वार्षिक प्रतिवेदन

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Contents

प्राक्कथन

मुझे, राष्ट्रीय भौतिक प्रयोगशाला की वर्ष 2008–09 की वार्षिक रिपोर्ट प्रस्तुत करते हुए हर्ष का अनुभव हो रहा है। एन पी एल, भौतिकी की एक प्रमुख प्रयोगशाला और भारत की राष्ट्रीय मापिकी संस्थान (एन एम आई) होने के कारण इसकी गतिविधियों के वर्णक्रम (स्पेक्ट्रम) के अन्तर्गत राष्ट्रीय मानक, पदार्थ विज्ञान और वायुमण्डलीय भौतिकी के क्षेत्र आते हैं।

भौतिकी के प्रमुख क्षेत्रों में उन्नत अनुसंधान, विभागीय संरचना के अन्तर्गत सात विभाग, क्रमशः भौतिक यांत्रिक मानक, विद्युत तथा इलैक्ट्रॉनिक मानक, इंजीनियरिंग पदार्थ, इलैक्ट्रॉनिक पदार्थ, पदार्थ अभिलक्षणन्, रेडियो एवं वायुमण्डलीय विज्ञान, अतिचालकता एवं क्रायोजेनिक्स द्वारा किए जाते हैं।

राष्ट्रीय मानकों का अनुरक्षण एवं उन्नयन (अपग्रेडेशन) राष्ट्रीय भौतिक प्रयोगशाला का एक संवैधानिक दायित्व है (माप एवं तोल अधिनियम 1956 एवं 1976 तथा मानक तोल तथा माप अधिनियम 1976 के लिए 1988 के नियमों के अन्तर्गत अधिदेशाधीन)। इसके साथ–साथ भौतिकी के अग्रणी क्षेत्रों में गहन अनुसंधान एवं विकास का कार्य अनेक बाह्य रूप से तथा आन्तरिक (इन हाउस) परियोजनाओं के माध्यम से निष्पादित किया जाता है। सी एस आई आर के नेटवर्क परियोजनाएं कार्यक्रम के आरम्भ किए जाने के साथ–साथ, एन पी एल द्वारा इन अनेक परियोजनाओं में महत्त्वपूर्ण भूमिका का निर्वहन किया जा रहा है जिसे इस वार्षिक रिपोर्ट में उल्लिखित गतिविधियों द्वारा देखा जा सकता है।

वर्ष 2008–09 के दौरान, भौतिक यांत्रिक विभाग, अंशांकन (अंशशोधन) एवं द्रव्यमान मापन क्षमता (सी एम सी एस), घनत्व, आयतन, श्यानता, प्रकाशीय विकिरण, दाब और निर्वात मानक को विश्व के अग्रणी अन्तर्राष्ट्रीय तकनीकी विशेषज्ञों द्वारा पुनरीक्षण कराया गया। नए अंशांकन एवं द्रव्यमान मापन क्षमता को शामिल किया गया एवं विशेषज्ञों द्वारा स्वीकृत कराया गया। कई नई प्रकार की सुविधाएं स्थापित की गयी । प्रकाशीय मानक, दाब एवं निर्वात मानक के क्षेत्र में रूचिकर मूलभूत अनुसंधान किए गए। द्रव्यमान, विमीय, प्रकाशीय मानक एवं दाब और निर्वात के लिए छः अन्तर्राष्ट्रीय की कमपेरिजन/निर्यामक अध्ययन कराया गया। एन ए बी एल (NABL) के समर्थन द्वारा भारतीय औद्योगिकों की मदद के लिए दक्षता परीक्षण कराया गया। एन पी एल, इंडिया को वर्ष 2008 से द्रव्यमान एवं उससे जुड़ी हुई अन्य चीजों (CCM) के लिए ब्यूरों इंटरनेशनल दे पायड्स एट मेजर्स (BIPM) पेरिस, फ्रांस की परामर्शक समिति के सदस्य के रूप में चुना गया है।

विद्युत और इलैक्ट्रॉनिक विभाग द्वारा मोबाइल नेटवर्क का प्रयोग करके टेली क्लॉक रिसीवर का एक रूपान्तर तैयार किया गया। प्रत्यावर्ती बिजली एवं ऊर्जा मानक विभाग को एन पी एल से AC/DC चुम्बकीय प्रभावित एनर्जी मीटर प्रदर्शित करने पर 'श्रेष्ठ अनुसंधान और विकासात्मक दल पुरस्कार' प्राप्त हुआ । हाल ही में निर्धारित संघटित एवं अभिलक्षित स्वचालित 10 वोल्ट J.V. मानक का प्रयोग करते हुए इकाई वोल्ट के राष्ट्रीय मानकीकरण को 'वैल्यू' प्रदान की गयी। एन पी एल ने टाइम अनुमाप की कार्यक्षमता में और ज्यादा सुधार किया है और अब इसकी अन्य देशों के श्रेष्ठ अनुसंधान से तुलना की गयी है। एक परियोजना के तहत् एन पी एल को एस ए सी की सहायता से स्पेस क्वालीफाइड रूबीडीयम क्लाक विकसित करना है । उपर्युक्त क्लाक का प्रयोग भारतीय क्षेत्र अधीन उपग्रह तन्त्र में किया जाएगा, जो कि 2011 में छोड़ा जाएगा। विभिन्न विभागों, जैसेकि जे वी एस एवं डी सी, एल इम्पीडेन्स, एल एफ एवं एच एफ वोल्टेज, धारा एवं आर एफ पावर, एटीन्यूऐशन और ए सी पावर एवं एनर्जी आदि द्वारा पुर्नअवलोकन सफलतापूर्वक सम्पन्न किया गया।

इंजीनियरिंग पदार्थ विभाग द्वारा, इस वर्ष के दौरान कई नेटवर्क, प्रायोजित एवं परामर्शी परियोजनाएं की गयी और उनमें महत्त्वपूर्ण सफलता हासिल हुई। छिद्रिल चालक कार्बन पेपर एवं आधुनिक यौगिक द्विध्रुवण प्लेट को फ्यूल सैल में प्रयोग करने के लिए एन पी एल में उन्हें विकसित किया गया उनकी क्षमता का अध्ययन किया गया और पाया गया कि ये संघटक आयातित संघटक के समतुल्य है। यूरिया एवं न्यूक्लिक एसिड एवं नैनो स्ट्रक्चर्ड आक्साइड फिल्म का प्रयोग बायोसेन्सर में किया गया एवं परिणाम आशापूर्ण पाए गए। आर्गनिक लाइट एमिटिंग डायोड में उपयोग करने के लिए इलैक्ट्रोल्यूमिनिसेंस जिंक आक्साइड काम्पलेक्स संश्लेषित किए गए एवं उनकी संदीप्तिशीलता पीले हरे क्षेत्र में पाई गयी। चुनावों में वोटिंग के दौरान वोटर द्वारा धोखेबाजी को रोकने हेतु उसकी उंगली पर निशान लगाने के लिए एक नए सूत्रयुक्त विश्वसनीय इंक को भी विकसित किया गया।

इलेक्ट्रॉनिक पदार्थ विभाग अपने लक्ष्य के अनुसार अनुसंधान को जारी रखते हुए संदीप्तशील पदार्थ, फोटो–वोल्टीक्स, प्लाज्मा प्रोसेसिंग, अतिचालक छड़, सतह भौतिकी, नैनो–स्ट्रक्चर्ड पदार्थ एवं चालक पोलीमर विषयों पर अनुसंधान कर रहा है। वर्ष के दौरान अर्धचालक नैनो संदीप्तीशील पदार्थ,

आर्गेनिक इलैक्ट्रॉनिक्स एवं सतह् भौतिकी विषयों के शोध के फलस्वरूप अत्यधिक प्रभावशाली शोध पत्रिकाओं में बहुत से शोध पत्र प्रकाशित हुए। एन पी एल द्वारा सेमटेल (SAMTEL) कम्पनी के साथ प्लाज्मा डिस्प्ले पैनल के लिए NMITLI परियोजना के तहत संदीप्तशील पदार्थ बनाया जो कि बाजार में उपलब्ध संदीप्तशील पदार्थों से बढ़िया पाया गया जिसे कि सेमटेल कम्पनी ने स्वीकृति भी प्रदान की।

राष्ट्रीय भौतिक प्रयोगशाला में पदार्थ अभिलक्षणन विभाग, ने विकसित अनेक पदार्थों जैसे तनु परतें, नैनों ट्यूब्स सहित नैनो पदार्थ, नैनो रॉडस, नैनो वायर्स, इंजीनियरिंग अनुप्रयोगों के लिए यौगिक पदार्थ, युक्ति संरचना के लिए इलेक्ट्रॉनिक पदार्थों और उनके संघटक आदि के अभिलक्षण के लिए सुविधाएं प्रदान की। इस विभाग ने प्रयोगशाला के अनुसंधान योजना के अनुरूप महत्त्वपूर्ण प्रौद्योगिकी पदार्थों के संश्लेषण एवं वर्धन और अन्त में अभिलक्षणन करके पदार्थों को बनाने की क्रिया में योगदान दिया।

रेडियो एवं वायुमण्डलीय विभाग में पृथ्वी तंत्र विज्ञान के वायुमण्डलीय संघटक के अध्ययन एवं रेडियो विज्ञान अध्ययन तथा उनका प्रयोग संचार एवं अन्य महत्त्वपूर्ण क्षेत्रों के साथ–साथ वायुमण्डलीय पर्यावरण प्रक्रियाओं तथा वायुमण्डलीय ट्रेस गैसीय संघटक के सम्बन्ध में होने वाले प्रभावों, ग्रीन हाउस गैसों, एरोसोल तथा सौर विकिरण एवं परिवर्तनशील वायुमण्डल का अध्ययन किया जाता है।

अतिचालकता विभाग कई दिशा में प्रगतिशील है। MgB_2 में नैनो–कण की डोपिंग के निरन्तर अध्ययन के साथ–साथ बहुत से अन्य ओक्सी–पनिकटाइड तंत्रों (oxy-pnictide systems), उदाहरण के रूप में, एक परत् को–डोपड $La O_{1-X} F_{e X} A_s$ एवं द्विपरत (Double layer) $Sr_4V_2O_6Fe_2As_2$ संश्लेषित किए गए। $SmFe_{0.9} Co_{0.1}AsO$ पदार्थ में अतिचालकता 14K तापमान पर SDW एनामोली सप्रेशन के साथ पाया गया।

एन पी एल ने मानव संसाधन विकास में विश्वविद्यालयों और अन्य शैक्षणिक संस्थाओं के विद्यार्थियों को उनके परियोजना कार्य एवं प्रशिक्षण के लिए सुविधाएं उपलब्ध कराने में अपना योगदान दिया है। पूरे भारत में स्थित विभिन्न संस्थानों से लगभग 177 विद्यार्थी जो MSc., M.E./M.TECH, MCA, B.E/B.TECH आदि में अध्ययन कर रहे हैं, ने एन पी एल से अल्पकालीन व दीर्घकालीन प्रशिक्षण प्राप्त किया है। तीन रिसर्च फैलो के शोध कार्य पूरे होने पर उन्हें पी एच डी प्रदान की गयी। बारह प्रशिक्षण कोर्स आयोजित किए गए जिनमें इंडस्ट्री, अन्य संस्थानों और एन पी एल से प्रतिभागियों ने भाग लिया । इसके अतिरिक्त एन पी एल में कई शैक्षणिक संस्थानों/संगठनों के आगमन की व्यवस्था की गयी।

वर्ष 2008–09 के दौरान लगभग 260 वैज्ञानिक एवं तकनीकी शोध पत्र SCI में प्रकाशित हुए और 207 पेपर्स विभिन्न राष्ट्रीय एवं अन्तर्राष्ट्रीय सम्मेलनों में प्रस्तुत किए गए। भारत में 10 पेटेन्टस् और विदेश में 18 पेटेन्टस् पंजीकृत कराए गए। वर्ष 2008–09 के दौरान पूर्व वर्षों में भारत में पंजीकृत कराए गए 16 पेटेन्टस् और विदेश में पंजीकृत कराए दो पेटेन्टस् स्वीकृत किए गए। 21 नई परियोजनाएं (प्रायोजित एवं कंसल्टेन्सी) प्रारंभ की गयी और 2868 अंशांकन रिपोर्टस् जारी की गयी जिससे लगभग 519 लाख का ECF अर्जित किया गया।

मैं एन पी एल के वैज्ञानिकों, इंजीनियरों और प्रशासन, वित्त, भण्डार एवं क्रय के स्टॉफ सदस्यों, वैज्ञानिक एवं तकनीकी सर्विसिज और इन्फ्रास्ट्रक्चर सपोर्ट सर्विसेज के योगदान के प्रति अपना आभार व्यक्त करता हूं क्योंकि उनकी रूचि एवं विशेष सहयोग के बिना हमारा यह सम्पादन संभव नहीं हो सकता था। मैं सी एस आई आर मुख्यालय, हमारे रिसर्च काउंसिल के सदस्यों और बाह्य विशेषज्ञों जिन्होंने जहां कहीं भी एन पी एल को आवश्यकता हुई, अपना सहयोग दिया, के प्रति भी अपना आभार प्रकट करता हूँ।

अन्त में, मैं प्रकाशन समिति तथा सम्बद्ध टीमों का विशेष आभारी हूं जिन्होंने इस रिपोर्ट को तैयार करने में अपना अमूल्य योगदान दिया है। श्री प्रेम चन्द, श्री एन. के. वधवा, श्रीमती अनिता शर्मा और श्री सुभाष चन्द्र का विशेष प्रयास भी सराहनीय है।

(आर सी बुधानी)
निदेशक

Foreword

It gives me great pleasure to present the Annual Report of National Physical Laboratory (NPL) for the year 2008-09. NPL being the primary laboratory for Physics and National Metrological Institute (NMI) of India, the spectrum of its activities covers the areas of National Standards, Materials Science and Atmospheric Physics.

Advanced research in important areas of Physics is carried out under the Divisional structure comprising of seven research divisions namely Physico-Mechanical Standards, Electrical and Electronic Standards, Engineering Materials, Electronic Materials, Materials Characterization, Radio & Atmospheric Sciences and Superconductivity & Cryogenics.

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

During 2008-09, in Physico-Mechanical Standards Division, Calibration and Measurement Capabilities (CMCs) of Mass, Density, Volume, Viscosity, Optical radiation, Pressure and Vacuum Standards were peer-reviewed by International technical experts from leading NMIs in the world. New CMCs were included and approved by these experts. Many new facilities were created. Interesting fundamental research in the areas of Optical standards, Pressure and Vacuum Standards were carried out. There was participation in six international key comparison/pilot studies in parameters such as Mass, Dimension, Optical Standards and Pressure & Vacuum. NABL sponsored proficiency testing was also organized to help the Indian Industries. NPL, India has been elected as Member of the Consultative Committee for the Mass and the Related Quantities (CCM), Bureau International des Poids et Mesures (BIPM), Paris, France, since 2008.

In Electrical and Electronic Standards Division, a version of Teleclock Receiver using mobile network was developed. AC Power & Energy Standard group received NPL's 'Outstanding Research & Development Team Award' for their study of AC/DC magnetic field influence on the performance of energy meters. "National Standards" of unit Volt was assigned values using recently integrated, characterized and established automatic 10-Volt Josephson Series Array Voltage Standard (JSAVS) system. NPL improved the performance of time scale and it is now comparable with all leading laboratories of the world. A project was received on the Development of Space Qualified Rubidium Clock jointly with SAC. This clock is to be developed for Indian Regional Satellite System (IRSS) which is to be launched in 2011. The International Peer Review of the groups, namely, JVS & DC, LF Impedance, LF & HF Voltage, Current & RF Power; Attenuation & Impedance and AC Power & Energy was successfully completed.

In the Division of Engineering Materials, the research & development work on several on-going Network, Sponsored and Consultancy projects was continued and substantial progress was made during this year. The performance of porous conducting carbon paper and advanced composite bipolar plate, developed at NPL for fuel cell applications was evaluated and found comparable to the imported components. Research on urea & nucleic acid bio-sensors was continued and application of nanostructure oxide films as bio-sensors yielded encouraging results. On the development of organic light emitting diodes, the electroluminescent zinc complex has been synthesized which gives photoluminescence in yellowish green

region. A novel formulation of improved indelible ink for marking the finger of a voter in the elections to prohibit fraud voting has also been developed.

The Division of Electronic Materials continued its mandated research in luminescent materials, photovoltaics, plasma processing, superconducting rods, surface physics, nano-structured materials and conducting polymers. During the year, the activities resulted in a large number of publications with high impact factor in the areas of luminescent semiconducting nanoparticles, organic electronics and surface physics. Phosphors developed for Plasma Display Panel (PDP) under NMITLI project along with SAMTEL have shown better performance compared to commercial phosphors. SAMTEL has approved NPL developed phosphors.

Material Characterization Division characterized various materials being developed at NPL, like thin films, nano-materials including nano-tubes, nano-rods, nano-wires, composite materials for engineering applications, electronic materials for device fabrication etc. The division also worked on development of technologically important materials, their synthesis and growth and finally characterizing them for optimization in process control of the growth mechanism, keeping in view the research plan of the laboratory.

Radio and Atmospheric Sciences Division carried out studies related to the atmospheric component of the Earth System Science including investigations on Radio Sciences, their applications to communication and other strategic sectors as well as work on atmospheric environmental processes in respect to trace gaseous constituents, green house gases, aerosols, radiation etc., and global change.

The superconductivity group progressed in several directions. Along with the continuation of studies on nano-particle doping in MgB_2, several oxy-pnictide systems, e.g., single-layered Co-doped $LaO_{1-x}F_xFeAs$ and double-layered $Sr_4V_2O_6Fe_2As_2$ were synthesized. Superconductivity appeared in $SmFe_{0.9}Co_{0.1}AsO$ at 14 K with a suppression of the *SDW* anomaly.

NPL has also been contributing in the human resource development by providing facilities to students from universities and other educational institutes for project work and training. About 177 students pursuing M.Sc., M.E./ M.Tech., M.C.A., B.E./ B.Tech. Courses from various institutes located all over India have undergone short and long term training. Three research fellows on completion of their thesis work has been awarded Ph.D. Twelve training coursed were organized where persons from industry, other institutes and NPL participated. Besides, numbers of visits by educational institutes/organization to NPL were arranged.

During 2008-09, about 260 scientific and technical papers were published in SCI and 207 papers were presented at various national and international conferences. Ten patents were filed in India and eighteen were filed abroad. Sixteen patents filed in India and two patents filed abroad in previous years were granted during 2008-09. Twenty one new projects (sponsored and consultancy) were undertaken and 2868 calibration reports were issued, which contributed to generation of an ECF of about 519 lakhs.

I would like to acknowledge the contributions of NPL scientists, engineers, and the staff of administration, finance, stores & purchase, the scientific & technical support services and infra-structure support services. Without their keen interest and outstanding cooperation, much of our accomplishment would not have been possible. I also take this opportunity to acknowledge the support received from CSIR headquarters, members of our Research Council and external experts who visited NPL as and when needed.

Last, but not the least, I would like to acknowledge the contribution of the publication committee and associated teams in bringing out this report. Special efforts made by Shri Prem Chand, Sh. N.K. Wadhwa, Ms Anita Sharma and Sh Subhash Chandra are also appreciated.

(R. C. Budhani)
Director

Preamble

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

CHARTER

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

CUSTODIAN OF NATIONAL STANDARDS OF MEASUREMENT

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

NATIONAL APEX BODY FOR CALIBRATION

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

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

MAJOR ACHIEVEMENTS

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

The major thrust areas of R & D are

(A) Metrology

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

(B) Materials

- Light weight, high strength metallic materials
- Bulk nano metallic and Nano composite materials
- Carbon & Carbon composites
- Plasma processed materials
- Organic and Inorganic Photovoltaic
- Luminescent Materials
- Organic Light emitting diodes
- Conduction Polymers & Composites
- Superconducting materials and Superconductivity
- Fuel cells
- Sensors (based on Bio, Gas, Chemicals, MEMS)
- Advanced Characterization Techniques

(C) Radio and Atmospheric Sciences

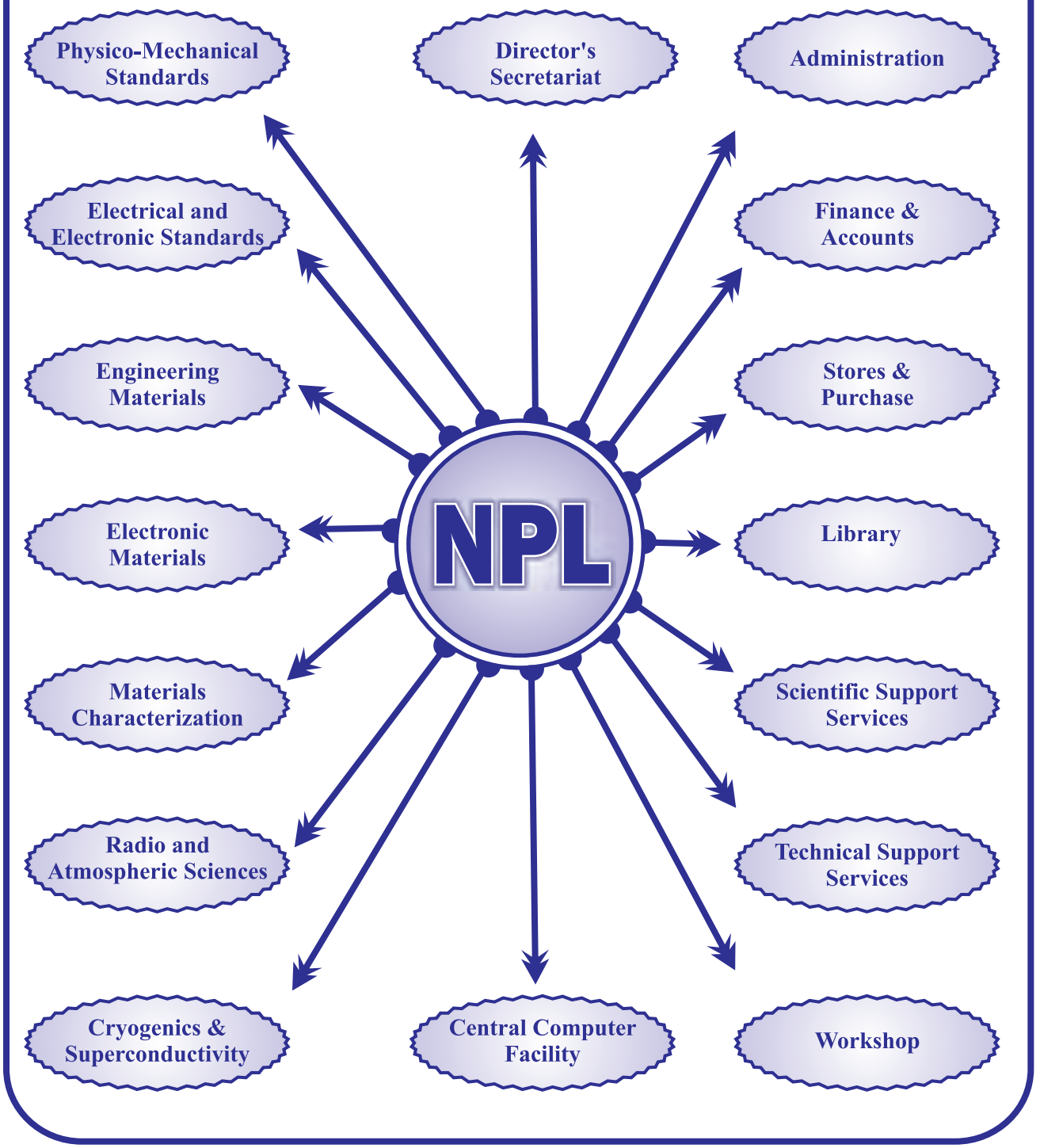
- Ionosphere & Troposphere
- Atomospheric Environment
- Global Climate change
- Antarctica and Arctic studies
- Radio- Propagation
- Communications (Fixed, mobile and marine)

ORGANIZATION AND MANAGEMENT

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

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

R & D GROUPS & MANAGEMENT



Photographs of Important Events

Inaugural Function of 14th APAM Conference on State of Materials and New Trends in Material Science, November 18-20, 2008.

Inaugural Function of 7th International Conference on "Advances in Metrology 2009" (AdMet 2009) February, 18-20, 2009

CSIR Foundation Day Celebrations,
(September 26, 2008)

Inaugural Function of International Conference on : Magnetic Materials & their Applications for 21st century (MMA-21), October 21-23, 2008

Inaugural Function of Indo-Taiwan Workshop on Solar & Fuel Cells, November 24-26, 2008

Indo-German Co-operation for Metrology in Chemistry (MIC), (October 15, 2008)

4th Course on Radio Meteorology for Indian Naval Officers, December 16-18, 2008

NPL Open Day Celebrations,
September 21, 2008

भौतिक–यांत्रिक मानक

PHYSICO-MECHANICAL STANDARDS

भौतिक यांत्रिक मानक

एन पी एल इंडिया, के सात अनुसंधान और विकास विभागों में से, भौतिक यांत्रिक मानक (पी एम एस) एक विभाग है। इस विभाग में नौ ग्रुपों के संबंध में, भौतिक तथा यांत्रिक मापन गतिविधियों संबंधी कार्य किए जाते हैं। पी एम एस विभाग मापन के राट्रीय मानकों को स्थापित, रख–रखाव और निरन्तर उन्नयन करने के लिए उत्तरदायी है। इस विभाग द्वारा देश के उद्योगों और संस्थानों को उच्च स्तरीय अंशांकन उपलब्ध कराया जाता है जिससे उन पैरामीटरों के आधार पर किए गए मापन का अनुरेखण किया जा सके।

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

विभाग की मुख्य विशेषताएं –

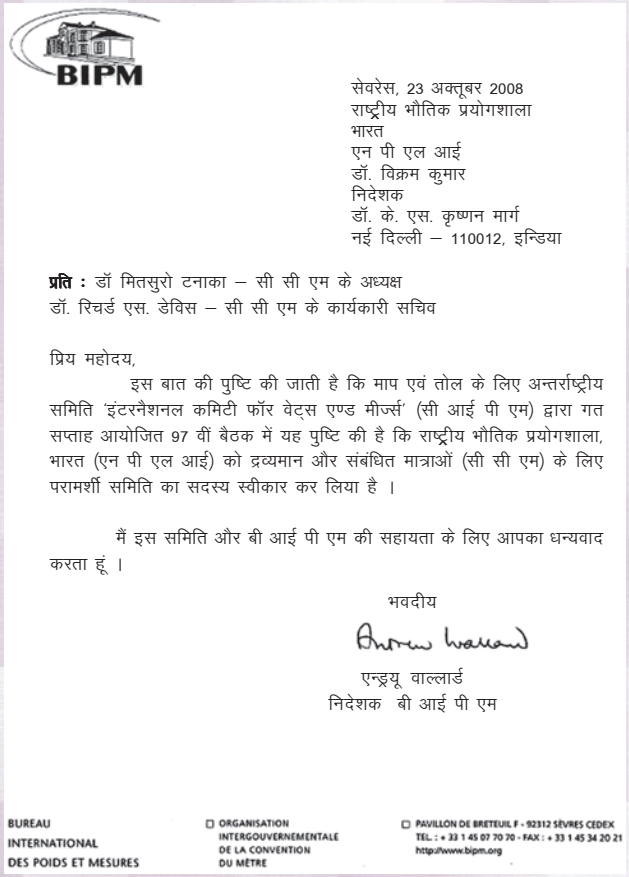
1. **मान्यता :** एन पी एल इंडिया को वर्ष 2008 से द्रव्यमान और संबंधित मात्राओं (सी सी एम) के लिए ब्यूरो इंटरनेशनल दे पोइद्स एट मीसेर्स (बी आई पी एम), पैरिस, फ्रांस की परामर्शी समिति का सदस्य बनाया गया है । प्रोफेसर एन्ड्रू वाल्लार्ड, निदेशक, बी आई पी एम का दिनांक 23 अक्तूबर, 2008 का प्रोफेसर "विक्रम कुमार", निदेशक, एन पी एल को संबोधित किया गया पत्र जिसमें सी सी एम/बी आई पी एम में सदस्यता की पुष्टि का उल्लेख किया गया है।

चित्र 1 : 24–25 अप्रैल, 2008 को सी सी एम बैठक में प्रतिभागियों का चित्र

2. **इस वित्तीय वर्ष के दौरान सृजित नई सुविधाऐं**

(क) 100µg की पठनीयता के साथ 50 किलोग्राम मास कॉम्पेरेटर

(ख) 1µg की पठनीयता के साथ 1 किलोग्राम मास कॉम्परेटेर



BIPM

सेवरेस, 23 अक्तूबर 2008
राष्ट्रीय भौतिक प्रयोगशाला
भारत
एन पी एल आई
डॉ. विक्रम कुमार
निदेशक
डॉ. के. एस. कृष्णन मार्ग
नई दिल्ली – 110012, इन्डिया

प्रति : डॉ मितसुरो टनाका – सी सी एम के अध्यक्ष
डॉ. रिचर्ड एस. डेविस – सी सी एम के कार्यकारी सचिव

प्रिय महोदय,

इस बात की पुष्टि की जाती है कि माप एवं तोल के लिए अन्तर्राष्ट्रीय समिति 'इंटरनैशनल कमिटी फॉर वेट्स एण्ड मीज्र्स' (सी आई पी एम) द्वारा गत सप्ताह आयोजित 97 वीं बैठक में यह पुष्टि की है कि राष्ट्रीय भौतिक प्रयोगशाला, भारत (एन पी एल आई) को द्रव्यमान और संबंधित मात्राओं (सी सी एम) के लिए परामर्शी समिति का सदस्य स्वीकार कर लिया है ।

मैं इस समिति और बी आई पी एम की सहायता के लिए आपका धन्यवाद करता हूं ।

भवदीय

एन्ड्रयू वाल्लार्ड
निदेशक बी आई पी एम

BUREAU INTERNATIONAL DES POIDS ET MESURES
ORGANISATION INTERGOUVERNEMENTALE DE LA CONVENTION DU MÈTRE
PAVILLON DE BRETEUIL F - 92312 SÈVRES CEDEX
TEL : + 33 1 45 07 70 70 - FAX : + 33 1 45 34 20 21
http://www.bipm.org

चित्र 2. में प्रोफेसर एन्ड्रयू वाल्लार्ड, निदेशक, बी आई पी एम का प्रोफेसर डॉ. विक्रम कुमार, निदेशक, एन पी एल को संबोधित पत्र जिसमें सी सी एम/बी आई पी एम की सदस्यता की पुष्टि की गई है ।

(ग) 100 मिलीग्राम की पठनीयता के साथ 500 किलोग्राम मास काम्पेरेटर

(घ) ऑटोकोल्लीमैटोर के रेसोल्यूशन को सवंर्धित करने के लिए मल्टीपल रिफ्लेक्शंस डिवाइस

(ड.) नॉन कंटेक्ट सर्फेस रफनैस और स्टैप हाइट के लिए सुविधाओं की स्थापना

(च) थर्मोकपल कैलिब्रेशन में आटोमेशन के लिए सेट अप

(छ) विशेष रेडियंस तथा कैलिब्रेशन कार्य के स्त्रोत आधारित प्राथमिक मानक

(ज) नियंत्रित क्लीयरेंस पिस्टन गॉज के अभिलक्षणन के लिए फिनाइट एलिमैन्ट विधि (एफ ई एम)

3. टास्क ग्रुप 1 (सी सी एम) का सदस्य चुना जाना : "मॉस मैट्रोलोजी अंडर वैक्यूम फार ए मिसे एन प्रोटिक" पर, और टास्क ग्रुप 2 (सी सी एम) : "किलोग्राम के अन्तर्राष्ट्रीय प्रोटोटाइप के अनुरेखण के कारण अनिश्चितता घटक।"

4. अंशांकन और मापन क्षमताओं की ग्रुप मास, घनत्व, आयतन, श्यानता, प्रकाशीय विकिरण और दाब तथा निर्वात मानकों के लिए विश्व के अग्रणी एन एम आई के समकक्ष तकनीकी विशेषज्ञों द्वारा समीक्षा की गई है । नए सी एम सी को शामिल किया गया और उनका विशेषज्ञ द्वारा अनुमोदन किया गया है । अब इंटर आर एम ओ अथवा इंटरा आर एम ओ द्वारा उनका मूल्यांकन किया जा रहा है और एक बार जब उनको स्वीकार कर लिया जाता है, तो उनका प्रकाशन बी आई पी एम डेटाबेस के परिशिष्ट 'ग' में किया जाएगा । एन पी एल (आई) में रखी गई मापन के राष्ट्रीय मानकों की मापिकी समकक्षता की इन सवंर्धित क्षमताओं से, अन्तर्राष्ट्रीय स्तर पर हमारी अंशांकन और मापन क्षमताओं के लिए पारस्परिक मान्यता प्राप्त होगी । इसके परिणामस्वरूप, सरकार, उद्योग तथा हमारे देशों के अन्य पक्षों को सुरक्षित तकनीकी आधार उपलब्ध होगा जिससे वे अन्तर्राष्ट्रीय व्यापार, वाणिज्य और विनियामक मामलों के संबंध में विस्तृत सहमतियां प्राप्त कर सकेंगे । इन कार्यक्रमों गतिविधियों के परिणाम स्वरूप निम्नलिखित उपलब्धियां प्राप्त होंगी ।

- अन्तर्राष्ट्रीय व्यापार, बाधाओं में कमी
- समाज के समग्र विकास और जीवन की गुणवत्ता पर प्रत्यक्ष प्रभाव
- सवंर्धित घरेलू और अन्तर्राष्ट्रीय आर्थिक गतिविधि

PHYSICO-MECHANICAL STANDARDS

The Physico-Mechanical Standards (PMS) Division is one of the seven R&D Divisions of NPLI. The division constitutes of physical and mechanical measurement activities involving nine groups. The PMS is responsible to establish, maintain and continually upgrade the National Standards of measurements. Provides the apex level calibration services to the industry and institutions of the country and thus ensures the traceability to measurements made by these parameters.

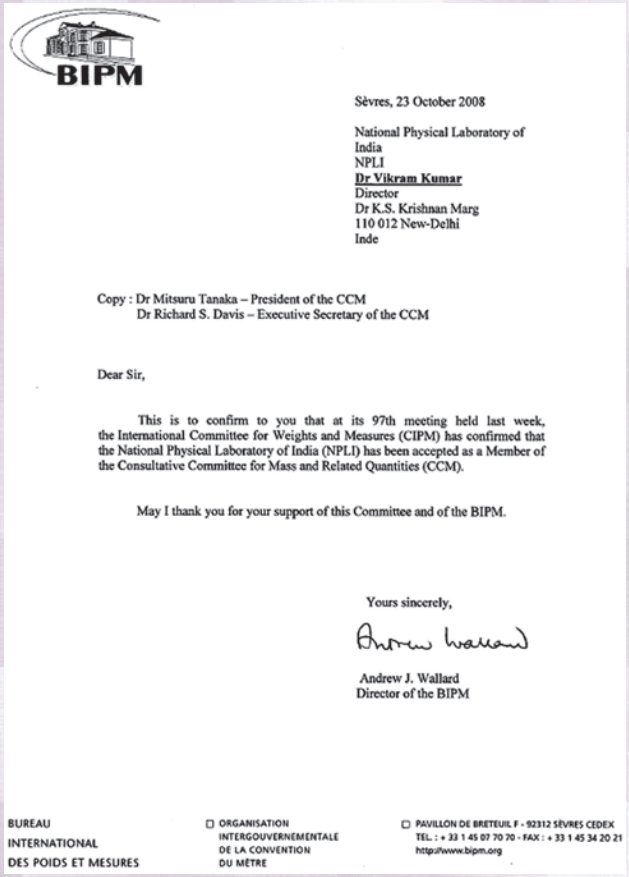
DP No.	Name of the DP
1.01	Mass Standards
1.02	Length and Dimension Standards
1.03	Temperature and Humidity Standards
1.04	Optical Radiation Standards
1.05	Force and Hardness Standards
1.06	Pressure and Vacuum Standards
1.07	Acoustic and Ultrasonic Standards
1.08	Fluid Flow Standards
1.09	Shock and Vibration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

Highlights of the Division :

1. **Recognization** : NPL India as Member of the Consultative Committee for the Mass and the Related Quantities (CCM), Bureau International des Poids et Mesures (BIPM), Paris, France from 2008: Letter dated 23rd October, 2008 from Prof. Andrew Wallard, Director, BIPM to Prof. Vikram Kumar, Director, NPL mentioning the confirmation of the membership in the CCM/BIPM.

Fig. 1.1 : The Photograph of Participants in the CCM Meeting on 24th - 25th April, 2008.

2. New Facilities created during this financial year :
   a) 50 kg Mass Comparator with readability 100 µg
   b) 1 kg Mass Comparator with readability 1 µg



BIPM

Sèvres, 23 October 2008

National Physical Laboratory of
India
NPLI
Dr Vikram Kumar
Director
Dr K.S. Krishnan Marg
110 012 New-Delhi
Inde

Copy : Dr Mitsuru Tanaka – President of the CCM
Dr Richard S. Davis – Executive Secretary of the CCM

Dear Sir,

This is to confirm to you that at its 97th meeting held last week, the International Committee for Weights and Measures (CIPM) has confirmed that the National Physical Laboratory of India (NPLI) has been accepted as a Member of the Consultative Committee for Mass and Related Quantities (CCM).

May I thank you for your support of this Committee and of the BIPM.

Yours sincerely,

Andrew J. Wallard
Director of the BIPM

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Fig. 1.2 : Shows the Letter Dated 23rd October, 2008 from Prof. Andrew Wallard, Director, BIPM to Prof. Vikram Kumar, Director, NPL Mentioning the Confirmation of the Membership in the CCM/BIPM.

c) A 500 kg Mass Comparator with Readability 100 mg

d) Multiple reflections device to enhance resolution of autocollimator

e) Establishment of Facilities for Non-contact Surface Roughness and step height,

f) Set-up for Automation in Thermocouple Calibration

g) Source based primary standard of spectral radiance and calibration work

h) Establishment of pneumatic pressure facility up to 40 MPa

i) Finite Element Method (FEM) for the characterisation of a controlled clearance piston gauge

3. Elected member of Task Group 1 (CCM) : on "Mass metrology under vacuum for a mise en pratique"; and Task Group 2 (CCM) : on "Uncertainty components due to traceability to the international prototype of the kilogram".

4. The calibration and measurement capabilities (CMCs) have been peer-reviewed by Technical experts of leading NMIs in the world for the group Mass, density, volume, viscosity, optical radiation and pressure and vacuum standards. New CMCs have been included and approved by the Expert. They are now in the process of evaluation by Inter RMO or Intra RMO and once they are accepted, they will br published in Appendix C of BIPM Database. These enhanced capabilities of metrological equivalence of the national standards of measurement maintained at NPLI will provide for the mutual recognition of our calibration and measurement capabilities at international level. As a result of this, government, Industry and other parties of our country have provided with a secure technical foundation for wider agreements related to international trade, commerce and regulatory affairs. These programs/ activities lead to:

- Reduction in International Trade barriers,
- Direct impact on overall growth of the society and quality of life
- Enhanced domestic and international economic activity.

Mass Standards

Re-established the national standards of mass

During the year 2008, national standards of mass multiples & sub multiples of 1 kilogram have been re-established through calibration of four 1-kg transfer standards of mass against the new values of the national prototype kilogram, recalibrated by BIPM in December 2002,

Under the Network Project CMM-25 a new 1 kg mass comparator has been procured and installed during the year 2007 and using this mass comparator we have upgraded our measurement capability from 40 µg to 28 µg at 1 kg level during the year 2008. With this capability we are at par with the best measurement capabilities at international level.

Fig. 1.3 : 50 kg Mass Comparator with readability 100 µg Make: Meitler Model : AX 64004

Fig. 1.4 : 1 kg Mass Comparator with readability 1 µg Make : Sartorius, Model : CC1000S-L

Under the Network Project NWP-45, a 50 kg and a 500 kg Mass Comparators procured, installed and placed in service during the year. Using these mass comparators we have again re-established the national standards of mass with new mass values of the four 1-kg transfer standards of mass. As a result of these new mass values, our measurement capabilities in the range of 1 mg to 500 g have been further improved and published in Special Issue of MAPAN Volume 23 No. 3 (July to September), 2008 and successfully Peer Reviewed by the International Experts during October 2008.

Fig. 1.5 : A 500 kg Mass Comparator with Readability 100 mg Make : Mettler : Model : XP604KM

Calibration and Measurement Capabilities (CMCs) in BIPM Database

Our six Calibration and Measurement Capabilities (CMCs) in mass, volume and density have already been included in Appendix C of BIPM Database in March 2002. These CMCs are the first CMCs of NPL India that included in Appendix C and successfully undergone the process of peer reviewed by the International Experts in January 2004.

These six CMCs have, again, been peer reviewed, successfully, along with one additional CMC in large volume measurement (100 liter to 2000 liter) and six new CMCs in viscosity measurements in the range (1.0 to 10000) mm^2/s, during October 2008, by a team of international technical experts.

APMP Pilot Study: Comparison of 1 kg Platinum-Iridium Mass Standards.

A pilot study of a Platinum-Iridium (Pt-Ir) Kilogram Mass Standard is being carried out through its inter-comparison among NMIs of nine participating countries of Asia-Pacific Region. This Pt-Ir Kilogram designated as No.651 calibrated and supplied by BIPM to NPL U.K. This kilogram has also been used in a comparison of primary platinum-iridium kilogram mass standards among eighteen European NMIs during the year 2007. The transfer standard (Pt-Ir No. 651) has been graciously provided by the mass laboratory of NPL, United Kingdom for this pilot study in APMP region. The participating NMIs of this study in APMP region are : NMIA (Australia), NIM(China), SCL (Hong Kong), NPL (India), AIST/ NMIJ (Japan), KRISS (Korea), A-STAR/NMC (Singapore), ITRI/CMS (Taiwan) and NIMT (Thailand).

The purpose of this project is to compare the values of the national copies of the prototype of nine NMIs of Asia-Pacific Region. While the results obtained can be used to demonstrate equivalence between the participants, the main objective of the work is to calculate the relative mass gains of the national copies, to analyze this data, and to draw conclusions about the relative stabilities of the kilograms. Each participating NMI uses an algorithm to predict the mass gain of their national standard. The results gained from this comparison will be used to evaluate the accuracy of these algorithms.

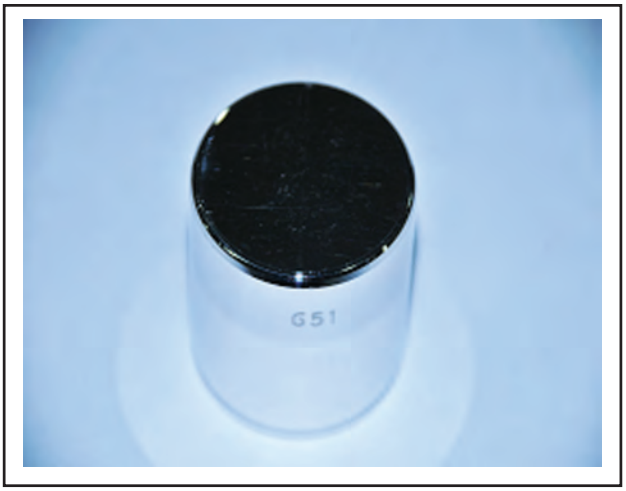


Fig. 1.6 : The Traveling Standard (Pt-Ir No. 651)

Fig. 1.7 : The Traveling Standard inside a transparent container

The KRISS (Korea) is coordinating the Program. In this Program the Pt-Ir Kilogram No. 651 is under circulation among each participating laboratory for inter comparison with its national prototype kilogram. From the Pilot Laboratory KRISS Korea, the Pt-Ir kilogram, under circulation, has been calibrated at National Metrology Institute of Australia (NMIA) against its national prototype kilogram during the month of February this year and after that it has been inter-compared at our Mass Metrology Laboratory against our Pt-Ir National Prototype Kilogram, copy no. 57 (k-57) of the international prototype of the kilogram, during the

month of March. As per the Protocol of the Program, the Pt-Ir kilogram under circulation is to be transported by hand-carrying only. Our responsible Scientist has delivered it by hand-carrying to the next participating laboratory, (CMS-ITRI) of Taiwan during the last week of March. After its calibration at CMS/ITRI Taiwan, it has been hand-carried to NMIJ Japan the next participating laboratory by responsible Scientist of CMS/ITRI Taiwan.

The comparison is targeted to be completed by December this year and then from the measurement results of various participating laboratories, relative mass gains of the national prototype copies will be calculated to analyze these data, and to draw conclusions about the relative stabilities of the kilograms.

APMP.M.M-K2 Inter-comparison in Mass Measurement

As per decision of the APMP-TCM, a multiples/sub-multiples of 1 kg, key comparison with title APMP.M.M-K2 was initiated in Asia-Pacific Region during the year 2004. The National Metrology Institutes (NMIs) of eleven countries i.e. Australia, Hong Kong, Indonesia, India, Korea, Malaysia, New Zealand, Singapore, South Africa, Thailand and Taiwan, have participated in this program. The four NMIs, Center for Measurement Standards, Industrial Technology Research Institute (CMS-ITRI) Taiwan, Korea Research Institute of Standards and Science (KRISS), Korea and Measurement Standard Laboratory, (MSL) New Zealand and National Physical Laboratory India (NPLI) form a Technical Management Group (TMG) for the comparison. This Group was headed by Mr. Tripurari Lal. NPL India took overall responsibility for the comparison and CMS-ITRI, KRISS and MSL have offered to provide all possible help to organize and run the program. The program was coordinated & piloted by the NPLI. A set of five weights (10 kg, 500 g, 20 g, 2 g and 100 mg) was circulated among all the participating laboratories in July 2004 and received back from the last participant in March 2007. NPLI took about six months to check the stability and to calibrate these mass standards before their circulation to the participants and recalibrated them two times in between and fourth time at the end of the inter-comparison. Then following CIPM (International Committee of Weights & Measures) Guidelines for key comparison and in consultations with the participants, members of the TMG and Chairman APMP TCM, the first Draft A Report of this comparison was prepared in September 2007. First revision of the Draft A Report was released in July 2008 and second revision and final Draft A Report in February 2009

For Draft B Report, the results were further analyzed to link APMP.M.M-K2 to CCM.M-K2 and establish the degrees of equivalence among the participants with each others and between the values of each participant with the Key Comparison Reference Value (KCRV) as required by the CIPM-MRA.

Draft B Report is the final Report which, on 15th April 2009, has been submitted to the APMP TCM Chairman. The APMP TCM has approved it and submitted to the Chairman of CCM for its approval for its inclusion in Appendix B of BIPM database and publishing in special Technical Issue of Metrologia.

SAARC-PTB Technical Cooperation Program

In the frame of the project "Support to the regional cooperation in South Asia for the establishment of MSTQ-systems", PTB is promoting the intra-regional collaboration of national metrology

institutes of SAARC countries. This collaboration includes the mobilisation of expertise available within the region. In this respect, a particular role for knowledge transfer is attributed to the National Physical Laboratory (NPL) India. By the letter of commission, PTB assigns NPLI to provide short-term technical expertise to NMIs in neighbouring SAARC-countries in order to prepare them for successfully participating in the planned inter-comparisons.

APMP.M.M-S1 Intercomparison

Under SAARC - PTB Technical Cooperation Program, a Supplementary Comparision in Mass Measurement had to be organized during the year 2008. The pilot Laboratory for this comparison was NPSL Islamabad Pakistan and the responsibility to prepare protocol and to calibrate & established the stability of the traveling standards to be circulated under this program was entrusted to NPLI by PTB Germany. All the planning related to this program, including preparation of the protocol and registering this intercomparison in Appendix B of BIPM database as APMP.M.M.S1, have been done by NPLI. NPSL Pakistan had to only pilot the program with all technical guidance from NPLI. But so far due to some technical reasons NPSL Pakistan, being pilot laboratory, could not take any initiatives to start this program.

Training Staff of NMIs of SAARC Countries

To train staff of NMIs/ National Laboratories of SAARC Countries, so that they may successfully participate in the APMP.M.M.S1 intercomparion, PTB has also entrusted this responsibility to NPLI in mass measurements.

We have already imparted six days training, each, to the staff of Mass Metrology Activities of NBSM Nepal and MUSSD Sri Lanka. Such trainings to the staff of Bangladesh Standard and Testing Institution (BSTI), National Institutes of Metrology , Bhutan and Maldives are to be organized during the current year.

Length and Dimension Standards

"Software for Calibration of angle gauges" - Copyright obtained

The software is useful for the calibration of angle gauges using indexing table and autocollimator by comparison method. Angle gauges are artifact standard to realize the angle.

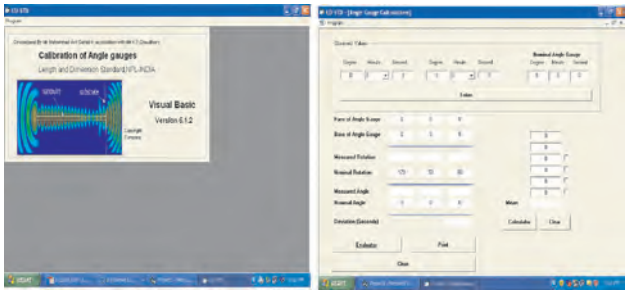


Fig. 1.8 : Calibration of angle gauges - Copyright

- *All the calculation of angle gauge measurements are coded in visual basic version-6*
- *Sign of the error is determined automatically*
- *The calculations are self explanatory for cross checking*
- *It saves time for calculations of average value and standard deviation*

The commercial value of this software may be approximately rupees two lacs. However, the demand of this software in market may be taken into account during the licensing.

Establishment of Facilities for Non-contact Surface Roughness and step height measurements using Optical Profiler (veeco

NT9800) of 3d optical Profiler with traceability to SI unit has been established.

Calibration of magnification was carried out using pitch standards. Detailed Performance Evaluation of the set up was made by measuring step heights of 9nm to 1um, traceable to NIST USA using various magnifications.

Comparison of Roughness Measurements using Stylus and Optical Method:

A Study has been made on the roughness measurements using two techniques (i) mechanical or contact method and (ii) optical or non-contact method. We have also studied the effect of sampling length and effect of window averaging size on optical method. We found the results are in agreements using both techniques and are within the uncertainty of measurement for roughness range 1 to 1.77 ì m.

Comparison of two techniques for step height is in progress

INTERNATIONAL INTERCOMPARISON

A) SIM LK-3 (Angle comparison) Pilot lab : Dimesion Metrology Lab INMETRO Brazillian NMI. Ten laboratories participated in theComparison

B) Euromet LK-7 (LINE SCALE) : Pilot Lab-University of MariborTwelve lab participated in the comparison.

C) APMP LK—4 (DIMETER STANDARD): Thirteen labs participated and the intercomparison is in progress. Artifact send to another NMI.

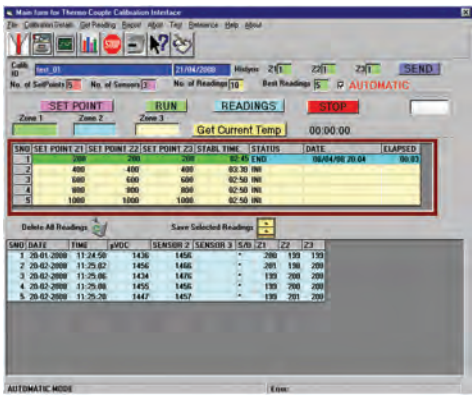
Temperature & Humidity Standards

Temperature & humidity standards maintains the national standards of temperature as per ITS-90 and is actively involved in providing the apex level calibration & dissemination of standards for maintaining the traceability of measurements.

The following thermal equilibrium states are maintained in the range of -189 deg.C to 962 deg.C as per procedure described in the text of International Temperature Scale of 1990. Realization, maintenance, up gradation and utilization of temperature standards as per International Temperature Scale, 1990 (ITS-90) and its dissemination to laboratories and industries through apex level calibration.

SIGNIFICANT ACHIEVEMENTS

1. Calibration range for noble metal thermocouples has been extended from 1100 ºC to 1600 ºC particularly, for the 10%Rh-Pt/Pt (Type-S) and 13%Rh-Pt/Pt (Type-R). Uncertainty achived between ±1 °C to ±1.5 °C.



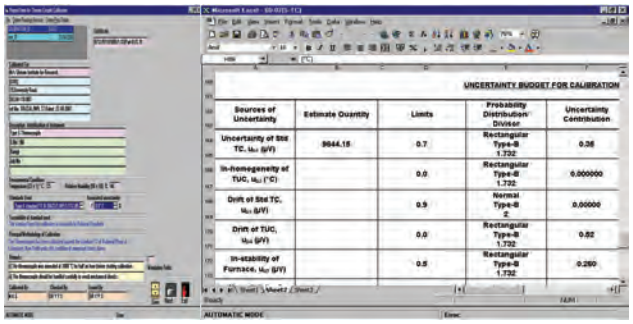


Fig. 1.9 : Set-up for Automation in Thermocouple Calibration

2. A complete automation in the thermocouple calibration has been completed using software developed based on the embedded technology.

3. Calibration of standard thermocouples was started at fixed points of In(156.5985 ºC), Sn(231.928 ºC), Zn(419.527 ºC), Al(660.323 ºC), Ag(961.78 ºC), and Cu(1084.62 ºC) and Au(1064.18 ºC) & Pd (1554.5C) by wire-bridge technique.

4. A facility has been created to provide calibration of IR pyrometers in the temperature range 50 ºC to 1300 ºC against a standard Type-S thermocouple using spherical blackbody source of high emissive power (0.99).

5. One national patent was filed with application No.213/NF/2008 entitled *"Ferro fluid based temperature sensor"* with a team of inventors namely; *R.P. Pant, Vinod Kumar, Anu Rana, V.K. Jain, S.K. Halder, Y.P. Singh & Vikram Kumar.* A repeatability of ± 2 mK was measured in the range 15° C to 40 °C to the best uncertainty of ± (5-10 mK) at k=2 for 95% confidence level.

Humidity standards

1. Mainintained the reference humidity standards (an aspirated psychrometer using two precise quartz thermometers) for calibrating RH instruments/hygrometers, in the RH range 15 % to 95 % RH with an uncertainty of 1 % RH.

   Regular maintenance and overhauling of the existing humidity oven (Gallen Kamp) twice in a year.

2. Developed three (3Nos.) prototype Compact RH Generator based on two pressure technique for humidity calibration to meet the industries requirement in the range of 15 to 95 % RH, with ?1 % RH stability. These devices were tested in the whole range for its satisfactory performance and these were sold to M/s. Labin Scientific Instruments and Calibration Pvt. Ltd., New Delhi, M/s EMM Tech Calibration, Faridabad (Haryana) and Precision calibration Laboratory Bhubaneswar (Orrissa) For Rs. 1,65,000/- (Rupees One Lakh Sixty Five Thousand) through CFCT Section. Two days training were also provided for their Personnel's.

3. Calibration of Digital RHT Sensors/indicators from calibration laboratory & Industries (ECF Rs. 2.5 Lakh) No. of Calibration reports issued = 22

4. In-house Calibration of RHT indicators of all Standards labs in NPL were calibrated (Notional Calibration Charges Rs.7.6 Lakh were saved) No. of Notional calibration reports issued during the period = 54

5. Implementation and practice of Quality System as per ISO/IEC –17025:2005 of the Humidity Standards. Internal audit of the DP 1.03 (Part-C) Humidity Standards was completed successfully on 12th August, 2008 by the Assessors Dr. Ashok Kumar and Mr. Ajit Singh.

6. As directed by Quality Manager ,NPL conducted the internal audit of CFCT Section on 09-09-2008 & 10-09-2008 by my self and Mr. Harish Kumar. Audit findings were submitted to the Quality Manager with in a week.

7. Experimental setup for the measurement of resistivity (Using Electrometer/High Resistance Meter Keithley 6517A) of various samples for the development of Mn-Zn Ferrite by high energy ball mill and Nanocristalline $CoGd_xFe_{2-x}O_4$ particles and its applications on Bench-Top Two Pressure Humidity Generator, in the RH range 10 % to 95 % RH, with different temperatures.

8. Made two nos. of Resistance and Temperature measurement probes of RT measurement experimental setup for Lab View automation of Superconductivity & Cryogenics Division.

9. Evaluation & expression of uncertainty in the measurement of calibrations of special Relative Humidity & Temperature (RHT) Sensors and Two pressure humidity generator Bench Top-2500 (Thunder Scientific) .

Optical Radiation Standards

Peer review of the CMCs of the Optical Radiation Standards

Re-assessment of the CMCs of the optical radiation standards was conducted in September 22-23, 2008 and the CMCs were recommended further to be continued as per BIPM regulations.

APMP Key Comparison (CCPR K4.x)

The transfer standards in the form of three Polaron LF 200W incandescent lamp having identification nos. as P591, P592 and P593 were received from China after first round of measurement at NIM China. Measurements with these lamps were made and the results were found very much similar to the results obtained before sending them to NIM China.

Fig. 1.10 : Polaron LF 200W incandescent lamp as transfer standard

Source based primary standard of spectral radiance and calibration work

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

Basic research

Correlated photon metrology experimental setup was established and some fundamental work on sub-wavelength interference with pseudo thermal light was done. This will pave path for establishing quantum base for the classical standards of optical radiation.

Fig. 1.11 : Correlated photon metrology experimental setup

New experiments were done for the first time to determine two point Stokes parameters and related two point coherence functions. These results have appeared in Optics letters. The phenomena of interference and polarization were studied in both space-time domain and space-frequency domain. Basic research on optical coherence for its application on encoding and information processing was pursued further. Important results obtained were published.

Vibrational spectroscopic (Infrared spectroscopy, Near infrared spectroscopy and Raman spectroscopy) studies were under taken to evaluate the stability of some pharmaceutical compounds under different stress conditions. Three different compounds namely 5- fluorouracil, Indinavir sulfate and Nelfinavir were chosen for this study. Thermal stability, photo stability and chemical stability were studied as per ICH guidelines. Differential scanning calorimetry (DSC) and X-ray diffraction (XRD) were used as complementary techniques to adequately implement and assist in the interpretation of vibrational spectroscopic data. The results suggest that vibrational spectroscopy can be used as a simple, rapid and reliable stability indicating technique to assess the stress stability of pharmaceutical compounds.

Externally Funded Projects

Funded by BDT, New Delhi

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

Compositional analysis of thirteen different packed fruit juices was done using high performance liquid chromatography (HPLC). Sugars (sucrose, glucose and fructose), organic acids (citric and malic) and vitamin C were separated, analyzed and quantified using different reverse phase methods. The precision results of the methods showed that the relative standard deviations of the repeatability and reproducibility were < 0.05 and < 0.1, respectively. Correlation coefficient of the calibration models developed was found to be larger than 0.99 in each case. It has been found that the maximum portion of sugars in most of the packed juices was of sucrose, while citric acid was found as the major organic acid.

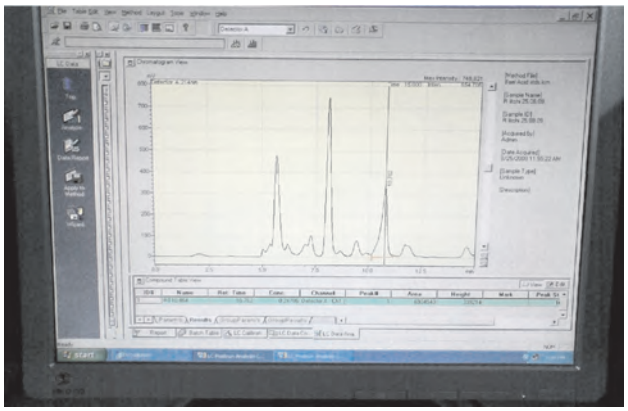


Fig. 1.12 : Experimental setup of HPLC

Bael fruit is an important part of ayurvedic practice, as it has got perceived medicinal benefits. The fruit mainly consists of water, protein, sugars and organic acids. Determination of sugars and organic acids in fruits are important, as they are responsible for the texture, sweetness and flavour. In the present work, sugars, organic acids and Vitamin C content in bael fruit were determined by high performance liquid chromatography (HPLC) using different reverse phase methods. It is evident from the results that the present HPLC method can be used successfully for the determination of sugars, organic acids and vitamin C in bael fruit.

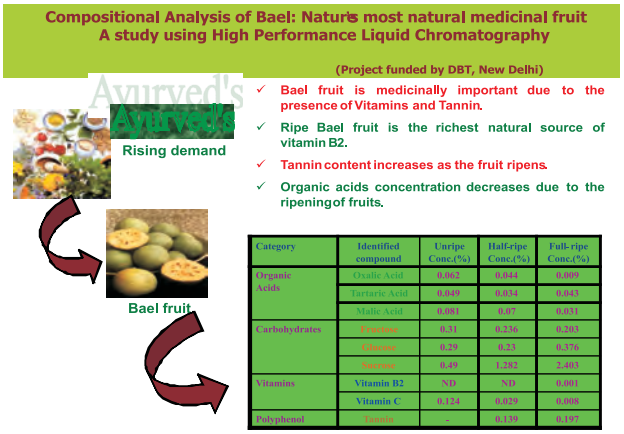


Fig. 1.13 : Bael fruit for ayurvedic practice

Funded by DST, New Delhi

Infrared spectroscopic study for tumor diagnosis

Several hospitals were contacted for getting human tissue samples. Detailed plan of work, protocol of the experiments and performa for patient's consent were submitted to the hospital prior to the collection of samples. Dharamshila hospital, Vasundhra, New Delhi agreed to provide the samples after fulfilling their conditions. Wax embedded and formalin fixed normal and cancerous tissue samples were brought from the hospital. Tissues were processed by xylene, ethanol and Tris-EDTA for dewaxing and rehydration. Each tissue was divided in to two parts. One part was homogenized and layered on ZnSe crystal for FTIR analyses. The second part of the tissue was processed for various steps of DNA extraction using a commercial kit. After extracting DNA, the ratio of UV absorbance at 260 and 280 nm was calculated to check the purity of DNA extracted. The purity of extracted DNA was further checked by Gel electrophoresis. FTIR spectra of extracted DNA from both cancerous and normal tissue samples were recorded.

Infrared spectra of normal and malignant breast tissues were measured in the 600 cm^{-1} to 4000 cm^{-1} region. The measured spectroscopic features, which are the spectroscopic fingerprints of the tissues, contain the vital information about the malignant and normal tissues. The novelty of this study lies in the fact that from the spectroscopic data we could differentiate malignant tissue from the normal one. We analyzed Fourier Transform Infrared (FTIR) data of thirty cases of different types and stages of cancer from patients of different age groups. Infrared spectra demonstrate significant spectral differences between the normal and the cancerous tissues. In particular, changes in frequency and intensity in the spectra of protein, nucleic acid and glycogen vibrational modes as well as the band intensity ratios for lipid/proteins, protein/nucleic acids, protein/glycogen was observed. This allows us to make a qualitative and semi quantitative evaluation of the changes in proliferation activity from normal to diseased tissue.

Sponsored Project from Space Application Center on 'Development of Calibration-Validation (CAL-VAL) site at Kavaratti Island'

On site calibration of the data obtained by the radiometer immersed in the seas of the island was carried out at. The results were quite encouraging. This project was completed in March 2009.

Based on the success of the above project another project entitled 'Validation of OCM-II Geophysical products (Optical instrument calibration)' was sponsored by SAC, Ahmedabad in September 2008. This project is on-going project now.

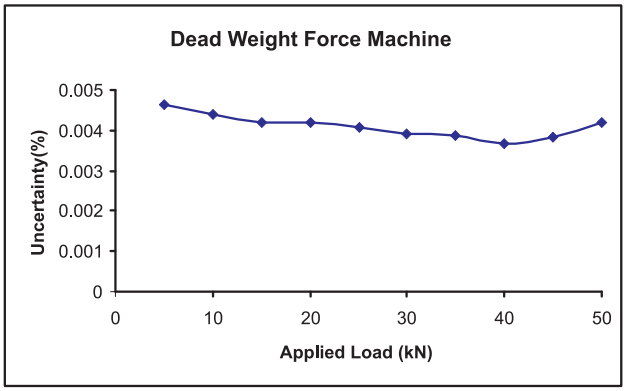
Force Standards

Consultancy project to design, develop and fabricate primary and secondary standard machines, for force as well as torque parameters

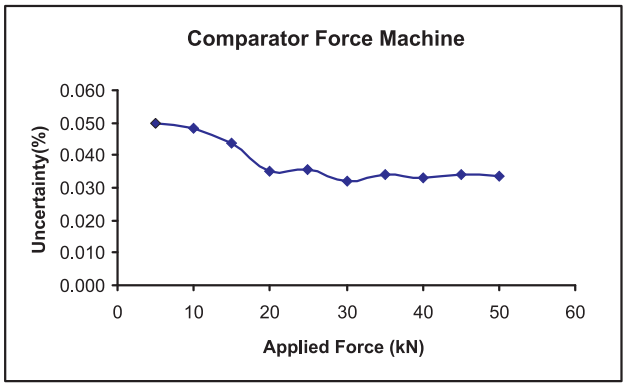
Four comparator type force machines of capacity 50 kN developed under the consultancy projects funded from the Department of Weights and Measures, Ministry of Consumer Affairs, food and Public distribution were fabricated, evaluated and delivered to Regional Reference Standard Laboratories at Faridabad, Guwahati, Bhubaneshwar and Ahmedabad. These machines were supplied with the necessary reference force transducers of capacities 5, 10, 20 and 50 kN to be used as standard in force comparator machines. The reference transducers were characterized to class 00 as per ISO 376-2004, and using these transducers the bmc of the comparator machines was affirmed to be within ± 0.05% at k=2 (Fig.1.14). A reliable, economic and sustainable technology, which can be deployed to transfer the force unit from NPLI to the shop floor level with a minimum loss of accuracy, has been established. This way NPL has assisted RRSLs to enhance their force measurement capability significantly. This newly developed technology has helped these RRSLs, for the first time outside NPL, to undertake calibration of force proving devices of class I. Design and development of torque standard machines of capacity 2000Nm was taken up and fabrication work of the machines was initiated during the year.

Consultancy project – simultaneous measurement of longitudinal and bending strains in Bolts used in Wind Mills – M/s Suzlon Energy (India) Outsourcing Calibration Work to NPL – A Benefit of MRA

M/s Suzlon Energy (India) is engaged in setting up Wind Energy Power Plants in



(a)



(b)

Fig.1.14 Measurement uncertainty of 50 kN reference force transducer in (a) dead weight force machine and (b) the force comparator machine.

India. Bolts of size M36 x 30 cm used to fix blades on the rotors form a critical component for reliable and efficient operation of the windmills. These have so far been using bolts manufactured and calibrated at their factory in Netherlands. Recently, the firm has started manufacturing the bolts in India. In an effort to establish an in-house calibration and testing facility, the firm outsourced to NPL a consultancy project to explore the feasibility of undertaking calibration of the bolts at NPL.

The task involved simultaneous measurement of longitudinal and bending strains at three different angles under 450 kN force and 200 Nm bending moment on specially designed metallic bolts to reduce the maintenance cost of windmill. The necessary fixtures, avoiding the area of the strain gauges, were designed and fabricated for the purpose and the methodology for the measurement of micro-strain generated in the strain gauges was evolved (Fig.1.15). The measurement results were reported to the sponsors as per their required format. The consultancy project generated an ECF of 4.25 lakhs and is successfully closed within the stipulated time frame.

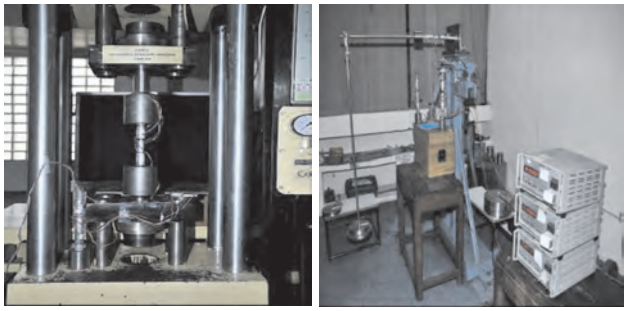


Fig.1.15 : Set-up used for measurement of longitudinal and bending strains in bolts.

Establishment of 1 MN Force National Standard **having an expanded uncertainty in the force realised less than ± 20 ppm upto 100 kN and less than ± 90 ppm from 100 to 1000 kN**

This is a major initiative for establishment of a state-of-art force standard machine of 1 MN capacity, which would be the national standard of force in this range and would have all the technical features necessary to enable class '00' calibration of force transducers as per latest standards ISO 376-2004, IS 4169-1988, ASTM E-74 2006 and participation in CCM or APMP key comparisons. The specifications of the force standard machine were drawn and finalised in consultation with the high power technical committee (having five external

members), duly approved by DNPL for the purpose. Purchase process was completed through a series of meetings of the technical committee right up to placement of order and opening of LC. It is expected that the machine would be delivered and commissioned in end 2009/ beginning of 2010.

An investigation was undertaken to evaluate the axial sensitivity of circular shape proving rings using FEM. The axial deflection of a 20 kN proving ring computed using FEM are within 5% of the experimentally measured value. Deviation is mainly due to approximations in FEM analysis including linear model and idealizing circular shape for the proving ring.

An attempt to evaluate the effect of the excitation voltage on the calibration sensitivity of force transducers was also undertaken in order to understand its relevance as a calibration parameter. It was observed that there is a significant change in sensitivity of the transducers studied for each excitation volt in the range 2.5V to 10V, which is more than repeatability deviation observed in these force transducers. The result signifies a need to maintain the same excitation voltage during use as that maintained during calibration of force transducers.

The Brinell hardness primary standard machine, comprising of two units for ranges from 9.807 N to 612.900 N applied force and from 980.7

N to 29420.0 N applied force, was installed on a specially constructed steel platform to ensure stablility of the machines. The installation work is in progress and thereafter performance evaluation of the hardness standard machine with particular reference to repeatability and evaluation of uncertainty will be undertaken. With the establishment of this facility, NPL shall be fully equipped to provide traceability in all the three dominant hardness scales in industry, i.e. Rockwell, Vickers and Brinell.

The force and hardness standards facility is providing national traceability in Force, Torque and Hardness (Rockwell and Vickers scales) through the calibration of force and torque measuring devices and hardness blocks to various users from industries, defence and other government organisations and also from foreign countries including Kuwait, Oman, Dubai and Nepal. Approximately 450 calibration reports were issued to different users during the year and an ECF of Rs 49 lakh was generated.

Special calibration jobs were undertaken from (i) M/s Maruti Udyog Ltd. to calibrate the load cell signal conditioners (ii) the calibration and evaluation of bmc of the force calibrating machine (50 kN), fabricated based on NPL know-how and belonging to M/s DVG Laboratory, Gurgaon.

Pressure & Vacuum Standards

Vacuum Standards

- Establishment of Traceability

A new innovative idea has been incorporated to translate the traceability of UIM towards ultra high vacuum standards, pneumatic pressure standards and hydraulic pressure standards. The bridge has been built up through the systematic studies of two piston gauges [Ruska Inc. USA, made model no 2465 and piston Number TL- 508 and V-607]. This rigorous exercise has helped us to reduce the uncertainty budget by roughly 40-50% from the earlier peer reviewed value (2004-09) and at the same time all our National Pressure and Vacuum standards are integrated.

- Traceability of Ruska –TL-508

The Piston-Cylinder Assembly associated with the Ruska Piston gauge–TL-508 was characterized against UIM. The effective area of the Piston cylinder assembly is estimated as 3.357206E-04 m^2 with expanded uncertainty of ±13.8 ppm at $k = 2$. Another budget for the generated pressure of this piston gauge is prepared where the expanded uncertainty of the pressure generated is evaluated as Q (0.14 Pa, 0.0015 % of reading) at $k = 2$.

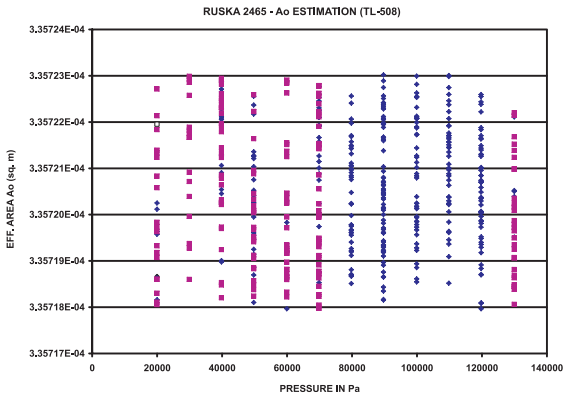


Fig. 1.16 : Effective area as a function of Pressure of Piston TL - 508

- Traceability of Ruska-V-607

The TL-508 Piston thus characterized against UIM was further used to characterize the V-607 Piston Cylinder assembly in the range 50 kPa to 250 kPa (gauge pressure) using method of cross floating where the effective area is estimated as 8.3924277*E*-06 m^2 with expanded measurement uncertainty of ± 20 ppm at $k = 2$. The effective area estimated is within 1.5 ppm agreement of the value evaluated through some recent key comparison exercises.

This piston in turn was used to characterize high range pistons for effective area estimation.

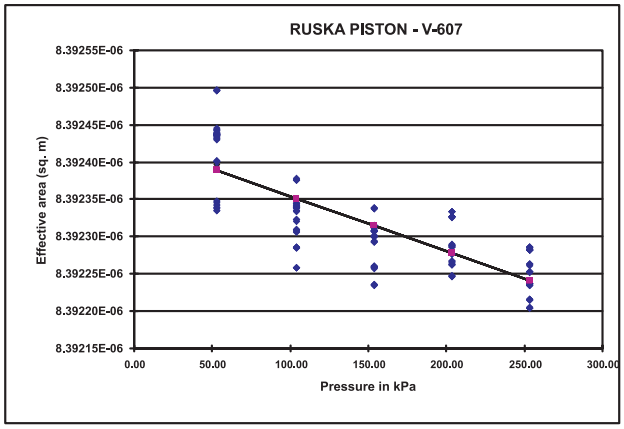


Fig. 1.17 : Effective area as a function of Pressure of Piston V-607

Through this exercise the expanded measurement uncertainty of all pneumatic and hydraulic piston gauges were evaluated and are found to have improve considerably.

Key comparison CCM.P-K12:

Participated in CCM.P-K12 key comparison in Nov. 2008 -Feb. 2009. Measurements were made on the leak rate of two helium permeation leaks (#1 and #2) for the comparison, one at a molar flow rate of about 3 x 10^{-11} mol/s (1 x 10^{-4} Pa l/s at 23°C), another of about 10^{-13} mol/s (3 x 10^{-7} Pa l/s at 23°C). The data is being analyzed and results would be shortly submitted to PTB, Germany for preparation of Draft A of the Key comparison. The participants of the key comparison are: 1. Czech Metrological Institute (CMI), 2. Czech Republik, INRIM, Italy, 3. IMT Institute of Metals and Technology, Slovenia, 4. LNE, France, 5. NIM (China), 6. NPL (India), 7. NMIJ-AIST (Japan), 8. NIST (USA), 9. VNIIM (Russia), 10. ASTAR, Singapore.

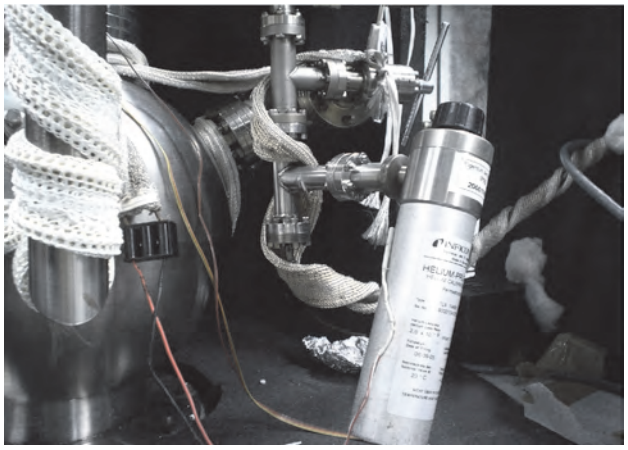


Fig. 1.18 : Artifact of the International key comparison CCM.P-K12

Finite Element Method (FEM) for the characterisation of a controlled clearance piston gauge

The preliminary study of the behaviour of a high performance controlled clearance piston gauge (CCPG) in the pressure range up to 1 GPa through finite elemental method (FEM) is carried out. The FEM analysis provides characterization of a pressure balance in terms of effective area and distortion coefficient of the piston and cylinder, the effect of gap profile between piston and cylinder of this controlled clearance piston gauge, under the influence of applied pressure (p) from 100 MPa to 1000 MPa, on the pressure distortion coefficient (ë) of the assembly. The gap profile is also studied at different applied jacket pressure (p_j) such that p_j/p varied from 0.3, 0.4 and 0.5. The (2-ethylhexyl) sebacate is used as pressure transmitting fluid. The piston fall rate values (v_f) are also determined as a function of applied jacket pressure (p_j). The results thus obtained using FEM are compared with the experimental values.

FEM analysis shows that the clearance h between piston and cylinder decreases as p_j increases. The gap width also increases along the engagement length from top to bottom due to the increase in pressure distribution in the gap profile. The d remains almost unchanged having average value as 2.21 x 10^{-6} mPa^{-1} with measurement uncertainty 6.4 x 10^{-9} MPa^{-1} from 400 MPa to 1000 MPa. Though the pressure distortion coefficient, ë is independent of applied pressure but, the values of ë are much higher in FDM in comparison to CCM. In FDM, the ë varies from minimum 2.95 x 10^{-6} MPa^{-1}

to maximum 5.29 x 10^{-6} MPa^{-1} having average value as 4.41 x 10^{-6} MPa^{-1} with measurement uncertainty 2.6 x 10^{-7} MPa^{-1}. The pressure distortion coefficient ë is not much affected by applied pressure p but it is greatly affected by jacket pressure p_j. Consequently, the values of ë are larger in the free deformation mode in comparison to controlled clearance mode. The fine tuning of the modeling is required to produce consistent results with experimental values, specially the pressure distribution in the gap. The major cause of discrepancy is due to the changing of density and viscosity equations from 300 MPa to 400 MPa. Our future emphasis would be focused on to remove such gaps in the methodology and obtain consistent results.

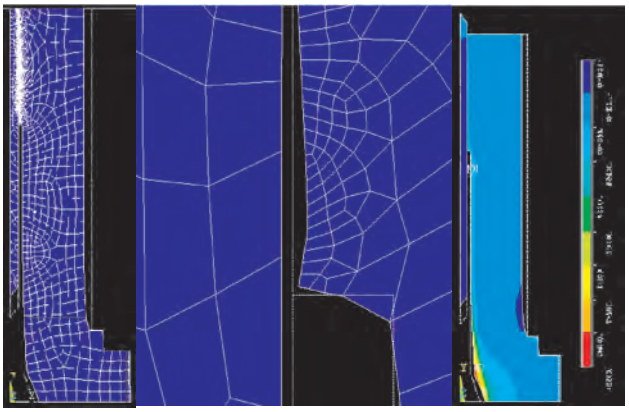


Fig. 1.19 : (a) Meshed structure of p-c assembly (b) meshing around engagement length and (c) image of the distorted p-c assembly in CCM mode at p = 1.0 GPa and p_j = 0.5 p

Establishment of pneumatic pressure facility up to 40 MPa

The work bench for the high pressure upto 40 MPa was completed and the traceability and uncertainty in pressure measurement was established with full characterization of the 40 MPa piston. This was brought about with the use of pressure boosting along with compressed air used for intensifying the input pressure up to the desired pressure. This work was presented at ADMET 2009.

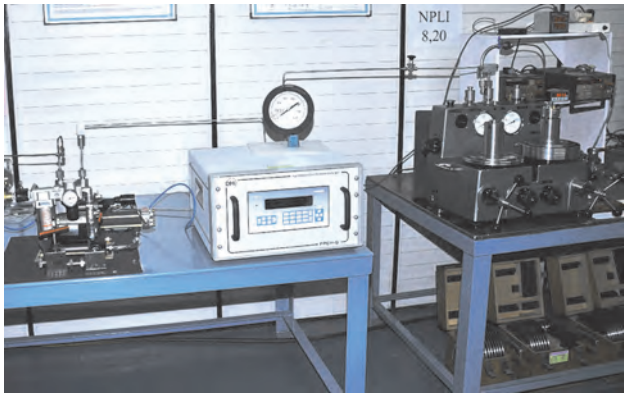


Fig. 1.20 : Establishment of pneumatic pressure facility up to 40 MPa

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

NABL-Pressure-PT005: This PT was organized for the laboratories having measurement capabilities better than 0.25 % and coarse than 0.05% of full scale using digital pressure calibrator as an artifact in the pressure range 7 – 70 MPa.

The results of the proficiency testing of the 21 laboratories, accredited by National Accreditation Board for Testing and Calibration of Laboratories (NABL) were included. The primary objective of organizing this proficiency testing was to assess the laboratory's technical competence to perform measurements and also assess the compatibility of results submitted by laboratories. This programme has been identified by code number NABL-Pressure-PT005. The program started in May, 2006 and completed during May, 2008. The comparison was carried out at 10 equally spaced pressure points i.e. 7, 14, 21, 28, 35, 42, 49, 56, 63 and 70 MPa throughout the entire pressure range of 7 – 70 MPa.

Out of the total 178 measurement results reported, 165 (92.7 %) measurement results are found in good agreement with the results of the reference laboratory, NPLI, New Delhi, in the present case. The relative deviations between laboratories

values and reference values are well within the 0.05 % for 123 measurement points, 0.1% for 162 measurement points and 0.25% for 177 measurement points. The difference of the laboratories values with reference values are found almost well within the uncertainty band of the reference values at 68.0 % measurement results, within their reported expanded uncertainty band at 81.5% measurement results and within the combined expanded measurement uncertainty band at 92.7 % measurement results. Overall, the results are considered to be reasonably good being the first proficiency testing for most of the participating laboratories.

NABL-Pressure-PT004: This PT was started during March 2008 for the laboratories having measurement capabilities better than 0.05 % of full scale using dead weight tester as an artifact in the pressure range 7 – 70 MPa. Total number of 9 laboratories participated in the PT. During the period under report, all the laboratories completed the measurements and submitted their results. The characterization of the artifact after completion of the loop would now be carried out. Results are under evaluation.

Basic Research : DST sponsored project on "High Pressure Raman studies of rare earth sesquioxides"

High-pressure X-ray diffraction studies on gadolinium sesquioxide (Gd_2O_3) have been carried out up to a pressure of 25 GPa in a diamond-anvil cell at room temperature. Gadolinium oxide, which has a cubic or bixbyite structure under ambient conditions, undergoes an irreversible structural phase at around 12 GPa. The high-pressure phase has been identified as a hexagonal La_2O_3-type structure. The bulk modulus and its pressure derivative of this phase have been calculated.

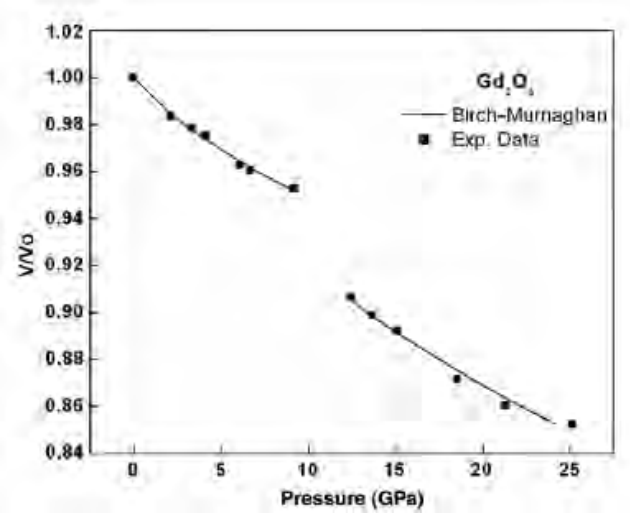


Fig. 1.21 : Cubic to hexagonal structural transformation in Gd_2O_3 at high pressure

Study of high-pressure-induced phase transition in nanocrystalline perovskite (LaSr)(MnFe)O_3 by Raman Spectroscopy

The nanocrystalline sample, synthesized by the sol–gel technique showed crystallite sizes of 140A° . The peaks originated as a consequence of the nano size of the sample as well as the Fe doping, reported for the first time in these manganites, could be identified and seem to be affected strongly by the application of pressure. Phonon softening observed in MnO_6 octahedra indicated structural instabilities with pressure and could be correlated to theM¨ossbauer parameter–quadrupole splitting. The results tally very well with those of high-pressure M¨ossbauer spectroscopy and electrical resistivity measurements.

Raman spectroscopic studies of nanostructures Zn(Mg,Cd)O alloy

We have arried non-resonant Raman study of $Zn_{1-x}Mg_xO$ (0d"xd"0.07) and $Zn_{1-y}Cd_yO$ (0d"yd"0.03) alloy nanostructures of sizes ~ 10 nm, synthesized by chemical route. Raman spectra of Bulk ZnO powder, series of $Zn_{1-x}Mg_xO$ and $Zn_{1-y}Cd_yO$ alloy nanostructures have been obtained.

Assigned Raman modes indicate that the LO mode of $Zn_{1-x}Mg_xO$ (x = 0.02) nanostructures can be fitted by two Gaussian to resolve A1 (LO) and E1 (LO) modes of ZnO. Observed and calculated shift in the E1 (LO) mode with Mg and Cd concentration is plotted. On alloying, both A1 (LO) and E1 (LO) mode of wurtzite Zn(Mg,Cd)O nanostructures show blue shift for $Zn_{1-x}Mg_xO$ and red shift for $Zn_{1-y}Cd_yO$ alloy nanostructures. Significant shift observed in E1(LO) mode for $Zn_{1-x}Mg_xO$ (73 cm-1 for x = 0.07) and $Zn_{1-y}Cd_yO$ (17 cm-1 for y = 0.03) however, accounts only 30% and 15% respectively of the calculated shift based on isoelectronic substitution of Mg and Cd into ZnO lattice. Our observation suggests that alloying achieved in the chemically synthesized nanostructures is partly intermixing of two atomic species in the random interstitial sites of ZnO lattice. Phase segregation in the alloy nanostructures is confirmed by the vanishing nature of the characteristic

Raman work under ambient conditions and under high pressures

Collaborative Raman spectroscopy work was carried out for IIT Delhi wherein In_2O_3 samples were studied. In addition, within NPL collaborative work was done on BN nanotubes as well as nano-silicon samples and good results obtained. We have also continued collaboration with High Pressure division at BARC Mumbai from July 21-27, 2008 and carried out high pressure Raman experiments on nano-crystalline Dy_2O_3, Yb_2O_3, Ho_2O_3 and CeO_2. The experiments were carried out upto a pressure of about 25-30 GPa. The results are presently being analyzed.

Combined Group Activities

The most important highlight of the year was the successful completion of the peer review on 23rd-24th Feb 2009. The group completed most of the necessary experimentation prior to the peer review. Except for the CMC of differential pressure, all the CMC's were revised and split into various ranges with new and much improved CMC's. The hard work of the whole team paid-off and no NC's were raised in the peer-review.

Acoustics & Ultrasonic Standard

Significant Achievements

1. Draft B of the Key comparison APMP.AUV.A-K3 on LS2P microphones has validated the CMC of Acoustics Standard.
2. Consultancy Project on Study of Noise and Vibration impact of Delhi Metro on proposed Taj Hotel in Dwarka successfully completed.
3. Consultancy Project on Acoustics treatment of Multipurpose Hall at Bhagidari Bhawan, Lucknow completed.
4. NPLI report on study for ascertaining the effect of metro train vibrations on Historical monuments (Tipu Palace and Tipu Sultan Fort) have led to clearance to Bangalore Metro corporation Limited by Archaeological Survey of India
5. As part of the project on the development of ultrasonic velocity referencematerial, an experimental set up has been designed, developed and installed at NPL. Continuous modifications and experiments using this setup have resulted in a system which now has many added features. The salient features include temperature stability to ±0.1° C, precision in velocity measurement to ±0.3% and possibility to work on volatile liquids with ease to ensure unchanged composition. The signal acquisition and processing is done through LabView.
6. The system for ultrasonic power measurement

has been improved. The target is now made of absorber. The entire tank can be moved up o down with a precision of 0.01 mm with the help of an indigenous platform.

7. As part of the project on the development of calibration procedure of cylindrical blocks having flat bottom holes, a battery of forty blocks have been fabricated with 1.2/1.6 mm diameter holes of flat bottom.

8. In the NABL sponsored Proficiency testing program in ultrasonic testing, NPL is a nodal laboratory. It has developed a special artifact for this purpose. The Artifact has been already sent to NABL for PTB-SAARC program.

9. For residual stress measurement in metallic alloys, detailed literature survey and analysis has been completed. Based on this study, it was decided that NPL will like to work on the development of Electro-Magnetic Acoustic system. Further work on technical specifications of the system to be developed has also been completed.

Fig. 1.22: Development of Calibration Procedurer For FBH Blocks

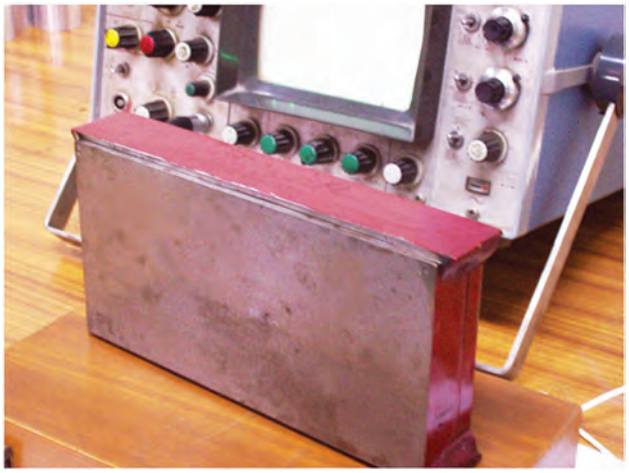


Fig. 1.23 : Artifact Developed For Ultrasonic NDT Proficiency Testing

Fluid Flow Measurement Standards

In Fluid Flow Measurement Standard, there are two Test Rigs namely 50 mm and 200 mm which are the Primary Standards for calibration of Water Flow Meters. The automation of the 50 mm est Rig was completed and automation work for 200 mm Test Rig was started. During the above period, 3 nos. of Test Reports were issued and an amount of Rs. 1.02 Lakhs was generated as an ECF for NPL.

विद्युत तथा इलेक्ट्रानिक मानक

ELECTRICAL AND ELECTRONIC STANDARDS

इलेक्ट्रिकल तथा इलेक्ट्रानिक मानक

इस विभाग द्वारा विभिन्न विद्युत, इलेक्ट्रॉनिक और चुम्बकीय पैरामीटरों के प्राथमिक और द्वितीय मानकों का अनुरक्षण किया जाता है और विभिन्न उद्योगों, अनुसंधान और विकसित प्रयोगशालाओं, रक्षा प्रयोगशालाओं तथा भारतीय अंतरिक्ष अनुसंधान संगठन इत्यादि को अनुरेखणीयता प्रदान की जाती है । यह विभाग अन्तर्राष्ट्रीय अंतर्तुलनाओं, द्विपक्षी और निपुणता परीक्षण कार्यक्रमों में संलग्न है ।

इस अवधि में विभाग की कुछ महत्वपूर्ण उपलब्धियां हैं जो निम्नलिखित हैं –

1. ऊर्जा मीटरों के निष्पादन पर एसी/डीसी चुम्बकीय क्षेत्र प्रभाव के अध्ययन के कार्य के लिए वर्ष 2007–2008 के लिए 26.9.2008 को उत्कृष्ट अनुसंधान तथा विकास टीम पुरस्कार ए सी पावर और ऊर्जा मानक विभाग को दिया गया ।
2. मोबाइल नेटवर्क का प्रयोग करते हुए टेलीक्लॉक रिसीवर के रूपान्तर का विकास किया गया है।
3. आई ई सी 404–2 मानक के अनुसार इलेक्ट्रिकल स्टील के शक्ति ह्रास मापन के लिए स्थापित परीक्षण सुविधा।
4. हाल ही में संघटित, अभिलक्षण और संस्थापित आटोमैटिक 10–वोल्ट जोसेफसन सीरीज ऐरे वोल्टेज स्टैण्डर्ड (JSAVS) पद्धति का प्रयोग करते हुए यूनिट वोल्ट के 'राष्ट्रीय मानकों' की उपयोगिता को निर्धारित (वैल्यु) किया है ।
5. एन पी एल ने टाइम स्केल (समय मापक्रम) के निष्पादन में सुधार किया है और अब सभी अग्रणी प्रयोगशालाओं से इसकी तुलना की जा सकती है ।
6. इस प्रभाग को SAG के साथ संयुक्त रूप से स्पेस क्वालिफाइड रूबिड़ियम क्लॉक को विकसित करने के लिए एक परियोजना मिली है । इस क्लॉक को भारतीय प्रादेशिक सैटेलाइट सिस्टम (IRNSS) के लिए विकसित किया जाना है जिसे 2011 में प्रक्षेपित किया जाएगा ।
7. प्रभाग द्वारा विकसित तीन सॉफ्टवेअरों को कॉपीराइट के लिए फाइल किया गया है ।

इस वर्ष पांच अनुभागों जे वी एस एण्ड डी सी, एल एफ इंपीडेंस, वोल्टेज, धारा एवं HF वोल्टेज व RF पावर, तनुकरण एवं प्रतिबाधा, एसी पावर व ऊर्जा और एसी उच्च धारा एवं उच्च वोल्टेज मानकों ने अंतर्राष्ट्रीय पीअर रिव्यु को सफलतापूर्वक पूरा कर लिया है ।

ELECTRICAL AND ELECTRONIC STANDARDS

Primary and secondary standards of various electrical, electronic and magnetic parameters are maintained by this division and provide traceability to the various industries, R & D laboratories, defence labs and ISRO etc. The division is also actively involved in the international intercomparison, bilateral and proficiency testing programmes.

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

i. The section of AC Power & Energy Std. received Outstanding Research & Development team award for the year 2007-2008 on 26.09.2008 for the work of studying AC/DC magnetic field influence on the performance of energy meters.

ii. A version of Teleclock Receiver using mobile network has been developed.

iii. Established test facility for the power loss measurement of electrical steel as per the IEC 404-2 standard.

iv. Assigned the values to the "National Standards" of unit volt using the recently integrated, characterized and established automatic 10-Volt Josephson Series Array Voltage Standard (JSAVS) system.

v. NPL has improved the performance of time scale and it is now comparable with all leading laboratories.

vi A project has been received on the Development of Space Qualified Rubidium Clock jointly with SAC. This clock is to be developed for Indian Regional Satellite System (IRNSS) which is to be launched in 2011.

vii Three softwares developed in the division has been filed for the copyright.

This year five sections namely JVS & DC; LF impedance, voltage, current and HF voltage and RF power; attenuation and impedance, AC power and energy and ac high current and high voltage standards have successfully completed the 2nd International Peer Review.

Time and Frequency Standards

NPL has the improved the performance of time scale and it is now comparable with all leading laboratories.

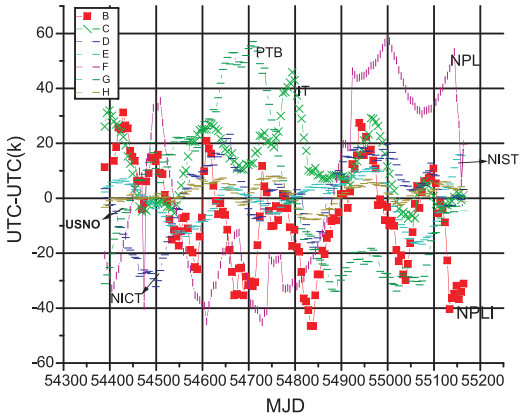


Fig. 2.1 Status of Time Scale of NPL

Project on the development of Laser cooled cesium fountain has shown significant progress. The entire optics has been completed and tested. The physics package has been assembled in parts and tested. The laser cooling of the Cs atoms have been achieved in a Magneto optic trap. Most electronic subsystems have been designed and developed.

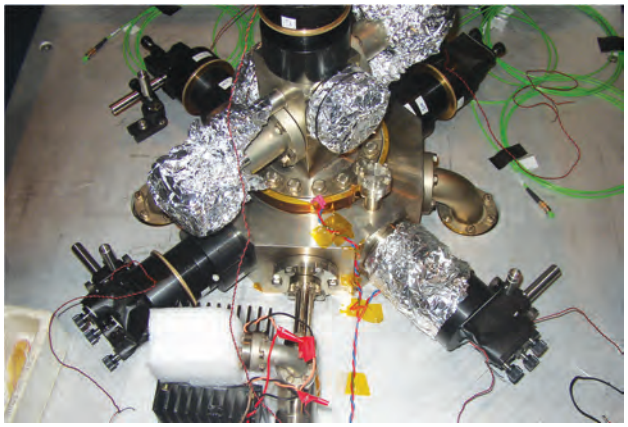


Fig. 2.2 MOT setup of the NPL

NPL has taken a project (Project code GAP 080632: Sept 2008: Rs 1.63 Crores sanctioned by SAC) on the Development of Space Qualified Rubidium Clock jointly with SAC. This clock is to be developed for Indian Regional Satellite System (IRNSS) which is to be launched in 2011. The Design Verification model, Engineering Thermal Model of Physics Package of the Rb atomic Clock is being developed at NPL.

Standard Time & Frequency Signal (STFS) via India Domestic Geostationary Satellite INSAT is being utilized by many users. Digital Time Service via Telephone (TELECLOCK Service) which has been started in early 2000, are now being used in many Airports and Railways station. A version of Teleclock Receiver using mobile network has been developed and final field trial is being conducted.

Quantum Hall Resistance and Superconducting Devices

Research and Development related to the Quantum Hall Resistance Standard

I. Traceability through the QHR has now extended to several other groups of NPL, e.g., Temperature Standards, DC high Voltage Standards and LF-HF Standards. Several Resistors ranging from 1 Ohm to 1 kOhm were calibrated during this period for the above mentioned groups.

II. The range of resistance calibration was extended. Earlier only 1 kOhm resistance was directly measured against QHR. To meet the high precision requirement of the other groups (such as Temperature and Humidity Standard) calibration range was extended down to 1 Ohm. Calibration procedures were optimized for various standard resistors in the ratio 10:1. The scaling down from QHR to 1 Ohm is achieved through the following chain: QHR (12.9 kOhm): 1000 Ohm→1000 Ohm : 100 Ohm→100 Ohm : 10 Ohm→10 Ohm : 1 Ohm. The combined expanded uncertainties (U_C) are given in the table below.

Nominal Value (Ohm)	Uc (ppm)
1000	0.08
100	0.10
10	0.15
1	0.20

Table 2.1

Development Work

An AC susceptibility measurement set up using the lock-in technique (this is the only AC susceptibility setup in NPL at present). The operation temperature range is from 77 – 300 K. This system has been found to be excellent for measuring the ferromagnetic transition in magnetic materials for bulk as well as thick films. However, in case of thin films the sensitivity is slightly lower, possibly because of much smaller volume of the material under study. The paramagnetic to ferromagnetic transition temperature (T_C) measured by this system shows excellent agreement with that measured by a vibrating sample magnetometer (VSM). A typical temperature dependence of χ_{ac} of polycrystalline bulk $Nd_{0.58}Sr_{0.42}MnO_3$ material (Reported T_C of single crystalline material is ~280 K) is shown in the main frame of the figure below. The inset shows the temperature derivative of χ_{ac} .

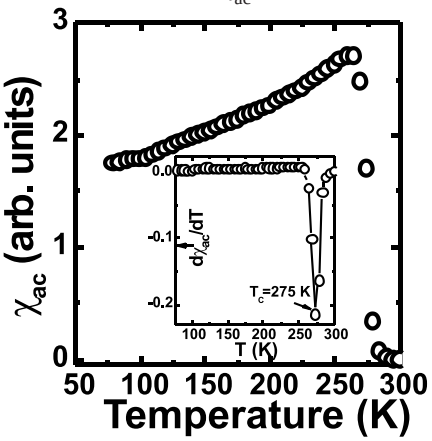


Figure 2.3: Temperature dependence of the c_{ac} of polycrystalline $Nd_{0.58}Sr_{0.42}MnO_3$ showing a sharp transition from PM to FM phase at T_C = 275 K.

Currently further modifications are being planned to make this system suitable for thin films as well as for superconducting materials.

Josephson Voltage Standard and DC Current, Voltage and Resistance Standards

During this period we have used the automatic 10-Volt JSAVS system integrated, characterized and established at NPL for the precision calibration of Zener reference standards (Model 7004, S/N 45366 & Model 734A, S/N 9085009). Based on these measurements we have assigned the values to the "National Standards" of unit volt. The results were presented in the Ad Met international conference. The results of calibration of the secondary standard of voltage shows the uncertainty of ± 300 nV at k=2 at 10V level as per the ISO/IEC 17025:2005.

Further the software used in the automation of Josephson series array voltage Standard was validated and the preliminary results were presented in AdMet conference.

The 'DC Standard Group' realizes, upgrade and maintain the 'Standards' of DC voltage, resistance and current at highest level of precision in India (on going). This year through controlled and precise measurement, uncertainty values of many secondary standards were brought down and range was increased.

The lab was prepared for the re-assessment of "2nd International Peer Review".

Six new CMC,s namely 10 V, 0.1 Ω, 1Ω, 10 mΩ, 100 mΩ, and 10 mΩ were added. Their calibration procedures were written and uncertainty evaluations were completed. Successfully completed the 'Peer' held in September 2008. External technical expert was from NIST, USA (Dr. Yi-hua Tang) and Quality expert was Mr. S. K. Kimothi.

In "Nanometrology Project" funded by Department of Information Technology, we have procured an 'Optical profiler' with self-calibration facility with respect to the laser. The facility has been tested and installed. The calibration and uncertainty evaluations of pitch, step height etc. is going on. Also, to establish the facilities of low-level electrical measurements namely nanovolt, nano ampere, micro-ohm and electrical charge, work of uncertainty evaluations are being carried out.

Total of 73 calibration reports were issued from this group and Rs. 15.10 Lakhs as notional value and Rs. 5.61 Lakhs as ECF were generated.

DC High Voltage Standards

The aim of this activity is establishment, realization, up gradation and maintenance of National Standard of DC high voltage through continuous research and development. It is providing calibration facility upto 100 kV for High Voltage DC equipments ie. DC High Voltage probe, divider, Power Supplies and Volt meter. Primary standard of DC High Voltage is the Resistive Divider, which is traceable to Josephson voltage standard of NPLI.

The facilities for high current and shunt resistance measurement (at high current) are also available in this group. Shunt resistance can be measured low up to 0.001 Ω at 600 A with an uncertainty of 30 ppm. This facility is traceable to Quantum Hall Resistance established at NPLI.

AC Power & Energy Standard

The section of AC Power & Energy Std. received Outstanding Research & Development team award for the year 2007-2008 on 26.09.2008 for the work of studying AC/DC magnetic field influence on the performance of energy meters.

The team consisted of M.K. Mittal, R.K. Kotnala, J.C. Biswas, A.S. Yadav, Sandeep Kohli, Kalp Kumar and Jaikishan

Energy theft was controlled to a large extent which was being done by these influences by inclusion of various clauses in standard specification of Central Board of Irrigation and Power (CBIP) for testing energy meters under these influences as shown in the figures2.4-2.6. In the forward of their new specification on Standardization of AC Static Electrical Energy Meters, CBIP recognized this R&D work done by NPL.

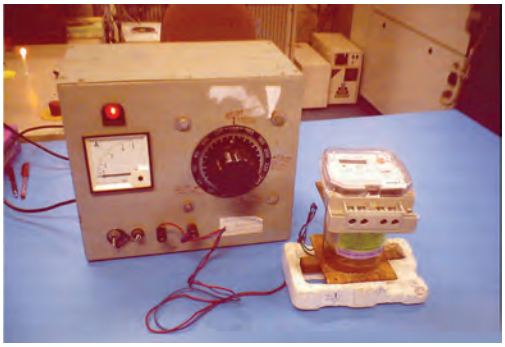


Fig. 2.4 Influence of Abnormal magnetic field : 0.27 Tesla dc

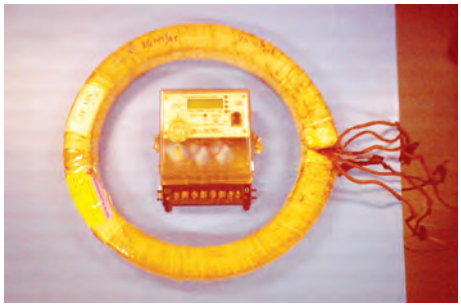


Fig. 2.5 Influence of Abnormal magnetic field (axial): 0.10 Tesla ac

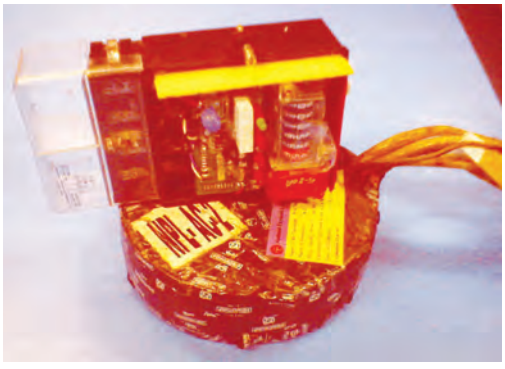


Fig. 2.6 Influence of Abnormal magnetic field (Probing) :0.20 Tesla ac

The activity was peer reviewed during 23-25 February 2009 for 28 number of CMC's Following improvement was demonstrated to the peer.

Active power/energy.

(1 Phase, 40Hz-70Hz) : from "100ppm-200ppm to 50ppm-150ppm"

(1 Phase, 70Hz-400Hz) : from "200ppm-500ppm to 150ppm-300ppm"

(3 Phase, 40Hz-70Hz) : from "100ppm-200ppm to 70ppm-150ppm"

Reactive power/energy

(1/3 Phase, 40Hz-70Hz) : from "100ppm-200ppm to 90ppm-150ppm"

Apparent power/energy

(1/3 Phase, 40Hz-70Hz) : from "100ppm-200ppm to 80ppm-150ppm"

All these improved uncertainties will be uploaded on BIPM website after due approval. The number of CMC,s are now 12 having matrices for different ranges.

We arranged a pre adMet workshop on Electrical Energy Metrology during Feb. 16-17. there were 47 participants from outside NPL in which 7 were from International laboratories. Afterwards a special issue of MAPAN (journel of MSI) volume 24, Issue 1, March 2009.

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 Break Down Test Sets and Voltage Transformer Burdens etc. As many as 64 calibration certificates were issued to the electrical manufacturers, utilities and referral laboratories of the country. The revenue earned was Rs. 24.63 lakhs.

LF and HF Impedance Standards

This activity is maintaining the primary standards of capacitance, inductance and ac resistance. Value to the 10 pF capacitor is assigned through primary standard, calculable cross capacitor, with an uncertainty of 0.6 ppm using precision ac bridges. Scale of capacitance is build up from 10 pF to 1 F using transformers bridges. The unit of inductance, Henry, is realized from capacitance and resistance using Maxwell-Wien bridge. Value to 100 μH to 10 H is assigned through this bridge. The unit of ac resistance, Ohm, is also realized from capacitance, using Quadrature Bridge and other precision ac bridges at 1k Ω. The scale of resistance from 1 Ω to 1 M Ω builds up with Kelvin double arms ac bridge. Precision reference airlines are being used as primary standards of HF impedance in frequency range of 10 kHz to 250 MHz.

This group had determined the temperature coefficient of standard inductors of value 1 mH (GR 1482, three nos.) by a PC based setup using difference voltage measurement technique. The temperature coefficient of these inductors in the temperature range of 22ºC to 27ºC lie between 42 to 47 ppm/ºC with deviation of ±5 ppm. It was also observed that these

inductors takes 10 to 12 hours to get stabilize against the temperature.

Similar studies were carried out using GR make standard mica capacitors of 0.01 μF (two pieces), 0.1 μF (two pieces) and 1μF (two pieces) to determine the temperature coefficient and stabilization time. These capacitors were kept in a commercial air bath, whose temperature stability is ± 0.05 ºC. The capacitors were kept at a desired temperature for 24 hours and after that their value was measured twice a day. It is found that the typical temperature coefficient for two mica capacitors of 0.01 μF is about 23 ± 10 ppm/ºC and 33 ± 10 ppm/ºC at a calibration temperature of 25 ±1°C. It is also observed, that these capacitors takes 2 to 3 hours to get stabilized against the change in temperature. Determination of temperature coefficient of these standards will be useful in inter comparison and proficiency testing programme

To calibrate impedance meter for high inductance values (>10 H), the reference standard inductors are fabricated using simulation technique. Using these standards, Inductance meters in the range 100 H to 10 kH can be calibrated with an uncertainty of 1% to 10%.

Second Peer Review of this group for claimed Calibration and Measurement Capabilities, which were uploaded on the BIPM website, was conducted as per APMP guidelines.

LF & HF Voltage, Current and RF Power Standards

LF Voltage & Current Standards:

Multi junction thermal converter (MJTC), the primary standard of LF voltage and current has been re-established in the frequency range 10 Hz to 1 MHz. Traceability of thermal voltage converters covering voltage range 250 mV to 1000 V and thermal current converters covering the current range from 1 mA to 20 A has been re-established to the primary standard MJTC.

RF Power Standards:

A bilateral comparison of RF power (100 MHz to 18 GHz) using coaxial microcalorimeter has been carried out between PTB-Germany and NPL India. The measurement result concludes that the RF power primary standard of NPL (India) has a close degree of equivalence with the primary standard of PTB.

RF Voltage Standards:

Twin resistive power head the primary standard of RF Voltage has been re-established against the primary standards of RF power, RF impedance and DC resistance. For the uncertainty of RF-DC transfer difference, sensitivity coefficients which depend upon the partial derivative of the dependent parameters (RF power, RF impedance and DC resistance) have been evaluated.

Automation Softwares:

We have applied for the copyright for three automation systems of RF Power standards developed for assigning the effective efficiency using coaxial microcalorimeter and assigning the calibration factor using direct comparison technique to the reference standard thermistor mounts and the power sensors to the IPMD CSIR HQ, New Delhi.

Developed an automation softwares for interfacing HP 3458A for data acquisition of fluxgate magnetometer for the measurement of earth magnetic field in microTesla using Agilent VEE Pro for the Magnetic standards group.

Developed an automated data acquisition system using Agilent VEE Pro for the measurement of resistivity of superconducting materials in the temperature range of 12 K to 325 K for Superconductivity and Cryogenics Division..

RF Attenuation and Impedance Standards

Re-establishment of traceability of attenuation and impedance parameters

The NPLI Primary standard of attenuation, 30 MHz WBCO attenuator have been re-calibrated from NMI Australia. The transfer standard of attenuation, attenuator & signal calibrator has been calibrated against the WBCO attenuator to further calibrate the coaxial step attenuator & fixed attenuators and rotary vane attenuators and other transfer standards in the traceability chain. The Primary standards of impedance i.e., Precision waveguides & coaxial airlines (Type N & 7 mm connector) have been re-calibrated from Dimensional metrology NPLI. The transfer standards of impedance, waveguide & coaxial mismatches have been calibrated against the Precision waveguides & coaxial airlines in the traceability chain. The activity issued 22 external and 18 internal calibration certificates and carved ELF of Rs. 5.2 lakhs.

Peer Surveillance:

Our activity has been successfully peer reviewed for CMC claims (Appendix C of BIPM MRA) for RF attenuation & Impedance standards and services based on International Standard ISO/ IEC 17025:2005 on 23-24 Feb. 2009 by the International technical expert Dr. Jeong-Hwan Kim, KRISS Korea and the Quality expert (Mr. S. K. Kimothi). The CMC entries in the Appendix C of BIPM MRA are still proudly maintained without any change in the dynamic range & frequency.

APMP Key Comparison (attenuation):

Report submitted: The artefact, a RF step attenuator has been calibrated in for Attenuation parameter at 60 MHz and 5 GHz APMP comparison No. APMP-RF-K19.CL with NIM, China as the pilot laboratory.

Establishment of calibration facility in 26.5 to 40 GHz range through Ka-band Primary & Transfer standards.

A precision waveguide and broadband standard mismatches of VSWR 1.10, 1.20 and 1.30 respectively have been indigenously developed at Ka-band frequencies (26.5 GHz to 40 GHz) in the form of reduced height waveguide terminated by matched sliding loads (Fig. 2.7).

Fig. 2.7 Laboratory developed Ka-band standards

The calibration of transfer wave guide standards have been performed against the primary wave guide standard using the conventional slotted line technique and their respective performance is shown in Fig. 2.8.

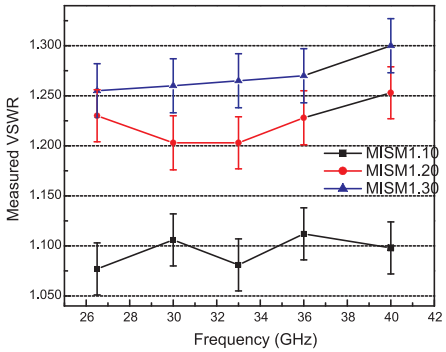


Fig.2.8 Measured VSWR along with their expanded uncertainties of standard mismatches

Magnetic Standards

Magnetic Standards

Calibration and testing of magnetic instruments and magnetic materials have been undertaken and issued 35 certificates, earning an ECF

of Rs. 2.5 lakhs. We have established test facility for the power loss measurement of electrical steel as per the IEC 404-2 standard. The power loss measurements are traceable to PTB Germany.

Magnetic Materials

Room Temperature CMR Material & Spintronics.

As a continuation of the research and development on the double perovskites CMR materials several studies have been conducted to enhance the magnetic and magneto-transport properties of the compound. These are listed below

Studies on the effect of substitution in the A site and effect of electron co-doping with Nd and La etc. have been explored.

Effect of substitution Mg in place of Sr in compound Sr_2FeMoO_6: Confirming the solubility of Mg ion at A site in this system

Mg content was added upto a stoichiometric amount of 0.5 in place of Sr. The solubility limit was found to be very low, which is less than 0.2 in stiochiometric amount. The sample with Mg content 0.1 showed better magneto-resistance behaviour compared to other samples. The figures given below show the variation of the magneto-resistance and magnetization of the samples. The effect of electon co-doping have shown that the Curie temperature of the system increases with respect to electron doping and we observed a slight increase in the magneto-resistance of the doped samples, though the magnetization of the samples were not as high as the undoped one.

Humidity Sensor Material Development:

To improve remarkably humidity sensing properties of magnesium ferrite special efforts were made to substitute cerium & Lithium in it.

It results into change in resistance of the material by two orders of magnitude while relative humidity is changed from 10 % to 90 % with a response time of 90 S exhibiting a least RH hystersis. This ceramic material is a better choice as humidity sensor in terms of stability, cost and excellent performance in wide operating range resistive sensitive device. The sensing property resistance

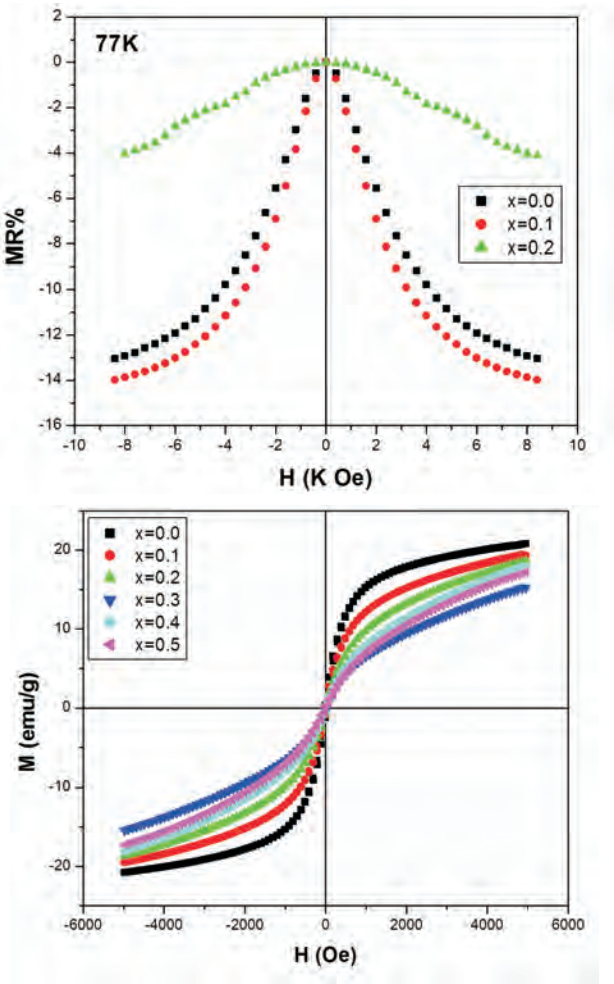


Fig.2.9 Magnetic moment versus field intensity. Magnetoresistance Vs applied field

change with RH follows a linear decrease in wide range by addition of rare earth alkali atoms to magnesium ferrite. This technical development would be very useful to integrate on silicon chip. Such efforts have made its potential very high for application as a resistive type humidity sensor.

[Sensor & Actuators B: Chemical 129, 2, 22, 909 (2008) & Sensor Letters 2009]

Nanomagnetism:

Nanoparticles of iron were prepared in distilled water using very thin wires by the electro-exploding wire technique in the range of 10 to 50 nm. The magnetic hysteresis loops indicate that the nanoparticles of iron are superparamagnetic in nature (J. Nanoscience & Nanotechnology). Such nanoparticles suspensions in water are being the effective potential application as decontaminant for ground water.

The effect of nano silicon dioxide substitution in lithium cadmium ferrite has been extensively studied in terms of magnetic and dielectric properties. It has been established that optimum content of nano SiO_2 in 2 wt% produces uniform grain structure of LiCd ferrite (prepared by sol-gel method) with a lowest dielectric loss in it at the frequency range 1 KHz to 1 MHz (Solid State Communication). There has been significant development for microwave component materials. Lithium ferrite as microwave component material. and Mn-Zn ferrite as shielding material in microwave X-band have been investigated.

Ferromagnetism in ZnO at room temperature

Stringently controlled experimentation on nanocrystalline ZnO doped samples by Lithium has resulted in room temperature ferromagnetism (upto 554 K). Ferromagnetism at room temperature has been unequivocally supported with formation of clear magnetic domains by MFM and broad ferromagnetic resonance by EPR in our studies. Besides ferromagnetism has been observed by M-H hystersis curve and Curie temperature measurements.

Magnetisation in p-type ZnO lattice due to Li doping confirms the role of Li in magnetic ordering at room temperature. Based on the experimental facts in ZnO:Li material system, a physical picture of spin ordering through exchange interaction between holes trapped in oxygen 2p orbital adjacent to Li_{zn+} site and its propagating influence through hole mediation results in long range ordering. Induction of local magnetic moments by vacancies on neighbouring atoms has been predicted from band structure calculations. Dependence of vacancy induced local magnetic moment and magnetic coupling required for long range ordering has been described via a single correlated band of oxygen orbitals with additional random potentials due to defects depending upon concentration of substitutional dopant & density of vacancies.

DMS, dilute magnetic semiconductors with Curie temperature above room temperature form an exceptional class of materials with immense potential for spintronic and magneto-optical devices. Li doped ZnO is a very good option for a new class of spintronic and spin LED devices as well.

MULTIFERROICS:

The work establishes new physical insight about the multiferroic origin of the magneto – electric coupling observed at the magnetic transition (Neel temp.) in the bismuth ferrite and barium titnate. This provides direct demonstration of magneto-electric coupling, which has been achieved for the first time in multiferroic materials among about 4000 research papers already published on the subject internationally. It is of high interest for applications due to their high possible working temperature esp. for actuators, sensors and data storage devices.

From the fundamental physics point of view, the coexistence of ferroelectric and magnetic order is contra-indicated by performing careful & precise measurements on the synthesized multiferroic material has been proved by experiments performed in this work:

Biomedical Measurements and Standards Group

ECG Parameters Extraction and Measurements:

The accuracy in the online measurement of ECG parameters has a decisive role in the better diagnosis and effective treatment of the diseases. From an engineering viewpoint, accurate measurement and acquisition of system observers is a fundamental necessity in order to model, understand and ultimately control a system. From a clinical viewpoint, the basis of a diagnosis is derived from observations and measurements. Pan Tompkins algorithm and Hilbert transform have undoubtedly been the most accepted solutions to extract out the parameters from the raw ECG signals. The work carried out describes a Lab-VIEW based programming using Pan Tompkins method and Hilbert transform to extract out some of the most informative and diagnostic elements such as QRS complexes, QT intervals and several other time domain measure of heart rate variability from the acquired ECG signal. Determination of QRS complexes employs Pan Tompkins algorithms, whereas QT interval measurements were carried out using Mat-lab based math-script module. Hilbert transform has been applied on the ECG signal to convert it into an analytical signal for better peak detection. The signal after acquisition, filtering by median filter and signal conditioning is preprocessed for its derivatives on which Hilbert Transform is applied. Peak detection and other parameters like RR interval, HR and several time domain measures of heart rate variability such as RR mean and standard deviations, HR mean and standard deviations, RMSSSD, NN50 count, pNN50 etc were calculated using the above algorithms for several other clinical applications apart from online disease diagnosis. Following are the front panels displaying respective parameters and their online measurements.

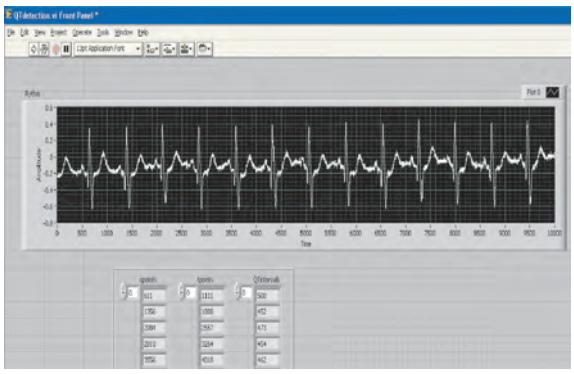


Fig.2.10 Front panel of QT detection

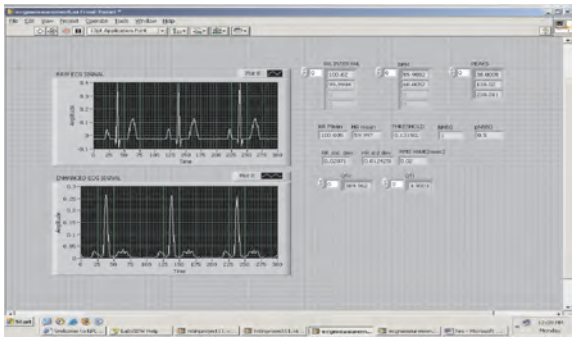


Fig.2.11 RR interval, Peak detection and HRV parameters of ECG Signal

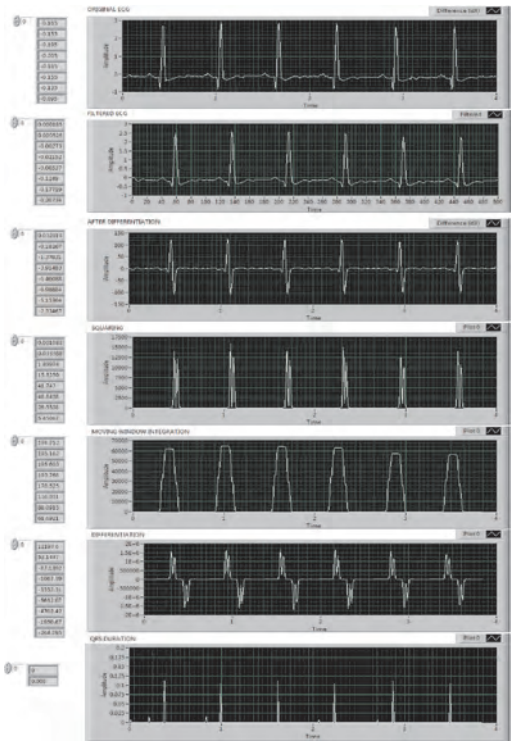


Fig. 2.12 Input/Output waveforms of a Normal Sinus Rhythm

इंजीनियरिंग पदार्थ

ENGINEERING MATERIALS

इंजीनियरिंग पदार्थ

इंजीनियरी पदार्थो के विभाग में धातु और मिश्रधातु, उन्नत कार्बन उत्पाद, बहुलक तथा मृदु पदार्थ और द्रव किस्टल समूह शामिल हैं । विभाग द्वारा, इसे सौंपे गए अनुसंधान और विकास कार्यो को विभिन्न सी एस आई आर नेटवर्क, प्रायोजित, सहायता अनुदान, परामर्शी और अन्य अन्तर्राष्ट्रीय परियोजनाओं के माध्यम से, उपरोक्त उल्लिखित क्षेत्रों के संबंध में पदार्थों प्रक्रियाओं और साधनों के विकास के लिए इस वर्ष जारी रखा गया है । अग्रणी पत्रिकाओं, राष्ट्रीय/अन्तर्राष्टीय पेटेन्टों, प्रौद्योगिकी हस्तांतरणों के रूप में अनुसंधान पत्रों द्वारा इस वर्ष अनुसंधान संबंधी कार्य निष्पादित किया गया है। जारी परियोजनाओं के संबंध में अनुसंधान और विकास गतिविधियों को जारी रखा गया है और इस वर्ष कुछ नई परियोजनाएं भी शुरू की गई हैं ।

ENGINEERING MATERIALS

The Division of Engineering Materials comprises of Metals & Alloys, Advanced Carbon Products, Polymeric & Soft Materials and Liquid Crystal groups. The division continued its mandated research and development this year on the development of materials, processes and devices in the above mentioned areas through different CSIR Network, Sponsored, Grant-in-aid, Consultancy and other International projects. Research output in form of research papers in high impact journals, National/International patents, technology transfers were produced this year. Research & Development activities were continued on the on-going projects and a few new projects also were initiated this year.

Metals & Alloys Group

R & D work this year was mainly concentrated on the processing of light alloys of Al & Mg and their composites under different network, consultancy and in-house projects. One of the significant achievements this year was the successful completion of the first phase of GM consultancy project, entitled "Advanced Magnesium Extrusion Alloys" which led to the award of its second phase for more than Rs. 65 lakhs. Research and development effort also was continued on other projects involving spray-forming of Al & Mg based alloys. Two important equipments for the processing of nanomaterials, viz., cryomilling and automated chamber glove box, were installed and commissioned this year.

I. Magnesium alloys

(a) General Motors Sponsored Project "mechanisms of recrystallization and grain refinement during extrusion of Magnesium-Rare Earth (RE) alloys"

The first phase of this project, entitled "Advanced Magnesium Extrusion Alloys" was successfully completed in the year 2007. One of the key achievements under above project was that slight addition of cerium (~0.2%) in magnesium resulted in room temperature ductility of more than 30% for hot extruded Mg-Ce alloys compared to only 9% in the case of extruded pure Mg. This significant enhancement in ductility of magnesium was achieved after the optimization of alloy composition as well as hot extrusion process parameters (such as, billet temperature, extrusion ratio, die design, etc).

Microstructural studies of the extruded samples showed equiaxed fine grains (Fig. 3.1). Based on the successful completion of this project, General Motors sponsored another project to NPL entitled, "to understand mechanisms of recrystallization and grain refinement during extrusion of Magnesium-Rare Earth (RE) alloys" for ~ Rs. 65 lakhs. The second phase of the project presently underway at NPL involves studying effect of rare earth addition on magnesium-zinc alloys. Magnesium-rare earth alloys with different amounts of zinc were hot extruded at different temperatures and extrusion ratios. The extruded square rods having 16 mm^2 cross-section have been characterized for their microstructure and mechanical properties. Detailed investigations are in progress to evaluate the microstructure and mechanical properties in order to establish structure-property correlation in these extruded Mg-Zn-rare earth alloys.

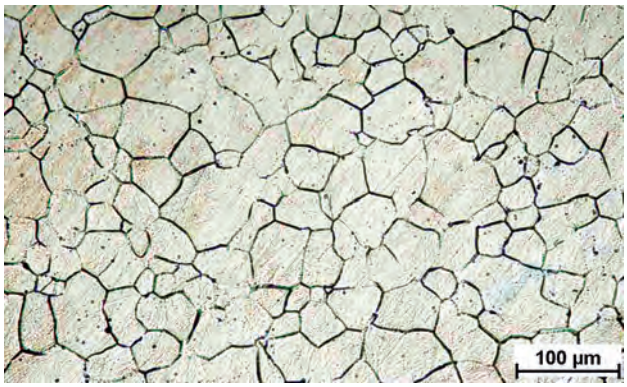


Fig. 3.1 : Microstructure of Mg-2Zn-0.2Ce alloy extruded square rods with extrusion ratio of 25:1 & temperature of 360° C

(b) CSIR Network Project on "Development of light-weight Al and Mg wrought products employing Secondary Processing such as Extrusion technique"

This project is under the CSIR Network project entitled "Development of Advanced Light Weight Metallic Materials for Engineering Applications". Under this project, magnesium alloys of different grades were hot extruded under different processing variables. Various hot extrusion process parameters are being optimized to obtain crack and defect-free circular rods and rectangular strips with

good surface finish. Microstructure and mechanical properties of these extruded products are being investigated.

(c) Synthesis of Mg-alloy using Spray atomization and deposition technique

Spray forming experiments were performed on high strength Mg alloy AZ 91C with chemical composition: Al-8.3; Zn-0.93; Si-0.30; Mn-0.25; balance Mg. The spray forming experiments were carried out by varying the delivery tube diameter from 3.25 mm to 4.00 mm and flight distance from 325 mm to 400 mm, keeping other process parameters constant. Circular nearly-flat plates as well as conical deposits were synthesized by varying the process parameters. The spray-forming yield was found to be about 60-65% of the weight of the melt and the density was observed to be 97 to 98% of the theoretical density. The optical microscopic observations of the spray formed samples indicated that by reducing the nozzle diameter the grain size of the sprayed deposits became finer. The mother alloy had grain size of 450-950 mm and by spraying it with the nozzles of ϕ 4 mm, ϕ 3.5 mm and ϕ 3.25 mm, the grain size was reduced to 25-65 mm, 20-40 mm and 15-30 mm, respectively (Fig. 3.2). The spray formed samples of the AZ91C alloy showed fine microstructure having intermetallic $Mg_{17}Al_{12}$ phase dispersed in matrix. The mechanical properties of as-sprayed samples were also improved by reducing the nozzle diameters. Samples sprayed through ϕ 3.25 mm nozzle showed UTS and % elongation 235 MPa and 10%, respectively, as compared to 140 MPa and 3.5% in case of cast mother alloy.

The AZ91 spray-formed alloy was rolled at different temperatures in order to reduce the inherent porosity and thereby improving the mechanical properties. The hot rolling process parameters optimization is currently underway to refine the microstructure & reduce the porosity of the rolled product.

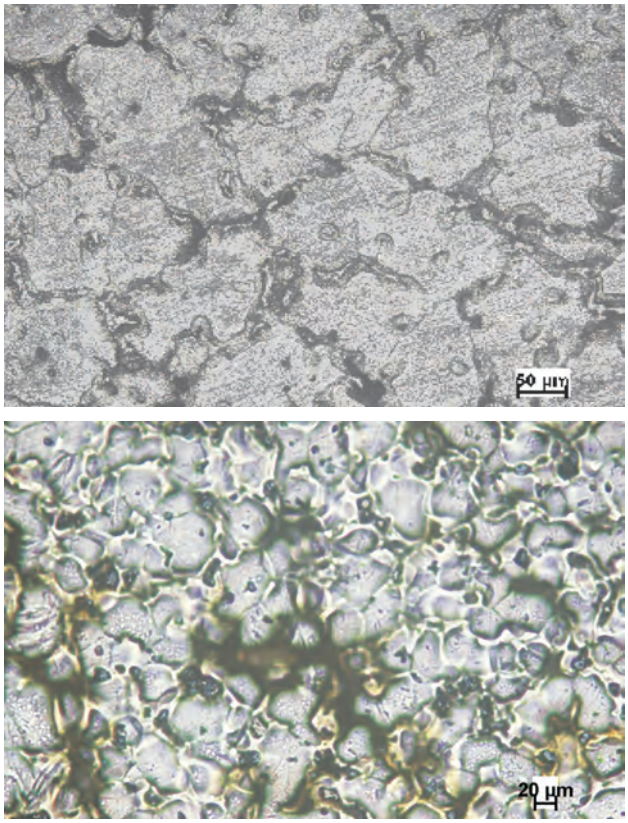


Fig.3.2 : Microstructure of AZ91 Mg-alloys (a) cast (b)) spray-formed

II. Aluminium alloys

(a) Non-Network Project entitled "Centre for Nanoscience & Nanotechnology"

The Centre of Nanoscience & Nanotechnology has been set-up at NPL under a non-network project. The project aims to develop bulk nanostructured lightweight Al/Mg metallic materials employing cryomilling or high-energy milling at room temperature followed by consolidation by an appropriate method. A cryomill (Make: Union process, USA; capacity: 5.6 litre) and facilities for mechanical alloying have been set-up under this project. A Glove Box (make: Mbroun, Germany) has also been set-up to process nanopowders under

protective atmosphere. Pure aluminum powder has been processed under liquid nitrogen as well as room temperature milling at different process parameters (such as, milling speed, milling duration, etc). The initial particle size of the aluminum powder was 300 mesh, which is considerably refined upon cryomilling and a crystallite size of about 50 nm (nanometer) is attained after cryomilling. Optimization of process parameters and further investigations are currently under progress.

(b) Synthesis & characterization of hypereutectic Al-30Si alloys using spray-forming

Al-Si alloys are important for many commercial automotive and aerospace applications, however, these alloys synthesized by Ingot Metallurgy route leads to non-uniform microstructure with large & coarse primary Si particles. These alloys when processed using spray forming result in fine size Si particles, uniform microstructure with reduced segregation and the rapid solidification makes synthesis of hypereutectic Al-Si alloys possible.

The work on the spray-forming of hypereutectic Al-30Si alloy was continued this year. The spray forming processing parameters were found to strongly influence the microstructure and it was observed that grain size & morphology of Si, depends on spray-forming processing parameters, mainly gas-to-metal ratio (GMR). On optimizing Spray-forming process parameters the cast microstructure breaks down and a uniform microstructure is evolved with Si having fine particulate-type morphology (submicron - 3 μm) and fine intermetallics (sub μm - 1 μm).

(c) Synthesis of Functionally Gradient MMC of 2124Al-alloy/SiCp

The work on the functionally gradient (FG) Al-alloy/SiCp Metal Matrix Composite (MMC) using centrifugal casting was continued. A number of experiments were made and functionally gradient MMC rings of 2124Al-alloy/15%SiCp (28mm) were synthesized by optimizing various process parameters, like, temperature of melt and rotating mould, rotation speed of mould, etc. The optical micrographs of the FG-MMC product rings displayed a variation of SiCp content from inner to outer periphery. The results indicated the lowest SiCp content at inner side of the ring, with increasing SiCp content towards outer periphery having a maximum at the outermost end.

Advanced Carbon Products

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

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

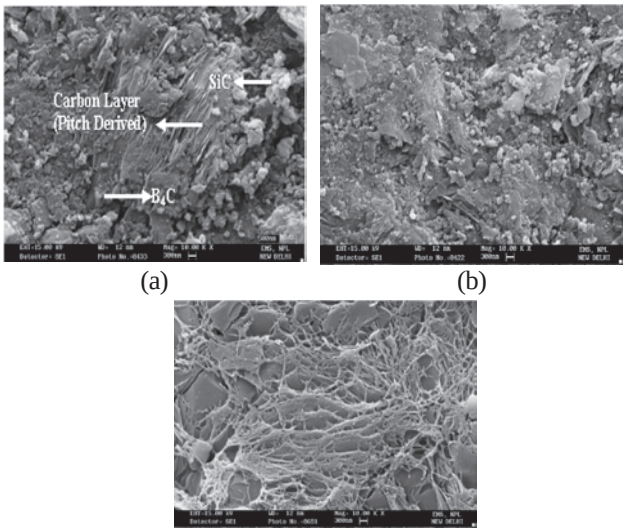
This project is sponsored by Department of Science & Technology, New Delhi. Carbon and graphite products are used widely in high temperature applications up to 3000°C in an inert atmosphere. However, they have a serious drawback of getting oxidized in air beyond 450°C and are completely lost / oxidized at 800°C in one hour. The development of carbon ceramic composites offers a solution to this serious problem. The carbon-ceramic composites

were prepared by incorporating silicon carbide (micro SiC particles as such or through reaction of Si and carbon which yields in-situ micro SiC) and B_4C in the green coke (developed in-house) at a HTT of 1400°C. These composites possessed a density of 1.86gcm^{-3} and their plates oxidized at 1000°C for periods up to 10 hours in air showed that they were resistant to oxidation and the oxidation had a little influence on their mechanical properties.

Carbon-ceramic composites were also developed by incorporating nano SiC developed in-situ by the reaction of silicon and carbon black as well as sol-gel silica and carbon black. X-ray, SEM and TEM confirmed the formation of nano-SiC in these composites. The oxidation resistance of these composites at 800°C to 1200°C for 10h showed that the size of the silicon carbide influenced the oxidation resistance. The weight gain due to protective coating formed on oxidation was higher in composites containing nano SiC as compared to the composites containing micro SiC.

The C-nanoSiC-B_4C composites exhibited low flexural strength as compared to the C-micro SiC-B_4C composites which was overcome by coating the precursor green coke with pitch. The physical properties of the carbon - ceramic composites (micro and nano) were improved significantly without affecting their oxidation résistance. The mechanical properties were increased by 25% in the carbon monolith and by 12% in C-micro SiC-B_4C composites developed with pitch coated green coke (Fig.3.3a). The bending strength increases remarkably from 66 to 147 MPa in the case of C-nano SiC-B_4C composites developed with pitch coated green coke (Fig.3.3b). It is interesting to note that pitch derived carbon layer covers the nano SiC rods / fibers formed on heat treatment which on oxidation got removed, thus exposing the nano rods/ fibers (Fig.3.3c).

The work is continuing to study the influence of oxidation at 1200°C on the properties of these composites.



(a) (b)

(c)

Fig. 3.3: SEM micrographs of pitch coated carbon-ceramic composites heat treated to 1400°C (a) C-micro SiC-B_4C before oxidation (b) C-nano SiC-B_4C before oxidation (c) C-nano SiC-B_4C oxidized at 800°C

II. Development of mesophase pitch for high performance carbon fibres

This project is sponsored by Defence Materials and Stores R&D Establishment (DMSRDE), Kanpur, as a sub-project of their major programme on Development of fibres. Carbon fibres are a special class of materials which are stronger than steel, stiffer than titanium and lighter than aluminium and are used in fabricating light weight fibre based composite materials. The objective of this project was to develop mesophase (liquid crystalline) pitch of low softening point (250-280°C), high coking value (80%) and high spinnability for spinning it into fibres. This mesophase pitch can also be used for the development of carbon-carbon composites and other high tech applications. A large number of experiments were carried out to prepare bulk mesophase pitch from coal tar pitch, petroleum pitch and their mixtures by suitable heat treatment in an inert atmosphere.

Mesophase pitch of the required characteristics was prepared and characterized for various parameters including bulk mesophase content using polarizing optical microscope (Fig.3.4). One interim report of the project was prepared and submitted to DMSRDE, Kanpur. The process parameters and composition of pitches were optimized for the preparation of spinnable mesophase pitches. Few mesophase pitch samples were spun at NPL and also supplied to DMSRDE, Kanpur for spinning into fibres. The project was successfully completed on March 31, 2009 and preparation of final report is in progress for the submission to DMSRDE, Kanpur.

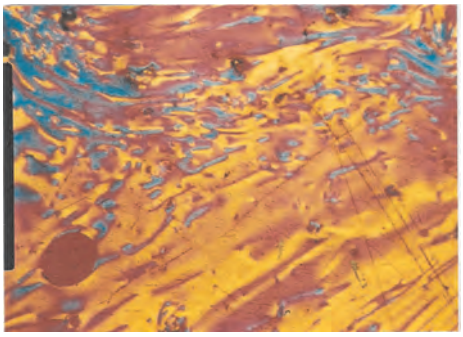


Fig. 3.4 : Bulk mesophase pitch for HPCF (SP 248°C)

III. Development of carbo-graphite material for aeronautical application

This project is also sponsored by DMSRDE, Kanpur. The carbo-graphite material is to be used as a seal for the aircraft engine. This material possesses a high density of 1.90 gcm^{-3}, high shore hardness of 55, high compressive strength of 2000 $kgcm^{-2}$, besides being stable in air at 650°C. A high pressure-high temperature impregnation assembly (designed and fabricated) was employed for impregnation of high density graphite with suitable boron and phosphorus salts to make it heat stable at 650°C. The SEM photographs of the impregnated samples baked at 650°C and oxidized sample showed the formation of a coating which inhibited oxidation at 650°C for 10h (Fig. 3.5a, 3.5b)

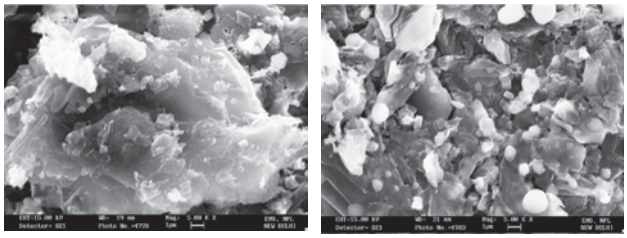


Fig.3.5 : SEM of (a) impregnated carbo-graphite baked at 650°C (b) after oxidation at 650°C for 10hrs.

IV. Development of fuel cells based on hydrogen (CSIR NMITLI Project)

Porous conducting carbon paper and Advanced composites bipolar plate

A batch of 80 numbers of carbon paper samples of size 20cm x 15cm and 80 nos. of carbon composite bipolar plates of similar size with specified characteristics were supplied to CECRI(CSIR), Chennai to be used in a 10 cell stack to compare the performance of the stack with NPL components vis-à-vis the imported components. This would ensure the reproducibility in the quality of the indigenous components since in one 10 cell stack 20 numbers of carbon papers and 22 numbers of bipolar plates are used. Their evaluation in the unit fuel cell as well as 10 cell stack confirmed performance equivalent to the imported components e.g. Carbon paper from Toray(Japan) and Bipolar plate from Schunk (Germany) and the results summarized in Table 3.1.

Table 3.1: Comparative performances of PEFC single cell of area 140 cm^2 operated on H_2/ Air made of commercial components with that of indigenous components*

Graphite bipolar plate + Carbon paper	Performance of 140 cm^2 single cell at 0.6V(W)
Shunk(Germany) + Toray(Japan)	50.85
Shunk + NPL	47.54
NPL + Toray	47.56
NPL + NPL	47.83

* Tests performed at CECRI, Fuel cell centre, Chennai

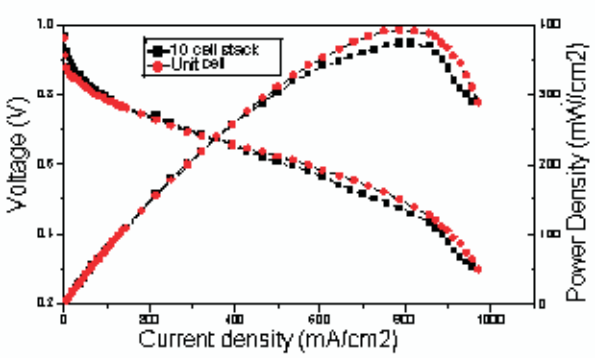


Fig. 3.6: Comparison of I-V performance of NPL carbon paper and the bipolar plate in a unit PEM fuel cell and in the 10 cell stack

It could be concluded from the table that the performance of the fuel cell using indigenous components is almost 95% that of the imported components.

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

This is a part of the XI Plan CSIR sponsored network project on "Design and fabrication capabilities for very high power microwave tubes" with CEERI, Pilani as the nodal agency. The objective of the project is to develop two types of graphites with stringent specifications namely (i) high density graphite, (ii) copper reinforced graphite suitable for multistage depressed collector of electron tubes viz. travelling wave tubes useful for space applications. Imported samples of both types of graphites supplied by CEERI, Pilani were characterized for various physical properties including microstructure. The two imported grades i.e high density graphite and copper reinforced graphite possessed bulk density values of 1.78 and 3.05 g/cm^3, electrical resistivity of 1.33 and 0.52 mohm cm, bending strength of 123 and 158 MPa, ash of 0.03% and 52.5% and interlayer spacing (d_{002}) of 0.338 and 0.338 nm respectively. Samples were also characterized for microstructure using optical microscope and SEM.

High density graphite samples were prepared from five types of suitable/modified green coke (self sintering) powders developed in-house which were ball milled into fine powder and moulded into rectangular plates/blocks and carbonized to 1000°C, 1400°C and then upto 2500°C to obtain high density graphite. The graphite samples were characterized w.r.t. various properties. A high density of 1.9 g/cm^3, electrical resistivity of 1.5 mΩcm or mohmun and bending strength of 90 MPa were obtained. These values are quite close to the targeted values required under the project.

Extensive work was also carried out to develop copper reinforced graphite by mixing copper in different amounts with green coke / modified green coke powders which were moulded, carbonised upto 1400°C and characterized. The bulk density values of 2.9 g/cm^3 were achieved for batches having copper to carbon weight ratio of 0.9 and 1.0 whereas, bulk density of 3.16 g/cm^3 was obtained for batches having copper to carbon ratio of 1.1 and 1.2 (Fig. 3.7). The electrical resistivity was observed to be in the range 0.8-0.85 in mΩcm or mohmun at a HTT of 1100°C. The bending strength was found to decrease from 136 MPa to 115 MPa as copper to carbon ratio was increased from 0.9 to 1.22 which has been attributed to the non wetting property of copper with

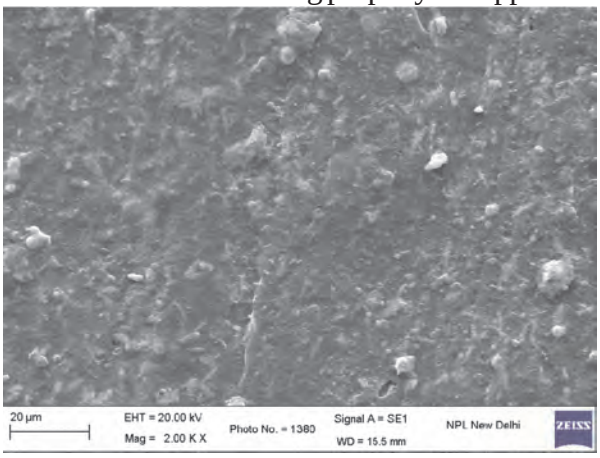
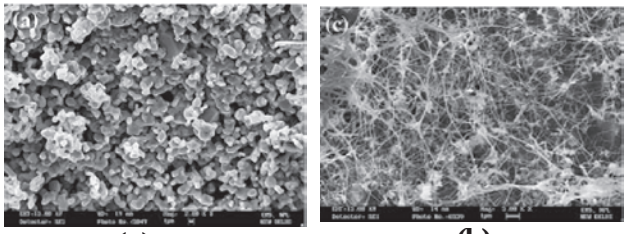


Fig.3.7 : Scanning electron micrographs of C-Cu composite 1100°C HTT

carbon at higher property concentrations. A technical report was prepared and presented before the Review Committee and the work was very much appreciated. Further work is in progress.

VI. (a) Development of nano composites using nano-SiC.

The experiments were carried out to synthesise of nanoSiC by the reaction between of carbon black with silicon (Fig.3.8a) or solgel derived silica from TEOS (Fig.3.8b). Both experiments resulted in the formation of nano SiC (50-100nm). The carbon-nano SiC composites were developed by incorporating nano-SiC in green coke matrix (Fig.3.9a and 3.9b). The properties of the green coke based carbon monolith are improved significantly by the incorporation of small amount of nano-SiC. The carbon-nanoSiC composites possessing a high bulk density of 1.85 to 1.91 g/cm^3, electrical resistivity 3.5 to 4.2 mΩcm or mohmun, bending strength 135



(a) (b)

Fig.3.8 : Scanning electron micrographs of (a) Nano-SiC synthesized from carbon black and silicon b) C–nano-SiC–B_4C, nano-SiC derived from sol–gel silica and CB

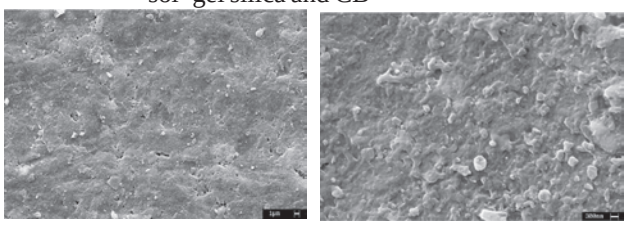


Fig.3.9: SEM of C-nanoSiC composites having (a) 5% and (b) 15 % of nanoSiC

to 155 MPa and shore hardness of 102 to 110 were prepared at the heat treatment temperature of 1400°C by varying the quantity of nano-SiC from 5 to 15% in the green coke derived carbon matrix.

(b) Development of high purity - high density - isotropic graphite

R&D work was continued to study the effect of incorporation of natural graphite and synthetic graphite in green coke on the properties of high density - high strength - isotropic graphite. In addition, green coke was also mixed with synthetic graphite coated with a suitable pitch material and the resulting mixture was used to prepare high density graphite. The influence of various additives on the final properties of such graphite is being investigated.

Ferroelectric Liquid Crystals

Numerous potential applications of liquid crystals (LCs) allow researchers to study different aspects of their basic properties, particularly the surface-anchoring effect, which forces near-surface molecules to align molecules in bulk in different modes – i.e. homogeneous or home tropic. The surface alignment is essential in liquid crystal displays (LCDs) as it controls the director of one of the two states of the display. Almost all kinds of electro-optic devices such as nematic, twisted nematic (TN), super twisted nematic (STN), and the ferroelectric liquid crystals (FLCs) are fabricated using a surface alignment technique. The LC materials are anchored at the substrate along the preferred direction induced by the surface. The surface plays a passive role in LCDs currently available in the market. But the situation becomes completely different when the surface plays an active role. The surface anchoring effect studies in FLCs are rather more difficult and rarely reported in the literature due to the complexity of surface interactions caused by the introduction of spontaneous polarization and layer structure.

Recently, we at NPL have studied a wide range memory effect in Deformed Helix Ferroelectric Liquid Crystal (DHFLC) material without any surface

treatment to the cell surface. The comparison of this memory effect has been done with strongly anchored DHFLC samples cells as shown in Fig.3.10. It has been proposed that an ultra weak surface anchoring leads to a lower saturation voltage and steepness in the electro-optical properties of FLCs. A long-lasting memory has been observed in sample cells in which no surface treatment was given. These observations open new ways to understand the effect of surface anchoring on the electro-optical properties of FLC materials and the substrate. The underlying concept of achieving the best memory effect can be applied to fabricate paper like displays because bistable LCDs do not require an electric power for holding

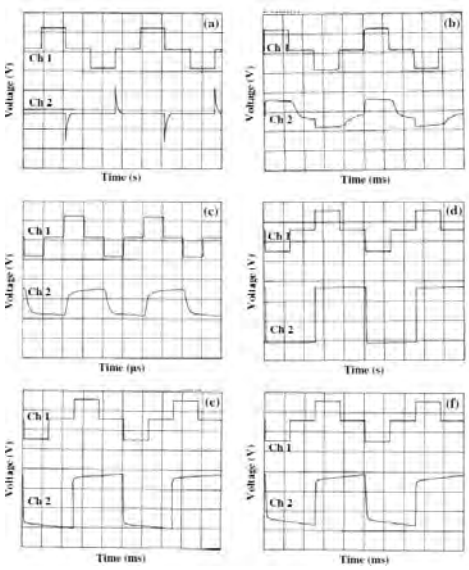


Fig. 3.10 : Optical response of DHFLCs at room temperature in 3.5ìm SA (a) g° #å• (c) and UA (d) g° #å• (f) sample cells at 20 V at (a) 100 mHz (time, 2 s / div), (b) 10 Hz (time, 20 ms/ div), (c) 100 Hz (time, 500 ms / div), (d) 100 mHz (time, 2 s / div), (e) 10 Hz (time, 20 ms/ div), and (f) 100 Hz (time, 2 ms/ div). The voltage on the y axis for channels Ch 1 and Ch 2 are 10 V/ div and 0.02 V/ div, respectively.

an image. Furthermore, the possibility of an ultra weak anchoring provides ideas to pursue future (or new) research i.e. surface switching and other areas which will lead to new applications.

Bio-Sensors

I. Iron Oxide –Chitosan Nanobiocomposites -A Platform For Urea & Nucleic Acid Sensors

(a) Iron Oxide –Chitosan Nanobiocomposites For Urea Sensor

The increasing demand for clinical diagnostics relating to kidney and liver diseases has necessitated evolution of new methods for faster and accurate estimation of urea in desired samples including urine and blood samples. Iron oxide (Fe_3O_4) nanoparticles (22 nm) prepared using co-precipitation method are dispersed into 10mL of chitosan (CH) (0.5 mg/mL) solution CH- Fe_3O_4 hybrid nanobiocomposite films have been fabricated onto an ITO surface and used for immobilization of urease (Ur) and glutamate dehydrogenase (GLDH) for urea detection. These films have been characterization using X-ray diffraction (XRD), FTIR spectrophotometer, scanning electron microscopy, cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS) and differential pulse voltammetry (DPV) measurements. Electrochemical response studies of Ur-GLDH/CH-Fe_3O_4 nanobiocomposite/ITO bioelectrode have been carried out as a function of urea concentration in the presence of 30µL of nicotinamide adenine dinucleotide (NADH, 3.7 mg/dL) and 70µL of á-Keto glutamate (á-KG, 47.5 mg/dL) using DPV in PBS solution {50mMPBS (pH 7, 0.9%NaCl) containing 5mM $[Fe(CN)_6]^{3-/4-}$. It is observed that magnitude of current obtained for the Ur-GLDH/CH Fe_3O_4 nanobiocomposite/ITO bioelectrode increases on addition of urea (Fig.3.11). The response time of the Ur-GLDH/CH-Fe_3O_4nanobiocomposite/ITO bioelectrode found to be about 10 s and is attributed to faster electron communication feature of CH- Fe_3O_4 nanobiocomposite. It is revealed that Ur-GLDH/CH-Fe_3O_4 nanobiocomposite/ ITO bioelectrode can be used to estimate urea from 5 to 100 mg/dL.

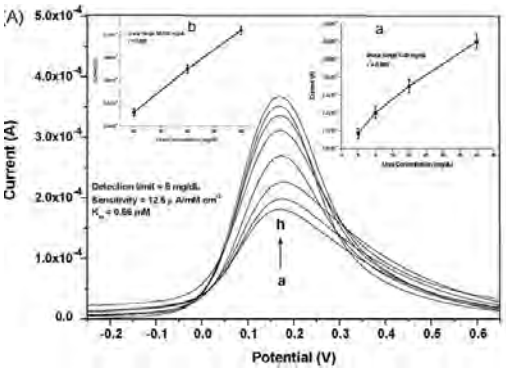


Fig. 3.11 : Electrochemical response of Ur-GLDH/CH-Fe_3O_4 nanobiocomposite/ITO bioelectrode as a function of urea concentration (5–100 mg/Dl)

(b) Nucleic Acid Sensor For Pyrethroid Detection

Further, these CH- Fe_3O_4 nanobiocomposite/ITO electrode has been used for the immobilization of single standard calf thymus DNA (ssCT-DNA) and used for pyrethroids detection. Among the various pyrethroids, cypermethrin (CM, type I) and permethrin (PM, type II) are being increasingly utilized due to increasing food demand. The results of Electrochemical impedance spectroscopy reveal that the semicircle part corresponds to electron-transfer limited process and its diameter is equal to the electron transfer resistance, R_{ct} that controls electron transfer kinetics of the redox probe at the electrode interface. It can be seen from the Nyquist plots (Fig.3.12) that semicircle of ITO electrode (*R*ct = 3.82, Curve a), characteristic of a diffusion limiting step of the electro chemical process, decreases for CH/ITO electrode (*R*ct = 2.7, Curve b) and it further decreases for the CH-Fe_3O_4 nanobiocomposite/ITO electrode (*R*ct = 2.54, Curve c). These results suggest that electron transfer in the CH-Fe_3O_4 nanobiocomposite film is easier between solution and the electrode, i.e., Fe_3O_4 nanoparticles not only provide the hydrophilic surface, but also promote electron transfer due to permeable structure of CH/ITO. However, on the immobilization of ssCT-DNA onto CH/ITO and CH-Fe_3O_4 nanobiocomposite/ITO, the semicircle part of the bioelectrode further. This may be attributed to improved electrical characteristics of ssCT-DNA resulting in increased electroactive surface area of both bioelectrodes and enhanced electron transfer between the electrode and medium.

Electrochemical response studies show that

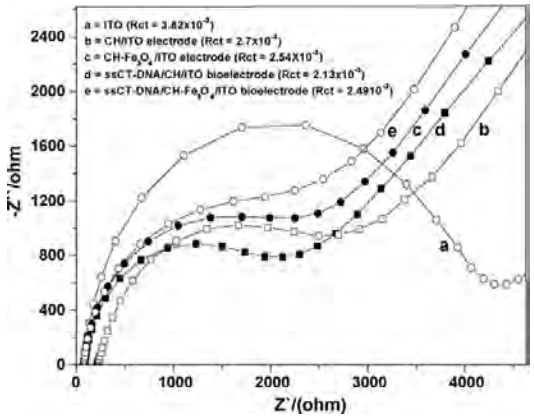


Fig.3.12 : Electrochemical impedance spectra of bare ITO electrode (a), CH/ITO electrode (b), CH-Fe_3O_4 nanobiocomposite/ITO electrode (c), ssCT-DNA/CH/ITO bioelectrode(d) and ssCT-DNA/CH- Fe_3O_4 nanobiocomposite/ITO bioelectrode (e) in phosphate buffer (50mM, pH 7.0) containing 5mM $[Fe(CN)6]^{3"/4"}$.

magnitudes of current response of ssCT-DNA/CH/ITO and ssCT-DNA/CH-Fe_3O_4 nanobiocomposite/ITO bioelectrode decrease on addition of CM. The ssCT-DNA/CH-Fe_3O_4 nanobiocomposite/ITO bioelectrode shows low detection limit 0.0025 ppm, linear range 0.0025–2ppm of CM concentration, high sensitivity of 20μA/μMcm$^{"2}$ and response time of 25 s. The magnitude of response current is found to decrease on addition of PM concentration (1.0–300 ppm). We have observed 45% reduction in current for ssCT -DNA/CH- Fe_3O_4 nanobiocomposite/ITO bioelectrode at 300ppm concentration of PM.

II. Application of Nanostructured Cerium Oxide Films as Bio Sensors

Sol-gel derived nano structured CeO_2 film has been fabricated onto ITO coated glass plate using dip coating technique and is allowed to dry at 400°C according to procedure reported earlier These films have been utilized for immobilization of lipase via electrostatic interactions at pH 7.0 due to difference in IEP of CeO_2 matrix and lipase. The fabricated electrodes (Nano-CeO_2/ITO, Lipase/Nano-CeO_2/ITO) have been characterized using XRD, SEM and CV. The electrochemical response of the Lipase/Nano-CeO_2/ITO bioelectrode has been investigated as a function of tributyrin concentration (50-500 mg/dl) using CV technique at 50 mV/s scan rate in PBS (50 mM, pH 6.5, 0.9% NaCl) containing 5 mM $[Fe(CN)_6]^{3-/4-}$. One of simplest of the triglycerides is tributyrin, which can use as a prototype for the

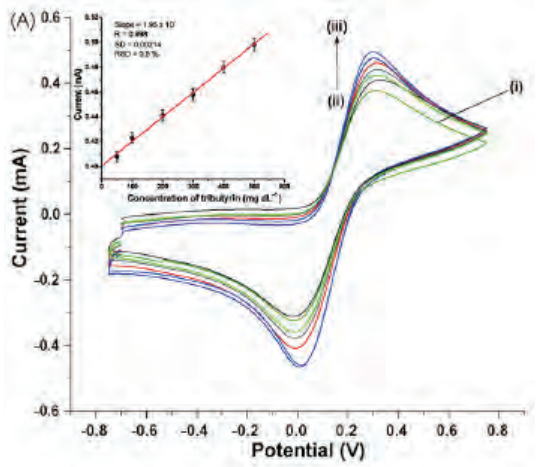


Fig. 3.13 : Electrochemical response studies of Lipase/Nano-CeO_2/ITO eeelectrode

quantitative determination of the triglyceride by the biosensor. It has been found that the magnitude of response current increases on addition of tributyrin (Fig.3.13).

The Nano-CeO_2/ITO bioelectrode shows fast response time (20 s), high sensitivity (0.195 mA/mg dL cm^2), low detection limit as 32.8 mg/dL and reproducibility around 15 times. This Lipase/Nano-CeO_2/ITO bioelectrode shows improved biosensing characteristics like linearity as 50-500 mg/dL, low detection limit of 32.8 mg/dL, response time of 20 s, shelf-life of 3 months, sensitivity of 0.1 mA/mg dL cm^2 with linear regression as 0.998 and standard deviation as 0.0021mA/mg dL-1. The low value obtained as 22.27 mg/dL (0.736 mM) indicates high affinity of Lipase/Nano-CeO_2/ITO bioelectrode for tributyrin.

(a) Immobilization of Horseradish Peroxidase (HRP) onto Cerium Oxide (CeO_2) Electrode

Horseradish peroxidase (HRP) has been immobilized nano-structured cerium oxide (NanoCeO_2) film deposited onto indium-tin-oxide (ITO) glass for estimation of H_2O_2 in solution. The electrochemical response of the HRP/NanoCeO_2/ITO bioelectrode has been investigated as a function H_2O_2 (1.0–170 µM) using CV technique at 50 mV/s (scan rate) in PBS (50mM, pH 6.5,0.9% NaCl) containing 5mM $[Fe(CN)_6]^{3-/4-}$. Fig. 3.14 shows the calibration curve as a function of H_2O_2 concentration obtained using cyclic voltammetry. The value of Michaelis–Menten constant (*K*m) has been estimated as 2.612µM. The results of the photometric response studies carried out on HRP/NanoCeO_2/ITO bioelectrode indicate reasonable agreement with those obtained using electrochemical technique. The

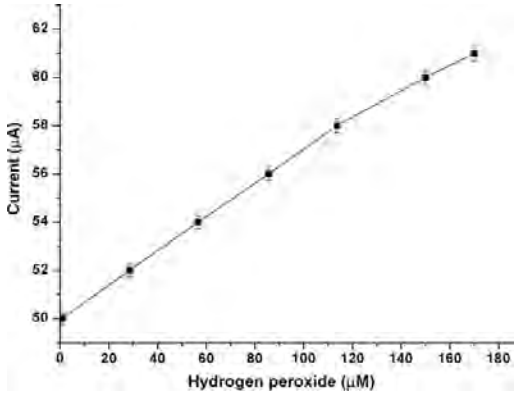


Fig: 3.14 Electrochemical response of HRP/NanoCeO_2/ITO bioelectrode as a function of H_2O_2 (mM) PBS (50mM, pH 7.0, 0.9% NaCl) containing 5mM $[Fe(CN)6]^{3"/4"}$.

HRP/NanoCeO_2 bioelectrode has response time of 3 s, detection limit of 0.5μM, and sensitivity of 8.44×10^{-3} μA (μMcm^2)$^{-1}$. The efforts are being made to improve the shelf-life of this bioelectrode beyond 5 weeks and to utilize the NanoCeO_2 electrode for fabrication of other biosensors.

III. Nano-Structured Zinc Oxide Matrix- a Plinth For Sexually Transmitted Disease Sensor

Gonorrhoea is currently the second most common bacterial sexually transmitted disease (STD). It is estimated that there are about 25 million cases of gonorrhoea worldwide. To prevent spread of this disease, increased attention is being focused on the early diagnosis and treatment of symptomatic or asymptomatic infected individuals. Traditional laboratory diagnosis of this infection is carried out by culture, microscopy and PCR techniques. However, these diagnostic methods are expensive, time consuming (14–72 h) and are not reliable. Therefore, efforts are being made towards the development of a rapid, sensitive and specific STD-sensing device. Electrochemical DNA biosensors based on nucleic acid hybridization have received considerable attention due to their potential application for the diagnosis of various diseases.

Sol-gel derived zinc oxide (ZnO) film was deposited onto ITO surface by dip coating method and subject to 5 minutes incubation for physisorption of the 20-mer thiolated oligonucleotide probe (th-ssDNA, 1 ng/ml) specific to N. gonorrhoeae in a humid chamber at 25 °C. This ZnO/ITO film is subsequently washed with buffer and dried in a nitrogen environment. The sol–gel derived nano-structured ZnO/ITO and th-ssDNA–ZnO/ITO electrodes have been characterized by UV-Visible, SEM, FTIR spectrophotometer, CV and EIS.

Figure 3.15 shows the results of differential pulse voltammetry (DPV) measurements carried out on the ITO electrode, thssDNA–ZnO/ITO, th-dsDNA-ZnO/ITO and th-ssDNA–ZnO/ITO treated with non-complementary DNA in PBS (50 mM, pH7.0, 0.9% NaCl) in the presence of methylene blue (MB). From the DPV curve of bared ITO it is clear that it has a well-defined peak at around -0.25 V. Curve b is the DPV of the th-ssDNA–ZnO/ITO electrode, indicating strong affinity of MB for free guanine bases and that no duplex/hybrid is formed at the th-ssDNA–ZnO/ITO electrode. This may be attributed to the positively charged ZnO molecules that may repel positively charged MB molecules facilitating MB molecules to get associated with both partially or unpaired nitrogenous bases of the DNA probe stationed at the th-ssDNA–ZnO/ITO surface. The observed peak seen at -0.25 V may be assigned to the reduction of unpaired nitrogenous bases or to the ZnO matrix. A significant decrease in MB signal is observed when hybridizing with the complementary target sequence (curve c), since interaction of MB and guanine residues of the probe is prevented by duplex formation on the electrode surface. The observed insignificant change in MB signal on its treatment with the non-complementary target sequence (curved) indicates non-hybridization.

Fig. 3.15B describes the results of response studies of th-ssDNA–ZnO/ITO bioelectrode after hybridization with different concentrations of target DNA of N. gonorrhoeae ranging from 0.000524 fmol to 0.524 nmol. The detection limit of the th-ssDNA–ZnO/ITO bioelectrode is 0.000704 fmol with a hybridization time of 60 s.The sol–gel nano-structured thssDNA–ZnO/ITO bioelectrode exhibits linearity in the range of0.000524 fmol–0.524 nmol, with a detection limit of 0.000704fmol and a hybridization time of 60 s. Efforts should be made to utilize this nucleic acid electrode for detection of gonorrhoea(STD) using clinical samples. This nucleic

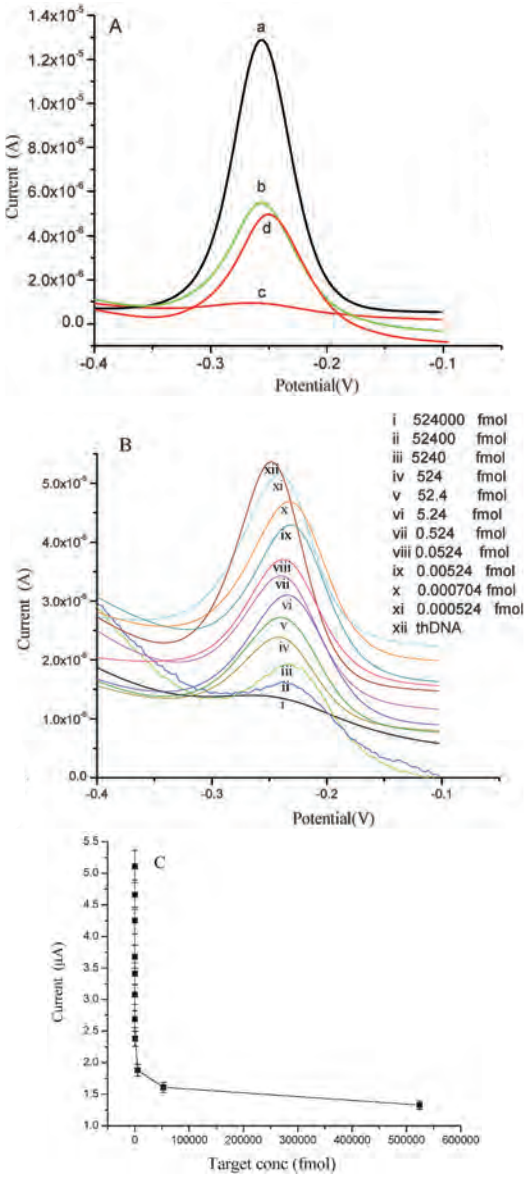


Fig. 3.15 : (A) Differential pulse voltammograms of (a) bare ITO electrode, (b) th-ssDNA–ZnO/ITO bioelectrode, (c) th-dsDNA-ZnO/ITO bioelectrode, and (d) th-ssDNA–ZnO/ITO bioelectrode treated with non-complementary target DNA at a pulse height of 50 mV and pulse width of 70 ms, in 0.05M phosphate buffer of pH 7.0 containing 0.9% NaCl and methylene blue (MB, 20 mM). (B) Response of the th-ssDNA–ZnO/ITO bioelectrode after hybridization with complementary target probe concentration 0.000524 fmol–0.524 nmol at a pulse height of 50 mV and pulse width of 70 ms, in 0.05M phosphate buffer of pH 7.0 containing 0.9% NaCl and methylene blue (MB, 20 mM). (C) The MB peak height as a function of target DNA

acid sensor has implications towards the clinical diagnosis of other sexually transmitted diseases.

IV. Fabrication of Matrices for Cholesterol Sensors

(a) Multi-Walled Carbon Nanotubes/Sol–Gel-Derived Silica/ Chitosan Nanobiocomposite (MWCNT/SIO_2-CHIT/ITO)

MWCNT/SiO_2–CHIT/ITO electrode has been used for the immobilization of cholesterol esterase (ChEt), cholesterol oxidase (ChOx) using using glutaraldehyde (0.1%) as a cross-linker. These ChEt–ChOx/MWCNT/SiO_2–CHIT/ITO bioelectrode used for cholesterol oleate detection using DPV studies. It can be seen (Fig. 3.16) that ChEt–ChOx/MWCNT/SiO_2–CHIT/ITO bioelectrode can be used to estimate cholesterol oleate from 10 to 500mg/dL with low detection limit as 0.634mg/dL and response time has been obtained as about 10 s. The value of the enzyme–substrate kinetics parameter (Michaelis–Menten constant, K_m)

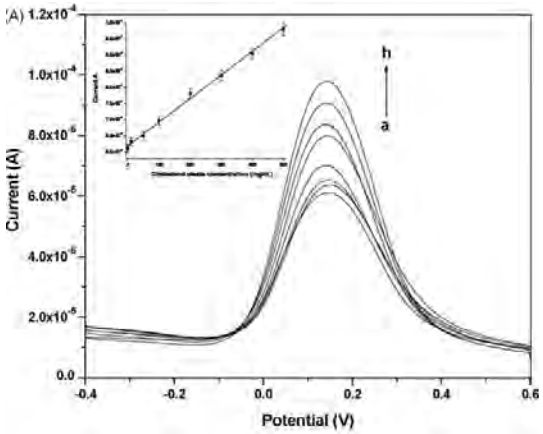


Fig: 3.16 : The DPVs obtained for ChEt–ChOx/MWCNT/SiO_2–CHIT/ITO bioelectrode as a function of cholesterol oleate (a) 0mg/dL, (b) 10 mg/dL, (c) 50 mg/dL, (d) 100 mg/dL , (e) 200mg/dL, (f) 300mg/dL, (g) 400mg/dL, and (h) 500 mg/dL at potential height as 0.4995 V, potential period 0.07ms and interval period as 0.14 ms. Inset: the linear regression curve of theChEt–ChOx/MWCNT/SiO_2–CHIT/ITO bioelectrode.

estimated using the Lineweaver–Burke plot reveals affinity of enzyme for desired analyte. It may be noted that K_m is dependent both on matrix and the method of immobilization of enzymes that often results in their conformational changes resulting in different values of K_m. The lower *K*m value indicates high affinity for cholesterol oleate attributed to the immobilization of ChOx and ChEt onto MWCNT/SiO_2–CHIT/ITO nanobiocomposite for faster biochemical reaction. The value of sensitivity of ChEt–ChOx/MWCNT/SiO_2–CHIT/ITO bioelectrode estimated from the slope of curve has been found to be 3.8μA/mM

(b) Electrochemical Cholesterol Sensor based on Tin Oxide-Chitosan Nanobiocomposite Film

Tin oxide (SnO_2) based nanoparticles and composite with the biopolymer chitosan (CS) have recently been used as an interesting matrix for immobilization of desired biomolecules. ChOx has been physisorption onto CS/ITO and CS-SnO_2/ITO cholesterol detection. ChOx/CS/ITO and ChOx/CS-SnO_2/ITO bioelectrodes were characterized using FTIR spectroscopy, SEM, CV and EIS techniques. The electrochemical response of the ChOx/CS/ITO and ChOx/CS-SnO_2/ITO bioelectrodes was monitored as a function of cholesterol concentration (10 – 400 mg/dL) under identical experimental conditions. The magnitude of the response currents of both the bioelectrodes rapidly increase on addition of cholesterol. During the biochemical reaction, in the presence of ChOx/CS/ITO and ChOx/CS-SnO_2/ITO bioelectrodes, cholesterol gets converted into cholesterone and ChOx gets oxidized. During reoxidation of ChOx, the electron is accepted by CS or CS-SnO_2 matrices via mediator and transferred to electrode. It may be noted that there is no peak relating to the generation of H_2O_2 (0.5 V) indicating that both CS and CS-SnO_2matrix behaves as good electron acceptor than that of molecular oxygen.

(c) Sol-Gel Derived Nano Zinc Oxide (ZnO) as Cholesterol Sensor

ChOx is immobilized onto nano ZnO/ITO film (0.25 cm^2) via physisorption and kept overnight for drying. The ChOx/nano-ZnO/ITO was characterized by XRD, UV-Visible spectra and SEM, CV and Electro chemical response studies. Electrochemical response studies (Fig. 3.17) of ChOx/nano-ZnO/ITO bioelectrode conducted as a function of cholesterol concentration reveal that current response increases with successive addition of cholesterol concentration (5-400 mg/dl). Electrochemical response of ChOx/nano-ZnO/ITO bioelectrode shows a sensitivity of 0.059 μA/mg dl^{-1} cm^{-2} with linear regression coefficient (R^2) as 0.997.

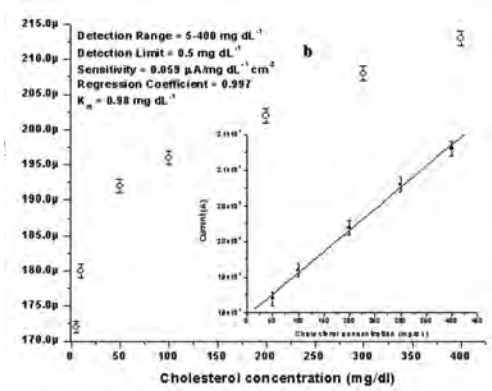


Fig.3.17 : Electrochemical response of ChOx/nano-ZnO/ITO bioelectrode with respect to cholesterol concentration (5–400 mg/dl) at the scan rate of 20 mV s^{-1}.

The selectivity of ChOx/nano-ZnO/ITO bioelectrode determined by measuring response current on addition of normal concentration of interferents such as ascorbic acid (AA), uric acid (UA), glucose (G),lactic acid (LA), sodium pyruvate, and urea (1) at normal concentration in blood samples (inset of Fig. 1(a) indicates maximum interference of 4.6%. The storage stability of ChOx/nano-ZnO/ITO bioelectrode determined by measuring change in current response at regular interval of 1 week exhibits 80% response after about 3 months when stored at 4°C. The ChOx/nano-ZnO/ITO cholesterol biosensor

has been found to have improved detection range 5–400 mg/dl, low detection limit (0.5 mg/dl), linear regression at 0.994, response time (10 s), and shelf-life (3 months). The low *Km* value (0.98 mg/dl) indicates high affinity of ChOx/nano-ZnO/ITO bioelectrode to cholesterol.

V. Electrophoretic Conductive Polymers as Sensors

(a) Polyaniline Nanotubes for Impedimetric Triglyceride Detection

Electrophoretic film fabrication of polyaniline nanotube (PANI-NT) has been carried out with DC battery onto ITO glass. Lipase (LIP) freshly prepared in phosphate buffer saline (PBS, 50 mM, pH 7.4)} is covalently immobilized onto PANI-NT/ITO electrode using glutaraldehyde (Glu) as cross-linker. PANI-NT/ITO and LIP/Glu/PANI-NT/ITO electrode have been characterized by SEM, FTIR, CV and EIS studies. LIP/Glu/PANI-NT/ITO bioelectrode shows fast response time (20 s), high sensitivity (2.59 x 10-3 KÙ-1mg-1dL), regression coefficient (0.99), reproducibility (6 times) and shelf life upto 10 weeks. The value of apparent Km has to be found 46.69 mgdL-1 (0.62 mM). The lower value of *K* suggests that PANI-NT matrix facilitates enzymatic reaction and helps the immobilized enzyme to achieve better conformation for faster enzymatic reaction resulting in enhanced enzymatic activity. The result reveals that this bioelectrode shows maximum activity around pH 7.4 at 28°C. The effects of interferents on the triglyceride measurement has been studied by taking normal concentration of interferents such as glucose (5mM), uric acid (0.1mM), urea(1mM) and cholesterol (5mM). The results reveal maximum interference of 6% in case of uric acid that can be attributed to the acidic nature of uric acid. When compared with the response of pure samples, results obtained are within the error of 5.4%, indicating negligible interference of proteins and other moieties present in serum.

VI. Mediator Free Enzyme Sensors

(a) Functionalized Gold Nanoparticles – Octadecylamine Hybrid Langmuir-Blodgett Film For Enzyme Sensor

Thin films of 11mercaptoundecanoic acid functionalized AuNPs (MUDA-AuNPs)-octadecylamine (ODA) hybrid Langmuir-Blodgett film for cholesterol sensor. The UV-visible spectra shows a shift in the peak of AuNPs towards higher wave length. This is due to coupled plasmon resonance, which reveals attachment of MUDA-AuNPs onto ODA LB electrode. CV studies of ODA LB film, MUDA-AuNP/ODA hybrid LB film and ChOx modified MUDA-AuNP/ODA LB electrodes in phosphate buffer saline solution (PBS) of pH 7.0. ODALB film on modification with 11-mercaptodecanoic acid functionalized gold nanoparticles (MUDA-AuNP) shows enhanced redox behaviour. Besides this, decrease in the peak-to-peak potential separation from 757 to 747 mV with significant growth of peak current from 0.324 to 0.685 mA is observed and is attributed to increased electrical conductivity due to attachment of AuNPs on to ODA LB film. Further, ChOx modified MUDA-AuNP/ODA LB bioelectrode displays a pair of well-defined redox peaks at about 363 mV with enhanced current (0.773 mA) and decreased peak-to-peak potential (450 mV). This indicates that well-aligned MUDA-AuNP/ODA LB film has good affinity for enzyme (ChOx) molecules. It appears that MUDA-AuNPs facilitate enhanced electrode reaction kinetics for ChOx and provide a favourable microenvironment for electron transfer between enzyme and electrode. The CV investigations at various potential scan rates (n) (5 to 70 mV/s) have been performed onto ChOx/ MUDAAuNP/ODA LB

bioelectrode to determine the concentration of ionic species on the bioelectrode surface. The total surface concentration is found to be 7.1809×10^{-8} mol cm^{-2} indicating better immobilization of enzyme onto MUDA-AuNP/ODA LB electrode.

The amperometric response of ChOx/ MUDA-AuNP/ODA LB bioelectrode with increasing concentration (25 mg/mL – 500 mg/dL) of cholesterol has been investigated in PBS (0.9% NaCl, pH 7.0) in the voltage range of - 0.7 to 0.7 V. It can be seen that there is increased oxidation peak current near 0.3 V with increasing cholesterol concentration. This indicates that MUDAAuNP/ODA LB electrode can be used to detect cholesterol at a lower potential of 0.3 V. This is attributed to favourable orientation of ChOx molecules on to the well aligned MUDA-AuNP/ODA LB film that facilitate direct electron transfer between enzyme and the electrode reducing the detection potential (0.3 V) and response time (20 s). The cholesterol detection at lower potential also reduces the effect of interferents such as ascorbic acid, uric acid, bilirubin and acetaminophen that are usually present in biological samples and get oxidized near 0.6 V.

The characteristics of the cholesterol biosensor based on the ChOx/MUDA-AuNP/ODA LB bioelectrode was compared with those reported in literature. It can be seen that the ChOx/MUDA-AuNP/ODA LB bioelectrode shows linearity in the broad range of 25 to 500mg/dL (0.65 – 12.91 mM) and has a good sensitivity without using any artificial mediator.

Organic photovoltaic devices

To meet the increasing demand and to overcome the future possible crisis of energy, new kind of sources of energy are being searched and developed. Organic solar cells are the potential candidates for energy generation as they are very eco-friendly and large area flexible devices can be fabricated at very low cost. The importance of organic solar cells has now been well recognized by the scientific community and efforts are being made to develop these devices all over the world. R & D work to develop organic solar cells has also been undertaken by National Physical Laboratory, New Delhi. During this year intensive work has been carried out on the basic and applied aspects to improve the performance of organic solar cells. Poly(3-hexylthiophene) (P3HT) and copper phthalocyanine (CuPc) are very important materials for solar cell applications.

NPL has developed and demonstrated organic solar cells exhibiting a power conversion efficiency of ~ 2 % in both the small molecular and polymeric systems. In view to improve further the performance of organic solar cells, extensive work has been carried out to understand the charge carrier transport in organic materials and devices. The effect of doping of various nano-particles on the charge transport in organic semiconductors has been investigated. The incorporation of CdSe nano-particles in P3HT reduces the trap density and enhances the current, which is an important finding to improve the short circuit current in organic solar cells based on P3HT. The application of dual donors viz. CuPc and ZnPc, which absorbs the light in different ranges of solar spectrum, in a single cell has been observed to enhance the spectral coverage and improve the efficiency of solar cell. The effect of various physical parameters e.g. temperature, electric field and illumination intensity have been investigated to understand the device physics and the reliability of devices in different environmental conditions. Temperature and illumination intensities have been found to have significant effect on the performance of organic solar cells. We have developed a model for current-voltage (*J-V*) characteristics of bulk

heterojunction solar cells and the model explains well the experimental observations in different experimental conditions. Fig.3.18 shows the *J-V* characteristics of P3HT:PCBM solar cell measured at different illumination intensities. Dark curves are the calculated characteristics using the developed model and symbols represent the measured *J-V* characteristics. The model shows a good agreement with the experimental data.

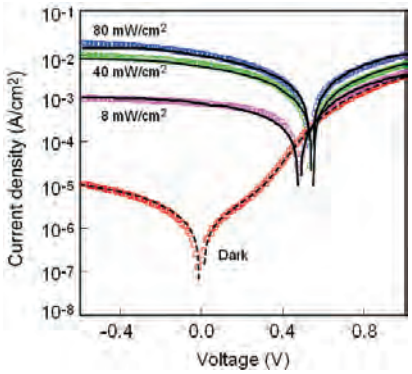


Fig. 3.18 : Calculated (dark) and measured (symbols) J-V characteristics of P3HT:PCBM solar cell at different illumination

Organic Light Emitting Diodes (OLED)

Synthesis and characterization of Electroluminescent Zinc complex Zn(hpb)mq and fabrication of stacked OLED for white light emission

Electroluminescent Zinc complex Zn(hpb)mq has been synthesized which gives photoluminescence in yellowish green region. It has been used with another Zinc complex $Zn(hpb)_2$ which is previously reported for blue emission to fabricate stacked OLED for white light emission. Thickness of both materials has been optimized to get white light emission. The EL spectrum of Devices (A), (B), (C), (D) and (E) is shown in Fig.3.19. In all the devices we have observed broad EL spectrum covering almost the entire visible region. The maximum luminescence of 8390 Cd/m^2 has been achieved at 14V (Fig.3.20) with maximum current

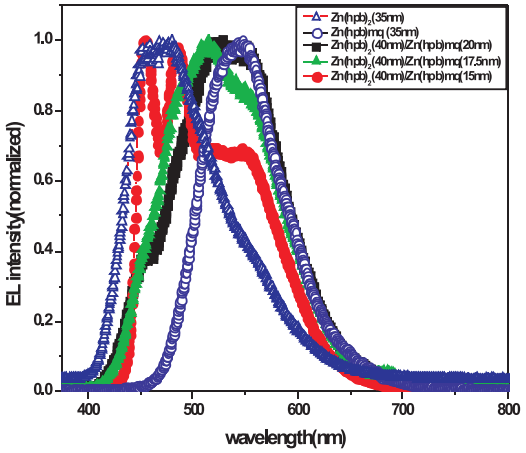


Fig. 3.19 : EL spectra of devices A,B,C,D and E

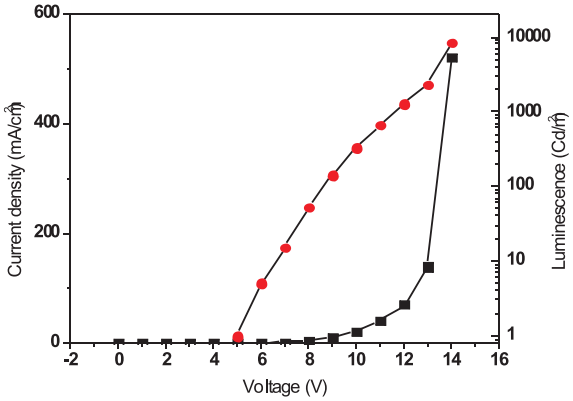


Fig. 3.20 : Current-Voltage-Luminescence characteristic of device C

efficiency 1.8 Cd/A(at11V) and maximum power efficiency 0.54 lm/W (at 8V). Commission Internationale de l'Eclairage (CIE) coordinates of the device are (0.29, 0.38) at 7 V and are well within the white region. A model has been developed for simulating the white light emission from stacked OLED based on Gaussian disorder model using Monte-Carlo technique. From the model we have estimated the energetic disorders of different emissive layers and the properties of interface.

Indelible Ink Formulations For Instantaneous Marking

We have developed a ready to use novel formulations of Indelible ink for marking the finger of a voter in the elections to prohibit fraud voting. It is a

two step process which instantaneously leaves a semi-permanent, penetrating, highly visible black stain on the finger. The first step involves the wiping of finger with an activator and the second step involves in marking the finger with silver nitrate, alcohol and water solution. The ink imparts black stain instantaneously and gets adjorbed in the skin with in a minute.

Majority of the Governments and civic agencies around strive hard to avoid fraudulent voting during the elections for those casting illegal votes to mark the fingers with an indelible ink prior to voting. The marked stain on the finger should persist for few days and should not be removable easily by bleaching powder solution, alcohol, light detergent, vim powder, solvents, acid solutions etc. the indelible mark helps the voting monitoring committee to identify the person having voted earlier and prevent the fraudulent voting.

The indelible ink presently being used to prohibit fraudulent voting in elections are as premixed solution of silver nitrate, violet dye, water and alcohol. The ink when applied to voter's finger leaves a violet colour which become dark brown black in an hour or so. The coloration which appears because of silver nitrate is clearly visible, semi-permanent has several shortcomings such as 1) Take a longer time to impart a brown-black stain on the finger 2) The stain comes out by using solvents, common detergents, bleaching powder solution, vim powder etc. 3) The penetration depth of the solution in the skin is very low. 4) The contrast is very low on a person with dark complexion. 5) The shelf life of the material is limited and 6) Shipping/transportation is dangerous because of use of solvent such as alcohol.

We have proposed an improved indelible ink formulations which mark the voter's finger instantaneously giving good contrast, having more penetration depth in the skin, resistant to removal by chemical and mechanical manipulation which may or may not contain any alcohol. The both of the solutions have a reasonable shelf life. The formulations imparts a temporary black stain on a palm finger tip instantaneously using less than 1 µL of the solution thus making it very cost effective. The marking applied on the finger tip rather than on the back of a finger gives a better contrast, has more penetration depth, cannot be scrubbed by match stick/foiler and can last for a much longer time thus leaving an indelible mark as a proof that the vote has been exercised.

Microwave Absoption Properties of Conducting Polymer Composites

(a) In-situ polymerization of aniline in the presence of nano ferrite and TiO_2 particles

Nanocomposites of polyaniline with barium ferrite and titanium dioxide (TiO_2) are synthesized via insitu emulsion polymerization. The TEM and HRTEM results shows the formation of array of nanoparticles encapsulated with in the polymer chains during the synthesis process. The high value of microwave absorption, 58dB (>99.999% attenuation) results from the combined effect of the nano particles and the polymer matrix. The amount of barium ferrite has the profound effect on permittivity (å), permeability (ì) and microwave absorption of the nanocomposite. The contribution to the absorption value comes mainly due the magnetic losses (ì ") in barium ferrite and dielectric losses (å") in TiO_2 and polyaniline.

(b) Microwave absorption properties of conducting polyaniline composite with TiO_2 and ã-Fe_2O_3 nanoparticles in 12.4-18 GHz

TEM images of ã- Fe_2O_3, TiO_2, and polyaniline composite (PTF12) are shown in Fig.3.19. Well-dispersed spherical particles of ã- Fe_2O_3, TiO_2 particles are observed. The particle size of ã- Fe_2O_3 was estimated to be 10-15 nm while TiO_2 has slightly

larger particles of 70-90 nm (Fig. 3.22 a & b). When these nanoparticles were incorporated in the polymer matrix, they show the agglomerated morphology (Fig. 3.22 c). The dispersion of ã-Fe_2O_3, TiO_2 particles in the polymer matrix is confirmed by the HRTEM image (Fig 3.22 d). The lattice fringes of ã-Fe_2O_3 with lattice spacing 0.25nm corresponding to (119) plane and 0.35nm corresponding to (101) plane for TiO_2 were

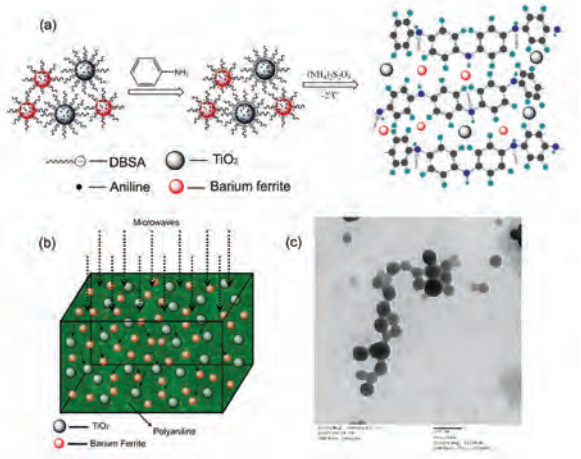


Fig. 3.21 : Mechanism of TiO_2 and Barium ferrite particles entrapped in polymer matrix

matched with the XRD pattern of the polymer composite.

Fig.3.23 shows the variation of the SE with frequency in the 12.4-18 GHz range. It has been observed that conducting ferromagnetic composite of polyaniline with Fe_2O_3 and TiO_2 have shielding effectiveness (SE) mainly due to absorption. Using shielding effectivness calculations, the shielding effectiveness due to absorption (SE_A) was found to be 8.8 dB polyaniline-ferric oxide composite, 22dB for polyaniline – TiO_2 composite. However, the shielding effectiveness of polyaniline embedded with TiO_2 and Fe_2O_3,nanoparticles was found to be 41dB for PT11 and 45 dB for PTF12 samples respectively. The shielding effectiveness due to reflection (SE_R) was nominal and contributed very little. The higher value of SE_A of PTF composites were mainly due to combined effect of TiO_2 and Fe_2O_3.

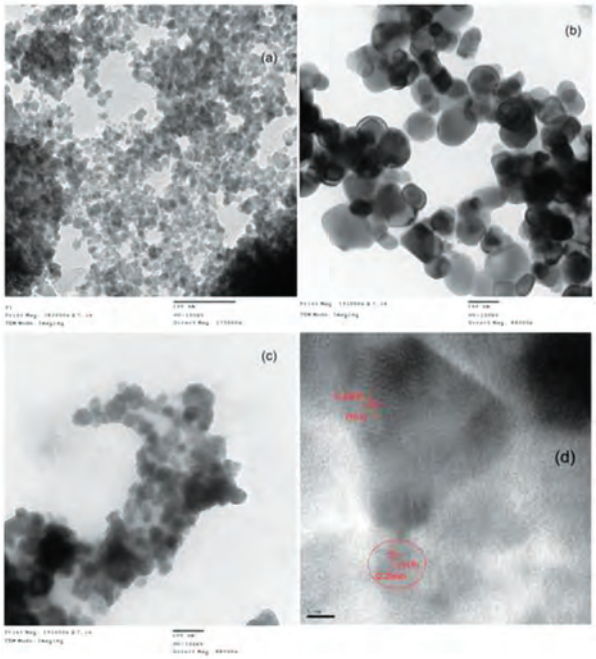


Fig. 3.22 : TEM images of (a) ã- Fe_2O_3, (b) TiO_2, (c) PTF12, and (d) HRTEM results of PTF12, showing the well dispersed nanoparticles of ã-$Fe_2O_3$and TiO_2 in the polymer matrix.

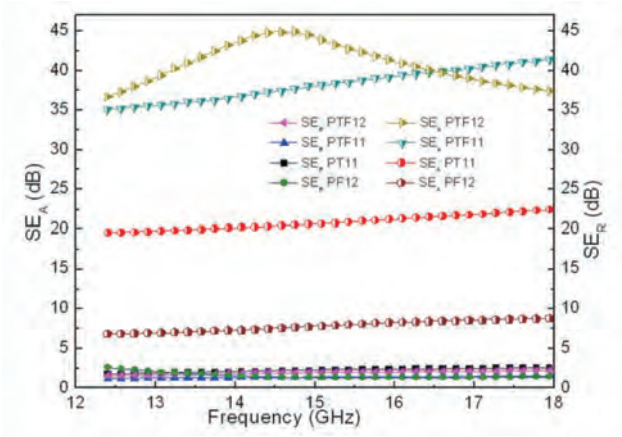


Fig. 3.23 : Shielding Effectiveness of Conducting polymer-TiO_2 and Fe_2O_3 composites in the frequency range 12.4-18 GHz

(c) Antistatic behaviour of the LDPE blended copolymer film:

0.5 wt % and 1.0 wt. % loading of PTSA and self doped copolymers of aniline and ANSA were extruded in twin-screw extruder with LDPE. The blown film of these copolymers was used for

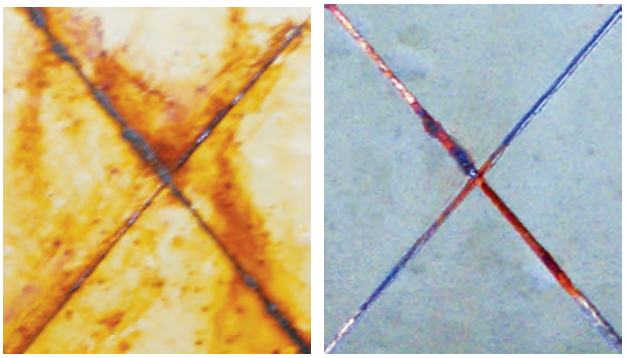
measurement of static decay time on Static Decay Meter by measuring the time on applying a positive charge of 5000 V and recording the decay time on going down to 500 V. Similarly the static decay time was measured by applying a negative charge of 5000 V. It was observed that blank LDPE film shows a static decay time of 120.1 sec whereas 1.0 wt. % blending of PANSA2-PTS with LDPE showed a decay time of 0.1 sec. However, the PANSA5-PTS/ LDPE film showed a static decay time of 0.2 sec. at 1.0 wt. % loading. Similarly 1.0 wt. % loading of self-doped copolymer i.e. PANSA2 and PANSA5 with LDPE showed a static decay time of 0.3 sec and 0.31 sec at 10 % cut-off. Any material which showed a static decay time less than 2.0 sec passes the criteria for its use as antistatic material. Based on above observations, we can say that these blended films with 1.0 wt. % loading can be used as effective antistatic films. Similar measurements were recorded with copolymer blended film with a cutoff value of 50 %. All these decay time measurement values were given in Table 3.2. Similar measurement has been carried out with the PTSA and self doped poly(AN-co-ANSA)/LDPE blends at 0.5 wt. % loading of copolymer with LDPE. It was observed that PANSA2-PTS/LDPE film showed the decay time of 1.4 sec. and 0.2 sec at 10 % and 50% cut-off respectively. While PANSA5-PTS/LDPE film showed the decay time of 0.8 sec. and 0.1 sec at 10% and 50 % cut-off respectively and PANSA2/ LDPE film showed the decay time of 1.9 sec. and 0.5 sec. at 10% and 50 % cut-off. The antistatic decay time was found to be increase (38 sec. at 10% cut-off and 15.6 sec at 50% cut-off) in the case of PANSA5/LDPE film. Hence the ESD protection performance of the conducting blends not only depends on the loading level of conducting materials but also depend on the morphology and dispersion of conducting materials in the polymer matrix.

Sample name 1 % loading of polymers with LDPE	10 % Cut off		50 % Cut off	
	Antistatic decay time for positive charge(Sec.) (Average value)	Antistatic decay time for negative charge(Sec.) (Average value)	Antistatic decay time for positive charge(Sec.) (Average value)	Antistatic decay time for negative charge(Sec.) (Average value)
Blank LDPE	120.10	110.80	94.99	93.12
PANSA 2 - PTS	0.1	0.1	.01	.01
PANSA 5 - PTS	0.2	0.1	.01	.01
PANSA 2	0.3	0.25	.01	.02
PANSA 5	0.31	0.4	.03	.04

Table 3.2 : Antistatic behaviour poly(AN-co-ANSA)/ LDPE film at 1.0 wt. % loading of copolymer

(d) Corrosion inhibition performance:

Conducting polymer coated on GF were tested for their performance for corrosion inhibition in 3 % NaCl on iron for different period of time both containing the epoxy resin without polymer and with polymer in salt spray chamber. The electrochemical impedance measurements were recorded and the panels were tested. It was observed that blank iron substrates containing only paint formulations deteriorated very fast on exposure whereas the polymer mixed pigment showed no sign of rust. It can be seen in the photographs (Fig. 3.24 b) also:



(a) **(b)**

Figure 3.24 : Photograph of Epoxy coated iron (a) without polymer (b) with polymer

इलेक्ट्रॉनिक पदार्थ
ELECTRONIC MATERIALS

इलेक्ट्रानिक पदार्थ

इस विभाग में अनुसंधान और विकास गतिविधियों को अनेक ग्रुपों द्वारा निष्पादित किया गया : संदीप्तिशील पदार्थ और साधन, प्लाज्मा संसाधित पदार्थ साधन और प्रणालियां : सिलिकॉन और सिलिकॉन साधन, इलेक्ट्रोक्रोमिक पदार्थ और साधन, गैस संवेदकों के लिए नैनोक्रिस्टलीय पदार्थो का संश्लेशण, मिश्र जैविक अजैविक, नैनोसम्मिश्र, चालन बहुलक, सतह अध्ययन और नैनोसंरचना, उच्च ताप अतिचालकीय पदार्थ और साधन, उन्नत सिरेमिक्स तथा प्रकाशीय तनु परत ।

ELECTRONIC MATERIALS

In this division, R & D activities are carried out by several groups : Luminescent Materials and Devices; Plasma Processed Materials, Devices and Systems; Silicon and Silicon Devices; Electrochromic Materials and Devices; Synthesis of Nanocrystalline Materials for Gas Sensors; Hybrid Organic-Inorganic Nanocomposites; Conducting Polymers; Surface Studies and Nanostructures; High Temperature Superconducting Materials & Devices; Advanced Ceramics and Optical Thin Films.

Luminescent Materials and Devices Group

Na^+ doped ZnO quantum dots were successfully prepared using Quantum Confinement Atom (QCA) methodology that shows exceptionally high PL brightness. The tuning of emission colors in the range 480-562 nm was achieved by dispersing them in polymeric solvents with varying index of refraction and studied the modifications assigned to the surface states by the polymeric medium. This work was immensely appreciated by Nanotech Community of Institute of Physics (IoP), UK and published as "*Technology Update*" on their website http://nanotechweb.org/cws/article/tech/35724 and also as a "*Research News in Applied Physics*" by VerticalNews.com (USA) on their website http://www.verticalnews.com/article.php?articleID=772852

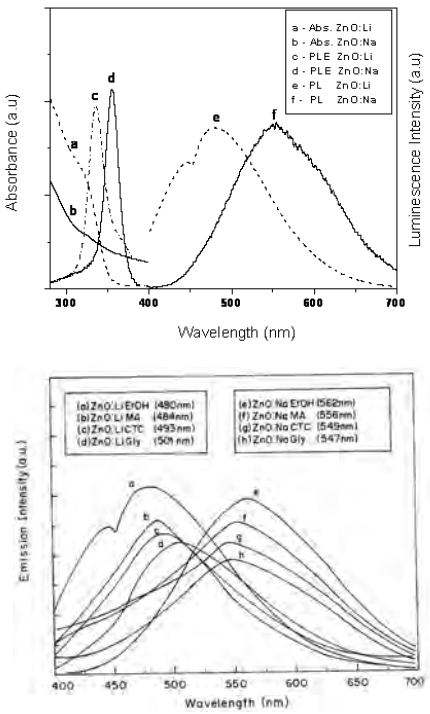


Fig. 4.1: Absorption, photoluminescence excitation and emission spectra of ZnO:Li (dotted line) and ZnO:Na (solid line) quantum dots and tuning of PL in various solvents.

High-quality field emitters are very desirable for designing advanced optoelectronic devices such as vacuum microwave amplifiers, parallel electron beam microscopes, X-ray sources, field-emission displays etc. The ZnO-tetrapod (TP), nanotetraneedle (NTN) and multipod (MP) with high aspect ratio and purity were achieved via controlled pressure-assisted thermal oxidation growth technique. Several systematic runs have been made to tailor the optimum growth conditions with large production yield (>92 %). We have also highlighted the synthesis mechanism to produce high-quality and homogeneously distributed ZnO nanostructures

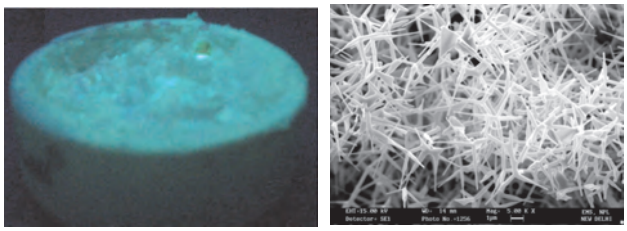
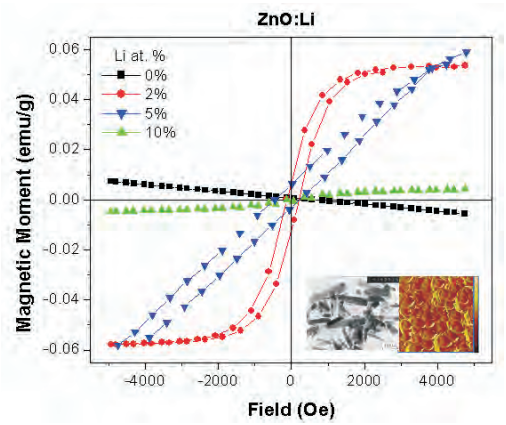


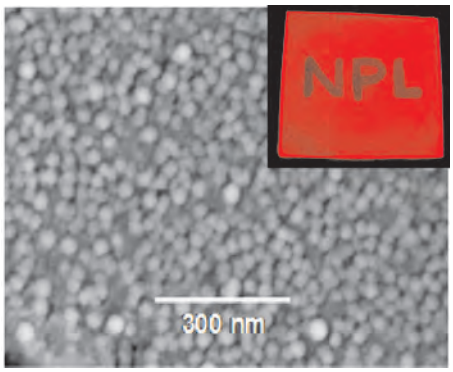
Fig. 4.2: Strong green (~505 nm) emission from ZnO tetrapods at 370 nm excitation and its homogeneous surface microstructure.

Ferromagnetism has been observed in Li doped luminescent ZnO nanorods with Curie temperature up to 554 K, which the first reported observation of DMS in ZnO with only alkali doping. Dilute ferromagnetic semiconductors (DMS) with Curie temperature at or above room temperature has immense potential for spintronic and magneto optic devices, which is generally been reported with transition metal doping in ZnO. Li forms shallow acceptor states in substitutional zinc sites giving rise to p-type conductivity. Occurrence of ferromagnetism at room temperature has been established with observed magnetic domain formation in ZnO:Li pellets in magnetic force microscopy. Magnetic ZnO:Li nanorods are luminescent showing strong UV emission. Li atoms can induce local moments on neighbouring oxygen atoms, which when considered

in a correlated model for oxygen orbitals could explain the observed ferromagnetism and high Curie temperature in ZnO:Li nanorods. This Physical Review B paper has been published in Virtual Journal of Nanoscale Science & Technology by the American Institute of Physics and the American Physical Society which covers a focused area of frontier research (http://www.vjnano.org)



(a)



(b)

Fig. 4.3: (a) B-H curve of ZnO:Li nanorods. Inset shows the TEM and MFM pictures. (b) 2-D layer of YVO_4: Eu^{3+} nanophosphor for solar cell applications.

Uniform 2D nanophosphor layer of red-emitting phosphor with 20% luminescence quantum efficiency and 80% transparency in the visible region has been developed for possible application as a solar cell phosphor towards improving efficiency of solar cell by solar spectrum modification.

In the NMITLI project with SAMTEL Colour Ltd., Red, Green and Blue PDP phosphors have been developed with luminescence quantum efficiency comparable or more than commercial PDP phosphors. Degradation of PDP phosphors is a worldwide problem which reduces the lifetime of PDP TV. Degradation problem has been nearly arrested in PDP phosphors developed at NPL, achieved by silica coating over the phosphor grains. The PDP phosphors developed at NPL have high quantum efficienctes, shorter decay time, negligible degradation and desirable particle size for PDP panel. Green and Blue PDP phosphors have been approved by SAMTEL for PDP panel preparation with indigenous phosphors.

Plasma Processed Materials Group

(A) Nano/micro crystalline silicon films deposition using PECVD technique

Hydrogenated nano/micro crystalline silicon films were grown by SiH_4+H_2 +Ar gaseous mixture using RF (13.56 MHz) PECVD technique. In particular, the role of Ar, which varies from 66 - 87 % in the total gaseous mixture, on the structural, electronic and optical properties of the films have been investigated. Raman scattering measurements (Fig 4.4 & 4.5) show that increasing Ar fraction favorus the enhancement of crystallinity and grain size and also in relaxing strained Si lattices. XRD studies also reveal the crystallinity in the hydrogenated amorphous silicon films deposited at different Ar fractions and the variation of grain size follows a similar trend to that estimated from Raman data. Photoluminescence spectra show two radiative transitions in the ranges 2.8-3.1 eV and 1.6-2.1 eV in the films. The high energy peaks arise from surface effects of the film whereas peaks in the range of 1.6

- 2.1 eV are due to nanocrystallinity in the film deposited. Optical band gap is estimated in the higher absorption coefficient region (> 10^4 cm^{-1}). The argon dilution in the range of 70-80% has also been found to be favourable for crystallinity in hydrogenated amorphous silicon.

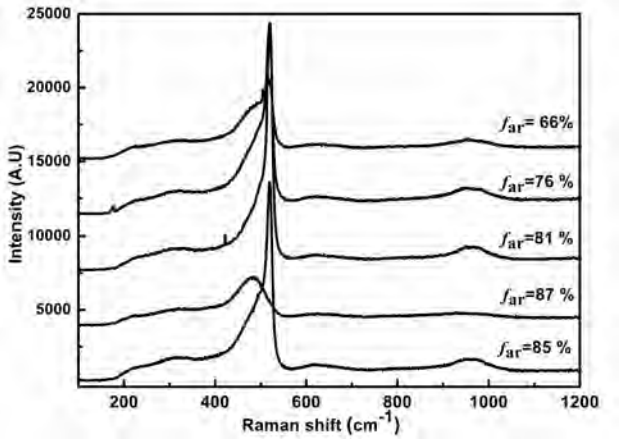


Fig 4.4: Raman spectra of nc-Si: H films deposited at different argon fraction.

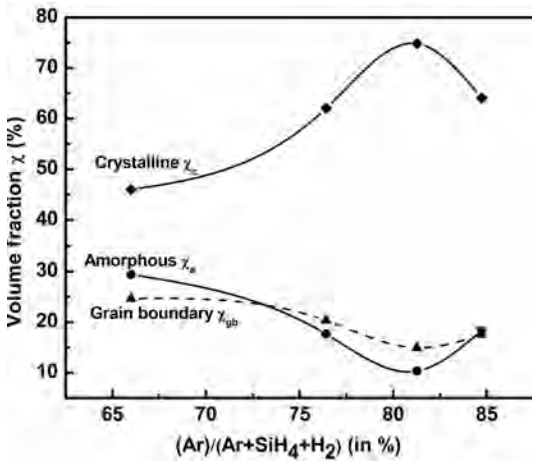


Fig 4.5: Crystalline, grain boundaries and amorphous phase volume fraction estimated from three peaks fit of Raman spectra of Fig 1.

(B) Diagnostic of acetylene plasma for the growth of DLC films

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

(C)Tetrahedral amorphous carbon (ta-C) films deposited by filtered cathodic Vacuum arc (FCVA) technique

The effect of substrate bias and hydrogen and nitrogen incorporation on the optical constants, sp^3/sp^2 ratio, electrical and mechanical properties of ta-C films deposited by FCVA technique have been studied. Undoped and hydrogen incorporated a-C films having nanoparticle inclusions at different substrate bias using these modified vacuum arc techniques have also been deposited and the characterization of the films deposited are in progress.

Silicon and Silicon Devices Group

Antireflection Properties of Silicon Nanowires Array for Solar Cell Applications

Reflection loss of the incident light is one of the major factors which limit the photovoltaic conversion efficiency. An antireflection surface consisting of vertically aligned silicon nanowires (SiNWs) arrays has been developed. Large area silicon nanowires (SiNWs) arrays were made on p-Si by wet chemical etching process at room temperature which consisted of high density of vertically aligned nanowires. The SiNWs in the array were aligned vertically as revealed by SEM investigations. The length of SiNWs (diameter in 50-200 nm range) was found to increase linearly with the reaction time. The remarkable reduction in reflectivity (R_l) was observed. The value of R_l as low as 2% was realized in the 300-600 nm wavelength range in the case of ~10 mm long arrays (average R_l <3% for the entire 300-1100 nm range), a value better

than the best R_l reported in anisotropically textured or porous silicon surfaces. The work on solar cell fabrication using SiNW based substrates are in progress.

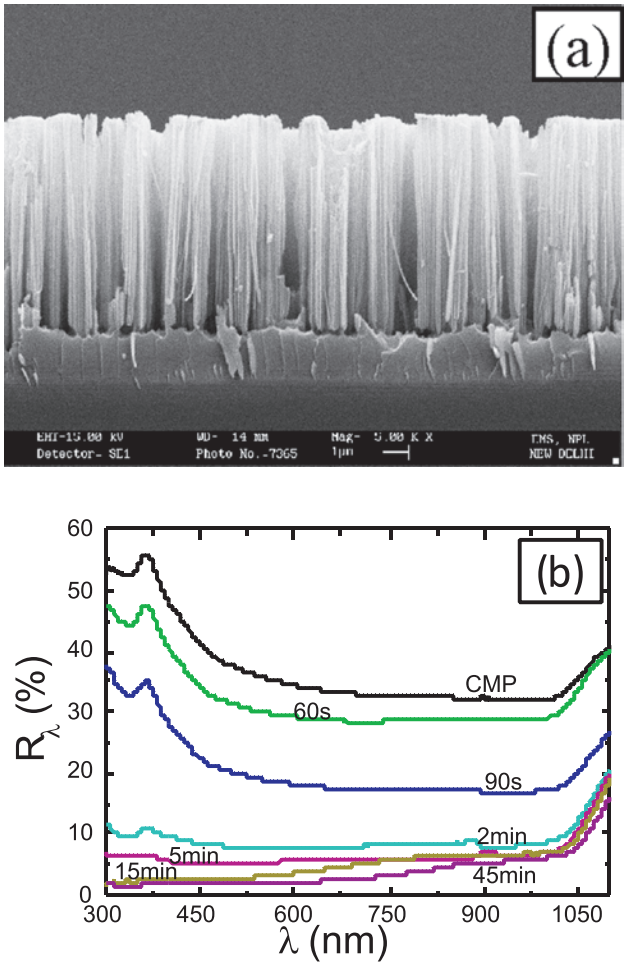


Fig. 4.6: SEM image of vertically aligned silicon nanowires, (b) reflectivity vs wavelength curves for different etching times.

Minority Carrier Lifetime Measurement Facility

A system for the measurement of minority carrier lifetime from Semi-Lab, Hungary consisting of microwave photoconductive decay (m-PCD), surface photo-voltage (SPV) and LBIC measurement tools was installed. m-PCD and SPV systems have been used to study process related lifetime degradation and surface passivation.

Poly(3,4-ethylenedioxythiophene) (PEDOT) films with enhanced performance characteristics for electro-chromic smart windows

PEDOT films have been functionalized after polymerization via a photochemical nitrene reaction using the reactive 1-fluoro-2-nitro-4-azidobenzene (FNAB), typically used for bio-chemical applications. The unusual surface morphology of the functionalized PEDOT film with micron sized outgrowths with a partially crystalline structure (Figure 4.7) is responsible for its extremely high coloration efficiency (340 cm^2 C^{-1} at 550 nm), large charge storage capacity (0.7 mC cm^{-2} at 5 mV s^{-1} and good electrochemical cycling stability (as high optical contrast is retained even after 3000 clear to dark and dark to clear cycles). These results demonstrate the unparalleled potential this functionalizing methodology has for creating electro-active polymer films with unique morphologies and electrochemical properties for electro-chromic applications.

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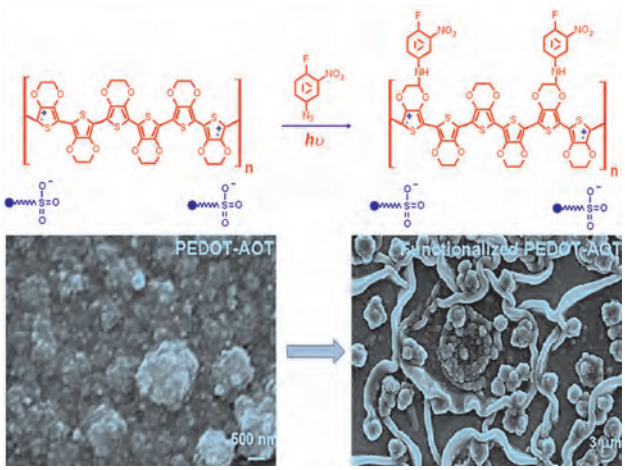


Fig. 4.7: Functionalization of doped PEDOT films by FNAB shown through an equation; SEM on left hand side corresponds to PEDOT before functionalization and SEM on right hand side is for PEDOT after functionalization.

Nanostructured Materials and Devices and Surface Studies Group

One-Pot Synthesis of Composition-Tunable CdSe-ZnSe (core-shell) and $Zn_xCd_{1-x}Se$ (Ternary-Alloy) Nanocrystals with high luminescence and stability

In this work, a simple single-pot synthesis procedure has been adopted to prepare both CdSe-ZnSe core-shell as well as $Zn_xCd_{1-x}Se$ ternary alloy nanocrystals systematic alloy varying the amounts of Zn-precursor. Few samples are also being prepared with the conventional double-pot approach and the results are compared with the corresponding samples obtained from single-pot synthesis approach.In this work, a simple, effective and reproducible synthetic route (single-pot approach) for the preparation of high quality core-shell CdSe-ZnSe quantum dots without the use of any pyrophoric organometallic precursors is presented. Effective surface passivation of stoichiometric, monodispersed, small-sized (~ 5 nm) CdSe nanocrystallites is achieved by overcoating them with a ZnSe shell using zinc acetate as a zinc source by single-pot approach. The resulting core-shell nanocrystallites exhibit high quantum yield values ~ 11.33%, narrow line-width of the PL band, stable surface-bonds configuration and superior structural properties at lower Zn content (~ 10 at%). With increasing Zn content (e" 20 at%), a composition-tunable emission across the visible spectrum has been demonstrated by a systematic blue-shift in emission wavelength due to the formation of ternary $Zn_xCd_{1-x}Se$ quantum dots with acceptable luminescence properties. Here, contribution to emission process from surface states of nanocrystallites increases with zinc content. The core-shell and ternary QD's formed by different routes are modeled, based on the observations of several complimentary techniques (XPS depth-profiling, PL, UV-VIS absorbance, TEM/TED).

Formation Of Water-Soluble And Biocompatible TOPO-Capped CdSe Quantum Dots With Efficient Photoluminescence

In this work, polysorbate surfactants with same functional groups but with varying molecular masses (Tween-80, Tween-40 & Tween-20) in different concentrations (0.1% to 20% w/w) were used to study the effect of the length of the surfactant chain on the luminescence of the entrapped TOPO-capped CdSe nanocrystals. Various phospholipids with different functional headgroups such as ethylene glycol (-PEG) and amine ($-NH_2$) were used to improve biocompatibility and provide sites for bioconjugation respectively. It is understood that that the hydrophobic ends of the surfactant binds with the water repelling groups of the cap layer, thus modifying the CdSe cap layer and making it soluble in aqueous media. It was observed that the PL emission intensity of CdSe increases with increase in concentration of Tween-series surfactant unlike in the case of thiol-coated CdSe nanoparticles. However, higher PL intensity was obtained in the case of stoichiometric CdSe with Tween-40 corresponding to 20% w/w. The efficient PL sustainability of water-soluble CdSe QD's can be attributed to the simpler chain structure of Tween-40 surfactant resulting in better passivation of the micelle.

Gas sensor array using metal oxide semiconductors

With the aim to integrate the sensor device on microheaters, sol-gel process was investigated to coat the alumina substrate. Preliminary investigations were carried out to drop deposition of the sol on the silicon microheater substrates. Indium, tungsten and

niobium doping were found very effective in reducing the resistance and imparting good sensing capacity over these substrates. The gas sensing properties were investigated after doping with Nb, Co and Ni, Sr, Sb. The gas response was measured for various gases such as ethanol, acetone, TMA, DMA, ammonia, NO_x, CO, LPG and CNG, DMMP, acetonitrile etc. Efforts were made to fabricate sensor arrays for selective gas detection. For this separate sensors were prepared and integrated to make a sensor array. To impart selective determination other metal oxides were also investigated such as ZnO nanorods, WO_3, TiO_2 etc. Various chemical routes were investigated to prepare nanocrystalline powders. Materials were characterized and gas sensitivities of these materials were investigated for bulk as well as thin films. Mesoporous oxide materials were synthesized and tested using BET surface area technique.

Synthesis of metal oxide / MWCNT composite

Recently, nanostructures such as nanotubes, nanowires etc have been studied for high gas sensitivity as they would provide more surface sites for more oxygen to be adsorbed and contacted with the gases. Composite films based on tin or tungsten oxide and carbon nanotubes have been investigated as new gas sensitive materials with improved sensitivity. Composites containing carbon nanotubes exhibit cooperative or synergetic effects between the metal oxide and carbon nanotube, and useful for many applications. Metal oxides SnO_2, W doped SnO_2 and WO_3 were used to prepare composites sensors. A sol-gel processing route was used to prepare composite films. Films were studied by X-ray diffraction, scanning electron microscopy (SEM). Sensing properties of the prepared composites have been tested with respect to NO_2 gas. The addition of carbon nanotubes during synthesis resulted in a highly porous structure. A high surface area and small crystallites present in the sol-gel synthesized composite films were attributed to this high sensitivity. NO_2 is a common air pollutant; presence of a low concentration even at the ppb level may cause breathing difficulties, particularly in children and the elderly. Low concentrations of NO_2 could be detected even at room temperature using these composite films which was not possible without CNT addition. AC impedance spectroscopy was used to study the electrical behaviour of these hybrid sensors.

The photo-catalytic oxidation of organic compound in aqueous solution containing a suspension of titanium (IV) oxide has been used for the removal of organic impurities from water. However, after degradation of these impurities, the suspended catalyst water has been removed to obtain fresh stream of water. In order to enhance photo catalytic activity of these compounds, metal ions having atomic radii near to Ti(IV) ion. These metal ion substitutes in crystalline network of quantum size. This quantum size effect anchor on solid support like glass bids, fibre glass, ceramic fibres, glaze tiles etc. which removes the pollutant from air and water.

Optical characterization of a large number of samples from NPL and outside NPL (JNU, New Delhi) were carried out using UV-Vis-NIR Shimadzu make Spectrophotometer for the development of coatings and materials for various applications. Some of the significant spectrophotometric studies pursued during the period are : Variation of reflectivity after each major process step of a single crystal Si solar cell ; reflectivity studies for various types of AR coatings on silicon, viz., silicon nanowires (SiNWs) made on porous silicon wafers, textured monocrystalline silicon with and without ZnO layer on it , ZnO:Al coatings on silicon with different Al

content, etc. for use in Si solar cells ; absorption studies of nanocrystals of PbSe, CdSe, nano-composites of polymer-CdSe for solar cell applications; changes in optical properties with variation in doping level and annealing temperature for silver doped sodium phosphate glasses for possible photonic applications . Holmium filters were calibrated using Shimadzu spectrophotometer for M/s Textiles Committee, Mumbai and M/s AVT McCormick Ingredients Pvt.Ltd., Ernakulam.

Surface Physics & Nanostructures

The change in the surface morphology of the oxygen induced faceted Re $(12\bar{3}1)$ surface has been studied due to the growth of gold nanoclusters. The nano trenches (two sided ridges) faceted rhenium surface was formed by oxygen interaction followed by annealing to elevated temperature which consists of facet along $(11\bar{2}1)$ and $(01\bar{1}0)$ orientation is used as a template to grow the gold nanoclusters. The growth modes and the influence of gold on the faceted rhenium surface were characterized by AES, LEED and STM. It is observed that the gold grows in the form of 2D & 3D islands on top of the ridges depending upon the gold coverages. On annealing the gold covered faceted surface undergoes drastic morphological change and form three sided nano pyramids. The facets of the nano pyramids were determined as, and. The STM analyses revealed that the facet of the nano pyramid covered with zigzag gold nano chains.

Further, we investigate morphological instability of a catalytically important hcp Rusurface. The Ru undergoes various surface reconstructions at low oxygen coverage followed by high temperature annealing. The study revealed the possibility of the formation oxygen-induced facets on morphologically stable Ru surface. The LEED observations and tilt angle calculation indicates two stable orientations formed on Rusurface specified as (10-10) and (01-10) surface. We also report the sub-monolayer adsorption of Indium metal on reconstructed high index Si (5512) surfaces under controlled thermodynamic & kinetic growth. The growth mode of the Indium adsorption is determined by AES while the formations of various superstructural phases are identified by LEED.

High Temperature Superconducting Devices, Advanced Ceramics and Optical Thin Films

The High Temperature Superconducting Materials and Devices Group has been engaged in the development of $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$ [Bi-2223] bulk tube/rod and current leads and long length tapes for high current transport. Joint assemblies of 1 – 1.5 m long three to five bulk tubes (L = 300 mm, OD = 12 mm, ID = 10 mm) carrying transport critical current not less than 80% of that of the individual tubes carrying 500 – 1000A and

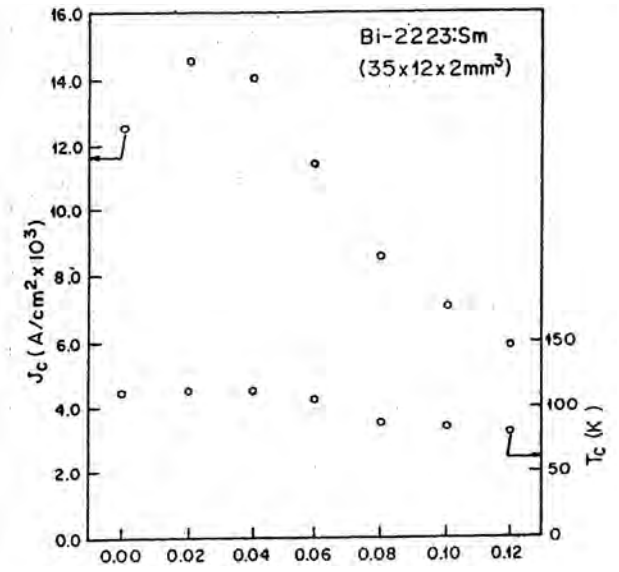


Fig. 4.8: Variation of J_c and T_c as a function of Sm concentration

contact resistivity of the order of 10^{-7} – 10^{-8} Ù Pº(‘¨– cm^2 at 77K in self field has been developed. Optimization of preparation parameters to improve the transport current though the joint is in progress. Multifilamentary Bi-2223 tapes (> 35 m long) having 7 filaments carrying J_c of the order of 103 A/cm^2 at 77 K in self-field have been developed. To understand the nature of pairing and in search of effective pinning centers, XRD, SEM, AC susceptibility, resistivity and EPR studies of $Bi_{1.84}Pb_{0.35}Sr_{1.91}Ca_{2.05}Sm_xO_{10+y}$ (x = 0 – 0.12M%) bar shaped (35 x 12 x 2 mm^3) samples prepared under optimized conditions have been carried out. XRD studies show that almost all peaks belong to the Bi-2223 and Bi-2212 phases. Transition temperature T_c and J_c have been found to vary with Sm concentration (x), as shown in Fig.4.8. SEM studies show that addition of Sm leads to a changes in grain size and porosity, depending on the value of x. EPR studies of these samples are in progress.

In the Advanced Ceramics Group, the beta alumina ionic conductor project was successfully completed. The microwave furnace designed under the above project is being used for microwave sintering of CCTO dielectric materials. One weight percent Chromium doped calcium-copper-titanate (Cr_2O_3-doped CCTO) ceramics were prepared by solid-state reaction method. These samples were sintered at temperatures 1100%C, 1150%C, and 1200%C. Samples sintered at 1200%C shows well defined helical grain growth. The average grain size of Cr_2O_3-doped CCTO increased with increase in sintering temperature. XRD patterns of these samples show diffraction profiles similar to the bcc perovskite structure. Dielectric properties of Cr_2O_3-doped CCTO materials were improved with increasing sintering temperature.

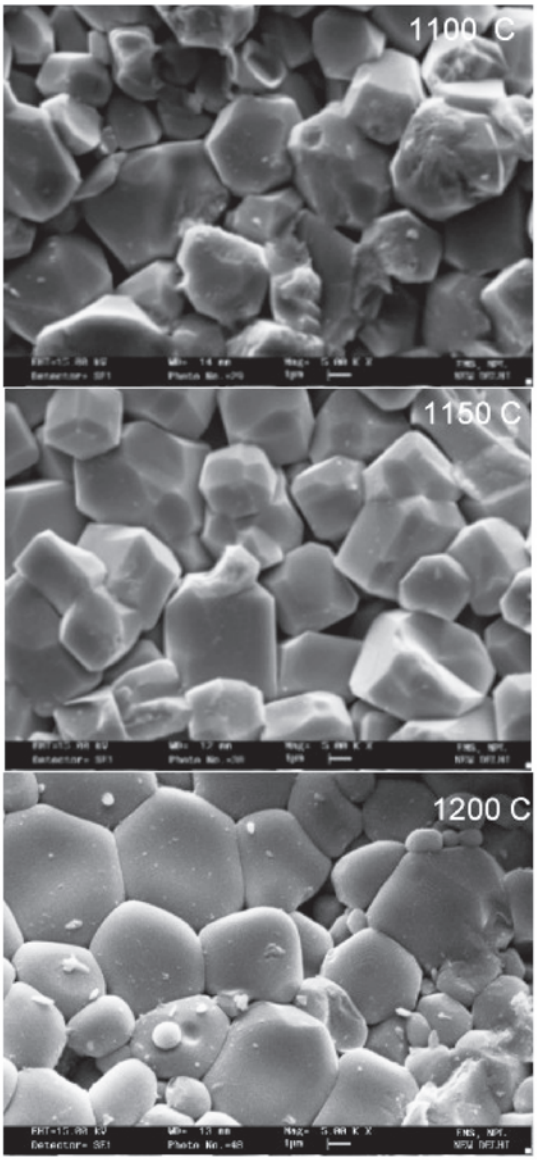


Fig. 4.9: Microstructure of Cr_2O_3-doped CCTO sample

Under the Optical Thin Films activity, the characterization of a large number of transparent or weakly absorbing thin films from different users to determine the optical constants and thicknesses has been carried out using manual ellipsometry and white-light spectrophotometry. A PC controlled fibre-optic based mini spectrophotometer has been set up to measure the transmittance and reflectance of samples over the wavelength range 200 to 1700 nm. Using

the in-house designed, fabricated and assembled plasma polymerization deposition system, with a argon-oxygen RF plasma at 13.56 MHz and non-toxic liquid organic precursors, processes have been successfully developed for the dpreparation of agglomerates of pure anatase-phase titania nanocrystals of large surface area, by applying different substrate bias voltages, at room temperature. Along with these, nanorods, nanotubes and nanoparticles of anatase phase titania have also been prepared (Fig. 4.10). A thin film deposition system which can execute simultaneous PECVD and ion beam sputtering processes for the deposition of nanocomposite films is in the process of fabrication.

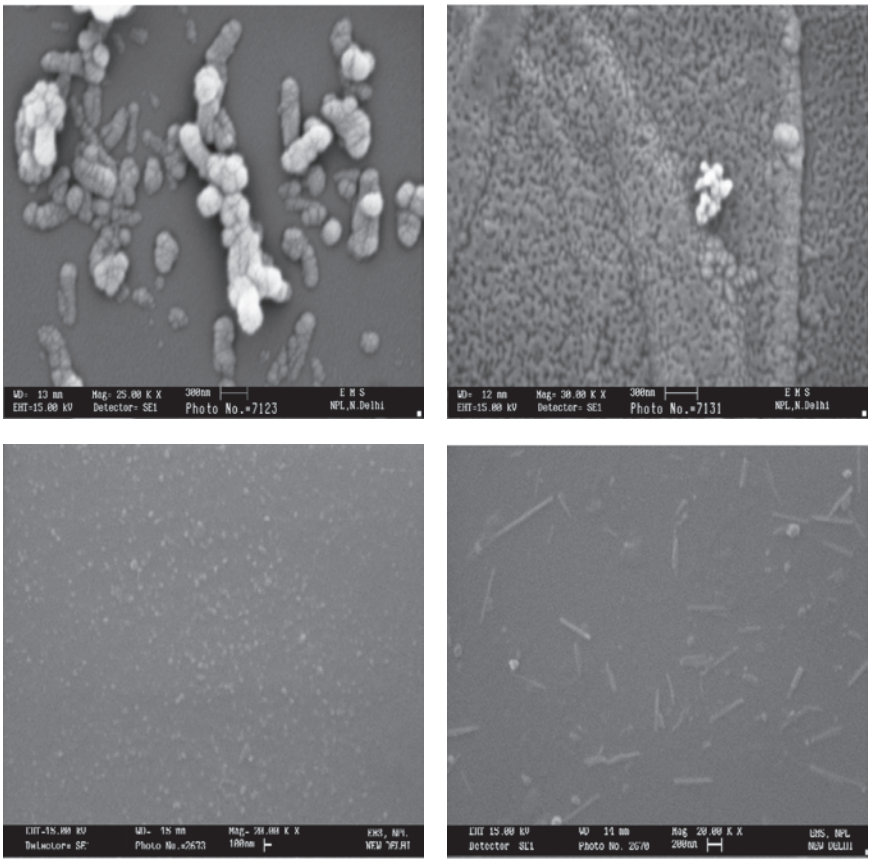


Fig. 4.10: Anatase phase titania agglomerates, nanotubes, nanoparticles and nanorods prepared by PECVD technique

पदार्थ अभिलक्षणन

MATERIAL CHARACTERIZATION

पदार्थ अभिलक्षणन

पदार्थो के अभिलक्षणन के अन्तर्गत संघटन और संरचना की उन विशेषताओं का वर्णन किया जाता है जो किसी विशिष्ट तैयारी, गुणधर्मों का अध्ययन और/या पदार्थ के पुनरोत्पादन के लिए पर्याप्त होते हैं । पदार्थों के गुणधर्मों के लिए उत्तरदायी उनके आधारभूत में उनका संघटन और शुद्धता, क्रिस्टलाइन अवसंरचना और परमाणु स्तर पर अवसंरचना की संपूर्णता शामिल होती है । एन पी एल में पदार्थ के विश्लेषण की योग्यता का महत्व, इसके आयोजन के समय ही समझ लिया गया था । वर्तमान में एन पी एल में पदार्थों के अभिलक्ष के लिए अत्याधुनिक और नवीनतम भिन्न – भिन्न सुविधाऐं उपलब्ध हैं । इनमें एक्स–रे विश्लेशण (एक्स आर डी, एक्स आर एफ, एच आर – एक्स आर डी), इलेक्ट्रॉन माइक्रोस्कोपी (एस ई एम, टी ई एम, ई डी एक्स, एच आर–टी ई एम), आयन माइक्रोस्कोपी (टी ओ एफ–एस आई एम एस, आई सी पी एम एस), आण्विक स्पेक्ट्रोस्कोपी (ए ए एस), प्रकाशीय स्पेक्ट्रोस्कोपी (यू वी – वी आई एस, पी एल), रासायनिक विश्लेषण (जी सी – ई सी डी, जी सी – टी सी डी/एफ आई डी, एच पी –एल सी एम एस), तथा चुम्बकीय मापन (ई पी आर) शामिल होते हैं ।

पदार्थ अभिलक्षणन विभाग द्वारा एन पी एल में विकसित किए जा रहे अनेक पदार्थों जैसे थिन फिल्म, नैनो पदार्थ जिनमें नैनो टयूब्स, नैनो राड्स, नैनो वायर्स, इंजीनियरी अनुप्रयोगों के लिए कंपोजिट पदार्थ, डिवाइस फ्रेब्रिकेशन के लिए इलेक्ट्रॉनिक पदार्थ आदि शामिल हैं, के अभिलक्षणन से संबंधित कार्य किया जा रहा है । इस विभाग द्वारा प्रयोगशाला की अनुसंधान योजना को ध्यान में रखते हुए, ऐसे इन भिन्न – भिन्न पदार्थों के विकास का कार्य भी किया जा रहा है जो कि प्रौद्योगिकीय रूप से महत्वपूर्ण है , तथा उनके विश्लेषण और विकास के साथ साथ, विकास तंत्र की प्रक्रिया नियंत्रण के इष्टतमीकरण के लिए अंततः अभिलक्षणन किया जाता है । अभी हाल ही में, इस विभाग द्वारा ग्यारहवीं पंचवर्षीय योजना के दौरान (ईएफ फी) पदार्थ मापिकी और रसायन मापिकी कार्यक्रम के अन्तर्गत लाने के लिए कदम उठाए जा रहे हैं ।

1. पदार्थ मापिकी और रसायन शास्त्र में मापिकी की नई गतिविधि के अन्तर्गत, एन पी एल द्वारा अपने मिक (MiC) नेटवर्क साझेदारों के साथ रासायनिक मापन में अनुरेखणीयता प्रदान करने के लिए ध्यान केन्द्रित किया जा रहा है जिसका लक्ष्य क्षमता निर्माण, विभिन्न क्षेत्रों में अनुसंधान और विकास करने, अन्तर्राष्ट्रीय प्रयोगिक और महत्वपूर्ण तुलनात्मकताओं में भाग लेने के लिए करना है और इसमें प्रमाणित संदर्भ पदार्थों (सी आर एम) को तैयार करना और संवितरण करना भी शामिल है । एन पी एल के आंतरिक अनुसंधान कार्य, सरकारी एजेंसियों और संस्थानों की विभिन्न पदार्थ अभिलक्षण आवश्यकताओं जैसे दिल्ली जल बोर्ड द्वारा पानी के शोधन के लिए प्रयोग किए जा रहे एल्युमिनियम क्लोराइड और एल्युमिना फैरिक ग्रेड–2, भारत के निर्वाचन आयोग की ओर से चुनाव उद्देश्यों के अमिट स्याही (इंडेलिबल इंक) अतिविशिष्ट व्यक्तियों की सुरक्षा के लिए गैस मिश्रण अभिलक्षणन, ग्रेफाइट, क्वार्ट्ज, सिल्वर कान्टेक्ट्स नमूनों आदि में धात्विक अशुद्वताओं से संबंधित कुछ महत्वपूर्ण सेवाऐं प्रदान की गई हैं ।

2. उच्च बारम्बारता क्षेत्रों में माइक्रोवेव अवशोषण के लिए मृदु धात्विक चुंबक संभावित पदार्थ है । इस संदर्भ में नैनो मैगनेटिक कोबाल्ट आयरन ($Co Fe_2$) नैनो मिश्रधातु को रासायनिक प्रिपेसीपीटेशन मार्ग से संश्लेशित किया गया हे तथा Ku बैंड (12.4 – 18 गेगा हट्र्ज) में माइक्रोवेव अवशोषण के लिए क्रिस्टेलाइन आकार, अणु आकर, चुंबकीयकरण तथा चालकता के संबंध में विश्लेषण किया गया ।

3. अर्ध स्वचालित और आधुनिकीकृत इन–हाउस विकसित क्रोचालस्की (Czochralski) 40 मिलीमीटर के बड़े व्यास तक के लिथियम निओबेट (एल क्रिस्टल पुलर के साथ आर एफ तापन प्रणाली की सफलतापूर्वक स्थापना के बाद, निम्नतापीय ग्रेडिएन्ट क्रोचालस्की तकनीक द्वारा उपस्कर अनुप्रयोगों को पूरा करने के लिए आई एन बी ओ$_3$) क्रिस्टलों को विकसित किया गया है । बेहतर यांत्रिकी और रासायनिक स्थिरता और विस्तृत पारदर्शिता के साथ–साथ विशिष्ट इलेक्ट्रो आप्टिकल (ई–ओ), एकास्टिक आप्टिक (ए–ओ), फोटोइलास्टिक, पीजो–इलेक्ट्रिक तथा अरेखीय ऑप्टिकल (एन एल ओ) गुणधर्मों के कारण लिथियम निओबेट ऑप्टोइलेक्ट्रोनिक्स के लिए सबसे आकर्षक सामग्रियों में आता है । 23 आर्क एस की एफ डबल्यू एच एम मान के साथ तीव्र और एकल उच्चतम डिफ्रेक्शन वक्रता द्वारा ए एस–ग्रोन क्रिस्टल की शानदार गुणवत्ता को दर्शाता है जिससे दरारें और आंतरिक अवसरचनात्मक ग्रेन सीमाएं दिखाई नहीं देती है।

4. ग्राफेन आक्साइड नेनोशीट्स (एक घोल आधारित एकल चरण विधि जो ग्राफेन आक्साइड नैनोशीट्स में सिल्वर नैनोपार्टिकल्स को अंतर्निहित करती है) में सिल्वर नैनोपार्टिकल्स को अन्तर्निहित करके ग्राफेन धातु नैनोहाईब्रिड असेम्बलियों को संश्लेषित किया गया है । इस प्रकार ग्राफेन शीट्स के आप्टो इलेक्ट्रिक गुणधर्मों को मैग्नीटयूड के अनेक आर्डरों में टयून किया जा सकता है जिससे वे संभावित लोचपूर्ण और पारदर्शी सेमीकंडक्टरों अथवा अर्ध धातुओं के लिए संभावित तौर पर उपयोगी हो सकते हैं ।

5. एस आई /टी एम (ट्रांजिशन मेटल) एस आई सिस्टम / एस आई सिस्टम (वी / एस आई, एफ ई / एस आई तथा सी ओ / एस आई) के संबंध में अपने पिछले कार्यों को जारी रखते हुए, एक अन्य ट्रांजिशन मेटल अर्थात् एम एन को अमारफस सिलिकॉन (ए एस आई के साथ मिश्रित करने को चुना गया है क्योंकि इस धातु पर शायद ही कोई अध्ययन किया गया हो / एस आई सिस्टम उच्च – ऊर्जा रेजीमेन में आता है । यहाँ तक कि एस ई – उच्चतम सीमा मान के संबंध में कोई जानकारी भी उपलब्ध नहीं है । मिश्रण दर के रूप में, इस कार्य को एस एच आई – प्रेरित इंटरफेस मिश्रण की मात्रात्मकता को निर्धारित किए जाने का प्रयास है जिसके परिणामस्वरूपतः तापीय स्पाइक मॉडल के फ्रेमवर्क में इस प्रवृत्ति को समझा जा सके और दूसरा इस बात की जाँच करना की कमरे के तापमान पर कोई सिलिसाइडेशन तो नहीं हुआ है ।

MATERIALS CHARACTERIZATION

Characterization of materials describes those features of the composition and structure (including defects) of a material, that are significant for a particular preparation, study of properties and/or suffice for the reproduction of the material. The basic characterization of materials responsible for their properties are the composition and purity, crystalline structure and perfection of structure at atomic level. The importance of the capability for material analysis at NPL was realized even at the time of its planning. Presently NPL has wide variety of state-of-the art sophisticated facilities for characterization of materials. These include X-ray analysis(XRD, XRF, HR-XRD), electron microscopy (SEM, TEM, EDX, HR-TEM), ion microscopy (TOF-SIMS, ICPMS), atomic spectroscopy(AAS), optical spectroscopy (UV-VIS, PL), chemical analysis (GC-ECD, GC-TCD/ FID, HP-LCMS) and magnetic measurements (EPR).

Material characterization division has been characterizing various materials that are being developed at NPL, like thin films, nano materials including nano tubes, nano rods, nano wires, composite materials for engineering applications, electronic materials for device fabrication etc. The division is also working on development of different materials which are technologically important, their synthesis and growth and finally characterizing them for optimization in process control of the growth mechanism, keeping in view the research plan of the laboratory. In the recent past, the division has taken up a new programme under the eleventh five year plan (EFP), Material Metrology and Metrology in Chemistry. Under this programme the implementation of Quality system as per ISO 17025 is being pursued in the division and all the necessary steps are being taken to bring this division under 'Advanced Metrology' programme of NPL.

1. Under the new activity of Material Metrology and Metrology in Chemistry, focus has been given for providing traceability in chemical measurements by NPL with its MiC network partners by building capacity, doing R&D in various areas, participating in international pilot & key comparisons and includes preparation & dissemination of certified reference materials (CRMs). The chemical characterization needs of NPL in-house research work, government agencies and institutions for characterization of a variety of materials viz. poly aluminum chloride and Alumina Ferric Grade-II used for treatment of water by Delhi Jal Board; indelible ink for election purpose from Election Commission of India; gas mixtures characterization for VVIP security, metal impurities in graphite, quartz, silver contacts samples etc. are some of the important services rendered during this period.

2. Soft metallic magnets are potential materials for microwave absorption in high frequency region. In this context nano-magnetic cobalt iron ($CoFe_2$) nano-alloy have been synthesized by chemical coprecipitation route and studied for microwave absorption in the Ku band (12.4-18 GHz) region. Prepared material was analyzed for crystalline phase, crystallite size, particle size, magnetization and conductivity measurement relevance to microwave absorption.

3. After successful installation of RF heating system with semi-automated and modernized in-house developed Czochralski crystal puller, good quality Lithium niobate ($LiNbO_3$).crystals with larger diameters up to 40 mm have been grown to meet the device applications by a low thermal gradient Czochralski technique. Lithium niobate is one of the most attractive materials for optoelectronics due to its unique electro-optical (E-O), Acousto-Optic (A-O), photoelastic, piezo-electric and nonlinear optical (NLO) properties combined with good mechanical and chemical stability and wide transparency. The sharp and single peak diffraction curve having FWHM value of 23 arc s depicts the excellent quality of the as-grown crystal revealing the absence of cracks and internal structural grain boundaries.

4. Graphene-metal nanohybrid assemblies have been synthesized by embeding the silver nanoparticles into graphene oxide nanosheets (a solution-based single step method that embeds the silver nanoparticles into graphene oxide nanosheets) . The opto-electronic properties of the graphene sheets can thus be tuned over several orders of magnitude, making them potentially useful for flexible and transparent semiconductors or semi-metals.

5. In continuation to our previous work on Si/TM(transition metal)/Si systems (V/Si, Fe/Si and Co/Si) the mixing of another transition metal, Mn, with amorphous silicon (a-Si). is chosen as hardly any detailed study has been done on this metal/Si system in high-energy regime. Even the information about its S_e-threshold value is not available. This work is an attempt to quantify SHI-induced interface mixing in terms of mixing rate and thereby understand this phenomenon in the framework of thermal spike model and secondly, to check if some silicidation has taken place at room temperature.

Chemical Metrology Section

Metrology in Chemistry (MiC) and Certified Reference Material (CRM) are major activities of the chemical metrology section under the 'Advances in Metrology' CSIR Network project. Herein, focus has been given for providing traceability in chemical measurements by NPL with its MiC network partners by building capacity, doing R&D in various areas, participating in international pilot & key comparisons and includes preparation & dissemination of certified reference materials (CRMs). The preparation & dissemination of CRM or Bhartiya Nirdeshak Dravya (BND) as calibration standards; maintain their international comparability and hence to provide SI traceability in chemical measurements are envisaged for various user levels. This section during this period had also catered to the chemical characterization needs of NPL in-house research work, government agencies and institutions for characterization of a variety of materials viz. poly aluminum chloride and Alumina Ferric Grade-II used for treatment of water by Delhi Jal Board; indelible ink for election purpose from Election Commission of India; gas mixtures characterization for VVIP security, metal impurities in graphite, quartz, silver contacts samples etc. during this period. A chemical process for ZnO nano particle synthesis has been developed for getting desired morphology. The ZnO powder has been seen to remove arsenic and chromium from potable water. Two sponsored projects are being implemented for Ministry of Environment & Forests national communication (NATCOM-SNC) for GHG QA/QC and traceability. NABL sponsored proficiency testing (PT) project in chemical discipline (code PT-44) for the NABL accredited laboratories has been completed for Phase-I and Phase-II is underway. Under APN sponsored aerosols & health project and under ISRO-GBP special observational programme (ICARB) in Delhi and data analysis under such field campaign studies by the group have been done for suspended particulate matter (SPM) and its chemical composition apart from aerosol size and mass distribution by Anderson and quartz crystal microbalance (QCM). Trace gas & aerosol measurements from residue burning have been carried out in Patiala district of Punjab in collaboration of Thapar University.

Participated in international inter-comparison viz. CCQM-K51 (CO in nitrogen), APMP.QM-K24/ P-12 key comparison for Cadmium content in Rice powder coordinated and conducted by NMISA South Africa, AASD Govt. Laboratory Hong Kong, and KRISS Korea respectively. These inter-comparison participations had shown our capability in gas & inorganic analysis area. An important achievement of Metrology in Chemistry (MiC) programme during February 2009, was the establishment of a Primary Standard Reference Photometer (SRP) at RASD NPL procured from NIST-USA, to calibrate air-monitoring instruments used to measure the ozone content of ambient air and which is going to help in quality assurances and traceability of the ozone measurement data generated in the country, comparable to international level. Six new CRMs of mono [BND-305.01 Arsenic, BND-401.04 Chromium, BND-405.01 Chromium, BND-2101.01 Potassium] and multi elemental [BND-

Fig. 5.1: Release of CRMs by Dr Robert Kaarls

2401.01 Copper, Iron & Zinc and BND-2305.01 Lead, Cadmium & Nickel] solutions have been released on 30th May 2008 at NPL in MiC international workshop, by Dr. Robert Kaarls, president CCQM & secretary CIPM.

EPR & IR Spectroscopy Section

The use of microwave absorption materials has attracted great interest due to rapid increases of electromagnetic interference (EMI) pollution by communication devices like mobile phones, local area network, radar systems etc. For the significant absorption of unwanted electromagnetic waves the materials are essentially required to have the specific shape and size distribution of particles is very important for the electromagnetic wave absorption. Particles with size less than the skin-depth (~1μm for iron in the 1–20 GHz range) are the best to increase effective incidence to EM wave absorbers by suppressing the eddy current phenomenon. Large surface to volume ratio of these conducting and magnetic materials makes them very important. Soft metallic magnets are potential materials for microwave absorption in high frequency region. In this context nano-magnetic cobalt iron ($CoFe_2$) nano-alloy have been synthesized by chemical coprecipitation route and studied for microwave absorption in the Ku band (12.4-18 GHz) region. Prepared material was analyzed for crystalline phase, crystallite size, particle size, magnetization and conductivity measurement relevance to microwave absorption. In a nano phase material particle size, shape and their distribution always plays a crucial role in modeling its physical properties. Figure 5.2 shows the electron micrograph of the sample.

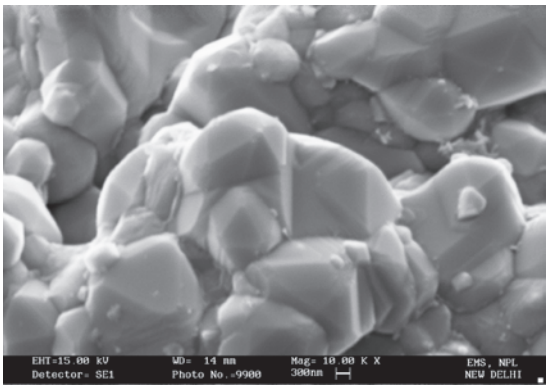


Fig.5.2: SEM micrograph of $CoFe_2$ nano-alloy

Micrograph shows the average particles size in the range of 20-100nm and majority of nano- alloy particles are spherical in shape. However, few individual particles seem to be made up of more then one small particles joined from the surface. The microwave absorption studies of material have been done using vector network analyzer. Electromagnetic parameters like dielectric constant, magnetic permeability and reflection, transmission and absorption losses by the sample were obtained for 1.75mm thick sheet. Results reveal the absorption loss of ~65 dB with reflectance loss less then 1dB and almost zero transmittance in the measured frequency range.

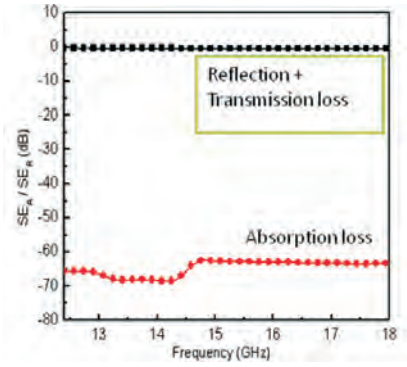


Fig. 5.3: (Refelection + transmission loss) and absortion loss vs. microwave frequency

Figure 5.3 shows the reflection and absorption loss of incident microwave and the values of dielectric constant and magnetic permeability of the material. An absorption loss of 65 dB was reached in the entire frequency range with an absorber thickness of 1.75 mm. The high-frequency permeability of metallic magnetic materials decrease due to the eddy current phenomenon induced by EM wave interference. These materials exhibit improved

microwave absorption properties because of their proper EM matching between the dielectric loss and the magnetic loss.

Size dependent nano crystalline cobalt ferrite ($CoFe_2O_4$) particles have been synthesized by co-precipitation and investigated in details. The effect of reducing the particle size on physical properties like crystalline phase, crystallite size, lattice strain, IR absorption, thermo magnetic measurements and magnetization parameter are studied. Structural parameters in relevance to shape and size of nano particles are discussed. The crystalline phase of cobalt ferrite remains stable down to 5 nm. Size dependent magnetization and the effect of surface area are presented. Characterization of samples has been done using XRD/TEM/FTIR/VSM and TGA techniques. The XRD, TEM and VSM results shows a decrease in crystalline properties, particle size and magnetization on increasing the nucleation rate by increasing the pH of the precipitating solution. Thus this work will have potential application in making ferrofluid and nano magnetic based devices.

Crystal Growth and Crystallography Section,

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

Due to high-speed and ease of production of photons (light), the area of photonics has become an active field of research in view of modern society's demand for improved telecommunications, data retrieving, storage, processing and transmission. The design of devices that utilize photons instead of electrons in the transmission of information has created a need for new materials with unique optical properties. Hence, it will be useful to synthesize new NLO materials and study their structural, physical, thermal and optical properties. It is also equally important to enhance the NLO properties of the known materials by either the incorporation of functional groups or dopants, for tailor made applications. Because of the complexity, integration, miniaturization of the modern technologies, the structural perfection and purity becomes very stringent. In view of the above facts, growth and characterization of various organic, semi-organic and a few inorganic crystals like lithium niobate, bismuth silicon oxide, lithium fluoride crystals have been carried out.

Some of the important R&D achievements (which were published in 37 SCI journals) made during this year are as follows: (i) Growth by SR method and characterization of bis(thiourea)zinc(II) chloride single crystals (ii) Growth and characterization of KDP crystals with potassium carbonate as additive, (iii) Growth and Characterization of a New Organic Non-Linear Optical (NLO) Material: L-Histidinium Trifluoroacetate, (iv) Growth by SR method and characterization of hippuric acid single crystals, (v) Optical, dielectric and surface studies on solution grown benzimidazole single crystals, (vi) Directional growth of organic NLO crystal by different growth methods: A comparative study by means of XRD, HRXRD and laser damage threshold, (vii) Influence of inorganic and organic additives on the crystal growth, properties and crystalline perfection of tris(thiourea)copper(I) chloride (TCC) crystals, (viii) The influence of Mn-doping on the nonlinear optical properties and crystalline perfection of tris(thiourea)zinc(II) sulphate crystals: Concentration effects (ix) Growth of L-histidinium bromide (LHB) single crystal and its characterization analyses by birefringence, HRXRD and photoluminescence (x) Growth of nonlinear optical single crystal of Glycine hydrofluoride (GHF) by conventional solution growth

method (xi) Growth of unidirectional potassium dihydrogen orthophosphate single crystal by SR method and its characterization, (xii) Nanocrystalline zinc oxide powder samples were prepared by wet-chemical method and characterized by XRD, EPR and FTIR techniques and (xiii) Growth of strategic NLO crystals of lithium niobate by employing an in-house developed CZ crystal growth system and their characterization which is described briefly (as a typical example) in the following.

Lithium niobate ($LiNbO_3$) is one of the most attractive materials for optoelectronics due to its unique electro-optical (E-O), Acousto-Optic (A-O), photoelastic, piezo-electric and nonlinear optical (NLO) properties combined with good mechanical and chemical stability and wide transparency. After successful installation of RF heating system with semi-automated and modernized in-house developed Czochralski crystal puller, we have grown good quality crystals with larger diameters up to 40 mm to meet the device applications by a low thermal gradient Czochralski technique. The sharp and single peak diffraction curve having FWHM value of 23 arc s depicts the excellent quality of the as-grown crystal revealing the absence of cracks and internal structural grain boundaries. In the recent past we have done good number of investigations on the undoped and Fe doped crystals. The annealing studies with low heating and cooling rates reveal significant improvement in crystalline perfection which leads to improvement in optical and piezoelectric properties. The defects like OH^- and undecomposed CO_3^{2-} ions have been reduced as revealed by FTIR. Optical transparency was enhanced. The piezoelectric response (d_{33}) has been improved to an unprecedented high value of 23 pC/N from the earlier reported value of 17 pC/N. These studies serve as an important input to industries related to opto-electronic, holographic storage devices etc. This work

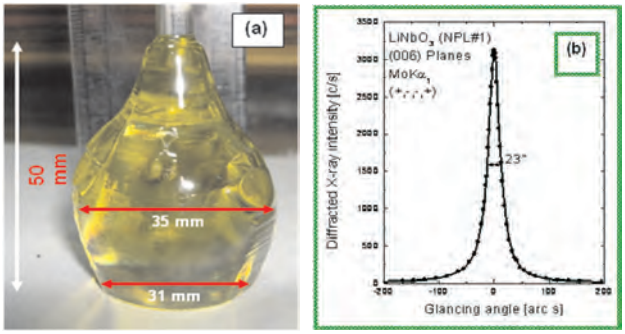


Fig.5.4 A crack free lithium niobate ($LiNbO_3$) single crystal and (b) high-resolution diffraction curve of the grown crystal (Z-cut) recorded by the in-house developed multicrystal X-ray diffractometer.

has been carried out as a part of the CSIR Network Project CMM-0022/1G.

This R&D group also actively involved in helping or collaborating various R&D projects from other groups of NPL and various other laboratories and educational institutes by characterizing variety of single crystal samples, epitaxial films and powder samples by high-resolution and powder XRD techniques. More than hundred single crystal samples to study the crystalline perfection or to study the effect of dopants or functional groups added to the semi-organic materials have been characterized by high-resolution X-ray diffractometry. Around 600 powder samples have also been characterized for structural studies and phase analysis. It is worth to mention here the characterization of big size (82x91x91 mm^3) crystals of KDP samples from RRCAT, Indore were completed at NPL. Such type of big and heavy crystals cannot be mounted easily on the goniometer heads of commercial diffractometers. It was made possible with NPL developed multicrystal X-ray diffractometer system, as it is versatile to change its configuration. In a non destructive way, various parts (bottom to top and left to right) of the crystal was characterized and found its excellent uniformity and quality for device fabrication.

Implementation of quality system as per ISO-17025 guidelines in the group is going on. In view of developing new CRMs (certified reference material), lanthanum hexaboride (LaB_6) is being studied in detail for development as X-ray line position standard.

The important technical achievements are: **(i)** The crucible setup of the RF heating system of the Czochralski crystal puller has been redesigned and developed with a bigger diameter RF coil for the growth of bigger crystals up to 50 mm dia. The heating system is atomized by controlling the feeding power of the RF coil through a Eurotherm temperature controller. With this we have grown good quality lithium niobate crystals with diameters up to 40 mm to meet the device applications, (ii) Similarly the resistive heating furnace of another Czochralski crystal puller is also automized recently with an independent Eurotherm temperature controller. With this system we have grown Bismuth silicon oxide (BSO) and lithium fluoride (LiF) single crystals and (iii) For achieving intense, parallel and monochromatic beam, Gobel Mirror was installed with the Bruker D8 Advance Powder X-ray Diffractometer. For the same system, reflectometry sample stage was also purchased and installed.

Electron Microscopy

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

Some of the samples which were characterized by using TEM and HRTEM are gold nano particles prepared through chemical route at 4 °C., 10°C and room temp., Ag nano particles, Al/Si alloy, WO_3 films, Lithium ferrites prepared by different routes, Gold on grapheme, CdTe thin films, Y_2O_3 powder calcinated at different temperatures, Te doped InSb thin thin films at Rt and annealed at 200°C , ZnO powder doped with Na (2 and 10 %) and Li 2%, CNT prepared by CVD technique, Ag ions in grapheme etc..Figure 5.5 shows the HRTEM bright field image of the graphene-metal nanohybrid assemblies depicting the embeding of the silver nanoparticles into graphene oxide nanosheets (a solution-based single step method that embeds the silver nanoparticles into graphene oxide nanosheets). The opto-electronic properties of the graphene sheets can thus be tuned over several orders of magnitude, making them potentially useful for flexible and transparent semiconductors or semi-metals. Incorporation of nanoparticles could represent a route for translating the interesting fundamental properties of graphene into technologically viable devices. Stable dispersions of graphene could become a reliable and economically feasible source of an ultrahigh surface area substrate.

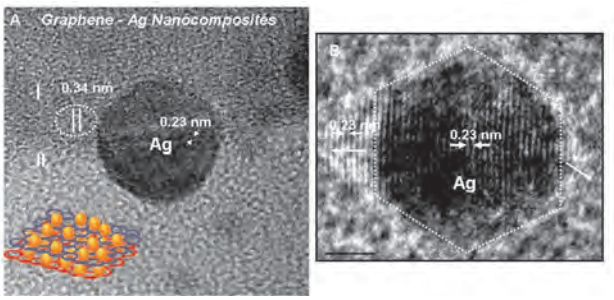


Fig. 5.5: Ag-nanoparticle (~ 15 nm) trapped between two Graphene sheets acting as spacer; B: single Ag particle with hexagonal shaped along 3-fold cubic symmetry; This material was prepared using a facile route for the reduction of Ag using graphite oxide.

About 110 sample were received from the various groups of NPL working on the development

of new and advanced materials. These sample were characterized by using TEM and HRTEM. This facility was also extended to various industries.

Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) is another central facility of the laboratory which is extensively used by various R & D groups of NPL, other scientific R & D institutes and Industrial organizations for characterization of materials for surface microstructure and chemical compositional measurement.

Some of the materials characterized by using SEM are Al-Si powder samples, Mg-Al Alloys, Oxidase coatings, metal doped polymer films, polymer powders and films with and without enzyme and DNA, Gold nanoparticles with and without enzymes, High Tc Superconducting, CaCuTitanate, boron nitride, Fe doped ZnO, Ceramic materials, Li-Mg Ferrite samples, Pr-Ba-MnO_3 Composites with different additives, SAM layers with PPY, TiO_2 films on different substrates, DNA, PANI plane, protein immobilized with and without DNA, PANI+CNT composites, LDPE films, CdSeTe Alloys of different ratios and at different temps, Particulate matter/filter paper collected from different locations, Au film/ITO, gold nanoparticles with enzyme and gold nanoparticles with pyrol, Lithium-Ce Ferrite Samples, PECVD grown TiO_2 films/Si, TiO_2 films on different substrates etched with HF and NaOH treated, MgB_2 Pure and with 10% SiC samples annealed at different temperatures, Graphite composites with mixing of Chitosan polymer, Al, Al_2O_3, Al+Al_2O_3 powders ball milled, La-Sr-MnO_3 films/$SrTiO_3$ substrate prepared by DC magnetron sputtering technique, Alkaline and acid texturised micro crystalline Silicon, Porus Silicon samples, rare earth nanophophor, etc. Fe doped ZnO (Fe 0, 0.5, 2 and 50) mole % prepared by solgel technique and annealed at 800^{O}C have been characterized by using SEM. Details of the surface morphology of Fe doped ZnO have shown in Fig. 5.6

More than 1000 samples have been examined by SEM and EDS for surface microstructure and compositional analysis.

SEM and EDS facility is also used by the industry for carrying out different type of testing and

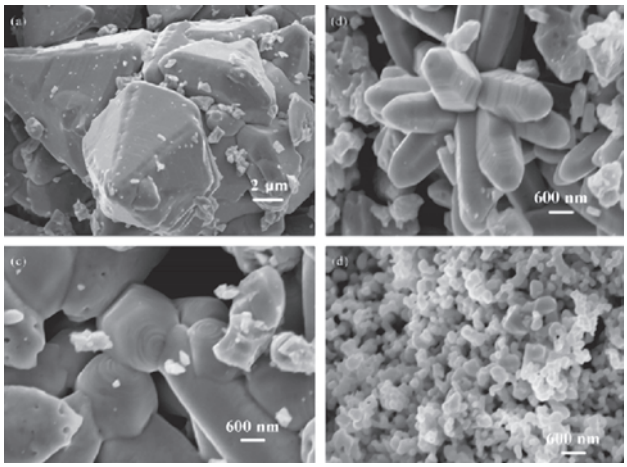


Fig. 5.6 SEM images of Fe (0, 0.5, 2 and 50) mol% doped ZnO by sol –gel technique using Zinc Nitrate and Ferric chloride annealed at 800^ C

analysis work. During the period different samples were received from industry for particle size, shape, surface structure, fracture analysis, thickness and chemical compositional analysis. Some of the industries for which SEM/EDS analysis were carried out are M/s. Oriental Carbon and Chemicals Ltd., New Delhi, M/s. Mindarika Pvt. Ltd., Gurgaon, M/s. MNIT, Jaipur, M/s. Ranbaxy R&D Lab. Gurgaon, M/s. NTPC, R&D centre Noida, Central Road Research Institute New Delhi, M/s. MoserBaer Photovoltaics Ltd., Gautam Budh Nagar, M/s. KPS Consultant & Impex Pvt. Ltd. New Delhi

Secondary Ion Mass Spectrometry

Quantification of the mixing effect in Silicon-Manganese thin films by swift heavy ion irradiation

Swift heavy ion (SHI) irradiation is an efficient mean to moidfy the composition and structure of thin films and interfaces. Amid different techniques to

transform thin films, SHI irradiaiton find their effectiveness in terms of its spatial selectivity, precise control and low temperature process. Since early nineties SHI induced mixing of thin films has been studied in various types of systems . In continuation to our previous work on Si/TM(transition metal)/Si systems (V/Si, Fe/Si and Co/Si) we consider here the mixing of another transition metal, Mn, with amorphous silicon (a-Si). Mn with amorphous silicon (a-Si) is chosen as hardly any detailed study has been done on this metal/Si system in high-energy regime. Though Mn is reported to be "S_e-sensitive" but we do not have an apparent picture of its behavioural changes due to electronic energy loss (S_e). Even the information about its S_e-threshold value is not available. Therefore this system has been selected for SHI-induced mixing studies. This work is an attempt to quantify SHI-induced interface mixing in terms of mixing rate and thereby understand this phenomenon in the framework of thermal spike model and secondly, to check if some silicidation has taken place at room temperature as reported earlier by Chakraborty et al.

Swift heavy ion induced mixing is reported in Si/Mn/Si thin films on a silicon wafer, when irradiated by 120 MeV Au ions at three different fluences of 1x 10^{13}, 3x 10^{13} and 1x 10^{14} ions/cm^2. The samples were characterized before (pristine) and after irradiation using Secondary Ion Mass Spectroscopy (SIMS) and Rutherford Backscattering Spectroscopy (RBS)Fig. 5.7. Atomic Force Microscopy (AFM) of the samples was used to determine surface roughness contribution to RBS and SIMS profiles. Depth profiles Fig. 5.8 showed distinct changes in the interface region and it was observed that interface mixing increased linearly with the increase in the ion fluence. The mixing rate was estimated to be ~1000 nm^4. The mixing effect was studied in the framework of thermal spike model.The track radius and duration of the transient melt phase have been theoretically calculated for this system to estimate the diffusivity during the transient melt stage at the interface.

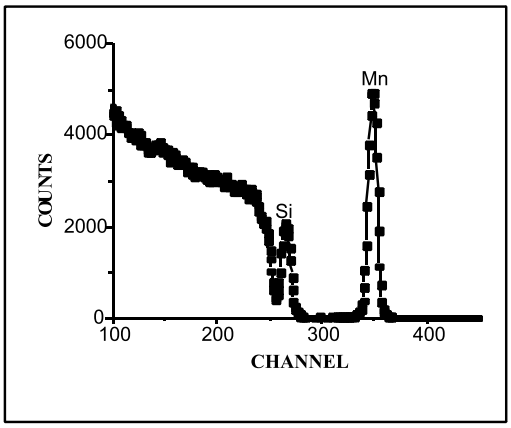
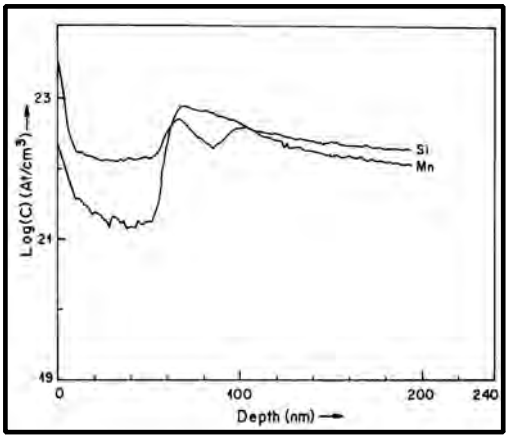
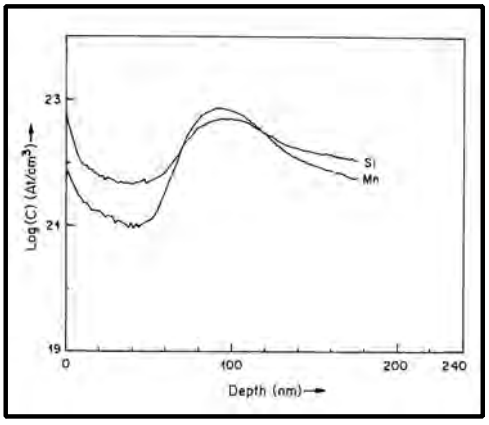


Fig. 5.7 RBS-spectrum of the pristine Si/Mn/Si.



(a)



(b)

Fig.5.8 SIMS depth profile of Si/Mn/Si interface before irradiation (a) and after irradiation with (b) 1x 10^{14} ions cm^{-2}.

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RADIO AND ATMOSPHERIC SCIENCE

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रेडियो तथा वायुमण्डलीय विज्ञान विभाग की गतिविधियों में प्रयोगशाला की दो मुख्य परियोजनाएं शामिल हैं। पहली परियोजना का नाम रेडियो भौतिकी और अनुप्रयोग है। यह रेडियो परिवेश के आईनोस्फैरिक और ट्रोपोस्फैरिक संप्रेषण प्रणालियों के लिए आईनाइज्ड और नॉन आईनाइज्ड माध्यम के अभिलक्षण से संबंध रखती है। आइनोस्फैरिक संचार कार्य में वृद्वि मुख्यतः अंतरिक्ष भौतिकी, एच एफ संचार तथा नेवीगेशनल अनुप्रयोग में होती है, जबकि ट्रोपोस्फैरिक संचार के संबंध में यह क्षैतिजिक तथा भू–अंतरिक्ष मार्ग पर रेडियो तंरगों के संचार के सभी पहलुओं तथा मोबाइल के साथ–साथ समुद्री संचार को शामिल करता है जिसमें वी एच एफ से लेकर रेडियो फ्रीक्वेंसी स्पेक्ट्रम के गीगा हट्र्ज तक की फ्रीक्वेंसी शामिल होती है। अंतरिक्ष भौतिकी के संबंध में मुख्य उपलब्धियों में भारतीय क्षेत्र (एन पी एल आइनोस्फैरिक मॉडल) के लिए आइनोस्फैरिक मॉडल का विकास शामिल है। इस मॉडल द्वारा एफ ओ एफ 2 (foF2) एच एम एफ 2 (hmF2), एन एम एफ 2 (NmF2), एम यू एफ (MUF2) (4000) एफ 2 (F2), कुल इलेक्ट्रॉन विषय सामग्री आदि के लिए किसी भी अक्षांश के लिए तथा चौबीस घंटे के आधार पर विभिन्न आइनोस्फैरिक पैरामीटर्स प्रदान किए जाते हैं। एशिया में हाल के तीन प्रमुख भूकंपों से पहले निम्न अक्षांशों पर आइनोस्फैरिक इलेक्ट्रॉन घनत्व तथा कुल इलेक्ट्रॉन के असामान्य संवर्धन के संबंध में विस्तृत जांच प्रतिवेदित की गई है। इन तीनों भूकंपों का मुख्य केन्द्र भारत–चीन सीमा के आस पास विस्तारित था। भारतीय अंटार्कटिका स्टेशन, मैत्री पर अन्तर्राष्ट्रीय ध्रुव वर्ष के एक भाग के रूप में एक आइनोस्फैरिक निगरानी प्रयोगशाला की स्थापना की गई है। प्रायोगिक सुविधाओं में मौजूदा दोहरी बारंबारता के साथ डिजिटल आईनोसोन्दे पर अंतरिक्ष मौसम के प्रभावों का अध्ययन किया जा सके, शामिल हैं। निम्न सौर गतिविधि अवधि के लिए इलेक्ट्रॉन घनत्व (एन ई–एच) प्रोफाइल मापन से आईनोस्फेयर आकार पैरामीटरों (बी 0, बी 1,) के बॉटम साइड मापन द्वारा अन्तर्राष्ट्रीय संदर्भ आईनोस्फेयर (IRI) को और अधिक मान्यकरण किया गया है। ट्रोपोस्फैरिक संप्रेषण के संबंध में किए गए कार्यों में, संचयी वर्षा दर वितरण वर्षा के संचयी संभावना कार्य के वर्ष दर वर्ष परिवर्तन, रेडियो संप्रेषण के लिए वर्षा की मौसम संबंधी तथा मासिक परिवर्तनशीलता जैसे अनेक पैरामीटरों का अनुमान लगाना शामिल है। नियत तथा मोबाइल संप्रेषण के मामले में, प्रयोगों के प्रचालन के माध्यम से तथा अवलोकन किए गए परिणामों के साथ तुलना करते हुए रेडियो प्रोपेगेशन मॉडलों की सटीकता की तुलना की गई तथा भारतीय परिस्थितियों के अनुसार मॉडलों में संशोधन करने का कार्य किया गया। उत्तरी तथा पश्चिमी भारत में भारतीय रेल मार्ग ग्रामीण क्षेत्रों से अवलोकन किए गए एकत्र डेटा की सहायता से एयरकॉम रेडियो योजना के पैरामीटरों को मॉडल किया गया है।

दूसरी प्रमुख प्रयोगशाला परियोजना को वायुमण्डलीय अध्ययन (परिवेश) और वैश्विक परिवर्तन (ग्लोबल चेंज) कहा जाता है। इस परियोजना के अंतर्गत ऑप्टिकल एयरोसोल स्पेक्ट्रोमीटर का प्रयोग करके शहरी स्थलों में समीप सतह एयरोसोल अध्ययन में मौसम परिवर्तनशीलता के साथ साथ एयरोसोल्स तथा बादलों और डायूरनल (DIURNAL) के अध्ययन के लिए माइक्रो पल्स लीडार का प्रचालन शामिल है। बर्फ में फोटो रासायनिक प्रतिक्रियाओं के संबंध में हाल के समय के दौरान अत्यधिक रूचि देखने को मिली है। प्राथमिक ओजोन मानक (मानक ओजोन फोटोमीटर एस आर पी–43) एक विशिष्ट सुविधा, जो कि दक्षिण एशिया में अपने आप में पहली सुविधा है, उसे एन पी एल में स्थापित किया गया है। इस प्रकार की सुविधा से सतह ओजोन मापन को अन्तर्राष्ट्रीय मानकों के साथ अनुरेखण किया जा सकेगा। सर्दियों के महीनों के दौरान, एयरोसोल ऑप्टिकल गहनता (ए ओ डी) के अवलोकनों का प्रयोग करते हुए

वातावरण में ब्लैक कार्बन (बी सी) संकेन्द्रण तथा O_3, CO, NO, NO_2 तथा SO_2 के संबंध में एम्बिएंट अमोनिया (NH_3) के डायूरनल विचलन के रूप में और मौसम विज्ञान पैरामीटरों के संदर्भ में दिल्ली के ऊपर दबाव बनाने वाले एयरोसोल विकिरण के अध्ययन किए गए। ग्रामीण क्षेत्रों में प्रयोग में लाए जाने वाले जैविक इंधनों से उत्पन्न कार्बनयुक्त एयरोसोल घटक उत्सर्जन का भारत के गंगा से जुड़े मैदानों में विभिन्न राज्यों में जिला स्तर पर अनुमान लगाया है। ग्रामीण क्षेत्रों में प्रयोग लाए गए जैविक इंधनों के वितरण से यह पता चलता है कि अन्य जैविक इंधनों (जैसे इंधन लकड़ी, फसल अपशिष्ट) में गाय के गोबर का मौटे तौर पर प्रयोग किया जाता है। मानसून से पहले बंगाल की खाड़ी और अरब सागर के ऊपर स्थिर कार्बन आईसोटॉप पद्वति से कार्बनयुक्त एयरोसोल्स के उद्‌गम का अनुमान लगाने का भी कार्य किया गया। मेगा सिटी वाइड नियर रियल टाइम माडलिंग तथा नगर के भिन्न–भिन्न शहरी क्षेत्रों और आसपास के क्षेत्रों में हवा में विषाक्त गैसों के संचयन का मूल्यांकन तथा इन क्षेत्रों में मानव स्वास्थ्य और खड़ी फसलों पर उनके प्रभाव को निर्धारित करने के लिए एक प्रायोगिक अध्ययन भी किया गया। नगर में रहने वाले ऐसे लोग जो शीघ्रता पूर्वक प्रभाव में आ जाते हैं तथा संबंधित एजेंसियों के लाभ के लिए पर्यावरण संबंधी चेतावनियों को जारी करने की क्षमता को विकसित करने में इस गतिविधि से लाभ प्राप्त होगा। सी एस आई आर के धुंध पूर्वानुमान मॉडल के मान्यकरण के लिए सी एम एम ए सी एस तथा आई ए एफ के साथ सहयोग करते हुए एन पी एल में एक 32 मीटर ऊंचाई का मौसम विज्ञान संबंधी टावर भी स्थापित किया गया है ।

रेडियों और वायुमण्डलीय विज्ञान विभाग में रेडियो विज्ञान (आर एफ आर एस) संबंधी क्षेत्रीय सुविधा को स्थापित किया गया जिसका उद्देश्य मानव संसाधन के संबंध में क्षमता सृजन तथा रेडियों विज्ञान में विशेषज्ञता विकास करना तथा जानकारी को वितरित करने एवं भारत तथा उसके आसपास के क्षेत्रों में रेडियो विज्ञान से संबंधित गतिविधियों में समन्वय करना है ।

RADIO AND ATMOSPHERIC SCIENCES

The activities of the Radio and Atmospheric Sciences Division comprise of two Major projects of the laboratory. The first project is entitled "Radio Physics and Applications". It deals with the characterization of radio environment both for ionized and non ionized media to aid ionospheric and tropospheric communication systems. The work are mainly on space physics, ionospheric dynamics, HF communication and navigational application related to ionospheric communication while for tropospheric communication, it covers all aspects of radio wave propagation over both horizontal and earth space paths and mobile as well as marine communication covering the frequency from VHF up to many giga hertz of radio frequency spectrum. The main achievements in the area of space physics include the development of an ionospheric model for the Indian zone (NPL Ionospheric Model). This model provides various ionospheric parameters such as foF2, hmF2, NmF2, MUF (4000) F2, total electron content etc., for any given latitude on twenty four hour basis. A detailed investigation has been reported regarding anomalous enhancement of ionospheric electron density and total electron content over low latitudes before three recent major Earthquakes over Asia. The epicenters of all the three earthquakes are distributed around the Indo-China border. An ionospheric monitoring laboratory at Indian Antarctica station, Maitri as part of International Polar Year has been established. The experimental facilities include a digital ionosonde with the existing dual frequency GPS Receiver and VLF experiment to study the effects of Space Weather on the high latitude ionosphere over the Antarctic region. The further validation of international reference ionosphere (IRI) model has been made by estimating bottom side profile of the ionosphere shape parameters (B0, B1) from electron density (Ne-h) profiles measurements for low solar activity period. The work carried out in tropospheric communication include estimation of several rain parameters like cumulative rain rate distribution, year to year variation of the cumulative probability function of rainfall, seasonal and monthly variability of the rainfall for radio communication. In case of fixed and mobile communication, studies are carried out by conducting experiments and verifying the accuracy of radio propagation models by comparing those with observed results and modifying the models suitable to Indian conditions. The parameters of Aircom's radio planning tool have been modeled with the help of observed data collected along Indian rail road rural zones in the northern and western India.

The second Major Laboratory Project is entitled "Atmospheric Environment and Global Change". The main achievements in this project are the operation of a micro pulse lidar for continuous measurements of aerosols and clouds and diurnal as well as seasonal variability in near surface aerosol number concentration at urban sites using Optical Aerosol Spectrometer. Photochemical reactions in snow have recently witnessed an unprecedented surge of interest. Recent investigations over Arctic have shown production and significant release of CO flux from the snow-covered region. A unique facility of Primary ozone (Standard Ozone Photometer, SRP-43) standard which is first of its kind in South Asian region has been set up at NPL. The

surface ozone measurements will be made traceable to International standards with such facility. The studies of aerosol radiation forcing over Delhi by using the observations of aerosol optical depth (AOD) and the black carbon (BC) concentration in the atmosphere as well as the diurnal variation of ambient ammonia (NH_3) in relation with O_3, CO, NO, NO_2 and SO_2 and meteorological parameters were done during winter months. The emission factor of carbonaceous aerosol from biofuels used by rural sector for energy, are estimated at district level in various states of Indo Gangetic Plain. The distribution of biofuels used by rural sector as energy show that cow dung is mostly used as energy among other biofuels (fuel wood, crop residue). The estimation of origin of carbonaceous aerosols by stable carbon isotope method over bay of Bengal and Arabian sea during pre-monsoon period has also been made. A pilot study has been undertaken to set-up a mega-city wide near real time modeling and prediction of accumulation of toxic gases in air in different urban and surrounding regions of the city and assigns their impacts to human health and cultivated crops in these regions. This activity will provide in generating capability to issue environmental alerts for the benefit of the vulnerable sections of the city dwellers and the concerned agencies. A Meteorological Tower of 32 m has been installed at NPL in collaboration with CMMACS and IAF for the validation of CSIR fog forecasting model.

A Regional Facility on Radio Science (RFRS) established in Radio and Atmospheric Sciences Division with the objectives to promote capacity building, in terms of human resource and expertise development in Radio Science and to disseminate information and coordinate the Radio Science related activities in India and around is also in operation.

Radio Physics and Applications

Ionospheric Model for the Indian zone (NPL Ionospheric Model)

Ionospheric Modeling is important for both scientific and practical purposes. Since the largest variability occurs in the ionospheric F-region and for practical HF communication and other applications it would suffice to model the changes in the F-region parameters of the ionosphere. Ionospheric Electron Content (IEC) is another useful parameter for the determination of phase path, group delay, dispersion, refraction and Faraday polarization rotation of trans-ionospheric signals. As a part of Space Weather Regional Warning Centre (RWC-India),several Ionospheric Models for Indian zone for different applications like i) HF-Link Prediction Model, ii) F-region Parameter Prediction Model, iii) Multi-regression (Total Electron Content) Model have been developed. All these models have been integrated into one namely "NPL-Ionospheric Model" for the benefit of the users. It provides all the ionospheric parameters like foF2, hmF2, NmF2, MUF (4000) F2, TEC and electron density (Ne-h) profiles etc for any given latitudes for twenty four hours. A detailed investigation has been reported also regarding anomalous enhancement of ionospheric electron density and total electron content over low latitudes before three recent major Earthquakes over Asia.

The NPL-Model is based on empirical relationship between Ionospheric parameters and the solar parameters like 12 monthly running average sunspot numbers (R12), monthly mean 10.7cm solar flux (F10). Firstly, Second Degree Coefficients are obtained for each month at all local times using 30-40 years of 14 stations data covering a geographic latitude range from about 0 to 45° N. In this way appropriate coefficients for all the stations at each hour for all the twelve months are obtained. These coefficients are then used by the computer based NPL Second Degree Model, to predict ionospheric hourly foF2, hmF2, MUF(4000)F2, NmF2 values for any given latitude between 0 and 45N, month, year and R12 as input. The model can take the values of R12 provided by the users otherwise it uses NPL Predicted R12 values for the forthcoming solar cycle 24 (2009-2018). Once F-region parameters namely foF2 and hmF2 are obtained from the model then these are used as an input to International Reference Ionosphere (IRI-2000) model to generate corresponding TEC and Ne-Profiles for two altitudes namely 1000 km and 2000 km. This is a computer based user friendly working model which is very easy to use by providing onscreen information as input. Some of the results of different ionospheric parameters are shown in Figs 6.1 to 6.4.

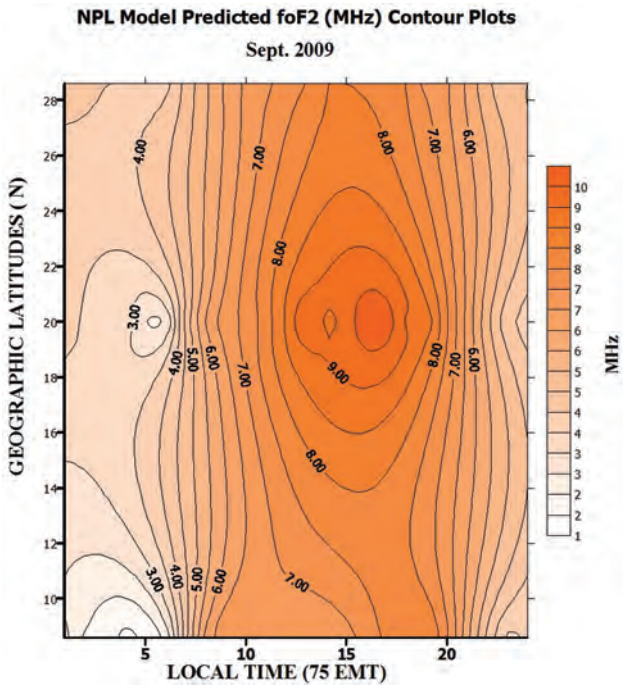


Fig. 6.1 Sample of NPL Model predicted foF2 for the month of Sept.2009

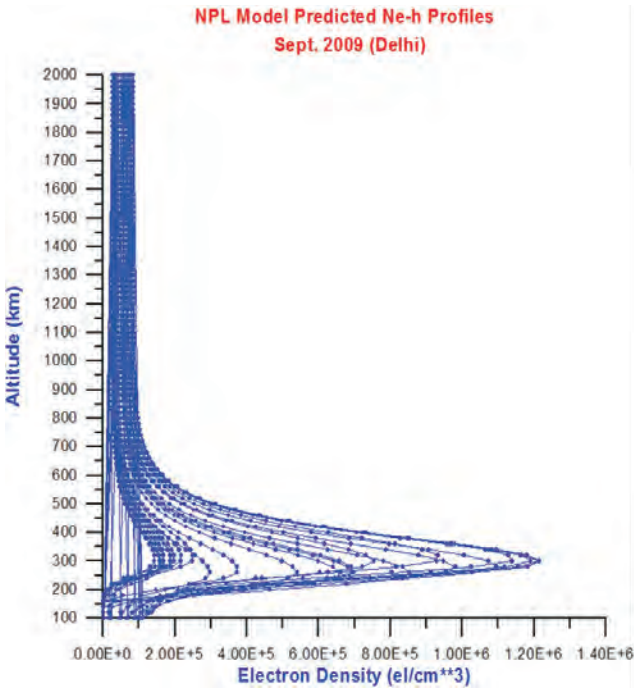


Fig. 6.2 Sample of NPL Model predicted Ne-h Profiles month of Sept.2009 over Delhi.

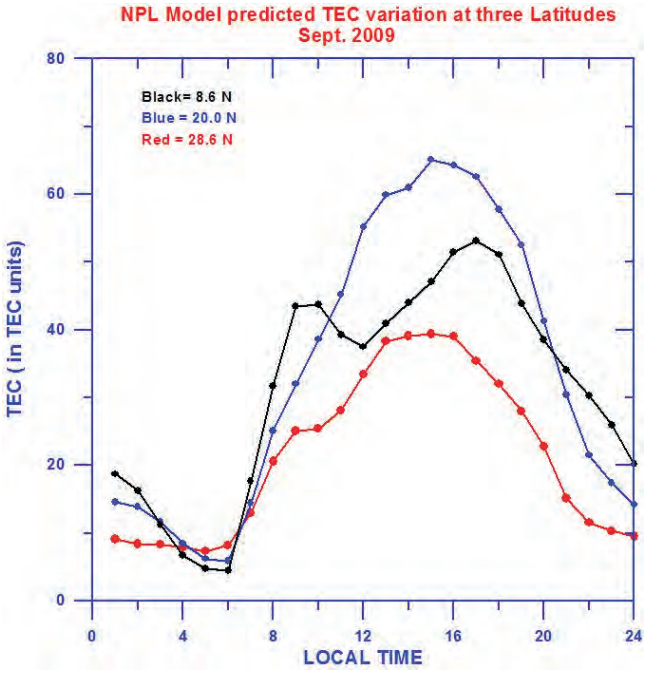


Fig. 6.3 Sample of NPL Model predicted TEC variations at different latitudes for the month of Sept.2009

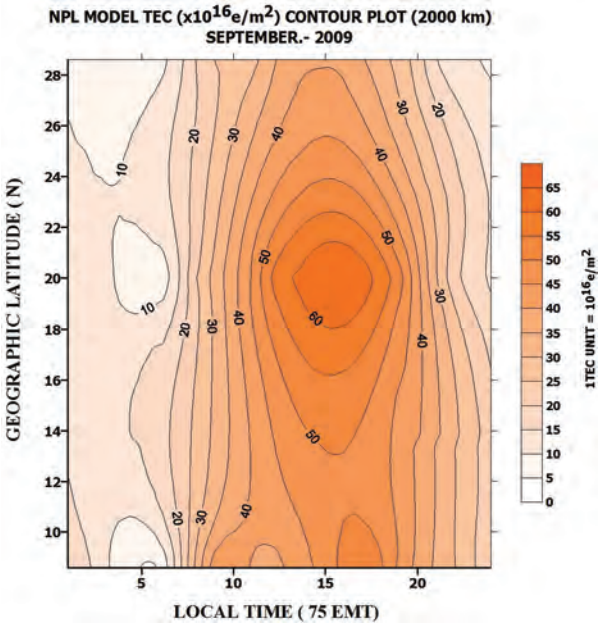


Fig.6.4 Sample of NPL Model predicted TEC for the month of Sept.2009

Anomalous Enhancement of Ionospheric Electron Density and Total Electron Content over Low Latitudes before three recent major Earthquakes over Asia

The unusual variations in the ionospheric Total electron Content (TEC) and the maximum ionospheric electron density at F2 peak (NmF2) few days before the main shock of three recent major earthquakes (magnitude greater than 6 on Ritcher Scale) were observed over China (Xinjiang-Xizang Border Region Earthquake on March 20, 2008, Great Wenchuan Earthquake on May 12, 2008 Western Xizang Earthquake on August 25, 2008).

Epicenters of all the three earthquakes are distributed around the Indo-China border as illustrated in Fig. 6.5. Ionospheric data, recorded by a network of Ionosonde, GPS and tomographic receivers at Delhi (28.6°N, 77.2°E), Bhopal (23.29°N, 77.46°E) and Trivandrum (8.4°N, 76.6°E) are used to monitor the ionospheric NmF2

and TEC variations for finding seismo-ionospheric signatures of these earthquakes. Large enhancements in NmF2 and TEC were observed on geomagnetic quiet days only at Delhi, nearest to the earthquake epicenters. The anomalous enhancements in NmF2 and TEC over Delhi appear 1 to 3 days prior to the main shock mainly during 1100 – 1700 LT. No such unusual variations of NmF2 and TEC were recorded over equatorial station, Trivandrum and equatorial anomaly station, Bhopal, thereby indicating the localized nature of unusual variations. The observed results suggest that the unusual enhancements of ionospheric NmF2 and TEC over Delhi before the main shock of each earthquake are most possibly due to seismo-ionospheric link.

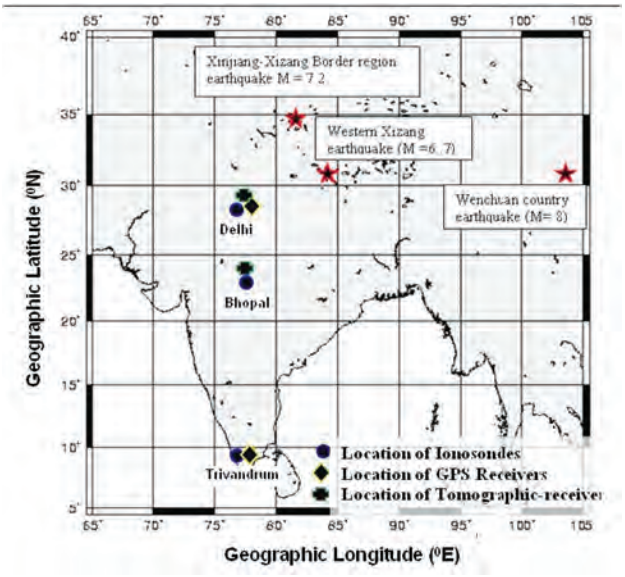


Fig. 6.5 Geographic location of three earthquake epicenters and ionospheric monitoring systems i.e. ionosondes, tomographic GPS-receivers. Red stars indicate the earthquake epicenters.

The anomalous enhancement of the ionospheric electron density over Delhi 1-3 days prior to three strong earthquakes of China was very unique. It was unlikely to be caused by the geomagnetic storm since the solar-terrestrial condition was quiet during the precursory days in all three cases. The spatial distribution was very local which is probably associated with seismo-ionospheric coupling process. Some results regarding three aforesaid earth quakes are presented in Figs.6.6 to 6.8.

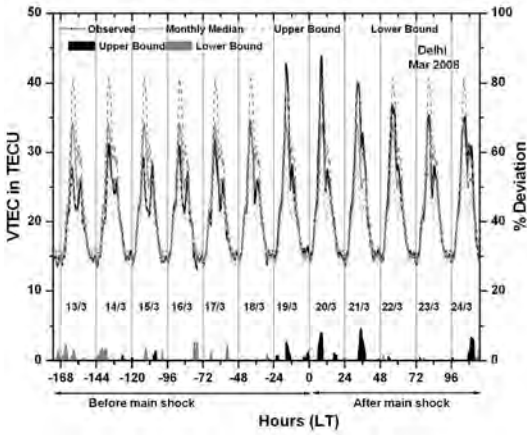


Fig. 6.6 VTEC observed by the Delhi GPS-receiver during 13th -24th March, 2008 (during Xinjiang-Xizang Border Region Earthquake of March 20, 2008)

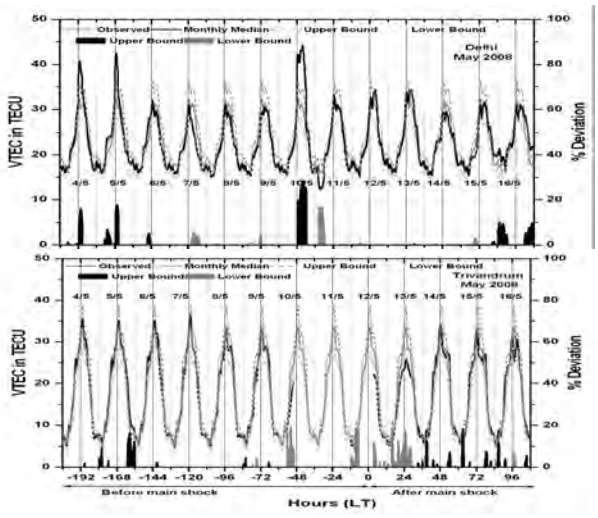


Fig. 6.7 The temporal variation of TEC recorded by the Delhi and Trivandrum GPS receivers during 4th -16th May, 2008. The variations of TEC in each station are shown in this figure according to its distance to the earthquake epicenter (the top panel for the nearest station, Delhi). Gray lines indicate the value of monthly median during Great Wenchuan Earthquake of May 1 2, 2008)

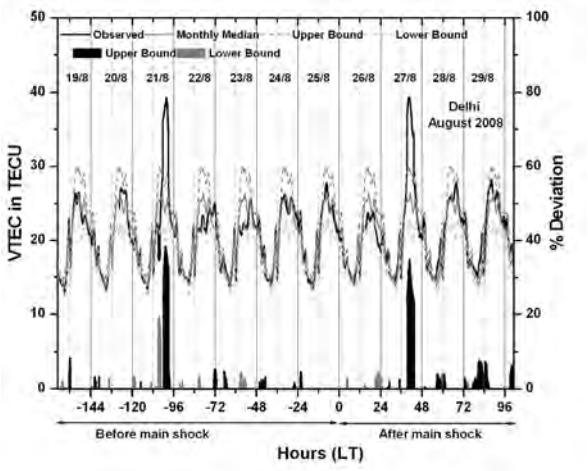


Fig.6.8 The temporal variation of TEC recorded by the Delhi GPS receivers during 19-29 August, 2008 (during Western Xizang Earthquake of August 25, 2008)

NPL Ionospheric Monitoring Station at Indian Antarctica Station, Maitri as part of International Polar Year (IPY)

Ionosphere plays an important role for long distance HF communications as well as affects the satellite communication and navigation services especially in high and equatorial latitudes. In this area during IPY period, it is aimed to study the effects of Space Weather on the high latitude ionosphere over the Antarctic region and its coupling with low latitudes using a) TEC and Scintillation data obtained from Tomographic and GPS receivers and b) digital ionosonde which will provide information on ionospheric layer parameters, on Doppler shifts, ionospheric irregularities (Spread F and Sporadic E), their morphology, dynamics, day-to-day variability, magnetic storm-time responses etc.

An ionospheric monitoring laboratory at Indian Antarctica station Maitri as a part of International Polar Year has been established in association with Barakatullah University, Bhopal. Recently a digital ionosonde has been established at Maitri over Antarctica along with the existing a dual frequency GPS Receiver and a VLF experiment. Fig. 6.9 presents the NPL Ionosonde Hut and 30 m Antenna Mast at the Indian Antarctica Station Maitri. A typical sample of ionogram is shown in Fig. 6.10 The installation of Ionosonde was inaugurated by the Prince Albert II of Monaco along with the Russian and UN Team (Fig.6.11).

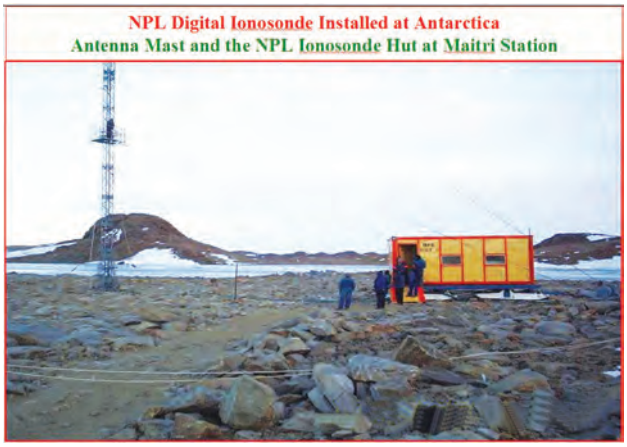


Fig. 6.9 NPL Digital Ionosonde at Maitri – 30m Antenna Mast and NPL hut for Ionosonde.

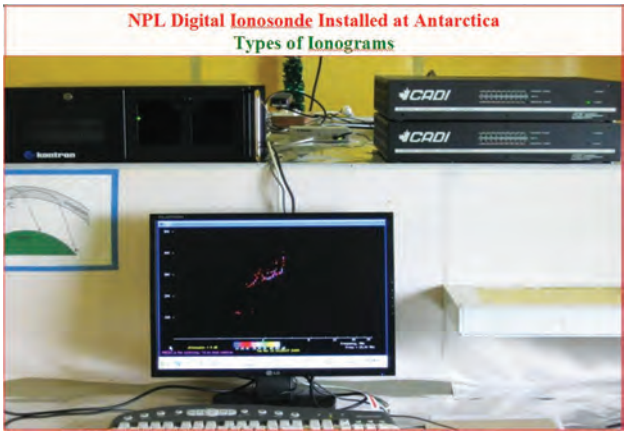


Fig.6.10 NPL Digital Ionosonde installed at Maitri in Dec. 2009 showing a sample ionogram.

Fig.6.11 NPL Ionosonde System at Maitri was inaugurated by the Prince Albert II of Monoco.

International Reference Ionosphere (IRI) model

The bottomside profile shape parameters (B0,B1) are derived from electron density (Ne-h) profiles measurements through digital ionosonde system at NPL, New Delhi, for low solar activity period (2004-06). Parameters B0 and B1 for each individual Ne-h profile for each month covering the period from January 2004 to July 2006 are derived and also the corresponding peak values of electron density and the height of the F2-region (NmF2, hmF2) are stored. The median values of observed B0, B1, hmF2 and NmF2 are then calculated for each month at each hour. The median values of hmF2 and NmF2 are used as an input to the IRI (International Reference Ionosphere) model to obtain IRI predicted B0,B1 values for each month. The B0,B1 values thus obtained are grouped into different seasons by clubbing summer, winter and equinox months and thereafter the average values of B0, B1 are obtained for both the observed and IRI model at each hour. The study reveals that during summer and winter as shown in Fig.6.12 below, the IRI model with B0 Tab. option in general, produces better agreement with the observed median B0 values during daytime as compared to IRI (Gulyaeva) option, while outside this time period, the IRI (Gulyeava), predicted values are found to be closer to the observed values than those obtained using IRI (B0 Tab.) option. However, during winter, the agreement between the IRI (Gulyaeva) and observed values are found to be more closer than IRI (B0 Tab,) option.

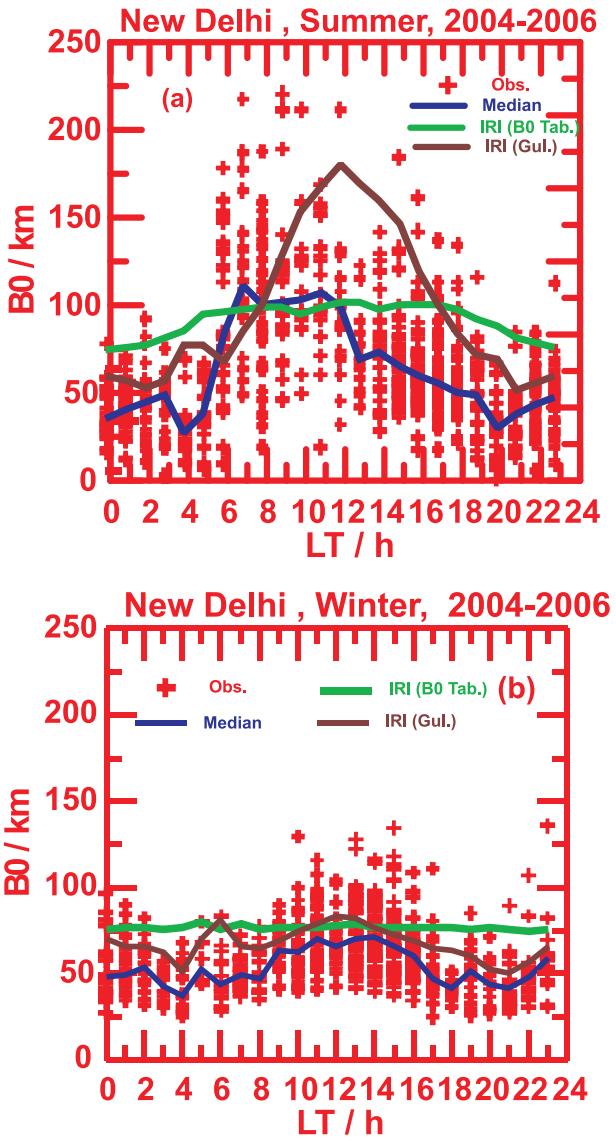


Fig. 6.12 shows the mass plot of observed B0 parameters as a function of local time along with the median and IRI predicted values for (a) summer and (b) winter.

Similarly in Fig.6.13, the diurnal variation of parameter B1 is shown along with the median and IRI predicted values. Both the options in the IRI model reproduce similar diurnal variations and are close to the observed median values in general.

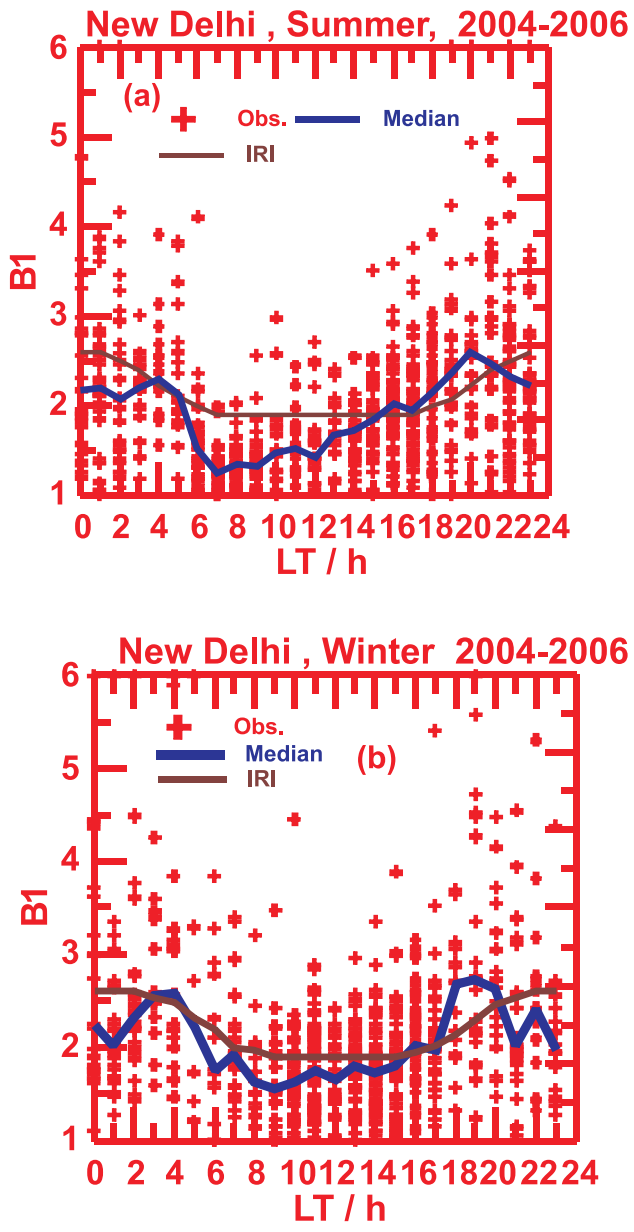


Fig. 6.13 shows the scatter plot of observed B1 along with the median and IRI predicted values for (a) summer and (b) winter. Both the options reproduce similar values of B1.

Rainfall dynamics over Indian tropical stations for radio communication

The influence of rainfall on radio wave propagation at frequencies above 10 GHz is crucial over ground to space radio links, especially in tropical regions because of the high intensity rainfall. This often makes direct-to-home; very small aperture terminal systems operating at these frequencies to be subjected to many fade occurrences due to heavy rain. In addition to annual and worst month's cumulative statistics, dynamic characteristics of seasonal and diurnal variations, together with average event length and separation over the day are needed to give the detailed insights for system design. A detailed study on the characteristics of rain distribution based on 5-year rainfall data for locations situated in north eastern part and south western coastal region in India indicates that at higher percentage of time of 0.1%, the average rain rate is about 45.3 mm/h and for 0.01% the rain rate is 123.4 mm/h over north eastern part while over south western coastal region for 0.01% time rain rate is 118.4 mm/h . Rain intensities for the average year and the average worst months, and monthly and diurnal dynamic characteristics of rain events were carried out. The resulting rain intensities are also compared with the relevant ITU-R recommendations. These results are useful to estimate signal outages in a year for the location.

Mobile Communications

For fiixed and mobile communications, studies are carried out by conducting experiments and verifying the accuracy of radio propagation models by comparing them with the observed values and modifying the models suitable to Indian conditions. The 1800 MHz data collected over various regions

of India has been partly analyzed with reference to base stations. Models suitable to dense urban region have been selected and path loss exponents have been deduced. It is observed that close to the transmitting station high path loss exponents have been observed and fall steeply up to a certain distance called "break point" beyond which the exponent flattens.

The parameters of Aircom's radio planning tool have been modeled with the help of observed data collected along Indian rail road rural zones in the northern and western India. Some typical results related to Meerut base station are shown in Fig.6.14..The results generated from Aircom's radio planning tool using digital terrain data have been utilized to identify new towers required over various rural regions of India. Mobile communication data generated along east Indian rail roads encompassing varying terrains has been analysed with the help of different methods and influence of terrain on signal levels has been investigated. Effect of railway tunnels on mobile communications have also been studied. A typical variation depicting the effect of tunnels on signal level for Thakurwadi base station is shown in Fig. 6.15.

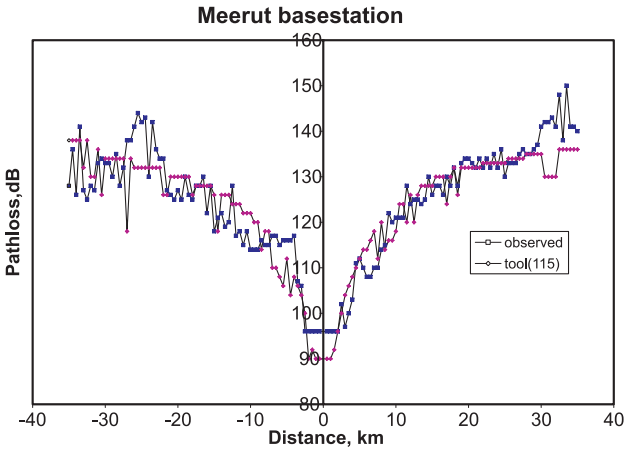


Fig.6.14 Comparison of tool predicted losses with observed losses vs track distance for Meerut base station

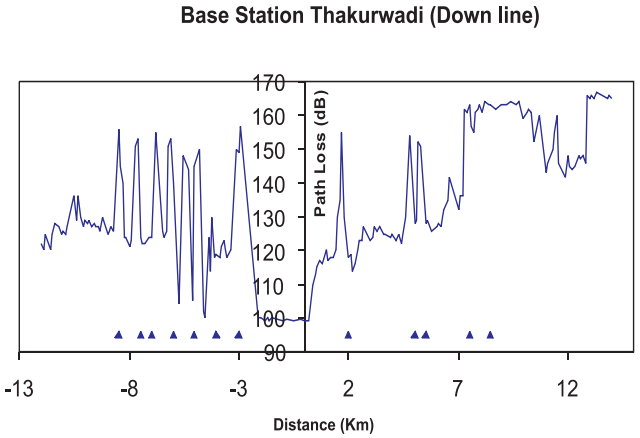


Fig. 6.15 Variation of observed path loss as a function of distance for Thakurwadi base station in down line direction

Atmospheric Environment and Global Change Studies on Atmospheric Aerosols

Atmospheric aerosols, particularly those near the surface, have strong direct and indirect influence on the environment, air quality, visibility and human health with immediate repercussions, while they alter the radiation budget of the Earth-atmosphere system through radiative forcing and also lead to formation of dew, mist and fog thereby affecting the climate on a long-term scale. Even though the significance of aerosols in these processes are globally recognized and several efforts have been made to model their characteristics from the above perspective, there still exists large uncertainties not only globally but also regionally. This arises mainly because of the large heterogeneity (spatial and temporal) in their properties (physical and chemical composition) and lack of experimental data with adequate spatial-temporal resolution. The particles in urban areas are typically formed mechanically by the abrasion of road material, tyres and brake linings, soil dust raised by wind and traffic turbulence, etc. Aerosols can also alter cloud properties acting as cloud condensation nuclei and

thereby affecting the droplet concentration, optical properties and lifetime of clouds.

In view of the above importance, study of diurnal and seasonal variability in near surface aerosol number concentration at an urban site New Delhi, India has been undertaken using Optical Aerosol Spectrometer.

A Polarization Micro Pulse Lidar (PMPL) has been setup at NPL, New Delhi to study the vertical distribution of aerosols and clouds and also temporal variation of Atmospheric boundary layer height. Lidar measurements have been proved to be promising tools to enhance our undertaking regarding impact of aerosols and clouds on precipitation, radiative processes and climate change. The PMPL, which is operational at NPL, New Delhi since August 2007 has a capability to monitor range – resolved back-scattered signals from aerosols and clouds at parallel and perpendicular polarization. The ratio of above two polarizations called depolarization is a useful parameter to study the aerosols and clouds microphysics.

Technologies developed covering new processes: A new Micro Pulse LIDAR has been designed and developed at NPL for the studies of vertical distribution of aerosols and atmospheric boundary layer. This developed MPL system is being used successfully for atmospheric studies.

Atmospheric studies over Arctic

The International Polar year has completed its one-year. National Physical Laboratory has contributed strongly to its scientific programmes. Photochemical reactions in snow have recently witnessed an unprecedented surge of interest. Recent investigations have shown production and significant release of CO flux from the snow-covered region.

The study of snow-pack production of carbon monoxide and its diurnal variability were started during First Indian Arctic Winter phase Expedition (3rd-31st March, 2008). In addition to the above, studies on Black carbon aerosols, aerosol number-size distribution, Aerosol Optical Depth were carried out. In continuation during second phase summer Indian Arctic Expedition (1st-28th, August, 2008), carbon monoxide and surface ozone analyzers have been installed for the measurement of ambient air CO and O_3 concentrations and Aerosol optical spectrometer for measurements of particle size distribution (Fig. 6.16 through Fig. 6.18).

Fig.6.16 Optical Spectrometer, Aethalometer and CO Analyser at Indian Arctic

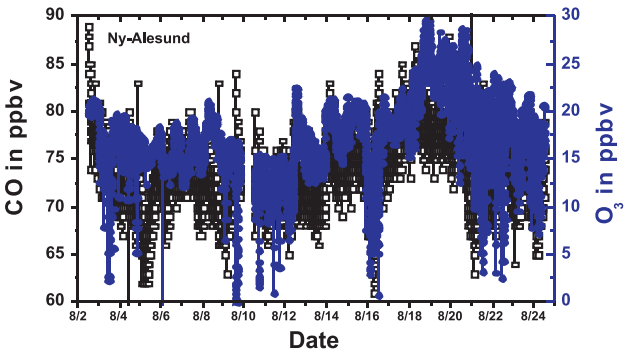


Fig.6.17 Time series of carbon monoxide and ozone concentrations during August 2008.

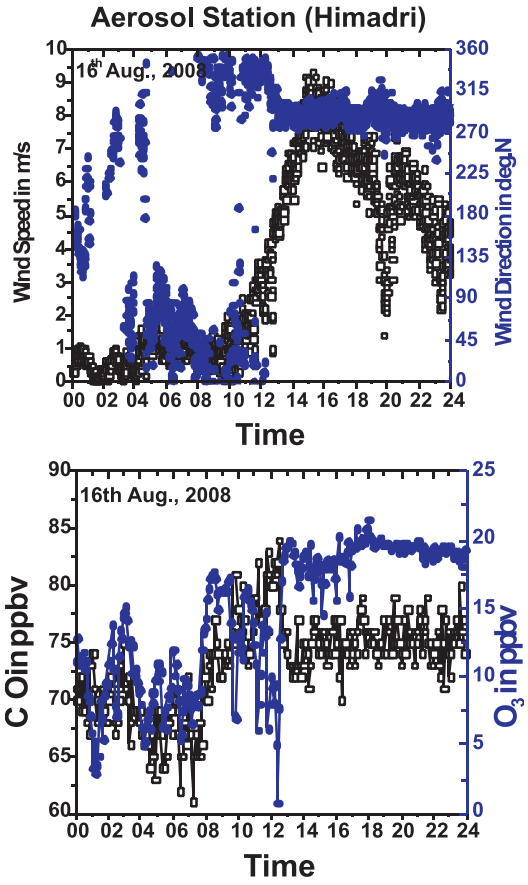


Fig.6.18 Diurnal variation of CO and O_3 on 16th August 2008 along with wind velocity at Ny-Alesund.

Setting up of Primary Ozone Standard (NIST Standard Reference Photometer) facility

In India and adjoining countries of South Asian region, various institutes and organizations have undertaken measurements of surface ozone to understand various Global change related problems and also to study air quality of the region. It is also very important that these measurements are made traceable to International standard (Fig. 6.19). Keeping in view of the above importance, a NIST's Standard Reference Photometer (SRP-43) – Primary Ozone Standard Facility has been setup at the National Physical Laboratory (Fig. 6.20). This facility will be an unique in the South Asian region. It is also planned to provide secondary ozone standards after calibration against primary standard at NPL to various institutes for their use to calibrate their Ozone analyzer systems.

Fig. 6.19 World wide NIST SRP

Fig. 6.20 SRP At NPL

Setting up of NOy monitoring facility at NPL

A key element in advancing the understanding of tropospheric production of ozone is the ability to make unequivocal measurements of the concentrations of the ozone precursors, the reactive nitrogen oxides (NOy compounds) and volatile organic compounds (VOCs). Because tropospheric chemistry is shaped by oxidants, such as ozone,

hydrogen peroxide (H_2O_2), and oxidizing radicals, the concentration of these compounds also must be measured to test present understanding of atmospheric oxidation mechanisms. The mega cities are major sources of these pollutants. In view of the above importance, we are procuring NOy system to undertake the simultaneous measurement of NOy along with the measurements of surface ozone, NOx, CO, VOC, CH_4 and NMHC at NPL to study the photochemistry of the region.

Studies of Aerosol radiation forcing over Delhi

The study of aerosol radiation forcing over Delhi was done by using the observations of aerosol optical depth (AOD) and the black carbon (BC) concentration in the atmosphere. The annual average AOD at 500nm is ~ 0.86 ± 0.42 with an average Angstrom exponent ~ 0.68 ± 0.35. The average monthly AOD throughout the year is found in the range 0.56 to 1.22 and the Angstrom exponent in the range 0.38 to 0.96. The average BC concentration over Delhi is quite high compared to all other urban centers in India (where measurements are available). It varied between 6.22 μg/m^3 during monsoon season to 25.75 μg/m^3 during winter. The BC concentration was basically controlled by the mixing layer height but the low ventilation coefficient during winters and night time was mainly responsible for the enhanced BC concentration

The monthly average single scattering albedo (SSA) over Delhi is found to be in the range from 0.72 to 0.89 which is largely affected by the BC concentration that lies in the range 4 – 15 mg/m^3 as monthly average during daytime. The monthly average clear-sky Direct Aerosol Radiactive Forcing at the surface varied in the range –38 W/m^2 to –68 W/m^2 throughout the year. The values of monthly Direct Aerosol Radiactive Forcing at Top of Atmosphere was found to be in the range –3 to 14 W/m^2 and in the atmosphere it was in the range 39 W/m^2 to 77 W/m^2 throughout the year.

Ambient NH_3, NO, NO_2, O_3, CO and SO_2 Over New Delhi

Diurnal variation of ambient ammonia (NH_3) in relation with O_3, CO, NO, NO_2 and SO_2 and meteorological parameters were studied during winter period at NPL. For the first time, ambient NH_3 was monitored very precisely and continuously using ammonia analyzer, which operates on chemiluminescence method. NH_3 estimation efficiency of the chemiluminescence method (>90%) is much higher than the conventional chemical trapping method (reproducibility 4.5%). Ambient NH_3 concentration reaches its maxima (46.17 ppb) at night and minimum during midday. It was observed that the ambient ammonia (NH_3) concentration is positively correlated with ambient NO (r^2 = 0.79) and NO_2 (r^2 = 0.91) mixing ratio and negatively correlated with ambient temperature (r^2 = -0.32). Wind direction and wind speed indicates that the nearby (~500m NW) agricultural fields may be major source of ambient NH_3 at the observational site.

Figure 6.21 shows the diurnal variation of NH_3 and other trace gases (O_3, CO, NO, NO_2, SO_2). Maximum ambient NH_3 concentration is being recorded at night through out the study period and minimum NH_3 concentration is mostly observed between 13:00h to 16:00h. Average day time concentration of the atmospheric NH_3 is recorded of the order of 17.43 ± 9.42 ppb, whereas, average night time concentration is observed as 22.96 ± 8.25 ppb (Table 6.1). Average NO mixing ratio is observed

of the order of 11.99 ± 4.66 ppb with a maximum value 41.62 ppb and minimum of 0.89 ppb. Ambient NO_2 mixing ratio ranges from 0.78 – 38.79 ppb with the average value of the order of 9.67± 3.25 ppb. NO_2 mixing ratio is also negatively correlated (r^2 = -0.42) with atmospheric temperature. Night time peak in the NO_2 mixing ratio may be attributed to conversion of NO to NO_2 with the reaction of ozone as well as lowering of the boundary layer during winter. Night time increase in NO_2 may also attribute to biomass burning (fuel wood) in the surrounding area due to very low temperature. Maximum O_3 mixing ratio recorded during the study period is 67.90 ppb with average concentration of 23.37 ± 20.12 ppb. CO mixing ratio ranges 0.81 – 5.62 ppm with average of 1.66 ± 1.04 ppm. Amplitude of diurnal variation (~1.0 ppb) in ambient SO_2 is very small unlike other trace gases with minimum during day and maximum at night

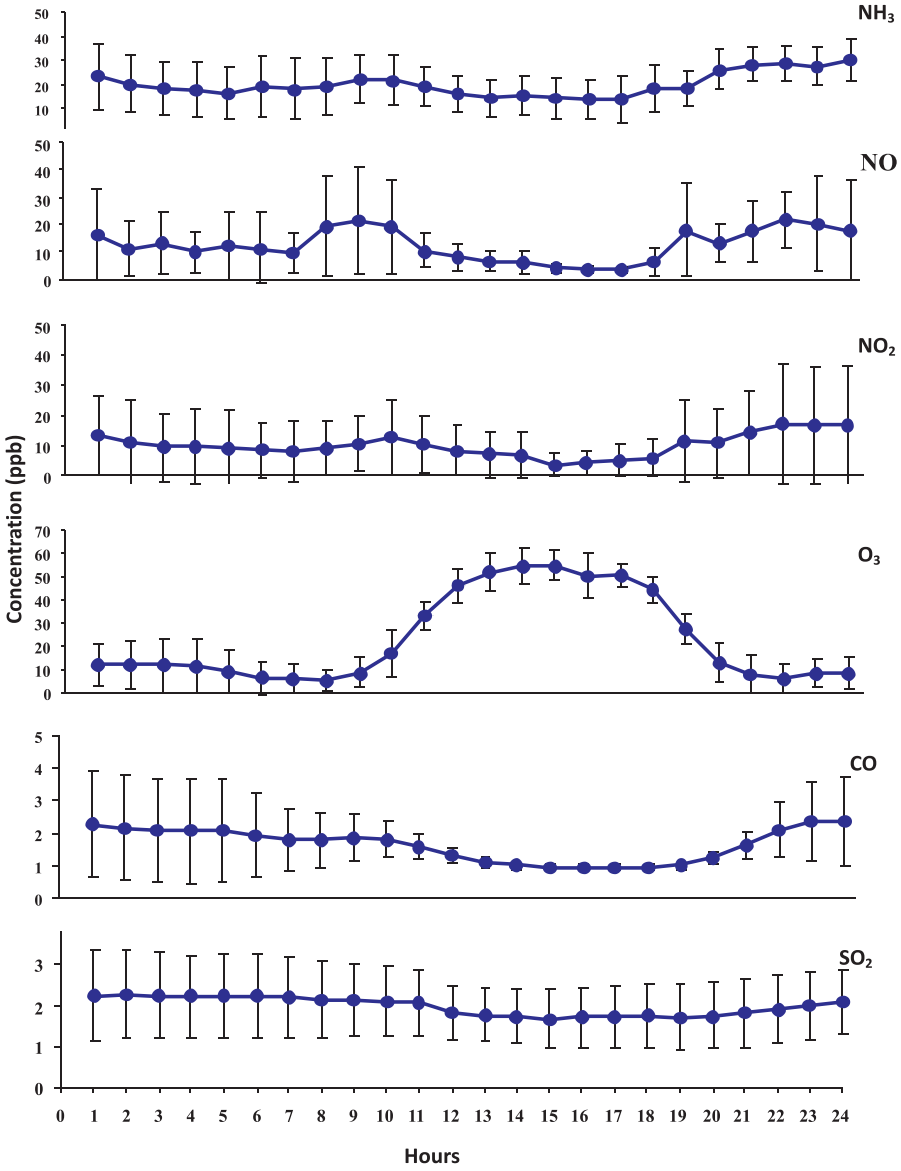


Fig .6.21 Diurnal variations of ambient trace gases NH_3, NO, NO_2, O_3, CO and SO_2

Table 6.1 Concentration of trace gases over the study period

Gas	Concentration				
	Maximum	Minimum	Day	Night	Average
NH_3 (ppb)	46.17	1.02	7.50 ± 9.97	22.96 ± 8.25	17.43 ± 9.42
NO (ppb)	41.62	0.89	10.31 ± 4.62	14.04 ± 6.44	11.99 ± 4.66
NO_2 (ppb)	38.79	0.78	7.94 ± 4.51	13.46 ± 5.46	9.67± 3.25
O_3 (ppb)	67.90	0.56	33.34 ± 21.69	14.79 ± 3.45	23.37 ± 0.12
CO (ppm)	5.62	0.81	1.40 ± 0.69	1.87 ± 1.25	1.66 ± 1.04
SO_2 (ppb)	4.19	0.59	1.91 ± 0.80	2.00 ± 0.91	1.97 ± 0.85

± Standard deviation

Determination of emission factor of carbonaceous aerosol from biofuel used in rural sector in India

Indo Gangetic (IG) plain is major emitter of pollutants in India.The emission factor of carbonaceous aerosol from biofuels used by rural sector for energy, are presented at district level in all states (Punjab, Haryana, Uttar Pradesh, Bihar, Jharkhand, Utttarakhand, Himachal Pradesh, West Bengal, Delhi, Rajasthan) of Indo Gangetic Plain. Distribution of biofuels used by rural sector as energy shows that cow dung is mostly used as energy among other biofuels (fuel wood, crop residue). Emission

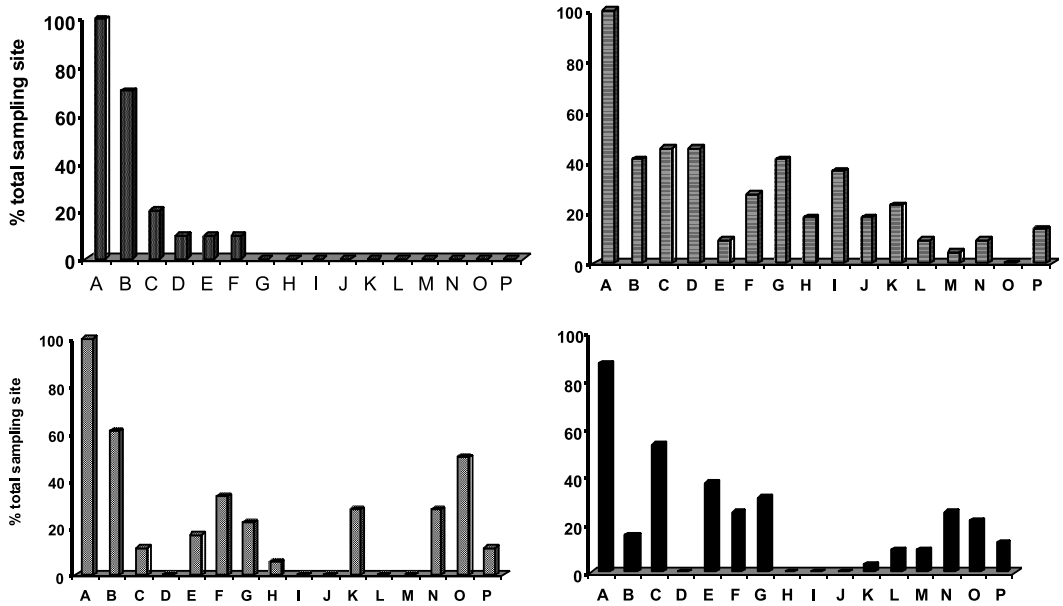


Fig. 6.22 Variation in biomass use for cooking purpose in rural sectors of north India. a. Delhi; b. Uttar Pradesh; c. Haryana; d. Punjab.

factor are determined by total burning (pyrolysis, flaming and smoldering) of those biofuel samples in the laboratory. Cow dung represents major emitter of organic carbon in this region. Samples were collected at district level from different rural areas of all states of IG plain to get the real picture of the biomass used in these areas by interrogating with local people. Demographic data were also collected to estimate the budget. Burning of those samples is being carried out in the laboratory and emission factor of carbonaceous aerosol are determined.

The study reveled that in the rural sector of north India cow-dung cake is the major biomass used as the fuel for cooking purpose. Uttar Pradesh has the largest variability among the biomass use. Further, *in situ* study of the biomass materials collected from the sampling locations will help to develop the mitigation strategy to reduce the atmospheric pollution (Figure 6.22). Contribution of dung cake in organic carbon is effectively more due to high emission factor (Table 6.2 and 6.3)

A. Cow-dung cake; B. Keeker; C. Neem; D. Sarson; E. Shatoot; F. Shesam; G. Eucalyptus; H. Jamun; I. Aam; J. Arandi; K. Arhar; L. Maize; M. Peeple; N. Jantar; O. Kapas; P. Poplar.

Table 6.2 Emission factor of carbonaceous aerosol from biofuels used in Delhi

Fuel	EC(g/Kg)	OC(g/Kg)
Fuel wood		
a. Shahtoot(Morus alba)	~0.5	~ 0.5
b. Keekar(Acacia arabica willd)	~ 0.07	~ 1.07
c. Sarso(Brassica rapa)	~ 0.1	~ 4.48
d. Ber(Zizyphus jujuba)	~ 0.06	~ 0.95
Dung cake	~ 0.07	~ 5.1 ~0.01 Chandra Venkkataraman et al, 2005

Table 6.3 Emission factor of NOx and PM from biofuels used in Delhi

Emission Factors for NOx and PM from Biofuels (Delhi)		
Species	NOx EF(g/kg)	PM EF (g/kg)
Cow dung	1.35±0.75	18.9±8.70
Shahtoot	4.82±0.56	2.3±0.57
Keekar	4.79±1.13	2.1±1.30
Mustard stem	2.04±1.30	12.1±9.13
Kabli keekar	0.87±0.50	1.5±0.47
Ber	0.15±0.12	3.9±3.14
Nagpan	2.87±1.06	4.0±1.79
Sheersh	0.83±0.36	11.5±6.35

Determination of origin of carbonaceous aerosols by stable carbon isotope method over bay of Bengal and Arabian sea during pre-monsoon period

The origin of carbonaceous aerosols of the samples collected over the Bay of Bengal (BOB) and Arabian Sea (AS) during the period of March-May 2006 has been looked into. The concentration of Organic Carbon is found to be as high as 10 $\mu g\ m^{-3}$ and highest Elemental Carbon concentration is found to be 4.4 $\mu g\ m^{-3}$ over Bay of Bengal region. This high value normally reflects that the origin of carbonaceous aerosols from anthropogenic activity. The average ratio of EC/TC (Total Carbon) over Bay of Bengal and Arabian Sea is found to be less than 0.23, which gives the clear indication that the origin of carbonaceous aerosol may be from biomass burning rather fossil fuel burning. EC/CO ratio supports that carbonaceous aerosol over BOB and AS is contributed from 80% biomass burning. Higher K^+/EC ratio (~0.40) over BOB and AS confirms the above conclusion and indicates that burning of non-woody biomass (agricultural residue, savanna type grasses, tree leaves etc) have major contribution in

origin of carbonaceous aerosol. Further carbon stable isotopic analysis (ä ^{13}C) of aerosol samples confirms that burning of combined C3 and C4 plants over south and south east Asia has contributed more in origin of carbonaceous aerosol over the BOB and AS. Contribution of C3 plants is relative more over C4 plants over Arabian Sea, whereas, C4 plants have dominated than C3 plants over Bay of Bengal. To confirm our result, we need more study over Bay of Bengal and Arabian Sea (Fig.6.23)

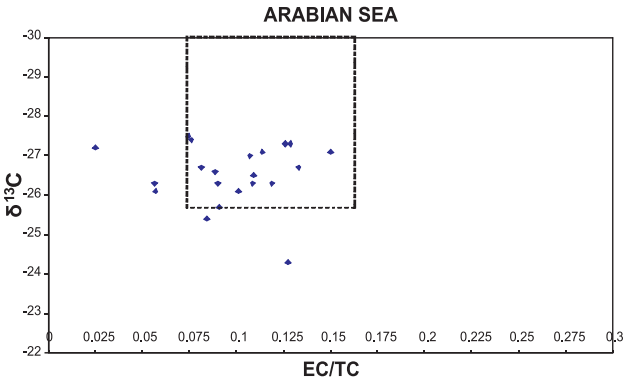


Fig.6.23 Scatter plot of EC/TC ratio against stable carbon isotope (ä ^{13}C) over Bay of Bengal

Mega-city atmospheric pollution precursor process modelling

Rapid industrialization, urbanization and growing need for food and comfort is leading to the emissions of pollutants in the atmosphere which have deleterious impacts. A pilot study has been undertaken to set-up a mega-city wide near real time modeling and prediction of accumulation of toxic gases in ambient air in different urban and peri-urban regions of the city and assign their impacts to human health as well as cultivated crops in these regions. This activity will help in generating capability to issue environmental alerts for the benefit of the vulnerable sections of the city dwellers and the concerned agencies. Delhi has been chosen as the target city for this study.

The research design of this project includes (i) use of ambient air pollutant data for validation of model outputs as well as for development of atmospheric alert index, (ii) development of gridded emission data inventory for city for use in forecast model and (iii) simulations by air quality forecasting model. Air quality data from the existing monitoring network has been envisaged to be used in this study to begin with. WRF-Chem model is at the core of this pilot study. The Weather Research and Forecast (WRF) model coupled with chemistry (WRF-Chem) is a meso-scale 3-dimensional air quality forecast model which provides the capability to simulate chemistry and aerosols from cloud scales to regional scales. Use of this model requires generation of the gridded data on emission fluxes as input parameters besides the meteorology.

In order to achieve desired objective, a step-by-step approach is being followed. Initial training for WRF-CHEM model simulation for air-quality forecasting has been undertaken and the development of gridded emission inventories for various pollutants has been initiated for which existing inventories are being updated (e.g. Figure 6.24 shows the NO_x and CO emission estimates from different kinds of vehicles in Delhi for 1990-91 to 2004-05 periods). These inventories would be gridded at an appropriate spatial scale using the GIS tool. Additionally, designing of the LabVIEW platform based spatially-distributed web-enabled data networking system has also been initiated.

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

The fourth Assessment Report (AR4) of Intergovernmental Panel on Climate Change (IPCC)

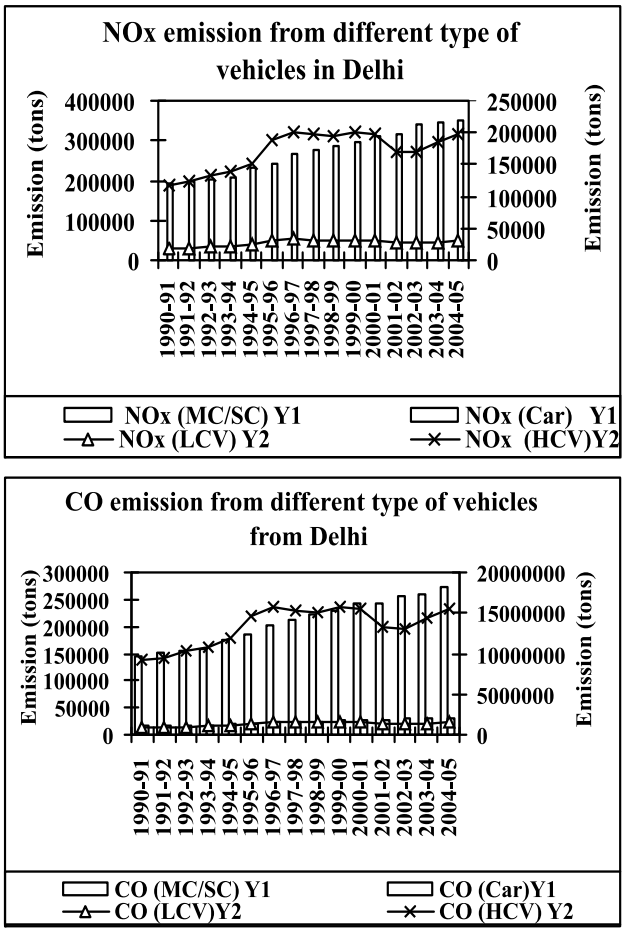


Fig.6.24 NO_x and CO emissions from different kinds of vehicles in Delhi for 1990-91 to 2004-05 periods

has clearly stated with very high confidence that the Climate change currently contributes to the global burden of disease and premature deaths. According to this report, human beings are exposed to climate change through changing weather patterns (temperature, precipitation, sea-level rise and more frequent extreme events) and indirectly through changes in water, air and food quality and changes in ecosystems, agriculture, industry and settlements and the economy. It has also stated that currently the effects are small but are projected to progressively increase in all countries and regions. Among the various health related impacts, there is likelihood of increased heat-wave-related mortality.

Globally the hot days, hot nights and heat-waves have become more frequent which are associated with marked short-term increases in mortality. Heat waves are normally associated with the high average temperature and the number of consecutive hot days. Heat stress-related mortality has been reported and evaluated mostly for mid-latitude countries and cities, but also in the hot subtropical and cold high-latitude environments. In India, eighteen heat-waves have been reported during the period between 1980 and 1998, with a heat-wave in 1988 affecting ten states and causing 1,300 deaths. In the present project, efforts are being made to assess the impacts of future climate change on heat stress in India for which required data are being collected and collated which would be used to develop empirical model. The future climate scenarios for India are being generated by IITM, Pune which would be used in this assessment.

Meteorological Tower

Lack of visibility during fog days is a cause of concern due to delays of flights and slow movement of trains. A model has been developed at CMMACS, Bangalore which can predict visibility during fog days. Efforts are on with India Meteorological Department (IMD) to induct this model into an operational service. CMMACS along with NPL and Indian Air Force have mounted a programme under which meteorological parameters by using an array of few met towers during fog days over Delhi will be monitored at several sites for validation of fog prediction model. The first of these towers has been installed at NPL in Delhi. The tower is instrumented to measure air and soil temperature, wind direction and speed, relative humidity etc at several level including net radiation and total rainfall as needed for the model.

अतिचालकता तथा निम्नतापिकी

SUPERCONDUCTIVITY AND CRYOGENICS

अतिचालकता तथा निम्नतापिकी

पिछले कुछ वर्षों के दौरान, अतिचालकता ग्रुप द्वारा अनेक दिशाओं में असीम प्रगति की गई है। एम जी बी$_2$ (MgB_2) में नैनोपार्टिकल डोपिंग तथा अन्य डायबोराईडस में अपने अध्ययन को जारी रखने के साथ, हमने अनेक प्रणालियों को संश्लेशित किया है जिसमें हाल ही खोजे गए विरल अर्थ आक्सी–निक्टाईड्स तथा उनके विद्युतीय तथा चुम्बकीय गुणधर्मों का मापन करना शामिल है ।

फरवरी 2008, टोकियो इंस्टीट्यूट ऑफ टेक्नोलोजी के हिडियो होसोनो तथा उनके सहकर्मियों द्वारा लैंथानम आक्सीजन फलूराइन आयरन आर्सेनाइड ($LaO_{1-x}F_xFeAS$) का पता लगाया गया जो कि एक ऐसा ऑक्सी–निक्टाईड है जो 26 K के नीचे सुपरकंडक्ट करता है। एन पी एल में हम सभी ने इसे चुनौती के तौर पर स्वीकार किया तथा इस नए खोजे गए आयरन आधारित सुपरकंडक्टर्स अर्थात REFeASO(RE=La, Sm, Gd, Pr etc.) पर कार्य करना आरंभ किया।

हमने Fe पर आधारित सुपरकंडक्टर्स अर्थात $LaFeAsO_{1-\delta}$ जिसमें $0.0 \leq \delta \leq 0.15$ लिया गया है, की आधार स्थिति के संश्लेशण के लिए एक सरल तथा बहुआयामी एकल मार्ग का अनुपालन किया।

परिणामस्वरूप प्राप्त हुए यौगिक एकल चरण के थे तथा वे P4/nmm संरचना में क्रिस्टीलाइज्ड थे। इन नमूनों द्वारा 150 के आस पास नीचे धात्विक व्यवहार जैसे ग्राउन्ड स्टेट स्पिन घनत्व तरंग (एस डी डब्ल्यु) को दर्शाया गया। एंटी फैरोमैग्नैटिक क्रम व्यवस्था और मूल प्रणाली में अतिचालकता को अभिप्रेरित करने के लिए Fe^{2+} को आंशिक रूप से Co^{3+} से प्रतिस्थापित किया गया। अतिचालकता 14K के आस पास $SmFe_{0.9}Co_{0.1}AsO$ प्रणाली में दिखाई दी क्योंकि Co–डोपिंग से मूल यौगिक में SDW असमान्यता को दबा दिया जाता है। हमने एच पी एच टी प्रकिया के अनुप्रयोग के बिना, निर्वात में सॉलिड स्टेट प्रतिकिया विधि द्वानान दोहरी परत आयरन आक्सीनिक्टाईड्स को $Sr_4V_2O_{6.}Fe_{2.}As_2$(42622) को संश्लेशित करने का प्रयास भी किया। प्रतिरोधकता मापनों द्वारा यौगिक में सपुरकंडक्टिंग पारगमन को नहीं दर्शाया गया, संभवतः उसमें अपर्याप्त संवाहक संकेन्द्रण था, लेकिन हमने 175K के नीचे SDW का अवलोकन किया।

अतिचालकता को प्राप्त करने के लिए इन पदार्थों में प्रभावी संवाहकों को शामिल करने के लिए हमारे द्वारा और आगे प्रयास किए जा रहे हैं।

SUPERCONDUCTIVITY AND CRYOGENICS

During the last few years, superconductivity group has made a profound progress in several directions. With the continuation of study of nano-particle doping in MgB_2 and other diborides, we have also synthesized several systems including the very recently discovered rare earth oxy-pnictides and measured their electrical and magnetic properties.

In February 2008, Hideo Hosono, from Tokyo Institute of Technology, and colleagues found lanthanum oxygen fluorine iron arsenide ($LaO_{1-x}F_xFeAs$), an oxypnictide that superconducts below 26K. We at NPL also took this as a challenge and started working on this newly discovered Fe based superconductors i.e. REFeAsO (RE= La, Sm, Gd, Pr etc.).

We followed an easy and versatile single step route for the synthesis of the ground state of the Fe based superconductor $LaFeAsO_{1-}$ with $0.0 \leq \delta \leq 0.15$. The resulting compounds were single phase and crystallized in tetragonal P4/nmm structure. These samples showed the ground state spin density wave (SDW) like metallic behavior below around 150 K. To destroy the antiferromagnetic ordering and to induce superconductivity in the parent system, the Fe^{2+} was partially substituted by Co^{3+}. Superconductivity appeared in $SmFe_{0.9}Co_{0.1}AsO$ system at around 14K because Co doping suppresses the *SDW* anomaly in the parent compound. We also tried to synthesize double-layered iron oxypnictides $Sr_4V_2O_6Fe_2As_2$ (42622) by an easy solid-state reaction method in vacuum without employing the HPHT process. The resistivity measurements did not exhibit superconducting transition in the compound probably due to insufficient carrier concentration, but we observed a SDW state below 175K.

Further attempts, to introduce effective carriers to these materials for achieving superconductivity, are being in progress by us.

(a). Bulk superconductivity at 14K in $SmFe_{0.9}Co_{0.1}AsO$

We report superconductivity in the $SmFe_{0.9}Co_{0.1}AsO$ system being prepared by most easy and versatile single step solid-state reaction route. The parent compound SmFeAsO is non-superconducting but shows the spin density wave (*SDW*) like antiferromagnetic ordering at around 140K. To destroy the antiferromagnetic ordering and to induce the superconductivity in the parent system, the Fe^{2+} is substituted partially by Co^{3+}. Superconductivity appears in $SmFe_{0.9}Co_{0.1}AsO$ system at around 14K. The Co doping suppresses the *SDW* anomaly in the parent compound and induces the superconductivity. Magnetization measurements show clearly the onset of superconductivity with T_c^{dia} at 14K, Fig. 7.1. The isothermal magnetization measurements exhibit the lower critical fields (H_{c1}) to be around 200 Oe at 2 K. The bulk superconductivity of the studied $SmFe_{0.9}Co_{0.1}AsO$ sample is further established by open diamagnetic $M(H)$ loops at 2, and 5K, Fig. 7.2. Normal state (above T_c) linear isothermal magnetization $M(H)$ plots excluded presence of any ordered magnetic impurity in the studied compound.

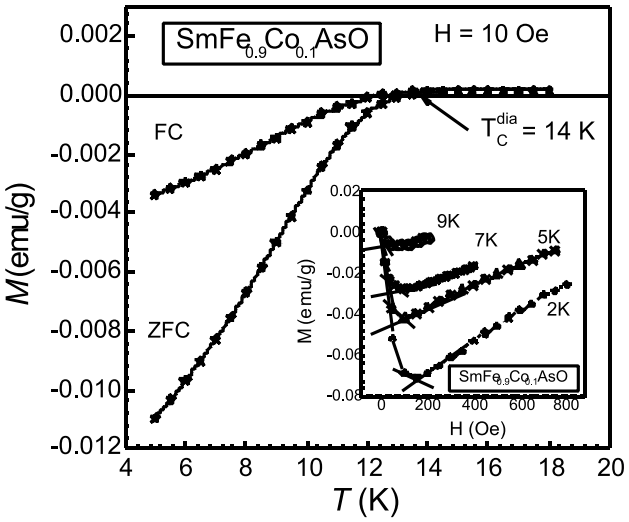


Fig. 7.1

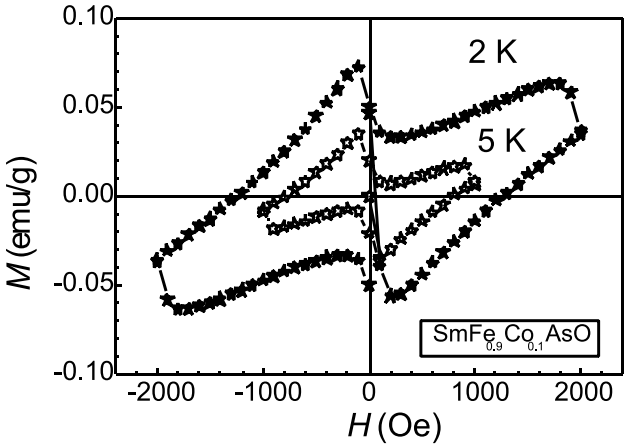


Fig. 7.2

(b). Enhanced room temperature coefficient of resistance (TCR) and magneto-resistance (MR) of Ag-added $La_{0.7}Ca_{0.3-x}Ba_xMnO_3$ composites

We report an enhanced temperature coefficient of resistance (TCR) and magneto-resistance (MR) close to room temperature in $La_{0.7}Ca_{0.3-x}Ba_xMnO_3 + Ag_y$ (x = 0.10,0.15 and 0<y<1.0) (LCBMO+Ag) composite manganites. The observed enhancement of TCR is attributed to the opening of new conducting channels and the disappearance of the barrier formed by the disorder/ strain at the grain boundaries. Ag addition has also been found to result in the grain growth and enhanced magneto-resistance. Intrinsic magneto-resistance is seen to increase whereas the extrinsic MR decreases. The enhanced TCR and MR at / near room temperature open up the possibility of the use of such materials as infrared bolometric and magnetic field sensors respectively.

(c). Synthesis and structural stabilization of various $MSr_2YCu_2O_8$ (M = Fe, Co, Ga, Nb, and Al)

We report synthesis and structural details of $MSr_2RECu_2O_z$ (M-1212) compounds with M = Ga, Nb, Fe, Al and Co) and RE = Eu, Y. These compounds are synthesized through solid-state reaction route at different sintering temperatures. The Reitveld refinement is done for all the samples on their respective X-ray diffraction (XRD) patterns, which showed that all compounds are crystallized in single phase (please see Fig. 7.3). The Nb, Fe and Al-1212 possess tetragonal *P*4/*mmm* space group structure, while Ga -1212 and Co-1212 are crystallized in orthorhombic *Ima*2 space group. The change of space group from *P*4/*mmm* to *Ima*2 resulted in doubling of unit cell and the buckling angle [Cu(2)-O(2)-Cu(2) angle] determined by *GSAS* program, showed that most of the studied samples are heavily under- doped and hence they lack superconductivity. Thermo gravimetric (TGA) analysis showed the M-1212 compounds to be more stable than widely studied 90K superconductor Cu-1212 (RE-123), see Fig. 7.4. The magnetization behaviour of Ga, Nb and Al-1212 follows a Curie–Weiss like behavior due to paramagnetic contribution of Cu. In case of Co,Fe-1212 short magnetic correlations/spin glass like features are seen below 100 K. Efforts are underway to dope mobile carriers in studied single phase under doped M-1212 (M = Ga, Nb, Fe, Al & Co) compounds and to introduce superconductivity in them.

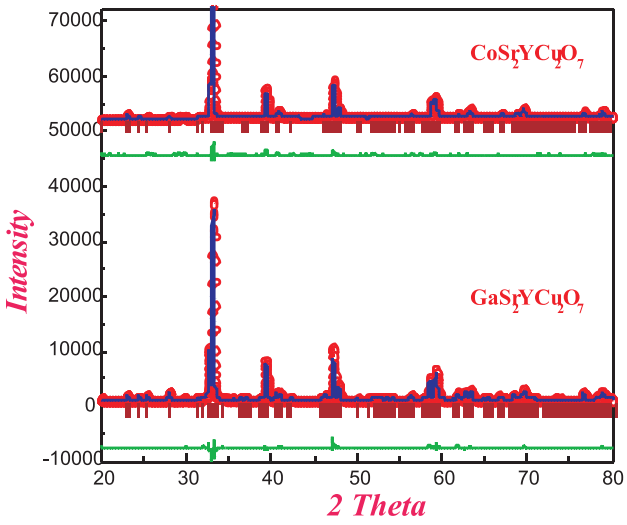


Fig. 7.3

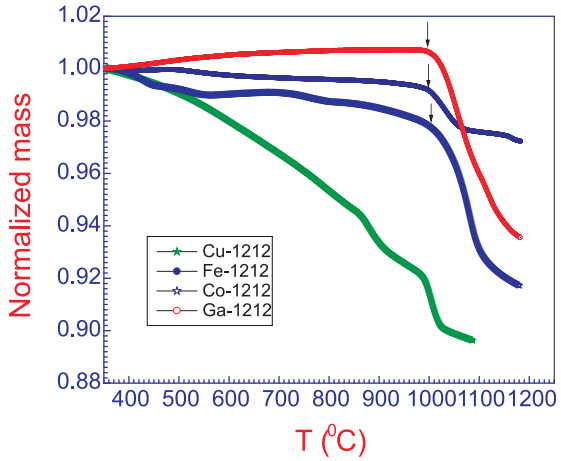


Fig. 7.4

(d). Substantial Increment in Critical Parameters of MgB_2 Superconductor by Boron Site *nano*-Carbon Substitution

This paper deals with the determination of critical properties of MgB_2 along with the impact of carbon substitution on critical parameters. The change in lattice parameters and decrease of transition temperature, T_c confirms the successful substitution by carbon at boron site. High field magnetization up to 12 Tesla and magneto transport measurements up to 14 Tesla [Fig. 7.5] are carried out to determine upper critical field (H_{c2}), irreversibility field (H_{irr}) and critical current density ($J_c(H)$). The upper critical field

values, H_{c2} are obtained from *r-T*(*H*) data based upon the criterion of 90% of normal resistivity. The prediction of $H_c(0)$ by Werthamer-Helfand-Hohenberg (*WHH*) formulation underestimates the critical field value even below than the field up to which measurement is carried out. After this the Ginzburg Landau theory (GL equation) is applied to the *r-T*(*H*) data which accounts for the temperature dependence behaviour of H_{c2} in the low temperature high field region along with the determination of $H_c(0)$ value[Fig. 7.6]. The $H_c(0)$ value of about 30 Tesla is obtained for the carbon doped sample while the same is just near to 16 Tesla for the pure MgB_2 sample. Magnetization measurements (*M-H*) determine other parameters like irreversibility field, H_{irr} and critical current density $J_c(H)$. The Carbon doping results in significant enhancement of critical parameters like H_{c2}, H_{irr} and $J_c(H)$.

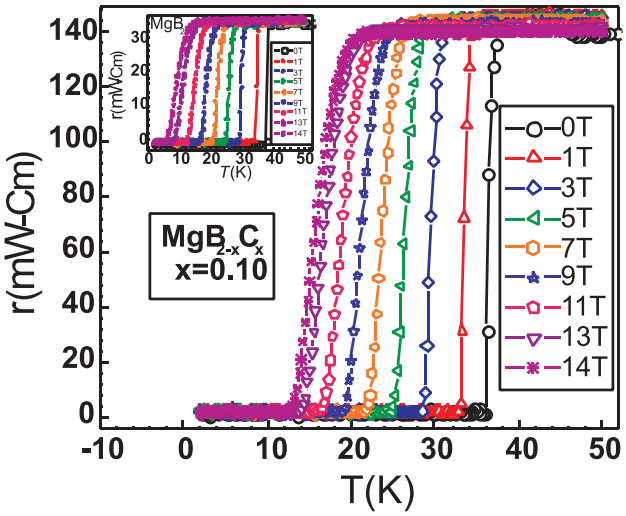


Fig. 7.5

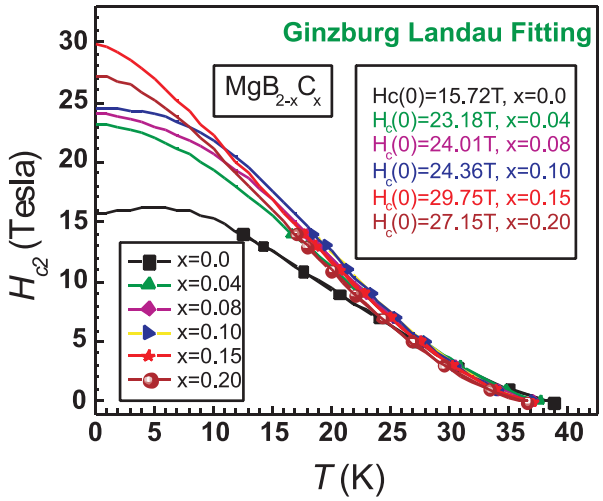


Fig. 7.6

(e). Single Step Synthesis of Various REFeAsO Compounds

Here, we report an easy and versatile single step synthesis route for phase formation of the ground state of newly discovered Fe based $REFeAsO_{1-ä}$ compounds at normal atmospheric pressure instead of widely used high-pressure and high-temperature (HPHT) method. In single step method, the Fe, REO, RE, and As are taken in stoichiometric ratio of REFeAsO and is sealed in evacuated quartz tube and followed by subsequent heating at 500, 850 and 1000°C for 12, 12 and 33 hours respectively. The resulting compounds are nearly single phase & crystallize in tetragonal P4/nmm structure. These samples show the ground state spin density wave (*SDW*) like metallic behaviour below around 150 K. Superconductivity can be brought in REFeAsO samples either by oxygen deficiency or by fluorine doping. Rietveld analysis of the room temperature diffraction pattern proceeded smoothly. RE and As atoms are located at Wyckoff positions *2c*, O is situated at *2a* and Fe are shared at site *2b*. The X-ray diffraction and Rietveld refinement confirms the formation of REFeAsO phase along with minor impurity phases. The SDW magnetic character is obtained in the ground state of these compounds between 130-150

K which is confirmed by a metallic step in resistivity measurements.

(f). Effect of single-walled Carbon Nano-Tube (CNT) addition on Superconducting Properties of bulk MgB_2 superconductor

Effect of single-walled carbon nano-tube (CNT) doping in MgB_2 on transition temperature, lattice parameters, critical current density and flux pinning was studied. The carbon substitution for B was found to enhance critical currant density J_c in magnetic fields but depress critical temperature T_c. The depression of T_c is caused by the carbon substitution for B, which is also confirmed by Rietveld analysis of room temperature XRD patterns of doped samples. We achieved enhancement of critical current density (J_c) and flux pinning by almost an order of magnitude, particularly in higher magnetic fields. Further there is also a significant enhancement in upper critical field (H_{c2}) and irreversibility field (H_{irr}) values.

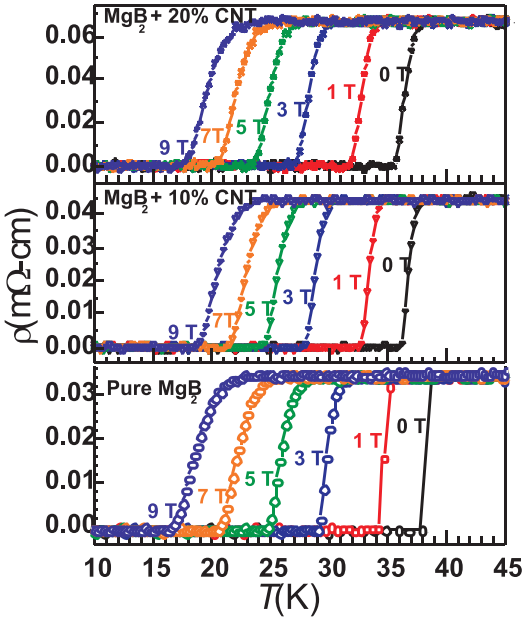


Fig. 7.7

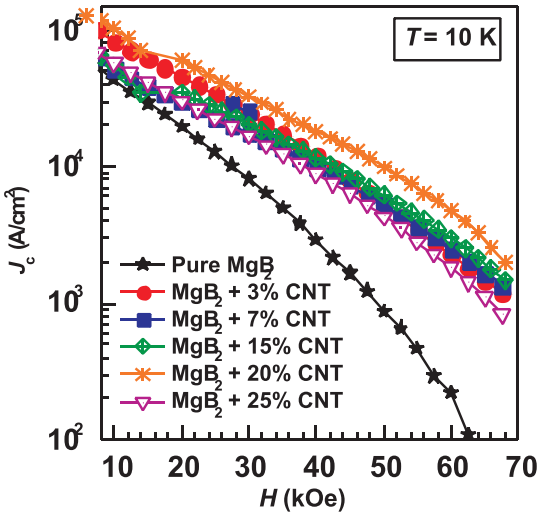


Fig. 7.8

The J_c is 22 times higher than pure MgB_2 at 10 K at 6 Tesla applied field in case of 20 wt% CNT added sample and J_c value is 4.80×10^3 A/cm^2 for the same. This improvement comes partly from C doping and partly from the pinning effect of the possible remaining CNTs. Fig. 7.7 shows the results of resistivity measurements in zero and different magnetic fields while Fig. 7.8 displays the estimated Jc values.

(g). Synthesis, Structure and Mössbauer Spectroscopy of $Sr_4V_2O_6Fe_2As_2$ compound

We report the synthesis and Mossbauer spectroscopy of $Sr_4V_2O_6Fe_2As_2$ (SVOFeAs). Studied SVOFeAs samples, crystallized in near single phase within space group P4/*nmm*, having a = b = 3.928 and c = 15.783 Å, but with some small impurity lines as evident from room temperature XRD pattern (Fig.7.9). The transport (resistivity) and magnetization measurements revealed the studied compound to be non-superconducting. Mössbauer spectroscopy (Fig.7.10) done at room temperature revealed the presence of pure Fe metal along with the main phase Fe^{2+} having quadrupole splitting of 0.29 mm/s and

the line width of 0.35mm/s. It is concluded that presence of pure Fe metal kills the superconductivity in an otherwise self-doped FeAs block of $Sr_4V_2O_6Fe_2As_2$ (SVOFeAs) superconductor.

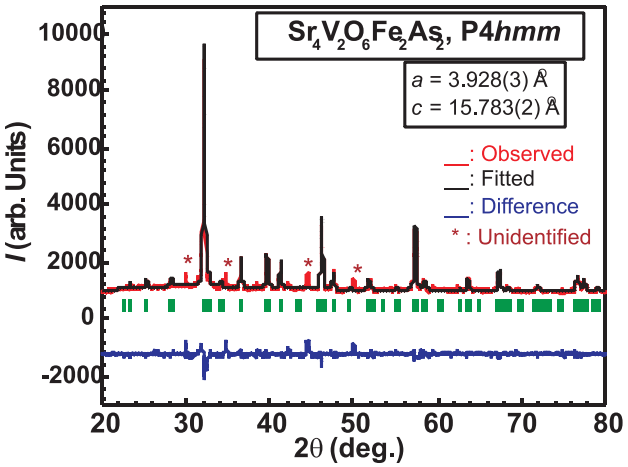


Fig.7. 9

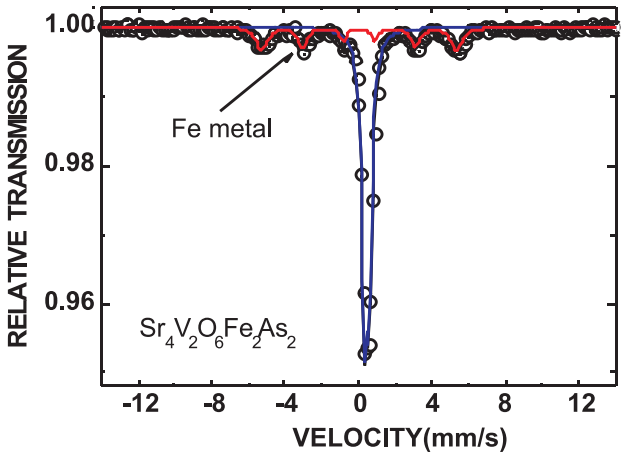


Fig. 7.10

सहायक सेवाएं
SUPPORT SERVICES

Planning, Monitoring and Evaluation Group (PME)

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

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

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

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

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

Industrial Liaison Group (ILG)

This group undertakes two major areas viz marketing of developed technologies and consultancy and technical services. Besides this, the group is responsible for all matters connected with business development, open day function, wherein few thousand schools and college students with their teachers are invited to see the various activities at NPL. Students are shown a film on NPL activities too. A technology day function is also observed where all licences are invited to deliberate with concerned PI of the technology for any suggestions. This group is also responsible for the dissemination of science through publication in CSIR news and in CSIR annual report, business and industrial magazines and their websites and through advertisements in news papers, conferences, symposiums, various other events and their souvenirs and also through participation in exhibitions Processes applications for the awards pertaining to technology or consultancy services rendered. Informs industries and licences for any new schemes. This group also takes care in the management of S & T outputs with other funding agencies viz. DST, CSIR, NRDC, AIMA,CDC, etc.. This group has recently initiated its efforts in setting-up an incubation Centre and possible knowledge Alliane with Moser Baer Photovoltaic Limited in Solar Energy area.

Human Resource Development Group (HRDG)

The HRD Group undertakes several activities in the areas of core competence of the laboratory, like organisation of Industrial Training in Metrology/ Standards, Students' Training / Project work for Ph.D. /M.Tech./ MCA/M.Sc./B.Tech and other equivalent degrees, Institutional Visits, Deputation of NPL staff members to attend conferences, etc., all of which eventually lead to the generation of trained S&T manpower in the country.

International Science and Technology Affairs Group (ISTAG)

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

Library and Technical Information Services

NPL Library has been providing library and information support to scientists for R&D pursuits.

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

During the current year library subscribed to 105 scholarly journals (82 foreign journals and 23 Indian journals) and added 98 S & T books and 402 bound volumes of journals. Library provides library services such as photocopying service, electronic document delivery service, inter library loan service, reference service and literature search.

The library offers online access to more than 5000+ full text journals under the e-consortium project of CSIR. It facilitate access to journals from various publishers i.e. Science Direct (Elsevier), Blackwell, Springer, AIP, APS (American Physical Society), Wiley Inter science, John Wiley and sons, Oxford University Press, Royal Society of Chemistry, American Chemical Society as well as to their archives going back to 1995 in case of Elsevier science and 2000 onwards in the case of other publishers. From this year, the Library has started providing access to intranet edition of Indian Standards.

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

This year, library has also installed 8 (Eight) dedicated computers in the library's reading hall to provide access to electronic journals for walk-in users (Who are mostly from the various educational & research institutes). Library Reading hall is also having the high-speed wireless internet area (HOT SPOT via D-Link DIR 655 N Series Modem) where one can have wireless connectivity for their Wi-Fi enable laptops.

The Library has a KSK Library site on the NPL intranet providing latest information on its activities such as additions to its collection, current subscribed journals, new journals received during the week, links to electronic libraries, publishing houses, and papers published by NPL scientists. The library continued to update this site during the year.

The Library also maintains NPL website (http://www.nplindia.org) on Internet. Library is in the process of renovating of the existing NPL site with many additional features and hopefully will be launched before 15th of June 2009. It is providing latest information on activities of NPL such as its role, thrust areas of research, facilities services, human resource, photo gallery, and achievements.

Central Workshop

In Central Workshop more than 1032 jobs have been completed including their designing, fabrication and development. Out of the above, a large no. of highly sophisticated components were produced notably of Cesium Fountain Clock, Rubidium Atomic Clock –a joint project of NPL and Space Application Centre, Ahmedabad, Helmotz Coil, technology development for Sensors, fabrication of LED devices & systems for Solid State Lighting applications etc.

During this period, the total output of the Central Workshop of the works done (Total Job Cards completed-1032) in the monetary terms was Rs. 1, 44, 41000/- (Rupees One crore forty four lacs forty one thousand only). In addition to the above, a large no. of drawings & design work was also undertaken at our Mechanical Drawing & Design Section.

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

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

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

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

The Central Computer Facility

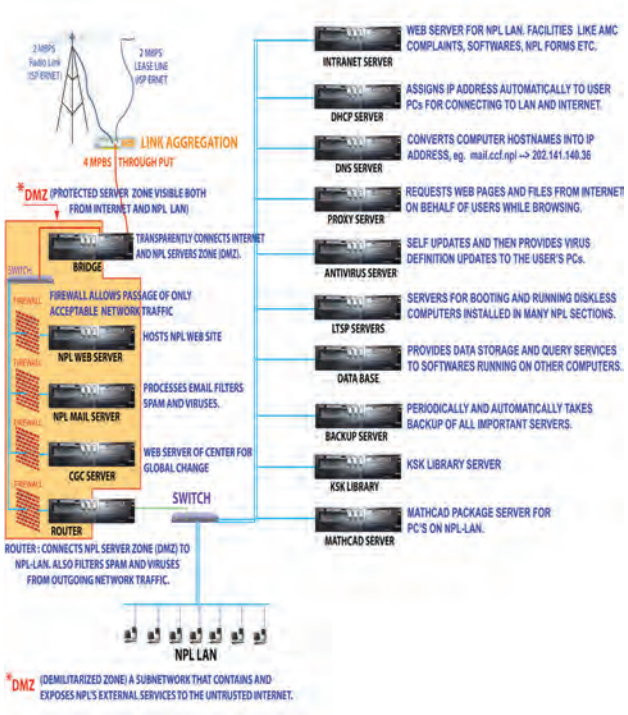
The Central Computer Facility (CCF) (a) offers several network, computing and user-support facilities to NPL scientists and staff, (b) is involved in software development for use at NPL and development of biomedical instruments, and (c) conducts research in the areas of pattern formation and nonlinear physics and evolving networks and (d) provides consultancy to other instutions and industry in the area of IT infrastructure and networking and automation and instrumentation.

IT Infrastructure and Facilities

A campus LAN (Local Area Network) has been set which connects together approximately 850 computers spread over the NPL campus. The network utilises a mixture of optical fibre, UTP cables and switches. The internet access is provided through a gateway to the external world via a 2 Mbps radio link and 2 Mbps leased line to the ERNET at the department of Electronics. Email and Internet services are thus brought to the user's desktops.

CCF has established and is actively maintaining various servers namely Mail, Web, LTSP, Intranet, DHCP, DNS, Router, Bridge, Anti-virus, Backup, Database and Other Dept. servers for providing networking, mailing and backup services. A schematic of the set up is shown in the figure below.

CCF has started the initiative to establish a new Data Center facility. Migration to improved



infrastructure, with new servers to improve of the quality of service has been already completed. Multi-layered firewall, anti-spam engine, antivirus solution have been implemented to enhance the overall network security.

Developmental Activities

Development of Personnel Inventory System (PIR) to enable the employees to retrieve their PIR records. Its purpose is to help store personnels for maintaining and updating the PIR records online.

CCF has developed the NPL intranet site (http://nplnet.ccf.npl) and is maintaining the same for providing information about latest circulars, notices, announcements etc. User friendly interfaces are also provided on the site for lodging PC/printer AMC related complaints and checking the status, to browse through the list of experts, personal inventory records, telephone directory, commonly used forms and open source softwares etc.

Research and Educational Activities

Development of biomedical instruments like blood oxygenation monitor, ECG machine and brain oxymeter. Experimental, theoretical, and computer simulation research on formation of patterns in a layer of a solid at the melting transition. Research on models for prebiotic evolution using numerical methods.

राजभाषा कार्यान्वयन

RAJBHASHA

प्रशासनिक कार्यशाला

प्रयोगशाला में राजभाषा नीति के प्रभावी कार्यान्वयन हेतु दिनांक 29 दिसम्बर, 2008 को वरिष्ठ वैज्ञानिकों के लिए आधे दिन की कार्यशाला का आयोजन किया गया। कार्यशाला में केन्द्र सरकार के सेवा निवृत्त वरिष्ठ अधिकारी श्री कृष्ण कुमार ग्रोवर ने 'राजभाषा हिन्दी का सरकारी कामकाज में प्रयोग' पर अपना व्याख्यान प्रस्तुत किया। उन्होंने अपने व्याख्यान में सरकारी कामकाज में सरल हिन्दी का प्रयोग करने पर बल देते हुए बताया कि केन्द्रीय सरकार सरकारी कामकाज में इस्तेमाल की जाने वाली हिन्दी के स्वरूप के बारे में कई बार अपनी नीति स्पष्ट कर चुकी है। इसके बावजूद इस सम्बन्ध में पूरी तरह से भ्रम दूर नहीं हो सका है लोगों के मन में यह विचार है कि सरकारी हिन्दी कोई अलग प्रकार की हिन्दी होती है इसी कारण वे अपने कामकाज में हिन्दी का इस्तेमाल करने में हिचकिचाते है। जबकि सरकारी कामकाज में इस्तेमाल की जाने वाली हिन्दी सरल व सुबोध होनी चाहिए। श्री ग्रोवर जी ने आगे बताया कि नोट लिखने में और पत्र लिखने में सरल हिन्दी का प्रयोग करना चाहिए सरकारी काम में आम शब्दों का ज्यादा से ज्यादा उपयोग किया जाना चाहिए और लिखते समय दूसरी भाषाओं के प्रचलित शब्दों का उपयोग करने में भी हिचक नहीं होनी चाहिए। साथ ही नए ज़माने की चीजों के जो अंग्रेजी नाम प्रचलित हैं उनका कृत्रिम अनुवाद करने की बजाए मूल रूप में ही देवनागरी लिपि में लिखना चाहिए। श्री ग्रोवर जी से वरिष्ठ वैज्ञानिकों ने अपने संशय दूर करने के लिए कुछेक सवाल भी किए जिनका उन्होंने समाधान भी किया। इस कार्यशाला की एक विशेषता यह भी रही है कि अंत में ग्रोवर जी ने वैज्ञानिकों को कुछ चित्र दिए जिस पर अपने–अपने विचार व्यक्त करने के लिए उनसे कहा गया। वैज्ञानिकों ने बड़े ही उत्साह से उन पर अपने विचार लिखे। इसके पश्चात् शीर्षक, भाषा, भाव को ध्यान में रखते हुए अंक दिए गए। इस प्रकार की कार्यशाला आयोजित करने का यह हमारा प्रथम प्रयास था जिसमें सभी वरिष्ठ वैज्ञानिकों ने हिन्दी के प्रति अपनी रूचि व आस्था दिखाई और उन्होंने अपने अधीनस्थ स्टॉफ से भी हिन्दी में काम करने के लिए प्रोत्साहित करने का आश्वासन दिया। वरिष्ठ वैज्ञानिकों द्वारा किया गया प्रयास वास्तव में सराहनीय रहा। वैज्ञानिकों ने यह भी सुझाव दिया कि इस प्रकार की कार्यशालाएं भविष्य में समय–समय पर आयोजित की जाए।

राष्ट्रीय संगोष्ठी विशयक जानकारी देते हुए
श्रीमती मंजु वरिष्ठ अनुवादक

हिन्दी पखवाड़ा

राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली में दिनांक 01.09.2008 से 15.09.2008 तक हिन्दी पखवाड़े का आयोजन किया गया। इसके दौरान विभिन्न प्रतियोगिताएं आयोजित की गयी।

दिनांक 15.09.2008 को प्रयोगशाला के ऑडिटोरियम में मुख्य समारोह आयोजित किया गया। इस अवसर पर मुख्य अतिथि के रूप में श्री महेन्द्र शर्मा, हास्य कवि को आमंत्रित किया गया था। प्रो. विक्रम कुमार, निदेशक, एन पी एल ने कार्यक्रम का उद्घाटन किया। इस अवसर पर उन्होंने प्रयोगशाला के सदस्यों को हिन्दी में अधिक से अधिक कार्य करने को प्रेरित करते हुए अपना संदेश दिया। पखवाड़े के दौरान जो विभिन्न प्रतियोगिताएं आयोजित की गयी थी उनमें से एक काव्य पाठ प्रतियोगिता के प्रथम विजेता श्री राकेश कौशिक ने अपनी कविता पुनः सभागार में उपस्थित सभी श्रोताओं को सुनायी। इसके पश्चात् मुख्य

डॉ. महेशचन्द्र गुप्त, व्याख्यान देते हुए

अतिथि ने हास्य रस से सराबोर अपनी विविध विधाओं से युक्त कविताएं सुनाकर श्रोताओं को मंत्र मुग्ध कर दिया। तत्पश्चात् निदेशक महोदय व मुख्य अतिथि श्री महेन्द्र शर्मा ने संयुक्त रूप से प्रयोगशाला की द्विभाषी टेलीफोन डायरेक्टरी का विमोचन किया जिसकी प्रयोगशाला के उपस्थित सदस्यों ने जोरदार तालियों से प्रशंसा की।

निदेशक महोदय के निर्देशानुसार इस वर्ष प्रतियोगिता सिर्फ पखवाड़े के दौरान ही आयोजित नहीं की गयी वरन् पूरे वर्ष के दौरान आयोजित की गयी। इन प्रतियोगिताओं में निबन्ध प्रतियोगिता, डिक्टेशन प्रतियोगिता, टिप्पण एवं प्रारूप लेखन, काव्य पाठ, साइंस क्विज़ आदि प्रतियोगिताएं मुख्य रूप से हैं। इन प्रतियोगिताओं में अधिकारियों ने सक्रिय रूप से भाग लिया।

व्याख्यान

राजभाषा हिंदी के कार्यन्वयन, इसके व्यापक प्रचार–प्रसार हेतु प्रशासन के साथ वैज्ञानिक/तकनीकी क्षेत्रों में और अधिक बढ़ावा देने के उद्देश्य से प्रयोगशाला में दिनांक 25 फरवरी, 2009 को एक व्याख्यान का आयोजन किया गया। डा. महेश चन्द्र गुप्त, पूर्व निदेशक, राजभाषा विभाग ने ''वैज्ञानिक और प्रौद्योगिकी में हिंदी का प्रयोग'' विषय पर व्याख्यान प्रस्तुत किया। डा. गुप्त ने विज्ञान और प्रौद्योगिकी में किस प्रकार हिंदी को अधिकाधिक बढ़ाया जा सकता है, इसके लिए आपने कई महत्वपूर्ण बातें बताई। उन्होंने बताया कि विज्ञान का संबंध हिंदी से बहुत पुराना है। विज्ञान और हिंदी एक दूसरे से जुड़े हुए हैं। विज्ञान को हिंदी में समझना मुश्किल नहीं है। उन्होंने यह भी बताया कि लगभग 300 पत्र–पत्रिकाएं हिंदी में निकलती हैं। उन्होंने विभिन्न उदाहरण देकर सहज एवं सरल भाषा में अपने विचार श्रोताओं के समक्ष रखे।

व्याख्यान समाप्त होने के बाद निदेशक महोदय ने वैज्ञानिकों के लिए 29 दिसंबर, 2008 को आयोजित डिक्टेशन लेखन प्रतियोगिता के विजेता प्रतिभागियों को नक़द पुरस्कार प्रदान किए।

व्याख्यान

प्रो. रामजन्म शर्मा हैड, डिपार्टमेंट ऑफ आफिशियल लेंग्वेजिस, एनसीईआरटी, नई दिल्ली, ने दिनांक 11 अप्रैल,

हिन्दी पखवाड़ा समापन समारोह के अवसर पर
पूर्व निदेशक, एन पी एल भाषण देते हुए।

2008 को ''राजभाषा कार्यान्वयन में आने वाली कठिनाइयां एवं उनका समाधान'' विषय पर व्याख्यान दिया जिसमें उन्होंने बताया कि भाषा का विकास किसी सभ्यता के विकास को प्रतिबिम्बित करता है। जितनी भाषा विकसित होगी उतना ही सभ्यता का विकास परिलक्षित होता है। श्री शर्मा ने आगे बताया कि निःसंदेह हिंदी को राजभाषा का दर्जा दिया जाना एक ऐतिहासिक क्षण था, किन्तु इसे लागू करने के लिए पंद्रह वर्ष का समय दिया जाना भी एक ऐतिहासिक भूल थी। यह इसी भूल का परिणाम है कि आज अट्ठावन वर्षों के पश्चात भी हिंदी को वह स्थान प्राप्त नहीं हुआ है जिसकी वह अधिकारिणी है। अंग्रेजी को हटाने के लिए पंद्रह वर्षों का समय दिया गया था किंतु आज तक उसका वर्चस्व कायम है। अब स्थिति यह आ गई है कि हिंदी ही अंग्रेजी की सहभाषा बन गई है ।

राजभाषा कार्यान्वयन की जो स्थिति इन दिनों सर्वव्याप्त है, वह हम सबसे छिपी नहीं है। यदि कहा जाए कि जिस किसी सरकारी कार्यालय में हिंदी में काम हो रहा है वह 95 प्रतिशत हिंदी अनुभाग और 5 प्रतिशत वहां के अन्य विभागों /अनुभागों में हो रहा है, तो अतिश्योक्ति नहीं होगी। इस स्थिति को बदलने के लिए कैसे ठोस कदम उठाने की आवश्यकता है, यह राजभाषा विभाग, गृहमंत्रालय के साथ–साथ राजभाषा के कार्यान्वयन से जुड़ा प्रत्येक कर्मचारी जानता है, लेकिन उसके लिए पहल करने की कोशिश कोई नहीं करता। अतः मेरा आप सभी से अनुरोध है कि प्रयोगशाला के वरिष्ठ अधिकारी इसको गंभीरता से लें जिससे कि उनके अधीनस्थ अधिकारी/कर्मचारी इस कार्य को आगे बढ़ाने के लिए प्रोत्साहित हो सकें।

APPENDIX - 1

PUBLICATIONS

Papers Published by NPL Scientists during April 2008 - March 2009
Publication in SCI Journals

1. Agarwal S. K., Panwar N., Sen V. and Pandya D. K.,, "Magneto-transport and thermal properties of $Pr_{2/3}Ba_{1/3}(Mn_{1-x}Sb_x)O_3$ system." Journal of Physics D-Applied Physics 41 (May 2008):105004- 105009.
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4. Ahmad S., Rustagi V. K., Govil A., Aggarwal R., Pal B. and Kothari P. C., "Study of the long term performance on the calibration data of the coaxial thermistor mounts up to 18 GHz." Mapan-Journal of Metrology Society of India 23 (Apr-Jun 2008): 71-78.
5. Ahmad S. and Singh S., "Electrochromic device based on carbon nanotubes functionalized poly (methyl pyrrole) synthesized in hydrophobic ionic liquid medium." Electrochemistry Communications 10 (Jun 2008): 895-898.
6. Ahmed J., Ramanujachary K. V., Lofland S. E., Furiato A., Gupta G., Shivaprasad S. M. and Ganguli A. K., "Bimetallic Cu-Ni nanoparticles of varying composition ($CuNi_3$. CuNi. Cu_3Ni)." Colloids and Surfaces a-Physicochemical and Engineering Aspects 331 (Dec 2008): 206-212.
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9. Ansari A. A., "H-1 NMR and spectroscopic studies of biologically active yttrium (III)-flavonoid complexes." Main Group Chemistry 7 (2008): 133-145.
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11. Ansari A. A., "Paramagnetic NMR shift. spectroscopic and molecular modeling studies of lanthanide(III)-morin complexes." Journal of Coordination Chemistry 61 (2008): 3869-3878.
12. Ansari A. A., Kaushik A., Solanki P. R. and Malhotra B. D., "Sol-gel derived nanoporous cerium oxide film for application to cholesterol biosensor." Electrochemistry Communications 10 (Sep 2008): 1246-1249.
13. Ansari A. A., Sharma R. K., Singh N. and Singh. S. P., "H-1 NMR. Spectroscopic Studies of Biologically Active Yttrium (Iii)-Flavonoid Complexes." Reviews in Inorganic Chemistry 28 (Jul-Sep 2008): 183-201.
14. Ansari A. A., Singh N. and Singh S. P., "Optical properties of pyridine funtionalized TbF_3 nanoparticles." Journal of Nanoparticle Research 10 (Apr 2008): 703-707.
15. Ansari A. A., Solanki P. R. and Malhotra B. D., "Sol-gel derived nanostructured cerium oxide film for glucose sensor." Applied Physics Letters 92 (Jun 2008).
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194. Tripathy S. Swarupa, Rajiv Saxena, Abha Bhatnagar, Sunita Raina, Arun K. Agrawal and Prabhat K. Gupta, "Quality Assessment for Metal Analysis in Water through Proficiency testing", Seventh International Conference on Advances in Metrology, (AdMet) 2009, February 18-20, 2009.

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207 भीखम सिंह, ज्योति शाह, एम ए अंसारी, प्रीति शर्मा, आर के कोटनाला एवं हरि किशन, ''विभिन्न प्रकार के विशेष आक्साइड का आर्द्रता संवेदक के रूप में संभव उपयोग भारतीय वैज्ञानिक एवं औद्योगिक अनुसंधान'', राष्ट्रीय विज्ञान संचार एवं सूचना स्रोत संस्थान वैज्ञानिक एवं औद्योगिक अनुसंधान परिषद् नई दिल्ली, भारत, पत्रिका 16 पृष्ठ 141, दिसम्बर 2008 वर्ष।

APPENDIX - 2

PATENTS

Patents Granted in India

Sr. No.	Title	Patent No.	Grant Date	Inventors
1	A long decay luminescent powder	225682	20/11/2008	V Shanker, J Chander, D Harnath and P K Ghosh
2	A method for the preparation of polymer coated long duration optical memory device	219633	12/05/2008	Ashok M Biradar, Sukhwant S Bawa, Ereuvassi P. Haridas and Subhash Chandra
3	A process for preparation of water repellent chemical useful for making water proof cellulose based textile materials,a process for manufacture of water proof cellulose based textile materials & water proof cellulose based textile material	221665	30/06/2008	Ajit Kumar Sarkar and Dinesh Chandra Parashar
4	A process for the preparation of compensated sulphonated poly aniline as a water soluble polymer useful for corrosion inhibition	220349	26/05/2008	Saraswati Koul, Sundeep Kumar Dhawan, Subhas Chandra and Ramesh Chandra
5	An improved constant temperature bath	220662	30/05/2008	Yeshpal Singh, Satish Kumar Nijhawan and Rasik Behari Sibal
6	A device for monitoring ion beam etching process	230784	28/02/2009	A.C. Rastogi and M.L.Sharma
7	A reusable heat pack	230562	27/02/2009	C P Sharma, R K Sharma, C Kant and A K Sarkar
8	A novel apparatus useful for slip gauge calibration and a technique for slip gauge calibration therefrom	230766	27/02/2009	M Karfa
9	An improved process for the preparation of doped lead iron tungstate relaxor material for wide range presurre measurement and a capacitive pressure transducer made thereby	231048	28/02/2009	Kamlesh Kumar Jain, Vinay Kumar, Subhash Chandra Kashyap
10	A smart eye for electronic remote detection	220338	23/05/2008	P K Banarjee, A Sengupta and R Shyam
11	A process for encapsulation of superconductor devices	223616	18/09/2008	Neeraj Khare, A K Gupta
12	A portable humidity generator and a process to generate relative humidity therefrom	233222	27/03/2009	H Kishan, B Singh, S D Sharm, O P Arora

Appendix - 2, Patents

Sr. No.	Title	Patent No.	Grant Date	Inventors
13	Automated dead weight force machine	221789	04/07/2008	Kamlesh Kumar Jain , Hari Nandan Prasad Poddar , Raghunandan Prasad Singhal , Mihir Kumar Chaudhauri
14	A process for the preparation of novel sol-gel based enzyme electrode useful for estimation of cholesterol in aqueous medium.	222859	26/08/2008	A Kumar, B D Malhotra and Rajesh
15	A lactate bio sensing strip	224946	27/10/2008	M K Pandey, A Chaubey, K K Pande, R K Sharma, K K Saini, B D Malhotra and Rajesh

Patents Filed in India

Sr. No.	Title	Application No.	Filing Date	Inventors
1	A conducting copolymer ferrimagnet composites and a process for the preparation thereof	1362DEL2008	09/06/2008	S. K. Dhawan, Kuldeep Singh, Nikhil Sobti, Anil Ohlan, Praveen Saini, Beena Gupta, R.P. Pant, R.K. Kotnala, Hari Kishan and P.C. Kothari
2	A process for the preparation of solid polymer electrolytes using ionic liquids	1363DEL2008	09/06/2008	Shahzada Ahmad, S A Agnihotri and M Deepa
3	A portable ferrofluid based electric power generator	1364DEL2008	9June2008	R.P. Pant, V.K.Jain, Vinod Kumar , S.K. Halder, J.C. Sharma and Vikram Kumar
4	A novel copolyaromatic amine, process of preparation thereof and a composite therefrom	2646DEL2008	24/11/2008	S K Dhawan, Parveen Saini and Rajesh Jalan
5	Ferrofluid based temperature sensor	0047DEL2009	12/01/2009	Pant Rajendra Prasad, Rana Anu, Vinod Kumar, Jain Vinod Kumar, Halder Sujit Kumar, Singh Yesh Pal and Vikram Kumar
6	High efficiency, light weight flexible carbon based heaters	0617DEL2009	27/03/2009	R B Mathur, Priyanka H Maheshwari and J C Sharma
7	High strength and low weight composite bipolar plate for fuel cell applications	0608DEL2009	27/03/2009	R B Mathur, T L Dhami, Priyanka H Maheshwari, S R Dhakate, R K Aggarwal, Chhotey Lal, D K Gupta, D D Sakalani and V K Chaddha
8	An improved process to deposit diamond like carbon as protective coating on inner surface of a shaped object	0313DEL2009	18/02/2009	Kumar Sushil, Dixit Prakash Narain and Rauthan Chandra Mohan Singh

Appendix - 2, Patents

Sr. No.	Title	Application No.	Filing Date	Inventors
9	A compact ECG monitoring device with a filter for impulse and channel switching adc noise and error correction for sequential sampling of ECG leads	0445DEL2009	09/03/2009	Ravi Mehrotra, Mohd. Imran Ansari, Ashish Ranjan, Deepti Chadha and Anjali Sharma
10	An improved process for the modification of semi coke suitable for the production of high density-high strength graphite products	0456DEL2009	09/03/2009	G. Bhatia, V. Raman, P.R.Sengupta , R S Bisht, T S Negi , P L Pundora, Mandeep Kaur, and Anil Kumar

Patents Granted Abroad

Sr. No.	Title	Patent No.	Country	Grant Date	Inventors
1	Lead iron tungstate capacitive transducer, relaxor material therefor and method of manufacture of said relaxor material	7,354,565	US	08/04/2008	Jain; Kamlesh Kumar (New Delhi, IN), Kumar; Vinay (New Delhi, IN), Kashyap; Subhash Chand (New Delhi, IN)
2	A Process for the preparation of a low contact Resistance contact on a high transition temperature Superconductors	1738437	EP	21/05/2008	S N Ekbote, G K Padam, N K Arora, Mukul Sharma, Ramesh Sethi, M K Banerjee

Patents Filed Abroad

Sr No	Title	Appl. No	Country	Filing Date	Inventors
1	An improved process based on the sol-gel technique for the preparation of ceti2o6 powder	PCT/IN0 8/00020	WO	14/01/2008	Anita Verma S.A. Agnihotry
2	An improved process based on the sol-gel technique for the preparation of ceti2o6 powder	08702734.8	EP	14/01/2008	Anita Verma S.A. Agnihotry
3	Process to make photo lumi-nescent nano-structure silicon thin films	097123735	Taiwan	25/01/2008	Kumar Sushil, Dixit Prakash Narain and Rauthan Chandra Mohan Singh
4	A process for preparation of metal oxides with dopants in lower valence state by combustion synthesis technique in nanowire form	10-2008-026658.2	Germany	04/06/2008	Harish Chander, Virendra Shanker, Divi Haranath and Pooja Sharma

Appendix - 2, Patents

Sr No	Title	Appl. No	Country	Filing Date	Inventors
5	A process for preparation of metal oxides with dopants in lower valence state by combustion synthesis technique in nanowire form	12/134635	USA	06/06/2008	Harish Chander, Virendra Shanker, Divi Haranath and Pooja Sharma
6	A process for preparation of metal oxides with dopants in lower valence state by combustion synthesis technique in nano-wire form	2008100 98697.5	China	06/06/2008	Harish Chander, Virendra Shanker, Divi Haranath and Pooja Sharma
7	Large area electrochemically stable electro-chromic device preferably for window	1020090 24207.4	Germany	08/06/2008	Shahzada Ahmad, S A Agnihotri and M Deepa
8	Process to make photo luminescent nanostructure silicon thin films	PCT/IN0 8/00371	WO	13/06/2008	Kumar Sushil, Dixit Prakash Narain and Rauthan Chandra Mohan Singh
9	Monoclinic $CeTiO_2O_6$ thin film and a sol-gel process for the preparation thereof	2008-553839	Japan	12/08/2008	Verma Amita, Agnihotry Suhasini Avinash and Bakhshi Ashok Kumar
10	Improved process for the development of high temperature superconducting bulk current leads	112006003792.7	Germany	05/09/2008	S N Ekbote, G K Padam, NK Arora, Mukul Sharma, Ramesh Sethi and M K Banjerjee
11	Improved process for the development of high temperature superconducting bulk current leads	2009-500004	Japan	10/09/2008	S N Ekbote, G K Padam, N K Arora, Mukul Sharma, Ramesh Sethi and M K Banjerjee
12	Improved process for the development of high temperature superconducting bulk current leads	PV 2008-579	Czech Republic	23/09/2008	SN Ekbote, GK Padam, NK Arora, Mukul Sharma, Ramesh Sethi and MK Banjerjee
13	An improved process based on the sol-gel technique for the preparation of $CeTi_2O_6$ powder	12/294617	USA	25/09/2008	Anita Verma, S.A. Agnihotry
14	Development of thick film ceramic gas sensor:lpg gas sensor	-	Mauritius	30/10/2008	Vipin Kumar, Jain Kiran, Lakshmikumar ST and Raghavendra T
15	A process for preparation of oxide superconducting rods	2008-279894	Japan	30/10/2008	Arora Narinder Kumar, Padam Gursharan Kaur, Sethi Ramesh, Sharma Mukul and Ekbote Shrikant Narayan

Appendix - 2, Patents

Sr No	Title	Appl. No	Country	Filing Date	Inventors
16	Development of thick film ceramic gas sensor:lpg gas sensor	PCT/IN 2008/000717	WO	31/10/2008	Vipin Kumar, Jain Kiran, Lakshmikumar ST and Raghavendra T
17	A process for preparation of oxide superconducting rods	10-200801 -010745	Repuglic DF Korea	31/10/2008	Arora Narinder Kumar, Padam Gursharan Kaur, Sethi Ramesh, Sharma Mukul and Ekbote Shrikant Narayan
18	A process for preparation of oxide superconducting rods	12/290581	US	31/10/2008	Arora Narinder Kumar, Padam Gursharan Kaur, Sethi Ramesh, Sharma Mukul and Ekbote Shrikant Narayan

Copy-right Registration

A Computer software package for commercial use in MSDOS QBASIC environment for the calibration of both hydraulic and pneumatic pressure measuring instruments using simple/reentrant type dead weight testers as pressure standards

Sanjay Yadav, AK Bandyopadhyay, V K Gupta, Om Prakash

No. 016CR2008 dt. 27.10.2008

APPENDIX - 3

TECHNOLOGIES MARKETED

Sr. No	Technology Developed	Licensee	Date of Transfer
1	Piezoelectric Accelerometer - Shear Mode	M/s Powercon Engineers, Ahmedabad - 382445 Gujarat	02.02.2009
2	System Controller and Software Algorithm for Mid-FACE	M/s Sheel Bio-Tech. Ltd New Delhi - 110048	23.03.2009

APPENDIX - 4

R & D COLLABORATIONS

Collaborating Institute	Area
Generic development of nanometrology for nanotechnology at NPLI (inter division,)	Nano metrology
R & D Collaboration with IISc Bangalore and Dharamshila Cancer Hospital, Delhi for the DST funded project entitled, 'Infrared spectroscopic study of tumor pathology'. It has also collaboration with Space Applications Centre, Ahmedabad sponsored project entitled, 'Validation of OCM-II Geo-physical products' (Optical instrument calibration)	Optical Radiation Standards Section
SAMTEL Colour Lab Ltd.; NAC, Allahabad	LMD group, NMITLI
CGCRI, Kolkata; IIT-Kanpur SSPL, Delhi	Project Deposition of undoped amorphous silicon films for making IR bolometer
Collaborative Academic Project between SIMS, NPL and IUAC, New Delhi	Swift Heavy Ion
Collaborative Academic Project between NPL and CARE, IIT-Delhi	Growth and characterization of nano structure material
Collaborative Academic Project between NPL and Applied Physics Dept., Okayama University, Japan	
Collaborative Academic Project between NPL and USIC, Jadavpur University, Kolkata	Growth and characterization of thin film material
Collaborative Academic Project between C.G.C., NPL and Phys. Dept., Anna University, Chennai - CAP-14 (PI)	Crystal Growth and Characterization
Collaborative Academic Project between C.G.C., NPL and Crystal Growth Centre, SNN College of Engg., Chennai, CAP-18 (PI)	Crystal Growth and Characterization
Collaborative Academic Project between C.G.C., NPL and Physics Department, Jamia Millia Islamia, CAP-24. (PI)	
Institute of Experimental Physics, Slovak Academy of science, Kosice, Slovak	Nanomagnetic fluids
NML, Jamshedpur	Ferrofluid
CEERI, Pilani	Ferrofluid thin films

Appendix - 4, R & D Collaborations

Collaborating Institute	Area
Bhavnagar University, Bhavnagar Thapar Instt. of Engg. & Tech (TIET) Patiala-147004, Punjab Tezpur univ. Napaam, Tezpur-784028, Assam RASD NPL for Biomass burning EF determination project (TK Mandal, NPL)/ DST	Ferrofluid
Hokkaido University, Sapporo, Japan,	Molecular characterization & hygroscopicity of Indian aerosols (MoCHIA) program
Under MiC/ CRM activities of CSIR Network project 'Advances in Metrology' for XI FYP, collaborations and coordination with all partners (22 nos) continued with special emphasis Bilateral S&T cooperation in the field of 'Strengthening the quality infrastructure in environmental analytics".	
• BHU, Varanasi	Superconductivity
• TIFR, Mumbai	
• IUAC, Indore	
• IIT Kharagpur	
• University of Delhi	
• IIT, Delhi	
• IIT, Kanpur	
• JNU, New Delhi	
• NIMS, Japan	
• MPI, Stuttgart, Germany	
• Unicamp, Brazil	
• Racah Institute of Physics, Jerusalem, Israel	
• DY Patil University, Kohlapur	
• University of Hyderabad, Hyderabad	
• Jamia Millia Islamia, New Delhi	
• Missouri University, USA	
• Univ. Notredame, USA	
• Univ. of Wollongong, Australia	
• H.P. University, Shilma	
• Karlsruhe Institute of Technology, ITP, Karlsruhe, Germany	

APPENDIX - 5

SPONSORED/SUPPORTED R & D PROJECTS

(Rs. In lakhs)

Sr. No.	Title	Agency/Client	Amount Received
New Projects			
1	Carbon Nanotube-polymer Composites for Electromagnetic Interference Shielding and Structural Applications	DST	4.56
2	Dynamics of Memory Effect in Layered Perovskite Ferroelectric Ceramics and Ferroelectr Liquid Crystal Materials	DST	5.83
3	Development of Naonstructured Metal Oxide Gas Sensor Array for detecting chemical warfare agents	DRDO	11.31
4	Centre on Bio-Molecular Electronics	DST	648.54
5	Development of DNA Biosensor, Phase II	DST	19.57
6	Study of defect centres in Nano-Piezoelectric Materials for application in Sensors	DST (Indo-Japan)	1.50
7	Assesment of Impacts of Heat Stress On Human Health and Adaptation Studies	MNEF (Winrock International India WII)	5.38
8	Development of Rubidium Atomic Clock by NPL & SAC	DSSAC, (AHMD) Department of Space, Space Application Centre), Ahmedabad	50.00
9	Validation of OCM-II Geo-Physical Products (Optical instrument calibration)	DSSAC,(AHMD) Department of Space, Space Application Centre), Ahmedabad	20.00
10	Dispersion an Alignment of CNTs and development of CNT Reinforced composites	ASL, Hyd	48.94
11	Development of Conducting Polymer-graphite Nanoferrites Composites for Absorption dominated EMI Shielding a Material of Strategic Importance	DRDO (Defence)	5.45
12	Technically imprtant high TCR (temperature coefficient of resistance) manganitenanometal devices for infrared/ bolometric detector applications	DST-DAAD (German Academic Exchange Serv.)	1.53
13	HPHT Synthesis and characterization of new novel physical property materials	DST (Indo-Japan)	1.25

Appendix - 5, Sponsored/Supported R & D Projects

Sr. No.	Title	Agency/Client	Amount Received
Continuing Projects			
1	Operation of the South Asian Regional Research Centre (SAS-RRC) for Study of Global Change Under SASCOM USA.	International START Secretariat, Washington,	0.00
2	To Conduct Inter-Laboratory Proficiency Testing Amongst the NABL Accredited Calibration Laboratories in India	DST (NABL)	0.00
3	Metal Induced Crystallization Behaviour on Thin Film of Amorphous Silicon	Indo-US (Fund from DST)	0.00
4	Coherent Radio Beacon Experiment (CRABEX) for Tomographic Studies of the Ionosphere on Board GSAT-II Satellite	VSSC, Thiruvananthapuram	1.74
5	Interaction with Universities/Lab in the Area of Superconductivity	UGC	0.00
6	Development of speciality carbon materials for novel nuclear rectors	BARC, Central Complex, Trombay, Mumbai	0.00
7	Proficiency Testing (PT) among National Accreditation Board for Testing and Calibration Laboratories (NABL) Accreditaed Laboraories in Chemical Discipline	DST (NABL)	0.00
8	SAARC-PTB Cooperation Programme	PTB-Germany	0.00
9	Development of Ultrasonic Method to Evaluate Moisture in Composite Materials	ARDB	0.00
10	Setting up of Facilities for dissemination of Indian Standard Time in North-Eastern States	DST	0.00
11	Development of Injection Solar Cells Utilizing Dye Sensitised Nono-crstalline TiO_2 Films	MNES	0.00
12	Development of Nonophosphors for Industrial Applications	DST	0.00
13	Investigation Study on Microwave Sintering of Beta Alumina Tubes	DST	0.00
14	Establishment of primary standards for Vickers & Brinell Hardness Scales	DST	0.00
15	Low cost technology for High efficiency Silicon Solar Cell	DST, Under Indo-Bulgarian Inter Govt. Prog	0.00
16	Generic Development of Nanometrology for Nanotechnology	DIT, New Delhi	0.00
17	Assessment of Effects of High Particulate on Pulmonary pollutants Health Status in Selected Magacities of South Asia	APN, Japan	0.00

Appendix - 5, Sponsored/Supported R & D Projects

Sr. No.	Title	Agency/Client	Amount Received
18	Ionospheres of Venus and Mars: Chemistry, Dynamic Thermal Structure and Solar Wind Interaction	Physical Research Laboratory, Ahmedabad	0.78
19	High rate deposition of the microcrystalline silicon films using high density microwave plasma and its application to efficient to large area thin film solar cells	DST	4.50
20	Integrated campaign for aerosols, gases & radiation budget	VSSC, Thiruvanthapuram	12.00
21	Dynamics studies at the phase transition region of Sm-C* -Sm-A phase in electrolinic liquid crystal materials	DST	5.50
22	Physico-chemical characterization of wet deposition at NPL, New Delhi and Pantnagar in Uttaranchal	Stockholm Environment Institute SEI, Sweden	0.00
23	Sol-gel derived Optical Biosensor for Water Pollution Monitoring	DST	0.00
24	High Stability Atomic Foutain Clocks	DST-DAAD(German Academic Exchange Serv.)	0.00
25	Study of the mechanisms involved in enhancement of electroluminescene propeties of inorganic nanophosphors	DST (Under SERC Fast Track Proposals)	0.50
26	Study on the effects of atmospheric dynamical activity in the tropical tropopause region: Implications on the stratosphere-Troposphere exchange of the minor constituents	DOS	0.00
27	Development of Carbon-Ceramic composites and the influence of oxidation at elevated temperatures on their properties	DST	4.00
28	Evaluation of emission factors and budgets of gases and particulate matter of relevance to climate change emitted by fuels particularly biomass used in India by the rural sector & small scale industries	DST	8.00
29	Formation of Alkali Metal nanostructures on reconstructed low and high index Silicon Surfaces (under SERC FAST TRACK Proposals)	DST	0.00
30	Physico-Chemical studies of metal and metal oxide nonoparticles (under SERC FAST TRACK Proposals)	DST	4.00
31	On-line approach to non-contact IR Sensor technique for estimation of sugar and its by products	DBT	0.00
32	Studies on rare earth substituted magnesium ferrite thin films and the effect of humidity on its performance	DRDO	0.00
33	High pressure Raman studies of rare earth sesquioxides (Ln=La,Ce,Pr,Nd,Sm,Eu,Gd,Tb,Dy,Ho,Er,Yb,Y)	DST	3.30

Appendix - 5, Sponsored/Supported R & D Projects

Sr. No.	Title	Agency/Client	Amount Received
34	Ferrofluid based electric power generator	DRDO	0.00
35	Development of DNA Biosensor for detection of Neisseria Gonorrhea in clinical samples	DBT	0.00
36	Application of new functional conducting polymers in Nio-sensor and Nano electronic	DST (Indo-Japan)	1.50
37	Development of white organic light emitting diodes (WOLEDs) for general lighting applications	DST	4.00
38	Growth and structural characterization of nearly perfect single crystals of oxide materials for scintillation applications	DST (Under Indo-Russian Joint Project)	0.00
39	Bio-sequestration and bio-impregnation of heavy metals leading to nanomaterials synthesis and decontamination of industrial effluent	DST	0.00
40	Infrared spectroscopic study for tumor diagnosis	DST	0.00
41	QA/QC support for GHG (CO2, CH4 and N2O) emission measurements undertaken by different national teams under the aegis of NATCOM-SNC	MOEF (Ministry of Environment & Forest, WINROCK)	4.84
42	Determination of country specific emission factor for methane from land fills and estimation of its emission inventry under the aegis of the NATCOM-SNC	MOEF (Ministry of Environment & Forest, WINROCK)	4.74
43	Amorphous carbon thin film having nanoparticle inclusions deposited by the modified vacuum plasma arc techniques	DST	0.00
44	Development of TiO_2 nanocatalyst for environmental purification (Under SERC FAST Track Scheme)	DST	0.00
45	Development of carbo-graphite material for aeronautical application	DRDO (DMSRDE) (Defence Material & Store R&D Establishment)	3.40
Completed Projects			
1	Molecular and biochemical sensor for identification of cells and diagnosis of diseases	DST	0.00
2	Studies and formulations for upscaling the process for making porous conductiong carb paper and establish pilot plant scale facilities at NMRL	NMRL (Navel Materials Research Laboratory)	0.00
3	Synthesis and characterization of carbon nono tubes/ polymer network composites	DST	2.00

Appendix - 5, Sponsored/Supported R & D Projects

Sr. No.	Title	Agency/Client	Amount Received
4	Development of Nanostructured electrochromic films with improved performance characteristics by wet chemical techniques for smart windows	DST	0.00
5	Synthesis and characterization of nono-size grains of Ruthenocuprates and MgB2 Superconductors	DST	0.00
6	Development of Mesophase Pitch for High Performance Carbon Fibres	DRDO (DMSRDE) (Defence Material & Store R&D Establishment)	4.44
7	Development of Calibration-Validation (CAL-VAL) Sites at Kavaratti Island	DSAC, Space Application Centre (ISRO) Ahmedabad	0.00
8	Modeling of orgnic Opto-electronic devices LEDs and Solar Cells	DST	0.00
Closed and Transferred Projects			
1	Melt/Solution processable conducting poly-aniline based magnetic films	DST	0.00
2	Synthesis of organic and inorganic Nanocompositess for sensor applications	DST	0.00
3	A novel development of lab-on-chip biosensor for determination of mycotoxins in food (mainly cereals) - under SERC FAST Track Scheme	DST	0.00
Project is completed in 2007- 08 but Amount received on 2008-09			
1	Cloud and Precipitation Phenomena estimation by using different Systems for Propagation Characteristics in Micro Wave and Millimetre Wave and Millimetre Wave Frequency bands	DST	1.44
		Total	**894.56**

CSIR Network Projects

Sr. No.	Name of the Project	Project Code	Nodal Officer	Name of the Laboratory
01	R&D on Photovoltaics and other Solar Energy Applications (Supra-Institutional Project)	SIP 0017	Dr P K Singh	NPL
02	Development of Advance Light Weight Metallic Materials for Engineering Applications	NWP 0028	Dr Anil Kumar Gupta/ Dr R C Anandani	AMPRI. Bhopal
03	Conducting Polymer paints and coatings for corrosion protection and shielding of concrete structures in strategic areas	NWP 0012	Dr S K Dhawan	NPL as Nodal Lab (Since Dec'2008)
04	Technology for Assessment and Refurbishment of Engineering Materials and Components	NWP 0027	Dr Sushil Kumar/ Dr Ashok Kumar	NML, Jamshedpur
05	Fabrication of LED Devices and Systems for Solid State Lighting Applications	NWP 0025	Dr S T Lakshmikumar	NPL
06	Advancement in Metrology	NWP 0045	Dr P Banerjee	NPL
07	Surface analysis of Dispensor Cathodes for High Power MWT	NWP 0024 NPL - II	Dr Mahesh Kumar	NPL as Partner Lab CEERI, Pilani as Nodal Lab
08	Design and Fabrication Capabilities for very High Power Microwave Tubes	NWP 0024 NPL - I	Dr G Bhatia	CEERI, Pilani
09	Mega-city atmospheric pollution precursor process modeling	NWP 0017	Dr M K Tiwari / Dr C Sharma	IITR, Lucknow

APPENDIX - 6

CONSULTANCY PROJECTS

(Rs. In lakhs)

Sr. No.	Client	Title	Contact Value	Amount Received 2008-09
NEW				
01	RRSL, Bhubaneswar	Design and fabrication of transfer standards confirming to class A	2.23	2.23
01	UP Samaj, Kalyan Nagar Nigam Ltd, Lucknow	Acoustic of multipurpose hall at Bhagdari, Bhawan, Gomati Near Lucknow	1.73	1.64
02	RRSL, Ahmedabad	Design Development & Fabricate Secondary force Std upto 50 kN	22.29	11.15
03	RRSL, Bhubaneswar	Design Development & Fabricate Secondary force Std upto 50 kN	22.29	11.15
04	RRSL, Guwahati	Design Development & Fabricate Secondary force Std upto 50 kN	22.29	11.15
05	Vijay Electrical Ltd, Hyderabad	Feasibility Study of transformer movie abatement	0.49	0.44
06	RRSL,Faridabad	Design, Development & Fabricate Secondary force Std upto 50 kN	22.29	11.15
07	Suzlan Pvt. Ltd, Vadodara	To strain gauge measurement to determine stress in tension and bending moment on given 3Nos etallic bolts used in wind mill energy upto 450N and 16N respectively.	4.75	4.21
08	Yantrika Instrument Pvt Ltd, New Delhi	Characterization of Yantrika dead weight tester model YW1307HBO/04 Sr No TSM311	3.48	3.07
COMPLETED				
01	NTPC, Gautam Budh Nagar, Noida	Purchase of low noise conventor	2.24	0.00
02	Jindal Steel Power Ltd., Raigarh	Calibration of test rails	3.84	0.00
03	Jadavpur University, Kolkata	Setting up-lab for calibration parameter-dimension and force in a ltd range as per IS 17025	3.14	0.00

Appendix - 6, Consultancy Projects

Sr. No.	Client	Title	Contact Value	Amount Received 2008-09
04	HEG Ltd, Noida	To check feasibility/suitability of HEG Ltd works, mandideep to manufacture nuclear grade graphite	1.00	0.00
05	Jindal Steel & Power Ltd., Raigarh (MP)	Ultrasonic response from hall and notches in reference test rails and theirs correlation with dimensions	5.46	0.00
CONTINUING				
01	Coal Chem, Bhilai	QI free coal tar pitch form coal tar	0.80	0.00
02	CPCB, Agra, Lucknow-Zone	Inversion/mixing height studies at CPCB, Agra	9.99	0.11
03	DMRCL, Delhi	Consultancy services for studying noise impact of Delhi Metro operation	5.33	0.00
04	MN Datur & Co Ltd., Kolkata	Mixing height determination at Paradeep, Orissa	2.76	0.00
05	ERTL, New Delhi	Characterization of dead weight tester	2.47	0.00
06	RRSL, Bhubaneswar	Design and fabrication of transfer standards confirming to class A at RRSL, Bhubaneswar	2.23	0.00
07	CSIO, Chandigarh (sister concern). Total consultancy fee walved off (as per CSIR guidelines)	Calibration facility-guidance for quality manual	0.00	0.00
08	RRSL, Guwahati	Setting up of torque standards machine at RRSL, Guwahati	14.29	0.00
09	RRSL, Faridabad	Design, fabrication and installation of primary torque measurement machine at RRSL, Faridabad	31.00	0.00
10	Bangalore Metro Rail Corporation Ltd (BMCL), Bangalore	Noise and vibration study in and around proposed Bangalore metro trains/stations	11.24	0.00
11	Aparna Carbon Pvt Ltd, Kolkata	General consultancy to improve the QI free coal tar-pitch	2.00	0.00
12	Aeronautical Development Agency (ADA), Bangalore	Certification of reference blocks of various materials as per 1.2 mn FBH standards of ASTM 127-PV3/PV5	9.36	0.00
13	RRSL, Bangalore	Setting up of torque standard machine at RRSL, Bangalore	31.00	0.00

Appendix - 6, Consultancy Projects

Sr. No.	Client	Title	Contact Value	Amount Received 2008-09
14	RRSL, Bangalore	Design, erection and commissioning of dead weight force	101.25	0.00
15	RRSL, Ahmadabad	Design, primary and secondary torque measuring facility at RRSL, Ahmadabad	14.29	0.00
16	RRSL, Bhubaneswar	Supply of one number of secondary torque measurement facility at RRSL, Bhybaneswar	14.29	0.00
17	MN Dastur & Co, Kolkata	Mixing height determination at Keonjhar, Orissa	5.90	0.00
18	Urban Waste Management Ltd., New Delhi	Performance checking of high pressure hose	0.34	0.00
19	General Motors India Ltd., Bangalore	Recrystallization and grain refinement mechanism during extrusion of magnesium alloys	65.97	17.88
20	HEG Ltd., Noida	To check feasibility/suitability of HEG Ltd works, Mandideep to manufacute nuclear grade graphite	1.00	0.00
21	TATA Steel, Jamshedpur	Inversion study for Tata Steel Plant at Jamshedpur	4.10	0.00
22	Jindal Steel & Power Ltd., Raigarh (MP)	Ultrasonic response from hall and notches in reference test rails and theirs correlation with dimensions	5.46	0.00
		Total	**450.36**	**71.95**

APPENDIX - 7

EARNING FROM CALIBRATION & TESTING

Physico-Mechanical Standards

Sr. No.	Activity	DP No.	No. of Reports	Calibration Charges
1	Mass	1.01	444	64.04
2	Length & Dimension	1.02	318	38.06
3	Temperature & Humidity	1.03A	66	12.04
4	Temperature & Humidity	1.03B	92	14.47
5	Temperature & Humidity	1.03C	32	5.29
6	Optical Radiation	1.04	473	76.16
7	Force & Hardness	1.05	455	57.55
8	Pressure & Vacuum	1.06	90	23.40
9	Acoustic	1.07	353	130.90
10	Fluid Flow	1.08	5	2.11
11	Ultrasonic	1.09	28	2.70
12	Shock & Vibration	1.11	20	0.91
		Sub-Total (A)	**2376**	**427.63**

Electrical & Electronic Standards

Sr. No.	Activity	DP No.	No. of Reports	Calibration Charges
1	Time & Frequency	2.01	23	2.23
2	Josephson Voltage Standards DCI, V & R	2.03	25	5.36
3	DC High Voltage	2.04	7	1.65
4	AC Power & Energy	2.05	78	17.78
5	AC High Current * High Voltage (CT/PT)	2.06	61	23.42
6	LF & HF Impedance	2.07	68	10.20
7	LF & HF Voltage, Current & RF Power	2.08	19	10.50
8	RF Attenuation & Impedance	2.09	22	4.82
9	Magnetic	2.10	17	1.68
		Sub-Total (B)	**320**	**77.65**

Appendix - 7, Earning From Calibration & Testing

Engineering Materials

Sr. No.	Activity	DP No.	No. of Reports	Calibration Charges
1	Metal & Alloys	3.01	21	0.41
2	Advanced Carbon Product	3.02	2	0.10
		Sub-Total (C)	**23**	**0.51**

Electronic Materials

Sr. No.	Activity	DP No.	No. of Reports	Calibration Charges
1	Thin Film	4.04	2	0.13
2	ENOP/Thin Film & Devices Standards	4.05	1	0.54
3	Surface Physics & Nanostructured Devices	4.06	4	0.30
		Sub-Total (D)	**7**	**0.97**

Material Characterization

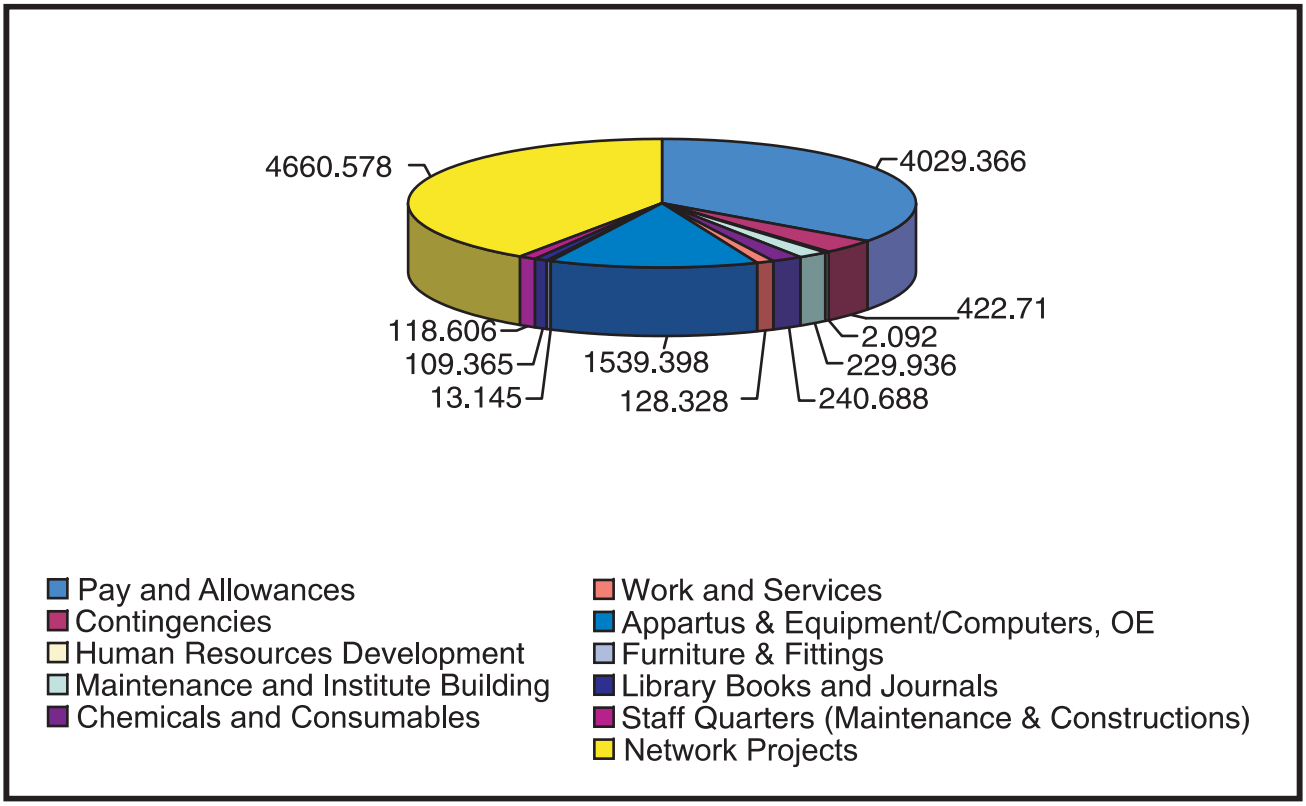
Sr. No.	Activity	DP No.	No. of Reports	Calibration Charges
1	Chemical Analysis	5.01	84	8.61
2	EPR & IR	5.02	6	0.90
3	X-Ray	5.03	0	0.00
4	Electron Microscope	5.04	42	2.97
		Sub-Total (E)	**132**	**12.48**
		GRAND TOTAL (A+B+C+D+E)	**2858**	**519.25**

APPENDIX-8

ACTUAL EXPENDITURE 2008-09

(Rs in lakhs)

Sr No	*Budget Heads*	Expenditure
1	Pay and Allowances	4029.366
2	Contingencies	422.710
3	Human Resources Development	2.092
4	Maintenance and Institute Building	229.936
5	Chemicals and Consumables	240.688
6	Work and Services	128.328
7	Apparatus & Equipment/Computers, OE	1539.398
8	Furniture & Fittings	13.145
9	Library Books and Journals	109.365
10	Staff Quarters (Maintenance & Constructions)	118.606
11	Network Projects	4660.578
	Total	**11494.212**



APPENDIX - 9

RECOGNITIONS, HONOURS AND AWARDS

A K Bandyopadhyay

CCM/BIPM Elected member of High Pressure and Low Pressure Working Group of CCM/BIPM Continued Chairman, TCM, APMP

Tripurari Lal

Member CCM WGM Task Group 1 (TG-1) Mass metrology under vacuum for a mise en pratique CCM WGM Task Group I1 (TG-I1)

Uncertainty components due to traceability to the international prototype kilogram)

Re-nominated member of CCM Working Group in Viscosity

H C Kandpal

Appointed as the Technical Expert for the accreditation of the optical fibre activity of NMISA, South Africa, October 1-3, 2008

Re-appointed as the Chairman of the ET-23 Committee on 'Lamps and lighting products' of the BIS from April 2008

Praveen Kumar Siwach

"Young Scientist Award" of Council of Science & Technology, Government of Uttar Pradesh, for the year 2007-2008.

Rashmi

1st Prize, Noting and Drafting competition in National Language Workshop held at NPL during 29th December 2008.

Vinod Kumar

Young Scientist Award, URSI GA, Chicago, July 2008

Prabhat K. Gupta

Chairman Industrial Gases Sectional Committee, CHD-6 of Bureau of Indian Standard (BIS) since Jan 2009.

Member Chemical Standards Committee, CHD of Bureau of Indian Standard (BIS)

Cooperation on International Traceability in Analytical Chemistry (CITAC) during 2008 from India.

Swarupa Tripathy Academy of Environmental Biology DEF Young Scientist Award-2008' of "Environmental Chemistry", on 21 November 2008.

R.S. Dabas

Member International Space Environment Services (ISES) National Steering Committee on climate and weather of sun and earth system (CAWSES) of ISRO.

C Sharma

Received a certificate from Inter-Governmental Panel on climate change (IPCC) for contribution to the award of the Noble Peace Prize 2007 to IPCC.

Member Technological Advisory Committee, Computer and Communication Division, Indian Statistical Institute, Kolkata.

Editorial Board Indian Journal of Radio and Space Physics.

V P S Awana

Scientist of the Year Award "SOYA-NPL" - Year 2008.

H.R. Singh

Member Editorial Board of "International Journal of Multidisciplinary Health Care", Australia.

Editorial Board of "International Journal of Clinical Audit", Dove Medical Press.

Peer Reviewer International Journal "Expert review on Medical Devices" U.K.

Reviewer Post Graduate journal of Medicine.

APPENDIX - 10

VISITS ABROAD
(2008-2009)

Sr. No.	Name & Designation	Country Visited	Duration	Purpose
1.	Dr. Sushil Kumar, Sci. C	France	19.04.2008 24.04.2008	To attend 51st Annual Society of (CVS) Technical Conference
2.	Dr. A.K. Bandyopadhyay, Sci.G	France	21.09.2008 25.09.2008	To attend WCM & CCM at BIPM
3.	Dr. Pradeep Mohan, Sci.F	France	22.04.2008	To attend Working Group Meeting of the low pressure (WGLP) of CCM at BIPM
4.	Sh. Tripurari Lal, Sci.F	France	21.04.2008 22.04.2008	To attend CCM Working Group Meeting on Gas Analysis at BIPM
5.	Dr. Vijayan, Sci.B	Spain	23.04.2008 22.04.2009	On BOYSCAST Fellowship
6.	Sh . Prabhat Kumar Gupta, Sci.F	France	30.03.2008 04.04.2008	To attend CCQM-Working Group meeting on Gas Analysis (GAWG)at BIPM
7.	Sh. Saood Ahmad, Sci.C	France & Germany	29.06.2008 11.07.2008	To attend BIPM Summer School-2008
8.	Dr. B.D. Malhotra, Sci.F	Korea	20.05.2008 24.05.2008	To attend 5th International Symposium on Molecular Electronics
9	Dr. Rajesh Kumar, Sci.C	UK	14.04.2008 18.04.2008	Leave due & admissible in conjunction with BOYSCAST Fellowship
10	Dr. Chhemndra Sharma, Sci. E-I	China	21.4.2008 23.4.2008	To participate as an SASCOM/SARC representative in the Int. workshop on Anthropogenic Impact on ASIAN Monsoon
12.	Dr. V.N. Ojha, Sci. F	France	26.05.2008 30.05.2008	To participate in the 6th ISO/TC 229 Nano Technology & its working groups as a member of Indian delegation
13.	Dr. Vikram Kumar, Director	Bangladesh	25.05.2008 29.05.2008	To attend 40th EC meeting and 9th EC/TC meeting to discuss issues such as i) APMP Award progress ii) New APMP status iii) Progress of APMP support for BIPM summer school iv) Treasurer report
14	Dr. A.K.Bandyopadhyay, Sci. G	Nepal & Bangladesh	19.05.2008 27.05.2008	To set up Pressure laboratory at NBS & to attend 40th EC meeting & 9th TC meeting
15.	Dr. H.R. Singh, Sci. E-II	U.K.	09.06.2008 11.06.2008	To attend International conference. ICMCC 08
16.	Dr. Rina Sharma, Sci. E-I	PTB Germany	16.06.2008 28.06.2008	To attend Metrology Seminar Dimensional Metrology

17.	Dr. Divi Har Nath, Sci.C	USA	14.07.2008 14.09.2008	To do research work related to Nanophosphor system and Nano crystal technology
18.	Dr. R.S. Dabas, Sci.F	Canada	10.07.2008 20.07.2008	International Space environment services 37th COSPAR Scientific Assembly
19.	Dr. H.C. Kandpal, Sci.F	Phillipines	01.06.2008 06.06.2008	2008 Asia Clean Energy forum and leading policy matters, finance proposals, civil society developers at Manila
20.	Dr. Vikram Kumar, Director	Canada	11.06.2008 13.06.2008	To attend VAMAS steering committee meetings and to visit Dr. Jennifer E. Decker, Ph.D, Team Leader, Metrology for Nano technology, Institute for National Measurement Standards, National Research Council
21.	Dr. Sachidanand Singh, Sci. E-I	Greece	01.06.2008 06.06.2008	To attend the First International conference from Desert to Monsoon
22.	Dr. P. Banerjee, Sci.G	Bangladesh	27.06.2008 30.06.2008	To deliver a talk in ICECC 2008 and also on Radio Science in one day Tutorial programme
23.	Dr. R.P. Aloybius, Sci. C	France Germany	i) 30.06.2008 02.7.2008 ii) 07.07.2008 08.07.2008	i) To attend the International Conference on European magnetic sensors & actuations ii) Visit to Darmstadt University of Technology
24	Dr. Ramadhar Singh, Sci.F	Malaysia	01.07.2008 03.07.2008	To deliver a lecture in the workshop on Electro active Polymers in University of Malaysia
25	Dr. A.K. Badhyopadyay, Sci. C	Canada	13.07.2008 20.07.2008	To attend 37th COSPAR scientific assembly
26	Dr. M.K. Goel, Sci.F	USA	07.8.2008 16.8.2008	To attend XXIX URSI-GA 2008
27	Sh. Prabhat Kumar Gupta, Sci. F	Germany	09.07.2008 20.07.2008	To visit PTB & discuss bilateral cooperation
		Canada	12.7.2008 20.7.2008	To attend 37th COSPAR Scientific Assembly
28	Dr. P.C. Kothari, Sci. G	Thailand	07.07.08 09.07.08	To discuss and to finalize the modalities of the cooperation in the area of metrology including the project under Indo-Thailand Cooperation
29	Dr. K.K. Jain, Sci. G	Thailand	07.07.2008 09.07.2008	- do-
30	Dr. Santa Chawla, Sci. E-II	Hong Kong	28.07.2008 31.07.2008	To attend the International conference on Multi functional materials and structures
31	Dr. B.R. Chakraborty, Sci. F	USA	04.08.2008 03.02.2009	To work as a guest researcher at the chemistry Department of Pennsylvannia state University
32	Sh.. N.K. Sethi. Sci. F	USA	10.08.2008 16.08.2008	To attend 29th URSI conference

33	Sh.N.K.Wadhwa, Sci. E-I	Germany	28.07.2008 01.08.2008	To attend the 4th International conference on Webometrics, informatics & scientometrics
34	Dr.Vikram Kumar, Director	Canada	03.08.2008 11.08.2008	As a leader of delegates to series of workshops in Canada-India Nano-Tech./ Nano-biotechnology Workshop
		USA	12.08.2008	To meet URSI Secretary
35	Dr.B.D.Malhotra, Sci.G	Canada	03.08.2008 12.03.2008	To attend series of workshop on Canada-India Nano technology/Nanobiotechnology
36.	Dr. B.S.Gera, Sci. G	USA	10.08.2008 16.08.2008	To attend IRS-2008 symposium
37.	Dr. Sachidanand Singh, Sci. E-I	Brazil	03.08.2008 08.08.2008	To attend IRS-2008 symposium
38.	Dr.B.D.Malhotra, Sci. F	Taiwan	15.09.2008 12.10.2008	To visit National Taipei University of Technology as a visiting professor on Sabbatical Leave
39.	Dr. Nirmalya Karar, Sci. C	Italy	09.09.2008 12.09.2008	To attend 2008 International conference on S&T of Emmissible Displays & Lighting
40.	Dr. P. Banerjee, Sci. G	USA	07.08.2008 16.08.2008	To attend URSI General Assembly-2008
		UK	04.08.2008 06.08.2008	Visit to NPL, Teddington
41.	Dr. Vikram Kumar, Director	Canada	03.08.2008 11.08.2008	As a member of Indian delegation in the joint India-Canada Nanotechnology/Nanobio technology workshop
		USA	12.08.2008	To attend the meeting with the secretary URSI for discussions on cooperation between URSI & RFRS(CSIR)
43.	Sh. Harish Kumar, Sci. B	USA	03.08.2008 07.08.2008	To attend the Metrology Impact on Business, CSL International 2008 workshop symposium
44	Dr. Vinay Gupta, Sci. C	South Africa	25.08.2008 29.08.2008	To visit University of Pretoria & to attend the workshop on" Electrochemical Supercap acitors"
45.	Dr.V.P.S Awana, Sci. C	Turkey	25.08.2008 29.08.2008	To attend the Int. conference on Supercond-uctivity and Magnetism(ICSM-2008)
46.	Dr. Y.P.Singh, Sci. F	Sri Lanka	18.08.2008 19.08.2008	To attend carry precision temperature artifacts or SAARC and PTB Regional Inter-comparison in Temperature Metrology
47	Dr .Sudhir Kr. Sharma, Sci. B	France	07.09.2008 12.09.2008	To attend IGAC 10th International Conference
48	Sh. Alok Muherjee, T.O.A	Nepal	08.09.2008 12.09 2008	10th Int. Symp. on High Mountain Remote Sensing Cartography

49	Dr. H.C. Kandpal, Sci. G	South Africa	01.10.2008 03.10.2008	To visit as a Tech. expert at Assessment of National Metrology Institute of South Africa, Fibre Optics Lab.
50	Sh. Kamlesh Patel, Sci. B	Australia	13.10.2008 17.10.2008	To visit NMI for taking training regarding the practical hands-on experience on calibration of NPLI attenuation std.
51	Dr. Y.P. Singh, Sci. F	China	20.10.2008 23.10.2008	To attend Int. Conference on Tempe beiijing 2008
52	Sh. Kamlesh Patel, Sci. B	Crotia	12.11.2008 15.11.2008	To attend 1st Int. symposium. RM02 2008-Regional Metrology; Testing & Accreditation
53	Dr. K.P. Chaudhary, Sci. F	Indonesia	03.11.2008 05.11.2008	To attend the 24th APMP General Assembly & related meetings (TCL Symposium)
54	Sh. A.K. Govil, Sci. F	-do-	03.11.2008 05.11.2008	-do- (TCEM symposium.)
55	Dr. Y.P. Singh, Sci. F	- do -	03.11.2008 05.11.2008	-do- (TCT Symposium)
56	Sh. R.K. Garg, Sci. F	- do -	03.11.2008 05.11.2008	-do- (TCM Symposium.)
57	Dr. Chhemdra Sharma, Sci. E-II	Japan	09.10.2008 10.10.2008	To participate in IGES-NIES-UNESCAPE Policy forum
58	Sh. Subodh Kr. Singhal, Sci. F	Malaysia	15.10.2008 17. 10. 2008	To attend 2nd technical seminar on Under-Water System & Technology
59	Dr. Anil Kumar Gupta, Sci. G	USA & Canada	29.10.2008 31.10.2008 03.11.2008 07.11.2008	To visit GM motors to R&D project To visit CAMET, Ontario
60	Dr. P. Banerjee, Sci. G	Indonesia	30.10.2008 05.11.2008	To attend the Asia Pacific Time & Frequency Workshop 2008 & 4th Asia Pacific Symposium on "Pressure & Vacuum 2008"
61	Dr. A.K. Bandyopadhyay, Sci. G	Indonesia	30.10.2008 05.11.2008	To attend the Asia Pacific Time & Frequency Workshop 2008 & 4th Asia Pacific Symposium on "Pressure & Vacuum 2008"
62	Dr. Ashok Kumar, Sci. G	France Germany	09.10.2008 10.10.2008 13.10.2008 14.10.2008	To attend 6th meeting of Consultative Committee for Acoustic Ultrasound & Vibration (CCAUV) & its working group To visit EMAT (Electromagnetic Acoustics tranducer)
63	Mr. Ajeet Singh, Sci.E-I	Indonesia	10.11.2008 14.11.2008	To visit under International Cooperation programme between NPL-KIMLIPI to train some of their staff
64	Dr.K.P.Chaudhary, Sci. F	Indonesia	17.11.2008 28.11.2008	-do-

65	Dr. Y.P. Singh, Sci.F	Indonesia	10.11.2008 14.11.2008	To visit under International Cooperation programme between NPL-KIMLIPI to train some of their staff
66	Dr. Ashok Kumar, Sci. G	Indonesia	03.11.2008 05.11.2008	To attend 24th APMP General Assembly & its associated meeting & events
67	Dr. H.C. Kandpal, Sci. G	Indonesia	03.11.2008 05.11.2008	-do-
68	Dr. A.K. Hanjurah, Sci. G	Indonesia	03.11.2008 05.11.2008	-do-
69	Sh. Prabhat Kumar Gupta, Sci. F	Indonesia	03.11.2008 07.11.2008	-do- (TCQM Symposium)
70	Sh. K.B. Ravat, T.O.E-I	South Korea	04.11.2008 03.12.2008	To work on 'High Voltage Divider' at KRISS
71	Dr. V.P.S. Awana, Sci. C	USA	10.11.2008 14.11.2008	To attend 53rd Annual conference on Magnetism & Magnetic Materials
72	Sh. Ajeet Singh, Sci. E-I	Canada	17.11.2008 21.11.2008	For taking equipment training of "High Precision Automatic DC Bridge Equipment"
73	Dr. P. Banerjee, Sci. G	Saudi Arabia	24.11.2008 25.11.2008	International Workshop on Metrology "Time & Frequency"
74	Dr. B.C. Arya, Sci. F	Norway	17.11.2008 18.11.2008	To attend the workshop being organized by Salvard Science Forum (SSF)
75	Dr. Vikram Kumar, Director	Indonesia	02.11.2008 07.11.2008	To attend the 24th Asia Pacific Metrology Programme (APMP) General Assembly & its related meeting & events
76	Dr. B.C. Arya, Sci. F	Norway	17.11.2008 18.11. 2008	To attend the workshop being organised by Svalvard Science Forum (SSF)
77	Dr. P. Banerjee, Sci. G	Saudi Arabia	24.11.2008 25.11.2009	Int. workshop on Metrology "Time & Frequency" being organised by SASO
78	Sh. A.K. Govil, Sci. F	Indonesia	01.12.2008 05.12.2008	Visit under Int. Cooperation programme between NPL-KIMLIPI to train their staff
79	Dr. S.S. Titus, Sci. E-I	Indonesia	01.12.2008 05.12.2008	Visit under International Cooperation programme between NPL-KIMLIPI to train some of their staff
80	Dr. Arun Vijay Kumar, Sci. E-I	Indonesia	01.12.2008 05.12.2008	Visit under International Cooperation programme between NPL-KIMLIPI to train some of their staff
81	Dr. Chhemendra Sharma, Sci. EII	Thailand	17.12.2008 18.12.2008	To participate in the Int. Workshop on Methodology & Development for ABC emmission inventory of selected countries.
82	Dr. A.K. Bandyopadhyay, Sci. G	Hong Kong	17.12.2008 18.12.2008	To participate in a technical reassesment at Standard and Calibration Laboratory(SCLs)

83	Dr. G. Sumana, Sci. C	Japan	13.12.2008 23.12.2008	Under Indo-Japan Project (IJCSP) entitled "Application of New Functional Conducting polymers in Biosensors and Nanoelectronics" for discussions related to ongoing project and to attend International conference on nano molecular electronics-2008 (ICNME-2008) at Kobe, Japan
84	Dr. B.D. Malhotra, Sci. G	Japan	14.12.2008 22.12.2008	(1)To meet Prof. M Onoda, Div. of Electrical engineering, Univ. of Hyogo, Himeji (2) To present paper at International Conference on Nano Molecular electronics at ICNME-2008, Kobe (3) To meet Prof.Mitsumasa lwamoto, Tokyo Institute of Technology, Meguroku, Tokyo (4)To visit Prof. K Kaneto, Kyushu Institute of Technology, Fukuoka
85	Dr. A.K. Srivastva, Sci.E-I	Japan	04.01.2009 19 01.2009	To carry out experiments under DST-JSPS collaborative project entiled "Study of defect centers in Nano-Piezoelectric Materials for Applications in Sensors" with Prof. Shin Toyoda of Okayama University of Sciences, Japan
86	Sh. Khem Singh, T.O.A	Thailand	11.01.2009 21.02.2009	To attend training at NIMT
87	Dr. V.P.S. Awana, Sci. E-I	Japan	16.01.2009 15.02.2009	Under the Indo - Japan research project entitled "HPHT Synthesis of newly discovered ReFeAsOSuperconductors
88	Sh. Tripurari Lal, Sci. F	Indonesia	12.01.2009 23.01.2009	To visit under International Cooperation programme between NPL-KIMLIPI to train some of their staff
89	Dr. Vikram Kumar, Director	South Africa	01.02.2009 05.02.2009	To deliver a key-note Lecture at the International Conference on "Nanoscience and Nanotechnology, NanoAfrica2009" and also to visit the National Metrology Institute of South Africa (NMIS)
90	Dr. V.N. Ojha, Sci. F	Canada	21.02.2009 26.02.2009	For the inspection of complete equipment at M/S Guildine Company of Canada before its despatch to NPL
91	Dr. Hari Kishan, Sci. F	Germany	09.03.2009 28.03. 2009	Under DST-DAAD PPP joint research project entitled "Technically important high TCR (Temperature Coefficient of resistance) manganite-nano-metal device for infrared/ bolometric detector applications
92	Sh. A.K. Saxena, Sci. F	France & Italy	10.03.2009 17.03.2009	i) To visit BIPM to attend WGCF & consultative committee for electrical & magnetism (CCEM) meeting (ii) March11,

				2009- to visit Dr. Alexandre BOUNOUH, Head of Low Frequency Metrology Laboratory, LNE to explore the possiblity to improve easurement capabilities of NPL LF impedance including calculable capacitor and High DC Voltage. To visit Dr.A. Bounach, LNE lab. To explore the possiblity to improve the meaurement capablities of NPL
93	Dr. R.B. Mathur, Sci. G	Germany	16.03.2009 21.03.2009	To attend the 2nd Indo-German Workshop on "Fuel Cells & Hydrogen Energy" as a member of the Indian delegation
94	Dr. R.K. Kotnala, Sci. F	Germany	19.03.2009 24.03.2009	To visit Prof Dr.-Ing. H.C.Hartmut Fuess, Darmstadt University, Darmstadt & to deliver a invited lecture as well for scientific discussions and to take equipment training from M/S BROCKHAUS MESSTECHNIK, Ludenscheild , Germany
95	Sh. Tripurari Lal, Sci. G	Taiwan	30.03.2009 01.04.2009	To deliver the Traveling Pt-Ir Kilogram to next participating Laboratory CMS-ITRI of the Pilot Study Program of APMP to discuss and finalize Draft Report of APMP M.M.K-2

APPENDIX - 11

PhDs BASED ON THE RESEARCH WORK DONE AT NPL

Sr. No.	Title	Awardee	University/ Institute	Guide(s)
1.	Computer Modeling based empirical study on diffraction-induced and coherence-induced spectral changes.	Bharat Kumar Yadav	Jamia Milia Islamia	Dr. H.C. Kandpal (NPL) Dr. S.A.M. Rizvi (JMI)
2.	Study of short and long term variations of ionospheric F-region parameters for empirical modelling of ionosphere over Indian zone	Kavita Sharma	Ch. Charan Singh University, Merrut	Dr R.S. Dabas (NPL) Dr. A.K. Mishra NAS College, (Merrut)
3.	Synthesis and physical property characterization of pure and nano-magnetic ions doped vacuum annealed MgB2 Superconductor.	Kongkham Premjit Singh	Jamia Millia Islamia, New Delhi	Dr. Hari Kishan (NPL) Prof. M. Husain (JMI) Prof. A. Shahabuddin (JMI)

HUMAN RESOURCE DEVELOPMENT ACTIVITIES

1. Organisation of External Training Courses

Organisation of Training Courses on various physical parameters in the area of Metrology / Standards, as well as on other specialised topics is an important activity of the HRD Group. These courses are primarily meant for the personnel belonging to various industries, Testing & Calibration laboratories and other S&T organisations. However, the NPL staff members are also encouraged to attend these courses, where ever found fit.

The Training Courses consist of theory lectures on various scientific & technical aspects of the training course, followed by practical demonstration and hands-on training on the related instruments / apparatus / machines.

Twelve (12) Training Courses on diverse topics of 'Material Characterisation Techniques', 'AC & DC Measurements & Calibrations', 'Pressure & Vacuum Metrology', 'Temperature Metrology', 'Dimensional Metrology', 'Mass Metrology', 'ISO-17025 based Quality System', etc., were organised by NPL during the year 2008-2009, which were attended by a large number of personnel belonging to various national & international organisations, including many participants from NPL also.

This activity led to an ECF generation of Rs. 10.2 Lacs. This ECF includes Rs. 4.5 Lacs received from KIM-LIPI (Indonesia) for training its staff members by the NPL scientists in 07 different areas of Metrology.

2. Formulation and Organisation of Internal Training Programmes

Besides the external training courses, efforts were also made to formulate special training programmes for the exclusive benefit and welfare of the NPL staff members. The basic objective was to provide the staff members knowledge and expertise in the area of relevance to their duties, so that they could perform in a more competent, productive and useful manner.

Accordingly, several special training programmes were thought about, out of which 3 were properly designed and executed also, during 2008-2009.

3. Dissemination of HRD-Related Information to NPL Staff Members

Dissemination of HRD-related information to the NPL staff members is another important task performed by the HRD Group. The information generally refers to conferences / symposia / workshops, or special training programmes conducted by DST, HRDC (Ghaziabad) or other such organisation, or awards instituted by various agencies.

More than 300 different types of HRD-related papers were displayed at 4-5 prominent places of the laboratory each, during the year 2008-2009.

4. Deputation of NPL Staff Members to Attend Conferences

NPL encourages and supports its staff members, including the floating members like JRFs, SRFs, PAs, RIs, RAs, SRAs, etc., to attend and present papers at national / international conferences / symposia / seminars / workshops, organised by different agencies in areas relevant to research activities being carried out at NPL. This is primarily meant to enable the staff members to put forward their views and research results before the leading national / international experts and interact with them on the latest developments in their research areas.

Besides the conferences / similar events, NPL also deputes its staff members to attend special training programmes organised by the DST, HRDC-Ghaziabad or other such organisation. These

programmes are aimed at enhancing the knowledge and expertise of the participants so that they could prove to be more competent, productive and useful to their organisations.

A large number of NPL scientists and other staff members (392 cases) were deputed to participate in various conferences / similar events and different Training Courses held across the country during the year 2008-09.

5. Placement, Ph.D. Registration and Other Support to Research Fellows

One of the most prominent activities of the HRD Group is to provide help and support to Research Fellows (JRFs / SRFs), starting from the time they join NPL till the time they leave NPL. This includes their placement in a suitable Division / Group and helping them in getting Hostel accommodation, if required. This also includes their Ph.D. registration, assessment for continuance / upgradation, deputation to attend conferences, etc. Sometimes, the help to the Research Fellows starts even before they join NPL. This refers to the cases wherein they are invited and inspired to join NPL for their Ph.D. programme.

Thirty one (31) fresh Research Fellows (JRFs/SRFs) were inspired and motivated to join NPL during the year 2008-2009, making a total strength of JRFs+SRFs to be 71 as on 31-March-2009.

6. Organisation of Students' Training at NPL

NPL provides both Short Term (Minimum Six Weeks to Six Months or so) and Long Term (One Year or so) training to students pursuing M.Sc. / B.Tech. / M.Tech. / MCA, or their equivalent degree programmes, at different educational institutions spread across the country, in the areas of research activities being carried out at NPL. The basic objective is to provide the students an exposure of the NPL's research activities and motivate them towards scientific research, and thus contribute towards the generation of trained S&T manpower in the country.

During the year 2008-2009, 177 students were provided training at NPL, oriented towards the fulfillment of their academic degree requirements, in different areas of research, under the guidance of senior scientists of the laboratory.

This activity led to an ECF generation of Rs. 15,000/-, to start with.

7. Organisation of Institutional Visits to NPL

Organisation of institutional visits involving students / teachers / faculty members / personnel belonging to schools / colleges / universities / technical institutes / S&T organisations is an important activity of the HRD Group. The basic objective is to provide the visitors a glimpse of the NPL activities and achievements, and thus enhance NPL's visibility in the society.

During the year 2008-2009, eighteen (18) institutional visits were organised by NPL, which involved around 500 visitors and included prestigious institutions like NIT-Kurukshetra, Amity University, BOSCH Limited, Scindia School (Gwalior) and Kendriya Vidyalayas, etc.

8. Placement of Newly-Recruited Scientists 'B'/'C'

Co-ordination was done towards the placement of newly-recruited Scientists 'B'/'C' in a particular Division/Section. These scientists were made to undergo a 2-week Orientation Programme consisting of meeting senior scientists, including all DU / DP Leaders, and interacting with them on their research activities. The basic aim of the Orientation Programme was to provide the freshly-inducted scientists an opportunity to have a glimpse of all the research activities being carried out at NPL, right in the very beginning of joining the NPL. This awareness could be very helpful in their proper placement by the authorities as well as in their pursuit of research activities in the future.

9. Formulation of NPL Training Calendar 2009-2010

The formulation of 'NPL Training Calendar' and its communication to the prospective industries / laboratories / scientific institutions is the very first step towards the organization of Training Courses by the NPL. The NPL Training Calendar for the year 2009-2010 was formulated by the HRD Group in consultation with the concerned DU / DP Leaders, and sent to all the relevant parties. These training courses, while benefiting the concerned personnel and thus contributing towards the generation of trained S&T manpower in the country, are beneficial to NPL also in terms of its image / visibility enhancement and ECF generation.

10. Formulation of DU-DP-wise Directory of NPL's Manpower

Efforts were initiated towards the formulation of a DU-DP-wise Directory of NPL's Manpower, seeing its immense usefulness in the execution of various HRD activities.

11. Organisation of CSIR Programme on Youth for Leadership in Science (CPYLS) - 2008

The CPYLS programme for the year 2008 was organised by NPL at its campus on 25-26 November 2008 and was attended by 24 bright young school children, specially chosen by CSIR for this programme. The programme involved a very fascinating inaugural lecture, entitled, "Metrology & Automation - Everyday of My Life" by Dr. Ramani Iyer, Forbes Marshall, Pune, besides various others lectures by the senior scientists of NPL on different topics like 'Optical Standards', 'How well do we know it?', etc. The programme also involved visits of the school children to various research groups of NPL involving the different R&D activities, namely, Metals & Alloys, Carbon Fibres & Nanotubes, Organic Light Emitting Diodes, Luminescent Materials & Devices, Optical Thin Films, etc. Beside this, the children were made to visit the Standards Groups also, such as, Time & Frequency Standards, Optical Radiation Standards, Force & Hardness Standards, etc., in addition to groups involved in materials characterisation w.r.t. techniques like Scanning Tunneling Microscopy, Transmission Electron Microscopy, Gas Chromatography,etc.

The basic objective behind the whole programme was to inspire and motivate the bright young school children towards Science and Scientific Research as the Career.

12. Organisation of National Science Day - 2009 (Poster Presentation Symposium)

A Poster Presentation Symposium comprising poster presentation of the work carried out by the Research Fellows (JRFs/SRFs) was organised by NPL on 27nd February 2009 as a novel way of celebrating the National Science Day - 2009. It was kept open to all the NPL scientists so that there could be a very useful and productive interaction between the two categories of NPL staff members. To make this symposium lively and attractive, it was decided to give Best Poster Presentation Award to three Research Fellows selected by the jury, specially constituted for this purpose by the DNPL.

13. CSIR Foundation Day Celebrations - 2008 (NPL Open Day)

Efforts were made towards the updation and publication of NPL Brochures (NPL at a Glance) at the occasion of CSIR Foundation Day Celebrations - 2008 in the form of NPL Open Day on 26-September-2008.

APPENDIX - 13

CONFERENCES, SYMPOSIA, WORKSHOPS AND EVENTS ORGANISED BY NPL

April 7-11, 2008
Training programme on organic electronics research and application

April 25, 2008
XXX11 Krishnan memorial lecture by Dr. APJ Abdul Kalam

May 16, 2008
Workshop on World Metrology Day and National Technology Day.

June 10, 2008
PTB German delegates meeting

July 7, 2008
User Awareness Programme on Material Characterization Technology.

July 7-11, 2008
Workshop on Materials Characterization Techniques

July 17, 2008
Meeting of Indian Woman Scientists Association. A lecture by Dr. Saskaran, Deptt. of Space.

August 12, 2008
1 Seminar for exposure for Lab-view software.
2 Introduction on Mat-Lab Training Programme.

August 25, 2008
Workshop on Electrical Metrology and Training course on dimensional metrology.

September 4, 2008
Workshop on Physics Research and Implementation.

September 5, 2008
1 Workshop on Indo-Canadian collaboration project.
2 Training course on Quality Management System evolution of uncertainty ISO 17025.

September 18, 2008
Seminar on Ferro Fluid

September 25, 2008
Open day celebration.

October 15, 2008
Discussion meeting on environment measurement and traceability, Indo German co- operation.

October 21, 2008
International conference on magnetic materials.

November 18, 2008
Fourteenth APAM conference and ILTP workshop on nano science and Technology. APAM General Assembly Programme.

November 22, 2008
Indo Taiwan DST sponsored workshop

November 24-26, 2008
"Indo-Taiwan Workshop on Solar and Fuel cells" sponsored by DST, Govt. of India.

December 4, 2008
Discussion between Vietnamese delegates with NPL Scientist regarding management technology transfer Issue. Training on Glass Technology

December 16, 2008
A course on Radio metrology and Radio wave propagation overseas.

December 16-18, 2008
A course for the Officers of the Indian Navy entitled "Fourth Short-term Course on Radio Meteorology and Radio Wave Propagation Over Sea"

December 22, 2008
Sir S.S. Bhatnagar Award Function

January 7, 2009
A lecture by Prof. C.G. Kim on translocation and sensing of Biomedicular tags/codes by magnetic method for biomedical application.

January 16, 2009
PT Planning meeting on "Pesticide in Tea" under MIC/ CRM Programme.

January 19 2009
Training cemtre in HRD

February 15, 2009
NPL-PTB Workshop & Discussion meeting on MiC Cooperation in Environment sector for MiC /CRM awareness and education.

February 16, 2009
ADMET Programme.

February 16-17, 2009
Chemical Metrology Workshop (CMW-2009) New Delhi, India organized by NPLI and Metrology Society of India.

February 18-20, 2009
7th International Conference on Advances in Metrology (Admet-2009) 2009, New Delhi, India organized by NPLI and Metrology Society of India

February 23, 2009
Training programme on Mass Metrology

February 25, 2009
DST Brain storming programme

APPENDIX - 14

LECTURES ORGANIZED UNDER NPL SEMINAR SERIES

S.No.	Date	Speaker	Affiliation	Title of the talk
01.	12.06.08	S. S. Parihar	Department of Physics, University of Wisconsin-Milwaukee, Milwaukee, WI 53211 USA	Direct-method analysis of surface alloying using surface X-ray diffraction
02.	07.11.08	S. T. Lakshmikumar	National Physical Laboratory, Dr. K. S. Krishnan Road, New Delhi- 110 012	Nobel Prizes (2008) in Science : An Appreciation
03.	17.11.08	John B. Pethica, FRS	Chief Science Adviser, National Physical Laboratory, UK	Measurement Challenges at the Nanoscale
04.	02.12.08	John J. Jonas	Birks Professor of Metallurgy, McGill University, Canada	The Transformation during the Slow Cooling of Metallic Meteorites
05.	20.12.08	Mitsumasa Iwamoto	Department of Physical Electronics, Tokyo Institute of Technology, Japan.	Visualized carrier motion in organic field effect transistors by optical second harmonic generation

APPENDIX - 15

INVITED TALKS, LECTURES BY NPL SCIENTISTS

S. No.	Speaker's Name	Topic		Event and Venue
01.	Vikram Kumar	i)	Metroloty and the role of NPL	Invited talk at SRI (Sri Ram Institute) on 09-04-08
		ii)	International System of Metrology & its Economic Impact	CII 23-05-08 at Kolkata
		iii)	Metrology in Chemistry-Indian Roadmap	Welcome address at the International Experts & Partners Meeting of MIC Programme at NPL 30 May 2008
		iv)	Meterials Research & Technologies in India-a glimpse	VAMAS Steering committee meeting, Montreal, Canada 12-06-08
		v)	Characterization of Materials for the new world of Nanotechnology on Materials Characterization	Workshop techniques (WMCT-2008) NPL, 07-07-2008
		vi)	Nano-Technology Research in India-a glimpse	University of Waterloo, Canada on 05-08-08
		vii)	Carrier Transport in Organic Electronic Devices	International Conference on Electroactive Polymers, Jaipur on 13-10-08
		viii)	Carrier Transport in Organic Electronic Devices	Asia Pacific Academy of Materials, NPL on 18-11-08
		ix)	Nanotechnology an Overview	Sri Venkateswara College, New Delhi, on 6-12-08
		x)	Nano-Technology Research at NPLI - a glimpse	India-Canada Meeting at IISC on 10-12-08
		xi)	Nano Science and Nanotechnology-an Overview	Keynote Talk, the National Symposium, Academy of Business & Engineering Services (ABES) Ghaziabad on 16-01-09
		xii)	Current in polymer solar cells	Invited talk at the 18th International Photovoltaic Science and Engineering Conference (PVSEC), 19-01-09
		xiii)	Organic and Hybrid photovoltaic cells	Invited talk at the Nano-Africa, Johannesburg, SA on 02-02-09
02.	Rina Sharma	i)	Dimensional Metrology	BIS training Programme for common wealth countries, 2008, NITS, Noida
		ii)	Evaluation and Expression	Pre AdMet Workshop on Electrical Energy

S. No.	Speaker's Name	Topic		Event and Venue
			of Uncertainty in Measurements	Metrology, Feb. 16-17,2009 National Physical Laboratory, New Delhi
		iii)	Dimensional Standards & Uncertainty in Measurements	National Workshop on Quality Assurance through Measurement Science, January 20-21, 2009, Central Mechanical Engineering Research Institute, Durgapur
03.	K P Chaudhary	i)	General concept of measure-ment and uncertainty evaluation in Biomedical measurement.	CSIO Delhi Center November 2008
		ii)	Calibration and uncertainty evaluation in Analytical instruments	CSIO Delhi Center April 2008
04.	Y P Singh	i)	"Basic concepts of temperature standards and measurement calibration as per ITS-90"	On-site training of scientists of KIM-LIPI, Indonesia in the area of Temperature Metrology during November 15-29, 2008
		ii)	Calibration of thermometers, thermocouples and pyro-meters.	
		iii)	Evaluation and expression of uncertainty in the thermo-meters, thermocouples and pyrometers.	
		iv)	Evaluation and expression of uncertainty in the thermo-meters, thermo-couples and pyrometers.	
05.	H C Kandpal	i)	High power factor CFLs and their advantages as Energy Efficient light sources.	Conference on Energy Efficient lamps, CFL phasing out, Manila, Philipinnes, during June 19-21, 2008.
		ii)	Photometry and colorimetry a series of ten lectures.	M. Tech sudents at ARAI Pune, Sept 12-13, 2008.
		iii)	Photometry measurements.	Crompton Greaves, Baroda. October 19, 2008.
		iv)	The quantum candela: a re-definition of the standard units for optical radiation NPL.	CPYLs programme, November 2008.
		v)	Photometry, colorimetry and radiometry.	VRDE Ahmednagar, December 15-16, 2008.

S. No.	Speaker's Name	Topic		Event and Venue
		vi)	The quantum candela: a re-definition of the standard units for optical radiation.	DAE-BRNS Symposium on Atomic, Molecular and Optical Physics held at IUAC, New Delhi during Feb. 9-12, 2009.
		vii)	Classical Candela heading towards quantum candela.	International Trends in Optics and Photonics ICONTOP-09 held in Calcutta during March 1-4, 2009.
		viii)	Quantum Base for Classical Photometry.	National Symposium on Photochemistry and Radiation NSRP-09, held at Kumaun University, Nainital during March 11-13, 2009.
06.	A K Bandyopadhyay	i)	TCM Chairman report	APMP EC/TC Chairs Joint Meeting, June, 2008 at Dhaka, Bangladesh.
		ii)	TCM report in APMP region	23nd APMP GA held at Jakarta, Indonesia on November, 2008.
		iii)	Finite element calculation method (FEM) for the characterization of a pneumatic piston gauge up to 8 MPa	4th APMP Pressure and Vacuum workshop at Jakarta, Indonesia on November, 2008.
07.	Pardeep Mohan	i)	Status of Vacuum Standards at NPL, India.	Low Pressure Working Group Meeting of CCM, BIPM, France, 24 April 2008.
		ii)	Vacuum Measurements by some primary and transfer standards in the range of one atmosphere to Ultra High Vacuum,	BARC, 14-15 May 2008.
08.	G. Bhatia	i)	Development of Green Coke based High density-High strength-Isotropic graphite for industrial applications.	Intl. Conf. on Processing and Fabrication of Advanced Materials, Indian Institute of Technology, Delhi, Dec. 15-17, 2008.
		ii)	Development of High Density Graphite suitable for Multistage Depressed Collector of Electron Tubes.	Symposium on Vacuum Electronic Devices and Applications (VEDA2009), Institute of Technology, BHU, Varanasi - January 8-10, 2009.
		iii)	Development of Carbon-Ceramic Composites incorp-orating micro or nano silicon carbide	Intl Symposium on high performance mater-ials, Organized by Institute of Plasma Research, Gandhinagar and Sardar Patel University, Anand, Feb.20, 2009.
09.	R. B. Mathur	i)	Characterization of Carbon Materials by X-ray Diffraction National, workshop on	National Workshop on the Characterization techniques of Carbon materials, Sardar Patel Univ., Vallabh Vidyanagar, Dec.23-24, 2008.

S. No.	Speaker's Name	Topic		Event and Venue
			characterization techniques for carbon materials.	
		ii)	Synthesis methods of carbon nanotubes and their Applications.	Structured seminar, Delhi University, 3rd June 2008.
		iii)	Synthesis of Carbon Nano-tubes- their composites and Applications in Industries.	Work-shop on Application of Carbon nanotubes in Industry" , IIT, Delhi, Oct. 24, 2008.
		iv)	Carbon components for Fuel cell Assembly : their Processing and Evaluation.	2nd Indo-German Workshop, Karlshruhe, Germany, 16-20 March, 2009.
10.	G.Bhagavannarayana	Realization of enhanced physical properties of single crystals through the improvement in crystalline perfection.		13th National Seminar on Crystal Growth held at SSN College of Engineering, SSN Nagar, Tamilnadu during Jan. 27-29, 2009.
11.	K. Nagarajan, C.K. Shashidharan Nair and G. Bhagavannarayana	High resolution X-ray diffraction and dielectric studies on phthalic acid and zinc tris (thiourea) sulphate single crystals.		13th National Seminar on Crystal Growth held at SSN College of Engineering, SSN Nagar, Tamilnadu during Jan. 27-29, 2009. Pg. I-13
12.	Sukhvir Singh	i)	Electron Microscopy Facilities at NPL and their utilization for characterization of various types of advance materials-An Introduction.	EMSI 2009 held at Bundelkhand University, Jhansi
		ii)	Characterization of materials using transmission electron microscope.	Workshop on Materials Characterization Techniques, July 7-11, 2008.
13.	B.R.Chakraborty	Time of Flight Secondary Ion Mass Spectrometry- Part I & Part II.		Invited talks(2) delivered at BARC, Mumbai on request from Mass Spectrometry Group. July 2008.
14.	P.K. Gupta	i)	Reducing Uncertainty in GHG emission estimates: Inter-calibration facilities',	NATCOM-SNC: Energy sector workshop, MoEF, New Delhi, 28 April 2008.
		ii)	Indian MiC & CRM Activities: NPL-I Partnership Model & Strategy for National Traceability Dissemination	MiC Work Shop, NPL New Delhi, 30 May, 2008.
		iii)	Atomic Absorption Spectrophotometer (AAS) Technique for Chemical Measurements	Workshop on Material Characterization Techniques (WMCT-2008), NPL New Delhi, July 7-11, 2008.

S. No.	Speaker's Name	Topic		Event and Venue
		iv)	Development of Country Specific EFs of CH4 from Representative Landfills in India,	NATCOM Consultative meeting: Livestock, Waste and Industrial Process; MoEF, New Delhi August 27, 2008.
		v)	NPL India MiC/CRM Activities: Overview of Progress	5th MiC APMP-Work Shop, Jakarta, Indonesia, 31st October 2008.
		vi)	Country Report - NPL India MiC/ CRM Activities, 8th TCQM (APMP) meeting	Nov.3-4, 2008, KIM-LIPI, Jakarta, Indonesia , 4 Nov. 2008.
		vii)	Metrological Challenges in Chemical Measurements - Indian Scenario,	CIMFR visit of MiC/ CRM Network Project, January 8-9, 2009, CFRI Dhanbad, 8 January 2008.
		viii)	Metrological Challenges in Chemical Measurements - Way ahead for coal CRMs in energy sector,	CMRI visit of MiC/ CRM Network Project, January 8-9, 2009, CMRI Dhanbad, 8 January 2008.
		ix)	Key issues for a Indian proficiency testing (PT) for pesticides in Tea and its planning	NPL New Delhi, Jan 16, 2009.
		x)	Indo-German Cooperation for MiC NPLI & PTB/BAM Initiatives'	NPL-PTB cooperation Work-shop, Clarion (Qutab) Hotel, New Delhi, Feb15, 2009.
15.	S. Swarupa Tripathy	Use of Impregnated Oxides and Natural Adsorbents as Drinking Water Purifier. Nov.20-22, 2008, Hamdard University, Delhi, India.		28th Annual Session of Academy of Environmental Biology, Environmental Stress and Bioresource Management.
16.	R.S. Dabas	Modelling of equatorial and low latitude ionosphere over Indian zone.		37th COSPAR Scientific Assembly held in Montreal, Canada , July 13-20 , 2008.
		Mobile communication links and their performance assessment.		Fourth course on Radio meteorology and radio wave propagation over the sea for Indian Navy, held at NPL, New Delhi, Dec. 16-18, 2008.
17.	C Sharma	i)	Emission Inventory: Emission Factors and Methodology.	GURME International Workshop on Air Quality Forecasting held at Pune, Dec. 8-12 2008.
		ii)	Air Pollution and Agriculture	GURME International Workshop on Air Quality Forecasting held at Pune, Dec. 8-12 2008.
		iii)	Climate change and its impact.	Workshop on Training Methodologies in Decentralised Watershed Management

S. No.	Speaker's Name	Topic		Event and Venue
				held at Indira Gandhi Panchayat Raj Institute, Jaipur, 16th March, 2009.
18.	S K Sarkar	i)	Characterization of non ionized media and wave propagation in clear air,	SERC Training programme on atmospheric and space science, 19 September 2008, Department of Physics, Vishakhapatnam, AP
		ii)	Effects of precipiataion on radiowave propagation over India	SERC Training programme on atmospheric and space science, 20 September 2008, Department of Physics, Vishakhapatnam, AP
		iii)	Radio environment characterization for radio communication	Refresher course in Physics and electronics, Department of Physics and Astrophysics, 5 Dec 09, Delhi University, Delhi
		iv)	Media characterization for radio communication.	Intl symp on Antennas and Propagation, ICRS, Jodhpur, 10 December 08
		v)	Radio refractivity and precipitation climatology	Fourth short term course for the Indian Navy on Radio Meteorology and radio wave propa-gation over sea, 16 December 08, NPL, New Delhi.
		vi)	Media characterization for radio communication	International symposium on microwave and millimeterwave : Basics and Technology, 15 January, Bose Institute, Kolkata.
19.	H R Singh	i)	Biomedical aids and technologies" delivered for the Faculty development Program sponsored by Ministry of Human Resources Development	Govt. of India, National Institute of Technology, Calicut
		ii)	Importance of Ethics in Nanoscience.	National Seminar on "Advancement of nanotechnology in physics" ISPAT College, Rourkela. 8 Feb., 2009.
		iii)	Application of Nano-technology in Computer Hard disk.	Computer Society of India, SAIL Rourkela Steel Plant, Rourkela 7 Feb., 2009.
		iv)	Nanomagnetism and Ferrites R&D work at NPL.	Guru Nanak Dev University, Amritsar, Research Consultant to DRDO Project 12 - 13 March, 2009.
		v)	Evidence for Magneto-electric Coupling of Multiferroic Systems.	Third Indo-US Science & Technology round table meeting, lecture National Institute of Advanced Studies, IISc, Bangalore, 4 - 5 March, 2009.

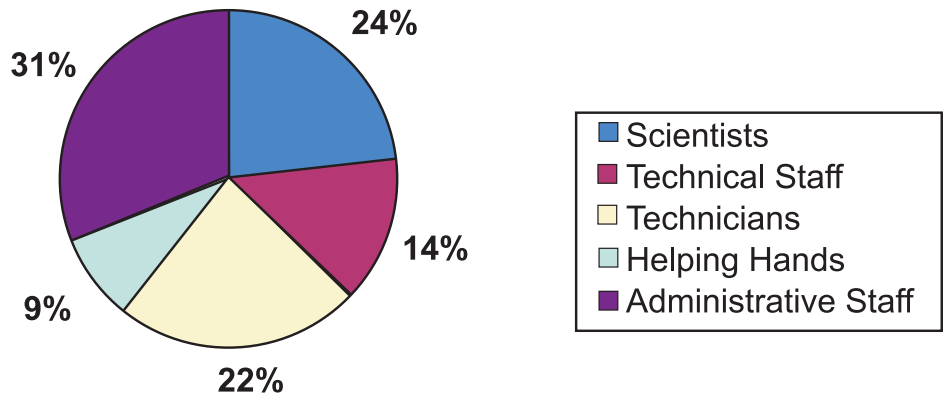
S. No.	Speaker's Name	Topic		Event and Venue
		vi)	Nanoscience & Magnetism.	Current trends in Physics" under the Center for advanced study program of UGC, lecture Department of Physics, PU, Chandigarh, March 30, 2009.
		vii)	New results in magnetic materials & measurements.	Refresher course in Physics & Electronics Department of Physics & Astrophysics, Delhi University , 12 December 2008.
		viii)	Need for Nanoscience and nanotechnology ethics.	International Conference on Magnetic Materials & its Applications for twenty first century, MMA-21", National Physical Laboratory, New Delhi, 22 October 2008.
		ix)	Different Humidity Sensors	HP University, Shimla, 12 December 2008.
		x)	Semiconducting Magnesium Ferrite Potential-Candidate for Humidity Sensing.	Gurukul Kangri Vishwavidhyalaya, 16 Oct 2008.
20.	Santa Chawla	Near UV emission and p-type conductivity in Zn1-xLixO and Zn1-xNaxO nanomaterial system		International Conference on Multifunctional Materials and Structures (MFMS-2008) held at Hong Kong.
21.	D. Haranath	i)	Multifunctional Fluorescent Magnetic Nanoparticles for Bio-related Applications	National Conference on Recent Advances in Nanoscience and Nanotechnology (NCRANT-2008), held at Shri Shankaracharya College of Engineering and Technology, Bhilai.
		ii)	Luminescence Measurements	CSIR program on Youth Leadership in Science (CPYLS-2008) held at National Physical Laboratory, New Delhi.
		iii)	Fluorescent and Magnetic Nanoparticles and Their Applications	National Seminar on Display Phosphors and Applications (NSDPA-2008) held at Saveetha Engineering College, Chennai during.
		iv)	Photoluminescence - Theory, Measurements and Applications	Workshop on Materials Characterization Techniques (WMCT-2008) held at National Physical Laboratory, New Delhi.
22.	Bipin Kumar Gupta	Investigations on the synthesis, characterization, hydrogenation behaviour of hydrogen storage materials: (a) Graphite Nanofibre (b) Sodium -aluminum hydride (c) AB5 Type alloy and its applications		Young Scientist Colloquium- Materials Research Society of India (MRSI) Kolkata Chapter., at Jadavpur University, Kolkata

APPENDIX - 16

HUMAN RESOURCE

As on March 31, 2009

GROUP IV			**GROUP II**	**Sub-Total**	**189**
Director		1			
Scientist G		39	**GROUP I**	**Sub-Total**	**73**
Scientist F		46			
Scientist EII		26	ADMN-A		8
Scientist EI		27	ADMN-B		83
Scientist C		32	ADMN-C		54
Scientist B		27	ADMN-C (Cafeteria Staff)		9
	Sub-Total :	**198**	ADMN-D		98
			ADMN-D (Cafeteria Staff)		9
GROUP III				**Sub-Total :**	**261**
TO (E-II)		6		**GRAND TOTAL**	**841**
TO (E-I)		16			
Supt. Engg.		3			
T O (C)		33			
TO (B)		9			
TO (A)		13			
STA		5			
Tech. Asst. VIII		34			
Junior Engg.		1			
	Sub-Total :	**120**			



SCIENTISTS AND OFFICERS AS ON 31.03.2009

Director
Dr Vikram Kumar

Name	Designation
Physico-Mechanical Standards	
Head : Dr Ashis Kumar Bandhyopadhyay	
Dr Ashis Kumar Bandhyopadhyay	Scientist G
Dr Ashok Kumar	Scientist G
Dr Hem Chandra Kandpal	Scientist G
Dr Bhim Sain Gera	Scientist G
Dr Sushil Kumar Jain	Scientist G
Dr Pardeep Mohan	Scientist G
Sh Tripurari Lal	Scientist G
Dr K P Chaudhary	Scientist G
Dr Desh Raj Sharma	Scientist F
Sh B V Kumaraswamy	Scientist F
Sh Omkar Sharma	Scientist F
Dr Rakesh Kumar Garg	Scientist F
Sh Subodh Kumar Singhal	Scientist F
Dr Yesh Pal Singh	Scientist F
Sh Anil Kumar	Scientist F
Dr Miss Ranjana Mehrotra	Scientist F
Dr Mrs Rina Sharma	Scientist EII
Dr Mahavir Singh	Scientist EII
Dr Sanjeev Sinha	Scientist EI
Sh D Arun Vijayakumar	Scientist EI
Dr Sanjay Yadav	Scientist EI
Dr Miss Nita Dilawar	Scientist EI

Name	Designation
Dr S Seela Kumar Titus	Scientist EI
Sh Rajesh Kumar	Scientist EI
Sh Gautam Mandal	Scientist C
Naveen Garg	Scientist B
Sh Gopan C K	Scientist B
Dr Parag Sharma	Scientist B
Sh Harish Kumar	Scientist B
Sh Virendra Babu	Tech Ofcr (EII)
Sh Ravi Khanna	Tech Ofcr (EII)
Sh Jagdish Kumar Gupta	Tech Ofcr (EII)
Sh Jai Bhagwan	Tech Ofcr (EI)
Sh Gurbir Singh	Tech Ofcr (EI)
Mrs Reeta Gupta	Tech Ofcr (EI)
Dr Yudhisther Kumar Yadav	Tech Ofcr (EI)
Sh Gurcharanjit Singh	Tech Ofcr (EI)
Sh T K Parameshwaran	Tech Ofcr (C)
Sh V K Ojha	Tech Ofcr (C)
Sh Ishwar Singh Taak	Tech Ofcr (C)
Sh Gurdeep Singh Lamba	Tech Ofcr (C)
Sh Bhikham Singh	Tech Ofcr (C)
Sh Mukesh Kumar	Tech Ofcr (C)
Sh K N Basavaraju	Tech Ofcr (B)
Sh Sudama	Tech Ofcr (B)
Sh Mahargha Baran Das	Tech Ofcr (B)
Sh Bharat Kumar Yadav	Tech Ofcr (A)
Sh Harish Kumar	Tech Ofcr (A)
Sh Rasik Behari Sibal	Tech Ofcr (A)
Sh Virendra Kumar Gupta	Tech Ofcr (A)

Electrical & Electronic Standards
Head: Dr P Banerjee

Name	Designation
Dr P Banerjee	Scientist G
Dr Amitava Sengupta	Scientist G
Dr Ashok Kumar Hanjura	Scientist G
Dr Vijay Narain Ojha	Scientist G
Dr Sita Ram Gupta	Scientist G
Sh Anil Kumar Govil	Scientist G
Sh Mukesh Kumar Mittal	Scientist G
Dr G M Saxena	Scientist F
Sh T Raghvendra	Scientist F
Sh Anil Kishore Saxena	Scientist F
Dr R K Kotnala	Scientist F
Sh H R Singh	Scientist F
Sh Pramendra Singh Negi	Scientist F
Sh Ritander Aggarwal	Scientist EII
Mrs Arundhati Chatterjee	Scientist EII
Sh Kavindra Pant	Scientist EII
Sh M P Singh	Scientist EII
Sh Joges Chandra Biswas	Scientist EII
Sh Ajeet Singh	Scientist EI
Sh Rajbeer Singh	Scientist EI
Sh M A Ansari	Scientist EI
Dr Hari Krishna Singh	Scientist EI
Sh Shiv Kumar Jaiswal	Scientist C
Ms Manju Singh	Scientist C
Dr Ashish Agarwal	Scientist C
Dr Aloysius R P	Scientist C
Sh Saood Ahmed	Scientist C

Name	Designation
Sh Chockalingam Sreekumar	Scientist B
Sh Kamlesh Kumar Patel	Scientist B
Miss Pranalee Premdas	Scientist B
Sh Anil Kumar Suri	Tech Ofcr (EII)
Sh Kul Bhushan Ravat	Tech Ofcr (EI)
Sh Mohammad Saleem	Tech Ofcr (C)
Sh Avdhesh Kumar Goel	Tech Ofcr (C)
Sh Bijendra Pal	Tech Ofcr (B)
Sh Sridhar Lingam	Tech Ofcr (A)
Ms Poonam Sethi Bist	Tech Ofcr (A)
Sh Anoop Singh Yadav	Tech Ofcr (A)

Engineering Materials
Head: Dr Anil Kumar Gupta

Name	Designation
Dr Anil Kumar Gupta	Scientist G
Dr Sukhwant Singh Bawa	Scientist G
Dr Gopal Bhatia	Scientist G
Dr Rakesh Behari Mathur	Scientist G
Dr M N Kamalasanan	Scientist G
Dr Bansi Dhar Malhotra	Scientist G
Dr Ashok Manikrao Biradar	Scientist G
Dr Suresh Chand	Scientist G
Dr Tarsem Lal Dhami	Scientist G
Sh Ramesh Chandra Anandani	Scientist F
Dr Chhotey Lal	Scientist F
Dr Krishan Kumar Saini	Scientist F
Dr S K Dhawan	Scientist F
Dr Ajay Dhar	Scientist F
Dr Tushya Kumar Saxena	Scientist EII
Sh Sudhanshu Dwivedi	Scientist EII

Name	Designation
Sh Sanjay Rangnate Dhakate	Scientist EII
Dr(Ms) Ritu Srivastava	Scientist C
Sh Vipin Jain	Scientist C
Dr Surendra Pal Singh	Scientist C
Dr (Ms) G Sumana Gajala	Scientist C
Dr Vinay Gupta	Scientist C
Dr Rajesh	Scientist C
Sh Ashok Kumar	Scientist B
Dr R G Mathur	Scientist B
Sh. Bhanu Pratap Singh	Scientist B
Sh Pankaj Kumar	Scientist B
Sh Bathula Sivaiah	Scientist B
Sh M Sarvanan	Scientist B
Ms Priunka Heda Maheshwari	Scientist B
Sh Rajiv Sikand	Tech Ofcr (EI)
Sh Pinaki Ranjan Sengupta	Tech Ofcr (EI)
Sh Gauri Datt Sharma	Tech Ofcr (EI)
Sh Rakesh Khanna	Tech Ofcr (C)
Sh Chander Kant	Tech Ofcr (C)
Sh Jokhan Ram	Tech Ofcr (C)
Sh Rajesh Kumar Seth	Tech Ofcr (B)
Sh Vinod Kumar Tanwar	Tech Ofcr (A)

Electronic Materials
Head: Dr S T Lakshmikumar

Name	Designation
Dr S T Lakshmikumar	Scientist G
Dr Virendra Shanker	Scientist G
Dr Amitabha Basu	Scientist G
Dr Parakram Kumar Singh	Scientist G
Dr Omvir Singh Panwar	Scientist F

Appendix - 16, Human Resource

Name	Designation
Dr S M Shivaprasad	Scientist F
Dr Sher Singh Rajput	Scientist F
Dr Mrs Kiran Jain	Scientist F
Dr Mrs Meenakshi Kar	Scientist EII
Dr Mrs Santa Chawla	Scientist EII
Sh C MS Rauthan	Scientist EII
Dr KMK Srivatsa	Scientist EII
Dr Abdul Mobin	Scientist EII
Dr Narinder Kumar Arora	Scientist EI
Dr T D Senguttuvan	Scientist EI
Dr(Ms) Gurusharan Kaur Padam	Scientist EI
Dr Shailesh Narayan Sharma	Scientist EI
Dr Sushil Kumar	Scientist EI
Dr Amish G Joshi	Scientist EI
Mrs Santosh Singh	Scientist EI
Dr Divi Haranath	Scientist C
Dr Govind	Scientist C
Dr(Ms)M Deepa	Scientist C
Sh Mahesh Kumar	Scientist B
Sh Sanjay Kumar Srivastava	Scientist B
Dr Bipin Kumar Gupta	Scientist B
Sh Rajiv Kr. Singh	Scientist B
Dr Praveen Kumar Siwash	Scientist B
Sh Ravi Kumar	Tech Ofcr (EII)
Sh Tarun Kumar Chakraborty	Tech Ofcr (EI)
Sh Mukul Sharma	Tech Ofcr (EI)
Sh T K Bhattacharya	Tech Ofcr (C)
Dr V K Hans	Tech Ofcr (C)
Sh Murari Lal Sharma	Tech Ofcr (C)
Sh Om Prakash	Tech Ofcr (C)
Sh Jagdish Chand	Tech Ofcr (B)

Materials Characterization
Head: Dr Bibhash Ranjan Chakraborty

Name	Designation
Dr Bibhash Ranjan Chakraborty	Scientist G
Dr Godavarthi Bhagavannarayana	Scientist G
Sh Prabhat Kumar Gupta	Scientist G
Dr Miss Rashmi	Scientist F
Dr Devinder Gupta	Scientist EII
Dr Rajendra Prasad Pant	Scientist EII
Dr Sukhvir Singh	Scientist EII
Dr Avanish K Srivastava	Scientist EI
Dr Kamlesh Kumar Maurya	Scientist EI
Dr Renu Pasricha	Scientist EI
Dr(Mrs) Prabha Johri	Scientist C
Dr Nirmalya Karar	Scientist C
Dr Nahar Singh	Scientist B
Sh.Parveen Saini	Scientist B
Sh N Vijayan	Scientist B
Dr Sushree Swarupa Tripathy	Scientist B
Dr (Mrs) Daya Soni	Scientist B
Sh Niranjan Singh	Tech Ofcr (EI)
Dr Miss Manju Arora	Tech Ofcr (EI)
Dr Dharam Pal Singh	Tech Ofcr (EI)
Sh Keadr Nath Sood	Tech Ofcr (EI)
Sh Rajiv Kumar Saxena	Tech Ofcr (C)
Mrs Abha Bhatnagar	Tech Ofcr (B)
Sh Khem Singh	Tech Ofcr (A)

Radio & Atmospheric Sciences
Head: Dr Swapan Kumar Sarkar

Name	Designation
Dr Swapan Kumar Sarkar	Scientist G
Dr Raj Singh Dabas	Scientist G
Dr Bhuwan Chandra Arya	Scientist G
Dr M S V N Prasad	Scientist G
Dr M K Tiwari	Scientist F
Dr Pradeep Kumar Pasricha	Scientist F
Dr Mahendra Kumar Goel	Scientist F
Sh Pattamatta Subrahmanyam	Scientist F
Mrs Madhu Bahl	Scientist F
Sh Narendra Kumar Sethi	Scientist F
Sh H K Maini	Scientist F
Sh Thomas John	Scientist F
Sh Deo Raj Nakra	Scientist F
Mrs Parvati Chopra	Scientist EII
Dr(Mrs)Meena Jain	Scientist EII
Dr Chhemendra Sharma	Scientist EII
Sh Randhir Singh Tanwar	Scientist EI
Ms Anuradha Sengar	Scientist EI
Dr Tuhin Mandal	Scientist EI
Dr Sachidanand Singh	Scientist EI
Dr Y Nazeer Ahammed	Scientist C
Dr Arun Kumar Upadhyay	Scientist C
Dr(Ms)Monika Kulshreshta	Scientist C
Sh Rupesh M Das	Scientist C
Dr Kirti Soni	Scientist B

Appendix - 16, Human Resource

Name	Designation
Dr Sudhir Kumar Sharma	Scientist B
Mrs Shiv Kumari Bhatia	Tech Ofcr (C)
Sh Arun Kumar Ghoghar	Tech Ofcr (C)
Sh Shambhu Nath	Tech Ofcr (C)
Mrs Beena Gupta	Tech Ofcr (C)
Sh Vinod Kumar Sharma	Tech Ofcr (C)
Sh Man Mohan Gupta	Tech Ofcr (C)
Sh Alok Mukherjee	Tech Ofcr (A)

Superconductivity & Cryogenics
Head: Dr Hari Kishan

Name	Designation
Dr Hari Kishan	Scientist G
Dr Ratan Lal	Scientist EII
Dr. Vijay Kumar Gumber	Scientist EII
Dr (Ms) P L Upadhyay	Scientist EII
Dr Anurag Gupta	Scientist EI
Dr Veerpal Singh Awana	Scientist EI
Sh Man Mohan Krishna	Scientist C
Sh Rajendra Singh Meena	Scientist C
Dr. (Ms) Anjana Dogra	Scientist C
Sh S B Samanta	Tech Ofcr (EII)

Director's Office
Head: Dr Vikram Kumar

Name	Designation
Dr Vikram Kumar	Director
Sh Rajan Babu Saxena	Scientist G
Dr Sunil Kumar Singhal	Scientist F
Mrs Shikha Mandal	Scientist F
Dr (Ms) S Niranjana N Goswami	Scientist EII
Sh Virendra Kumar Jaiswal	Scientist C
Sh Vishwa Deepak Arora	Tech Ofcr (EI)
Mrs Anita Sharma	Tech Ofcr (A)

Library
Head: Sh Deepak Kumar Tewari

Name	Designation
Sh Deepak Kumar Tewari	Scientist F
Sh N K Wadhwa	Scientist EI
Sh Jagdish Prasad	Tech Ofcr (C)
Sh Rajpal Zamaji Walke	Tech Ofcr (B)
Ms Neetu Chandra	Tech Ofcr (A)

Scientific Support Services
Head: Dr Virendra Shanker

Name	Designation
Dr Virendra Shanker	Scientist G
Dr R K Aggarwal	Scientist G
Sh S Uma Maheshwar Rao	Scientist F
Sh Narinder Kumar Babbar	Scientist F
Dr Rajeev Chopra	Scientist F
Dr Miss Jyoti Lata Pandey	Scientist F
Dr D P Bhatt	Scientist F
Sh Sushil Kumar Sharma	Scientist F
Sh Ganga Prasad	Scientist F
Mrs Indra Tiwari	Scientist F
Sh P L Pashricha	Scientist EII
Sh S K Rastogi	Tech Ofcr (C)
Sh Ashwani Kumar Suri	Tech Ofcr (C)
Sh Jagan Nath Prasad	Tech Ofcr (C)
Mrs Shashi Lekha Bhatnagar	Tech Ofcr (C)

Technical Support Services
Head: Dr Jagdish Chandra Sharma

Name	Designation
Dr Jagdish Chandra Sharma	Scientist F
Sh K P S Yadav	Sr. Supt. Engnr.(Elect)
Sh Dharam jit Singh	Supt. Engnr.(Civil)
Sh Deepak Bansal	Tech Ofcr (C)
Sh Prabhu Shankar Tripathi	Tech Ofcr (C)
Sh Mohan Chandra Singh	Tech Ofcr (C)
Sh Rambir Singh	Asstt. Engineer

Workshop, GTU & Cryogenic Infrastructure
Head: Sh Surendra Singh Verma

Name	Designation
Sh Surendra Singh Verma	Scientist F
Sh Srinivasan P	Scientist C
Sh Jai Pal Singh	Tech Ofcr (B)
Sh Amar Singh	Tech Ofcr (A)

Central Computer Facility
Head: Dr Ravi Mehrotra

Name	Designation
Dr Ravi Mehrotra	Scientist G
Ms Deepti Chaddha	Scientist C
Sh Ashish Ranjan	Scientist C
Sh Nitin Sharma	Scientist C
Ms Anjali Sharma	Scientist C
Sh Trilok Bhardwaj	Scientist B
Sh Ashok Kumar	Tech Ofcr (C)
Sh Kanwaljit Singh	Tech Ofcr (C)
Sh Vijay Sharma	Tech Ofcr (C)

Administration & House Keeping
Head: Sh R P Sharma

Name	Designation
Sh R P Sharma	COA
Sh S K Mehta	CO (F & A)
Dr Mrs Shakuntala Sharma	Sr Hindi Officer
Sh Prem Singh	SPO
Sh Mukesh Khanna	SPO
Sh Sudipto Chaterjee	F&AO
Sh Vijay Kumar	Sr Security Ofcr
Ms Veena Jain	Admn. Ofcr
Sh Umesh Gupta	S O(G)
Sh Balraj Singh	S O(G)
Sh Rajiv Sharma	S O(G)
Sh M C Meena	S O(G)
Sh Vikram Singh	S O(G)
Sh Surendra Kumar	S O (Str & Pur)
Sh Bhag Singh	S O (Str & Pur)

Name	Designation
Sh S S Chaudhary	S O (Str & Pur)
Sh S K Thakur	S O (F&A)
Sh Upendra Kumar	S O (F&A)
Sh Mange Ram	PS
Ms. Paramjit Kaur	PS
Sh Inder Jeet Taneja	PS
Mrs Gulshan Arora	PS
Sh Amar Singh	PS
Sh Ram Gopal Meena	PS
Mrs S K Bajwa	PS

Retired Persons

Dr Ram Kishore, Scientist F

Sh Raj Singh, Scientist EII

Dr P N Vijayakumar, Scientist F

Sh Megh Raj, Halwai (ACP)

Dr Sujit Kumar Halder, Scientist F

Sh J B Soni, Tech Ofcr (EI)

Sh Ram Kumar (II) Yadav, Jr Sec Grd (ACP)

Dr Prafulla Chandra Kothari, Scientist G

Dr V T Chitnis, Scientist G

Dr Ramadhar Singh, Scientist F

Sh Harsh Kumar Verma, Gr II(4)

Mrs Sundari, Safaiwala

Dr Mukesh Chandra, Scientist EII

Sh Lalit Jain, Tech Ofcr (C)

Sh Navin Kumar Srivastava, Scientist EII

Mrs Santosh Sharma, PS

Sh H N P Poddar, Scientist F

Dr S K Agarwal, Scientist EII

Sh Hasan Haider, Tech Ofcr (EI)

Sh Iqbal Ahmed, Tech Ofcr (EI)

Sh Balbir Singh, Sr Mech Asstt

Dr P K Banerjee, Scientist F

Dr Kamlesh Kumar Jain, Scientist G

Sh Vipin Kumar Singhal, Tech Ofcr (C)

Dr R K Sharma, Scientist EII

Dr Sukhmal Chand Jain, Scientist G

Sh K G M Pillai, Tech Ofcr (EII)

Sh Balbir Singh, Gr II(4)

Obituaries

Sh Binda Prakash, Peon

Dr Harish Bahadur, Scientist F

Sh Amrik Singh, Sr Mech Asstt

Sh Gokul Singh Bisht, Clerk

Mrs Shakambari Devi, Workshop Asstt VII

Sh Daulat Ram Tanwar, Gr II(4)

Mrs Samli Devi, Group D

Sh Balram Kumar Manocha, Gr II(4)

Sh Bhagwati Deen, Workshop Asstt VII

Scientists Fellow & Emeritus Scientists

Dr Ashok Kumar Gupta, Emeritus Sci

Dr P K Ghosh, Emeritus Sci

Dr U N Sinha, Emeritus Sci

Dr Subhash Chandra, Emeritus Sci

Sh S C Garg, Emeritus Sci

Dr R Bhattachryya, Emeritus Sci

Dr S L Jain, Emeritus Sci

Dr Lakha Singh, Emeritus Sci

Dr Vinod Kumar Jain, Emeritus Sci

Dr V Mohanan, Emeritus Sci

Dr S N Singh, Emeritus Sci

Dr O P Bahl, Emeritus Sci / Co-ordinator

Dr K K Mahajan, INSA Sr Sci

Dr Krishan Lal, INSA Sr. Sci

Dr S K Joshi, Platinum Jub. Emr. Sci

Dr P C Kothari, Project Adviser

Dr V T Chitnis, Project Adviser

Dr (Mrs) V Raman, Project Adviser

Sh Dharam Pal Singh, Rajiv Gandhi Fellow

Mr Joseph Sunday Ojo, CSIR TWAS Fellow

Dr Vikram Soni, Research Sci C

Research Fellows/Associates/ Interns

Sh Vinod Kumar Chahar, JRF (CSIR, NPL)

Sh Annveer,JRF (CSIR, NPL)

Sh Vinod Kumar Chahar, JRF (CSIR, NPL)

Sh Bikash Ghosal, JRF (GATE)

Sh Deepak Kumar Jangir, JRF (ICMR)

Sh Anoop Kumar S, JRF (UGC)

Sh Jitesh K, JRF(UGC-NPL)

Sh Ajay Kumar, JRF (UGC-NPL)

Sh Hemant Kumar, JRF(CSIR)

Sh Krishna Shankala, JRF(CSIR)

Sh Arunandan Kumar, JRF(CSIR)

Ms Manisha Bajpai, JRF(CSIR)

Mohd Taukheer Khan, JRF(CSIR)

Sh Sudeep Singh, JRF(CSIR)

Sh Manoj Kesaria, JRF(CSIR)

Ms Prachi Joshi, JRF(CSIR)

Sh Shiva Kumar Singh, JRF(CSIR)

Ms Anu Malik, JRF(CSIR)

Sh Anand Pal, JRF(CSIR)

Ms Rakhi Grover, JRF(CSIR)

Sh Amit Kumar, JRF(CSIR)

Sh Parveen, JRF(CSIR)

Ms Omwati, JRF(CSIR)

Sh Manoj Kumar Srivastava, JRF(CSIR)

Ms Anita, JRF(CSIR)

Sh Ravindra, JRF(CSIR)

Sh Saurabh Srivastava, JRF(CSIR)

Sh Ravinder Kumar, JRF(CSIR)

Sh Ashok Kumar, JRF(CSIR)

Sh Gaurav Kumar, JRF(CSIR)

Sh Amit Kumar Chauhan, JRF(CSIR)

Sh Shailendra Pratap Singh, JRF(UGC)

Sh Manish Uppal, JRF(UGC)

Sh Ravi kant, JRF(UGC)

Ms Suman Sharma, RA

Dr Amita Verma, RA

Ms Vibha Srivastava, RA

Appendix - 16, Human Resource

Dr Arvind Awadhia, RA	Ms Priya Shukla, Res. Intern
Dr (Ms) Punita Singh, RA	Ms Shivani Joshi, Res. Intern
Ms P Jemima, RA	Sh Ramesh Bhatt, Res. Intern
Sh Ravinder Singh Parmar, RA	Dr Sushri Pratima, Sr. Res. Assoc.
Ms Indrani Coondoo, RA	Dr Manoj Kumar Srivastava, Sr. Res. Assoc.
Sh Premshankar K. Dubey, RA	Kumari Priyanka, SRF
Sh Arindam Datta, RA	Sh Sanjay Kumar, SRF
Ms Kavita Arora, RA (CSIR)	Sh Neeraj Panwar, SRF
Dr Shahzada Ahmad, RA (CSIR)	Gaytri Chauhan, SRF(CSIR)
Sh Neeraj Dwivedi, Res. Intern	Sh Amit Choudhary, SRF(CSIR)
Ms Deepa Joshi, Res. Intern	Ms. Taranuum Bano, SRF(CSIR)
Sh Dalip Sharma, Res. Intern	Sh Pavan S Kulkarni, SRF(CSIR)
Sh Rajiv Narang, Res. Intern	Sh Satya Kumar Kushwaha, SRF (CSIR)
Sh Mahesh Chand, Res. Intern	Ms Jhuma Gope, SRF (CSIR)
Ms Vasudha Agarwal, Res. Intern	Mrs. K Jayanti, SRF (CSIR)
Sh Virendra K. Rai, Res. Intern	Sh Feroz Khan, SRF (CSIR-UGC)
Ms Anubha Sharma, Res. Intern	Sh Dinesh Kumar, SRF (CSIR-UGC)
Sh Deepak Chhikra, Res. Intern	Ms Sweta Bhandari, SRF (CSIR-UGC)
Ms Gunjan Mittal, Res. Intern	Ms Zimple Matharu, SRF (CSIR-UGC)
Km Sonal, Res. Intern	Ms Chetna Dhand, SRF (CSIR-UGC)
Ms Neha Batra, Res. Intern	Sh Praveen Kumar, SRF (CSIR-UGC)
Ms Tanvi Vats, Res. Intern	Sh Ravi Kant Prashad , SRF (CSIR-UGC)
Ms Anu Rana, Res. Intern	Ms Arpita Vajpayee, SRF (CSIR-UGC)
Sh Anand Dev Tewari, Res. Intern	Sh Vivek Kumar Varma, SRF (CSIR-UGC)
Sh Ajay Kumar Singh, Res. Intern	Ms Hema Bhandari, SRF (CSIR-UGC)
Ms Anjali Sharma, Res. Intern	Sh Umesh kumar, SRF (CSIR-UGC)
Sh Anuj Kumar, Res. Intern	Sh Vikram Sen, SRF (NET)
Ms Somya Aggarwal, Res. Intern	Sh Anil Ohlan, SRF (NET)-CSIR
Sh Neeraj Kumar, Res. Intern	Sh Bhaskar Kanseri, SRF (NET)-CSIR
Sh Vipin Singh, Res. Intern	Sh Ayushman Prashar, SRF (NRE)
Sh Tilak Joshi, Res. Intern	Sh Nandan Singh, SRF (CSIR)

Ms Monika, SRF (CSIR)	Sh Vinod Kumar, SRF(CSIR)
Sh Vibhav Pandey, SRF (CSIR)	Ms Moumita Das, SRF(CSIR)
Ms Swati Raman, SRF (CSIR)	Sh Bhaskar Gahtori, SRF (EXTD.)
Sh Rajesh Kumar, SRF (CSIR)	Ms Parul Singh, SRF(NPL)
Sh Amitava Bandhyopadhyay, SRF(CSIR)	Ms Shruti, SRF(NPL)
Sh Ajeet Kumar Kaushik, SRF(CSIR)	Sh Trailokya Saud, SRF(NPL)
Sh Ravi Ranjan Pandey, SRF(CSIR)	Ms Monu Dahuja, SRF(NPL)
Ms Shalini Singh, SRF(CSIR)	Ms Nirmal Prabhakar, SRF-NET(UGC)
Sh Atif Khan, SRF(CSIR)	Sh Rahul Tripathi, SRF-UGC
Ms Kavita Sharma, SRF(CSIR)	Dr Ashutosh Tiwari, Young Scientist
Mr. Johny C.J., SRF (CSIR)	Sh Sunil Dutta Sharma, Young Sci-DST
Ms Jyoti Shah, SRF(CSIR)	Dr(Mrs) Nupur Bahadur, Young Sci-P.I.
Sh Ashok Kr. Sharma, SRF(CSIR)	Dr Shilaja Pande, P.I. (WOS-A)

RESEARCH AND MANAGEMENT COUNCILS

Research Council
(01.04.2008 - 31.03.2009)

01.	Prof Ajay Kumar Sood Chairman, Division of Physical and Mathematical Sciences, Department of Physics, Indian Institute of Science, BANGALORE - 560 012	Chairman,
02.	Prof S S Jha Distinguished G. Professor Department of Physics Indian Institute of Technology Powai MUMBAI - 400 076	Member (External)
03.	Dr V C Sahni Director Raja Ramanna Centre for Advanced Technology Department of Atomic Energy Govt. of India INDORE - 452 013 **And** Director Physics Group Bhabha Atomic Research Centre (BARC) MUMBAI - 400 085	Member
04.	Prof G K Mehta Distinguished Honorary Professor IIT-K Inter University Accelerator Centre, Aruna Asaf Ali Marg, NEW DELHI - 110 067	Member
05.	Prof B M Arora Professor Tata Institute of Fundamental Research (TIFR) Homi Bhabha Road, Colaba MUMBAI - 400 005	Member

06.	Dr U C Mohanty Professor Centre for Atmospheric Sciences Indian Institute of Technology Hauz Khas NEW DELHI - 110 016	Member
07.	Dr M J Zarabi C - 28, Pamposh Enclave NEW DELHI - 110 048	Member
08.	Dr B Hari Gopal Director National Accrediation Board for Testing Calibration Laboratories 3rd Floor, NISCAIR Building 14, Satsang Vihar Marg, New Mehrauli Road NEW DELHI - 110 067	Member (Agency Representative)
09.	Dr S K Bhadra Scientist Central Glass and Ceramic Research Institute (CGCRI) 196, Raja S C Mullick Road KOLKATA - 700 032	Member (DG's Nominee)
10.	Dr Chandrashekhar Director Central Electronics Engineering Research Institute (CEERI) PILANI - 333 031 (RAJASTHAN)	Member (Sister Laboratory)
11.	Dr Naresh Kumar Head, (RDPD) Council of Scientific & Industrial Research, Anusandhan Bhawan, 2 Rafi Marg, NEW DELHI - 110 001	Member (Permanent Invitee)
12.	Dr Vikram Kumar Director National Physical Laboratory Dr K S Krishnan Marg NEW DELHI - 110 012	Member
13.	Sh R B Saxena Scientist 'G' & Head, Planning Monitoring & Evaluation Group National Physical Laboratory Dr K S Krishnan Marg NEW DELHI - 110 012	Non-Member Secretary

Management Council
(01.07.2007 – 30.06.2009)

01.	Dr Vikram Kumar, Director … … …	Chairman
02.	Dr A Sengupta, Scientist Gr IV(6) …	Member
03.	Dr Hari Kishan, Scientist Gr IV(5) …	Member
04.	Dr(Ms) Rajana Mehrotra, Scientist Gr IV(4) …	Member
05.	Dr(Ms) Rina Sharma, Scientist Gr IV(3) …	Member
06.	Dr D Harnath, Scientist Gr IV(1) …	Member
07.	Dr(Ms) Manju Arora,Tech Ofcr Gr III(4) …	Member
08.	Head, PME … … …	Member
09.	Sr F&AO(SG)/Sr F&AO/F&AO … …	Member
10.	Sr COA/COA/AO … … …	Member Secretary