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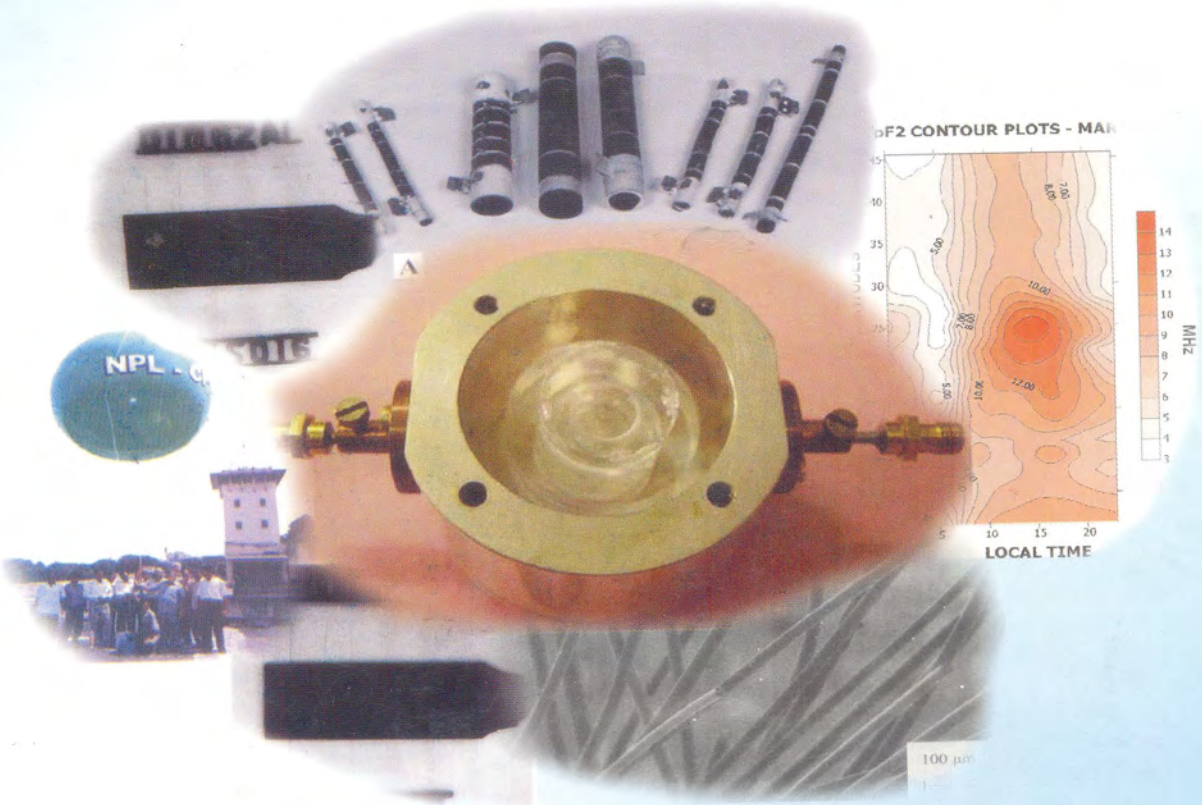
वार्षिक प्रतिवेदन
annual report



राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली

NATIONAL PHYSICAL LABORATORY, NEW DELHI

CONTENTS

प्राक्कथन

वर्ष 2002–2003 की रिपोर्ट प्रस्तुत करते हुए मुझे प्रसन्नता हो रही है। इस वर्ष के दौरान डॉ. कृष्ण लाल प्रयोगशाला के निदेशक थे। यह रिपोर्ट इस समयान्तराल में प्रयोगशाला में किये गये कार्य को प्रस्तुत करती है।

राष्ट्रीय भौतिक प्रयोगशाला के चार्टर तथा 'बाट और माप मानक अधिनियम 1956', जो 1988 में लोक सभा के 1976 के अधिनियम के अन्तर्गत फिर से जारी किया गया, के प्रावधान के अनुसार भौतिक माप के विभिन्न मानकों का संरक्षण तथा उनका उन्नयन एन पी एल का उत्तरदायित्व है। प्रयोगशाला ने अन्तर्राष्ट्रीय माप तोल ब्यूरो के परस्पर पहचान समझौते पर भी हस्ताक्षर किये है तथा इसके लिए यह समय–समय पर अन्तर्राष्ट्रीय अन्तर्तुलनाओं में प्रतिभागिता कर, अपने मानकों की 'अन्तर्राष्ट्रीय समकक्षता' को बनाये रखती है। यह प्रयोगशाला मानकों, इन्जीनियरी पदार्थो, इलेक्ट्रानिक पदार्थो, पदार्थ अभिलक्षणन, रेडियो एवम् वायुमण्डलीय विज्ञान तथा अतिचालकता तथा निम्न ताप भौतिकी के क्षेत्र में शोध कार्य भी करती है।

वर्ष के दौरान प्रयोगशाला ने एशिया पैसिफिक मीट्रोलॉजी कार्यक्रम द्वारा आयोजित अन्तर्राष्ट्रीय अन्तर्तुलनाओं में भाग लिया तथा अपने मानकों का पुर्नज्ञापण किया। प्रयोगशाला में एसी/डीसी वोल्टता ट्रांसफर मानक, लम्बाई, श्यानता तथा रेडियो आवृति शक्ति को अन्तर्राष्ट्रीय अन्तर्तुलनाओं में भाग लिया। इन अन्तर्तुलनाओं के परिणाम बी आई पी एम एम आर ए (BIPM MRA) के ऐपेडिक्स–बी में सम्मिलित किये जाते हैं। एन पी एल ने अपनी बहुत सी कैलीब्रेशन (अंशशोधन) सुविधाओं में सुधार (upgrade) किया। इस वर्ष के दौरान कई नई सुविधाए स्थापित की गई जैसे कि चुम्बकीय मीडिया पदार्थों के अभिलक्षणन के लिए वी एस एम तथा नैनोस्कैन वोल्टता रेफरेंस मानक प्रयोगशाला ने एन ए बी एल प्रत्यायित प्रयोगशालाओं के लिए संधारिता, तापमान, लम्बाई तथा भार मापन में प्रवीणता परीक्षण कार्यक्रमों का संचालन किया।

प्रयोगशाला ने नये/संशोधित (सुधारे गये) पदार्थों को बनाने (Synthesize) तथा अभिलक्षणन करने में विशेष प्रयास किया। इनमें कार्बन नैनोट्यूब, लीथियम टैट्रा (8 हाईड्राक्सी क्यूनोलीन) बोरॉन, टाल्वीन तथा नैप्थालीन के सहपालीमर सम्मिलित हैं। पदार्थ के वैद्युतीय तथा चुम्बक–वैद्युतियगुणों के साथ–साथ विभिन्न पदार्थों की संरचना को समझने, और फेब्रीकेशन अथवा सिंथेसिस की विधि के साथ इनके सम्बन्ध को समझने तथा विधि को आप्टीमाइज करने के लिए अनुसंधान कार्य किया गया।

उच्च धारा तथा कम कांटेक्ट प्रतिरोध वाली अतिचालक नलियो/छड़ो का विकास करने के लिए किए गये अनुसंधान एवम् विकास कार्य के फलस्वरूप उत्कृष्ट परिणाम प्राप्त किये गये। हमारे वैज्ञानिकों ने 20cm तक लम्बाई की विस्मथ 2223 की होमोजिनियस नलियो तथा 200A तक धारा के लिए सिल्वर जाइंट (चांदी के जोड़) बनाने की विधि का विकास किया है।

डी आर डी ओ द्वारा प्रायोजित एक परियोजना के अन्तर्गत एक्स–रे तथा न्यूट्रान इमेजिंग में प्रयोग के लिए गैडोलिनियम आक्सीसल्फाइड (GOS) प्रदीप्ति फास्फर की पर्त चढाये गये ल्युमिनिसेंट पर्दो का विकास इस प्रयोगशाला ने किया। इस वर्ष में विकसित कुछ अन्य महत्वपूर्ण युक्तियों में 'हानिकारक PAH की कम मात्रा वाला कोलतार पिच का विकास तथा उच्च तापीय संवहकता वाले कार्बन पदार्थों का विकास आदि नये कार्यक्रम इस वर्ष शुरू किये गये।

इसके अतिरिक्त एन पी एल में किये गये अनुसंधान एवम् विकास कार्यों का एक महत्वपूर्ण हिस्सा जीवन की गुणवत्ता सुधार के लिए तथा सामाजिक–आर्थिक प्रभाव डालने वाला था। उदाहरण के लिए एन पी एल ने केन्द्रीय प्रदूषण नियन्त्रण बोर्ड (CPCB) द्वारा प्रायोजित परियोजनाओं के अन्तर्गत प्रदूषण नियन्त्रण तथा प्रदूषण के प्रभावों को समझने के लिए प्रयास किए। एन पी एल ने कोहरा/धुंध (fog) पर शोध कार्य किये तथा प्रदूषण के लिए डीज़ल जेन–सेट्स की टाइप टेस्टिंग के लिए प्रोसीजर (विधियों) का सूत्रपात किया। इसने यू एन फ्रेमवर्क ऑफ कन्वेंशन क्लाईमेट चेन्ज से भारत की प्रारम्भिक वार्ता (कम्यूनिकेशन) के लिये तैयारी हेतु लाइवस्टाक तथा बायोमास, प्रक्षेप के जलाने के कारण होने वाली ग्रीन हाऊस गैसों के अध्ययन पर एक परियोजना का उत्तरदायित्व लिया।

प्रयोगशाला से कुल 179 शोध पत्र प्रकाशित हुए जिसमें से 113 साइंस साइटेशन इन्डेक्स जरनलों में थे। इसके अतिरिक्त 139 शोध पत्र विभिन्न सम्मेलनों की प्रोसिडिंग द्वारा तथा 101 पत्र विभिन्न राष्ट्रीय एवं अन्तर्राष्ट्रीय सम्मेलनों में प्रस्तुत किए गए। कुल 17 पेटेंट प्रयोगशाला से देश व विदेश में प्राप्त हुए। फाइल हुए 4 पेटेंट जो गत वर्षों विदेशों में फाइल किए गए थे इस वर्ष प्राप्त हुए। प्रयोगशाला में 10 नयी प्रायोजित परियोजनाएं ली गयी जिससे 117.88 लाख रुपए अर्जित किए गए। अंशशोधन व परीक्षण से कुल आय 261 लाख रुपए हुई।

विभिन्न उपलब्धियों के लिए 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. एस. के. गुप्ता, 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, श्री सुधांशु द्विवेदी, श्री विश्व दीपक अरोड़ा तथा श्री एन. के. वधवा के द्वारा किये गये प्रयासों की मैं सराहना करता हूं।

(विक्रम कुमार)
निदेशक

Foreword

It gives me a great pleasure to present the Annual Report of NPL for the year 2002-2003. During the year the laboratory was headed by Dr Krishan Lal. The report presents the work done at National Physical Laboratory during this period. As per the NPL charter and as provided under the Legislations of Weights and Measures Act 1956, reissued in 1988 under the 1976 Act of Parliament, NPL has the statutory responsibility of maintaining and upgrading various standards of physical measurement. The laboratory is also a signatory of Bureau International des Poids et Mesures.(BIPM) Mutual Recognition Arrangement (MRA) and in this regard it maintains international equivalence of its standards by participating in international intercomparisons. The laboratory also carries out advance research in standards, engineering materials, electronic materials, materials characterization, radio and atmospheric sciences and superconductivity & cryogenics.

During the year the laboratory participated in international intercomparisons initated by Asia Pacific Metrology Programme (APMP) and sought reaffirmation of its national standards. It participated in international intercomparisons for AC/DC voltage transfer standards, length and viscocity and RF Power. Such programmes are aimed at harmonization of measurement practices at international level. The results of international comparisons are included in BIPM MRA – Appendix B.

NPL also upgraded its various calibration facilities and added new facilities like VSM for characterization of magnetic media material and nanoscan – voltage reference standard was added as new facility this year. Through its calibration facilities NPL provided to various organizations under government, public and private sectors traceability to national standards at NPL. It conducted proficiency testing programmes for NABL accredited laboratories for capacitance, temperature, length and mass measurement.

The laboratory made special efforts for synthesizing and characterizing new/improved materials during the year. These include materials like carbon nanotubes, lithium tetra (8 – hydroxy quonoline) boron, copolymers of toluene and napthalene. R& D studies were carried out to understand electrical and magneto electrical properties of materials as well as the structure of various materials and their relationship to fabrication/synthesis processes with a view to optimize these processes.

Outstanding results have been achieved as a result of R&D efforts to develop high temperature super-conducting tubes / rods capable of carrying high current and having low contact resistance. Our scientists have developed highly homogeneous tubes of Bi 2223 up to 20 cm in length and a process for making silver joints to carry more than 200A.

NPL has developed luminescent screens coated with gadolinium oxysulfide (GOS) phosphor under a DRDO sponsored projects, for application in X-ray and neutron imaging. These have shown better performance in X-ray imaging as compared to conventional lead screens. The important devices developed during the year include Whispering Gallery Mode (WGM) resonator using composite of sapphire and rutile for frequency – temperature comparison. The other

programmes initiated this year include development of coal tar pitch with reduced content of harmful PAH, development of high thermal conductivity carbon materials etc.

Besides this, a significant amount of R&D work, carried out at NPL was aimed to improving the of quality of life and effecting socio-economic impact. For instance, NPL has made R&D efforts in area of pollution control and understanding effects of pollution under projects sponsored from Central Pollution Control Board. NPL carried out studies on 'fog' and formulated procedures for type testing of diesel generator sets for pollution. It has undertaken projects on measurement studies on green house gases from live stock and biomass burning of residue for preparation of India's initial national communication to UN Framework of Convention Climate Change.

The laboratory published a total of 179 papers, of which 113 were in SCI-indexed journals. Besides, 139 papers were published in conference proceedings, and 101 papers presented at various national and international conferences. A total of 17 patents were filed in India and abroad. Four patens filed abroad during previous years were granted in this year 2002-03. The laboratory took up 10 new sponsored projects and generated a sum of Rs. 117.88 lakh during the year. Earnings from calibration and testing reached Rs.261 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 staff for making several notable achievements. I also acknowledge with great pleasure the contributions made by the Publication Committee and the Publications Group in bringing out this report. In particular the efforts made in this regard by Dr. S.M. Dhawan, Sh. S.K. Chakladar, Dr S.K. Gupta, Dr. M.K. Goel, Dr. Ravi Mehrotra, Dr V.N. Ojha, Dr. (Ms.) P.L. Upadhaya, Dr. T.D. Senguttuvan, Dr. (Mrs.) Rina Sharma, Dr. (Mrs.) S. Sharma, Sh. Sudhanshu Dwivedi, Sh. N.K. Wadhwa and Sh V.D. Arora are highly appreciated.

(Vikram Kumar)
Director

Preamble

The National Physical Laboratory is one of the earliest national laboratories set up under the Council of Scientific & Industrial Research. Late Shri Jawaharlal Nehru laid the foundation stone of NPL on the 4th January 1947. Late Dr. K. S. Krishnan, FRS, was the first Director of the laboratory. The main building of the laboratory was formally opened by Late Deputy Prime Minister, Sardar Vallabhbhai Patel on the 21st January 1950.The Silver Jubilee Celebration of the Laboratory was inaugurated by Late Prime Minister, Shrimati Indira Gandhi, on 23rd December 1975.

CHARTER

The main aim of the laboratory is to strengthen and advance physics-based research and development for the overall development of science and technology in the country. In particular its objectives are:

- To establish, maintain and improve continuously by research, for the benefit of the nation, National Standards of Measurements and to realize the Units based on International System (Under the subordinate Legislations of Weights and Measures Act 1956, reissued in 1988 under the 1976 Act).

- To identify and conduct after due consideration, research in areas of physics which are most appropriate to the needs of the nation and for advancement of field

- To assist industries, national and other agencies in their developmental tasks by precision measurements, calibration, development of devices, processes, and other allied problems related to physics.

- To keep itself informed of and study critically the status of physics.

CUSTODIAN OF NATIONAL STANDARDS OF MEASUREMENT

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

NATIONAL APEX BODY FOR CALIBRATION

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

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

R&D ACTIVITIES

In the pursuit of its chartered objectives, the laboratory undertakes sponsored projects, consultancy assignments, and in-house research projects in areas such as physical measurement standards, engineering materials, electronic materials, soft and polymer materials, materials characterization, radio and atmospheric sciences, and cryogenics and superconductivity.

ORGANIZATION AND MANAGEMENT

The laboratory has structured its total activities under seven scientific decision units. These are: (i) Physico-mechanical standards, (ii) Electrical and electronic standards, (iii) Engineering materials, (iv) Electronic materials, (v) Materials characterization, (vi) Radio and atmospheric sciences, and (vii) Cryogenics and superconductivity.

In addition, it has set up nine support units for its organization and management. These are: (i) Director's office, (ii) Administration & house keeping, (iii) Finance & accounts, (iv) Store & Purchase, (v) Library, (vi) Scientific support service, (vii) Technical support service, (viii) Workshop, (ix) Computer centre.

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भौतिक - यांत्रिक मानक

PHYSICO-MECHANICAL STANDARDS

भौतिक - यांत्रिक मानक

इस प्रभाग का मुख्य कार्य द्रव्यमान, लम्बाई तथा विमीय मापिकी के मापन मानकों, तापमान, प्रकाशीय विकिरण, (दृश्य, पराबैंगनी तथा अवरक्त क्षेत्रों) बल, दाब (वातीय, द्रवचालित) तथा निर्वात, ध्वानिक, पराश्रव्यिकी, तरल बहाव आर्द्रता, आघात तथा कंपन तथा प्रकाशीय मापनों के मानकों से सम्बन्धित है।

प्रभाग का मुख्य उत्तरदायित्व सभी भौतिक मापों के राष्ट्रीय मानकों को स्थापित करना, उनका अनुरक्षण करना और उनका लगातार उन्नयन करना है। इसके अतिरिक्त उद्योगों, संस्थाओं, निजी और सार्वजनिक क्षेत्रों, रक्षा विभाग आदि को शीर्ष स्तरीय अंशांकन सेवाएं प्रदान करना और इन सेवाओं की परस्पर अदला–बदली करना भी इस प्रभाग का कार्य है। अन्य जिम्मेदारियों में अंशांकन प्रयोगशाला की स्थापना करने में परामर्श सेवाएं प्रदान करना, ज्ञान का विकास करना और उद्योगों से आए कार्मिकों को मापिकी में प्रशिक्षित करना है तथा एक जिम्मेदारी यह भी है कि मापन क्षमता सर्वोत्तम प्रकार की है, इस के लिए एन ए बी एल (परीक्षण और अंशांकन प्रयोगशालाओं के लिए बनाया गया राष्ट्रीय प्रत्यायन बोर्ड) का विश्वास प्राप्त हो सके और गुणवत्ता प्रणाली के प्रलेख तैयार किए जा सकें।

इन कार्यकलापों के लिए और ज्ञान प्राप्त करने तथा ज्ञान का विनिमय करने के लिए यह प्रभाग अनुसंधान और विकास कार्य भी करता है तथा राष्ट्रीय और अन्तर्राष्ट्रीय सम्मेलनों, संगोष्ठियों में अपने वैज्ञानिकों को भेजता है तथा प्रशिक्षण पाठ्यक्रमों और कार्यशालाओं में और विभाग के अन्दर संगोष्ठियां कराने की भी सुचारू व्यवस्था करता है ।

एन पी एल अपने मानक क्रियाकलापों के माध्यम से देश में ही शीर्ष–स्तरीय अंशांकन सेवाएं प्रदान करता है जो कि आवेदन करने वाली प्रयोगशाला की सर्वोत्तम मापन क्षमता स्थापित करने के लिए प्रदान की जाती हैं। ये सेवाएं आवश्यक अर्हता प्राप्त मूल्यांकन अधिकारियों के नाम भी प्रस्तावित करके प्रदान की जाती हैं। इस रूप में एन पी एल राष्ट्र के कार्य में योगदान करता है। विशेषकर उक्त एन ए बी एल प्रत्यायन समिति में वैज्ञानिक और तकनीकी निवेश प्रदान करता है ताकि प्रामाणिक होने का विश्वास प्राप्त करने के लिए आवेदन करने वाली प्रयोगशाला की उपयुक्तता के सम्बन्ध में निर्णय लेने में योग्य हो सके।

इस प्रभाग ने वर्ष के दौरान 2660 अंशांकन और परीक्षण प्रमाण पत्र जारी किए हैं और 169 लाख रुपए के लगभग कर्मचारी अंशदायी निधि के रूप में राशि प्राप्त हुई है। परामर्श, प्रशिक्षण और बाहरी रूप से सहायता प्राप्त परियोजनाओं से संबंद्ध तकनीकी और गुणवत्ता प्रणाली से हुई आय भी काफी महत्वपूर्ण रही है।

PHYSICO – MECHANICAL STANDARDS

This division is concerned with measurement standards of Mass, Length and Dimensional Metrology, Temperature, Optical Radiation (visible, ultra violet and infrared regions), Force, Pressure (pneumatic, hydraulic) and Vacuum, Acoustics, Ultrasonics, Fluid Flow, Humidity, Shock and Vibrations and Optical Measurements.

The main responsibility of this division is to establish, maintain and continuously upgrade National Standards of all physical measurements; interact with and provide apex level calibration services to industry, institutions, private and public sector, defence etc; provide consultancy in the setting up of calibration laboratory; develop knowledge, and train the personnel from industry in metrology and for obtaining NABL (National Accreditation Board for Testing and Calibration Laboratories) accreditation for the best measurement capability and preparing quality system documents.

In pursuit of these activities and for seeking and sharing knowledge, the division undertakes R&D work, nominates its scientists to national and international conferences, symposia, etc., and arranges training courses and workshops as well as in-house seminars.

NPL through its standards activities helps the nation by providing apex level calibration services in the country; offering NABL its qualified assessors as needed for establishing best measurement capability of the applicant laboratory; in particular its scientific and technical input to NABL Accreditation Committee to enable it to decide the suitability of the applicant laboratory for accreditation.

The division issued 2660 calibration and test certificates during the year realizing an ECF of about Rs 169 lakh. Its earnings from Technical and Quality Systems, related consultancy, training and externally funded projects were also quite significant.

Mass Metrology

NPL establishes and maintains primary standard of mass, volume, density and viscosity compatible to international standards. It provides calibration services; consultancy and training besides pursuing R&D work. Seventeen officials from the Indian Institute of Legal Metrology, Ranchi were given one day training in mass and volume measurements. One trainee from SASO, Saudi Arabia was given two weeks training in volume and density measurements during March 2003. Coordinated as reference laboratory, prepared technical protocol and organized NPL – NABL proficiency testing program (phase II) in mass measurement in which 20 calibration laboratories from all over the country participated. This program was started in August 2002.

This section participated in CCM.V-K1 International Intercomparison in Viscosity Measurement in June, 2002 and CCM.V-K5 International Intercomparison in Mass Measurement during November-December 2002. It coordinated APMP.M-K2 Intercomparison in Mass for which APMP-TCM had nominated Mass Metrology as the Head of the Management Group responsible for organizing the intercomparison activity.

Length and Dimension Standards

Length and Dimension standard maintains the apex level standards and is actively involved in the dissemination of traceability by way of calibration and testing services. The services were provided to clients from industries and other organizations and 474 calibration and test reports were issued. Studies were carried out for development of electro-optic displacement sensors using gratings. In this area theoretical studies were carried out to study the error components effecting the position control and alignment based on Moiré technique. It was found that the intensity fluctuations of the laser used for alignment are the major component limiting the accuracy of alignment. A concept of digital displacement using envelope of Moire cycles was developed. This concept has potential application in displacement measurement e.g. photolithography and step and repeat printing. Special optical components were fabricated for a DRDO sponsored project being carried out by Polymeric and Soft Materials Section. Plasma tubes were filled for R & D work of Optical Radiation Standards.

A new data processing method has been developed for on line measurement of Sieve parameters using wavelet transform. The measurement is by noncontact optical method, based on image acquisition using CCD camera. The method was validated by comparing the results with those obtained by using profile projector. The uncertainty in measurement has been evaluated and is about 0.001 mm at 95% confidence level. This method is very promising and offers advantages like ease of operation, time saving and online calculations. A patent has been submitted to obtain IPR for this technique.

Two training programmes were organized in the month of December, 2002 and February, 2003 respectively. About 60 Indian delegates and 8 delegates from developing nations were trained on issues concerning dimensional metrology and evaluation of uncertainty in measurements. The consultancy in setting up a calibration laboratory was provided to industries and laboratories.

Proficiency testing (PT) programme in calibration of gauge blocks was completed; PT in calibration of ring gauges was started. Various NABL accredited laboratories participated in these programmes. The programme is funded by NABL, DST, and Government of India. In order to ensure the compatibility with international standards the section participated in APMP international intercomparisons, APMP LK1 for calibration of ten steel gauge blocks and ten ceramic gauge blocks of lengths up to 100 mm and APMP LK2

for three long gauge blocks of length up to 500 mm .

Temperature Standards

Temperature Standards group of NPL is engaged in the realization, establishment and maintenance of temperature standards as per the International Temperature Scale, 1990 (ITS-90), development of calibration facilities and their improvement through continuous measurement in the over all range from -90°C to 2200°C. The calibration range for thermometers has been enhanced from the existing range of -75°C to -90°C. A set of 3-liquid baths (range: -20°C to 300°C) of high temperature stability was given to NTH, Ghaziabad (CNP 510332). An indigenously made vacuum system and water circulation line was installed for the realization of Cu fixed point by Rh-Pt/Pt thermocouple using new high temperature automatic furnace. The system is to be used for fixed-point calibration work on noble metal thermocouples to extend their range of calibration from l000°C to 1600°C. Under the collaborative project NABL-NPL PT-Program, IInd –Phase of PT- was conducted, on glass thermometers (0-300°C) in Nov. 2002 and on Rh-Pt/Pt thermocouples (0-1000°C) in Feb. 2003. Section acted as the reference laboratory. The fixed point of triple point of mercury (-38.8344°C) was realized and established.

A two-day advance-training course on temperature metrology was arranged for the participants from industry and NABL accredited laboratories at NPL during Dec. 12-13, 2002. More than 60 participants attended the course. Besides, it provided training to individuals from some laboratories on triple point of water setup and on calibration of industrial PRT (Platinum Resistance Thermometrs). Under the cooperative programme on primary temperature standard, one delegate from SASO, Saudi Arabia was given training in PRT..

Optical Radiation Standards (including Infrared & Ultraviolet)

Performance of samples of barium sulphate, diamond, silicon and carbon tetrachloride were evaluated using facility for Fourier-Transform Raman studies for development of the materials for IR reflectance/ transmittance standards. The work was continued on new method for absolute measurement of luminous flux using integrating sphere, reported earlier. Calibration services, consultancy and training were provided to the industry. 303 calibration reports were issued.

In addition basic R&D work was pursued (i) on the effect of spatial coherence in optical measurements (ii) improved technique for determining the optical source intensity-profile (iii) phenomena of correlation induced spectral shift(wolf effect) (iv) quantification of individual components of sugar in sugarcane juice (v) determination of moisture in tobacco (vi) thermal denaturation of dehydrophenylalanine containing peptides using variable-temperature FTIR spectroscopy (vii) infrared spectroscopic studies of polycyclic aromatic hydrocarbons (viii) theoretical and experimental study on generation of cross spectrally pure light by two diffusers moving in opposite directions and determination of diffuser surface roughness.

Force and Hardness Standards

In pursuit of its R&D work, a precision force transducer based on axy-symmetrical diaphragm pierced by a number of holes was designed and developed. A finite element software to optimize the design of the force transducers in the range of 100 kN, 200 kN, 500 kN was developed. The 5 kN, 10 kN and 50 kN dead weight force primary standards with an uncertainty of 20 to ± 50 ppm (at k=2) were also designed and developed. Calibration, consultancy and training was continued to be provided to industry.

Pressure and Vacuum Standards

Study of Metrological Characteristics of Capacitance Diaphragm Gauges

The capacitance diaphragm gauges (CDGs) have been in use for a few decades now and have been employed as transfer standards and reference standards. In a recent CCM Key Comparison, (CCM.P-K4), the transfer standard consisted of two CDGs in addition to two RSGs. The participants were not allowed to adjust the zero potentiometer and the temperature was maintained at 23°C by enclosing the sensors in a temperature controlled Igloo. The sensors were not heated to 45°C because the temperature differences between the sensor and the rest of the system lead to the problem of thermal transpiration. We have performed a study to establish the link between the calibration factor and the system check, between the system check and the temperature of the CDG sensor, between the temperature and the shift in the sensor zero. For this study a number of CDGs have been calibrated at different temperatures. A Resonant Silicon Gauge (Yokogawa, MT 220) of 130 kPa f. s. range was used as a secondary standard for the calibration of the CDGs. This RSG has been procured recently and was calibrated against the NPL UIM. Its accuracy was found to be ±0.02 % of the reading. The plots of CF against the pressure at different temperatures are shown in Fig. 1.1. It is seen that over a range of pressures, typically 100 torr to 1000 torr, the CF varies linearly with pressure and both the slope and the intercept values of this linear fit go on increasing as the temperature increases from about 290 K (the lowest ambient temp. studied) to 318 K, the maximum temperature to which the heated CDG can go.

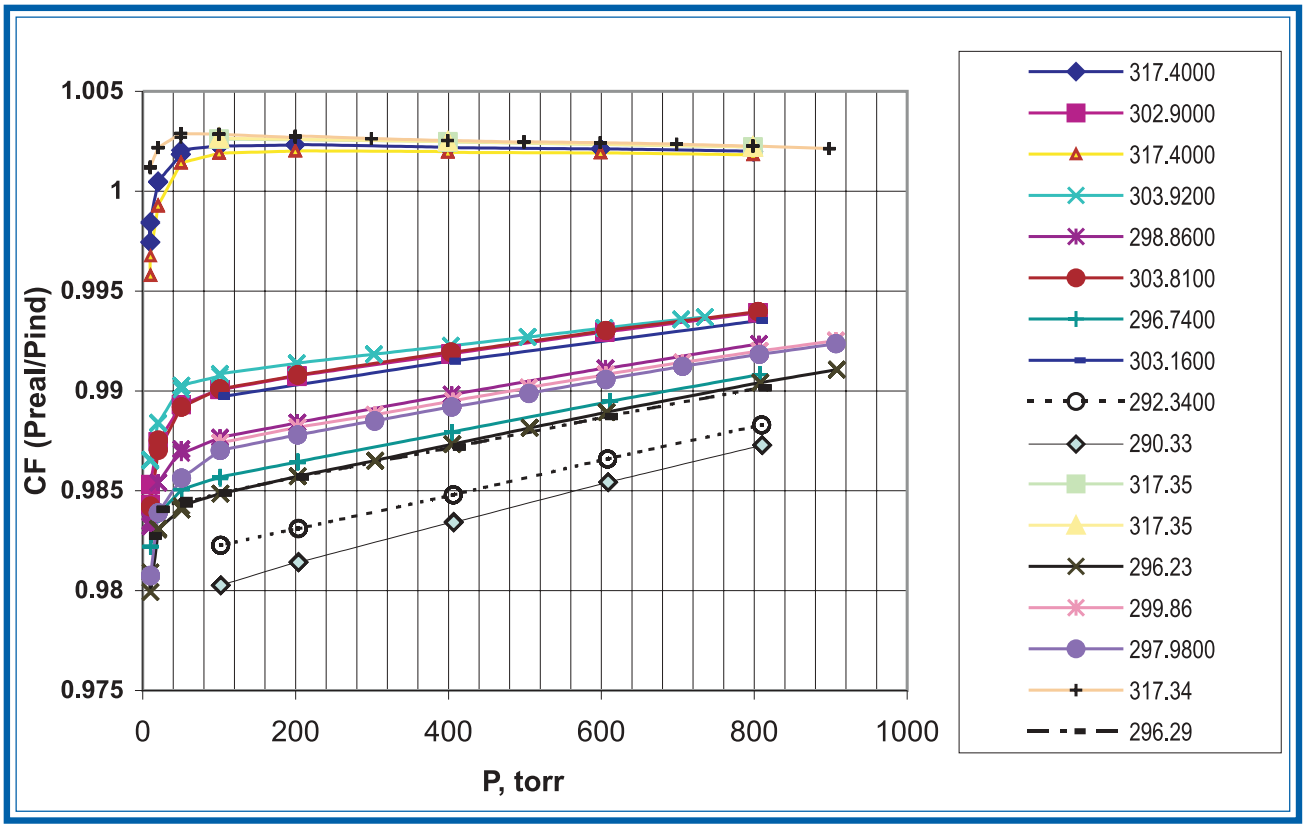

Fig. 1.1 CF vs Pressure (torr) at different ambient temperatures

Characterization of a Gas-Operated Pressure Balance with a 360 kPa Ultrasonic Interferometer Manometer

The effective area of a primary pressure standard i.e. a gas-operated pressure balance was measured in the range 27 kPa to 292 kPa by comparison with the 360 kPa Ultrasonic Interferometer Manometer, a primary pressure standard at the National Institute of Standards and Technology (NIST), USA. The effective area (A_o) was studied with the pressure balance operating either in absolute mode or in gauge mode using nitrogen or helium gas. Repeated measurements of A_o under identical conditions revealed some small but systematic differences in results depending on operating mode and / or gas used. The A_o of the pressure balance showed virtually no pressure dependence when operating in absolute mode with nitrogen gas. These measurements were repeated at selected pressures after a two-month interval and were found to agree with the earlier data to within approximately 1 ppm. Measurements under other conditions revealed small systematic increases in A_o with increasing pressure between 100 kPa and 292 kPa that ranged from approximately 3 to 5 ppm. The A_o did not depend on operating mode when using helium but did show a large difference when using nitrogen, yielding values that were 2 to 5 ppm higher for absolute mode operation. The effect of different gases on A_o yielded results that were 1 to 2 ppm higher for helium than for nitrogen in gauge mode but were 1 to 4 ppm lower in absolute mode.

Pressure Drop During Measurements in a Liquid Displacement Gas Flowmeter of Improved Design

A sizeable and unnoticeable error in the throughput measurement is detected in a liquid displacement gas flowmeter, constructed based on Stevenson's design. It is observed that as soon as the flow measurement is started, the pressure inside the burette falls rapidly for first few seconds and afterwards it becomes constant. The reason for this pressure drop and its contribution to the magnitude of error in the measured throughput value is discussed. The root cause of this pressure change is found to be due to an initial delay in falling of the oil in the burette from the reservoir. To find out the magnitude of pressure drop, an experimental study is carried out using the 1000 cm^3 and 500 cm^3 burettes incorporated in the present flowmeter. As a result of this study it is found that the magnitude of pressure is ranging from 4 to 6 mbar, which to some extent depends on the initially trapped volume of the gas. Therefore, due to this sizeable pressure change all the advantages associated with this unique design of the apparatus are being lost. Hence, the measured throughput values with this apparatus are being lost. Hence, the measured throughput values with this apparatus require correction, the magnitude of which depends on the combined contribution of pressure change and the ratio of the trapped volume to the displaced volume. In the present case this correction is found to lie between 2 to 6 % for the two burettes, though in general the magnitude of this correction depends on several factors.

Characterizations of a Controlled Clearance Pressure Balance for the Hydrostatic Pressure Measurements up to 500 MPa

This section carried out a systematic study to characterize a controlled clearance pressure balance in the hydraulic pressure region up to 500 MPa using pure J-13 and mixture of J-13 and aviation turbine fuel (ATF) (one part of J-13 and 2 parts of ATF) as pressure transmitting fluids. It also carried out a detailed study on the measurement of piston fall rate as a function of the applied jacket pressure (p_j) for each of several loads (50 kg).

NPL participated in the APMP.M.P-K7

(10-100MPa) in December 2002, along with fourteen other laboratories. It conducted proficiency testing under NPL- NABL PT programme in hydraulic region up to 70 MPa. R&D work was also pursued on i) High pressure phase transition in Cerium mono-chalcogenides ii) High - pressure phase transition in 57Fe0.03Cr 0.97 Sb_2 iii) Simulation of differential pressure data iv) Laser Raman Spectroscopy v) In-House intercomparison vi) Swift heavy ion induced interface mixing and (vii) Surface modification and phase stabilization in nanophase materials.

Other activities

Calibration services in calibration of dead weight testers, pressure dial gauges in pneumatic hydraulic and vacuum ranges were provided to industry. Also provided consultancy to M/s Nagman, Chennai and CEERI Pilani.

Acoustic Standards

The Acoustics Section maintains two primary standards viz. the standard of sound pressure and vibration amplitude. The standard of sound pressure is maintained by reciprocity calibration of standard condenser microphones in coupler cavity in the frequency range 20 Hz-20 kHz with an overall uncertainty of ± 0.1 dB. The standard of vibration amplitude is maintained through absolute calibration of standard accelerometer by laser interferometer technique using the fringe counting technique in the frequency range 5 Hz – 5000 Hz with an overall uncertainty of ± 0.5%. The accuracy of the above primary standard is maintained through participation in key comparison exercises with leading standard laboratories abroad.

The Acoustics Section also undertakes calibration, testing and evaluation of electro-acoustical equipments and acoustic products as per national / international specifications. The section also undertakes consultancy and sponsored projects in building acoustics, noise and vibration control, EIA studies, Sodar studies of the atmospheric boundary layer (ABL).

Under a sponsored project from Central Pollution Control Board, New Delhi the Acoustics Section has formulated procedures for type testing of Diesel Generator Sets manufactured/imported in the country aimed at reducing the emitted noise levels from the set. The section also undertook the evaluation of firecrackers periodically to verify compliance with the existing noise pollution standards. As a member of the National Committee on Noise Pollution Control constituted by CPCB, the section has contributed significantly towards drafting existing noise pollution standards and specifications.

The Acoustic Section maintains monostatic and Doppler Sodar systems operational throughout the year. Both the systems are programmed to take measurements automatically and exhibit the data on computer screen with the creation of 24 hour fax record. Similarly under a sponsored project from Department of Science and Technology a phased array acoustic wind profiler was developed to study wind velocity and thermal structures of ABL. The Sodar systems were used in the fog studies undertaken by NPL. These indigenously developed systems have high commercial potential.

Fluid Flow Standards

Facility for domestic water meter testing has been installed as per IS- 779 & 6784 which is found suitable for testing of domestic water meters in the range of 15mm to 50mm diameter. Accuracy test, pressure loss test, pressure tightness test, temperature suitability test and endurance/life test can be performed with this facility. Calibration/testing of 18 domestic type of water meters was carried out using this newly created domestic water meter testing facility.

Ultrasonic Standards

For the development of an in-situ method to assess the quality of inhomogeneous material such as concrete, a new device was designed and fabricated. Based on the principle of impedance mismatch, experiments were conducted to select the material that would give highest signal strength. Contrary to the theoretically calculated values, the perspex was found to give 12 dB higher signal than the aluminium. Results have been obtained for various orders of back wall echoes with different acoustic couplants in a variety of concrete samples. A method was also developed that evaluates the Poisson's ratio of concrete in-situ without the knowledge of thickness of member. It also evaluates dynamic as well as static modulus of elasticity. In an attempt to develop ultrasonic liquid level sensor, the count rate method conceived earlier, was established based on the theory and basic set up developed last year. Various parameters such as threshold voltage, gain factor and window width have been optimized to get highest sensitivity.

R&D on Shock and Vibration Sensors

Piezoelectric Accelerometers

With its growing technology base, the laboratory has successfully developed an in-house capability and expertise in taking up the developmental work. The NPL has so far developed several different types of piezoelectric accelerometers, each featuring intrinsic performance characteristics and can be used with advantages in a variety of applications.

In the sequence of new developments, a new piezoelectric accelerometer with a remarkable low weight and extended frequency and dynamic range has been developed. It has a reference sensitivity of 5mV/g and usable frequency range from 1 Hz to 20 kHz. It is designated as PL-901. The use of special shear mode piezoelectric elements in the accelerometer PL-901 enable them a reduced transverse sensitivity, low base strain sensitivity, low inherent noise, and low susceptibility to temperature transients. This accelerometer also exhibits a peculiarly low sensitivity to extraneous environmental influences and an exceptional stability with a high signal to noise ratio in all kinds of operating environments. These added features of accelerometer PL-901 make them most suitable for use in a large variety of vibration measurement applications.

The characteristic specifications of accelerometer PL-901 are given in the Table-1.1. Technology process know-how of all these piezoelectric accelerometers are readily available.

Table – 1.1: Piezoelectric Accelerometer Developed at NPL

MODEL No.	**PL- 901**
Weight	18 gm
Sensitivity	~5 mV/g
Resonance	>60 kHz
Freq. Range	1 Hz – 20 kHz
Linearity	0.2%
Max. Shock	3000 g
Dimensions	16Hex X 20H
Case Material	SS 316

Optical Measurements

This section carried out, for the industry, calibration and testing of the optical instruments and their components such as pathological microscopes, micro-microscopes, micro lenses, microscope objectives and eyepieces, quartz control plates, neutral density filters and sun control films. The industry people were advised accordingly to improve the quality of their respective products.

It pursued R & D work on a new method to measure focal length of microscope eyepieces and applied the newly developed

method for the calibration of sample eyepieces from the industry. The measurements of focal length of a convex lens were carried out by using the nodal point and the magnification methods and the uncertainties associated with the results by two methods were compared.

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विद्युत तथा इलेक्ट्रॉनिक मानक

ELECTRICAL AND ELECTRONIC STANDARDS

विद्युत तथा इलेक्ट्रॉनिक मानक

विद्युत तथा इलेक्ट्रॉनिक मानक प्रभाग निम्नलिखित कार्यों के एस आई यूनिट को ज्ञात करने में संलग्न हैः– समय और आवृत्ति जैसे विद्युत इलेक्ट्रॉनिक और चुम्बकीय प्राचल के प्राथमिक/राष्ट्रीय मानक के समय विकास और अनुरक्षण के कार्य में जोसेफसन वोल्टता, डी सी वोल्टता, धारा और प्रतिरोध, ए सी शक्ति और ऊर्जा, ए सी उच्चधारा तथा उच्च वोल्टता, ए सी वोल्टता, धारा प्रतिरोध, एल एफ और एच एफ प्रतिबाधा (स्थानीकृत प्राचल), एच एफ तथा सूक्ष्मतरंग शक्ति, क्षीणता, प्रतिबाधा और शोर तथा चुम्बकीय क्षेत्र। यह प्रभाग ए पी एम पी और बी आई पी एम तथा द्विपक्षीय तुलनाओं द्वारा आयोजित अन्तर्राष्ट्रीय अन्तर्तुलनाओं के विषय में भागीदारी करता है ताकि अन्तर्राष्ट्रीय अनुमार्गणीयता/समानता का स्तर निर्धारित हो सके। यह प्रभाग प्राचलों में शीर्ष स्तरीय अंशांकन सेवा तथा तकनीकी परामर्श को अन्य अंशांकन प्रयोगशालाओं और उद्योगों को प्रदान करता है।

पारस्परिक मान्यता देने की व्यवस्था के अंतर्गत विभिन्न प्राचलों से सम्बन्धित अंशांकन एवं मापन क्षमताओं के दावें बी आई पी एम में दाखिल किए गए हैं। निम्नलिखित क्षेत्रों के कुल 456 दावे बी आई पी एम के परिशिष्ट–सी में शामिल किए गए हैं। जोसेफसन वोल्टता मानक (2), डी सी मानक (23), ए सी शक्ति और ऊर्जा (32), ए सी उच्च वोल्टता तथा उच्च धारा (8), एल एफ और एच एफ प्रतिबाधा मानक (44), एल एफ तथा एच एफ वोल्टता, धारा और आर एफ शक्ति (334), आर एफ क्षीणन और प्रतिबाधा (5), डी सी उच्च वोल्टता (3) और चुम्बकीय मानक (5)।

धारिता और ए सी प्रतिरोध मापन में आने वाले प्रवीणता प्रशिक्षण कार्यक्रम एन ए बी एल–एन पी एल एम ओ (MoU) यू के अन्तर्गत संचालित किए गए हैं। यह प्रभाग तकनीकी मूल्यांकक अधिकारी प्रदान कर अंशांकन प्रयोगशालाओं के मूल्यांकन में एन ए बी एल की भी सहायता कर रहा है।

ELECTRICAL AND ELECTRONIC STANDARDS

The Electrical and Electronic Standards Division is engaged in realization of SI Unit of Time. 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 inpedance (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/degree of equivalence. It provides apex level calibration service and technical consultancy in the above parametes to other calibration laboratories and industries.

Calibration and Measurement capabilities (CMC) claims of various parameters have been submitted to BIPM, as a part of Mutual Recognition Arrangement. A total of 456 claims in the following parameters have been included in Appendix C of BIPM: Josephson Voltage Standards (2), DC Standards (23), AC Power & Energy (32), AC High Voltage and High Current (8), LF & HF Impedance Standards (44), LF & HF Voltage, Current and RF Power (334), RF Attenuation and Impedance (5), DC High Voltage (3) and Magnetic Standards (5).

Proficiency Testing (PT) programmes in capacitance and AC resistance measurement were conducted under NABL-NPL MoU. This division is also helping NABL in assessment of calibration laboratories by providing technical assessors.

Time & Frequency Standards

NPL is custodian of the Indian Standard Time (IST). It disseminates IST signals via INSAT known as STFS Service and also through Telephone Network called Teleclock Service. The IST, maintained at NPL by Cesium Atomic Clock, is continuously kept traceable to UTC of BIPM through GPS Network. There are now more than 50 dedicated users of STFS time service located all over the country. The latest receiving systems for STFS service, designed by NPL, provides time transfer accuracy of the order of 1 ms. The power generating and distribution agencies are the single largest users of this service other than Badarpur Thermal Power Station and Agilent Technologies, Bangalore. A project on setting up of facilities for dissemination of IST in North Eastern States using both STFS and Teleclock Time services is being implemented.

The design, development, fabrication and commissioning of the transmitting and receiving systems to initiate digital time data service through telephone line in Saudi Arabia has been completed. The performance of GPS Receiver (of M/s Accord Software & System) for PTTI timing application is being optimised. Evaluation of the performance of the DGPS (Differential GPS) stations belonging to the Department of Light Houses & Light Ships, Govt. of India, has been undertaken under consultancy project. "Replacement of Centralized Clock System in Parliament House" has been started with the advice and assistance of NPL.

A Distributed Bragg Reflector (DBR) diode laser was frequency stabilized against hyperfine transition of Cs D_2 line at 852 nm. The stability of the diode laser system was estimated against a frequency stabilized Extended Cavity Diode Laser (ECDL) system at 852 nm, developed earlier, by heterodyne beat frequency experiment. Relative standard uncertainty of 3.15×10^{-11} has been observed.

Optimization of the Physics Package of Rubidium standard of the Department of Lighthouse and Lightships has been undertaken by NPL as consultancy project . One NPL scientist has been associated with the R&D work related to the space qualified Rb atomic clock for the Galelio Satellite under the European Commission's CRAFT project.

Josephson Voltage Standard & Superconducting Devices

Josephson Voltage Standard

Josephson series array voltage standard is maintained at 1 volt level. The "National standard" of volt is calibrated against the Josephson voltage at regular intervals. R&D work is in progress to realize 10 volt Josephson series array voltage standard.

Cryo-cooled Sapphire Dielectric Resonator as 'Flywheel' Standard for Atomic Clock

Time and frequency standards based on cold atoms require microwave flywheel oscillator with frequency stability $\sim 10^{-14}$. The single crystal sapphire loaded dielectric resonators are in focus as high Q, highly stable frequency-determining elements in dielectric resonator oscillators (DRO). Dielectric resonators using low loss sapphire as the dominant dielectric material has the potential for Q-value of the order of 10^5-10^7 depending on the mode and frequency of operation. However, sapphire has a rather poor thermal behavior that leads to frequency temperature sensitivity of the order of –10 ppm / K at 77K. Thus, there is a great interest in the development of temperature-compensated sapphire resonators operating at a convenient temperature of operation (i.e. above 77K).

In a cylindrical dielectric the whispering gallery (WG) modes are high order modes of large azimuthal mode number m>5. In WG mode the electromagnetic energy is confined around the dielectric/ air interface inside the crystal because of total internal reflection that

minimizes the radiation and conduction loss thereby increasing the Q-value. Since the permittivity of the sapphire is low, large size of crystal (3-5 cm diameter) is needed to excite WGM for operation in the frequency range close to the hyperfine transition of cesium clock (9.192 GHz). We designed and fabricated, Figure 2.1a, a WGM resonator and achieved frequency-temperature compensation by employing composite of sapphire and rutile making use of the opposite temperature coefficient of permittivity of sapphire and rutile. The resonator shows the turn-over temperature at around 92 K for the $WGE_{6,0,0}$ mode at 9. 98828 GHz, Figure 2.1b. The maximum Q-value measured in this mode is ~ 1.48 x 10^5 at the turn-over temperature. The resonator was used, in a preliminary oscillator design, which included an amplifier, a feedback loop and a phase shifter. The phase shifter was inserted to adjust the correct mode for the oscillator. The phase noise of the oscillator, measured using an HP 8562A spectrum analyzer was ~ -90 dBc/Hz at 10 kHz at the turn over temperature which is actually limited by the sensitivity of the measurement set up.

It is proposed to design high-Q sapphire and rutile rings with a larger diameter to achieve higher Q-value and to operate close to the hyperfine transition frequency 9.192631770 GHz.

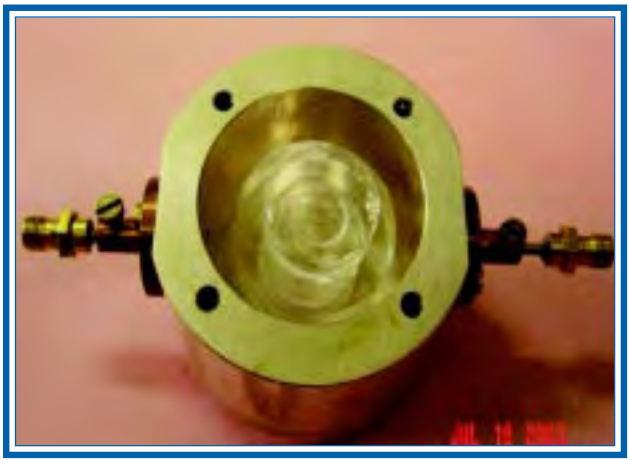

Fig. 2.1a: WGM sapphire-rutile resonator

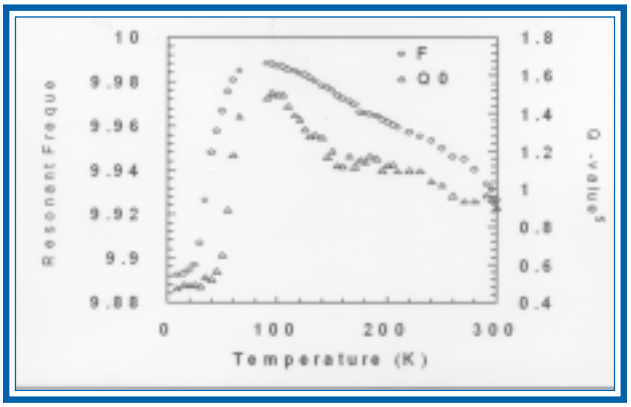

Fig. 2.1b: Variation of f and Q-value with temperature showing turn-over temperature.

Studies on MgB_2 Superconductors

Noise due to thermally activated vortex in polycrystalline MgB_2 superconductor is measured using a high-T_c SQUID sensor. The SQUID is mounted just above the MgB_2 sample. The sample is cooled in earth magnetic field. Figure 2.2 shows the temperature dependence of the noise at the SQUID output which essentially represent the noise due to vortex motion in MgB_2 superconductors. An increase in noise is observed as the temperature approaches to T_c of the sample.

A study of generation of higher harmonics in MgB_2 polycrystalline superconductor when the superconductor is exposed to ac and dc field has been carried

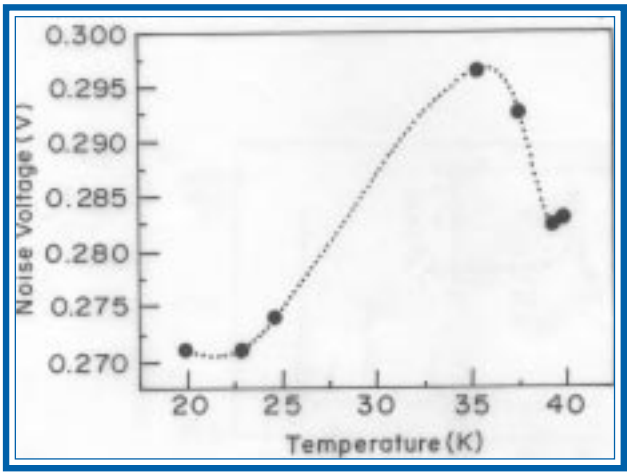

Fig. 2.2: Temperature dependence of the noise due to vortex motion in MgB_2 superconductors

out with a view to understand the nature of grain boundaries in MgB_2 superconductors. Two coil arrangement is used for this study. On the application of ac field of 10 kHz, generation of odd harmonics correspondingly to 30, 50 kHz is observed whereas on the application of dc field in addition to the ac field leads to generation of even harmonics also (Figure 2.3). Generation of even harmonics indicates presence of weak link grain boundaries in MgB_2 superconductors. This is in confirmation to our earlier experiment of observation of SQUID voltage-flux oscillations in polycrystalline MgB_2 superconductor which also indicated the presence of some Josephson junction type weak link grain boundaries. Our result of the presence of some weak link grain boundaries in MgB_2 is of great significance for high current applications and electronic devices such as Josephson junction and SQUIDs.

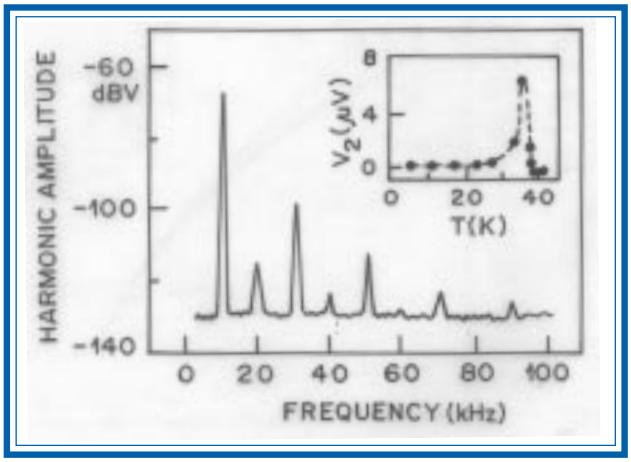

Fig. 2.3: Harmonic generation response of MgB_2 superconductor at 31 K (Hac = 3.5 G and Hdc = 3.7 G). The inset shows the temperature dependence of amplitude of second harmonic.

Study of Magnetic Field Dependence of Transport across Bicrystal Grain Boundary in CMR Film

Bicrystal grain boundary in $La_{0.7}Ba_{0.3}MnO_3$ thin film is found to exhibit substantial magnetoresistance at low field and non-linear I-V characteristics. In order to understand the effect of magnetic field on the transport across grain boundary, I-V characteristics of the junction is recorded at different field. Figure 2.4 shows conductance (dI/dV=G)- voltage curves for different magnetic field. These curves are fitted to $G/G_0 = 1+kV^{\alpha}$ where k and α are constants. Decrease of the value of k at higher field suggests that metallic channel increases across the grain boundary with the increase of magnetic field.

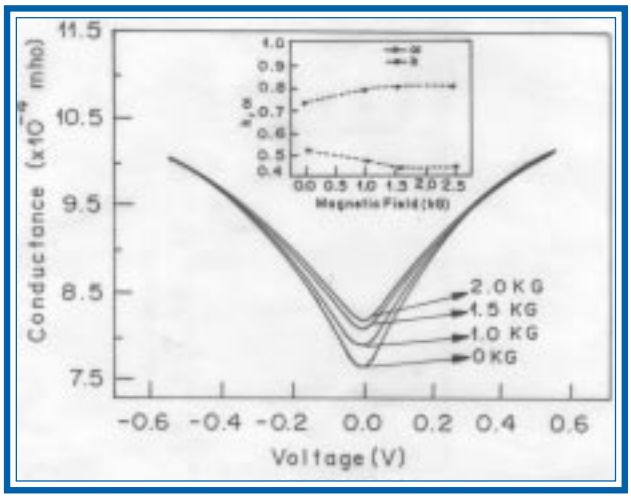

Fig. 2.4: conductance (dI/dV=G) - voltage curves for different magnetic field. The inset shows variation of α and k with the field.

Effect of Substrate on Magneto-Transport Properties of Polycrystalline Manganite Films

Polycrystalline films of $La_{0.7}Ca_{0.2}Ba_{0.1}MnO_3$ (LCBMO) are deposited on $LaAlO_3$ (LAO), $SrTiO_3$ (STO), Al_2O_3 and YSZ single crystal substrates by spray pyrolysis technique. Deposition and annealing conditions for all four films were kept identical. The magneto-transport properties of these polycrystalline LCBMO films are found to depend strongly on the substrate. The lattice mismatch between the film and substrate induces strain of various degrees. The strain is believed to get relaxed and accommodated. This produces disorders dominantly through the increase in the grain boundary density. The largest strain leads to the creation of highest degree of disorder. The

observed MR for the case of YSZ/LCBMO & Al_2O_3/ LCBMO is found to be significantly higher than for the LCBMO films on STO and and LAO.

DC Voltage, Current and Resistance Standards

An automated DCC bridge, first of its kind in the country, was set up in the group. This has low uncertainty in the measurement range (10 $\mu\Omega$ -10 GΩ) and at par with international level. The newly procured bank of four, 1Ω standard resistors, are kept in an oil-bath at temperature of 25° C ± 0.001 °C and calibrated against 1Ω resistor (uncertainty ± 0.06 mΩ at k=2) which is traceable to Quantum Hall Resistance of NPL, U.K. using this automated DCC Bridge having an uncertainty of ± 0.05 ppm at k=2 in the basic range (DCC bridge traceable to NRC Canada). This bank forms 'National Standard' of resistance in India.

The Nanoscan voltage reference standard, Fluke 7004N was set up as a bank of Zener reference standard. It consists of four module of individual reference standard (with temperature controlled oven for the Zener diode) having 10 volt and 1.018 volt output traceable to Josephson series array voltage standard of NPL-UK with an uncertainty ± 0.03 ppm at k = 2 (at 10 volt). The Nanoscan system provides a 10V average output, a 1V divided output and a 4-wire buffered 10 V output, together with a measurement scan controller, a null detector and fiber-optic based RS-232 interface to a computer. The complete system is operated automatically using 'Voltage Maintenance Software'. The software having facility to calibrate the Zener standard/ reference standard (Device Under Calibration) automatically and estimates the uncertainty in measurement, store the history, drift record/drift plotting and report preparation. This setup is used for dissemination of calibration for other reference standard/ secondary standard in the country with an uncertainty of ≤ ± 1 ppm for 10 volt and 1.018 volt respectively.

AC High Current & High Voltage Standards

This section is maintaining National Standards of AC High Current and High Voltage Ratios at power frequencies (50Hz) by using Reference Standard Current Transformers and Reference Standard Voltage Transformers. Calibration services were provided for Current Transformers, Current Transformer Testing Sets, Clamp Meters, Weld Testers, CT Burdens and for Voltage Transformers, Voltage Transformer Testing Sets, HV Probes, Electrostatic Voltmeters (ESVMs), HV Breakdown Test Sets and Voltage Transformer Burdens etc. As many as 23 calibration certificates were issued to the electrical manufacturers and utilities.

LF and HF Impedance Standards

Proficiency testing in capacitance measurement for NABL accredited laboratories has been conducted in collaboration with NABL. A 100 pF air capacitor was used as traveling standard. In this programme NPLI was the Reference Laboratory and 13 calibration laboratories of India had participated. Second proficiency testing programme for capacitance measurement has been initiated. In this programme 16 laboratories are participating including NPLI as Reference Laboratory. A 10 pF air capacitor is being used as traveling standard.

Proficiency testing programme in the field of ac resistance measurement for NABL accredited laboratories was conducted in collaboration with NABL. A set of four standard resistors having nominal values of 1 Ω, 100 Ω, 1 kΩ, and 10 kΩ were selected as artifacts and NPLI acted as the coordinating laboratory.

Development of direct reading resistance bridge based on Inductive Voltage Divider was completed. This bridge was evaluated using standard resistors. An accuracy of 5 ppm was obtained in 1 kΩ resistor at 1 kHz.

One Scientist of this group visited CSIR-NML (South Africa) to help them in setting up the Quadrature bridge and other precision ac bridges used in determination of Farad from Ohm, under MoU signed between NPLI and CSIR- NML (South Africa).

LF & HF Voltage, Current & RF Power Standards

The following entries in LF & HF Voltage, Current & RF Power have been included in the Appendix-B (Key and Supplementary Comparisons) of MRA.

- CCEM–K6.a : Comparison of AC/DC voltage transfer standards at the lowest attainable level of uncertainty 1993 – 1999
- CCEM – K6.c : Comparison of AC/DC voltage transfer standards at high frequencies 1995 – 1999
- APMP.EM.RF-S2 : Comparison of RF Power; 1995 – 1998
- APMP.EM- S2 : Comparison of AC/DC voltage transfer standards; 1996 - 1998
- APMP.EM-K6.a: Comparison of AC/DC voltage transfer standards at the lowest attainable level of uncertainty 2000 -2003
- CCEM.RF–K13.CL : Voltage measurements at 1 mV, 30 MHz
- EUROMET.EM.RF- K10.CL : Comparison of radio frequency power; 2002 – 2003.

RF Attenuation and Impedance Standards

A 30 MHz Attenuator and signal calibrator (Model No. VM-7 from M/s Tegam Inc. USA) and a frequency converter (Model No. 8853 from M/s Tegam inc. USA) based on triple conversion of frequencies from 6-13.333 GHz (available from existing synthesised signal sources upto 18 GHz) to 18 - 40 GHz range and a picowatt power sensor from 50 MHz to 50 GHz (Model No. 8487D from M/s Agilent Technologies, USA) have been procured under the Upgradation programme of National Standards of Measurement and Apex Calibration Facilities in Critical Areas of Industrial Importance. The frequency range of the attenuation measurement has been extended upto 40 GHz in coaxial and waveguide systems using the above equipments. The experimental set-up for the measurement of attenuation in the 18 – 40 GHz microwave frequency range is shown in Fig. 2.5. 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.

Fig. 2.5 Experimental set-up for the measurement of attenuation (18 – 40 GHz)

Magnetic Standards

We have received Vibrating Sample Magnetometer from M/s Lakeshore Crytronics Inc., USA. The installation work is in progress. By addition of this facility it will be possible to characterize magnetic media materials, permanent magnetic materials including electrical steel, ferrites etc. Calibration / Testing

work was continued with the existing facilities available with us. In all 32 calibration certificates/ test reports were issued.

Biomedical Measurements & Standards

Lithotripsy

The basic research in lithotripsy was continued further. The removal of kidney stones (renal calculi) or gall bladder stones is made non-invasively, without surgery, these days. It is cosidered that the disruption is due to transient cavitation from the extracorporeal-shock-wave lithotripsy (ESWL) on the stone surface. Also, the shock wave from the ESWL, due to focussed ultrasound, is used to disintegrate the stone fragmentation faster. Theoretical modelling of stress wave propagation in the renal calculi under focussed ultrasound has been studied and proposed. The Extracorporeal Shock Wave Lithotripter (ESWL) was characterized for its working parameters like excitation voltage, resonance frequency, bandwidth, and output energy. It was found that an acoustic transducer with 40 to 60 kHz, with several watts of power can be used, for external stimulation. For this investigation, a special VFVAT (variable-frequency-variable-amplitude transducer) was developed and used for acoustic stimulation. It was found that with the increase of the frequency and power of the stimulating transducer, the size and the number of cavitation bubbles are found to be enhanced. Further work on the design of a novel smart silicon sensor was done to measure the acoustic power output of the ESWL. The sensor system has a four-arm Wheatstone strain gauge and the associated electronic circuitry on the same chip. The sensor is very useful in the study of the pressure amplitudes of the shock wave lithotripter.

Safety Standards for Lithotripters

Performance output was measured to determine the safety limits of dosage level required for the optimization of acoustic lithotripters.

Electro-medical Standards

Study of ECG calibration system was undertaken. Procurement of the ECG standard and associated systems like phantoms and simulators is in active process. As is aware, these days, there is an urgent need to develop and establish standards and calibration facilities for biomedical equipment in the country, for better healthcare. A new programme on the 'development and establishment of standards and calibration facilities for electro-medical equipment' has been formulated at NPL, for better healthcare in the country.

Characterization of Biological Tissues

a) Human Teeth and Dentures: The work was continued further. Dielectric and ultrasonic properties of the human teeth and denture materials, collected from different hospitals, have been studied. Porosity and XRD studies are made for comparative data with respect to the chemical constituents.

b) Bone Cyst: Ultrasonic properties of bone cyst, in vitro, gave propagation velocity and attenuation in the range 1600 to 1670 m/s and 1840 to 2180 dB/m, respectively. The variation of these parameters are due to porosity and complex nature of the samples used.

c) Malignant Bone with Osteosarcoma: Further studies were made on osteosarcoma to get standard data for the proper treatment of such abnormalities in the bone.

d) Uterine Leiomyoma:. Ultrasonic characteristics of these uterine tumours, uterine Leiomyoma, solid in nature, in vitro, studied by using a double-probe through-transmission technique, showed the average acoustic velocity and attenuation as 1550 m/s and 435 dB/sq m, respectively, at 3.5 MHz frequency

and room temperature 28 degree C. The present investigation is useful in tissue differentiation to enable the doctors to give proper treatment. This is an original investigation.

Dosimetry and Safety Standards

Safety standards were identified for various biological parameters under ultrasound effect.

Study of Preservative Materials for Ancient Monuments

The research has been pursued further in the study of materials and preservatives for the protection of historical monuments against ageing effect and other environmental impacts on the structure.

a) Study of Weathered Red Sandstone with Petrographic Technique

With the ever increasing pollution level, the stone structures, a historic landmark in world's culture, have started showing a degradation phenomenon. Though the building materials get disfigured, discoloured and fragile as a result of normal environmental weathering, but with exposure to the steadily increasing pollution, the structures are getting plagued to irreversible damage. A number of scientific and instrumental techniques are used in the field of conservation to study different stone parameters for understanding the behaviour of the building structure with respect to weathering. Here, an attempt has been made in this direction by using petrographic technique. A comparison between the thin sections and photomicrographs of the weathered and the fresh stone samples has also been made to give an extent of decay. The results show appreciable losses in the weathered stone matrix as a result of the leaching out of the cementing material resulting in porosity.

b) XRD Study of Red Sandstone

Further study was made in this direction**.** The stones with and without polymer as preservatives were studied for the elemental analysis to know the appropriate material for long term maintenance of the historical monuments against the deterioration from weather and other environmental effects.

c) Ultrasonic Study of Red Sandstone

Ultrasonic studies were carried out on different types of red stone samples with and without the application of preservative materials, in this case polymers and with other chemicals.

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इंजीनियरी पदार्थ

ENGINEERING MATERIALS

इंजीनियरी पदार्थ

इंजीनियरी सामग्री प्रभाग विभिन्न क्षेत्रों में प्रयुक्त होने वाली सामग्री, संघटक और युक्तियों के विकास कार्य में संलग्न है। यह सामग्री मृदु और पॉलीमरिक सामग्री से लेकर धातु और मिश्रधातु, सम्मिश्रों और कार्बन सामग्री तक अलग–अलग प्रकार की होती है। इस प्रभाग का प्रमुख कार्य औद्योगिक और सामरिक क्षेत्रों, दोनों में अनुप्रयोगों के लिए प्रयुक्त नवीनतम और उच्चस्तरीय सामग्री और युक्तियों के लिए देश की आवश्यकताओं को पूरा करना है। यह प्रभाग इंजीनियरी सामग्री के उक्त क्षेत्रों में लगे हुए निजी उद्योगों को परामर्श सेवाएं प्रदान करता है।

ENGINEERING MATERIALS

The Division of Engineering Materials is dedicated to the development of materials, components and devices in widely varying areas, ranging from soft and polymeric materials to metals, alloys, composites and a variety of carbon materials. The main thrust of this division is to cater to the country's needs for newer and advanced materials and devices for applications in both industrial and strategic fields. The Division also provides consultancy to private industries in the above areas of engineering materials.

Metals & Alloys

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

This project was sanctioned in two phases, which were sponsored by Hindustan Aeronautics Limited, Bangalore, and formed the total Technology Development package for the development of oval shaped tube as skid landing gear for ALH. This project was successfully completed this year.

Phase I of this project comprised of converting the circular mother tubes (2024 Al-alloy) into oval shaped tubes. Six nos. of such full sized oval shaped tubes were earlier developed at NPL and inspected by the officials of Helicopter Division of HAL. These tubes met all the specified dimensional tolerances. These oval shaped tubes were to be used for carrying out the developmental work under Phase II of the project which involved (i) Solutionising of these tubes, (ii) Converting them into T_3 condition, (iii) Imparting a cold reduction of 1 to 2% and (iv) Bending one end to achieve a radius of 800 R within the dimensional tolerances as specified by HAL.

Bending of oval shaped tube on its major axis is a very challenging job, as there is a significant differential in length between the inner arc and the outer arc of the bent tube. On the outer contour, the material flows leading to thinning of the wall thickness, while on the inner contour of the tube, the excess material results in wrinkles. In view of these anticipated problems, it was initially proposed by HAL, Bangalore, to get the bending of the oval shaped tubes developed at NPL, done by a private firm in Mumbai, which had the technology and the expertise in tube bending. However, after this firm expressed its inability in taking up this work, NPL took up this challenge and designed and developed a hydraulically operated tube-bending machine and the experiments to bend these tubes on its major axis were taken up. As expected, wrinkles were observed on the inner contour of the oval shaped bent tube. Modification were incorporated in the hydraulic circuitry of the bending machine to achieve a controlled strain rate. After making lot of trials, success was obtained in getting a tube, which was wrinkle-free on the inner contour of the bent tube.

The other challenge in this project was to quench these solutionized oval shaped tubes in water in 30 seconds, impart a cold draw achieving a reduction of 1 to 2%, and finally bend these T_3 condition tubes (2024 Al alloy) to achieve a radius of 800 R within almost 30 minutes from its quenching. Initial experiments revealed that when a heated and soaked tube at 490°C was withdrawn from the furnace and quenched in the water, it resulted in a distorted tube showing a banana shape. This was mainly because of very large length (5 m long) and a very low wall thickness of tube (i.e., 3 mm).

To overcome this problem of distortion, special fixtures were designed and got fabricated so that the oval shaped tube is encapsulated all along its length in these fixtures before it is kept in the furnace. When the temperature is attained, the tube along with the encapsulating fixture is withdrawn from the furnace and quenched. All this minimised the distortion of the tube to a great extent. To carryout this, the total furnace had to be dismantled and large diameter furnace tube was fitted to accommodate the oval shaped tube along with the fixture.

After successfully overcoming the problems for imparting T_3 condition (solution heat-treatment and cold reduction of 2-3%) in the oval shaped tubes and in bending the actual sized oval shaped tubes, experiments were conducted in order to bend this oval shape tube in T_3 condition on the bending machine within the specified time interval of 30 minutes. After optimizing the experimental process parameters, the oval shaped tube in T_3 condition was successfully bent to the desired radius maintaining all the dimensional tolerances.

NPL has thus successfully demonstrated the technology development of converting the

circular tubes into oval shaped tubes within the specified dimensional tolerances. It has also successfully demonstrated the process technology development of wrinkle-free bending of the oval shaped tubes in T_3 condition, on a specially designed hydraulically operated tube bending machine, achieving a radius of 800 R on one end. NPL has already sent 3 nos. of 2024 Al-alloy actual cross section oval shaped tubes and the 3 nos. of actual oval shaped bent tubes to Foundry & Forge Division, HAL, for their further evaluation. After receiving a written communication from HAL, about the successful completion of the technology development of oval skid tube followed by subsequent bending and heat treatment, this project was completed this year.

Development of Spray Forming Technology of Mg-alloy systems (Mg-Al-Zn)

Work was continued in this VSSC sponsored project with an emphasis on process parameter optimization in order to obtain large sized flat shaped as-sprayed AZ31 Mg-alloy (Mg-Al-Zn) deposits with enhanced mechanical properties. The spray atomization & deposition of Mg-alloys is very challenging, primarily because Mg-alloys are very prone to oxidation, which is detrimental to the mechanical properties of the spray formed products. In order to avoid oxidation, several precautions had to be taken in conducting these spray forming experiments. Efforts were made to pre-heat the mother alloy, crucible as well as the atomization chamber prior to atomization and deposition. For each experiment, the chamber was carefully evacuated and purged with Argon gas and this cycle was repeated several times to ensure oxygen/moisture free atomization & deposition atmosphere. Even while heating and melting the mother alloy, Argon gas was continuously purged and exchanged while maintaining a positive pressure of Argon gas in the atomization chamber to further avoid oxidation. Even after spray forming was completed, a continuous stream of Argon gas in the atomization chamber had to be maintained till the Mg-alloy deposit cooled to about 200°C. These precautions had earlier ensured that the formation of undesired MgO phase was eliminated, as evidenced by X-ray diffraction studies made on as-sprayed Mg-alloy deposits. A few experiments of spray atomization and deposition of Mg-alloys were also witnessed by senior scientists from VSSC, Trivandrum.

By varying the process parameters, using Argon as atomizing gas, it was possible to obtain nearly flat shaped as-sprayed Mg-alloy deposits. The yield of the as-sprayed deposits (for 7~7.5 kg melt) was found to be in the range of 60-65% of the weight of the melt. The optical microscopy of the Mg-alloy as-sprayed samples indicated finely divided equiaxed microstructure with average grain size of about 30-50 microns with no indication of any dendritic features. A detailed density analysis of a typical Mg-alloy as-sprayed sample indicated nearly uniform density along the entire central transverse cross-section (length ~ 170 mm) of 94-95% of the theoretical density. The Ultimate Tensile Strength of the spray formed Mg-alloy samples, as measured on the Tensile Testing Machine (Instron), varied between 130-150 MPa with an elongation of 6%. The Young's Modulus measured using the elasto-sonic equipment, exhibited values in the range of 39-41 GPa. However, on secondary processing this as-sprayed Mg-alloy deposit using warm forging on a 500-ton vertical hydraulic press, employing specially designed forging tooling, the mechanical properties were found to increase considerably. The Ultimate Tensile Strength improved to about 208 MPa, elongation increased to 12% and the Young's Modulus to about 44 GPa. Efforts are still underway to further improve these mechanical properties and to increase the size of spray formed deposits so as to obtain blocks of acceptable dimensions and mechanical properties after secondary processing.

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

Several experiments were carried out on the spray atomization and deposition unit to synthesize Aluminium in flat shapes and in relatively large sizes. Spray forming process parameters were optimized in order to achieve a spray formed deposit with high density and low grain size so as to exhibit high mechanical properties. In particular, the flight distance and delivery tube diameter were varied to study their effect on spray-formed product. After optimizing the process parameters, it was possible to achieve nearly flat shaped deposits. Typical yields were found to be about 70-75% of the weight of the melt with a density of about 88-92% of the theoretical density, in the central core of the deposit. The optical microscopy studies conducted after polishing/lapping and etching these as-sprayed samples in Keller's reagent indicated finely divided microstructure with average grain size of about 25-40 microns with no indication of dendritic features generally associated with cast alloys. These as-sprayed deposits would be secondary processed to study the effect of deformation on the mechanical properties.

A few spray forming experiments were conducted in order to obtain Al-Si alloy deposits using Nitrogen as atomizing gas. Al-Si alloys are an important class of materials primarily due to their tribological, mechanical and thermal properties, especially for automobile piston applications. Presently this material is generally synthesized using liquid metallurgy technique. A few spray forming experiments were carried out by varying the delivery tube diameter (3–4 mm) and the flight distance (350–400 mm) to study their effect on the properties of the as-sprayed product. Work is in progress to secondary process this as-sprayed material to study its physical and mechanical properties, after hot extrusion.

Synthesis of Al-Alloys/Graphite MMC Using Stir-Casting (Liquid Metallurgy) Technique

Exploratory work was carried out to synthesize MMCs using Al (commercial grade), Al-Cu-Mg (2124) and Al-Si alloys as the matrix materials reinforced with 5% Graphite, using stir-casting technique. The results indicated that in case of Al (commercial grade) and Al-Si as matrix materials, there was very little wetting of graphite by liquid metal even after churning at 250 rpm, and as a result, MMCs with homogenous dispersion of reinforced graphite could not be obtained. However, Al-Cu-Mg alloy when used as the matrix material, gives reasonably better wetting of graphite reinforcement by the liquid metal, resulting in a better homogeneous distribution of graphite in 2124 Al-alloy matrix. This could be due to the presence of Mg as an alloying element in 2124 Al-alloys, which is known to enhance wettability (in case of SiCp).

CSIR Network Projects under the X Five Year Plan

Two projects were sanctioned this year in the CSIR Network programme under the X Five Year Plan.

(i) Under the CSIR Mission Mode Programme on "Custom Tailored Special Materials", we have been sanctioned a project entitled *"Development of discontinuously reinforced metal matrix composites reinforcement using powder metallurgy technique".*

(ii) Under the CSIR Mission Mode Programme on "Catering to Specialized Aerospace Materials", a project entitled *"Development of Al and Mg-alloys using different primary processing techniques, followed by secondary processing, employing hot-extrusion/warm forging to produce rods/tubes/sections"* has also been approved.

Advanced Carbon Products

Development of Pitch-based Carbon Monofilament

Work was continued under the on-going ARDB-sponsored project on the "Development of carbon monofilament suitable for CVD-based SiC fibres". Having already tried successfully the use of polycarbonate (PC) among a variety of polymers as an additive to improve the strength, flexibility and handleability of the carbon monofilament in the green stage, a study of the effect of diameter on the mechanical properties of the carbon monofilament was conducted using neat and modified pitches (by PC addition). The tensile strength (TS) of monofilaments based on neat and 20% PC modified pitches showed enormous increase from 630 and 800 MPa at a diameter of 38 μm to values of 1600 and 2320 MPa at a diameter of 16 μm, respectively. Similarly, the tensile modulus (TM) also showed a remarkable increase in its value from 45 and 62 GPa at 38 μm diameter to 160 and 200 GPa at a diameter of 16 μm. Besides this, a study of viscosity–temperature behaviour showed that the viscosity of the neat and modified pitches lies in a narrow range of 12–15 Pa.s at the respective suitable spinning temperatures. This finding is very useful for estimating the suitable spinning temperature of a precursor pitch.

In addition, a study of the effect of heat-treatment temperature (HTT) on the characteristics of the resultant carbon monofilaments based on neat and 20% PC modified pitches was carried out. The monofilaments based on the neat pitch, upon heat treatment to 600° C, were found to have a linear shrinkage of 4.9% coupled with a TS of 281 MPa and a strain-to-failure (STF) of 2.2%, compared to a TS of 2.9 MPa with a STF of 0.2% of the filaments in the green stage. In the case of PC (20%) modified pitch, a much higher value of TS of 425 MPa but coupled with a lower STF of 1.4% and a higher linear shrinkage (14.3%) were obtained. The neat pitch was thus found to provide a good system for its conversion into a good carbon monofilament (shown in Fig.3.1) via the pre-carbonisation method. The project was successfully completed, the final report of which was submitted to the sponsoring agency (ARDB).

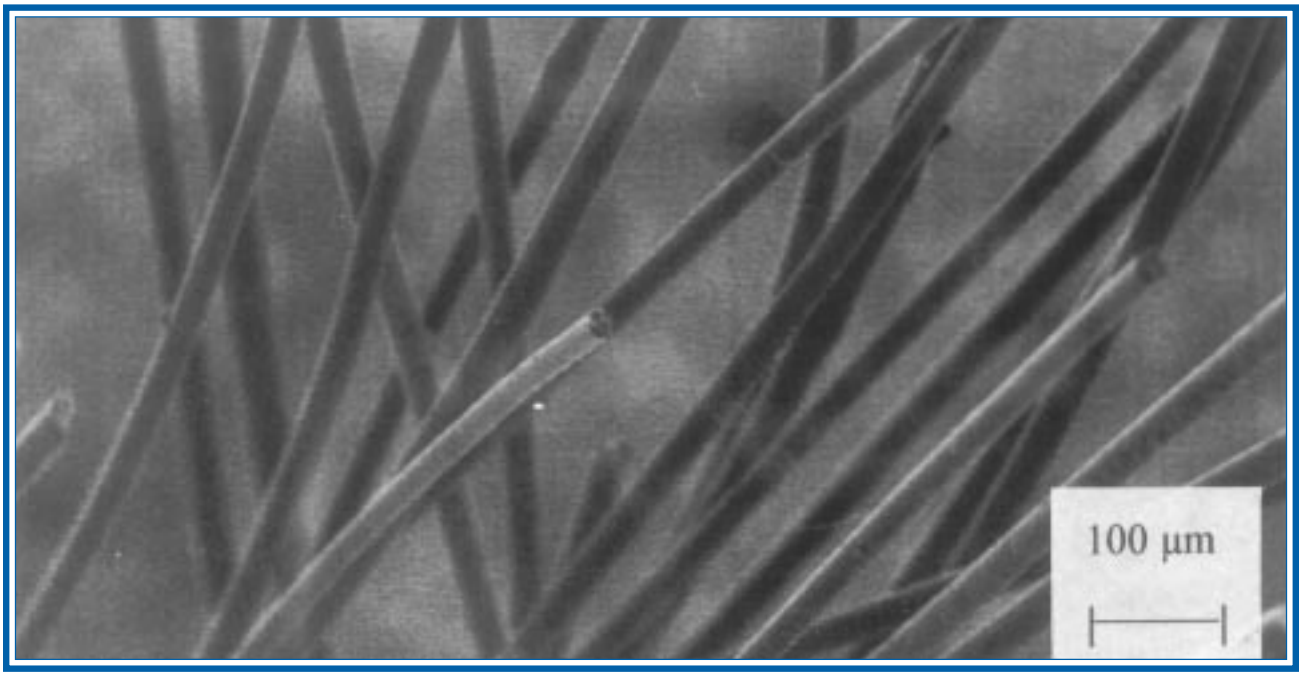

Fig. 3.1 SEM photograph of carbon monofilaments based on neat pitch.

Development of Carbon-Ceramic Composites

Work was continued under the in-house project on the "Development of carbon-ceramic composites". Having found the 'particulate route' to be the better option compared to the 'sol-gel route' for incorporating SiC into the green coke (carbon source), efforts were made to develop C-SiC-B_4C composites using the particulate route only. The composites made using unidirectional as well as isostatic moulding and heat-treated to 2200 °C were found to possess a bulk density of 1.90–1.95 g cm^{-3}, bending strength of 70–80 MPa and an electrical resistivity of 1.3–2.8 mΩcm, and exhibited a weight loss of 0.5–7.0 % at 800–1200 °C. Efforts are continuing to bring down the weight loss further by optimisation of the various parameters.

Synthesis of Carbon Nanotubes and their Application in Composites

Systematic studies were undertaken to produce carbon nanotubes inside the D.C. arc discharge reactor by incorporating various combinations and atomic percent of catalysts. The processing parameters were optimized to give 5 g of carbon soot per run, containing a minimum of 50% carbon nanotubes, as revealed by SEM and TGA characterization.

Studies were continued to isolate the tubes from the carbon deposits by removing catalyst particles, nanostructured carbon and amorphous carbon by various physical and chemical routes, such as thermal and hydrothermal treatment, soxhlet extraction, decantation, microfiltration etc.

For making high performance composites from nanotubes, the most important step is the dispersion of nanotubes in the pitch matrix. A new approach was adopted which gives quite uniform distribution of the nanotubes/ropes in the matrix pitch, as shown in Fig.3.2. Another advantage with this process is that one can achieve a desired softening point in the reinforced pitch. This reinforced pitch will be used as a precursor for making composites of size 50mm×5mm×3mm.

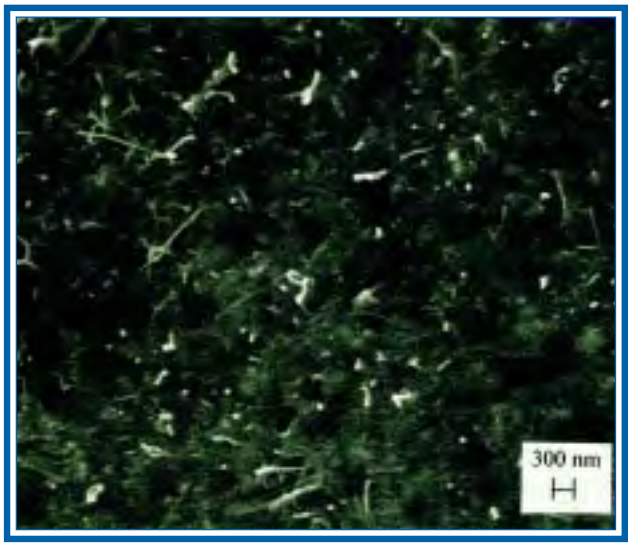

Fig.3.2 SEM photograph showing the dispersion of carbon nanotubes in the matrix pitch.

Development of Porous Conducting Carbon Paper

The studies were continued under the project sponsored by NMRL, Ambernath (DRDO). Several batches of Porous conducting carbon paper of size 400mm×400mm×0.3mm with desired specifications (density 0.5 g/cm^3, porosity >70%, gas permeability ~3 cm^3/s. electrical resistivity 0.005 Ωcm, flexural strength 40 MPa) were developed, using the paper making and composite technologies.

These papers were supplied to NMRL, Ambernath for evaluation and performance as electrode in the fuel cell. The results were found to be highly encouraging. Efforts are going on to involve an industrial partner to scale up the technology developed at NPL for commercial production of carbon paper under the next phase of the project.

A comprehensive final report, after the completion of the project was submitted to the sponsoring agency.

Consultancy Project

Consultancy was rendered to M/s. Graphite India Ltd., Bangalore, under the on-going consultancy project (Rs. 3.0 Lakhs) on the "Upscaling of NPL's green coke based high density - isotropic graphite technology". This included advice on the optimisation of heat-treatment conditions of suitable coal tar pitches (3 kg batch) to obtain the green coke, and its subsequent processing into the final graphite product (HTT= 2600 °C), followed by the characterisation of the graphite products w.r.t. various parameters.

New Projects

(i) A NPL-SRI joint project on the "Development of coal tar pitch with a reduced content of harmful PAH" was sponsored by the Ministry of Environment and Forests. Work was initiated to reduce the content of Benzo(a)pyrene by heat-treatment of coal tar pitches under reduced atmospheric pressure.

(ii) A project on the "Development of high thermal conductivity carbon materials was specially sanctioned by CSIR. A good preforming pitch was developed by suitable heat treatment of a blend of CTP and PP, which possessed a high softening point of 180-220 °C, QI of ≤ 0.5% and a CV of ~ 75%. This was used to develop carbon-carbon composites involving HT up to 600°C, and finally to 1000 °C under an atmosphere of nitrogen gas.

High Pressure Technology

In an ongoing DST-DAAD funded project entitled "Low pressure synthesis of cubic boron nitride by means of supercritical fluids", in collaboration with Mineralogical Institute, University of Bonn, Germany, experiments on cBN synthesis using the hBN-Li_3N-NH_3 system were carried out in the presence of ammonium fluoride solid compound, which is supposed to release ammonia at high temperatures. From the series of experiments using this system, it was observed that cBN was formed in the reaction products synthesized at 55 kb and 1300°C, as evidenced by the XRD pattern of the reaction products. Though cBN conversion takes place in the presence of ammonia as a supercritical fluid, the P-T conditions are much higher. From this investigation, it was concluded that reduction of pressures required for cBN crystallization in the presence of supercritical fluids (NH_3), does not take place to a significant level.

Soft and Polymeric Materials

Liquid Crystals: Basic and Applied Aspects

The discovery of surface stabilized ferroelectric liquid crystal (SSFLC) has shown a tremendous application potential. The fast and bistable switching SSFLC displays are ideal for highly multiplexible video rate addressed flat panel displays. Typical SSFLC devices or cells require long pitch liquid crystal materials and narrow cell gaps. Recently, a new type of ferroelectric liquid crystal material is being studied at NPL, called Distorted helix ferroelectric liquid crystal (DHFLC) which is in many ways complementary to the SSFLC effect and uses a short pitch FLC material 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 so gray scale can easily be obtained by using these materials. The other type of ferroelectric liquid crystal material called electroclinic liquid crystal which has got the switching response in nanosecond range is also being studied. The switching and molecular reorientation dynamics of DHFLC and electroclinic liquid crystal material is being vigorously studied by electro- optical and dielectric methods.

The dielectric behaviour of an electroclinic liquid crystal material has been investigated by dielectric relaxation method in

the frequency range of 50 Hz to 10 MHz in a thin (2.5 μm) cell. The studies are being carried out in planarly aligned samples where the measuring electric field is perpendicular to the director and parallel to the smectic layer planes. The work is also being carried out on the bistability aspect of deformed helix ferroelectric liquid crystal by deforming the helix under the application of square voltage pulses of known magnitude and frequency. For the first time the bistability effect in DHFLC material has been predicted, based on the electro-mechanical effect of helix deformation due to electric field.

The applied aspect of liquid crystal materials being carried out at NPL is the spatial light modulators (SLM) which is the key component for a variety of optical and opto-electronic systems, such as optical computing, image processing and information display applications. A liquid crystal based SLM configuration consists of non-alkaline flat glass substrate, covered with transparent electrodes, photoconductor and mirror coatings over the transparent electrodes and then the alignment layer is given on both the electrodes and then the liquid crystal material is sandwitched between the two electrodes. The SLM impresses wave-front modulation on an optical readout beam thereby facilitating the propagation and manipulation of information in the optical domain. We at NPL have prepared optically addressed spatial light modulators using a wide variety of liquid crystal materials for the IRDE, Dehradun, (DRDO) organization. Ferroelectric liquid crystal based SLMs are prepared for them and are being characterized for applications at IRDE, Dehradun.

Biomolecular Electronics & Conducting Polymers

Glucose Biosensor : A glucose biosensor based on poly(An-FAn)/GOD enzyme electrode has been fabricated. These enzyme electrodes have been characterized by various techniques such as UV-visible, FTIR, X-ray diffraction techniques. These enzyme electrodes were suitable for glucose estimation from 0.5 to 22mM (Fig.3.3) and are stable up to 45°C.

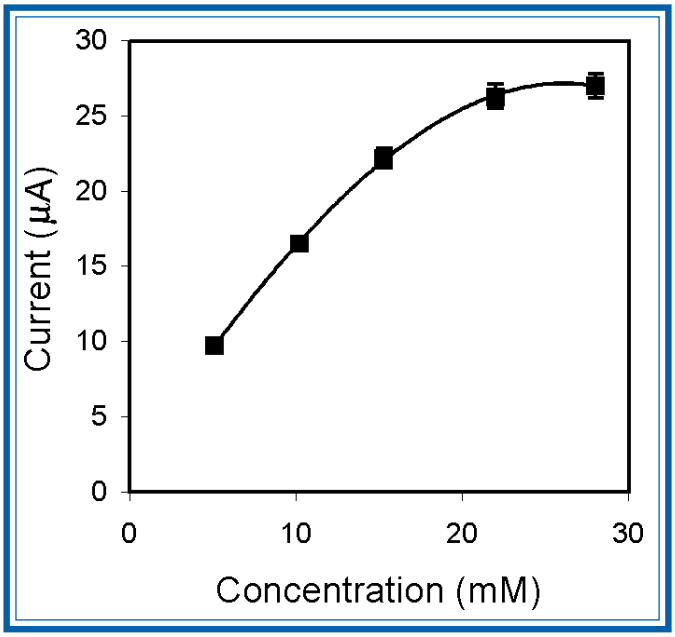

Fig. 3.3 Variation of amperometric current (μA) as a function of glucose concentration (mM).

Lactate Biosensor : A composite of polyaniline and sol-gel has been prepared by electrochemical entrapment of polyaniline within sol-gel films. An attempt has been made to extend the linearity upto 10 mM for lactate by coating an external layer of polyvinyl chloride (PVC) over the sol-gel/PANI/LDH electrodes. These sol-gel/PANI/LDH electrodes (Fig.3.4) have a response time of about 60

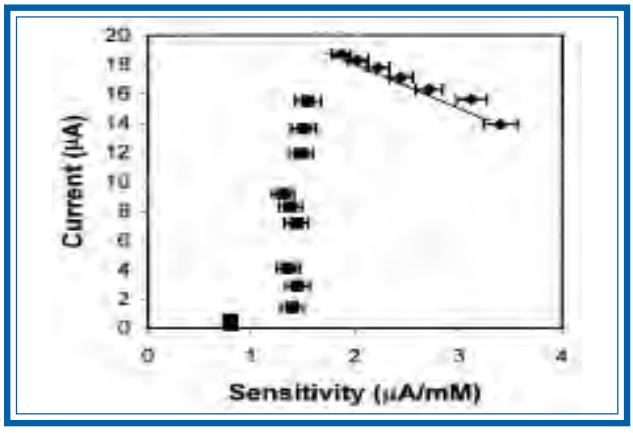

Fig. 3.4 Eadie Hofstee Plot (sensitivity I/C Vs response current I) for sol-gel/PANI/LDH electrodes as a function of the lactate concentration before a PVC coating ( ) and after a PVC coating ( ).

seconds, shelf life of about 8 weeks at 0-4°C and have implications for lactate biosensor.

Cholesterol Biosensor : Cholesterol esterase (ChEt) and cholesterol oxidase (ChO_x) has been electrochemically entrapped within the polypyrrole films during the process of electrochemical polymerization onto the Pt disc electrode. The attempts were made to characterize these PPY/ChEt/ChOx enzyme electrodes w.r.t. the effect of cholesterol palmitate concentration, applied potential, pH (Fig. 3.5), temperature and storage time.

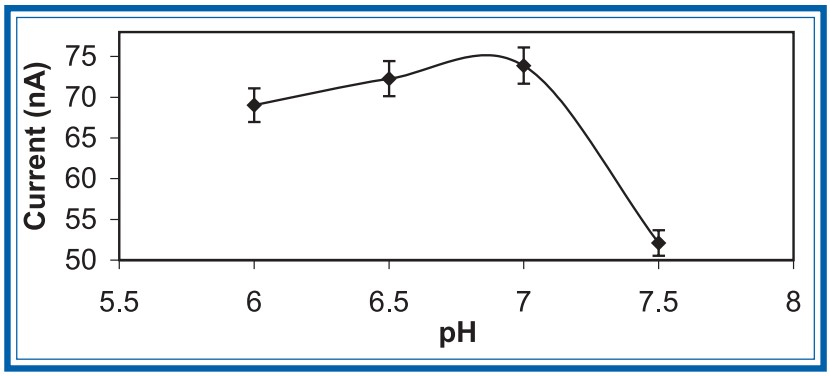

Fig. 3.5 Effect of pH on the amperometric response of PPY/ChEt/ChOx electrode using 4mM cholesterol palmitate at 0.5V.

Nanocrystalline Polymer Electronics

Development of Nanocrystalline Polymeric Sensors

The development of semiconductive polymeric thin films for fabrication of sensors for detection of pathogenic and non-pathogenic microbes was continued during 2002-2003. Vacuum deposited nanocrystalline thin films of copolymers of aniline and formaldehyde with a variety of dopings have been prepared and gas sensors for detection of carbon monoxide, HCl have been prepared from vacuum deposited polymeric thin films for detection of microorganisms. Sensors for water quality management and for detection of E.Colli have been developed. For this reason microbiological sensors prepared from Fe and Fe-Cu doped polyaniline thin film, vacuum deposited on porous silicon substrates have been found to exhibit an excellent sensitivity towards the most commonly encountered microorganisms E-Colii. A wide variety of combination of dopants Al, Fe, Ni, Co, Cu, in various stoichiomeric combination has been used to prepare fast response specific and highly sensitive sensors. A prototype of electronics gadgetry to provide audiovisual alarm has been developed. The sensors were tested for their specificity and selectivity for various gases at relevant institutions.

Basic Sudies on Polyaniline Thin Films

The structural, optical and electrical characterization of the polyaniline vacuum deposited thin films was carried out with the help of X-ray diffraction, scanning electron microscopy, surface topography etc. The scanning electron microscopy of the polymer film with various dopants and on various substrates was carried out. The semiconducting polyaniline thin films, prepared by vacuum deposition have been found to exhibit electrical and optical non-linearity. The energy band gap of polyaniline thin films was determined by reflectance measurement also. The thermal conductivity of doped polyaniline was determined between –180 and 300°C. The surface structure and topography of vacuum deposited polyaniline thin films between –180 and 300°C was carried out to study the effect of temperature surface topograpy.It was found that the nanocrystallinity of polyaniline undergoes changes during phase transitions.

Nanotechnology of Magnetic Polymeric Thin Films

The need of miniaturization of electronic devices has led to the development of polymeric thin films magnetic devices. A great deal of attention has been focussed on the magnetic polymers that include polyaniline. The material is environmentally stable and solution processible. Although polyaniline has been known for years, its electronic uses have only been established recently. The structure and properties of this polymer have been widely studied and its feasibility as solid state devices for use as sensors, optoelectronic devices, energy storage devices, metallization of printed circuit boards and radiation shielding materials has been established. Polyaniline was prepared by various methods. The nanocrystalline thin films of polyaniline have been proved to be suitable for fabrication of electronic devices. The characterization of thin films by optical absorption, SEM, X-ray have been carried out. These studies suggest that vacuum deposited magnetic polyaniline thin films are suitable for magnetic data storage device fabrication. These polymeric thin films find application in magnetic gyrator for phase shifters, insulators and amplifiers, magnetic memory disc storage devices, magnetic tapes and sheets, cards, electric field controlled FM resonance devices for usage as a switch or isolator, magnetically switched phase shifter, magnetically modulated piezoelectric devices, and magnetic non-linear optical devices. Preparation of undoped and Fe doped polyaniline nanocrystalline films was done. The optical, electrical, structural and magnetic characterization of Fe doped polyaniline thin films was carried out. We have developed a unique and novel method for preparation of polyaniline magnetic thin films by vapour deposition of magnetic polyaniline powder on various substrates.

Conducting Polymers

The conducting polymer technology finds its applications in electronic and industrial sectors mainly due to its ability to fabricate and design new shapes and patterns. Molecular design opportunities in conducting polymers opens a new vista for new generation of high tech speciality polymers, with improved properties. Wide range of possible applications in various sectors are:

- Aerospace, Defence - For EMI shielding and microwave absorption in 8 to 26 GHz range and stealth applications
- Energy Resource – As electrode material for batteries, supercapacitors
- Optoelectronics – OLEDs, FET, Schottky Junctions

Synthesis of conducting polymer polyaniline, polypyrroles and substituted polythiophenes have been carried out in the presence of ferrofluids in order to see the effect of magnetic particles attached in the polymer backbone. Interesting results were obtained when in-situ polymerization of monomers was carried out in the presence of ferro-fluids. Characterization and technological applications of the polymer are in progress. Conducting polymer-ferrofluids composites can find applications in EMI shielding, ESD, microwave absorption and RAM. The composites of conducting polymers with acrylonitrile-butadiene have been developed and static decay time of the composites have also been evaluated which revealed that these composites can be used as antistatic materials.

Conducting polymers based on anilines and its analogues and their co-polymers have been tested, which have emerged as an important class of corrosion inhibiting materials because of their potential and technological applications in the protection of iron and mild steel besides finding applications in concrete structures. The new class of copolymers are giving better corrosion inhibition efficiency in comparison to its parent polymer in highly corrosive mediums like saline water. The persual of data reveals that whereas 1000 ppm of monomers aniline and substituted aniline gives a corrosion inhibition efficiency of 32 % and 21 %, the copolymer of

aniline and substituted aniline gives a corrosion inhibition efficiency of 93 % when a 100 ppm of the copolymer is used. Thus co-polymer gives a better response than the parent polymer polyaniline or substituted polyaniline.

Soluble conjugated copolymers of benzene have been synthesized. The copolymerization of benzene and naphthalene using Kovacic's method, which uses the mechanism of propagation of oxidative coupling occurring through a dehydrogenation step via radical cations results in the formation of a copolymer which is soluble in common organic solvents like toluene and has interesting electrical and optical properties and was showing strong photoluminescence. The copolymer has low melting point and could be purified using vacuum sublimation. The new polymer has an optical absorption band in the visible region of the optical spectrum and a photoluminescence maximum in the yellow region. The polymer has been characterized using spectroscopic and thermo gravimetric techniques. Organic Light Emitting diode structures were fabricated using ITO as the anode electrode, evaporated polymer as the luminescent layer and aluminum as the cathode. The devices gave bright electroluminescence on application of about 5V D.C. Under the CSIR Network taskforce project on Development of speciality Polymers, the Conducting Polymers Group is participating in development of electroactive polymers.

Development of Organic Light Emitting Diodes

Organic LEDs are the future of flat panel displays. The device performance of OLEDs has strong dependence on the work function of the Indium Tin Oxide (ITO). The modification of ITO to get a higher work function has been taken up in our laboratory. As a part of these studies, ITO plates were exposed to corona discharge and the change in the work function using X-ray photoelectron spectroscopy (XPS) was studied. The changes in the core electron spectra of various elements like tin, indium, and oxygen were recorded and found that the exposure to corona discharge modifies the substrates favourably by improving the work function of ITO from 4.2 eV to 4.7 eV. Devices are being fabricated using the modified substrates to assess the effect of corona discharging on the OLEDs performance.

New materials like Lithium tetra (8-hydroxy quinoline) boron ($LiBq_4$), co-polymers of toluene and naphthalene (Poly TN), and anthracene and benzene (Poly AB) were synthesized and characterized in the laboratory. Devices were fabricated using these materials, which give blue, orange and red electro-luminiscence, respectively. The devices were characterised and optimized. The devices are being encapsulated for longer lifetime.

Under the CSIR network taskforce, a project on "Development of Key Technlogies for Photonics and Optoelectronics", the OLED Section is participating in a major way.

Sun – Shielding Window Glass By Sol-Gel

In recent years, there is significant increase in the use of double glaze insulating glass for architectural purpose. In countries with a high average of periods of sunshine and a warm or even hot climates, the prime issue is the saving of energy in air conditioning of the rooms, buildings or even vehicles.

98 % of whole sunlight energy arriving at the surface of the earth is contained in the spectral range between 200 nm & 2500 nm. It is exactly this range of wavelengths where the transparency of window glass is at its best. On the other hand 98 % of all the infrared energy irradiated out of room covers the wavelength 3.0 µm – 0.7 µm. When determining the transparency across the entire energy spectrum of room radiation, the value of common glass is only 3 %, i.e., glass is highly transparent for the energy of sunlight or day light but almost opaque to infrared radiation. It is however possible to alter the properties of

window panes oxides. These thin film coatings with a high degree of reflectance in the spectral range of sunlight energy are deposited upon the glass surface to produce the so called sun reflecting window panes. A project entitled "Study of metal oxide coating by sol-gel technique " has been sanctioned by DST in March, 2003 for Rs. 13 lakhs. For this, Pd/Au/Ag in the colloidal form will be incorporated in the Titanium alkoxide solution to control the reflectance, transmission and absorption of the substrate.

Development of Injection Solar Cells Utilising Dye Sensitized Nanocrystalline TiO_2 Films

In a conventional p-n junction, PV cell made, for example, from silicon, the semiconductor assumes two roles at the same time; it harvests the incident sunlight and conducts the charge carriers produced under light excitation. In order to function at a high efficiency, the photons have to be absorbed close to the p-n interface. Electron hole parts produced away from the junction must diffuse to the p-n contact where the local electrostatic field separates the charges. To avoid charge carrier recombination during the diffusion, the concentration of the defects in the solid must be low. This improves severe requirements on the purity of the semiconductor material, rendering solid state devices of the conventional type expensive.

We have initiated work on new molecular photovoltaic system for solar light harvesting and conversion to electricity. It is based on the special sensitization of a thin ceramic membrane by suitable transition – metal complexes. The film consists of nanometer size colloidal titanium dioxide particles sintered together to allow for charge carrier transport. When derivatized with a suitable chromophore, these membranes yield extraordinary efficiencies for the conversion of incident photons into electric current, exceeding 90 % for certain transition metal complexes within the wave length range of their absorption band.

A project entitled, "Development of solar injection cells utilizing dye sensitized nanocrystalline TiO_2 films" has been sanctioned by MNES for ~ Rs. 40.50 lacs in March, 2003.

Process Developed for the Chemical Silvering of Plain and Hollow Bodies

Most common method used for silvering of various type of objects (hollow and plain glass surfaces) is by glucose which is used for converting silver nitrate to silver which is deposited on the surface but in this process 40% silver goes as sledge in the solution which is to be recovered later on. In recovering also 20% silver goes waste. Further more, adherence of the film is also not very good and is also not very bright. It is also difficult to control the thickness. It is due to the fact that rate of reaction is very fast than the rate of deposition on the surface of the substrate. This process is being used for manufacture of vacuum flasks, dewar flasks and hollow bodies, silvering of mirror, silvering of electric bulbs and silvering of the objects where controlled coating of the silver is required. We have developed a solution (in place of glucose/fructose) which has the 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 sledge formation (no need of silver recovery).
- Wide range of working temperature (8 – 45^0C).

Bag Warmer (Hot Water Bottle)

The Bag Warmer is fabricated with metal salt solution and a triggering device loaded in the sealed bag. The air of this bag has to be completely removed. After this the bag is sealed. This is then heated to become liquid which is then filled in the plastics bags as per requirements.

To operate the bag warmer, user has to apply a pressure to the triggering device which

will initiate the crystallization in the salt solution. The crystallization reaction will generate heat which may vary from 45°C to 80°C and will last for about several minutes to three hours depending on the ambient temperature.

The bag may be recharged by placing it in hot water. Care should be taken so that it should not touch the container. For this put some cotton / cloth at the bottom of the container. After 10-15 minutes the crystallized solid will change again to liquid. Allow it to cool. This bag warmer can be used for number of times.

Xeroradiography

In order to develop economic and better sensitive X-ray imaging materials for xeroradiography (XR) photoreceptors, R&D was carried out on a new concept, i.e., using polymer interface barrier layer in combination with amorphous selenium (a-Se) films in XR photoreceptor mode for enhancing its X-ray sensitivity. To find the suitability of a polymer as interface barrier layer, it is essential to study its fundamental and applied properties, such as charge transport mechanism, charge storage mechanism, charge decay effects, etc. Keeping this in view, we made fundamental and applied investigations in potential polymers, such as polyvinyl fluoride (PVF) and polyvinlydene fluoride (PVDF).

As regards PVF, we have studied for the first time in its vacuum deposited films, the mechanism of high field conduction. PVF films of thickness (2500 - 10,000 Å) were vacuum deposited onto ultrasonically cleaned glass slides at a pressure of $\sim 10^{-5}$ torr. I-V characteristics of these films were studied as a function of temperature in the range 303 to 403K, as a function of thickness in the range of 2500 - 10,000 Å and as a function of voltage in the range of 10^1 to 10^4 volts. I-V characteristics of these films show two distinct regions of conduction, viz., ohmic region at low fields with a slope of ~1 and non-ohmic region at high fields with a slope of ~2. Further, it was found that the transition voltage separating the two regions of conduction, i.e., V_{tran} was proportional to d^2, and I in the high field conduction region was proportional to $1/d^3$. Based on these observations and further analysis of the experimental data, the space charge limited conduction was suggested as the dominant mechanism of conduction at high fields in vacuum deposited PVF films. The results have been published.

As regards PVDF, we have studied the effect of PVDF interface barrier layer on charge storage and residual potential in a-Se films. In these investigations, sample configuration of Al-PVDF -a-Se was used. For this, PVDF films were vacuum deposited on ultrasonically cleaned Al substrate. Thicknesses of these films was in the range 2000-8000 Å. On top of these PVDF films, thick films of ~100 µm of a-Se were deposited again under vacuum at a pressure of $\sim 10^{-5}$ torr. Thermally stimulated discharge current (TSD) and potential decay measurements were made on these films. TSD spectra of these films show a considerable effect of PVDF interface barrier layer on charge storage capacity and built up of residual potential in a-Se films. The charge storage capacity and residual potential decreased considerably on the incorporation of PVDF interface barrier layer. Using the experimental data, the X-ray sensitivity of a-Se films was calculated and it was found that the sensitivity increased from $6.29R^{-1}$ in pure a-Se films to ~ 21 R^{-1} in a-Se films incorporated with PVDF interface barrier layer of thickness ~8000 Å. This enhancement in X-ray sensitivity of a-Se films was attributed to blocking and field enhanced mobility role of the PVDF interface barrier layer.

Besides the above fundamental and applied work, we have developed a demonstrative portable laboratory prototype of XR based X-ray imaging instrument for non-destructive testing (NDT) applications.

Liquid Crystals and Self-Assembled Monolayer

A novel technique to produce uniform alignment of liquid crystals (planar and homeotropic) using photo-dimerized self-

assembled molecular films of amino-alkyl silanes and photopolymer films has been developed.

One of the primary requirements for fabricating liquid crystal display devices, based on different principles, is to produce planar/homeotropic orientation of liquid crystal molecules on the two bounding surfaces. A variety of techniques have been in existence to produce uniform 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.

A new technique has been developed to produce uniform homeotropic and planar orientation of liquid crystals based on polymerization of a photopolymer-coated surface by irradiating it with polarized and unpolarized UV-light. The alignment regulation on the photopolymer surface has been found to be critically dependent on the dosage and state of polarization of the linearly polarized UV-light. A uniform homeotropic alignment is produced when the dosage of the linearly polarized light ranges between 0.1 to 0.8 J/cm^2 and uniform planar orientation is produced when the UV-energy >3 J/cm^2. Irradiating the photopolymer film with unpolarized light also resulted in homeotropic alignment of liquid crystals. Both types of alignment have been found to be stable with time and temperature.

Figure 3.6 shows a set of photographs of a liquid crystal cell wherein two different portions of the cell have been exposed with different UV-energies to produce homeotropic and planar orientation of liquid crystals. Nearly one half central of the cell (ABC) exposed with polarized UV-light (0.5 J/cm^2) exhibited homeotropic alignment and remained completely dark on rotation between cross polarizers from 0-180° [Figs. 3.6(a)-3.6(d)]. The other half portion of the cell (ADC) exposed with 3J/cm^2 showed uniform planar orientation with preferred orientation direction of liquid crystalline molecules lying parallel to the polarizing axis of the polarizer. The ADC portion of the cell is dark when the planar orientation

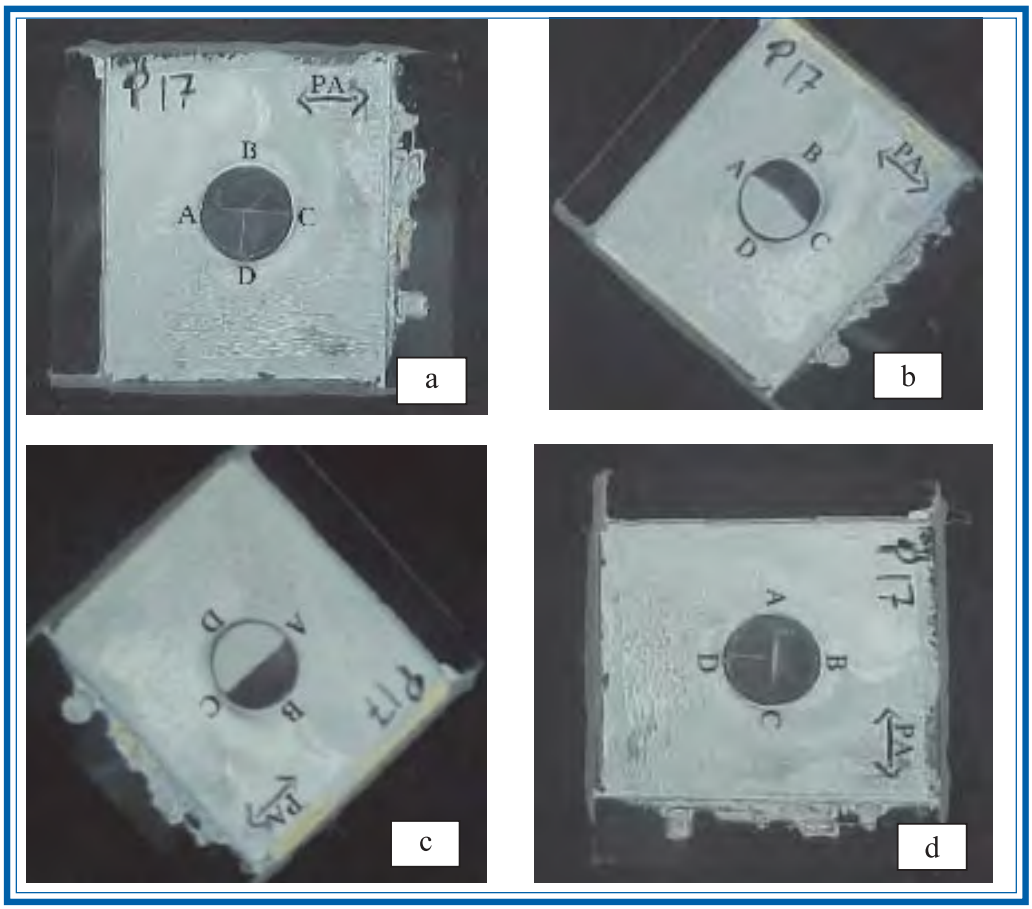

Fig.3.6 Photographs of a liquid crystal cell showing homeotropic and planar orientation under various orientations between cross polarizers; (a) 0°, (b) 45° , (c) 90°, and (d) 135°, respectively.

axis lies parallel or perpendicular to the polarizer and becomes transparent [Figs. 3.6(b), 3.6(d)] on rotating it through 45° and 135°, respectively. The unexposed portion of the cell outside the circle showed little variation in contrast on rotation confirming to no preferred orientation in the region.

Cryogenic Plants & Facilities

A total of approximately 24,000 litres of liquid nitrogen was procured and supplied to various divisions/groups of the laboratory during the year. The liquid nitrogen was procured commercially as well as produced in our own old plant. New liquid nitrogen plant of Stirling Cryogenics of 44 litres/h capacity has arrived at NPL.

1400 litres of liquid helium was procured from outside agencies and utilized for various important experiments in the laboratory. R&D activities for the repair and development of high-speed turbo-expander for liquid helium plant is in progress.

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पदार्थ अभिलक्षणन

MATERIALS CHARACTERIZATION

पदार्थ अभिलक्षणन

प्राथमिक संयोजन के निर्धारण संबंधी सामग्री, ट्रेस अशुद्धताओं के आकलन संबंधी, संरचनात्मक विश्लेषण संबंधी, क्रिस्टलीय कलाओं के अभिनिर्धारण संबंधी, क्रिस्टल के दोषों संबंधी तथा सूचना विषयक सामग्री की विशेशता बताने की महत्त्वपूर्ण भूमिका निम्नलिखित के संबंध में होती है – गुणता नियंत्रण और उन्नत सामग्री के विकास तथा विशुद्ध मापन बताने वाली युक्तियों में उनके उपयोग (के संबंध में होती है)।

पदार्थ अभिलक्षणन प्रभाग बहुत सी उन्नत और असाधारण अभिलक्षणन सुविधाएं प्रदान करने के सामर्थ्य से संपन्न है । रासायनिक संयोजन और विशुद्धता के विश्लेषण के लिए इस प्रभाग के पास एटोमिक अवशोषण, स्पेक्ट्रममापी, आई सी पी उत्सर्जन स्पेक्ट्रममापी, वर्णलेख (क्रोमेटोग्राफस) एफ टी आई आर तथा ई पी आर स्पेक्ट्रममापी, यू वी–विस स्पेक्ट्रोप्रकाशमापी, एक्सरे प्रतिदीप्ति स्पेक्ट्रममापी, तथा एस ई एम आदि के ई डी एस संलग्नक भी हैं । एक्सरे विवर्तन और इलेक्ट्रॉन सूक्ष्मदर्शी/विवर्तन सुविधाएं बड़े पैमाने पर संरचनात्मक अभिलक्षण बताने वाली पतली पर्त या क्वांटम संरचना सामग्री के लिए काम में लायी जाती है । पदार्थ की सतह और इंटरफेस के सूक्ष्म संरचनात्मक अध्ययन की विशेषताएं अत्याधुनिक एस इ एम और टी ई एम के लिए बताई जाती है । हाल ही में एक ताप और शीत स्टेज तथा एक टेन्साइल स्टेज एस ई एम के साथ जोड़ी गयी है जिसमें इलेक्ट्रॉन बीम के अन्तर्गत विभेदी तापन तापमान (–185 से 400^0 से.) और लोड (300 N तक) की स्थितियों के अन्तर्गत इन सीटू (in-situ) सूक्ष्म संरचनात्मक परिवर्तनों के संबंध में अध्ययन करना संभव हुआ है। परफेक्शन, खराबियों तथा स्ट्रेस (दबाव) संबंधी अध्ययनों के बारे में दी गयी एकल क्रिस्टलों, पतली एपीटेक्सियल पर्तों और इंटरफेसों की अभिलक्षणन सुविधाओं में स्वदेश में ही विकसित बहु क्रिस्टलीय एक्सरे विवर्तनमापी अत्याधुनिक लेवल रेजोल्यूशन शामिल हैं। यह प्रभाग विभिन्न अनुप्रयोगों जैसे सिंटीलेटर क्रिस्टल जो एकमात्र उच्च ऊर्जा वाले विकिरण के लिए उपयोगी है, के लिए लगभग दोषरहित एकल क्रिस्टलों की वृद्धि के काम में लगा हुआ है। अन्तर प्रयोगशाला सहयोगी कार्यक्रम के अन्तर्गत प्रमाणित संदर्भ की सामग्री की आयोजना, तैयारी और उसका प्रचार–प्रसार करने का कार्य इस प्रभाग की एक अन्य महत्त्वपूर्ण गतिविधि है। एन पी एल में मोल स्तर की स्थापना करने के लिए कुछ प्रारंभिक पृष्ठभूमि स्तर का कार्य कर भी लिया गया है।

पदार्थ अभिलक्षणन के लिए सुविधाएं एन पी एल के विभिन्न अनुसंधान एवं विकास ग्रुपों और अन्य अनुसंधान संगठनों/उद्योगों को प्रदान की गयी थीं पर्याप्त संख्या की परामर्शी और प्रायोजित संविदा अनुसंधान परियोजनाओं के संबंध में कार्रवाई भी की गयी थी। इस अवधि के दौरान जो कुछ महत्त्वपूर्ण अनुसंधान एवं विकास गतिविधियों के संबंध में कार्रवाई की गयी वह इस प्रकार हैं– (1) जलवायु परिवर्तन पर हुए सम्मेलन के संयुक्त राष्ट्र के फ्रेमवर्क (यूएनएफसीसीसी) के साथ भारत प्रारंभिक संप्रेषण (नेटकाम) तैयार करना जिसमें विभिन्न ग्रीन हाउस गैसों के मापन अध्ययन शामिल हैं। (2) इ सी आर स्पेक्ट्रोस्कोपी का इस्तेमाल करते हुए चार्ज वाहकों का डी सी कंडक्टिविटी के साथ किया गया एक महत्वपूर्ण सहसंबंधन अध्ययन यह देखने के लिए किया गया कि सल्फ्यूरिक एसिड (अम्ल) के साथ डोप्ड पोलीएनीलीन में विद्युतीय कन्डक्शन की क्रियाविधि समझी जा सके। (3) क्वार्टर्नरी खराबी कंपाउंड यौगिक $CuZnCa_3Te_6$ का संश्लेषण किया गया और संरचनात्मक एक्सरे विश्लेषण यह देखने के लिए किया गया कि रूम टेम्परेचर पर 2 से 6 वर्ष के लिए किए गए भण्डारण पर संरचनात्मक एवं कला (फेज) रूपान्तरण निर्धारित किया जा सके। (4) पॉलीमर आधारित फेरोफलूड कंपोजिट पर्तों का संश्लेषण किया गया और उनके अभिलक्षण UV, XRD, TEM, EPR और सूक्ष्म तरंग मापों द्वारा बताए गए। (5) एन पी एल के विभिन्न ग्रुपों से लिए गए कार्बन नैनोट्यूबें/रेशे/सम्मिश्रों/ फेरोफ्लूड सम्मिश्र CdTe, MnInTe आदि सहित उच्चस्तरीय पदार्थ के बड़ी संख्या में विविध नमूनों के अभिलक्षण SEM, TEM और EDX विश्लेषण द्वारा बताए गए। (6) छह नए BND और तीन तनुकारी (डाइल्यूटिंग) माध्यम (मीडियमस) तैयार किए गए और उन्हें जारी किया गया। एन पी एल ने अन्तर्राष्ट्रीय रसायन मापन संबंधी अन्तर तुलना के सम्मेलनों में भाग लिया और विभिन्न प्रारंभिक कन्सेन्ट्रेशन जल तथा चावल के नमूनों का मापन किया। (7) मिश्रित क्षारीय हालीडे क्रिस्टलों का विकास सी जेड (CZ) विधि द्वारा विभिन्न कन्सेन्ट्रेशन के साथ किया गया और HRXRD द्वारा तनु और अशुद्ध LiF एकल क्रिस्टलों में गतिज प्रभाव देखे गए थे तथा (8) क्वांटम कूपों के कंपोजिशन और मोटाई XRXRD द्वारा निर्धारित की गयी तथा इस कार्य में इन हाउस विकसित सॉफ्टवेयर कार्यक्रम अपनाया गया। एक अन्तर्राष्ट्रीय सम्मेलन दो राष्ट्रीय संगोष्ठियों, तीन नेटकॉम बैठकें आयोजित की गयी। 22 अनुसंधान लेख प्रतिष्ठित जर्नलों में प्रकाशित किए गए तथा प्रायोजित अनुसंधान एवं विकास परियोजनाओं, परामर्श और अंशांकन परीक्षण के मार्फत 56.46 लाख रुपए की ई सी एफ निधि जुटायी गयी थी।

MATERIALS CHARACTERIZATION

Characterization of materials regarding determination of elemental composition, estimation of trace impurities, structural analysis, identification of crystalline phases and information on crystal defects play an important role for the quality control and development of advanced materials and their use in precision devices. Materials Characterization Division is equipped with many advance and unique characterization facilities. For the analysis of chemical composition and purity it has atomic absorption spectrophotometers, ICP emission spectrometer, chromatographs, FTIR and EPR spectrometers, UV-Vis spectrophotometer, X-ray fluorescence spectrometer, EDS attachment to SEM etc. X-ray diffraction and electron microscopy/diffraction facilities are employed for the structural characterization of bulk, thin film or quantum structure materials. Microstructural studies of the surface and interface of the materials are characterized by state-of-the art SEM and TEM. Recently a heat & cold stage and a tensile stage have been attached with SEM which are capable to study in-situ micro structural changes under different heating temperatures (-185 to 400^0 C) and load (up to 300 N) conditions under the electron beam. The facilities for characterization of single crystals, thin epitaxial films and interfaces regarding perfection, defects and stress studies include indigenously developed multicrystal X-ray diffractometers with state-of-the-art level resolution. This Division is also engaged in the growth of nearly perfect single crystals for various applications like scintillator crystals exclusively useful for high-energy radiation. Planning, preparation and dissemination of certified reference materials under an inter-laboratory collaborative programme is another important activity of the Division. To establish the Mole Standard at NPL, some initial background work has been done.

The facilities for materials characterization were provided to various R&D groups of NPL as well as to other research organizations/industries. Quite a good number of consultancy and sponsored contract research projects were pursued. Some of the important R&D activities pursued during this period are: (i) Preparation of India's Initial National Communication (NATCOM) to UN Framework of Convention on Climate Change (UNFCCC) which include measurement studies of various greenhouse gases, (ii) Using EPR spectroscopy, an important correlation study of charge carriers with DC conductivity was done to understand the mechanism of electrical conduction in polyaniline doped with sulphuric acid, (iii) Quaternary defect compound $CuZnGa_3Te_6$ had been synthesized and structural X-ray analysis was done to determine its structure and phase transformation on storage at room temperature for 2 to 6 years, (iv) Various types of polymer based ferrofluid composite films were synthesised and characterized by UV, XRD, TEM, EPR and microwave measurements, (v) A large variety of samples of advanced materials including carbon nanotubes/fibers/composites, ferrofluid composites, CdTe, MnInTe etc. from various groups of NPL and industries were characterized with SEM, TEM and EDAX analysis, (vi) Six new BNDs and three diluting mediums were prepared and released. NPL has participated in International Inter-comparison on Chemical measurements and measured the various elemental concentrations in water and rice samples, (vii) Mixed alkali halide crystals were grown with various concentrations by CZ method, dynamical effects were observed in thin and imperfect LiF single crystals by HRXRD and (viii) The composition and thickness of quantum wells were determined by HRXRD and using the in-house developed software programme. One international conference, two national workshops, three NATCOM meetings were organised. About twenty two research papers were published in reputed journals and ECF of ~ Rs. 56.46 lakhs through sponsored R&D projects, consultancy and calibration\testing was generated.

Analytical Chemistry

Characterization of materials for purity, chemical composition and environmental species by chemical metrology have been done for various areas viz. chemicals, ecology & environment, health, drugs & pharmaceuticals, metals, minerals, manufacturing sector including scientific and technological support. This includes need of industries, government agencies and institutions for characterization of a large variety of materials viz. aluminum and other parameters in poly aluminum chloride samples used for cleaning of water, and evaluation of indelible ink used in the electoral process. The facilities utilized for trace metal analysis of materials are Flame Atomic Absorption spectrometer (FAAS), Graphite Furnace Atomic Absorption spectrometer (GFAAS), UV visible Spectrophotometer and Flame photometer. The Gas Chromatographic techniques have been utilized for evaluation of gaseous samples form different sources for Green House Gases (GHGs), trace gas impurities in samples from security agencies, and pollutants viz. CO, NO-NO_2 – NO_x , CO_2 using respective gas analysers for environmental studies like studies on anthropogenic influence on fog/ smog in Delhi under CPCB-NPL collaborative program, and NPL-NRSA collaboration under ISRO-GBP for biomass burning emissions in shifting cultivation areas.

National Communication for UNFCCC

During this period, three contract project work related to preparation of India's Initial National Communication (NATCOM) to UN Framework of Convention on Climate Change (UNFCCC) has been undertaken from ministry of environment & forests (MoEF) funded by global environmental facility (GEF)/ UNDP and executed through Winrock International India (WII) as a facilitating agency of MoEF. These included measurement studies of greenhouse gases (GHGs) viz. N_2O, CH_4 and CO_2 emissions, apart from CO and NOx from various agricultural sectors viz. emissions and uncertainty reduction from livestock [in collaboration with NDRI Karnal and CLRI Chennai], rice cultivation [in campaign mode] involving ten institutions [RRL Bhubaneswar, RRL Trivandrum, IARI Delhi, CRRI Cuttack, IRP&E Kolkata, AAU Jorhat, AU Chennai, NRSA Hyderabad, and CFRI Dhanbad, apart from nodal institution NPL], and biomass burning of agricultural residue. Another NATCOM contract project under the guidance of Dr. A.P. Mitra, relating to agriculture sector inventory for GHGs and Indian budget estimates had also been carried out during the period. The ECF generated for NPL under above NATCOM uncertainty reduction projects are 20 lakhs (CM/Rice), 18 lakhs (CM/Biomass) and 10 lakhs (CM/Livestock), respectively.

EPR Spectroscopy

Electron Paramagnetic Resonance (EPR/ESR) Spectroscopy is one of the major techniques of the division used for the characterization of materials for investigating paramagnetic centres / point defects / impurities in different substances. Such centres / defects are usually produced in different fabrications / preparation processes and may play important role in controlling the properties of the materials. Investigation of different kinds of materials for such paramagnetic centres was undertaken for different NPL groups and outside organizations. In collaborative work with Polymer Physics Group of NPL, a correlation of ESR and dc conductivity data was made to understand the mechanism of electrical conduction in polymer polyaniline doped with sulphuric acid. Spin concentration of charge carriers determined by EPR spectroscopy was found to depend on the doping level of the specimen. For an observed change of about 9 orders of magnitude in electrical conductivity of the polyaniline at different doping levels, the spin concentration was found to increase by two orders of magnitude only. Analysis of the results suggested that polarons formed at low doping levels and polaron – bipolaron equilibrium

established at higher doping levels may be mainly responsible for electrical conduction in this system. Characterization of ferrofluid – conducting polymer composite samples undertaken in collaboration with X-ray group suggested that decrease in dipole-dipole interaction between the magnetic ions was responsible for observed change in EPR linewidth values of the samples whereas broadening of the signal on lowering the temperature was assigned to change in spin – lattice relaxation of the magnetic ions in the host lattice. No evidence of magnetic phase transition or superparamagnetism was observed during variable temperature EPR investigations of the aqueous based ferrofluid Fe_3O_4. EPR study of microstructure of different ternary oxide glasses was continued in collaboration with M. D. University, Rohtak. In glasses having composition $xTiO_2(0.30-x)Li_2O.70B_2O_3$, V^{4+} ions were found to exist as VO^{2+} in octahedral co-ordination with tetrahedral distortion which decreases with increase in TiO_2: Li_2O ratio. The decrease in $\Delta g_{11}/\Delta g_1$ also suggested the improvement in octahedral symmetry with increase in mol% of TiO_2. The decrease in Fermi contact interaction parameter with increase in TiO_2: Li_2O ratio observed may be due to decrease in the tetragonality of the $V^{4+}O_6$ complex. Further it was observed that this increase in ratio also resulted the expansion of 3dxy orbit of the unpaired electrons of vanadium ions.

X-ray Analysis

X-ray diffraction and fluorescence analysis were carried out for about 215 samples for various groups of NPL, research organizations and industries which include high Tc superconductors, cBN, diamond powder, coke, carbon powder, bismuth molybdate, carbon nanotube & soot, CuInAs, CdZnAs, fly ash, Al-Si alloy & composites, $(Na,K)TaO_3$, ferrites, lead iron tungstate, lead zirconium titanate etc. Thin films of WO_3 , Bi_2Te_3 , CdTe, prussian blue, CeO_2 : TiO_2 , CdS, $MnIn_2Te_4$, In_2Te_3 , ZnTe, SnO_2 , CdSnTe, ferrites etc. on various substrates have also been analysed. Assistance was provided to M/s Gayatri Metals, Agra; Eskayjay Diamonds Products Pvt. Ltd., Chennai; Sudarshan Minerals & Industries, Udaipur; IIT, Delhi; NTPC Noida regarding the X-ray analysis of their materials.

Research work was continued on synthesis and structural analysis of technologically important chalcogenide materials. Quaternary defect compound $CuZnGa_3Te_6$ had been synthesized and X-ray diffraction data collected earlier was analyzed. The compound was found to crystallize in a defect tetrahedral structure with possible space group I4 with Z=4/3 and a = 0.5946(2) nm, c = 1.1891(5) nm, $D_x = 5.81x10^3$ kg/m^3. The figure of merit was found as $M_{20} = 11$; $F_{30} = 6(0.057, 83)$. In the Ga-Te system, the compounds Ga_2Te_3 , Ga_2Te_5 and GaTe crystallizes in cubic, tetragonal and monoclinic system respectively, show phase transformation on long storage time. Our investigations confirm that all these compounds acquire a stable hexagonal structure with cell dimensions, a = 0.832 nm, c = 3.065 nm and reduction in the unit cell volume by 0.0125 nm^3. The complete phase transformation took place within 2 to 6 years on storage at room temperature.

An attempt has been made to channalise Bi(2223) particles of size 10 nm range using ferrofluid in a host matrix of PVA. Various types of composite films were prepared by varying the magnetic field. The sample grown with the influence of magnetic field shows less crystallinity of the material. The dipole interaction controlled by external magnetic field leads to the chain like cluster formation of the domains in the composites of superimposing high Tc phase. Surface morphology and the degree of orientation of the particles has been analyzed by SEM technique. Perhaps polymerization of high Tc may be useful in making technical feasibility of the material. Also synthesized films of polymer based ferrofluid by incorporating conducting polymer polyaniline in the ferrofluid system. These films were characterized by UV, XRD, TEM, EPR and microwave measurements in collaboration with other groups of NPL. The study reveals that the polymerization technique

of ferrofluid composite material has potential for EMI shielding.

The Rietveld method of analysis in powder X-ray diffraction technique provides a standard-less method for quantitative phase analysis of polycrystalline samples. Quantitative phase analysis of some materials like synthetic diamond and fly ash samples were carried out. The results are being compared with those of chemical analysis.

In the IRM activity under the project on planning, preparation and dissemination of certified reference materials for quality assurance in analytical measurements, the particle size of silicon powder prepared earlier were reduced in the range 5-20 µm using planetary ball mill and sieve shaker. About 80 g of material was prepared and to be used as BND 1501. A microprocessor controlled high temperature furnace has been procured for the preparation of certified reference materials for X-ray diffraction standards and is presently under the installation and calibration stage.

Electron Microscopy

Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) facilities are fully equipped with electron imaging detectors and spectroscopic observations to analyze the different types of materials. PC controlled SEM model LEO 440 is fitted with turbo molecular pump for producing clean vacuum and is attached with secondary & back scattered electron image detectors, cathodoluminescence detector and specimen current monitor to investigate the microstructure of materials under different modes of operation. SEM has an attachment of energy dispersive spectrometer (EDS, Oxford Link ISIS 300) using Si(Li) detector to analyze elements from atomic no. 5 to 92 with a resolution of 133 eV. Recently a heat & cold stage (model Gatan C1003) and a tensile stage (model Gatan Microtest 300) have also been attached with SEM. These stages are capable of examining the specimen under various heating conditions (-185 to 400 °C) and different load conditions (up to 300 N) under the electron beam so the in-situ microstructural changes can be studied.

Various groups in the laboratory working on the development of advanced materials for different applications have extensively used the SEM facility. More than 260 samples were characterized with SEM and more than 55 samples were subjected to EDAX analysis. Some of the materials characterized by SEM/EDS are carbon nanotubes,carbon fibres, carbon composites, ferrofluid composites, Ag/Si nanoparticles, CdTe, CdTe-TiO_2 , CdZnTe, MnInTe, CdS films on glass substrates, TEOS polymeric films, metal doped polyaniline films, bismuth molybdate films on quartz substrates, PANI with lactate oxidase coatings, high T_c superconducting Bi2223 rods and tubes, MgB_2 bulk and thin films on sapphire substrates, relaxer material alloys, Bi_2Te_3, c-BN composites, ZnS phosphors, diamond powder, spray deposited Mg, Al/Si alloys, aerosol and bio-fuel samples, $AgNO_3$ sol coatings.

The SEM/EDS facility was also used to help the industries located in and around Delhi for the characterization of their samples and giving them input in the form of test report to solve their problems associated with particle size analysis, surface microstructure, failure analysis, chemical composition of their products etc. More than 31 samples were analysed and 18 test reports were issued. A sum of Rs.1,08,000/- have been realized as testing charges for the same. The products analysed were molecular sieves, coated Al foils, metallic powders/automobile components, insoluble sulphur powder, roller and shafts, precipitated silica, steel pieces, nimonic 90 strips, Al/Si alloys, inorganic ashes etc. The companies include, M/s Bry Air(Asia) Pvt. Ltd, M/s. Maruti Udyog Ltd, M/s. Oriental Carbon & Chem. Ltd., M/s. GKN Driveshaft Ltd, M/s. Madhu Silica Pvt. Ltd. , M/s. Vardhman Special Steels Ltd. M/s.GPEC Ltd., M/s. Century NF Castings,M/s. M.S. Iyengar & Associates, M/s. Ranbaxy Laboratories Ltd.

The TEM (make JEOL, JEM 200 CX) is fully operational for microstructural analysis of variety of materials. The TEM facility is associated with modern techniques of sample

preparation including the precision saw, variable speed grinder – polisher, ultrasonic disc cutter, dimple grinder, dual ion mill etc. The TEM, working at electron accelerating voltage of 200 kV is a central facility, being utilized actively by various groups in NPL and outside R&D organizations. There were about 50 samples characterized and analyzed using TEM facility including the other groups in NPL and outside institutes like IIT New Delhi and IACS Kolkata. The materials studied include carbon nanotubes, coconut whiskers, nano-structured thin films, indium oxide powder, Nd-Ba-Ca-Zn-TiO powder, Au/Ag nano particles and oxides of Cu containing Ba & Ti.

The group is also involved in various own research activities including the preparation and characterization of semiconducting bulk as well as thin films. The specimens are being tried to prepare for the standard gold resolution test samples using thermal evaporation technique for the purpose of SEM and TEM, both. Different types of nanomaterials including the carbon nanotubes, whiskers and nano-structured thin films are being extensively analyzed by microscopy facilities and results are interpreted.

Indian Reference Materials

In the present scenario of globalization of economy, use of Certified Reference Materials (CRMs) in measurements has become essential for global acceptance of products and test reports. Use of certified reference materials also ensure high quality in measurements and provide traceability to the analytical measurements with national /international measurement system (SI unit). These fulfill a mandatory requirement of all international level quality systems (ISO/IEC guide 17025) including our national accreditation body, National Accreditation Board for Testing and Calibration Laboratories (NABL). These are required for use in calibration of analytical equipments namely atomic absorption spectrometers, ICP emission spectrometers, ICP-mass spectrometers, UV-visible spectrometers, ion chromatographs, gas chromatographs, HPLC, X-ray diffractometers etc. to generates precise, accurate & reliable results and in validation of test methods. There is great demand of the CRMs in India in all the sectors including environment, health, power and industries. This demand is growing continuously with the increase of the awareness of quality system in the country. It is further enhanced with the growth of ISO/IEC 17025 and ISO 9000 accredited laboratories. To meet the requirement of CRMs indigenously, National Physical Laboratory, India has created a network of the 30 reputed laboratories of the country and identified lead laboratories for various sectors of CRMs. Some of the important participating laboratories from outside CSIR system are Bhabha Atomic Research Centre, Mumbai; Indian Agricultural Research Institute, New Delhi; National Remote Sensing Authorities, Ahmedabad; R&D Centre, National Thermal Power Corporation, NOIDA and R&D Centre, Indian Oil Corporation, Faridabad. Certified reference materials prepared under this programme have been christened as Bharatiya Nirdeshak Dravyas (BNDs) or Indian Reference Materials. Their certification has been done in accordance with ISO Guide 35 "Certification of Reference materials – General and Statistical Principles".

During this year following six New BNDs prepared earlier were sent for round-robin test at participating laboratories. Three diluting mediums have been certified and Prof. V.S. Ramamurthy, Secretary, Department of Science and Technology released them on January 07, 2003:

a) *Mono-elemental Solutions*

1. BND 901 Nitrate in water: 49.94 ± 0.48 mg/l
2. BND 1801 Calcium in water: 50.24 ± 0.42 mg/l
3. BND 1901 Manganese in water: 1.00 ± 0.02 mg/l

b) *Pesticides*

4. BND 1701 Chlorpyriphos purity standard: 99.15 ± 0.90%

5. BND 2001 Isoproturon purity standard: 98.79 ± 1.42%

c) *Gas Mixture*

6. BND 1601 Methane in Nitrogen (Gas mixture): 9.65 ± 0.66 ppmv

d) *Diluting Mediums*

7. Solution A: Sub-boil Distilled Water
8. Solution B: 2% HCl in Sub-boil Distilled Water
9. Solution C: 2% HNO_3 in Sub-boil Distilled Water

Use of these materials in the analytical laboratory ensures the generation of data with low uncertainty in measurement and it has wider acceptability at global level.

Crystal Growth and Characterization

Single crystals of mixed halide KCl and KBr in various molar ratios were grown by Czochralski technique in an indigenously developed crystal growth system by resistance heating of the charge. Different crystals with compositions of KCl (80%) + KBr (20%); KCl (50%) + KBr (50%) and KCl (30%) + KBr (70%) were grown.

To analyse the experimentally observed dynamical X-ray diffraction results of single crystals of thin and varying degrees of perfection, theoretical calculations were made for normal and forward diffracted X-ray intensities around Laue diffraction maxima. A software programme has been developed both in FORTRAN and C++. In many crystals like (-) 2-(α-methylbenzylamino)-5-nitropyridine (MBANP), the experimentally observed total transmitted intensity (sum of normal diffracted and forward diffracted beams) through the specimen shows a dip and a peak at and near the Laue peak which may be due to phase shift between incoming and outgoing X-ray beams. To understand this, quite a number of theoretical curves have been computed with different values of thicknesses/absorption of the sample. However, the large experimentally observed shift in case of MBANP crystals could not be attributed to the thickness of the sample. This might be probably due to defects and their diffuse scattering. Theoretical rocking curves were simulated for silicon single crystal using conventional Dynamical Theory. Takagi-Taupin equation has been explored in detail. An effort has been made to simulate theoretical rocking curve for Si(111) using Takagi-Taupin's approach.

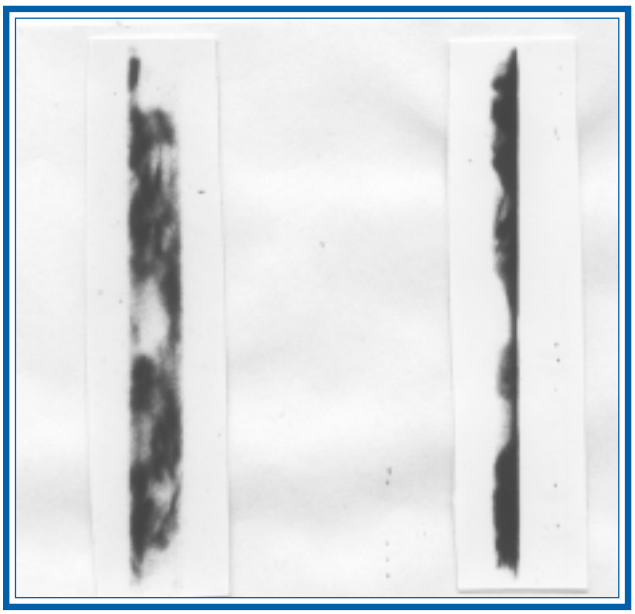
The existing third monochromator stage of the multicrystal X-ray diffractometer developed earlier has been upgraded to suit as a specimen stage so that the fourth crystal stage can be used as an analyser stage depending upon the requirement. The commercial goniometer has been replaced by a versatile home made goniometer. The length of the rotating arm of the turntable has increased upto one meter with proper couplings, adopters, L bends etc. Its rotations are provided with a high precision digital micrometer with least count equal to 0.001 mm so that the minimum rotation to the crystal in the diffraction plane becomes one arc sec.

A detailed study on the dynamical effects in LiF single crystals and high resolution X-ray diffraction (HRXRD) characterization of $In_xGa_{1-x}As$/InP quantum wells have been done which are described in the following subsections.

Direct Observation and characterization of Forward Diffracted X-ray Beam in Thin and Imperfect Lithium Fluoride Crystals

According to the dynamical diffraction theory, one expects two diffraction beams in Laue geometry namely, the normal diffracted beam and the forward diffracted beam which propagates along the direction of the incoming beam. However, these two beams are observable when crystals are nearly perfect and 'thick', characterized by $\mu t > 10$ (where μ is absorption coefficient of the material for X-ray and t is the thickness of the specimen along the direction of the diffracted beam). However, high-resolution X-ray diffraction experiments conducted earlier at NPL have shown that the forward diffracted beam is also observable even with 'thin' and

imperfect diamond crystals. During this year, similar experiments were made on 'thin' and imperfect alkali halide crystals like lithium fluoride ($\mu t < 1$) and it was found that the forward diffracted beam can be observed even with these crystals. This proves the universal nature of the observations made earlier. Figures 1(a) and (b) show the normal diffracted stationary topograph and forward diffracted stationary topograph, respectively. There has been a recent development in dynamical diffraction theory analysis of these results, which demonstrated that a residual direct beam is implicit even in the existing theory. If this is taken into account, a forward diffracted beam can be demonstrated to be present at all thicknesses of the crystals.



(a) (b)

Fig. 5.1 (a) and (b) respectively show a typical set of stationary topograph of normal diffracted beam and forward diffracted beam observed with a 'thin' (100) lithium fluoride single crystal. These experiments were performed with ($\bar{2}$ 2 0) planes in symmetrical Laue geometry and by using $MoK\alpha_1$ radiation.

Characterization of Quantum Wells by high resolution X-ray diffractometry using in-house developed software programme for the simulation of rocking curves

The existing semi kinematical theory developed by Kyutt et. al., [Phys. Stat. Sol. A **60**, 381 (1980)] for characterization of ion-implanted samples has been extended to characterize quantum wells. For the thin epitaxial layers (both wells and barriers) whose thickness is much less than the extinction length, kinematical approach has been adopted and for the relatively thick substrate, plane wave dynamical diffraction theory has been used. The composition of the layers was accounted for by the strain due to lattice mismatch between the layers with respect to the substrate. The thickness of each layer was estimated through the proper phase angle, which is directly related to the thickness of the layer. The composition and the thickness of various quantum wells and barriers could be accurately determined by simulation of the experimentally obtained high-resolution diffraction curves with that of the theoretically calculated curve. For simulation, FORTRAN based software programme has been developed. This programme was well tested by simulating the experimental diffraction curves of known structures. Lot of numerical data like structure factors, Fourier coefficients of dielectric susceptibilities of the crystal for the reflection concerned, elastic constants and absorption coefficients of binary and ternary structures etc. required to simulate variety of quantum wells: Ge_xSi_{1-x}/Si, $Al_xGa_{1-x}As/GaAs$, $In_xGa_{1-x}As/GaAs$, $In_xGa_{1-x}As/InP$ have been calculated by developing various other software programmes. The experimentally recoded high-

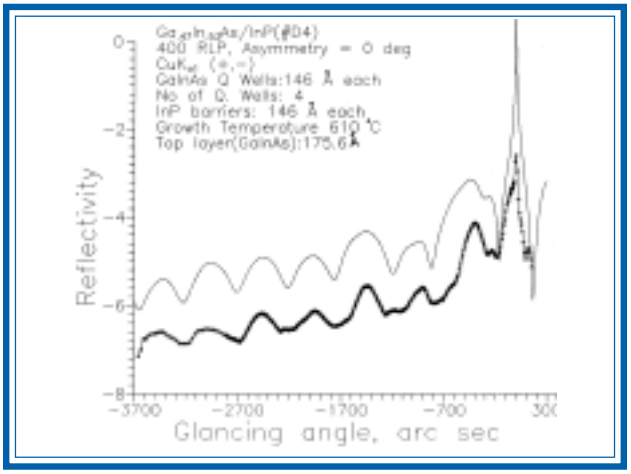


Fig.5. 2: Rocking Curve of a four-quantum well $In_{0.53}Ga_{0.47}As/InP$ structure. The upper curve (solid line) is the simulated curve using the in-house developed software programme and the lower one is the experimentally recorded curve.

resolution diffraction curve (rocking curve) along with the simulated theoretical diffraction curve (solid curve) for a four layer $In_xGa_{1-x}As$ quantum well with InP barriers has given in the figure 4.2. The composition of the wells obtained from the simulation is $In_{.53}Ga_{.47}As$. The thickness of each well and barrier is 146 Å and that of top layer ($In_{.53}Ga_{.47}As$) is 175.6 Å. The accuracy in the composition is ± 1% and that of the thickness is ±0.1 Å.

Realization of Mole

Attempts have been initiated to establish the Mole Standard at NPL to complete the realization of all the base units in the country. It is intended to make NPL the apex body in the nation for measurements related to quantity of matter and detection of ultra-trace impurities and their molar concentration. The immediate objective determined and details drawn are as follows:

1. To establish an ICP-MS (Inductively Coupled Plasma Mass Spectrometer) with Magnetic Sector for Isotope Dilution.
2. Set up of chemical metrology primary standards with Gravimetric, Titrametric and Coulometric techniques, to compliment the ICP-MS.
3. Determination of purity of coinage metals such as Gold, Silver, in SI units.
4. Trace impurity analysis of materials (gases, liquids and solids) related to environmental, food and pharmaceuticals.

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रेडियो तथा वायुमण्डलीय विज्ञान

RADIO AND ATMOSPHERIC SCIENCES

रेडियो तथा वायुमण्डलीय विज्ञान

कुहरा/धुंध (फॉग/स्मॉग) संबंधी अध्ययन दिल्ली में सर्दी की ऋतु में कोहरा होने पर मानवोद्भवी (मनुष्यों द्वारा उत्पन्न) प्रदूषण के प्रभाव का अध्ययन करने के लिए किए जाते हैं। टॉवर आधारित तापमान और आर्द्रता मापन के साथ–साथ टेलीमीटरी के साथ लगाये गये टीथर्ड गुब्बारे द्वारा दो सौ मीटर ऊंचाई तक वायुमण्डलीय तापमान, दाब और सापेक्ष आर्द्रता का भी पता चला है।

विश्व व्यापी परिवर्तन कार्यक्रम (ग्लोबल चेंज प्रोग्राम) के अन्तर्गत लेह/हेनले और दार्जिलिंग (उच्चतुंगता वाले स्थल) अंडमान निकोबार, सुन्दरबन इत्यादि जैसे विशेष स्थानों पर मापनों से उत्पन्न वायुमण्डलीय ट्रेस गैसों का संश्लेषण किया गया है। टयूनेबल CO_2 लेजर (9–11 सूक्ष्म मीटर) का प्रयोग करते हुए एक विभेदीय खपत लिडार (डीआईएएल) प्रणाली का प्रयोग वायुमंडल में छोटे–छोटे घटकों का मॉनीटरन करने के लिए किया गया है। विभिन्न स्थलों पर किए गए यू वी विकिरण मापों का प्रयोग अलग–अलग स्थानों और ऊॅचाइयों पर यू वी फ्लक्स की विशेषता बताने के लिए किया गया है और भारत में मनुष्य की त्वचा के लिए माध्य एरीथमल डोज की व्याख्या को बताने के लिए भी किया गया है। ज्ञात हुआ है कि दिल्ली में विशेषकर गर्मी के महीनों में एयरोसॉवल द्वारा यू.वी. फ्लक्स कम हो जाता है। मनु य के स्वास्थ्य पर जलवायु के प्रभाव से सम्बन्धित तथा वेक्टर वाहित बीमारियों से संबंधित अध्ययन लगातार किए जा रहे हैं।

क्षेत्रीय चेतावनी केन्द्र आर ड्ब्ल्यू सी जो आई एस ई एस का भाग है, के कार्यकलापों का उन्नयन किया गया है। यह उन्नयन संप्रेषण के प्रयोग के लिए तथा सौर कार्यकलाप से संबंधित भविष्यवाणी करके तथा लिंक संबंधित भविष्यवाणी करके किया गया और वेब पर उपलब्ध है। भारतीय क्षेत्र में आर पी ए सेटेलाइट पे लोड डाटा के सात वर्षों का विश्लेषण यह देखने के लिए किया गया है कि इलेक्ट्रॉन और आयन के तापमान के दीर्घकालिक भिन्न–भिन्न रूप क्या–क्या हैं और निम्न से उच्च सौर कार्यकलाप अवधि सहित पूरी अवधि के आयन घनत्व क्या–क्या हैं? एक ऐसी नई कार्यविधि तैयार की गयी है जिसमें और अधिक सही–सही फाराडे रोटेशन (एफ आर) शुद्धि (6 प्रतिशत के अन्तर्गत) जो समुद्र की सतह के तापमान का मापन करने में प्रयोग की जाएगी, का अनुमान लगाया गया है। आई आर आई मॉडलों का विधि मान्यकरण हो जाने से बिखरे हुए राडार आंकड़ों संबंधी उपलब्ध डाटा सैटों का प्रयोग निरन्तर किया जा रहा है। साफ हवा, कुहरे पर वर्षा का प्रभाव और बादल संबंधी स्थितियों संबंधी अध्ययन GHz संप्रेषणों में किया गया है।

RADIO & ATMOSPHERIC SCIENCES

Fog/smog studies are pursued to study the effect of anthropogenic pollution in Delhi on fog occurrence in winter season. In addition to tower based temperature and humidity measurements, a tethered balloon with telemetry has also been added to get the atmospheric temperature, pressure and relative humidity profile upto 200m height.

Under the global change program, synthesis of atmospheric trace gases from measurements conducted at special sites, like, Leh/Henle, & Darjeeling (high altitude sites), Andaman Nicobar, Sunderban etc. has been done. A Differential Absorption Lidar (DIAL) system using a tunable CO_2 laser (9-11 micro meter) is used to monitor the minor constituents in the atmosphere. The UV radiation measurements made at different sites are used to characterize the UV flux at different places and heights and also for defining the Mean Erythemal Doses for human skins in India. The aerosols are found to reduce UV flux substantially specially during summer months at Delhi. Studies related to impact of climate change on human health and vector borne deceases are continued.

The activities of Regional Warning Centre (RWC), which is a part of ISES, providing forecast of solar activity, link prediction etc. for use in communication, are upgraded and put on the web. Seven years of RPA satellite payload data over the Indian region is analysed to see the longtime variations of electron & ion temperatures and ion density over the period covering low to high solar activity period. A new procedure estimating more precisely the Faraday Rotation (FR) correction (within 6%) to be applied in the measurement of sea surface temperature has been developed. The IRI model validation is continued using the Incoherent scatter radar data sets available. The effect of rain on clear air, fog and cloudy conditions are studied on GHz communications.

Atmospheric Environment and Global Change

Fog & Anthropogenic Pollution Study:

The study of fog phenomena witnessed in Delhi during winter season and its relationship with anthropogenic pollution was started a year back in collaboration with Central Pollution Control Board (CPCB). Observations were continued during 2003. The coordinated measurements of atmospheric boundary layer Temperature, Relative Humidity, atmospheric Pressure, Aerosol samplers, Fog thickness along with event marking of fog occurrence, Monostatic Sodar have yielded interesting results. Delhi being the capital city is highly populated and polluted and therefore results may represent the urban highly polluted environment.

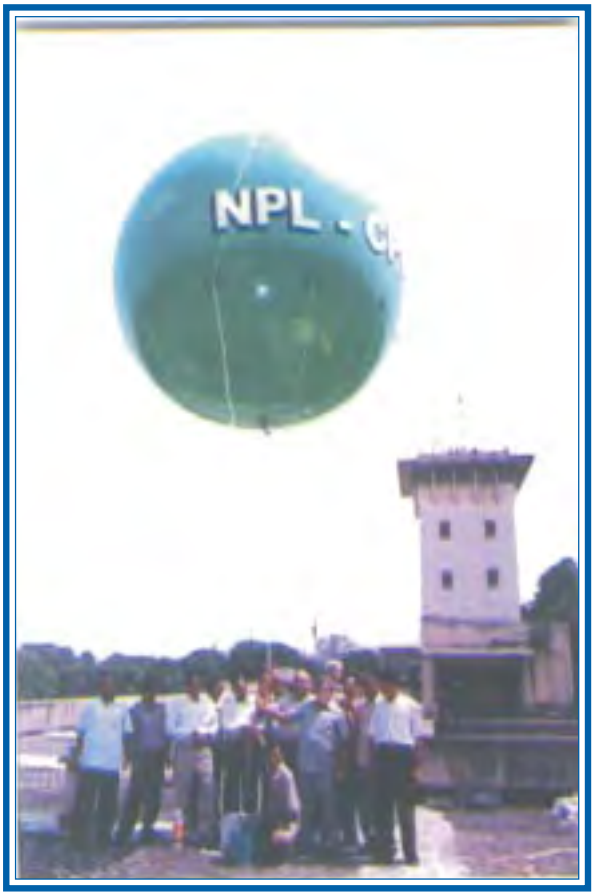

Fig. 6.1: Tethered Ballon for T & RH measurement

The sensors used for temperature monitoring are the matched micro-bead thermisters for having fast response time. They are matched to within 0.1 deg C in order to resolve small temperature differences. The data is logged at one minute time interval round the clock. Temperature sensors are mounted at 35m, 30m, 18m, 13m, 6m, 2m, 1m, 0.5m and 1cm height above the ground surface. In addition, four sensors are buried underground at 1m, 0.5m, 0.1m and 1cm depth below the earth surface for monitoring the soil conditions simultaneously. Sometimes, the temperatures are recorded at 50m and 100m heights also using tethered balloon (Fig. 6.1) with telemetry (Fig. 6.2) for data transmission.

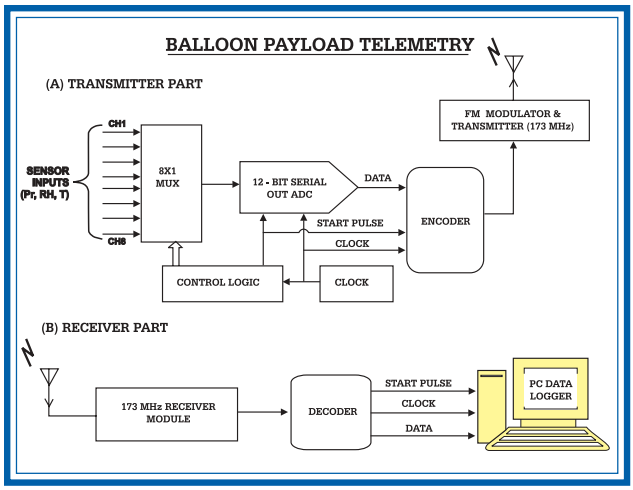

Fig. 6.2: Telemetry for Tethered Ballon

Temperatures recorded (Fig. 6.3) in the atmospheric boundary layer show very structured layer within 100m altitude from the earth surface specially during night time hours. Every day a strong temperature inversion very close to ground is observed. This inversion appears to be in addition to the inversion usually observed at 100m and above through Sodars and Radiosonde flights. We call this new inversion layer close to ground as Ground Inversion Layer or Garg Inversion Layer (GIL). GIL has number of features that are inconsistence, as well as, in contradiction to the present understating of formation of evening inversion in the Atmospheric Boundary Layer (ABL).

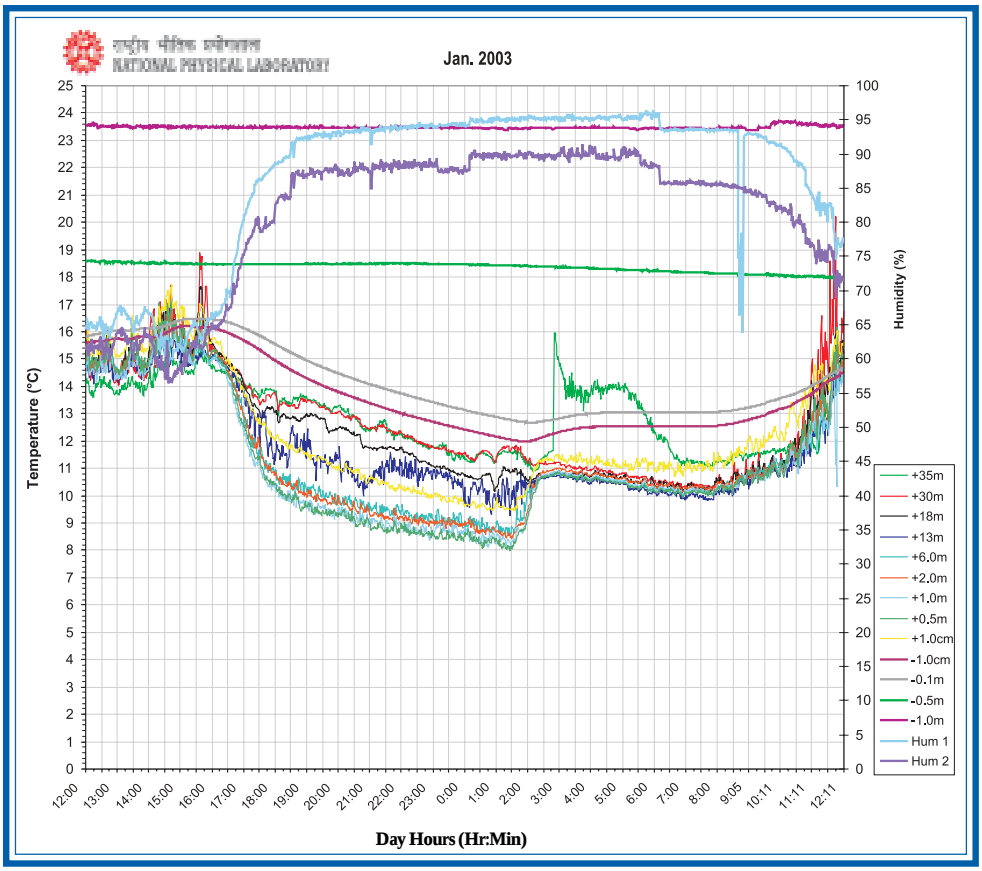

Fig. 6.3: Temperature recordings at different heights

Some of the typical features of GIL are described below:

- The formation of GIL starts around sunset with the faster cooling of atmospheric layers close to earth surface than the upper layers, thereby forming the inversion. The temperature difference between the ground and 30m layers becomes as large as 3 to 8^{0}C within 2 hours after sunset on different days. This means that when temperature within 1m height is 5^{0}C, the temperature at 30m height may reach as high as 13^{0}C. The maximum temperature gradient is seen generally between 6m and 18m layers. The temperature change above 30m or below 2m levels is relatively much smaller.

- On some days, the temperatures at all the observing heights converge to a common value, meaning thereby that perfect thermalisation of the lower atmosphere occurs with no temperature gradients. Such a situation occurs specially after rains and after the onset of strong radiative fog during nights.

- The ground temperature increases as we go deep during nights. Temperature variation is minimal at 1m and 0.5 m levels underground. The 0.1m and 1cm level temperatures vary with atmospheric temperatures. Sometimes temperature difference between 1cm above and 1cm below ground becomes as large as 2 to 3^{0}C.

- One of the important observation is that soon after sunset, the temperature of atmospheric layers close to ground decreases rapidly and becomes lower than the earth surface temperature (i.e. at 1cm below earth surface) by 3 to 4^{0}C and starts forcing the earth surface to cool faster. The increase or decrease of the atmospheric temperature thereafter is clearly seen modulating the earth's surface and inner side temperature during rest of the night. It may be mentioned that the temperature minima is seen to lie between 1m level down to 1 cm level and not at the earth surface level on different days. Under such conditions, both, earth and higher level atmospheric layers remain at elevated temperatures with a cooler layer sandwiched of atmosphere near to ground. This aspect

is in contradiction with the present understanding of creation of inversion that cooling of earth forces the atmosphere in its proximity to cool down thereby temperature minima lies at the earth surface. The important question arises how the cooling of atmosphere takes place after sunset when top and bottom are hotter.

- On many days in winter months GIL is seen to persist even after sunrise and continues for the whole day and round the clock; whereas, the higher height inversion disappears after a few hours of sun rise. Thus, GIL acts as an umbrella protecting the pollutants to disperse for a much longer period.

Further studies are in progress and there are indications that this GIL is the result of local pollution involving GHGs and SPMs and is closely related to the longer persistence of Haze / Smog / Fog in polluted cities.

Synthesis of Trace Gas Measurements at Special Sites in India

Measurements of trace gases e.g., ozone, CO, NO_x and SO_2 has been done at several places continuously in addition to organized campaign mode observations viz INDOEX, Biomass Burning Campaigns, and Corridor campaigns. As a follow of INDOEX, measurements were also done at four specially selected sites Darjeeling, Hanle, the Sunderbans and Port Blair from 2001 onwards in campaign modes. Observation at special sites of India shows large variation in the concentration of trace gases: Sunderbans (Ozone~60-80 ppbv, CO ~100-650 ppbv), Darjeeling (Ozone~30-45 ppbv, CO~100-150 ppbv), Port Blair (Ozone~ 10-45 ppbv, CO~ 150-350 ppbv) and Hanle (Ozone~ 60-80 ppbv, CO~350-600 ppbv).

Kaikhali(Sunderban)

Kaikhali (Sunderban) is a remote marine station in the southern tip of Indo-Gangetic flow. The observational site is on the confluence of River Matla and River Nabipukur and 150 km from Kolkata To assess the characteristics of Kaikhali, Sunderban, a joint campaign, of Jadavpur University, Kolkata & National Physical Laboratory (NPL), New Delhi, has been organized to experimentally observe the pollution level over Kaikhali, Sunderbans from December 21-30, 2001 at the Observational Centre, which belongs to Jadavpur University.

The analysis of the first coordinated campaign at Kolkata and Kailkhali/Sunderban of ozone, other trace gases and aerosol shows some important features in this campaign:

- Ozone concentration at three different sites of Kolkata shows large variation from 5 to 80 ppbv, whereas, Kaikhali, a though tropical remote coastal site, also show variation from 20 to 70 ppbv.
- Carbon monoxide at Kolkata represents typical urban nature with the variation from 3 to 10 ppmv. Surprisingly, CO concentration at Kaikhali has also reported large value from 1.5 to 3.0 ppmv. Local biomass burning, which is the only source of energy of Sunderban delta, may be one of the cause of it.
- Comparative study of trace gases at Kolkata and Kaikhali suggests that Kaikhali has registered higher value of concentration of CH_4, CO_2, N_2O than that of Kolkata.
- At Kaikhali, AOD observed at wavelengths of 340, 500, 870, 936, 1020 nm has been varied from 0.2 to 1.8, which is the representation of marine atmosphere. TSP at three sites of Kolkata varies between 225 to 629 mg/m^3 with the average value of 447 mg/m^3. Concentration of NO_x observed at Kolkata during this campaign varies from 40 to 130 mg/m^3, whereas, at Kaikhali it has been varied from 5 to 30 mg/m^3.

Port Blair (Andaman & Nicobar)

The Port Blair is a remote marine station.

This station was chosen to understand the flow pattern from East Asia. A campaign was made by National Physical Laboratory during the period of March 16-29, 2003. Couple of features were observed during this period:

(i) It shows the very low ozone of the order of 2-3 ppbv in the presence of large concentration of pollutants e.g., CO, NOx, CO_2.

(ii) The concentration of carbon monoxide was 300-600 ppbv whereas, NOx concentration was around 40 ppbv. Generally this concentration was observed at the very high polluted cities.

(iii) Backward trajectory suggests that pollutants might have come from the Indian Subcontinent.

(iv) The concentration of SPM was in the range of 30-90 $\mu g/m^3$

In addition, continuous observation of ozone using DASIBI Model 1008 is being done at PortBlair

Leh / Hanle:

Hanley is a hill station in the western side of the Himalayas. The position of this station is crucial in the context of transport of trans-boundary pollutants. At Hanle we have done three campaigns for measurement of atmospheric parameters during

- May 1999, May 2000
  Parameters measured during these campaigns
- Ozone, CO, NOx, CO_2 Aerosol (Chemical, Optical Depth, Fine Particles), UV

The unique feature at Hanle is that large increase in ozone concentration during morning hours with decrease in CO concentration during the campaign of 2000. This could be explained that large NO is built up during the night hours becomes activated to produce large ozone concentration with decrease of CO.

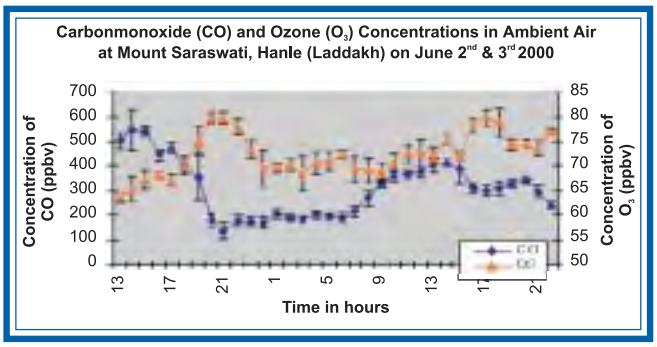

Fig. 6.4: CO and O_3 Concentration at Henle

Darjeeling:

Darjeeling is a hill station situated in the Eastern side of the Himalayas. The position of this station is crucial from the point of transport of trans-boundary transport. At Darjeeling we have done so far three campaigns for measurement of atmospheric parameters during

- July 1999, May 2001
  The parameters measured during these campaigns are
- Ozone, CO, NOx, CO_2 Aerosol (Chemical, Optical Depth, Fine Particles), UV

The earlier results show that ozone concentration is between 30-40 ppbv at Darjeeling and its associated places.

The concentration of GHGs viz, carbon dioxide, Nitrous oxide, and methane are higher compared to the Silliguri, a nearby place city.

Differential Absorption Lidar (DIAL)

A Differential Absorption Lidar (DIAL) system using a tunable CO_2 laser (9-11 micro meter) designed and developed at National Physical Laboratory, New Delhi is being used to monitor various minor constituents in the atmosphere. It is observed that some times ethylene and ozone were found to be on higher side which is a health hazard. The high value of ethylene observed in the morning hours and evening hour may be attributed to traffic density. The observations show that urban areas like Delhi may have large variation in day to day ethylene concentration which depends upon automobile

exhaust and petrochemical industries. The ammonia concentration is quite variable and depend on meteorological conditions particularly wind direction as shown in Fig. 6.5. Ammonia was found to be higher when the wind was blowing from agricultural fields of IARI, New Delhi which is very near to our observational site.

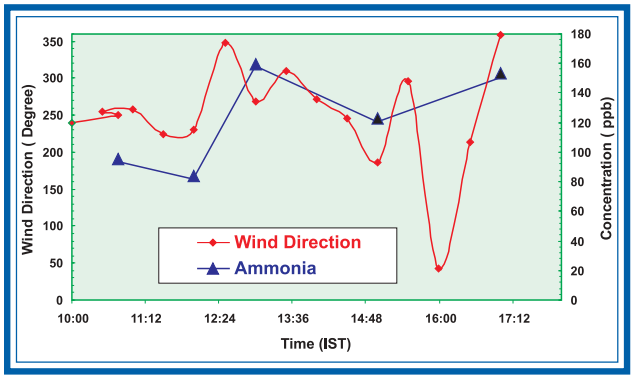

Fig. 6.5: Temporal variation of ammonia with wind direction on 11-4-02

Surface Ozone

Tropospheric ozone is secondary pollutant as well as non-radical oxidizing compound, formed from the photochemical reactions involving oxides of nitrogen and hydrocarbons in the presence of sunlight. The high surface ozone concentration at a particular place depends on the concentration of oxides of nitrogen and hydrocarbons. Being a precursor to highly chemically active OH radical, ozone plays a significant role in the tropospheric chemistry. High concentration of O_3 can affect human health, animal and vegetation. The high densities of population, industrial activities and automobiles in Delhi leads to high emission of air pollutants injected into the atmosphere. The measurements of surface ozone on round the clock basis using ozone analyzer to study the diurnal as well as seasonal variations are carried out at NPL since 1997. It has been also observed that in Delhi most of the time during April, May and October months the surface ozone is found to be higher then the ambient air quality standard defined by WHO which is a health hazard. The frequency distribution of hourly average values of surface ozone exceeding 80 ppb at NPL, New Delhi from May 1997 to December 2002 is depicted in Fig. 6.6 which is of a serious concern. Therefore it is high time that India should define the ambient air quality standard for surface ozone.

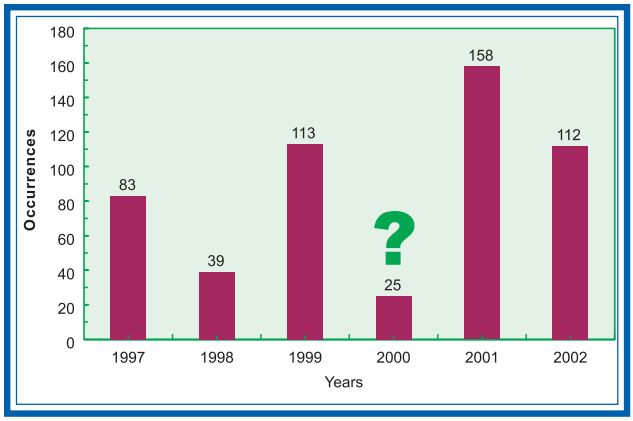

Fig. 6.6 Occurrences of hourly average values of surface ozone exceeding 80 ppb at New Delhi during 1997- 2002

Nitrogen Oxides

NO_x (NO + NO_2) is a one of the key species in tropospheric chemistry. It affects the concentration of OH radicals and controls the ozone production. NO_x in the troposphere is photo chemically oxidized to other odd nitrogen species such as HNO_3 and peroxyacetylnitrate (PAN). Its ultimate sink is HNO_3, which contributes to acid rain. The lifetime of NO_x in mid-latitudes is on the order of 1 day. NOx also plays an important role in ozone chemistry. In view of the above round the clock measurements of NO_x, NO and NO_2 has been started at NPL from June 2002. Monthly average concentration of NO was found to be low in summer month and high in winter months which may be attributed to high photo chemical processes in summer compared to winter. It may also be due to the less mixing during winter being low PBL in winter as compared to summer time. The NO & NO_2 concentration was found to be in the range 1 to 50 ppb and 2 to 16 ppb respectively. It has also been observed that normally NO_2 and NO are found to be higher during night time.. The average daily variation of NO_x is shown in Fig. 6.7.

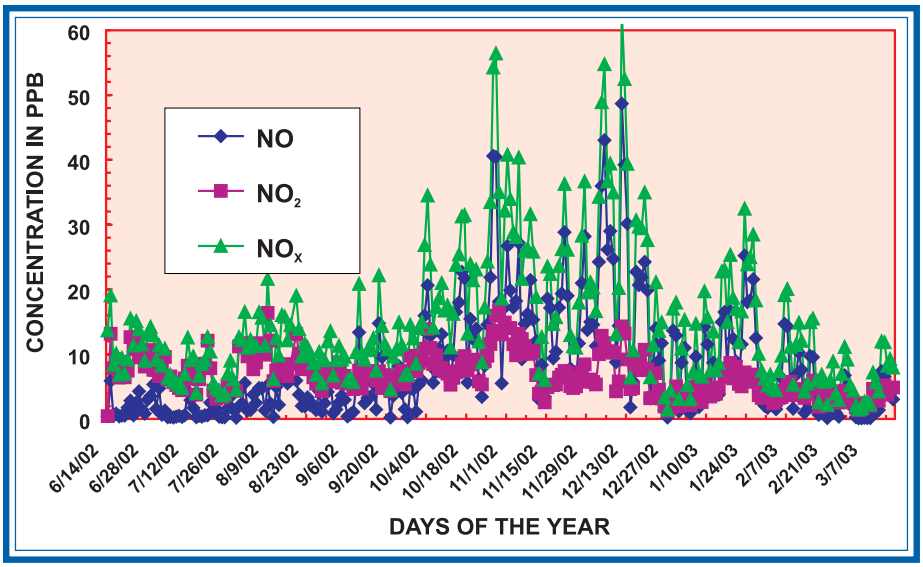

Fig. 6.7 Daily mean concentration of NO, NO_2, NO_x at NPL, New Delhi during June, 2002- March, 2003

Measurement of Total Ozone, Water Vapour etc.

A highly sophisticated and hand held microprocessor based sun photometer is being used to measure the solar radiation at 300, 305, 312, 940 and 1020 nm. The first three filter channels were used to derive atmospheric total ozone while later two channels were used for water vapour and aerosol optical depth. The hourly observations were taken on all clear cloudless sunny days at NPL and also during field campaigns. The total ozone measured at NPL was compared with that of TOMS data and found to be in good agreement. The regular measurements are being continued on all clear days. The variation of water vapour observed at Delhi and that at Antarctica is shown in Fig. 6.8. The water vapour found to be very low over Antarctica compared that at Delhi.

The Measurement of Extinction and Liquid Water Content of Fog

The study of atmospheric fog is important for radiative transfer in the atmosphere. Fog and haze degrade the visibility and affect the climate. An Infrared system designed and

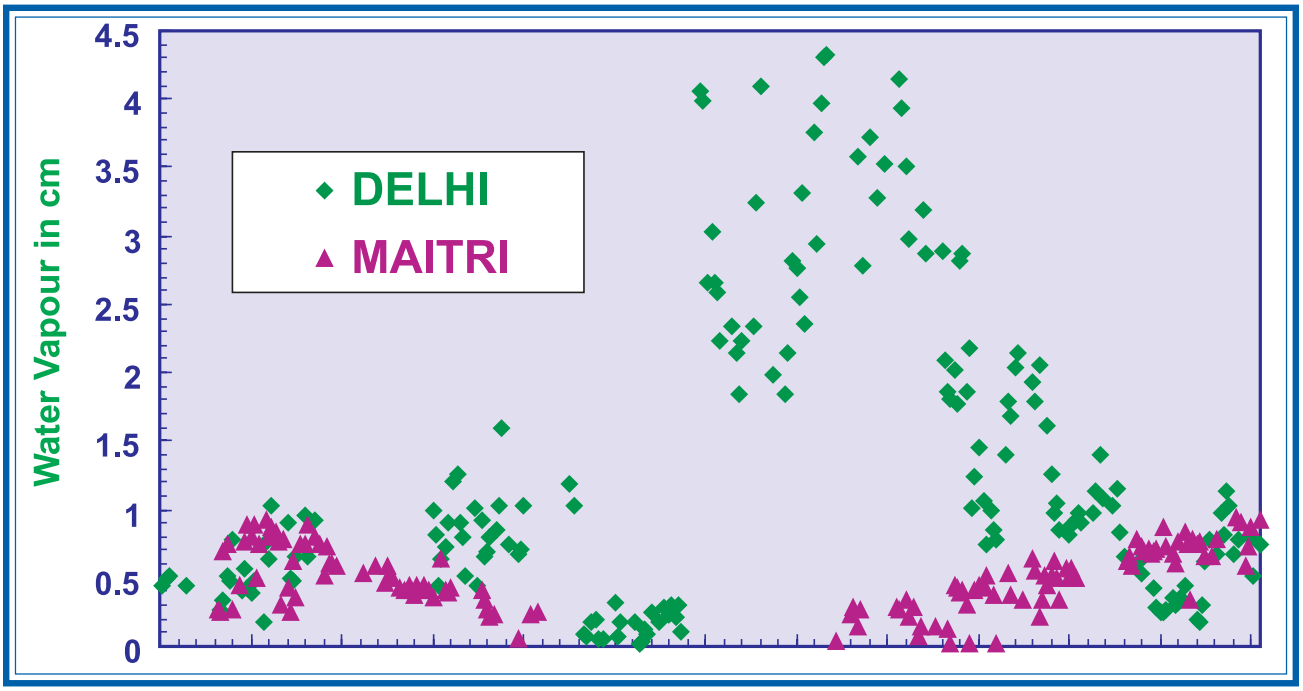

Fig. 6.8 Comparison of water vapour over Maitri, Antarctica & Delhi during the year 2002

developed at National Physical Laboratory has proved to be an important tool to monitor the onset and dissipation of the fog quite accurately. The block diagram of the system is shown in Fig. 6.9. The typical onset and dissipation of fog observed on different days during 2003 using IR system is depicted on Fig 6.10. The day to day variation of fog intensity is clearly seen from the Fig. 6.10. During fog it has been observed that as soon as the fog sets in NOx suddenly increases and then settles to its normal trend.

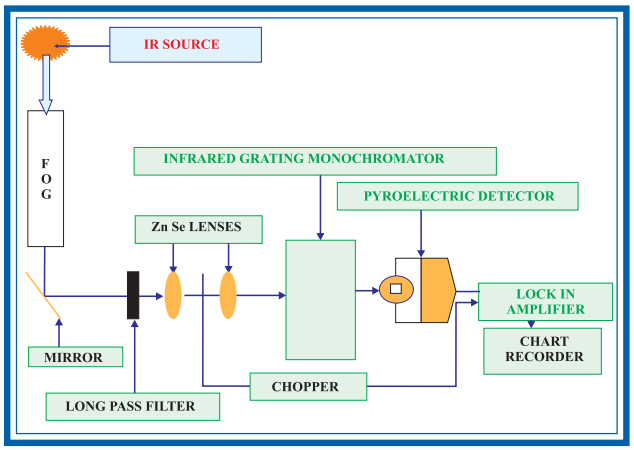

Fig. 6.9 Block diagram of INFRARED system for fog studies

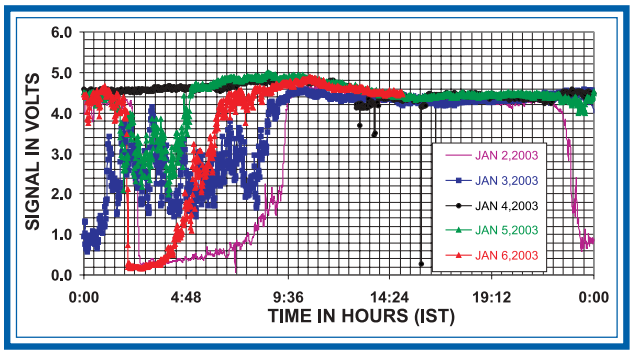

Fig. 6.10 IR SIGNAL AT 1.940 MICROMETER DURING JAN 2-6, 2003

On Line Aerosol Monitoring

The study of aerosol is interesting for a number of reasons. It is thought that aerosol may be involved in a 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 to ecosystems. Keeping this in view round the clock on line aerosols measurements have been started at NPL The system has also been used during fog. The aerosol (PM 2.5) found to be increased almost 5 to 6 times during Dipawali festival due to burning of crackers as shown in Fig. 6.11 which is a health hazard.

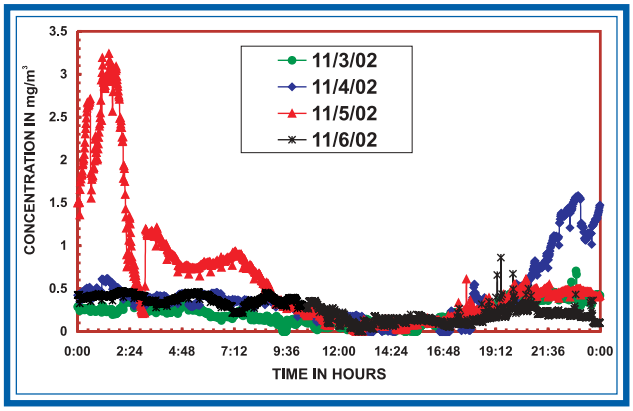

Fig. 6.11 Diurnal variation of aerosol (PM 2.5) at NPL, New Delhi before, after and Dipawali- November, 2002

Automatic weather station

Round the clock monitoring of the various meteorological parameters such as temperature, relative humidity, solar radiation, wind direction and speed etc. are continued.

Antarctica Expedition 2002-2003

The earth's environment is constantly changing. The scientific evidence indicates that these changes are result of a complex interplay among a number of natural and human related systems. Therefore in the recent times, concern has grown about global change - which is related to natural and anthropogenic alteration of the Earth's environment. Among them the important issues, which are dangerous for the survival of life on the earth, are global green house warming, urban and regional atmospheric pollution, regional increases in tropospheric ozone, the decrease in stratospheric ozone in general and ozone hole over Antarctica in particular, acid rain etc. The monitoring of green house gases has

an important role in the understanding of global change.

In view of the above measurements of various green house gases have been started during 21st Indian Scientific Antarctica Expedition at Maitri on regular basis which in turn will go a long way to fill in the gaps and provide valuable data for modeling studies. The observations, made at high latitude like Antarctica will also help to understand photochemical, heterogeneous and dynamical processes that control the distribution of atmospheric trace gases.

Green house gases

a. Carbon dioxide: The carbon dioxide measurements carried out at Maitri using a Gas Chromatograph was found to be in the range 330 to 390 ppm depending on the wind and other meteorological conditions. The average CO_2 during the year 2002 was found to be 367 ppm. The variation of CO_2 at Maitri during 2002-2003 is shown in the Fig 6.12.

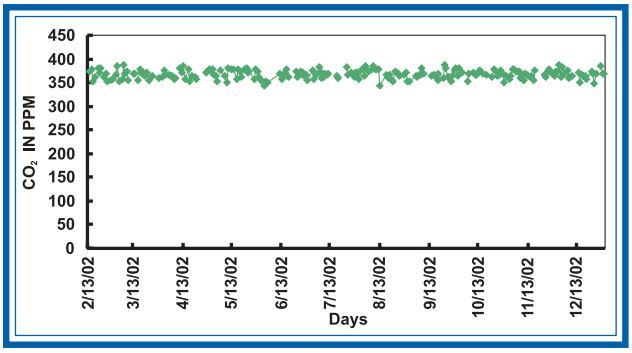

Fig. 6.12 Daily average co_2 in the year 2002 at Maitri, Antarctica

b. Methane: The measurements of methane were also started on regular basis at Maitri form Jan. 30, 2003 after rectifying the problem associated with ghost negative peak. The average value of CH_4 during February – March 2003 was found to be 1.7 ppm which is in good agreement with other measurements. The daily average methane observed at Maitri is depicted in Fig. 6.13

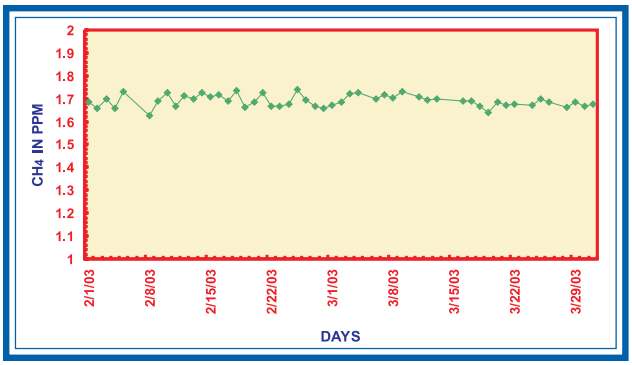

Fig. 6.13 Daily average CH_4 at Maitri Antarctica from February - March 2003

c. Carbon monoxide: During 22nd Indian Scientific Antarctica expedition a new system has been deployed at Maitri, Antarctica to monitor Carbon-monooxide on round the clock basis. The variability in CO concentration has been observed, with hourly mean mixing ratios ranging from 30 ppb to 65 ppb. Diurnal changes in CO concentrations were systematically observed in Antarctic Atmosphere showing higher CO during day time. The day time increase of carbon-monooxide is attributed to the photolysis of formaldehyde in Antarctic atmosphere. Recent studies have reported production of formaldehyde in the snow pack. Formaldehyde is rapidly destroyed by sunlight to produce HO_2 and carbon monooxide. The average diurnal variation of CO observed over Maitri is depicted in Fig. 6.14.

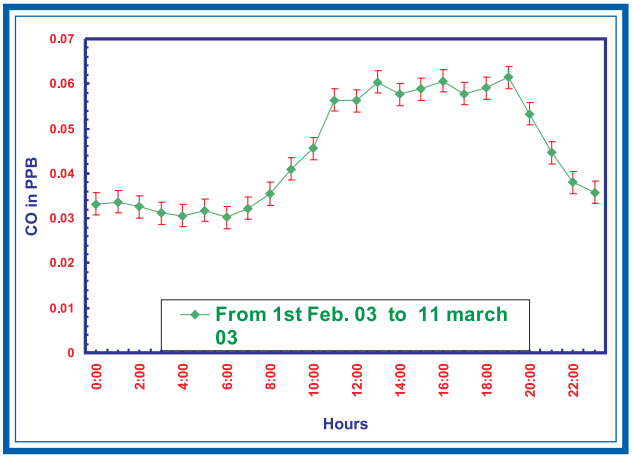

Fig.6.14 Average hourly mean CO at Maitri, Antarctica during Feb-March 2003.

Signature of Recovery of Ozone Hole

The column ozone measurements were carried out during 1996-1998 and again during 2002-2003 at Maitri Antarctica on all clear days. Integrated column Ozone observations during 1997, 1998 and 2002 at Maitri show ozone concentration up to 320 DU in the months of January-February. The minimum value of column ozone during spring of 1997 observed was about 135 DU in the first week of October while during spring of 2002 the minimum value of column ozone was found to be 185 DU as shown in Fig 6.15. Thus it is found that the ozone hole during Antarctica spring of 2002 was not as deep as it was during 1997 and also it was for short duration during 2002 as compared to that in 1997 spring. This may be the signal of recovery of ozone hole as a result of international efforts in reduction of use of CFC's which are the main culprit for ozone hole. Our measurements were also compared with those obtained by satellite data and are in good agreements with our findings. However it will be too early to conclude about ozone hole recovery and to confirm it regular observations are being continued at Maitri.

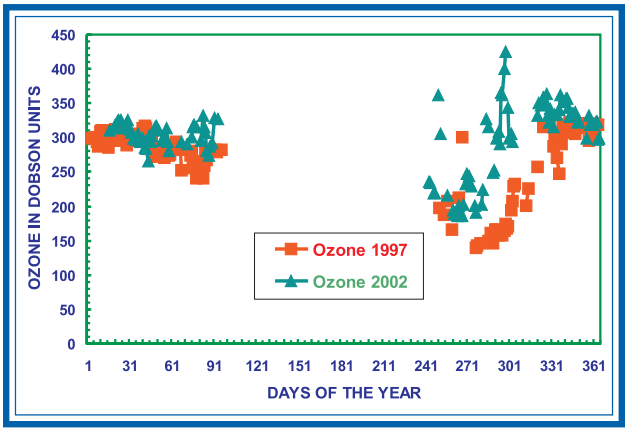

Fig.6.15 Column Ozone at Maitri, Antarctica during 1997 and 2002

UV-B and Atmospheric Aerosol

UV-B and Atmospheric aerosol study program was undertaken with emphasis on the following aspects:

Correlation of UV-B intensities with Human skin reflectances: From the data base we have for the previous years on UV-B intensities for different locations a correlation between these intensities and skin reflectances of the inhabitants of these locations has been studied. The skin reflectance data used was obtained by using a CCD based Spectroradiometer for the skins of the subjects originally coming from different locations of the country. The white skin reflectance was taken to be unity and other reflectances were normalised to this value. The maximum values of UV-B intensities and yearly average duration periods of these values correlate fairly well with skin reflectances at different locations. This study is just a preliminary one and an effort is being made for an exhaustive study.

Defining the Minimum Erythemal Dose (MED) in Indian Context: The UV-B Minimum Erythemal Dose defined as the minimum UV-B intensity, which after falling continuously for one hour start effecting (reddening) the human skin. Western countries have defined it to be 5.83 microwatts for their white skin. As we know skin response to UV-B radiation depends upon the skin structure which are different for different coloured skins. The Indian skin structure is quite different from that of white skin of Western people, so the MED for Indian skins should have been defined separately. This has been attempted by taking into consideration that the human skin have been evolved, during a very long duration of time, according to the radiation fields , including UV-B, present during all these years at different locations .The total yearly average UV-B intensity falling at any location is , therefore, taken to be the indicator of the evolved stage of the human skin and also the level of MED for that particular location. The total Yearly average UV-B intensity falling at Delhi location are compared to a selected mid latitude 45^0 North latitude location. This is accomplished by comparing the periods of UV-B intensities periods of MED level remaining above 1.0 between the entire period of 21^0 (summer solstice) and 68^0 (Winter solstice) of solar zenith

angle for mid latitude location and between 5^0 (Summer solstice) and 51^0 (Winter solstice) of solar zenith angle for Delhi and then taking the ratio of these period. This ratio has been found to be around 2.0 and therefore the MED for Indian conditions has been taken to be approximately twice the value adopted for mid latitudes ie 2x5.83 ≅ 10.0 microwatts/ centimeter square.

Field characteristics in environments of high altitude, marine and forests: Studies of UV-B and Atmospheric aerosol characteristics carried out of the data collected during various field campaigns include.

High altitude at Darjeeling: The observations at and around Darjeeling hills show that the Minimum Erythemal Dose (MED) values show an increase of 60% between a site (Siliguri) 492 feet above msl compared to a site (Tiger hill) at 8480 feet above msl . The AOD values change (decrease) by almost 100% from Siliguri to Tiger hill. The changes are not very sharp upto 6000 feet above msl but above this altitude the changes are very sharp.

Marine Environment at Port Blair: The UV-B intensities measured with Erythemal Probe (290-305 nm band) exhibit a change in direct radiation, between Delhi and Port Blair are of the order of 20% when compared for good sky conditions at 30^0 solar zenith angle and 10% change during not so good sky conditions at both the sites. The change for Global radiation exhibits a different pattern in which the change in radiation is more at higher solar zenith angles compared to low solar zenith angles. The ratio of Global/Direct radiation shows that these values are between 2.0 and 7.2 at different solar zenith angles for Port Blair and between 2.5 and 16.5 for Delhi.

Mizoram forest environment: The UV-B intensity measurements by Erythemal Probe in Mizoram forests during biomass burning episode and during normal days show that there was substantial reduction in intensity during biomass burning period compared to normal days. The ratio Global / Direct intensities showed a substantial increase during the biomass burning period. The Aerosol Optical Depth (AOD) measurements were also carried out during these days. The AOD values increased during biomass burning periods compared to normal days. A correlation between the AOD (500 nm) and the Erythemal intensities has been established for there forest environment.

Antarctic Environment : The UV-B and AOD experiments were conducted during summer time of 22^{nd} Indian Antarctic expedition. It is found that the general feature of the magnitudes of the UV-B intensities and AOD did not change very much but the total amount of the UV-B radiation energy during the month of January 2003 was found to be the highest compared to the previous years.

Fog Environment : The UV-B , Total Solar radiation and AOD experiments were conducted during fog/smog campaign conducted at NPL during the months of Dec.2002-Jan. 2003 . It is found that the reduction in solar radiation intensities is more in the UV-B band compared to the visible band.

Retrieval of Aerosol size Distribution: The aerosol optical depths (AOD) were obtained from the solar radiation measurements using the multiple wavelength spectro-radiometer at Delhi (28^0 43' N, 77^0 13' E, 216 masl) and at very high altitudes site Hanle (32^0 47' N, 78^0 58' E, 4517 masl) and Leh (34^0 09' N, 77^0 34' E, 3441 masl). The spectral variation of this AOD was then used for the inversion calculations from which the size distribution was obtained by the iteration procedure. The AOD values at Hanle and Leh are found to be lower than that at Delhi (Fig. 6.16). The size distribution of column aerosols (Fig. 6.17) generally shows a bi-modal distribution at Delhi. On the other hand generally mono-modal behaviour is found at Hanle. Although bi-modal behaviour is also seen at Leh but the aerosol density is much smaller than that at Delhi.

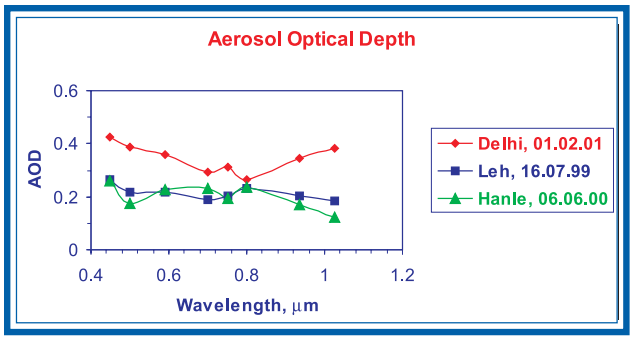

Fig. 6.16: Aerosol Optical Depth at Different Wave lengths.

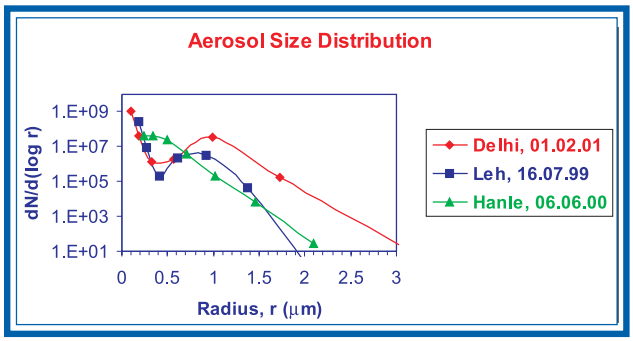

Fig. 6.17: Aerosol Size Distribution Spectrum

Centre For Global Change

The South Asian START Regional Research Centre (SAS-RRC) working under the Centre for Global Change continued its activities during this period. These include organization of a workshop on finalization of emission factors for Inventorization Mar. 3-5, 2003 at NPL as part of its activity for capacity building, SASCOM Planning meeting at Dhaka, in May 2002 .

As part of its activities related to Global Change falling under the sponsored projects, considerable efforts were made to generate activity data needed for making inventories.. These programmes include impact of Climate Change on human health and The budget of GHGs, urban air pollutants and their future scenarios in selected mega cities in Asia.

In impact of Climate Change on human health, Effect of climate change on the spread of vector borne diseases with special emphasis on malaria is already going on in center on Global change for South Asian Region. Out of the target of seven states in India four(Orissa, Rajasthan, Gujarat and M.P.) have been covered already. rainfall, humidity, temperature data are being collected. API of Hot Spots of plasmodium vivex and plasmodium falciparum is being analysed.

Efforts were also made to study the effects of pollutants on human health related to respiratory problems under a collaborative efforts between NPL, Patel Chest Institute, Delhi and Chitranjan Cancer Research Institute, Calcutta. During Diwali festival, when pollution due to burning of crackers reaches a peak, a special campaign was mounted and trace gases and aerosols were monitored at selected sites in Delhi accompanied with a survey of the area to identify any increase in respiratory problems.

In the other research programme on mega cities, activity data from Delhi, Calcutta and Manila. However, not much data about Manila could be found and therefore, efforts have been concentrated on Delhi and Calcutta and include detailed information about geographical, demographical, aggregate energy data, house holds, commercial and industrial establishment, transportation, agriculture infrastructure. waste etc. This data is compiled in digital forms. Additionally, data about surrounding urban satellite towns of Delhi & Calcutta have also been collected and compiled. Attempts are now on to develop inventories of GHGs and other urban pollutants for Delhi and Calcutta using the IPCC reference approach as well as bottom up approach.

The data Centre of the Centre for Global change was earlier one of the three international INDOEX Data Centres and also reflected SASCOM activities as well as some of the Global Change data on its web site. This web site was modified during this period to include more components including campaigns data, ursigrams, ionospheric data , space data including satellites Inventory and emission data for GHGs, special programmes etc. A new architecture of the web site has been worked out as a dummy web site on a Silicon Graphic server and its trial on regular server are on, for its compatibility. In the mean time the existing site on the old server, daily Ursigrams issued by our RWC, information

about activities, events and announcements are put up from the existing web site.

In the experimental activities, monitoring of trace gases as well as aerosols was continued during this period both in continuous mode as well as in campaign mode. The campaign mode observations included observations during Diwali in Delhi, Fog campaign at NPL etc. The data obtained from the campaign carried out in Port Blair from March 5-20, 2002 was analyzed and synthesized . Based on the observations, regular monitoring of ozone and aerosols (chemical composition) has been started in collaboration with CERI .

As part of CSIR efforts for having network projects in CSIR laboratories, a programme on Impact of Anthropogenic perturbations on oceanographic –atmospheric processes in and around India in context of Global Change was identified with NIO as the nodal institute and NPL and NGRI as the participating institutes. Considerable efforts were put in with a lot of deliberations and a proposal was evolved which was submitted to planning commission and is under consideration.

Radio Communications and Space Physics

New procedure for Faraday rotation correction

A new procedure has been developed which estimates more precisely the Faraday Rotation (FR) correction (within 6%) to be applied in the measurement of sea surface temperature using microwave radiometers onboard remote sensing satellites. The new procedure uses the FR derived from observed TEC from GPS satellites (using Titheridge method) to optimize the IRI model. In the old procedure TEC was directly used to optimize the IRI model and FR estimation was within 30%. Figure 6.17 shows a comparision of different methods. The red curve represents the percentage deviation of FR obtained directly from IRI model (without optimization) from the FR as derived using new procedure. Yellow curve represents the same when IRI model is optimized using observed TEC from GPS satellites (old method). The brown curve is when Faraday Rotation is used as an optimization parameter (new method). It may be seen that the new method shows least deviation from the observations.

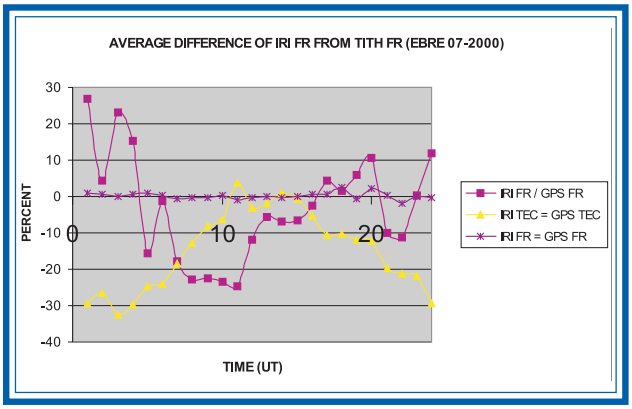

Fig. 6.18 Average Difference of IRI FR from Titheridge

Validation of the IRI (International Reference Ionosphere) model

The validation of IRI model been attempted using Digital ionosonde measurements at NPL and Incoherent scatter radar measurements at Arecibo.

Using Digital ionosonde measurements at NPL we have examined the diurnal and seasonal variations of the critical frequency of the F2-region (foF2), for the period from August 2000 to July 2001 (a high solar activity period). Also, we have derived the noontime bottomside electron density profiles, using in-built POLAN software. These profiles are then normalized individually to the peak height and density of the F2-region. These observations are used to assess the predictability of the IRI-2000 model. Further, the diurnal and seasonal variations of height of the peak density of the F2 layer (hmF2), are analyzed for the period from January 2001 to August 2002. In order to derive the hmF2, the propagation factor, M(3000)F2 values are used at each hour, obtained from Digital ionosonde, and then using Bilitza's empirical formulation, the hmF2 values are deduced at each hour for different

seasons. These observations are compared with those obtained from the IRI-2001 model.

Incoherent scatter radar measurements at Arecibo, are used to examine seasonal and solar activity variations of electron temperature (Te) in F-region and topside ionosphere. The data includes low solar activity (1974-77) and high solar activity (1989-90) periods. Our results show that during low and high solar activity periods, the seasonal variations in average Te is identified, with winter temperatures significantly higher in the topside ionosphere. Comparison of average Te profiles for each season too reveal distinct solar activity variations – large increase in F-region Te, during summer and equinox, where the Te, during high solar activity is larger by about 50 % than low solar activity. The IRI model in general, overestimates Te in the topside ionosphere during all the seasons. We have also made an attempt to generate empirical models of Te in the topside ionosphere from the same aforesaid Arecibo measurements.

Seven Years of RPA Experiment onboard SROSS-C2:

RPA experiment onboard SROSS-C2 yielded about 3000 orbits of data covering equatorial and low latitudes over and around the Indian region. The altitude coverage of this data during the entire mission varied from 930 km (immediately after launch and for 2 months there after) to as low as 200 km(during the last month in the orbit). But the maximum data from this mission is available between 400 to 600 km altitude. The normal latitudinal coverage, in a high elevation orbit, seen from Bangalore ground station and lasting for about 7 to 8 minutes, is 5°S to 30° N. The northern latitude limit was extended to 38°, when the data was acquired from Lucknow ground station. During campaign modes and also during special events such as meteor showers, the data was acquired from Mauritius ground station also, thereby extending the southern latitude coverage to about 40°. The longitude belt covered extends from 50° to 100° E.

The sweep mode electron and ion RPA data were subjected to curve fitting to derive electron temperature, ion temperature and ion constituents. The ionic constituents derived were O^+, H^+ He^+ and O_2^+. The total ion density is derived from the duct mode ion current collected, when the sensor was facing the velocity vector of the satellite.

Some new features are unearthed in the electron and ion parameters and all the known features reported in literature are established.

Electron Temperature:

- Morning shoot out in electron temperature is observed in all seasons
- The rise in temperature is 3000 to 4000 K from the night time low of about 800 - 1000 K
- Evening enhancement in electron temperature, prominent during summer and equinox months.
- The evening rise in electron temperature is by about 500 to 1500 K from an average midday temperature of 1500 K.

Ion Temperature:

- Ion temperature is found to be lesser than electron temperature and at all times of the day and in all seasons, with few exceptions.
- Morning overshoot is seen in ion temperature also, more prominent during winter and equinox months
- The rise in temperature being 2000 to 3000 K from a night time low of about 600 K,
- Evening enhancement is also seen in ion temperature, although it is not as high compared with electron temperature
- Evening enhancement in temperature is very prominent during summer months and the rise in temperature is higher than morning overshoot by about 500 K, which is not reported in the literature.
- The morning and evening rise in ion temperature is found to be visible only above 500 km altitude as is evident from the ion temperature plots.

Ion Density:

- Ion density followed a fixed diurnal pattern in all the seasons, with a minimum density varying between few parts in 10^9 to $1x10^{10}$ per m^3 at around 03 to 04 LT.
- The local time at which maximum ion density reached varied from season to season.
- The value of peak ion density varied from few parts in 10^{11} to few parts in 10^{12} per m^3. The higher values are found during equinox months.
- In general an inverse relation is found to exist between ion temperature and ion density

Ion constituents:

- O^+ constitute the major (heavy) and H^+& He^+ constitute the minor (lighter) ion constituents in the height region of 400 to 600 km.
- The density of heavier ions is 1 to two orders of magnitude higher than the lighter ions during daytime hours. But during night time hours, they are comparable, especially in equinox and winter months
- During meteor shower events heavy metallic ions like iron, cobalt, magnesium and calcium were detected in the height region of 400 to 600 km.
- Although the number density of these ions are very small (about 100 /cm^3), the existence of these heavy elements at those altitudes cannot be explained by the existing theories.

The enclosed figures 6.19 show the diurnal variation of electron and ion parameters in different seasons during low and high solar activity periods

Study of Mid-latitude Night Time Enhancement in F Region Electron Density using tomographic Images over UK

Earlier night time enhancements in ionospheric electron content (IEC)/ peak electron density (NmF2) have been studied by various workers in the anomaly and mid latitude regions. Such studies give an idea about their enhancement over that location only. In the present study tomographic images over UK, which gives a latitudinal versus height distributions of ionospheric electron density in a much wider area, have been used to study the anomalous increases in nighttime F region electron density at mid latitudes (An example of night time Ne enhancement is shown in figure 6.12). From the analysis of four seasonal representative months (November 1997, March, June and October 1998) data it was noted that majority of the cases of night time enhancements were observed after local midnight with a maximum between 0300-0400 hours LT (see figure 2a) in the month of November 1997. Enhancements were observed mostly between 45-50 N latitudes and their positions are not affected by magnetic activity (Kp) variations whereas the separation between mid-latitude trough and

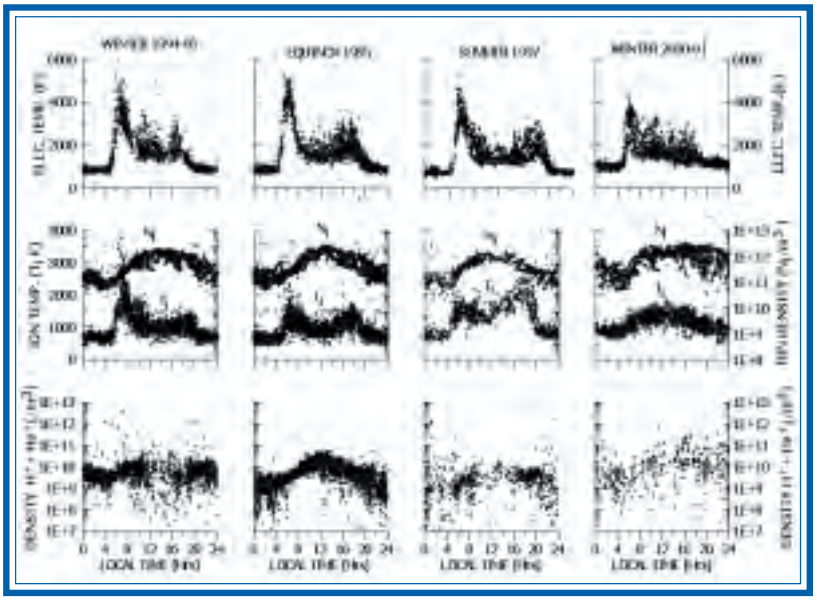

Fig. 6.19: Diurnal variation of electron and ion parameters in different seasons during low and high solar activity periods

enhancement decreases with increases in magnetic activity. This shows that only the trough moves equator ward with the increase of magnetic activity. It is also noted that the electron density gradient from trough to enhancement increases with increase of Kp. Results are discussed in terms of down ward plasma transport from the protonosphere to the ionosphere and night-time the neutral winds.

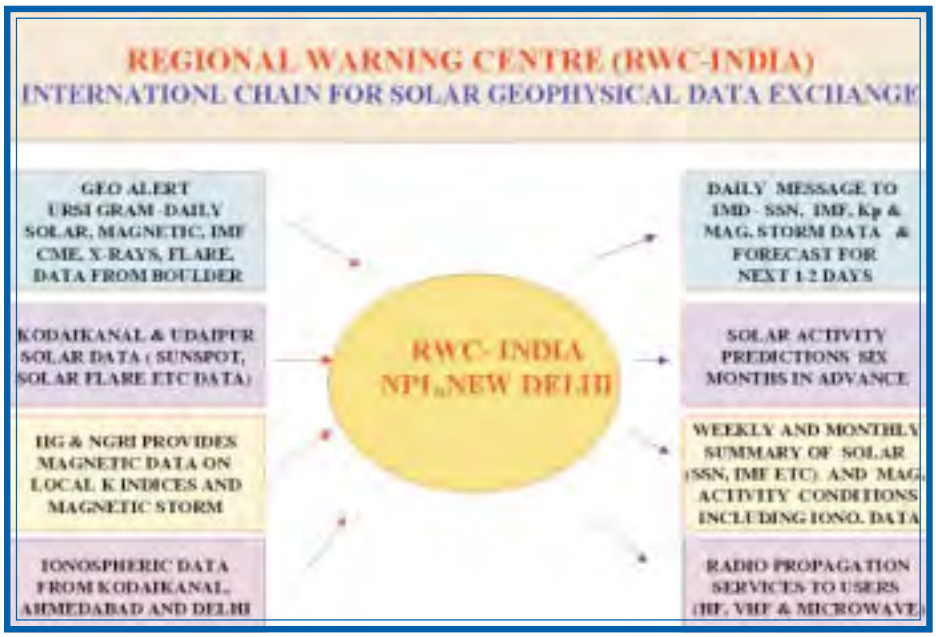

Fig. 6.20. Summary of RWC-India Activities

Regional Warning Centre (RWC-India) and Related Activities

National Physical Laboratory, New Delhi operates Indian Regional Warning Centre (RWC, India) as a part of ISES chain and is responsible for collection and dissemination of recent observational data on solar geophysical conditions to users with in the country and also in neighbouring countries. Based on the various data sets collected from observatories with in India and from other centers issues a daily forecast on solar geophysical conditions and weekly and monthly bulletins of solar geophysical and ionospheric parameters to some specified users. The users of RWC services and forecasts include mainly radio communication, satellite and space research communities. The summary of the RWC - India activities are shown in figure 6.20 and some of the mail activities are briefly described below.

1. Ionospheric Data Services

India now has an impressive chain of Ionosondes covering almost the entire country starting from geomagnetic equator to about 20 N geomagnetic latitude. The latest to join this chain is the Modern Digital Ionosonde installed during July 2000 at New Delhi in the campus of National Physical Laboratory. This chain also covers the equatorial ionization anomaly region in the Indian sector and provides data critical to long term planning as well as for short term frequency updates for HF links operating in the country. The data from this ionosonde network is also being used in a number of nationally coordinated research programs to study the equatorial ionospheric dynamics.

2. Daily RWC Forecast

Indian RWC issues a daily message at 1500 hrs IST every day consisting of actual observations obtained during the previous 24-36 hours and a forecast on solar and geophysical conditions valid for the following 1 or 2 days. This consolidated message based on the information received from different centers is made available to users by e-mail or fax. In addition special forecasts are issued on abnormal geophysical conditions, e.g. Geomagnetic storms. Special forecasts are also provided during nationally coordinated

scientific programs. Daily URSIGRAM and the MONTHLY GEOPHYSICAL BULLETIN are available in NPL website : www.npl-cgc.ernet.in

3. Solar Activity Predictions

An important activity at NPL traditionally has been prediction of sunspot cycle since early 1950s (see figure 6.21 for solar cycle number 23). The 6 months in advance sunspot predictions are being used widely in India for long term planning of HF communications. Sunspot predictions are being provided to a number of user organizations including Defence, Para military and civilian agencies. Solar activity predictions are also being used by Indian Space Research organizations for optimization of orbital parameters of LEOs and in determining satellite life times etc. Daily predictions of 10.7 cm solar flux are also being provided to Indian Space Research Organization [ISRO] to aid in estimation of orbital decay due to atmospheric drag.

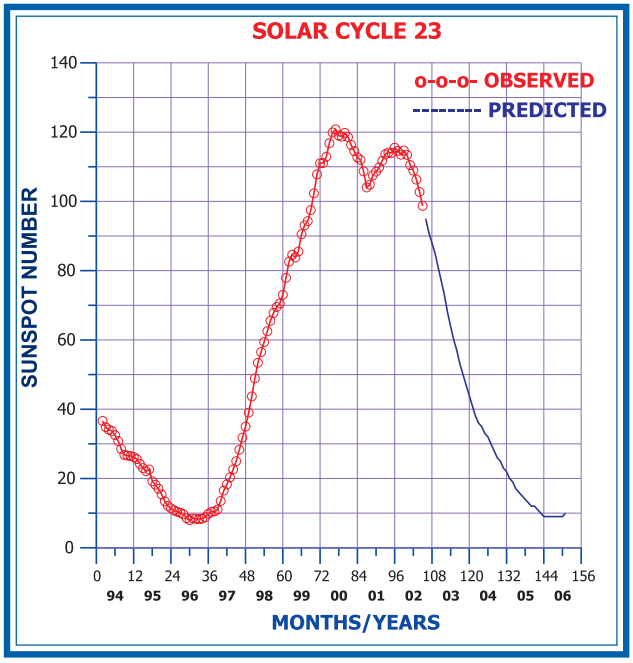

Fig. 6.21: Sunspot Cycle 23 - Observed and Predicted.

4. Ionospheric Predictions

Short wave radio communication at HF frequencies [3-30 MHz], which is still extensively used by the military, for overseas broadcasting and for many point-to-point links remains to be a major mode of long distance communication in tropical India because of a number of natural advantages the tropical latitudes provide. One of the major responsibilities of NPL is to provide ionospheric predictions for long term planning of HF Communications and also warnings on possible disruptions caused by a variety of space weather disturbances. Two examples one of point-to-point predictions of MUF (4000)F2 for Delhi-Madras Link (figure 6.15) and second one is a contour map of foF2 for the entire region shown in figure 6.16. It has been realized from the studies conducted recently that HF links operating in equatorial latitudes can suffer serious disruptions during severe geomagnetic storms especially during night time hours lasting for several hours. Appropriate MUFs for such periods are suggested for use. Indian RWC has also taken up several studies to gain prediction capability for day-to-day variability in foF2 and Total Electron Content [TEC] using EEJ strength as an index.

User Services

RWC [New Delhi] caters to the needs of a large number of users in India. Some of the important user organizations include.

i) Radio Communication Organizations
ii) Indian Space Research organization
iii) Three Wings of Defence
iv) Scientific Community.

Radio Communication

Microwave propagation under clear air, fog and cloudy atmospheric conditions

Results on carrier intensity of a microwave communication link situated between Raichur and Adoni having path length 60 km and affected by three atmospheric conditions viz. clear air, fog and cloud have been deduced.The results are mainly related when

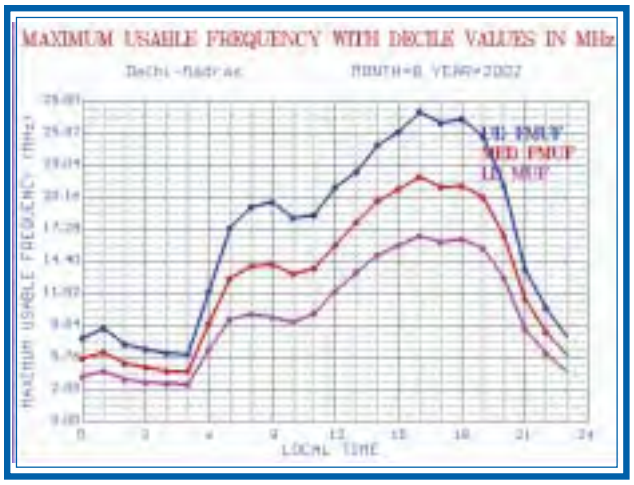

Fig. 6.22. Ionospheric Predictions for Delhi-Madras HF Link

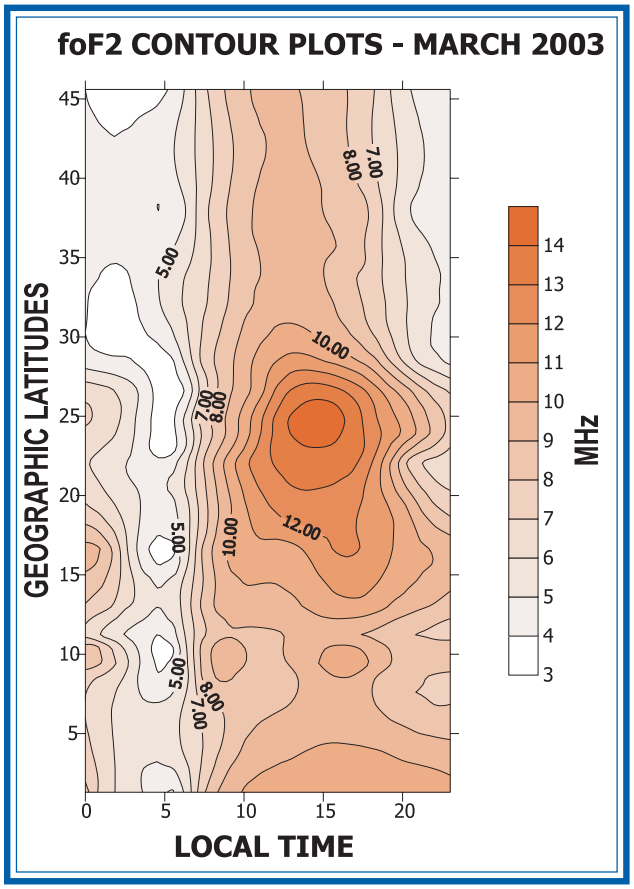

Fig. 6.23 Contour Map of foF2

the performance of the link was not satisfactorily under the three different meteorological conditions. The low signals associated with deep fades were observed for large percentage of time during foggy and cloudy situations. In clear air condition also it has been observed that the carrier intensity was low and associated with large fades. It is observed that there is wide variation in signal level under foggy condition. The low signal associated with less than -70 dBm was found to occur for 74% out of total observations (100%) under foggy situation. The fog always occur near the earth's surface upto a height 150 m or 200 m. The meteorological situations during fog are associated with both saturated water vapour and some amount of liquid water. The change of meteorological situation (temperature or water vapour or liquid water content) from normal condition level leads to change in atmospheric condition. Such change on atmospheric condition gives rise to change in signal level with fades. In case of cloudy condition, the low signal -70 dBm has been found to occur for around 91% out of the total observations (100%). The low signal characterized with fades as it has been seen in cloudy condition can only be explained on the basis multipath propagation phenomena as it is done for microwave signals under clear air condition.

Mobile communications:

Based on the UHF train mobile communication experimental results conducted in northern India, a new sixth order adaptive polynomial model is proposed to further model the deviation of earlier adaptive three coefficient model. The standard deviations of the predictions made by the proposed model from the experimental data are within 2.1 dB throughout the region of experimentation in contrast to a maximum of 24 dB reported earlier. The model can be made universal for different environmental conditions if more practical data at several frequencies are available. A comparison of double knife edge diffraction prediction techniques is carried out by comparing the predicted losses against the path losses deduced from the experimental measurements conducted in western India. The paths are 1. Mumbai-Kasara 2. Mumbai-Karjat 3. Mumbai-Chauk

4. Mumbai-Bulsar 5.Pune- Mahabaleshwar. Whenever the number of knife edges are more like in the case of Mumbai-Bulsar the predicted path loss in the case of Epstein-Peterson and Edward-Durkins methods is much more than the observed path loss. Epstein- Peterson method gives good agreement when the knife edges are prominent. Out of all the methods Giovanel's method gives better agreement and can be used for designing diffraction links over mountainous regions.

Rain attenuation:

Rain attenuation studies were made at 11.7 GHz in collaboration with SV Univ,Tirupati by utilizing INSAT-2C satellite signals over southern India during rain events. The observed cumulative distribution functions were compared with prominent predicted models and found that Garcia-Lopez and Moupfouma methods fare better and ITU-R method deviates largely from the observed rain attenuation values.

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अतिचालकता तथा निम्नतापिकी

SUPERCONDUCTIVITY AND CRYOGENICS

अतिचालकता तथा निम्नतापिकी

अतिचालकता तथा निम्न तापिकी प्रभाग के कार्यकलाप मुख्यतया अतिचालकता संबंधी मूल अनुसंधान पर बल देते हुए निम्न तापमान तकनीकों के क्षेत्र में तथा अतिचालकता चुम्बकीय प्रणालियों के विकास के क्षेत्र पर केन्द्रित हैं। द्वितीयक आर्द्रता मानक को भी स्थापित किया गया है और यह विभिन्न उद्योगों को अंशांकन सेवाएं प्रदान करता है। इसके साथ–साथ -10^{0} से. से लेकर $+25^{0}$ से. तक की रेंज ड्यू प्वाइंट (ओसांक) जनरेटर तैयार किया गया है और इसमें सुधार किया गया है। इसके अतिरिक्त यह प्रभाग इस प्रयोगशाला के विभिन्न अनुसंधान ग्रुपों को निम्नतापिकी द्रव (हीलियम और नाइट्रोजन) की आपूर्ति करता है।

अतिचालकता और चुम्बकत्व के परस्पर संबंध पर मूल अध्ययन किया जा रहा है। इन्टर तथा इन्ट्रा ग्रेन्युलर क्रीटिकल धारा घनत्व अतिचालकता आर्डर पैरामीटर के उतार चढ़ाव (SCOPF) एस टी एम/एस टी एस आयन इररेडिएशन वाले दोषों पर एस टी एस अध्ययन और सी यू डी डी (Cu-d-d) की भूमिका क्यूप्रेटस में आउट ऑफ प्लेन कंडक्शन पर (interobital) इलेक्ट्रॉन संबंधों पर अध्ययन किया जा रहा है। Yb(Pr)–123 में विद्युत ट्रांसपोर्ट और चुम्बकीय क्रम दोनों को मापने से नई जानकारी मिली है। जेनरेटिंग खराबियों की संभावना की उच्च चालक Bi(Pb)–2223 ग्रेन सीमाओं पर प्रभाव आयन इरेडिएशन सबस्टीट्यूशन द्वारा उत्पन्न धात्विक प्रवाह में जांच पड़ताल की गयी थी। Cu–1234 प्रणाली में यह पाया गया कि इंटरा–ग्रेन श्रब विकल्प में सुधार लाता है और इंटर ग्रेन श्रब डह विकल्प में सुधार लाता है। स्काफ (SCOPF) में Zn और Fe में पाए गए उतार–चढ़ावों की जांच पड़ताल की गयी।

SUPERCONDUCTIVITY AND CRYOGENICS

The main focus of the activities of Superconductivity and Cryogenics Division are in the area of low temperature techniques with emphasis on basic research on superconductivity and development of superconducting magnet systems. The secondary humidity standard is also maintained and it provides calibration services to various industries. In addition to this, a portable dew point generator in the range –10°C to +25°C has been designed and developed. Besides, the division takes care of supply of cryogenic fluids (helium and nitrogen) to various research groups of the laboratory.

In the area of basic studies the focus has been on the correlation of superconductivity and magnetism, inter- and intra- granular critical current densities, superconducting order parameter fluctuations (SCOPF), STM/STS studies of ion irradiation induced defects, and the role of Cu d-d interorbital electron correlation on the out-of-plane conduction in cuprates. By measuring both electrical transport and magnetic ordering in Yb(Pr)-123, new light is thrown on correlation of superconductivity and magnetism in these systems. By STM/STS studies the possibility of generating defects in MgB_2 superconductor, the effect on grain boundaries in Bi(Pb)-2223 superconductor, and possibility of mass flow in metallic glasses generated by ion irradiation were investigated. In Cu-1234 system, it was found that the intra-grain Jc improves with Zn substitution and inter-grain Jc improves with Mg substitution. SCOPF was investigated in varying Zn and Fe substituted Er-123 system.

Superconducting Magnet Technology

An 11 Tesla Superconducting Magnet

The 11 Tesla (50 mm bore dia.) Superconducting (SC) magnet, which has been developed for Indira Gandhi Centre for Atomic Research under a Consultancy agreement, was tested for its reliability and stability. In the first run both the outer (Nb-Ti) and the inner (Nb_3Sn) magnet coils were connected in series on the top plate of the cryostat. The coils were energized up to 92.6 A producing 10 T. Fig.(7.1) shows the graph of Current–Field relation for the outer & inner coils in series. The magnet was kept at this current value for one hour and no drift in the magnetic field value was observed. The observed field homogeneity was 0.06 % over 10 mm DSV.

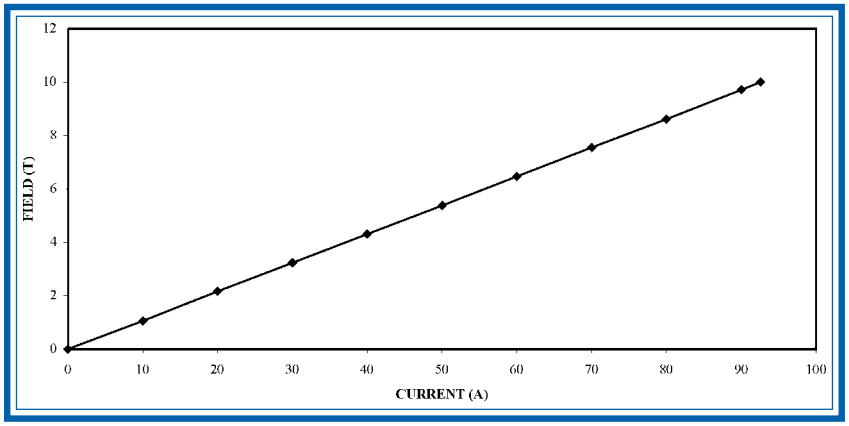

Fig. 7.1 : Current-Field relation for the outer and inner coils connected in series

In the second run, the outer coil was connected to 100 A, 5 V power supply, while the insert coil was connected to 250 A, 7.5 V power supply and each coil was energized individually. The outer coil current was increased to 90.5 A producing a field of 7.3 T. Keeping the outer coil current at 90.5 A, the inner coil current was increased to 140 A producing a combined field of 11 T. Fig.(7.2) shows the graph of Current–Field relation for the outer & inner coils energized separately.

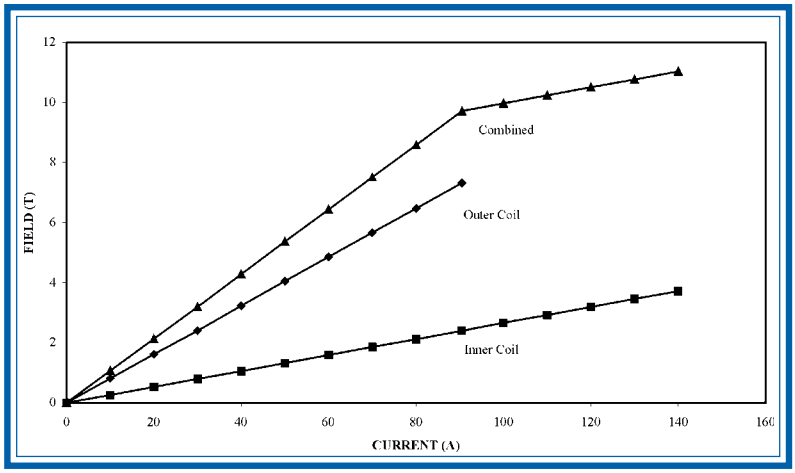

Fig. 7.2 : Current-Field relation for the inner and outer coils energized separately

The magnet was kept at 11 T for one and half hours to check the stability of the magnet.

This is the first indigenously developed superconducting solenoid magnet producing 11 T in a 50 mm working bore. The SC magnet in operation was demonstrated to IGCAR scientists.

Superconductivity Studies

Basic Studies on High Temperature Superconductors

Polycrystalline samples of Pr doped $Yb_{1-x}Pr_xBa_2Cu_3O_{7-\delta}$ (i.e., Yb(Pr)-123) system for $0 \leq x \leq 1$ have been investigated for resistivity (ρ) and magnetization (M) as a function of temperature in normal and superconducting state. The gradual decrease in superconducting critical temperature $T_c(x)$ is found to be correlated with the x dependent ratio of resistivity slope $(d\rho/dT)_{cc}$ (corresponding to the linear $\rho(T)$ region) and residual resistivity ρ_0. In particular, the observed difference of critical Pr concentration where superconductivity is destroyed (x_c) in Yb(Pr)-123 ($x_c \approx 0.65$) and Y(Pr)-123 ($x_c \approx 0.55$)

matches with the difference in the value of Pr concentration where the ratio $(d\rho/dT)_{cc}/\rho_0$ tends to go to zero in them. The M(T) data of Yb(Pr)-123 samples show magnetic ordering for $x > x_c$ at characteristic temperatures, T_n, that increases with x. Interestingly, the Yb(Pr)-123 sample with Pr content (x=0.6) near x_c reveal several anomalous features like transition from metallic to semiconducting- like ρ(T), an excessive broadening of the diamagnetic transition and weakening of the M(T) signal related with antiferromagnetic ordering of Pr ions. These observations can be consistently interpreted by assuming the presence of dynamically fluctuating striped phase in these systems.

The effect of swift heavy ion (SHI) irradiation on the surface of Bi-O layers of polycrystalline Pb doped Bi-2223 superconductors has been studied using Scanning Tunneling Microscope (STM) technique. The STM images of the unirradiated Pb doped Bi-2223 samples show perfect periodicity of neighbouring atoms whereas the topographs of the irradiated samples reveal atomic displacements and disorder caused by SHI irradiation. The microstructures of these samples are found to be depth dependent. Studies of the electronic structure of the unirradiated and irradiated superconductors have been performed by Scanning Tunneling Spectroscopy (STS). These measurements show setting in of increased non-metallicity on the surface of Bi-O layers as a result of irradiation.

Surface modification induced in four metallic glasses by 4.64 MeV/u ^{28}Si ion irradiation has been investigated in detail using optical microscopy, SEM and STM. Results obtained in two separate runs have been presented here. The effects of ion fluence (ϕ) and tilt angle (θ) on surface modification have been studied both qualitatively and quantitatively. It has been found that for S_e values smaller than that for track formation, swift heavy ion irradiation leads to smoothing of the irradiated surfaces. The smoothing is evident from decreasing mean roughness R_q and reduction in height of the 'hills' and filling up of the 'valleys' in the SEM and STM pictures. The observations have been explained on the basis of the theory of shear flow within the framework of the viscoelastic model.

Low anisotropic $CuBa_2Ca_3Cu_4O_{12-y}$ (Cu-1234) high temperature superconducting materials doped with Zn (up to 2%) at Cu-sites were synthesized using high temperature-high pressure technique. High field magnetization were carried out between 5K and 77K in fields up to 14T. Critical current densities Jc of the different samples were estimated using the critical state method. It is revealed that Zn-induced pinning centers increase Jc of Cu-1234 several fold, depending on field and temperature. From the experimentally determined field – temperature region in which a higher Zn content leads to higher Jc, we have suggested the existence of a cross-over from quite efficient extended (in the c-direction) pinning centers to point-like (inefficient) pinning centers at a certain temperature depending on the field value. Such an effect can be attributed to the fact that, unlike other HTSC systems, in Cu-1234 there is a second critical temperature T_{c2} of about 70-80K (in zero field) and 60-70K (in 15T), related to the over-doping of the pyramidal basal plane (outer CuO_2 planes). In view of such different doping levels in the 4-fold and 5-fold Cu-O planes in the Cu-1234 lattice, further investigations of such materials with Ba-site substitutions are underway vis-a-vis their T_c and superconducting anisotropy factor. AC susceptibility studies conducted on the least anisotropic Mg-substituted Cu-1234 at different fields (up to 10 Oe) and frequencies (up to 1KHz) have revealed an increase in the Jc of the intergranular regions (weak links) with increasing Mg content. Intragranular Jc, however, remained unaffected.

Host of studies reported on Pr substituted Y-123 have been inconclusive about the valence state of Pr and the non superconducting state (NSC) in Pr-123. Strategic heat treatment planned to turn a NSC Pr-123 into SC Pr-123 is expected to generate a new understanding about oxygen site vacancies and the re-ordering mechanism. AC susceptibility studies

on single crystals of NSC Pr-123 with various heat treatments are in progress.

Zn concentration variation effects on superconducting order parameter fluctuations (SCOPF) are compared in $ErBa_2Cu_{3-x}Zn_xO_{7-\delta}$ polycrystalline bulk samples for x=0.0, 0.03,0.05,0.12 and 0.18; perhaps as a first ever study. The SCOPF in pure and Zn doped samples are 3D. Zn seems to cause suppression of 2D fluctuations. SCOPF dimensionality shows independence from carrier concentration variation due to Zn in the planes and also suggests strong coupling between two nearest CuO_2 planes in the unit cells in pure and Zn doped samples. Fluctuations remain almost invariant to Zn doping vis-a-vis the pure sample.

Fe substitutions in $ErBa_2Cu_{3-x}Zn_xO_{7-\delta}$ shows large reduction in superconducting order parameter fluctuations (SCOPF) near the dynamic critical region, suggesting an anomalous crossover and slow suppression of superconductivity. Near Tc the SCOPF suggest Cu-O network coupling deterioration. The SCOPF show invariance (marked dimensionally variation) to low (increased) concentration of Fe and increased oxygen content dependence. Higher Fe concentration seems to promote dimensionally reversal.

Critical Currents

Work on transport critical currents in doped high temperature superconductors of Bi(Pb)SrCaCuO and the YBaCuO series was continued to investigate the role of pinning centres in these materials. Measurements of the critical current density Jc (transport), at 4.2K on f-level doped samples showed a striking dependence of Jc on dopant concentration for some particular dopants, while the effect was not so significant for Jc measured at 77K. In most other cases, however, a similar behaviour of Jc at 77K and at 4.2K was observed which clearly point towards the role of these dopants in influencing the inter-grain and intra-grain Jc of these superconductors. Detailed investigation of these results and their correlation with X-ray diffraction (XRD) scanning electron microscopic (SEM) studies is presently underway.

Theoretical Studies

Theoretical studies have been made to study the role of Cu d-d inter-orbital electron correlation on the out-of-plane conduction in cuprates. Condensation energy and spectral function have been calculated for various doping concentration for superconducting and normal states of bi-layer cuprates. Studies for impurity concentration dependence on coherence length in cuprate superconductors have been made. Reviewed transport behaviour of high temperature cuprate superconductors along c-axis and physical behaviour of nano-wires.

Fig. 7.3 : Simple and compact dew point generator (Mini RH generator)

Humidity Standards

Humidity generation based on two-pressure technique is considered to be excellent, traceable and fundamental calibration standard. Last year a portable relative humidity (RH) generator based on this principle was developed. As an extension to this device, a simple and compact dew point generator (mini RH generator) has been designed and developed. In this device the generated RH or dew point is measured using a capacitance type hygrometer (Model Testo 650). With this device we are able to generate dew point in the range of –10°C to +25°C without any difficulty. The developed unit is totally indigenous, very handy (weight ~ 5Kg), mobile and versatile. The novelty of the device is in the design, development and use of a simple expansion valve. We have submitted the required documentation to the IPR section for filing an Indian patent on this development. It finds immense application in the Indian Industries. Figure 7.3 depicts the developed dew point generator (mini RH generator).

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सहायक सेवाएं

SUPPORT SERVICES

Library and Technical Information Services

NPL Library has been providing library and information support to scientists for R&D pursuits. For this purpose it has since developed a rich collection of scholarly books and journals in physics and related sciences. During the year, it continued to update its collection and subscribed 113 scholarly journals, added 72 books, 104 standard specifications and 219 bound volumes of journals.

The library introduced Science Direct service under the e-journal consortium project of the CSIR. The service is significant as it offers Internet access to 1700 electronic journals published by Elsevier Science. The service permits full-text access to current journals and their archives going back to 1995. This service was first made operational in NPL on 31 July 2002. During the year the scientists downloaded 4007 articles by using this service.

The library introduced another electronic library service, ERL/INSPEC, in this year. It provides bibliographic access to published literature in physics dating back to 1969. The INSPEC database is hosted on the KSK Library site on the NPL intranet. The KSK Library now offers unlimited multi-user web access to INSPEC database laboratory wide.

The library continued to update its KSK Library site with latest information on its activities such as additions to its collection, current subscription, new issues received during the week, links to electronic journals, electronic libraries, publishing houses, library catalogue, and papers published by NPL scientists.

The library also continued to update NPL website hosted on the Internet under the domain name www.nplindia.org. The site is providing latest information on NPL activities such as its roles, thrust areas of research, facilities, services and achievements.

It continued to perform its house keeping functions on computer using a Library Management package developed in-house. Besides, It continued to provide library services such as circulation, inter-library loan, reference, and literature search.

Publication and Documentation

This unit 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.

Planning, Monitoring and Evaluation Group

Contract R & D projects such as sponsored projects, collaborative projects and Grant-in-aid projects are undertaken by the laboratory. The laboratory also undertakes in-house projects which are funded by CSIR and NPL. The complete date base of these projects is maintained by this group. It keeps a watch over budget allocation and expenditure, indents and staff employed under contract R & D Projects. This group handles matters relating to Research Council.

Intellectual Property Right

This unit provides help to the scientists 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 five patent applications have been filed in India and twelve in foreign countries. Four patents were granted in foreign countries.

Marketing Group

This group handles all matters connected with

business development, marketing and pricing of technology and interface with entrepreneurs.

Consultancy and Technical Services Group

The work relating to monitoring of industrial consultancy projects is done by this group. Further, distribution of royalty, premium honorarium and receipts from consultancy services is also a part of the activities of this group.

Human Resource Development Group

This group arranges training programmes for the benefit of NPL staff and also organizes NPL sponsored training courses for the benefit of industries in various areas of calibration. Processing of proposals submitted by scientists for attending various conferences, symposia and workshops held within the country is attended to by this group. It supports organization of symposia, conferences, etc. at NPL. It also attends to various public relations activities and follows up on various MOUs NPL has signed 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. It also arranges important lectures.

International Science and Technology Affairs Group

International visits play an important part in scientific R&D. Processing applications of scientists for international visits under bilateral exchange programmes, sabbatical study period or deputation abroad is attended to by this group. It also arranges important invited talks. Arranging training programmes for international candidate is also handled by this group.

Technical Support Services Group

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. Civil Engineering of laboratory and colony comes is under the purview of this group.

Central Workshop

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

Glass Technology

This unit undertakes jobs relating to the design, development, fabrication of scientific apparatus and equipments both for internal and external customers. This year the unit processed 151 jobs for NPL and 23 external jobs and earned a sum of Rs. 1.05 lakh as E.C.F.

Central Computer Facility

Patterns of Melting Snow*:* A two dimensional model of a natural phenomenon whereby snow lying on ground, under certain atmospheric conditions, metld forming ordered patterns of snow and water was built and studied theoretically and by computer simulations. Simulations show a rich variety of patterns including hexagonal snow (water) islands as well as strips. Defects in the patterns can also be varied by control parameters. Various

quantitative features of these patterns have been understood in terms of linear analysis and physical arguments. This study was carried out in collaboration with Jawaharlal Nehru University, New Delhi.

Evolution and Auto Catalytic Sets*:* Interacting species in adaptive systems can form complex networks of inter-dependent species. Various studies on the application of Auto Catalytic Sets to such systems already exist. Examples of such systems include prebiotic chemical evolution, biological evolution, and economic and social evolution.

A very fast and efficient algorithim to solve the coupled differential equations numerically has been developed at NPL. This algorithim speeds up the computation by almost two orders of magnitude when the system is in the Auto Catalytic Set state. This immediately enables us to undertake study of large systems which was not feasible earlier.

Various "mutation" rules for the evolution are being studied using population dynamics equations. One such rule for an updation step which give interesting results is – allow a randomly chosen species to dissociate itself from the least populated species attached to itself provided the population of the linked species is smaller by more than a fixed amount. Similarly allow a randomly chosen species to make a new association with another randomly chosen species if the population of the latter is within a given range (interaction radius) around the population of the former species. It is found that the system evolves and its complexity saturates if the interaction radius is below a critical value. When the interaction radius exceeds a critical value the complexity keeps on increasing in time.

NPL-LAN, Intranet and it Infrastructure

- The bandwidth for the Internet connectiviey has been further enhanced with the installation of 2 Mbps radio link to DOE. The router and gateway needed to interconnect the NPL-LAN to Internet have been configured in software on Linux platform, in line with our commitment to use open source software.
- A new mail server mail.nplindia.ernet.in has been configured and tested to meet the increasing demand of such communication and at faster speeds.
- A plan has been prepared to expand the NPL-LAN for another 200 nodes.
- Work has been started to provide the NPL Expert Database on the Web enabled Intranet so that it is available to all staff connected to the NPL-LAN using any Web browser.

Rajbhasha Unit

As in the previous years, this unit continued to help the scientists in the Hindi transcription of their papers, articles, reports etc. 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. A detailed report of the unit is given in Hindi in the following pages.

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संलग्न

APPENDICES

APPENDIX - 1
PUBLICATIONS

Publications in Journals

1 Agarwal S.K., Saxena R.B. & Kishan Hari. Physical properties of liquid helium – a review. *Indian Journal of Cryogenics*. 27, 266-276 (2002).

2 Agnihotry S.A., Sharma N., Deepa M. Ion exchange derived precursor materials for deposition of WO_3 electrochromic films : Spectroscopic investigations. *Sol-Gel Science and Technology*. 24, 265-270 (2002).

3 Agrawal A. K., Lal Krishan, Saxena R.K., Bhatnagar Abha & Ganju Sunita. Programme on preparation and dissemination of Certified reference materials in India, MAPAN- *Journal of Metrology Society of India*, 291-298,18 (2003).

4 Agrawal A. K., Saxena R.K., Bhatnagar Abha, Ganju Sunita & Lal Krishan, Role of certified reference materials in ensuring quality of drinking water, MAPAN- *Journal of Metrology Society of India*, 18, 17-24, (2003).

5 Ajay, Pratap A. & Joshi S.K. Role of Cu d-d inter-orbital electron correlation on the out-of-plane conduction in cuprates, *Physica -C*. 371, 139-145 (2002).

6 Amit Pratap, Ratan Lal, Govind & S.K. Joshi. Spectral properties of doped bilayer cuprates at finite temperatures. *Pramana*, 58, 855-860 (2002).

7 Anand S. & Kandpal H.C. Reconstruction of optical source-profile from spectral measurements in Young's interference experiment. *Optics & Lasers in Engineering*. 38 ,321-332, (2002)

8 Anand S., Vaishya J.S. & Kandpal H.C. Correlation-induced spectral changes-a review, recent researches & applications. MAPAN-*Journal of Metrology Society of India*. 17, 43-66 (2002)

9 Anand S., Yadav B.K. & Kandpal H.C. Experimental study of the phenomenon of IxN spectral switches due to diffraction of partially coherent light. *J. Opt. Soc. America-A.* 19, 2223-2228 (2002)

10 Babudayal P., Mehta B.R., Aparna Y. & Shivaprasad S.M. Surface mediated structural transformation in CdTe nanaparticles dispersed in SiO_2 thin films. *Appl. Phys. Lett*., 81, 4254 (2002)

11 Balamurugan B, Mehta B.R. & Shivaprasad S.M. Formation of copper carbide phase using nanoparticle route. *Appl. Phys. Lett*. 82, 115, (2003)

12 Balamurugan B., Mehta B.R., Awasthi D.K. , Singh F., Arora A.K., Rajalakshmi T. , Ragavan G. , Tyagi A.K. & Shivaprasad S.M. Tailoring the nanocrystalline characteristics: size, strucutre and surface states of Cu_2O thin films using high energy heavy ion irradiation. *J. Appl. Phys*. 92, 1 (2002)

13 Banerjee P. & Suri A.K. Synchronisation of slave clocks through local exchange network using Teleclock Service", MÃPAN – *Journal of Metrology Society of India*., 18, supplementary issue,197-202, Jan-Mar, (2003)

14 Banerjee P. Sanctity of Indian Standard Time and its social relevance. *J. Instrument Society of India*.31(3&4) 195-207, (2002)

15 Banerjee P., Bose Anindya & Dasgupta Ashish .The usefulness of GLONASS for positioning in the presence of GPS in Indian subcontinent. *J. of Navigation (U.K.)*, 55(3), 463-475, (2002)

16 Banerjee T., Samanta S.B., Gupta A., Kanjilal D., Kumar R., Ramasamy S. & Narlikar A.V. STM/STS studies at Bi-O layers of Pb doped Bi-2223 superconductors irradiated by 100 MeV oxygen ion. *Solid State Communication*, 123, 117-122, (2002)

17 Basu A. & Bhattacharyya R. Antireflection coatings on glass for use at 852 nm wavelength, for windows of UHV

chamber of laser cooled cesium fountain clock at NPL. MAPAN-*Journal of Metrology Society of India* 18, 203-209 (2003).

18 Basu A. & Bhattacharyya R. Spectral characteristics of an inhomogeneous film Reflectance & transmittance spectra for different film refractive index profiles. *Jour. of Optics* (India), 31, 59-72 (2002).

19 Basu A. & Bhattacharyya R. Spectral characteristics of an inhomogeneous films Determination of refractive index profile from reflectance & transmittance spectra. *Jour. of Optics (India)*, 31 ,73-86.21, (2002).

20 Bhatia & Singh, V.R. Ultrasonic propagation in breast tissue with ductal carcinoma. *Ind J. Pure & Appl Phys*., 40 (7), 515-519, July (2002)

21 Bhatia G., Aggarwal R.K., Raman V., Saha M. & Mishra A. Influence of polycarbonate addition on the development of pitch based carbon fibres. *J. Mater. Sci. Lett*. 21, 1641–1643 (2002)

22 Bhuyan P.K., Chamua M., Subrahmanyam P. & Garg S.C. Diurnal, seasonal & latitudinal variations of electron temperature measured by the SROSS C2 satellite at 500 km. altitude & comparison with the IRI. *Ann. Geophysicae.* 20, 807-815 (2002).

23 Bhuyan P.K., Chamua Minakshi, Bhuyan Kalyan, Subrahmanyam P. & Garg S.C. Diurnal, seasonal & latitudinal variation of electron density in the topside F-region of the Indian zone ionosphere at solar minimum & comparison with the IRI. *J. Atmos. & Solar Terr. Phys.* 65, 359-368 (2003).

24 Bhuyan P.K., Kakoty P.K., Garg S.C. & Subrahmanyam P. Electron & ion temperature and electron density at ± 10° magnetic latitudes from SROSS C2 measurements over India and comparison with the IRI. *Adv. Space Res.* 29 (6), 865-870 (2002).

25 Chakraborty B.C., Vinod P.N., Singh S.N & Chakraborty B.R. Design & simulation of antireflection coating for application to silicon solar cells. *Solar Energy Materials & Solar Cells*. 73/1, 59-66 April, (2002)

26 Chakraborty B.R.,Dilawar Nita, Pal S.& Bose D.N., SIMS Characterization of GaAs MIS devices at the interface with N-rich PECVD silicon nitride dielectric. *Thin Solid Films*, 411, 240-246 May (2002)

27 Chakravarty B.C. Calibration methods for solar cells & panels. MAPAN-*Journal of Metrology Society of India* .18, 15-23 (2003)

28 Chander Harish , Shanker V., Haranath D., Dudeja Suman, Sharma Pooja. Characterization of ZnS:Cu, Br electroluminescent phosphor prepared by new route. *Materials Research Bulletin*. 38, 279-288 (2003)

29 Chandra Usha, Sharma V. K. , Gupta A., Parthasarathy G. & Bandhyopadhyay A. K. High - pressure phase transition in 57Fe0.03Cr 0.97 Sb2 - a Mössbauer & resistivity study up to 8 GPa. *Phil. Mag. Lett* 83, 273, March (2003)

30 Chaubey A. & Malhotra B.D. Mediated Biosensors. *Biosensors & Bioelectronics*. 17(6-7), 441-456 (2002)

31 Chaudhary K.P., Sharma Rina, Farid Niveen, Singhal R.P., Calibration of Step gauge by substitution method on coordinate measuring machine & evaluation of uncertainty of measurement, MAPAN–*Journal of Metrology Society of India*,17(2),63-74 (2002)

32 Chawla Santa, Sen Gupta A., Pugla Sarika, Roy B. K., Kanjilal A. K. & Ahmad S. A., A frequency stabilized diode laser system at 852 nm. *J. Instrumentation Soc. of India*, 32(2), 110-119, (2002)

33 Chawla Santa, Roy B.K., & Kanjilal A.K. A frequency stabilized diode laser at 852 nm. *Journal of Instrument Society of India.* 32 (2), 110-119 (2002)

34 Chawla Santa. An Iodine frequency stabilized He-Ne laser as a primary standard of length, Kiran, *Bulletin of Indian Laser Association*, 13(3), July, 43-49 (2002)

35 Chen C., Wondre F., Ryan J.F., Narlikar A.V. & Samanta S.B. Growth mechanism

and additive effect of high Tc superconducting crystals.*Journal of Crystal Growth*. 237-239, 772-777, (2002)

36 Chikara Shalinee, Lal Ratan & Joshi S.K., Physical behaviour and theoretical understanding of nanowires. *Indian Journal of Physics*. 76A, 325-342 (2002)

37 Choubey A., Bhagavannarayana G., Shubin yu. V., Chakraborty B.R. & Lal Krishan, Study of effect of thermal annealing on crystalline perfection of bismuth germanate singal crystals grown by low thermal gradient Czochralski method. *Z Kristallogr*, 217 515-521 (2002).

38 Crisan A., Agarwal S.K., Koganezawa T., Kuroda R., Tokiwa K., Watanabe T., Iyo A., Tanaka Y. & Ihara H. The effect of pinning centers in Zn-doped $CuBa_2Ca_3Cu_4O_{12-y}$ high temperature superconductors. *J. Phys. Chem. Solids*. 63, 1073-1076(2002).

39 Deepa M. , Sharma N. , Agnihotry S.A.,Chandra R, Sekhon S. S. , Effect of mixed salts on properties of gel polymeric electrolytes, *Solid State Ionics* 148, 451 - 455 (2002)

40 Deepa M., Sharma N., Agnihotry S.A., Chandra R. FTIR investigations on ion-ion interactions in liquid and gel polymeric electrolytes : $LiCF_3SO_3$ - PC- PMMA. *Journal of Materials Science*. 37, 1759-1765 (2002).

41 Dhakate S.R., Mathur R.B., Dhami T.L. & Chauhan S.K. Role of interface on the development of microstructure in carbon-carbon composites. *Carbon Science*, .3(4), 192-197, (2002)

42 Dhakate, S.R., Mathur, R.B. & Dhami, T.L. Mechanical properties of unidirectional carbon-carbon composites as a function of fibre volume content. *Carbon Science* 3(3), 1-11 (2002)

43 Dhar, A., Clapham, L. & Atherton, D.L. Influence of Luders b&s on magnetic barkhausen noise and magnetic flux leakage, leakage signals. *Journal of Material Science*. 37, 2441-2446 (2002)

44 Dhawan J.K., Jain Kamlesh & Jain S.K. Design, development & characterisation of 5 kN force transducer', MAPAN-*Journal of Metrology Society of India*, 18 (2003)

45 Dhawan S.K., Singh N. & Rodrigues D. Electromagnetic shielding behaviour of conducting polyaniline composites. *Science & Technology of Advanced Materials*, 4, 105 -113 (2003)

46 Dilawar Nita, Varandani D., Bandyoapdhyay A.K. & Gupta A.C. Differential pressure measurements through automated data acquisition. MAPAN– *Journal of Metrology Society of India*, 18, 25, 3-10 (2003)

47 Gadi Ranu, Sarkar A.K. , Gera B.S., Mitra A.P. & Prashar D.C. Chemical composition of atmospheric aerosols at New Delhi, *Indian Journal of Radio Science & Physics*, 31, 93-97, (2002)

48 Gahtori Bhaskar, Lal Ratan & Joshi S.K. Importance of coherence length in explaining superconducting behaviour of cuprate superconductors. *Ind. J. Pure & Appl. Phys*. 40, 574-576(2002)

49 Gambhir A., Kumar A., Malhotra B. D., Miksa B. & Slomkowski, S. Covalent immobilization of urease on polypyrrole microspheres for application as a urea biosensor., *e-Polymers*, No 052, 1 - 9 (2002)

50 Gambhir A., R.Singhal, Annapoorni S. & Malhotra B.D. Immobilzation of urease in polyvinylcarbazole/stearic acid Langmuir- Blodgett films, for application to urea biosensor. *Biosensors & Bioelectronics*, 17, 697-703 (2002)

51 Garg R.K. & Ram R.S., Calibration of broad band UV intensity meters, MAPAN-*Journal of Metrology Society of India*. 18, 67 (2003)

52 Garg S.C., Anand J.R., Bahl M., Subrahmanyam P., Rajput S.S., Maini H.K., Chopra P., John T., Singhal S.K., Vishram Singh, Dhan Singh, Das U.N., Bedekar S.M., Soma P., Venkateswarlu & Goel D.P. RPA Aeronomy experiment onboard the Indian satellite SROSS-C2 Some important aspects of the payload and satellite. *Ind. J. Radio & Space Phys.* 32, 5-15 (2003).

53 Gerard M., Chaubey A. & Malhotra B.D. Application of conducting polymers to biosensors. *Biosensors & Bioelectronics 17,345-359 (2002).*

54 Giardini W.J., Calderon C., Cheng-yen F., Hau K.K., Kang C.S., Lee S.M., Lesha F., MeKawi A.M., Monteros R., Quan C., Roonwal V., Sakano N., Singhal R.P., Wong S.Y. & Zahwi S.Z.A., International comparison of surface-texture parameters organized by the Asia-Pacific Metrology Programme, *Metrologia* 39, 225-229 (2002)

55 Govind, Ajay & Joshi S.K. Condensation energy of the superconducting bilayer cuprates. *Pramana.* 58, 861-866(2002)

56 Gupta A. K., Application of cryogenics in standards and metrology. *Indian J. Cryogenics*, 27, 24-34 (2002)

57 Sen Gupta A., Pugla Sarika, Chawla Santa, Roy B. K. & Kanjilal A. K. Temperature controller & current source for extended cavity diode laser system. *J. Instrumentation Soc. of India*. 32(1), 66-71, (2002)

58 Gupta A., Mehrotra R., Varma S.P., Joshi R.M. & Chauhan V.S. Infrared Spectroscopic studies on a dehydrophenylalanine acid containing model peptide: Boc-Ala-(Δ Phe)4- NHMe. MAPAN-*Journal of Metrology Society of India*, 18, 63-66, (2003)

59 Gupta Anurag, Narayan H., Lisboa-Filho P.N., Cardoso C.A., Fernando M., Moreira Araujo, De Lima O.F. & Narlikar A.V. A possible correlation between suppression of superconductivity, magnetic ordering & normal state resistivity parameters in the $Yb_{1-x}Pr_xBa_2Cu_3O_{7-\delta}$ system. *Modern Physics Letters- B*. 16, 261-273(2002)

60 Gupta Prabhat K., Sharma C., Bhattacharya Sumana & Mitra A.P. Scientific basis for establishing country greenhouse gas estimates for rice-based agriculture: An Indian case study. *Nutrient Cycling in Agro-ecosystems*. 19-31, 64 (2002).

61 Haranath D., Shanker Virendra, Chander Harish , Sharma Pooja. Studies on the Decay characteristics of ctrontium aluminate phosphor on thermal treatment. *Journal of Materials Chemistry and Physic*s. 78., 6-10(2002)

62 Jain Kamlesh K., Cen Y., Walter J. Bowers & James W. Schmidt. A double- primary dead-weight tester for pressures (35–175kPa) in gauge mode, *J of Research of National Institute of Standards & Technology*, 108, 11-20, (2003)

63 Jain Kiran & Lakshmikumar S.T. Porous alumina template based nanodevices. *IETE Technical Rev*. 19, 293-306 (2002).

64 Jain S. C., Tanwar, V.K. & Dixit V. Homeotropic and planar orientation of liquid crystals on a photopolymer coated surface irradiated with UV-light. *Jpn. J. Appl. Phys*. 41, L 1106-L 1108 (2002)

65 Jain S. K., Jain Kamlesh & Kumar Anil. A proposal of a method for calibration of force transducers to establish traceability in force measurement. MAPAN-*Journal of Metrology Society of India*., 18 Suppl.(2003)

66 Jain S.L., Arya B.C. & Arun Kumar. Measurements of various minor constituents using a differential absorption lidar. *Asian J. Phys*. 11, 163-170 (2002).

67 Jain S.L., Arya B.C., Kumar Arun & Ghude Sachin D. Green house gases measurement at Maitri Antarctica. *Asian J. phys.,* 12, 103-107 (2003).

68 Jaiswal S.K., Singh Ajeet & Ojha, V.N. Uncertainty evaluation of high value standard resistors using automatic high resistance bridge & digital tera ohmmeter. MAPAN-*Journal of Metrology Society of India*. 18, 81-85, (2003)

69 Kalra, N., Jain, M.C. Joshi, H.C., Choudhary, R., Kumar, S., Sharma, S.K., Kumar, V., Kumar, R., Harit, R.C., Khan, S.A. & Ahmed, A.Z.. Soil properties & crop productivity as influenced by flyash incorporation in soil. *J. Environment*

Monitoring & Assessment. 32, 161-173, (2002)

70 Kamlesh K. Jain, S K Jain, Anil Kumar & H N P Poddar. A newly developed 5 kN dead weight force machine for reference calibration, MAPAN-*Journal of Metrology Society of India*, 18 , 147, (2002)

71 Kandpal H.C. Generation of cross-spectrally pure light by two diffusers moving in opposite directions & determination of diffuser constant, *Optics Commun*. 207, 73-76 (2002)

72 Kandpal H.C., Anand S., Vaishya J.S. Experimental observation of the phenomenon of spectral switching for a class of partially coherent light, *IEEE J. Quant. Electron* 38, 336-339 (2002)

73 Kar J., Choudhary R.K. & Mahajan K.K. Revisiting the stratospheric fountain hypothesis using UARS/HALOE data. *Adv. Space Res*. 29, 1725-1729 (2002).

74 Kaur Devinder & Gupta A. K. Grain boundary Josephson studies in Bi-Sr-Ca-Cu-O microbridges. *J. Phys. D: Appl. Phys*. 35, 729-731 (2002)

75 Khan M.N. ,Pradeep Kumar, Garg R.K., Patel B.S. & Zaidi Z.H. Infrared soectroscopic studies of polycyclic aromatic hydrocarbons in solid waxfilma; Anthracene & Phenthrene. *Spectroscopic Letters*. 35, 489 (2002)

76 Khare Neeraj . High-T_c superconductor electronics. *Science Letters*. 25, 239 (2002)

77 Khare Neeraj, Gupta A.K., Moharil U.P., Raychaudhuri, Pai S.P. & Pinto R. Study of magnetoresistance & conductance of bicrystal grain boundary in $La_{0.67}Ca_{0.33}MnO_3$ thin film. *Pramana-J. Phys*. 58, 1165-1170 (2002)

78 Khare Neeraj, Moharil U.P., Gupta, Raychaudhuri A. K., Pai S.P. & Pinto R. Temperature dependence of magnetoresistance & non-linear conductance of bicrystal grain boundary in epitaxial $La_{0.67}Ca_{0.33}MnO_3$ thin film. *Appl. Phys. Letters.* 81, 325-327 (2002)

79 Kishan Hari & Agarwal S.K. Physical properties of liquid nitrogen – A Review *Indian Journal of Cryogenics*. 27, 254-265(2002).

80 Kishan Hari, Ram Jokhan, Singh Bhikham, Singh J.P. & Chadha Deepti, Vapour pressure calculations based on the International temperature scale (ITS-90) used in the computation of relative humidity. MAPAN-*Journal of Metrology Society of India*. 18, 35-42(2003)

81 Kishore Ram, Sood K.N. & Naseem H.A. Microstructural and analytical investigation of low temperature crystallized amorphous silicon/ crystallized silicon interface using SEM & EDS. *J. Mater. Sci. Lett*. 21, 647, (2002).

82 Kumar Ashok. Development, characterisation & applications of ultrasonic transducers for NDT. *Insight - Non-Destructive Testing & Condition Monitoring*. 45,70-72 (2003)

83 Kumar N., Singh V.R., Kumar P. & Singh B. Computer controlled transit time flowmeter. *Acta Ciencia Indica*, 28 (4), pp. 165-168, (2002)

84 Kumar N., Singh V.R., Kumar P. & Singh B. Optimisation of accuracy of ultrasonic flowmeter. *Acta Ciencia Indica*. 28 (3),151-154, (2002)

85 Lakshmikumar S. T. & Singh P. K. Formation of carbonized porous silicon surfaces by thermal and optically induced reaction with acetylene. *J. Appl Phys*. 92, 3413, (2002).

86 Lal Krishan, High resolution X-ray diffraction: a powerful tool for materials science and fundamental research, *PINSA*, 68, 315-331 (2002).

87 Lal Tripurari , Kumar Harish, Singhal R.P., Saxena A.K. & Rao S.U.M. Interlaboratory Proficiency Testing: Mass Measurement-2001/02. MAPAN-*Journal of Metrology Society of India*, Jan.- Mar. (2003)

88 Luthra, V.,Singh, R., Gupta, S. K. & Mansingh A. Mechanism of D.C. conduction in polyaniline doped with sulphuric acid. *Current Applied Physics,*. 219-222,3, (2003).

89 Mahajan S.K., Singh Ajeet, Ojha, V.N. & Gupta, A.K. Participation of NPL-India in CCEM-K8 key comparison of DC voltage ratios. MAPAN –*Journal of Metrology Society of India*.18, 119-124, (2003)

90 Mathur R.B., Dhami T.L., Bahl O.P. & Gupta. V. Carbon/Kevlar/PEEK thermoplastic composites. *High Performance Polymers*, 14,285-292 (2002)

91 Mehrotra R. & Varma S.P. Infrared spectroscopy in sugar industry: An overview, MAPAN-*Journal of Metrology Society of India*, 18, 189-195, (2003)

92 Mehrotra R., Gupta A., Tewari J. & Varma S.P. Estimation of sugar & reducing sugar in molasses using near infrared spectroscopy. *J. Near-Ir Spectros*., 207-211, (2002)

93 Mishra S.C.K., Pant R.P., Pandey J.L. & Kumar N. Preparation and characterization of magnetic polymeric thin film. *J. Magn. Magn. Mater*. 252, 20 (2002).

94 Misra S.C.K., Sharma S.K., Kapoor A. & Tripathi K.N. Optical Wave guiding in vacuum deposited polyaniline thin films. *Ind. J. Engg. Materials*, 41,756 (2002)

95 Misra S.C.K., Bhattacharya R. & Angelucci R. Integrated Polymer/ Silicon. Microsystems. *Journal of the Indian Institute of Science*, Aug.(2002)

96 Mitra A.P. & Sharma C. Indian aerosols-present status. *Chemosphere,* 49, 1175-1190 (2002).

97 Mitra A.P., Gupta P.K. & Sharma C. Refinement in methodologies for methane budget estimation from rice paddies. *Nutrient Cycling in Agroecosystems,* 64, 147-155 (2002).

98 Mohanan V.& Sharma Omkar. Evaluation of uncertainty in accelerometer calibration – A case study. *J. Acoustical Society of India*, 30(1&2), 242-245, (2002)

99 Mukerjee C., Anandan C., Seth T, Dixit P.N., Bhattacharyya R. Photoconducting a-Si:H films grown at high deposition rates by pulsing a VHF 100 MHz discharge. *Thin Solid Films* 423, 18-26 (2003)

100 Nagarajan R., Gupta D. & Varma S.P. Analysis of diffuse reflectance theories in the MIR region. *Infrared Physics & Technology*. 43,377-382 (2002)

101 Narayan H., Samanta S.B., Agrawal H.M., Kushwaha R.P.S., Gupta A., Sharma S.K., Narlikar A.V. & Kanjilal D. A detailed investigation of surface modification in metallic glasses subjected to 130 Mev ^{28}Si ion irradiation. *NIMB*, 196, 89-99(2002).

102 Narayan H., Samanta S.B., Gupta A., Narlikar A.V., Kishore R., Sood K.N., Kanjilal D., Muranaka T. & Akimitsu J. SEM, STM/STS and heavy ion irradiation studies on magnesium diboride superconductor. *Physica- C*. 377, 1-6, (2002).

103 Ojha V.N. & Sharma, S.K.. Calibration & estimation of uncertainty of reference standard of voltage using newly established bank of Zener reference standard, MAPAN - *Journal Metrology Society of India*. . 18, 87-93, (2003)

104 Ojha, V.N., Singh, A., Jaiswal, S.K. & Sharma, S.K. Automatic & manual calibration of high precision multifunction calibrator. MAPAN-*Journal of Metrology Society of India*. 18, 43-48, (2003)

105 P. Mohan. Vacuum Measurements by some primary & transfer standards. MAPAN-*Journal Metrology Society of India*.17(4), 119-132, July-Sep. (2002)

106 Paik B., Kumar Ashok , Gupta Reeta & Kumar Yudhisther. Selection of lining material for anechoic water tank. *Acta Acustica* 88 ,195-198 , (2002)

107 Pal S., Chakraborty B.R., Shivaprasad S.M & Bose D.N., Microwave plasma oxidation of GaN. *Thin Solid Films*, 425, 20, (2003)

108 Paliwal V. K., Vedeshwar A. G. & Shivaprasad S. M. Observation of novel superstructures at low Sb coverages on Si(111)-7x7 surface. *Surf. Sci. Lett*. 513, L397 (2002)

109 Paliwal V. K., Vedeshwar A. G. & Shivaprasad S.M. Formation of interfacial phases in the epitaxial growth of Sb on Si(111) 7x7 reconstructed surface. *Pure & Appl. Chem.,* 74,1651 (2002)

110 Paliwal V. K., Vedeshwar A. G. & Shivaprasad S.M. Residual thermal desorption studies of the room temperature formed Sb/Si(111) *Interface, Phys. Rev. (B)*, 66, 245404 (2002)

111 Pandey V.K., Sethi N.K. & Mahajan K.K. Dependence of F2-peak height on a solar activity: A study with incoherent scatter measurements. *Adv. Space Res*. 31, 543-548 (2003).

112 Pant R.P., Dhawan S.K., Kataria N.D. & Suri D.K. Investigation of ferrofluid-conducting polymer composites and its application. *J. Magn. Magn. Mater*. 252, 16-19 (2002)

113 Pant R.P., Kandpal, H.C. & Suri, D.K. Anomalous enhancement in the optical scattered radiation in magnetite base ferrofluid. *J. Magn. Magn. Mater*. 252, 107 (2002)

114 Panwar O. S., Kumar Sushil, Rajput S. S., Sharma Rajnish & Bhattacharyya, R. Field-emission in diamond-like carbon films grown by various techniques. *Indian J Pure Appl. Phys*. 41, 175-182, March (2003)

115 Paranjape Mandar A., Raychaudhuri A.K.,Mane Anil U., Shalini K., & Shivashankar S.A. & Chakraborty B.R. Metalo organic chemical vapour deposition of thin films of cobalt on different substrates. *Thin solid films*, 413/1-2, 8-15, Aug.(2002)

116 Pasricha P.K., Gera B.S., Shastri S., Maini H.K., John T., Ghosh A.B., Tiwari M.K., Garg S.C. Role of the water vapour greenhouse effect in the forecasting of fog occurrence. *Boundary Layer Meterology*. 107,469-482 (2003).

117 Pasricha P.K., Prasad M.V.S.N. & Sarkar S.K. Comparison of evapouration duct models to compute duct height over Arabian sea and Bay of Bengal. *Ind. J. Radio & Space Phys*. 31, 155-158, (2002).

118 Paul A., Ray S., Dasgupta A. & Garg, S.C., First in situ observations of equatorial ionospheric bubbles by Indian satellite SROSS-C2 and simultaneous multisatellite scintillations. *Radio Science*. 37, 1087 (2002).

119 Prakash Om, Pant R.P. & Mohammad Islam, Sankaranarayanan V.K. Lithium ferrite nanoparticles for ferrofluid applications. *Magnetism & Magnetic Materials* 252(7-9), 2002.

120 Prasad V.Krishna, Gupta Prabhat K., Sharma C., Kant Yogesh & Badarinath K.V.S. & Elvidge Chris. Biomass burning and related trace gas emissions from tropical dry deciduous forests of India– A Study Using DMSP-OLS data and ground based measurements. *International Journal of Remote Sensing*. 123(14), 283-285, (2002).

121 Qureshi G. J., Patha N., Gupta V.K., Kamalasanan M.N., Singh A.P., Kapoor A. & Tripathi, K.N. Styrene acrylonitrile (SAN) based polymeric wave-guides. *Optics & Laser Technology*, 35, 401- 407 (2003)

122 Rai Kavita, Sarkar A K & Mitra A.P. Characterization of Aerosol in a urban residential environment. MAPAN-*Journal of Metrology Society of India* 18, 147-151, (2003).

123 Rajput S. S. & Garg S. C. Instrumentation for a retarding potential analyzer experiment for measurement of electron parameters. *Indian J of Eng. Material Sci*. 9, 315-322, Oct. (2002)

124 Rajput S. S. & Jamuar S. S. CCII based low voltage high performance linear current electrometer. *Review of Scientific Instruments*. 73(10), 3644-3651, (2002)

125 Rajput S.S. & Jumuar S.S. A Versatile Wide Bandwidth CCIII Structure for CMOS Technology. *IETE Journal of Education* . 44(1), 13-19, January-March (2003)

126 Rajput S.S..& Jamuar S.S. Current Mirror: Essential unit for analog circuit structures. *IETE Journal of Education*. 43(4), 171-185, (2002)

127 Raman V., Parashar V.K., Dhakate S.R. Synthesis of silicon carbide whiskers from substituted silicon alkoxides and rayon fibres. *J. Sol gel. Sci. Tech*. 25, 175–179 (2002)

128 Ramanathan V., Crutzen P.J. Mitra A.P.& Sikka D. The Indian Ocean Experiment and the Asian Brown Cloud. *Current Science*. 83, 947-955 (2002).

129 Rao S.V.B., Rao T.R., Reddy I.V.S., Prasad M.V.S.N., Reddy G.V. & Reddy B.M., Rain attenuation studies at 11.7 GHz over southern India. *Ind. J. Radio and Space Physics*. 31,107-109 (2002).

130 Rao S.V.B., Rao T.R., Reddy V.G., . Lakshmi D.R., Veenadhari B., . Dabas R.S., Ahmed I., Gupta M.M., & Reddy B.M. HF radio signal fading and atmospheric radio noise measurements at low latitudes. *Radio Science.* 37, 1083-1089 (2002).

131 Ravindra K., Sarma A.D. & Prasad M.V.S.N. An adaptive polynomial path loss model at UHF frequencies for mobile railway communications. *Ind. J. Radio & Space Physics*. 31, 278-284 (2002).

132 Sankaranarayanan V.K., Prakash Om, Pant R.P. & Islam, Mohd. Lithium ferrite no particles for ferrofluid application, *J. Magn. Magn. Mater*. 252, 7 (2002).

133 Sarkar A.K., Singh Mewa, Singh Niranjan & Rai Kavita. Spectrophotometric determination of sulphur dioxide (sulphite) in environmental samples. MAPAN-*Journal of Metrology Society of India*, 18,.261-265 (2003).

134 Sarkar A.K; & Singh Niranjan. Atomic absorption spectrometric method for the determination of phosphorous in different alloys, MAPAN-*Journal of Metrology Society of India* 18, 217-221 (2003).

135 Sarkar S.K. & Rajesh Kumar. Cloud characteristics & cloud attenuation in microwave and millimeter wave frequency bands for satellite and remote sensing applications over a northern Indian tropical station. *Int. J. Infrared and Millimeter Wave*. 23, 937-944 (2002).

136 Sarkar S.K., Raju K. Megha, Punnyaseshudu D., Gupta M.M. & Rajesh Kumar. Some observations on microwave propagation under clear air, fog cloudy atmospheric condition in Indian southern region. *Indian J. Physics*. 76B, 255-258 (2002).

137 Saxena A.K, Saleem Mohd., Rao S.U.M & Singhal R.P. Inter laboratory proficiency testing in capacitance measurement for NABL accredited laboratories – 2001/02. MAPAN- *Journal of Metrology Society of India,* 17(4) 157-164,(2002)

138 Saxena G.M. Eigenvalue equation of squeezed coherent states & time evolution of squeezed states. *Journal of Physics A: Mathematical & General* 35, 8953-60, (2002)

139 Saxena R.B., Ansari M.A., Kumar Ashok & Sharma R.G. Design of a Cryogen-free 5 Tesla superconducting magnet. *Indian Journal of Cryogenics*, 27, 277-281(2002).

140 Saxena R.B., Ansari M.A., Kumar Ashok & Sharma R.G. Development of large number of 7T laboratory superconducting magnet systems at NPL. *Indian Journal of Cryogenics*. 27, 146-150(2002).

141 Saxena R.B., Lal Kasturi, Babbar N.K., Kishan Hari, Gera S.C., Jain A.P., Reddy Y.S., Ansari M.A., Kumar Ashok, Verma S.S. & Sharma R.G.Cryogenics at National Physical Laboratory: A review. *Indian Journal of Cryogenics*. 27, 247-253(2002).

142 Sethi N.K. & Mahajan K.K. The bottomside parameters B0, B1 obtained from incoherent scatter measurements during a solar maximum and their comparisons with the IRI-2001 model. *Ann. Geophysicae*. 20**,** 817-822 (2002).

143 Sethi N.K., Goel M.K. & Mahajan K.K. Solar cycle variations of foF2 from IGY to 1990. *Ann. Geophysicae*, 20, 1677-1685 (2002).

144 Sharma C., Gupta Prabhat K. & Mitra A.P., Rural India & Environment. *Science & Culture*..68 (9-12), 257-263 (2002).

145 Sharma Nidhi, Deepa M. , Varshney P. & Agnihotry S.A. FTIR and absorption edge studies on tungsten oxide based precursor materials synthesized by sol-gel technique. *J. Non-Crystalline Solids*. 306, 129-137 (2002).

146 Sharma R.G., Saxena R.B., Ansari M.A., & Kumar Ashok. The design & fabrication of a 50 mm bore, 11 Tesla superconducting magnet. *Indian Journal of Cryogenics*. 27, 151-154(2002).

147 Sharma R.P., Raghuvanshi M.S.S, Bhawsar V. & Misra S.C.K. Infrared optics applications of thin films of polyaniline emeraldine. *Polymer for Advanced Technlogies,* 13, 475 (2002)

148 Sharma Rina, Chitnis Vijay, Zhou T.Lizhong, Furuhashi Hideo & Uchida Yoshiyuki. Digital displacement measurement using differential moiré signals, Hideo Uchida, MAPAN-*Journal of Metrology Society of India*. 18,165-171(2003)

149 Sharma Rina, Ojha V.N. & Kothari P.C. ISO/IEC 17025 vs ISO Guide 25: Assessor's Resposibility" MAPAN-*Journal of Metrology Society of India*, 17(2) 75-80, April-June(2002)

150 Sharma S.K. & Misra S.C.K. Optimization of conducting polymer thin film optical and electrical waveguides, OPTIK *International J. of Light & Electron Optics*, 113, (9), 351 (2002)

151 Sharma S.N., Shivprasad S.M., Kohli S., Rastogi A.C. Substrate temperature dependence of electrical conduction in nanocrystalline CdTe:TiO_2 sputtered films. Pure and Applied Chemistry. 74 (9), 1739 (2002).

152 Sharma Sudhir K., Ojha V.N., Singh Ajeet, Jaiswal S.K. & Sharma Rina. Traceability & Calibration - A Case Study, MAPAN-*Journal of Metrology Society of India*. 18, 57-61(2003).

153 Sharma, S.K., Kalra, N. & Singh, G.R.. Soil physical & chemical properties as influenced by flyash addition in soil & yielding of wheat. *J. Scientific & Industrial Res*. 61, 617-620, (2002)

154 Sharma, S.K., Ojha, V.N., Singh, A., Jaiswal, S.K. & Sharma, Rina. Traceability & calibration: A case study. MAPAN-*Journal of Metrology Society of India*. 18, 57-61, (2003)

155 Singh Ajeet & Ojha, V.N. Calibration of national standard of resistance using newly established automatic direct current comparator resistance bridge. MAPAN-*Journal of Metrology Society of India*. 18, 49-55, (2003)

156 Singh Mahavir, Pujara K.K. & Mohanan V. A working estimate of measurement repeatability & within-laboratory reproducibility for sound transmission through wall panels. MAPAN-*Journal of Metrology Society of India*, 18(Sup. Issue), 101-106, (2003)

157 Singh Mahavir, Pujara K.K. & Mohanan V. Sound Transmission loss of gypsum board faced wall panels with glassfiber batt of different densities. *J. Acoustical Society of India*. 30(1&2), 201-205, (2002)

158 Singh Nahar, Rashmi & Sarkar A.K. Application of fusion technique in synthetic diamond for the determination of impurities by flame atomic absorption spectrometry. MAPAN-*Journal of Metrology Society of India*, 18,.153-158 (2003).

159 Singh P.K. & Lakshmikumar S.T. Quenching and recovery of photoluminescence intensity of silicon nanoparticles embedded in optically transparent polymers. *Semiconductor Science and Technology*. 17, 1123 (2002).

160 Singh Y.P. Evaluation & expression of uncertainty in the calibration of liquid-in-glass thermometer" MAPAN-*Journal of Metrology Society of India*, 17(1), (2002)

161 Singh, V.R. On the Increase of disintegration efficiency of an acoustic lithotripter. *J. Acou. Soc. of America*. (2002)

162 Singhal R. P. ISO/IEC 17025 vis a vis ISO/IEC guide 25-a Review. MAPAN-*Journal of Metrology Society of India.* 17(4), (2002)

163 Singhal R., Annapoorni S., Kaneto K., Takashima W. & Malhotra, B.D. Langmuir-Blodgett films of poly-3-dodecyl thiophene for application to Glucose biosensor. *Sensors & Actuators*, B86, 42-48 (2002)

164 Singhal R.P.,Aggarwal N.K., Saxena A.K. & Rao S.U.M. Interlaboratory proficiency testing: gauge block intercomparison – 2001/02. MAPAN -*Journal of Metrology Society of India,* 17(3), 91-99 (2002)

165 Siwach P. K. , Singh D. P., Singh H. K., Khare Neeraj, Singh A. K. & Srivastava O.N. Effect of substrate on magneto-transport properties of polycrystalline manganite films. *J. Phys. D: Appl. Phys*. 36, 1361-1365 (2003)

166 Siwach P. K., Singh H. K., Khare Neeraj, Singh A. K. & Srivastava O. N. On the synthesis & characterization of a new manganite type CMR material: $La_{0.7}Hg_{0.3}MnO_3$. *J. Alloys & Compounds*. 350, 56 (2003)

167 Srivastava A.K., Lal Kasturi, Singh Sukhvir & Kishore Ram, Preparation and characterization of standard gold resolution test specimen for Electron Microscopy. MAPAN – *Journal of Metrology Society of India*. 18, 159 (2003).

168 Suri Komilla, Annaporni S., Sarkar A.K. & Tandon R.P. Gas and humidity sensor based on iron oxide-polypyrolle nanocomposites. *Sensors & Actuators*. B81, 277-282 (2002).

169 Swarup, R. & Negi, P.S. Measurement of reflection and transmission phase at HF & microwave frequencies, MAPAN-*Journal of Metrology Society of India*. 18, 241-247, (2003)

170 Swarup, R., Negi, P.S. & Mendiratta, R.L. Estimation of uncertainty in impedance measurement at narrow & broadband microwave frequencies, *Measurement*. 33(1), 55-66 (2003)

171 Tripathi O.P. & Jain S.L. Abrupt change in total ozone column over Indian Antarctic Station. Ind. J. Radio and Space Phy. 32, 38-42 (2003).

172 Upreti U.C. & Narlikar A.V. Effect of Cu-site occupancy on superconducting order parameter dimensionality & related correlations in low-disorder Fe & Zn doped YBCO. *Ind. J. Pure & Appl. Phys*. 40, 476-481(2002).

173 Upreti U.C. & Narlikar A.V. Exploring the comparative role of Zn & Fe doping on superconducting order parameter fluctuation dimensionality in $ErBa_2Cu_3O_{7-\delta}$ *Indian Journal of Cryogenics*. 27, 127-130(2002)

174 Upreti U.C. & Narlikar A.V. Exploring the site occupancy effects of equal low concentrations of Zn & Fe dopants on order parameter fluctuations in Y123 bulk samples: A preliminary investigation. *Ind. J. Pure & Appl. Phys*. 40, 795-800(2002).

175 Upreti U.C. & Narlikar A.V. Low concentration dopant disorder modified carrier scattering & related correlations in YBCO. *Ind. J. Pure & Appl. Phys*. 40, 637-642(2002).

176 192 Upreti U.C. Anisotropy dependence of the critical region width in $YBa_2Cu_4O_8$ *Indian Journal of Cryogenics*. 27, 123-126(2002).

177 Upreti U.C.Superconducting order parameter dimensionality effects in equal low concentration Zn & Fe doped Y123 – A preliminary investigation. *Indian Journal of Cryogenics*, 27, 131-134(2002)

178 Yadav Sanjay, Bandhopadhyay A.K. & Gupta A.C. Characterization of national hydraulic pressure standards in the pressure ranges 100 MPa, 200 MPa & 500 MPa., Cal Lab. *The International J. of Metrology*. Jan-March, 28-35 (2003)

179 Yadav Sanjay, Bandyopadhyay A.K, Gupta V.K. &. Gupta A.C. Tracebility & stability of hydraulic transfer pressure standard up to 140 MPa. MAPAN-*Journal of Metrology Society of India*. 17, 3-10 (2003)

Papers Published in Conference/ Symposium/Workshop Proceedings

1 Abbott P. & Mohan P., The effect of ambient temperature on the sensitivity of hot-cathode ionization gauges, *AVS 49th International Symposium*, Denver, Colorado, Nov. 3-8, 2002

2 Agarwal, A., Seth, V. P., Gahlot, P. S., Chand., I., Khasa, S. & Gupta, S. K., Effect

of titanium ions on the electron paramagnetic resonance in vanadyl doped $TiO_2.M_2O.B_2O_3$ (M=Li and Na) glasses. *Proceedings DAE SSP Symposium*,Panjab University, Chandigarh, p26-30, Dec. 2002

3 Agnihotry S.A., Sol-gel derived Electrochromic WO_3 films, *Proceedings of the Seventh International Symposium on Advances in Electrochemical Science and technology*, Chennai 27-29 November, 2002

4 Agrawal A. K, Estimation of Uncertainty in Chemical Measurements (In Hindi), *Scientific Workshop in Hindi*, Organized by NPL, New Delhi, December 4, 2002.

5 Agrawal A. K, Reliable and Traceable Measurements. *Proceedings: National Conference on Impact of Environmental Pollution on Health: Problems and Solutions*, New Delhi, p45-50, August 29-30, 2002

6 Agrawal A. K, Saxena R.K., Bhatnagar Abha, Ganju Sunita & Lal Krishan, Measurement of the Quality of Water (Hindi), *National Conference on Radio and Atmospheric Science*, New Delhi, February 17-18, 2003

7 Agrawal A. K., Lal Krishan, Sharma S. N., Chauhan R. K., Anand O. N., Singh A. K, Agrawal S. K., & Datta A., Development of Hydrocarbon Soluble Organo-metallic Standards, *5th International Petroleum Conference and Exhibition*, New Delhi, January 9-12, 2003

8 Anand S. & Kandpal H.C., Experimental study of the generation of cross-spectrally pure light by two diffusers moving in opposite directions and determination of diffuser surface characteristics, *XXVII Optical Society of India (OSI) Conference on Optics and Photonics in Engineering(COPE-03)*, Netaji Subhash Institute of Technology, New Delhi-45, Jan. 6-8, 2003.

9 Aruna I., Mehta B. R. & Shivaprasad S. M., Gd Nano—particles for H_2 sensing, *MRSI Delhi Chapter Seminar on Sensor Technology Development*, New Delhi, 28th Jan. 2003

10 Badarinath K.V.S., Latha K.M., Gupta Prabhat K., Christopher S.A.& Zhang J., Biomass Burning Aerosols Characteristics and Radiative Forcing - A Case Study from Eastern Ghats, India, *IASTA Conference on Aerosol Remote Sensing in Global Change & Atmospheric Pollution (IASTA-2002)*, VSSC, Trivandrum, Sept. 18-20, 2002

11 Badarinath K.V.S., Latha K.Madhavi, Kiran Chand T.R., Dutt C.B.S., Gupta Prabhat K., Ghosh A.B., Jain S.L., Gera B.S., Risal Singh, Sarkar A.K., Nahar Singh, Parmar R.S., Kaul S.. Kohli R., Nath Shambhu, Ojha V.K. & Singh Gurbir, Trace gas emissions from biomass burning – a case study from north eastern region forests, India using remote sensing,GIS and ground based measurements, *Proc. ISPRS Symposium on Resource and Environmental Monitoring*, December 3-6, Hyderabad, p12-16, 2002

12 Badrinath K.V.S., Latha K. Madhavi, Kiran Chand T.R., Dutt C.B.S., Gupta P.K., Ghosh A.B., Jain S.L., Gera B.S., Singh Risal, Sarkar A.K., Singh Nahar, Parmar R.S., Koul S., Koul R., Nath Shambhu, Ojha V.K. and Singh Gurbir, Trace gas emission from bio-mass burning- A case study from N.E. region forests, India using remote sensing, *Proc. ISPAS Commission VII Symp., Resources and Environmental Monitoring* (Publisher: National Remote Sensing Agency, India), Hyderabad, India, Dec.3-6, 2002

13 Bahadur, H., Pant, R.P., Kandpal, H.C., Anand, S., Dhawan, S.K., Suri, D.K., Kumar, Y. & Kumar, A. Optical and ultrasonic investigations of Fe-doped crystalline quartz in magnetic fluid, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003

14 Bahaguna D.P., Jai Bhagwan, Basavaraju K.N.. Sudama & Kandpal H.C., Study of the photometric characteristics of LEDs – the light for future. *4th International*

Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003), National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003.

15 Banerjee P., Kramer G., Klische W., A study on the frequency stability of a PLL with GPS Signal as Input, *CPEM 2002,* Ottawa, June 2002.

16 Banerjee P., Status of time & frequency activities of NPL, New Delhi, *Asia Pacific Workshop on Time and Frequency (ATF2002)* Daejeon, Korea, Nov. 5-8, 2002

17 Baruah K.K., Gogoi Nirmali, Gogoi B., Goswami S., Barman B., & Gupta Prabhat K., *Non CO_2 Greenhouse Gases: Understanding, Options and Pects* by J. Van Ham, A.P.M. Baede, R. Guicherit & J.G.F.M. Williams-Jacobse (eds), Millpress, Rotterdam, 2002. p 101-106.

18 Basu A. and Bhattacharyya R., Wavelength dependent beam steering by thin film optical multilayer stack for WDM applications in fiber optic communication systems, *Sixth International Conference on Optoelectronics, Fiber Optics and Photonics (Photonics 2002)*, TIFR Mumbai, 16 – 18 Dec., 2002

19 Bhardwaj P., Sharma V., Agnihotry S.A. & Saxena T.K., Computer aided Measurements and Data analysis of Analog Potentiostat, *Proceedings of the National Seminar & Exhibition on Role of IT in the Present Scenario of globalization*, CMRI, Dhanbad, 1-2 February, 2003

20 Bhatt, S.C., Bhatt, K., Singh, K., Uniyal, M., Semwal, H.K., Pant, R.P., Suri, D.K. & Semwal, B.S., Rheological study of ferrofluids, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003.

21 Bose D. N., Pal S., Ray S. K. & Chakraborty B.R., Novel gate dielectrics for nanoscale semiconductor devices, *National Seminar on Science & Technology of Nanomaterials, IACS*, Kolkata, March 6-7, 2003

22 Chakarvorty B.C., Pant R.P. & Kotnala R.K., Determination of the galvanomagnetic tensor coefficients of the clusters of ferromagnetic inks by imbedding them in the nanopores of mesoporous silicon, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003

23 Chakraborty B. R., Laser post ionization Time-of-flight Secondary Ion Mass Spectrometry to study Benzene ejection from C_6H_6 / Ag {111} due to keV ion bombardment, *Proceedings of ISMAS-SJS-2003 International symposium on Mass Spectrometry*, Vol. II, p 505, Jan 2003

24 Chakraborty B. R., Optimization of depth resolution in sputter depth profiling of interfaces and the need for standards in surface characterization, *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003)*, National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003

25 Chakravarty B.C., Pant R. P., Vinod P.N. & Kotnala R.K, Determination of the Galvano-Magnetic Tensor Coefficients of Ferromagnetic Inks by Imbedding them of in the Pores of Mesoporous Silicon, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003

26 Chakravarty B.C., Singh P.K., Sinha S.P., Singh R.K., Lal M., Kumar R. & Singh S.N., Fabrication of PIN structures for Application in photodiodes, *National Conference of Materials, Components and Application*, (MCA'03), Kalinga Institute of Technology, Bhubaneshwar, February 15-16, 2003

27 Chakravarty B.C., Sinha S.P., Singh R.K., Lal M., Kumar R. & Singh S.N., *Processing and Fabrication of Silicon Photodiodes*, Scientific Workshop, N.P.L., New Delhi 4 Dec., 2002

28 Chakravarty, B.C., Pant R.P., Vinod, P.N. & Kotnala, R.K. Determination of the galvanomagnetic tensor coefficients of the clusters of ferromagnetic inks by imbedding them in the nanopores of mesoporous silicon, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003

29 Chander Harish, Shanker Virendra, Haranath D., Sharma Pooja, Luminescence Characteristics of $CaAl_2O_4:Eu^{2+}$, Nd^{3+} Phosphor, *Proceedings of National Symposium on Luminescence and its Applications (NSLA)-2003*, National Physical Laboratory, New Delhi, Feb.12-14, 2003. p.328.

30 Chaudhary K.P., Sharma Rina, Tanwar L.S., Singhal R.P. & Chandersakher, Machine evaluation using laser interferometer-a practical approach, *XXVIII Optical Society of India (OSI) Conference on Optics and Photonics in Engineering (COPE-03)* Netaji Subhas Institute of Technology, New Delhi-45, Jan. 6-8, 2003.

31 Chawla Santa & Gupta A. Sen, Optical setup of the proposed laser cooled Cs fountain at NPL, India, *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003*), National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003

32 Choudhary N K, Kumar Ashok, Kumar Yudhisther & Gupta Reeta, Evaluation of elastic moduli of concrete by ultrasonic velocity, *Proc. National Seminar on NDE (NDE-2002)*, Chennai, Dec. 5-7, 2002

33 Colliex C., Imhoff D., Samet L., Suenaga K., Srivastava A.K. & Trasobares S., EELS Characterization of Nanolayers and Interfaces, *12th International Conference on Thin Films, Bratislava (Slovakia)*, September 15-20, 2002

34 Dilawar Nita, Varandani D., Bandyopadhyay A. K. & Gupta A. C., Estimation of differential pressure through strain gauge transducer in the pneumatic range 0-3.5 MPa using a regression relation, *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003*), National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003

35 Dixit P.N., Rajput S.S., Rauthan C.M.S., Kumar S., & Bhattacharyya R., Microwave plasma chemical vapour deposition processing of nanodiamond and carbon nanotube thin films, *National Seminar on Sci. & Tech. of Nanomaterials*, CGCRI, Kolkata, 6-7 March, 2003

36 Gadi Ranu, Sarkar A.K., Parashar D.C. & Mitra A.P., SO_2, NO_x, Organic and elemental carbon emission studies for biofuels used in India. *Proceeding of Non CO_2 Green House Gases* Van Ham, Baede, Guicherit and Williams-Jacobse (eds), Millipress, Rotterham, p. 2002. p. 61-65.

37 Gera B.S., Saxena T.K., Matrantonio G., Singh A. Stefania, Singh G., Ojha V.K., Design & development of micro controller based multi-frequency Doppler Sodar, *Proc. Int. Symposium of Acoustic Remote Sensing of Atmosphere and Oceans (ISARS-2002)*, Rome,Italy, June 24-28, 2002. p 107-110

38 Gera B.S., Singh G., Ojha V.K., Gazanand G. & Dutta H.N., Sodar studies of foggy bounday layer, Proc. Int. Symposium of Acoustic Remote Sensing of Atmosphere and Oceans (ISARS-2002), Rome, Italy, 263-266, June 24-28, 2002

39 Ghosh A.B. & Kohli R., Concentrations of atmospheric greenhouse gases, aerosols and their comparison with COSMIC, *Proc. International Conference on Current Developments in Atomic, Molecular and Chemical Physics with Application* – Kluwer Academic /Plenum Publishers, New York, 2002. p. 253-258

40 Ghosh A.B., Parmar R.S. & Kohli R., Trend analysis of aerosol optical depth, aerosol size distribution from measurements of solar radiation by sunphotometer at New

Delhi, *Proc. ISPRS Symposium on Resource and Environmental Monitoring*, December 3-6, Hyderabad, p23-25, 2002

41 Golia Santosh, Study of electrochemically deposited SnTe thin films *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003

42 Golia, S., Arora, M., Rastogi, A.C. & Suri, D.K., Study of electrochemically deposited SnTe thin films *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003

43 Gupta A. C. & Miiller Archie P., Characterization of a Gas operated pressure balance with a 360 kPa Ultrasonic Interferometer Manometer, *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003*), National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003

44 Gupta A. Sen & Hanjura A. K., Refining the Geostationary Satellite Orbit Determination using Multi-station INSAT STFS Observations, *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003*), National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003

45 Gupta A., Mehrotra R., Joshi R. M., Chauhan, V. S., Conformation of dehydropeptides using Infrared spectroscopy: Influence of a D amino acid residue on conformational stability of helical model peptides as probed by variable temperature IR, *Euroanalysis 12* Dortmund, Germany, September 2002

46 Gupta J. K. & Sharma Rina, Digital PRT : A case study for Uncertainty Estimation, *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003)*, National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003.

47 Gupta S.K., Singh Ramadhar, Arora Manju & Kaur Amarjeet, ESR study of conduction mechanism in doped poly(3-methyl thiophene) polymer, *14th Annual General Meeting and Theme Symposium on Novel Polymeric Materials*, BARC, Mumbai, February 11-13, 2003

48 Gupta V.K., Yadav Sanjay, Bandopadhyay A.K. & Gupta A C , 275 MPa Tak Daab Mapan Ke Liye Ek Vishwasniy Quartz Digital Sthanantaran Daab Manak Ki Sthapna, , *Raj Bhasa Ki Ek Deni Vegyanik Karyshala* Dec. 4, New Delhi, 2002

49 Gupta Vandana, Gupta Prabhat K., Garg S.C. & Mitra A.P., Uncertainties in Indian Agriculture Sector inventory: Rice cultivation, *paper presented in the Hindi Conference*, NPL, New Delhi, February 17-18, 2003

50 Gupta, S.K., Pant, R.P. & Arora, M., Variable temperature electron paramagnetic resonance investigations of an ionic ferrofluid, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003

51 Hanjura A. K., Design of decoder for IRIG-B time code, *National Symposium on Instrumentation*, Bharathiar University, Nov. 27-29, 2002

52 Haranath D., Shanker Virendra, Chander Harish, Sharma Pooja, Multicolour Emissions in Strontium Aluminate Phosphors, *Proceedings of National Symposium on Luminescence and its Applications (NSLA)-2003*, National Physical Laboratory, New Delhi, Feb. 12-14, 2003. p. 335

53 Howe D. A., Hatt A., Nelson C., Walls F. L., Garcia Nava J. F. & Gupta A. Sen, Wide-range microwave frequency synthesis using an offset passive resonator, *Proceedings 2002 IEEE International Frequency Control Symposium*, New Orleans, June 2002. , p. 584-588.

54 Howe D. A., Nelson C., Walls F. L., Garcia Nava J. F., Hatt A. & Gupta A. Sen, A 100 GHz AM and PM Noise Measurement

System: Preliminary Design and Performance, *Proceedings 20002 IEEE International Frequency Control Symposium*, New Orleans, June 2002. p. 690-698

55 Jain Kiran & Sharma R.K., Impedence spectroscopic analysis on electrodeposited CdTe thin films, *Proc. Seventh International Symposium on Advances in Electrochemical Science and Technology*, Vol 2, 2002. D 184-187.

56 Jain Kiran, Kumar Vipin, Gupta H. P. & Rastogi A. C., Bismuth molybdate thick films as ethanol sensor, *International Conference on Smart Materials Structures and Systems, Indian Institute of Science*, Bangalore, India 12-16 December 2002.

57 Jain Kiran, Kumar Vipin, Pant R.P., Sood K.N. and Rastogi A.C., Ethanol sensing characteristics of Bismuth Molybdate, *One day seminar on Materials, Processes, Devices and Systems for Sensor Technology Development*, NPL, New Delhi, 28 Jan. 2003

58 Jain Kiran, Sharma R. K., Kohli S., Sood K. N. & Lakshmikumar S. T., Growth and microstructural studies of electrodeposited indium telluride thin films, *Proceedings of the Seventh International Symposium on Advances in Electrochemical Science and Technology*, Vol 2, 2002. D 184-187.

59 Jain S.C., Dixit V., Tanwar V.K. & S.M. Shivaprasad, Orientation of ferroelectric liquid crystals by self-assembled bilayer molecular assembly, *Mat. Res. Soc. Proc.* 709 cc1.4.1-6 (2002).

60 Jain S.L., Arya B.C. & Arun Kumar, Measurement Of Ammonia and other Minor Constituents in the Atmosphere Using Differential Absorption Lidar, *Proc. 21st ILRC,* Quebec City, Canada, July 8-12, 2002. Part I, p261, 2002.

61 Jain, K., Kumar, V., Rashmi, Sood, K.N. & Lakshmikumar, S.T. Preparation of Sb doped SnO_2 transparent conducting oxide thin films by dip coating technique *National Seminar on Science & Technology of Nanomaterials*, CGCRI, Kolkata, 6-7, Mar. 2003

62 Kamlesh K. Jain, Jain S K., Best measurement capability of a newly developed 5 kN dead weight force machine, *Proceedings 18th IMEKO TC3 International Symposium on Force, Mass and Torque*, Celle, Germany September 24-26, 2002. pp347

63 Kandpal H.C. & Anand S., Anomalous behaviour of Spectra at wave front dislocations. *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003*), National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003.

64 Kandpal H.C. & Anand S., Anomalous behaviour of spectra near phase singularity: an experimental study,. *XXVII Optical Society of India (OSI) Conference on Optics and Photonics in Engineering (COPE-03)*, Netaji Subhas Institute of Technology, New Delhi-45, Jan. 6-8, 2003

65 Kandpal H.C., Roy S. & Kafatos M., Experimental verification of Dopplor - like shift and multiple scattering theory, *Annual Meeting of Optical Society of America,* Orlando Florida, Sept 29-Oct. 3, 2002.

66 Khanna R.M., Bahl Madhu, Gupta Beena, Chakraborty G., Jha V., Roy S. & Garg S.C. Experiences of wind measurement using phased array Doppler sodar developed at NPL *Proc. Int. Symposium of Acoustic Remote Sensing of Atmosphere and Oceans (ISARS-2002)*, Rome, Italy, June 24-28,2002. p 119-122

67 Khanna R.M., Jha Vivekanad., Roy S., Bahl Madhu, Gupta Beena, Chakraborty G. & Garg S.C., Configuring a Doppler Sodar for an Acoustic Measurement of CT2 of the Boundary Layer Proc. *Int. Symposium of Acoustic Remote Sensing of Atmosphere and Oceans (ISARS-2002)*, Rome, Italy, 115-117, June 24-28, 2002

68 Khare Neeraj & Gupta A K Low field magnetoresistance of bicrystal grain-boundary in $La_{0.67}Sr_{0.33}MnO_3$ films, *90th*

Indian Science Congress, Jan 3-7, Bangalore 2003

69 Khare Neeraj, Singh D.P., Singh H K, Gupta A K, Siwach P.K., & Srivastava O.N. Improved stability of $La_{0.67}Ca_{0.33}MnO_3$ film due to silver addition, *Proc. DAE Solid State Physics Symposium*,Panjab University, Chandigarh, 26-30 Dec 2002

70 Khatri P. K., Baheti G. L., Meena V. L., Shanker Virendra, Chander Harish, Radiographic Imaging with Indigenous Developed Gadolinium Intensifying Screens, *Proceedings of National Symposium on Luminescence and its Applications (NSLA)-2003*, National Physical Laboratory, New Delhi, Feb. 12-14, 2003. p. 355

71 Kishan H., Singh B. & Ojha V.N. Uncertainty analysis of the NPL's aspirated psychrometer, *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003*), National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003

72 Kishan Hari & Bhikham Singh, Establishment of the Indian national humidity standard facility, *Proceedings 4th International Symposium on Humidity & Moisture*, Taipei, Taiwan, 16-19 September, 2002. p 566-570.

73 Kishan Hari & Bhikham Singh, Mixed flow relative humidity generator, *the 4th International Conference on Advances in Metrology: Equivalence of Standards and Global Recognition (Admet-2003)*, NPL, from 5th February – 7th February 2003

74 Kishan Hari, Development of a portable relative humidity generator, *Proceedings 4th International Symposium on Humidity & Moisture*, Taipei, Taiwan, 16-19 September, 2002. p 88-92

75 Kumar, L., Dhawan, S.K., Kumar, M., Kamalasanan, M.N. & Chandra, S., Designing of heterojunction light emitting diodes based on poly (p-phenylenevinylene) /CdS thin films., *National Symposium on Luminescence and its Applications (NSLA-2003)*, National Physical Laboratory, New Delhi, February 12-14, 2003. p. 384-389.

76 Kumar, S. and Singh V.R., Study of human teeth with IR technique for better dental care, *Proc. 89th Session of Ind. Sci. Cong.*, Lucknow, Jan 3-7, 2002

77 Kumar, Singh V.R., Kumar P. & Singh B., Ultrasonic transit time flowmeter, *Proc. Int. Conf. On Computer Appl. in Elec. Engg. (CERA-02)*, Roorkee, 43-45, Feb. 21-23, 2002

78 Lal Kasturi, Srivastava A.K., Khurana D. & Kishore Ram, Microstructural Features Associated with Thermally Evapourated Thin Films of Bi-Te Thermoelectric Sensors, *Proc. National Conference on Sensor Technology,* New Delhi, India, p 398, 2002

79 Lal M., Electrical Activity of Au^+ trap in P-type silicon *PV NET Workshop,* University of Liverpool, U.K., 10 September 2003

80 Latha M., Badarinath K.V.S., T.R. Kiran, Dutt C.B.S., Gupta Prabhat K., Ghosh A.B., Jain S.L., Gera B.S., Singh Risal, Sarkar A.K., Singh Nahar, Parmar R.S., Koul S., Kohli R., Nath Shambhu, Ojha V.K. & Singh Gurbir, Biomass Burning and related Trace Gas Emissions: A Study from North East Region, India using ground based instruments and Satellite Remote Sensing Data, *Indian Science Congress*, Bangalore January 2003.

81 Latha M., T.R. Kiran, Badarinath K.V.S., Dutt C.B.S., Gupta Prabhat K., Ghosh A.B., Jain S.L., Gera B.S., Singh Risal, Sarkar A.K., Singh Nahar, Parmar R.S., Koul S., Kohli R., Nath Shambhu, Ojha V.K. and Singh Gurbir. Trace Gas Emissions from Biomass Burning - A case study from North East Region forests, India using remote sensing, GIS and ground based measurements, *International Symposium on Resource and Environmental monitoring, NRSA*, Hyderabad, December 3-6, 2002

82 Mahajan S.K. & Ravat K.B., Establishment of DC high voltage calibration laboratory upto 100kV at N.P.L. *4th International*

Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003), National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003

83 Mathur, R.B., Lal,C., Seth, R.K., Dhami., T.L., Sood, K.N. and Kishore, R. Influence of Catalysts on the production of Carbon nanotubes, *National Symposium on Nanostructural Materials*, IIT Delhi ,Dec. 5-6, 2002

84 Mehrotra R., Tewari, J. Gupta A., Varma, S.P., Quantification of Brix and Pol in sugarcane juice using FTIR/ATR spectroscopy, *Euroanalysis 12*, Dortmund, Germany, September 2002

85 Mehrotra Ranjana, Gupta Alka, R. Nagarajan & Varma S. P., NIR spectroscopy and fiber optic probe for determination of alcohol, sugar and tartaric acid in alcoholic beverages, *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003)*, National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003.

86 Misra, S.C.K., Dixit, V., Mathur, P., Pant, R.P. & Gupta, A.K. Nanocrystalline magnetic alloy thin films, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003

87 Moodley S.S., Saleem Mohd. & Saxena A.K., Progress on deriving the Farad from the Ohm at CSIR-NML, *Proceeding of Satellites Meeting on Impedance Metrology,* National Physical Laboratory, New Delhi, *4th Feb. 2003*

88 Nath Omkar & Gupta A.K., Lumped Parameter Impedance Standards at NPL(India) and Measurement Traceability- National & International Perspective *Satellites Meeting on Impedance Metrology,* National Physical Laboratory, New Delhi, 4th Feb. 2003

89 Ojha V.N., Furuhashi H., Uchida Y. and Chitnis V.T., Analysis of errors for photolithographic mask-wafer alignment using modified moiré technique, *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003)*, National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003.

90 Ojha V.N., Saxena A.K., Pant R.P., Suri D.K. & Dhawan S.K., Investigations on Ferrofluid Base Transducer, *International Conference on Recent Advances in Nanotechnology of Magnetic Fluids,* National Physical Laboratory, New Delhi, 22nd – 24th Jan. *2003*

91 Ojha V.N., Sharma S., Singhal, S.K., & Lamba, G.S., Insulation resistance measurement of high impedance accelerometer cables, *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003)*, National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003

92 Ojha, V.N., Saxena, A.K., Pant R.P., Suri, D.K. & Dhawan, S.K., Investigations on ferrofluid base transducer, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003. p263

93 Pant, R.P., Dhawan, S.K., Suri, D.K., Arora, M., Gupta, S.K., Koneracka, M., opcansky, P. & Timko, M., Synthesis and characterization of ferrofluid-conducting polymer composite *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003. p73.

94 Pant, R.P., Suri, D.K., Sood, K.N., Dhawan, S.K., Koneracka, M., Kopcansky, P., Timko, M. & Tomko, L. Synthesis and polymerization of ferrofluids nano-particles in high Tc superconductor (BSCCO), *Proceedings International Workshop on Recent Advances in the*

Nanotechnology of Magnetic Fluids, National Physical Laboratory, New Delhi, Jan. 22-24, 2003.

95 Rajput S. S. & Jamuar S. S., Advanced Applications of Current Conveyors, *World Engineering Congress Malaysia*, 22-25 July 2002.

96 Rajput S.S. & Jamuar S. S., Low voltage high performance current conveyors and their applications as current sensors, , in Proc. APCCAS- 2002/IEEE, Singapore. 16-18 Dec 2002. p343-346

97 Rajput S.S. & Jamuar S. S., Ultra low voltage current mirror op amp and its applications, *Proc. APCCAS- 2002/IEEE*, p145-148, 16-18 Dec 2002

98 Rashmi & Ramachandran, R. Estimation of uncertainty of measurement in quantitative analysis of minor constituents of steel, *4th International Conference on Advances in Metrology: Equivalence of Standards and Global Recognition*, New Delhi, February 5-7, 2003

99 Rashmi, Synthesis and structural studies on some chalcopyrite type compounds, *Indo-Japan Academic and Educational Conference: Symposium on advances in electronic materials*, IHC, New Delhi, 6-7, Nov. 2002

100 Rauthan C.M.S., Dixit P.N., Kumar Sudheer, Rajput S.S., & Bhattacharyya R., Formation of nanodiamond films by plasma enhanced chemical vapour deposition technique, *National Seminar on Sci. & Tech. of Nanomaterials*, CGCRI, Kolkata, 6-7 March, 2003

101 Sanjid Arif, Singhal R.P., Kumar Vijay & Sameer, Investigation of hystersis loop of Universal Length Measuring Machine and its effect on linear measurement, *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition (AdMet-2003)*, National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003.

102 Sankaranarayanan V.K., Prakash Om & Pant R.P., Cobalt ferrite nanoparticles synthesized by a self-ignition reaction, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003

103 Sankaranarayanan, V.K., Prakash, Om & Pant, R.P., Synthesis and characterization of cobalt ferrite nanoparticles from a citrate precursor, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003. p 71.

104 Satyanarayan B. S., Panwar O. S. & Sharma Shashank, Field emission from doped and undoped tetrahedral amorphous carbon grown using direct and pulsed cathode arc source, *157th International Vacuum Microelectronics Conference,* Lyon, France, 7-11 July, 2002

105 Saxena A.K., Saleem Mohd. & Singh Naib, Application of Inductive Voltage Dividers in Precision AC Measurements, *Proceeding of Satellites Meeting on Impedance Metrology,* National Physical Laboratory, New Delhi, *4th Feb. 2003*

106 Sen Gupta A., Garcia Nava J. F.& Walls F. L.,A novel low noise regenerative divide-by-four circuit, *Proceedings 2002 IEEE International Frequency Control Symposium*, New Orleans, June 2002. p. 680-684.

107 Shanker Virendra, Phosphors with Europium Doped Aluminate Host Lattices, *Proceedings of National Symposium on Luminescence and its Applications (NSLA)-2003*, National Physical Laboratory, New Delhi, Feb. 12-14, 2003. p. 67.

108 Sharma C., Sarkar A.K., Gupta Prabhat K., Rai Kavita, Parmar R.S., Chowdhury Z., Mittal Moti L. & Mitra A.P., Aerosol Studies and new initiatives in developing a regional transport model, *Atmospherics Deposition Workshop, Kualalampur Malaysia*, November 21-23, 2002.

109 Sharma D. R. & Gupta A. C., Establishment of Gas Flow Measurement Standards at NPL, *4th International*

Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003), National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003

110 Sharma Pooja, Shanker V., Chander H., Haranath D., Synthesis of $SrAl_2O_4:Eu^{2+}$ Phosphor by Combustion Synthesis, *Proceedings of National Symposium on Luminescence and its Applications (NSLA)-2003*, National Physical Laboratory, New Delhi, Feb. 12-14, 2003. p. 341

111 Sharma R Chaudhary K.P., Mangal M.L., Singhal R.P., A simple approach of ring gauge measurement and comparative study using different schemes of measurements,*4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003)*, National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003.

112 Sharma R., Ojha V.N., Furuhashi H., Uchida Y. and Chitnis V.T. Analysis of error for photolithographic mask-wafer alignment using modified Moiré technique. *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003)*, National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003

113 Sharma Susheel, Rajput S. S., Magotra L. K. & Jamuar S. S., FGMOS based wide range low voltage current mirror and its applications, *Proc. APCCAS /IEEE*, Singapore, 16-18 Dec, 2002. p-331-334.

114 Shukla, R.S., Pant, R.P., Suri, D.K., Dhawan, S.K., Kopcansky, P. & Koneracka, M. Ferrofluid catalyzed oxidation of ascorbic acid by hydrogen peroxide in aqueous acidic medium, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003. p. 74.

115 Singh H K, Singh D P, Khare Neeraj , Gupta A K, Siwach P K, & Srivastava O N, Effect of average La-site cationic radii on magneto transport in $La_{1.4}Sr_{1.6-x}Ba_xMn_2O_7$(x=0.0,0.8,1.6) films grown by spray pyrolysis, *Proc. DAE Solid State Physics Symposium*,Panjab University, Chandigarh, 26-30 Dec, 2002

116 Singh P.K., A New Relation between Curve Factor and Open Circuit Voltage for Solar Cells made on Anisotropically Etched Silicon, *Indian Science Congress*, Bangalore, 2003

117 Singh Ramadhar, Kaur Amarjeet, Sinha R.D.P. & Gupta N.P., A comparative study of ac conductivity and dielectric relaxation behavior of as grown and uniaxially stretched poly (vinylidene fluoride) films, *Twelfth National Seminar on Ferroelectrics and Dielectrics (NSFD-XII),* MRC, I. I. Sc., Bangalore, December 16-18, 2002

118 Singh, D.P. & Suri, D.K. Structural stability of Ga-Te system, *32nd National Seminar on Crystallography*, Jammu University, Jammu, 24-26, Oct. 2002

119 Singh, H., Sharma, S.K. Ojha, V.N. Study of LabVIEW Software based digital filters and their applications in automation of digital multimeter, *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003)*, National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003

120 Singh, V.R., Comparative Study of RF and Ultrasound Cancer Hyperthermia, *Proc. EPSM-2002*, New Zealand, 2002

121 Singh, V.R., EM Interaction Study in Bones, *Proc. Fifth Int. Conf. on EM Wave Interaction with Water and Moist Substances (ISEMA-2003)*, Rotorua, New Zealand, March 23-26, 2003

122 Singh, V.R., Mobile Lithotripsy Instrumentation System, *Proc. Nat. Symp. on Instrumentation (NSI-27),* Coimbatore, Nov. 27-29, 2002

123 Singh, V.R., Novel Bone Piezoelectric Sensors, Proc. *IEEE/ISA Int. 'Sensors for*

Industry Conference, ppr SI-2040, Houston, Texas, USA, Nov. 18-21, 2002

124 Singh, V.R., Standardisation of Shock Wave Lithotripters, *Proc. Int. Conf. Nat. Calib Sci Labs (NCSL)*, San Diego (USA), Aug. 4-8, 2002

125 Singh, V.R., Ultrasonic Study of Bone Tumours', *Asia Pacific Biomed Engg. Conf.*, Singapore, June, 2002

126 Sinha R.D.P., Kaur Amarjeet & Singh Ramadhar, Dielectric and piezoelectric behaviour of barium titanate / poly(vinylidene fluoride composite, *Twelfth National Seminar on Ferroelectrics and Dielectrics (NSFD-XII),* MRC, I.I.Sc., Bangalore, December 16-18, 2002

127 Siwach P.K. Singh H K, Khare Neeraj, Singh A K, & Srivastava O.N. Investigations on the effect of substrate on magneto transport in polycrystalline $La_{0.7}Ca_{0.2}Ba_{0.1}MnO_3$ films, *Proc. DAE Solid State Physics Symposium*,Panjab University, Chandigarh, 26-30, Dec. 2002

128 Sood, K.N. & Kishore, R., Microstructural Characterization of recorded and unrecorded magnetic audio tapes using Scanning Electron Microscopy, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003.

129 Srivastava A.K., Gloter A., Tencé M., Colliex C., Häfele A. & Haberland H., HREM and EELS Studies on High Energy TiN_x Nanoclusters Deposited on Si, *15th International Congress on Electron Microscopy*, Durban, September 1-6,2002

130 Srivastava A.K., Kishore Ram, Swati & Agnihotry S.A., Electron microscopy and diffraction analysis of nano structured prussian blue films, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003

131 Srivastava A.K., Kishore Ram, Swati & Agnihotry S.A., Electron Microscopy and Diffraction Analysis of Nano-Structured Prussian Blue Thin Films, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003.

132 Srivastava A.K., Lal Kasturi, Singh Sukhvir & Kishore Ram, Preparation and Characterization of Standard Gold Resolution Test Specimen for Electron Microscopy, *4th International Conference on Advances in Metrology: Equivalence of Standards and Global Recognition*, New Delhi, February 5-7, 2003

133 Srivastava A.K., Yu-Zhang K., Kilian L., Frigério J.M. & Rivory J., Microstructural Phase Transformations from Crystalline to Quasicrystalline Structures on Annealing in Al/Mn Multilayers, *8th International Conference on Quasicrystals*, Bangalore, September 8-13, 2002

134 Srivastava N.K. & Kohli N.K., A Study of thermal conductivity measurement with analysis of different parameters, *Proceedings of all India Seminar on Self Reliance in Materials and Machining MATMATCH- 2003*, Institution of Engineers (India), Delhi State Centre, New Delhi, March 21-22, 2003.

135 Srivastava N.K., Important aspects in Thermometry, *Proceedings of all India Seminar on Self Reliance in Materials and Machining MATMATCH- 2003*, Institution of Engineers (India), Delhi State Centre, New Delhi, March 21-22, 2003.

136 Sudama, Bahuguna, D.P. Jai Bhagwan, Basavaraju K.N. & Kandpal H.C., Absolute measurement of luminous flux using integrating sphere. *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003)*, National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003.

137 Thakur, A.K., Kaur, S., Biradar, A.M. & Bawa, S.S., Dielectric relaxation in deformed helix ferroelectric liquid crystal materials, *Proceedings International Workshop on Recent Advances in the*

Nanotechnology of Magnetic Fluids, National Physical Laboratory, New Delhi, Jan. 22-24, 2003. p. 261.

138 Upadhyay, R.V., Parekh, K., Mehta, R.V., Upadhyay, T. & Pant, R.P. A low temperature angle dependent hystersis in ESR resonance field : Mn-Zn-Gd nanoparticle system, *Proceedings International Workshop on Recent Advances in the Nanotechnology of Magnetic Fluids*, National Physical Laboratory, New Delhi, Jan. 22-24, 2003.

139 Yadav B.K., Bahaguna D.P., Jai Bhagwan & Kandpal H.C., Illuminancemeter - an important device for photometry. *4th International Conference on Advances in Metrology : Equivalence of Standards and Global Recognition(AdMet-2003*), National Physical Laboratory, New Delhi -110 012, Feb 5-7,2003.

140 Yudhisther Kumar, Ashok Kumar and Reeta Gupta, On the calibration of ultrasonic flaw detectors, *Proc. National Seminar on NDE (NDE-2002)*, Chennai, Dec. 5-7, 2002

141 Zaidi Z.H., Kumar P. & Garg R.K., Study of non-radiative transitions by photoacoustic spectroscopy Cabcum 2002, *International Symposium on Materials Development in Liquid Crystal and electroluminescent Displays* (International Materials Research Congress, Maxico, August 25-29, 2002.

Papers Presented in Conferences/ Seminars/Workshops

1 Agrawal A. K, Lal Krishan Saxena R.K., Bhatnagar Abha,& Ganju Sunita, Preparation and dissemination of Certified Reference Materials in India, 4th International Conference on Advances in Metrology: Equivalence of Standards and Global Recognition (AdMet-2003), New Delhi, p-6, 2003

2 Agrawal A. K, Lal Krishan,Sharma S.N, Chauhan R.K,Anand O.N. Singh A.K., Agrawal S.K., Datta A., Development of hydrocarbon soluble organo-metallic standards, 5th International Petroleum Conference and Exhibition on Global Cooperation for Hydrocarbon Technology (PETROTECH-2003), New Delhi, p-152-153, 2003

3 Ansari M.A., Kumar Ashok, Saxena R.B. & Sharma R.G., Test results of 7 T superconducting magnet systems developed at NPL Nineteenth Symposium on Cryogenics (NNSC-2002), Jadavpur University, Kolkata during 24–26 March, 2003

4 Arora M.& Gupta S. K., Characterization of hydrogenated amorphous silicon thin films by FTIR and EPR Spectroscopic techniques. National Seminars on Recent Trends in Optoelectronic Materials and Devices, Deptt. Of Physics, Sri Venkateshwara University, Tirupati, 21-22 Nov, 2002

5 Arya B.C., Jain S.L., Arun Kumar, Pankaj Singh & Tiwari M.K., Measurement of particulate matter during fog, Aerosol Remote Sensing in Global Change & Atmospheric Pollution (IASTA–2002), Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvanthapuram during September 18– 20, 2002

6 Bahl Madhu, Khanna R.M., Garg S.C. & Maini H.K., Faced array acoustic wind profiler ke liya face programebal sine wave ka sanshleshn, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi on 17-18 February, 2003

7 Bhatia G., Aggarwal R. K., Raman V., Saha M. & Mishra A., Development of coal tar pitch with a reduced content of harmful polycyclic aromatic hydrocarbons, National Symposium on Radio and Atmospheric Science, NPL, New Delhi, Feb. 17–18, 2003

8 Bhatia S.K. & Goel M.K., 13 March 1989 ke chumbkiya toofan ka madhya akchansa ion mansal par prabhav ka adhayayan, Paper presented at National Conference on "Radio avam

Vayumandaliya Vigyan, National Physical Laboratory, New Delhi 17-18 February, 2003

9 Chaubey A., Sol-gel/polyaniline composite films for application to lactate biosensor, 9th International Meeting on Chemical Sensors, Boston, U.S.A, 7-10 July 2002

10 Chauhan Pratima, Annapoorni S., & Trikha S. K., Effect of Cobalt Concentration on the Structural and Electrical Properties of Cobalt Ferrite Films. International Workshop on Recent Advances in Nanotechnology of Magnetic Fluids (RANMF) -2003

11 Chauhan Pratima, Annapoorni S., & Trikha S. K., Structural and magnetic properties of nanocrystalline cobalt ferrite films prepared by sol-gel processing, International Workshop on Recent Advances in Nanotechnology of Magnetic Fluids (RANMF)-2003

12 Chopra P., Subramanyam P., Garg S.C., Maini H.K., Bahl Madhu, Rajput S.S., John Thomas, Chunal D.S., Vishram Singh & Gupta Meenu, Upagraha SROSS-C2 par aarohit RPA prayog dwara dhatu ionon ka aanveshan, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

13 Das J. & Sarkar S.K., Radar ke prayog se precipitation ka adhayayan, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi , 17-18 February, 2003

14 Dhakate S.R., Mathur R.B. & Dhami T.L., Mechanical Properties of unidirectional carbon-carbon composites as a function of fiber volume fraction, First ISAMPE National Conference on Composites, New frontiers in materials and processing, INCCOM-1, Triruvananthapuram, May 3–4, 2002

15 Dhami T.L., Mathur R.B. & Dhakate S.R., Oxidation resistant coatings for carbon-carbon composites-past, present and future, First ISAMPE National Conference on Composites, New frontiers in materials and processing, INCCOM-1, Triruvananthapuram, May 3–4, 2002

16 Dhami T.L., Mathur R.B., Dhakate S.R., Chauhan S.K., Bahl O.P., Rand B. & Adrian A., Development of high thermal conductivity isotropic carbon/carbon composites, International Conference on Carbon , CARBON-2002, Beijing, China, 15-20 Sept. 2002

17 Dhawan S.K., Kumar L., Kamalasanan M.N. & Chandra S., Properties of organic light emitting diodes fabricated using benzene-naphthalene copolymer, Sixth International Conference on Optoelectronics, Fiber Optics and Photonics, TIFR, Mumbai, India December 16-18, 2002

18 Dixit V., Misra S.C.K., & Mathur P., Detection of Ammonia Using Vacuum Evapourated Polyaniline Thin Film Gas Sensors, National Conference on Materials, Components and Applications, KIIT, Bhubneswar, February 2003

19 Dutta H.N., Sharma Pawan Kumar, Gera B.S., Gajananda Kh, Ashok Kumar, Ojha D., Gurbir Singh, Ojha V.K., Study of planetary boundary layer processes at the Ice-Air-Ocean interaction over Prince Edward coast, East Antarctica,. 22nd Annual Conference of the Academy of Environmental Biology on Biodiversity at NIFR, Lucknow, Sept. 11, 2002

20 Gajanand Kh., Deb N.C., Dutta H.N., Lagun Victor E., Winter warming: a possible mechanism for the sustenance of microorganisms during long polar night at Antarctica, 22nd Annual Conference of the Academy of Environmental Biology on Biodiversity at NIFR, Lucknow, September 11, 2002

21 Gajanand Kh., Dutta H.N., Deb N.C., Kaushik Anubha & Lagoon Victor E., Purvi antarkatika sthita sirmachar kshatra par sardiyon mai hawa ki garmahat, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

22 Gajanand Kh., Shambhu Nath, Ashok Kumar, Dev N.C., Gupta V.B., Kaushik A. Tanwar R.S., Singh R. & Dutta H.N., Kya sirmachar kshatra Antarctica par vishvyapee parivartan ho rahe hen, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

23 Gajananda Kh, Kaushik Anubha, Dutta H.N. & Lagun Victor E., Study of Atmospheric Parameters and their role on the Biodiversity of the Schirmacher oasis, East Antarctica, 22nd Annual Conference of the Academy of Environmental Biology on Biodiversity at NIFR, Lucknow, Sept., 2002

24 Gera B.S., Gurbir Singh, Ojha V.K, Pasricha P.K., Gajananda Kh & Dutta H.N., Sodar studies of foggy boundary layer characteristics, International Symposium on Acoustic Remote Sensing & Associated Techniques of the Atmosphere & Oceans, Italy, Rome, June 24-27, 2002

25 Gera B.S., Gurbir Singh, Ojha V.K., Dutta H.N., & Kamyotra J.S., Kohre vali seemant stahe ke abhilakshan ka sodar yantra dwara adhayayan, National Conference on Radio avam Vayumandaliya Vigyan National Physical Laboratory, New Delhi, 17-18 February, 2003

26 Ghosh A.B. & Kohli R., Vayumandaliya haritkasksh gason va aerosolon ki matra ke rujhan ka vishlation tatha uski cosmic model se anumanit matraon ke sath tulna, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

27 Ghosh A.B., Peshin S.K.& Kohli R., Calibration of sunphotometer with Brewer spectrometer for ozone measurements at New Delhi, 4th International Conference on "Advances in Metrology –Equivalence of Standards and global recognition (AdmET –2003), NPL, New Delhi, 5-7 February, 2003

28 Ghosh A.B., Yogesh Kant, Prasad V.Krishna, Badarinath K.V.S., Gupta Prabhat K., & Tiwari M.K., Studies of urban aerosol using synchronous sunphotometer and satellite data, IGAC 2002 conference: Atmospheric chemistry with the earth system from regional pollution to global change, Greece, 18-25 September, 2002

29 Gupta Ajai K., Singh H.K., Singh D.P., Khare Neeraj & Gupta A.K., Low field magnetoresistance in layered perovskite La_2-2xCa1+2xMn_2O_7. National Seminar on Materials and its Applications, Dr.R.M.L. Avadh University, Faizabad on Feb 27-28, 2003

30 Gupta Anil K.., Light weight, high strength, material development at NPL, using novel processing techniques, Conference on light metals & composites of strategic and societal needs, RRL, Trivendrum. October 22-23, 2003

31 Gupta Meenu, Chopra P., Subramanyam P., Garg S.C., Maini H.K., Bahl Madhu, Rajput S.S., John Thomas, Chunal D.S., & Vishram Singh, RPA dwara prapta aankro ka prakaman, Paper presented at National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

32 Gupta Prabhat Kumar, Sharma C., Kaul S., Sarkar A.K. & Mitra A.P., Chaaval ki khetee se utserjit hone valee methane ke aankalan ki navin parivartit bharteeya padhti ki vikas, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

33 Gupta S. K., Pant R.P. & Arora M., Variable temperature electron paramagnetic resonance investigations of an ionic ferrofluid, International Workshop on Recent Advances in Nanotechnology of Magnetic Fluids, NPL, New Delhi., January 22-24, 2003

34 Gupta S. K., Singh R., Arora M. & Kaur A., ESR Study of conduction mechanism in doped poly (3-methyl thiophene) polymer, MRSI Symposium on Novel

Polymeric Materials, Bhabha Atomic Research Centre, Mumbai, Feb. 11-13, 2003

35 Gupta Vandana , Gupta Prabhat Kumar, Garg S.C. and Mitra A.P., Chaaval ki khetee se grenn gouhe gason ke naapane mai anishichtta, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

36 Jain Meena, Garg S.C., & Tiwari M.K., Dilli mai kohre ke dino mai drishtiseema ka ONET (neural network) model dwara T+ 3 ghante ki avadhi par alpkalik poorvanumaan, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

37 Jain Meena, Unchai ke anusaar unkeher ozone ka rookh vishlation aur UV-B mai parivartan, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

38 Jain S.L. , Arya B.C., Arun Kumar, Pankaj Singh, Tiwari M.K. & Garg S.C., Injection of Very High Concentration of RSPM in Boundary layer during Diwali Festival, Aerosol Remote Sensing in Global Change & Atmospheric Pollution (IASTA – 2002), Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvanthapuram during September 18 – 20, 2002

39 Jain S.L., Arya B.C., Arun Kumar & Pankaj Singh, Dilli ke dharatal par ozone ki matra, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

40 Jain S.L., Monitoring of atmospheric parameters at Maitri Station, Antarctica, , XXVII Scientific Committee on Antarctic Research (SCAR) and XIV Council of Managers of the National Antarctic Programs (COMNAP) meetings, Shanghai Exhibition Center (SEC), Shanghai, China, July 15 – 26, 2002

41 Jain, S.L., Arya B.C., Arun Kumar, Sachin D. Ghude, Green House Gases Measurement at Maitri, Antarctica, National Conference on Lasers and Spectroscopy, Meerut College, Meerut, February 25-28, 2003

42 Joshi G.P., Saxena N.S., Sharma T.P., Verma S., Dixit V. & Misra S.C.K., Band gap determination of chemically doped polyaniline from reflectence measurements, Conference on Thermophysical Properties of Materials, University of Rajasthan, Sept.2002

43 Khare Neeraj, Singh D.P., Singh H. K., Gupta A. K., Siwach P. K. & Srivastava O. N., Magnetoresistance, Conductance and conduction noise of polycrystalline manganite Film deposited on different substrates, 14th Annual meeting of MRSI at BARC, Mumbai, Feb 11-13, 2003

44 Khare Neeraj, Gupta A.K., Singh D.P., Sen S., Aswal D.K., Gupta S.K & Gupta L.C., Weak-Link Grain – Boundaries in MgB_2 Superconductor, 14th Annual meeting of MRSI at BARC, Mumbai, Feb 11-13, 2003

45 Kishan Hari & Saxena R.B., Low temperature thermometry in relation to the international Temperature Scale of 1990 (ITS-90), Nineteenth Symposium on Cryogenics (NNSC-2002), Jadavpur University, Kolkata during 24–26 March, 2003

46 Kishan Hari & Singh Bhikham, Mixed flow relative humidity generator , 4th International Conference on Advances in Metrology: Equivalence of Standards and Global Recognition (Admet-2003), NPL, 5–7 February, 2003

47 Kishan Hari, Singh Bhikham & Ojha V.N., Uncertainty analysis of the NPL's aspirated psychrometer, 4th International Conference on Advances in Metrology: Equivalence of Standards and Global Recognition (Admet-2003), NPL, 5–7 February, 2003

48 Kishore R., Sood K.N., & Misra S.C.K., In-situ SEM investigations of vacuum deposited Cu doped polymer films (–180 and 300^0 C), Materials Research Society

Meeting, Mumbai, Dec.2002

49 Kumar Ashok, Ojha Deepak, Gupta V.B. & Dutta H.N., Sirmachar kshatra par catabatic hawaon ka model, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi on 17-18 February, 2003

50 Kumar L., Dhawan S.K., Kamalasanan M.N. & Chandra S., Designing of organic light emitting diodes using novel phenylene based conjugated copolymers, International workshop on recent advances in nanotechnology of magnetic fluids (RANMF-2003), National Physical Laboratory, New Delhi, India , January 22-24, 2003

51 Lal Krishan, Metrology and materials evaluation and characterization, Proceedings of Seminar for Developing an APEC S&T Network in Materials Testing and Evaluation Technology, Korea, 85-103, 2002

52 Lal Krishan, Real Structure of Materials, International Workshop on Recent Advances in Nanotechnology of Magnetic Fluids (RANMF-2003), New Delhi, p-15, 2003

53 Lal Mohan & Jain S.L., Saf aakash ke global va sidhi kirnon ke solar spectra mai sambandhit mapan va manak, National Conference on Radio avam Vayumandaliya Vigyan National Physical Laboratory, New Delhi, 17-18 February, 2003

54 Latha K.Madhavi, Badrinath K.V.S., Kiran Chand T.R., Risal Singh, Tanwar R.S., Shambhu Nath & Gupta Prabhat K., Impact of biomass burning aerosols on UV- Erythemal Dose –A case study from North –East region of India, International Symposium on Resource and Environmental monitoring at NRSA Hyderabad, Dec. 3-6, 2002

55 Malhotra B.D. & Chaubey A., Biosensors for clinical diagnostic industry, 9th International Meeting on Chemical Sensors, Boston, U.S.A, 7-10 July, 2002

56 Mathur P., Dixit V. & Misra S.C.K., Nanocrystalline Polymeric sensors for detection of HCl, National Conference on Materials, Components and Applications, KIIT, Bhubneswar, February 2003

57 Mathur R.B., Lal C., Seth R.K., Dhami T.L., Sood K.N. & Kishore R., Influence of catalysts on the production of carbon Nanotubes, National Symposium on Nanostructured Materials, IIT, New-Delhi, Dec. 5-6, 2002

58 Mathur R.B., Synthesis of Carbon Nanotubes and their applications in composites, First ISAMPE National Conference on Composites, New frontiers in materials and processing, INCCOM-1, Triruvananthapuram, May 3–4, 2002

59 Misra S.C.K., Dixit V., Mathur P., Pant R.P., & Gupta A.K., Nanocrystalline magnetic alloy thin films, International Workshop on Recent Advances In Nanotechnology of Magnetic Fluids, New Delhi , Jan 2003

60 Misra S.C.K., Dixit V., Mathur P., Upreti U.C., Preparation and characterization of vacuum deposited magnetic polyaniline thin films, International Workshop on Recent Advances In Nanotechnology of Magnetic Fluids, New Delhi, Jan 2003

61 Misra S.C.K., Dixit V., Verma, S. & Tripathi P., Smart polymeric sensors for monitoring of toxic and corrosive gases, National Symposium on Instrumentation, Coimbtore, 27-29 Nov. 2002

62 Misra S.C.K., Dixit, V. Pandey J. & Bawa S.S., Polymeric sensors for detection of microbiological species in food processing industry, DRDO , Delhi, Sept. 2002

63 Misra S.C.K., Polymers For Water Management, International Conference on Advanced Polymers, IIT Delhi, April 2002

64 Mohan M. & Tiwari M.K., Vanaspati chhatra (canopy) ke ander vayumandaliye hawa ke sanveg sthanantran ka adhayayan, National Conference on Radio avam Vayumandaliya Vigyan National Physical Laboratory, New Delhi, 17-18 February, 2003

65 Mondal N.C & Sarkar S.K., Freezing tal ki uchaai ka distribution Bharat mai, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

66 Nath Shambhu, Tanwar Randheer Singh & Singh Risal, Bharat ke vibhinna kchtron mai ultra violet ki varshik matra oor tvacha ke pratichepak (reflectence) ke brrch parsapar sambandh, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

67 Ojha Deepak, Ashok kumar, Gupta V.B. & Dutta H.N., Bharat ke Maitri station par inversion ka adhayayan, National Conference on Radio avam Vayumandaliya Vigyan National Physical Laboratory, New Delhi, 17-18 February, 2003

68 Pandey V.K., Manav jeevan par Antrikch mausam ka dushprabhav, National Conference on Radio avam Vayumandaliya Vigyan National Physical Laboratory, New Delhi, 17-18 February, 2003

69 Pandey V.K., Sethi N.K. & Mahajan K.K., Topside electron temperature models for low and high solar activity, 34th COSPAR Scientific Assembly (World Space Congress), Houston, Texas, USA, October 10-19, 2002

70 Pant R. P., Dhawan S. K., Suri D. K., Arora M., Gupta S. K., Koneracka M., Kocansky,P. & Timako M., Synthesis and Characterization of ferrofluid–conducting polymer composites. International Workshop on Recent Advances in Nanotechnology of Magnetic Materials Fluids, NPL, New Delhi, January 22-24, 2003

71 Pasricha P.K., Shastri S., Chopra P., Prasad M.V.S.N. & Sarkar S.K., Arab oor Bangal ki khari ke uper evapouration duct ke banane ki samikcha, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

72 Prakash R. & Saxena V., Conducting Polymers as novel sensing materials, 9th International Meeting on Chemical Sensors, Boston, U.S.A, 7-10 July 2002

73 Prasad M.V.S.N., Gupta M.M., Iqbal Ahmad & Sarkar S.K., Antenna beam tilting effects in fixed and mobile communication, Conf. on horizons of telecommunication, Calcutta University, Calcutta, February 3-5, 2003

74 Ram Jokhan & Saxena R.B., Awareness and requirements of basic precautions in handling cryogens, Nineteenth Symposium on Cryogenics (NNSC-2002), Jadavpur University, Kolkata, 24–26 March 2003

75 Raman V., Bhatia G., Aggarwal R.K., Sengupta P.R., Saha M. & Mishra A., Synthesis of silicon carbide whiskers from coconut fibres and sol-gel derived silica, International Conference on Carbon, Beijing, China, Sept. 2002

76 Sarkar A.K., Rai Kavita, Gaddi Ranu & Mitra A.P., Karbanikrat aerosol ka dilli ke vibhinna mosamon mai sanrachnatmak parivartan, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

77 Sethi N.K., Dabas R.S. & Vohra V.K., Dilli mai Digisonde dwara pratap E-region parameters oor unki IRI-2000 se tulanaa, National Conference on Radio avam Vayumandaliya Vigyan National Physical Laboratory, New Delhi , 17-18 February, 2003

78 Sethi N.K., Pandey V.K. & Mahajan K.K., Seasonal and solar Activity changes of electron temperature in F-region and topside ionosphere, 34th COSPAR Scientific Assembly (World Space Congress), Houston, Texas, USA, October 10-19, 2002

79 Sharma Chemendra & Mitra A.P., Brahat shharon kee rashtriya paryavaran mai bhumika, National Conference on Radio avam Vayumandaliya Vigyanm, National Physical Laboratory, New Delhi, 17-18

February, 2003

80 Sharma D.K., Rai Jagdish, Ismail M., Subramanyam P., Chopra P. & Garg S.C., Garjanotpadak badalon ke doran ion mandal ke tapkram mai vridhi, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

81 Sharma S.D., Ionmandal adhayayan mai prayukta Febry-Perot Etalon ka laser dwara gunvatta mulyaankan, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

82 Shastri Shashi Kala, Soor sakriyata mai deerghkaleen parivartan, uchch aavatti sancgar ka sandarbh mai, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

83 Singh B.P., Kumar L., Misra A., Sharma T.P. & Misra S.C.K., Study of optical constants in vacuum evapourated chalcogenides, thin films, National Conference on Thermophysical Properties of Materials, University of Rajasthan, Sept.2002

84 Singh Darshan, Singh Manjit, Dhillo S. & Dutta H.N., Paschimi kolahalon ka prathvi ke samipi vayumandal ki tapkramiya sanrachna par prabhav, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

85 Singh H. K., Khare Neeraj, Singh D.P., Gupta A. K., Siwach P. K., & Srivastava O. N., Structure and magneto transport characterization of double layer manganite films deposited on polycrystalline Al_2O_3 substrates, 14th Annual meeting of MRSI at BARC, Mumbai, Feb 11-13, 2003

86 Singh H.K., Khare Neeraj, Singh D.P., Gupta A.K., Siwach P.K. & Srivastava O.N. Synthesis, Structure and magneto transport characterization of double layer manganite thin films, National Seminar on Materials and its Applications, Dr.R.M.L. Avadh University, Faizabad on Feb 27-28, 2003

87 Singh Lakha, Global Positioning System se total electron content ka peshan: Samudratal tapman mai sudhar, National Conference on Radio avam Vayumandaliya Vigyan National Physical Laboratory, New Delhi , 17-18 February, 2003

88 Singh S., Chaubey A. & Malhotra B.D., Electrochemical entrapment of cholesterol esterase and cholesterol oxidase in conducting polypyrrole films for application to cholesterol biosensor, Indo-Japan Academic and Educational conference, India Habitat Centre, New Delhi, 6-7 November, 2002

89 Singh Sachida Nand, Risal Singh, Tanwar R.S., Shambhunath & Sethi N.K., Dilli, Henlay and leh ke aerosol optical depth tatha aerosol size distribution ka tulnaatmak adhayayan, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

90 Singh V. R., Smart transducers for tele-medicine, Nat. Conf. on Communication Tech., Vellore, Dec. 12-14, 2002 (invited talk)

91 Singh V.P., Billore S.K., Gupta P.K. & Parasar D.C., Vishvavyapi parivartan, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

92 Singh V.R., A novel smart sensor for the characterisation of lithotripters, Proc. Int. Meas Confed (IMEKO):TC-7 Symp, USA, June 25-27, 2002

93 Singh V.R., Role of biotelemetry in rural healthcare in India, Nat. Conf. on Communication Tech., Vellore, Dec. 12-14, 2002 (invited talk)

94 Singh, V.R., New piezo-electric biomedical materials for sensors applications, Proc. National Conf. on

Materials, Components and Applications, Bhubnaneswar, Feb. 15-16, 2003 (Invited Talk)

95 Subrahmanyam P., Bahl Madhu, Maini H.K., Chopra Parvati, John Thomas, Vishram Singh, Dhan Singh & Garg S.C., A CMOS processor based data acquisition and telemetry interface system for satellite borne ionospheric experiments, National symposium on instrumentation (NSI-27), Bharathiar University, Coimbatore, 27-29 November 2002.

96 Subramanyam P., Chopra P., Garg S.C., Maini H.K., Bahl Madhu, Rajput S.S., John Thomas, Chunal D.S., Vishram Singh & Gupta Meenu, RPA vayumandaliya prayog Antrikch mai, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

97 Tanwar Randheer Singh, Nath Shambhu & Singh Risal, Bharat varsh ke sandarbh mai nyunatam arithmal matra (minimum arithmal dose) ki paribhasha ka nirdharan, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

98 Upreti D.C., Garg S.C., Maini H.K. & John Thomas, Hawa mai carbon-dioxide ki kratrim badht: sanyantr va prabhav, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

99 Veenadhari B., Dabas R.S. & Vohra V.K., bhumandaliya chumbkiya toofan ke karan ionmandaliya parivartan ki vyakhya, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003.

100 Vijaykumar P.N., Garg S.C. & Singh Dhan, Some Typical Design Concepts for the Development of a Passive Bi-static Radar using Commercial FM Broadcast Signals, National symposium on instrumentation (NSI-27), Bharathiar University, Coimbatore, 27-29 November 2002

101 Vijaykumar P.N., Garg S.C. & Singh Dhan, Vyasayik FM prasaran sanket aadaharit nishkriya dwiesthit radar vikas ki sankalpanaa, National Conference on Radio avam Vayumandaliya Vigyan, National Physical Laboratory, New Delhi, 17-18 February, 2003

Books, Chapters in Books & Technical Reports

1 A.K. Saxena, A.K., Kothari, P.C. & Singhal, R.P (*eds*). Proceedings "2nd NPL-Industry meet on calibration services" 18th May, 2002 at India International Centre

2 Jain, S.L., Arya B.C. & Tripathi O.P., Laser Heterodyne System at Maitri, Antarctica, *Advances in Marine & Polar Sciences* Dinbandhu Sahoo and P.C.Pandey (*Eds*)2002

3 Khare Neeraj, High Temperature SQUID Magnetometer, in *Handbook of High Temperature Superconductor Electronics* Neeraj Khare (*Ed*). Marcel Dekker, USA, p-233-277, 2003

4 Khare Neeraj, Introduction to High Temperature Superconductor, in *Handbook of High Temperature Superconductor Electronics* Neeraj Khare (*Ed)* Marcel Dekker, USA, p-1-27, 2003

5 Lal T., Singhal R.P., Saxena A.K., & Rao S.U.M, Proficiency Testing Programme for Mass Metrology, *Report No. NABL-M-Mass-001*, 2002

6 Lal Krishan (Chairman, Writing Team), SCIENCE AND TECHNOLOGY, *Textbook for Class IX*, NCERT, New Delhi, p-258, 2002

7 Lal Krishan (Guest Ed.), CRYSTALLOGRAPHY, Special Issue, *Proceedings of Indian National Science Academy*, PINSA, New Delhi. 68 p-175-331, 2002

8 Lal Krishan, High Resolution X-ray Diffraction Techniques for Structural

Characterization of Silicon and Other Advanced Materials, *The Technology of Crystal Growth and Epitaxy,* H J Scheel and T. Fukuda (Eds.), John Wiley & Sons Ltd., England*(In press)*

9 Lal Krishan, Murthy Anantha R.V., Choubey A. & Goswami N., Growth and characterisation of technologically important oxide single crystals, *in "Crystal Growth Technology"* eds. K.Byrappa and T. Ohachi , Springer and William Andrew, 2003

10 Nath Omkar, Saxena A.K., Singh Naib, Rao S.U.M & R.P.Singhal, Proficiency Testing Programme for AC Resistance Measurements, *Report No. NABL-E-ac Resistance-001*, 2002

11 Saxena A.K., Saleem Mohd., Rao S.U.M & Singhal R.P., Proficiency Testing Programme for Capacitance Measurements, *Report No. NABL-E-Capacitance-001*, 2002

12 Singh Y.P., Singhal R.P., Saxena A.K., & Rao S.U.M., Proficiency Testing Programme for Temperature Metrology*, Report No. NABL-T-Temperature-001*, 2002

13 Singhal R.P., Chaudhuri K.P., Saxena A.K., & Rao S.U.M., Proficiency Testing Programme for Dimension Metrology, *Report No. NABL-M-Length-001,* 2002

14 Tripathi O.P., Jain S.L. and Arya B.C., Monitoring of ozone, water vapour, and aerosols optical thickness at Maitri, Antarctica, *Advances in Marine & Polar Sciences*, Dinbandhu Sahoo and P.C.Pandey (*Eds*) 2002

15 Activity Data Report to WII & MoEF on "Enabling Activities for the Preparation of India's Initial National Communication: Agriculture Sector Inventory" under NATCOM, April 15, 2002.

16 Final Inventory Estimates Report to WII & MoEF on "Enabling Activities for the Preparation of India's Initial National Communication: Agriculture Sector Inventory" under NATCOM, 15 December 2002.

17 Final Report to WII & MoEF on "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" under NATCOM, November 2002.

18 Final report to WII & MoEF on "Uncertainty reduction in CO_2, CH_4, N_2O, and Black carbon emissions from Biomass Burning in India in relation to the enabling activities for initial communication to UNFCCC" under NATCOM, November 2002.

19 Final report WII & MoEF on "Reducing uncertainties in emissions of CH_4 and N_2O from Livestock in India in relation to the enabling activities for initial communication to UNFCCC" under NATCOM, November 2002.

20 Preliminary Inventory Estimates Report to WII & MoEF on "Enabling Activities for the Preparation of India's Initial National Communication: Agriculture Sector Inventory" under NATCOM, July 30, 2002.

21 Preliminary Report to WII & MoEF on "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" under NATCOM, August 2002.

22 Preliminary report to WII & MoEF on "Uncertainty reduction in CO_2, CH_4, N_2O, and Black carbon emissions from Biomass Burning in India in relation to the enabling activities for initial communication to UNFCCC" under NATCOM, August 2002.

23 Preliminary report WII & MoEF on "Reducing uncertainties in emissions of CH_4 and N_2O from Livestock in India in relation to the enabling activities for initial communication to UNFCCC" under NATCOM, August 2002.

24 Status Report to WII & MoEF on "Enabling Activities for the Preparation of India's Initial National Communication: Agriculture Sector

Inventory" under NATCOM, January15, 2002.

25 Status Report to WII & MoEF on "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 toUNFCCC" under NATCOM, May 2002.

26 Status Report to WII & MoEF on "Reducing uncertainties in emissions of CH_4 and N_2O from Livestock in India in relation to the enabling activities for initial communication to UNFCCC" under NATCOM, May 2002.

27 Status Report to WII & MoEF on "Uncertainty reduction in CO_2, CH_4, N_2O, and Black carbon emissions from Biomass Burning in India in relation to the enabling activities for initial communication toUNFCCC" under NATCOM, May 2002.

28 Swarup, R., Negi, P.S. & Mendiratta, R.L., Status of Microwave Impedance Standards and Measurement Techniques at National Physical Laboratory, New Delhi, in: *Microwave Measurement Techniques and Applications,* Ed.: J. Behari, Anamaya Publishers, New Delhi, p-17-28, (2003).

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APPENDIX:2

PATENTS

Patents Filed in India

No.	Title	NF No	Application No	Filing Date	Inventors
1	A lactate biosensing strip	308NF2002	0655DEL2002	17.06.2002	B D Malhotra, Asha Chaubey, Rajesh
2	Novel Sol-gel based enzyme Electrode useful for estimation of cholesterol in aqueous medium	312NF2002	0652DEL2002	17.06.2002	B D Malhotra, Arun Kumar , Rajesh
3	A process for the preparation of novel Sol-gel based enzyme electrode useful for estimation of cholesterol in aqueous Medium.	313NF2002	0654DEL2002	17.06.2002	B D Malhotra, Arun Kumar, Rajesh, P S Grover
4	A process for the preparation of lactate biosensing strip useful for the determination of lactate in an aqueous solution.	314NF2002	0653DEL2002	17.06.2002	B D Malhotra, Asha Chaubey, Rajesh
5	Computer simulation of reflectance profile	409NF2001		15.01.2003	R Nagaraj, Devinder Gupta, S P Varma

Patents Filed Abroad

No	Title	Application No	Country	Filing Date	Inventors
1	Polymer based enzyme electrode for estimation of cholesterol	10/277,089	USA	22.10.2002	B D Malhotra, Arun Kumar, Rajesh
2	Lead iron tungstate capacitive transducer	10/319,601	USA	16.12.2002	K K Jain, Vinay Kumar, R S Kashyap

3	Lactate biosensing strip and method for manufacture thereof	IB02/05677	WO	31.12.2002	B D Malhotra, Asha Chaubey, Rajesh
4	Lactate biosensing strip and method for manufacture thereof	IB02/05679	WO	31.12.2002	B D Malhotra, Asha Chaubey, Rajesh
5	Enzyme electrode and process for preparation thereof.	IB02/05680	WO	31.12.2002	B D Malhotra, Arun Kumar, Rajesh, P S Grover
6	Enzyme electrode and process for preparation thereof	IB02/05684	WO	31.12.2002	B D Malhotra, Arun Kumar, Rajesh, P S Grover
7	Lactate biosensing strip and method for manufacture	10/342,303	USA	15.01.2003	B D Malhotra, Asha Chaubey, Rajesh
8	Enzyme electrode and process for Preparation thereof	10/345,163	USA	16.01.2003	B D Malhotra, Arun Kumar, Rajesh, P S Grover
9	Copolymer of benzene and substituted benzene		USA	31.03.2003	S K Dhawan M N Kamalasasan S S Bawa
10	Copolymer of benzene and substituted benzene		WO	31.03.2003	S K Dhawan M N Kamalasasan S S Bawa
11	Computer software on reflectance profile	10/341,595	USA	14.01.2003	R Nagaraj, Devinder Gupta, S P Varma
12	A method for determining the reflectance profile of material	300925.5	GB	15.01.2003	R Nagaraj, Devinder Gupta, S P Varma

Patents Granted Abroad

No	Title	Application No	Date Granted	Inventors
1	A simulation circuit layout design for low voltage, low power and high performance type ii current conveyor for analog signal processing applications	Taiwan 165972	14.03.2003	S S Rajput, S S Jamuar
2	A reusable heat pack	Canada 2380664	30.09.2002	C P Sharma R K Sharma, Chander Kant and A.K.Sarkar.
3	A reusable heat pack	USA 6537309	25.03.2003	A K Sarkar, C P Sharma, R K Sharma, Chander Kant
4	Polymer coated long duration optical memory device and a method for the development thereof	USA 6407797	18.06. 2002	A M Biradar, S S Bawa, Subhas Chandra

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APPENDIX: 3

R & D COLLABORATIONS

Collaborating Institution	Area
Indian	
University of Delhi, Delhi. (Physics and Engineering):	Ultrasonic sensors
Jamia Millia Islamia University, Jamia Nagar, New Delhi (Physics, Engg. and Computer Sciences):	High power piezoelectric transducers.
All India Institute of Medical Sciences, New Delhi (Ophthalmology, Radiotherapy and Rotary Cancer Research Institute):	Biometry and cancer hyperthermia
Safdurjung Hospital, New Delhi (Orthopaedics, Biophysics) New Delhi	Bone fracture studies with stress waves.
Indian Instt. of Technology, New Delhi	SODAR studies Sensors and bio-MEMS. Development of photosensor for radiation measurement Studies of semiconductor devices Surface and interface studies
Indian Instt. of Technology, Kharagpur	Studies of semiconductor devices
Indian Instt. of Technology, Guwahati	Preparation and study of α-Si:H and SiG:H for PV application
Indian Association for the Cultivation of Science, Kolkata	Studies of semiconductor devices Surface and interface studies
Tata Institute of Fundamental Research, Mumbai	MgB_2 superconductors
Banaras Hindu University, Physics Department	CRM materials
Bhabha Atomic Research Centre, Mumbai	MgB_2 superconductors Development of silicon photodiodes Preparation and dissemination of Bharatiya Nirdeshak Dravyas on elemental solutions, pesticides and gas mixture
Solid State Physics Laboratory, Delhi	Passivation of HgCdTe devices Studies of semiconductor devices
Election Commission of India, Delhi	Improvement of indelible ink

Collaborating Institution	Area
CSIR Sister Labs, India	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of elemental solutions, pesticides and gas mixture
M D University, Rohtak (Physics Department)	Characterization of materials for application in solar energy,microelectronics power electronics.
National Accreditation Board for Testing & Calibration Laboratories (NABL), DST, Delhi	Proficiency testing, accreditation laboratory assessment, quality awareness & training programme
Central Pollution Control Board, Delhi	Noise pollution
Central Public Works Deptt., Delhi	Building acoustical treatment
Nuclear Science Centre, Delhi	Swift heavy ion induced mixing
Central Electronics & Electrical Research Institute, Pilani	Surface analysis
The Energy & Resources Institute AES Testing & Research Laboratory Gharda Chemicals Ltd.	Bhartiya Nirdeshak Dravyas
HACE India Ltd., Delhi	SODAR studies
India Gypsum Ltd., Delhi	Applied acoustics
Naval Materials Research Laboratory Ambernath, Maharastra	Development of porous conducting carbon paper
Shriram Institute for Industrial Research, Delhi	Development of low-PAH coal tar pitch
Defence Metallurgical Research Lab. Hyderabad	Development of carbon monofilament for CVD- based SiC fibers
Graphite India Ltd., Bangalore	Upscaling of high density graphite technology
Vikram Sarabhai Space Center (VSSC) Thiruvananthapuram	Spray atomization of Mg-alloys
Hindustan Aeronautics Ltd. (HAL), Bangalore	Development of oval-shaped tube as skid landing gear for ALH
Indian Agricultural Research Institute, Delhi	Free air CO_2 enrichment studies on crops and gas emission using FACE and OTC facilities.
National MST Radar Facility, Tirupati Central Pollution Control Board, Delhi	Lower atmosphere and F-region studies 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, Saurashtra and Kerala	RPA aeronomy payload onboard SROSS-C2 Satellite, data management and data analysis
Indian Meteorological Department, Delhi	Rain effects on microwave communications

Collaborating Institution	Area
Department of Ocean Development	Green house gases at Antarctica PBL studies over Antarctica
Indian Statistical Institute, Kolkata	Estimation of rain characteristics using X-band radar
Space Application Center, Ahmedabad	Ionospheric correction in sea surface temperature measurements by radiometer onboard IRS Indian satellite
Bose Institute, Darjeeling	Global change studies
Overseas	
SASO, Saudi Arabia	HRD and establishment of calibration facilities
Aichi Institute of Technology, Toyata, Japan	Moire techniques in measurement
Department of Physics and Astronomy Clemson University, Clemson, USA, and Department of Materials Science and Engineering, Univ. of Pennsylvania, Philadelphia, USA	Applications of carbon nanotubes in composites-adhesion and alignment problems
Institute of Experimental Physics, Kosice, Slovakia	Development of ferrofluid composite films and their characterization- Bilateral exchange programme on scientific & technical co-operation between CSIR, India and Slovak Academy of Sciences (SAS)
Institute for Reference Materials and Measurements (IRMM), Belgium	International key inter-comparison programme on chemical measurements.
National Analytical Reference Laboratory (NARL), Australia:	International key inter-comparison programme.
Indo-Russian ILTP Projects	Growth of nearly perfect crystals of oxide materials with technological applications
	Growing by MBE method of epitaxial structures on the basis of compound a_3 b_5 (GaAs, AlGaAs, in GaAs) of different compositions for various applications
	Semiconductor silicon for application in solar energy, microelectronics, power electronics.
START Washington, USA	Operation of the South Asian Regional
APN, Tokyo, Japan	Research center for the study of global change
NCAR, USA, DOS Govt, of India	Indian Ocean Experiment (INDOEX)

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APPENDIX: 5

RECIEPTS THROUGH CONSULTANCY PROJECTS

Sl. No.	Client	Title	Amount Received (Rs in Lakhs)
1.	National Library Division, Calcutta	Removal of powdered coating from the sample of aluminum needed before composite analysis	0.250
2.	AIMIL Pvt. Ltd, New Delhi	Instrumentation & automation, phase VII	0.332
3.	CEERI, Pilani	Reactivation of auger electron spectrometer	0.358
4.	Nagman Instruments & Electronics Pvt. Ltd, Chennai	Characterization of deadweight tester	1.923
5.	MED-INDIA	Performance optimization of electronic circuitary of automatic ESR analyzer	0.916
6.	SPG Project Div.1, CPWD, New Delhi	Acoustic treatment of auditorium at SPG complex, Dwarka ,New Delhi	0.632
7.	SPG Project Div.1, CPWD, New Delhi	Acoustic treatment of the gymnasium & UAC hall	0.307
8.	CPWD,Kanpur	Acoustic treatment of conference hall at IIPR campus, Kanpur (Ex.En CPWD, Kanpur)	0.640
9.	AIMIL Pvt. Ltd, New Delhi	Instrumentation & automation, phase VIII	0.332
10.	Deptt of Lighthouses & Lightships, Jamnagar	Installation of DGPS station phase-I at Porbandar, Jamnagar (Gujarat) & verfication of DGPS phase II at Pandya (Gujarat)	0.933
		Sub Total	**6.623**

Technical Services Projects

Sl. No.	Client	Title	Amount Received (Rs in Lakhs)
1.	Light House, Calcutta	Optimisation of physics package of HP-RB Stds.	2.000
2.	CBRI, Roorkee	Design & development,fabrication of transducers 20T/50T	4.925
		Sub Total	**6.925**
		Grand Total	**13.548**

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APPENDIX:6

EARNINGS FROM CALIBRATION & TESTING

PHYSICO-MECHANICAL STANDARDS

Activity	Gr. Code	Reports	Charges (Rs.)
Dimension metrology	2	441	3409625
Mass density, volume & viscosity	3	680	2727254
Force & hardness standards	4	407	3287120
Pressure & vacuum standards	5	103	1740539
Temperature standards	6	457	2257339
Optical radiation standards	7	303	1900800
UV radiation standards	8	7	58600
IR radiation standards	9	68	201200
Accoustic standards	10	149	1096594
Ultrasonic standards	11	11	151500
Humidity standards	12	33	113700
Fluid flow standards	13	1	-
	Sub Total	**2660**	**16944271**

ELECTRICAL & ELETRONICS STANDARDS

Activity	Gr. Code	Reports	Charges (Rs.)
Power & energy AC & LF standards (up to 1 kHz)	20	328	3247790
AC & LF standards (CT/PT)	21	23	439670
DC standards	22	87	638080
HF & microwave attenuation standards	23	16	318054
LF & HF impedance standards	24	78	324070
HF & microwave standards	25	36	1300179
Magnetic measurement activity	26	32	165200
Time & frequency standards	27	38	127400
DC high voltage	28	6	50000
	Sub Total	**644**	**6610443**

TESTING

Activity	Gr. Code	Reports	Charges (Rs.)
Chemical analysis	31	59	865858
Indian reference materials	32	11	145025
Metals & alloys	43	1	20000
X-ray, SEM, Carb, Elec		34	289100
	Sub Total	105	1319983

JOB WORK

Activity	Gr. Code	Reports	Charges (Rs.)
Piezoelectric accelerometer	46	2	151540
Central workshop	47	10	98336
Thin film	48	3	35400
Cryogenics	52		601088
	Sub Total	**15**	**886364**
	Surplus in Calibration		**357961**
	Grand Total	**3424**	**26119022**

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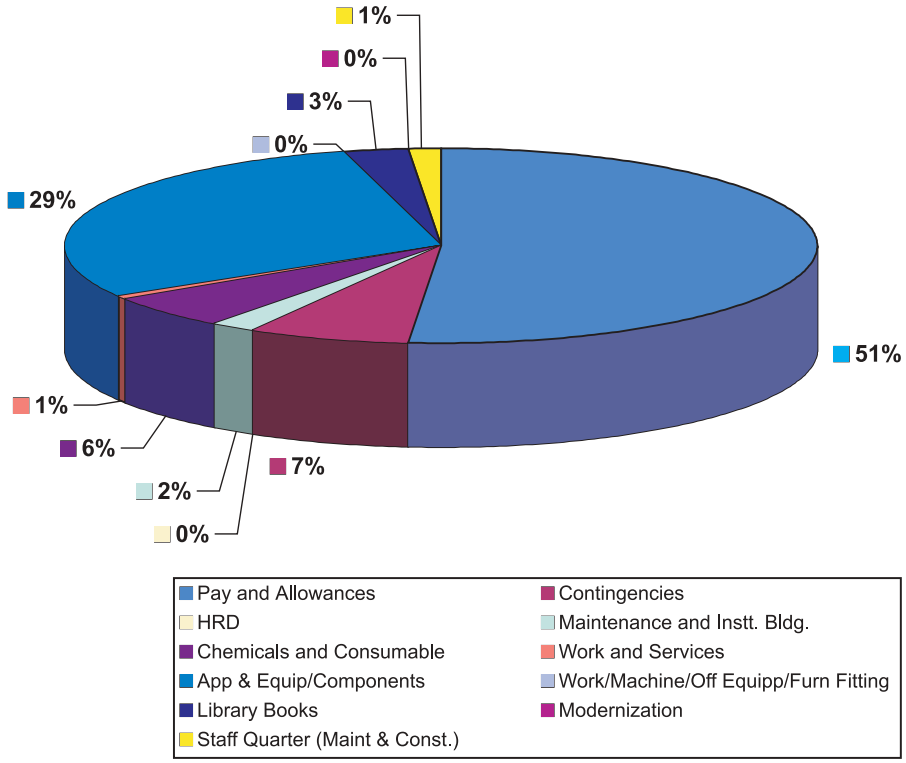
APPENDIX : 7

ACTUAL EXPENDITURE 2002-2003

Sl.No.	Budget Head	Expenditure (Rs. in Lakhs)
1	Pay and Allowances	1850.309
2	Contingencies	253.796
3	Human Resources Development	4.295
4	Maintenance and Instt. Bldg.	62.921
5	Chemicals and Consumables	203.433
6	Work and Services	20.669
7	Apparatus & Equipment/Components	1060.032
8	Work/Machine/Office Equipment/Furniture Fittings	3.317
9	Library Books	97.118
10	Modernization	–
11	Staff Quarters (Maintenance & Construction)	52.108
	Total	**3607.998**

Source of funds: CSIR Grant



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APPENDIX : 8
HONOURS AND AWARDS

Dr. Krishan Lal, Director

Honoured and felicitated at University of Mysore, Mysore by Sri Srinivasa Prasad, Hon'ble Union Minister of State for Consumer Affaires, Food and Public Distribution during the Inaugural Function of the International School on Crystal Growth of Technologically Important Electronic Materials on January 20, 2003. This International School, sponsored by the International Union of Crystallography, had been dedicated to Dr. Krishan Lal for his untiring services in developing and promoting the field of Crystal Growth and Materials Characterization in India.

Dr. Ashok K. Gupta, Sc G

Elected President, Indian Cryogenic Council, North Zonal Branch.

Member, Electronics and Telecommunication Division Council (ETDC), Bureau of Indian Standards.

Dr. P. Banerjee, Sc G

Nominated convenor of Local Organization Committee (LOC) to organize General Assembly of International Union of Radio Science (URSI) in New Delhi during October 23-29, 2005.

Chairman, Project Review Steering Committee of the project, "Real Time Passenger Information System" of APSRTC & CMC Hyderabad.

Dr. V.R. Singh, Sc G

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

Elected as Chairman of BIS Committee on Electromedical Equipment and Dental Materials (MHD-12 & MHD-19).

Dr. S.L. Jain, Sc F

Program Committee Member for SPIE Interntional Symposium on SPIE's 47th Annual Meeting, AM'02 on Optical Science & Technology held at Washington State Convention Ctr., Seattle, Washington 7 - 11 July 2002.

Program Committee Member for SPIE's Third International Asia-Pacific Symposium on Remote Sensing of the Atmosphere, Ocean, Environment, and Space held during 23-27 October 2002 at Dragon Hotel* Hangzhou, China.

Dr. A.B. Ghosh, Sc F

Member of the board of research studies for technology of the University of Delhi.

DR. H.N. Dutta, Sc F

Expert Committee Member on Air Monitoring in the NMDC team to present Environmental Clearance proposal of the NMDC Iron & Steel Plant proposed at Nagarnar Village, Bastar Dist., Chhattisgarh, constituted by Ministry of Environment., CGO Complex, New Delhi.

Dr. R.P. Pant, Sc E-I

Elected as a President of the Indian Society of Magnetic Fluid Research (ISMFR) for the period 2003-2005.

Mr. A.K. Srivastava, Sc B

Member, International Advisory Board, 8th Asia – Pacific Conference on Electron Microscopy, Kanazawa, Japan, June 7-11, 2004.

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APPENDIX : 9

VISITS ABROAD

Name & Designation	Country Visited	Duration / Period	Purpose
Sh. A.C. Gupta Sc. F	USA	16.03.2002 to 31.08.2002	On sabbatical leave, NIST.
Dr. R.S. Dabas Sc. E-II	USA	14.04.2002 to 19.04.2002	To attend international space environment service (ISES) and space weather week meeting at NOAA space environment center, Boulder, USA.
Dr. D.K. Suri Sc. E-II	Germany	07.10.2002 to 18.10.2002	For equipment training.
Dr. Sanjay Yadav Sc. B	Saudi Arabia	06.03.2003 to 03.05.2003	Visit under foreign service term as per CSIR-SASO agreements.
Dr. Pardeep Mohan Sc. F	USA	06.03.2003 to 25.08.2003	On sabbatical leave to NIST.
Dr. K.K. Jain Sc. F	Saudi Arabia	16.04.2002 to 15.07.2002	CSIR-SASO technical cooperation programme.
Dr. S.N. Sharma Sc. B	USA	12.04.2002 for one year	University of Notredam, on EOL.
Dr. K. Lal Director	Sweden	07.04.2002 to 09.04.2002	To attent the 47th meeting of executive committee of CODATA.
Dr. A. Sen Gupta Sc. F	USA	15.04.2002 to 15.09.2002	Guest researcher on sabbatical leave.
Dr. K. Lal Director	France	22.04.2002 to 23.04.2002	To attend the meeting of Directors of NMIS at BIPM.
Mr. Ajeet Singh Sc. C	Canada	02.05.2002 to 04.05.2002	To undergo advanced precision measurement training.
Dr. A.K. Bandyopadhyay Sc. F	France	21.05.2002 to 24.05.2002 25.05.2002 to 01.06.2002	To attend the 8 CCM meeting at BIPM, Paris. To visit PTB Germany to discuss about the future intercomparison.
Sh. Sukhvir Singh Sc. C	Taiwan	25.06.2002 for six months	To carry out research studies in the area of optical thin film.
Dr. P. Banerjee Sc. G	Saudi Arabia	25.05.2002 to 25.07.2002	Visit under foreign service terms to start the transmission of digital time data service, via telephone net work.

Name & Designation	Country Visited	Duration / Period	Purpose
Dr. S.S. Titus Sc. B	Germany	21.05.2002 to 25.05.2002	For equipment training and to have a wider exposure in the field of force and hardness standards.
Dr. S.K. Mahajan, Sc. EII	Singapore	27.06.2002 to 28.06.2002	For equipment training on high precission calibration with automation calibration.
Sh. K.B. Rawat T.O.'B'	Singapore	27.06.2002 to 28.06.2002	For equipment training on high precission calibration with automation calibration.
Mohd. Saleem T.O.B	South Africa	22.06.2002 to 02.08.2002	Visit under cooperation in fabrication of ac fridgeges at CSIR-NML,South Africa.
Dr. B.D. Malhotra, Sc. EII	USA	07.10.2002 12.19.7.2002	To present a paper at the 9th international meeting on chemical sensors,USA To visit centre of molecular macro-molecular studies Polish Academy of Science, Poland.
Sh. R.M. Khanna, Sc. F	Rome,Italy	24.6.2002 to 28.6.2002	To attend the 11th international symposium on acoustic remote and associate techniques of the atmosphere and oceans-2002.
Dr. K. Lal Director	Korea	4.7.2002 to 6.7-2002	To attend 13th workshop on survey of Data Sources in Asian Oceanic Countries (ASAO) at Korea Institute of Science and Technology Information.
Dr. S.L. Jain, Sc. F	Switzerland	01.07.2002 to 03.07.2002	To visit Intitute of quantum electronics lab. for laser spectroscopy & environment sensing
	UK	04.07.2002 to 06.07.2002	To visit NPL Teddington, UK
	Canada	08.07.2002 to 12.07.2002	To give presentation at an international laser radar conference(ILRC),Canada.
Dr. Mohan Lal, Sc. F	UK	15.07.2002 to 14.10.2002	INSA- Royal society ,UK under exchange programme.
Dr. Ranjana Mehrotra Sc. EI	Germany	01.08.2002 to 31.10.2002	NSA-DFG international exchange programme.
Dr. S.A. Agnihotry Sc. EII	USA	06.08.2002 to 09.08.2002	To attend the 15th international meeting on electrochromism
Dr. Ashish Agarwal Sc. B	USA	02.09.2002 to 01.09.2003	As a visiting position offered by Prof. Prem Kumar of Western University

Name & Designation	Country Visited	Duration / Period	Purpose
Dr. G.M. Saxena, Sc. F	UK	01.9.2002 for two months	For R&D work on optical components and microwave cavity of the Rb Physics.
Dr. N.D. Kataria, Sc. F	Japan	01.10.2002 to 31.01.2003	To work at graduate school of engineering, Osaka university, Japan on sabbatical leave
Dr. Krishan Lal Director	Korea	09.09.2002 to 13.09.2002	To attend seminar for development on APEC , S&T network in material testing & evaluation technology
Dr. M.K. Mittal Sc. EII	France	11.09.2002 to 13.09.2002	To attend the 23rd meeting of the consultative committee for electricity and magnetism (CCEM) and 6th meeting of the working group on key Comparison
Mr. Anil Kumar Sc. EII	USA	30.09.2002 to 04.10.2002	To attend equipment training to understand finer print of installation appreciation and maintanance of 50 units Dead weight primary force standard machine at M/s Morehouse instrument company.
Dr. K.K. Jain Sc. F	Germany	24.09.2002 to 09.10.2002	To Attend the International conference to carry out bilateral intercomparison expertise at PTB
Dr. S.K. Dhakate Sc. C	Japan	25.11.2002 for one year	To avail JSPS post Doctoral fellowship for one year under the leadership of Toshio Ogasware,Material Aerospace Lab of Japan
Dr. Krishan Lal Director	Canada	29.09.2002 to 05.10.2002	To attend,18th Int. Conference and 23rd CODATA General Assembly
Dr. A.K. Bandyopadhyay Sc. F	USA	01.03.2002 for six months.	To visit NIST as guest researcher on sabbatical leave
Dr. S.S. Bawa Sc. G	Japan	14.10.2002 to 29.10.2002	To visit Kyusku Inst. of Technology, Iizkue,Fukuska, Japan under the Indo - Japan Prog. Application of some conducting polymers.
Dr. P. Banerjee Sc. G	Korea	05.11.2002 to 09.11.2002	To attend the ATF 2002 Workshop for oral presentation.
Dr. Krishan Lal Director	Vietnam	11.11.2002 to 15.11.2002	To attend the 18th APMP general assembly and related meetings at VMI.
Dr. A.K. Gupta Sc. G	Vietnam	11.11.2002 to 15.11.2002	To attend the 18th APMP general assembly and related meetings at VMI.

Name & Designation	Country Visited	Duration / Period	Purpose
Dr. A.C. Gupta Sc. G	Vietnam	11.11.2002 to 15.11.2002	To attend the 18th APMP general assembly and related meetings
Dr. Tripurari Lal Sc. EII	France	13.11.2002 to 15.11.2002	To handover National Prototype to BIPM authorities for its verification and also to attend 3rd meeting of viscosity
Dr. V.K. Sankaranaryanan, Sc. B	South Korea	01.01.2003 one Year	Kongju National Univ. South Korea on sabbatical leave as a distinguished Scientist.
Dr. Tripurari Lal Sc. EII	China	22.01.2003 to 25.01.2003	For delivering transfer standards to NIM, Beijing.
Dr. Arun Kumar STA	USA	24.02.2003 to 23.09.2003	As a visiting scientist.
Dr. Krishan Lal Director	USA	23.02.2003 to 02.03.2003	On a business development programme.
Dr. Krishan Lal Director	France	12.03.2003 to 15.03.2003	To attend 48th CODATA executive committee meeting and to attend International.Symposium.
Dr. Rina Sharma Sc.C	France	13.03.2003 to 14.03.2003	To attend International BI&M workshop on frequency comb.

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APPENDIX : 10

Ph.D. AWARDS BASED ON RESEARCH WORK DONE AT NPL

Title	Awardee	University/ Institute	Guide(s)
Preparation & characterization of superconducting films and study of harmonic generation	Shailaj Kumar Shrivastava	University of Delhi	Dr. Ashok, K.Gupta Prof. G.L.Bhalla
Measurements of ozone and other minor constituents in the atmosphere at Antarctica and India.	Om Prakash Tripathi	University of Delhi	Dr. S.L.Jain Prof. M.M.Bajaj
An experimental study of sound transmission through light weight wall panels.	Mahavir Singh	IIT Delhi	Dr. V. Mohanan Prof K.K.Pujara (Mech. Engg).

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APPENDIX : 11

NPL TRAINING PROGRAMMES , FUNCTIONS AND PARTICIPATION IN VARIOUS EVENTS

Training Programmes/Functions Organised

- Technology Day Lecture on 11 May, 2002
- CSIR Foundation Day Celebration on 26 September, 2002
- Shanti Swaroop Bhatnagar Award Ceremony Function and Prize Distribution on 03 October, 2002
- Function of National Innovation Foundation on 17 & 18 December, 2002
- CSIR Programme on Youth for Leadership in Science (CPYLS) on 28 & 29 November, 2002
- 34 students from various educational institutes carried out project work and undertook training towards the fulfilment of their academic course work during vacations period.

Training Courses Organised for Industry.

- Training Course on Mass & Volume Standard from 24 to 27June, 2002
- Training Course on Temperature Standard from 24 to 26 June, 2002
- Training Course on AC/DC Calibration from 24 to 27 June, 2002
- Training Course on Photometry from 07 to 11 October, 2002

Participation of NPL Personnel in Various Events

- 200 persons were deputed to attend various Seminars/Symposia/Conferences/Workshops/Training Programmes held within India. The important ones were Orientation Programme on ISO/IEC: 17205 held at Jaipur on 9 and 10 May, 2002, NABL Assessor Training Programme held at Jaipur on 6 to 9 August, 2002, National Symposium on Accoustic NSA-2002 held at Aligarh on 23 & 24 October, 2002 Seventh International Symposium on Advances in Electro-Chemical Science and Technology held at Chennai on 29 November, 2002, 90 Indian Science Congress held at Bangalore from 3 to 7 January, 2003, International Workshop on Recent Advances in Nano-Technology of Magnetic Fluids (RANMF) held at NPL New Delhi from 22 to 24 January, 2003, 4th International Conference on Advances in Metrology, Equivalence of Standards and Global Recognition held at NPL New Delhi from 5 to 7 February, 2003 etc.

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APPENDIX : 12

CONFERENCES, SYMPOSIA AND WORKSHOPS AT NPL

26 December, 2002
Brain Storming Session on Emerging Needs of Environmental Metrology.

22 to 24 January, 2003

International Workshop on Recent Advances in Nano-Technology of Magnetic Fluids (RANMF- 2003)

05 to 07 February, 2003

4th International Conference on Advances in Metrology : Equivalence of Standards Global Recognition (ADMET-2003).

12 to 14 February, 2003
National Symposium on Luminescence and its Applications.

03 to 05 March, 2003
Workshop on Finalization of Emission Factors for Inventorization.

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APPENDIX : 13

LECTURES BY EMINENT SCIENTISTS

Scientist	Address	Date	Topic
Dr. Paneer Selvem	Deptt. of Civil Engg., University of Arkansas, Fayeteville, USA	01.04.2002	Microjet arrays cooling (MEMS) devices & modelling of HTS tunable filters
Dr. Victor E. lagun	State Research Center of Russian Federation –the Arctic & Antarctic Research Institute, St. Petersburg, Russia.	15.04.2002.	Cyclone climatology in the global atmosphere: special emphasis on Antarctica
Dr. Victor E. Lagun	State Research Center of Russian Federation –the Arctic & Antarctic Research, Institute of St. Petersburg, Russia.	16.04.2002	Antarctic climatology and data management
Dr. Deepak Luma	Research Scientist, Russia	18.04.2002	Fabrication of efficient GaN based laser diodes
Dr. U. P. Singh	Polyplex Corporation, USA	31.05.2002	Copper gallium indium diselenide (CIGS) thin film solar cells
Dr. Daljit Singh Bedi	Head USD, CSIR, New Delhi, India	18.06.2002	Services extended by USD to disseminate information on technologies developed at the CSIR laboratories
Dr. J. Schanda	Secretary, CIE Prof. & Ex-Head, Deptt. of Image Processing & Neuro Computing, Univ. of Vezprem, Hungry	04.09.2002	Light emitting diodes, problems related with their photometric & colorimetric measurements
Prof. Geoffery Oldham	Honorary Prof., Science Policy Research Unit, Univ. of Sussex, UK	31.10.2002	Trends in strategic management in scientific management
Prof. Dr. Susumu Sugiyama	Deptt. of Robotics, College of Science and Engineering, Ritsumeikan University, Japan	16.12.2002	Micro/nano electro-mechanical systems (MEMS)-from research to industry

Scientist	Address	Date	Topic
G. N. Fursay	Vice President, Russian Academy of Natural Science and Director of Surface and Electronics Research Centre of St. Petersburg, University of Elecommunication.	18.12.002	Field emission in vacuum microelectronic
Dr. John Ponsonby	Consultant Scientist, UK	02.01.2003	Detection of near earth objects by Radar
Prof. Vikram L. Dalal	IOWA State University, USA	03.01.2003	Microcrystalline silicon solar cells
Prof. K. L. Oyama	Director, Space Science Laboratory, Inst. of Space and Aeronautical Science, Japan	14.01.2003	F region electron temperature measure-ments using satellite borne electron temperature probe
Dr. S.Bandyopadhyay	School of Materials Science & Engineering, University of New South Wales, Australia.	21.01.2003	Micro-macro studies in composites and nanomaterials
Dr. Shigetosudo	Sr. Scientist, National Institute of Agro-Environmental Science Tukube, Japan	19.02.2003	Trace gas emissions from biomass burning in Asia
Prof. Ing. Jiri iederie	President of the Council for International Co-operation of the Academy of Science, Czech Republic	11.03.2003	Particle physics

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APPENDIX:14

INVITED TALKS, LECTURES BY NPL SCIENTISTS

Speaker's Name	Topic	Event and Venue
	Physico-Mechanical Standards	
T. Lal	Mass metrology and uncertainty evaluation in mass measurement.	2nd NPL-Industry meet on calibration services organized by NPL on May 18, 2002.
T. Lal	General guidence to the measurement of mass & weight.	Workshop on non-electrical parameter calibration on 5th Decembers 2002 at ETDC Mohali.
T. Lal	Uncertainty evaluation in mass measurement.	Workshop on non-electrical parameter calibration on 5th Decembers 2002 at ETDC Mohali.
R.P. Singhal	Dimensional metrology: principles and industrial metrology.	35th International training programme on standardization and quality assurance for developing countries, 29th Jan -14th march, 2003, Bureau of Indian Standards, New Delhi.
R.P. Singhal	Surface roughness: concept definition and assessment.	Advance training programme on dimensional and temperature metrology, Dec 10-13, 2002, NPL, New Delhi .
R.P. Singhal	Organization of effective calibration	Advance training programme on dimensional and temperature metrology, Dec 10-13, 2002, NPL, New Delhi.
R.P. Singhal	Dimensional metrology	Training programme on dimensional metrology for participants from common wealth countries, Feb 8-9,2003, NPL, New Delhi.
K.P. Chaudhary	Laser application in biomedical instrumentation	DST. Sponsored training programme on repair, maintenance and calibration of biomedical instruments for hospitals doctors, Dec 23, 2002, Government Hospital, Bulandshahr.

Speaker's Name	Topic	Event and Venue
K.P. Chaudhary	Laser application in biomedical instrumentation.	DST Sponsored training programme on repair, maintenance and calibration of biomedical instruments for hospital doctors, June 2, 2002, CSIO, Delhi centre, New Delhi.
K.P. Chaudhary	Latest trends of measurement in dimensional & temperature metrology & CMM calibration and its uncertainty evaluation.	Advance training programme on dimensional and temperature metrology Dec.10-13, 2002, NPL, New Delhi.
K.P. Chaudhary	CMM calibration and its uncertainty evaluation.	Training programme on dimensional metrology for participants from Common Wealth countries, Feb 8-9, 2003, NPL, New Delhi .
R.P. Singhal	Measurement of uncertainty in dimensional measurements.	2nd NPL Industry Meet, May 18, 2002, India International Centre, New Delhi.
R.P. Singhal	ISO/IEC 17025 the new standard for competence of testing and calibration laboratories: benefits and responsibilities.	2nd NPL industry meet, may 18, 2002, India international centre, New Delhi.
N.K. Aggarwal	Calibration of gauge blocks.	Advanced training programme on dimensional and temperature metrology, Dec 10-13, 2002, N PL, New Delhi.
N.K. Aggarwal.	Calibration of dial gauge, surface plate.	Advanced training programme on dimensional and temperature metrology, Dec 10-13, 2002, NPL, New Delhi.
N.K. Aggarwal	Evaluation of uncertainty in case of interferometric calibration of gauge blocks,	Training programme on dimensional metrology for participants from common wealth countries, Feb 8-9, 2003, NPL, New Delhi.
Rina Sharma	An introduction to evaluation and expression of uncertainty in measurement,	Advanced training programme on dimensional and temperature metrology Dec.10-13, 2002, NPL, New Delhi.

Speaker's Name	Topic	Event and Venue
Rina Sharma	ISO/IEC-17025:1999,	Advance training programme on dimensional and temperature metrology Dec.10-13, 2002, NPL, New Delhi.
Rina Sharma	Evaluation and expression of uncertainty in measurements,	Training programme organized by Bureau of Indian Standards at Radison Hotel, New Delhi, Sept. 20, 2002.
Rina Sharma	ISO/IEC 17025–Vs. guide 25	2nd NPL-Industry meet, May 18, 2002, India international centre, New Delhi.
Rina Sharma	Uncertainty in calibration of a gauge block.	Training programme on measurement assurance, calibration, and uncertainty in measurement, Dec.11, IIQM, Jaipur.
Rina Sharma	Evaluation and expression of uncertainty in measurements.	Training programme on dimensional metrology for participants from common wealth countries, Feb 8-9, 2003, NPL, New Delhi.
Y.P. Singh	Temperature standards and calibration on international temperature scale (ITS-90)	2nd NPL-Industry meet on calibration services held on 18 May,2002 at India Internationl Centre, New Delhi.
Y.P. Singh	Temperature measurement and techniques	Training course organized by CSIO centre, New Delhi for officers from Delhi Jal Board held at CSIR complex, New Delhi. On 16 & 26th Dec. 2002.
Y.P. Singh	Temperature scales & expression of uncertainty in the measurement of temperature using liquid-in-glass thermometers and thermocouples.	Advanced training course on dimensional and temperature metrology held at NPL, New Delhi. Organised by MSI New Delhi from 10-13 Dec. 2002.
J.K. Gupta	Calibration of RTDs and evaluation of uncertainty	Advanced training course on dimensional & temperature metrology held at NPL, New Delhi organized by MSI, New Delhi from 10-13, December, 2002.

Speaker's Name	Topic	Event and Venue
H.C. Kandpal	Determination of the angular diameter of stars	CPYLS programme organised by NPL, New Delhi Nov. 27, 2002.
H.C. Kandpal	Phase singularity and spectral switches.	XXVIII Optical society of India (OSI) conference on optics and photonics in engineering (COPE-03), Netaji Subhash Institute of Technology, Sector-3, Dwarka, New Delhi-45, Jan. 6-8, 2002.
H.C. Kandpal	Phenomenon of spectral switches as a correlation induced and diffraction induced spectral changes.	National conference on lasers and spectroscopy, NCLS-2003, Meerut College Meerut, U.P., Feb. 25-28, 2003.
R. Mehrotra	Infrared spectroscopy in sugar house products	Department of physical chemistry, University of Essen, Germany.
A.C. Gupta	Status of vacuum, pressure and mass standards at NPL-India	TCM workshop (APMP) at Hanoi, Vietnam 12th Nov. 2002.
A.C. Gupta	Measurement and calibration techniques for pressure measuring systems	CSIO, S & M Centre, Delhi on 18th and 26th Dec. 2003.
S.M. Shivaprasad	Surface probes and thin film growth.	Academic Staff College, Jawaharlal Nehru University, New Delhi, 4th Feb., 2003.
S.M. Shivaprasad	Thin film growth an atomistic view.	Physics deptt., Indian Institute of Technology, Mumbai, 15th Jan., 2003.
S.M. Shivaprasad	Epitaxial phases and surface phase transformations of submonolayer phases of Sb on Si(111), (100)	National symposium on nanostructured materials, 5-6th Dec., 2002, held at Indian institute of technology, New Delhi.
S.M. Shivaprasad	Surface science and heteroepitaxial growth	CPDHE refresher course in physics, 3rd Oct., 2002, Deptt. of physics & astrophysics, University of Delhi, Delhi.
Sanjay Yadav	Pressure measurement: concept, theory and applications	National measurement and calibration laboratory, Saudi Arabian Standards Organization (SASO), Riyad on March 11, 2003.

Speaker's Name	Topic	Event and Venue
Sanjay Yadav	Pressure measuring instruments and their calibration	National measurement and calibration laboratory, Saudi Arabian Standards Organization, Riyadh on March 26, 2003.
Sanjay Yadav	Manual computation of pneumatic pressure/ generated by reference pressure standard.	National measurement and calibratoion laboratory, Saudi Arabian Standards Organization (SASO), Riyadh on March 29, 2003.
V. Mohanan	Environmental noise pollution regulations/legislations/ standards	NSA – 2002, AMU, Aligarh, Oct. 22-24, 2002.
V. Mohanan	Status of noise pollution in India.	Environment & health, public lecture series, arranged by M/s TOXICS Link, New Delhi at India international centre on Oct. 30, 2002.
V. Mohanan	Fundamentals of noise control	Workshop on control of noise pollution from DG sets arranged by Faridabad industries association on Nov. 29, 2002 at FIA house, Faridabad.
V. Mohanan	Fundamentals of noise and vibration and testing of fire crackers	Training programme on noise pollution control arranged by CPCB and WBPCB, during 4-5, Dec., 2002 at Kolkata.
V.R. Singh	Nanotechnology in bio-medical instrumentation.	Indian Science Congress, Bangalore, Jan. 3-7, 2003.
V.R. Singh	EM interaction study in bones.	5th International Conference on EM wave interaction with water and moist substances (ISEMA-2003), Rotorua, New Zealand, March 23-26, 2003.
V.R. Singh	Smart transducers for tele-medicine	National Conference on Communication Technology, Vellore, Dec. 12-14, 2002.
V.R. Singh	Basics of control flow valves.	CSIO Centre New Delhi, Dec. 18, 2002.
V.R. Singh	New piezo-electric biomedical materials for sensors applications	National conf. on materials, components and applications, Bhubneswar, Feb. 15-16, 2003.

Speaker's Name	Topic	Event and Venue
V.R. Singh	Biomedical micro devices: current trends.	International Conference on Computer Application in Electrical Engineering (CERA-2002), Roorkee, Feb. 23-25, 2003.
V.R. Singh	Smart piezoelectric sensors and mems.	National Symposium Acoustics (NSA- 2002), Aligarh, Oct. 22-24, 2002.
V.R. Singh	Recent advances in smart sensors: technology and applications.	Conference on Sensor Technology, DRDO, New Delhi, Sept. 26-27, 2002.
V.N. Ojha	Evaluation and expression of uncertainty in measurement: a general introduction.	IIQM course on ISO/IEC 17025 and uncertainty in measurement, 16-18 Aug. 2002, held at Indian Institute of Quality Management, Jaipur.
V.N. Ojha	Evaluation and expression on uncertainty in electrical measurements.	IIQM course on ISO/IEC 17025 and uncertainty in measurement, 16-18 Aug. 2002, held at Indian Institute of Quality Management, Jaipur.
V.N. Ojha	DC measurements - from classical to quantum.	CSIR programme on youth for leadership in science (CPYLS) at NPL,28-29th November, 2002.
V.N. Ojha	Evaluation and expression of uncertainty in measurement: A general introduction.	IIQM course on ISO/IEC 17025 and uncertainty in measurement 9-11 Dec. 2002, held at Indian institute of quality management, Jaipur.
V.N. Ojha	Evaluation and expression on uncertainty in electrical measurements- A case study.	IIQM course on ISO/IEC 17025 and uncertainty in measurement, 9-11 Dec. 2002, held at Indian institute of quality management, Jaipur.
V.N. Ojha	Uncertainty in measurement: Its evaluation and estimation.	Workshop on uncertainty in measurement, 25-26 March, 2003 at NIO- Goa.
V.N. Ojha	Uncertainty in measurement of electrical DC parameters: a case study.	Workshop on uncertainty in measurement, 25-26 March, 2003 at NIO- Goa.
P. Banerjee	GPS time and its applications.	GPS-GIS technology and applications seminar, 9-10 Sep.2002, Bangalore.

Speaker's Name	Topic	Event and Venue
G.M. Saxena	Rb atomic frequency standard	Time and frequency user's club meeting on 25th Sept., 2002 in London, sponsored by deptt. of trade and industry U.K and NPL, U.K.
Neeraj Khare	Superconducting electronics: materials and devices.	90th Indian Science Congress, Bangalore, Jan. 3-7, 2003.
Neeraj Khare	Grain boundary transport in colossal magnetoresistance manganites.	National Symposium on Colossal Magnetoresistance in Rare Earth Manganites at S. N. Bose National Centre for Basic Sciences, Kolkata Jan 7-10, 2003.
Neeraj Khare and Ashok K. Gupta	Colossal magnetoresistance materials.	National seminar on materials and its applications, Dr. R.M.L. Avadh university, Faizabad on Feb 27-28, 2003.
Ashok K. Gupta	Studies on high-T_c RF-SQUIDs.	National seminar on frontiers in physics, department of physics, IIT, Roorkee, 7-8 March, 2003.
R.B. Mathur	Carbon nanotubes–A material to meet new technological challenges.	Refresher course in physics and electronics, centre for professional development in higher education, University of Delhi, Delhi, October 17, 2002.
V. Raman	Synthesis of ceramic materials and composites by sol-gel technique.	Seminar on recent advances in sol-gel science and technology, NPL, New Delhi Feb. 25, 2003.
M.N. Kamalasanan	Recent improvements in the performance of organic light emitting diodes.	National Symposium on Luminescence and its Applications (NSLA-2003), February 12-14, 2003, NPL, New Delhi.
M.N. Kamalasanan	Sol-gel synthesis of ceramic thin films.	MRSI Seminar on Recent Advances in Sol-gel Science and Technology, NPL, New Delhi, 25th February, 2003.
S.C.K. Misra	Advances in semiconducting polymer thin films.	Second National Conference on Thermophysical Properties of Materials, University of Rajasthan, Jaipur, Sept., 2002.

Speaker's Name	Topic	Event and Venue
S.C. Jain & V.K. Tanwar	Photo-responsive self assembled monolayer/ photopolymer film for optical information storage using liquid crystals.	6th International Conference on Optoelectronics, Fiber Optics and Photonics (Photonics 2002) 16-18 Dec. 2002, Mumbai, Biosensors for Clinical Diagnostics Industry International Meeting on Chemical Sensors-9, Boston, U.S.A, 7-10 July 2002.
B.D.Malhotra	Biosensors for medical diagnostics centre for molecular & macromolecular studies, Polish academy of Sciences.	Polish Academy of Sciences. Sienkiewicza, Lodz, Poland 18 July 2002.
B.D.Malhotra	Conducting polymer based biomolecular electronic devices, liquid crystals & other soft materials.	Raman Research Institute, Bangalore, 18-20 Dec., 2002.
B.D.Malhotra	Conducting polymer electronics: why? what? where?	DCE-annual industry meet, 13-15 March 2003.
B.D.Malhotra	Electrochemical biosensors, chemo electronic laboratory.	United phosphorous limited, Vapi, India, 14-15 February 2003.
B.D.Malhotra	Recent developments in molecular electronics.	DST expert group meeting on molecular electronics, conducting polymer electronics, non-invasive & other biosensors, NPL, New Delhi. 11 February, 2003.
B.D.Malhotra	Trends in conducting polymer biomolecular electronics.	Advanced materials organized jointly by NPL and SSPL, Delhi, at SSPL, Delhi, 15 January 2003.
B.D.Malhotra	Recent developments in biosensors.	Materials processes, devices & systems for sensor technology development organized by MRSI Delhi chapter, NPL , New Delhi, India ,28 January 2003.
Krishan Lal	Recent advances in high resolution X-ray diffraction studies of semiconductors for technological applications	CODATA task group meeting and 13th workshop on the survey of data sources in asian-oceanic countries (DSAO), Daejeon, Korea 2002

Speaker's Name	Topic	Event and Venue
Krishan Lal	Metrology and materials evaluation and characterization	Seminar for developing an APEC S&T network in materials testing and evaluation technology, Korea (2002).
Krishan Lal	Structural characterization of single crystals epitaxial films and micromachined devices	International conference on smart materials, structures and systems (ISSS-SPIE 2002) Bangalore 2002.
Krishan Lal	NPL, India and global MRA.	4th International conference on advances in metrology: equivalence of standards and global recognition (AdMet-2003), New Delhi 2003.
Krishan Lal	Real structure of materials	International workshop on recent advances in nanotechnology of magnetic fluids (RANMF-2003), New Delhi 2003.
S.K. Gupta	Characterization of shallow junctions in ion – implanted silicon wafers	Seminar on advanced materials, Solid State Physics Laboratory, New Delhi, January 15, 2003.
Krishan Lal	Crystalline perfection of bismuth germanate crystals and effect of thermal annealing	32nd National seminar on crystallography, Jammu 2002.
Krishan Lal	R&D services in natural science: quality management and WTO agreement	National workshop on strategies for global marketing of R&D services, Indian Institute of Foreign Trade, New Delhi 2002.
Krishan Lal	Growth and structural perfection of bismuth germanate single crystals	Aligarh Muslim University, Aligarh 2002.
Krishan Lal	Structural characterization of low dimensional crystals	Aligarh Muslim University, Aligarh 2002.
Krishan Lal	Quality management: a major challenge in the era of globalization	2nd national seminar on quality consciousness - movement for quality culture, Institute of Trade and Industrial Development, New Delhi 2002.
Krishan Lal	Growth of nearly perfect single crystals and characterization of defects in the same.	Banaras Hindu University, Varanasi 2003.

Speaker's Name	Topic	Event and Venue
S.L. Jain	Monitoring of various trace species in the atmosphere.	Institute of quantum electronics, laboratory for laser spectroscopy & environmental sensing, Zurich, Switzerland on July 3, 2002.
S.L. Jain	Ozone depletion and ozone protection.	The international ozone day celebrations organised by the eco-club of SPM College for women New Delhi, on 20 September, 2002.
S.L. Jain	Monitoring of green house gases and ozone over maitri centre, Antartica.	Challenge and opportunities in the 21st century held at ICSSR seminar complex of Punjab university, Chandigarh during Feb. 3-4, 2003.
S.L. Jain	At Maitri, Antarctica	National conference on lasers and spectroscopy, Green house gases measurement held at Meerut College, Meerut during February 25- 28, 2003.
H.N. Dutta	Antarctica: the most efficient ice-air-ocean interactive system in the world.	Keynote address delivered at the inauguration of the UGC sponsored training course on environmental science & engineering, Guru Jambheshwar Univ., Hisar, September 2, 2002.
H.N. Dutta	Environmental laws governing antarctica	UGC sponsored training course on environmental science & engineering, Guru Jambheshwar Univ., Hisar, September 2, 2002.
H.N. Dutta	The study of planetary boundary layer processes at the ice-air-ocean interaction over prince edward coast, East Antarctica	Y N Sahai Memorial oration lecture in the 22nd annual conf. of the academy of environmental biology on biodiversity & resource management at national bureau of fish genetic resources, Lucknow, September 11-13, 2002.
H.N. Dutta	Antarctica	Department of journalism in Devi Ahilaya University, Indore, November 21, 2002.

Speaker's Name	Topic	Event and Venue
H.N. Dutta	Antarctica: the least explored & the most inspiring continent in the world.	IIT, Delhi January 9, 2003.
Hari Kishan	Low temperature thermometry and level sensors.	CEP course on cryogenic engineering and technology on 26th November 2002 at Solid State Physics Laboratory, Delhi.
R.B. Saxena	Applications of cryogenic engineering.	CEP course on cryogenic engineering and technology, on 28th November 2002 at Solid State Physics Laboratory, Delhi.
Hari Kishan	Role and importance of humidity measurements in agricultural products particularly in grains.	National science day celebration. on 28th February 2003 at Indian Agricultural Research Institute.

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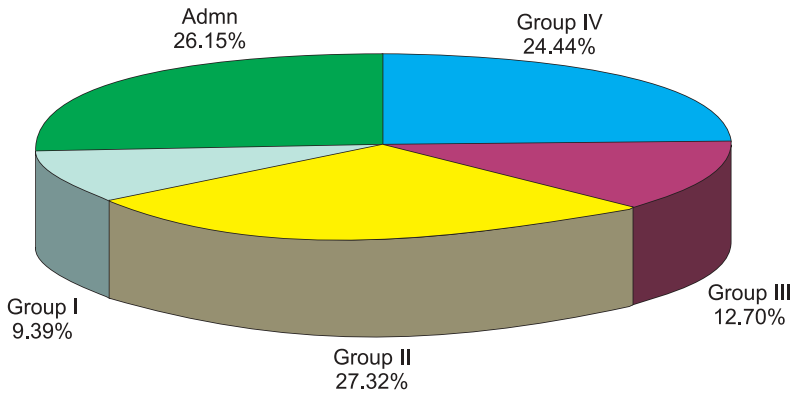
APPENDIX : 15

HUMAN RESOURCES

As on April 1, 2003

S.No.	Category	Grade	Number
(A)	**Scientific & Technical Staff**		
1	Scientific Staff	Group IV	229
2	Technical Staff	Group III	119
	Sub-Total 1+2 :		**348**
3	Engineering Cadre Staff	Group V	
4	Supporting Technical Staff	Group II	256
5	Supporting Technical Staff	Group I	88
	Total S&T Staff :		**692**
(B)	**Administrative & Non-Technical Staff**		
6	Administrative (Gazetted)	Group A	8
7	Administrative (Gazetted)	Group B	89
8	Administrative (Non-Gazetted)	Group C	49
9	Non-Technical Staff	Group D	99
Total Administrative & Non-Tech. Staff :			**245**
GRAND TOTAL (A)+(B) :			**937**



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
Sh. Ganga Prasad	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 & Dimension Standards		
Dr. Raghunandan Prasad Singhal	Scientist G	DP 01.02
Sh.S. Uma Maheshwar Rao	Scientist F	DP 01.02
Sh. K.P. Chaudhary	Scientist EII	DP 01.02
Dr V G Kulkarni	Scientist EII	DP 01.02
Sh. Mrityunjay Karfa	Scientist EI	DP 01.02
Dr Mrs Santa Chawla	Scientist EI	DP 01.02
Dr Mrs Rina Sharma	Scientist C	DP 01.02
Mrs. Veena Roonwal	Tech Ofcr (EI)	DP 01.02
Sh. N.K.Aggarwal	Tech Ofcr (EI)	DP 01.02
Sh B K Roy	Tech Ofcr (EI)	DP 01.02
Sh. Ravi Khanna	Tech Ofcr (C)	DP 01.02
Sh. S.L. Thind	Tech Ofcr (C)	DP 01.02
Temperature Standards		
Dr Yesh Pal Singh	Scientist EII	DP 01.03
Sh Navin Kumar Srivastava	Scientist EII	DP 01.03

Name	Designation	Decision Package
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 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 Jagdish Kumar Dhawan	Scientist EII	DP 01.05
Sh Anil Kumar	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 Vijaya kumar	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 Om Prakash	Scientist F	DP 01.07
Dr Devinder Gupta	Scientist EII	DP 01.07
Dr Miss Ranjana Mehrotra	Scientist EII	DP 01.07

Name	Designation	Decision Package
Ultraviolet Radiation Standards		
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
Dr Janardan Singh	Scientist F	DP 01.11
Mrs Reeta Gupta	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
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

Name	Designation	Decision Package
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
Mrs Santa Chawla	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
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 Omkar Nath	Scientist F	DP 02.06
Sh Anil Kishore Saxena	Scientist EII	DP 02.06

Name	Designation	Decision Package
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
Sh Pramendra Singh Negi	Scientist EII	DP 02.08
Dr. Ranjit Singh	Scientist EI	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
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
Sh Mitthan Lal	Scientist EII	DP 02.12
Sh. Mukhesh Chandra	Scientist EII	DP 02.12
Dr Mansha Ram	Scientist EI	DP 02.12

Name	Designation	Decision Package
Sh G K Kapoor	Tech Ofcr (B)	DP 02.12
Sh. S.K.Rastogi	Tech Ofcr (B)	DP 02.12
Mrs. Shashi Lekha Bhatnagar	Tech Ofcr (A)	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
Dr. R.G.Mathur	Scientist B	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

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. Tushya Kumar Saxena	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 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

Name	Designation	Decision Package
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 K.M.K. Srivatsa	Scientist EI	DP 04.02
Sh C.M.S Rotham	Scientist EI	DP 04.02
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 C	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)

Name	Designation	Decision Package
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 CHARACTERISATION

Head : Dr Krishan Lal FNA

Characterisation 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
Mrs Prabha Johri	Scientist B	DP 05.01
Sh M K Dasgupta	Tech Ofcr (B)	DP 05.01
Sh Niranjan Singh	Tech Ofcr (B)	DP 05.01
Characterisation of Materials by EPR Spectroscopy		
Dr S K Gupta	Scientist F	DP 05.02
Dr Miss Manju Arora	Tech Ofcr (B)	DP 05.02
Characterisation 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
Characterisation 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 Kedar Nath Sood	Tech Ofcr (B)	DP 05.04

Name	Designation	Decision Package
Planning, Preparation, Certification and Dissemination of Indian Reference Materials		
Dr Arun Kumar Agrawal	Scientist EII	DP 05.05
Sh Rajiv Kumar Saxena	Tech Ofcr (B)	DP 05.05
Mrs Abha Bhatnagar	Tech Ofcr (A)	DP 05.05
Growth & Structural Characterisation of Single Crystals		
Dr (FNA) Krishan Lal	Scientist (Director Grade)	
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. Veerpal Singh Awana	Scientist C	DP 05.06
Dr Kamlesh Kumar Maurya	Scientist 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
Sh. V.K.Hans	Tech Ofcr (B)	DP 05.07
Bio-Mass Energy		
Sh Har Prakash Narang	Scientist F	DP 05.08

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

Name	Designation	Decision Package
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 Sachchidanand Singh	Scientist C	DP 06.01
Sh. Sher Singh	Scientist B	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 Singh 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

Name	Designation	Decision Package
Dr Hirday Nath Dutta	Scientist F	DP 06.03
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 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

Sh Pratim K Dutta	Scientist EII	DP 07.02
Sh. Surendra Singh Verma	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

Name	Designation	Decision Package
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

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

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
Sh Tushar Kanti Chakravarty	Scientist EI	DP 13.01
Sh V D Arora	Tech Ofcr (B)	DP 13.01
IPR Management Group		
Dr P K Ashwinikumar	Scientist F	DP 13.02

Name	Designation	Decision Package
Dr D P Bhatt	Scientist EII	DP 13.03
Marketing of NPL Developed Technology		
Sh Narinder Kumar Babbar	Scientist EII	DP 13.03
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
Dr. Miss Jyoti Lata Pandey	Scientist EII	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
Sh. Ashwani Kumar Suri	Tech Ofcr (B)	DP 13.06
Publication & Reports		
Sh. S K Chakladar	Scientist F	DP 13.07
Seminar Complex		
Sh Subhash Chandra	Tech Ofcr (C)	DP 13.08

TECHNICAL SUPPORT SERVICE

Head : Dr Anil Kumar Gupta

Electrical, Air Conditioning & Pumping Section		
Sh Jagdish Chandra 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 Hitesh Jain	Tech Ofcr (B).	DP 14.22
Sh Prabhu Shankar Tripathi	Tech Ofcr(A).	DP 14.01
Sh Dharam jit Singh	Asst. Exe. Engnr.	DP 14.22

Name	Designation	Decision Package

WORKSHOP & GTU

Head : Sh H N P Poddar

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 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 & HOUSE KEEPING

Head : COA

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
Sh S C Tyagi	A O	DP 09.01
Sh Brijesh Sharma	SPO Gr. I	DP 11.01
Sh. S.N.Gupta	Dy. SPO	DP 11.01
Sh. Kuldeep Kaushik	Dy. SPO	DP 11.01
Sh. J.M.Jolly	Dy. SPO	DP 11.01
Dr Mrs Shakuntala Sharma	Sr Hindi Officer	DP 09.11
Sh Lakhpat Singh	Security Ofcr (Sr)	DP 09.14

Name	Designation	Decision Package
Sh Vijay Kumar	Sr Security Ofcr	DP 09.07
Sh Subhash Chander	SO(G)	DP 09.12
Ms Beena Anupa Kullu	SO(G)	DP 09.13
Sh D K Salone	SO(G)	DP 09.02
Sh Jitendra Kumar Singh	SO(G)	DP 09.05
Sh Chhering Tobden	SO(G)	DP 09.04
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
Mrs Santosh Khanna	PS	DP 01.11
Horticulture		
Sh Rama Shankar Singh	Tech Ofcr (EI)	DP 09.06

RETIRED PERSON

Sh. Bhudev Singh, Tech VIII
Sh. S.C. Bahl, Sr. Steno
Sh. O.P. Arora, Sr. Steno
Sh. Dharam Singh, Mali (Gr. I)(4)
Sh. Tara Chand, Tech VIII
Sh. Kishan, Daftry
Mrs. Chanderkala, SMA
Sh. B.S. Negi, Tech. Ofcr. (B)
Sh. R.L. Mendiratta, Tech. Ofcr. (C)
Sh. R.K. Seth, SMA
Sh. Kuldip Singh, SMA
Sh. Harmohinder Singh, Str. & Pur. Asstt.
Sh. S.D. Bhatt, Jr. Sec. Grd.
Sh. Nural Hasan, UDC
Sh. M.K.Wadhwa, SMA
Sh. S.C. Yadav, SMA
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Sh. H.S. Dahiya, Sc. EII
Sh. J.S. Vaishya, Sc. F
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Sh. Lachhu Singh, SMA
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Sh. Tapeshwar Prasad, SMA
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Dr. R.S. Yadav, Sc. F
Dr. Ramji Rai, Sc. F
Sh. B.M. Kakkar, SMA
Dr. R.S. Ram, Sc.F
Dr. P.C. Saran, Tech. Ofcr. (B)
Sh. S.N. Das, SMA
Dr. S.P. Varma, Sc. F
Sh. G.P. Bhardwaj, Dy. SPO
Sh. K.K. Ninderjog, SMA
Dr. A.K. Agarwal, Sc. F
Sh. R.R. Khullar, SMA
Sh. Om Prakash, Workshop Asstt.II

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Sh. Raj Kumar Sethi, Workshop Asstt. VII
Sh. Bhajan Singh, Technician VIII
Sh. Keshar Deo, Sr. Mech. Asstt.
Sh. Dhiraj Singh, Safaiwala (ACP)
Sh. Shyam Sunder, Workshop Asstt. II
Sh. Pramod Bhandari, Str, & Purchase Asstt.III
Sh. Babu Ram, Workshop Asstt. II
Sh. Deepak Yadav, Helper B
Sh. Gokul Singh, Sr. Mech. Asstt.

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 Research Scientist.
Dr. A.R Verma, Hon. Scientist

RESEARCH ASSOCIATES

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

* * * * * * * * * * *

APPENDIX : 16

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	Chairperson
Dr. Girish S Agarwal Director, Physical Research Laboratory, AHMEDABAD-380009	Member
Dr. D.D.Bhawalkar Director, Centre for Advanced Technology, INDORE-452013	Member
Prof. Sushanta Dattagupta S N Bose Institute of Basic Science, Block-JD, Sector III, Salt Lake, KOLKATA- 700098	Member
Dr. S K Sikka Scientific Secretary, Office off the Principal Scientific Adviser to the Govt. Of India, Vigyan Bhavan Annexe, Maulana Azad Road, NEW DELHI-110011	Member
Dr. S M Chitre Department of Astronomy and Astrophysics, Tata Institute of Fundamental Research (TIFR), MUMBAI-400005	Member

Name	Status
Sh. Nirmal Singh Director General, Bureau of Indian Standards, Manak Bhawan, NEW DELHI-110002	Member
Dr. O P Agarwal Head, Research Planning & Business Development (RPBD), Council of Scientific & Industrial Research, Anusandhan Bhawan, 2 Rafi Marg, NEW DELHI-110001	Member DG'S Nominee
Dr. S Ahmad Director, Central Electronics Engineering Research Institute, PILANI-333031	Member
Dr. Krishan Lal Director, National Physical Laboratory, Dr. K S Krishnan Marg, NEW DELHI-110012	Member
Dr. V T Chitnis Scientist 'G' & Head, Planning, Monitoring & Evaluation Group NPL, Dr. K S Krishnan Marg NEW DELHI-110012	Non-Member Secretary

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Sr. COA / COA / AO NPL	Member Secretary

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