Standards
Engineering Materials
Physico Mechanical Standards
NPL
Electronic Materials
Super Conductivity and Cryogenics
Radio and Atmospheric Sciences
Materials Characteri-zation

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PHYSICO MECHANICAL STANDARDS

भौतिक – यांत्रिक मानक

भौतिक यांत्रिक मानक डिवीजन निम्नलिखित वस्तुओं के राष्ट्रीय मानकों की स्थापना, उनके विकास और अनुरक्षण के कार्य में लगा हुई है:– द्रव्यमान (मास) , यात्रा (वाल्यूम), श्यानता (विस्कासिटी), कठोरता (लैंथ), लंबाई चौड़ाई आदि (डायमेन्शन), कोण (एंगल) सतह की कठोरता (सरफेस रफनैस), तापमना, आयनकारी विकिरण – पराबैंगनी (नान आयनाइंजिंग रेडिएशन), दृश्यमान अवरक्त क्षेत्र (विजिबल एंड इन्फ्रारेड रीजन), बल (फोर्स), कठोरता (हार्डनैस) टार्क (), दाब और निर्वात (प्रैशर और वेक्यूम) तरल बहाव (फ्लूड फ्लो), ध्वनि–विज्ञान (एकास्टिक्स) पराश्रबय ध्वनियों संबंधी (अल्ट्रासोनिक) और कंथन (वार्डब्रेशन्स)। मानकों की अनुरूपता का रख–रखाव अन्तर्राष्ट्रीय अन्तर्तुलना विधि विधियों द्वारा किया जाता है और उनके उपकरणों और उन्हें संदर्भ मानकों द्वारा प्रयोग किया जाता है और उनके उपकरणों और उन्हें संदर्भ मानकों द्वारा प्रयोग करने वाले उद्योगों को उपलब्ध कराया जाता है। इस डिवीजन के अन्य कार्यकलाप इस प्रकार हैं : – (1) उद्योगों की तकनीकी परामर्श प्रदान करना ताकि उनके कार्यों में गुणवत्ता की वृद्धि हो सके। (2) अनुसंधान एवं विकास विषयक प्रोजेक्टस पर कार्य करना विशेषकर उद्योगों द्वारा एवं विकास अपेक्षित नई प्रणालियों को अपनाकर उन प्रोजेक्टस पर कार्य करना (3) मौजूदा मानकों में सुधार करना (4) उद्योग और अंशांकन / परीक्षण प्रयोगशालाओं में गुणवत्ता, अंशांकन, मापन के बारे में जागरूकता उत्पन्न करना एवं मापों की अनिश्चिता के बारे में सजग करना (5) मानव संसाधनों का विकास करना। यह डिवीजन राष्ट्रीय परीक्षण अंशांकन प्रयोगशालाओं के विश्वास प्राप्त बोर्ड के घनिष्ठ सहयोग से कार्य कर रही है। और इसमें निम्नलिखित योग्य व्यक्ति अपना योगदान प्रदान करते हैं – (क) भलीभाँति प्रशिक्षित एवं अत्यंत अनुभवी मूल्यांकक (ख) मापों का अंशांकन करने, उनकी अनिश्चितता का प्राक्कलन करने तथा अंशांकन प्रयोगशालाओं की स्थापना करने में लगी हुई अंशांकन / परीक्षण प्रयोगशालाओं के स्टॉफ को प्रशिक्षित करने के लिए नियुक्त गुणी व्यक्ति (ग) एन ए बी एल विश्वास प्राप्त अंशांकन प्रयोगशालाओं के बीच में आयोजित प्रबीणता परीक्षण कार्यक्रमों के लिए उपलब्ध कराई गई उपकरणों की सुविधा एवं विशिष्ट ।

वर्ष के दौरान इस डिवीजन में संस्थाओं, अंशांकन / परीक्षण प्रयोगशालाओं, सरकारी और निजी क्षेत्रों, सरकारी और अन्य संगठनों के विभिन्न क्षेत्रों में अनुसंधान और विकास के कई कार्यकलाप किए ओर उद्योगों को अंशांकन परीक्षण संबंधी परामर्शी सेवाएं प्रदान कीं। एक भारत अमरीकी सहयोग प्रोजेक्ट, एक सहायता अनुदान प्रोजेक्ट तथा दो परामर्शी प्रोजेक्ट पर वर्ष के दौरान कार्य पूरा किया गया और छः पेटेन्ट भारत और विदेश में प्रस्तुत (फाइल) किए गए। इस डिवीजन ने भारत ओर विदेश में विभिन्न जनरलों में 29 लेख प्रकाशित किए। कान्फ्रेंसों में कार्यवाही में 27 लेख प्रकाशित किए गए और विभिन्न कान्फ्रेंसों में 34 प्रस्तुतियां (प्रजेन्टेशन्स) दीं । तकनीकी जानकारियों का अंतरण (नो–हाओ) किया गया इसमें निम्नलिखित शामिल हैं – (1) एन पी एल के पेटेन्ट किए गए डिजाइन के अनुसार तापमान (2) मोनोस्टैटिक डॉप्लर विधि में कार्य कर रहे मूल सोडार (3) पीजोइलैक्ट्रिक एक्सीलरोमीटर (4) दाब मानकों के अंशांकन के लिए सॉफ्टवेयर।

अन्तर्राष्ट्रीय माप एवं तोल ब्यूरो (बी आई पी एम) के कार्यकलाप के परस्पर मान्यता देने संबंधी व्यवस्था के एक भाग के रूप में विभिन्न मानदंडों (पैरामीटरों) की अंशांकन और मापन क्षमताओं के दावे बीआईपीएम के पास प्रस्तुत किए गए हैं। दाव और निर्वात मानक और प्रकाशीय विकिरण मानक (दृश्य मानरेंज) के सी एम सी दावों को बाई आई पी एम के परिशिष्ट ग में शामिल किया गया है। अल्ट्रासॉनिक मानक और विमीय मापिकी गुणों ने क्रमशः बी आई पी एम और एशिया प्रशान्त मापिकी कार्यक्रम (ए पी एम पी) द्वारा आयोजित अन्तर्तुनता संगोष्ठियों में भाग लिया। छः प्रवीणता प्रतिरोध के क्षेत्रों में पूरे कर लिए गए थे। इसके अतिरिक्त एन पी एल वैज्ञानिकों ने अंशांकन प्रयोगशालाओं के मूल्यांकन (असैसमेंट) में और मापों में अनिश्चितता के संबंध में प्रशिक्षण कार्यक्रम एन पी एल में आयोजित किए गए। इसमें ये कार्यक्रम भारतीय उद्योगों और विकासशील देशों से आए प्रतिनिधियों के लिए मापों के अंशांकन और अनिश्चिता पर विचार करने के लिए किए गए। भारत से लगभग 60 व्यक्ति और मित्र तथा सऊदी अरब के मानक संस्थाओं से एक–एक व्यक्ति की प्रशिक्षण दिया गया

PHYSICO – MECHANICAL STANDARDS

The Physico-Mechanical Standards Division is engaged in the establishment, development and maintenance of national standards of Mass, volume, density, viscosity; Length, dimension, angle, surface roughness; Temperature; Non ionizing radiation- ultraviolet, visible and infrared region; Force, hardness, torque; Pressure and vacuum; Fluid flow, Acoustics; Ultrasonic; and Vibrations. The compatibility of standards is maintained through international intercomparison methods and disseminated to the user industries by way of calibrating their instruments and reference standards. Other activities include (i) providing technical consultancy to industries for enhancing their quality, (ii) undertaking research and developmental projects, in particular establishing new systems as required by industry, (iii) improving upon the existing standards, (iv) generating awareness about quality, calibration, measurement and uncertainty of measurements amongst the industry and calibration/ testing laboratories, and (v) developing human resource. The division maintains a very close cooperation with National Accreditation Board for Testing & Calibration Laboratories (NABL) for providing (a) trained and experienced assessors, (b) faculty to train the staff of calibration/ testing laboratories in calibration, estimation of uncertainty of measurements and establish calibration laboratory, and (c) instruments facility and expertise for the proficiency testing programme carried amongst the NABL accredited calibration laboratories.

During the year this division carried out R&D activities in various areas, provided calibration, testing and consultancy services to industries, institutions, calibration/ testing laboratories, public & private sector, government and other organizations. One Indo-US collaborative project, one Grant-in-Aid project and two consultancy projects were completed during the year and six patents were filed in India and abroad. It published 29 papers in journals, 27 papers in conference proceedings and made 34 presentations at various conferences in India and abroad. Know-hows transferred include (i) Temperature calibration bath as per NPL patented design, (ii) Basic SODAR operating in monostatic /doppler mode, (iii) Piezoelectric accelerometers, and (iv) Software for calibration of pressure standards.

As a part of Mutual Recognition Arrangement (MRA) of International Bureau of Weights and Measure (BIPM) activities, Calibration & Measurement Capabilities (CMC) claims of various parameters have been submitted to BIPM. CMC claims for Pressure and Vacuum standards, Mass and Optical Radiation standards (visible range) have been included in Appendix C of BIPM. Ultrasonic standard and Dimensional Metrology groups participated in intercomparisons organized by BIPM and Asia Pacific Metrology Programme (APMP) respectively. Six Proficiency Testing (PT) programmes were completed in areas of Mass, Temperature, Length, Capacitance and AC Resistance. Besides, NPL scientists helped NABL in assessment of calibration laboratories and for organizing training programmes on uncertainty in measurements. Training programmes were organized at NPL for calibration and uncertainty of measurements for Indian industries and delegates from developing nations. About sixty persons from India and one person each from standards institutes of Egypt and Saudi Arabia were trained.

Acoustics Standards

During the year testing and calibration services were provided to industries and other organisations. Consultancy services were provided on inversion monitoring and acoustic treatment of halls to various organizations. A knowhow of Basic Sodar Operating in Monostatic/ Doppler Mode was transferred to M/s Global Environmental Technologies, New Delhi. A sponsored project on *Development of a Phased Array Acoustic Wind Profiling Radar* was completed successfully. The R& D activities during the year include the following:

Improving the Diffusion Characteristics of Built up Areas

Various techniques were applied in acoustic designs of halls provided by NPL to promote diffusion by designing irregularities in walls and ceilings. These include use of convex and prismoidal surfaces, design of diffusors with a baselength to bulge ratio of 4 and the Quadratic Residue Diffuser (QRD) of Schroeder. The results show that the sound distribution at low frequencies (250 Hz) was within ± 2 dB in these halls.

Study of Sound Transmission Loss (STL) Characteristics of Complicated Structures

A number of wall panels were evaluated with gypsum board of different furrying types on one/both sides. The furring system for attaching gypsum board to wood wool panels has to be carefully selected to improve STL at low frequencies. While no comprehensive theory exists to predict sound transmission through these complicated structures, a simplified model has been suggested to obtain the STL values for these structures.

Development of a Phased Array Acoustic Wind Profiling Radar

A Phased Array Acoustic Wind Profiling Radar capable of measuring boundary layer atmospheric winds has been developed at a total cost of about 29.3 Lacs. This project was funded by DST's MONTCLIM & ICRP program. The profiling radar operates at a frequency of 2150 Hz and has been used to measure atmospheric winds in the height range of 70 m – 600 m with a height resolution of 35 m and structure constant of atmospheric temperature in the range of 70 m – 800 m with the same resolution.

The acoustic beam of the radar is electronically steered to look in three spatial directions i.e. towards zenith and 19^0 steered from zenith in two near orthogonal directions by using a complex switching matrix that uses 104 miniature electromechanical relays. The profiling radar has been developed around a powerful directional phased array acoustic antenna designed by using 104 piezo-electric transducers, capable of radiating acoustic intensities of the order of 1600 wm $^{-2}$ in a narrow beam of 10^0. The antenna is shown in Fig 1.1 in a flat octagonal structure of physical

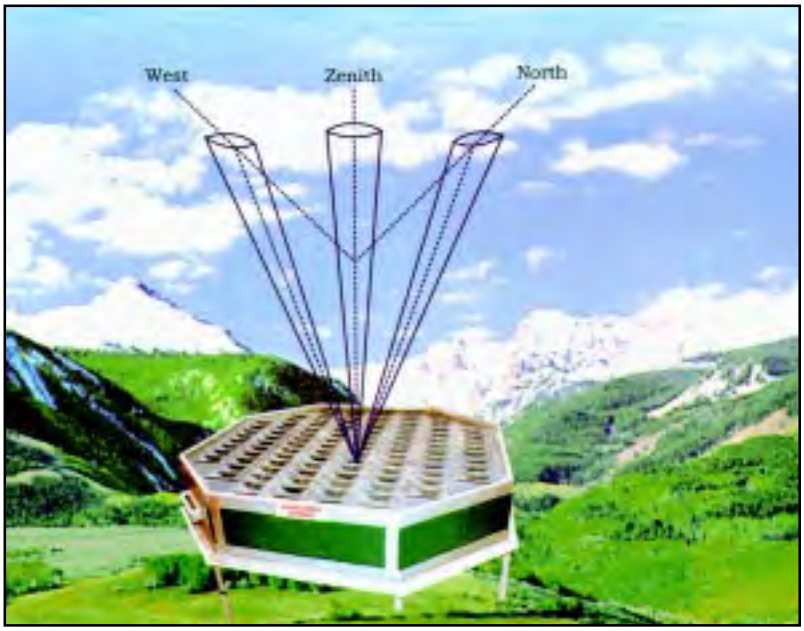

Fig. 1.1 : The antenna steers the sound beam in three orthogonal directions i.e. zenith,tilted from zenith by 19^0 towards antenna north as well as antenna west

aperture of the order of 1.7 m^2

Fig 1.2 gives a schematic diagram of the phased array acoustic wind profiling radar. Different elements of the antenna are excited at controlled phase relationship by an 8- Channel transmitter to generate three narrow beams to illuminate the vertical, north and west modes. The radiated signals interact with the atmospheric inhomogeneities of the temperature present in abundance in the atmospheric boundary layer and are scattered in different directions. Scattered signals are captured by the phased array antenna and converted to low level electrical signals. These signals are processed by a multi-channel low noise front end system, suitably delayed and combined in such a way that the antenna is directed to look in the same direction in which it had transmitted the pulses. The received signal after stringent analog processing are fed to a computer for digital processing in the frequency domain using a 1024 port FFT algorithm. All the control signals required for the antenna switching matrix, signal switching matrix and other sub-assemblies are generated by the computer. Fig1.3 gives a view of the shielded antenna that is located on the NPL main building roof top and the hut where the system is installed.

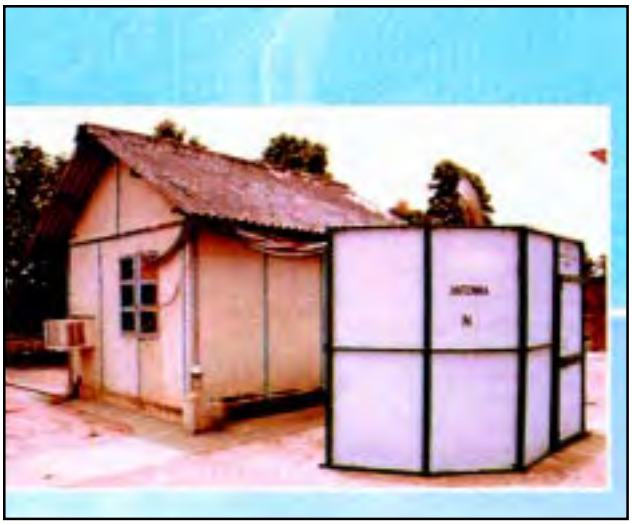

Fig. 1.3 : Acoustically shielded Phased Array Antenna (right) coupled via the transmitter, receiver and control cables to the main Radar system in the control room (left)

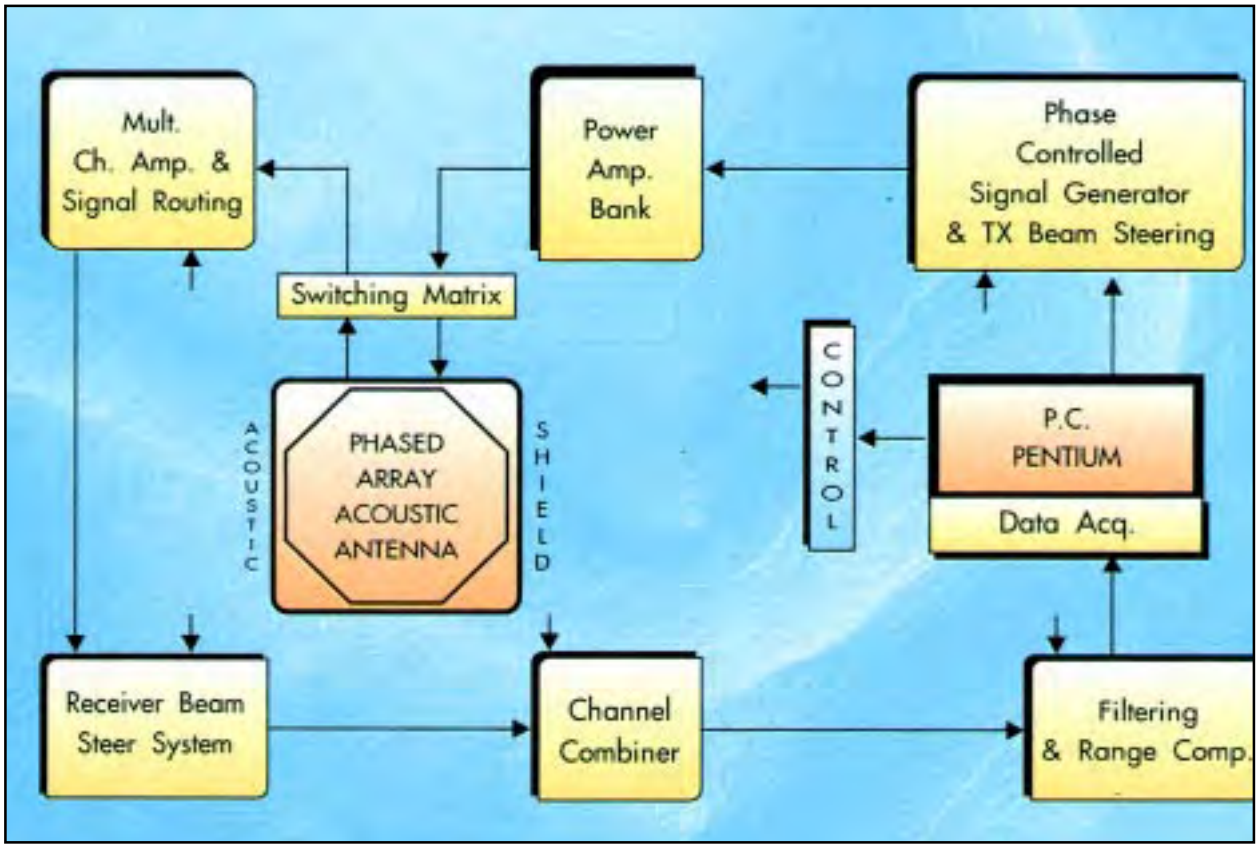

Fig. 1.2 : A simplified block schematic of the wind profiling radar

Shock & Vibration Sensors

Piezoelectric Accelerometers

The technological process know-how for commercial production of piezoelectric accelerometer type PL-810 has been transferred to Dynaspede Integrated Systems (P) Ltd., Hosur. The firm has successfully started the production of accelerometer. The developmental efforts of the laboratory have resulted in the indigenous production of a critical component in the field of vibration measurements and control. The ongoing developmental program of the laboratory towards a continuous upgradation of the technology has further led to the development of tow new modules of piezoelectric accelerometers, PL-810 and PL-900 (Fig. 1.4). The characteristic specifications of these accelerometers are given in the Table-1.1.

Fig. 1.4 : Piezoelectric accelerometers PL-811 & PL-900

MODEL No.	PL- 810	PL- 811	PL-900
Weight	40 gm	19.35 gm	24.5 gm
Sensitivity	22 mV/g	10 mV/g	15 mV/g
Resonance	39 kHz	-	>30 kHz
Freq. Range	10 Hz–15 kHz	20 Hz-20 kHz	10 Hz–10 kHz
Linearity	0.1%	0.1%	0.47%
Max. Shock	3000 g	-	3000 g
Dimensions	19 Hex X 23H	14 Hex X 20H	19Hex X 21H
Case Material	SS 316	SS 316	SS 316

Table – 1.1 : Piezoelectric Accelerometers Developed at NPL

In the miniaturized low weight version PL-811, the weight of accelerometer has been reduced to 50 (w.r.t. PL-810, developed last year) by cutting down the overall dimensions of such as monitoring of vibration on light weight structures like, satellites, aircrafts, etc. The other module, PL-900 has been development with intrinsic features. Designed on bi-lateral shear mode operation, this module is most suitable for many defence applications. It features a very low transverse sensitivity. The incorporation of temperature compensators in its design allows it to exhibit an extremely low sensitivity to temperature transients. Technological process know-hows for both the new generation accelerometers are available for transfer to industry.

Ultrasonic Standards

During the year ultrasonic standards participated in Bureau Internationale Des Poids et Measures (BIPM) key comparison, carried out for the first time in the area of Ultrasonics. NPL was identified as one of the 9 laboratories to participate in this first ever round robin comparison. Two methods fully designed and developed at NPL for total power output measurement were used. Radiation conductance of the artifact was evaluated as per the conditions laid down in the technical protocol. Complete report with final values and uncertainty budget for both the methods were sent well in time to PTB, the pilot laboratory for CCAUV-U.K1(Consultative Committee for Acoustics, Ultrasonics and Vibrations).

The R&D was carried out for the development of new techniques for measurement of various parameters

of ultrasonic medical and nondestructive testing equipment, special transducers and devices and new methods of ultrasonic NDT. The R&D work is described below briefly.

For the design of anechoic water tank, suitable traps were devised using the material characterised earlier for this purpose. The prism shaped traps were fabricated on the basis of theory developed. Absence of any echo even at 99 dB gain experimentally verified the design.

An ultrasonic method was developed to measure parallelism between opposite faces of an opaque plate. The method has the sensitivity of 1' of an arc and is cost effective, simple to perform and requires only one surface to be accessible. It has the potential of updating to automatic on-line measurements.

A new signal processing parameter, count rate, was experimentally studied as a function of liquid level for various pipes and at different frequencies. This parameter, defined as number of positive half cycles crossing the threshold level in the preselected time window, was found to be more sensitive than other parameters studied so far for the design of ultrasonic liquid level sensor.

Length Standards

Calibration and testing services were provided to clients from industries and other organizations. Work was carried on development of frequency stabilized diode lasers in near infrared region as a part of a BRNS sponsored project. A new activity on development of frequency stabilization of diode lasers in the visible region was planned during the year. Studies were carried out for development of electro-optic displacement sensors using gratings. Special optical components were fabricated for a DRDO sponsored project being carried out by Polymeric and Soft materials Section.

Analysis of various parameters affecting the uncertainty in measurement for calibration of Metre Bars using transverse comparator was made as per ISO guidelines.

Dimensional Metrology

Calibration and testing services to industries, laboratories and other organizations were provided. Consultancy for setting up the calibration laboratory in Dimensional measurements as per NABL guidelines and developing trained staff was provided to the industry.

Under APLAC MRA it is mandatory for Accredited Calibration Laboratory to participate in proficiency testing (PT). The responsibilty of conducting Inter-Laboratory Proficiency Testing amongst the NABL Accredited Calibration Laboratories has been assigned to Dimensional Metrology. Under this project, PT in the area of length (Gauage Block), Temperature (liquid in glass thermometers), Capacitance 100 µF and AC Resistance 1,10,100 KΩ, were conducted. Substitution method for calibrating step gauges using CMM was tried and the uncertainty of measurement was estimated as per ISO guidelines and found to be improved by almost 30%. Sieve Parameter measurements were successfully carried out using optical method based on CCD and wavelet transforms. A patent is in the process of being filed in India for this measurement process.

Pressure and Vacuum Standards

Under modernisation of Barometric Pressure Standards, an Air Piston Gauge (Range: 5 kPa to 360 kPa) working in absolute as well as differential mode has successfully been installed. Hydraulic primary pressure, 1.0 GPa has been successfully installed and commissioned.

Asia Pacific Metrology Programme (APMP) comparison [APMP.M.P-K1c and APMP.M.P-K6] CCM data base were successfully piloted and completed. The report for Key Comparison CCM.P-K3 (10^{-3} – 10^{-6} Pa) comparison was prepared and communicated to the pilot Lab. (NIST, USA).

- Characterization of differential pressure transducer upto 35 bar differential pressure, against twin pressure balance at line pressures of 5, 20, 35, 50 and 70 bar.

- Completion of the development of software in Visual Basic 6.0 for automated data acquisition, calculation of differential pressures and the associated uncertainty of measurement. Another software was developed for Evaluation of Measurement Uncertainty and Calibration Report Generation.

A study was carried out to make a comparison of the different approaches to estimate the uncertainty in measurement i.e as per NABL, ISO guidelines and traditional one through a case study carried out on an industrial dual range simple type dead weight tester.

An extensive in-house intercomparison exercise was carried out on NPL140MPA by cross-floating it against three other national hydraulic pressure standards, designated as NPL200MPA, NPL100MPN and NPL100MPA. The traceability, compatibility and stability of the metrological characteristics thus obtained are established by comparing the values with the values obtained during international key comparisons sponsored by BIPM during 1990, in-house comparison carried out during 1997 and data provided by the manufacturer during 1987. The metrological characteristics show excellent agreement within $\pm$14 x 10^{-6} over a 13 years period. The results thus obtained on the metrological characteristics of NPL140MPA i.e. zero pressure effective area (A_0), distortion coefficient (b) and measurement uncertainty associated with pressure measurement in this in-house intercomparison exercise have been published.

A study was undertaken to understand how laboratory temperature affects the sensitivity of hot cathode injection gauge. The sensitivities of several hot-cathode ionization gauges were measured for ambient laboratory temperatures between 23 and 31 degrees Celsius, the results are presented (Figs. 1.5 & 1.6)

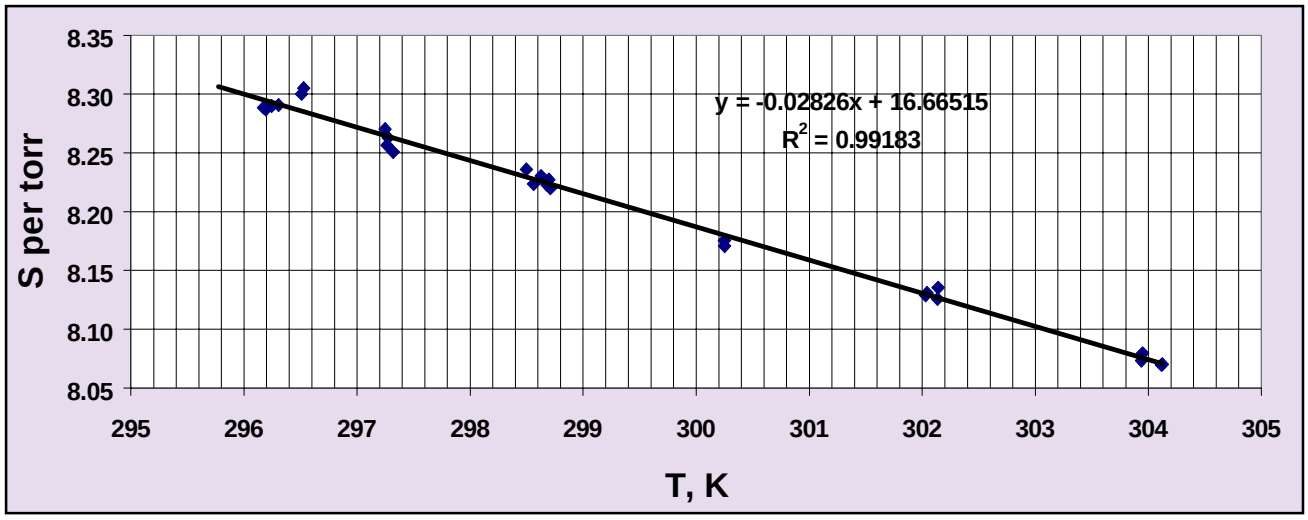

Fig.1.5 : Sensitivity vs temp. of the extractor gauge at 8e-4 Pa hot-cathode transfer standards.

It was found that all of the ionization gauges exhibited very similar behavior, and that the sensitivity dependence on temperature could be adequately modeled with a linear fit over the investigated temperature range. This study will help in applying corrections to the results of individual labs when the intercomparison is carried out and the laboratory temperature of participants labs are different.

SIMS Characterization of GaAs MIS Devices at the Interface

SIMS characterization of GaAs MIS devices at the interface was carried out to study NH_3 plasma pretreatment of GaAs surface prior to in situ deposition of N-rich Si_xN_y by PECVD. The Si_xN_y/GaAs structures were characterized by SIMS for the top layer

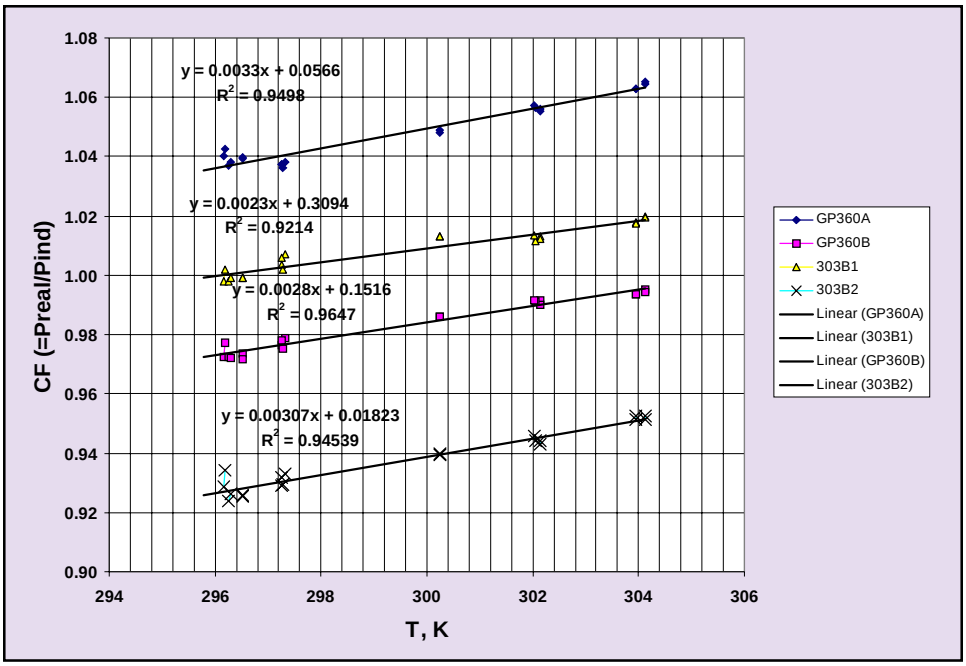

Fig. 1.6 : Calibration factor vs. chamber temp. @8.7e Pa for B-A gauges

A comparison of these As-O and Ga-O layers between samples S2 and S3, shown in Fig. 1.7 reveals that on annealing the sample, the interface layers diffuse towards the substrate, and both the oxide layers broaden. Also the increase in concentration gradient of SiN towards the interface was enhanced further by annealing. This was attributed to difference of atomic density in Si_3N_4 (10.29×10^{22} /cm^3) and GaAs (4.42×10^{22}/cm^3) and high diffusion co-efficient of oxygen into GaAs. Due to annealing inter-diffusion of the interface material takes place and the impurities / defects shift towards the substrate (i.e. GaAs) causing the broadening of the oxide layers.

composition and presence of surface impurities in the survey scan mode. It was further probed by SIMS at the interface in depth profile mode to detect oxide layers after different treatments applied to the samples. The survey scan on all the samples viz. S1-without pretreatment, S2-with pretreatment & S3- with pretreatment and annealing, indicated formation of well defined Si_3N_4 film.

Depth profiles of the samples S1, S2 and S3 upto a depth of about 300 nm, i.e. inside the GaAs substrate showed that for un-passivated and un-annealed sample S1, the native oxides penetrate into both sides of the interface, i.e. the film as well as the substrate. Similarly, elemental As, which is considered to be the primary cause of Fermi level pinning was also seen to diffuse into the film and as a result the concentration of SiN is seen to decrease as the film substrate is approached whereas for samples S2 and S3 passivated with NH_3, sharper interface and reduction in layers of As, As-O and Ga-O and the elemental As are observed. The nitridation increase led to increased concentration of SiN towards the interface unlike sample S1.

The observed improvement of C-V modulation and reduction in the interface state density was explained in terms of depth profile results by SIMS. The native arsenic oxide present on the surface of GaAs is significantly reduced by NH_3 plasma pretreatment, which in turn leads to unpinning of the GaAs surface.

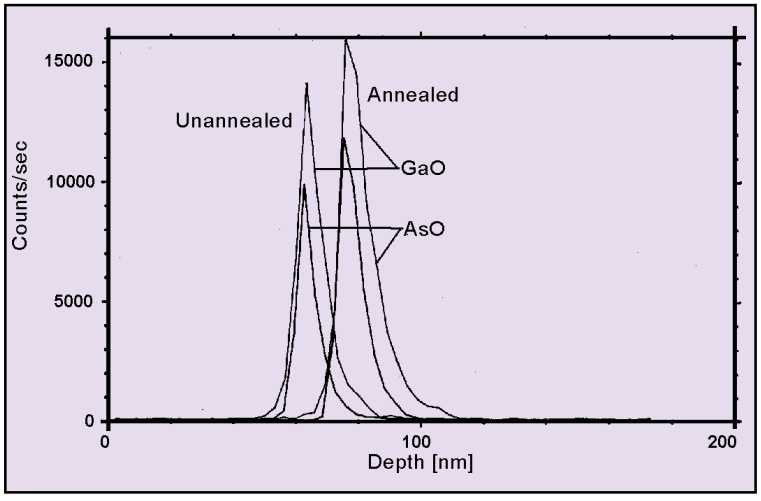

Fig. 1.7 : A comparison of As-O & Ga-O layers of samples S2 & S3

The lowest interface state density of $1.1x10^{11}$ eV^{-1} cm^{-2} was obtained from the G-V curve for sample S3. This again was suggested to be due to the fact that the defect centers may be annealed out and the film becomes N-rich giving lowest interface state density.

Observation of Novel Superstructures at Low Sb Coverages on Si(111)-7x7 Surface:

Adsorption of Sb onto Si(111)surface was studied using in-situ auger electron spectroscopy and low energy electron diffraction (LEED).Sb has been adsorbed at pre-determined flux rates from a Knudsen cell onto clean Si(111)-7x7 reconstructed surface held at various temperatures at a base pressure of $5x10^{-11}$ Torr. The interplay between the deposition rates, substrate and annealing temperatures manifests as several superstructural phases such as (√3x√3-R 30)_ at 1.0 monolayer (ML) and at 0.33 ML, (2x2) phase at about 0.8 ML, (5√3x5√3-R 30) at 0.5 –0.7 ML, etc. Two new LEED superstructures, namely, the (5x5)surface phase at a coverage of 0.4 ML, and (5√3x5√3-R 30) surface phase at a coverage of 0.2 ML were observed. The Sb/Si(111)phase diagram reported in literature was redefined (Fig.1.8).The variations observed indicate novel arrangements of Sb atoms on the Si(111)surface at low Sb coverages and high substrate temperatures, making the system useful in the formation of delta-doped structures.

XPS Study of Surface-modified CuO Layer in Size-stabilized Single-phase Cu_2O Nanoparticles.

Phase stabilization of nanoparticles was probed by the surface sensitive proble of X—ray Photoelectron Spectroscopy on copper oxide nanoparticles in the size range of 8–100 nm, grown using activated reactive evaporation. These studies showed an increase in the ionicity of the Cu_2O system with decreasing particle size. X-ray diffraction spectra clearly showed the presence of a single Cu_2O phase. Depth profiling and finger printing by X-ray photoelectron spectra revealed that the Cu_2O nanoparticles are capped with a CuO surface layer of thickness 1.6 nm. This study strongly suggests that the stabilization of the cubic Cu_2O nanophase is enhanced by the formation of a CuO surface layer.

Force and Hardness Standards

A new 5kN dead weight force machine, with loading and unloading mechanism based on a central pin instead of the conventional three point couplings at the circumference, has been developed (Fig. 1.9) for use as a force reference calibration machine. The machine is capable of applying precision forces in various steps on load cells in a fully controlled way using a hydraulic system. Two well characterized load cells of GTM make have been calibrated in the machine as per IS 4169-1988 standard and the best measurement capability of the machine has been derived to be ±50 ppm (k=2).

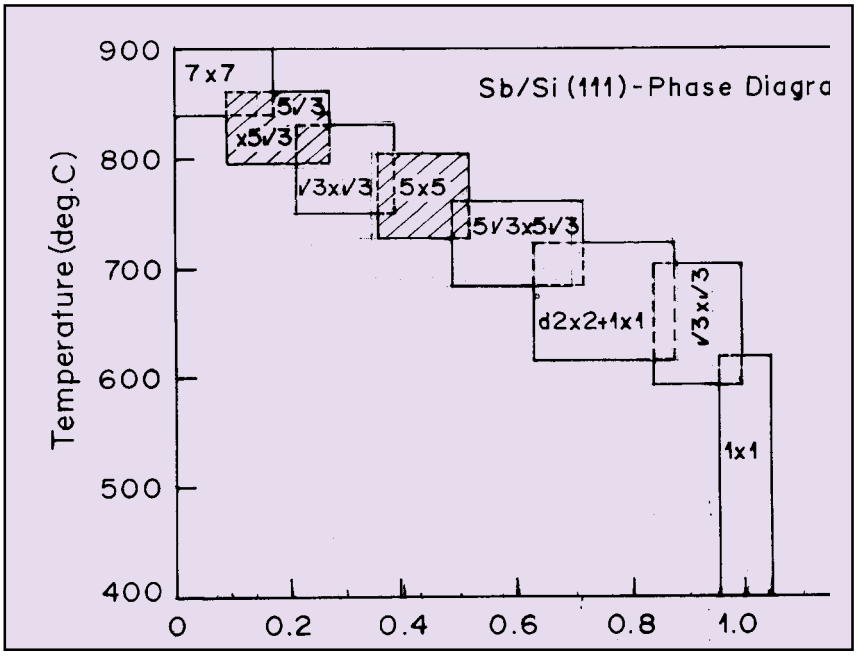

Fig. 1.8 : Surface phase diagram of the Sb/Si (111) interfac3e

Fig. 1.9 : Dead weight force standard machine designed and developed at NPL

A strain gauge force transducer of 250 kN capacity using a new design based on 12 radial arms spring element has been developed with a view to reduce the rotational effect and to lower down the creep. The developed transducer (Fig. 1.10) shows an overall accuracy of ±0.08%.

Development of resonant force transducers, based on double ended tuning fork transducer (DETF), was taken up for a load capacity of about 5 kN. Resonant force transducers use frequency as the force sensing parameter and can provide potentially a superior alternative to the conventional strain gauge transducers due to their higher resolution and low creep. An experimental DETF transducer has been designed and fabricated. It uses a piezoelectric excitation and an electronic amplifier feedback loop to make it oscillate. Initial measurement of the frequency

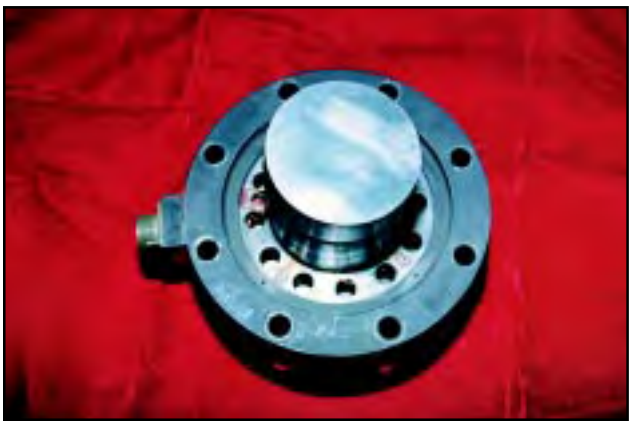

Fig. 1.10 : Multiple bending beam type force transducer designed and developed at NPL

output, performed using a 0.1 Hz resolution frequency counter and up to a compressive force of 1 kN only, shows a linear variation. Further work on metrological characterization of the developed force transducer for higher loads and using higher resolution frequency counter is in progress.

The work on development of hardness blocks for reference calibration was carried further to improve the surface variation of hardness from ±1.0 HRC to ±0.5 HRC. In order to optimize the fabrication parameters of the hardness blocks, studies were undertaken on the composition analysis, surface roughness and aging characteristics of the fabricated blocks vis a vis those of some standard reference blocks available in the international market. The hardness values and its distribution over the surface in some batches of hardness blocks fabricated with optimized parameters have been found to be stable over a six month period within ±0.5 HRC.

It has already been determined and established that certain ceramic relaxor materials can be used for developing pressure transducers. In order to improve upon the accuracy of such pressure transducers and also to explore the feasibility of using such materials for developing force transducers, further investigations have been taken up on Lead Magnesium Niobate (PMN) materials. It is desirable to synthesize materials with >99% perovskite structure with low temperature coefficient and high force coefficient in order to develop the required kind of transducer. These PMN

materials, synthesized using different calcination and sintering temperature were characterized using X-ray, SEM and X-ray photoelectron studies. Capacitance measurements were performed on these samples to estimate their temperature coefficient. The results obtained are quite encouraging and promising to understand the transport mechanism in these materials and to achieve the goals of developing force / pressure transducers.

Temperature Standards

The Standard Platinum Resistance Thermometers SPRTs which fulfil the international norms had been indigenously developed earlier and a patent was filed in India. SPRTs (ranges -196°C to 420°C and -196°C to 660C), triple point of water cells and heat pipe immersion cooler to freeze the ice mantle in the TPW cell were fabricated and supplied after calibration. Two nos. of Triple Point of Water Cells were filled with de-ionized distilled water & sealed. TPW Cells were calibrated at triple point of water temperature after forming ice mantle in the cell and their value was found within 0.2 m°C.

Fixed point calibration of standard thermocouples of Type-S (10%Rh/Pt-Pt) and Type-R (13%Rh/Pt-Pt) on fixed points of tin (231.927°C), zinc (419.58°C), aluminium (660.323°C) and silver (961.78°C) by fixed point cell method and gold point (1064.43°C) by wire bridge method has been established for user industry and secondary laboratories.

Two NABL-NPL PT-Programmes were coordinated. These included 15 accredited laboratories for glass thermometers (0-300°C) and 11 labs for thermocouples (0-1000°C). Two numbers of Type-S reference thermocouples were fabricated and calibrated by inter-comparison method in the range 0-1000°C for this purpose.

Three Automatic temperature baths(-20° to 300°C) were developed and supplied to M/s National Test House, Ghaziabad under a technical consultancy project. Technical know-how on the development of temperature calibration bath as per NPL patented design (Patent # 610/DEL/2001) was given to M/s Labin Scientific Instruments, New Delhi.

Calibration work on temperature measuring instruments in the range from –80°C to 2200°C including Hg and alcohol filled glass thermometers, oceanographic reversing thermometers, Beckmann thermometers, thermocouples digital thermometers, liquid baths, optical pyrometers and tungsten strip lamps, has been carried out for industries and laboratories.

Two Triple Point of Water Cells were made using R. O reference grade water provided by Reference Materials Division. Studied their behavior at triple point of water temperature and found their value within 0.2 m°C.

Ultraviolet Radiation Standards

Calibration and measurement facilities in air UV spectral region was maintained and extended to user industries and institutions. Total 16 calibration/test reports were issued. Special calibration arrangement was made for the calibration of large area (2" x 1") size UV-A intensity meter detector. A movable platform system was designed and fabricated in NPL workshop to reduce the measurement uncertainty in calibration of UV intensity meters. Argon-ion laser plasma tube purchased under DST sponsored project was installed; performance of the laser system was evaluated. Photoacoustic spectroscopic studies of polycyclic aromatic hydrocarbons were continued. Efforts are being made to use the laser system for the study of "Photoinduced superconductivity and non-equilibrium states" in collaboration with superconductivity group of NPL.

Optical Radiation Standards

Establishing Primary Standard of Spectral Radiance

Primary standard of optical radiation in the form of high temperature blackbody, having temperature range 1800

K – 3200 K with emissivity 0.999 at 500 nm and 3200 K and radiance uniformity across the blackbody aperture better than 0.1% has been established for realization of scale of optical radiation. The measurement uncertainty of spectral radiance at k=1 in the wavelength range 2500 nm – 400 nm is 0.1-0.3%, and in the wavelength range 400 nm – 250 nm is 0.3-0.5%. The scale of spectral radiance will be the primary standard of optical radiation in the spectral range 250 nm to 2500 nm.

A New Method for Absolute Measurement of Luminous Flux

Experiments have been carried out to establish high accuracy measurements for the total luminous flux using an integrating sphere. In this experiment, the total luminous flux of a lamp inside the sphere is calibrated against the known amount of luminous flux introduced into the sphere from an external source through a calibrated aperture and a detector calibrated for its luminous responsivity. By measuring the illuminance produced at the aperture by the external lamp, the total luminous flux introduced into the sphere from an external source is determined.

Photometry Radiometry CMC Claims

The details of measurement capability along-with the measurement uncertainty of various photometric units are summarized in the NPLI PR CMC claims and are available at BIPM web site (MRA Appendix C).

Research Work on the Effect of Spatial Coherence in Optical Measurements

Experiments were performed to determine the coherence properties of wave fields, produced by the broadband stellar sources on the earth surface, from the study of spectral changes produced on interference in the Young's double slit experiment. The spectral degree of coherence obtained experimentally in this study for four bright stars namely -Boo, -Sco, -CMa and -Ori was found in close agreement with the value that is expected theoretically from the known angular diameter of the stars. It is shown that the spectral degree of coherence obtained experimentally by this spectral interferometric technique could be used to determine the angular diameter of stars.

Experimental Observation of Phenomenon of Spectral Switch

It has been shown experimentally that when a class of partially coherent light obeying the scaling law is incident on a circular or a rectangular aperture, the on-axis spectrum of the diffracted light close to certain critical distance z from the aperture plane in the near zone, changes drastically. A spectral line becomes red shifted to one side of these critical distances, blue shifted on the other side and splits into two lines at special distances. This phenomenon is called 'spectral switch', i.e. the spectrum of the diffracted light changes drastically. It has also been shown that depending on the values $\overline{L}(\omega)$ of some parameters, namely the radius of the aperture 'a' and the effective correlation length $\overline{\overline{L}(\omega)}$ of the light at the aperture, the spectral shift shows a gradual change, but for a particular value of the spectral shift exhibits a rapid transition and the phenomenon of spectral switch occurs.

DST Sponsored Project

DST sponsored a project entitled "Studies on Spatial-Coherence Spectral Filters and their Applications." The achromatic Fourier transform system and the coherent filter system, the main instruments required for undertaking these studies, were ordered. In the meantime some preliminary investigations have already been completed and some interesting results, showing the application of phenomenon of the correlation-induced spectral changes in the fabrication of spectral switches, have been observed.

Infra-Red Radiation Standards

To develop diffuse reflectance standards in the spectral region from 2.5 µm to 25µm, spectral diffuse reflectance studies by using Fourier Transform Infrared (FT-IR) spectrophotometer and integrating sphere were carried out on various materials. Materials studied were: (a) Red, Blue, Gray and Black paints on aluminium substrates; (b) aluminium, zinc sulphide and zinc selenide coatings through evaporation on glass plates having surface coarseness of 8 µm, 16 µm 22 µm and 60 µm; (c) black cloth and diffuse gold coated surfaces of various coarseness and (d) KBr, zinc sulphide, zinc selenide powders. The spectral - diffuse as well as - total (diffuse + specular) reflectance studies were performed on most of these materials at NIST, USA also on their FT-IR spectrophotometer and custom-built integrating sphere. There was good agreement between the results obtained at two institutions. This ensures that the systems available at two institutions for this study are compatible to each other.

Fourier Transform Raman facility was installed for recording Raman shifts in the spectral range 3500-100 cm^{-1} with maximum resolution of 0.2 cm^{-1}. Its performance was evaluated by recording Raman shift of silicon, CCl_4, $BaSO_4$ etc.

Quantitative analyses of sugar cane juices for individual components of sugars were carried out from their near infrared studies. Also, near infrared spectroscopic studies were performed on (a) fruit juices for determination of sugars and organic acids; (b) milk and milk products for quantification of fat, protein and lactose, (c) milk for identification of adulterants, (d) tobacco for quantification of moisture, and (e) sugar for their particle size. A methodology was evolved for identification of polymer sheet sandwiched between thick glass plates from refractive index measurements and using near infrared spectroscopic techniques.

A reflectometer to characterize surfaces from their specular reflectance and a polarimeter to measure optical rotation of reflected light from specular reflecting surfaces as well as from diffusing surfaces were set up and used for characterization of the sample surface received for testing and also the surfaces of silicon wafers used for optimization of their efficiency as solar cells.

Mass, Volume and Viscosity Standards

As part of the activities on measurement assurance and maintenanance of mass standard four 1 kg transfer standards of mass were calibrated against the national prototype kilogram with expanded uncertainty of 28 mg in 1 kg with k=2. Various other national standards of mass at level I and level II and Reference grade hydrometers were also calibrated against national/ primary standard of mass and density. Calibration of master viscometers and oils was also carried out during the year. These standards are used to provide traceability to our customers through calibration and testing.

The density of solid density transfer standard of silicon was measured using automated computer controlled hydrostatic weighing system with relative standard uncertainty of 10 ppm

A proficiency testing program in mass measurement NABL-NPL – MASS – 001 was coordinated and conducted for a set of four weights of nominal values of 1g, 10g, 200g and 1kg and a fifth "non-standard'' weight of 124 g, to assess the compatibility of the participating laboratories. Mass Metrology Laboratory of NPL acted as reference laboratory and eight laboratories participated in the program.

On the basis of results published in the Asia/ Pacific Metrology Programme Report (APMP –IC-3-96-2001) and the previous inter-comparisons, our measurement capabilities in mass, volume and density parameters have been included in the CMC table of Appendix C of BIPM Database. NPL has been nominated to organize APMP M.M-K2 (submultiples) comparison for a set of five mass standards (10 kg, 500 g, 20 g, 2 g, 100 mg) involving twelve national laboratories in the Asia-Pacific Region .

Fluid Flow Measurement Standards

Flowmeters of various types had been calibrated during the period. These include electromagnetic flow meters (5 meters, Flow range: 100 m^3/h to 50 m^3/h , 100 m^3/h to 10 m^3/h , 500 m^3/h to 100 m^3/h, 100 m^3/h to 10 m^3/h , and 580 hectolitre /h to 56 hectolitre/h), one mass flow meter (Flow range : 0 to 8000 kg / h), one vortex flow meter (prototype meter under development, 12 m^3/h to 50 m^3/h), and two rotameters (variable area flow meter, Flow range : one having the range 234 l/h to 1080 l/h and another upto 1149 l/h). For some meters, suitable mounts were fabricated and fitted in the test line. In the case of one electromagnetic flowmeter calibration (size: 80 mm), calibration was carried out in digital mode as well as in analogue mode as desired by the customer.

Work was carried out for setting up facility based on volumetric method for domestic water meter testing and calibration in accordance with Indian Standards to cater the needs of the domestic water flow meter manufacturers, organizations using/ dealing in the domestic water meters and the miscellaneous users in the Northern part of India.

The facility is suitable for domestic water meters from the range of 15mm to 50 mm diameter and the following tests can be done in accordance with Indian Standards

- Accuracy test
- Pressure loss test
- Pressure tightness test
- Temperature suitability test and
- Endurance test / life test

The equipment used in the facility i.e. volumetric vessels, pressure gauges, thermometers etc. are traceable to national standards.

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विद्युत तथा इलेक्ट्रॉनिक मानक

ELECTRICAL & ELECTRONIC STANDARDS

विद्युत तथा इलेक्ट्रॉनिक मानक

विद्युत और इलेक्ट्रॉनिक मानक डिवीजन निम्नलिखित कार्यों में लगी हुई है – समय और धारा की एस आई यूनिटों का प्रापण (रीअलाईजेशन) करने, विद्युत, इलेक्ट्रॉनिक और चुम्बकीय मानदण्डों जैसे समय तथा आवृत्ति के मुख्य राष्ट्रीय मानकों के विकास और अनुरक्षण में जोसफसन वाल्टेज, डी सी वॉल्टेज, धारा और प्रतिरोध, ए सी पावर ऊर्जा, ए सी उच्च धारा और उच्च वोल्टता, ए सी वोल्टता, धारा प्रतिरोध एल एफ तथा एच एफ प्रतिबाधा, सथानीयकृत पैरामीटर्स, एच एफ और सुक्ष्मतरंग शक्ति, संकीर्णन, प्रतिबाधा, और शोर और चुम्बकीय तेल। यह डिवीजन ए पी एम पी और बी आई पी एम द्वारा आयोजित अन्तर्राष्ट्रीय अन्तर्तुलनाओं में भाग लेती है तथ द्विपक्षीय तुलनाओं (बाईलेटरल इन्टरकम्पैरिजन्टस) में भी भाग लेती है। ताकि अंन्तर्राष्ट्रीय अनुमार्गणीयता को स्थापित किया जा सके। यह शीर्ष स्तर का अंशांकन सेवा ओर तकनीकी परामर्श सेवा उक्त मानदण्डों में अन्य अंशांकन प्रयोगशालाओं और उद्योगों को प्रदान करती है।

ELECTRICAL & ELECTRONIC STANDARDS

The Electrical and Electronic Standards Division is engaged in realization of SI Units of Time and Current, development and maintenance of primary/national standards of electrical, electronic and magnetic parameters such as time and frequency; Josephson voltage; DC voltage, current and resistance; AC power and energy; AC high current and high voltage; AC voltage, current, resistance; LF and HF impedance (lumped parameter); HF and Microwave power, attenuation, impedance and noise and magnetic field. The division participates in international intercomparisons organized by APMP and BIPM as well as bilateral comparisons to establish international traceability. It provides apex level calibration service and technical consultancy in the above parameters to other calibration laboratories and industries.

Time and Frequency Standards

A study has been undertaken to find the accuracy of GPS time for on-line applications. The time from GPS receivers has been found to be off by few microseconds in many situations. After the optimization of bias errors, the accuracy of the receiver was found to have improved.

During high solar activity period, it has been found that the accuracy of GPS time gets deteriorated when there is a strong scintillation. This effect on time cannot be cancelled even in common view mode.

Time service via telephone network (i.e. Teleclock Service) has been in operation. Some improvement in the transmitting units has been done to make the system more efficient operationally. To start similar service in SASO, Saudi Arabia, the necessary design and development of the equipment have been completed.

Standard Time & Frequency Signals (STFS) have been broadcast over the INSAT 2C parked at 93.5 Deg East. This broadcast with national coverage has been operational with 0% down time over the full year. Precise orbital elements were updated every fortnight for accurate time transfer using the differential technique. During the year the following new contract projects were carried out. The entire STFS receiving system was installed at Badarpur Thermal Power Station (BTPS), Badarpur. At National Thermal Power Corporation (NTPC), Dadri the existing STFS system was augmented by installing large Slave Clock units synchronized to the STFS. Work was initiated to design and develop a Differential STFS receiving system at the Agilent Technologies (Pvt) Ltd, Bangalore. This project is ongoing and the actual installation is yet to be made.

Progress made in the Laser Cooled Cs Fountain programme mainly consisted of establishing frequency stabilized 852 nm extended cavity diode laser systems. The lasers were frequency locked to Cs D2 line in a saturated absorption spectrometer. Necessary electronics for the temperature control, laser diode current supply and the servo circuits were developed.

Josephson Voltage Standards and Superconducting Devices

Josephson Voltage Standard

Josephson series array voltage standard has been maintained at 1 volt level. The "National Standard" of volt is being calibrated at regular interval of six months against the Josephson Voltage Standard (JVS). Calibrated Zener reference standard against JVS was used in CCEM-K8 intercomparison to provide traceability. R&D work is in progress to develop 10 volt Josephson series array voltage standard.

Process for Encapsulation of High-T_c SQUID Sensor

For a long term operational life of high-Tc SQUID, the characteristics of SQUID sensor should not deteriorate with thermal cycling. A process for encapsulation of the SQUID sensor in a copper cavity has been developed. The performance of encapsulated sensor has been tested over a long period. Figure 2.1 shows the values of peak to peak amplitude and the flux noise of the encapsulated SQUID as recorded at 77 K after several thermal cycling at different period of time upto 34 months. It is evident that no change in the SQUID characteristics has been noticed over a long period even after several thermal cycling from room temperature to liquid nitrogen temperature.

Setup for the Measurement of Magnetic Fluctuation in Doped Rare Earth Manganite using High-Tc SQUID

For measuring magnetic fluctuation in doped rare earth manganite, a setup is developed in which high-Tc rf-SQUID works as a magnetic sensor having a field sensitivity $\approx 5 \times 10^{-11}$ T/$\sqrt{Hz}$ in the white noise region. In this setup, SQUID remains dipped in liquid nitrogen inside a tail type glass dewar and the sample is kept outside at the tip of the tail. The temperature of the

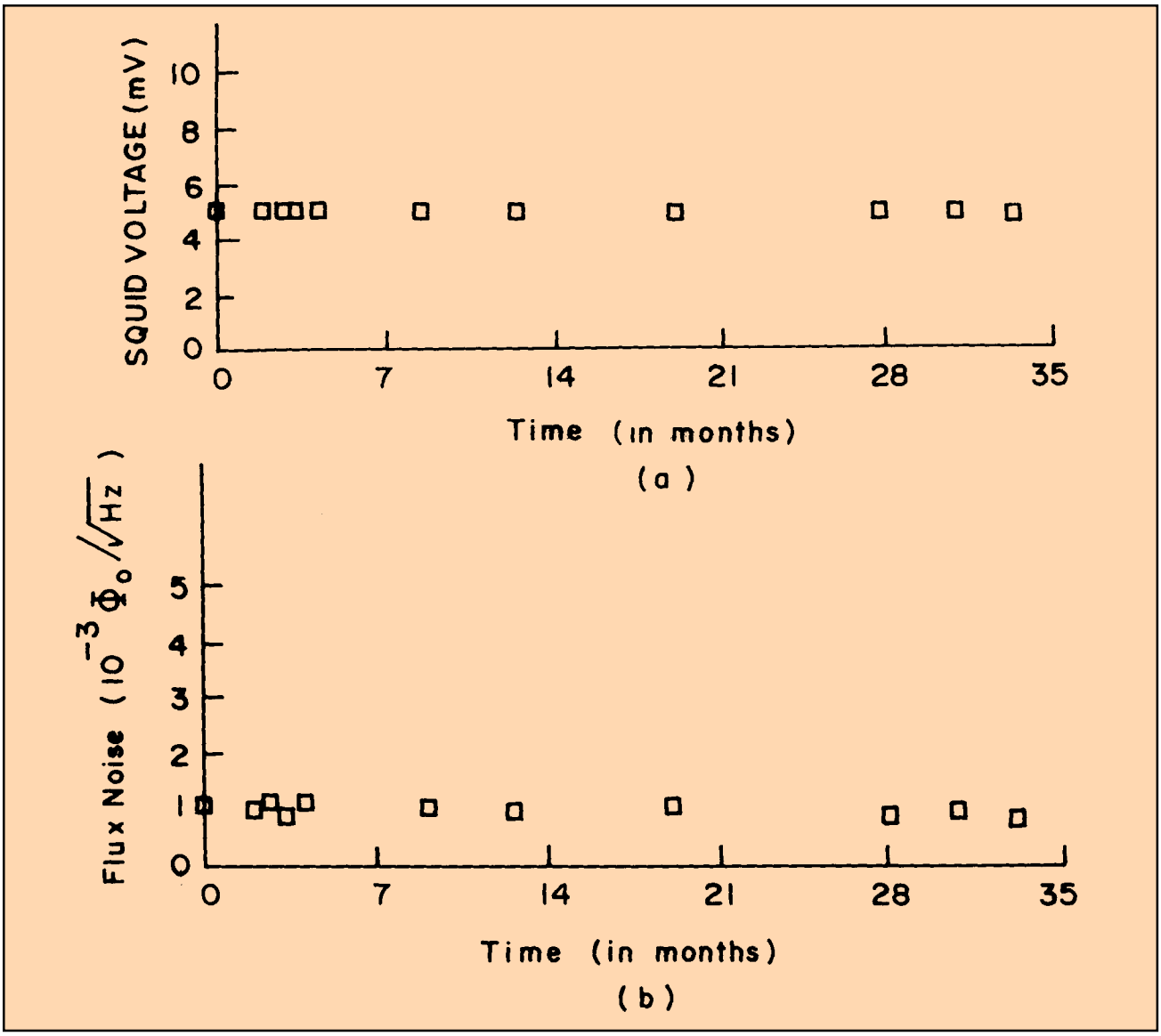

Fig. 2.1 : SQUID voltage and flux noise of the encapsulated high-T_c SQUID sensor

sample can be varied from room temperature to liquid nitrogen temperature. This setup is also being used for measuring temperature dependence of magnetic phase separation of doped rare earth manganites.

Weak-link Grain-boundaries in MgB_2 Supreconductors

In order to understand the nature of natural grain boundaries in MgB_2 superconductors, rf-SQUID studies have been carried out using a small piece of bulk MgB_2 superconductor. The MgB_2 sample was surrounded by eight turn coil which formed a part of the inductance of the tank circuit of the rf-SQUID electronics. The resonance frequency and quality factor of the tank circuit was 18.3 MHz and 62 respectively. Periodic oscillation in the voltage-flux (V-Φ) oscillation was 3 mV at 4.2K. The amplitude of SQUID modulation was found to decrease with the increase of the operating temperature and it disappeared at T=35K. The observation of rf-SQUID effect in bulk MgB_2 superconductor indicates the presence of weak-link grain-boundaries in the bulk superconductors.

Improvement in the Stability of $La_{0.67}Ca_{0.33}MnO_3$ Film due to Silver Addition

Metal insulator transition temperature (T_p), resistance and magnetoresistance (MR) of $La_{0.67}Ca_{0.33}MnO_3$ (LCMO) polycrystalline film have been studied after each thermal cycling from room temperature to 77K. It has been found that values of T_p and MR changes after couple of cycling. Resistance of the film increases and T_p shifts to lower temperature after each thermal cycling. Silver added LCMO film is also prepared and similar studies have been carried out. Figure 2.2 shows values of T_p for LCMO film and silver added LCMO film. The addition of silver has been found to improve stability of the film against thermal cycling. T_p of silver added LCMO did not change even after several thermal cycling. The change in T_p of polycrystalline LCMO film after thermal cycling is attributed to loss of oxygen from the grain boundary due to thermal stress.

Conduction Noise of Bicrystal Grain - Boundary in Doped Rare Earth Manganite

Behaviour of a single artificial grain boundary in $La_{0.67}Ba_{0.33}MnO_3$ (LBMO) epitaxial film is studied for understanding the role of grain boundaries in generating excess noise in polycrystalline doped rare earth manganite films. The artificial grain boundary is realized by depositing the film on a 36.7° $SrTiO_3$ bicrystal substrate. Figure 2.3 shows normalized conduction noise (S_v/V^2) of the grain boundary and the epitaxial film. It is evident that the presence of grain boundary introduces more conduction noise which has been attributed to oxygen deficient layer at the grain boundary.

DC Current, Voltage and Resistance Standards

DC Standards maintains "National Standard" of dc voltage and resistance and provides apex level

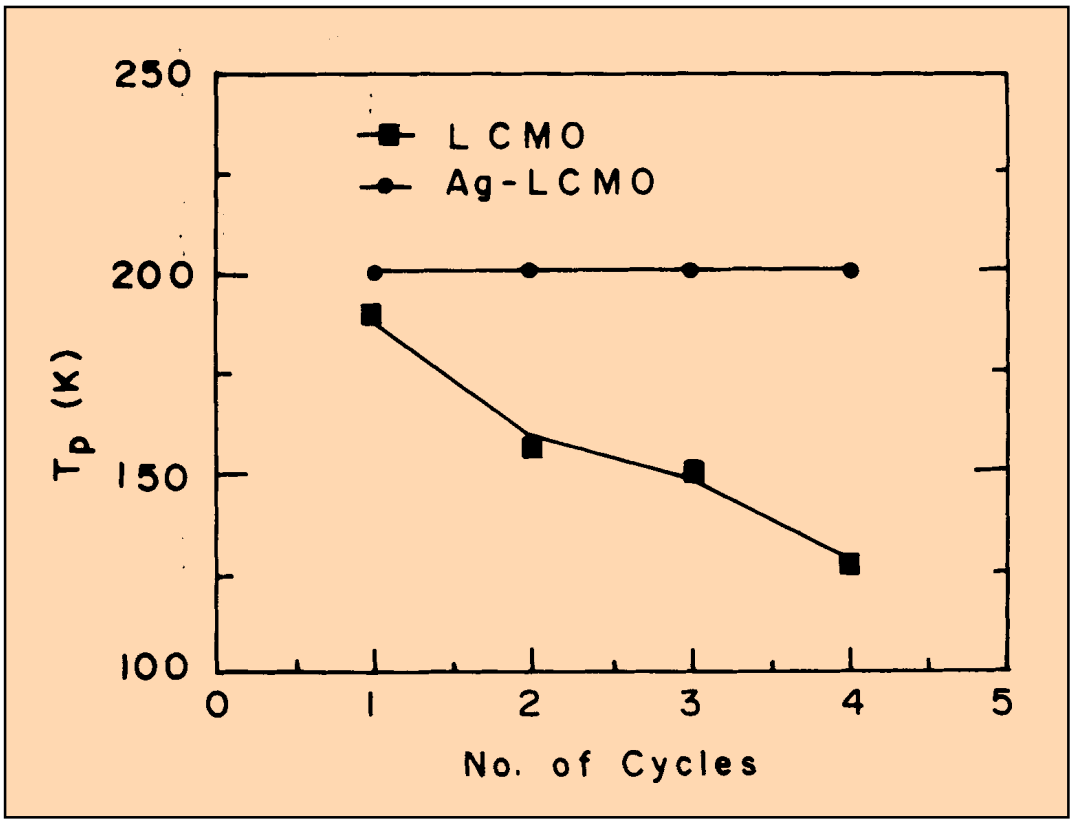

Fig. 2.2: Metal-insulator transition temperature (T_p) of LCMO and silver added LCMO film

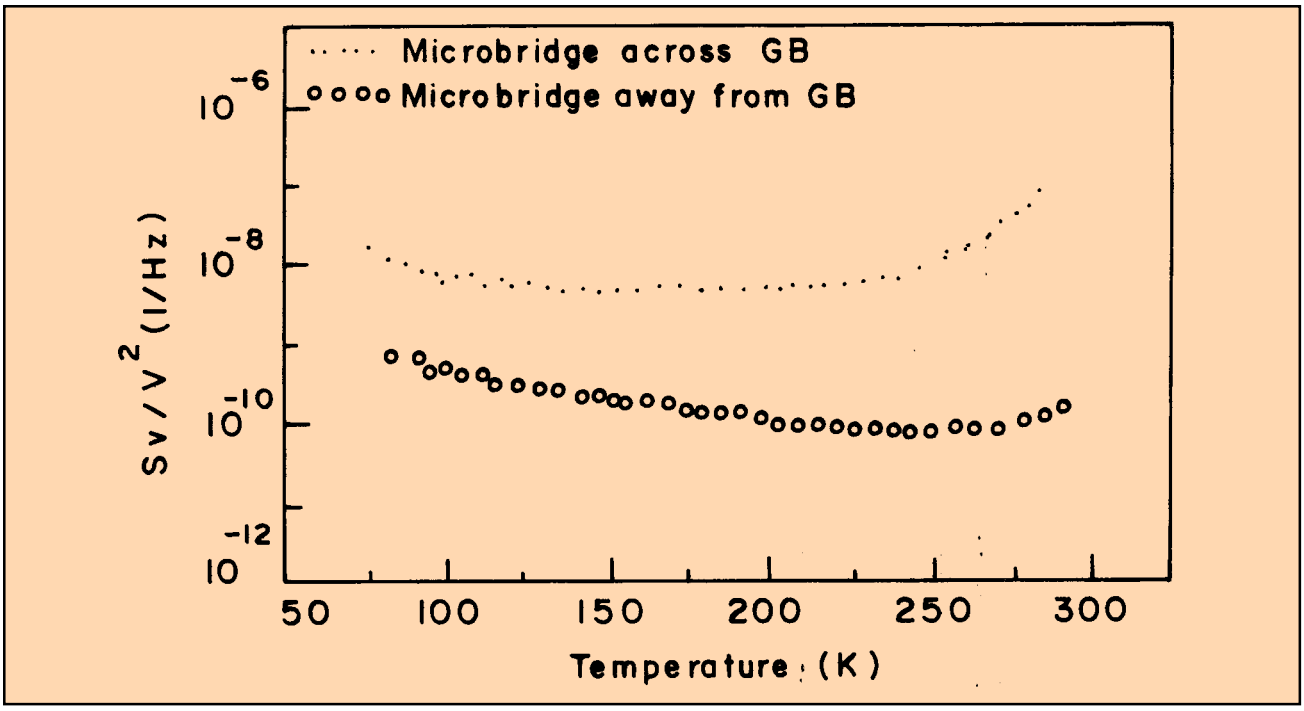

Fig. 2.3 : Temperature dependence of normalized conduction noise (S_v/V^2) of the microbridge across bicrystal grain-boundary and for the microbridge away from the grain boundary in LBMO epitaxial film

calibration to various laboratories and industries. The group also participated in CCEM-K8 Key Comparison of DC Voltage Ratios, details given below.

DC High Voltage Standards

Participation of NPL-India in CCEM-K8 Key Comparison of DC Voltage Ratios

NPL India has participated in CCEM-K8 Key Comparison of DC voltage ratios 1000:10, 300:10, 100:10, 30:10 and 10:1. NMIs of fourteen countries participated in this Key comparison and IEN, Italy was the pilot laboratory.

The IEN, Italy was given the responsibility to start the international inter comparison (key comparison) on DC voltage ratios by Consultative Committee of Electricity and Magnetism (CCEM) in its 20th meeting in June 1995. The key comparison CCEM-K8 started in October 1998 and finished in June 2001, with fourteen participating National Metrology Institutes (NMIs) namely CSIR-South Africa, NIST U.S.A, LCIE France, SP Sweden, NPL U.K., CEM Spain, KRISS Korea, CSIRO-NML Australia, NIM China, VNIIM Russia, NRC Canada, MSL New Zealand, NPL India (NPLI), NMIJ Japan.

As per the schedule of CCEM-K8 Key Comparison, one travelling standard (DC voltage divider Datron 4902S) was received in NPLI during March 2001. It has one hundred 10kW resistive elements, each made up of two parallel 20 kW thick film resistors. Adjustment trimmers in the divider were sealed (not to be adjusted by participants) by the pilot laboratory.

The ratios 1000:10 and 100:10 were mandatory while other ratios were optional for the comparison. The mandatory ratios 1000:10, 100:10 and optional ratios 300:10, 30:10 were to be measured at the corresponding terminals while ratio 10:1 at 100V/10V terminal and ratio 10:0.1 at 1000V/10V terminal respectively. The standard ambient conditions of temperature (T) 23 ± 0.5 °C and relative humidity (H) 45% ± 5% were recommended for CCEM-K8 intercomparison. The goal of the comparison was to achieve a relative uncertainty (combined Type 'A' and Type'B') of ± 0.5 ppm or less at k=1 for the ratios 1000:10 and 100:10.

We have carried out various measurements on different ratios using NPLI reference divider and travelling standard. The uncertainty of results were estimated using Type 'A' and Type'B' methods and reported at k=1 for all the ratios.

At NPLI, measurements were done by comparison method against the reference divider maintained by NPLI. The schematic of measurement is shown in Fig.2.4. The circuit consists of a stable voltage source like a calibrator, a Zener voltage reference standard at 10V & 1.018V, a reference divider and a sensitive null detector. The reference divider was powered by a calibrator which was regulated to balance the 10V output of the divider against a calibrated Zener voltage reference standard, using a sensitive null detector. The calibrator was set at approximately the voltage of measurement and its voltage was adjusted to produce a null in the detector. The value at which the calibrator produces a null and the value of voltage of the Zener standard (10V or 1.018V) were divided to get the ratio of the reference divider. The measurements were then repeated after replacing the NPLI divider with travelling standard (divider) and recording all the measurement data. The measurements were performed during the period from March 30, 2001 to April 16, 2001.

The measurements were done in the laboratory which was having controlled conditions of temperature & humidity, the value of which are given below:

Temperature :	23 °C ± 1 °C
Relative humidity:	45% ± 10%
Atmospheric pressure:	980.56 hPa ± 0.50 hPa

The pilot laboratory has reported the results of intercomparison as uncertainty budget in the form of tables as given in the draft 'B'. NPLI results included the following sources of uncertainty (at k=1) as given below (Table 2.1):

Degree of Equivalence

One of the main aim of CCEM-K8 key comparison was to determine the degree of equivalence of the participating NMIs. The degrees of equivalence were evaluated following the Mutual Recognition

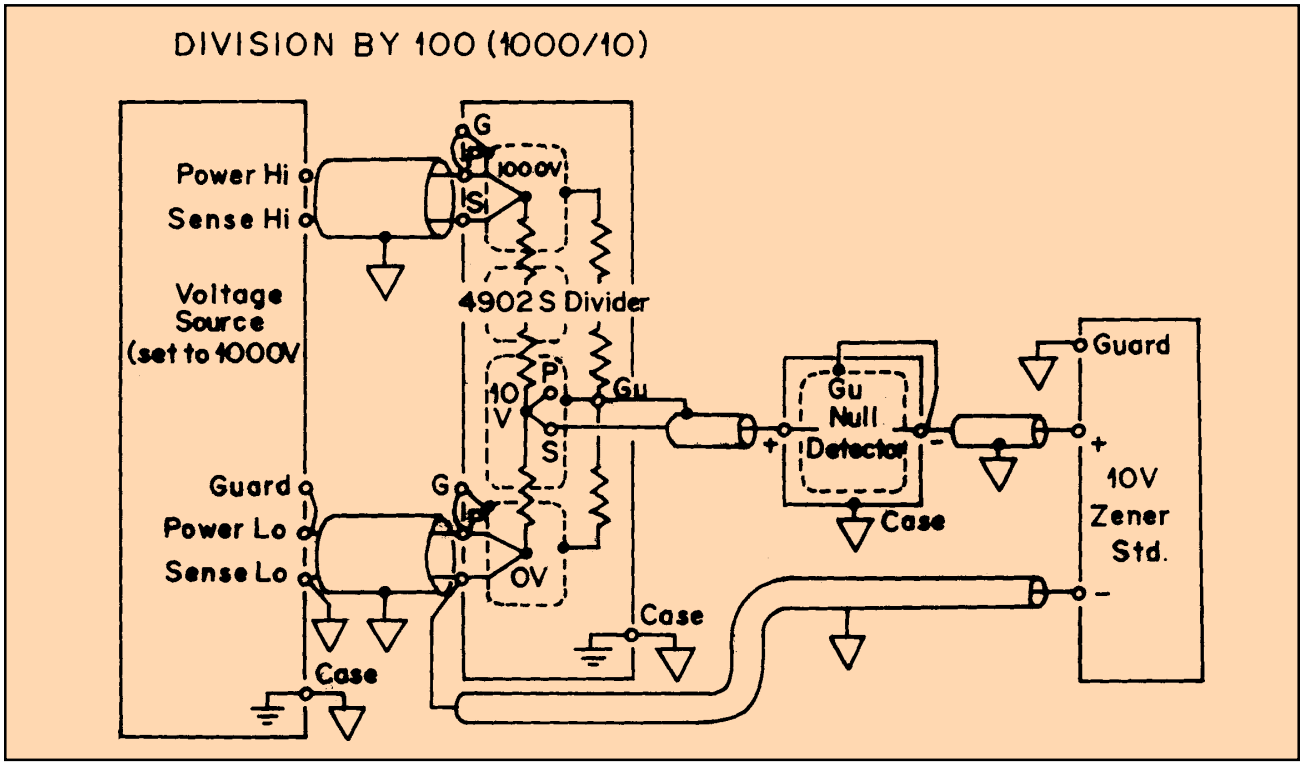

Fig. 2.4 : The circuit diagram of the traveling standard (voltage divider 4902S) used for inter comparison. Also shown the electrical connections and instruments used

Table 2.1 : Relative uncertainty budget for the ratio 1000:10 (at k=1)

Source of Uncertainty	Estimate x_i (ppm)	Standard uncertainty $u(x_i)$	Probability Distribution / method of evaluation	Sensitivity coefficient c_i	Uncertainty contribution $u_i(R)$ (ppm)	Degrees of freedom
u_1 (divider)	0.2	0.12	Rectangular, B	1	0.12	∞
u_2(detector)	0.03	0.02	Rectangular, B	1	0.02	∞
u_3 (source stability)	0.7	0.27	Normal, B	1	0.27	∞
u_4 (Zener stability)	0.1	0.06	Rectangular, B	1	0.06	∞
u_5 (repeat-ability)	u (ξ)	0.19	Normal, A	1	0.19	6
$R_{1000/10}$					***u(R) = 0.36***	n_{eff} = 70

Arrangement of the CIPM. The key comparison reference value, D_R of this comparison is the arithmetic mean of the differences, with respect to the pilot laboratory. The degrees of equivalence with respect to the reference value is given by $D_i = (D_i - D_R)$, where D_i is the differences between laboratory *i* and the pilot lab. The corresponding expanded uncertainty $U(D_i)$, assessed for a level of confidence of 95%. The plot of degree of equivalence for the ratios 100:10 and 1000:10 are given here as Fig.2.5 (a,b).

It implies that international intercomparisons are not only useful to determine the degree of equivalence but also to develop more precise methods of measurements. The degree of equivalence of NPLI obtained in mandatory ratios 1000:10 and 100:10 is found to be within 1 ppm from the mean value.

AC Power and Energy Standards

The AC Power & Energy Standards section is providing testing and calibration facility for single phase and three phase power and energy meter for active, reactive and apparent values to electricity boards, meter manufactures and other test and calibration laboratories.

To overcome the problem of tampering of the static energy meters from the influence of AC/DC

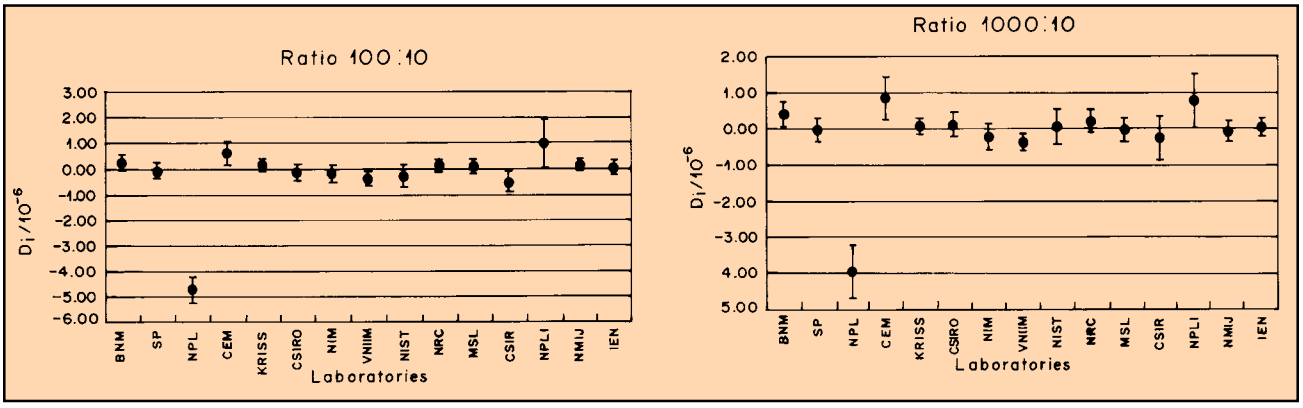

Fig. 2.5 (a,b) : Plot of degree of equivalence for the ratio 100:10 and 1000:10

magnetic fields several coils were developed and depending upon the severity of the influence, five type of tests have been finalized and recommended to CBIP. These have been included in CBIP-88 report as amendment from 5.6.2.1 to 5.6.2.5. During all the five tests no abnormality like movement of digits (for Electrochemical registers), flickering/switching On-Off of display (for digital display), abnormal heating should occur and the % error should not change beyond the allowed limits.

Test of accuracy of the static energy meter in the presence of only two wires, either neutral and one phase or any two phases without neutral has been included.

AC High Voltage and Current Standards

The facility for the calibration of AC Current Ratio for currents up to 5000A at 50 Hz has been upgraded (as shown at Fig. 2.6) from ± 0.005% accuracy to ± 0.001% accuracy. Also the traceability for CT calibrations has been established with PTB, Germany.

This section is also providing calibration facilities by maintaining the National Standards of AC High Current Ratios at power frequencies. Calibration services were provided for Current Transformers, CTTS, Clamp meters, AC Current Shunts, Weld Testers, CTTS Jigs, CT Burdens and for Potential Transformers, PTTS, HV Probe, Electro Static Volt Meters (ESVM), HV Break Down Test Sets and PT Burdens etc. As many as 27 calibration certificates were issued to the electrical manufacturers and utilities.

Work has been planned for extending the range of AC High Voltage Ratio Calibration up to 100 kV at 50 Hz.

LF & HF Impedance Standards

This activity is working to establish, maintain and update primary and transfer standards of capacitance, inductance, ac resistance and ac voltage ratio at low and high frequencies. As such this activity provides apex level calibration facilities for the above parameters to various user

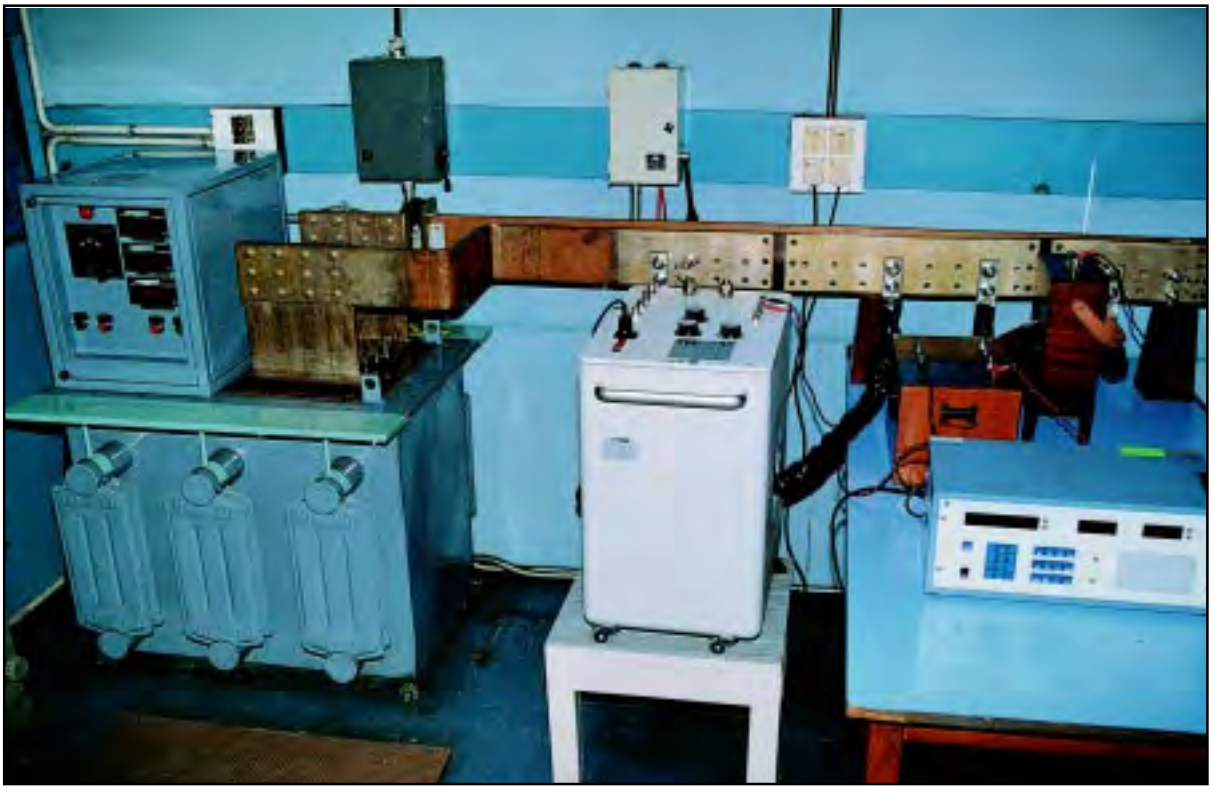

Fig. 2.6 : Experimental set-up for calibration of AC High Current Ratio (5A-5000A/1A,5A) at 50 Hz.

organizations all over India.

The design and development of Direct Reading Resistance Bridge based on inductive voltage dividers has been completed. The evaluation of this bridge indicates that it can measure 1 k Ohm resistance with a measurement uncertainty of 5ppm at 1kHz. This bridge can be used for high precision ac resistance measurements at different frequencies up to 10 kHz. In addition to this it can also be used for primary work related to international inter-comparison of capacitance, to measure the temperatures of capacitance standards in terms of resistance.

Inter-laboratory proficiency testing programmes with NPL as the pilot laboratory have been conducted in the field of capacitance and ac resistance measurements; among the NABL accredited calibration laboratories in India. This programme was coordinated by NPL and funded by NABL, New Delhi.

We participated in the International inter-comparison of AC voltage Ratio under CCEM-K7 key comparison programme. In this inter-comparison 14 laboratories like NIST (USA), PTB(Germany), NPL (UK) – Pilot laboratory, NML (Australia) etc. have participated. The transfer standard IVD (Inductive Voltage Divider) sent by the pilot laboratory were measured for ratios from 0.1 to 1 in steps of 0.1 and from 1/11 to 10/11 in steps of 1/11; at 1 kHz, 10V and at 50Hz, 3V, with an uncertainty of $5x10^{-9}$ and $5x10^{-8}$ respectively.

LF & HF Voltage, Current & HF and Microwave Power Standards

Two international comparison have been carried out in low frequency voltage under Asia Pacific Metrology Programme. The details are as follows:

APMP International Comparison of AC-DC Transfer Standards at the lowest attainable level of uncertainty. The comparison is a part of Global Mutual Recognition Arrangement (MRA) process. The comparison has been carried out at a nominal voltage 3 volt in the frequency range 1kHz to 1MHz. There are 13 participating countries including Australia, India, Germany, Japan and Korea in the comparison. The relative ac/dc transfer error of the travelling standard with our standard is very low at all frequencies. The coordinating laboratory in this comparison is NML, CSIRO, Australia.

APMP International Comparison of high voltage AC-DC Transfer has been carried out at nominal voltages of 500 and 1000 volts in the frequency range 1kHz to 100kHz. The travelling standard has been provided by ITRI, Taiwan. Besides Taiwan, India and Australia there are 8 more participating countries. The relative ac/dc transfer error of the travelling standard with respect to our standard in this comparison also, is very low at all frequencies.

RF Attenuation and Impedance Standards

The calibration facilities in attenuation and impedance parameters established in the frequency range 30 MHz to 20 GHz in 50 ohm coaxial system and 3.95 to 26.5 GHz in waveguide system (G-band, Xn-band, X-band, Ku-band and K-band) are being used for the calibration of transfer standards of attenuation and impedance of various user organizations e.g. AMSE Palam, ERTLs, BEL, ISRO, Naval Dockyard etc. To extend the existing calibration facilities upto 40 GHz frequency range, a synthesized signal generator from 10 MHz to 40 GHz frequency range has been procured and Ka-band (26.5 – 40 GHz) waveguide components e.g. slotted line, multi-stub tuners and match terminations have been designed and developed. The experimental set-up for the measurement of impedance at Ka-band microwave frequencies is shown in Fig. 2.7.

Magnetic Standards

Setting up Facilities for the Calibration of Search Coils

Facilities have been established for the calibration of search coils against standard search coils of known

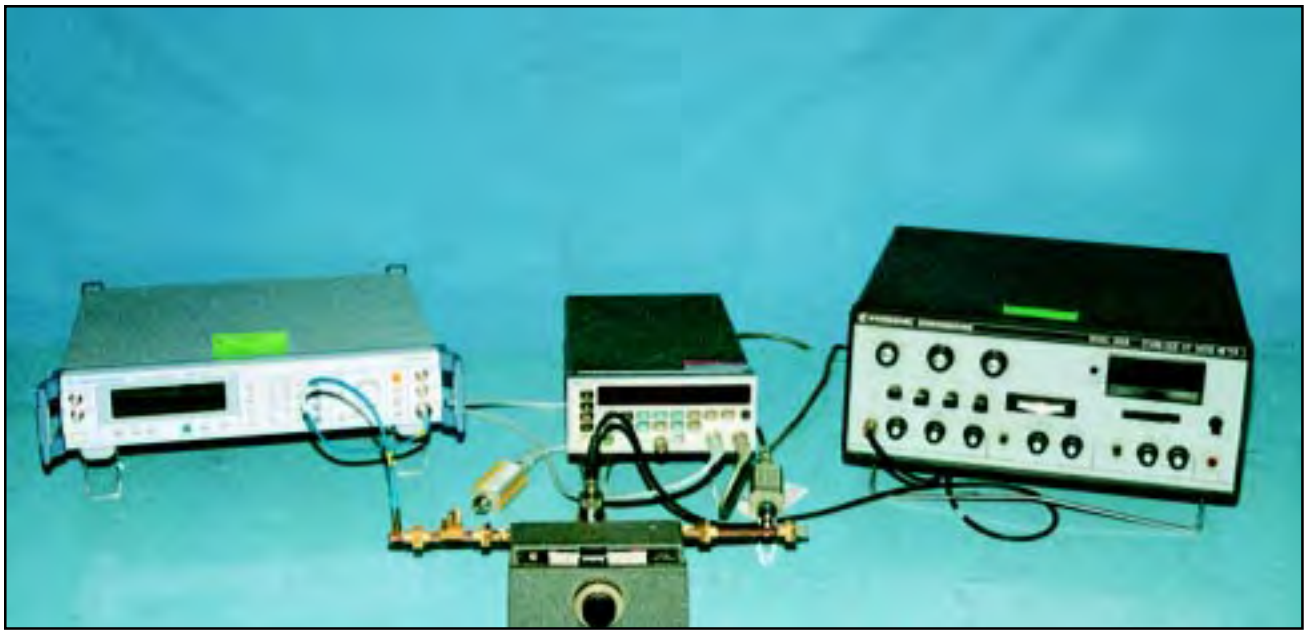

Fig. 2.7: Experimental set-up for impedance measurement at Ka-band frequencies

turn-area traceable to PTB, Germany using DC solenoid. The standard search coils with known turn-area available with us are:

N. A (Turn-Area) = 549.52 ± 0.50 cm^2

N.A (Turn-Area) = 59.34 ± 0.20 cm^2

Fig.2.8 shows the photograph of the standard search coils. Direct comparison technique has been used for the measurement of Turn-area of the search coils. Magnetic flux generated by the standard DC solenoid is measured by the standard search coil as well as by the search coil under calibration and the turn-area of the unknown search coil is determined. The uncertainty in the measurement is ± 1%

Fig. 2.8 : Photograph of the standard search coils

Biomedical Measurements and Standards

Basic investigations in biological tissues and other materials for ultrasonic and electrical properties have been carried out to enable develop 'safety standards' for avoiding side effects on the surrounding tissues. Hard tissues like human teeth and tumours, in particular, have been characterised in detail. A new programme on the 'development and establishment of standards and calibration facilities for electro-medical equipment', has been formulated, for better health care in the country. It has been investigated first time that the efficiency of the stone disintegration in lithotripters is enhanced by external acoustic stimulation, wherein the

cavitation bubble formation is increased.

Characterization of Biological Tissues

Malignant bone with osteosarcoma

Ultrasonic parameters of bone tumour, osteosarcoma, have been determined, in vitro. Average propagation velocity and attenuation are found to be 1640.44 m/s and 2032 dB/m. The causes of low velocity and high attenuation are the porosity and complex nature of the samples used. Standardizing the data assists in the development of a direct technique for the diagnosis and differentiation of tumours.

Safety Standards

Dosimetry and safety limits

As the ultrasound dosage level is required to be controlled within limits for a particular duration for a particular treatment, to establish the safety limits for ultrasound usage on the biological tissues, it became important to utilize the basic characteristics. Therefore, ultrasonic properties of both soft and hard tissues have been studied and correlated with the anatomy and chemical constituents of the organs or tissues. The effect of ultrasound intensity on the tissue structure, particularly thermal behaviour, has been studied in detail. The safety limitations of ultrasound dosage are established on the basis of these basic findings. The study would help the clinicians to use ultrasound machines with proper dosage level and for proper duration for a particular human body or tissue to be treated.

Safety Standards for Lithotripters

High power acoustic lithotripters are in extensive use, these days, to disintegrate renal calculi, non-destructively. It is investigated first time that acoustic stimulation assists in the enhancement of stone disintegration in lithotripters, used for the removal of kidney stones, without surgery. Safety limits of lithotripter intensity on the human tissues have been studied and discussed, by giving comparative data on the Laboratory samples of renal calculi, in vitro.

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इंजीनियरी पदार्थ

ENGINEERING MATERIALS

इंजीनियरी पदार्थ

इंजीनियरी पदार्थ डिवीजन विभिन्न क्षेत्रों में सामग्री, प्रक्रिया और घटकों, युक्तियों और सिस्टमों के प्राद्योगिकी विकास में सक्रिय रूप से लगी हुई हैं। उच्च निष्पादन और कार्यनीति अनुप्रयोगों के लिए एस सामग्री में एरोस्पेस मेटेलिक सामग्री, कंपोजिटस, उच्च कार्बन उत्पाद और विद्युत प्रकाशीय और ऑप्टो इलेक्ट्रॉनिक युक्तियाँ शामिल हैं तथा द्रव क्रिस्टल स्वास्थ्य की देखभाल वाली और मॉनीटरन युक्तियाँ शामिल है।

शानदार अवसंरचना भी मौजूद है जिसमें सामग्री, विकास और आधुनिक अभिलक्षण सुविधाओं के क्षेत्र में कार्य कर रहे विशेषज्ञ और प्रशिक्षित व्यक्ति भी शामिल हैं। कई विकासशील प्रोजेक्टों में प्रायोजित सहायता अनुदान (ग्रांट इन एड) सहयोगी और परामर्शी प्रोजेक्ट शामिल हैं और ये प्रोजेक्ट विभिन्न अनुसंधान और विकास संगठनों जो सरकारी और निजी दोनों क्षेत्रों के हैं के लिए सफलतापूर्वक प्रोजेक्टों का कार्य पूरा किया जा चुका है।

ENGINEERING MATERIALS

The division of Engineering Materials is actively engaged in the material, process and technology development for components, devices and systems, in a variety of areas. These materials, for high performance and strategic applications, include aerospace metallic materials, composites, advanced carbon products, and electro-optical and opto-electronic devices including liquid crystals, health care and monitoring devices.

There exists an excellent infrastructure, expertise and trained manpower in the areas of materials development and sophisticated characterization facilities. Several developmental projects including sponsored, grant-in-aid, collaborative and consultancy projects have been successfully completed for different R&D organizations, both in public and private sectors. There had been close interaction in various areas of materials development with advanced countries.

Metals & Alloys

Development of Oval Shaped Tube, as Skid Landing Gear for Advanced Light Helicopter - Phase II

The second phase of the HAL sponsored project is to develop 2024 Al-alloy oval shaped bent tubes, to be used as Skid Landing Gear, in Advanced Light Helicopter. The project is under the weight reduction and indigenization programme of HAL. Phase I of this project was successfully completed last year and six numbers of actual sized Al-alloy oval shaped tubes (150mm major axis X 100mm minor axis X 3mm wall thickness and 5meter long) were developed, achieving the desired dimensional tolerances as specified by HAL. These tubes were inspected by the officials of Helicopter Division of HAL. The Phase II of this project, involves solutionizing the 5m long oval shaped tubes (developed in the first phase of the project), followed by quenching and finally giving a 1 ~ 2 % cold draw on a draw bench to achieve T3 condition. These tubes are then required to be bent on the front end, achieving a radius of 800R, using a special tube bending machine.

Bending of Al-alloy oval shaped tubes on its major axis is a challenging job, as there is a significant differential in arc length between the inner and outer arc of the bent tube. On the outer contour of this bent tube, the material flows leading to reduction in wall thickness, while on the inner contour of the tube, the excess material results in wrinkles. An oval shaped tube bending machine , which was conceptualized, designed & fabricated at NPL , was used to do the bending trials on the major axis of oval shaped tube (Fig 3.1).

The trial experiments on bending these tubes on the tube-bending machine indicated that wrinkles were observed on the inner contour of the oval shaped bent tubes. Although these wrinkles were drastically reduced by optimizing the tube-bending process parameters, they could not be totally eliminated. It was ensured in each experimental tube-bending trial that the bending of the tube was completed within 30 minutes of the quenching treatment of the tubes as specified. This unit had to be modified by incorporating a special hydraulic cylinder, special fixture and by incorporating a modified hydraulic power pack to achieve very fine speeds. Speed control is the most critical feature to obtain low strain rates required for bending this special contoured aerospace material on its major axis.

After making lot of trial runs and optimizing bending process parameters, it was finally possible to obtain wrinkle-free oval-shaped tubes (in annealed condition) bent to the desired radius of 800R. All these trial runs were made on dummy commercial grade Al-alloy tubes (locally procured from the market) and first by converting them into oval-shaped tubes and finally bending these to the desired radius. About 20-25 nos. of these dummy commercial grade Al-alloy tubes were employed in making these bending trial runs. After all these developmental efforts in achieving a wrinkle-free

Fig. 3.1 : Hydraulically operated oval shaped tube bending machine with bent oval tube of Al alloy in annealed condition

oval shaped bent tubes, the work was extended in bending the actual 2024 Al-alloy shaped tubes in annealed condition by fine tuning the bending process parameters already optimized for dummy commercial grade Al tubes.

Efforts are presently underway to heat treat these long tubes and then give a cold bend using the above mentioned equipment. The last phase of this developmental work, on heat treated tubes, is still in progress.

Spray Forming for Mg-alloys

The main objective of this project is to develop the process for spray forming of Mg-alloys AZ31 (Mg-Al-Zn) followed by secondary processing of these as-sprayed deposits using hot forging to produce block with target properties.

The main driving force for the development of Mg-alloys using spray atomization and deposition technique, is to synthesize lighter materials with better microstructural features leading to higher specific strength and stiffness for aerospace and other general engineering applications. The main advantage of Mg-alloy synthesized employing rapid solidification and using spray atomization and deposition technique is that they possess fine and reduced grain size with refined and equiaxed microstructure with no indication of dendritic features associated with conventional cast alloys. The other advantage is that the inert conditions required for atomization and deposition minimizes surface oxidation and other deleterious surface reactions to which Mg-alloys are generally prone. Spray deposition of Mg-alloys is a challenging job, primarily because of their extreme reactive nature owing to their strong affinity for oxygen and moisture.

Some exploratory work was carried out to spray deposit Mg-Al-Zn alloys using Spray Atomization and Deposition unit. After lot of experimental trials and by incorporating several modifications in the spray atomization and deposition unit, it has now been possible to successfully spray deposit Mg-alloy by disintegrating the liquid melt by a stream of high velocity gas jets and depositing the atomized droplets on a copper substrate. Using Argon as the atomization gas and atomizing in an inert atmosphere, it has been possible to eliminate the formation of the undesired MgO phase, as suggested by the X-ray diffraction results.

The as-sprayed deposits of these alloys have a fine-grained equiaxed microstructure with a grain size of 40-60 microns with no indication of dendritic features. The average density in the as-sprayed Mg-alloy deposits was found to be about 93% of the theoretical density, in the core of the deposit. Typical yields of the as-sprayed deposits were found to be in the range of 60-65% of the weight of the melt. Figure 3.2 shows a typical scanning electron micrograph of the over-sprayed powder of Mg-alloy obtained at a melt temperature of 800°C and with gas atomization pressure of 1.2 MPa. It is evident form this figure that the Mg-alloy atomized particles are perfectly spherical in shape with an average size of about 15 to 20µm although some fraction of smaller grains (2 ~ 3µm) is also present. Efforts are presently underway to optimize the process parameters in order to improve the yield and reduce the grain size of the as-sprayed deposit.

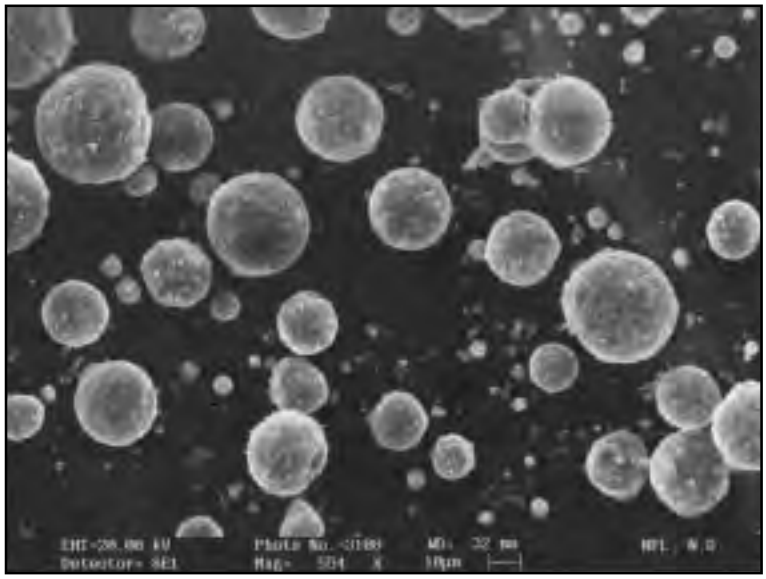

Fig. 3.2 : Mg-alloy over sprayed powder developed by SEM

Development of Aluminium based Alloys using Rapid Solidification and Employing Spray Atomization and Deposition Technique

Work was continued to synthesize Aluminium-alloys using spray atomization and deposition technique. A few spray deposition experiments were carried out using Al-Cu-Mg alloys mainly to check the reproducibility of the shape of deposits and their resultant microstructures.

Work was extended to spray-deposit commercial grade Aluminium in conical and flat shapes by varying the spray forming process parameters (temperature and flight distance), in order to study their effect on the size, shape of deposit and the resulting microstructure. It was found that these processing parameters have a significant effect on the shape of the as-sprayed deposits. This work is still in progress and will be extended to study the effect of other processing parameters on the shape, microstructure and yield of the as-sprayed deposits.

Al-Si alloy is an important alloy due to its high wear resistance, low coefficient of thermal expansion and high thermal conductivity. This makes it suitable for automobile application. Exploratory studies were made to spray-deposit Al-Si alloy (Si ~ 12%), using spray atomization and deposition unit. It was observed that in the as-sprayed deposits, although the porosity was quite high (about 13-15%) but finely grained necklace-type microstructure was observed. Optical and scanning electron microscopy (with EDS) results indicated that on spray-forming, the dendritic microstructure of the parent alloy (cast Al-Si) completely breaks down and a necklace-type microstructure evolves with matrix Al-grains (50-70 microns) and fine grained Si (3-7 micron), preferentially nucleated on its grain boundaries. This work is currently underway to optimize spray-forming processing parameters in order to reduce the grain size and the porosity of the as-sprayed deposit and increase the yield of the process.

Hot Extrusion of Mg-alloy (ZK30) Light Weight Inserts

This exploratory work was carried out to develop Mg-alloy - ZK30 (Mg-Zn-Zr) light-weight inserts for possible usage for aerospace applications, jointly with VSSC, Trivandrum. Various extrusion process parameters, like extrusion temperature, extrusion ratio, ram speed, lubrication etc, were optimized to obtain acceptable quality products. These Mg-alloy extruded rods have been supplied to VSSC, Trivandrum for further characterization and evaluation.

Advanced Carbon Products

Development of Carbon-Ceramic Composites

Work was continued on the "Development of carbon-ceramic composites" by incorporating SiC and B_4C in the NPL-developed green coke. The composites were heat-treated to 1000–2200°C and then characterized for their physical, mechanical and oxidation resistance properties. By changing ceramic components and contents, the carbon-ceramic composites were obtained which exhibited a weight loss of < 0.5% at 800 °C, 1–6% at 1000 °C and 4–10 % at 1200 °C. Work is continuing to obtain C-SiC-B_4C composites with further improved oxidation resistance.

Development of Pitch -Based Carbon Monofilament

Studies were continued to improve the strength, flexibility and handleability of the pitch-based carbon monofilament in the green stage under the on-going ARDB-sponsored project. Having already tried some polymers (as additives in suitable precursor pitches), namely, high density polyethylene, polypropylene, polyvinyl chloride, polystyrene, high impact polystyrene, polymethy lmethacrylate for this purpose, efforts were made to use other polymers, namely, polyphenylene oxide (PPO) and polycarbonate (PC). It was observed

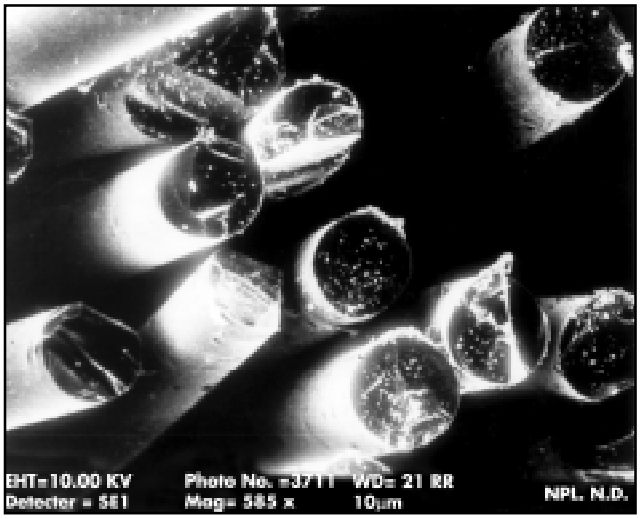

Fig. 3.3 : SEM photograph of carbon monofilaments based on pitch modified with 20% polycarbonate

that the addition of PPO deteriorated the spinnability of the resultant pitch while that of PC (10–20 % by wt. of pitch) not only maintained the spinnability but also caused a 10–14 times increase in the tensile strength (TS) and 5–10 times increase in the tensile modulus (TM) along with a slight increase in the strain-to-failure, thus improving remarkably the handleability of the filaments in the green stage. The resultant carbonised monofilaments also exhibited a considerable improvement in the mechanical properties as evident from a TS of 2180–2320 MPa, TM of 170–190 GPa and a strain-to-failure of 1.3–1.4%, as against corresponding values of 1690 MPa (TS), 160 GPa (TM) and 1.06 % (strain-to-failure) obtained without the addition of PC. The SEM studies revealed single phase in the carbon filaments developed from PC-modified pitches, as seen from Fig. 3.3.

Development of High Thermal Conductivity Graphite

Extensive work was carried out under the on-gong IPR-sponsored project on the "Development of high thermal conductivity special graphite for first-wall component of SST-1 tokamak". Since the green coke based graphite made using the isostatic pressing was found to meet all these specifications except the thermal conductivity, wherein a value of 77 W/mK as against the threshold value of 90 W/mK was obtained, efforts were concentrated on the modification of the green coke by the addition of natural graphite. Finally, an isostatically-moulded green coke based special graphite (HTT = 2600 °C) was successfully developed by the modification of green coke with the addition of 16-21% of natural graphite. This graphite possessed all the characteristics surpassing their targeted values, including thermal conductivity where a value of 105 W/mK was obtained. The project was thus successfully completed.

Feasibility Studies of Petroleum Streams as Precursor for High Performance Carbon Fibres

Work was continued under the project entitled, "Feasibility studies of various petroleum refinery streams as precursor for high performance carbon fibres", sponsored by the Indian Oil Corporation R&D Centre, Faridabad. Out of the five streams short-listed by us for this purpose and supplied by the IOC, namely, Short Residue, Residual Fuel Oil, Blue Oil Extract, Clarified Oil and Coker Fuel Oil, the Residual Fuel Oil (RFO) was adjudged to be the best stream, as it exhibited the highest value (11.7%) of overall coke yield obtainable from any of these streams. Attempt was made to develop general-purpose carbon fibres using a pitch derived from RFO stream. A number of experiments involving condensation, polymerization and distillation under nitrogen and / or reduced atmospheric pressure conditions were performed to develop a QI-free high softening point (SP) (200-250 °C) precursor pitch using a standard (SP = 125 ± 10 °C) RFO-based pitch alone or its 1 : 1 blend with a QI-free (≤ 0.5%) coal tar pitch. Finally, two high softening point pitches were obtained – one from RFO-based pitch alone possessing a SP of 213 °C and a QI of 1.4 %, and the other from its blend with a suitable coal tar pitch, which was found to have a SP of 231 °C and a QI of 0.4 %. However, the former pitch did not spin well probably due to a high QI content of 1.4 %, while the latter pitch exhibited a good spinnability and led to carbon fibres (18µm dia.)

possessing a tensile strength of 1676 MPa, tensile modulus of 211 GPa and a strain-to-failure of 0.8 %. The project was thus successfully completed.

Upscaling of NPL's Technology of High Density Graphite

A consultancy project relating to the upscaling of NPL's green coke based high density - isotropic graphite technology, sponsored by M/s. Graphite India Ltd., Bangalore, was undertaken. The consultancy was provided to the firm in respect of raw materials, type of reactor, heat-treatment conditions, fine grinding equipment, and testing and characterization of the green as well as carbonised final graphite w.r.t. physical and mechanical properties.

Development of Silicon Carbide Whiskers

Silicon carbide whiskers (SiCw) are employed in the development of ceramic matrix composites and metal matrix composites due to their superior mechanical and thermal properties. Efforts were made to synthesize SiCw from coconut fibres (an agrowaste material). Since the silica content in coconut fibres is very low (~3 %), attempts were made to impregnate the coconut fibres with silica through sol-gel process. The coconut fibres, which contain around 30% of carbon, were impregnated with the sol derived by hydrolysing tetraethoxysilane (TEOS), methyltriethoxysilane (MTEOS) and dimethyldiethoxysilane (DMDEOS) and then pyrolyzed at 1400 °C in an argon atmosphere. X-ray powder patterns of the pyrolyzed samples showed the formation of β-SiC. SEM micrograph given in Fig.3.4 shows the formation of SiCw.

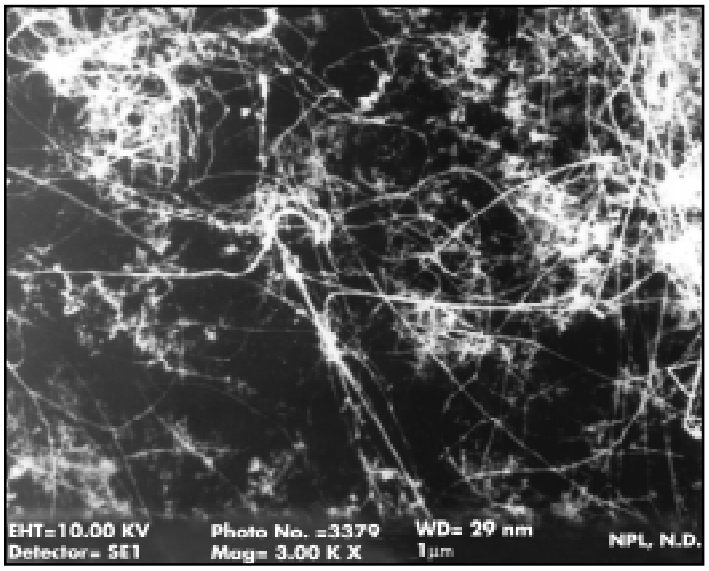

Fig. 3.4 : SEM photograph of SiC whiskers

Synthesis of Carbon Nanotubes and their Application in Composites

Systemetic studies were undertaken to produce carbon nanotubes using D.C. arc discharge reactor. Various process parameters such as gas pressure, nature of the gas, arc current and voltage, nature of graphite electrodes, catalysts or the combination of these two, were studied in detail using the deposits collected from the cathode and from the chamber wall.

These carbon nanotube samples were characterized using SEM, TEM, TGA and Raman analysis. Raman spectra of the as prepared carbon soot showed the presence of single walled carbon nanotubes(SWNT) with different diameters corresponding to breathing modes in the frequency range 100–200 cm^{-1}. This is further confirmed from TGA, SEM and TEM studies. TEM micrograph shows the presence of both SWNT and MWNT (Fig. 3.5) in the carbon soot. Studies were also initiated to purify the carbon deposits by removing catalyst particles, nanostructured carbon and amorphous carbon produced along with the nanotubes, especially in the chamber by different techniques.

Asbestos Free Brake Materials for Automobiles – Tailoring, Characterization and Evaluation

Under the DST sponsored project, this activity was continued to arrive at an optimum composition of brake pad material (binder resin, reinforcement,

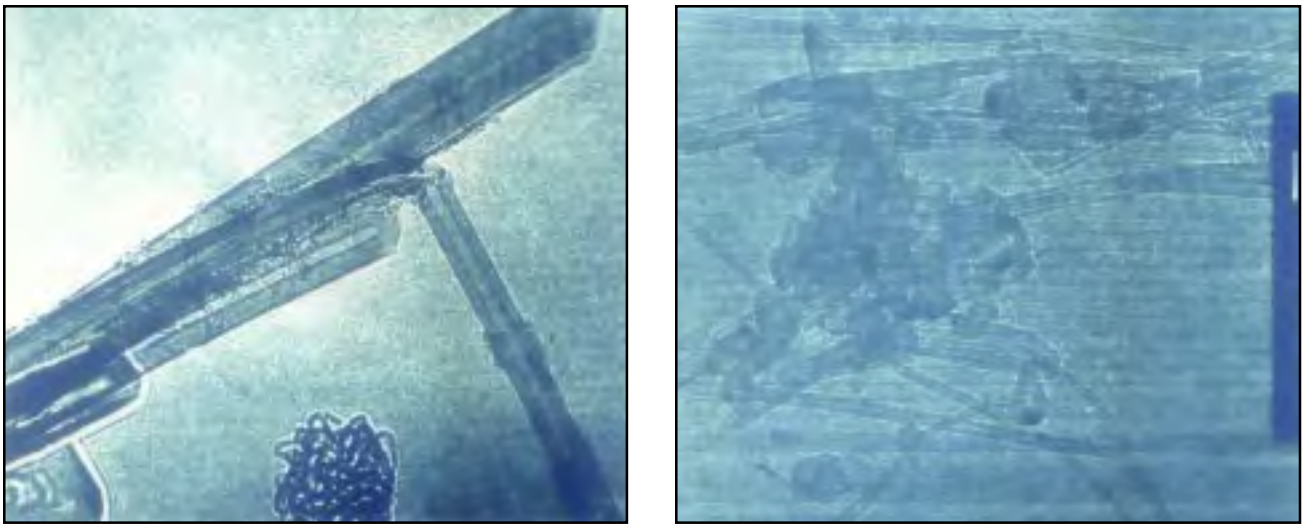

Fig. 3.5 : HRTEM of multi walled and single walled carbon nano tubes

friction modifiers and fillers). Samples, which met the desired characteristics in terms of physical and mechanical properties, were supplied to ITTMEC, IIT, Delhi, for their tribo-performance. Coefficient of friction was in the expected range of 0.2 to 0.3 and remains almost constant for the entire duration of number of braking cycles (500). The average wear of the samples was found to be in the range of 0.016-0.058% wt. loss at loading of 19-26 Kg/cm2. The optimum composition of friction material was found to be Phenolic resin 20%, Glass Fiber 6%, Friction modifier (CD-16) 10%, Cu powder 10%, Barium Sulphate 22% and Talc 32%.

Development of Carbon Fibre Reinforced Ceramer Matrix Composites

The polymer ceramic hybrid, known as ceramer, was synthesized by sol gel process by incorporating different types of alkoxides as source of silicon in resorcinol formaldehyde resin in the presence of basic catalyst. Unidirectional composites prepared with ceramer matrix with high strength carbon fibers show lower value of flexural strength at polymer stage as compared to those prepared with resorcinol-formaldehyde resin as matrix. However, after heat treatment at 1450°C, the ceramer matrix composites show significant improvement in the mechanical properties(100% increase in FS & 40% in FM) as compared to resorcinol formaldehyde resin matrix based composites . Best results were obtained when silicon content in the ceramer was 7 %. This work was undertaken to overcome the drawback of low strain-to-failure and large carbonisation shrinkage of the carbonaceous matrix derived from thermosetting and thermoplastic resins generally used in C/C composites. Resorcinol formaldehyde resin was modified by incorporating ceramic network.

Role of Matrix Precursor in the Development of High Thermal Conductivity Carbon-carbon Composites

Work under joint Indo-UK collaborative project(UISTRF) with University of Leeds was continued and various carbon/carbon composites developed at NPL were characterized for their microstructure and physical,thermal and electrical properties using different techniques.

Thermal conductivity('K') was found to be influnced by microstructure of matrix carbon as well as that of reinforcement (PAN or Pitch based CFs) and the processing conditions. 'K' of Pitch based carbon fibers and modified coal tar pitch / mesophase pitch based matrix composite was found to be higher(128 & 98W/mK) than that of PAN based fibers and coal tar pitch or

modified coal tar pitch based composites(25-30W/mK) which is mainly due to graphitic nature of matrix carbon generated from modified coal tar pitch / mesophase pitch. This is further confirmed from crystallite dimensions determined through X-Ray diffractrometry which increased from 31, 20.46 nm (L_a, L_c) to 45.2, 22.41 nm (L_a, L_c) in case of pitch based CFs. A general correlation exists between electrical resistivity and 'K' of CFs but in case of C/C composites the co-relation was found on a broader scale. Attempts were made to develop VGCF based composites(VGCF 'K' being 2000 W/mK) but no wetting was observed between VGCF and matrix carbon .

Development of Porous Conducting Carbon Paper

Studies were continued under the project sponsored by NMRL, Ambernath (DRDO) to develop porous carbon conducting paper for fuel cell. Test samples of size 10cm x10cm were prepared for unit cell trials at NMRL and the results were found to be highly encouraging. A complete design of the filtration unit to make chopped carbon fibre preform of size 40 cm X 40 cm was made and got fabricated and commissioned at NPL. Some teething problems observed during trial runs were overcome and 6 sample preforms were prepared and supplied to NMRL for evaluation.

Development of High Density, Isotropic and Radiationally Stable Carbon Precursors

Under this activity, composites with a density of 1.35 g / cm^3 comprising 20% PAN (chopped) based CFs as reinforcement and phenolic resin as matrix were concluded to serve the requirements of BARC. These composites even on heat treatment to 2600°C remain non-graphitic with degree of graphitisation being 2-3 %. This was further confirmed through optical microscopy, which showed very little anisotropic regions. Samples consisting of 50% chopped CFs (PAN) and phenolic resin were found to graphitise on HTT 2600°C even though PAN CFs and phenolic resin are well known to give hard carbons (non-graphitic in nature). This observation led to development of a new method to graphitise non-graphitic (hard) carbons.

High Pressure Technology

Low Pressure Synthesis of Cubic Boron Nitride by means of Supercritical Fluids

Efforts were made to replace liquid ammonia with a solid compound which when heated released ammonia gas in the reaction capsule. Hexamine cobalt (III) chloride and ammonium fluoride were identified as such compounds. It was observed that cBN conversion takes place at 60kb, 1300^{0}C and 55kb, 1300^{0}C in case of hexamine cobalt (III) chloride and ammonium fluoride respectively.

Polymeric & Soft Materials

Liquid Crystals/ Display Devices

The ferroelectric liquid crystals have been extensively studied due to their interesting basic and applied aspects since its discovery as these materials have considerable advantages over nematic liquid crystals in display applications. The most widely studied liquid crystal displays based on ferroelectric liquid crystals are the surface stabilized ferroelectric liquid crystals (SSFLC), in which all the molecules are aligned parallel to the substrate and helix is suppressed by means of a binding glass substrate. The bistability is an inherent property in this configuration. Typical SSFLC devices or cells require long-pitch liquid crystal materials and narrow cell gaps.

Recently, at NPL, research on other types of ferroelectric liquid crystal materials, called distorted helix (DHFLC) and electro-clinic ferroelectric liquid crystal materials is being carried out extensively for its basic and applied aspects. Distorted helix ferroelectric liquid crystals are in many ways

complementary to the SSFLC effect and uses short-pitch FLC materials where the Smectic planes are perpendicular to the glass substrates of the cell. It has no inherent bistability. DHFLC exhibit no inherent optical threshold voltage and so gray scale can be easily obtained by using these materials. An interesting phenomenon of stability (memory) effect has been observed in DHFLC materials. The memory effect in DHFLC materials is exploited in the optically addressed spatial light modulators (OASLM) and seems to work SLM devices in the memory mode. The dynamic aspect of memory effect in DHFLC materials is being carried out at NPL.

Ferroelectric liquid crystals with considerably wide range of Sm A phase and showing strong electro-clinic effect are known as electro-clinic ferroelectric liquid crystals. It has become of increasing interest in the last few years due to its ultra fast nanosecond response time as compared to the ferroelectric liquid crystals. Symmetry arguments predicting ferroelectricity in the chiral tilted smectics (Sm C*), describes the origin of electro-clinic effect (Sm A) as composed of chiral molecules. In case of orthogonal chiral Smectic (Sm A) phase, the application of an electric field parallel to smectic layers, biases the free rotation of the molecules and produces a non- zero average of the transverse component of the molecular polarization. When such a dipole moment is present, a tilt of the long molecular axis (the director) is induced in plane perpendicular to dipole moment. Such effect is termed as electro-clinic effect and the materials are called as electro-clinic liquid crystals. It also gives the possibilities of gray scale generation due to almost linear relation between induced tilt angle and applied electric field. The switching and molecular dynamics of electro-clinic liquid crystal materials is being studied in detail by electro-optical and dielectric relaxation methods at NPL.

Bio Molecular Electronics

Preparation and Characterization of Conducting Polymers

A conducting poly (aniline-co-fluoroaniline) has been prepared by chemical and electrochemical methods in acidic medium. Characterization was accomplished by various techniques such as UV-visible, FTIR spectroscopy, differential scanning calorimetry, thermal gravimetric analysis, X-ray diffraction and scanning electron microscopy techniques respectively.

Development of Biosensors

A glucose biosensor based on polyhexyl thiophene Langmuir-Blodgett films has been fabricated. These films have been characterized by various techniques such as UV-visible, FTIR, X-ray diffraction techniques. The films have been found suitable for glucose estimation from 100 mg/dl to 500 mg/dl (Fig 3.6).

Uric acid biosensor has been fabricated by immobilizing uricase on conducting polyaniline films

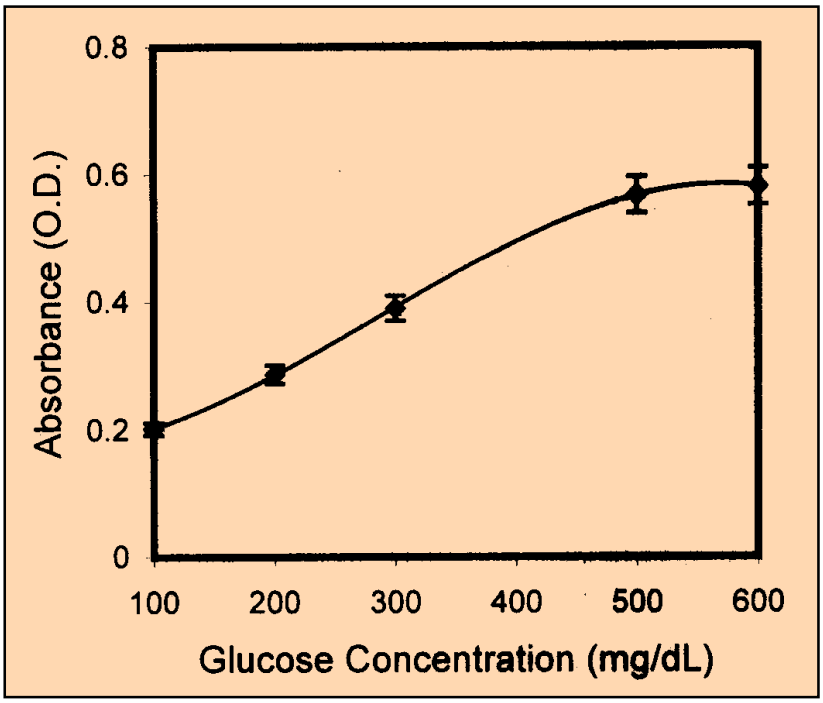

Fig. 3.6 : UV-visible spectrum of P3HT/SA/GOX LB electrodes at different concentration of glucose solution

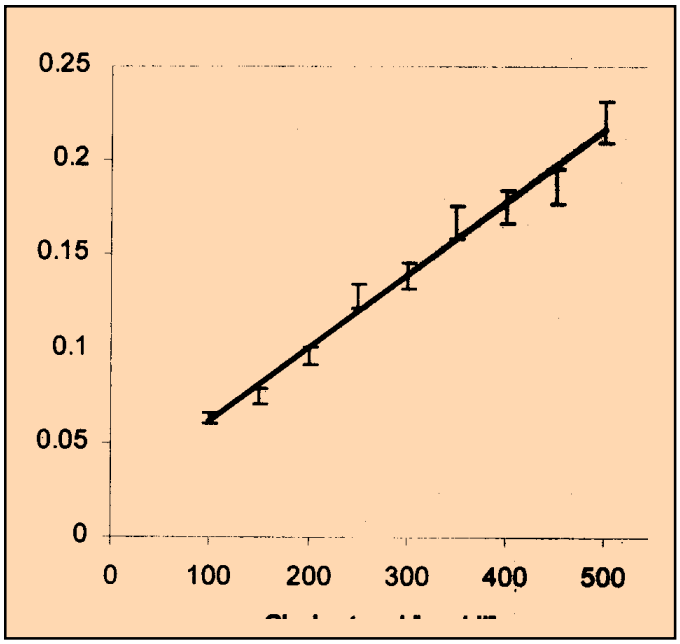

Fig. 3.7 : Effect of cholesterol solution concentration on PPY-ChOx electrode

for estimation of uric acid concentrations. The enzyme electrode was fabricated by electrochemical technique. Effect of pH and applied potential on the response of the enzyme electrode was systematically studied.

Lactate biosensor has been developed by the immobilization of lactate oxidase (LOD) and lactate dehydrogenase (LDH) on its conducting polyniline (PANI) films. The PANI/LOD/LDH bienzyme electrode has been shown to provide signal amplification by substrate recycling to detect lactate at lower concentration viz. 0.1-1mM.

DNA biosensor has been fabricated by absorption of DNA on to the electrochemically prepared polypyrrole-polyvinyl sulphonate films and the adsorption characteristics have been studied as a function of pH. Characterization of adsorbed DNA onto the PPY-PVS films was carried out by UV-visible, FTIR and cyclic voltametric techniques.

Cholesterol biosensor has been developed using cholesterol oxidase (COD) by electrochemically entrapment within the polypyrrole films during the process of electrochemical polymerization onto the Pt disc electrode. The attempts were made to characterize the enzyme electrode and effect of cholesterol concentration, applied potential, pH, temperature and storage time on the response of the PPY/COD electrodes were systematically studied. Fig. 3.7 shows the response curve of the PPY/COD electrodes as a function of cholesterol concentration.

Development of Polymeric Sensors and other Electronic Materials / Devices

The development of semiconductive polymeric thin films for fabrication of sensors for detection of pathogenic and non-pathogenic microbes was continued. The project was funded by Ministry of Environment & Forests, Govt. of India. The nanocrystalline copolymers of aniline and formaldehyde with a variety of doping for fabrication of fast response polymer based sensing devices have been prepared by a chemical process. Fig.3.8 shows the effect of exposure to E Colli.

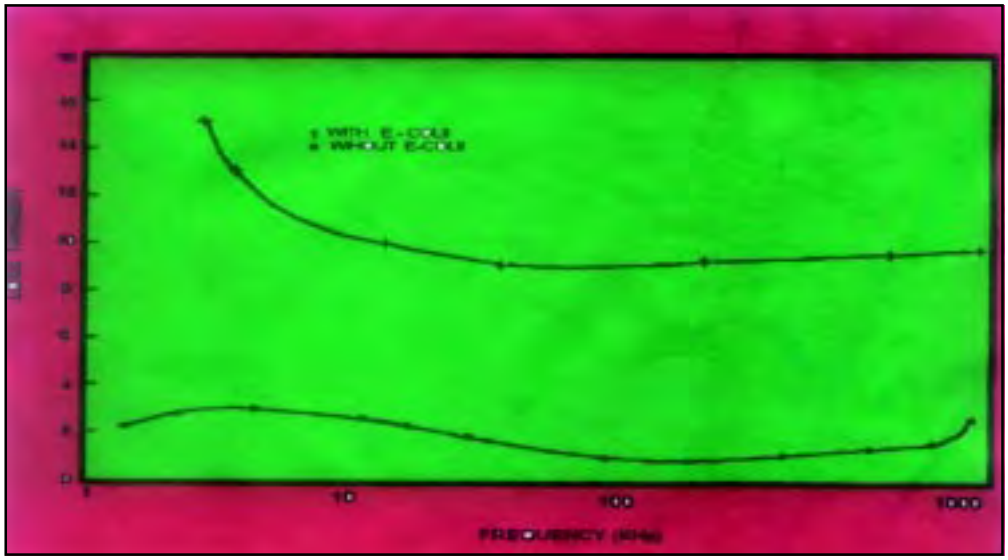

Fig. 3.8 : Effect of exposure to E.Colli

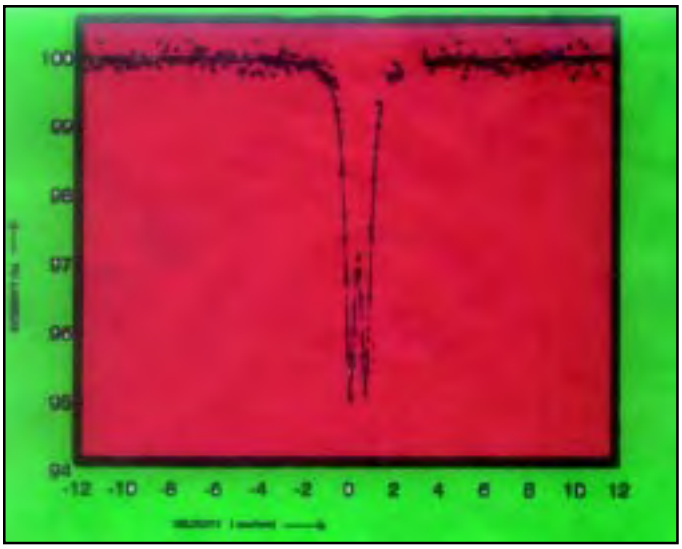

Fig. 3.9 : Mossbauer spectra of magnetic polyaniline thin films

Recently significant advances have been made in the development of materials, possessing smart and intelligent functions of magnetic data storage and capable of handling highly specific requirements from information technology sector. This has led to the synthesis of a variety of combinations of magnetic materials, inorganics, alloys and magnetic polymers and composites having large data storage capacity. The characterization of such thin films by optical absorption, SEM, X- ray has been done. These studies suggest that vacuum deposited magnetic polyaniline thin films are suitable for magnetic data storage device fabrication. The optical absorption, ESR/EDMR study indicates presence of magnetizable domains in thin films. The Mossbauer spectra of magnetic polyaniline thin films is shown in Fig.3.9.

In continuation of the UISTRF sponsored work on development of polymeric optoelectronic devices the polymeric thin films of higher molecular weight polymethylmethacrylamide, substituted with polarizable p-amino benzophenone pendant side groups which may be oriented by several techniques, have been prepared. The collaborative program progressed well with preparation of electrooptically non-linear polymeric thin films from various polymers. The second order optical non - linearity was assessed by the Maker fringe method with a 1064 nm fundamental wavelength and the $d_{effective}$ was calculated as 0.4 pm V^{-1}. Fig. 3.10 shows the maker fringe analysis of dispersed orange doped polymethylmethacrylate film, upper trace poled and lower trace unpoled. The optical bandgap of these films was determined from the reflectance spectra.

Xeroradiography

Under the DST sponsored project entitled "Development of a portable analytical x-ray imaging instrument for biomaterials", a laboratory prototype, portable x-ray imaging instrument has been developed. The instrument was demonstrated to the expert committee from DST. As a result, a demonstration meet was organised where participants from industries and potential users from biomaterial areas, such as, veterinary, forensic, industrial non-destructive testing participated.

Work was also undertaken to develop new and improved x-ray sensitive imaging materials using new concept of polymer interface layer in xeroradiography photoreceptors. The effect of PVF interface layer on

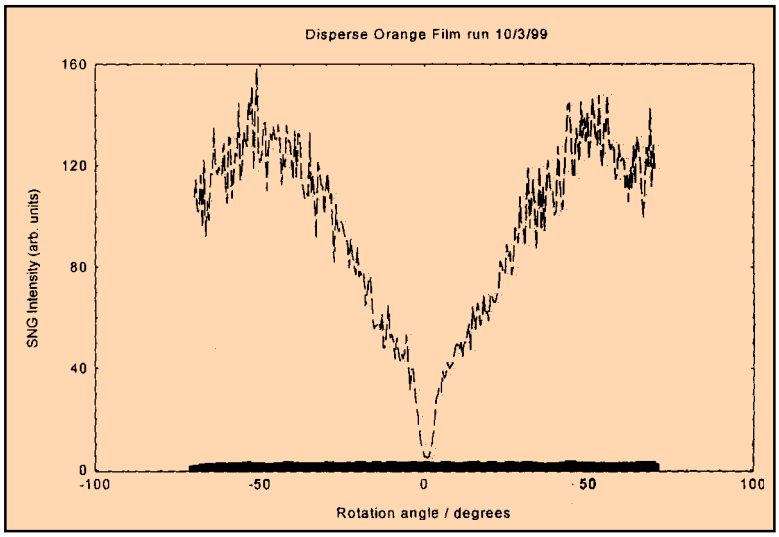

Fig. 3.10 : Maker fringe analysis of disperse orange doped polymethylmethacrylate film (10% w/w, upper trace poled and lower trace unpoled)

charge storage/ built up of residual potential in a-Se films was studied using thermally stimulated discharge current (TSD) technique. It was found that incorporation of PVF interface layer with a-Se reduces considerably the built up of residual potential in it. This effect was attributed to the blocking and field enhanced mobility role of PVF interface layer. Subsequently the effect of PVF interface layer was investigated on x-ray sensitivity of a-Se films and encouraging results were found with the incorporation of the interface layer. Detailed investigations, using the concept of polymer interface layer, are in progress.

Conducting Polymers

Conducting polymers have emerged as an important class of electronic materials because of their potential and technological applications in opto-electronic devices, organic light emitting diodes (OLED), electromagnetic interference (EMI) shielding, corrosion preventive coatings, super capacitors, sensors and in energy storage systems. They acquire importance over inorganic semiconductors and metals in their applications because of high strength to weight ratio, toughness, low cost and ease of designing.

The processing and solubilization of conducting polymers are still the major unsolved problems from scientific and industrial point of view. To solve the unprocessible nature of these conducting polymers, emphasis had been made to obtain conducting polymer composites by blending conducting polymers with conventional polymers like polystyrene, polymethyl-methacrylate, HIPS, ABS etc. so that the resultant composites retain the electrical properties of conducting polymers and the mechanical strength of insulating polymers. The resultant conductive composite can then be effectively used as a protective sheath for EMI shielding in radio frequency range, microwave range and mm range.

Conducting polymer composites with PS, PMMA and ABS have been designed and melt blended in the temperature range 180-220oC. These conducting composites can be effectively used for the dissipation of static charge. A 2 % loading of the conducting polymer in the PS matrix gives a static decay time of 0.02 seconds whereas in PMMA-conducting polymer composites, a static decay time of the order of 0.09 to 0.11 seconds is observed. Conducting polymer composites shows a shielding effectiveness of 20-58 dB against electromagnetic interference in the frequency range 101 GHz, depending upon the loading of the conducting polymer in the host matrix like polystyrene and poly methylmethacrylate. Conducting polymers synthesized in the laboratory can find applications in organic light emitting diodes (OLEDs) displays.

Copolymers of aniline and its analogues have been synthesized which can be used for the prevention of corrosion. The copolymer when applied on iron and mild steel surface can be used as a protective coating in hostile saline corrosive atmosphere, HCl and neutral water.

Organic Light Emitting Diodes

Organic electroluminescence is the property of certain organic compounds to emit light on application of an electric field. This property is used in the fabrication of Organic Light Emitting Diodes. There are two types of OLEDs that are very popular which are based on small molecules and polymers. The class of polymeric materials for which metallic and semiconductor characteristics can be observed are conjugated polymers. These are polymers possessing a de-localized pi-electron network along the polymer back bone: the delocalized pi-electron system confers semiconducting properties to the polymer and gives it the ability to support positive and negative charge carriers with high mobility along the polymer chain. There are so many ways to synthesize conjugated polymers by chemical and electrochemical techniques.

At NPL, substituted poly-paraphenylenes based on benzene and its analogues like naphthalene, anthracene and pentacene have been synthesized by Kovacic's method. It was observed that the resultant polymer is soluble in common organic solvents like benzene, toluene etc. and is fluorescent and shows electroluminescent behavior. The polymer has been characterized by using FTIR, UV-Visible absorption

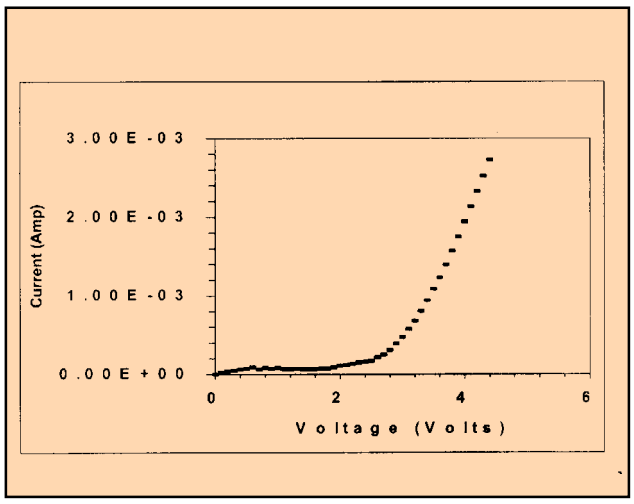

Fig. 3.11 : I-V Characteristics of co-polymer device (Active area = 4mm²)

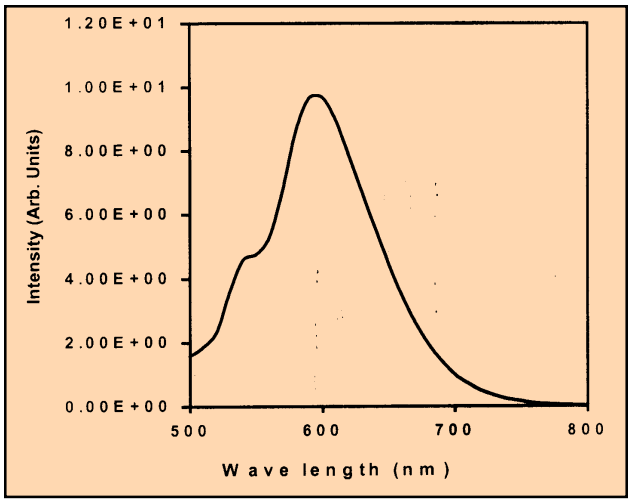

Fig. 3.12 : Photoluminescence (PL) spectra of copolymer Benzene and Naphthalene

spectroscopy, thermogravimetric analysis and photoluminescence spectroscopy. A device based on co-polymer of benzene and its analogue emit orange light on application of 5V DC, and the results are shown in figs 3.11 and 3.12.

Device fabrication involves the following four steps:

1. A patterned array of optically transparent conducting ITO electrode is made, which acts as a good hole injecting contact to semi-conducting organic materials.
2. A thin layer (transverse dimension ~ 1000A°) of luminescent conducting polymer is spin cast onto the prepared substrate coated with transparent electrically conducting film. Alternatively semi conducting molecular solid / polymer can be vacuum deposited on an ITO substrate.
3. On top of the coated polymer film an electron injecting strip electrode of a low work function metal is deposited (e.g. calcium or magnesium) under high vacuum. Typically a protective overcoat of a relatively non-reactive metal is deposited over these strips before the final encapsulation step.
4 A protective back cover is fixed to the open surface of the device structure using an appropriate adhesive. The cover is cut smaller than the substrate so that the row and column electrodes can extend beyond the cover to allow connections to the external drive circuitry.

The devices so far fabricated in the OLED lab shows red, orange and green electro-luminescence and further studies are going on to achieve blue and white electro-luminescence and to improve the life of the device by proper encapsulation.

Process for the Chemical Silvering of Plain and Hollow Bodies

Most common method used for silvering various types of objects (hollow and plain glass surfaces) is by glucose, which is used for converting silver nitrate to silver. This in turn gets deposited on the surface, but in the process approx. 40% silver goes as sludge in the solution which is to be recovered later on. In recovery, 20% silver goes waste. Furthermore, adherence of the film is also not very good and it is not very bright. It is thus difficult to control the thickness. This is mainly as the rate of reaction is faster than the rate of deposition on the surface of the substrate. The process is being used for the manufacture of vacuum flasks, Dewar flasks, hollow bodies, silvering of mirrors, electric bulbs and objects where controlled coating of silver is required. We have developed a solution (in place of glucose / fructose) which has following advantages:

- More than 99.5% efficiency (in terms of silver consumption).

- Good adherence of the film.
- Highly bright and uniform coating.
- Thickness of the film can be controlled.
- No silver sludge formation (no need for silver recovery).
- Wide range of working temperature, 8-45°C.

Liquid Crystalline Materials & Devices

A Novel Non-rubbing Photo-alignment Technique to make Twisted Nematic Liquid Crystal Display Cell

One of the primary requirement for fabricating a twisted nematic (TN) liquid crystal display cell is to produce planar orientation of the liquid crystal molecules on the two bounding surfaces with direction of orientation being orthogonal to each other. A variety of techniques have been developed to produce uniform planar orientation of liquid crystals with a precise control on the surface tilt angles. They include angular deposition of dielectric materials, surface-coupling agents, polymer coating followed by buffing, photo alignment techniques etc.

In all hitherto published literature on making a twisted nematic display, direction of planar orientation on the two substrates is controlled separately and the two substrates are subsequently so assembled as to have orientation direction orthogonal to each other. We have developed photo alignment techniques to produce planar orientation of liquid crystals wherein the direction of preferred alignment could be either parallel or perpendicular to the polarized light.

A new concept to produce twisted nematic display has been developed based on single shot photo-irradiation of the photo-coated substrates. The two substrates treated with two different kinds of photo alignment materials have been used to make a cell such that one of them produces planar orientation direction parallel to, and the other one produces planar orientation perpendicular to the electric field vector of the linearly UV-polarized light. Such a sealed cell on irradiating with linearly polarized light produces planar orientation on the two substrates, which is orthogonal to each other. This way one is able to meet the primary requirement for making a twisted nematic cell on the two bounding substrates by single shot photo irradiation. The surface tilt angle can be controlled by slanted photo irradiation. The twisted nematic liquid crystals cells with high contrast ratio have been prepared. Figure 3.13 shows one such twisted nematic cell produced by the above-defined technique.

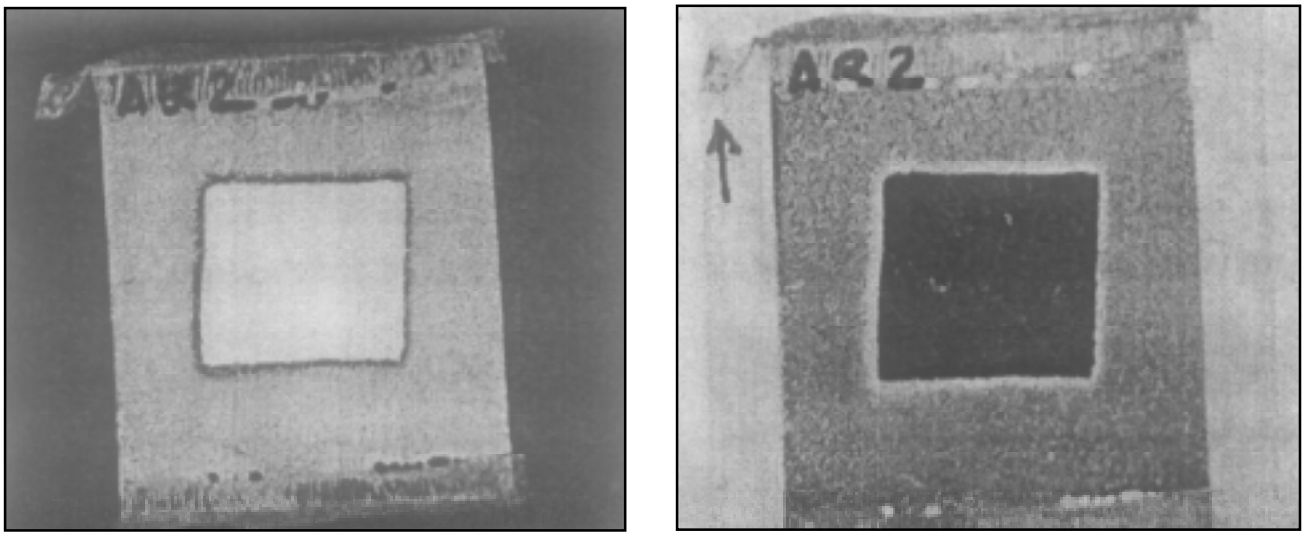

Fig. 3.13 : Twisted nematic cell between crossed and parallel polarizers

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इलेक्ट्रॉनिक पदार्थ

ELECTRONIC MATERIALS

इलेक्ट्रॉनिक पदार्थ

इलेक्ट्रानिक सामग्री का विकास पिछले बहुत से दशकों में एन.पी.एल. का महत्त्वपपूर्ण क्षेत्रा रहा है क्योंकि यह विकास अकेले नई युक्तियों और सिस्टमों के बनाने में सफल होने को सुनिश्चित करता है। परन्तु हाल के वर्षों में ध्यान ऐसे क्षेत्राों पर दिया जा रहा है जहाँ एन.पी.एल. ने कुछ असाधारण अवसंरचना को बनाया है और विशेषज्ञता की है। मोटे तौर पर वे विशेषज्ञता इस प्रकार है–

- कार्यनीति अनुप्रयोगों और दोहरा प्रयोग भी जैसे लांग डिके फास्फोरस। हाल का विकास नैनोसामग्री पर आधारित फॉस्फोरस है।
- डिवाईसिज, फोटोनिक्स (WDM & OASLM), ट्रीबायोलॉजिकल अनुप्रयोग (एप्लीकेशन्स) (DLC, DLN, C-BN etc.), संवेदी अनुप्रयोग (a-si: He alloys) को प्रदर्शित करने के लिए संगत तनु फिल्म प्रौद्योगिकियाँ।
- विकिरण डिटैक्टरों के लिए थोक रूप में सिलिकॉन, च्ट तथा मेम्स द्धडम्डैक्ऋ अनुप्रयोग।
- पोरस सिलिकॉन और नैनोस्ट्रक्लरड पोरस एलुमिना टैम्पलेट्स, अर्धचालक नैनोक्रिस्टल और चुम्बकीय बहुपरतें।
- लम्बी लैंथ टेप्स के लिए उच्चतापी सुपरकंडक्टर्स, विशेषकर प्रदूषण नियंत्राण के लिए सेरामिक।
- लम्बे क्षेत्रा की इलेक्ट्रो क्रोमिक विन्डोज द्धस्मार्ट विन्डोजऋ के लिए इलेक्ट्रोडिपॉजिटिड टंगस्टिक ऑक्साइड, पॉलीमर्मारक जैल इलैक्ट्रिोलाईटस आदि और इलेक्ट्रॉनिक तथा बॉयोटैनॉलोजिकल सूक्ष्मम प्रौद्योगिकियाँ और संबंधित अनुप्रयोगों की विविधता के लिए पॉलीमर को कंडक्ट करना।

ELECTRONIC MATERIALS

Development of Electronic Materials has been an important area of activity at NPL for the last many decades as this development alone ensures success in the fabrication of novel devices and systems. Focus, in recent years, has however shifted to those areas where NPL has been able to create some unique infrastructure and expertise. Broadly speaking they are the following:

- Phosphors for some strategic applications, as also of dual use, such as long decay phosphors. Recent development has been phosphors based on nano-materials.
- Thin Film Technologies relevant to display devices, photonics (WDM & OASLM), tribological applications (DLC, DLN, C-BN etc.), sensor applications (a-Si:H & alloys).
- Silicon in the bulk form for radiation detectors, PV and MEMS applications.
- Porous silicon and nanostructured porous alumina templates, semiconducting nanocrystals and magnetic multilayers.
- High temperature superconductors for long length tapes, specialty ceramic for pollution control.
- Electrodeposited tungstic oxide, polymeric gel electrolytes etc. for large area electrochromic windows (SMART WINDOWS) and conducting polymers for a variety of electronic and bio-technological and related applications.

Luminescent Materials

The synthesis of strontium aluminate based long decay phosphor (LDP) was taken to meet the demand of Defence Laboratory, Jodhpur (DLJ). Initial brightness and decay times are the key features of any long decay phosphor. Therefore, some key processing steps like of heat treatment was carefully controlled to further improve the quality of the phosphor.

Figure 4.1 shows the dependence of decay characteristics and initial brightness as a function of heating rate of firing composition of the phosphor. The best heating rate for optimum brightness and decay has been found to be in the range of 300^0 - 600^0 C/hr. Similarly, other parameters like heating time at constant temperature, rate of cooling and atmosphere during firing were also studied. On the basis of feedback from the user agency i.e. DRDO, phosphor characteristics e.g. brightness, decay time, particle size etc. were tailored to meet their specific requirements. Process modification for industrial adaptation, with the aim of cost reduction, environmental pollution, energy saving and process simplification was also carried out.

Long Decay Phosphor developed earlier was also modified to be used as pigment for preparing paints by mixing with suitable paint vehicle. Particle size of the phosphor, transparency, viscosity, chemical inertness to phosphor and adhesion of paint vehicle to substrate were some of the important parameters that had been worked out for deciding formulation of L D Paint.

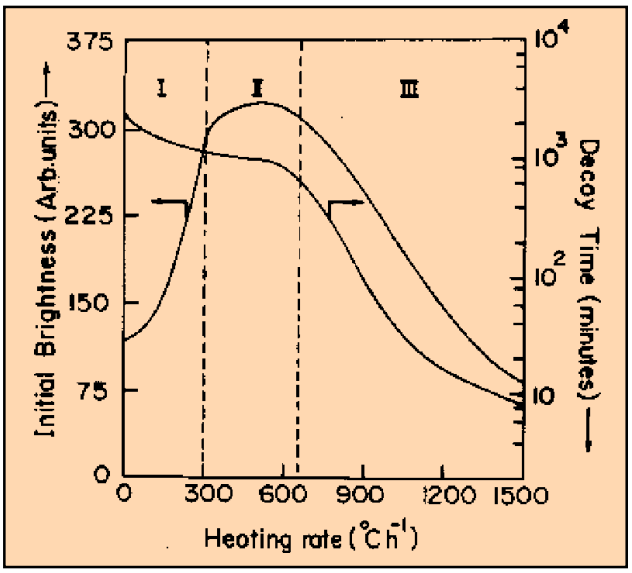

Fig. 4.1 : Decay characteristics as a function of heating rates at fixed values of rate of flow of N_2 gas = 1 litre/min., time of constant heating = 3 h at 1200°C and cooling rate = 125°C h^{-1}

One kg of LDP powder, one litre of LD paint and 5mx10cm of LDP tape were sent to Defence Laboratory,Jodhpur (DLJ) on 31st August 2001. The photograph of a pilot facility developed to produce such phosphor is given in Fig. 4.2.

Next, on the basis of evaluation report received on small fluorescent screens (4"x4") of gadolinium oxysulfide sent earlier to DLJ, under another sponsored project of DRDO entitled "Development of Luminescent Screens", work on preparation of gadolinium oxysulfide phosphor in bulk quantities and fabrication of larger area (8"x8") fluorescent screens were taken up. A number of samples of Tb/Pr doped gadolinium oxysulfide phosphor with varying amounts of alkali halides were made in significantly large amounts. The thermo-luminescence studies were simultaneously carried out to investigate effect of trapping states present in the system on radiative transitions of activator centers. Figure 4.3 shows effect of Tb concentration on thermal glow curves of Gd_2O_2S samples.

Using these phosphors, development work on trial screens of 8"x8" size were initiated. Some of the screens in pairs were sent to DLJ for further evaluation under x-rays/gamma rays before batch production for supply to DLJ commenced. Results of acceptance tests are still awaited. Electroluminescent powders, emitting in orange-red and blue colour were also developed for fabricating multi-colour flexible electroluminescent devices under the same project.

Work on development of Nano-phosphors was also initiated.Initial experiments were performed on growth of ZnS particles in nano-scale using some known chemical routes. The existence of nano particles was investigated by SEM and XRD measurements. The formation of ZnS lattice has been confirmed as shown in Fig. 4. 4

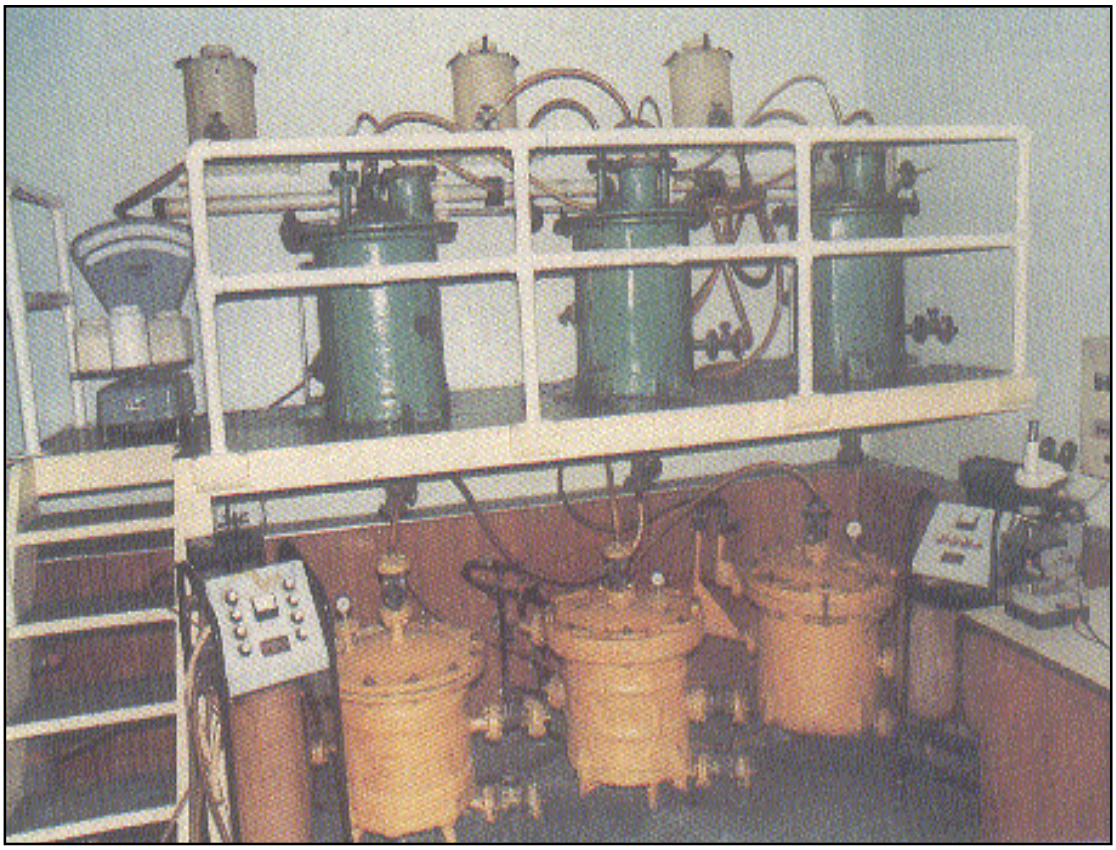

Fig. 4.2 : Photograph of the Phosphor Pilot Plant at NPL

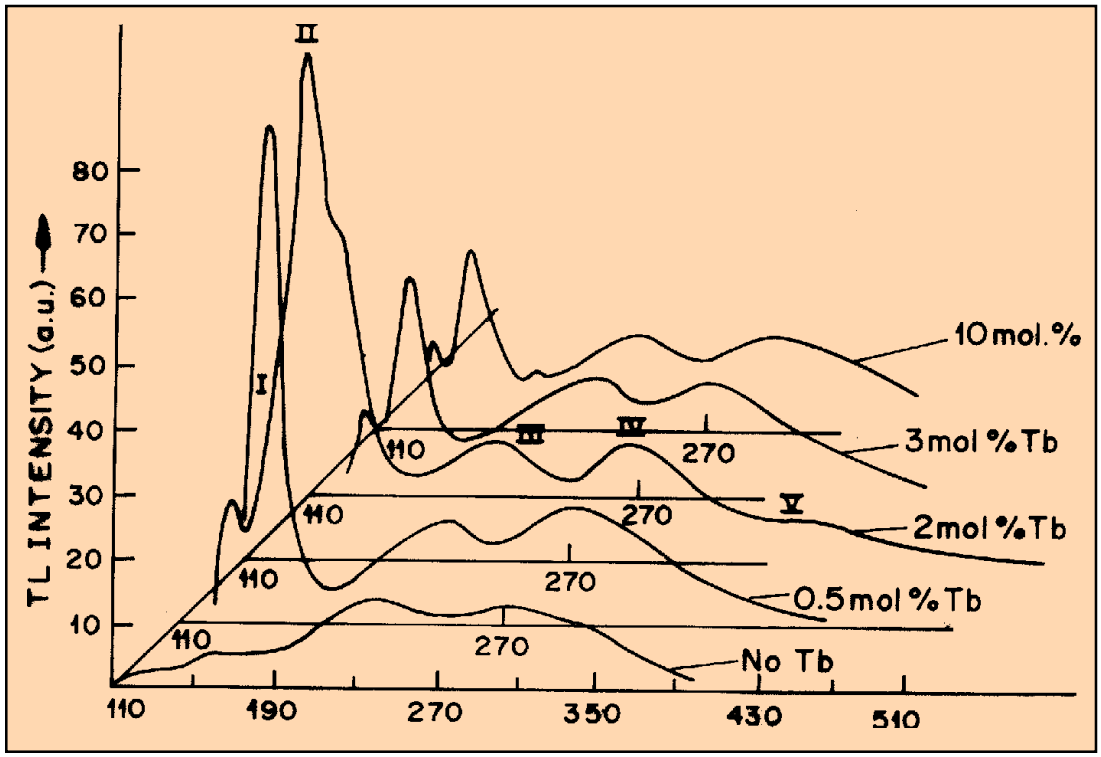

Fig. 4.3 : Glow curves of Gd_2O_2S:Tb with different Tb concentrations

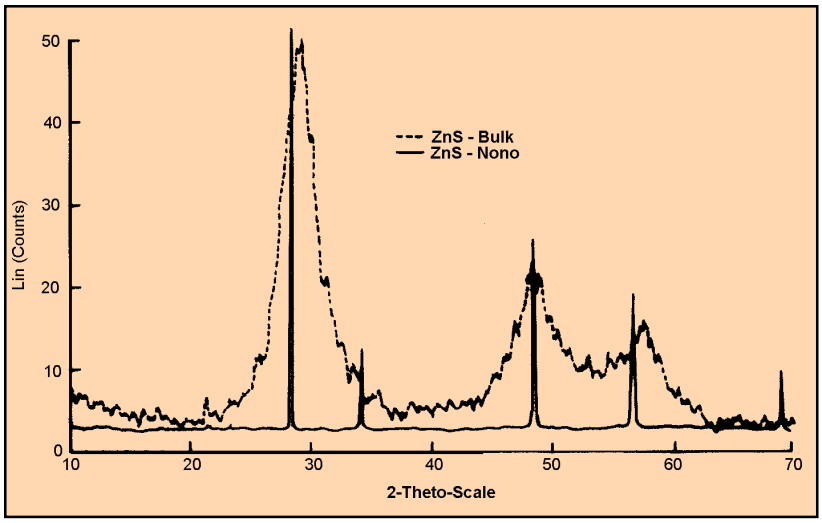

Fig. 4 .4 : XRD Pattern of ZnS bulk and nanophase

The group have succeeded in reducing the particle size from normal 10 micrometer size of bulk particles to 50 nm. The work is continuing to further reduce it to about 5 nm without agglomeration and loss of desirable luminescence properties.

Thin Film Technology

A project funded by Ministry of Information Technology, Govt. of India, entitled "Silica-on-silicon integrated optical devices for wavelength division multiplexing (WDM) applications (Part-I)" was concluded in Dec. 2001. Under this project, the deposition of silica layers several microns thick on silicon substrates by Plasma Enhanced Chemical Vapour Deposition (PECVD), Flame Hydrolysis Deposition (FHD) and electron beam deposition were successfully carried out. Whereas transparent and fairly uniform silica films were deposited by electron beam deposition and PECVD, the films deposited by FHD were not of the desired optical quality and need further development to achieve good quality films. The films were characterized for their refractive index, extinction coefficient and thickness from spectrophotometric measurements of the reflectance vs wavelength, using in-house developed calculation procedures and software. Samples of thick silica films were provided to CEERI, Pilani, the co-investigators of this project, for the fabrication of complete integrated optic devices in silica-on-silicon optical waveguides. Very valuable exposure to state-of-the-art PECVD deposition facilities and film characterisation facilities, as well as some recipes for successful deposition of uniform thick silica films, were gained during visits of NPL scientists to U.K. and the Netherlands, as well as through correspondence with foreign researchers. This knowledge will be valuable for future work in this area, where all technology and knowledge is usually cloaked in commercial secrecy.

Transparent conducting coatings of ITO and high reflectance all-dielectric mirror coatings were deposited by electron beam deposition, and thick amorphous silicon layers were deposited by PECVD, on polished ophthalmic glass substrates, for the fabrication of optically addressed spatial light modulators (OASLM) by the Display Devices group at NPL, as part of an external project funded by IRDE (DRDO). By July 2002, this work should reach its successful conclusion with the fabrication of complete OASLM's on highly polished fused silica substrates, meeting all the specifications of the sponsors.

Studies were conducted on the modelling of binary composite films for determining the refractive index and extinction coefficient as functions of film composition.

A sophisticated vacuum plasma arc deposition system, indigenously designed and fabricated (as shown in Fig.4.5) to grow ta-C (highly tetrahedral amorphous carbon) films became fully functional.

Design and Development of Large Area PVD Coaters for MgO Deposition for PDP Displays

This was taken up as a consultancy assignment (contract R&D) for a reputed manufacturer of such displays. The work involved providing design of PVD & PECVD reactors (vacuum evaporation, Magnetron sputtering

Fig. 4.5: Vacuum Plasma arc deposition system developed under a DST Project at NPL

and PECVD) to handle very large area substrates (up to 150 cm diagonal). In case of Magnetron sputtering Mg target was required to move to and fro under a static substrate. Such systems have earlier not been manufactured in the country. NPL provided all the design details and closely interacted with the fabricators of these equipment in the country and helped install the system. In a parallel activity small area MgO coatings were developed in our laboratory and fully characterized to gain first hand experience to support the user industry in its efforts.

High Rate Deposition of a-Si:H and SiO_2 for Photonics and Sensor Application

NPL has been successful in developing many PECVD based processes and equipments in past and such equipment have been supplied to other institutions as well. High rate deposition of a-Si:H for photovoltaic, photonic (OASLM), sensor (radiation detector, color sensing) has also been investigated for some time. In recent past VHF PECVD of SiO_2 was also attempted to see its utility for controlled deposition of thick layers (doped and undoped) for optical waveguide application. For investigating VHF & pulsed VHF processing of amorphous semiconductor and dielectric layers an ambitious project with DST support has since been defended.

Silicon & Silicon Devices

R &D work on development of silicon PIN photodiodes was continued. During the year 2001-02 some shallow junction n+-p-p+ structures of 1 cm x 1cm size were made on 10 ohm-cm resistivity p-Cz -Si wafers of 50mm diameter by carrying out B-diffusion at the back using a borosilica film and P- diffusion on the front surface using a solid dopant source. The n+ - front junction had a junction depth of 0.2 μm and the sheet resistivity of the n+ emitter was ~ 95 Ω/□. Front and back contacts were made with vacuum deposited Al metal. The back surface was fully covered but the front contact was in the form of a 0.75 mm wide strip using photolithography. Four PIN photodiodes, each of 1 cm x 1 cm size, made in a 50mm diameter wafer, are shown in Figure 4.6. The dopant impurity concentration profiles in the n+ front emitters of a photodiode were determined using SIMS and are shown in Fig. 4.7. The profile marked 1 was obtained by diffusion of phosphorous using a solid dopant source and was used for fabrication of the photodiode. The profile marked 2 was obtained by diffusion of phosphorous using a liquid dopant source and was used for fabrication of solar cells. The figure clearly shows that not only the junction depth (x_j) but the front surface concentration of the dopant impurity is also significantly smaller in case of profile 1. It was used for fabrication of the shallow junction n^+-p-p^+ structures for photodiodes.

I-V characteristics of each photodiode were measured under dark as well as under illumination

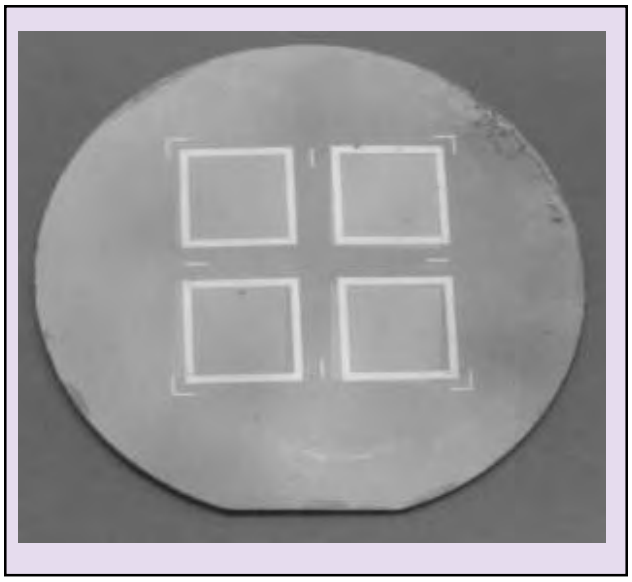

Fig. 4.6 : Four 1cm x 1cm size n^+-p-p^+ photodiodes made in a 50 mm diameter p-Cz silicon wafer

before and after scribing it out from the wafer. The dark current was found to be rather large (in micro ampere range) for small reverse bias (-2V). The studies were planned to determine its cause and to find out ways of reducing it substantially. Spectral responses (SR) of the photodiodes were measured in 400-1100 nm range and compared with that of a typical solar cell made having screen printed contacts. Figure 4. 8 depicts the SR curves for a silicon photodiode and a solar cell. In the visible range (400-750 nm) the SR of the photodiode is much superior to that of the solar cell also fabricated at NPL. This is indicative of superior quality of the n^+ emitter of the photodiode. High spectral response of the photodiode in the short wavelength range is very important for detection of scintillation radiations emitted by BGO, CWO crystals under excitation by gamma rays which lie in the visible range.

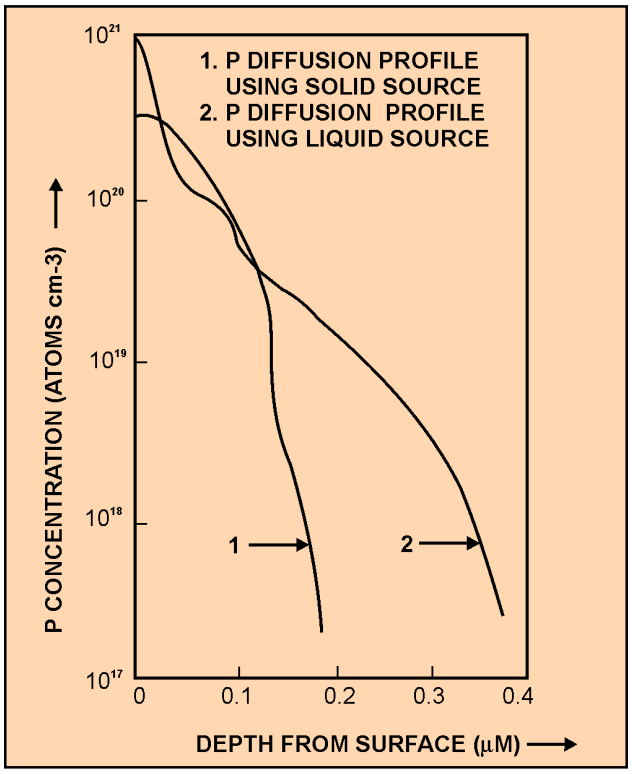

Fig. 4.7 : Dopant impurity concentration profiles of n^+emitters of a shallow (0.2μm) junction photodiode and a deep (0.4μm) junction solar cell

Microstructure Devices

The activity of the group during the year 2001-02 has been focused on nanostructured materials for chemical and magnetic sensors. Other activities include the externally sponsored projects on CdTe passivation of HgCdTe by electrodeposition technique for use in PV FPA's and the DST Project on Magnetic Multilayers. Significant research results are briefly mentioned below:

Porous Silicon

This is a new activity started to explore the utility of porous silicon as a chemical sensor material. The formation process of porous silicon was optimized. Our process involves deposition of 300 nm Al on Si wafer, 500^{0}C anneal in Ar for 10 min, anodization in an electrolyte consisting of HF and H_2O_2 in a 2:1 ratio by volume at a current density of 30-50 mA/cm^2 for 10-30 min. A strong photoluminescence signal was detected in the wavelength region of 500-750 nm with a peak at about 650nm. Quenching under laser illumination at 10 mW has been observed and studied in depth. To stabilize the porous silicon surface, PSi nanoparticles (PSNs) separated mechanically from the wafer were embedded in polymers. On embedding in PMMA, complete absence of quenching was observed. In optically transparent NOA85, quenching and recovery was repeatedly observed. Time dependence

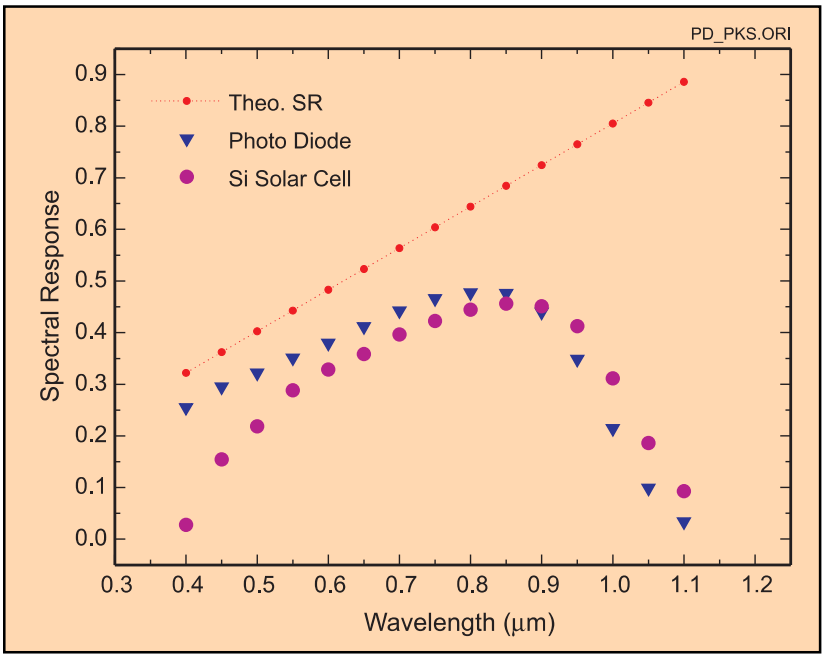

Fig. 4.8 : Spectral responses of 1 cm x 1 cm size Si photodiode (x_j ~ 0.2μm) and a typical 13% efficiency (AM1.5) silicon solar cell (x_j ~ 0.4 μm)

studies showed that τ Recovery >>> τ quenching. Porous silicon stabilization by acetylene exposure was also studied. Low temperature optical illumination during acetylene exposure leads to quenching followed by recovery of the peak at 650 nm. High temperature thermal reaction however leads to quenching followed by recovery with a peak at 580 nm. Lowering of nanocrystal size is responsible for these results. This is confirmed by FTIR studies which show complete replacement of Si-H bonding, formation of four membered Si-C=C-Si rings during optical reaction and penetration of C into PSi in the case of thermal reaction. Electrodeposition of CdTe in porous silicon was also studied. Cyclic voltametry was used to determine deposition potential for CdTe electrodeposited in nanopores. FTIR investigations and I-V and C-V studies were performed. Non linear I-V relationship indicates barrier formation.

Nanostructured Porous Alumina Templates

A new activity for the preparation of nanostructured porous alumina templates by a simple anodization process was initiated. This would enable the study of an array of nanowires of semiconducting materials for photoelectronic and sensor applications. Optimization of anodization was performed using (I) Aluminium sheet and (II) Al film thermally deposited on Si wafers. Porous films with 20-40 nm pores were formed. Incorporation of compound semiconductors and oxides in these pores is being investigated. Bismuth Molybdate Ethanol Sensor material was investigated for possible incorporation in the nanostructured templates. Thin/thick film preparation was investigated. Sol gel process was also investigated. Films were prepared using hexanoate precursor. XRD, IR studies confirm single phase formation. The response time to ethanol was τ ~ 2 sec which decreases with film thickness. These results show an improvement compared to ceramic processing where mixed phase formation and long time constants are observed. Highest sensitivity is obtained with the beta phase. The effect of additives such as Sb_2O_5, TiO_2 was also studied.

Semiconducting Nanocrystals in Insulating Matrix

This activity has been continued and studies on CdS, CdSe and CdTe in TiO_2 and SiO_2 were undertaken. Nonlinear optical properties and quantum confinement effects were observed in RF sputtered films. Post deposition anneal to 300°C has been shown to lead to Cd vacancies and surface effects. Optimization of parameters such as Ar pressure, RF power, temperature of deposition was performed. It has been shown that Cd concentration is critical for the formation of stress free films of high conductivity. The current transport mechanism has been shown to be space charge limited and mediated by Cd-vacancies. The peak in current is related to Cd vacancies.

Magnetic Materials

As part of the DST sponsored project on development of multilayer magnetic films for sensor applications, multilayers of Co/Ag were deposited. The total structure including capping layers of Ti is represented by Ti(5nm)[Co(1nm)/Ag(4nm)]$_{35}$Ti(5nm). This stack of 35 alternating layers of Co and Ag was subjected to 300-350°C anneal for formation of a discontinuous multilayer structure. XRD SEM studies confirm that (111) oriented growth has taken place. VSM studies indicate ferromagnetic coupling in layers. Moderate Magnetoresistance (MR) has been observed at 3500 Oe. Lithium Ferrite Nanoparticles were also investigated for possible ferrofluid applications. Lithium ferrite nanoparticle synthesis was achieved using citrate precursor. XRD, IR studies confirm single phase lithium ferrite formation. Disordered α-$LiFe_5O_8$ is observed at 200°C and an ordered β-$LiFe_5O_8$ at 350°C. Magnetic properties are found to be suitable for ferrofluid applications. Microwave processing of Ni-ferrite Nanoparticles was investigated. The Ni ferrite nanoparticle synthesis was performed using citrate precursor. Comparison of conventional and microwave processing showed that microwave processing results in superior product.

Electrodeposited Polycrystalline Compound Semiconductors.

This is an established activity and earlier a sponsored project from MNES was undertaken to develop CdTe solar cells. Attempts were made to vary the band gap and lattice parameters to produce superior films for photovoltaic and related applications.

Electrodeposition, pulsed electrodeposition, chemical bath deposition and spray pyrolysis were all investigated for the formation of ternary compounds based on CdTe. Electrodeposition process was optimized for the formation of CdPbTe, CdBiTe, CdSnTe, and CdSbTe. EDX, SEM, XRD, optical bandgap and IR absorption studies were performed on these films. One of the interesting results is the formation of highly conducting CdInTe2 by simultaneous electrodeposition. It was observed that optical band gap E_g 1.2 eV is obtained at a cathode potential of –0.5 V in contarst to 1.1 eV at - 0.54 V. As part of the externally sponsored project, CdTe passivation of HgCdTe by electrodeposition technique for use in PV FPA's: a feasibility study, CdTe electrodeposition over MCT was investigated. Chemomechanical etching & polishing of MCT was necessary and the conditions optimized by using cyclic voltametry studies. CdTe electrodeposition was performed at both room temperature and 50 C. Thickness and growth rate were optimized. XRD confirms cubic CdTe phase formation. XPS confirms absence of Hg on surface. MIS fabrication and C-V measurements are in progress. Alternate approaches for passivation were investigated. These included formation of Double layer CdS/CdTe and ZnTe.

Superconducting & Ceramic Materials

Special Ceramics and Superconducting Tapes

This group has been engaged in the development of long length tapes of Bi based HTS compounds and exploring a new concept in high current transport.

Efforts have been focused on the development of process technology of $Bi_{1.84}Pb_{0.4}Sr_2Ca_{2.2}Cu_3O_{10+x}$: 10wt% Ag (an optimum value) high temperature superconductor (HTS). This is aimed at producing reproducibly,(i) HTS magnet for (high magnetic fields) at relatively high temperature and also for low loss high electrical power transport (Ic) at, 77K, in long length multifilamentary tapes, and (ii) high Ic values at 77K in Bi – 2223 tubes/rods as current leads for cryogen free cryo-cooled superconducting magnet.

A significant achievement in this direction has been realizing 25 meters long Bi-2223 Ag clad multi-filamentary (32 filaments) tape, which is then translated into spool form required for winding small proto type magnets. The preliminary studies showed that tape in spool form is end-to-end superconducting, having

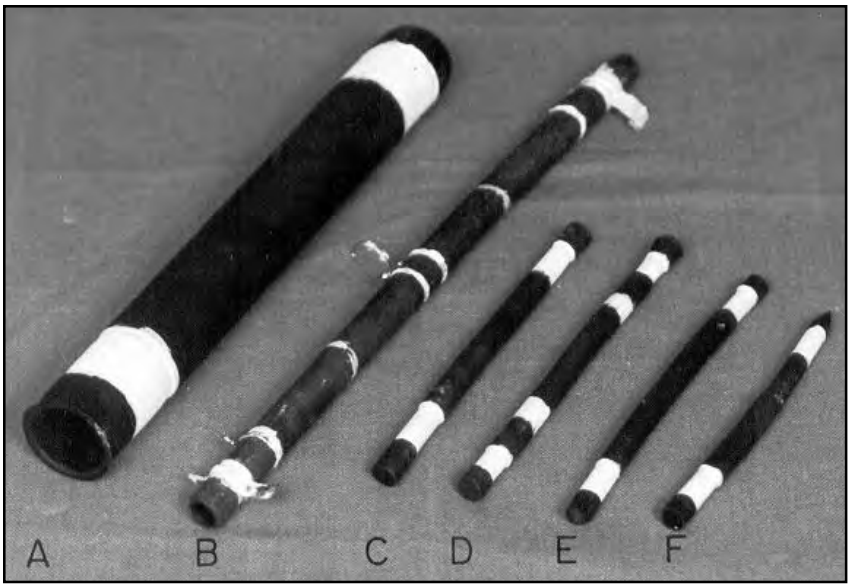

Fig. 4.9 : Tube and rod conductors of Bi-2223 of various Sizes: A/B tube conductors of 30cm length, C/D/E/F rod conductors of Bi–2223 HTSC (not to scale)

reproducible Jc value of order of 10^4A/cm^2 at 77K and ~ 10^6 A/cm^2 at. at 4.2K Magnetic field studies are in progress.

Alongwith multifilamentary Bi-2223 tapes, current leads of various sizes of Bi-2223 tube conductor and of Bi-2223 rod conductors which are needed for high current transport were also developed. Studies on more than fifty tubes (L=10cm, O.D.=1.2cm, I.D.=1.0cm; L=20cm, O.D.=3.0cm, I.D.=2.8cm; L=30.5cm, O.D.=1.2cm, I.D.=1.0cm) and fifty rods (L=10cm, D=0.5cm and 0.7cm) confirmed more than 60% reproducibility of Ic > 150A at 77K under self field (Fig.4.9). The fabrication of 30.5 cm long tube conductor needs a special mould, which has been developed by us. In the process of development of 30.5 cm long bulk tubes and rod conductors (perhaps, the first such indigenous development) the group has evolved a new initial sintering process, which appears to produce-required Ic values in a shorter interval of time.

Under the development of ceramic filters for automobile and other engine exhausts the fabrication process for the filter for 10 Bhp Engine was standardized (Figure 4.10).

Problem of filter breakage could not however be solved by only material design. It could be handled by innovative ways of packing the filter in the mechanical system. New compositions for porous ceramics were investigated. Uniaxial pressing of NaCl: Al_2O_3 was used to prepare new porous ceramics. Its processing parameters were investigated. It was found from crashing strength measurements and SEM method that porous bodies strength decrease with addition of NaCl (Figure 4.11). Optimum sintering temperature for Al_2O_3: NaCl was investigated by XRD Method. A project on microwave sintering of beta Alumina tubes was initiated.

Fig. 4.10 : Bhp diesel engine filter

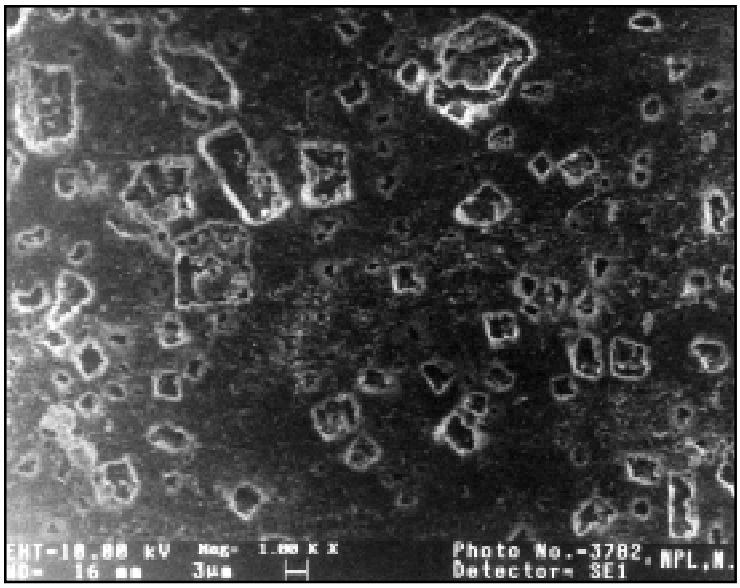

Fig. 4.11 : SEM photograph of alumina:NaCl sintered at 1600°C

Electrochromic Materials and Devices

Smart Electrochromic Windows for Energy Conservation

The main goal in this as well as the in-house project is ultimately to fabricate low cost prototype large area Electrochromic Windows (ECWs). This needs bulk preparation of the precursor materials for both the primary as well as counter electrodes. The last step of the sol-gel process developed earlier for preparing the precursor material for depositing WO_3 films involves drying of the solution at low pressure and for bulk preparation use of a diaphragm pump & a rotary evaporator ensures contamination-less uniformly dried precursor material.

Fabrication of a few ECWs of dimensions up to 4" x 4" and investigation of their performance characteristics were carried out earlier. However, the constraint of preparation of bulk precursor material didn't allow us to scale up the window area. But then we focused our attention to an alternate technique that would give WO_3 films of comparable or better electrochromic performance preferably at a lower cost. The technique adopted was electrodeposition of WO_3 films using the solution in the sol-gel process, before drying, as mentioned above. With an appropriate dilution and eliminating the drying step the films could be easily electrodeposited. On the counter electrode part of the devices, development of two passive counter electrodes e.g. SnO_2: Mo and CeO_2: TiO_2 was undertaken. To overcome issues like short duration stability experienced in the former and need of high temperature around 500°C for both, developmental work on another potential active counter electrode Prussian blue was initiated, the films of which could also be deposited by Electrodeposition and needed no further heat treatment. Similarly for the third component of the ECWs namely the electrolyte, a new methodology was attempted which is likely to make the device packaging easier.

Thus all the work carried out during this year was directed towards easy preparation of the electrodes and the electrolyte that would result in ECWs with improved performance characteristics, possibly at a lower cost.

Electrodeposition of WO_3 Films

Peroxotungstic acid (PTA) or Acetylated PTA (APTA) as such and with chemical additive have been the precursor materials prepared and used to deposit WO_3 films. Extensive investigations have been carried out in the past in understanding the chemistry of the various steps involved, the properties of the WO_3 films prepared, roles of different additives, complexing agents etc. Best films prepared were characterized to have a small volume of nanocrystallites in an amorphous matrix resulting in faster kinetics.

The technique of electrodeposition was found to be advantageous. As mentioned above, it eliminated the step of drying under vacuum. With the available potentiostat we could easily deposit the films of WO_3 by cathodic reduction of PTA in alcoholic medium. The films were also prepared using APTA in alcoholic medium. Elaborate investigations have been carried out

using the techniques XRD, SEM, TEM. The electrochromic characteristics have shown superior properties than the films made by spin coating the alcoholic solutions of PTA & APTA solid precursor materials. Our preliminary TEM studies have shown the films to be nanocrystalline. More detailed investigations of the films at different stages of heat treatment and their correlation with the properties are underway.

Electrodeposited Prussian Blue Films as Active Counter Electrodes

Prussian blue films have complimentary properties with respect to WO_3 films i.e. these films in the oxidized state have blue colour similar to that shown by WO_3 films in their reduced state and they become transparent respectively in their reduced and oxidized states. As a result, when used with an electrolyte separating them, the resultant electrochromic transmissive devices are expected to show superior optical transmission modulation.

This work has been just initiated. Electrodeposition of Prussian blue films by constant current is being attempted.

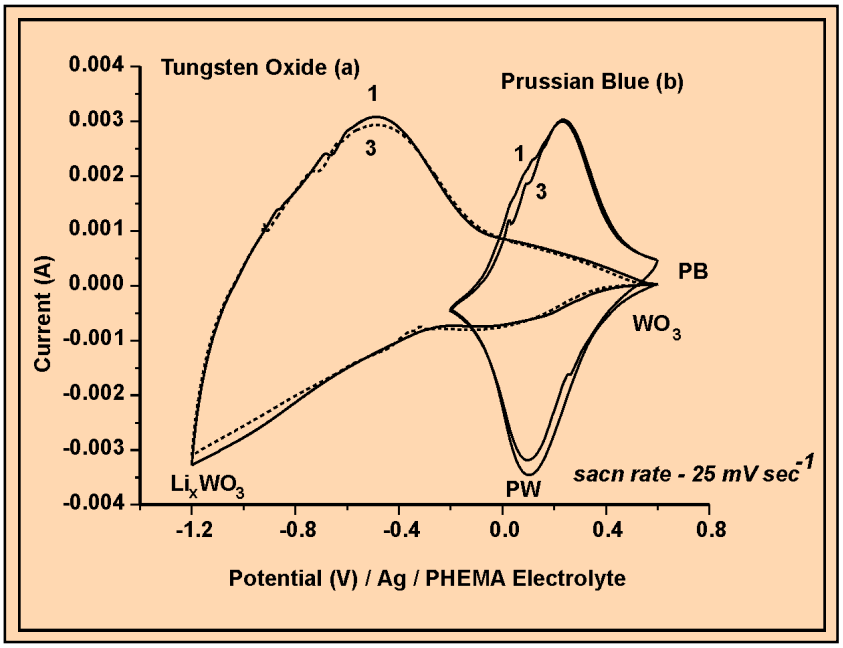

Fig. 4.12 : Cyclic voltammogram of tungsten oxide, Prussian blue in a chemical gel electrolyte

Chemical Polymer Gel Electrolyte

Starting from the liquid electrolytes and trying a variety of electrolytes over the years, the group has successfully made PMMA based gel polymeric electrolytes , incorporated them into prototype ECDs and established their suitability for window applications. However, their use necessitates good sealing / lamination of the devices. Instead of such a physical gel – wherein no chemical bond formation occurs between the liquid electrolyte and the polymer, a chemical gel has been attempted – wherein covalent bond formation occurs between the polymer chains – which comprises the conventional liquid electrolyte along with an acrylic monomer, a copolymer as a cross linker and another photo initiator. On irradiation with a UV lamp, photo polymerization takes place with the formation of the in-situ thick electrolyte film on one of the electrodes.

Such a polymeric gel electrolyte has been characterized by many techniques and its suitability for ECW applications has been checked.

Figure 4.12. illustrates the cyclic voltammograms of tungsten oxide, Prussian blue in one of the chemical gel electrolytes using Pt plate and Ag wire as counter and reference electrodes respectively. Figure 4.13 depicts cyclic voltammograms of an ECW (WO_3 as primary and Prussian blue as counter electrodes) cell scanned between 0.6 V to -1.7 V (first and tenth cycle) in a two electrode system. Transmission characteristics (at λ = 650 nm) of an ECW with a chemical gel (a) in coloured state (after precharging at –1 V for 60 seconds); (b) in bleached state by applying 0.6V for 30 seconds; (c) and (d) in coloured and bleached states respectively are again shown in figure 4.14.

All the three above mentioned attempts will definitely have a role to play for our future project work in which the commitment is to make large area ECWs.

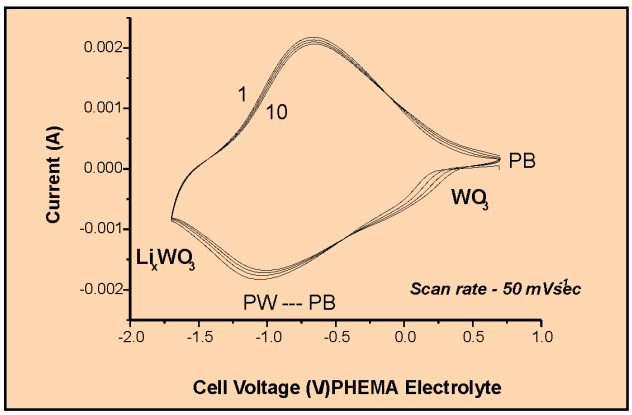

Fig. 4.13 : Voltammograms of an ECW (WO_3 as primary and Prussian blue as counter electrodes) scanned between 0.6 V to -1.7 V (first and tenth cycle) in a two electrode system

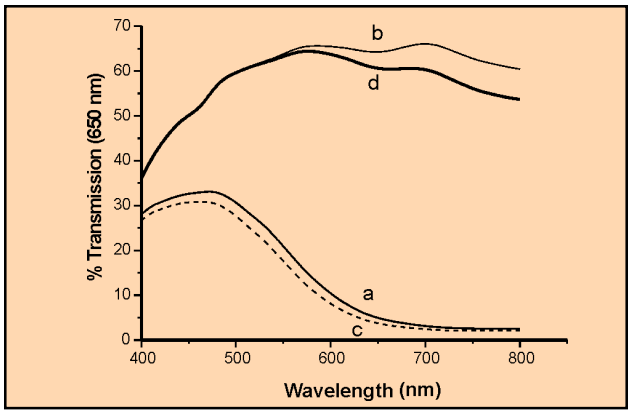

Fig. 4.14 : Transmission characteristics (at λ = 650 nm) of an ECW with a chemical gel (a) in coloured state (after precharging at –1 V for 60 seconds); (b) in bleached state by applying 0.6-V for 30 seconds; (c) and (d) are coloured and bleached states

Polymeric Materials and Devices

Poly(3-methyl thiophene) (P3MT) is one of the most promising materials from polyheterocyclics family having good environmental and chemical stability with excellent electronic and optical properties. We have synthesized poly(3-methyl thiophene) by chemical oxidation method in an inert atmosphere using ferric chloride as dopant. Samples of different dopant concentration have been synthesized and analyzed by Fourier transform infrared (FTIR) spectroscopy, scanning electron microscopy, and direct current conductivity measurement. Synthesis of the polymer was confirmed by FTIR studies. FTIR spectra showed a shift in the heterocyclic bands in the region of 700-1200 cm^{-1} with a decrease in temperature at which the synthesis of the polymer was performed. It was evident from the scanning electron micrographs that the surface structure of the polymer became denser with an increase in the doping level. The room temperature measured dc conductivity increased initially up to the doping level of 0.8 M and then this increase tended to slow down. Samples having a doping level of 0.4 M were synthesized at 300, 280 and 270 K while maintaining the other synthesis parameters. The conductivity and yield were found to increase as the temperature of the polymerization decreased. The dc conductivity of P3MT samples has been measured as a function of temperature in the low temperature region (77-300 K). The observed dc conductivity data were analyzed in the light of Mott's variable range hopping (VRH) model. Different Mott's parameters such as characteristic temperature (T_0), average hopping energy (W), average hopping distance (R), and the density of states at the Fermi level [N (E_F)] were evaluated. By taking the inverse of the coefficient of exponential decay of the localized states involved in the hopping process as 0.5 nm, a realistic value of density of states at the Fermi level [N(E_F)] has been obtained. The measurement of dc conductivity from 10-300 K on P3MT samples having different dopant concentration is in progress. Measurement of ac conductivity and dielectric constant in the temperature range 77-300 K and in the frequency region 100 Hz-10 MHz on the lightly doped samples of P3MT is also in progress.

The insulating emeraldine base (EB) form of polyaniline (PAN) and electrically conductive sulfuric acid and phosphoric acid doped emeraldine salts (ES) form of PAN were synthesized by chemical oxidative polymerization technique. Their vibrational spectra were studied in the region 4000-400 cm^{-1} at ambient temperature by Fourier transform infrared (FTIR) spectroscopy. Infrared transmittance spectra of EB and ES were investigated to understand the bonding behaviour of different organic and inorganic groups present in the polymeric chains and their structural

variations on protonation by sulfate or phosphate ion inclusion in the polymer salt network. These studies revealed the para-coupling of deformed disubstituted benzenoid (B) and quinoid (Q) rings with ends capped predominantly by B4Q1 units. The deformation of B and Q rings was confirmed by the appearance of many weak bands, very weak bands, and satellite structures in strong transmittance peaks of polymeric chain-constituting groups. Protonation takes place at the nitrogen sites of Q rings and forms semiquinone radical ions in ES. The vibrational bands pertaining to B rings, Q rings, B4Q1 units, semiquinone segment, sulfate ions, and phosphate ions were observed and assigned from these measurements. The shift in peak position of some bands with gain or loss in intensity and appearance of some new bands were observed in sulfuric acid and phosphoric acid doped ES spectra. These variations are attributed to the formation of new structural groups in ES on protonation and a change in crystalline field by sulfate and phosphate ion doping for cross-linking the polymeric chains through hydrogen bonding. The detailed analysis of dc conductivity and ac conductivity data of different doped forms of polyaniline (PAN) is in progress.

Samples of polypyrrole(PPY), poly(N-methyl pyrrole) [P(NMPY)] and their copolymer; poly(N-methyl pyrrole-pyrrole) [P(NMPY-PY)] were prepared by electrochemical polymerization technique. Their conductivity values were optimized for fabricating indium-polymer Schottky junctions. The current-voltage characteristics of the indium-polymer Schottky junctions were investigated. The results have been explained on the basis of thermionic emission theory. Out of the various polymers synthesized for the present investigations, the copolymer formed using monomers of 0.025 M pyrrole and 0.075 M N-methyl pyrrole having bulk conductivity ~ 10^{-2} - 10^{-3} Ω^{-1} cm^{-1} is a promising candidate, for making Schottky junction devices because of the better values of the ideality factor (η) ~ 1.48 and the rectification constant (ρ) ~ 1808. The current density and Chot plot as function of bias voltage are shown in Figs 4.15 and 4.16 for different conductivity values of copolymer, P(NMPY-PY). Search for other conducting polymers with suitable conductivity values for making Schottky junction devices is under investigation.

Synthesis of composites based on lead titanate ($PbTiO_3$) and barium titanate ($BaTiO_3$) dispersed in a piezoelectric polymer poly vinylidene fluoride (PVDF)

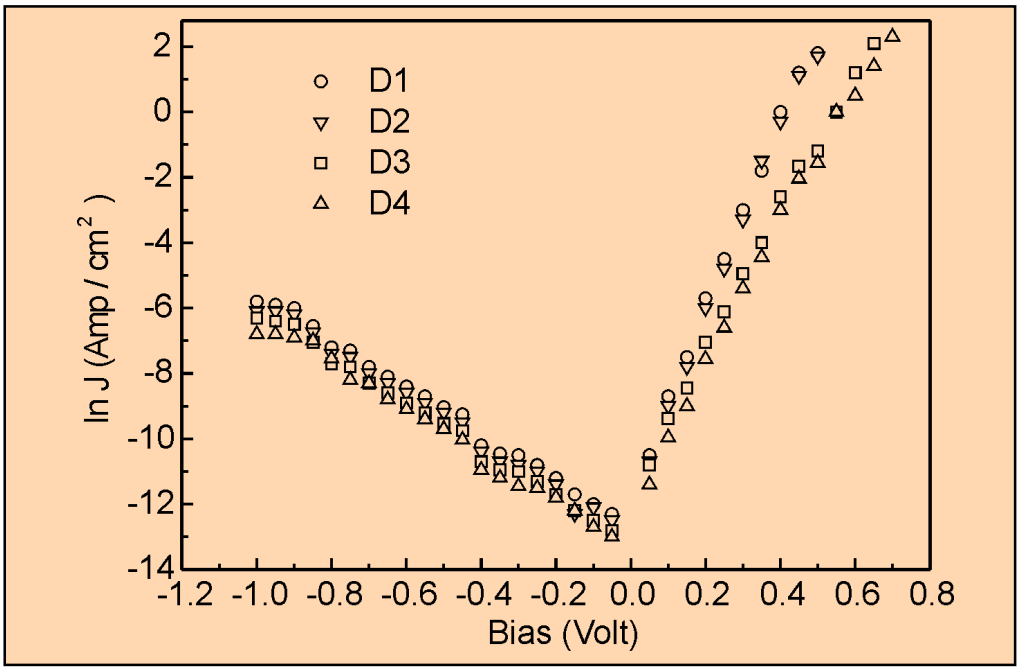

Fig. 4.15 : ln J-V characteristics of various In-P(NMPY-PY) junctions on samples of copolymer P(NMPY-PY)(75:25)

matrix have been undertaken. The composites were formed using sintered $PbTiO_3$ and $BaTiO_3$ powder dispersed in PVDF granules using dimethylformamide (DMF) as the solvent. Smooth films (thick ~ 1 mm) of $PbTiO_3$/PVDF and $BaTiO_3$/PVDF composites were developed. The dielectric and piezoelectric measurements were carried out on the poled films of the composites. The results indicate that the measured values of dielectric constant (ε′) and piezoelectric charge constant (d_{33}) were strongly influenced by the relative proportions of the two constituents and the poling conditions. The dielectric behaviour of these composites can be explained well by Yamada's relation, which furnishes a unique method to tailor these composites. The present study indicates that the effective field acting on the grain is a fraction of the actual applied field, which puts an upper limit on the d_{33} coefficient using conventional poling methods. This points out the fact that alternative technique such as corona poling should be adopted for getting better characteristics of these composites

The synthesis and characterization of polypyrrole/sodium nitrate (PPY/$NaNO_3$) composite films have been undertaken for its possible use as a substrate to support endothelial cell proliferation and the dc conductivity of the film has been measured as a function of temperature. The analysis of the observed dc conductivity data is in progress using different models of mechanism of charge transport.

The conducting polymer has a unique property of having large number of charge carriers in their polymer backbone. Keeping this in view the conducting polymer membranes have been developed for capturing viruses through electrostatic interactions of charges between viral particles and the polymer because RNA protein of virus contains some intrinsic charges. Various combinations of pyrrole and N-methyl pyrrole monomers were tried in order to get optimum value of conductivity and environmental stability of the membrane. Then these membranes were prepared at different temperatures in an inert atmosphere using the required amount of pyrrole and N-methyl pyrrole monomers. These prepared conducting polymer membranes have been tested for virus retention on it by Department of Microbiology, All India Institute of Medical Sciences (AIIMS), New Delhi. Results indicate that some of the membranes retain almost 100% viruses. A prototype of Water Purifier has been designed and fabricated using the above said membrane and other available materials and is being tested for its efficacy.

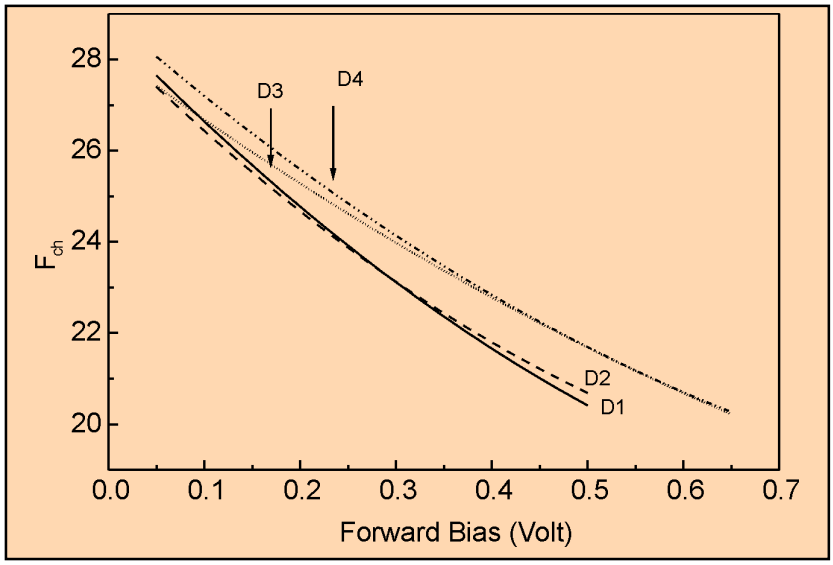

Fig. 4.16 : Chot plots of various In-P(NMPY-PY) junctions on samples of copolymer P(NMPY-PY) (75:25)

पदार्थ अभिलक्षणन

MATERIALS CHARACTERIZATION

पदार्थ अभिलक्षणन

पदार्थ अभिलक्षणन प्रभाग को रसायन संयोजन, विशु)ता, संरचना और क्रिस्टलोग्राफी गुणोंके संबंध में वस्तुओं की विशेषता बताने के लिए उच्च गुणवत्ता वाली सुविधाएँ प्राप्त हैं। इन सुविधाओं का रख–रखाव इस डिवीजन द्वारा किया जाता है और ये सुविधाएँ भौतिकी प्रयोगशाला के अन्य गुणों और बाहरी संगठनों को प्रदान की जाती है। इस डिवीजन के वैज्ञानिक पदार्थ अभिलक्षणन के उन्नत क्षेत्रों में अपने अनुसंधान और विकास कार्य सिलिकॉन, Ga Sb/ Ga As हेटरोस्ट्रकलर, BGO बल्क क्रिस्टल, उच्च Tc सुपरकंडक्टिंग मेटीरियल्स, C-C कंपोजिटस, टरनेरी ऑक्साइड ग्लासिस, फेरोफ्लूएडस, कंडक्टिंग पालीमर्स, Cate, WO_3 इत्यादि की सामग्री के संबंध में किया जा रहा है।

छः नए प्रमाणित संदर्भ पदार्थ जो कि पानी कीटनाशक (क्लोरोपाइरीफोस तथा इसोप्रोटयूरान) के मानक और गैस (नाइट्रोजन में मीथेन) में पाई जाने वाली अशुष्यिों के संबंध में है, में तैयार किए गए है औरा राउंड रोबिन टेस्ट के लिए भेजे गए हैं। कृषि क्षेत्रा में GHG इन्वेंटरी प्रोग्राम–मालसूची कार्यक्रम के लिए ग्रीनहाउस गैस उत्सर्जन (एमीशन) में पाई जाने वाली अनिश्चितताओं में कमी कार्यक्रम भारत की नेटकॉम परियोजना के लिए शुरू किया है। "ए फारमुलेशन फॉर आयरन केलेशन एण्ड ए प्रोसैस फार प्रीपेयरिंग दि सेम" नामक थैलीसीमिया को एक पेटेन्ट की मंजूरी नौ देशों ने दे दी है।

इस अवधि के दौरान एक्सरे के एनोमेलस ट्रांसमीशन जैसी डायनामिकल डीफ्रैक्शन विशेषताओं पर डठ।छच सिंगल क्रिस्टल पर अध्ययन किया गया है। उच्च विभेदन विसरित एक्सरे प्रकीर्णन (हाई रिजोल्यूशन डिफ्यूज़ एक्सरे स्कैटरिंग) का उपयोग ऊच क्रिस्टलों के प्वाइंट डिफैक्टस और क्रिस्टलों के गुच्छों पर अध्ययन करने के लिए किया गया है। अत्यधिक गलत मैच वाली Ga Sb/ Ga As हेलरोस्ट्रकचर्स पर अध्ययन पाँच क्रिस्टल डिफैक्ट्रोमीटर पर उपयोग करते हुए और अन्य विशेषताओं को शामिल करते हुए किया गया था। एन पी एल में बनाए गए BGO क्रिस्टल का उपयोग सिंटिलेशन गुणों पर अध्ययन करने के लिए किया गया। एक नये डबल क्रिस्टल एक्स रे डिफ्रेक्टोमीटर की स्थापना तीन किलोवॉट (3KW) एक्सरे जेनरेटर का उपयोग करते हुए की गई है। एक्सरे विवर्तन और प्रतिदीप्ति अध्ययन उच्च तकनीक वाली अतिचालक सामग्री, C-C feJ] Bi_2 Tc_3, I_4Sb, BN आदि सहित नमूनों की किस्मों के लए किया था। Zn Ga_2 Tc_4 के एक्सरे पाउडर आंकड़ों की स्थापना की गई थी। Ga_2 Tc_3 ds XRD पैटर्न ने लम्बे भण्डारण समय के साथ–साथ स्थिर षट्कोणीय कला (फेज) प्रकट किया है। पोलीएनीलाईन और पोली विनायल एल्कोहल मिश्रों के साथ फेरोफ्लूड परते संश्लेषित की गई हैं। और इस पर अध्ययन सूक्ष्मतरंग क्षेत्रों में वैद्युत चुंबक हस्तक्षेप वाली प्रभावोत्पादकता के लिए किया गया है। प्रमाणित संदर्भ सामग्री (सी आर एम) बहु प्रयोगशाला सहयोग कार्यक्रम पर आगे कार्य किया गया था और पहले के सी आर एम एस (CRMS) के पाँच नए बैच तैयार किए गये थे। इस ग्रुप ने अन्तर्राष्ट्रीय रसायन मापन अन्तर्तुलना कार्यक्रम में भाग लिया जो कि यूरोपीय आयोग ओर एशियन पेसिफिक मेट्रॉलोजी कार्यक्रम जैसे अन्तर्राष्ट्रीय मानक संगठन द्वारा आयोजित था।

पोली अल्यूमिनियम क्लोराइड, संश्लिष्ट डायमंड, अमिट स्याही, ऐरोसोल्स जिसमें ब्लैक कार्बन अम्ल वर्षा (एसिड रेन) आदि शामिल है का रासायनिक विश्लेषण किया गया है। षि क्षेत्रा के जलवायु परिवर्तन से संबंधित कायू N_2O और CH_4 ग्रीन हाउस गैस उत्सर्जन के मापन का कार्य अन्तर्देशीय प्रोजेक्टों और बाहरी ऐजेंसियों के लिए किया गया था। रासायनिक विधि द्वारा मोल के पहचानने पर किए गए प्रारंभिक कार्य की स्थापना हो चुकी है। इलेक्ट्रॉन माइक्रोस्कोपी सुविधाओं का उपयोग माइक्रोस्ट्रकचर की विश्लेषण करने और CdTc, WO_3, CNTs, पालीमर्स का संचालन आदि जैसी सामग्री के अन्य ब्यौरों के लिए किया गया था। Bi_2 Tc_3, AlSb, In Sb तथा A_4 पार्टिकल्स पर भी अध्ययन ग्रुप में चलाई जा रहे आंतरिक प्रोजेक्टों के अन्तर्गत किया गया। ये सुविधाएँ मैसर्स गैबरियल तथा मैसर्स GKN ड्राइव और शैटस आदि जैसे उद्योगों को प्रदान की गई थी। ऑटोमोबाईल्स घटकों की परीक्षण सामग्री और असफल होने के विश्लेषण की विशेषताएँ बताने के लिए एक MOU पर मैसर्स मारुति उद्योग लिमिटेड के साथ हस्ताक्षर किए गए। अनुसंधान और विकास कार्य IACS कोलकत्ता, आई आई टी दिल्ली और याक पर राष्ट्रीय अनुसंधान केन्द्र (ICAR) के सहयोग से किया गयां विभिन्न टरनेरी ऑक्साइड की पतली परतों पर अध्ययन ई पी आर एपेक्ट्रोस्कोपी का उपयोग करते हुए किया गया था। अनेक प्रायोजित और सहयोगी का उपयोग करते हुए किया गया था। अनेक प्रायोजित और सहयोगी प्रोजेक्ट पर कार्य चल रहा है। अनुसंधान लेख अन्तर्राष्ट्रीय और राष्ट्रीय जर्नलों में प्रकाशित किए गये थे। कई आमंत्रित वार्ताएँ भी की गई थीं।

MATERIALS CHARACTERIZATION

Materials Characterization Division has high quality facilities for characterization of materials regarding chemical composition, purity, structure and crystallographic properties. These facilities are maintained by the division and provided to other groups of the laboratory and outside organizations. The scientists in the division are very actively involved in their own R&D programmes in advanced areas of materials characterization. R&D work has been carried out on materials like silicon, GaSb/GaAs heterostructures, BGO bulk crystals, high T_c superconducting materials, C-C composits, ternary oxide glasses, ferrofluids, conducting polymers, CdTe, WO_3 etc.

Six new Certified Reference Materials for impurities (NO_3^-, Mn, & Ca) in water, standards on pesticides (chlorpyriphos & isoproturon) and gas standard (methane in nitrogen) have been prepared and sent for round robin test. Reduction in uncertainties in Green house gas emission for GHG- inventory program in agriculture sector has been initiated for India's NATCOM project. A patent on Thalessamia entitled, "A formulation for iron chelation and a process for preparing the same" has been granted in nine countries. A number of sponsored and collaborative projects have been pursued.

During this period dynamical diffraction features like anomalous transmission of X-rays have been studied in MBANP single crystals. High resolution diffuse X-ray scattering has been used to study point defects and their clusters in BGO crystals. Highly mismatched GaSb/GaAs helerostructures were studied using the five crystal X-ray diffractometer with added features. BGO crystals grown at NPL were used to study the scintillation properties. A new double crystal X-ray diffractometer has been set up using 3kW X-ray Generator. X-ray diffraction and fluorescence studies were carried out for varieties of samples including high Tc superconducting materials, C-C composites, Bi_2Te_3, InSb, BN etc. X-ray powder data of $ZnGa_2Te_4$ were established. XRD patterns of Ga_2Te_3 revealed a stable hexagonal phase with long storage time. Films of Ferrofluid with polyaniline and polyvinyl alcohol composites were synthesized and studied for the electromagnetic interference (EMI) shielding effectiveness in microwave region. Further work on Certified Reference Materials(CRMs), a multi-laboratory collaborating programme, was carried out and six new and five new batch of earlier CRMs were prepared. The group participated in International Inter-comparison programme on chemical measurements organized by International Standards Organization namely Europeon Commission and Asian Pacific Metrology Programme. Chemical analysis of poly aluminium chloride, synthetic diamond, indelible ink, aerosols including black carbon, acid rain etc. was carried out. Work related to climate change for agriculture sector, measurement of N_2O and CH_4 green house gas emissions was carried out for inhouse projects and outside agencies. Initial work on the realization of mole by chemical method has been established. Electron Microscopy facilities were used to analyse the microstructure and other details for materials such as CdTe, WO_3, CNTs, conducting polymers etc. Studies on Bi_2Te_3, AlSb, InSb and Au particles were also carried out under internal projects in the group. The services were provided to the industries such as M/s Gabriel and M/s GKN Drive and Shafts etc. An MOU for characterization of the material testing and failure analysis of automobile components was signed with M/s Maruti Udyog Ltd. R&D work was carried out in association with IACS, Kolkata, IIT, Delhi and National Research Centre on Yak (ICAR). Different ternary oxide glasses and thermally grown amorphous silicon dioxide thin films were studied using EPR spectroscopy. A number of sponsored and collaborative projects have been pursued. Research papers were published in international and national journals. Several invited talks were delivered.

Analytical Chemistry

Characterization of Materials for Purity and Composition by Chemical Methods and Analysis of Environmental Species.

A number of samples received from various industries, research organizations and sister divisions of NPL were analyzed for their major and minor constituents by classical as well as by instrumental methods like UV-Vis Spectrophotometry, Atomic Absorption Spectrometry, Gas Chromatography etc.

- A number of poly aluminium chloride samples received from Delhi Jal Board were analyzed for their aluminium content, which is useful for purification of water.
- A number of synthetic diamond samples received from Delta Export, Mumbai were analyzed for major constituents like carbon, silica by gravimetry and other impurities such as Fe, Na, Mg, Ca, were analyzed by flame atomic absorption spectrophotometer (FAAS).
- A number of samples of indelible ink received from Election Commission of India used for Election purpose were analyzed for important constituent like $AgNO_3$ and performance test.
- Purity of air conditioning gas was ascertained for VVIP security on Independence Day.
- Compositional analysis of Aerosol samples has been done including black carbon collected throughout the year by cascade impactor / HVS in Delhi at various locations.
- Besides this, different samples such as petrol, ceramics, alloys, water, hair, nails, polyester and copper scrap received from various private industries / Govt. agencies and other institutions were analyzed.
- Evaluation of different samples received from Indian Reference Materials Section for Ni, Cu, Zn, Se, Hg, As, Ca, and Nitrate have been evaluated using concentration atomic absorption and u-v, vis spectrophotometric method against internal standards prepared in the section. Also measurements were carried out from time to time to study the stability of these solutions. Also participated in international proficiency testing for rice for the evaluation of trace elements present in rice (Received from Belgium).
- Activities related to preparation of India's initial national communication (NATCOM) to the UN frame work of convention on climate change (UNFCCC) for agricultural sector are being carried out for reducing uncertainties in Greenhouse gases emission in the area of livestock, rice cultivation and biomass burning of agriculture residues.
- A national campaign for the measurement of N_2O and CH_4 emission from rice / wheat ecosystem in relation to reducing uncertainties in emission factor in a coordinated work mode is going on. The institutions participating in this campaign are Indian Agricultural Research Institute New Delhi, Central Rice Research Institute Cuttack, Regional Research Laboratory Trivandrum, Regional Research Laboratory Bhubaneswar, Central Fuel Research Institute Dhanbad, National Remote Sensing Agency Hyderabad, Institute of Radio Physics & Electronics University of Calcutta, Anna University Chennai and Assam Agricultural University Jorhat.
- GHGs emission studies have been done first time in India on rice cropping system during 2001 Kharif season under elevated carbon dioxide atmosphere using the open top chambers (OTC) and also free air carbon dioxide enrichment (FACE) facility at IARI New Delhi. The results show an increase in methane emissions under OTC and FACE and have correlation with increased plant biomass.
- A field campaign study, during February 21 to March 7th, 2001, to quantify the trace gas including GHGs emissions from slash and burn agriculture practices (Shifting or Jhum Cultivation) at Balasib-Mizoram area in North Eastern region of India has been done in association with NRSA, Hyderabad.

EPR Spectroscopy

Electron paramagnetic resonance is a very sensitive and specialized technique to detect and characterize the materials containing unpaired electrons like free radicals, transition metal ions complexes, irradiated materials and many biological systems etc. Characterization of different types of materials for such paramagnetic centres/ impurities was provided to many NPL research groups and outside organizations. EPR study of microstructure of different ternary oxide glasses was continued in collaboration with Physics Department, M.D. University, Rohtak. Glasses containing transition metal oxide were investigated by EPR technique because these can be expected to possess interesting and unusual properties arising from the fact that transition metal ion can exist in more than one valence state in glasses. In $xNiO.(0.3\text{-}x)Li_2O.0.7B_2O_3$($0 \leq x \leq 0.15$) glasses containing 1.0 mole%V_2O_5, it is concluded that V^{4+} ions exit as VO^{2+} ions in octahedral coordination with a tetragonal compression and belongs to C_{4v} symmetry. The tetragonal distortion around vanadyl ion was found to increase and 3dxy orbit of unpaired electron of vanadium was found to expand with increasing concentration of NiO in the glasses. Decrease in DC conductivity with increase in NiO:Li_2O ratio indicates that the mobility of the alkali ions responsible for conduction are blocked by Ni ions. EPR study of ferric chloride doped poly (3-methyl thiophene) has shown the formation of polarons which are responsible for charge conduction mechanism in these materials.

Thermally grown amorphous silicon dioxide and its annealed thin films were characterized by EPR and IR techniques to understand the local bonding arrangements of silicon and oxygen in terms of different molecular groups and defects formed in amorphous film network during growth. An isotropic narrow EPR signal at $g \approx 2.005$ was attributed to dangling bond states which is characteristics of amorphous phase of silicon. The vibrational bands pertaining to Si-O-Si group and modifications in Si-Si bands of distorted SiO_4 tetrahedron, silicon phonons and crystalline silicon SiO_2 were observed in these films. The annealing has shown improvement in film quality in terms of decrease in defect density and disappearance of certain bands. IR studies of PECVD grown phosphosilicate glass (PSG) films on p-type silicon wafers at ambient and different low temperatures have revealed the formation of hydrogen bonded Si-OH molecular group and crystalline silicon particles in the film lattice network. These studies revealed the crystallization and densification of amorphous PSG film during annealing process of film growth.

XRD / XRF Techniques

X-ray diffraction and fluorescence studies were carried out for about 195 samples of materials including high Tc superconductors with different dopants, carbon-carbon composites and powder, SiC, diamond like carbon films, Bi_2Te_3, InSb, lead zirconate titanate, bismuth molybdate, lead magnesium niobate, cBN, calcium phosphate, TiO_2 and thin films of CdTe, CdO, CdS/TiO_2, ZnTe, CdZnTe etc. Assistance was provided to M/s G. Surgiwear, Shahajanpur; Central Revenue Control Laboratory, New Delhi; Dy. Commissioner of Customs, Mumbai regarding the X-ray Analysis of their materials.

X-ray powder data of $ZnGa_2Te_4$, which crystallizes in the defect tetrahedral structure having space group I4 and Z=2 has been established. The lattice parameters are calculated as a = 0.5930(1)nm, c = 1.1859(3) nm and $Dx=5.7x10^3$ kg/m^3. The figure of merit was finally found as M_{20}=40; F_{30} =15(0.023, 82). The post growth structural stability was carried out in the Ga-Te system. Various compounds synthesized earlier and having storage time more than six years have been studied. XRD patterns of Ga_2Te_3, Ga_2Te_5, GaTe and their solid-solutions show only 8-10 broad and diffuse lines which are identical to all the compounds and revealed that these compounds have now obtained a stable hexagonal phase with long storage time.

In the area of ferrofluids, an analysis on optical transmission of laser beam through ferrofluid had shown an anomalous increase in the induced scattered light

intensity under the influence of magnetic field in comparison to without magnetic field. This may be due to the degree of orientation of super paramagnetic particles on varying the magnetic field. Also, the optical reflectance observed at 25° incidence angle shows an increase in the reflectivity by about 15% for the films grown in the presence of magnetic field as compared to without field. Films of ferrofluid (Fe_3O_4) with conducting polymer polyaniline and PVA composites were synthesized and characterized using various techniques. The results of our measurements for the films grown under the influence of with and without magnetic field are quite interesting and encouraging for the electromagnetic interference (EMI) shielding effectiveness in the microwave region (18-26 GHz). Ordered orientation improves the shielding effectiveness.

In collaboration with Analytical Chemistry group, manganese oxide powder prepared earlier was characterized for crystalline phase, Mn content, morphology and impurities, which are critical for ferrite manufactures and was compared with the imported one. The uncertainities of measurement, using ISO guidelines, have also been estimated for quantitative analytical measurements. The results were found to be comparable to the imported Mn_3O_4.

A DST sponsored project on "Development of powder X-ray Diffractometer" has been completed successfully and the final report of the project and the technology transfer document has been submitted to DST. Recently, a new Bruker make D8 advance Powder X-ray diffractometer has been installed in the group and is fully operational. It has been planned to organize an International Workshop on Recent Advances in Nanotechnology of Magnetic Fluids (RANMF-2003) in association with Indian Society of Magnetic Fluid Research(ISMFR) to be held at NPL from Jan. 22-24, 2003.

Electron Microscopy

Electron Microscopy group is equipped with sophisticated micro-structural characterization facilities which include Transmission Electron Microscope (TEM model JEOL JEM 200CX) and Scanning Electron Microscope (SEM model Leo 440). The state of the art SEM is fully PC controlled and has the facility of Energy Dispersive Spectroscopy (EDS model Oxford Link ISIS 300). The SEM and TEM facilities are fully operational and provide extensive services for the surface as well as internal structure characterization of various types of materials including semi-conducting thin films, nanomaterials of various kind and carbon nanotubes.

During this year 320 samples have been analysed using the SEM and EDS system for various NPL groups in their process of developing new materials, like CdTe, WO_3, Bi_2Te_3, AlSb, InSb, carbon nanotubes, conducting polymers, Bi-Pb-Sr-Ca-Cu-O+Ag wires and tapes, SiC composites (Fig. 5.1). Different industries involved in various R & D activities also approached with more than 50 samples. Some of these industries are M/S Nupore, M/S Arctic India, M/S Desicant Rotors, M/S Swil, M/S Gabreil, M/S GKN Drive & Shafts, M/S Bousch & Lomb, M/S Samtel and M/S

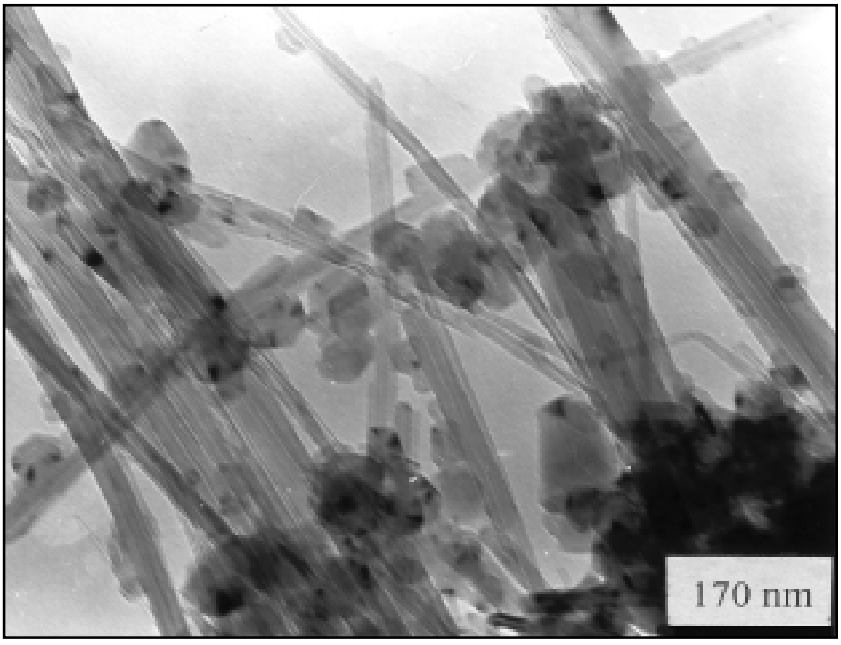

Fig. 5.1 : TEM image of a network of carbon nanotubes developed at NPL

Fig. 5.2 : Photograph showing the exchange of documents by Mr. G.K. Bhatnagar, COA, NPL and Mr. G. Vijayan, AGM (QA-2), Maruti Udyog Ltd in the presence of Dr.K.Lal , Director, NPL after signing the MOU for characterization of materials using facilities available in the Materials Characterization Division

NTPC. The samples received from industries were of various types. Some of these specimens are: filter paper, molecular sieves, desicants, ball bearings, broken piece of rollers and rust of boiler tube. An MOU was signed with M/s Maruti Udyog Ltd to take up failure analysis of the automobile components on priority basis (Fig. 5.2).

TEM studies were conducted to study the internal structure analysis for grain size, grain growth & distribution of various phases and selected area electron diffraction analysis for various phase formation. There were 35 specimens from different R & D activities of NPL and microstructural characterization using this facility was carried out.

Efforts were made to prepare and characterize the cross sectional specimens of GaAs in the group. The materials received from IACS Kolkata and IIT Delhi have been analysed for the study of nano-phase distribution of different oxide particles in the matrix.

The group is involved in various research activities including the preparation and characterization of different semiconducting materials in as grown as well as thin film form. The growth feature at micro-scale and different phase formation were studied in InSb, AlSb, and BiTe compounds. These as grown compounds were utilized to prepare thin films on various substrates under different process conditions during thermal evaporation. Efforts have been made for deposition of Au particles of various size distribution for making standard resolution test specimens which can be possibly used for SEM and TEM (Fig. 5.3).

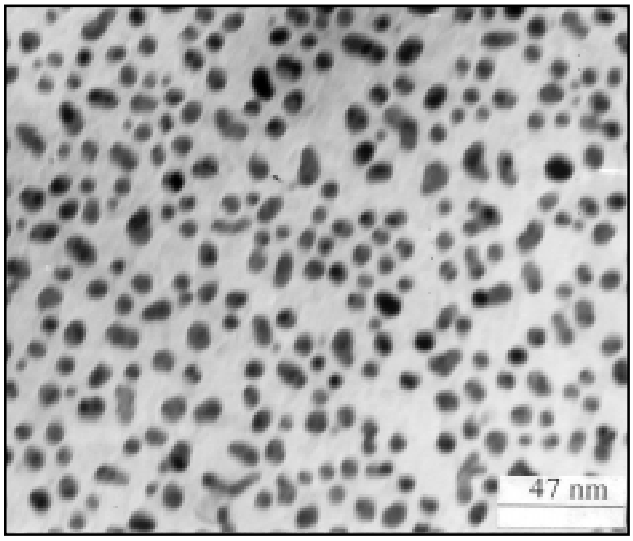

Fig. 5.3 : TEM micrograph of a gold resolution test specimen prepared at NPL

Indian Reference Materials

NPL is coordinating a multi-laboratory collaborating programme on preparation and dissemination of certified reference materials (CRMs). Twenty seven laboratories of the country including national laboratories of CSIR and ten other reputed laboratories of the country namely Bhabha Atomic Research Centre, Indian Agricultural Research Institute, New Delhi; National Remote Sensing Authorities, Ahmedabad; R&D Centre of National Thermal Power Corporation and R&D Centre of Indian Oil Corporation etc are participating in this programme. Use of the CRMs in measurements is mandatory to get measurement values traceable to national and international measurement systems. Their use is also mandatory for the laboratories accredited by national or international accreditation boards under ISO – 9000, ISO/IEC – 17025 etc. These are being used for calibration of analytical equipments namely atomic absorption spectrometers, ICP emission spectrometers, ICP-mass spectrometers, UV-visible spectrometers, ion chromatographs etc. and validation of test methods to generate precise, accurate and reliable results. Use of CRMs is also essential for quality control of industrial products. Some of the major users of CRMs prepared under this programme are the laboratories of Defence, Bureau of Indian Standards, National Test House, various State Pollution Control Boards, Public Health laboratories and National Accreditation Board for Testing and Calibration laboratories (NABL) accredited laboratories. During this year following CRMs had been prepared and sent for round-robin tests:

New BNDs:

1. BND 901 Nitrate in water
2. BND 1901 Manganese in water
3. BND 1801 Calcium in water
4. BND 1701 Chlorpyriphos purity standard (Pesticide)
5. BND 2001 Isoproturon purity standard (Pesticide)
6. BND 1601 Methane in Nitrogen (Gas mixture)

New Batch of Earlier BNDs:

1. BND 601.02 Mercury in water
2. BND 701.02 Selenium in water
3. BND 801.02 Fluoride in water
4. BND 1001.02 Nickel in water
5. BND 1101.02 Multi-elements (Cu, Fe & Zn) in water

Data of these BNDs had been discussed in the meeting of the scientists participating in this programme (Fig. 5.4). The Six BNDs are under certification and these will be released next year. For marketing of the BNDs prepared under this programme, information brochure have been published for distribution at several exhibitions, meetings, conferences etc. Advertisement have also been published in the souvenirs of the conferences and daily newspapers.

International Inter-comparison on Chemical Measurement

Participated in following two international key inter-comparison programme:

1. IMEP-12: Institute for Reference Materials and Measurements (IRMM), Belgium on behalf of European Commission has coordinated this programme. Measured the concentration of B, Cd, Cr, Cu, Fe, Mg, Mn, Ni and Pb in one water sample. Concentration of the elements is found to be in the concentration range of 40.78 X 10^{-12} to 1.590 X 10^{-6} mol.ml^{-1}.
2. APMP.QM-P2: This programme had been coordinated by National Analytical Reference Laboratory (NARL), Australia on behalf of Asian Pacific Metrology Programme (APMP). Measured the concentration of Cd in rice sample. Concentration reported is1.9039 E^{-8} mol.g. Combined uncertainty was found to be 2.056 E^{-10} mol.g.

Crystal Growth and Characterization

Dynamical diffraction features like anmolous transmissiom of X-ray have been studied in MBANP

Fig. 5.4 : Dr. Krishan Lal, Director NPL addressing the meeting of the scientists participating in the programme on preparation and dissemination of Bharatiya Nirdeshak Dravyas on March 18, 2002. Seen on his left are Dr. A. K. Agrawal and right Dr. A. K. Chakrabarty, Director, NABL

single crystals having thickness corresponding to μt = 3.8, μt = 1.0 and μt = 0.65 have been studied. (110) and (220) diffracting planes with CuKα_1 exploring beam were investigated. It is observed that the X-ray intensity at the peak of the diffraction curve of the forward diffracted beam intensity was quite intense even though the specimen is rather imperfect. An interesting new feature of these results is the angular separation between the peaks of the normally diffracted and forward diffracted beams. The two peaks are well separated by a large angle of ~47 arc sec. For the study of the anomalous transmission of X-rays through MBANP single crystals variation of the total transmission intensity was measured as a function of glancing angle q around the Laue diffraction. The total transmitted intensity through the specimen shows a dip and a peak at and near the Laue peak position. The peak clearly indicates the loss in the absorption coefficient of the crystal for X-rays near Laue diffraction.

Point defects and their clusters in bismuth germanate single crystals free from grain boundaries having low density of dislocations have been studied by high resolution diffuse X-ray scattering measurements (Fig. 5.5). Differences in defects in the colourless crystals (type A) and the crystals having yellow tinge (type B), which were grown with different raw materials were investigated. Also, interesting differences in defect structures in specimens from different regions of same boule have been investigated. The diffraction curves of all the samples are quite narrow with half width in the range: 7-11 arc sec, which are close to the theoretically expected values. The observed distribution of diffuse X-ray scattering (DXS) intensity showed that all the point defects are not isolated but a significant fraction is agglomerated into clusters. From DXS analysis the cluster radius R_{cl}, cluster volume A_{cl}, the number of point defects within a cluster N_{cl} and the relative concentration of the point defect clusters among the samples have been determined. It has been observed that cluster sizes do not vary from sample to sample. However, it is found that the concentration of clusters is approximately double in the coloured sample than that of the colourless sample from the same boule. Annealing of the crystals at 1000 ^{o}C produced an increase in point defect clusters by a factor of ~200. It was accompanied by a reduction in volume of clusters by a factor of ~0.14.

Integration of low temperature attachment using thermo-electric element to the multicrystal X-ray

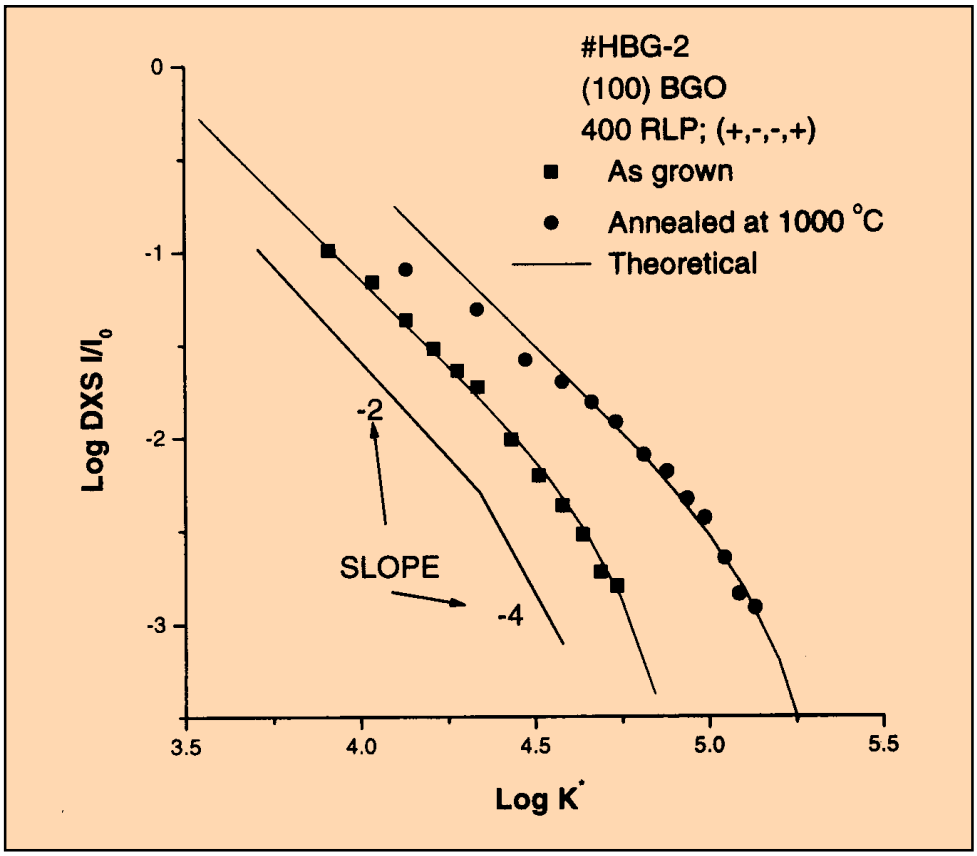

Fig. 5.5 : Typical set of DXS intensity vs. K* plots for a bismuth germanate ($Bi_4Ge_3O_{12}$) single crystal

diffractometer has been completed. In-situ low temperature diffraction studies on a silicon single crystal have been performed. The shift of diffraction peak due to change in lattice parameter has been determined. Temperatures up to – 6 ^{0}C have been achieved.

Additional features have been added in the five crystals X-ray diffractometer designed, developed and fabricated earlier at NPL for grazing incidence studies. In this direction experiments with a highly asymmetric reflection of highly mis-matched GaSb / GaAs hetrostructures with glancing angle ~3^0 have been performed. Four equivalent orientations were studied for each reflection. These experiments helped in determining the accurate value of composition of the epitaxial films.

Single crystals of bismuth germanate grown at NPL have been cut lapped and polished for the study of scintillation properties. To optimize the thickness of the sample, a number of experiments were performed with wedge shaped samples. Variation in light intensity with different thicknesses has been measured. A critical thickness at which the scintillation efficiency is maximum has been determined.

A new double crystal X-ray diffractometer has been setup with the newly acquired 3kW X-ray generator.

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रेडियो तथा वायुमण्डलीय विज्ञान

RADIO AND ATMOSPHERIC SCIENCES

रेडियो तथा वायुमण्डलीय विज्ञान

भारत के दो बड़े शहरों में ग्रीनहाउस गैसों के आकलन और शहरी प्रदूषण तत्वों पर रात–दिन दिल्ली में तीन प्रकार की श्रेणियाँ बनाकर रोसोल्स के मॉनीटरन पर और अंटार्कटिका पर ग्रीनहाउस के मॉनीटरन पर दो ऐसे नए अध्ययन शुरू किए गये हैं जो इस डिवीजन के वायुमण्डलीय पर्यावरण अध्ययन कार्यक्रम के अन्तर्गत आते हैं। इस समय चल रहे फॉग अध्ययन कार्यक्रम के अन्तर्गत फॉग के द्रव जलअंश का अनुमान आई आर (IR) एब्जॉपश तकनीक का उपयोग करते हुए किया गया है। और तापमान की वर्टिकल प्रोफाइलिंग, सापेक्ष आर्द्रता और निम्न प्लेनेटरी बाउंडरी परत में दाब पर कार्य चल रहा है। दिल्ली पर फॉग की पूर्व सूचना प्राप्त करने के लिए सिनोप्टिक मेट्रॉलोजिकल आंकड़ों की व्यवस्थित परीक्षा करना इस कार्यक्रम का एक भाग बन गया है। इस संबंध में लेह/ हानले, दार्जिलिंग और सुन्दरबन में अभियान शुरू किया गया है। एक अध्ययन से यह पता चला है कि कुछ स्थितियों में वायुमण्डल में पाए जाने वाले एरोसोल्स जममीन तक यू वी–बी (UV-B)के स्तर को भी बदल सकते हैं। सरफेस ओजेन और अन्य मॉनीटरन कार्यकलाप किए जाने जारी हैं।

रेडियो संचार के अध्ययन के क्षेत्रा में बादलों के अलग–अलग स्थान पर आने और उसकी विशेषताओं के कारण संचार सिग्नल के अटैनुएशन के कारण और वर्षा की ऊँचाई और वर्षा की दर का प्रयोगात्मक आधार पर अनुमान लगाया गया है। मल्टी पाथ पर प्रभाव के कारण संचार के खराब होने पर भी अध्ययन किया गया है। समुद्र पर उक्ट प्रोपेगेशन के कारण वी एच एफ (VHF) संकेतों का भी पता चला है। आई एम डी (IMD) और जहाजों द्वारा मॉनीटरन किया गया रोटीन मैट डाआ (routine meet data) का उपयोग करते हुए ऐसी वाष्प नालियों के कंटूरों को गिनने के लिए एक कार्यक्रम शुरू किया गया है। मोबाइल ट्रेन रेडियो संचार प्रयोग भी उत्तरी और पश्चिमी भारतीय क्षेत्रों में सेल्युलर संचार के लिए अनुपयुक्त क्षेत्रों का पता लगाने के लिए किए गए एक और अध्ययन के भार के रूप में किए गए हैं।

आथनोस्फारिक ममॉडलिंग के क्षेत्रा में इस डिवीजन ने दो महत्वपूर्ण कार्यक्रम शुरू किए हैं। इनमें से एक फैराडे रोटेशन के कारण होने वाले लाइन–आफ–साइट पाथडिलेस (line-of-sight pathdelays) में बेहतर संशोधन आकलन के संबंध में है ताकि नौ संचालन और पोजीशन फिक्सिंग के लिए आयनोस्फरिक भविष्यवाणी करने में सुधार किया जा सके और दूसरा कार्यक्रम आयनोस्फरिक टोमोग्राफी के संबंध में है। फलीटसैट (Fleetset) सेटेलाइट डाटा में ग्रहण की गई सिंटिलेशन इवेन्ट (Scintillation event) की स्थापना लियोनिड उल्का शावर के साथ की गई है जिसका मॉनीटरन ऑप्टोमीअरीकली किया जाता है और प्रेक्षण किए गए सिंटिलेशन पैटर्न को उत्पन्न करने के लिए विकसित किए गए मॉडल के बीच चालू अध्ययन संबंध मौजूद है। एक अन्य अध्ययन से पाँच स्थानों में सिंटिलेशन में आँकड़ों के साथ–साथ रखे गये रिकार्ड से ई एक्स बी (ExB) दरार को समझने में सहायता मिली है और इक्वेटोरियल प्लाजमा बब्बल्स (equatorial plasma bubblies) वृद्धि और विकास में सूर्यास्त के बाद आयोनाईजशेन की विसंगति समझने में सहायता मिली है। स्रॉस सी2 (SROSS C_2) सेटेलाइट एन पी एल का आर पी ए पेलोडाऑनबोर्ड (RPA payload ouboard) ने यह संभव बना दिया है कि सूरज द्वारा आयनोस्फेयर में घटित प्रभावों की तुलना निम्न सौर क्रियाकलाप से लेकर उच्च कार्यक्लाप की कलाओं से की जा सके और आयनोस्फारिक मॉडलों द्वारा पहले से पता लगाई गई कुछ विशेषताओं को सही बताया जा सके। SROSS आँकड़ों का उपयोग भी अल्टीच्युडिनल और लैटीच्यूडिनल घट–बढ़ का अध्ययन करने के लिए और भूमि के आयनोस्फेयर में 400–600 किलोमीटर की उच्च रहेंज में 32 बट से अधिक ऊर्जा के सुपराथर्मल प्रवाह के लिए भी किया गया है। पिछले आयनोस्फरिक रिकार्डों का उपयोग करते हुए निम्न लैटिरयूड के लिए आयनोसुरिक मॉडल के प्रभावीकरण और सुधार के अध्ययन अभी भी चल रहे हैं।

RADIO & ATMOSPHERIC SCIENCES

Budgeting of greenhouse gases and urban pollutants for two mega cities of India, round the clock monitoring of aerosols in three size categories in Delhi and monitoring of greenhouse gases at Antarctica are the new studies initiated under the atmospheric environment study programme of this division. Under the ongoing fog study programme estimation of liquid water content of fog has been attempted using an IR absorption technique and vertical profiling of temperature, relative humidity and pressure within the lower planetary boundary layer has been started. Systematic examination of synoptic meteorological data to look for precursors of fog over Delhi has been made part of this programme. Campaigns were carried out at Leh/Hanle, Darjeeling and Sunderbans. A study has revealed that under certain conditions aerosols in the atmosphere could also alter the level of UV-B reaching ground. Surface ozone and other monitoring activities have continued.

In the study area of radio communication, the attenuation of communication signals due to coverage and characteristics of clouds and due to rain height and rain rate has been experimentally estimated. Fading of communication links due to multi-path effect has also been studied. Enhancement in VHF signals due to duct propagation over the sea has been noticed. A programme to compute contours of such evaporation ducts using routine met data monitored by IMD and by ships has been developed. Mobile train radio communication experiments have also been conducted over northern and western Indian regions as part of another study to identify regions not suitable for cellular communications.

In the area of ionospheric modeling the division has started two significant programmes. One of these is on better estimation of corrections in line-of-sight pathdelays caused due to Faraday rotation so as to improve ionospheric prediction for navigation and position fixing and the other is on ionospheric tomography. As part of ongoing studies connection between a scintillation event captured in the Fleetsat satellite data has been established with Leonid meteor shower monitored optometrically and a model developed to generate the observed scintillation pattern. In another study simultaneous recording of scintillation data at five locations has helped in understanding the role of ExB drift and post-sunset ionization anomaly in growth and evolution of equatorial plasma bubbles. SROSS C2 satellite and NPL'S RPA payload onboard has made it possible to compare the influences caused on ionosphere by the sun from low solar activity to high activity phases and to validate certain features predicted by ionospheric models. SROSS data has also been used to study the altitudinal and latitudinal variation supra-thermal flux of energies above 32 eV in the height range 400 to 600 kms in earth's ionosphere. Studies in validation and improvement of ionosphreric model for low latitudes using past ionospheric records have continued.

Atmospheric Environment and Global Change Studies

Mega Cities Greenhouse Gases Emissions

NPL along with the Institute of International Global Environment Strategies, Japan has initiated a multi-country project sponsored by the Asia Pacific Network for Global Change Research (APN) titled "The budget of GHGs, Urban Air Pollutants & their future scenarios in Mega Cities in Asia". Seven mega-cities in 5 Asian countries, including Delhi and Kolkata in India, are being investigated. The Centre on Global Change at NPL is responsible for related investigations in these two cities in India and also the city of Manila in Phillipines. The goal of the project is to assimilate/ generate a scientific database on amounts of emissions of direct and indirect sources of greenhouse and other urban gases, etc. caused by these cities. This will enable identifying viable mitigation options that can have significant impact on the total country level emissions. Studies so far in Delhi and Kolkata have revealed the following per capita emissions for the year 1990:

City	**Delhi**	**Kolkata**
CO_2 emissions per capita per annum	1.5 tons	1.1 tons
CH_4 emissions per capita per annum	23 kg	24 kg

Emissions for CO, NOx, HC, particulate matter, black carbon & organic carbon have also been estimated.

Effect of Aerosols on UV-B Intensity

UV-B levels, total column ozone and aerosol optical depth over the city of Delhi are recorded regularly round the year by NPL since past two decades. Contrary to the normally held belief that UV-B intensities reaching ground are governed primarily by the amount of total column ozone, an episode in the month of June 2001 observed by NPL has shown that aerosols also can significantly alter UV-B levels under certain conditions. Delhi during summer months of May-June normally has daytime temperatures above 40 degrees C, relative humidity below 40% and the sky appears whitish or brownish but cloud free, with solar disc visible by naked eye. Such a colour of the sky implies the presence of a lot of suspended dust particles in the air. On June 11, 2001 the atmospheric conditions over Delhi were similar and continued to be so for the next three days. Following this, it so happened that on June 14 there was a heavy rain, a rare event in this season, removing the suspended dust particals resulting, therefore, in very clear skies having blue color on June 15. The aerosol optical depth decreased by 50-60% but the total column ozone content was found to have changed by 1% only. Surprisingly, the UV-B intensities were also found to increase by 70-80% over the same period, a change so large which cannot be attributed to 1% change in column ozone (Fig. 6.1). This has given conclusive evidence that aerosols could also, under certain conditions, play a major role in affecting the UV-B intensities during summer months. The scattering and the absorption of the UV-B intensities by the brownish haze could be the responsible factor.

Fog Monitoring Programme

Under this inter-Divisional major activity of NPL aimed to understand the role of pollutants in fog occurrences in Delhi, several parameters of fog season were monitored using available facilities. These included, among others, planetary boundary layer, fog layer thickness, visibility, vertical profiles of temperature, relative humidity and pressure, IR absorption by fog liquid water, suspended particulate matter including black carbon, concentrations of SO_2, NOx, surface ozone and greenhouse gases etc. On intervening sunlit days aerosol optical depth and UV-radiation doses were also monitored. As described below, some of these were new initiatives requiring indigenous development.

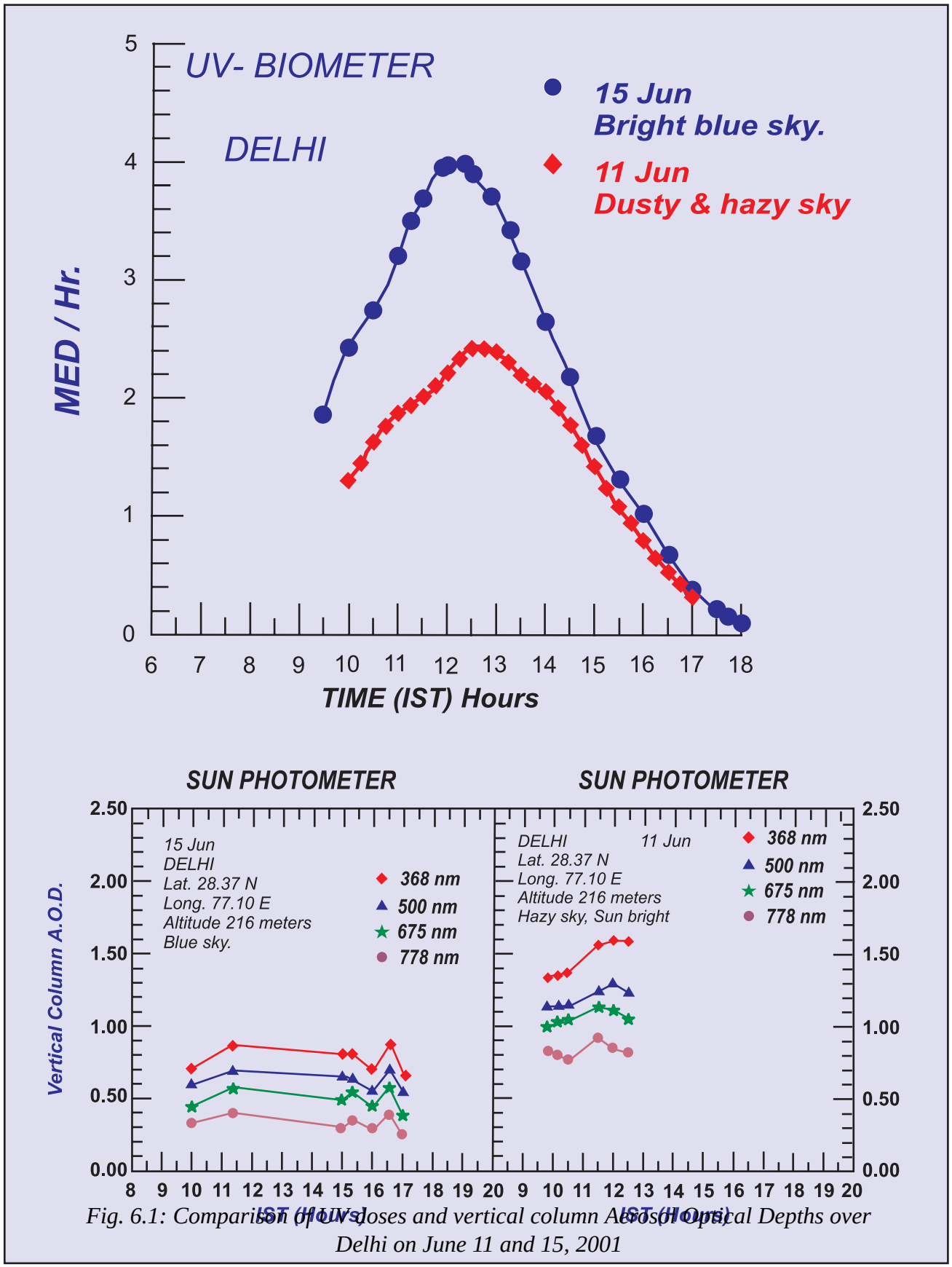

Fig. 6.1: Comparison of UV doses and vertical column Aerosol Optical Depths over Delhi on June 11 and 15, 2001

Humidity monitoring near super saturation

One of the difficulties experienced in monitoring relative humidity using available humidity sensors is the measurement above 85% and up to 100% accurately in the condensing environment. Once the humid air nears super saturation stage, a film or drop of water sets on the sensing element hampering further measurements accurately till the drop evaporates fully. We have successfully developed a low cost portable system that overcomes this lacuna. A microelectronics capacitive type sensor from Honeywell with a micro-heating facility has been used in this. The device has been inter-compared and calibrated against the NPL humidity standards.

Also, for measuring the atmospheric pressure, a portable device has been developed that has resolution better than 0.1 mbar.

Vertical profiling of temperature and humidity

For vertical temperature profile measurements, a remote telemetry system has been developed that can make measurement of ambient temperature and RH and is also capable of formatting the digitized data in multiplexed serial bit form for transmission on a serial FM link. Low power FM telemetry Transmitter and Receiver have also been developed for modulation and decoding of the data within a distance of 1 km. Necessary software have also been developed for formatting, decoding and processing of the data and then display on a PC based system. A 10' dia tethered balloon with a carrying capacity of 5 kg or more payload up to an altitude of 200 m specially for in-situ monitoring of air temperature, relative humidity and pressure during fog, was also put into operation.

Automated detection of fog appearance

In order to avoid a difficult round the clock manual vigil necessary to detect the time when fog forms, two techniques have been developed indigenously. The direct technique uses the principle of detection of changes in absorption in a light beam passing through a 30 m air column at a specific band of a 1.9 micron in the IR range, sensitive not to water vapor but to the liquid water droplets in air that form when fog condenses. A commercially available system employing diode-lasers used for automatic visibility monitoring at

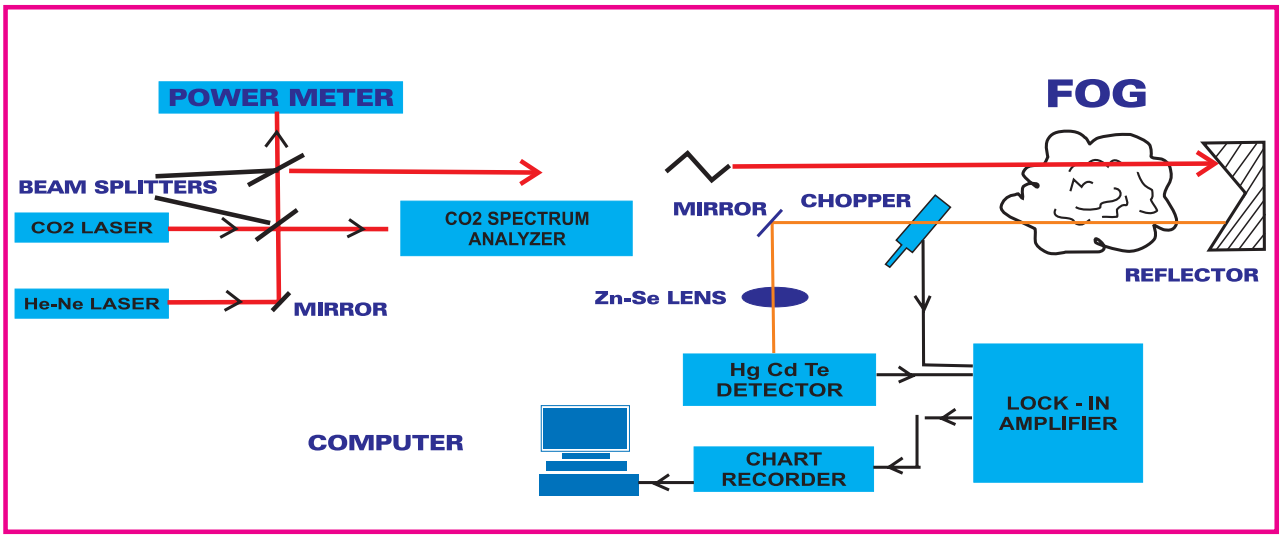

Fig. 6.2 : Block diagram of laser based infrared system for fog studies

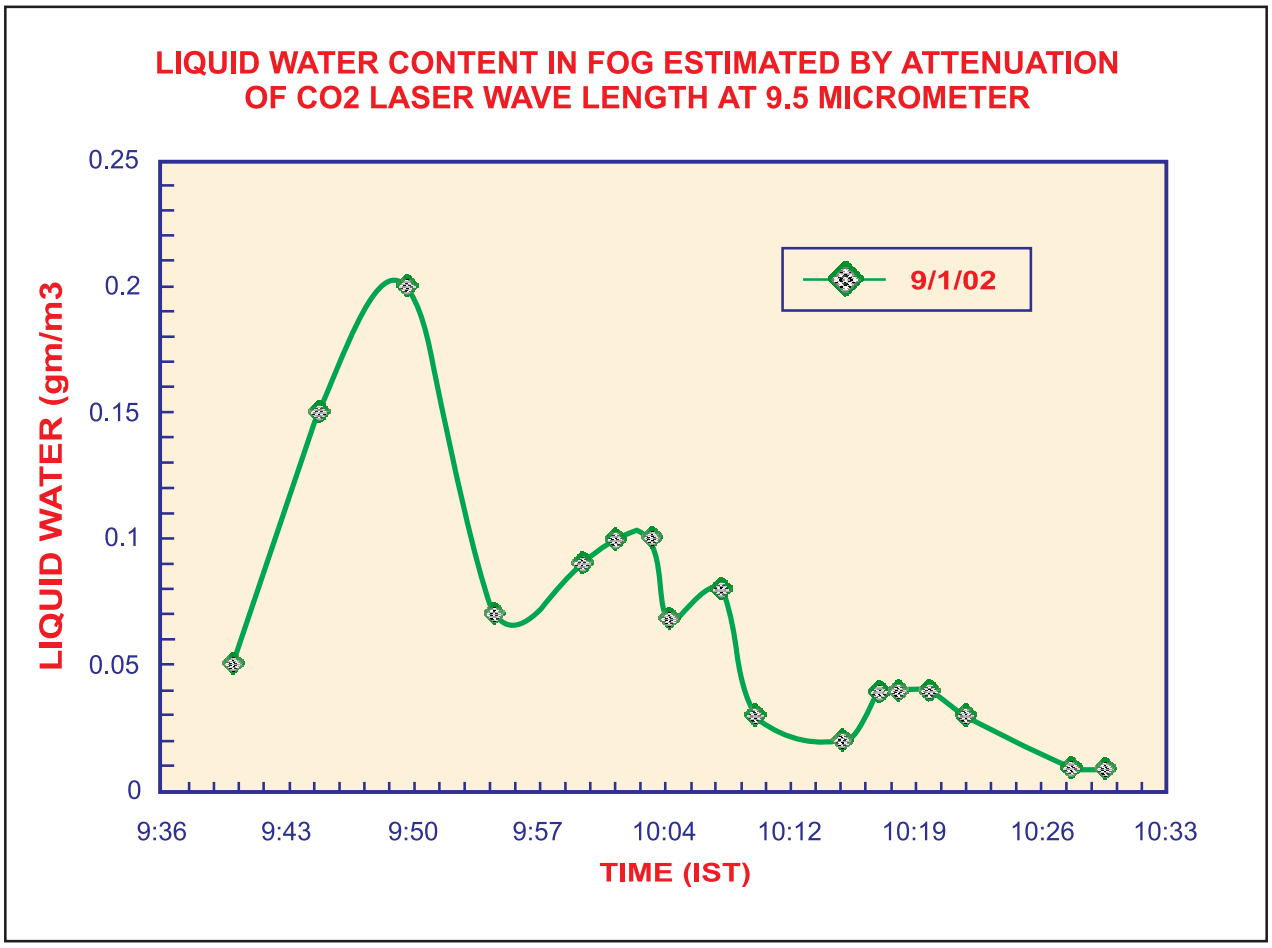

Fig. 6.3 : Estimated variability in fog liquid water content on January 9, 2002 using the infrared system

airports is very expensive in comparison. The NPL developed system operated round the clock successfully during the fog season. Work is progressing to exploit the potential of this technique to measure changes in amount of liquid water in fog. A systems diagram of the instrument developed by NPL is shown in Fig. 6.2. Figure 6.3 shows the fog liquid water content derived form data obtained using this system.

The second technique, which detects fog appearance indirectly, resulted from our study of vertical profile of air temperature within 30 m of ground which revealed that temperature gradient present before fog formation, referred to as temperature inversion, becomes zero at the moment fog appears. The air temperature profilers using an array of calibrated sensors and a customized automatic data acquisition system have been developed indigenously to suit the specific requirements of fog monitoring. The system was operated round the clock giving a wealth of information on soil-air heat exchanges. A typical output on a fog day is shown (Fig. 6.4).

Monitoring synoptic met conditions during fog

This year it was decided to also pay attention to synoptic met conditions around Delhi that affect appearance of fog. For this purpose we have started to archive synoptic mean sea level pressure (mslp), winds at surface and 850 mbar over the Indian subcontinent from Singapore Meteorological Services; satellite imageries from Dundee Satellite Receiving Station, U.K. and radiosonde profiles from NOAA, USA. A total of 100 MB data in

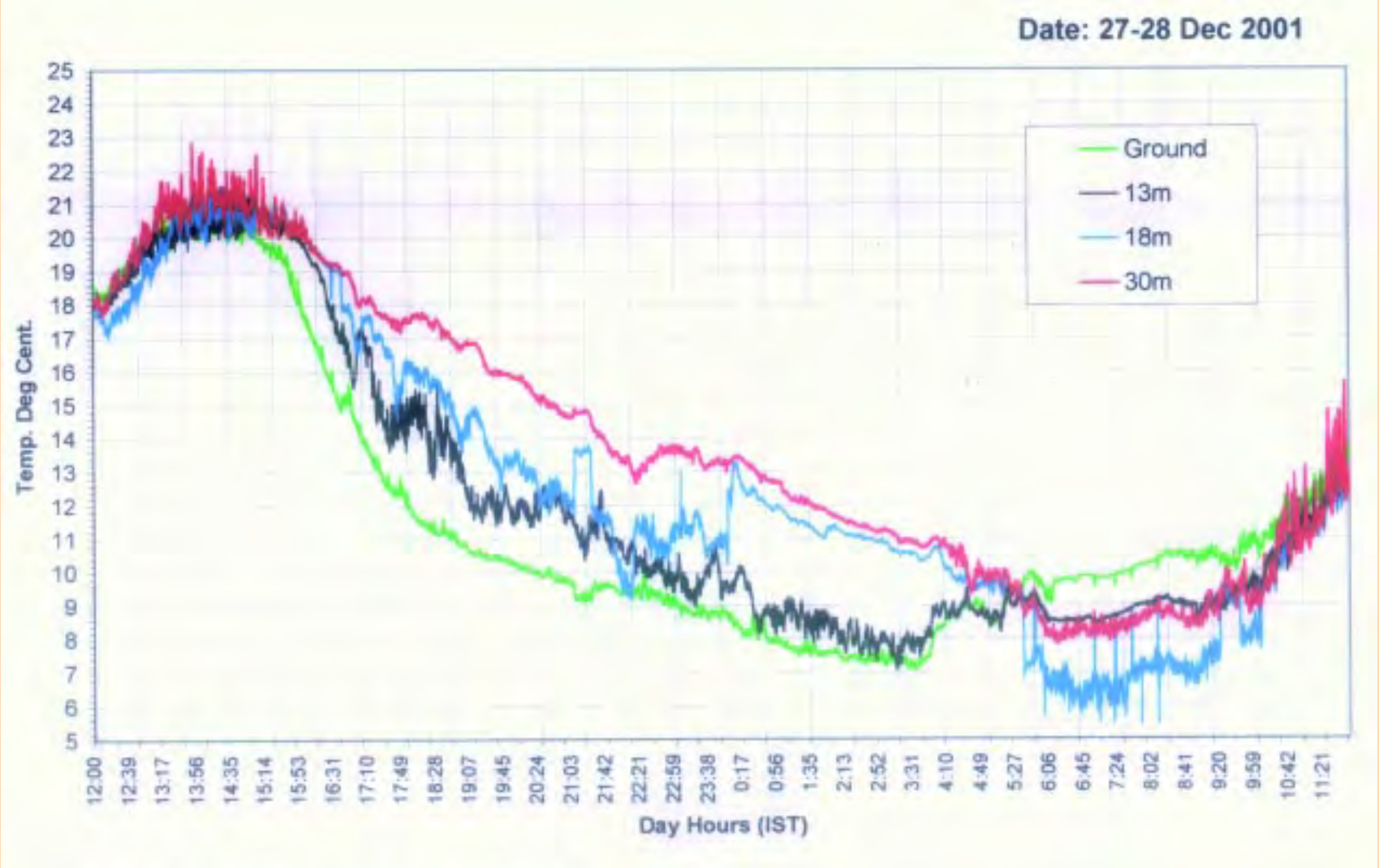

Fig. 6.4 : A typical 24 hour output from the 12 element vertical temperature profiler. Appearance of fog is detected when vertical gradient above ground collapses to zero as at 04.49 hrs in this graph

1315 files have been achieved. On the basis of analysis of this data, we have understood that intense fog in Delhi forms normally only under a high-pressure condition.

New notable features of fog

Fog days in this season were scattered over a 90-day period, unlike last year when most of the fog days were between Jan 1-25, 2001. Many days in the last season saw setting up of fog in the late night hours due to radiative process; the fog formed this time mostly around dawn time and was on several occasions adiabatic in nature. In SODAR an inversion layer at more than 300 m height is also noticed on some days. It was multi-layered on some days. Haze due to fine particles was prevalent on many days during this winter. Even on fog days, when on solar heating fog disappeared at ground level and relative humidity reduced to below 95%, haze was seen to persist for a long time. This seems to indicate the tendency of fog to leave behind raised concentration of certain size particles. This needs to be investigated in detail. There were also certain occasions when sky appeared clear but there was fog at ground level or occasions of multi-layered fog. The real time airborne particle analyzer data indicates a positive correlation of enhanced aerosol particles of 1 & 2.5 microns during fog events.

Round the Clock Aerosol Monitoring

Aerosol particles influence visibility and radiative energy balance of the earth by absorption and scattering of solar and terrestrial radiation. The study of aerosol is considered important for a number of reasons including their possible role in generating a negative feedback to global warming. It is certainly important in the Earth's radiation budget. There are also concerns about the effects of aerosol on human health. Finally it is, in some cases, an important part of the chemical deposition budget for certain chemical species in ecosystems. Formation and persistence of haze, fog and clouds depend upon number, size and hygroscopic properties of ambient aerosols particles. Aerosol are present throughout the boundary layer, at number concentrations depending upon factors such as location, atmospheric conditions, annual and diurnal cycles and presence of local sources. The highest concentrations are usually found in urban areas, reaching up to 108 and 109 particles per cc. The optical and chemical properties of atmospheric particles depend upon their affinity to water vapor. In big urban areas like Delhi where wide variety of aerosol compounds are released in the atmosphere, they degrade visibility and also may alter fog and haze forming processes.

Keeping above in view a round the clock on line measurement of PM1/ PM 2.5/PM10 size aerosols has been started using a haze-dust monitor model EPAM-5000. The equipment uses the principle of near-forward light scattering to measure aerosol concentration. Aerosols are drawn into sensor head; as the particles enter in the path of infrared beam they scatter light. The amount of light received by photo-detector is directly proportional to the aerosol concentration. The sensing range of this equipment is 1 - 20000 mg/m^3. It can measure particles in the range 0.1 to 100 micron also and has an internal calibration facility using a fixed scattering probe.

The measurements of fine particles of size PM 1/PM 2.5 were continued round the clock during fog season also. In general, on a normal clear day when humidity of air does not reach super saturation, the diurnal variation of fine particulate matter exhibits minimum level as low as 50m g/m^3 or less during mid day and slightly increasing trend reaching to 100 to 300 mg/m^3 in the evening and night. The daytime minimum value may be resulting from dilution of boundary layer during its vertical expansion in spite of additional injection of aerosols during daytime. The increasing trend in evening and nighttime may be due to strong inversion. Further the observations indicate an increased concentration of aerosol during foggy days as depicted in Fig. 6.5. The aerosol level was seen to increase from 200 mg/m^3 to 800 mg/m^3 during the event of fog on 9 Jan 2002. The observations indicate enhanced concentrations of aerosols during fog. Our

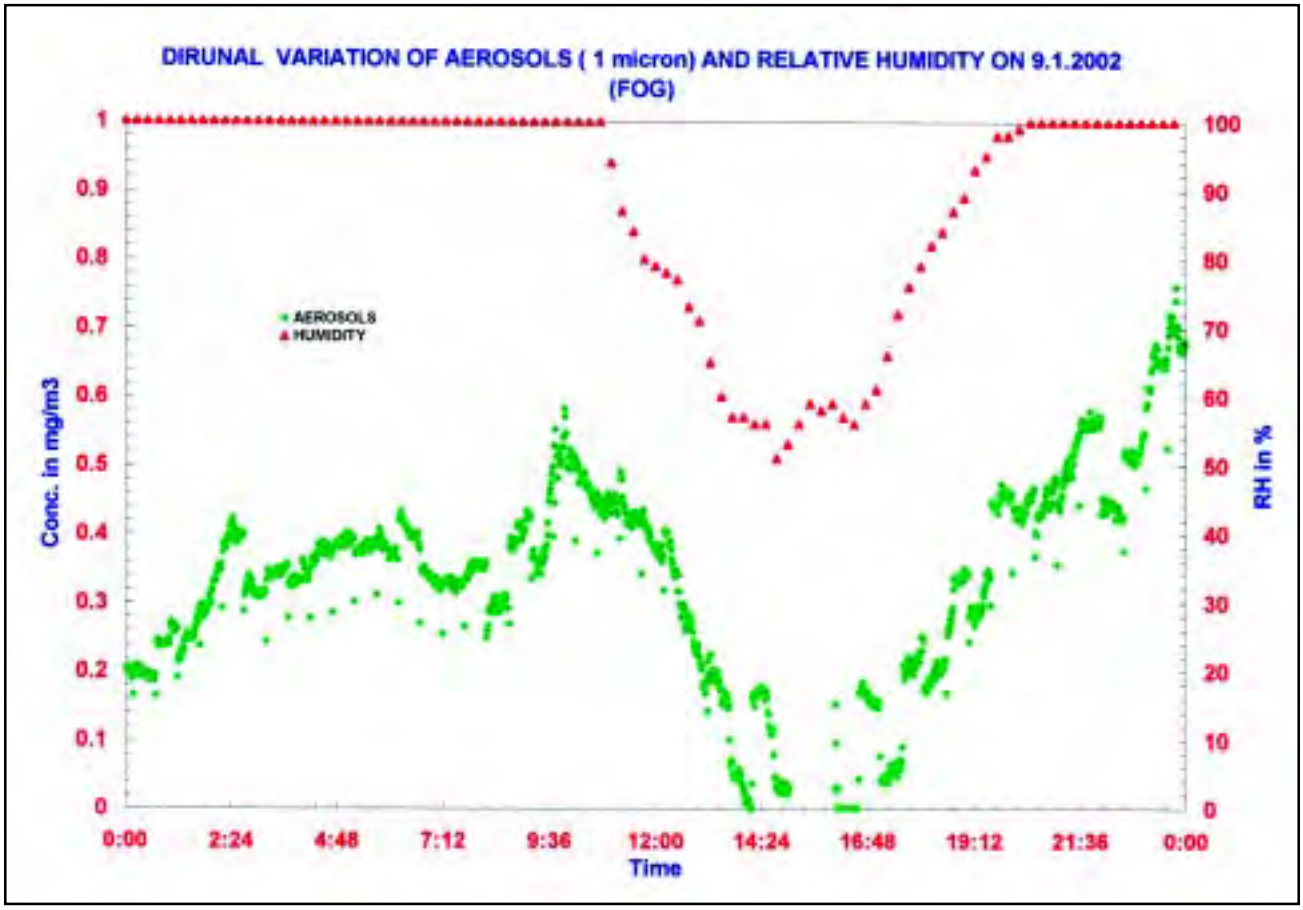

Fig. 6.5 : Diurnal variation of aerosols up to a size of lμ on a fog day, January 9, 2002, plotted along with relative humidity to indicate presence of fog at all times except from roughly 1100 hrs to 1900 hrs

results are found to be in good agreement with Central Pollution Control Board (CPCB) data of 24 hourly respirable suspended particulate matter (RSPM) measured at ITO, Delhi. During fog when relative humidity of air reaches saturation the water condenses on aerosol particles, as a result of which small hygroscopic aerosols get activated and their size grows. The fog formation provides the reacting medium, the liquid water, for aqueous phase chemistry. The dissolved SO_2 in a fog is primarily oxidized to sulphate aerosols by H_2O_2 and leads to increase of sulphate concentrations in fog.

21st Indian Antarctic Expedition

Greenhouse gases in Antarctica

Under the sponsorship of DOD a project for monitoring CO, CO_2 and CH_4 from the Indian Maitri Station has been initiated during the 21st Indian Antarctic Expedition. CO_2 is the prime greenhouse gas. CH_4 is next greenhouse gas in order of its greenhouse warming potential and its levels are affected, apart from others, mainly by anaerobic microbial activities in wetlands such as those associated with paddy cultivation. CO is a pollutant produced from fuel use. It is expected that CO and CH_4 are transported to Antarctica and not generated locally. Determination of the ambient concentrations of these three gases in this remotest continent will help in understanding photochemical, heterogeneous and dynamical processes that control the distribution of atmospheric trace gases. For the purpose of monitoring, a Gas Chromatograph has been established, along with a liquid nitrogen generator plant for producing nitrogen at site for use as a carrier gas in this chromatograph. The gas chromatograph is calibrated using the Peaknet software on regular basis

with CO (9.67 ppm), CH_4 (5.35 ppm & 11.1 ppm) and CO_2 (303 & 320 ppm) standards. Based on these measurements, the carbon dioxide was found to vary in the range 330 to 390 ppm depending on the wind and other meteorological conditions. The average CO_2 during February 2002 was found to be 361 ppm. The data taken during February 2002 is depicted in Fig. 6.6. CO levels were found to be too low and are being looked into.

Total column ozone, water vapor and aerosol optical depth enroute Antarctica

While UV radiation monitoring from Maitri was continued as in earlier years, a hand held microprocessor based sun-photometer, *Microtop*, for monitoring of column ozone, water vapor and the aerosol optical depth was also put to use. Measurements using *Microtop* were started onboard ship from Goa itself to study the latitudinal variation of these parameters during the voyage. Further, the measured values of ozone at Maitri during January and February 2002 were compared with those obtained by IMD's Brewer spectrophotometer. The average ozone measured by NPL's *Microtop* and that obtained by Brewer system were found to be within 3 %. The water vapor measured at Maitri was found to be in the range 1.0 cm to 0.2 cm during the whole period of measurement and the average water vapor was found to be around 0.66 cm and maximum during noon time. The water vapor at Maitri is found to be very low compared to tropical regions and during the voyage. The aerosol optical depth (AOD) was measured for 1020 nm using the above said *Microtop* and found to be in the range 0.1 to 0.022 with average value of about 0.054 at Maitri during January and February 2002.

Shipborne acoustic sounder using digital processing

Only a few countries in the world have the capability to operate Shipborne SODAR. The noise caused by ship machinery and the prevailing winds, sea states, pitch and rolling of the ship are the major sources that deteriorate signal to noise ratio making it very difficult to retrieve useful SODAR signals. Noise in the signal can be eliminated through FFT based digital signal

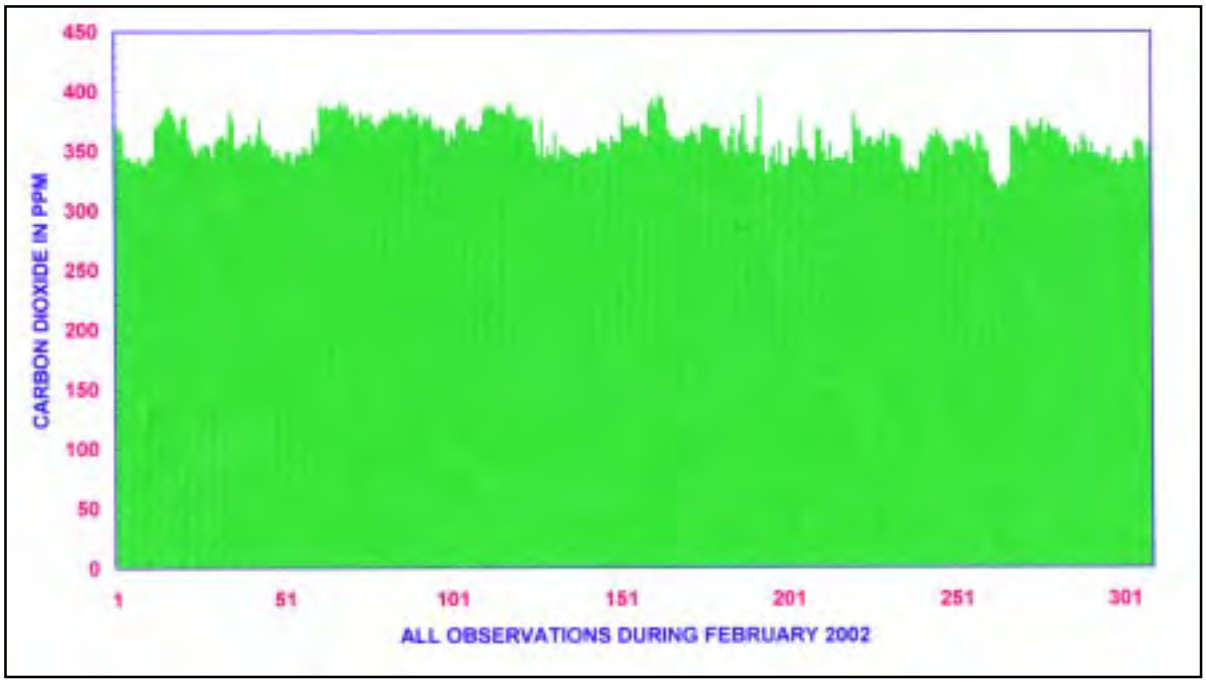

Fig. 6.6 : Measured values of atmospheric carbon dioxide concentration over maitri during February 2002. X-axis gives serial numbers of measurement when arranged in chronological order

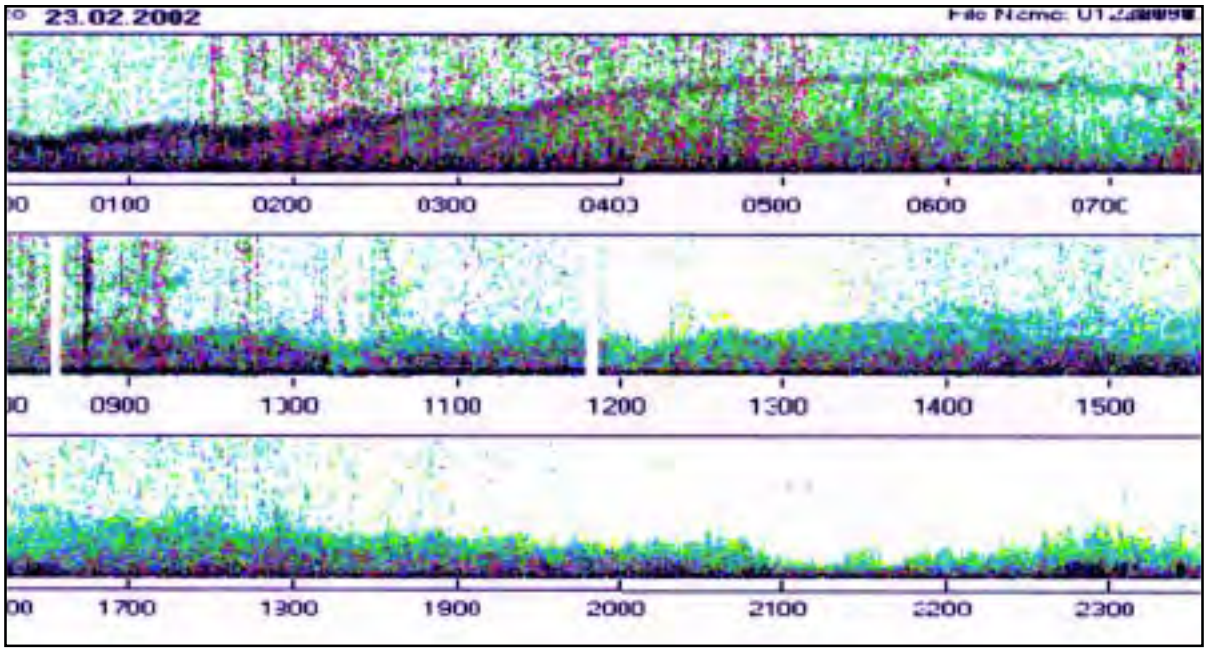

Fig. 6.7 : A typical scan of signals obtained from Ship-borne Sodar obtained for Feb. 23, 2002

processing. This year during the 21st Indian Scientific Expedition to Antarctica NPL has succeeded in establishing Shipborne Monostatic Acoustic Sounder onboard the ship Megdalena Oldendroff. Excellent data using digital filtering technique has been received over the east Antarctic coast while the ship was trailing. Earlier attempts by NPL in 1992-93 and 1995-96 had not met with success. The successful attempt this year has made India the first country in the world to do this at Antarctica. The data for the period January 22, 2002-March 3, 2002 has been gathered and is being analyzed. A typical scan of a day using this Shipborne SODAR at Antarctica is shown in Fig. 6.7.

Cross-Country Campaigns

High altitude measurements of surface ozone

The measurement of surface ozone was carried out at three high altitude sites in a campaign mode. These stations are Bose Institute, Darjeeling (27.03º N, 88.26º E), 2195 meter above sea level, Leh (34.13º N, 77.60º E) 3311 meter above sea level and at Indian Astronomical Observatory, Hanle (32.78º N, 78.96º E), 4467 above mean sea level. The surface ozone measurements carried out at Leh and Hanle during June 1-11, 2000 are compared with those measured at Darjeeling from May 19 to 27, 2001. These high altitude stations (mountain sites) show little diurnal variation of ozone and maintain rather large concentration throughout the day whereas the urban locations on plains, like Delhi, show strong diurnal variation. During the days with low wind speed surface ozone concentration was observed to be about 60 ppb at Darjeeling, 75 ppb at Leh and 85 ppb at Hanle exhibiting a very little diurnal variation. As local photochemical O_3 production does not contribute to net balance at these high altitude stations, this indicates that significant reservoir of ozone is present in the free troposphere above these places. In the high altitude mountain sites ozone showed increasing trend in night, this may be attributed to cooling of mountain causing down slope flow which draws more ozone rich air from aloft and carrying it downward and maintaining high ozone concentration during night. The nighttime decrease of O_3 in plane urban station is expected mainly due to surface deposition and destruction, by NO, of ozone trapped in nocturnal inversion layer. The observations suggests that the exposure of human and

vegetation for high ozone values is for longer time duration at high altitudes The sudden decrease of 10 to 20 ppb surface ozone that was observed at Leh and Hanle at the time of sunrise could be attributed to NOx chemistry. Total ozone measured at Hanle and Leh was found to be around 300 DU and at Darjeeling around 284 DU. The difference may be due to the difference in the latitudes of the stations and also to the different years of observations.

Sun photometer measurements

Measurements of aerosol optical depth, water vapor and total ozone using handheld microprocessor based sun-photometer, *Microtop,* were made at Darjeeling during May 16-28, 2001, at Sunderbans during December 22-29, 2001 and at Port Blair during March 14-28, 2001 as part of a series of campaign for monitoring cross-country transport of pollutants. At Darjeeling, data on related health parameters for two measurement sites Siliguri and Tiger Hills were also collected by the Chittoranjan Cancer Research Institute. Quick look analysis indicates that pollution at Siliguri is higher than at Tiger Hill, Sunderbans has low AOD but excessive water vapor, while at Port Blair all the three parameters had low values. Detailed analysis and correlation with health parameters, only in case of Darjeeling, is in progress.

Trend of Greenhouse Gases, Aerosols, Solar Flux, etc. over Delhi and Comparison with COSMIC Satellite Data

The monthly variations of atmospheric CO_2, CH_4, CO, N_2O, O_3, H_2O and aerosols monitored during 1992-1997 using the high resolution IR spectrophotometer have been compared. In general an increasing trend of all the trace constituents from 1992 onwards is noticeable. Surface concentrations of trace constituents were estimated using a model profile of each trace constituents and are also found to increase. The observed intra-seasonal and inter-annual surface air temperatures obtained at Delhi are compared with the model-simulated monthly mean surface air temperature for the present day prescribed radiative forcing. The surface air temperature simulated by COSMIC using GEM model is the monthly mean temperature for a given radiative forcing averaged over the entire Indian sub-continent. The annual cycle of surface air temperature (observed as well as model simulated) also has similarity with the annual cycle in CO_2, CH_4, CO, O_3, and UV-B flux and with the dependence on atmospheric mixing layer depth.

Radio Communication and Space Physics

Tropospheric Radio Communication

Multi-path effects on line-of-sight microwave communication

The effects of multi-path in relation to deteriorated performance of several microwave communication links located over Indian southern region have been investigated. The received signal under normal condition is usually found to be around -60 dBm. The performance of the link is satisfactory when the signal level is equal and greater than -74 dBm, which is the satisfactory level of the signal. It has been seen that the performance starts deteriorating when the signal level reduces to as low as around -75 dBm. The most problematic months during which the performance of the radio links are not up to the satisfactory level are found to be usually from November to May. The peaks of the disturbances are in the months of February through May. The performance of the links has been found to be disturbed during 2300-0800 hrs L.T. The multi-path fading is responsible for performance deterioration of the links. Such multi-path fading is caused due the stratified atmosphere and is formed due to temperature inversions which occur for substantial percentage of time during December-May.

Cloud characteristics and cloud attenuation for radio system applications

The cloud occurs for longer period than the rain. Therefore, the study on the effects of cloud on radio wave in microwave and millimeter wave frequency bands during different months and time is rather important over different locations in India. A study on cloud occurrences when the sky is covered wholly or partially over Kolkata during different time of the day and night for all the months has been made. It has been found (Fig. 6.8) that during daytime (0830, 1130, 1430 and 1730 Hrs IST) in the months of June, July, August and September, the sky is covered with cloud for a significant percentage of time (92% to 95%). While during night time, it has also been observed that in the month of June, July, August and September the sky is covered with clouds for a considerable percentage of time (83% to 88%). The specific attenuation of radio wave due to cloud for different water particle density at frequency ranging from 10 GHz to 100 GHz varies between 0.008 dB/km and 7.690 dB/km. Such results are of interest to radio engineers for estimation performance or to predict the field strength results for microwave communication and radar propagation.

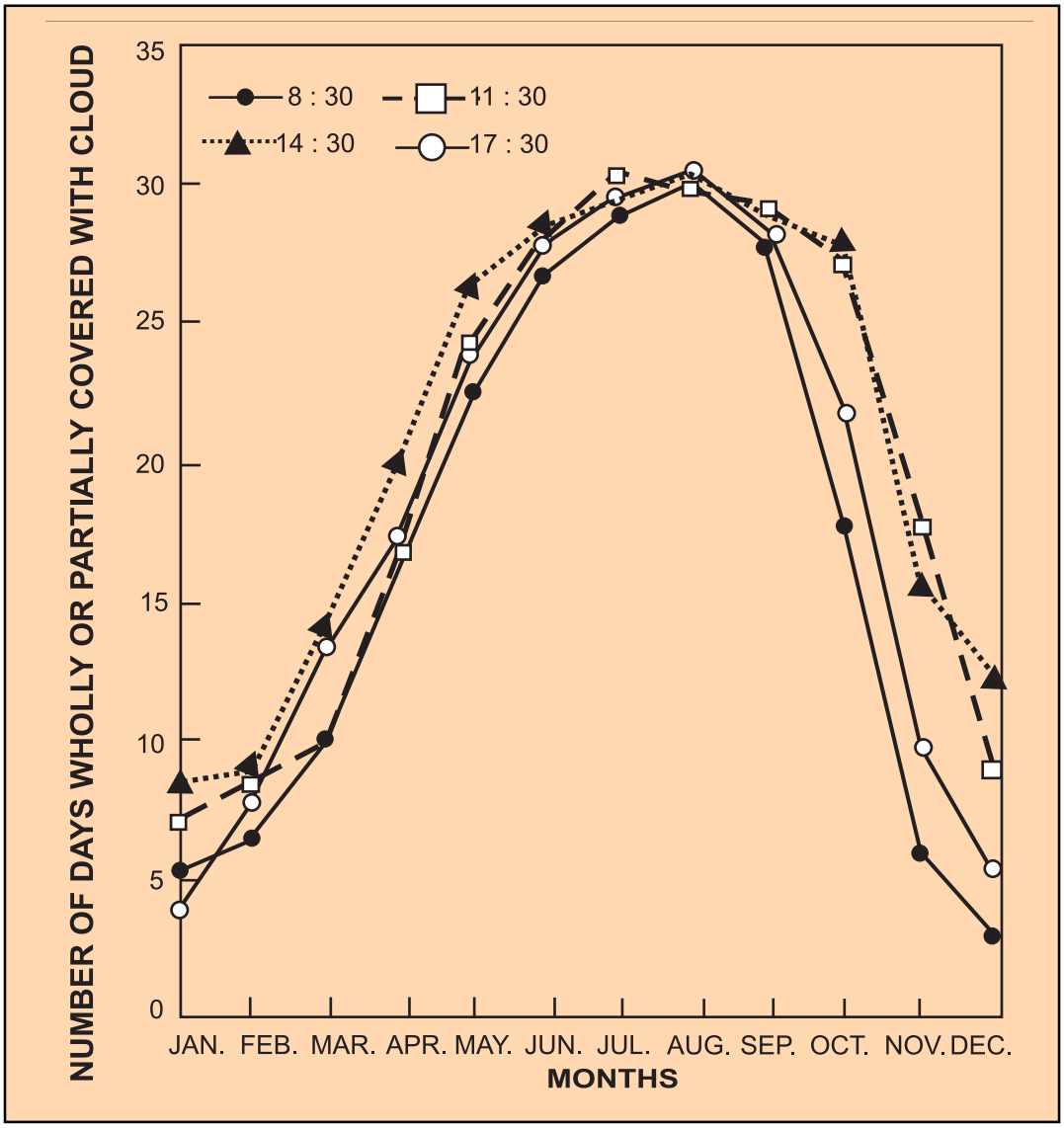

Fig. 6.8 : No. of wholly or partially cloud cover days at different times of the day

Rain attenuation over an Indian south coastal station

There is dearth of results on rain height over Indian tropical stations. Efforts are on to deduce results on rain height in relation to 0^0C isotherm height over different locations in India. On the basis of upper air data, recently some results on rain height in relation to 0^0C isotherm height over four stations having different latitudes were deduced. Four stations were chosen in such a way that all have different latitudes and are located in different geographical regions having different local weather conditions. It is seen that the 0^0C therm height in all months varies between 2.70 km and 6.85 km over these stations. The seasonal variation of rain height in relation to 0^0C isotherm height has been found to be appreciable over the stations located in Indian east coast and Gujarat region, while seasonal variation is not significant at lower and intermediate probability levels over the stations located in Indian south-east coast and island. Based on observed rain heights and rain rates, the attenuation of radio wave at different frequencies lying in the range from 10 GHz to 150 GHz, for different probability levels over an Indian south-east coastal station have been estimated. The one way total attenuation increases with frequency at all probability levels. The estimated results on attenuation at 20 GHz for 0.5%, 0.1% and 0.01% levels are 15 dB, 42dB and 63 dB, respectively, while attenuation at 30 GHz are 30 dB, 77 dB and 111 dB for 0.5%, 0.1% and 0.01% probability levels.

Mobile train radio measurements in northern and western India

Mobile radio channel over urban, sub-urban and rural western India has been characterized with the help of mobile train radio measurements carried out using the following base stations: Kurla, Kalyan, Vengani, Neral, Karjat, Pangoli, Talegaon and Pune in western India and New Delhi, Ghaziabad, Meerut, Muzzafarnagar and Saharanpur base stations over northern India. The heights of base stations vary from 26 to 115 m presenting greater variability of mobile signal levels. The mean path losses as a function of distances for the eight base stations have been deduced and compared with various empirical and theoretical prediction techniques, like Hata, Egli, Ibrahim and Parson, Blomquist and Ladell, etc. The deviations of these methods from the observed values have been deduced and standard deviations have been computed. Reasons for the deviations have been identified along with the suitable methods for this region. The major fallout of this study is the identification of regions having large variability of signal levels. These regions cannot be included under cellular category. Efforts are underway to identify a suitable method over urban, hilly, sub-urban and rural regions suitable to train mobile communication systems. These investigations can form valuable inputs for the design of future mobile communication systems in this region.

Evaporation ducts over Arabian sea and Bay of Bengal

Evaporation ducts are formed due to the rapid decrease in water vapour content, which in turn, leads to a rapid decrease in radio refractivity within about 20m over the sea-surface. Evaporation ducts affect the radio propagation at microwave frequencies over the sea-surface. For example (i) a radar loses contact with low flying targets, (ii) line-of-sight communication is extended to much larger ranges beyond the horizon, (iii) a complete loss of signal occurs in the so-called shadow zone, (iv) radar' scope is full of noise (or atmospheric clutter) even when sea is calm (or with no sea clutter), etc. Evaporation ducts are almost always present over the sea-surface, yet their heights are highly variable in space and time. We have developed a computer program to compute evaporation ducts over the sea-surface using routine measurements, such as: sea-surface temperature, deck-level temperature, deck level relative humidity, deck-level wind speed, etc. The program has been used to compute contours of duct height over the sea-surface based upon measurements complied by the India Meteorological Department, New Delhi. A sample

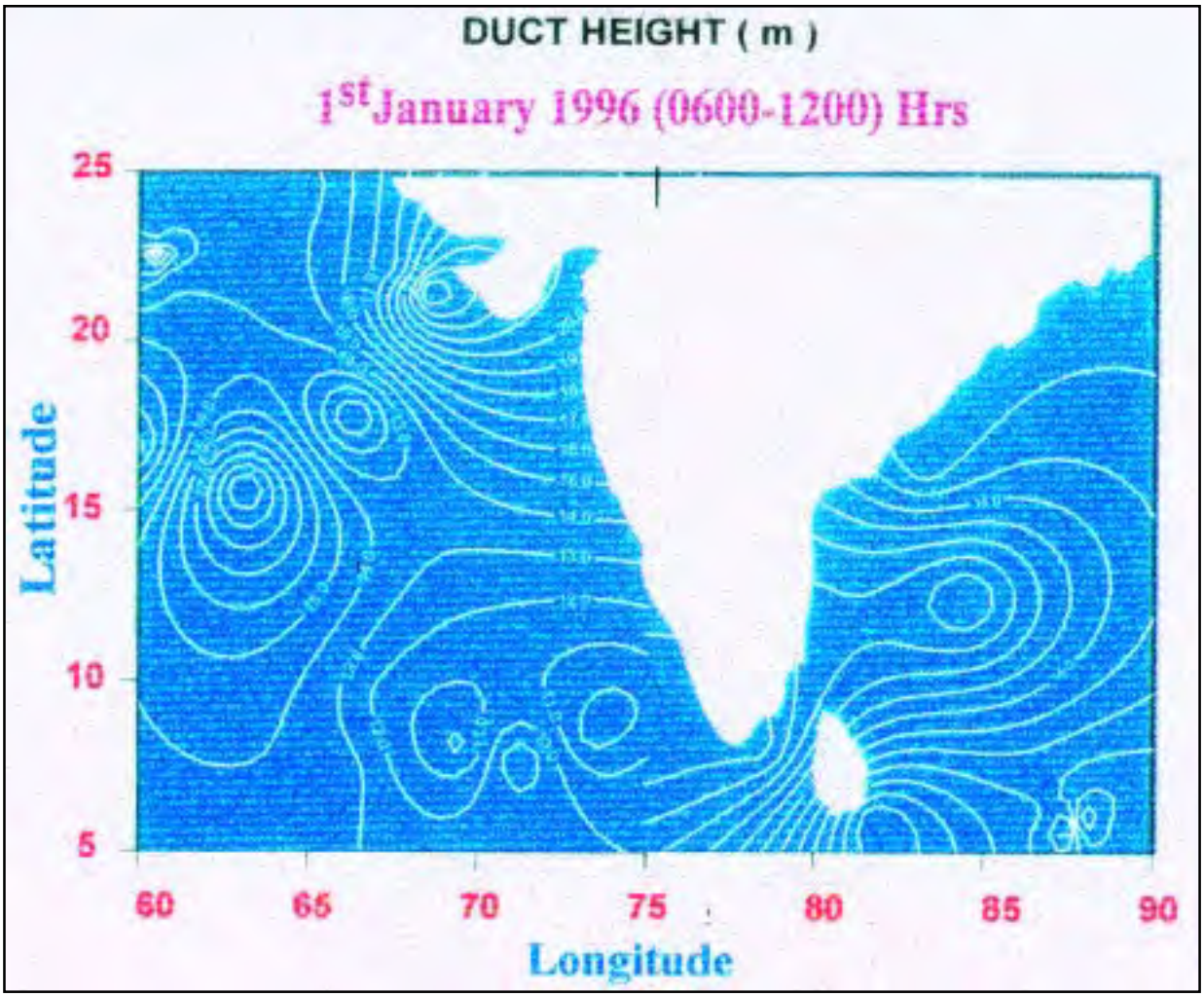

Fig. 6.9: Contours of evaporation duct height (m) over the Arabian sea and Bay of Bengal during the morning hours in winter

output of the computer program is given in the Figure 6.9. The work has been carried out under a sponsored project from the Indian Navy for computation of evaporation ducts at selected locations in the Indian ocean area.

Field intensity of FM signals

The Field Intensity measurements, of the commercial FM broadcast signals of opportunity at 107.1 MHz and 101.7 MHz over the sea upto 200 km range, were performed on-board a ship. The objective of this experiment was to study the VHF signal enhancement due to duct propagation over the sea. The field intensity data obtained is plotted in the Fig. 6.10 wherein the best fit trend curves (blue and pink solid curves) are obtained by fitting a 4th order polynomial to the observed data noted on 107.1 MHz and 101.7 MHz. The green curve denotes free-space loss corresponding to 107 MHz. Duct mode signal enhancement of 5-10 db is seen.

New Results from Analysis of RPA SROSS-C2 Data

Seasonal & solar cycle evolution in electron/ion density and temperatures at equatorial and low latitudes from RPA measurements

SROSS-C2 satellite carrying electron & ion Retarding Potential Analyzer (RPA) experiment was put in

630x430 km orbit in June 1994 during low solar activity period and remained in this orbit for four years until the rising solar activity started lowering the satellite orbit. After 1998, the satellite apogee started lowering from 630 km and came down to 400 km and below by the beginning of year 2001. Solar cycle variations seen in the electron/ion density and temperatures in the low latitude ionosphere in the height region of 400-500 km from the data collected from the RPA experiment on SROSS-C2 satellite yielded important new results. Season wise (summer, winter and equinox) plots of the electron/ion density and temperatures for the low solar activity period of 1995 are compared with that of the year 2000, which is a high solar activity period. The average 10.7 cm solar flux values for the year 1995 and 2000 respectively are 78 and 180. The salient points of this comparative study are:

- Daytime peak ion density during high solar activity period in all seasons is found to be more than double than that measured during the corresponding seasons of the low solar activity period.
- Minimum nighttime densities are lower by 1 decade during low solar activity period as compared to those observed during high solar activity period.
- Electron/Ion temperatures during nighttime hours are higher by 100-150K during high solar activity period compared to the corresponding values during low solar activity period.
- Morning overshoot in electron temperature after sunrise is higher (5500 K) during low solar activity period as compared to the high solar activity period value (4500 K)
- The above observations compare well with IRI model. IRI model shows an increase in minimum electron/ion temperature in high solar activity as well as increase in peak electron/ion density during day time compared with that observed during low solar activity period.

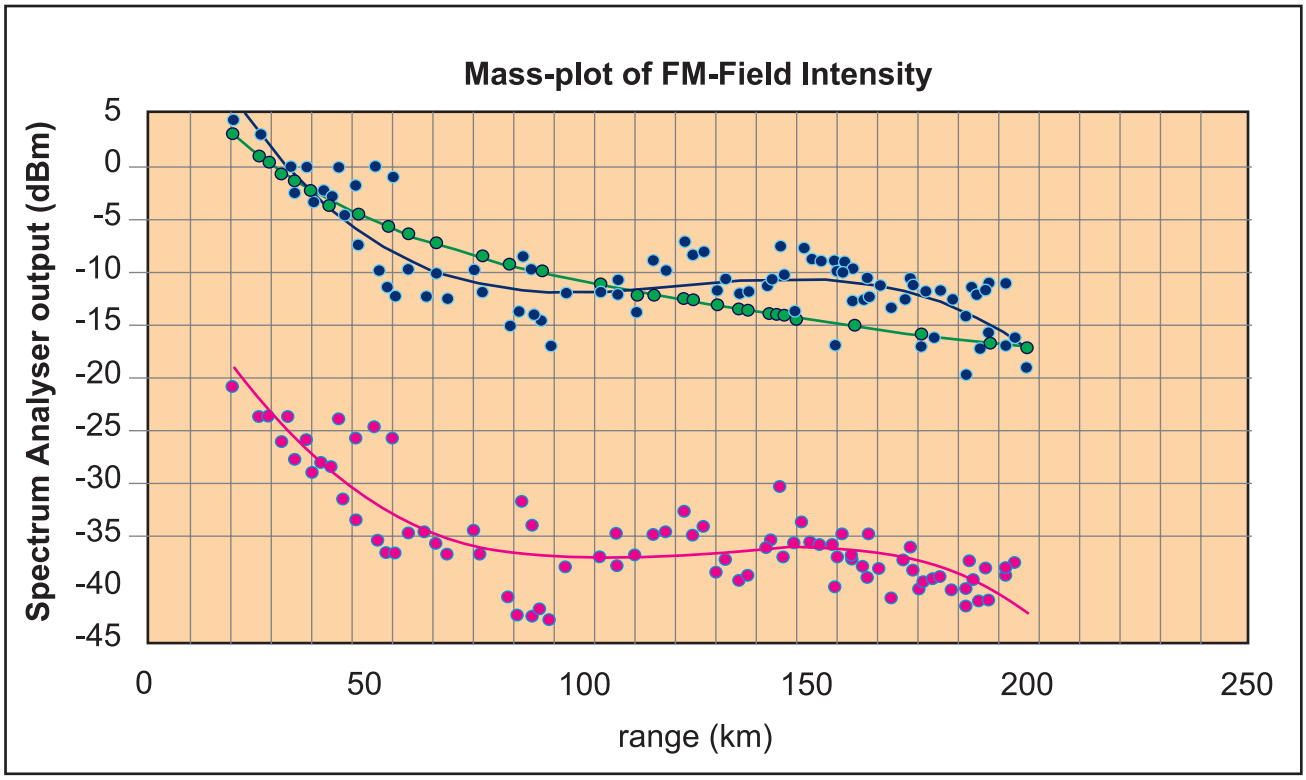

Fig. 6.10 : Monitored spectrum analysis of the detected field intensities of FM broadcast signals

Supra-thermal electron flux at low latitudes from RPA measurements

Supra-thermal electron flux is one of the parameters that is available from the electron RPA measurements on the SROSS-C2 satellite. In the supra-thermal mode of operation of the probe, electron currents were measured for a retardation voltages down to -32 V applied on the retarding grid of the RPA probe. The resulting data can give the integral flux of supra-thermal electrons of energies above 32 eV. The available data indicate that the daytime supra-thermal flux is at least an order of magnitude higher than the nighttime flux primarily because of the photo electron flux which dominates the daytime values. Analysis of the data for the period June 1998 to May 1999 for nighttime flux shows variation of the supra-thermal flux with altitude, and latitude as shown in Fig.6.11. During this period the satellite altitude remained between 420 km and 590 km.

Meteor induced satellite scintillations at VHF and optical observations during Leonid meteor showers - a possible connection

An attempt is made to establish a connection between satellite VHF scintillations induced by Leonid meteor showers and the optical observations of Leonids. It is a well known fact that the luminosity efficiency and ionization efficiency are interrelated by the square of the meteor velocity factor. The present study aims at understanding and interpreting the time-evolution trends displayed in the two data sets. While the optical observations are represented by a set of sequential snap shots of a particular meteor dissipation in the earth's upper atmosphere, the scintillations are recorded using 250 MHz transmission from the geo-stationary satellite Fleetsat which is positioned at 73^{O} east longitude. The optical observations in terms of minute-wise sequential snap shots were downloaded from the NASA web site. In order to

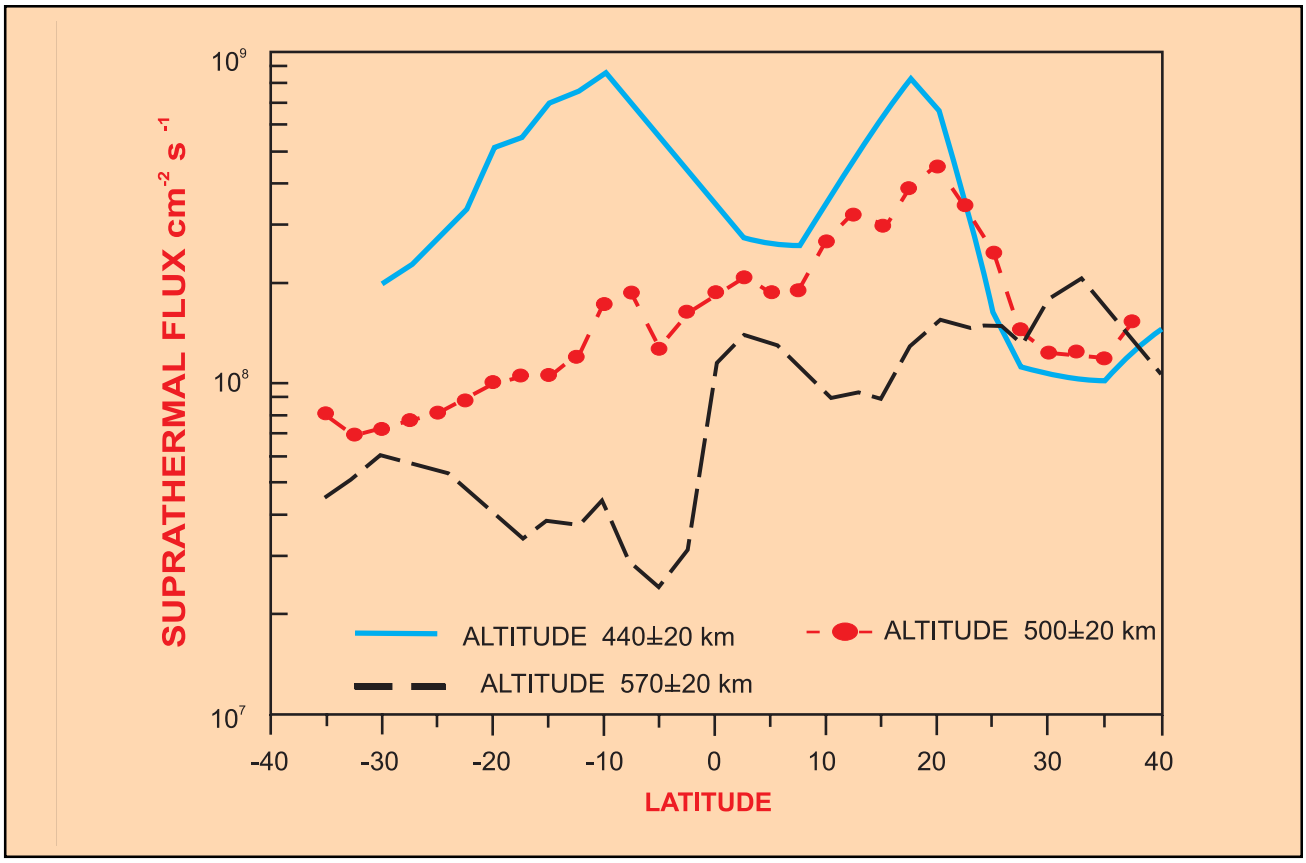

Fig. 6.11 : Variability of suprathermal flux with latitude and altitude

establish the connection between scintillation data on the one hand, and optical observations on the other, a simple but an intuitively suggested method was followed. This method first needed generation of a model for the fluctuations in electron density (ΔN) at meteoric heights due to the passage of the meteor, based on the optical observations. Next, the fluctuating electron density was converted into a fluctuations of phase in a phase screen model (PSM) for a particular satellite radio frequency. This PSM was plugged into a standard parabolic differential equation to solve for the complex electric field fluctuations (scintillations) at the observer's plane, which was fixed at a distance of 100 km from the phase screen, in a computer simulating program. Results were compared with actual scintillation patterns recorded to establish the required connection.

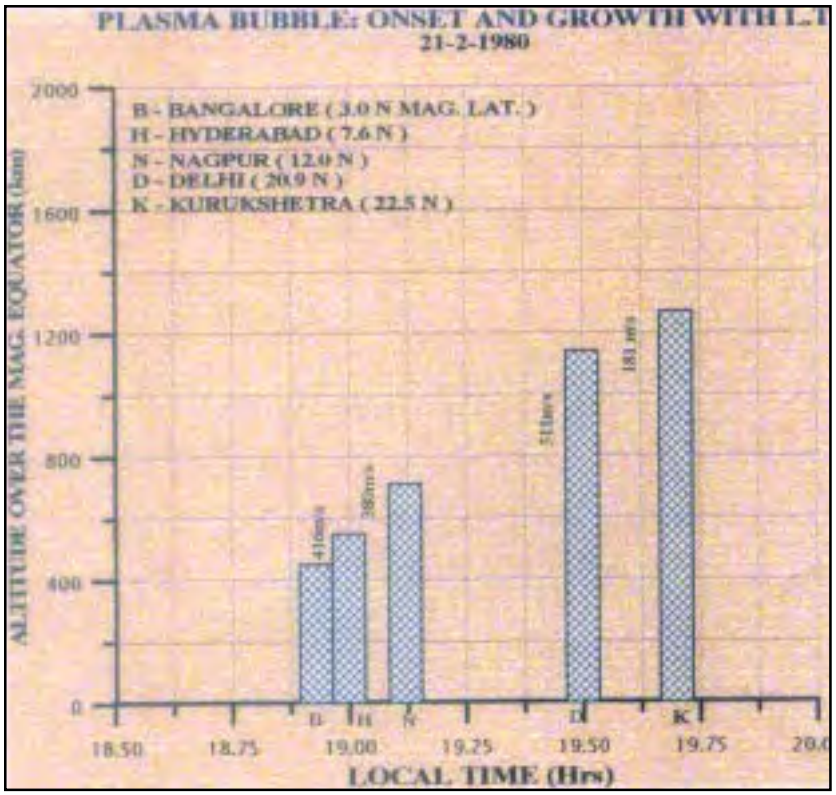

Fig. 6.12 : Onset of equatorial plasma bubble and its altitudinal / latitudinal growth over the Indian zone. Bubble rise velocity is also given for different altitude ranges

Ionospheric Scintillation and Faraday Rotation

Evolution and dynamics of equatorial plasma bubbles

The growth in latitude, and consequently in altitude, of equatorial plasma bubbles was examined using simultaneous recordings of VHF scintillations at five locations situated between 3° and 23°N magnetic latitudes along a common meridian in the Indian zone recorded during February 1980 (Fig. 6.12). The onset of the scintillations were mostly abrupt in character and their occurrence at higher latitudes was conditional to prior appearance at lower latitudes, indicating thereby a causal link to irregularities associated with rising equatorial plasma bubbles. The day-to-day occurrence and the latitudinal, and effectively altitudinal, growths were examined in relation to: the pre-reversal enhancement in h'F and its rate of rise, the onset of a secondary maximum in total electron content at 21°N, and equatorial electrojet strength variations. It was found that the bubble rise velocity over the magnetic equator maximized at heights in the range 450 to 550 km, with a subsequent decrease at higher altitude. The bubbles and associated irregularities reached the highest altitudes / latitudes on those days when h'F in the evening over the magnetic equator exceeded 500 km and had a growth rate of more than 30 ms^{-1}, though no relationship was found with the initial rise velocity. Scintillations were observed at the highest latitude only on those days when a secondary maximum in total electron content was also observed there. It was found that equatorial h'F and dh'F/dt are both positively correlated with day time (1100 LT) electrojet strength values, and consequently to the latitudinal / altitudinal extent of the plasma bubble and associated irregularities. Results clearly indicate that, after the initial

development of a bubble, the ExB drift and the post-sunset ionization anomaly plays an important role in the subsequent growth and evolution, and that electrojet strength is a useful parameter for the prediction of the development.

Faraday polarization fluctuations and their dependence on post sunset secondary maximum and amplitude scintillations at Delhi

Another data set of VHF Faraday rotation (FR) and amplitude scintillation data recorded simultaneously during May 1978 - December 1980 at Delhi (28.6 °N, 77.2 °E; Dip 42.4 °N) is analyzed to study Faraday polarization fluctuations (FPF) and its dependence on the occurrence of post sunset secondary maximum (PSSM) and amplitude scintillations. It is noted from Figure 6.13 that FPFs are observed only when both PSSM and scintillations also occur simultaneously. FPFs are observed only during winter and equinoctial months of high sun spot years. FPF events are associated with intense scintillation activity, which are characterized by their sudden onset and abrupt end and are observed one to three hours after the local sunset. When FPFs and scintillation data from Delhi is compared with the corresponding data from a still lower latitude station, Hyderabad (17.3 °N, 78.4 °E), it is found that the occurrence of FPFs and scintillations at Delhi is conditional to their prior occurrences at Hyderabad which indicates their production by plasma bubble and associated irregularities generated initially over the magnetic equator. In addition, FPFs and scintillation data for the October 1979 month, when their occurrence was maximum, is also examined in relation with daytime (1100 LT) electrojet strength (EEJ) values and evening hour h'F from an equatorial location, Kodaikanal (10.3 °N, 77.5 °E). From figure 6.13 it is interesting to note that FPFs and scintillations are most likely observed when EEJ was 100 nT or more and h'F reaches around 500 Km. These results show that EEJ and evening hours h'F value over the magnetic equator are important parameters for predicting FPFs and scintillation activity at a location like Delhi where scintillation activity is much more intense compared to the equatorial region because of enhanced back ground ionization due to the occurrence of PSSM.

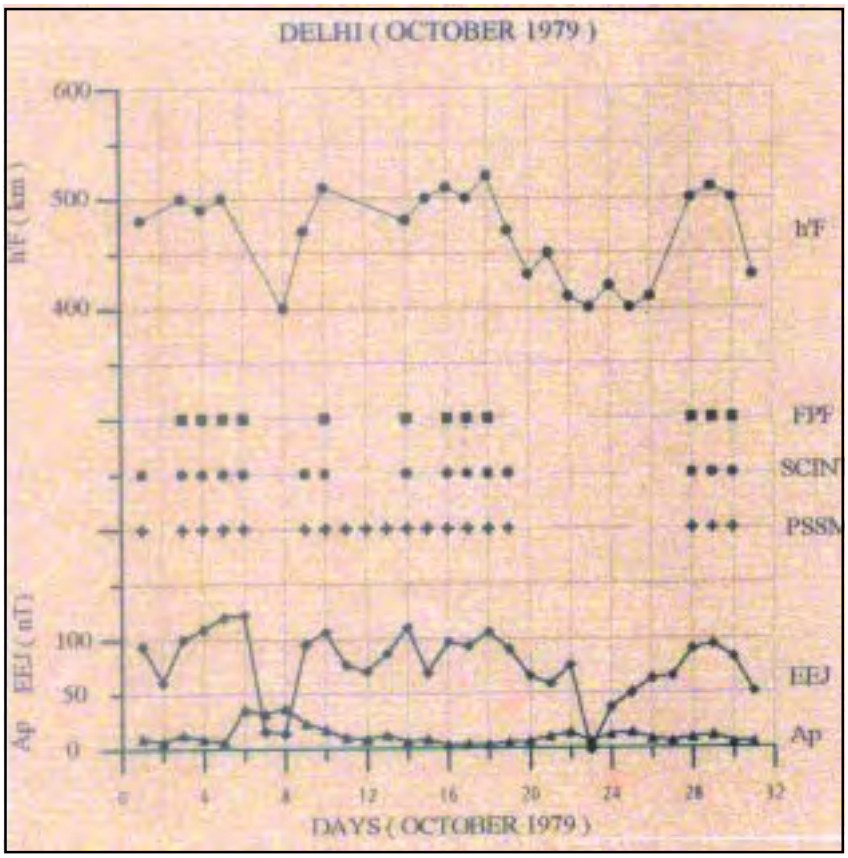

Fig. 6.13 : Daily variations in Ap, h'F and EEJ strength along with the occurrences of scintillation, FPF and PSSM at Delhi

Global Positioning System (GPS) studies of the ionosphere and application to WAAS

The Global Positioning System (GPS) satellites are being used increasingly to study the behaviour of ionosphere as well as for a variety of applications,

such as, Faraday correction for remote sensing satellites and to support a precision approach capability of Category I aircraft landing. NPL has started pursuing research work in this direction.

Wide Area Augumentation System (WAAS) is a network of GPS stations which is used to provide ionospheric correction using GPS satellites. Carrier phase measurements have good signal to noise ratio but they suffer from full cycle ambiguity and cycle slips. Full cycle ambiguity is the number of completed cycles while passing through the medium. The cycle slips are due to loss of lock of the GPS signal due to other reasons like an obstruction between satellite and receiver path. A software has already been developed at NPL to remove full cycle ambiguity using pseudo range data and to detect and repair cycle slips. Further a Kalman filter software has also been developed to derive diurnal variation of electron content and satellite biases accurately within specified limits. To estimate ionospheric correction GPS signals (both psudeo range and carrier) are used.

Ionospheric Modelling

Validation and improvement of IRI model for low latitude

High resolution electron density profiles from incoherent scatter radar measurements at Arecibo, were used to deduce bottomside profile shape parameters and the height of the peak electron density of the F2 region (HmF2), for the solar maximum (1989-90) conditions. The control of solar cycle was also studied for these parameters. Solar cycle variations of critical frequency of the F2 layer, using data from low to middle latitudes were studied and their comparisons were made with the improved version of the IRI (International Reference Ionosphere) model.

Further, using the Modern Digital Ionosonde operational at NPL the scaled data of foF2, was used during the period from August 2000 to July 2001. The data was then analyzed to obtain its diurnal, seasonal variations. Further, efforts were made to deduce the noontime bottomside electron density profiles These observations were then compared with the latest version of the IRI model.

Long term ionospheric electron content variations over Delhi

Ionospheric electron content (IEC) observed at Delhi for the period 1975-80 and 1986-89 belonging to an ascending phase of solar activity during first halves of solar cycles 21 and 22 respectively have been used to study the diurnal seasonal solar and magnetic activity variations. The diurnal variation of the seasonal mean of IEC on quiet days shows a secondary peak comparable to the day time peak in equinox and winter high solar activity. IEC_{max} shows winter anomaly only during high solar activity. Further IEC_{max} shows positive correlation with $F_{10.7}$ up to about 200 flux units at equinox and 240 units both in winter and summer; for larger values of $F_{10.7}$, IEC_{max} is substantially constant in all seasons. IEC_{max} and magnetic activity (A_p) are found to be positively correlated in summer in high solar activity . Winter IEC_{max} shows positive correlation with A_p in low solar activity and negative correlation in high solar activity in both the solar cycles. In equinox IEC_{max} is independent of A_p in both solar cycles in low solar activity. A study of day to day variations in IEC_{max} shows single day and alternate day abnormalities, semi-annual and annual variations controlled by the equatorial electrojet strength, and 27 day periodicity attributable to the solar rotation.

Dependence of F2 peak height on solar activity

Comparisons of hmF2 obtained from incoherent scatter radar, during high solar activity (1989-90) and low solar activity (1974-77), indicate that diurnal characteristics of median hmF2 are the same as those during low solar activity. However, there is a considerable increase in hmF2 during high solar activity period during all the seasons and it varies from about 5 to 50 %. In general, the difference between

the two occur during the daytime, particularly from about 08:18 LT. During this time period, the difference varies from about 30 - 50 % for the winter. The difference between the IRI predicted hmF2 and the observed hmF2 is less than 15 % for most of the time during all the seasons.

Dependence- of foF2 on solar activity: saturation effect

Studies have been made on the dependence of foF2 on solar activity. The noon time monthly median values of foF2(m) are examined for their dependence on solar activity and compared with those obtained with IRI model. The data covered the period from IGY i.e. 1957 to 1990. It was found that at all the six locations selected for the study a second degree fit gives a better correlation. It was found that at low latitudes the increase in foF2 with R12 is very fast at low solar activity and vanishes at high solar activity showing the saturation effect. The IRI exhibits a fair agreement with slight lower values with observations up to R12 of 150. Thereafter IRI shows saturation and overestimates the observed values. At mid latitudes foF2 varies linearly with R12 right up to the highest levels of solar activity. The IRI model shows reasonably good agreement with observations during winter and equinox up to R12 of 150 and thereafter IRI shows saturation effect as usual and the discrepancies between foF2 and the IRI are noted. During summer however, the agreement between the observed and IRI model is just a fair one and the IRI produces systematically foF2 values slightly lower than the observed ones.

Radio tomography of ionosphere and its application in ionospheric modelling

The national program on ionospheric tomography called Coordinated Radio Beacon Experiment (CRABEX) was planned in 2000 by ISRO in which various National

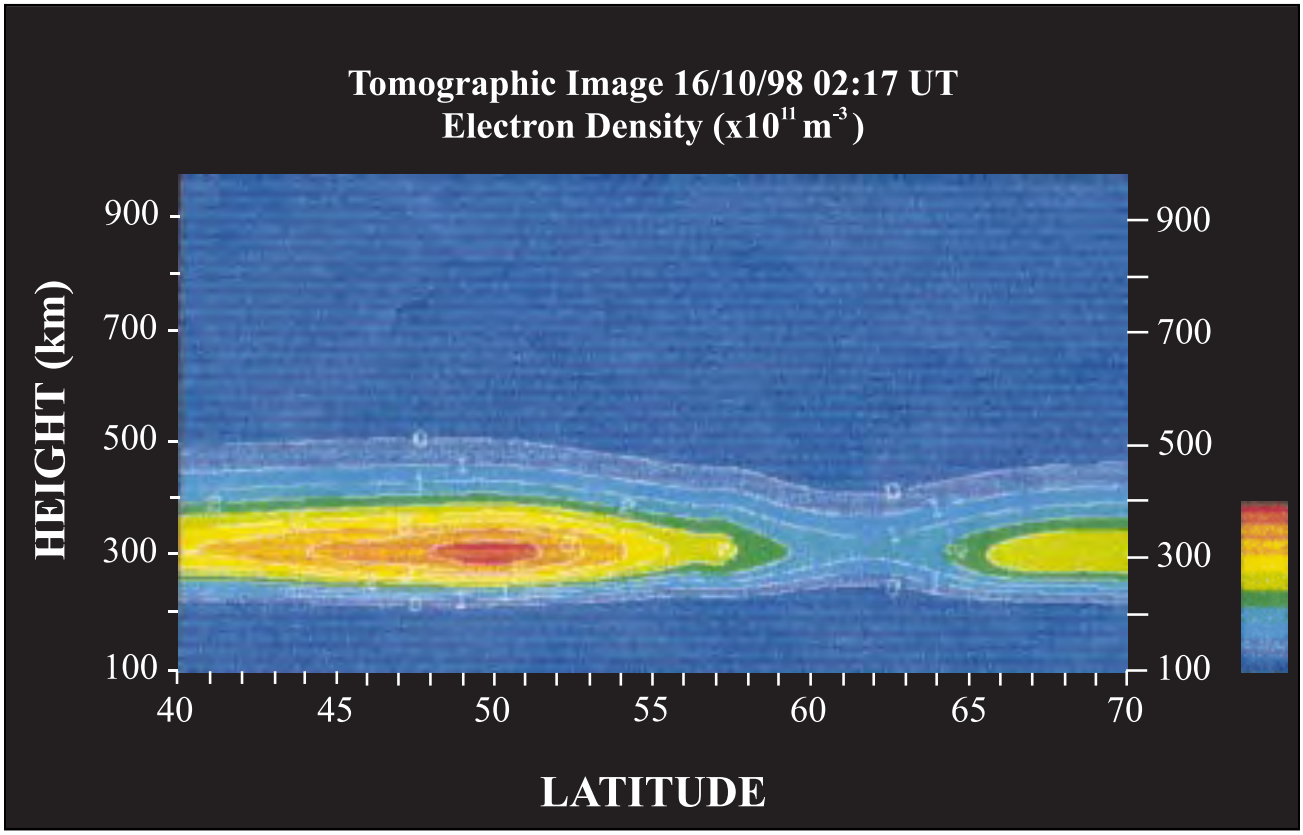

Fig. 6.14 : Tomographic image of ionospheric conditions obtained over UK using TEC measurements

institutes and universities including the National Physical Laboratory, New Delhi, are participating. Under this programme tomography of the ionosphere over Indian region is to be done using a nation wide network of radio beacon receivers. With this aim one of the scientists from RASD, NPL was deputed to UK to work on ionospheric tomography at the Department of Physics, University of Wales, Aberystywth. Radio and Space Group of this Department headed by Prof. Len Kersley is one of the leading groups in the world on ionospheric tomography and its applications for ionospheric modeling and radio communications. In addition to learning of technique the work was also carried out jointly on the use of radio tomographic images for adaptive modeling of ionosphere over Northern Europe.

Models of ionosphere, used in applications for the prediction or correction of propagation effects on practical radio systems, are often inadequate in their representation of the structure and development of large-scale features in the electron density. Over northern Europe, the characterization of the main trough presents particular problems for such empirical models and hence for radio propagation forecasting and ionospheric mapping. Results are presented from a study aimed at investigating the possible role of radio tomographic imaging in adapting models to yield a better representation of the ionosphere over Europe. It is shown that the use of radio tomography gives better agreement with actual ionosonde data than can be obtained from any of the models (IRI, COST and PIM) investigated alone. It is suggested that the technique may have a possible role in the mapping of ionospheric conditions (like mid latitude trough and equatorial ionization anomaly) in near-real time for future systems applications. An example of a tomographic image over UK showing nighttime trough is given in figure 6.14 and its mapped image over the entire Europe is shown in figure 6.15.

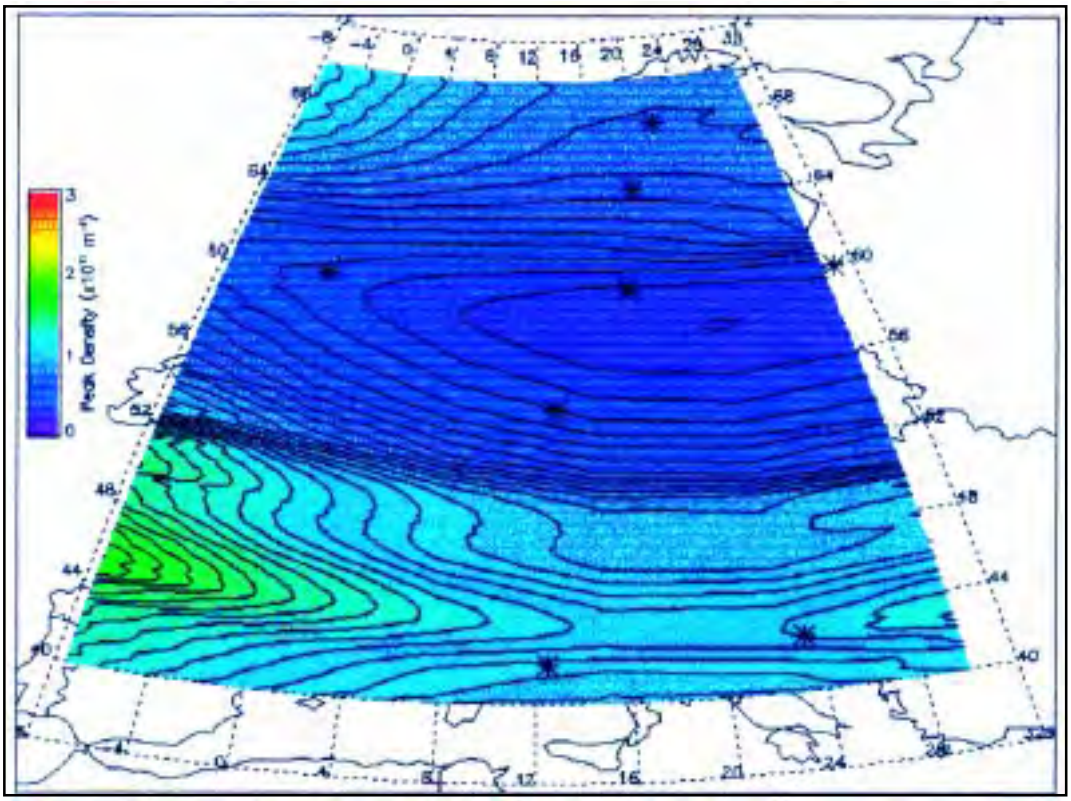

Fig. 6.15 : Mapping of ionospheric conditions over Europe using tomographic image over U.K. and zonal gradients calculated from PIM model (0327 UT on 20-11-97)

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अतिचालकता तथा निम्नतापिकी

SUPERCONDUCTIVITY & CRYOGENICS

अतिचालकता तथा निम्नतापिकी

उच्चचालकता और निम्नतापिकी डिवीजन के कार्यकलाप मुख्यताः अनुसंधान अनुप्रयोगों की विविधता के लिए उच्चचालकता चुम्बक विकास सिस्टम कीउच्चचालकता और विकास में अनुसंधान पर विशेष जोर देने के साथ निम्नतापमान तकनीकों के विशिष्टिता प्राप्त क्षेत्रा पर केन्द्रित है। राष्ट्रीय आर्द्रता मानक का यहाँ रखरखाव किया गया है और ये उद्योगों में हाइड्रोमीटर के लिए अंशांकन सेवाएँ प्रदान करता है। इसके अतिरिक्त यह डिवीजन क्रायोजेनिक संयंत्राों के रख रखाव और प्रचालन की भी देखभाल करता है और द्रव नाइट्रोजन तथा हीलियम की सप्लाई इस प्रयोगशाला के विभिन्न अन्य ग्रुपों को करता है।

वर्ष के दौरान उच्चालकता के क्षेत्रा में मूल अनुसंधान उच्च ज्ब तकनीक वाले सुपरकंडक्टरस व्यवहार के अनेक महत्वपूर्ण निष्कर्षों को सामने लेकर आया है और नवीन विकसित इंटर मेटेलिक कंपाउड $Mg\ B_2$ को भी सामने लाया है। सब्सीटयूशनल अध्ययन अभी जारी है। जो डोपेन्टस को भूमिका पर महत्वपूर्ण जानकारी प्रदान करते हैं। ckbZcsLM HTSCs के महत्वपूर्ण चालू गुण पर जाँच पड़ताल सामग्री द्रव हीलियम तापमानों पर की जा रही है जो ि.समअमस डोपेन्टस के अलग–अलग प्रभाव को दर्शाती है तथा एस टी एम/ एस टी एस अध्ययन से हैक्साजोनल हनीकम $Mg\ B_2$ संरचना का पता चला है और इन सामग्रियों में कमजोर लिंक के प्रभाव न होने का भी पता चला है। जैसे कंडेन्सेशन ऊर्जा, सिंगल पार्टिकल इंटरप्ले और बाईलेयर कूपरेटस के लिए कूपर पेयर टनलिंग का पता चला है। अनुप्रयोगों की तरफ एक पोर्टेबल सापेक्ष आर्द्रता (RH) जेनरेटर बनाया गया है। इसके अलावा पोर्टेबल परिवत्री ऊर्जा साइकलोट्रॉन केन्द्र कोलकाता ने एन पी एल में पहले से विकसित एक 7 टेसला सुपरकंडक्टिंग मेग्नेट प्राप्त करने में रुचि दिखाई है। चुम्बक का परीक्षण सफतापूर्वक किया गया है।

SUPERCONDUCTIVITY & CRYOGENICS

The activities of the division of Superconductivity and Cryogenics are mainly concentrated in the specialized area of low temperature techniques with particular emphasis on research in superconductivity and development of super-conducting magnet systems for a variety of research applications. National standard for humidity is also maintained here and it provides calibration services for hygrometers to industries. In addition, the division takes care of the maintenance and operation of cryogenic plants and supply of liquid nitrogen and helium to various research groups of the laboratory.

During the year, basic research in the area of superconductivity led to a number of important conclusions on the behaviour of high Tc superconductors (HTSC) and on the newly developed inter-metallic compound MgB_2. Substitutional studies have continued to provide vital information on the role of dopants: in rare-earth based cuprates: $R_{1-x}Ca_xBa_2Cu_3O_{7-y}$ the substitution of Ca affects the oxygen loss mechanism and in Cu-1234 the substitution of Mg at Ca-site optimizes the synthesizing conditions required for a single phase material. Critical current property of Bi-based HTSCs is being investigated at liquid helium temperatures for materials showing a distinct effect of f-level dopants and STM/STS studies have revealed the hexagonal honeycomb structure of MgB_2 and the absence of weak-link effect in these materials. Theoretical investigations have resulted in evaluation of a number of parameters such as the condensation energy, the interplay of single-particle and cooper pair-tunneling for bilayer cuprates. On the applications side; a portable relative humidity (RH) generator was developed. Besides, Variable Energy Cyclotron Centre , Kolkata has shown keen interest for acquiring one 7-Tesla superconducting magnet already developed at NPL. The 11TNb_3Sn magnet was successfully tested.

Basic Superconductivity

Basic Studies on High Temperature Superconductors

STM/STS and SEM investigations were carried out on MgB_2 superconductor (T_c = 39 K). The SEM pictures show porous surface and well-linked granular structure in which bigger grains (few micrometer size) seem to be agglomeration of smaller, nearly hexagonal grains (size nearly 100 nm). Hexagonal honeycomb structure of Mg and B layers have been directly observed in atomically resolved STM images (Fig.7.1). The lattice constants have been determined to be a_{Mg} = 3.1 Å, a_B = 1.7 Å and c = 3.5 Å. Grain boundaries (GB) of width ranging from 50 Å to 200 Å have been observed. Absence of weak link effects despite wide GBs has been attributed to the metallic nature of the amorphous region of the GB interior as inferred from STS analysis. This observation supports proximity coupling between the grains, which explains why supercurrent density does not degrade in this material. The results for another intermetallic superconductor YNi_2B_2C having GB (width ~ 30 Å), which are quasi-insulating in nature have also been presented and compared with the former.

The influence of heat treatment, at 450° C in Ar environment, on oxygenated ($6.72<7-\delta<6.93$) samples of $R_{1-x}Ca_xBa_2Cu_3O_{7-s}d$ (i.e. R(Ca)-123, with R=Y, Sm) with $0<x<0.3$ has been investigated. Measurements of oxygen loss, normal state resistivity behaviour $\rho(T)$, superconducting critical temperature T_c and transition widths reveal that Ar treatment effects both the series differently. The Sm(Ca)-123 samples, for all values of x, show a considerable loss of oxygen ($\Delta\delta(x)$=0.4 to 0.6) and decrease in T_c ($\Delta T_c(x)$ = 35 to 55 K). Whereas, surprisingly, the Y(Ca)-123 samples show a much smaller loss of oxygen ($\Delta\delta(x)$=0 to 0.3), along with a decrease in T_c for $x<0.2$ and an increase in it for $x\geq0.2$. In particular, the x=0.3 sample shows a negligible change in oxygen content accompanied by an increase of 20 K in T_c. These and host of other observations suggest that the presence of Ca may influence the oxygen loss mechanism in these series.

An investigation of structure by X-ray diffraction, microstructure by atomic force microscopy (AFM), and broadening of resistive transitions in high dc magnetic field (0-20 kOe) in $Er_{1-y}Ca_yBa_2Cu_{3-x}(Fe,Zn)_xO_{7-s}\delta$ (y=0.1,0.2; and $0 \leq x$ 0.20) ceramic superconductors was carried out. The XRD shows that the presence of Ca does not alter the known effect of Fe/Zn substitution on the structure of pure (y=0) system. Substitution of both Fe and Zn lead to a decrease in the grain-size and micro-hardness. Interesting results were obtained on the influence of various dopants on the broadening

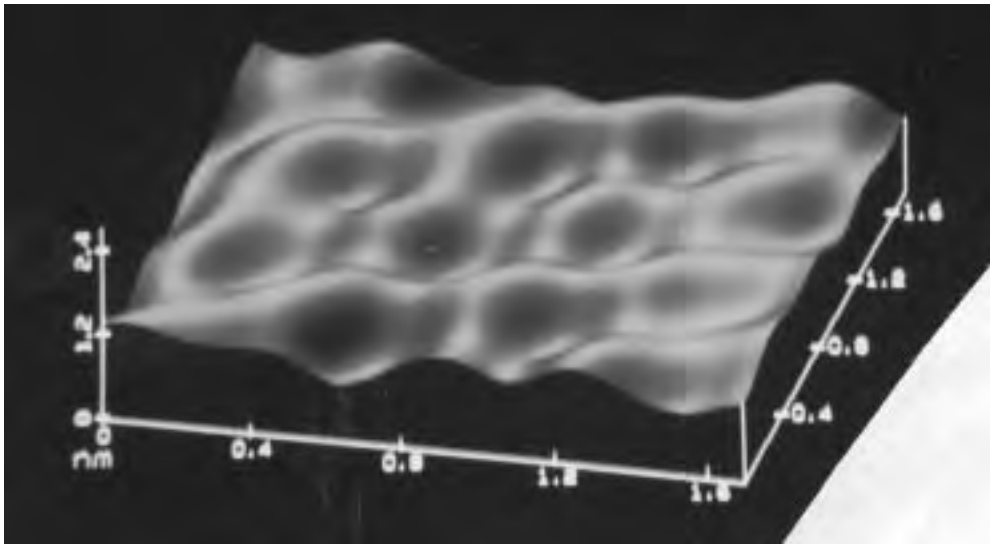

Fig.7.1 : STM image of hexagonal honeycomb structure of B layer observed in a MgB_2 sample (Image in 3D mode at 30° pitch, scan size: 1.7 nm x 1.7 nm)

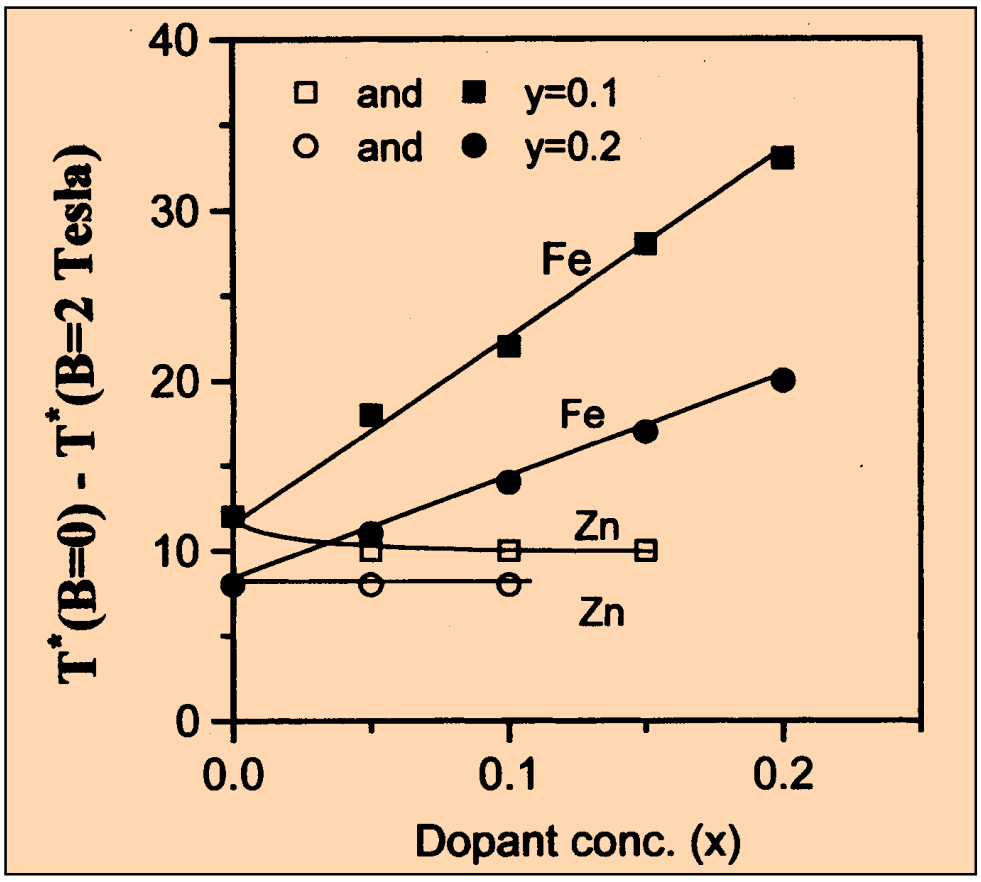

Fig. 7.2 : Shift in T^* (where R (T) goes to zero) as a function of Ca, Fe and Zn content in $Er_{1-y}Ca_yBa_2Cu_{3-x}(Fe,Zn)_xO_{7-\delta}$

of resistive transitions in dc magnetic field (Fig.7.2), in general: (a) increase in Ca content suppresses it; (b) Zn substitution shows no effect; and (c) Fe substitution enhances it. We show that these results can be interpreted in terms of thermally activated flux motion (TAFM), and the effect of various dopants on the properties like pinning barrier and anisotropy.

$CuBa_2Ca_3Cu_4O_y$ (Cu-1234) is a high temperature-high pressure (1000^{0}C, 3.5GPa) phase exhibiting superconductivity at 118K at ambient pressure. To improve upon its superconducting properties, substitution of Mg ions at the Ca-sites in the superconducting block in the crystal structure of the Cu-1234 material has been attempted vis-à-vis the effect of synthesizing temperature T_s on the phase purity of the material. Synthesizing temperature governed by the carbon heater power in the high pressure cell has been found to have a pronounced effect on the phase purity (Fig.7.3) and subsequently on the T_c of the final compound (Fig.7.4). There is seemingly a narrow range of T_s (i.e. heater power) for obtaining the single phase material.

Critical Currents

Investigation of the critical current property of high T_c superconductors continues to remain an important study because of their limited use in devices, particularly for high current applications. At the operating temperature of 77K (Liquid nitrogen), weak-link phenomenon limits the current carrying capacity of polycrystalline samples of HTSC and complicates the role of pinning centres in determination of J_c. In our study of pinning centres, critical currents studies have been carried out at the operating temperature of 77K and 4.2K (liquid helium) where the intra-grain J_c dominates, and the role of pinning centres can be identified without ambiguity. Materials being studied are the high T_c superconductors

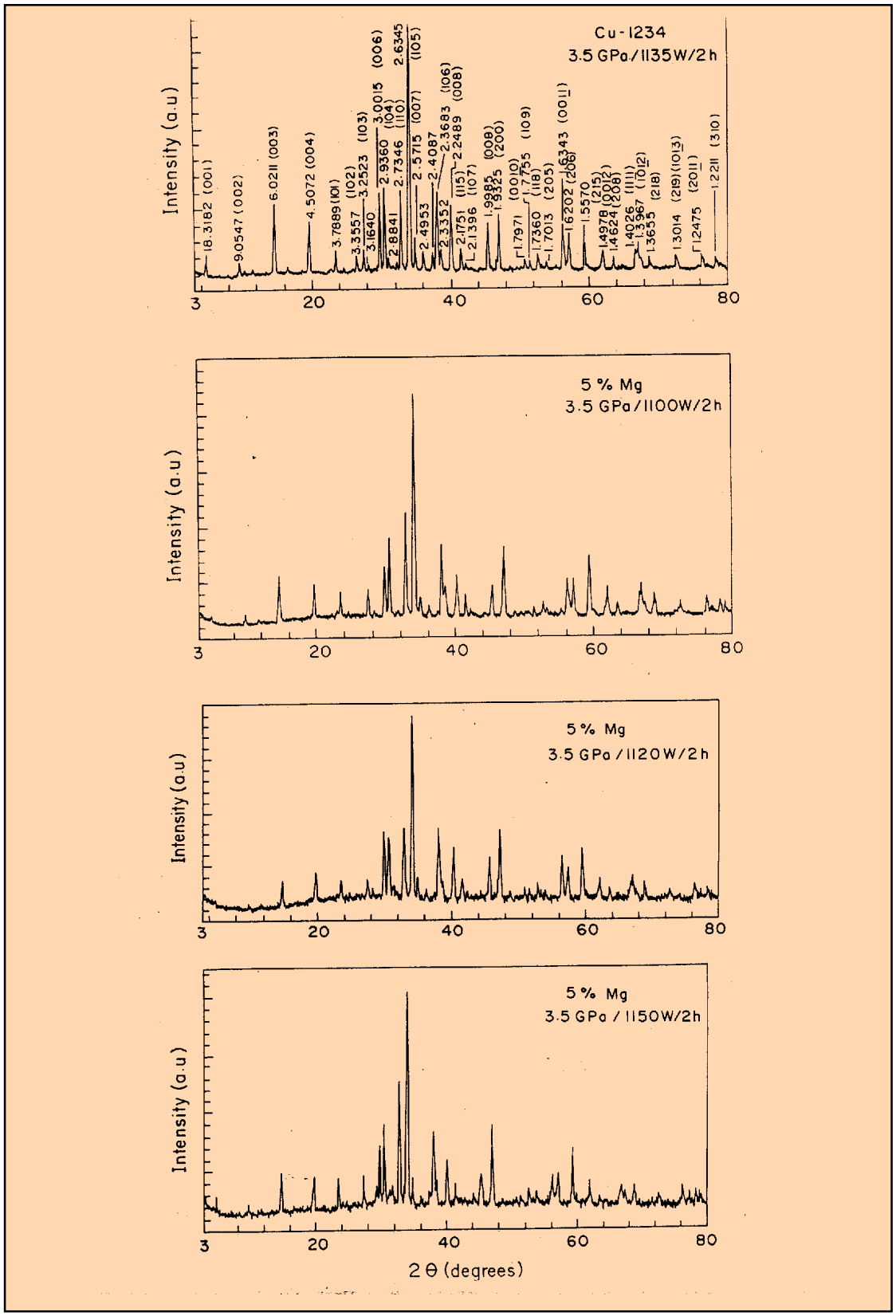

Fig. 7.3 : XRD of the Mg-doped Cu-1234 samples synthesized at different Ts values (heater power). Heater power of 1100W results in the single phase formation

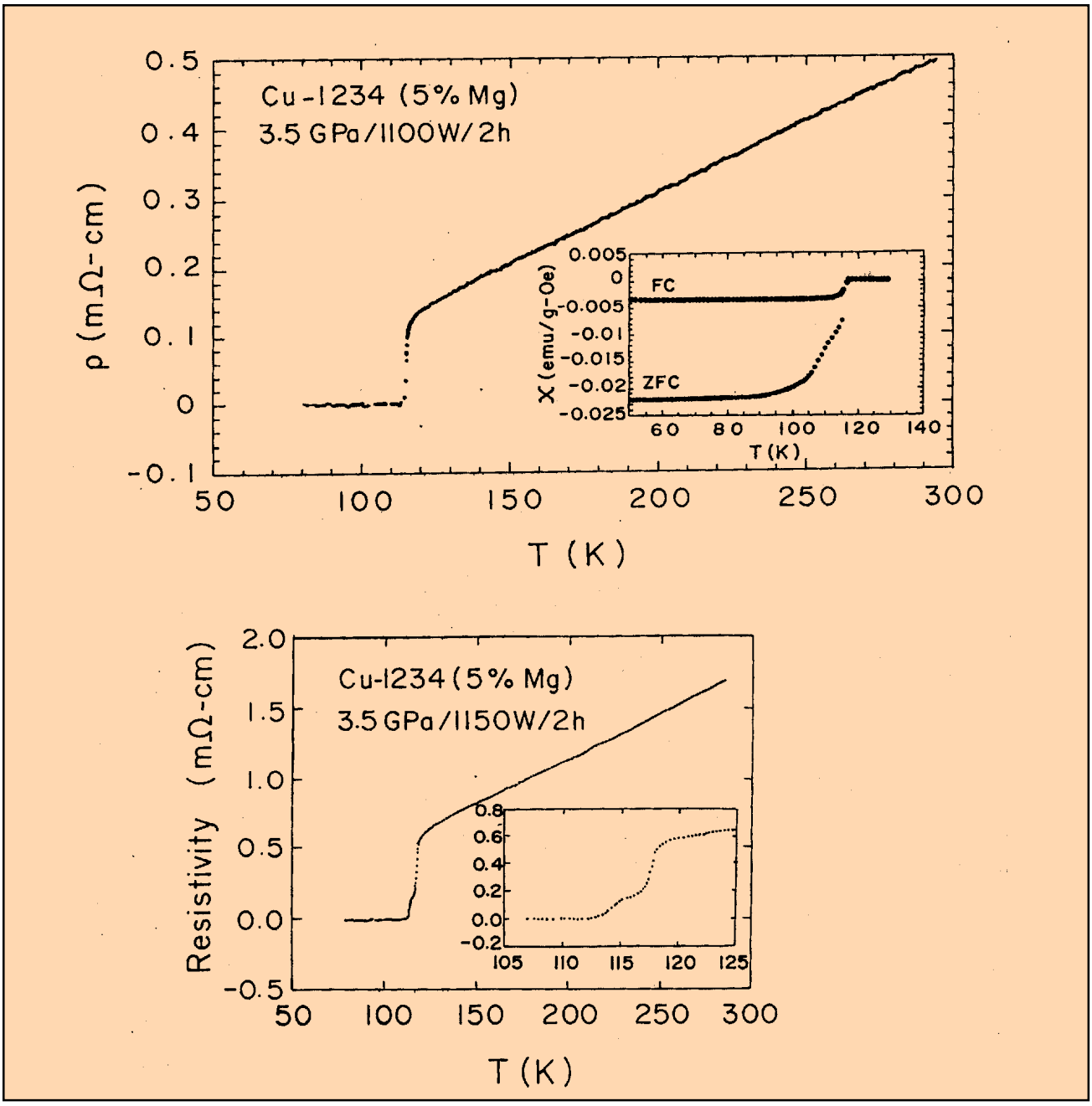

Fig. 7.4 : Resistivity transitions of Cu-1234 samples synthesized at 1100W and 1150W heater powers. 1100W sample shows a clear single phase transition with $T_c(\rho = 0)$ of 118K

of Bi-based series : the Bi-2223 and the Bi-2212 phases, and the Y-Ba-Cu-O series containing the Y-123 and the Y-124 phases. These superconductors of Y-Ba-Cu-O series have been prepared by sintering in air and without the help of any oxidizing agent so that the role of a magnetic dopant can be studied more efficiently. Superconducting properties (T_c) and TGA studies also suggest that the oxygen content of these samples to be the same as those sintered in flowing oxygen. Critical current behaviour has been studied in the pure and magnetically doped state of these superconductors. A wide variation of results is obtained and a correlation of J_c values with the nature and concentration of dopant is suggestive of the dopants, even though not significantly affecting the superconducting T_c, playing an important role in the critical current phenomenon of

high T_c superconductors. Critical current studies under high magnetic fields are expected to further elucidate the role of pinning centres.

Theoretical Studies

Theoretical studies have been made for magnetic, superconducting and spectral properties of bilayer cuprate systems. Sublattice magnetisation, Neel temperature, Specific heat and optical magnon gap are calculated for various values of intrabilayer exchange couplings. Spectral function and self energy are calculated for the matellic state of bilayer cuprates for different values of doping, temperature and anisotropy parameters. Interplay of single particle and cooper pair tunnelling have been studied in superconducting state. Condensation energy in the superconducting state has also been calculated.

Humidity Standards

Development of a portable relative humidity (RH) generator based on the two-pressure principle has been completed and patented. With this generator, humidity in the range of 10 to 95 % RH can very easily be generated. It has advantages like speed, low cost, traceability and ease of use in calibrating RH sensors. The system (Fig.7.5) is quite handy, mobile and can also be used as a travelling standard among calibration laboratories for inter-comparison and proficiency testing. Besides, a laboratory model of two-pressure cum two-temperature RH generator is under progress with an objective to have uncertainties at par with the international level. The developed unit will be used to calibrate dew point meter in the range –30°C to +60 °C dew point.

Superconducting Magnets

An 11 Tesla SC Magnet

Development of an 11 Tesla (50 mm bore dia.) SC magnet has been successfully completed. The magnet is in hybrid form. The outer coil consisting of NbTi was completed previously. The inner coil which was reacted at 570°C for 120 hrs followed by 700°C for 80 hrs under argon atmosphere for Nb_3Sn formation was vacuum impregnated with bees wax. The magnet was tested in three steps using the current terminals provided at the top plate of the housing cryostat.

The inner coil was tested individually. The coil was energized upto 140 A producing a field of 3.7 T without quench. The outer coil was then energized upto 93.3 A producing 7.53 T, before quenching second time. The two coils were then tested together. First, they were put in series and energized upto 90 A producing 9.67 T without quench. Then the two coils were energized separately using two power supplies, the

Fig. 7.5 : Portable relative humidity generator

outer coil energized upto 90.5 A and inner coil upto 140 A producing a combined field of 11 T. (Fig.7.6)

7 Tesla SC Magnet Systems

The testing of three of the recently developed six 7 T SC magnets (50 mm bore dia.) with their suspension system and cryostat have been successfully completed. All the systems performed very well. The magnets have been energized to a field well above 7 Tesla. The magnet produces a field of 7 T at 84.7 A with a field homogeneity of 0.07 % over 10 mm DSV. Negotiations are on for transferring one of these systems to Variable Energy Cyclotron Centre, Kolkata.

A large bore 6 Tesla SC Magnet

In our collaborative project with Institute for Plasma Research (IPR), Gandhinagar, the fabrication of large bore (255 mm) 6 Tesla SC magnet has been completed. The magnet consists of 42 layers of multifilamentary Cu / Nb-Ti wire of 0.56 mm dia. Each layer accommodates ~ 1000 turns. The coil after winding was overbanded with four layers of SS 304 wire to withstand the hoop stress. The overall dimension of the magnet is ϕ 400 X 680 mm. The magnet is ready for impregnation followed by testing at IPR.

Fig. 7.6 : An 11 Tesla (50 mm bore dia.) SC magnet is being tested. The magnet with support system was mounted in the 10 inches bucket type dewar. The inner and outer coils were individually connected to the two power supplies 250A, 7.5 V and 100A, 5V respectively. Also seen in the photograph on the left side are Hall Effect Gaussmeter and liquid helium level meter

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सहायक सेवाएं

SUPPORT SERVICES

Library and Technical Information Services

NPL Library has been providing library and information support for R&D pursuits. Over the years it has developed a rich collection of scholarly books and journals in physics and related sciences. It is hailed as one of the leading libraries in the field of physics in the country. During the year, it added 45 books on S&T subjects, 203 books in Hindi, and 531 bound volumes of journals. It subscribed 129 journals .

The library designed and developed the NPL Web site and hosted it on the Internet under the domain name www.nplindia.org. It was launched by the DGCSIR on 8 January 2002. With this development, the NPL is now on the world map providing latest information on its activities, roles, thrust areas of research, facilities, and services as well as its achievements on the Internet.

The KSK Library, the electronic library on the NPL intranet, was updated on periodical basis for latest information on current journals, online journals, library books catalogue, papers published by NPL scientists, library statistics, links to electronic journals, electronic libraries, reputed publishing houses, etc.

The library subscribed to four leading databases in physical sciences on CD-ROM — *Current Contents: Physical, Chemical & Earth Science, Current Contents: Engineering, Technology, and Applied Sciences*, *Materials Science Citation Index* and *INSPEC*. These were used extensively for literature search. Besides, it continued to offer user services such as circulation, inter-library-loan, and newspaper clipping service. It continued to perform its house keeping functions on computer using a Library Management package developed in-house.

Publication and Documentation

This Unit cell is responsible for compiling, editing, printing, and distribution of Annual Reports and other documents describing laboratory activities. This unit also compiles information on NPL achievements during the year and submitting it to the CSIR as the NPL input for the CSIR annual report.

Scientific Support System

Planning, Monitoring & Evaluation

This group coordinates all the projectized activities of the laboratory, including in-house, collaborative, sponsored and grant-in-aid projects. It keeps track of current manpower deployment. On these activities it collects information, analyses it and places it to the top management for decision making. This year the group handled work relating to 17 new projects, 47 on-going projects, and 10 completed projects. This group also handles matters relating to Research Council.

Marketing Group

This cell is totally responsible for marketing and liaisoning of technological know-how transfer of the laboratory. It marketed five technologies this year.

Intellectual Property Right

Realizing the strategic importance of intellectual property in the ever-changing global economic scenario, this totally independent Unit was created with the exclusive purpose of managing IP portfolio of the laboratory. This unit provides help to the scientist in filing patents on their R&D outputs. It also scouts around and looks for possibilities of protecting any R&D output, which otherwise might have been missed by scientists for taking protection.

During this year 10 patent applications have been filed in India and 6 in foreign countries. Four patents were granted in India and three in foreign countries.

Human Resource Development Group

This group arranges training programmes for the benefit of NPL staff and also organises NPL sponsored training

courses for the benefit of industries in various areas of calibration. It also supports organization of symposia, conferences, etc. at NPL. It also attends to various public relations activities and follows up various MOUs with educational institutions in respect of doctoral, post-graduate and summer training on reciprocal basis. It processes induction of JRFs, SRFs, Research Associates for NPL programmes. The group also pursues other schemes of CSIR on EMR and HRD activities. List of training programmes and other events organized by the group is given in the respective appendices.

International Science & Technology Affairs Group

This group is responsible for maintaining and processing applications of scientists for deputation abroad. It also arranges K.S. Krishnan Memorial lectures, invited talks, and special lectures by visitors coming to the laboratory. The details regarding these activities are listed in the respective appendices.

Technical Support System

Responsibility of general maintenance of technical infrastructure like electricity, pumping, air-conditioning, telephones, fax, photography service, auditorium, maintenance of campus and colony, etc. lies with this section.

Central Workshop

NPL Central Workshop undertakes design, development and maintenance of work related to scientific equipment of the laboratory and assists industry by accepting outside assignments on payment. It is equipped with general purpose machines, CNC machines and has precision measurement facilities. CNC machines aided by computerized modeling enables the machining of complicated parts such as die cavities, moulds and punches.

Glass Technology Unit

Glass Technology Unit undertakes jobs relating to the design, development, fabrication of scientific apparatus and equipments. The Unit offers its services to internal customers and to external customers from industry, R&D organizations, medical and educational institutions. This year the unit processed 183 jobs for NPL and 36 external jobs and earned a sum of Rs.1.47 lakh as ECF.

Central Computer Facility

Automation : One stage of a multi-crystal X-Ray diffractometer was automated for the X-Ray Diffraction group at NPL. The exercise involved interfacing a stepper motor to control and sweep the diffraction angle and a photon counter to record the readings. A full fledged Graphics User Interface (GUI) was developed on Linux platform for operating the equipment. Software drivers were written to drive and control the stepper motor as well as access the photon counter on an RS-232 serial port. The setup sould scan for Bragg peaks automatically and record the data. An online plotting of photon count vs. angle is included in the GUI.

Mathematical Modelling and Computing : Studies on modelling of the melting of a layer of snow and patterns of snow spots emerging under "right" atmospheric conditions has been set up. Software has been developed to simulate the system involving partial differential equations for heat flow and snow density.

Exploratory studies on application of Auto Catalytic Sets to evolution in Nature has been started. Auto catalytic sets appear in a network of cooperative species whereby the network evolves to attain higher complexity and degree of structure.

The CCF also provided consultancy to Aimil Ltd. in the area of automation and instrumentation.

Rajbhasha Unit

This Unit helps the scientists in the Hindi transcription of their papers, articles, reports etc. This year also it arranged various training programmes and organized events for encouraging the use of Hindi in all official proceedings as well as in writing research paper publications in Hindi for the benefit of the society. As per Government of India directives the unit arranges selection of NPL employees who contribute the most to the propagation of Hindi in office work. Cash awards are given to the winners in various categories. Detailed report of the Unit is given in Hindi in the following pages.

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राजभाषा कार्यान्वयन

राष्ट्रीय भौतिक प्रयोगशाला प्रशासन के साथ–साथ वैज्ञानिक व तकनीकी कार्यों में राजभाषा नीति का सम्यक् अनुपालन सुनिश्चित करने के लिए हर संभव प्रयास कर रही है । प्रयोगशाला में समय–समय पर विशिष्ट व्यक्तियों द्वारा व्याख्यान दिए जाने की व्यवस्था, संगोष्ठियों व अन्य कायक्रमों का आयोजन इस उद्देश्य से किया जा रहा है कि प्रयोगशाला के वैज्ञानिकों/अधिकारियों व अन्य कर्मचारियों की मानसिकता में परिवर्तन लाया जा सके और वे अपना अधिक से अधिक कार्य हिन्दी में ही करें। वर्ष के दौरान प्रयोगशाला में राजभाषा हिन्दी के प्रगामी प्रयोग सम्बन्धी कार्यकलाप इस प्रकार रहेः–

व्याख्यानों की श्रृंखला में विशिष्ट वैज्ञानिक व्याख्यान

प्रयोगशाला में हिन्दी के व्यापक प्रचार–प्रसार के लिए सितम्बर, 2000 से विशिष्ट व्यक्तियों द्वारा हिन्दी में व्याख्यान दिए जाने का कार्य आरम्भ किया गया था । व्याख्यानों की इस श्रृंखला में प्रोफेसर सुरेश चन्द्रा, भौतिक विभाग, बनारस हिन्दू विश्वविद्यालय ने दिनांक 20 अप्रैल, 2001 को 'सुपर आयनिक सोलिड' नामक विषय पर व्याख्यान प्रस्तुत किया तथा 8 अक्तूबर, 2001 को प्रो. एस.के.जोशी, पूर्व महानिदेशक ने 'नैनो पार्टिकल की चमत्कारी दुनिया' विषय पर व्याख्यान दिया जो अत्यंत रुचिकर व ज्ञानवर्द्धक था।

प्रशासनिक कार्यशाला : 1

प्रयोगशाला में राजभाषा नीति के प्रभावी कार्यान्वयन हेतु दिनांक 7.6.2001 को प्रशासन के अधिकारियों/कर्मचारियों के लिए कार्यशाला का आयोजन किया गया । कार्यशाला का शुभारंभ निदेशक द्वारा पूर्वाह्न 10.00 बजे प्रयोगशाला के टी.ई.सी. कान्फ्रेंस–रूम में किया गया । कार्यशाला में लगभग 50 अधिकारियों/कर्मचारियों ने भाग

चित्र : 'सुपर आयनिक सॉलिड' विषय पर विशिष्ट व्याख्यान देते हुए प्रो. सुरेश चन्द्रा, भौतिक विभाग, बनारस हिंदी विश्वविद्यालय, वाराणसी

चित्र : 'नैनो पार्टिकल की चमत्कारी दुनिया' विषय पर विशिष्ट व्याख्यान देते हुए प्रो. एस.के. जोशी, पूर्व महानिदेशक, सी एस आई आर

लिया। कार्यशाला में बी.एच.ई.एल. के प्रबन्धक श्री गोपेश गोस्वामी द्वारा सरकार की राजभाषा नीति और हमारा दायित्व तथा सी.एस. आई.आर. के वरिष्ठ हिन्दी अधिकारी डा. पूरन पाल द्वारा हिन्दी की मानक वर्तनी एवं शब्दावली नामक विषयों पर व्याख्यान प्रस्तुत किए गए। दोनों वक्ताओं ने हिन्दी में कार्य करने के लिए प्रोत्साहित किया । कार्यशाला का आयोजन सफल रहा ।

प्रशासनिक कार्यशाला : 2

29 दिसम्बर, 2001 को प्रशासन के अधिकारियों/ कर्मचारियों के लिए एक दिवसीय कार्यशाला का आयोजन किया गया । इस कार्यशाला में लगभग 56 कर्मचारियों ने सक्रिय रूप से भाग लिया। व्याख्यान के लिए प्रो. सूरजभान सिंह, निदेशक (सेवानिवृत्त)

चित्र : डा. कृष्ण लाल, निदेशक, एन पी एल प्रतिभागियों को प्रशासनिक कार्यशाला के दौरान संबोधित करते हुए

तथा श्री सुरेन्द्र कुमार उनियाल, कृषि मंत्रालय को आमंत्रित किया गया था । प्रतिभागियों ने इस कार्यशाला के प्रति अपनी प्रतिक्रिया व्यक्त करते हुए कहा कि इस प्रकार की कार्यशालाओं का आयोजन समय–समय पर होना चाहिए क्योंकि इससे विशिष्ट व्यक्तियों के ज्ञानवर्द्धक व प्रेरणादायक व्याख्यानों से हिन्दी में कार्य करने के लिए मानसिकता में परिवर्तन होता है और हिन्दी में कार्य करने में रुचि पैदा होती है ।

वैज्ञानिक कार्यशाला 5.9.2001

दिनांक 5.9.2001 को 'वैज्ञानिक लेखन अनुसंधान एवं विकास गतिविधियां' नामक विषय पर वैज्ञानिक कार्यशाला का आयोजन किया गया । कार्यशाला में मुख्य अतिथि के लिए डा. विक्रम कुमार, निदेशक, ठोसावस्था भौतिकी प्रयोगशाला को आमंत्रित किया गया।

इस एक दिवसीय कार्यशाला में लगभग 20 वैज्ञानिकों ने अपने पेपर हिन्दी में प्रस्तुत किए जिनकी सारांश पुस्तिका तैयार की गयी । कार्यशाला का उद्घाटन निदेशक महोदय ने किया । इसके पश्चात् मुख्य अतिथि महोदय डा. विक्रम कुमार ने व्याख्यान प्रस्तुत किया, जिसमें उन्होंने प्रतिभागियों को और अधिक हिन्दी में कार्य करने के लिए प्रेरित व प्रोत्साहित किया । तत्पश्चात् राजभाषा कार्यान्वयन समिति के उपाध्यक्ष श्री एस.सी. गर्ग द्वारा धन्यवाद प्रस्ताव प्रस्तुत किया गया । तत्पश्चात् तीन सत्रों में वैज्ञानिकों ने अपने पेपर प्रस्तुत किए ।

हिन्दी पखवाड़ा, सितम्बर, 2001

अन्य वर्षों की तरह इस वर्ष भी प्रयोगशाला में दिनांक 1.9.2001 से 17.9.2001 तक हिन्दी पखवाड़ा मनाया गया जिसके अन्तर्गत विभिन्न कार्यक्रमों का आयोजन किया गया जिसका संक्षिप्त विवरण निम्नांकित है :–

1. टिप्पण एवं प्रारूप लेखन
2. हिन्दी डिक्टेशन प्रतियोगिता
3. हिन्दी निबंध प्रतियोगिता
4. हिन्दी टंकण प्रतियोगिता
5. कविता पाठ प्रतियोगिता

चित्र : डा. विक्रम कुमार, निदेशक, ठोसावस्था भौतिक प्रयोगशाला, वैज्ञानिक कार्यशाला में प्रतिभागियों को संबोधित करते हुए

दिनांक 17.9.2001 को पूर्वाह्न 11.00 बजे प्रयोगशाला के ऑडिटोरियम में हिन्दी पखवाड़ा समापन समारोह का आयोजन किया गया । डा. कृष्ण लाल, निदेशक, एन.पी.एल. ने कार्यक्रम की अध्यक्षता की तथा कार्यक्रम के मुख्य अतिथि के रूप में प्रो.ए.आर.वर्मा, पूर्व निदेशक, राष्ट्रीय भौतिक प्रयोगशाला को आमन्त्रित किया गया। कार्यक्रम के प्रांरभ में निदेशक महोदय ने अपने स्वागत भाषण में प्रयोगशाला में हो रहे हिन्दी के प्रगामी प्रयोग की सराहना की तथा उपस्थित सभी सदस्यों से अनुरोध किया कि वे अपने दैनिक कार्यों के साथ–साथ वैज्ञानिक कार्यों में भी हिन्दी को अपनाएं । तत्पश्चात् प्रो.ए.आर.वर्मा, मुख्य अतिथि ने अपने भाषण में प्रयोगशाला के सभी सदस्यों को हिन्दी में कार्य करने के लिए प्रेरित व प्रोत्साहित किया ।

गीत एवं काव्य प्रतियोगिता के प्रथम व द्वितीय विजेताओं द्वारा अपनी–अपनी कविताएँ सुनाई गई तथा उसके बाद माननीय प्रो.ए.आर.वर्मा ने सभी विजेताओं को पुरस्कार प्रदान किए ।

कार्यक्रम का समापन डा. एस.सी. गर्ग के धन्यवाद प्रस्ताव के साथ हुआ ।

उपर्युक्त विशिष्ट कार्यों के अतिरिक्त वार्षिक रिपोर्ट तथा समीक्षा पत्रिका का द्विभाषी रूप में निकाला जाना, तिमाही प्रगति रिपोर्ट को सी.एस.आई.आर. निर्धारित समय में भेजा जाना, राजभाषा कार्यान्वयन समिति की तिमाही बैठक को समय पर बुलाया जाना विशेष सराहनीय कार्य रहे हैं । यह बड़े हर्ष की बात है कि वर्ष के दौरान केन्द्रीय सचिवालय हिन्दी परिषद् द्वारा आयोजित 20वीं अखिल भारतीय वैज्ञानिक तथा तकनीकी विषयों पर हिन्दी लेख प्रतियोगिता में उच्च क्रांतिक ताप अतिचालक स्क्विडः उपलब्धियां एवं संभावनाएं विषय पर लेख के लिए डा. नीरज खरे, वैज्ञानिक, एन.पी.एल. को प्रथम पुरस्कार से सम्मनित किया गया ।

चित्र : हिन्दी पखवाड़ा समापन समारोह में पुरस्कार प्रदान करते हुए मुख्य अतिथि प्रो.ए.आर.वर्मा, पूर्व निदेशक, एन पी एल

राष्ट्रीय कार्यशाला

राष्ट्रीय भौतिक प्रयोगशाला में दिनांक 6–7 फरवरी, 2002 को पदार्थों के संश्लेषण, अभिलक्षणन एवं अनुप्रयोगों पर दो दिवसीय राष्ट्रीय कार्यशाला का आयोजन किया गया । हिन्दी माध्यम से राष्ट्रीय स्तर पर आयोजित की जाने वाली विज्ञान की यह दूसरी कार्यशाला थी ।

साधारण पदार्थों से लेकर जटिल संरचना वाले पदार्थों तक की संरचनाओं की गुत्थियों को सुलझाने में संलग्न अनेक वैज्ञानिकों के अथक परिश्रम का प्रभाव आज जीवन के सभी क्षेत्रों पर अपनी छाप छोड़ रहा है । विभिन्न प्रकार के तकनीकी साधनों का विकास उपयुक्त गुणों के पदार्थों के उपलब्ध होने पर ही निर्भर है । इसलिए पूरे विश्व में ऐसे साधनों के विकास और उनके अभिलक्षणन पर अनुसंधान और विकास कार्य जारी है । राष्ट्रीय भौतिक प्रयोगशाला भी अर्धचालक साधनों तथा विभिन्न संसूचकों जैसे आधुनिक परिष्कृत यंत्रों को बनाने में इस्तेमाल होने वाले पदार्थों के निर्माण और अभिलक्षणन के महत्वपूर्ण कार्य में संलग्न है। पदार्थ विज्ञान से जुड़े देश भर के विशेषज्ञों को आपसी विचार–विमर्श और अनुभवों के आदान–प्रदान के लिए एक मंच पर एकत्र करने के साथ–साथ राजभाषा हिन्दी का वैज्ञानिक क्षेत्रों में अधिकाधिक प्रयोग करने के उद्देश्य से राष्ट्रीय भौतिक प्रयोगशाला ने इस कार्यशाला का आयोजन किया है । इस कार्यशाला में सी.एस.आई.आर. मुख्यालय, बनारस हिन्दू विश्वविद्यालय, दिल्ली विश्वविद्यालय ठोसावस्था भौतिकी प्रयोगशाला, नई दिल्ली, बी.आई.एस., नई दिल्ली, आई.आई.टी., एन.एस.सी., सरदार पटेल विश्व विद्यालय, गुजरात, भौतिक विभाग, ए.एन. कॉलेज पटना, भौतिक विभाग, आई.आई.टी. खड़गपुर, आई. आई.टी. रूड़की, रीजनल इंजीनियरिंग कॉलेज कुरूक्षेत्र, पंजाब विश्वविद्यालय, चण्डीगढ़ के अलावा सी.एस.आई.आर. की विभिन्न प्रयोगशालाओं/संस्थानों से प्रतिभागियों ने सक्रिय रूप से भाग लिया ।

कार्यशाला का उद्घाटन समारोह प्रयोगशाला के ऑडिटोरियम में आयोजित किया गया । उद्घाटन समारोह के आरम्भ में डा. कृष्ण लाल, निदेशक, एन.पी.एल. ने उपस्थित सभी विशिष्ट व्यक्तियों, मुख्य अतिथि, प्रतिभागियों तथा सभी श्रोताओं का हार्दिक स्वागत किया तथा सरकारी कामकाज में एन.पी.एल. द्वारा किए गए हिन्दी के प्रयोग की सराहना व इस कार्यशाला के सफल आयोजन की कामना की ।

चित्र : पदार्थों से सम्बन्धित कार्यशाला में प्रोफेसर पी. रामचन्द्र राव, निदेशक, राष्ट्रीय धातुकर्म प्रयोगशाला, मुख्य अभिभाषण देते हुए

श्री सतीश चन्द्र गर्ग ने कार्यशाला विषयक जानकारी दी । प्रो. अरूण निगवेकर, यू.जी.सी., नई दिल्ली ने उद्घाटन अभिभाषण दिया । प्रो. पी. रामचन्द्र राव, निदेशक, राष्ट्रीय धातुकर्म प्रयोगशाला ने मुख्य अभिभाषण दिया । प्रो. अजित राम वर्मा ने अध्यक्षीय अभिभाषण दिया ।

डा. अनिल कुमार गुप्ता ने धन्यवाद देकर समारोह का समापन किया ।

कार्यशाला में कुल सात सत्र रखे गए जिसमें प्रस्तुत किए गए पेपर निम्नलिखित विषयों से सम्बन्धित रहे :–

1 एकल क्रिस्टल एवं क्रिस्टली तनु परतें
2. सौर ऊर्जा पदार्थ एवं प्रणालियां
3. स्मार्ट पदार्थ, संसूचक एवं उनके अनुप्रयोग
4. ओप्टी इलेक्ट्रॉनिक एवं दूर संचारोपयोगी पदार्थ एवं प्रणालियां
5. वायु अंतरिक्षोपयोगी पदार्थ, पुर्जे एवं उनका अभिलक्षणन
6. नवीन पदार्थ संश्लेषण एवं अभिलक्षणन विधियां
7. नैनो अतिसूक्ष्म पदार्थ
8. उन्नत अभिलक्षणन विधियां

इस कार्यशाला में प्रत्येक सत्र की अध्यक्षता वरिष्ठ वैज्ञानिकों द्वारा की गयी तथा सभी सत्रों में मौखिक प्रस्तुतीकरण के साथ साथ आमन्त्रित वार्ताएं रखी गयी जिनमें कुछ विशिष्ट आमन्त्रित वार्ताएं निम्नलिखित हैं :–

1. वर्तमान परिप्रेक्ष्य में पदार्थों का अभिलक्षणन : डा. कृष्ण लाल, निदेशक, एन.पी.एल.
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3. हीरक तनु फिल्मों का संश्लेषण एवं उनके कुछ विशिष्ट अभिलक्षणन एवं अनुप्रयोगः डा. वसन्त द. वणकर, आई.आई.टी., नई दिल्ली
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APPENDIX: 2

PATENTS

Patents filed in India

No	Title	NF No	Application No	Filing Date	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.	282NF2001	0075DEL2002	30-01-2002	Dr K K Jain Dr.Vinay Kumar Prof S C Kashyap
2	A sensitive, fast responsive thin film ethanol sensor and a process for the preparation of a sensitive, fast response thin film ethanol sensor and a process for the preparation of a recursor solution for ethanol sensor.	346NF2001	WO PCT/ IN02/000	01-01-2002	Dr A C Rastogi Dr Kiran Jain Mr H P Gupta Mr Vipin Kumar
3	Conducting copolymer for corrosion protection coating of iron and mild steel and a' process for the preparation of conducting copolymer.	524NF2001	1276DEL2001	06-12-2001	Dr S K Dhawan Dr Nivedita Singh
4	A process for the preparation of relaxor material useful in the manufacture of lead iron tungstate capacitive transducer.	032NF2002	0076DEL2002	30-01-2002	Dr K K Jain Dr Vinay Kumar Prof S C Kashyap
5	Automated dead weight force machine	052NF2002	0405DEL2002	28-03-2002	Dr K K jain Dr R P Singhal Mr HNP Poddar Mr M K Chaudhury

6	A portable humidity generator	059NF2002	0393DEL2002	28-03-2002	Dr Hari Kishan Mr Bhikham Singh Mr Shiv Dutt Sharma Mr V P Arora
7	A process for encapsulation of superconductor devices	060NF2002	0387DEL2002	28-03-2002	Dr Neeraj Khare Dr Ashok K Gupta
8	A smart eye for electronic remote detection.	154NF2002	0281DEL2002	27-02-2002	Dr P K Banerjee Dr Amitava Sen Gupta Dr R S Arora
9	A piezoelectric accelerometer.	155NF2002	0282DEL2002	21-0 3-2002	Dr S K Singhal
10	Long decay luminescent powder.	163NF2002	0371DEL2002	28-03-2002	Dr V Shankar Dr Harish Chander Dr Divi Harnath Dr P K Ghosh

Patents Granted In India

S.No	Title	Patent No	Date Granted
1	A method for producing conducting grid useful for solar cell	No 184729	12-04-2001
2	An improved process for preparation of oxysulfide phosphors	No. 184746	20-04-2001
3	An improved process for preparation of chalcogenide films	No. 185592	07-09-2001
4	An improved process for the production of coal tar pitch	No. 186256	07-09-2001

Patents Filed Abroad

No	Title	Application No	Country	Filing Date	Inventors
1	A capacitive pressure transducer made thereby.	09/896,935	US EPO[1] PCT*	29-06-2001	Dr K K Jain Dr Vinay Kumar Prof S C Kashyap
2	A sensitive, fast response thin film ethanol sensor Ethanol sensor	10/045,472 PCT/IN/02/00001	US EPO[2] PCT** 	08-12-2001 01-01-2002	Dr A C Rastogi Dr Kiran Jain Mr H P Gupta Mr Vipin Kumar
3	Reusable heat pack	01303084.6-2310 PCTIN/01/00074	EPO[3] PCT***		Dr C P Sharma Dr A K Sarkar Dr R K Sharma Mr Chander kant
4	Software for reflectance profile	60/347,878	USA UK	15-01-2002	Dr S P Varma Dr Devinder Gupta Mr R Nagaraj
5	A long decay luminescent powder	10/113,555 02-096198	US JP	28-03-2002 29-03-2002	Dr V Shankar Dr Harish Chander Dr Divi Harnath Dr P K Ghosh

Patents Granted Abroad - Regular

No	Title	Application No	Date Granted	Inventors
1	A formulation for iron chelation	EPO (# 0853229)	09-01-2002	Dr A K Sarkar Ghanshyam Das Sudarshan Kumar
2	A formulation for iron chelation	Japan (#3253878)	22-11-2001	Dr A K Sarkar Ghanshyam Das Sudarshan Kumar
3	Compensated sulphonated polyaniline and a process for the preparation thereof	US (# 6326441)	04-12-2001	Dr S K Dhawan Sarasati Kaul Ramesh Chandra Subhash Chandra

4	Conducting polymer membrane and method of preparation of the said membrane	BD (# 1003216)	25-07-2001	Dr Ramadhar Singh Dr Subash Chandra Mr Hawa Singh Dr Amarjit Kaur Narula Dr Shobha Broor

Notes:

1 EPO designated states: Still to be decided.
2. EPO designated states Still to be decided
3. EPO designated states Great Britain, Germany, France, Netherlands, Belgium, Luxumberg, Sweden, Denmark, Austria, Switzerland, Finland, Italy, Spain, Ireland

(*) PCT states designated: China, Canada, Russia

(**) PCT states designated: Still to be decided

(***) PCT states designated: China,Japan,South Korea, Australia, Canada, Russia, Czech Republic, Hungary, Norway, New Zeland, Poland, Romania, Slovakia.

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APPENDIX - 4
R & D COLLABORATIONS

Physico-Mechanical Standards

Collaborating Institution	Area
Overseas	
Optical Technology Division, National Institute of Standards and Technology, Gaithersburg, Maryland, USA.;	Infrared radiation standards
PTB, Germany-	Low forces
Indian	
CPWD, New Delhi	Building acoustics
CPCB, New Delhi	Noise/ air pollution
DST, New Delhi	Acoustic wind profiler
HACE India Ltd., New Delhi	Air pollution
Indian Institute of Technology, Delhi	Capacitance transducer
Indian water meter manufacturers' Association	Domestic water meters testing and calibration
IPCL, Nagathane, Bharuch	Air pollution
RRL, Bhopal	Building acoustics
Sabergo Organics Gujarat Ltd.	Air pollution
SAIL, Durgapur	Air pollution
Transducer India	Load cells
NABL	Proficiency testing, accreditation, laboratory assessment, quality awareness & training programmes
SASO	Human resource development
Industry	Calibration, training, consultancy
Nuclear Science Centre, New Delhi.	Swift heavy ion induced interface mixing
Indian Association for the cultivation of science, Kolkata.	Characterization of thin film based materials
Indian Institute of Technology, Kharagpur.	Characterization of semiconductor device materials for their surfaces and interfaces

Collaborating Institution	Area
Solid State Physics Laboratory, Delhi.	Study of semiconductor device materials for impurity and dopant concentrations

Electrical & Elecrtonic Standards

Overseas

BIPM	Key comparisons of standards.
APMP	International intercomparisons of standards
CSIR-NML, South Africa	LF impedance standards

Indian

NABL, New Delhi	Proficiency testing, accreditation, laboratory assessment
TIFR, Mumbai	RF-SQUID effect in Borocarbide superconductors
Banaras Hindu University	CMR and high-Tc superconducting materials
Univ. of Delhi-South Campus	Microwave superconductivity
AIIMS, New Delhi	Cancer hyperthermia & biometry
Safdarjung Hospital, New Delhi	Bone fracture detector
Jamia Millia Islamia, New Delhi	High power ultrasonic transducers

Engineering Materials

Overseas

Department of Materials Science, University of Leeds, UK	Role of matrix precursor in the development of high thermal conductivity carbon-carbon composites
Department of Materials Science and Engineering, Univ. of Pennsylvania, Philadelphia, USA,	Application of carbon nanotubes in composites - alignment and adhesion problems
Naval Research Laboratory, Washington DC, USA	Surface order & structure studies of polymer-solid interface

Indian

Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram	Spray atomization of Mg-alloys
Hindustan Aeronautics Ltd. (HAL), Banaglore	Development of oval shaped tube as skid landing gear for ALH

Collaborating Institution	Area
Indian Oil Corporation Ltd. (R&D Centre), Faridabad	Feasibility studies on various petroleum refinery streams as precursor for high performance carbon fibres
Institute for Plasma Research, Gandhinagar, Gujarat	Development of high thermal conductivity special graphite for first wall component of SST-1 tokamak
Aeronautics R&D Board, Ministry of Defence, New Delhi	Development of carbon monofilament suitable for CVD-based SiC fibres
Graphite India Ltd., Bangalore	Upscaling of high density graphite technology
Indian Institute of Technology, Delhi / DST, New Delhi	Development and characterization of asbestos free brake-pad materials
NMRL, DRDO	Development of porous conducting carbon paper
BARC, Mumbai	Development of radiationally stable carbons

Electronic Materials

Indian

Deptt. of Microbiology, AIIMS, New Delhi	Conducting polymer membrane for arresting waterborne viruses
Maitreyi College (Delhi University), Chanakya Puri, New Delhi	Studies on conducting polymers
Deptt. of Physics and Astrophysics, Delhi University, Delhi	Studies on conducting polymers
National Institute of Immunology, New Delhi	Bio-compatible polymer composites
Central Electronic Engineering Research Institute, Pilani	Silica-on-Silicon integrated optical devices for WDM applications
Bhabha Atomic Research Centre, Mumbai.	Development of silicon photodiodes
Defence Laboratory (DRDO), Jodhpur	Development of luminescent screens

Materials Characterization

Overseas

Institute for Reference Materials and Measurements (IRMM), Belgium	International key inter-comparison programme on chemical measurements

Collaborating Institution	Area
National Analytical Reference Laboratory (NARL), Australia	International key inter-comparison programme
Indian	
Bhabha Atomic Research Centre, Trombay, Mumbai	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions, pesticide and gas mixture
Central Building Research Institute, Roorkee	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions
Central Food Technological Research Institute, Mysore	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions and pesticide
Central Fuel Research Institute, Dhanbad	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of gas mixtures
Central Glass & Ceramic Research Institute,	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of silicon powder for X-ray diffraction
Central Rice Research Institute, Cuttak	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Gas Mixtures
Central Salt & Marine Chemicals Research Institute, Bhavnagar	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions and gas mixture
Indian Agricultural Research Institute, New Delhi	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of pesticide and gas
Indian Institute of Chemical Technology, Hyderabad	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions and pesticide
Indian Institute of Petroleum, Dehradun	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions and pesticide
Industrial Toxicology Research Centre, Lucknow	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions and pesticide
National Aeronautical Laboratory, Jamshedpur	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of silicon powder for X-ray diffraction

Collaborating Institution	Area
National Botanical Research Institute, Lucknow	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions and gas mixture
National Chemical Laboratory, Pune	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of silicon powder for X-ray diffraction
National Environmental Engineering Research Institute, Nagpur	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions
National Geophysical Research Institute, Hyderabad	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions
National Institute of Oceanography, Goa	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions
National Metallurgical Laboratory, Jamshedpur	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions.
National Remote Sensing Agency, Hyderabad	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of gas mixture
Regional Research Laboratory, Bhubaneswar	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions, pesticide and gas mixture
Regional Research Laboratory, Jorhat:	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions and gas mixture
Regional Research Laboratory, Thiruvananthapuram	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of gas mixture
Indian Oil Corporation, R & D Centre, Faridabad	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions and pesticide
National Thermal Power Corporation, R & D Centre, Goutambudhanagar	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions and gas mixture
M/S AES Testing & Research Laboratory, Goutambudhanagar	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of mono-elemental solutions, pesticide and gas mixture
Tata Energy Research Institute, New Delhi	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of gas mixture

Collaborating Institution	Area
M/S Gharda Chemicals Ltd., Dombivli	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of pesticide

Radio & Atmospheric Sciences

Overseas

START, Washington, USA APN, Tokyo Japan	Operation of the South Asian Regional Research Centre for Study of Global Change
NCAR, USA, DOS Govt. of India	Indian Ocean Experiment (INDOEX)

Indian

Indian Agricultural Research Institute, New Delhi	Free air CO_2 enrichment studies on crops and gas emission using FACE and OTC facilities
National MST Radar Facility, Tirupati.	Lower atmosphere and F-region studies.
Central Pollution Control Board, New Delhi	Study of fog/smog in and around the city of Delhi
Indian Space Research Organisation, Bangalore and Universities of Osmania, Roorkee, Waltair, BHU, Dibrugarh, Kolkata, Saurastra and Kerala	RPA Aeronomy payload onboard SROSS-C2 satellite, data management and data analysis
Indian Meteorological Department, New Delhi	Rain effects on microwave communication
Department of Ocean Development	Greenhouse gases at Antarctica
Department of Ocean Development	PBL studies over Antarctica
Indian Statistical Institute, Kolkata	Estimation of rain characteristics using X- band radar
Kurukshetra University, Kurukshetra	Particitation in NPL's activities in the 21st Indian Antarctic Expedition
Space Application Center, Ahmedabad	Ionospheric correction in sea surface temperature measurements by radiometer on board IRS Indian satellite

Superconductivity & Cryogenics

Indian

Institute for Plasma Research, Gandhinagar	SC magnets
University Grant Commission	HTSC
Department of Science & Technology	Photo-induced superconductivity & Indo-Japan project on HTSC
DST on Humidity Standard	Indo-Japan project

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APPENDIX: 5
SPONSORED/ SUPPORTED R&D PROJECTS

New Projects

Sl.No.	Title	Agency/Client	Amount Received (Rs. In Lakhs)
1	Development of polymeric sensors for detection of environmentally hazardous gases and micro-organisms	ME&F	2.496
2	Application of some conducting polymers films	Indo-Japan (DST)	1.436
3	Studies on humidity standards	Indo-Japan	0.545
4	Studies on critical current and vortex dynamics in high Tc superconducting bulk samples and tapes	Indo-Japan	1.250
5	National mapping of physical science using inspec database under scientometric programme of NISSAT/DSIR	DST	0.500
6	A new approach for memory effect in ferro-electric liquid crystal materials based on charge accumulation phenomenon	DST	13.500
7	Development of new formulation of indelible ink	Election Commission of India	5.290
8	Impact of climate change on human health	ME&F	3.361
9	Reducing uncertainties in emission of CH_4 and N_2O from livestock in india in relation to the enabling activities for initial communication to UNFCCC	ME&F (Winrock)	5.504
10	Measurement of CH_4 and N_2O emissions from rice/wheat ecosystem in relation to reducing uncertainties in emission factor for enabling activities for initial communication to UNFCCC	ME&F (Winrock)	10.496
11	Reducing uncertainties in emissions of co2, ch4 and from biomass burning in india in relation to the enabling activities for initial cummunication to UNFCCC	ME&F (Winrock)	11.929

Sl.No.	Title	Agency/Client	Amount Received (Rs. In Lakhs)
12	Agriculture sector inventory	ME&F (Winrock)	4.127
13	Development of hard coating of cubic boron nitride for industrial applications	DST	9.662
14	The budgets of GHGs, urban air pollutants and their furture emission scenarios in selected mega-cities in Asia	APN,IGES,Japan	6.840
15	Development of ultrasonic method to evaluate mositure in composite materials	ARDB	4.348
16	Feasibility study on characteristic-D method for ORPAS	DRDO (CDA-Navy)	2.650
17	Growth of nearly perfect single crystal of oxide materials with technological applications	INDO-Russia (ILTP)	0.000
		Sub Total New Projects	**83.934**

Continuing Projects

1	Rain characteristics and estimation using X-band radar for rain attenuation in microwave and millimeter bands	DST	3.000
2	Research and development on (a) atomic hydrogen masers and (b) precision frequency metrology (CP)	Indo-US	0.000
3	Development of an acoustic wind profiler (with multi beam acoustic array antenna) for remote atmospheric wind measurement (GA)	DST	0.000
4	Programme of technical collaboration and co-operation in metrology with NIST (USA)	NIST	0.000
5	Interaction with universities/laboratories in the area of superconductivity (UGC)	UGC	0.000
6	Indian INDOEX programme	ISRO/UCAR(USA)	0.000
7	Continuous measurement, updating, modelling and assessment of greenhouse gases	ME&F	0.000

Sl.No.	Title	Agency/Client	Amount Received (Rs. In Lakhs)
8	Ozone over India - change in the past & future (GA)	ME&F	0.000
9	Development of luminescent screens i) gaddinium oxysulfide based X-ray/ gamma ray/neutron sensitive phosphor screens ii) electro- luminescent screens	DRDO	2.400
10	SASCOM activity as meeting on indo-gengetic plain research effort	Int. START Secr.	0.00
11	Operation of the south asian regional research centre (SARRC) for study of global change under sascom	Int. START Secr.	11.657
12	Surface order and structure studies of polymer solid interfaces	Indo-US	0.000
13	A study of flare tringgering and associated hard X-ray emissions and other flare –related phenomena for modeling of flares. (GD)	DST	0.000
14	Development of carbon monofilament suitable for CVD-based SiC fibres	ARDB	1.148
15	Development of frequency stabilised diode laser for laser cooling of alkali atoms	DAE	0.893
16	Development of a portable analytical X-ray imaging instrument for biomaterials	DST	3.500
17	Growing by MBE method of epitanial sturcture on the basis of compound A"B" GaAs, al in gaas of different composition for various applications	Indo-Russia	0.000
18	To develop 10 PF capacitor using ule quartz for use by accredited calibration laboratory	DST	0.000
19	Tetrahedral amorphous carbon (ta-c) films deposited by a filtered vacuum arc discharge (FVAD) technique	DST	0.000
20	Planning preparation and dissemination of certified reference materials (CRM) for quality assurance in analytical measurements	DST (NABL)	1.500

Sl.No.	Title	Agency/Client	Amount Received (Rs. In Lakhs)
21	Development of oval shaped tubes as skid landing gear for Advanced Light Helicopter (Phase II)	HAL	0.000
22	Development of porous conducting carbon papers	NMRL	9.700
23	Studies on bio-mass burning and related trace gas emissions using IRS-P3 satellite data	NRSA	2.000
24	SROSS-C2 satellite RPA aeronomy payload data management	ISRO	0.000
25	Studies on fog ocurrence in Delhi	CPCB	0.000
26	Faraday correction for 6.6 Ghz radiometer data from IRS P4 using Global Positioning System (GPS) observations	DST	0.000
27	Development of ultrathin magnetic films for engineering applications in magnetic recording & sensing	DST	0.000
28	Spin fluctuations and high temperature superconductivity in bilayer cuprates	DST	3.000
29	Photoinduced superconductivity and non-equilibrium states	DST	0.000
30	Low pressure synthesis of cubic boron nitride (cBN)	Indo-German (DAAD)	1.164
31	Development of superconducting magnet	IPR	0.000
32	Development of specific methods to identify adulterants in milk and to develop a spot testing kit	DMS	1.000
33	Studies on emission from biomass combustion in cookstoves	AIT, Thailand	0.960
34	Development of silicon photodiodes for use with scintillating crystals for detection of gamma rays	DAE	3.425
35	Synthesis and properties of conducting polymers for biosensors	Indo-Polish	0.500

Sl.No.	Title	Agency/Client	Amount Received (Rs. In Lakhs)
36	Development of strain gauge force transducer to measure forces upto 1 MN with accuracy ± 0.03%	DST	0.000
37	Application of carbon nanotubes in composites-alignment and adhesion problems	DST/NSF	0.000
38	CdTe passivation of HgCdTe by electrodeposition technique for use photovoltaic FPAs : a feasibility study	DRDO/SSPL, Lucknow	0.000
39	Self assembled layers of conducting polymers for molecular devices	DST	0.000
40	Development of optically addressed spatial light modulators for photonics applications	DRDO(IRDE)	0.000
41	R&D in non-invasive optical fiber probe based near-infrared spectroscopy (NIRS) for accessing brain activity	DST	0.000
42	Development of piezo electric accelerometers for general purpose applications	DRDO, Hyederabad	3.600
43	Monitoring of green house gases at Maitri-Antarctica	DOD, Goa	14.903
44	Studies on spatial-coherence spectral filters and their applications	DST	0.000
45	Swift heavy ion induced mixing at the interface	DST	0.000
46	Development of cholesterol biosensors	DBT	0.000
47	To conduct inter-laboratory proficiency testing amongst the NABL accredited calibration laboratories in india	DST (NABL)	25.000
		Sub Total Continuing Projects	**89.350**

Sl.No.	Title	Agency/Client	Amount Received (Rs. In Lakhs)
	Completed Projects		
1	Role of matrix precursor in the developemnt of high thermal conductivity carbon-carbon composites.	Indo-UK	2.000
2	Total spectral reflectance,total spectral transmittance and spectral emittance study in the infrared region of various materials in thin and thick films and bulk sample	Indo-US	0.000
3	Asbestos free brake material for automobile tailoring characterization & evaluation	DST	0.880
4	A study of QUAS; horizontal and vertical transport of air from tropical upper troposphere and stratosphere	ISRO	0.000
5	Development of high thermal conductivity special graphite for first wall component of SST-1 Tokamak	IPR(Inst.for Plasma Res.)	2.180
6	Feasibility study on various petroleum refinery stream as precursor for high performance carbon fibres	IOC	0.000
7	Study of doped rare earth manganese oxide films for enhorning low field magnetoresistance effect	DST	0.000
8	One year village level trial of filter tablet for arsenic removal from ground water	RGNDWM (Rajiv Gandhi National Drinking)	0.000
9	Studies on surface layer in relation to turbulent kinetic energy budgeting	DST	0.000
10	Preparation of long decay phosphor (LDP) and adhesive tape	DRDO, Jodhpur	0.000
11	Silica on silicon integrated optical components for wavelength division multiplexing (WDM) applications (Part-1)	Ministry of Information Technology	0.000

Sub Total Completed Projects	**5.060**
Grand Total	**178.344**

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APPENDIX: 6

RECEIPTS THROUGH CONSULTANCY PROJECTS
Consultancy Projects

Sl. No	Client	Title	Amount Received (Rs in Lakhs)
1	Graphite India Limited, Calcutta	General consultancy relating to upscaling of high desity graphite technology	3.000
2	CPWD Commercial Complex, Ghaziabad, UP	Removal of powdered coating from the samples of aluminium, which is needed before the composition	0.150
3	Sabero Organics Gujarat Ltd.	Inversion monitoring at vapi (Gujarat)	1.778
4	Samtel Color Ltd.	Providing consultancy services in the design, fabrication & installation of large area reactor for coating MgO films	1.305
5	CMC Ltd.	Assistance in synchronization to IST of the computer system used for disturbance recording and event logging at (1) MP State Electricity Board SLDC, Nayangaon, Jabalpur (2) CMC Centre Gochibowli, Hyderabad	0.017
6	DAE, Indira Gandhi Centre for Atomic Research	IIT superconducting magnet development	3.500
7	RRL, Bhopal	Acoustic treatment of seminar hall at RRL, Bhopal	0.527
8	AIMIL Ltd.	Instrumentation and automation (Phase V)	0.527
9	Mitutoyo South Asia Pvt. Ltd.	To help in setting up of calibration facility in dimensional measurement as per NABL	3.338
10	BARC, Mumbai	General consultancy regarding isotropic and radiationally stable carbons	3.000
11	Sri Kalishari Fire works, Sivakasi	To characterise the chemical mixture used in fire cracker “Bullet by chemical methods”	0.350
12	AIMIL Ltd.	Instrumentation and automation (Phase V)	0.269
13	OLYMPUS (India)	To give advice on admissible tolerance of N.A. of microscope objective	0.158
		Sub Total Consultancy Projects	**17.917**

Sponsored Projects

Sl. No.	Client	Title	Amount Received (Rs in Lakhs)
1	MNES	Design & development of a mechanical load tester for determining the ability of PV module to withstand wind snow and ice loads	2.787
2	NTPC, Gautam Budh Nagar,	Supply of a set of six cards of STFS system, demodulator for STFS and S-band low noise convertor (LNC) for STFS	1.140
3	HACE India Pvt. Ltd.	Inversion studies at ISM, Dhanbad	1.000
		Sub Total Sponsored Projects	**4.927**

Technical Services Projects

Sl. No.	Client	Title	Amount Received (Rs in Lakhs)
1	ATCO Industries	To assist in establishing the facilities at ATCO, Bombay to calibrate the load cells upto 6 Kn capacity as per IS & ISO Stds	8.780
2	CBRI, Roorkee	Design development and fabrication of the force transducer of 20 T & 40T capacity	2.200
3	National Test House	Development and fabrication of temperature heating baths for thermometers and other associated temperature measuring instruments, covering range 20°C to 300°C	5.500
4	DG of SASO, NMCL, Saudi Arabia	Initiation of time service via telephone line at SASO	2.500
5	M.S.E.B Mumbai	Repair work	0.488
		SubTotal Technical Services Projects	**19.468**
		Grand Total	**42.312**

APPENDIX:7

EARNINGS FROM CALIBRATION & TESTING

PHYSICO-MECHANICAL STNDARDS

Activity	Gr. Code	Reports	Charges (Rs.)
Length standards	1	42	251200
Dimension metrology	2	600	3027382
Mass, density, volume & viscosity	3	627	2455921
Force & hardness standards	4	489	4321614
Pressure & vacuum standards	5	164	2168438
Temperature standards	6	564	1787298
Optical radiation standards	7	396	1893700
UV radiation measure standards	8	22	125300
IR radiation standards	9	25	40600
Acoustic standards	10	141	624700
Ultrasonic standards	11	13	83600
Humidity standards	12	33	60500
Fluid flow standards	13	9	417400
	Sub Total	**3125**	**17257653**

ELECTRICAL & ELETRONICS STANDARDS

Activity	Gr. Code	Reports	Charges (Rs.)
AC & LF standards (up to 1 kHz)	20	501	3513125
AC & LF standards (CT/PT)	21	27	416400
D.C. standards	22	50	725000
HF & microwave attenuation	23	21	195400
LF & HF impedance standards	24	90	571000
HF & microwave standards	25	33	574500
Magnetic measurement activity	26	29	116220
Time & frequency standards	27	35	136300
	Sub Total	**786**	**6247945**

TESTING

Activity	Gr.Code	Reports	Charges (Rs.)
Material characterization	30	64	485900
Chemical analysis	31		100100
Indian reference material	32	3	24600
X-ray analysis	33	27	173400
Electron microscope analysis	34	1	40000
EPR analysis	35		17400
Carbon technology	42		24000
Metal & alloys group	43		10000
Others			657488
	Sub Total	**95**	**1532888**

JOB WORK

Activity	Gr. Code	Reports	Charges (Rs.)
Piezoelectric accelerometer	46		100800
Central workshop	47		45200
Thin film	48		15000
	Sub Total	**–**	**161000**
	Grand Total	**4006**	**25199486**

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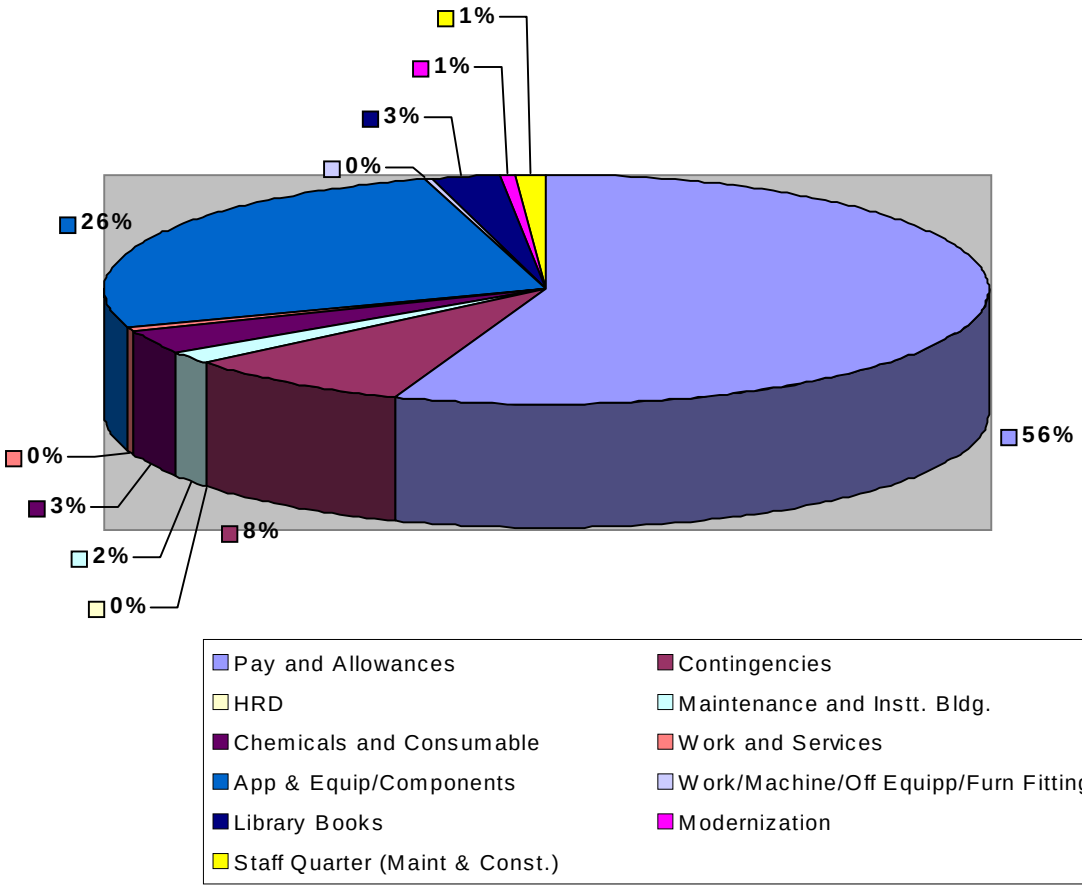
APPENDIX : 8
ACTUAL EXPENDITURE 2001-2002

Sl.No.	Budget Heads	Expenditures (Rs. in Lakhs)
1	Pay and allowances	1786.316
2	Contingencies	264.426
3	HRD	4.000
4	Maintenance and instt. Bldg.	59.114
5	Chemicals and consumable	110.000
6	Work and services	13.508
7	App & equip/components	831.305
8	Work/machine/off equipp/furn fitting	7.362
9	Library books	85.00
10	Modernization	17.313
11	Staff quarter (maint & const.)	34.089
	Total	**3212.433**

Source of funds: CSIR Grant



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APPENDIX:9
HONOURS AND AWARDS

Physico-Mechanical Standards

Dr. V. Mohanan, Scientist F

Distinguished Services Award of the Acoustical Society of India for the term 1997-99.

Served as referee for evaluating two papers for the Journal of Molecular liquids, Germany.

Dr. H.C. Kandpal, Scientist E-II

Appointed permanent referee by the Optical Society of America for reviewing the paper submitted to, Journal of Optical Society of America, Optics letters etc.

Chaired a sessions on Optical Instrumentation and Engineering" in the *2nd International Conference and XXVII annual convention of OSI Optonic 2001 Millenium Challenges in Optics and Optoelectronics, August 27-30, 2001*

a paper entitled " Experimentation verification of non-Doppler spectral shift and dynamic scattering theory authored by H.C. Kandpal, J.S.Vaishya, Suman Anand, Sisir Roy and Manas Kafatos and presented by H.C. Kandpal in the above mentioned conference was adjudged to be *the best paper of* the conference with the comments that such research may open many vistas in astrophysics and astronomy.

Dr. J.S. Vaishya, Scientist F

Chaired a sessions on Optical Instrumentation and Engineering" in the *2nd International Conference and XXVII annual convention of OSI Optonic 2001 Millenium Challenges in Optics and Optoelectronics, August 27-30, 2001*

K.P. Chaudhary, Scientist E-II

Invited as an examiner for M.Tech thesis at Kurukshetra University.

Nita Dilawar Dr.(Ms.), Scientist 'B'

Received CSIR Young Scientist Award for the Year 2001 in Physical Sciences.

Dr. R.P. Singhal, Scientist G

Nominated as a Member of Advisory Committee attached to Regional Testing Centre (NR), Ministry of Small Scale Industries, Government of India, New Delhi

Nominated as Chairman of Sizing Methods Sectional Committee CED55 of Bureau of Indian Standards.

Re-elected General Secretary of Metrology Society of India for 2001-03

Invited as External examiner to evaluate M. Tech Thesis, Instrument Design & Development Centre (IDDC), Indian Institute of Technology (IIT), New Delhi on December 22, 2001.

Tripurari Lal, Scientist F

Nominated as the Head of the management group responsible for organising APMP M.M-K2 for the year 2002-2003.

Electrical and Electronic Standards

Dr. Ashok Kumar Gupta, Scientist G

Elected, Vice Chairman, Metrology Society of India

Chairman, Programme Committee, Metrology Society of India

Member, Editorial Board, MAPAN-J. Metrology Society of India

Member, Editorial Board, Indian J. Cryogenics

Member, Management and Systems Division Council (MSDC), Bureau of Indian Standards

Secretary, Indian Cryogenic Council (North Zonal Branch)

Vice Chairman, Organising Committee and Chairman, Technical Programme Committee, Eighteenth National

Symposium on Cryogenics, held at NPL, 21 – 23, November, 2001

Member, National Advisory Committee, International Symposium on Advances in Superconductivity & Magnetism: Materials, Mechanisms and Devices, organized by TIFR at Mangalore Univ., 25 – 28 Sept, 2001

Vice Chairman, Local Organising Committee, Second International Pressure Metrology Workshop and International Conference on High Pressure Science and Technology, NPL, New Delhi, 25 – 30 Nov. 2001.

Dr. P. Banerjee, Scientist G

Associate Editor of "The Radio Science Bulletin"- a quarterly Journal from The URSI Secretariat, Belgium(2000-2002)

Member, Project Review Steering Committee of " WAAS for India-A test Bed Approach" of NERTU, Osmania University, Hyderabad

Member, Project Review Steering Committee of "A GPS-WAAS receiver for Civil Aviation for Non Precision Approach" of Accord Software, Bangalore

Member, Project Review Steering Committee of "Fleet management of DTC through GPS", of CMC Ltd. Hyderabad

Dr A. Sen Gupta, Scientist F

Was elected as Senior Member of the Institution of Electronic and Electrical Engineers (IEEE), USA starting with the year 2001. He is also associated with the IEEE Ultrasonic Ferroelectrics and Frequency Control Society (UFFC).

Guest Editor of a Special issue of MAPAN, JMSI Supplement 2 in 2001. This was a special supplement on Current Trends in Time & Frequency, which consisted of papers presented at the International Conference on Time & Frequency (ICTF), held in NPL, New Delhi during 6-7 February, 2001.

Invited to attend the 6th Symposium on Frequency Standards and Metrology, held during 9-14 September, 2001 at the University of St Andrews, Fife, Scotland, UK, where he presented the work on Microwave Synthesizers for Atomic Frequency Standards.

Chairman of the Academic Committee of NPL. In this capacity he headed the organizing committee of the CSIR Programme on Youth for Leadership in Science (CPYLS) on 28-29 November, 2001.

Dr A. K. Hanjura, Scientist F

Elected as a Fellow of the Metrology Society of India (MSI)

Elected as a Fellow of the Institution of Electrical and Telecommunication Engineers (IETE), India

Dr. V.R. Singh, Scientist G

Elected as Associate Editor of IEEE Transactions on Instrumentation and Measurements (USA).

Elected as the Joint Secretary of Instrument Society of India (Bangalore).

Continued to serve on Editorial Review Committee of IEEE Trans on Instrumentation and Measurements (USA).

Elected again as the Chairman of Fellowship & Awards Committee, IEEE- Delhi.

Continued to be a Member of the Senate of Thapar Inst. of Engg & Tech, Patiala

Continued to serve as Vice-Chairman of IFUMB (Ind. Fed Ultr Med. Biolog), Delhi.

Continued to work as a Zonal Member of Indian College of Medical Ultrasound (IFUMB) Mumbai.

Re-elected as Vice-President of Ultrasonic Society of India.

Continued to serve on Executive Councils of NAFEN & IEEE- Delhi, and Metrology Soc of India.

Continued to serve on Res Degree Comms of University of Delhi (Faculty of Technology), GND Univ, Amritsar & CCS Univ, Meerut.

Continued to serve as a Member of Board of Studies / Faculty of Science, Kurukshetra University.

Continued to serve as a Member of Board of Studies (Electronics Engg), Institute of Technology, Banaras Hindu Univ, Varanasi.

Elected as Chairman of BIS Comms. on Electromedical Equipment and Dental Materials Comm.

Served as a Member of Intnl Advisory Comm, CERA-2002 (Int. Conf. on Computers & Elect. Engg.), Univ of Roorkee (now IIT – Roorkee).

Nominated as a Member of Comm. on Characterization of Materials of Ancient Monuments (Mainly Metal Antiquities) at National Institute of Museology, New Delhi.

Engineering Materials

Dr. Anil K.Gupta, Scientist G

External and Viva-Voce Examiner of Dr.Rajnish Garg, PhD (Engg), Department of Metallurgy & Materials Engineering, IIT, Roorkee – April 2001

Vice chairman, Local Organising Committee & Chairman, Technical Programme sub-committee of National Workshop on Synthesis, Characterization & Application of Material, at National Physical Laboratory, 6-7, February, 2002

Member of the Local Organizing Committee and Chairman, Techincal Program & Auditorium Management sub-committee of 2nd International Pressure Metrology Workshop and International conference on High Pressure Science and Technology organised at National Physical Laboratory, 26-30, November, 2001.

Dr. S.C. Jain, Scientist G

Elected Council Member to Indian Liquid Crystal Society, Bangalore, India

Materials Characterization

Dr A. K. Agrawal, Scientist E II

Appointed member of Board of Research Studies,Industrial Chemistry, M.J.P.Rohilkhand University,Bareilly (U.P.)

Nominated Principal Member, C.M.D10-Glass,Glassware and laboratoryware Section Committee of Bureau of Indian Standards,New Delhi

Dr. A. K. Srivastava, Scientist B

BOYSCAST Fellowship awarded by DST, Government of India to work at University of Paris, France for a period of one year March 20, 2001 – March 19, 2002.

Ranu Gadi, Dr. A.K. Sarkar, Dr. D.C. Parashar and Dr. A.P. Mitra

The Thomas Kuhn Honor Pin was awarded to this team, by the International Union of Air Pollution &Prevention & Environmental Protection Associations and the International Academy of Science for the best paper, "SO_2, NOx, organic and elemental carbon emission studies from biofuels used in India'' in the 3rd International Symposium on Non-CO_2 Greenhouse Gases (NCGG-3) Scientific understanding control and implementation, held in Masstricht, The Netherlands, 21-23 January 2002.

Radio & Atmospheric Sciencies

Dr. A.B. Ghosh, Scientist F

Appointed member of the Faculty of Technology, Delhi College of Engineering, Delhi from 2001 for a period of three years.

Dr H.N. Dutta, Scientist F

Awarded Guest of Honour at the Third Haryana State Electronics Conference at Dayanand College, Hisar, January 24, 2002.

Declared Archana Gold Medal awardee for the year 2001-2002 by the Academy of Environmental Biology, Lucknow.

Dr. S.L. Jain, Scientist F

Nominated as deputy leader & summer station commander during 21 st Indian Scientific Antarctica Expedition.

Nomination as member expert in the subject field of Laser Technology for award of the scholarships offered by Japanese Government for the year 2002 by Ministry of Human Resource Development, Department of Secondary & Higher Education, Shastri Bhavan, New Delhi.

Review meeting PRWG of "Development of Micro Pulse Lidar" at Guwahati University, Gauhati During Nov. 23-25, 2001

Holding membership of the following

- SPIE-The International Society for Optical Engineering
- AGU- The American Geophysical Union
- APS - The American Physical Society
- AIS - The American Institute of Physics

Name is included in the Outstanding People of the 20 th Century Second Edition of the International Biographical Centre Cambridge, UK

Dr. M.K. Tiwari, Scientist F

Invited by the international Rice Wheat Consortium to be part of an International Team to formulate the multi-disciplinary natural and social science research programme needed to determine strategies to cope with the impact of global environment change on food provision systems and to analyze the environmental and socioeconomic consequences of adaptations. These studies contitute the international GECAFS programme launched recently by IGBP, IHDP and WCRP.

Invited as Advisor in a three year multi-institutional programme launched by ICAR for the study of the effect of land-cover & environmental change on sustainability of livelihood of Diara-Land agriculture community. Both above activities relate to global change study progrmmes.

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Dr. G.Bhagavannarayana, Scientist EII

Visited Arbeitsgruppe Roentgenbeugung, Institut fur Physik, Humboldt Universitat zu Berlin, D-10117 Berlin, Germany under the INSA-DFG Exchange Programme during 3rd Sept. 2001 to 28th Feb. 2002.

APPENDIX : 10

VISITS ABROAD

Name & Designation	Country Visited	Duration / Period	Purpose
Dr. Pradeep Mohan Sci. E-II	NIST, USA	16.4.2001 to 15.10.2001	As guest researcher at NIST, Gathersburg, USA for six months on sabbatical leave.
Dr. O.S. Panwar Sci. E-II	UK	1.5..2001 to 31.7.2001	Visited under Raman Research Fellowship for 3 months.
Dr. A.C. Rastogi Sci. F	USA	25.4.2001 to 24.4.2002	As visiting research associate at the Department of Electrical & Computer Engineering University of Massachusetts, USA on sabbatical leave for one year.
Dr. Devender Gupta Sci. E-II	NIST,USA	25.4.2001 to 27.7.2001	As a guest researcher under the NIST-NPL, INDO-US project on total spectral reflectance, spectral transmittance and spectral study in the infra-red region of 2.5 to 6.25.
Dr. Chotey Lal Sci. E-I	USA	6.6.2001 to 5.7.2001	To work with Prof. J.E.Fisher,Deptt. of Materials Science & Engineering, Univ. of Pannsylvania, under DST- NSF, INDO-US project on applications of carbon nanotubes in composites alignment & adhesion problem.
Dr. Yudhisther Kumar Tech. Ofcr. (B)	Germany	8.5.2001 to 9.5.2001	To carry out the aretefact under BIPM, key comparison & to demonstrate its working to PTB scientists
Dr. K.K. Saini Sci. C	Poland	20.5.2001 to 09.6.2001	Visit under Indo -Polish inter governmental agreement project
Dr. K.S. Zalpuri Sci. E-II	Nepal	22.5.2001 to 24.5.2001	To attend a workshop on automobile emission & SASCOM planning meeting in Nepal
Dr. S.K. Sarkar Sci. E-II	Hungary	28.5.2001 to 30.5.2001	To attend a symposium on CLIMPARA- 2001 at Hungary
Sh. A. Mukherjee Sci. T.O.A	Nepal	22.5.2001 to 24.5.2001	To attend a workshop on automobile emission & SASCOM planning meeting in Nepal
Dr. P. Banerjee Sci. F	France	19.6.2001 to 25.6.2001	To attend TAI and CCTF meeting at BIPM, Paris and to interact with Time Section of BIPM
Dr. Lakha Singh Sci. E-II	USA	3.6.2001 to 8.6.2001	To attend International Beacon Satellite Symposium at Boston, USA from 3-6 June and a workshop on communication & navigation signals from 7-8 June

Name & Designation	Country Visited	Duration / Period	Purpose
Dr. A. Basu Sci. E-II	Netherland	3.6.2001 to 9.6.2001	Visit the facilities for characterization deposition of silicon, silicon optical wave grides & optical integrated devices at Univ. of Twente, Netherland
Dr. R. Bhattacharyya Sci F	Netherland UK	3.6.2001 8.6.2001	to Visit the facilities for characterization, Twente, Netherland
		13.6.2001 to 14.6.2001	Technical discussion related to memos & optical activities of surface technology
Dr. B.P. Singh Sci. E-II	Germany	3.7.2001 to 2.8.2001	To work on the joint project entitled Low Pressure Sysnthesis of Cubic Boron Nitiride using supercritical fluid under DST-DAAD project, personnel exchange programme for 2000-2001
Dr. S.L. Jain Sci. F	USA	11.6.2001 to 12.6.2001	To attend national oceanic & environmental technology lab boulder. Colorado, USA from11-12, June
		13.6.2001 to 16.6.2001	International solar cycle studies 01, solar viability climate & space weather at Colorado, USA from 13-16 June
		17.6.2001 to 22.6.2001	2001 CEDAR workshop an SCOSTEPS 10th Quadrennial at symposium at Colorado, USA from 17-22, June
Dr. Ranjana Mehrotra, Sci. E-I	South Korea	11.6.2001 to 14.6.2001	To attend the 10th international conference on near infrared spectroscopy held at Kyongu
Dr. N.D. Kataria E-II	Japan	19.6.2001 to 29.6.2001	To attend the superconductive electronic conference (ISEC- 2001) held at Osakaa, Japan from 19-22 June for presenting a paper and chairing microwave devices a systemic session To visit Prof. M Tonouchi Osaka Univ., Japan to work at Research Centre for superconductor photonics during 23- 29 June for fabrication of masks using B-Beam lithography for HTS microwave filters
Dr. A.S. Agnihotry Sci. EII	Australia	8.7.2001 to 13.7.2001	To attend the International conference on solid state ionics (SSI-01) held at Cains, Australia
Dr. S.C. Jain Sci. F	USA	16.7.2001 to 22.7.2001	To visit Naval Research Laboratory under ongoing Indo-US Project

Name & Designation	Country Visited	Duration / Period	Purpose
		23.7.2001 to 26.7.2001	To participate in the technical discussion at the Univ of Texas, Arlimgten and discuss work plan on future collaborative programme
Dr. S.C. Jain Sci. F	Germany	15.9.2001 to 14.12.2001	Under CSIR-DAAD exchange programme
Dr. T.K. Mandal Sci. B	Germany	1.7.2001 to 8-7-2001	Scientific discussion at Max Plank Institute, Germany
		10-7-2001 to 13-7-2001	To attend the International Global Change Open Science Conference at the Netherlands
Dr. B.D. Malhotra Sci. EII	Japan	16.8.2001 to 31.8.2001	To visit Department of Computer Science and Electronic, Kyushu Institute of Technology (KIT) under Indo -Japan collaborative project on application of some conducting polymers
Dr. R.P. Pant Sci EI	Germany	23.7.2001 to 27.7.2001	To attend 9th international conference on magnetic fluid (ICMF) at Breman, Germany
		28.7.2001 to 11.8.2001	To participate as the project investigator to institute of experimental physics under CSIR- Slovak Academy of Science exchange programme, Slovak
Dr. K. Lal Director, NPL	Russia	19.8.2001 to 31.8.2001	To visit Russia during under integrated long term programme (ILTP) of cooperation in science & technology between India and Russia
Dr. G. Bhagvannarayana Sci E-II	Germany	1.9.2001 to 28.2.2002	To carry out work for characterization of low dimensional semiconductor structure by employing high resolution X-ray diffraction technique at Humbolt Univ. Berlin, Germany
Dr. R.B. Mathur Sci E-II	UK	6.9.2001 to 17.10.2001	To visit Univ. of Leeds under joint Indo-UK collaborative research project on role of matrix precursor in the development of high thermal conductivity carbon /carbon composites.
Mr. Mahavir Singh Sci. C	Italy	2.9.2001 to 7.9.2001	To attend the international congress on Acoustics (17th ICA) at Rome, Italy
Dr. V.R. Singh Sci. F	Italy	2.9.2001 to 17.9.2001	To attend the 17th international congress on acoustic from 2-4 September in Italy To make a scientific visit at the Univ. of Karlsruhe, Germany from 10-14 September

Name & Designation	Country Visited	Duration / Period	Purpose
Dr. A.C. Gupta, Sci. F	Korea	4.9.2001 to 7.9.2001	To visit Korea Research Institute of Stds. & Science (KRISS), Korea as a member of an international team visiting KRISS for peer assessment in the field of vacuum and pressure standards
Dr. A. Sen Gupta Sci. F	Scotland	9.9.2001 to 14.9.2001	To present a paper entitled microwave, synthesizers for atomic frequency standards and metrology
Dr. A.K. Sarkar Sci. EII	Greece	4.10.2001 6.10.2001	To present papers at the 3rd Int. Symposium in trace element in human new perspective at Greece
Dr. N.D. Kataria Sci. EII	Japan	26.11.2001 to 29.11.2001	To present an invited talk as author and chairing physics for novel devices at First Asia symposium on superconducting electronic-2001 To Visit quantum hall resistance standards facility at National Metrology Institute, at AIST, Tsukuba
Dr. K.K. Jain Sci. F	USA	12.2.2002 for six weeks	To work at pressure vacuum group at NIST, Department of Commerce, USA
Dr. S.S. Bawa Sci. F	China	22.9.2001 to 24.9.2001	To attend 2001 seminar on international personnel exchange & technological cooperation
Dr. C.P. Sharma Sci. EII	- do -	22.9.2001 to 24.9.2001	- do -
Dr. K.K. Saini Sci. C	- do -	22.9.2001 to 24.9.2001	- do -
Dr. Rina Sharma Sci. B	- do -	22.9.2001 to 24.9.2001	- do -
Dr. M.N. Kamlasnan, Sci. EII	- do -	22.9.2001 to 24.9.2001	- do -
Dr. Suresh Chandra Sci. EII	- d o -	22.9.2001 to 24.9.2001	- do -
Dr. V. Mohnan Scientist F	France	4.10.2001 to 5.10.2001	To attend the 2nd meeting of consultative committee for accurate ultrasonic and laboratory visit (CCAUV) at BIPM, Paris
Dr. K. Lal Director	China	24.10.2001 to 28.10.2001	Visit under project exploration expert exchange programme (PEEP) of Indo-China scientific and technological co-operation

Appendix - 10 : Visits Aboard

Name & Designation	Country Visited	Duration / Period	Purpose
Dr. Sushil Kumar Sci. B	France	1.3.2002 for one year	To avail BOYSCAST research training fellowship offered by DST, Govt .of India for a period of one year at Dr. Christian Godet Lab PICM, Ecole Polytechnique, Palaiseau
Sh. Sreekumar Sci. B	USA	20.12.2001 to 19.12.2005 (4 years)	Study leave
Dr. A.K. Agrawal Sci. EII	Japan	5.11.2001 to 9.11.2001	1. To attend 3rd APMPTCQM meeting at National Metrology Institute of Japan, 5-6 November 2. 17th APMP General Assembly on 7-8 November 3. Technical visit to TOPCON Corporation on 9th November
Dr. Ashok Kumar Gupta Sci. G	Japan	5.11.2001 to 9.11.2001	1. To attend 3rd APMPTCQM meeting at National Metrology Institute of Japan, 5-6 November 2. 17th APMP General Assembly on 7-8 November 3. Technical visit to TOPCON Corporation on 9th November
Dr. S.P. Verma Sci. F	Japan	5-11-2001 to 9-11-2001	1. To attend 3rd APMPTCQM meeting at National Metrology Institute of Japan, 5-6 November 2.17th APMP General Assembly on 7-8 November 3. Technical visit to TOPCON Corporation on 9th November
Dr. T.L. Dhami Sci. E-II	UK	15.11.2001 to 29.12.2001	To visit Univ. of Leeds, UK under joint INDO-UK collaborative research project on role on matrix precursor in the development of high thermal conductivity carbon/carbon composites
Dr. T.K. Mandal Sci. C	Germany	28.2.2002 for six months	To avail BOYSCAST fellowship 2001-2002 at Max Plank Institute fur Chemie, Germany for six months.

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APPENDIX : 11

PhD AWARDS BASED ON RESEARCH WORK DONE AT NPL

Title	Awardee	University / Institute	Guide(s)
Effect of additives on the normal and super-conducting state properties of Cu-Nb and Cu-V multifilamentary composite wires prepared by insitu technique.	S.S. Dubey	Delhi University	Dr. R.G. Sharma, NPL Dr. P.N. Dheer, DU
Studies on some novel diamond like carbon thin films and carbon forms by plasma enhanced chemical vapour deposition technique (RF & Microwave).	Sudheer Kumar	Jamia Millia Islamia	Dr. P.N. Dixit, NPL Prof. M.Y. Khan, JMI
Field emission studies in DLC films grown by saddle field fast atom beam sources.	Rajnish Sharma	Kurukshetra University	Dr. R. Bhattacharyya, NPL Prof. P.I. George, KU
Improvement in signal processing for ultrasonic testing of concrete.	N.K. Choudhari	Jamia Millia Islamia	Dr. Ashok Kumar, NPL Prof. M.R. Khan, JMI (Dept. of Electronic Engineering)
Pattern formation in nonequilibrium systems.	S.K. Das	Jawaharlal Nehru University	Dr. Ravi Mehrotra, NPL Dr. Sanjay Puri, JNU (School of Physical Sciences)

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APPENDIX : 12

NPL TRAINING PROGRAMMES AND PARTICIPATION IN VARIOUS EVENTS

Training Programmes/Functions Organised

- Technology Day Lecture on 11 May 2001.
- Shanti Swarup Bhatnagar Award Function & Prize Distribution on 10 September 2001.
- CSIR Fundation Day Celebration on 26 September 2001.
- CSIR Programme for Youth Leadership in Science (CPYLS) during 8-9 November 2001
- Open Day on National Science Day 28 February, 2002.
- 38 students from various educational institutions carried out project work at NPL and undertook training towards the fulfilment of their academic course work during their vacation period.

Training Courses Organised for Industry

- Training Course on Uncertainty Estimation in the areas of Temperature, Pressure, Electrical Measurements on 10 -11 May 2001.
- Training Course on Evaluation of Expression of Uncertainty in Measurement. (Mass, Temperature, Acoustic & Dimension) on 20-22 August 2001.
- Training Course on Temperature Measurements (M.O.U.) on 17-21 September 2001.
- Training Course on Mass Measurement (M.O.U.) on 17-21 September 2001.
- Training Course on Pressure Measurements (M.O.U.) on 24-28 September 2001.
- Training Course on Mass Measurements (M.O.U.) on 29 October to 2 November 2001.
- Training Course on Thermocouple Calibration on 4-8 February 2002.
- Training Course on Mass Measurements on 11-15 March 2002.
- An amount of Rs.2,22,500.00 was earned from the above training Courses.

Participation of NPL Personnel in Various Events

- 337 persons were deputed to participate in various seminars/ symposia/ conferences/ workshop / training programmes held within India viz. Strategic Competetive Advantage Clean Room India 2001,held at Delhi on 11&12 April,2001; National Symposium on Vacuum Science and Technology held at Bangalore on 5to7 September 2001; National Symposium on Acoustics(NSA-2001) held at Vellore on 18to20 October 2001; National Conference on Carbon 2001 held at Vidyanagar on 19&20 October 2001; Eleventh International Workshop on Physics of Semiconductor Devices held at Delhi on 11to15 December 2001; Workshop on New Advanced Material in Molecular Electronic held at NPL on 10&11 December 2001;80th Session of Indian Science Congress held at Lucknow on 3to7 January 2002; International Seminar on New Dimension of Intellectual Property in Changing Scenario..Seminar on ISO 9000: 2000 held at New Delhi on 21&22 January 2002, XII National Space Science Symposium held at Bhopal from 25to28 February 2002.
- Out of this above total number, 160 NPL staff attended various Computer Courses on MS Office 97, Window 98, Internet, E-mail, C ++ and Training Programmes on Uncertainty Estimation in the areas of Temperature, Dimension, Pressure and Electrical Measurements; Evaluation of Expression of Uncertainty Measurements in the areas of Mass, Temperature, Acoustics and Dimension arranged at NPL during the year.

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APPENDIX : 13

CONFERENCES, SYMPOSIA AND WORKSHOPS ORGANIZED BY NPL

16-17 April 2001

Workshop on Greenhouse Gas Inventory sponsored by UNEP.

21-23 November 2001

Eighteenth National Symposium on Cryogenics (ENSC - 2001).

26 November 2001

Global Change Workshop on Target Research.

26-28 November 2001

22nd International Pressure Metrology Workshop.

27-30 November 2001

Global Change Workshop on Good Practice on Inventory Preparation.

29-30 November 2001

National Conference on High Pressure Science & Technology.

10-11 December 2001

Workshop on New Advanced Material in Molecular Electronics (NAMME).

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APPENDIX : 14

LECTURES BY EMINENT SCIENTISTS

Scientist	Address	Date	Topic
Dr. Hermann Sachdev	University of Saarbrucken, Germany	10-4-2001	Path ways to the CVD of cBN
Prof. M.K. Sanyal	Surface Physics Division, Saha Institute of Nuclear Physics, Kolkata	24-4-2001	Growth and structure of ultra thin films
Prof. Jurgen Bosse	Freie University, Berlin, Germany	25-4-2001	Dielectric properties of supercooled coulomb liquids and transitions
Dr. S. Vardharajan	Former DG,& Former President, INSA	11-5-2001	Energy and Development
Prof. Prem Kumar	Department of Electrical and Computer Engg., USA	21-5-2001	Fibre optic quantum communication
Prof. Grish Sachdeva	Regional Engineering College, Warangal	13-6-2001	Parallel computing at NPL
Dr. Devki N. Talwar	Indiana University of Pennsylvania, USA	29-6-2001	Characterizing of intrinsic defects in low-temperature GaAs growth by MBE using Raman and FTTR spectroscopy and model calculations.
Prof. Ashtosh Sharma	IOS,INC, USA	2-7-2001	Advanced process control & monitoring using sensors
Dr. L.M.Rangarajan	SAMTEL Group	24-7-2001	Large area flat panel display development
Prof. V. Sapristky	NIST, USA	7-9-2001	Precision radiometery and photometery based on blackbodies
Dr. Jee Dong Kim	Korean Institute of Energy Research, Korea	29-10-2001	Preparation of carbon molecular sieve
Prof. J.N. Nanda	Ex. Scientific officer, Indian Navy	10-10-2001	Recent advances in geophysics
Dr. Blint Podor	Research Institute for Technical Physics Materials Sci, Hungary	2-11-2002	Microwave hydrothermal synthesis of materials

Sr.No.	Scientist	Address	Date	Topic
	Prof. M.S. Tomar	University of Puerto Rico, USA	5-12-2001	Properties of InGaAs/ Inp grown from rare earth containing melts by LPE
	Swamiji Prof. S.S. Malik	Shri Ram College of Commerce, New Delhi	11-1-2002	Nano crystalline approach to microrechargeable batteries
	Prof. W. Hasse	Institute of Physical Chemistry, Technical University, Darmstadt, Germany	24-1-2002	Neuropacer- an effective well tested device for human mind and body
	Prof. Bengt Danielsson	Department of Pure and Applied Biochemistry, Llund University, Sweden	21-2-2002	Ferroelectric liquid crystals for grey scale addressing and for photonic crystals
	Prof. Bengt Danielsson	Department of Pure and Applied Biochemistry, Llund University, Sweden	26-3-2002	Current approaches to environmental analysis

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APPENDIX:15

INVITED TALKS, LECTURES BY NPL SCIENTISTS

Speaker's Name	Topic	Event and Venue
	Physico-Mechanical Standards	
Chakraborty, B. R., Scientist F.	Study of oxygen plasma treated GaN film using X-ray photoeletron spectroscopy (XPS) and secondary ion mass spectrometry (SIMS)	International workshop on physics semiconductor devices.(IWPSD-2001), I.I.T. Delhi, Dec. 11-15, 2001.
Chakraborty, B. R., Scientist F	Electron and ion spectroscopy used as analytical techniques for solid surface characterization	CEP course on characterization of solid surfaces, Solid State Physics Laboratory, Delhi on 20th Nov.2001,
Chakraborty, B. R., Scientist F	Laser post ionization in time-of-flight SIMS	National workshop on advanced compositional and micro structural characterization Dec. 27-28, 2001, Solid State Physics Laboratory, Delhi.
Chaudhary, K.P., Scientist E-II	Application of laser in biomedical instrumentation	Training program on repair, maintenance and calibration of bio medical instruments for hospital technicians/ doctors, sponsored by DST, CSIO, Delhi center
Garg, R. K. , Scientist E-II	Study of non-radiative transitions of polycyclic aromatic hydrocarbons using photoacoustic spectroscopy	National seminar on materials and devices (MD-2002), M J P Rohilkhand University, Bareilly, India, March 9-10, 2002.
Gupta, D., Scientist E-II	Infrared light scattering experiments at NPL India,	National institute of standards & technology (NIST), U.S.A., May 24, 2001.
Gupta, D., Scientist E-II	IR spectrophotometers	CSIO centre, CSIR Complex, New Delhi, August 21, 2001.

Speaker's Name	Topic	Event and Venue
Gupta, A.C., Scientist G	Pressure and vacuum standards facilities at NPL	Workshop on calibration and testing of pressure measuring instruments, Thapar Institute of Engineering and Technology, Patiala, Dec.12, 2001.
Gupta, A.C. ,Scientist G	Status of vacuum and pressure standards at NPL-India	2nd International pressure metrology workshop (PRESMET-2001) at NPL, New Delhi, November 26-27, 2001.
Kandpal , H.C., Scientist F	Fundamentals of photometry	Workshop on photometry for automotive engineering , ARAI, Pune, Oct. 17-18, 2000
Kandpal ,H.C. , Scientist F	Physical photometry and photometric standards	Workshop on photometry for automotive engineering , ARAI, Pune, Oct. 17-18, 2000
Kandpal ,H.C. , Scientist F	Recent research on correlation-induced spectral shifts	Perspectives in modern optics, photonics and instrumentation, IIT Delhi, Jan 4-6, 2002.
Lal ,T., Scientist F	Uncertainty evaluation in mass measurement	First residential course on evaluation and expression of uncertainty in measurement, August 20-22, 2001, NPL-New Delhi
Mohanan ,V., Scientist F	Acoustical materials	One day workshop in architectural acoustics, NSA-2001 at VIT, Vellore, Oct. 2 2001.
Sharma ,Rina , Scientist C	Uncertainty in calibration of a 50mm gauge block	Npl training programme on evaluation and expression of uncertainty in measurements, NPL, New Delhi, May 10-11,2001
Sharma, Rina, Scientist C	ISO/IEC 17025 - the new standard for the competence of testing and calibration laboratories: added responsibilities and benefits	First residential course on evaluation and expression of uncertainty in measurements, NPL, New Delhi, Aug20-21, 2001.

Speaker's Name	Topic	Event and Venue
Sharma, Rina, Scientist C	Uncertainty in calibration of a 50mm gauge block	NPL- NABL workshop on ISO 17025 and uncertainty in measurements, April 2001, ARAI, Pune.
Sharma, Rina, Scientist C	Uncertainty in dimensional measurements	NPL-NABL workshop on ISO 17025 and uncertainty in measurements, Vimta Labs, Hyderabad, Nov. 25-26, 2001
Shiva Prasad , S. M., Scientist EII	Aspects of growth of ultra-thin heteroepitaxial films	Seminar on physics of materials, Jamia Millia Islamia, New Delhi, Feb. 1, 2002.
Shiva Prasad , S. M. , Scientist EII	Aspects of heteroepitaxial growth: morphology, geometric and electronic structure	PSI-2002 International conference on physics at surfaces and interfaces, Toshali Sands, Puri, organized by Institute of Physics, Bhubaneshwar. March 4-8, 2002,
Shiva Prasad, S. M. , Scientist EII	Characterization of solid surfaces and, heteroepitaxial growth	Academic staff college, Jawaharlal Nehru University, New Delhi, Feb. 2, 2002.
Shiva Prasad, S. M. , Scientist EII	X-ray photoelectron spectroscopy for surface & interface analysis	Joint workshop cum seminar on surface modification and characterization, University of Rajasthan, Jaipur, 23-24th Nov. 2001. Nuclear Science Centre / University of Rajasthan
Singhal, R.P. , Scientist G	Dimensional metrology-current trends	34th International training programme on standardization and quality system for developing countries (10 October – 7 December, 2001), Bureau of Indian Standards (BIS), New Delhi, December5, 2001
Singhal, R.P., Scientist G	Proficiency testing in measurement of gauge blocks	Workshop on interlaboratory comparison for testing and calibration laboratories, February 22-23, 2002 organized by CII, NABL, NPL, Kolkata

Speaker's Name	Topic	Event and Venue
Varma, S. P., Scientist F	Calibration, standardization, and certification aspects of instrumentation	Instrumentation committee (H-10), Indian Road Congress (IRC), New Delhi, June 29, 2001.
Varma, S. P., Scientist F	Need of calibration and its facility at NPL	NIO, Goa, February 13, 2002.
Varma, S. P., Scientist F	Temperature standards and calibration facility at NPL, India	TCT meeting, general assembly of APMP, Nov.6, 2001, NMIJ, Japan.
Yadav, Sanjay, Scientist C	Pressure balances: a reliable instrument for accurate pressure measurements	One day workshop on calibration and testing of pressure measuring instruments, TIET, Patiala on Dec. 12, 2001.
Yadav , Sanjay, Scientist C	Pressure measuring instruments and their calibration	One day workshop on calibration and testing of pressure measuring instruments, TIET, Patiala, Dec. 12, 2001.

Electrical and Electronic Standards

Banerjee, P., Scientist G	Sanctity of Indian standard time and its social relevance	National symposium on instrumentation (NSI-26), Dehradun, Oct. 31- Nov.2, 2001.
Gupta, Ashok K., Scientist G	Applications of cryogenics in standards and metrology	Eighteenth national symposium on cryogenics (ENSC-2001), NPL, New Delhi, Nov. 21-23, 2001.
Gupta, Ashok K., Scientist G	An overview of realization of SI base units and national standards of measurements at NPL, New Delhi	Second International pressure metrology workshop (2nd PRESMET-2001), NPL, New Delhi, Nov. 26-27, 2001.
Kataria, N.D. & Daya, K.S. , Scientist F	Microwave characterization of HTS thin films by dielectric resonator technique and application towards stable frequency reference	National workshop-cum symposium on microwave measurement techniques & applications. Jawaharlal Nehru Univ., New Delhi, Feb. 4-6, 2002.
Kataria, N.D. & Daya, K. S. , Scientist F	Composite dielectric resonator: novel scheme for stable oscillators for cesium atomic clock	First East Asia symposium on superconductive electronics. Sendai, Japan, Nov. 26-28, 2001.

Speaker's Name	Topic	Event and Venue
Kataria, N.D., Scientist F, Misra, Mukul & Pinto , R.	Sensitivity of surface resistance measurement of HTS thin films by cavity resonator, dielectric resonator and micro strip line resonator	International symposium. On advances in superconductivity & magnetism; materials, mechanisms & devices. Mangalore University, Sept. 25-28, 2001.
Khare, Neeraj., Scientist EI, Gupta, A. K., Scientist G. Moharil, U.P., Raychaudhuri, A. K., Pai, S.P., & Pinto , R.	Study of magneto resistance and conductance of bicrystal grain boundary in	$La_{0.67}Ba_{0..33}MnO_3$ thin film International symposium on advances in superconductivity & magnetism: materials, mechanisms & devices. Mangalore University, India, Sept 25-28, 2001.
Ojha, V.N. , Scientist F	Evaluation and expression of uncertainty in measurement: a general introduction	First residential course on evaluation and expression of uncertainty in measurement. NPL, New Delhi, Aug. 20-22, 2001.
Ojha, V.N. , Scientist F	Evaluation and expression of uncertainty in measurement : a general introduction.	NABL-NPL sponsored workshop on ISO/IEC 17025 and uncertainty in measurement, VIMTA Lab., Hyderabad, Nov. 24-25, 2001.
Ojha, V. N., Scientist F	Evaluation and expression of uncertainty in electrical measurements	NABL-NPL sponsored workshop on ISO/IEC 17025 and uncertainty in measurement, VIMTA Lab., Hyderabad, Nov. 24-25 2001.
Singh, V.R. , Scientist G	Biomedical micro devices: current trends	International conference on computer application in elec. engg (CERA-2002), Roorkee, Feb. 23-25, 2002.
Singh, V. R., Scientist G	Smart sensors in precision biomedical measurements for better health care	89th Session of Indian science congress, Lucknow, Jan 3-7, 2002.
Singh, V. R., Scientist G	Recent biomedical portable devices: new trends in telecare and telesurgery	89th Session of Indian science congress, Lucknow, Jan 3-7, 2002.

Speaker's Name	Topic	Event and Venue
	Engineering Materials	
Misra, S.C.K., Scientist F	Advances in semiconducting polymer thin films	Second national conferenece on thermophysical properties of materials, University of Rajasthan, Jaipur, Sept.2002
Gupta, Anil K., Scientist G	Development of aerospace materials at NPL	CSIR programme for youth for leadership in science (CPYLS), NPL New Delhi, 8-9 November 2001
	Electronic Materials	
Sankaranarayanan , V.K., Scientist B	Nanoscale magnetic materials and their applications,	National conference and symposium on solid state chemistry and allied areas at IIT, Kanpur, Dec., 2001.
Singh , Ramadhar , Scientist F	Mechanism of charge transport and applications of conjugated polymers,	National seminar on physics of materials for electronic and optoelectronic devices, held at department of physics, J.N.V. University, Jodhpur during February 25-27, 2002.
Singh , Ramadhar , Scientist F	Water pollution by microbiological species: causes and removal,	Seminar on environmental pollution and public health, Deen Dayal Upadhyaya College,Delhi during February 21-23, 2002.
Bhattacharyya , R., Scientist G	Optical coatings and waveguides for fiber optic communication systems	National symposium on science and technology of vacuum and thin films, IISc, Bangalore, Sept. 5, 2001.
Agnihotry , S.A., Scientist F	Sol gel derived electrochromic Tungsten oxide films- a review	Fifth national conference on solid state ionics, held at Nagpur, 15-17 February 2002
Shankar , Virendra, Scientist F	Analyses of glow curves in Tb doped gadolimium oxysulfide phosphors	National seminar on luminescence and its applications (NSLA-2002), Jabalpur, Dec. 16-18, 2001.

Speaker's Name	Topic	Event and Venue
Ekbote , S.N., Scientist F	Super conductivity beyond text	Refresher course in physics – centre for professional development in higher education (UGC-ASC) University of Delhi, Delhi – 11007, Oct. 16, 2001
Singh , S.N., Scientist F	Uchcha dakshata purna silikan saur sel sanrachanaun ka vikask : aek punaravalokan (in Hindi)	One day workshop held in September 2001 at SSPL during the Hindi Week celebrations
Singh , S.N., Scientist F	Two lectures on solar cells to college lecturers	Dept. of physics & astrophysics, Delhi University, on October 9, 2001.
Singh , S.N., Scientist F	Kristaliya silikan par anusandhan avam vikash (in hindi)	Padarthon ke sanshleshan, abhilakshanan avam anuprayog par rashtriya karyashala, held at NPL during February 6-7, 2001.
	Materials Characterization	
Agrawal, A.K., Scientist EII	Certified reference materials and their status in India	National workshop on measurement system and quality management, New Delhi (2001)
Krishan Lal, Director	Characterization of semiconductor thin films for high quality devices	Indo-Israel workshop on advanced materials, Hyderabad (2001).
Krishan Lal, Director	Characterization of disorder in nearly perfect crystals	Condensed matter physics – liquid and solid states, international conference on disordered materials, Indore (1998).
Krishan Lal, Director	Evaluation of perfection of semiconductor thin films and determination of biaxial	International workshop on physics of semiconductor devices, New Delhi (2001). (plenary talk)
Krishan Lal, Director	Structural characterization of thin films and interfaces for microelectronic	IInd International school on powder diffraction, Kolkata-2002 (keynote Lecture).

Speaker's Name	Topic	Event and Venue
Krishan Lal, Director	Recent advances in dynamical diffraction of x-rays from thin crystals of varying degrees of perfection	IInd International school on powder diffraction, Kolkata-2002
Krishan Lal, Director	Recent advances in high resolution x-ray diffraction studies of semiconductors for technological applications	13th CODATA task group meeting on survey of data sources in Asian-Oceanic Countries, Daejeon, Korea (2002).
Krishan Lal, Director	Structural characterization of bulk crystals, epitaxial films and single crystal devices	Varanasi (2001)
Krishan Lal, Director	Single crystals in modern science and technology	Panjab University, Chandigarh (2001).
Krishan Lal, Director	Fascinating world of crystals	Foundation day of M.J.P. Rohilkhand University, Bareilly (2001).
Krishan Lal, Director	Role of x-ray diffraction advancement in materials science	Sardar Patel University, Vallabh Vidya Nagar (2001).
Krishan Lal, Director	Role of precision measurements in science, technology as well as in industrial development of a Nation	Council of Science and Technology, Lucknow (2001).
Krishan Lal, Director	High resolution X-ray diffraction: applications and fundamental research (inaugural lecture)	National conference on solid state chemistry and allied areas, Kanpur (2001)
Krishan Lal, Director	High resolution X-ray diffraction and characterization of crystal defects (inaugural lecture)	National conference on lasers and spectroscopy, Meerut (2001).
Krishan Lal, Director	National measurement system and traceability	CII national workshop on inter-laboratory proficiency testing, New Delhi (2001).
किशन लाल, निदेशक	माणिकी एवम् मूल अचरांक (Metrology and Fundamental Constants)	मापन व्यवस्था व गुणवत्ता प्रबंधन पर राष्ट्रीय कार्यशाला नई दिल्ली – 2001

Speaker's Name	Topic	Event and Venue
Krishan Lal, Director	Science education and challenges in R&D Sector	National seminar on qualitative improvement of scientific and technical manpower through improvement of practical work in schools and colleges, New Delhi (2001).
Krishan Lal, Director	Role of certified reference materials in solving critical societal problems: possible approach to standardization of unani drugs	Workshop on standardization of unani drugs, CCRUM, New Delhi (2001).
Krishan Lal, Director	Reference measurements	Targeted research workshop, New Delhi (2001).
Krishan Lal, Director	Precision and accuracy in analytical measurements	Training workshop on good practices in inventory estimates, New Delhi (2001).
Krishan Lal, Director	Structural characterization of lattice imperfections in single crystals (inaugural lecture	National seminar on physics of materials for electronics and optoelectronic devices, Jodhpur (2002)
Krishan Lal, Director	Impact of metrology on industry, trade and society: (keynote address)	IInd NPL-Industry meet on calibration services, New Delhi (2002).
Krishan Lal, Director	High resolution X-ray diffraction and characterization of crystal defects (inaugural lecture)	National seminar on frontiers in condensed matter physics, Hussar (2002)
Krishan Lal, Director	Mutual recognition arrangement for traceability to national and international standards	CII national workshop on inter-laboratory comparison of testing and calibration laboratories, Collate (2002).
किशन लाल, निदेशक	वर्तमान परिपेक्ष में पदार्थो का अभिलक्षणन	पदार्थो के अभिलक्षणन एवम अनुप्रयोगों पर राष्ट्रीय कार्यशाला नई दिल्ली – 2002.
Krishan Lal, Director	Fascination of diamond crystals: C.V. Raman and recent high resolution X-ray diffraction experiments	National science day, New Delhi (2002).

Speaker's Name	Topic	Event and Venue
Ram Kishore, Scientist EII	TEM, SEM and EDS investigations of aluminum induced crystallization of amorphous silicon	XXVth annual conference of the electron microscopy society of india on electron microscopy and allied fields, I.I.T. Bombay, February 20-22, 2002
Srivastava, A.K., Scientist B	Electron microscopy and diffraction analysis of weed-shape morphologies during deposition of Sb_n nanoclusters	Laboratoire Aime Cotton, Associé C.N.R.S., Université Paris-Sud, France, February 28, 2002.
Radio and Atmospheric Sciences		
Arya, B.C., Scientist EII	Measurements of surface ozone & other minor constituents	Invited talk at National conference on laser & spectroscopy held at NAS College, Meerut during Dec. 28-31, 2001.
Dutta, H.N., Scientist F	On need of electronics in Antarctica	Dr S K Chattopadhyaya memorial inaugural lecture in third Haryana state electronics conference at Dayanand College, Hisar, January 24, 2002
	Fascinating facts of Antarctica and participation of students	In the face-to-face program under science meet-2001, organized by the Manipur Science and Technology Council, May 22, 2001.
	Antarctica and monostatic acoustic sounder and its application to NE States	Invited speaker at the business meet organised by the Manipur Science and Technology Council, May 23, 2001
Jain, S.L., Scientist F	Atmospheric Environmental studies at Maitri, Antarctica	Invited talk at K. Banerjee Centre of Atmospheric & Ocean Studies, University of Allahabad, Allahabad – 211 002 on Sept. 15, 2001
	Voyage to Antarctica (1993-94 and 1996-97) - Slide show	- Do -

Speaker's Name	Topic	Event and Venue
	High altitude measurements	Invited talk at Indian Institute of Peroleum, Dehradun during Sept 18-21, 2001
	Differential absorption lidar and liquid mirror telescope	Brain-storming session on liquid mirror telescopes at IUCAA, Ganeshkhind, Pune during Aug 27-28, 2001
	NPL activities to monitor trace gases in the atmosphere	Invited talk at Environmental Technology Laboratory (ETL) of National Oceanic and Atmospheric (NOAA) at Boulder Co., USA on June 11, 2001
Garg, S.C., Scientist G	RPA Aeronomy experiment onboard SROSS-C2 Indian Satellite	Invited talk at XII National Space Sciences Symposium (NSSS-2002) held at Barakatullah University, Bhopal during Feb. 25-28, 2002
	Mid-FACE-First South Asian Free Air CO_2 Enrichment Facility for Crop Experiment	Invited talk at Workshop on Greenhouse Gas Inventory sponsored by UNEP held at NPL during April 16-17, 2001

Superconductivity and Cryogenics

Agarwal, S.K., Scientist E-II	Superconductivity at the seminar on physics of materials	Department of physics, Jamia Millia Islamia, New Delhi on 31st January 2002.
अग्रवाल श्याम किशोर	वैज्ञानिक लेखनः अनुसंधान एवं विकास गतिविधियां	एक दिवसीय वैज्ञानिक कार्यशाला, 5 सितम्बर, 2001 राष्ट्रीय भौतिक प्रयोगशाला
		उच्च ताप अतिसंवाहक – विलक्षण पदार्थ

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APPENDIX – 16

HUMAN RESOURCES
As on March 31, 2002

S.No.	Category	Grade	Number
(A)	**Scientific & Technical Staff**		
1	Scientific Staff	Group IV	234
2	Technical Staff	Group III	124
Sub-Total 1+2 :			**358**
3	Engineering Cadre Staff	Group V	
4	Supporting Technical Staff	Group 11	272
5	Supporting Technical Staff	Group 1	94
Total S&T Staff :			**724**
(B)	**Administrative & Non-Technical Staff**		
6	Administrative (Gazetted)	Group A	8
7	Administrative (Gazetted)	Group B	92
8	Administrative (Non-Gazetted)	Group C	54
9	Non-Technical Staff	Group D	108
Total Administrative & Non-Tech. Staff :			**262**
GRAND TOTAL (A)+(B) :			**986**

Scientists and Officers as on 1.4.2002

DIRECTOR : DR. (FNA) KRISHAN LAL

Name	Designation	Decision Package
PHYSICO-MECHANICAL STANDARDS		
Head : Dr S P Varma		
Mass, Volume & Viscosity		
Sh Tripurari Lal	Scientist F	DP 01.01
Sh Mati Lal Das	Scientist EII	DP 01.01
Dr Sanjeev Sinha	Scientist EI	DP 01.01
Sh Gautam Mandal	Scientist B	DP 01.01
Sh T K Parameshwaran	Tech Ofcr (B)	DP 01.01
Length Standards		
Dr V G Kulkarni	Scientist EII	DP 01.02
Dr Mrs Santa Chawla	Scientist EI	DP 01.02
Dr Mrs Rina Sharma	Scientist C	DP 01.02
Sh B K Roy	Tech Ofcr (EI)	DP 01.02
Temperature Standards		
Dr Yesh Pal Singh	Scientist EII	DP 01.03
Sh Navin Kumar Srivastava	Scientist EII	DP 01.03
Sh Satish Kumar Nijhawan	Tech Ofcr (EI)	DP 01.03
Sh Jagdish Kumar Gupta	Tech Ofcr (C)	DP 01.03
Sh Gurcharanjit Singh	Tech Ofcr (A)	DP 01.03
Optical Radiation Standards		
Dr J S Vaishya	Scientist F	DP 01.04
Dr Hem Chandra Kandpal	Scientist F	DP 01.04
Sh Jai Bhagwan	Tech Ofcr (C)	DP 01.04
Force & Hardness Standards		
Dr Kamlesh Kumar Jain	Scientist F	DP 01.05
Dr Sushil Kumar Jain	Scientist F	DP 01.05
Sh Mihir Kumar Chaudhuri	Scientist EII	DP 01.05
Sh Jagdish Kumar Dhawan	Scientist EII	DP 01.05
Sh Anil Kumar	Scientist EII	DP 01.05

Name	Designation	Decision Package
Sh Ganga Prasad	Scientist EII	DP 01.05
Dr S Seela Kumar Titus	Scientist C	DP 01.05
Sh Rajesh Kumar	Scientist B	DP 01.05
Pressure & Vacuum Standards		
Sh Akhilesh Chandra Gupta	Scientist G	DP 01.06
Dr Ashis Kumar Bandhyopadhyay	Scientist F	DP 01.06
Dr Bibhash Ranjan Chakraborty	Scientist F	DP 01.06
Dr Desh Raj Sharma	Scientist F	DP 01.06
Dr Pardeep Mohan	Scientist F	DP 01.06
Sh D Arun Vijayakumar	Scientist C	DP 01.06
Dr Sanjay Yadav	Scientist C	DP 01.06
Dr Miss Nita Dilawar	Scientist C	DP 01.06
Infra - Red Radiation Standards		
Dr Satya Prakash Varma	Scientist F	DP 01.07
Dr Devinder Gupta	Scientist EII	DP 01.07
Dr Om Prakash	Scientist EII	DP 01.07
Dr Miss Ranjana Mehrotra	Scientist EII	DP 01.07
Ultraviolet Radiation Standards		
Dr Ram Sagar Ram	Scientist F	DP 01.08
Dr Rakesh Kumar Garg	Scientist EII	DP 01.08
Acoustic Standards		
Dr Bhim Sain Gera	Scientist F	DP 01.09
Dr Vellur Mohanan	Scientist F	DP 01.09
Sh Ravi Mohan Khanna	Scientist F	DP 01.09
Sh Omkar Sharma	Scientist EII	DP 01.09
Sh Mahavir Singh	Scientist C	DP 01.09
Sh V K Ojha	Tech Ofcr (B)	DP 01.09
Sh Gurbir Singh	Tech Ofcr (A)	DP 01.09
Fluid Flow Measurement Standards		
Dr Jnanendra Nath Som	Scientist F	DP 01.10
Sh Raj Singh	Scientist EI	DP 01.10
Sh Virendra Babu	Tech Ofcr (EII)	DP 01.10
Sh Ishwar Singh Taak	Tech Ofcr (A)	DP 01.10
Ultrasonic Standards		
Dr Ashok Kumar	Scientist F	DP 01.11

Name	Designation	Decision Package
Dr Janardan Singh	Scientist F	DP 01.11
Sh Mukesh Chandra	Scientist EII	DP 01.11
Mrs Reeta Gupta	Tech Ofcr (B)	DP 01.11
Sh V K Hans	Tech Ofcr (B)	DP 01.11
Dr Yudhisther Kumar	Tech Ofcr (B)	DP 01.11
Sh N C Soni	Tech Ofcr (B)	DP 01.11
Dimensional Metrology		
Dr Raghunandan Prasad Singhal	Scientist G	DP 01.12
Sh S Uma Maheshwar Rao	Scientist F	DP 01.12
Sh K P Chaudhary	Scientist EII	DP 01.12
Sh Mrityunjay Karfa	Scientist EI	DP 01.12
Sh N K Aggarwal	Tech Ofcr (EI)	DP 01.12
Mrs Veena Roonwal	Tech Ofcr (EI)	DP 01.12
Sh Ravi Khanna	Tech Ofcr (C)	DP 01.12
Sh S L Thind	Tech Ofcr (C)	DP 01.12
R&D on Shock & Vibration Sensors		
Sh Subodh Kumar Singhal	Scientist EII	DP 01.13
Sh Gurdeep Singh Lamba	Tech Ofcr (A)	DP 01.13

ELECTRICAL & ELECTRONIC STANDARDS

Head : Dr. Ashok Kumar Gupta

Time & Frequency		
Dr P Banerjee	Scientist G	DP 02.01
Dr G M Saxena	Scientist F	DP 02.01
Dr Amitava Sengupta	Scientist F	DP 02.01
Dr Ashok Kumar Hanjura	Scientist F	DP 02.01
Mrs Mithlesh Saxena	Scientist EII	DP 02.01
Mrs Arundhati Chatterjee	Scientist EI	DP 02.01
Dr Ashish Agarwal	Scientist B	DP 02.01
Sh Chockalingam Sreekumar	Scientist B	DP 02.01
Sh Anil Kumar Suri	Tech Ofcr (C)	DP 02.01
Sh Gurdial Singh	Tech Ofcr (B)	DP 02.01
Josephson, Voltage & Superconducting Devices		
Dr Ashok Kumar Gupta	Scientist G	DP 02.02
Dr N D Kataria	Scientist F	DP 02.02
Sh Vijay Kumar	Scientist EII	DP 02.02
Dr Neeraj Khare	Scientist EI	DP 02.02
Sh Man Mohan Krishna	Scientist C	DP 02.02

Name	Designation	Decision Package
DC Current, Voltage & Resistance		
Dr Vijay Narain Ojha	Scientist F	DP 02.03
Sh Ajeet Singh	Scientist EI	DP 02.03
AC Power & Energy		
Sh Mukesh Kumar Mittal	Scientist F	DP 02.04
Sh Joges Chandra Biswas	Scientist C	DP 02.04
AC High Voltage & High Current		
Dr Sita Ram Gupta	Scientist F	DP 02.05
Sh Shiv Kumar Jaiswal	Scientist B	DP 02.05
LF & HF Impedance		
Dr Om Kar Nath	Scientist F	DP 02.06
Sh Anil Kishore Saxena	Scientist EII	DP 02.06
Sh Naib Singh	Scientist EI	DP 02.06
Mrs Asha Rani Kaushik	Tech Ofcr (C)	DP 02.06
Sh Mohammad Saleem	Tech Ofcr (B)	DP 02.06
Sh Avdhesh Kumar Goel	Tech Ofcr (A)	DP 02.06
LF & HF Voltage, Current & RF Power		
Sh Vijay Kumar Rustagi	Scientist F	DP 02.07
Sh Anil Kumar Govil	Scientist F	DP 02.07
Sh Ritander Aggarwal	Scientist EII	DP 02.07
RF Attenuation & Impedance		
Dr Ram Swarup	Scientist F	DP 02.08
Dr Rajvir Singh Yadava	Scientist F	DP 02.08
Sh Pramendra Singh Negi	Scientist EII	DP 02.08
Dr Ranjit Singh	Scientist EI	DP 02.08
Sh Roshan Lal Mendiratta	Tech Ofcr (C)	DP 02.08
Magnetic Standards		
Dr Prafulla Chandra Kothari	Scientist G	DP 02.09
Dr R K Kotnala	Scientist EII	DP 02.09
DC High Voltage Standards		
Dr Surender Kumar Mahajan	Scientist F	DP 02.10
Sh Kul Bhushan Ravat	Tech Ofcr (B)	DP 02.10

Name	Designation	Decision Package
Bio-Medical Measurement & Standards		
Dr Ved Ram Singh	Scientist G	DP 02.11
Dr Ramesh Babu Tripathi	Scientist EII	DP 02.11
CFCT		
Sh C S Prasannakumar	Scientist G	DP 02.12
Dr Hukum Singh Dahiya	Scientist EII	DP 02.12
Sh Mitthan Lal	Scientist EII	DP 02.12
Dr Mansha Ram	Scientist EI	DP 02.12
Sh G K Kapoor	Tech Ofcr (B)	DP 02.12
Sh P C Sharan	Tech Ofcr (B)	DP 02.12
Sh Satya Pal Sharma	Tech Ofcr (B)	DP 02.12
Sh Jagan Nath Prasad	Tech Ofcr (A)	DP 02.12
ENGINEERING MATERIALS		
Head : Dr Anil Kumar Gupta		
Metals & Alloys		
Dr Anil Kumar Gupta	Scientist G	DP 03.01
Sh Ramesh Chandra Anandani	Scientist EII	DP 03.01
Dr Rajeev Chopra	Scientist EII	DP 03.01
Dr Ajay Dhar	Scientist EII	DP 03.01
Sh Islamuddin Anwar Malik	Tech Ofcr (EI)	DP 03.01
Sh Rajiv Sikand	Tech Ofcr (C)	DP 03.01
Sh Rakesh Khanna	Tech Ofcr (B)	DP 03.01
Advanced Carbon Products		
Dr Gopal Bhatia	Scientist F	DP 03.02
Dr R K Aggarwal	Scientist F	DP 03.02
Dr Rakesh Behari Mathur	Scientist F	DP 03.02
Dr Mrs Vasantha Raman	Scientist F	DP 03.02
Dr Tarsem Lal Dhami	Scientist F	DP 03.02
Dr Chhotey Lal	Scientist EII	DP 03.02
Sh Sanjay Rangnate Dhakate	Scientist C	DP 03.02
Sh Pinaki Ranjan Sengupta	Tech Ofcr (B)	DP 03.02
High Pressure Technology		
Sh Ashok Kumar Agarwal	Scientist F	DP 03.03
Dr Bhanu Pratap Singh	Scientist F	DP 03.03
Dr Sunil Kumar Singhal	Scientist EII	DP 03.03
Sh K D Sharda	Tech Ofcr (C)	DP 03.03

Name	Designation	Decision Package
Polymeric & Soft Materials		
Dr Sukhwant Singh Bawa	Scientist G	DP 03.04
Dr M N Kamalasanan	Scientist F	DP 03.04
Dr Satish Chandra Kant Mishra	Scientist F	DP 03.04
Dr Ashok Manikrao Biradar	Scientist F	DP 03.04
Dr Chhatra Pal Sharma	Scientist F	DP 03.04
Dr Suresh Chand	Scientist F	DP 03.04
Dr Harish Bahadur	Scientist EII	DP 03.04
Dr Bansi Dhar Malhotra	Scientist EII	DP 03.04
Dr S K Dhawan	Scientist EI	DP 03.04
Sh Sudhanshu Dwivedi	Scientist EI	DP 03.04
Dr R K Sharma	Scientist EI	DP 03.04
Dr Krishan Kumar Saini	Scientist EI	DP 03.04
Sh Chander Kant	Tech Ofcr (B)	DP 03.04
Sh Gauri Datt Sharma	Tech Ofcr (B)	DP 03.04
Liquid Crystalline Materials & Devices		
Dr Sukhmal Chand Jain	Scientist G	DP 03.05
Cryogenic Plant & Facilites		
Sh Subhash Chandra Gera	Scientist F	DP 03.06
Sh Surinder Singh Verma	Scientist EII	DP 03.06
Sh Ashok Kumar	Scientist B	DP 03.06

ELECTRONIC MATERIALS

Head : Dr R Bhattacharyya

Luminescent Materials		
Dr Virendra Shanker	Scientist F	DP 04.01
Dr Harish Chander	Scientist F	DP 04.01
Dr Divi Haranath	Scientist B	DP 04.01
Thin Film Technology		
Dr Raghunath Bhattacharyya	Scientist G	DP 04.02
Dr Amitabha Basu	Scientist F	DP 04.02
Dr Prakash Narain Dixit	Scientist F	DP 04.02
Dr Mrs Meenakshi Kar	Scientist EII	DP 04.02
Dr Omvir Singh Panwar	Scientist EII	DP 04.02
Sh Sher Singh Rajput	Scientist EII	DP 04.02
Dr KMK Srivatsa	Scientist EI	DP 04.02
Sh C MS Rotham	Scientist C	DP 04.02

Name	Designation	Decision Package
Dr Sushil Kumar	Scientist B	DP 04.02
Sh T K Bhattacharya	Tech Ofcr (B)	DP 04.02
Sh Tarun Kumar Chakraborty	Tech Ofcr (B)	DP 04.02
Silicon & Silicon Devices		
Dr Shiv Nath Singh	Scientist F	DP 04.03
Dr Mohan Lal	Scientist F	DP 04.03
Dr Bidhan Chandra Chakravarty	Scientist EII	DP 04.03
Dr Parakram Kumar Singh	Scientist EII	DP 04.03
Sh Ravi Kumar	Tech Ofcr (C)	DP 04.03
Microstructure Devices		
Dr A. C. Rastogi	Scientist F	DP 04.04
Dr S T Lakshmikumar	Scientist F	DP 04.04
Dr Mrs Kiran Jain	Scientist EII	DP 04.04
Mrs Santosh Singh	Scientist C	DP 04.04
Dr V K Sankaranarayanan	Scientist B	DP 04.04
Dr Shailesh Narayan Sharma	Scientist B	DP 04.04
Sh Murari Lal Sharma	Tech Ofcr (A)	DP 04.04
Sh Vipin Kumar Singhal	Tech Ofcr (A)	DP 04.04
Superconducting and Ceramic Materials		
Dr Srikant N Ekbote	Scientist F	DP 04.05 (1)
Dr Narinder Kumar Arora	Scientist EI	DP 04.05 (1)
Dr T D Senguttuvan	Scientist C	DP 04.05 (2)
Dr(Ms) Gurusharan Kaur Padam	Scientist B	DP 04.05 (1)
Sh M K Banerjee	Tech Ofcr (C)	DP 04.05 (1)
Sh Mukul Sharma	Tech Ofcr (B)	DP 04.05 (1)
Electrochromic/Polymeric Devices		
Dr Mrs S A Agnihotry	Scientist F	DP 04.06 (1)
Dr Ramadhar Singh	Scientist F	DP 04.06 (2)

MATERIALS CHARACTERIZATION

Head : Dr Krishan Lal, FNA

Characterization of Materials by Chemical Methods		
Dr Ajit Kumar Sarkar	Scientist F	DP 05.01
Sh Prabhat Kumar Gupta	Scientist EII	DP 05.01
Dr Nahar Singh	Scientist B	DP 05.01

Name	Designation	Decision Package
Sh M K Dasgupta	Tech Ofcr (B)	DP 05.01
Sh Niranjan Singh	Tech Ofcr (B)	DP 05.01
Characterization of Materials by EPR Spectroscopy		
Dr S K Gupta	Scientist F	DP 05.02
Dr Miss Manju Arora	Tech Ofcr (B)	DP 05.02
Characterization of Materials by XRD/XRF Techniques		
Dr D K Suri	Scientist F	DP 05.03
Dr Miss Rashmi	Scientist EII	DP 05.03
Dr Rajendra Prasad Pant	Scientist EI	DP 05.03
Dr Dharam Pal Singh	Tech Ofcr (B)	DP 05.03
Characterization of Materials by Electron Microscopy		
Dr Ram Kishore	Scientist EII	DP 05.04
Sh Kasturi Lal	Scientist EII	DP 05.04
Sh Sukhvir Singh	Scientist C	DP 05.04
Dr Avanish K Srivastava	Scientist C	DP 05.04
Sh Keadr Nath Sood	Tech Ofcr (B)	DP 05.04
Planning, Preparation, Certification and Dissemination of Indian Reference Materials		
Dr Arun Kumar Agrawal	Scientist EII	DP 05.05
Dr Nijhuma Kayal	Scientist B	DP 05.05
Sh Rajiv Kumar Saxena	Tech Ofcr (B)	DP 05.05
Mrs Abha Bhatnagar	Tech Ofcr (A)	DP 05.05
Growth & Structural Characterization of Single Crystals		
Dr Krishan Lal, FNA	Director	
Dr Sujit Kumar Halder	Scientist F	DP 05.06
Dr R V Anantha Murthy	Scientist F	DP 05.06
Dr Godavarthi Bhagavannarayana	Scientist F	DP 05.06
Dr Mrs S Niranjana N Goswami	Scientist EI	DP 05.06
Dr Kamlesh Kumar Maurya	Scientist B	DP 05.06
Sh S K Rastogi	Tech Ofcr (B)	DP 05.06
Realisation of Mole		
Dr S M Shivaprasad	Scientist EII	DP 05.07
Dr Amish G Joshi	Scientist C	DP 05.07
Bio-Mass Energy		
Sh Har Prakash Narang	Scientist F	DP 05.08

Name	Designation	Decision Package
RADIO & ATMOSPHERIC SCIENCES		
Head : Sh S C Garg		
Radio & Atmospheric Environmental Monitoring & Associated Instrumentation Development		
Sh Satish Chand Garg	Scientist G	DP 06.01
Dr P K Banerjee	Scientist F	DP 06.01
Dr P N Vijayakumar	Scientist F	DP 06.01
Mrs Madhu Bahl	Scientist EII	DP 06.01
Sh Thomas John	Scientist EII	DP 06.01
Sh H K Maini	Scientist EII	DP 06.01
Dr S D Sharma	Scientist EII	DP 06.01
Sh Vijay Kumar Vohra	Scientist EII	DP 06.01
Sh C B Tandel	Scientist EI	DP 06.01
Dr Sachidanand Singh	Scientist C	DP 06.01
Sh Iqbal Ahmed	Tech Ofcr (C)	DP 06.01
Sh K G M Pillai	Tech Ofcr (C)	DP 06.01
Sh Dhan Singh Chaunal	Tech Ofcr (B)	DP 06.01
Sh Ramesh Kohli	Tech Ofcr (B)	DP 06.01
Sh Vishram Sing Yadav	Tech Ofcr (B)	DP 06.01
Mrs Beena Gupta	Tech Ofcr (A)	DP 06.01
Sh Man Mohan Gupta	Tech Ofcr (A)	DP 06.01
Radio Communication & Space Physics		
Dr Swapan Kumar Sarkar	Scientist F	DP 06.02
Dr Lakha Singh	Scientist F	DP 06.02
Dr Raj Singh Dabas	Scientist F	DP 06.02
Dr Mahendra Kumar Goel	Scientist F	DP 06.02
Dr Vijay Kumar Pandey	Scientist EII	DP 06.02
Dr M S V N Prasad	Scientist EII	DP 06.02
Sh Narendra Kumar Sethi	Scientist EII	DP 06.02
Sh Pattamatta Subrahmanyam	Scientist EII	DP 06.02
Mrs Parvati Chopra	Scientist EII	DP 06.02
Mrs Shashi Kala Suresh Shastri	Tech Ofcr (EI)	DP 06.02
Mrs Shiv Kumari Bhatia	Tech Ofcr (B)	DP 06.02
Sh Dharam Bir Sharma	Tech Ofcr (B)	DP 06.02
Atmospheric Environment and Global Change Studies		
Dr M K Tiwari	Scientist F	DP 06.03
Dr Sohan Lal Jain	Scientist F	DP 06.03
Dr Asit Baran Ghosh	Scientist F	DP 06.03
Dr Hirday Nath Dutta	Scientist F	DP 06.03

Name	Designation	Decision Package
Dr Kanwar Sushil Zalpuri	Scientist F	DP 06.03
Dr Pradeep Kumar Pasricha	Scientist F	DP 06.03
Dr Radhe Shyam Arora	Scientist EII	DP 06.03
Dr Bhuwan Chandra Arya	Scientist EII	DP 06.03
Dr Mahendra Mohan	Scientist EII	DP 06.03
Sh Deo Raj Nakra	Scientist EII	DP 06.03
Dr Risal Singh	Scientist EII	DP 06.03
Dr(Mrs)Meena Jain	Scientist EI	DP 06.03
Dr Jayanta Kar	Scientist EI	DP 06.03
Sh Randhir Singh Tanwar	Scientist EI	DP 06.03
Dr Tuhin Kumar Mandal	Scientist C	DP 06.03
Sh Arun Kumar Ghoghar	Tech Ofcr (B)	DP 06.03
Sh Shambhu Nath	Tech Ofcr (B)	DP 06.03

SUPERCONDUCTIVITY & CRYOGENICS

Head : Dr Hari Kishan

Superconducting Magnets

Sh Rajan Babu Saxena	Scientist EII	DP 07.01
Sh M A Ansari	Scientist C	DP 07.01

Basic Superconductivity

Dr Ramji Rai	Scientist F	DP 07.02
Sh Pratim K Dutta	Scientist EII	DP 07.02
Sh B V Kumaraswamy	Scientist EII	DP 07.02
Dr Ratan Lal	Scientist EII	DP 07.02
Dr S K Agarwal	Scientist EII	DP 07.02
Dr Miss P L Upadhyay	Scientist EII	DP 07.02
Sh Umesh Chandra Upreti	Scientist EI	DP 07.02
Dr Anurag Gupta	Scientist C	DP 07.02
Sh S B Samanta	Tech Ofcr (C)	DP 07.02
Sh Mohan Chandra Singh	Tech Ofcr (A)	DP 07.02

Quantum Hall Efect

Dr Harikrishna Singh	Scientist C	DP 07.03

Humidity Standards

Dr Hari Kishan	Scientist F	DP 07.04
Sh Bhikham Singh	Tech Ofcr (A)	DP 07.04

Nanowires

Dr B V Reddi	Scientist EII	DP 07.05

Name	Designation	Decision Package
LIBRARY		
Head : Dr S M Dhawan		
Library & information service		
Dr S M Dhawan	Scientist F	DP 12.01
Sh Deepak Kumar Tewari	Scientist EII	DP 12.01
Sh N K Wadhwa	Scientist C	DP 12.01
Sh Hasan Haider	Tech Ofcr (C)	DP 12.01
Sh Jagdish Prasad	Tech Ofcr (B)	DP 12.01
Mrs Shashi Lekha Bhatnagar	Tech Ofcr (A)	DP 12.0
SCIENTIFIC SUPPORT SERVICE		
Head : Director, NPL		
Planning, Monitoring & Evaluation Group		
Dr V T Chitnis	Scientist G	DP 13.01
Mrs Shikha Mandal	Scientist EII	DP 13.01
Dr Miss Jyoti Lata Pandey	Scientist EII	DP 13.01
Sh Tushar Kanti Chakravarty	Scientist EI	DP 13.01
Sh V D Arora	Tech Ofcr (B)	DP 13.01
Marketing of NPL Developed Technology		
Dr P K Ashwinikumar	Scientist F	DP 13.02
Sh Narinder Kumar Babbar	Scientist EII	DP 13.03
Dr D P Bhatt	Scientist EII	DP 13.03
Sh Ashwani Kumar Suri	Tech Ofcr (B)	DP 13.02
Consultancy & Technical Services Group		
Mrs Indra Tiwari	Scientist EII	DP 13.04
Sh Vinod Kumar Sharma	Tech Ofcr (A)	DP 13.04
Human Resource & Development Group		
Sh F C Khullar	Scientist F	DP 13.05
International Science and Technology Affairs Group		
Sh Sushil Kumar Sharma	Scientist EII	DP 13.06
Sh Mohinder Kumar Chhibber	Tech Ofcr (C)	DP 13.06
Seminar Complex		
Sh Subhash Chandra	Tech Ofcr (C)	DP 13.08

Name	Designation	Decision Package
Automation Group		
Dr Tushya Kumar Saxena	Scientist EI	DP 13.09

TECHNICAL SUPPORT SERVICE

Head : Dr Anil Kumar Gupta

Electrical, Air Conditioning & Pumping Section		
Sh Jagdish Chander Sharma	Scientist EII	DP 14.01
Sh Sham Lal Sharma	Tech Ofcr (C)	DP 14.01
Sh Deepak Bansal	Tech Ofcr (B)	DP 14.01
Sh B S Negi	Tech Ofcr (B)	DP 14.01
Sh Prabhu Shankar Tripathi	Tech Ofcr(A).	DP 14.01
Sh B M Sahu	Asst Exe Engnr.	DP 14.15
Sh Hitesh Jain	Tech Ofcr (B).	DP 14.22
Sh Dharam jit Singh	Asst. Exe. Engnr.	DP 14.22
Workshop & GTU		
Sh H N P Poddar	Scientist F	DP 15.01
Sh Ram Sarup	Tech Ofcr (C)	DP 15.01
Sh Karnail Singh	Tech Ofcr (C)	DP 15.02

CENTRAL COMPUTER FACILITY

Head : Dr Ravi Mehrotra

Dr Ravi Mehrotra	Scientist F	DP 16.01
Ms Deepti Chaddha	Scientist B	DP 16.01
Sh Sher Singh	Scientist B	DP 16.01
Sh Kanwaljit Singh	Tech Ofcr (B)	DP 16.01
Sh Ashok Kumar	Tech Ofcr (A)	DP 16.01
Sh Vijay Sharma	Tech Ofcr (A)	DP 16.01
Not Reporting		
Sh V K Gogia	Scientist C	XXX
Sh S K Gupta	Scientist C	XXX

ADMINISTRATION ACCOUNTS, STORES & PURCHASE

Administration, Accounts, Stores & Purchase		
Sh B C Joshi	Sr. Dy Fin. Adviser	DP 10.01
Sh G K Bhatnagar	COA	DP 09.01
Sh K A Naidu	F&AO	DP 10.01

Name	Designation	Decision Package
Sh S C Tyagi	A O	DP 09.01
Sh Brijesh Sharma	SPO Gr. I	DP 11.01
Sh. Kuldeep Kaushik	Dy. SPO	DP 11.01
Dr Mrs Shakuntala Sharma	Sr Hindi Officer	DP 09.11
Sh Lakhpat Singh	Security Ofcr (Sr)	DP 09.14
Sh Vijay Kumar	Sr Security Ofcr	DP 09.07
Sh Subhash Chander	SO(G)	DP 09.12
Ms Veena Anupa Kullu	SO(G)	DP 09.13
Sh D K Salone	SO(G)	DP 09.02
Sh Balraj Singh	SO(G)	DP 09.03
Sh Jintendra Kumar Singh	SO(G)	DP 09.05
Sh Chhering Tobden	SO(G)	DP 09.04
Sh D L Verma	SO(G)	DP 10.01
Sh Hankolin Chongloi	SO (F&A)	DP 10.01
Sh Satish Kumar	SO (F&A)	DP 10.01
Sh S Seelan	SO (F&A)	DP 10.01
Sh R K Bhasin	PS	DP 06.03
Mrs S A Joseph	PS	DP 03.02
Mrs Paramjit Kaur	PS	DP 01.12
Sh Mange Ram	PS	DP 07.01
Sh Shish Ram	PS	DP 09.02
Horticulture		
Sh Rama Shankar Singh	Tech Ofcr (El)	DP 09.06

RETIRED PERSONS

Sh. Bal Kishan, Tech. VII
Sh. H P Gupta, TOE-I
Sh. Ram Kishan, W/S Asstt. II
Sh. S K Rai, SMA
Sh. H S Kalsi, TOE-I
Sh. Gurmej Ram, Sc. E-I
Sh. Kailash, SMA
Sh. P D Aggarwal, Dy. SPO
Dr. B S Mathur, Sc. G
Sh. Ram Kishore, W/S Asstt. VII
Dr. B.S.Verma, Sc. E-II
Sh. Harbans Singh, Asstt. Exe Engr.
Sh. B M Tolani, Assitant
Sh. Har Chand, Jr. Sec. Grd.
Sh. Mahabir, Daftry
Dr. R G Sharma, Sc.G
Sh. Raksha Marwal, TOB
Dr. D R Lakshmi, Sc. G
Sh. Inder Raj, Tech. VIII
Dr. R Ramachandran, Sc. E-II
Sh. Kewal Krishan, Sc. E-I
Sh. Sher Singh, UDC
Sh. Shashi Bhushan, TOE-I
Sh. Mohan Singh Negi, Tea Maker
Sh. Damodar Prasad, TOB
Dr. V S Tomer, Sc. F
Sh. Inder Singh, SMA
Sh. S N Narula,SMA
Sh. R K Sikri, Sr. Stenographer
Sh. Ram Mehar, Security Guard
Dr. R C Saksena, Sc. F
Sh. H L B Bhaskar, Sc. E-I
Sh. Tilak Raj, Tech. VIII
Sh. N S Verma, Sc. C
Sh. Rattan Lal, Jr. Sec. Grd.
Sh. S K Sarda, TOC
Sh. R C Goel, TOE-I
Sh. Om Prakash, SMA
Sh. S D Bahl, Sr. Stenographer
Sh. V S Yadav, TOB
Sh. Charan Singh, Record Keeper
Sh. Kamla Devi, W/S Asstt. VII
Sh. S K Verma, W/S Asstt-II

OBITUARIES

Sh. Raghuvir Singh Sharma, Tech. VII
Sh. Nand Kishore S MA
Sh. Sis Ram Saini, Tech. VIII
Sh. M L Verma, TOE-I

SCIENTIST FELLOW & EMERITUS SCIENTISTS

Dr. A P Mitra, Hony Scientist of Eminence
Dr. A V Narlikar, Emer. Scientist
Dr. B S Mathur, Emer. Scientist
Dr. K K Mahajan, Emer. Scientist
Dr. O P Bahl, Emer. Scientist
Dr. P K Ghosh, Emer. Scientist
Dr. Subhas Chandra, Emer. Scientist
Dr. Vikram Soni, UGC Res. Scientist
Dr. Govind Res. Scientist

RESEARCH ASSOCIATES

Dr. B. Vinadhari, SRA
Dr. Deepak Varandani, SRA
Dr. Y Aparna, SRA
Dr. A K Singh, RA
Dr. Asha Chaubey, RA
Dr. A K Dwivedi, RA
Dr. A L Sharma, RA
Dr.Daya Soni, RA
Dr. Himanshu Narian, RA
Dr. Karyta Rai , RA
Sh. Kuldeep Singh, RA
Dr. Lakender Kumar, RA
Dr. Mitali Shah, RA
Dr. Pratima, RA
Sh. Rajkishan Sharma, RA
Dr. S K Chauhan, RA
Dr. S P Singh, RA
Dr. Suman Anand, RA

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APPENDIX : 17

RESEARCH COUNCIL AND MANAGEMENT COUNCIL OF NPL

Research Council

Name	Status
Prof. V S Ramamurthy Secretary, Department of Science & Technology Technology Bhawan, New Mehrauli Road, NEW DELHI-110016 (UP).	Chairperson
Dr. Girish S Agarwal Director, Physical Research Laboratory, AHMEDABAD-380009 (Gujarat)	Member
Dr. D.D.Bhawalkar Director, Centre for Advanced Technology, INDORE-452013 (MP)	Member
Prof. Sushanta Dattagupta S N Bose Institute of Basic Science, Block-JD, Sector III, Salt Lake, KOLKATA- 700098 (WB)	Member
Dr. S K Sikka Scientific Secretary, Office off the Principal Scientific Adviser To the Govt. Of India, Government of India, Vigyan Bhavan Annexe, Maulana Azad Road, NEW DELHI-110011 (UT)	Member

Sr. No. Name of the Member	Status
Dr. S M Chitre Department of Astronomy and Astrophysics, Tata Institute of Fundamental Research (TIFR), MUMBAI-400005 (MS)	Member
Sh. Nirmal Singh Director General, Bureau of Indian Standadrds, Manak Bhawan, NEW DELHI-110002 (UT)	Member
Dr. O P Agarwal Head, Research Planning & Business Development and (RPBD), Council of Scientific & Industrial Research, Anusandhan Bhawan, 2 Rafi Marg, NEW DELHI-110001 (UT)	Member DG'S Nominee
Dr. S Ahmad Director, Central Electronics Engineering Research Institute, PILANI-33031 (Rajasthan)	Member
Dr. Krishan Lal Director, National Physical Laboratory, Dr. K S Krishnan Marg, NEW DELHI-110012 (UT)	Member
Dr. V T Chitnis Scientist 'G' & Head, Planning, Monitoring & Evaluation Group NPL, NEW DELHI-110012. (UT)	Non-Member Secretary

Name	Status
Management Council	
Dr. Krishan Lal Director NPL	Chairman
Dr. S.C. Garg Scientist G NPL	Member
Dr. R.P.Pant Scientist El NPL	Member
Dr. T.K.Chakraborty Scientist El NPL	Member
Sh. S.B. Samanta TO-C NPL	Member
Dr. Mahavir Singh Scientist NPL	Member
M/s. Ranjana Mehrotra Scientist El NPL	Member
Dr. S.N. Joshi Scientist (Sister Lab) (CEERI, Pilani)	Member
Sr. F. & A.O. (SG)/Sr. F.& A.O./F. & A.O. NPL	Member
Sr.C.O.A./C.O.A./A.O. NPL	Member-Secretary

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