वार्षिक प्रतिवेदन

ANNUAL REPORT 2019-20

सी एस आई आर - राष्ट्रीय भौतिक प्रयोगशाला
नई दिल्ली

Annual Report

2019 - 20

सी एस आई आर - राष्ट्रीय भौतिक प्रयोगशाला

CSIR-National Physical Laboratory

(राष्ट्रीय मापिकी संस्थान)

(National Metrology Institute)

नई दिल्ली/ New Delhi

राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली
(वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्)

NATIONAL PHYSICAL LABORATORY
(Council of Scientific and Industrial Research)

Dr. K.S. Krishnan Marg, New Delhi-110012
www.nplindia.org

गुणवत्ता नीति • Quality Policy

अन्तर्राष्ट्रीय मानकों के अनुरूप बनाए गए राष्ट्रीय मापन मानकों को सतत् अनुसंधान और विकास द्वारा स्थापित करना, उनका रख रखाव करना और उनका उन्नयन करना।

To establish, maintain and upgrade the national standards of measurement compatible to international standards through continuous research and development.

आई एस/आई एस ओ/ आई ई सी 17025:2005 के अनुसार शीर्ष स्तर का अंशाकन प्रदान करना एवं मानकों के प्रसार का कार्य करना जिससे गुणवत्ता प्रणाली का सजगता और दक्षता से पालन करते हुए मापों की अनुमार्गणीयता को बनाए रखना।

To provide apex level calibration and dissemination of standards for maintaining the traceability of measurement following Quality System as per IS/ISO/IEC 17025:2005 consciously and effectively.

उद्देश्य • Objectives

पूर्व निर्धारित अवधि में अंशाकन और परीक्षण का कार्य पूरा करना जिससे ग्राहक भी पूर्णतया संतुष्ट हों।

To provide calibration and testing within the specified time, and to the satisfaction of the customers.

सभी अंशाकन व परीक्षण से सम्बन्धित कार्मिकों को गुणवत्ता प्रणाली की नीतियों और कार्य विधियों के प्रलेखन और कार्यान्वयन से अवगत कराना।

To familiarize all personnel concerned in calibration and testing with quality system documentation and implementation of policies and procedures.

डा. दिनेश कुमार असवाल
निदेशक

Dr. Dinesh Kumar Aswal
Director

Shri Narendra Modi
Prime Minister
President, CSIR

Dr. Harsh Vardhan
Hon'ble Cabinet Minister for Ministry of Science & Technology, Ministry of Health & Family Welfare, Ministry of Earth Sciences
Vice President CSIR

Dr. Shekhar C. Mande
Director General,
CSIR and Secretary DSIR

Dr. Dinesh Kumar Aswal
Director, CSIR-NPL

Vision and Mission

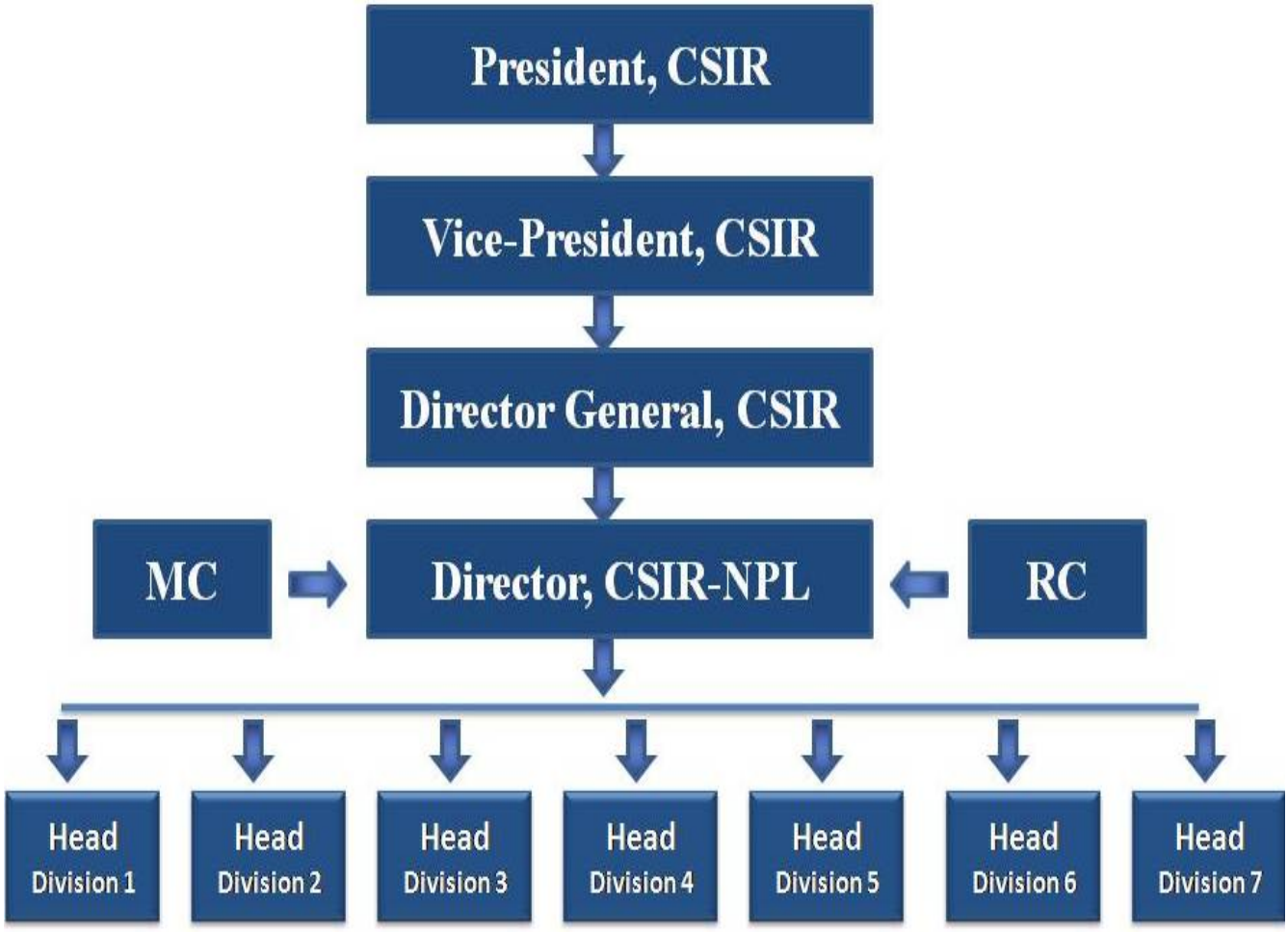
"Accurate and precise measurement are essential to drive the growth engines of Indian Science & Industry as it removes chaos and prompts innovations, which in turn, would save precious lives, resources and time....

a) *Developing India's measurement standards that are internationally accepted and disseminating the measurement capabilities to industry, government, strategic and academia that underpin the India's prosperity and quality of life.*
b) *Conducting multidisciplinary R&D with a mission to establish the futuristic quantum standards and upcoming technologies so that India remains on par with international measurement laboratories.*
c) *Developing sophisticated analytical equipments (i.e. import substitutes) under "Make in India" programme to cater the ever increasing demands of emerging India.*
d) *Training of young scientists and industry personnel in the area of measurements under "Skill India" programme.*

Mandate

CSIR-National Physical Laboratory (NPL-India) is mandated to be India's "National Metrology Institute" (NMI) by the act of Parliament and is the custodian of "National Standards" with a responsibility of the dissemination of measurements to the needs of the Country.

CSIR-NPL: Assuring Quality of Life



Division 1:	**Physico-Mechanical Metrology**
Division 2:	**Electrical & Electronics Metrology**
Division 3:	**Environmental Sciences and Biomedical Metrology**
Division 4:	**Advanced Materials and Device Metrology**
Division 5:	**Bhartiya Nirdeshak Dravya (BND®): Indian Reference Materials**
Division 6:	**Indian Standard Time Metrology**
Division 7:	**Directorate**

Contents

Preface

I am pleased to present the **Annual Report** of CSIR-National Physical Laboratory (CSIR-NPL) for the year **2019-20**. The CSIR-NPL is mandated to be India's **"National Measurement Institute"** (NMI) by an act of Parliament and is the custodian of **"National Standards"** with a responsibility of the dissemination of measurements to the needs of the country apart from being a premier research laboratory for the fundamental and emerging field of Physical Sciences. Keeping continuous pace with a developing environment powered by science and technology, CSIR-NPL has to retain its glory time to time to maintain its significant contribution to India's national competitiveness with efficient way to solve the national problem with the global image. Thus, maintenance and up-gradation of the National Standards of Measurements remained the constitutional responsibility of CSIR-NPL. Besides this, intensive R&D was carried out in frontier thrust areas of Physical Sciences under several externally funded and in-house projects to address the several national problems to make the nation self-reliant.

The year 2019-20 has been one of the most productive years for us in all dimensions of CSIR-NPL mission, including knowledge creation, development of several new technologies that not only generates the capital but also provides the solutions for several national issues. In brief, the World Health Organization (WHO) and Minamata convention have a mission to phase out mercury in health care by the year 2020, and India is a signatory to these missions. To enable this, CSIR-NPL established the in-house traceability for high temperature thermometry using fixed point blackbodies, which could save the money and time that would be spend in its external calibration. The other establishment of CSIR-NPL has been the blood pressure simulator and other related accessories to test and type approval of automatic non-invasive blood pressure (NIBP) devices for dynamic condition. This device is capable to provide the test and type approval of NIBP

devices in dynamic condition. The system is dedicated to nation for common people, industries, research laboratories, and NIBP devices manufactures.

During this year, CSIR-NPL documented policy on metrological traceability, intending to state the CSIR-NPL role in establishing an unbroken chain of metrological traceability. The CSIR-NPL has conducted the pressure dependent studies to find out the stability of the strategic material. This study becomes vital as this material found application in nuclear waste host materials, laser etc. and has many strategic applications. The new hemispherical facility for directivity measurement of SODAR driver unit and disc arrangement for Sound Power Measurement has been installed at CSIR-NPL by the Acoustic and Vibration Metrology Group. Besides this, the upgraded Primary Water Flow Calibration Facility is fully functional for calibration of different types of flowmeters of sizes DN2 to DN200 in the flow range upto 650 m^3/h using *weighing method* as per ISO 4185 standard. The new system was completely designed by the CSIR-NPL where five pipe lines (DN25, DN50, DN100, DN150 and DN200) have been installed and connected to 3 nos. of high accuracy weighing systems (300 kg, 3000 kg and 6000 kg capacities) through fishtail, nozzle and diverter systems. Thus, NMI status in water flow area is maintained by the CSIR-NPL. Furthermore, CSIR-NPL has also launched the Ferroelectric Property Measurement System (FEPMS).

In the domain of Atmospheric Pollution and Biomedical Metrology, CSIR-NPL is promoting the quality measurements under its mission projects. In this connection, the Ministry of Environment, Forest & Climate Change (MOEF&CC), Government of India, has designated the CSIR-NPL as the **"Certification Agency"** for Air Pollution Monitoring Equipments. Given this, a group at CSIR-NPL is actively working to establish a testing and calibration facility for various automated Air Monitoring Systems (AMS) especially for the Continuous Emission Monitoring Systems (CEMS) and Continuous Ambient Air Quality Monitoring Systems (CAAQMS), which would be a new national facility to provide Certification. This will help in removing the major barrier in ensuring the quality of environmental monitoring data from various sources.

To cater the need of lighting industries and energy-efficient LED and LED-based lighting manufacturers in India, 'Creation of Testing and Calibration Facility for LED and LED-based Lighting at CSIR-NPL India as per National/International Standards' has been initiated. A 5-axes fully motor controlled ultrasonic scanning tank facility has also been established by the CSIR-NPL. Such an automated 5-axes tank with NPL's own developed customized software will be utilized to provide

the improved metrological facility to the end-users. We have also started providing the time and frequency traceability to times scale systems at Bengaluru and Lucknow of ISTRAC/ISRO. NavIC satellites are also synchronized to time provided by the CSIR-NPL. SAR and Phasor Measurement Unit Calibration Systems to cater DoT and Smart Grids, respectively, are being established. The traceability of AC High Voltage and High Current is also being disseminated to Power Sector.

The CSIR-NPL expanded its mission for metrological traceability and development of indigenous Certified Reference Materials/ Bharatiya Nirdeshak Dravyas (BND®) and joined hands with various Reference Material Producers (RMP's) for creation of new BND's. During the period, CSIR-NPL has developed several Certified Reference Materials (CRMs)/ Bharatiya Nirdeshak Dravyas (BND®) in collaboration with Reference Material Producers (RMPs) of India in various parameters such as building materials, high purity compound, aqueous elemental standards, pH standards, and petroleum-based products. Additionally, the instruments like SEM, AFM, TEM mostly use nanodimensional artefacts for the calibration purposes. There are more than 1000 SEMs and AFMs are installed in India and are routinely performing nanodimensional measurements. Presently, all the dimensional reference materials used in India are imported and expensive. It costs 5-10 times more money for purchasing dimensional reference material traceable to SI unit. Taking into consideration this requirement, the fabrication of dimensional artefacts has already been started at CSIR-NPL.

Further, for quantum metrology, particularly quantum electric-field measurements, CSIR-NPL is continuously working towards the realization of RF E-field strength measurement by utilizing the characteristics of Rydberg alkali atoms. This technique relies on various quantum phenomena like Electromagnetically Induced Transparency (EIT) and Autler-Townes Splitting (ATS), which are observed in Rydberg alkali atoms under the continuous exposure of laser and RF fields.

Also, time dissemination is one of the primary mandates of CSIR-NPL. The dissemination of time is done through satellite and internet at present. For time dissemination over landline telephone lines, a complete system, named Fonoclock, including hardware for transmitters and receivers and coding for delay compensated time transfer with ± 10 ms accuracy was developed by the CSIR-NPL. Furthermore, CSIR-NPL developed several indigenous technologies for the societal and industrial benefit to make India self-reliant. The development of Indigenous potential induced degradation (PID) test set-up for cell level (**SEMI**

Draft Document 5889) has been developed to test individual solar cells in the laboratory for PID indigenously. Non-encapsulated solar cells are used for testing and hence both expenses on module production as well as tests in large climate chambers could be avoided in contrast to conventional IEC 62804-1 standard. Further, the significant indigenous development of Color shift ink (CSI), which is an important feature employed globally to protect the counterfeiting of the currency. Although this feature is currently available on the Indian currency notes, the security ink at present is resourced largely through imports thereby leading to a large outflow of foreign exchange. Thus, the premise of this project is to indigenize the process technology for the production of CSI under the "Make in India" mission of India, which would not only lead to the huge savings but also limit a large outflow of foreign exchange for its import. In addition to this, CSIR-NPL has also developed a novel strategy of a single excitable dual emissive luminescent pigment for the formulation of unclonable security ink. The new advanced security features of the ink have been demonstrated successfully and make it highly suitable for the printing of valuable products, such as currency, passports, pharmaceuticals, and so forth for protection against duplicity.

Further, CSIR-NPL developed the CNT based personal armour materials for the improvement of Kevlar properties, Kevlar-CNT paper interleaved epoxy hybrid composites. This development could be useful for designing the light weight ballistic resistant helmet for security personals.

Apart from being a key research and development institute, CSIR-NPL plays a vibrant role in Human Resource Development in the areas of Metrology. During 2019-20, eight foreign delegations have visited the CSIR-NPL. Arranging training programmes for international candidates is also the job of this group. International collaborative projects, bilateral exchange programme and MOU are also handled by the group. The CSIR-NPL provided facilities to students from universities and other educational institutes like IITs, IISc-Bangalore, etc. for project work and training. During the period from 1st April, 2019 to 31st March, 2020, 51 research fellows (JRFs/SRFs) joined CSIR-NPL and AcSIR Ph.D. Programme, resulting in a total strength of Research Fellows (JRFs+SRFs) in CSIR-NPL is 289 as on 31.03.2020.

I wish to acknowledge the significant support, cooperation and motivation that CSIR Headquarter, Research Council and Management Council have provided from time to time, which has proved very helpful in achieving our goals. I am also thankful to the external experts who visited CSIR-NPL on various occasions and

have always given us a committed and devoted impetus to excellence. I would also like to recognize all CSIR-NPL staff and young researchers for their valuable contributions. I am sure that they will continue to work harder in the years ahead to make CSIR-NPL as one of the most competitive institution.

(D K Aswal)
Director, CSIR-NPL

CSIR-NPL: Enabling Quality Infrastructure

List of selected organizations to whom support, advices and apex calibration services are being provided

Government/Semi-government Organizations

Air Force; Air India; Bharat Electronics; BHEL; Bhilai Steel Plant; Bureau of Indian Standards; Central Pollution Control Board; Central Power Research Institute; Central Public Works Department; Railway Information System; Central Institute of Mining and Fuel Research; Defense Electronics Applications Laboratory; Delhi Jal Board; Directorate of Border Security Force; Hindustan Aeronautic Limited; Indian Oil; ISRO Inertial Systems Unit; Maharashtra State Electricity Board; Micro, Small and Medium Enterprise Testing Center; NTPC; Nuclear Fuel Complex (DAE); Ordnance Factory; Rail Coach Factory; FCRI, DRDO, etc.

Industries

ABB India; ACC; AIMIL Ltd.; Alstom India; Ambuja Cement; Binani Cement; Birla Tyres; Blue Star; Bureau Veritas; Casio India; Crompton Greaves Limited; Diesel Locomotive Works; Essar Oil Ltd.; Godrej & Boyce Mfg. Co. Ltd; Havells India; Honda Cars; International Zinc Association; J.K. White Cement; JK Lakshmi Cement; Kirloskar Brothers; Larsen & Toubro; Maruti Suzuki; Mysore Paints & Varnish; Philips India; Piramal Healthcare; Ranbaxy; Rapid Metro Rail Gurgaon; Samsung India; Endress + Hauser India Pvt. Ltd.; Capital Power, Itron, Padmini VNA Mechatronics etc.

SAARC Nations

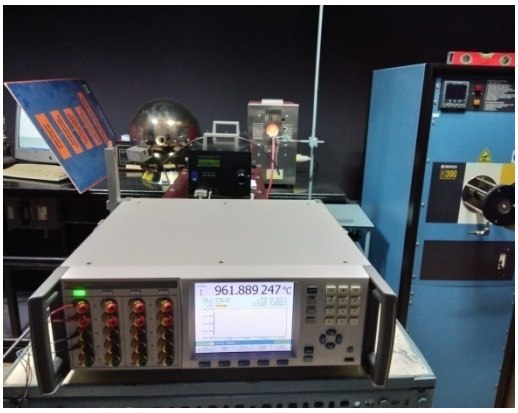
Nepal Bureau of Standards & Metrology (MBSM), Nepal; Bangladesh Standards and Testing Institution (BSTI), Bangladesh; Measurement Units, Standards and Services Department (MUSSD), Sri Lanka; National Physical and Standards Laboratory (NPSL), Pakistan; Bhutan Standards Bureau (BSB), Bhutan; Afghanistan National Standards Authority (ANSA), Afghanistan; Maldives Standards and Metrology Unit (MSMU), Maldives.

Significant contributions

during 2019-20

CSIR-NPL

Established the In-house Traceability for High Temperature Thermometry using Fixed Point Blackbodies

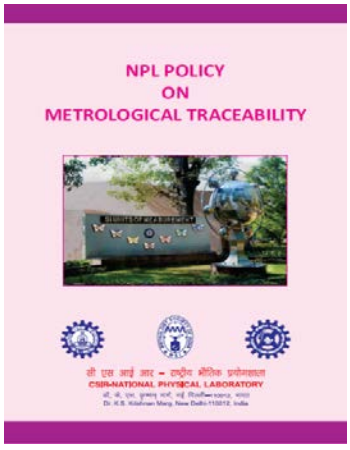


We have successfully developed Fe-C and Co-C blackbody fixed point cells with in-house R&D efforts. High temperature **blackbody fixed point cells** (Ag, Cu, Fe-C, Co-C) are realized using non-contact thermometry. **In-house traceability** of the primary standard for high temperature measurement upto 3000 ^{o}C, "**linear pyrometer (LP4)"** is **established** based on these indigenously developed fixed points which will save the money and time which would be spend in its external calibration.

Testing and Type Approval of Automatic Noninvasive Blood Pressure System

Most of the automatic noninvasive blood pressure (NIBP) measuring devices are based on the algorithm derived after clinical trials of human blood pressure pulses. We have set-up blood pressure simulator and other related accessories to test and type approval of automatic NIBP devices for dynamic condition. With the help of blood pressure simulator, we can generate a know dynamic human blood pressure and check the authenticity, reproducibility, repeatability, stability and accuracy compared to the traceable pressure/output voltage or pulses of the blood pressure simulator. This device is capable to provide the test and type approval of NIBP devices in dynamic condition. The system is dedicated to nation for common people, industries, research laboratories, and NIBP devices manufactures.

NPL Policy on Metrological Traceability

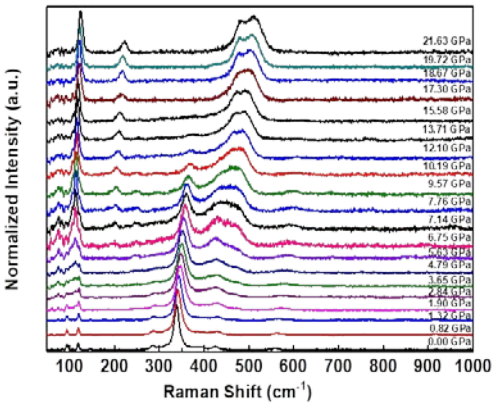


CSIR-National Physical Laboratory documented policy on metrological traceability with the aim to state the CSIR-NPL role in the establishment of the unbroken chain of metrological traceability. It also stipulates CSIR-NPL role as National Metrology Institute of India in establishing, upgrading, maintaining, and disseminating national measurement standards through an unbroken chain of traceability to SI units. The policy and supported reference documents are for intended use within CSIR-NPL and also to serve its clients/customers in their understanding, interpretation, and implementation of metrological traceability. The policy document also addresses

many of the frequently asked queries and doubts raised by customers.

High Pressure Raman Studies Using the Diamond Anvil Cell (DAC) up to a Pressure of 21.63 GPa

The pressure dependent studies are carried out to find out the stability of the strategic material. In the figure, one such study of Eu_2O_3 shows a phase transition from cubic to hexagonal phase at 15.58 GPa of pressure and hexagonal phase was stable up to the studied pressure of 21.63 GPa. This study becomes important as this material found application in nuclear waste host materials, laser etc. and have many strategic applications.



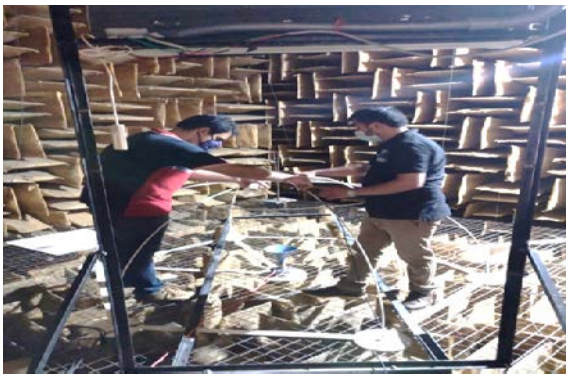
Variation of the Raman Modes with the Application of Pressure on Eu_2O_3

- International Inter-comparisons
  - Successfully participated in APMP.M.P K4 key comparison in the pressure range of 1 Pa to 10 KPa and submitted the results to pilot laboratory KRISS Korea.
  - Submitted the APMP.M.P K15 key comparison draft-A data to NMIJ, Japan in the vacuum range of 10-4 Pa to 1Pa.

- Skill development through training programs for industries, manufacturer and calibration labs, 02 training programs were organized in Fluid flow, Force, Pressure and Vacuum Metrology and 01 Post graduate diploma course .
  - Training program on "Fluid flow, Force, Pressure & Vacuum Metrology" (4-6), Sept. 2019, (08 participants)
  - Training program on "Fluid flow, Force, Pressure & Vacuum Metrology" (13-15), Jan. 2020, (06 participants)
  - Post Graduate Diploma in Precision Measurement and Quality Control (07 students)

Establishment of New Hemisphere Structure Facility

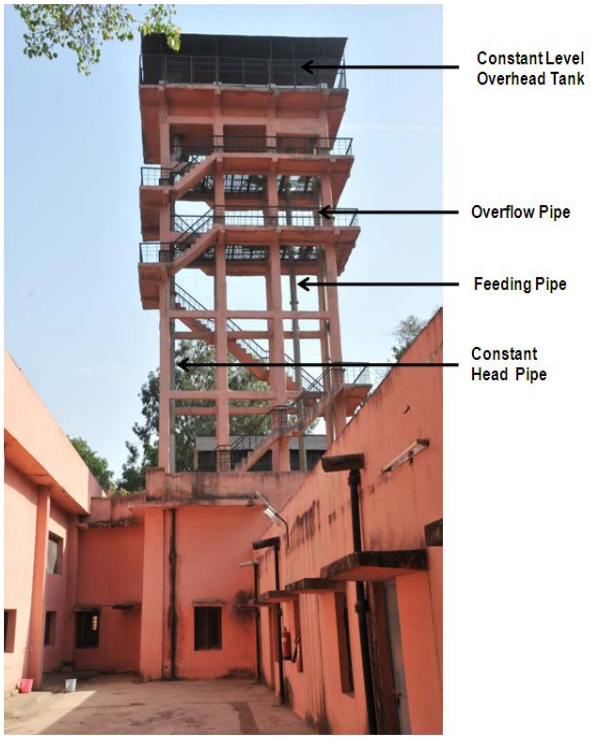
The new hemispherical facility for directivity measurement of SODAR driver unit and disc arrangement for Sound Power Measurement has been installed at CSIR-NPL by Acoustic and Vibration Metrology Group.



- **Successfully Participated in *APMP.AUV.V-K*3.1 Key Comparison in the frequency range of 0.1 Hz to 40 Hz:** The final report of International Key Comparison Exercise, APMP.AUV.V-K3.1 with Center for Measurement Standards, ITRI, Taiwan as pilot Laboratory in September 2019. The final report of International Key Comparison Exercise, APMP.AUV.V-K3.1 with Center for Measurement Standards, ITRI, Taiwan as pilot Laboratory in September 2019 revealed the degrees of equivalence of CSIR-NPL values for sensitivity and phase determination in comparison to the KCRV supported CSIR-NPL calibration and measurement capabilities in the low frequency range of 0.1 Hz to 40 Hz.

Upgradation of Primary Water Flow Calibration Facility

The upgraded Primary Water Flow Calibration Facility is fully functional for calibration of different types of flowmeters of sizes DN2 to DN200 in the flow range upto 650 m^3/h using *weighing method* as per ISO 4185 standard. The new system was completely designed by the CSIR-NPL where five pipe lines (DN25, DN50, DN100, DN150 and DN200) have been installed and connected to 3 nos. of high accuracy weighing systems (300 kg, 3000 kg and 6000 kg capacities) through fishtail, nozzle and diverter systems. A separate line of DN15 size has been also derived for calibration of DN2 to DN4 size mass flowmeters using 12 kg weighing scale employing standing start and standing finish method. These weighing systems are of **electromagnetic force compensation** type. A new direct pumping header of DN150 size was added using 3 HP, 5 HP and 10 HP pumps for calibration of flowmeters upto DN100 size in the flow range upto 175 m^3/h. These pumps were integrated with variable frequency drives (VFDs) for flow control and energy saving. Out of 3 nos. of 50 HP pumps, 1 no. of 50 HP pump was integrated with VFD for flow control and energy saving. **The uncertainty in flowmeter calibration for *totalized mass* and *totalized volume* parameters is in the range of 0.01-0.02% (at *k*=2) whereas for *mass flow rate* and *volume flow rate* parameters is in the range of 0.03-0.05% (at *k*=2) which are at par to international level. Thus NMI status in water flow area is maintained now by the CSIR-NPL.**



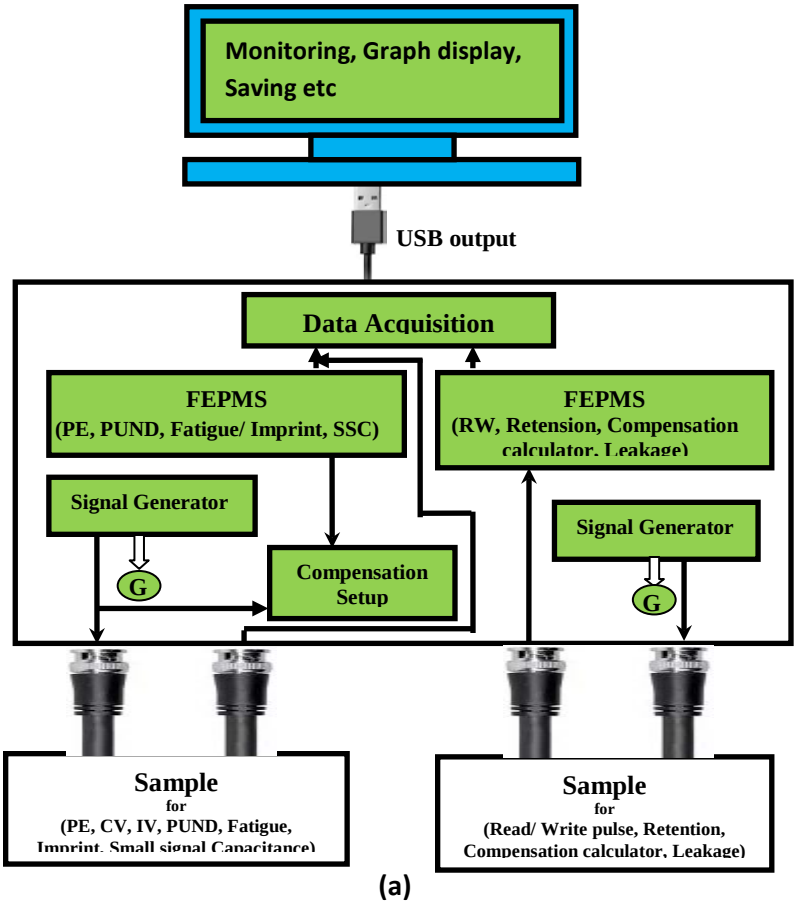
Constant Level Overhead Tank of Primary Water Flow Calibration Facility

- **APMP Key comparison (APMP.M.FF-K6.2018) on Low Pressure Gas Flow:** Participated in the APMP key comparison on low pressure gas flow during January-March 2020 piloted by KRISS Korea. Total 09 NMIs has participated in this comparison and Rotary Gas Meter, model Delta S-flow G65 has been used as artifact. The measurements were performed and results submitted to the pilot laboratory. For this inter comparison, a fully automatic set-up was developed.

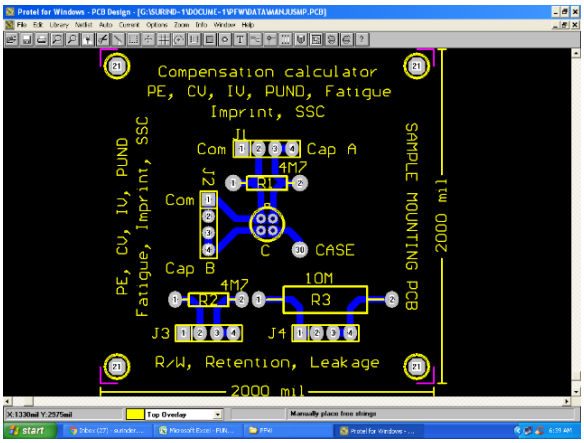
Launch of Ferroelectric Property Measurement System (FEPMS)

FEPMS is an integrated circuit for the measurement of ferroelectric properties of a sample. The sample is connected to the FEPMS through two cables with BNC connector at another end. The output of FEPMS can be plugged in with PC using USB cable. The software installed in PC can communicate with hardware of the system.

- **Hardware Output:** The frequency range of the system is 10Hz to 2.5 kHz and voltage range is 0 volt to 10 volt. The output of the FEPMS consists of 18 bits integer's resolution on all 2 input channels. The software drivers calculate all the monitored parameter values, graph plotting and saving of acquired data.
- **Interfacing with FEPMS:** FEPMS can be interfaced with computer using GUI program called FEPMS2019_01. Before launching the FEPMS2019_01 it is necessary to have the FEPMS powered and connected to the PC through a USB cable. Otherwise the FEPMS2019_01 will display the error prompt "Can't connect to controller, please check power and USB wiring". If this happens close all processes, power and connect the FEPMS and restart the program. If the FEPMS is connected properly, launch the FEPMS2019_01 and wait a few seconds.
- **Operation Modes:** The main function of FEPMS is Hysteresis loop (Polarization vs Electric field) measurement. Few more functions of FEPMS are IV (current vs voltage), CV (capacitance vs voltage), PUND, Fatigue, Imprint, Small signal capacitance, Read/ write pulse measurement, Retention, Compensation calculator and leakage current measurement.



(a)



(b)

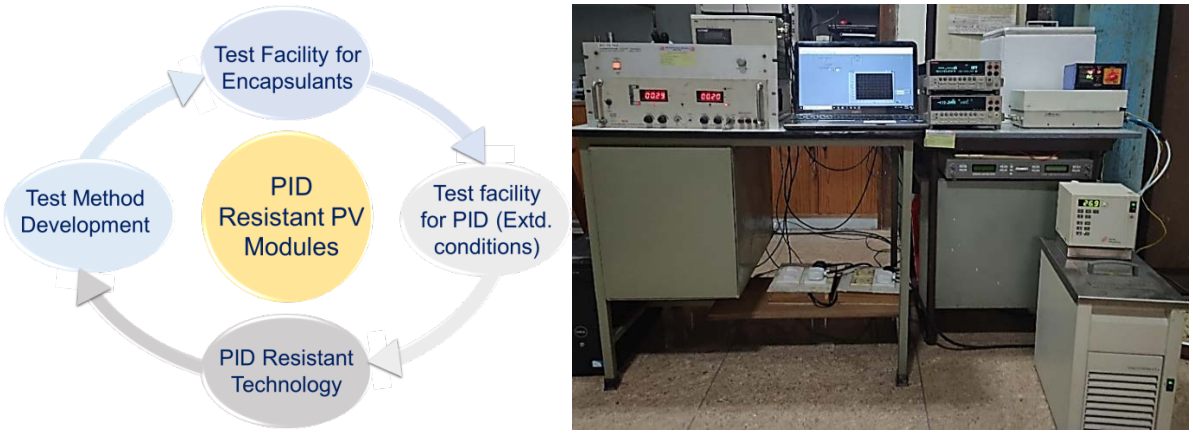
(a) Block Diagram of FEPMS
(b) PCB design for 'Standard Sample'

Launch of Ferroelectric Property Measurement System

Development of Indigenous PID Testing Facility

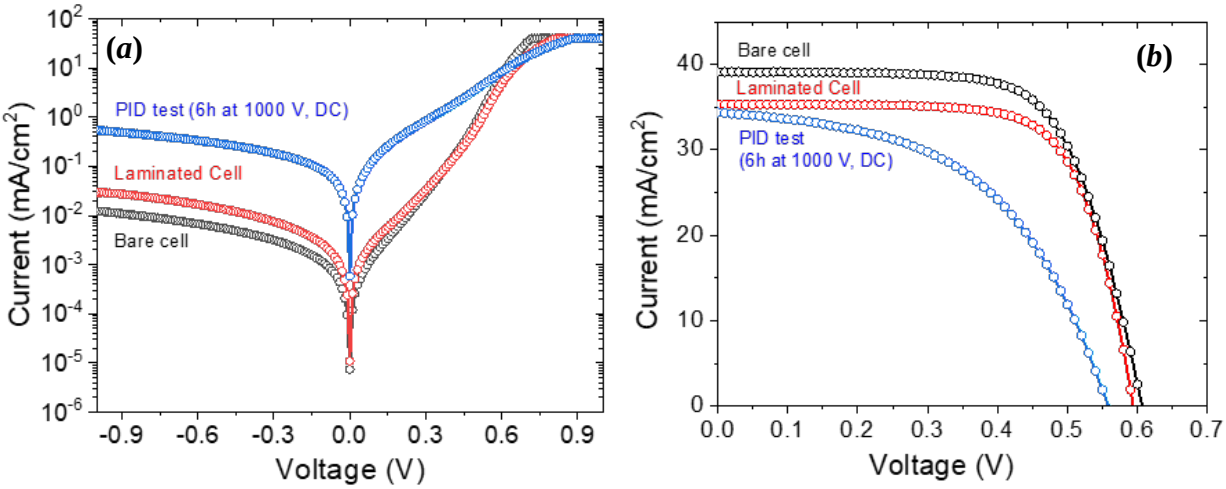
Potential induced degradation (PID) is known to be third most expensive technical risk (PV module power loss > 40% within 5 years) with an average economic impact of €0.12 per Wp. Addressing the PID effects for the development of PID resistant solar PV modules is a four-fold strategy, including (*a*) test facility for module encapsulants, (*b*) test facility for PID encompassing country-specific extended test conditions, (*c*) development of appropriate PID resistant technology for mitigating the PID effects followed by (*d*) development of country-specific test method.

PID test set-up for cell level (**SEMI Draft Document 5889**) has been developed to test individual solar cells in the laboratory for PID indigenously. Non-encapsulated solar cells are used for testing and hence both expenses on module production as well as tests in large climate chambers could be avoided in contrast to conventional IEC 62804-1 standard. Therefore, test facility is being set-up according to the SEMI Test Method on cell level for PID susceptibility of solar cells and module encapsulation materials.



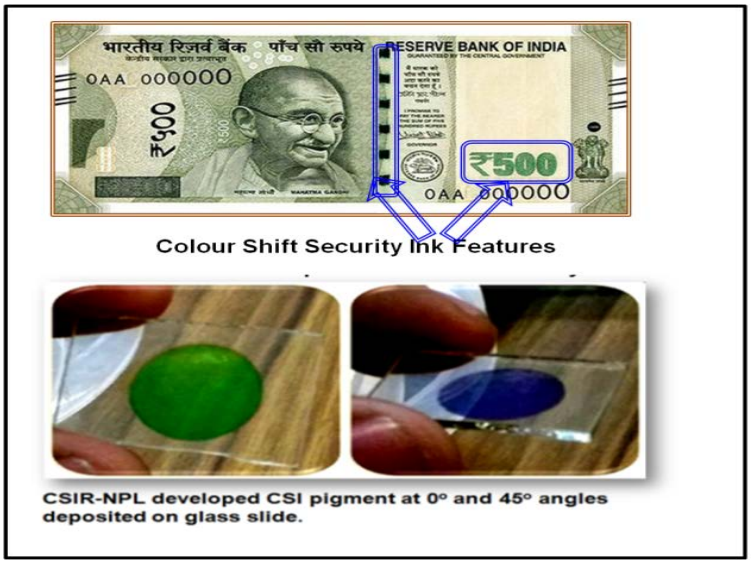
(*a*) Components Involved in the Development of PID Resistant Solar PV Modules that Sustain the Country Specific Conditions and to Ensure its Long-term Performance as per the Predicted Lifetime, (*b*) PID Test Facility, which is being Set-up according to the SEMI Test Method (SEMI Draft Document 5889)

The efficacy of the test set-up is demonstrated using the test structures of solar cells. PID test has been carried out at a voltage stress of 1000 V for 6 hours at the temperature of the solar cell was maintained 80 ±1 ^{o}C. The dark and illuminated I-V characteristics of silicon solar cell before and after PID test were recorded and the results are shown in the following figure. From the I-V curves, the solar cell parameters like open circuit voltage (V_{oc}), current density (J_{sc}), maximum power voltage (V_m), maximum power (P_m), shunt resistance (R_{sh}), series resistance (R_s), fill factor (FF), efficiency, power loss were evaluated for the cells before and after PID stress. Severe degradation in all the cells parameters was noticed as a result of voltage stress on the cells.



I-V Characteristics of the Cells Before and After PID test at ~ 80 ±1 ^{o}C (a) Dark and (b) Illuminated Measurements

Indigenous Development of Colour Shift Pigment for Security Ink



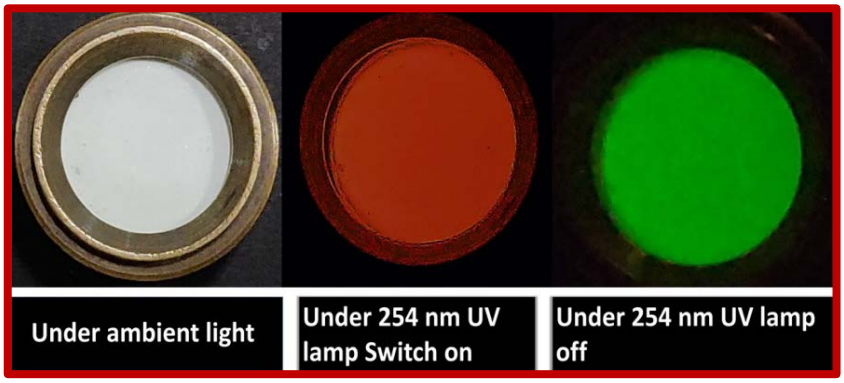
CSIR-NPL Developed Optically Variable/color Shift Intaglio ink that Changes Colors Depending upon the Viewing Angle for Indian Banknotes Applications

Color shift ink (CSI) is an important feature employed globally to protect the counterfeiting of the currency. The intaglio printed security features using this ink displays two distinct colors depending on the viewing angle of the currency. Although this feature is currently available on the Indian currency notes, the security ink at present is resourced largely through imports thereby leading to a large outflow of foreign exchange. The technology for this product is mainly monopolized by a few select European countries, which have protected this invention by filing several hundred patents and they charge an exorbitant amount for this CSI. Thus, the premise of this project is to indigenize the process technology for the production of CSI under the "Make in India" mission of India, which would not only lead to the huge savings but also limit a large outflow of foreign exchange for its import. This would also address the challenge that our Hon'ble Prime Minister of India had posed to the scientists and industrialists in his address on the 80th foundation day of RBI on 1st April 2015 for indigenizing the production of ink and paper used for the currency notes. NPLI has developed CSI ink that changes colors depending upon the viewing angle and this technology has been transferred to BNP, Dewas for scaled-up ink, which will lead to a huge saving of foreign exchange for Govt. of India. MOU was signed on 20th April 2017 with Security Printing & Minting Corporation of India Ltd.(SPMCIL), an enterprise of Govt. of India, and received a project as Project Investigator on "Make in India-Colour Shift Intaglio Ink" of Rs. 236 Lakhs (1st November 2019) from BNP, Dewas, M.P., SPMCIL. As an outcome of the project during first phase, CSIR-NPL has discovered the know-how of preparing Colour Shift pigments (green to blue) and sent to BNP Dewas to examine at ink factory Dewas for the colour shift effect. The report received from BNP Dewas on 14th February 2020 and the report was found satisfactory by BNP Dewas and stated that, *"the synthesized CSIR-NPL pigment is comparable to standard sample used at present"*.

Development of Single Excitable Dual Emissive Novel Luminescent Ink to Curb the Counterfeiting of Fake Currency, Passports, and Important Documents

CSIR-NPL has developed a novel strategy of a single excitable dual emissive luminescent pigment for the formulation of unclonable security ink. The new advanced security features of the ink have been demonstrated successfully and make it highly suitable for the printing of valuable products, such as currency, passports, pharmaceuticals, and so forth for

protection against duplicity. The formulation of the single excitable dual emissive luminescent pigment is based on the unexplored combinatory concept of the

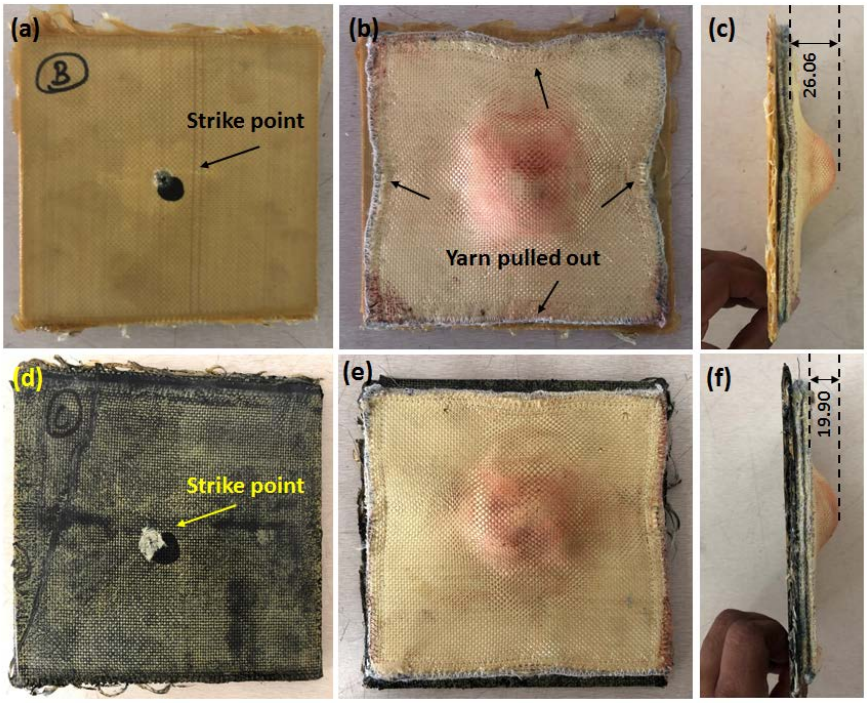


Optical Photographs of the Single Excitable Dual Emissive Luminescent Pigment under Daylight and 254 nm UV Lamp Switched On and Off

fluorescence@phosphorescence phenomenon, which provides a new feature in the composite. It emits intense red color (611 nm) upon illumination with a 254 nm UV lamp excitation source and long persisting green color (532 nm) when the excitation source is switched off as shown in the figure. To study the feasibility of the single excitable dual emissive luminescent security ink for commercial applications, the patterns printed using this ink were not only subjected to rigorous atmospheric conditions such as hot, cold and humid conditions for six months but also examined after treatment with various bleaching agents (ethyl alcohol, ethyl acetate, xylene, acetone, soap solution, and laundry detergent) to ensure their chemical stability. The security features printed using the single excitable dual emissive luminescent security ink was found to be very stable against all of these stringent conditions. Hence, the exceptional results obtained using the single excitable dual emissive luminescent security ink offer a new pathway to prevent counterfeiting by generating advanced security features.

Development of CNT Based Personal Armour Materials

For the improvement of Kevlar properties, Kevlar-CNT paper interleaved epoxy hybrid composites have been developed with Kevlar and CNT paper alternatively. A 3-D interlocked Kevlar and Kevlar-CNT multiscale composite of size 15 cm x15 cm was prepared and high velocity projectile test (Type III-A) was performed. It was found that both the composite blocks, CNT bucky paper based Kevlar composites (KEBC) and without CNT bucky paper based Kevlar composites KE completely stopped the 9 mm FMJ bullet. But, in case of $KEBC_{Block}$, back face signature (BFS) reduced to an average value of 19.90 mm which shows the overall reduction of 23.63% over base line composite KE_{Block}. This study will be useful for development of light weight ballistic resistant helmet for security personals.



Post Failure Digital Micrographs of (a) Front, (b) Rear and (c) Lateral Surfaces of Kevlar Epoxy Block and (d) Front, (e) Rear and (f) Lateral Surfaces of Kevlar Epoxy –CNT Paper Block following NIJ 0108.01 Level III-A

Production of Indian Reference Materials: Bharatiya Nirdeshak Dravya-BND®)

The primary responsibility of the BND Division is dissemination of SI traceability to the RMPs through in-house and external production and in-house or on-site validation-certification based BND development and associated development of materials standards. In that context, BND Division developed twelve nos. BND®s of aqueous elemental standard solutions related to drinking water and high purity compounds through RMP i.e. Aashvi Technology LLP. established SI traceability through CSIR-NPL and validation work for the following BND®s given in Table below-

Through M/s Aashvi LLP Tech

S. N.	Name of BNDs	BND® No.
1	Nickel Standard Solution	BND® 1004
2	Lead Standard Solution	BND® 1010
3	Mercury Standard Solution	BND® 1012
4	Cadmium Standard Solution	BND® 1013
5	Zinc Standard Solution	BND® 1015
6	Iron Standard Solution	BND® 1019

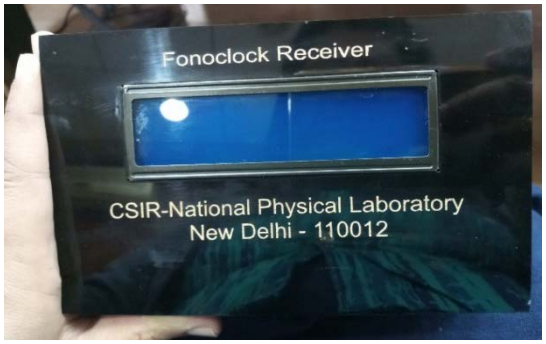
7	Arsenic Standard Solution	BND® 1011
8	Total Dissolved Solids (TDS)	BND® 1021
9	Potassium Hydrogen Phthalate	BND® 1016
10	Sodium Chloride	BND® 1018
11	Sodium Carbonate	BND® 1023
12	Calcium Carbonate	BND® 1024

Through M/s HPCL

S. N.	Name of BNDs	BND® No.
1	Sulphur 2.5 ppm	BND® 7001
2	Sulphur 5 ppm	BND® 7002
3	Sulphur 10 ppm	BND® 7003
4	Sulphur 25 ppm	BND® 7004
5	Sulphur 50 ppm	BND® 7005
6	Sulphur 50 ppm	BND® 7006
7	Sulphur 1000 ppm	BND® 7007
8	Sulphur 2.5 ppm	BND® 7026
9	Sulphur 5 ppm	BND® 7027
10	Sulphur 10 ppm	BND® 7028
11	Smoke point	BND® 7017
12	Distillation Standard	BND® 7018
13	Distillation Standard	BND® 7019
14	Total Base Number	BND® 7023
15	Total Acid Number	BND® 7024
16	FIA-Aromatics, Olefins, Saturates	BND® 7025

Fonoclock

Time dissemination is one of the primary mandates of CSIR-NPL. The dissemination of time is done through satellite and internet at present. For time dissemination over landline telephone lines, a complete system, named Fonoclock, including hardware for transmitters and receivers and coding for delay compensated time transfer with ± 10 ms accuracy has been developed. Dedicated transmitters attached to telephone lines have been installed in the laboratory and have been synchronized to Indian Standard time. The receivers have been tested for time synchronization from within and outside CSIR-NPL. The miniaturized version of the Fonoclock receiver has also been developed. The Fonoclock receivers with LED time display have been put up at multiple locations within CSIR-NPL campus for displaying the IST. The technology for making the Fonoclock receivers is available commercialization. A 5-channel 1 PPS distribution amplifier has also been developed to support the Fonoclock technology and is also available as a separate technology for commercialization. Technology details of Fonoclock and pulse distribution amplifier, shown in following figures, are available on the CSIR-NPL website.



Miniatured Fonoclock Receiver

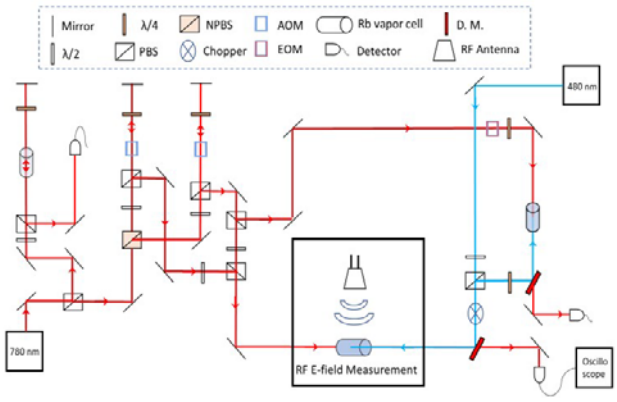
5-Channel Pulse Distribution Amplifier

Cesium Fountain Clock Activity

CSIR-NPL indigenously developed India's Cs fountain clock (NPLI-CsF1), operated and evaluated it as a PFS for contribution to international atomic time (TAI) for few months. Due to ageing systems, the operation of NPLI-CsF1 could not be sustained on regular basis. In order to have a stable timescale at NPLI, regular operation of NPLI-CsF1 is crucial. It was realized that the lasers and optical system needed to be upgraded for continues operation. A new Master laser has been installed which has maximum output power of 3W in comparison to earlier master laser having only 250 mW total output power. The new master laser will help in improving the overall power budget and hopefully will improve the S/N ratio of cold atoms as well. For the repump laser, a cost-effective yet quite stable electronic locking circuit has been developed indigenously and which is keeping the repump laser locked for days without major perturbations. On the development of the second fountain (NPLI-CsF2), optical system of the fountain is being prepared. The lasers have been installed and being stabilized. The complete optics set-up has to be laid out next.

Quantum Electric-field Measurements

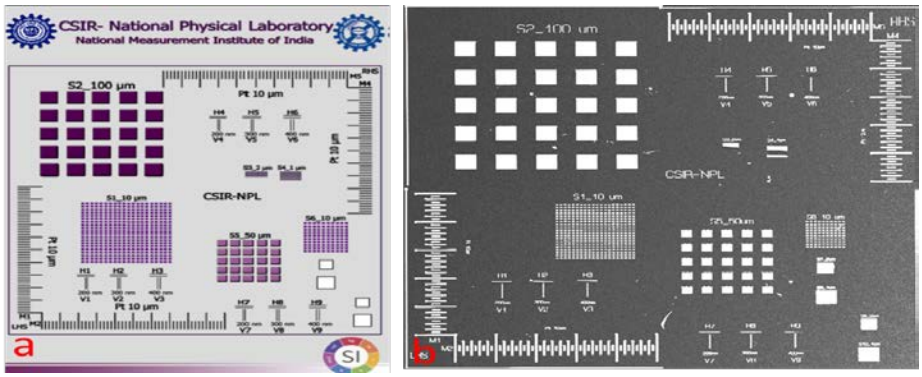
CSIR-NPL is continuously working towards the realization of RF E-field strength measurement by utilizing the characteristics of Rydberg alkali atoms. This technique relies on various quantum phenomena like Electromagnetically Induced Transparency (EIT) and Autler-Townes Splitting (ATS) which are observed in Rydberg alkali atoms under the continuous exposure of laser and RF fields. The idea is that the atoms inside an atomic vapor cell act as antennae (under controlled conditions) which can sense the fields ranging from few MHz to 500 GHz and above. The numerical and analytical simulations of the atomic model have been successfully realized at CSIR-NPL. The experimental results have also been successfully realized by working in collaboration with NISER-Bhubaneswar, the schematic is shown here in the figure. The fully functioning facility, once established at CSIR-NPL, will provide calibration for the E-field probes with traceability to the physical constants such as Plank's constant and atomic constants. Rohde & Schwarz India Pvt. Ltd. (R&S) has participated with CSIR-NPL in Prime Minister Fellowship for Doctoral Scheme by funding a Ph.D. scholar in this project.



Schematic of Experimental Setup for Quantum E-field Measurement

Fabrication of BND (2009-P): SemCali Array

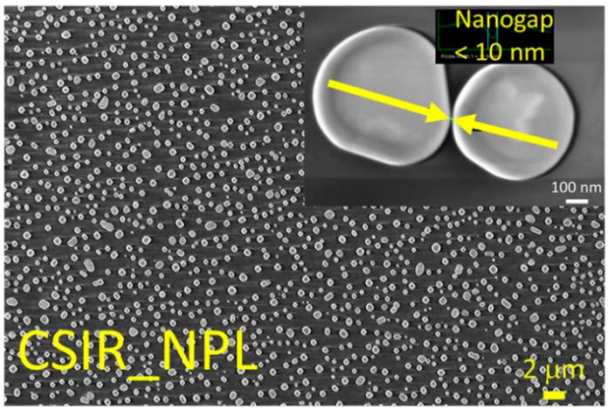
The instruments like SEM, AFM, TEM mostly use nanodimensional artefacts for the calibration purposes. There are more than 1000 SEMs and AFMs are installed in India and are routinely performing nanodimensional measurements. Presently, all the dimensional reference materials used in India are imported and expensive. It costs 5-10 times more money for purchasing dimensional reference material traceable to SI unit. Taking into consideration of this requirement, fabrication of dimensional artefacts has been already started at CISR-NPL. We have demonstrated a prototype of dimensional artefact and further production of it with traceability certificate has a direct impact on the industrial requirement.



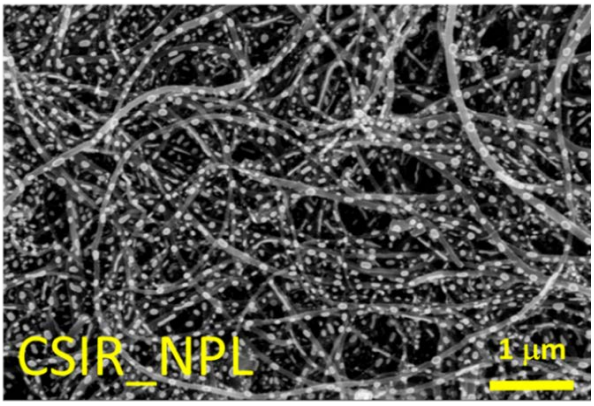
(a) The Schematics of the Nanodimensional Artefact
(b) The Actual FESEM Image of Nanodimensional Artefact Fabricated using FIB Nanofabrication Facility

Fabrication of BND (2011-P): SemRes Test Samples

High and medium quality scanning electron microscope instruments are commercially available in the market. The high resolution is one of the important parameter which decides the quality of the instruments and many available SEMs claim best resolution < 1nm. The reference materials like gold nanoislands or tin spheres on carbon separated by a nanogap are often used to get the practically attainable resolution of the SEM instrument. These reference materials contain miilions of nanogaps between the two adjacent nanoislands. FIB lab is working on such resolution SEM specimens and the following images shows gold nanoislands fabricated on Si/SiO2 and carbon nanotube substrates.

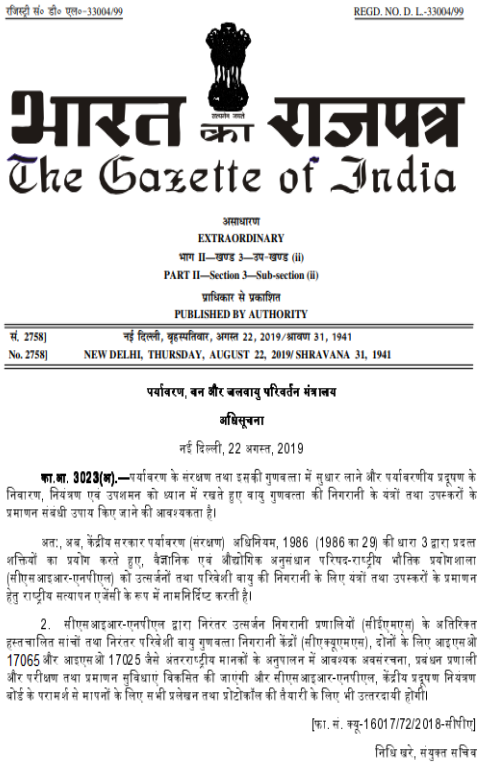


High Resolution SEM Specimen_Gold Nanoislands on SiN Substrate



High Resolution SEM Specimen Gold Nanoislands on Flexible CNT Substrate

CSIR-NPL India Certification Scheme (NPLI CS) for Air Pollution Monitoring Equipment



रजिस्ट्री सं० डी० एल०-33004/99 REGD. NO. D. L.-33004/99

भारत का राजपत्र
The Gazette of India

असाधारण
EXTRAORDINARY
भाग II—खण्ड 3—उप-खण्ड (ii)
PART II—Section 3—Sub-section (ii)
प्राधिकार से प्रकाशित
PUBLISHED BY AUTHORITY

सं. 2758] नई दिल्ली, बृहस्पतिवार, अगस्त 22, 2019/श्रावण 31, 1941
No. 2758] NEW DELHI, THURSDAY, AUGUST 22, 2019/SHRAVANA 31, 1941

पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय

अधिसूचना

नई दिल्ली, 22 अगस्त, 2019

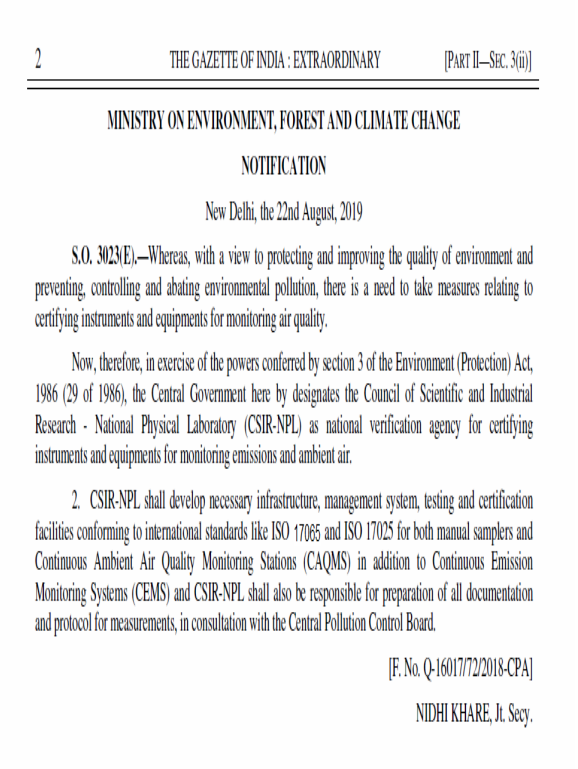
का.आ. 3023(अ).—पर्यावरण के संरक्षण तथा इसकी गुणवत्ता में सुधार लाने और पर्यावरणीय प्रदूषण के निवारण, नियंत्रण एवं उपशमन को ध्यान में रखते हुए वायु गुणवत्ता की निगरानी के यंत्रों तथा उपस्करों के प्रमाणन संबंधी उपाय किए जाने की आवश्यकता है।

अतः, अब, केंद्रीय सरकार पर्यावरण (संरक्षण) अधिनियम, 1986 (1986 का 29) की धारा 3 द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, वैज्ञानिक एवं औद्योगिक अनुसंधान परिषद-राष्ट्रीय भौतिक प्रयोगशाला (सीएसआइआर-एनपीएल) को उत्सर्जनों तथा परिवेशी वायु की निगरानी के लिए यंत्रों तथा उपस्करों के प्रमाणन हेतु राष्ट्रीय सत्यापन एजेंसी के रूप में नामनिर्दिष्ट करती है।

2. सीएसआइआर-एनपीएल द्वारा निरंतर उत्सर्जन निगरानी प्रणालियों (सीईएमएस) के अतिरिक्त हस्तचालित सांचों तथा निरंतर परिवेशी वायु गुणवत्ता निगरानी केंद्रों (सीएक्यूएमएस), दोनों के लिए आइएसओ 17065 और आइएसओ 17025 जैसे अंतरराष्ट्रीय मानकों के अनुपालन में आवश्यक अवसंरचना, प्रबंधन प्रणाली और परीक्षण तथा प्रमाणन सुविधाएं विकसित की जाएंगी और सीएसआइआर-एनपीएल, केंद्रीय प्रदूषण नियंत्रण बोर्ड के परामर्श से मापनों के लिए सभी प्रलेखन तथा प्रोटोकॉल की तैयारी के लिए भी उत्तरदायी होगी।

[फा. सं. क्यू-16017/72/2018-सीपीए]

निधि खरे, संयुक्त सचिव



2 THE GAZETTE OF INDIA : EXTRAORDINARY [PART II—SEC. 3(ii)]

MINISTRY ON ENVIRONMENT, FOREST AND CLIMATE CHANGE

NOTIFICATION

New Delhi, the 22nd August, 2019

S.O. 3023(E).—Whereas, with a view to protecting and improving the quality of environment and preventing, controlling and abating environmental pollution, there is a need to take measures relating to certifying instruments and equipments for monitoring air quality.

Now, therefore, in exercise of the powers conferred by section 3 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government here by designates the Council of Scientific and Industrial Research - National Physical Laboratory (CSIR-NPL) as national verification agency for certifying instruments and equipments for monitoring emissions and ambient air.

2. CSIR-NPL shall develop necessary infrastructure, management system, testing and certification facilities conforming to international standards like ISO 17065 and ISO 17025 for both manual samplers and Continuous Ambient Air Quality Monitoring Stations (CAQMS) in addition to Continuous Emission Monitoring Systems (CEMS) and CSIR-NPL shall also be responsible for preparation of all documentation and protocol for measurements, in consultation with the Central Pollution Control Board.

[F. No. Q-16017/72/2018-CPA]

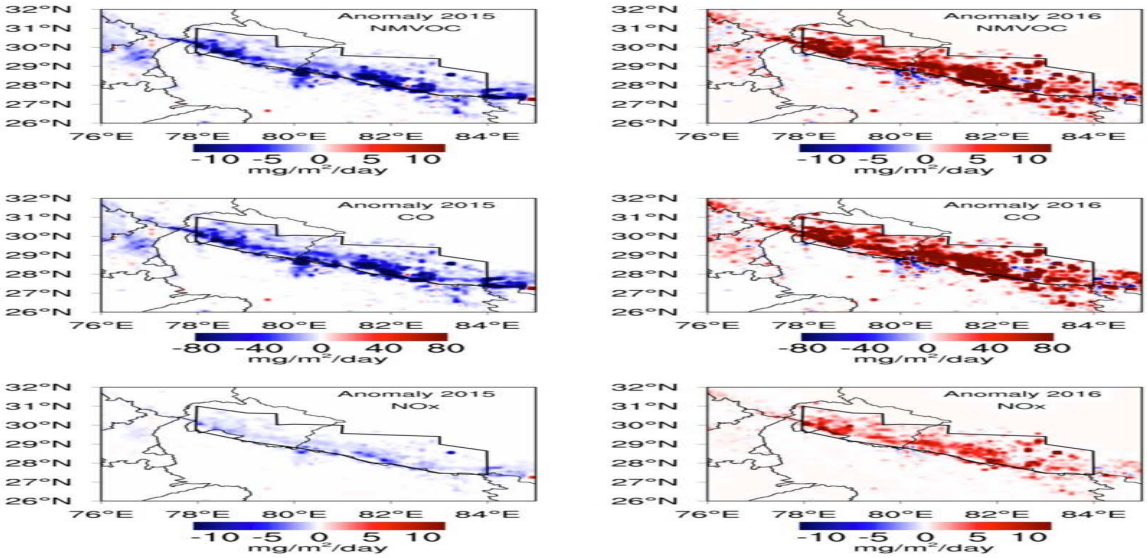
NIDHI KHARE, Jt. Secy.

CSIR-NPL being the National Metrology Institute is uniquely positioned to cater to the emerging needs of calibration in these areas because of the availability of relevant expertise and mandate of the laboratory. In view of this, the Ministry of Environment, Forest & Climate Change has designated the CSIR-NPL as verification and certification agency for emission and ambient air pollution monitoring equipment through a gazette notification No.Q-16017/72/2018-CPA dated 22 August, 2019.

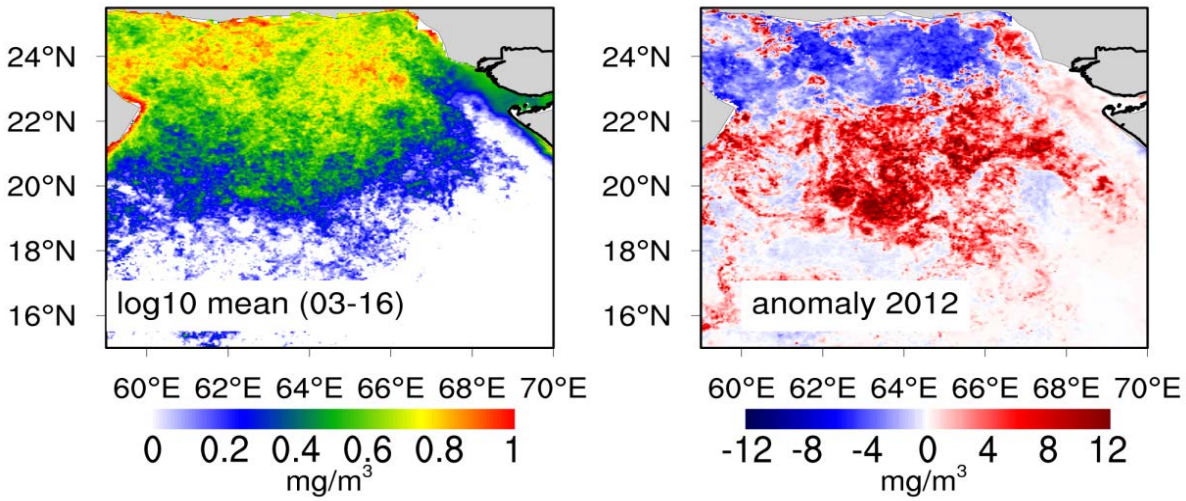
To meet this requirement, CSIR-NPL has developed a CSIR-NPL India Certificate Scheme (NPLICS) to provide certification of performance evaluation of air pollution monitoring equipment and to support the NPLI CS framework, CSIR-NPL undertake to establish a test facility for measuring the performance of OCEMS which will be first of its kind and a new national facility. This facility will facilitate indigenous manufacturers to demonstrate the quality of these equipments and overcome trade barrier in a cost effective way, and also attribute in Atamnirbhar Bharat.

The scheme will provide a complete and cost effective solution for test, calibration and certification to the Indian as well as foreign Air pollution monitoring equipment's/systems. Being signatory to the CIPM-MRA, the certificates issued by CSIR-NPL will be acceptable world-wide. This will help manufacturers of these equipments to trade in international market as well besides helping in `Make in India' program. The estimated global market value of air pollution monitoring system is US $ 3997.8 million. It is that its Compound Annual Growth Rate (CAGR) during the year 2017 to 2025 is 7.5% which means, it is expected to reach worth US$ 7, 1187 Million by the end of 2025.

Impact of Forest Fire on VOC Emission in Himalayan Region and Dust Storm on Phytoplankton Bloom in Arabian Sea



The Forest Fire in the Himalayan Region during April 2016 led to Enhanced Emission of NMVOCs, CO and NOx. The figure Represents the Anomalies in the Emission from Mean (2003-2016) during the Month of April. The Anomaly for Various Trace Gases is Calculated by Subtracting the Corresponding Mean Emissions for the Period 2003-2016 (April) from the Individual Emission of a Single Year. Large Variations in the Anomalies during 2015 and 2016 are Due to the Highest Forest Fire Episodes in 2016



A Severe Dust Storm in the Arabian Sea during March 19-20, 2012 Led to a Phytoplankton Bloom in the Region. Left Panel Shows the Mean (2003-2016) Spatial Variability of Satellite Derived Chl_a (mg m-3 on log scale) of March Month Over the Arabian Sea and Right Panel Represents the Spatial Distribution of Chl_a Anomaly for the March 2012 as Compared to 14 Years (2003-2014) March Mean

Wind Tunnel Facility

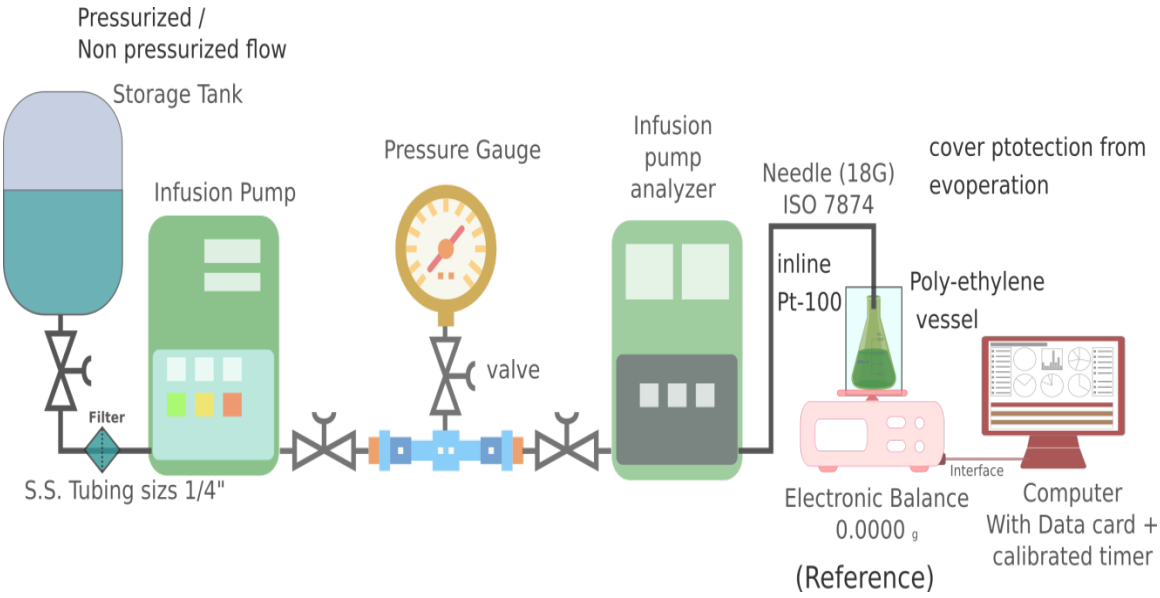
Wind tunnel facility developed indigenously for calibration of PM sampler is started for giving services to many customers in India.

Mask Testing Facility

Reliable measurements of air quality parameters are highly important as it directly relates with the health issues. Importantly, the mask test facility is established recently, where particle efficiency of surgical masks is measured for 0.3 μm particles at the flow rate of 30 liter per minute.

Design and Prototype for the Setup of Calibration Facility for Infusion Pump Analyzer

A syringe pump is extensively used in biomedical equipment. The prime application of the syringe pump is the accurate and precise delivery of drugs, blood and even nutrition, as volume (mass) is the most critical parameter in medical treatment. Gravimetric method is most preferred primary calibration method for infusion pump and syringe pump. Gravimetric principle associate the flow of a liquid to its volume delivered in the specific time. Further, the volume and density of the known liquid, at a given temperature, is directly associated with the weight of the liquid, which is measured using high precision balance, and thus obtained its traceability from mass. Biomedical metrology section has done initial tests and established prototype of same, which soon will be translated into National Standard for dissemination of traceability.



Proposed Setup of Calibration of Infusion Pump Analyzer, National Standard

Glimpses of events

during 2019-20

CSIR-NPL

Workshop on Materials Processing and Characterization (MPC - 2019); August 26 – 30, 2019

Lecture on Need for BND; August 26, 2019

Training Program on Mass, Volume, Density and Viscosity Metrology; August 28-30, 2019

Imparted training on Mass, Volume, Density and Viscosity Metrology during (28th – 30th) August, 2019 as per CSIR-NPL training calendar. Twelve participants from various laboratories, industries participated in this program.

CSIR-NPL in Collaboration with IEEE organized Authoring Workshop on 'A Better Approach to Quality Publications'; September 13, 2019

Reference Materials Manufacturer (MSME) Meeting the Scientists of BND Division; October 16, 2020

SAARC-PTB Preparatory Workshop on Inter-laboratory Comparison (ILC) for Volume and Length Metrology; November 19-20, 2019

Organized SAARC-PTB preparatory workshop on inter-laboratory comparison (ILC) for volume with eight members from BSTI, Bangladesh; BSB, Bhutan; MUSSD, Sri Lanka and NBSM, Nepal. Mr. Chanchal Chand Sarkar, Director, Economic, Trade and Finance Division (ETFD), South Asian Association for Regional Cooperation (SAARC) Secretariat and Mr. Ramesh Khadka, Deputy Director, South Asian Regional Standards Organization (SARSO) has also attended the program.

National Metrology Conclave and 6th National Conference on Advances in Metrology (AdMet 2020); January 04-06, 2020

National Metrology Conclave and 6th National Conference on Advances in Metrology (AdMet 2020) based on theme 'Redefinition of SI Units and their Implications' was held at CSIR - NPL, New Delhi, India. The event was attended by over two hundred participants from R&D, Academia and Industry Participants.

Post-AdMet Workshop: Criteria for Air Quality Measurement Devices; January 07, 2020

A joint workshop as Post-Ad Met workshop was organized at CSIR-NPL on "Criteria for Appropriate Devices used for the Measurement of Air Quality in India". More than 80 participants actively took part in this workshop

Visit of Jigyasa Students from K.V. Hapud (UP) (100 no's) on April 24, 2019 at CSIR-NPL and CSIR-NPL Open Day September 2019

Under the Jigyasa Programme of CSIR –NPL, students Mr. Bharat Reddym, Mr. Yash and Mr. Dishansh from Kendriya Vidyalaya came to CSIR-NPL on May 17, 2019. They worked on "Yellow phosphor coated on InGaN blue LED to convert highly efficient white light" with the CSIR-NPL team and demonstrated devices

CSIR-NPL Scientist demonstrated the Luminescent Materials lab and motivated the Kendriya Vidyalaya Students towards Science under the Jigyasa Programme; July 12, 2019

Demonstration of Mass Metrology Activities under Jigyasa Programme

Demonstrated mass metrology activities to the students of various Kendriya Vidyalayas under Jigyasa Program.

Training Motivation to School Children under Jigyasa Programmes on Solar PV Systems

Several batches of Kendriya Vidyalaya school children were trained/motivated on different aspects of solar energy and solar cells as well as "solar photovoltaic - as a potential green energy technology for every walks of our life". All the demonstrations were carried out in the Solar Park developed at CSIR-NPL campus.

Divisional activities

during 2019-20

CSIR-NPL

Physico-Mechanical Metrology: Division 1

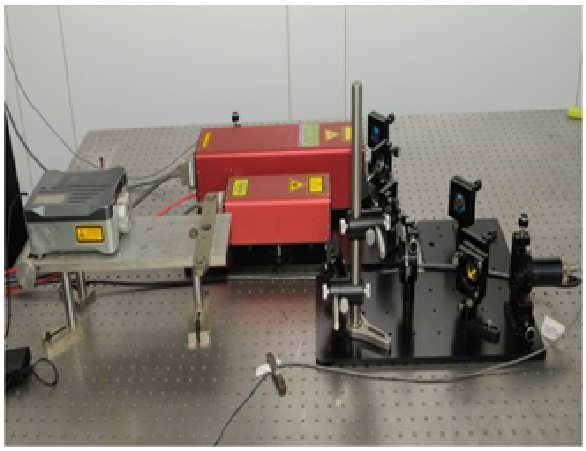
The mandate of Physico-Mechanical Metrology (PMM) division is to establish, maintain, disseminate and continuously upgradethe Physico-mechanical standards such as Mass; Length and Dimensions; Temperature andHumidity; Optical Radiation; Force and Hardness; Pressure, Vacuum & Ultrasonic; Acousticand Vibration, and Fluid Flow Metrology. PMM houses four SI base units, viz. kilogram, metre, kelvin and candela and establishing the state-of-the R&D facility for the realization of fundamental constant based new primary standards for kilogram, kelvin and pascal. PMM sub-divisions continuously participate in the International Inter-comparisons for the establishment of measurement equivalence and to get globally competitive calibration measurement capabilities (CMCs) for various parameters. This enables the international harmonization with international bodies and precision disseminations to the stakeholders of NPLI, to support the robust quality infrastructure required for various government missions such as AtmaNirbhar Bharat, Make-in-India, Vocal-for-local via supporting MSMEs.

During the year 2019-20, the division has published over 60 SCI papers, about 50 conference presentations and invited talks and few book chapters. The division has successfully conducted three training programmes in Mass, Force, Pressure and Flow parameters. A glimpse of activities of each subdivision is described below.

Mass Metrology

Mass measurements are essential for trade, technology, fundamental research etc. Reliable measurements of mass and its derived parameters which include volume, density, force, pressure, hardness, etc. are indispensable to support many diverse areas. Mass Metrology section provides traceability to the various sectors such as Legal Metrology, Space, Atomic Energy, MSMEs,Delhi Jal Board, Indian Oil Corporation, CPCB,various industries, etc. One of the important sectors is pharmaceutical industries which are making drugs and medicines. During the year 2019-20, the section has continued its efforts for unceasing upgradation of the national standards and providing traceability to the whole nation. The following are some of the significant work for 2019-20; a) Completed process for facility creation of the advanced Robotic mass comparator of 5 g and the complete operation will be commencing soon. b) Inter-laboratory Comparison for volume under the SAARC-PTB project has started with procurement of micropipettes to be used as the travelling standards. c) During the COVID-19 pandemic Mass Metrology Section has provided traceability of E_1 and E_2 accuracy class weights to the pharma companies like Zydus, Ajanta Pharma and IPCA labs which are lead producers of Paracetamol and HCQ drugs. d) Provided continuous traceability to the various fields (derived parameters) related to mass like Force, Pressure, Hardness, Vacuum, Fluid Flow, Gas, Environment, Biomedical, Advanced materials.

Length, Dimension and Nano-metrology

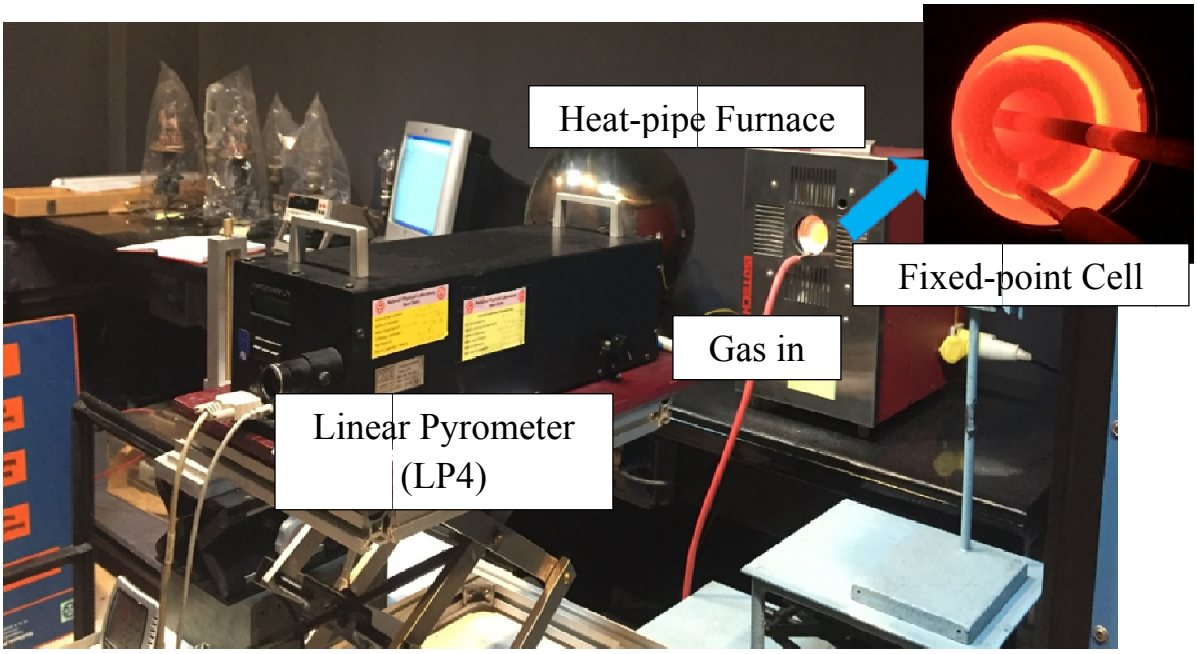


Primary Standard of Length at CSIR-NPL

Length measurement has been an indispensable part of human life since ancient era till present days. The subdivision maintains primary standard of length i.e. iodine stabilized He-Ne laser (wavelength≈ 633 nm) for realization of SI unit "meter". In the subdivision, the dimensional metrology traceability chain is maintained at national level through various state-of-the-art facilities such as liner displacement measuring laser interferometer, coordinate measuring machine, roundness measuring machine, flatness measuring laser interferometer and gauge block interferometer etc. providing apex level calibration services in dimensional metrology. We cater leading automobile industries, manufacturing industries, academic institutions, defense sectors, various CSIR laboratories, calibration industries, and SAARC NMIs contributing significantly towards socio-economic growth of the nation. In addition to this, we conduct technical workshops, training programs and provide consultancy services to various industrial segments. We are involved in numerous relevant research and development activities to augment our capabilities in dimensional metrology. We continuously pilot and participate in different international intercomparison in order to establish our equivalence in international system of measurements.

Temperature and Humidity Metrology

The subdivision maintains the primary standard of temperature and humidity parameters from -200 ^{o}C to 3000 ^{o}C and 10 % RH to 95 % RH. Apex level calibrations and traceability to SPRTs, RTDs and various resistance sensors, LIGTs, thermocouples, pyrometers, blackbodies, thermo-hygrometers, 30^{o}C to 50 ^{o}C dew/frost measurements, moisture measurements and mercury-free (electrical and IR based) clinical thermometers to NABL accredited Labs, SAARC NMIs and the government sectors lies in the mandate of division. During this year, our research activities include: (i) Development of Fe-C, Co-C and Ni-C fixed point blackbodies for high temperature thermometry, (ii) In-house calibration of IR pyrometer LP4, using indigenously developed fixed point blackbodies of Fe-C and Co-C along with Ag and Au fixed point blackbodies, (iii) Calibration of the capsule SPRTs required for the temperature mapping of the resonator for the Boltzmann constant based work, (iv) improved the CMC of TPW cell which will be used to realize the Boltzmann constant at the initial step, (v) Development of testing facility for establishing the traceability to IR forehead thermometers in India in COVID-19 pandemic.



Experimental Set-up for the Realization of Pure Metal Fixed Point Blackbodies

Optical Radiation Metrology

Luminous Intensity and Illuminance Measurement Setup

Optical Radiation Metrology at CSIR-NPL India encompasses the measurement of visible radiation perceived by human eye (photometry) and the measurements of UV to IR radiation in an absolute manner (radiometry) in certain spectral range of the electromagnetic radiation. The prime mandate of the section includes maintenance of national standards of optical radiation, realization of one of the SI base unit, 'candela', other derived parameters, namely luminous flux, illuminance, luminance, detector responsivity, correlated color temperature, spectral irradiance etc. and establishing the traceability chain of photometric and radiometric parameters to SI units. Apart from its core mandate of measurement and calibration/traceability services to major sectors which includes Lighting industry, Automotive industry, Pharma industry, Paint and Mint industry, auxiliary units of Defense sector, Micro, Small and Medium Enterprises (MSMEs), NABL accredited various calibration and testing laboratories, Public sector undertakings and other regulatory Agencies/Authorities, the section is also engaged in R&D activities in frontier areas of beam shaping, phase dislocation study, non-linear experimental optics and their metrological applications.

Light emitting diode (LED) metrology have become a priority area in the present scenario of ever increasing demand of energy, when LED based energy efficient illumination technology is paving its way as a future lighting source, phasing out the traditional energy

inefficient lighting devices. The section is tirelessly making effort to strengthen the initiatives of Govt. of India towards energy saving, reducing carbon foot prints and the quality infrastructure of the country in lighting. The endeavor to establish an apex level testing and calibration facility for such long life, energy efficient LED and LED based lightings as per national/international standards to contribute in mission programs of Govt. of India on energy saving and promotion of LED lights namely, Prakash path and Ujala schemes, has been taken up on priority to address the traceability needs of LED lighting industries and for stopping the substandard products to reach into Indian markets along with the evaluation requirements of the of lamps and lamp systems for their photobiological safety.

Force and Hardness Metrology

Disseminating the measurement standards in force, torque and hardness scales provides the apex level traceability to several user organizations. Recently, we have established an automated dead weight force calibration machine of 5kN capacity having the applied force uncertainty of ± 0.008% in this range. This machine comprises of 19 stainless steel weights including a loading hanger, out of which ten weights are having a nominal force values of 0.05kN and the remaining nine weights are having a nominal force value of 0.5kN. These calibrated dead weights are properly rested on a static horizontal platen during unloaded condition and the selected weights are properly supported by a central loading rod running through all the weights having suitable studs. This machine uses a pneumatic system with solenoid valves for engaging and disengaging the desired masses to the loading hanger by deflating and inflating the bellows fixed under the static platen. Thus, we can exert forces on the Force Transducer, which supports the upper platen of the hanger, without much oscillation and vibration thereby reducing the stabilization time between the application and removal of the force steps. This force machine can be used for calibrating force proving instruments ranging from 0.5kN to 5kN capacity according to the IS 4169, ISO 376 and ASTM E13a standards in both compression and tension mode to our stakeholders enabling them to obtain the necessary traceability with the highest classifications as per these standards.

5 kN Dead Weight Force Machine

Pressure, Vacuum & Ultrasonic Metrology

The Pressure, vacuum and ultrasonic metrology section at CSIR-NPL maintains the primary, secondary and transfer standards of highest accuracy in the pressure, vacuum & ultrasonic parameters. The group has the capability to measure pressure from 10^{-6} Pa to 1GPa.The various primary standards established are Ultrasonic Interferometer Manometer

(UIM), Static Expansion System (SES), Orifice Flow System (OFS), Force Balance Piston Gauge, Air and Pneumatic Piston Gauges, Hydraulic Controlled Clearance Piston Gauges, Large Diameter Piston Gauge, Differential Piston Gauges, Ultrasonic Power Measurements and EMAT based Non Destructive Testing (NDT) facilities. One of the recent highlights has been the CSIR approved FBR/NCP mega project for design development and establishment of Optical Interferometer Manometer: A Primary Quantum Pressure Standard at CSIR-NPL. Recently, we have obtained the effective area of air piston-cylinder assembly using the data of dimension metrology, hence now this device can be considered as primary pressure standards in the range of 6.5 kPa to 360 kPa. A detailed study has been carried out on the limitations in piston-cylinder dimension measurements uncertainty and resolution constraint for the evaluation of effective area of air piston gauges and a total re-characterization of all standards for the impending peer review has been completed. The section is strategically involved in providing calibration, technical services and technology development in the above areas to Indian industries and also engaged in R&D in the areas of Monte-Carlo/Finite element simulations, studies on materials under high pressure, synthesis of new materials, Raman metrology etc.

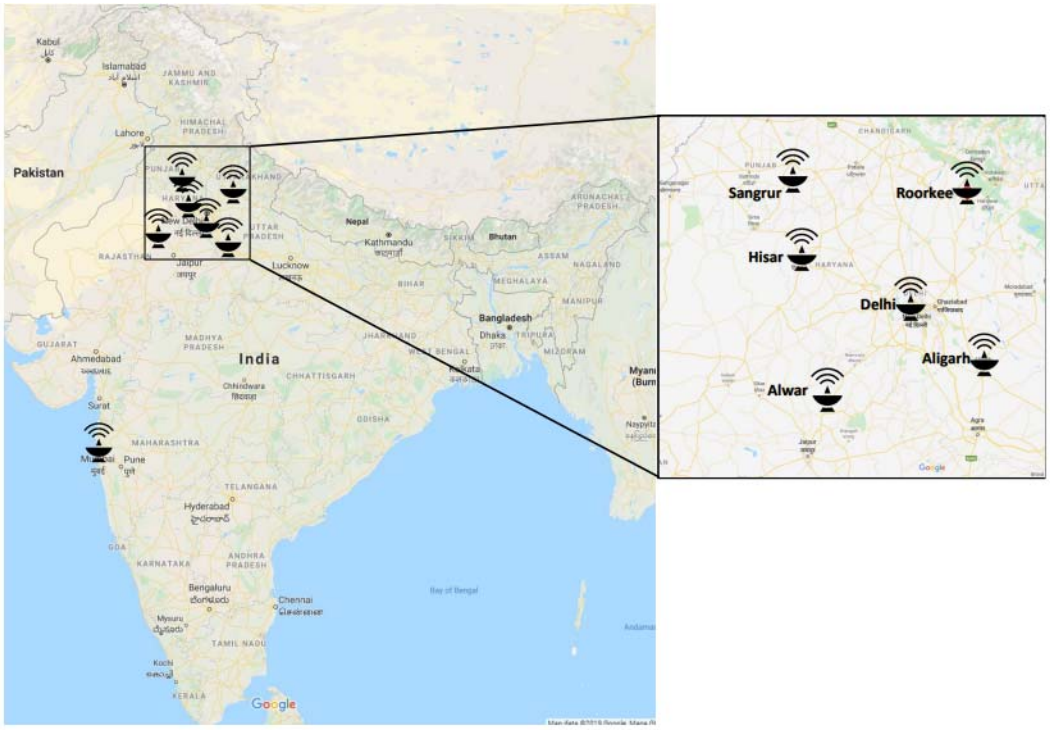
Acoustic and Vibration Metrology

The Acoustics and Vibration parameter of CSIR-NPL, since its inception, has played a key role in the industrial growth and has immensely contributed to reduce the air and noise pollution in the country. The major activities involved are calibration of acoustical instruments, evaluation of industrial products, acoustical materials, performance characteristics of audio equipment, auditorium acoustics, and noise and vibration measurements, and control. The calibration and other facilities available in CSIR-NPL in the area of Acoustics and Vibration are comparable with facilities in other countries. It is equipped with advanced instrumentation for measurement of sound and vibration and calibration of electro-acoustic equipment such as a Sound Level Analyzer, Vibration Analyzer, Sound Intensity Probe and Impedance Tube system, specialized Reverberation and Anechoic Chambers for carrying out sound insulation and absorption studies of materials and diagnosing machinery noise. CSIR-NPL had been able to provide apex level calibration and testing services and technical advisory consultancy in architectural acoustics to the industries and institutions of the country. The Acoustics and Vibration activity focuses on maintenance and up-gradation of two primary standards viz., the standard of sound pressure and standard of vibration amplitude. This activity is responsible to establish, maintain, and upgrade continually the measurement standards of sound and vibrationfor providing the apex level calibration services to the users across the country ensuring the measurement traceability in these parameters. The establishment of a self-reliant traceable sound and vibration systems and outstanding performance in recent key comparisons participated had been instrumental in strengthening the traceability chain. To date, 34 Calibration and Measurement Capabilities (CMCs) in the field of sound and vibration have been included in the BIPM database. Efforts are targeted to increase the number of CMCs in the BIPM database to solve the problems and challenges faced by industries and other stakeholders. The sub-division successfully participated in *APMP.AUV.V-K*3.1 Key Comparison in the frequency range of 0.1 Hz to 40 Hz in September 2018.The final report of International Key Comparison Exercise, APMP.AUV.V-K3.1 with Center for Measurement Standards, ITRI, Taiwan as pilot Laboratory in September 2019 revealed the degrees of equivalence of CSIR-NPL values for sensitivity and phase determination in comparison to the KCRV supported CSIR-NPL calibration and

measurement capabilities in the low frequency range of 0.1 Hz to 40 Hz. There are only very few NMIs in the APMP region having low frequency CMCs in the key comparison database.

The sub-division is working in collaboration with the Central Pollution Control Board and State Pollution Control Boards in noise mapping of cities in India for reducing the noise pollution. The National Green Tribunal (NGT), New Delhi in their orders dated 15th March 2019 has directed the Central Pollution Control Board (CPCB) of India to prepare a noise pollution map and identify hotspots and categorize the cities with specified hot spots and propose a remedial action plan. CSIR-NPL is focused on working on noise mapping of various cities of India and suggesting remedial control measures for controlling the high ambient noise levels.

- **Seven SODAR (SOnic Detection and Ranging) systems installed successfully for air quality management of Delhi - NCR. (funded by CPCB)**

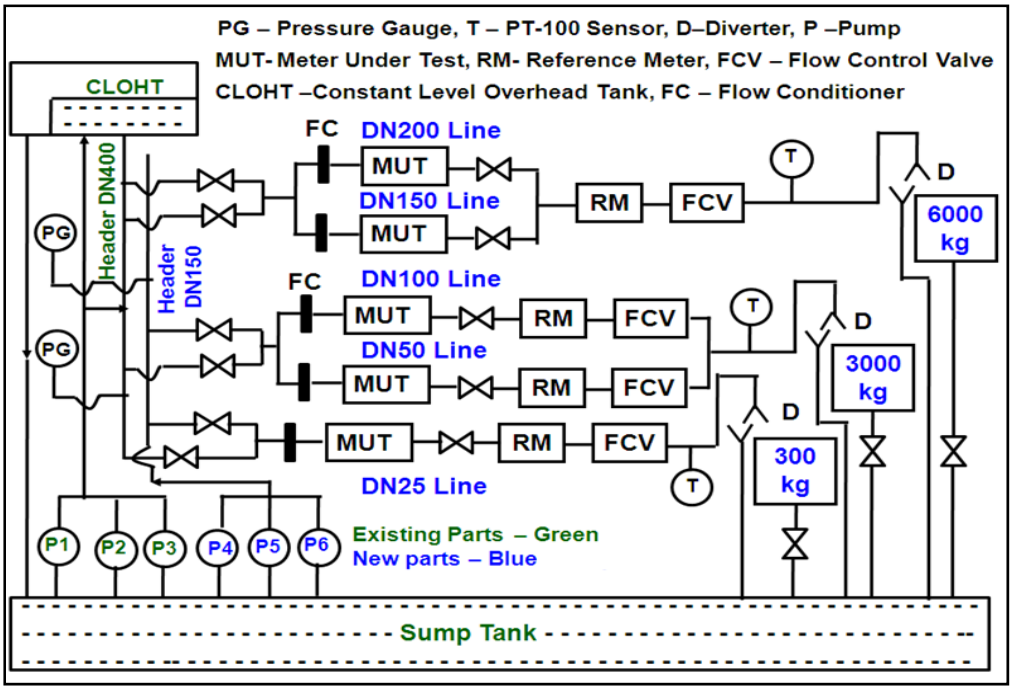


CSIR-NPL developed the SODAR System Network for Air-Quality Management of Delhi-NCR

Fluid Flow Metrology

The Fluid Flow Metrology section has mandate to establish, maintain and upgrade standards of Fluid Flow measurements and provide apex level testing and calibration services of various types of water and gas flowmeters to various users across the country. Recently, the group/section has upgraded the 25 years old Primary Water Flow Calibration Facility (WFCF) by using latest instrumentations and controls to maintain NMI status in water flow area. At present, we are providing calibration services of various types of water

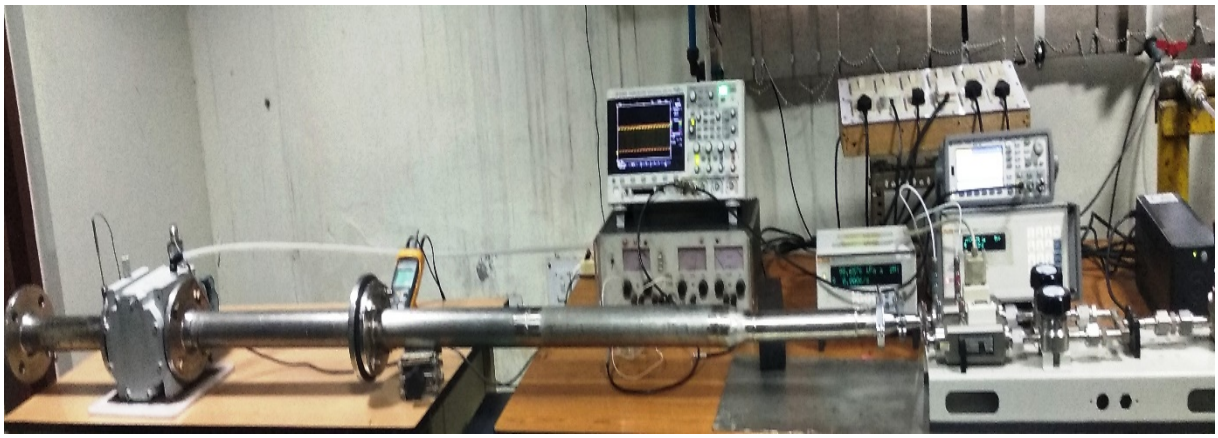
flowmeters such as coriolis, magnetic, ultrasonic, vortex, bulk etc apart from testing of domestic water meters and calibrations of various types of gas flowmeters. Below illustrated figure shows schematic diagram of new & upgraded Primary Water Flow Calibration Facility and calibration of weighing scales of Primary Water flow Calibration Facility using standard weights.



Schematic Diagram of New Water Flow Calibration Facility through Upgradation

Calibration of 6000 kg Weighing Scale for Performance Evaluation of Primary WFCF

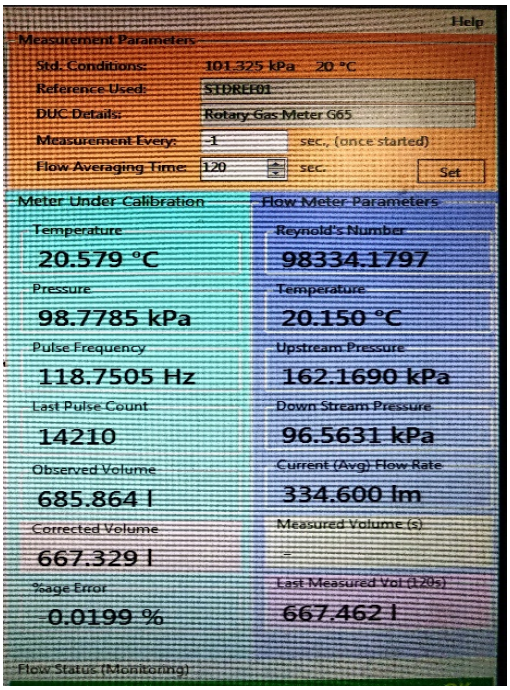
Fluid Flow Metrology Section (Sub-Division) has also participated in the APMP Keycomparison(APMP.M.FF-K6.2018)on low pressure gas flow during January-March 2020. Total nine NMIs are participating in this comparison and Rotary Gas Meter, model Delta S-flow G65 has been used as artifact. The measurements were performed and results submitted to the pilot laboratory i.e. KRISS, Korea. For this intercomparison, a fully automatic set-up was developed. Figure shows photograph of the set-up:



(a) Set-up showing Reference FlowMeter, Rotary Gas Meter, Pressure & Temperature Instrumentation, CRO, Frequency Counter and Piping System

(b) Air Receiver of 1000 L Capacity

(c) Air Compressor System and Gas Cylinders



(d) Screenshot of Automation Program

Set-up for Calibration of APMP.M.FF-K6.2018 KeyComparison Artifact i.e. Rotary Gas Meter

Electrical and Electronics Metrology: Division 2

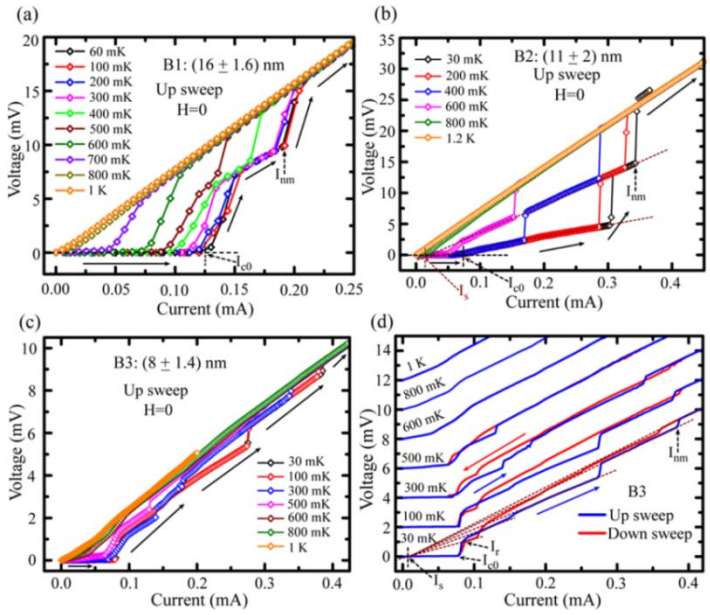
The major activities of this division are based on the research and indigenous development of quantum standards of electrical and electronic parameters. These include DC parameters such as voltage, current and resistance; low frequency and high frequency impedance related quantities such as capacitance, inductance and AC resistance; AC/DC high voltage and AC high current; AC power & energy; and quantum which includes quantum hall resistance (QHR), quantum current (QC) and quantum nanophotonics (QN). The metrological traceability of the electrical and electronics parameters to SI units is derived from Josephson Voltage Standard (JVS), Quantum Hall Resistance (QHR) standard and frequency(time) standards; all of them are being maintained at CSIR-NPL with metrological precision at par with international standards. The traceability of the aforementioned parameters is disseminated through an unbroken chain of apex level calibrations and testing at par with international level to the industries, strategic sectors,regional calibration and testing labs and R&D organization of the country to improve the quality of life, which in turn will lead to the inclusive growth of the country and economic development. The division is continuously putting efforts to upgradethe facilities for various parameters to cater the demand and needs of the country. Calibration and Measurement Capabilities (CMCs) of this Division are published on Key Comparison Database (KCDB) of BIPMand to be at par with leading NMIs. Along with these, research efforts on the development of quantum standards like single photon detection, quantum current standard, graphene and topological insulators based quantum Hall resistanceare a constant endeavour and continue to be at the forefront.Among these, the research on quantum current needs special mention as this will lead to realization of the SI unit of electric current(ampere), the only unit out of the seven base units of SI system. A glimpse of activities of each subdivision is described below.

LF, HF Impedance and DC Metrology

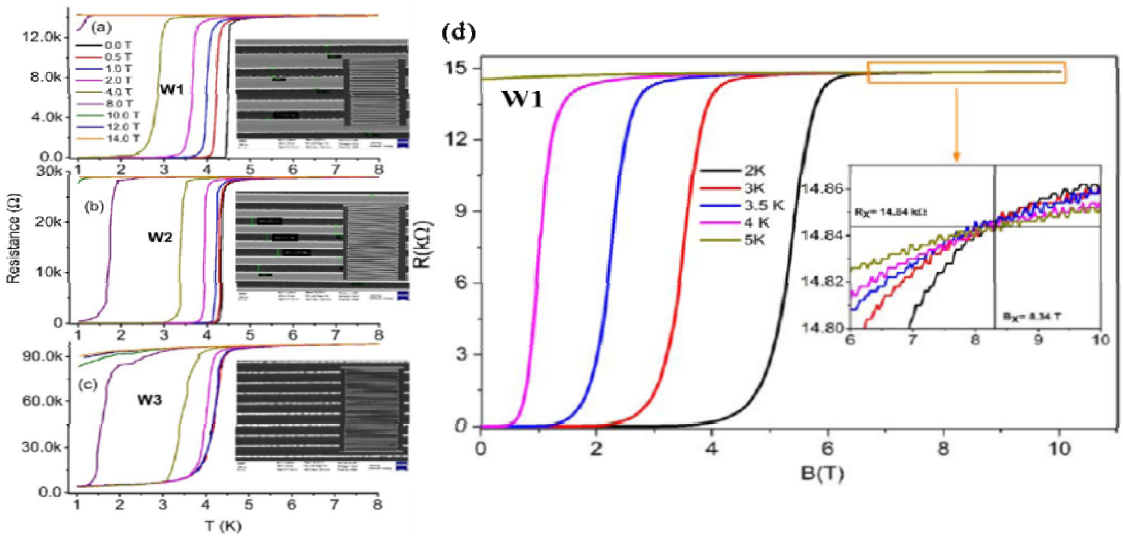
This sub-division provides calibration services for a large number of electrical parameters, standards and instruments. The laboratory is responsible for maintaining national and reference standards of impedance parameters at audio and radio frequencies, precise ac voltage ratio, dc voltage, dc current, dc resistance and dc high voltage upto 100 kV. High-voltage (HV) resistive divider is the heart of DC high voltage measurement. The traceability of HV measurements is directly related to divider's traceability to Josephson voltage standard, which is the primary standard of DC voltage.

Apart from the regular calibration and testing services, the division also has strong R&D program on the development of quantum current standard (QCS). The R&D activity on QCS assumes greater significance as the recent revision of the SI units demands that the SI unit of current (ampere) should be defined in terms of the electron charge 'e'. The QCS activity is mostly focused on the phenomenon of quantum phase slip (QPS) observable in superconducting nanowires of area of the order of the coherence length of the material. A superconducting nanowire under microwave irradiation produces Shapiro steps in current akin to the Shapiro steps in voltage for Josephson junction. We have obtained signature of quantum phase slip in Nb_2N superconductor films prepared by the nitridation of Nb films. The figuregiven below shows the signature of QPS as steps in current voltage

characteristics (CVC) measured at ultra-low temperatures. Also, we could observe signature of quantum phase fluctuations in focused ion beam (FIB) deposited W nanowires. Further, the successive figure shows the superconductor to insulator transition (SIT) observed W meander structures under an applied magnetic field. The division also has R&D programs on single electron tunneling (SET) devices and quantum condensed matter research specifically on topological semiconductors and insulator materials.

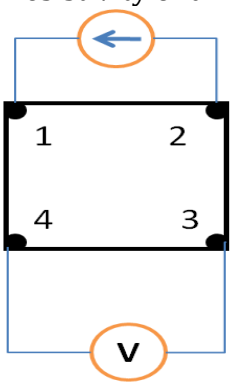


Transport Properties of Nb2N Films of Different Thickness Showing Steps in Current Voltage Characteristics at Ultra-low Temperature. (a) Corresponds for 16 nm Thick Film, (b) Corresponds for 11 nm Thick film, (c) Corresponds for 8 nm Thick Film, and (d) Shows the Shifted CVC for Both Up-sweep and Down- sweep Currents for the 8 nm Thick Film



Transport Measurements on FIB-deposited W-meanders with Varying Dimensions. (a)-(c) Temperature Dependent Resistance [R(T)] Data for Three Different Samples. The Dimensions are shown in the Insets. (d) Magnetic Field Dependent Resistance [R(B)/ MR], Measurements for Sample W1. Inset: Crossing of MR Isotherms at Single Critical Field Bx Indicates the Onset of Field Induced Superconductor-insulator Transition (SIT)

- **Establishment of Resistivity Measurement Setup using Van der Pauw Method at CSIR-NPL:** The laboratory has initiated to establish the resistivity measurement facility for solid conducting materials at CSIR-NPL using Van der Pauw Method. The method is applicable for the measurement of thin sheet conducting / metallic samples with uniform thickness. This technique used four-contact collinear probes on the boundary of flat, arbitrary shaped sample and it involves the total of eight measurements. A constant current source is used to apply the fixed current to the sample through two-contact probes and a precise voltmeter is used to measure the potential drop across the other two probes. A suitable fixture has been designed with four spring loaded contact which will be used to measure the resistivity of different metallic samples.



Schematic of Van de Pauw Method

AC High Voltage and Current Metrology

This subdivision is maintaining the National Standards of AC High Voltage Ratio upto 100kV, High Voltage Capacitance & Tan δ facility upto 200 kV and AC High Current Ratio upto 5 kA. It is providing Apex Level Calibration Services for Current Transformers, Current Transformer Test Sets, AC High Current Sources, Clamp Meters, Current Probes, CT Burdens, Voltage Transformers, Voltage Transformers Test Sets, HV Probes, Electrostatic Voltmeters (ESVM), HV Break Down Test Sets, Voltage Transformer Burdens, AC High Voltage Sources, HV Dividers, kV Meters, Capacitance & Tan δ Bridges, etc. to Power Utilities, Electrical Equipment Manufacturers and Accredited Electrical Testing and Calibration Laboratories.The subdivision is planning to enhance AC high voltage facilities upto 300kV in near future.

AC High Voltage Setup of 200kV is being Operated for Calibration

Current Transformer Calibration Set-up

AC Power & Energy Metrology

Precision Power Calibration System

The group is engaged in the maintenance and upgradation of primary standards and to disseminate apex level of measurement traceability for power and energy parameter to those who needs the best accurate and reliable measurement as per world leading NMIs.The primary and alternative power/energy standards with measurement uncertainty from 10 ppm to 150 ppm are being used to maintain traceability chain throughout the nation. As it is primary concern to fulfill industrial requirements, the laboratory provide testing services on all types of energy meters as per international/ nationalstandards such as IEC: 62053-21, IEC: 62053-22, IS: 13779, IS-14697, IS: 13010 and CBIP-88.However, under influence of conducted& radiated emission, electromagnetic HF field, fast transient burst, electrostatic discharge, surge, voltage dips and short interruptions severally affect the performance of energy meter. In this regards, the laboratory in the initiation of to establish primary Electromagnetic Interference and Electromagnetic Compatibility (EMI/EMC) Measurement facility upto 40GHz at par at par IEC 62052- 11, CISPR 22, IS 16444 (Part 1) and IS 6842 for IS 16444 (Part 2) guidelines. In addition, laboratory also initiated the process of establishing apex level for measurement facilities for Smart Metering as per IEC/IS/CBIP specifications for the growing demands of Smart Grid.

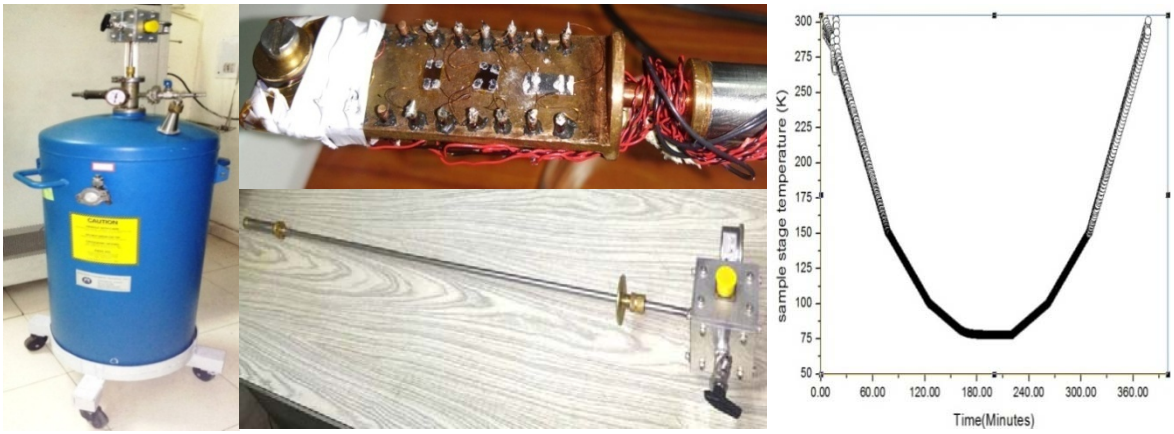
Quantum Nanophotonics Metrology

Quantum Technology has been given massive boost in India's latest budget, receiving 80 billion rupees over five years as part of a new national quantum mission. Quantum nanophotonics metrology section is working on the same technology and is part of this mission. It is working on two projects namely CSIR funded "Setting up of low temperature experimental facility towards the establishment of single photon based quantum metrology for optical radiation" with the objective of establishment of several measurement facilities in a low temperature and high magnetic field measurement platform for the characterization of superconducting thin films and nanowires is proposed in this scheme and DST funded "Advanced single photon detector and establishment of single photon detection based quantum standard for QuEST" with the objective of (a) Single-photon detection system – design, optimization and performance demonstration and (b) Establishment of single photon detection based quantum standard. Superconducting thin films using different materials were deposited and their performance was studied at low temperature to find out the suitability of material for its application as single photon detector and detailed study about perspective of setting up metrology infrastructure in CSIR-NPL has been performed. Few outcomes of the research work are as follows:

- R-T results for 130 nm YBa2Cu3O7-x film so far showed Critical temperature in the range of 87K to 92K and transition width in the range of 5K to 6K.
- NbTiN thin films deposited on the MgO (001) single-crystal substrate by DC Magnetron sputtering at 600^{0}C for epitaxial growth with varying partial pressure of Nitrogen and

Argon gases. Non linear behavior of superconducting transition temperature with nitrogen concentration was found in RT measurement.

- **Design and Fabrication of Low Temperature Transport Measurement Probe**
  - Fabrication of probe is completed
  - Probe tested in vacuum as well as in pressure @ 1Kg /cm2
  - Labview programme for measuring transport properties is designed
  - Probe tested through entire temperature range from 300K -77K-300K
  - Designed & fabricated measuring box having facility to measure three samples at a time



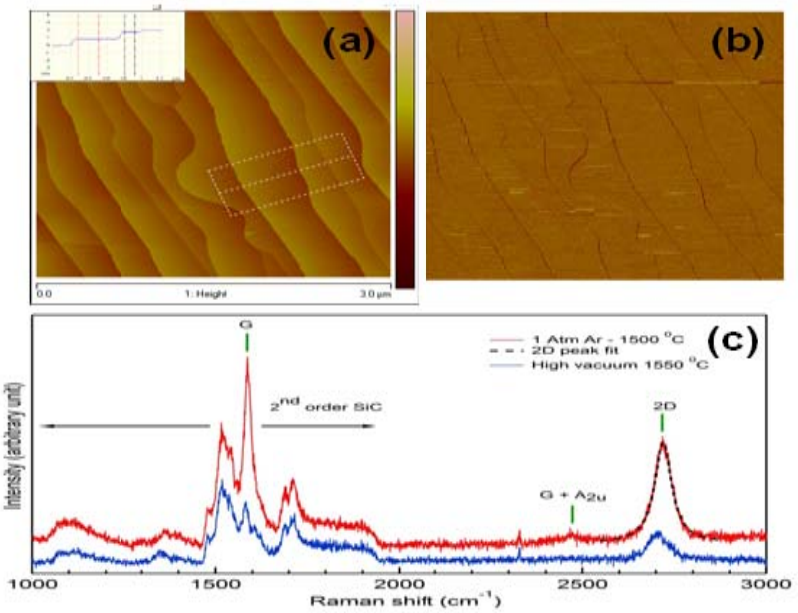
(a)Setup with Probe immersed in Liquid Nitrogen Dewar (b) Lower Part of Probe showing Connections (c) Low Transport Measurement Probe (d) Temperature vs Time Measurement for Increasing as well as Decreasing Temperature

Quantum Hall Resistance Metrology

The measure of electrical resistance is very fundamental to electrical/electronic metrology. Quantum Hall Resistance Standard (QHRS) provides an invariant quantum standard of resistance in terms of the fundamental constants. The Quantum Hall Effect (QHE) is a characteristic of a perfectly quantized 2-dimensional electron gas (2DEG) system realized in Si-MOSFETs, GaAs/AlGaAs quantum wells, Graphene, etc. at low temperatures and intermediate to high magnetic field.The group carries out exhaustive work on the design and computational modeling of new 2DEG systems, their growth and magnetotransport characterization. This effort is directed towards the realization of QHE and related quantized phenomena in epitaxial graphene and oxide heterostructures (LAO/STO and similar artificial structures) and quantum anomalous Hall effect in magnetic topological insulators.

This group is aiming to develop indigenous technology/devices for the realization of graphene based quantum Hall resistance standard (QHRS).Graphene growth is being performed in custom built growth system. This indigenous customized epitaxial graphene growth system has been designed and fabricated and commissioned at CSIR-NPL.AFM image of monolayer epitaxial graphene grown on 4H-SiC (1000) are shown in the figure (a), (b). It is evident from the figure (a) that graphene covers underneath SiC surface like a carpet and height profile shown in the inset shows clearlythat unit cell height (1 nm) of 4G-SiC is intact even after the growth.

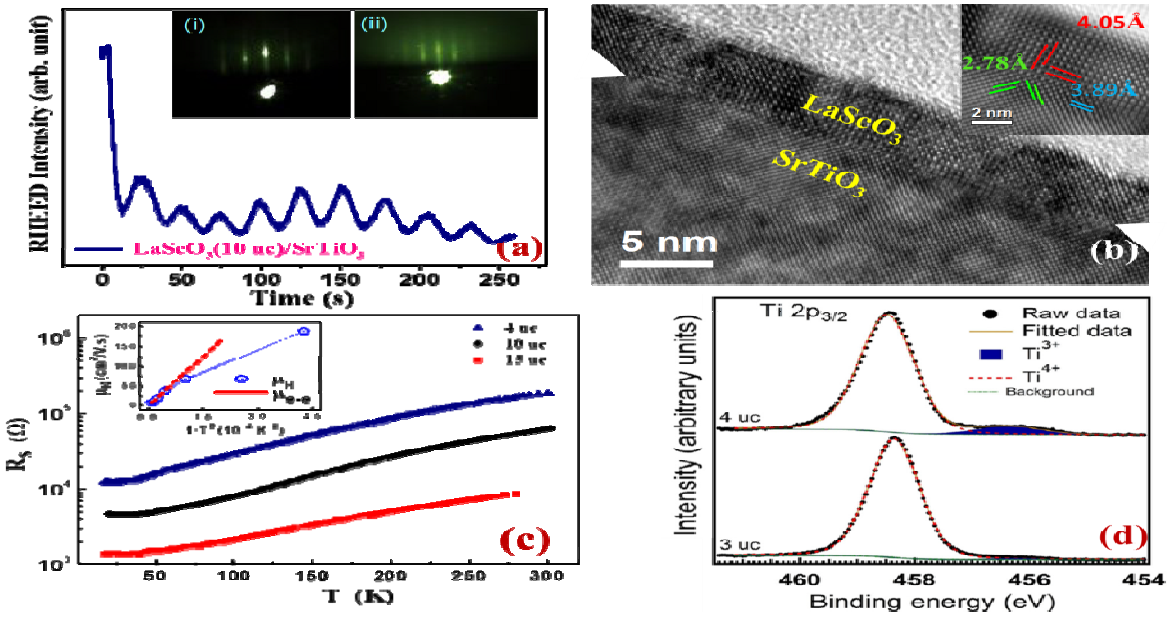
Phase contrast image shown in figure (b) demonstrates the uniformity of grown graphene. Figure (c) exhibits the Raman spectra of graphene grown in Ar gas environment, vacuum conditions (~5 x 10^{-6} mbar) at 1500 – 1500 ℃. There are two important features to look for graphene in Raman spectrum, G (1580 – 1590 cm^{-1}) peak associated with in-plane vibration mode of graphitic carbon and 2D (~ 2700 – 2770 cm^{-1}) peak associated with double phonon scattering. In figure (c), we can observe both G and 2D peaks for both the samples along with multitude of features at lower wavelength range (1000 – 2000 cm^{-1}) originating from underlying SiC substrate. For graphene grown at vacuum environment, G and 2D peaks are diminished compared to growth at Ar gas environment. It shows growth at Ar gas environment is favorable to better quality graphene.Peak position and FWHM of 2D peak of graphene grown at Ar gas environment turns out to be 2715 ± 6 cm^{-1} and 50 ± 0.45 cm^{-1}, respectively and these numbers support the monolayer thickness of grown graphene.



AFM Image (3 x 3 µm), (a) Topography Image and (b) Phase Contrast Image of Epitaxial Graphene Grown on 4H-SiC (1000) at 1500 ℃, 1030 mbar Ar Gas Pressure along with Height Profile [inset of (a)] across dashed Line shown in (a). (c) Raman Spectra of Epitaxial Graphene Grown at Ar Gas and High Vacuum Environment

In oxide based 2DEG system, $LaScO_3/SrTiO_3$,new 2DEG heterointerface is studied to probe the quasi-2DEG on the basis of theoretical study that is followed by experimental study. The epitaxial thin films of $LaScO_3$ with varying thickness(3–15 unit cell) are deposited on the (001) TiO2-terminated$SrTiO_3$ single-crystal substrate by the pulsed laser deposition (PLD)technique with layer-by-layer growth monitoring by in situ reflectionhigh-energy electron diffraction (RHEED).The following figure (a) shows the regular RHEED intensity oscillations for 10-unit cell (uc) thick films recorded in situ during the growth, whichclearly exhibits the two-dimensional (2D) epitaxial growth of the$LaScO_3$. The 2D streaky RHEED pattern shown in the inset of(a) in the following figure confirms the layer-by-layer growth for the $LaScO_3$ film withidentical distance between two streaks to that for the $SrTiO_3$ substrate. The Fourier filtered XTEM image for the samemicrograph shows an atomically flat and coherent heterointerfacewith smooth relaxation in the thin film [see (b) of the following figure], excluding anycation inter-diffusion between the substrate and thin film.Electrical transportR(T), shown in (c), confirms the conducting nature of the deposited films which have a thickness equal or above to critical thickness i.e. 4-unit cell (uc) [see(c) of the following figure], which indicates the q-2DEG formation at the $LaScO_3/SrTiO_3$heterointerface. And the mixed valence state of Ti atoms which are responsible for conducting carriers is cross checked by x-ray photoelectron spectroscopy(XPS). For nonconducting $LaScO_3$ (3 uc)/$SrTiO_3$, spin-orbit doublet peaks of Ti

$2p_{3/2}$ and Ti $2p_{1/2}$ appear at 458.4 and 464.2 eV core level binding energy(BE), respectively, corresponding to the 4+ charge state of Ti ions. Incomparison, for the conducting $LaScO_3$ (4 uc)/$SrTiO_3$, peaks correspondingto Ti^{4+} appear at 0.1 eV higher BE compared to 3 uc$LaScO_3$/$SrTiO_3$. Besides, we can clearly observe the emergence of anextra well resolved feature at the lower BE side of the Ti $2p_{3/2}$ mainpeak of 4 uc $LaScO_3$/$SrTiO_3$.



RHEED Intensity Oscillation during the Growth of the Thin Film along with the RHEED Pattern of the Bare Substrate (i) and Thin Film (ii). (b)XTEM Image of the 10 uc Structure along with Fourier Filtered XTEM Image shown in Inset of figure (b). (c) The Thermal Variation of Sheet Resistance showing a Metallic Behavior. The Inset shows the Hall Mobility of the 15 uc $LaScO_3$/$SrTiO_3$ Structure Plotted against $1/T^2$ with a High Temperature Linear Variation (red line), Corresponding to e-e (2D) Interactionsand (d)Ti $2p_{3/2}$ Core-level Photoemission Spectra for 3 uc and 4 uc $LaScO_3$/$SrTiO_3$. Experimental Spectra (open circles), Fitted Spectra (green solid line), Deconvoluted Components used to Fit Ti^{4+} (red dashed line), and Ti^{3+} (blue shaded) along with the Simulated Shirley Background (pink dashed line) are also shown

Environmental Sciences and Biomedical Metrology: Division3

The Environment Sciences & Biomedical Metrology Division (ESBMD) of CSIR-NPL has been promoting the quality measurements in the domain of atmospheric pollution and biomedical metrology under its mission project through working with different stakeholders. The division has five specialized subdivisions i.e. Atmospheric Sciences and Metrology, Gas Metrology, Biomedical Metrology, Theoretical Environment, and Sensor Devices & Metrology. Each of the five subdivisions has been ceaselessly working on the national issues related to the field of environment, gas standards and sensor development and biomedical. A brief outline of the activities of each subdivision has been described below.

Atmospheric Science and Metrology

In the field of environmental monitoring, the data quality has posed a major challenge as the reliability of such measurements needs to be ascertained. The role of instruments and calibration are the major issues that need to be addressed. While most of the instruments which are used are usually imported, comes with certifications from agencies like USEPA, TUV, and MCERT etc. These certificates are issued on the basis of environmental conditions of the certificate issuing country, which are very different from the environmental conditions prevalent in India. This affects the quality of measurements by the instrument operation in the long run in Indian conditions. Therefore, the certification process needs to be updated at regular intervals. However, at present no certification system is available in India for environmental monitoring equipment's.

The traceability of measurement is also an integral part of the generation of reliable data. In December 2018, the Ministry of Environment, Forest & Climate Change (MOEF&CC) had designated the CSIR-NPL as the "Certification Agency" for Air Pollution Monitoring Equipment's. In view of this, the subdivision has been actively working to establish a testing and calibration facility for various automated Air Monitoring Systems (AMS) especially for Continuous Emission Monitoring Systems (CEMS) and Continuous Ambient Air Quality Monitoring Systems (CAAQMS). This would be a new national facility to provide Certification in the upcoming time. It will buttress the process of removing the major barriers in ensuring the quality of environmental monitoring data from various sources.

This subdivision also measures various atmospheric species including greenhouse gases and particulate matter to study their chemical and physical properties and identifying their roles in influencing the atmosphere and climate through state-of-the art instruments and models. The Environment Sciences & Biomedical Metrology Division is currently working on developing best practices for accurate measurement of atmospheric trace species for adoption by different agencies and institutions in India engaged in atmospheric monitoring. The Work in this field is of great importance as air quality and climate change has direct impact on human health and ecosystem. The improvement in measurement quality will have societal benefits as it will foster better policy formulations for the amelioration of air quality and mitigation of climate change. This subdivision is also engaged in developing low cost indigenous monitoring equipment for air pollution

measurement. Further, it is also involved in the characterization of the ionized and non-ionized atmospheric media over Indian latitudes, Polar Regions and terrestrial environment. The scientific activity involves radio propagation study for the purpose of betterment of radio communication, navigation, atmospheric coupling processes (in lower and upper atmospheres), ionospheric precursor studies and other societal/strategic applications. Henceforth, the subdivision also provides ionospheric forecasting to users worldwide through the space weather Regional Warning Centre (RWC, NPL-India).

Gas Metrology

The mandate of this subdivision is realization of mole in gas measurements throughgravimetric preparation of gas standards and to provide traceability for greenhouse gases, pollution gases, emission and air quality measurements as per National Ambient Air Quality Standards (12 parameters). This group is disseminating services to various stakeholders through calibration, testing, training, consultancy projects and providing traceability via primary reference gas mixture (PRGM) standards. Consultancy services are available in gas and aerosol metrology area to solve the pollution related problems e.g. control efficiency testing, filter testing, performance testing of sensors and analyzers, etc. This group had also rendered support to the CSIR-NPL in-house research work for gas sensor development by providing gas mixture standards of CO and SO_2 in nitrogen. The group periodically participates in international pilot & key comparisons at BIPM and APMP level for various gases in nitrogen matrix for international comparability. To establish NPLI capability at international level, during this period,successfully participated in international inter-comparison viz.APMP- QM- S15 Carbon dioxide in Nitrogen (1000 µmol/mol); APMP- QM-S9.2017 Carbon monoxide in Nitrogen (100 µmol/mol); APMP.QM-S13: Nitrous Oxide in Nitrogen (1000 µmol/mol) and APMP-QM-S7.1 – CH_4 in nitrogen (2000 mmol/mol). This group also developed PRGM of CO_2 in nitrogen (13%mol/mol), CH_4 in nitrogen (2.5 %mol/mol), CO in nitrogen (50 µmol/mol) and NO in nitrogen (100 µmol/mol) for dissemination to the industry. These PRGMS were prepared as per ISO 6142, validated by GC as per ISO 6143 and certified according to ISO 6141.The four PRGM certificates issued to the customer were BND6002/M1804005088; BND6005/M1812010021; BND6015/M1812010011; BND 6017/M1503004039 along with the material safety datasheet (MSDS) for all the four standards. Gas metrology group also provide testing facility to meet national testing needs for VVIP Security by testing of R-22 gas every year. Final Report of APMP.QM-P30 'Calibration solutions of As, Ni, Pb and Fewhich was jointly coordinated by NPL India and KRISS Korea, was written by this group and discussed in APMP-2019 at NMI Australia.

Biomedical Metrology

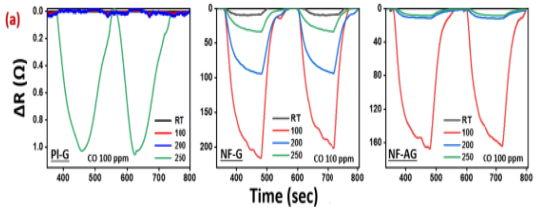
The Biomedical Metrology section at CSIR-NPL contributes enormously to the healthcare sector of the country by providing calibration and consultancy services to accredited laboratories, hospitals and testing laboratories etc. The section is working on the development of primary/secondary standards for biomedical equipment to cater the need of Indian healthcare sector and supporting the national quality health care systemunder the provisions of "Medical Device Rule 2017". We have established a calibration facility for a life saving device, Defibrillator. Defibrillator is lifesaving equipment widely used in emergency situations towards recovery of fibrillating heart. Defibrillator works by supply biphasic pulse to patient with energy levels in range of 50J to 360J. It is critical to supply defined energy to patient as per physiological conditions; else either treatment will be ineffective or may even result in loss of life. Thus, it is extremely essential to keep

instrument calibrated with high precision The section is also working for the establishment of primary/secondary set ups for providing calibration services to other biomedical equipment such as Infusion and syringe pumps, incubator analysers etc.Besides this, the section is also involved in the R & D activities pertaining to development of clinical diagnostic devices.

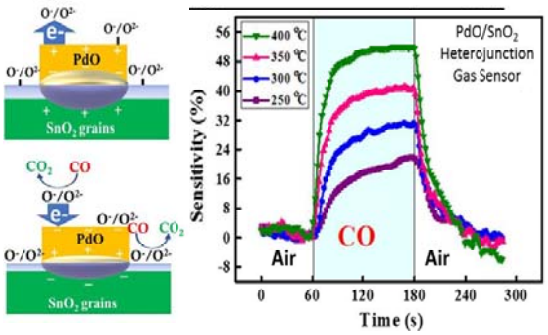
Sensor Devices & Metrology

Sensor Devices and Metrology (SDM) group is actively engaged in the development of nitride and metal oxide based efficient gas sensing and photo-sensing devices.Recently, the group has developed catalyst-free nanostructured GaN and AlGaN/GaN based CO sensors operable at room temperature operating is feasible using surfaces, though further research is required for optimization of device performance. Catalyst free CO sensing measurements divulged a sensitivity of 33% along with a response & recovery of 94 & 44 seconds at 100^0 C using nanostructured AlGaN/GaNheterostructure. Lower barrier height, electron accumulation and higher amount of surface native oxide (especially O2- species) of nanostructured surfaces enhance CO adsorption and yield optimum sensing efficiency.Semiconducting metal oxide-based gas sensors added with sensitizers are attractive for toxic gas detectionSnO2/Au multi-layered heterostructures based CO gas sensors have been fabricated by thermally oxidizing Sn/Au multilayer structure. The electrical properties of SnO2/Au multi-layered heterostructures were deliberated in the temperature range 25-300 °C and sensing of gas was performed for CO (100ppm). A significant enhancement in CO sensing at 300 °C was observed and sensitivity of 30.81% (plan SnO2) is reported which increased to 67.46% for SnO2/Au multi-layeredheterostructures. PdO/SnO2heterojunction gas sensors were developed using vacuum evaporation process and tested for their sensing performance towards 915 ppm of calibrated CO molecules. A maximum CO sensitivity of 52% is obtained at 400 °C with a lowest response/recovery time of 34/46 s due to the effective formation of PdO/SnO2heterojunction, which is four times higher than pure SnO2 sensing layer.The group has also successfully demonstrated the process for development of metal oxides based memory devices utilizing unbalanced magnetron sputtering. Besides, the group has successfully developed GaN nanostructured and ZnO/GaNheterostructure based efficient ultra violet photodetectors. In addition, current transport and band alignment of two-dimensional (2D) Molybdenum disulphide (MoS2) with GaN and AlGaN thin films are thoroughly investigated on an industrially-

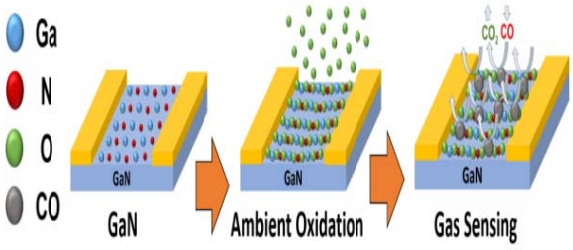
Sensing Mechanism at GaN surfaces



Change in Resistance (ΔR) due to 100ppm CO Sensing at various Temperature@2Vbias



Sensing Mechanism and Characteristics of PdO/SnO_2 Senor for 915ppm CO Gas



compatible silicon platform. These 2D/3D heterojunctions are promising to cover broadband photodetection from UV-A (UV-B) to visible solar spectrum.

Sensor metrology is an inevitable requirement for our country to realize valid air pollution measurements and quality assurance of indigenous gas sensor production. our group is also in the process of establishing a “National Facility for Testing & Calibration of Solid State Gas Sensors” which will provide a complete and cost effective solution for test, validation and certification to the Indian as well as foreign manufacturers of solid state gas sensors.

Advanced Materials and Device Metrology: Division 4

The Division of Advanced Materials and Device Metrology aims towards synergizing the research, development and their metrology for state-of-the-art bulk and nano-scale materials, process technologies and devices for industrial, strategic, health, energy and societal applications. The central aim is to design and develop the materials with metrological grade to convert into all laboratory research invention to innovation, which will directly help all industrial sectors to promote their quality products with world class infrastructure. The thrust is on the development of indigenous, economically viable and efficient organic and inorganic photovoltaic and thermoelectric devices, luminescent materials, advanced carbon based materials, composites and products. During the year 2019-20, the division has continued its efforts to undertake the above mandated research and development through several International and National projects, including Consultancy, Collaborative, Grant-in- aid and Sponsored projects. A glimpse of activities of each subdivision is described below:

Photovoltaic Metrology

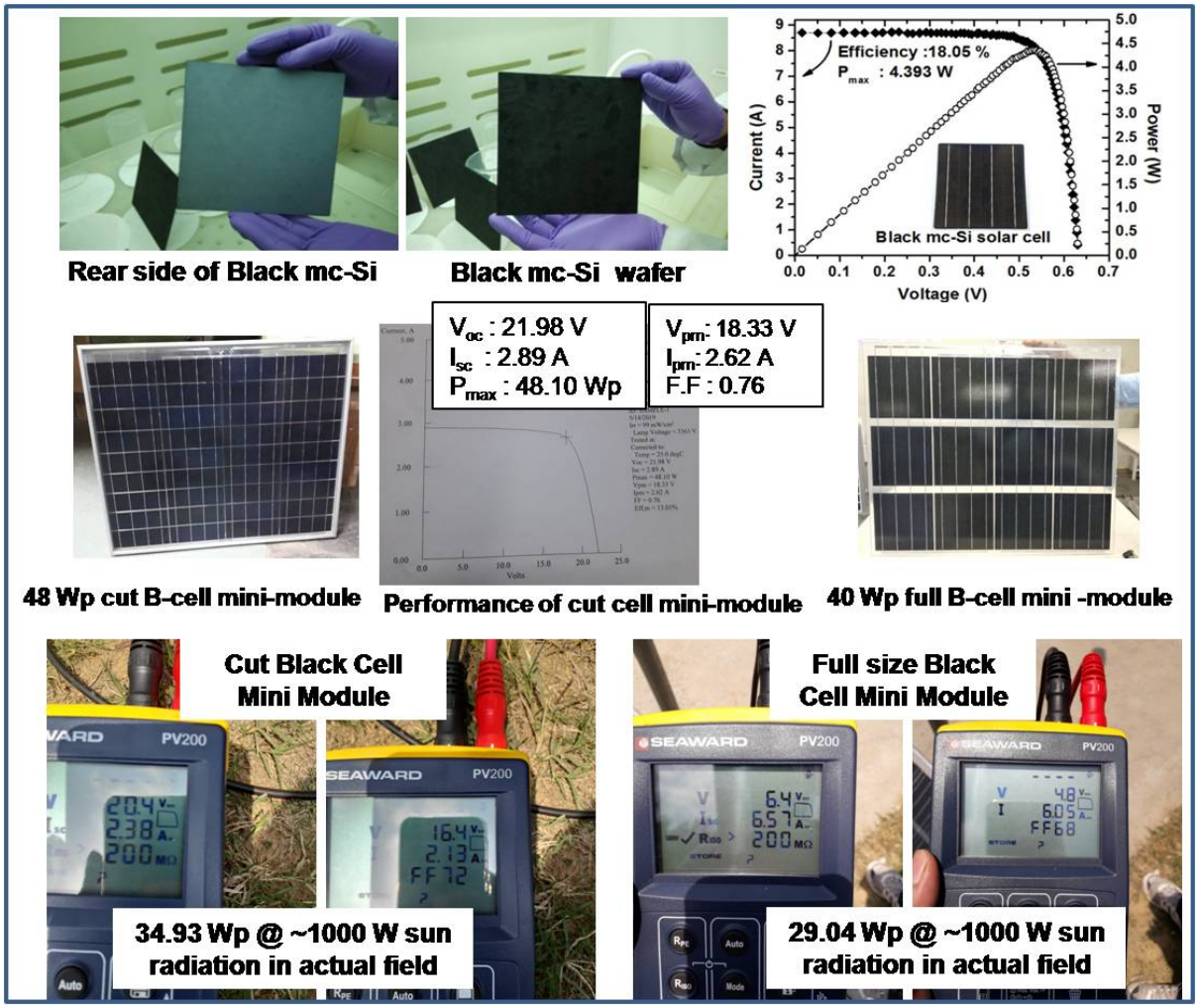
This subdivision is actively involved in basic and applied research spanning from wafer based silicon photovoltaic technology, thin film to latest concepts such as organic and perovskites based photovoltaic devices development, testing and measurements. The major focus is to develop efficient and cost effective photovoltaic devices, develop protocols for precise and accurate measurements of PV cells and modules as well as generating skilled manpower for supporting Indian PV sector. The group is currently engaged in the following R&D activities:

- **Photovoltaic Metrology**: Setting national primary standard for solar cell calibration, secondary cell standard and national centre for photovoltaic module testing
- Validation of solar cell efficiency
- **Silicon-based Photovoltaics**: Unit process development for addressing optical, electronic and electrical losses
- **Thin Film Photovoltaics**: Amorphous/microcrystalline silicon & HIT solar cells
- Organic and Perovskites photovoltaic devices
- **PV Modules**: Performance analysis, energy yield and degradation related investigations specific to Indian climatic conditions
- **Training Programmes**: Solar photovoltaic systems, fundamentals, design and metrology

The highlights of the achievements of the subdivisions are as follows:

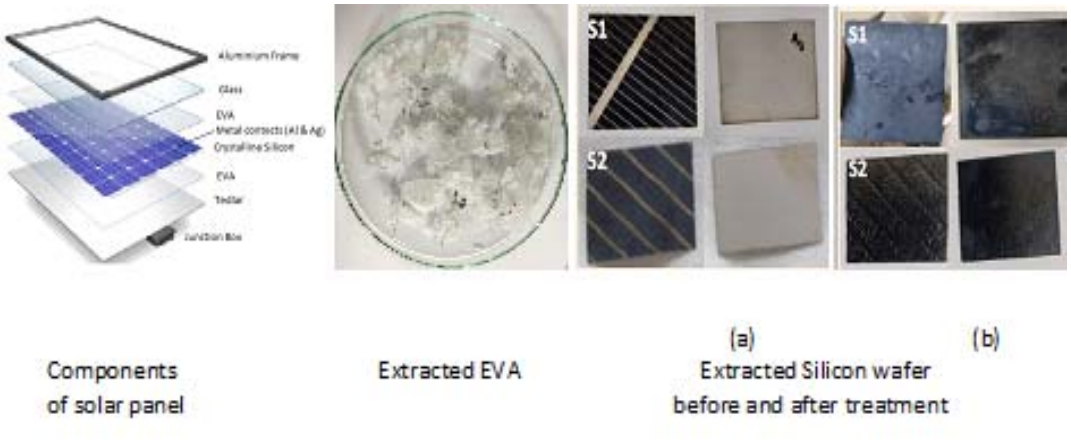
- **Blackmc-Si Photovoltaics: Minimodue Fabrication and Performance Testing:**The lab level black Si concept has been demonstrated in industrial line **on 156 x156 mm^2 multi-crystalline silicon wafers** with **champion cell efficiency >18.0%** (Ave.:~17.75% over 10 cells' batch). **The performances of the black cells are better.**

Further,the **black mc-Si cell based mini-modules (48 Wp and 40 Wp capacity**) have been manufactured (in collaboration with M/s CEL) for its performance evaluation in the actual field and further trials before putting in the pilot line at TATA Power Solar Systems, Bangalore. The 48Wp minimodule consisted of cut-cells (each black cell cut into 3 pieces of equal dimensions) and therefore the ct-cells mini-module consisted of 36 pieces, all connected in series to increase the output voltage and keeping lower output current. In contrast, the another minimodue based on full size black mc-Si solar cells, consisted of 12 solar cells, all connected in series. This minimodule has lower power output (~40 W). It has lower voltage of ~7 Volts and current of 6.0 Amps. The performance of the minimodules was tested in the manufacturing facility at CEL. Thereafter, both the minimodules were tested in field under sun light conditions. The output power in both the cases was ~10Wp lower due to various conditions including the outdoor climatic conditions and variation in the spectrum and radiation intensity. The performance of the minimodules were tested regularly in the field conditions and no obvious degradation in the performance of any module could be observed indicating that the black mc-Si solar cells based modules can work in the field effectively. The representative results of one of the best black mc-Si solar cell and black mini-modules tested under actual field conditions are given in the figurebelow:



Highlights of Achievements on Black mc-Si Solar Cell Technology Concept: Lab Concept to Field Test

- **Recycling of Crystalline Silicon Based Solar Cells & Modules:**Solar photovoltaic (PV) panel are not so green if its scrap is not suitably handled after the end of life (EOL) of these panels, which is usually 25-30 years. Thus, disposal of PV systems will become huge problem in coming years in view of the continually increasing installation of PV modules in India and across the world. The EOL modules can be recycled for recovery of toxic as well as valuable materials from it, which demand sustained R&D efforts toward process development for the same. Therefore, CSIR-NPL has initiated the work on recycling of silicon (Si) solar cells & modules.We at CSIR-NPL were successfully able to recover EVA and silicon wafer from the waste solar panel. Ethylene vinyl acetate **(EVA)** is a random co-polymer of ethylene and vinyl acetate, which we extracted by thermal/mechanical as well as by chemical process, for utilization in same or different applications. The same can be reused for the encapsulation of solar cell/solar module and also for other application such as electrical insulation, low temperature sealing, packaging, hot melt adhesive etc.



Various Components of Solar Panel

Extracted components (EVA and Silicon Wafer)

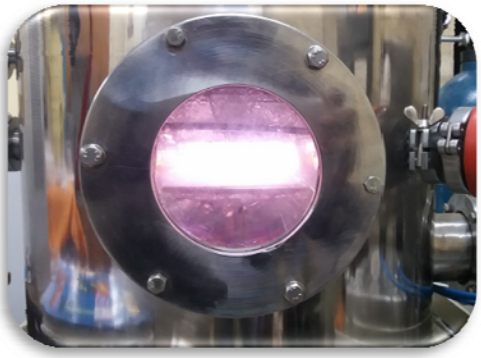
Silicon Waferis a thin slice of semiconductor material, such as crystalline silicon (c-Si), used in microelectronics for fabrication of integrated circuits, inPVs to manufacture solar cells and for many other devices.Experiments were carried out for the extraction of silicon wafer from the solar panels and extracted wafer were processed to make them reusable. As the extracted wafer has shown encouraging result, it seems that if we could recover the wafer as a whole (unbroken), they can be useful for the fabrication of solar cells and other application. Hence, there is an urgent need, to look out for the piling up of solar waste and to develop simple, efficient, eco-friendly process to safely recycle the used solar panels. As wafer cost accounts for almost 50% cost of the solar cell, reusing recycled wafer might be helpful in reducing the cell processing cost as well as hazard to our environment.

- **Development of Solar Chulha:**Main aim for developing the Solar Chulha is to provide appropriate cooking technology while considering the health and environmental impact. Till now, many solutions have been provided by many researchers/technologist but the same are often not readily adopted for reasons including inconvenience, safety issues, dissimilarity to traditional cooking methods, inability to work in absence of grid connected power, energy inefficiency and cost issues.

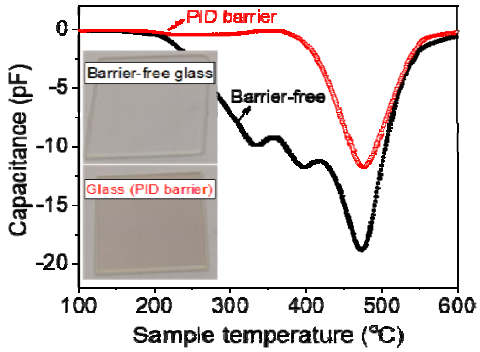
Actual Images of the Solar Chulha under Development at CSIR-NPL

With the progress in the area, cost of solar panels is coming down and the importance of solar energy as clean fuel is also very well understood. In this context, we at CSIR-NPL are trying to make a Solar Chulha that can be powered using the energy generated through the standalone (as well as grid connected) solar systems. In these lines, efforts are being made by us to design Solar Chulha that should work comparatively at low watt (input power) and give sufficiently good output (heat energy) for cooking or other purposes.

- **Indigenously Developed PVD System:** The module components such as glass, EVA and other pottants are being engineered and tested to improve the efficiency of these components against the PID effects in solar cells. In order to fulfill the requirements, testing facilities for the module encapsulant materials and other technical tools are being generated. Customized PVD system (RF sputtering) has been developed for the deposition of impurity barrier layers to minimize PID effect and as an import substitution. Several batches of solar cells/EVA/glass with impurity barrier are subjected to PID test to verify its PID resistance using in-house developed PID test set-up. In the following, deep levels/impurities diffused from different sources such as glass, EVA, etc., in the solar cells are being examined. As of now, there is a general consensus that Na^+ impurities diffused from glass cover sheet is responsible for the power-loss of the PV module. However, there are other elements that diffused from different sources of encapsulating environment. This approach is the proprietary of CSIR-NPL.



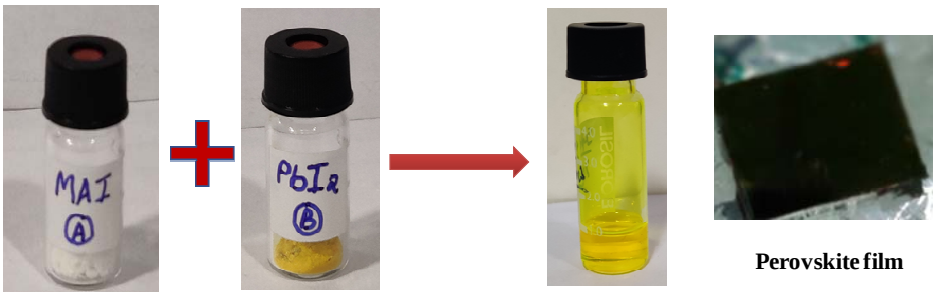
Indigenously Developed PVD System for PID Barrier



Impurity Levels Detected for Bare Glass and with PID Barrier on Glass, Showing the Prevention of Defects and its Concentration in Solar Cells after PID Test

- **Organic and Perovskite Solar Cells:** Generally organic materials such as polymers and small molecules are the key component in organic solar cells. Organic solar cells are fabricated by layer-layer deposition of different components such as active layer (mixture of donor and acceptor), hole transport layer, electron transport layer, electrodes. For perovskite solar cells the active layer is perovskite material. Perylenediimides (PDI) and naphtahlenediimides (NDI) have been developed as potential materials for n-type semiconductor materials for organic and perovskite solar cells. The PDI and NDI derivatives showed excellent electron conductivity without doping and 5-10 times higher electron mobility than that of state-of-the-art fullerene acceptor phenyl-C61-butyric acid methyl ester (PC61BM). Charge generation and charge transfer phenomenon was studied by transient absorption spectroscopy (TAS). TAS showed ultrafast charge transfer from the poly(3-hexyl)thiophene (P3HT) donor polymer to PDI and formation of long-lived charge-separated states similar to fullerene derivative PC61BM/P3HT blends. Such PDI derivatives with excellent solubility and photophysical and electronic properties are potential n-type materials to be used in organic electronic devices.

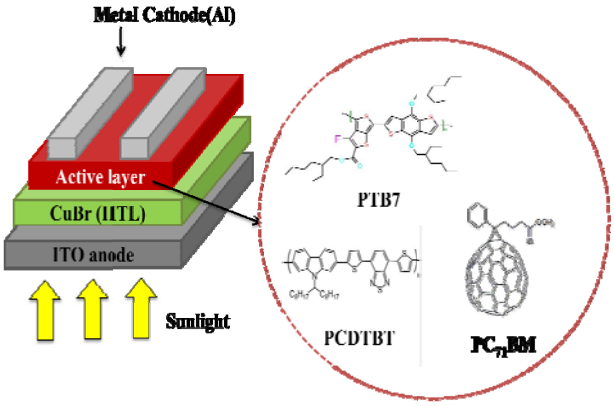
  Perovskite ink has been prepared for easy fabrication of large area perovskite solar cell at CSIR-NPL. CH_3NH_3I and PbI_2 mixture solution was prepared for methylammonium lead iodide (CH3NH3PbI3) ink. As can be seen in the following figure the ink delivers perfect perovskite film and characterized for device performance delivering efficiency >8%. Further, optimization of ink and device fabrication parameters are ongoing.



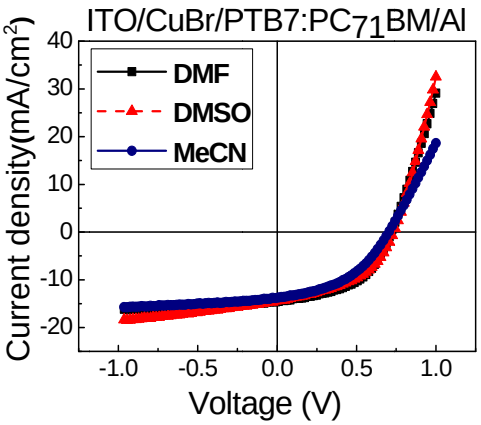
$CH_3NH_3PbI_3$

Perovskite film

- **Solution-Processable Hole Transporting Layer for Organic Solar Cells:**Copper bromide (CuBr) as an efficient, inexpensive, solution-processable hole transporting layer (HTL) for organic solar cells. To examine the effectiveness of the material in general, three different solvents such as acetonitrile (MeCN), dimethyl sulfoxide (DMSO) and dimethylformamide (DMF) are used for solution process thin film deposition of CuBr. CuBr thin films deposited from different solvents shows high transparency and no significant difference has been observed in absorption in visible and near IR range, whereas slight difference has been found in the near UV range by changing the solvents. Furthermore, two most studied combinations of active layer such as PTB7:PC71BM and PCDTBT: PC71BM are used for device fabrication with geometry of ITO/CuBr(HTL)active layer/Al. By using CuBr as a HTL in organic solar cells the power conversion efficiencies (PCE) have been achieved to up to 5.16 % and 4.72 % with PTB7:PC_{71}BM and PCDTBT:PC_{71}BM active layers respectively.



Device Geometry of OSC with CuBr as HTL and the Chemical Structures of Organic Materials used in Active Layer



J-V Characteristics of PTB7:$PC_{71}BM$ Devices under Illumination Condition

- **Recycling of Waste Plastic Scrap into Designing of Tiles for Societal Usage:**The main objective of the CSIR-NPL technology is to utilize waste plastic scrap for designing tiles in building of structures and rooms for general public for societal benefits. The various issues like mechanical strength, flame retardency, water permeability, UV-protection from sunlight, acid and alkali resistance and antistatic response are the novelty of the technology.The technology provide a solution for solid waste management problem and promote waste-to-usable technology program, a much-needed impetus to India's recycling industry. These tiles can be used in building of toilets and rooms for general public for societal benefits.

Tiles from Waste Plastic installed by Municipal Corporation, Hyderabad

Our technology on "Utilization of waste plastic to tiles designing", offers a simple and novel process of production of tiles from the waste plastic bags and bottles. Thus, this technology not only provides a sustainable living for the people who are collecting them from the garbage but also convert waste into a useful product and saves the environment. Some specific tests like flammability test, water absorption, and mechanical strength of the tiles have been carried out as per ASTM standards. This

technology has been transfer to seven industries including three in the year 2019-20 to making a significant contribution with great impact to support the make in India initiative of Govt. of India in addition to addressing the environmental issue of nation caused by plastic waste.

Photonic Materials Metrology

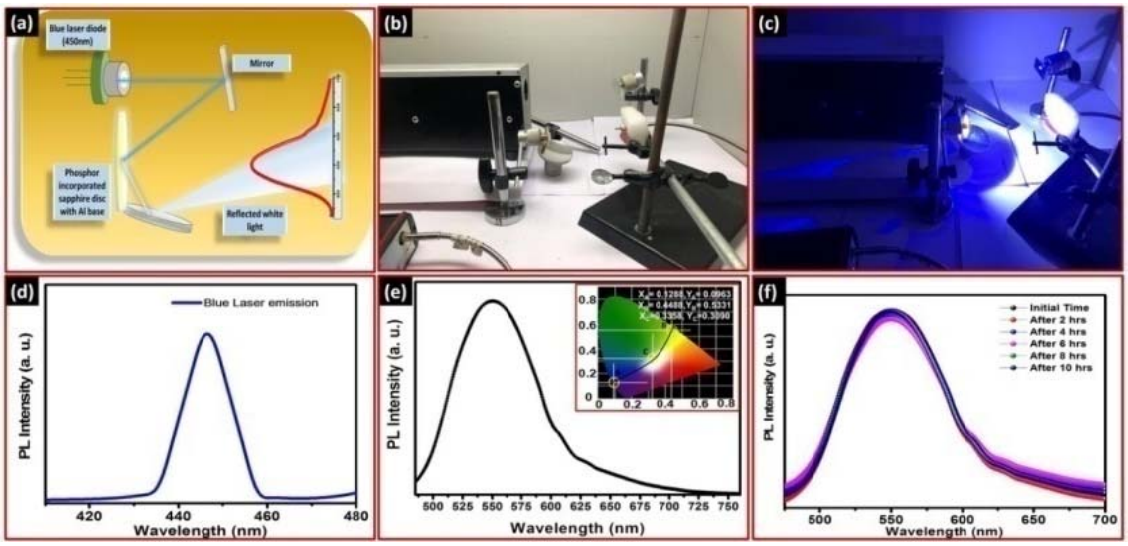
The objective of this subdivisionis to explore the various photonic organic and inorganic materials for its potential applications to address the issues of several thrust areas such energy harvesting, luminescent security ink, plasmopnic metamaterials, detectors etc. with metrological aspects. The group is actively engaged in the areas of nano photonics, organic photonics and optoelectronics, ultrafast optoelectronics &terahertz photonics and advanced luminescent materials for security ink.During the year 2019-20, the subdivision has focused on the following theme projects:

- Luminescent Security Ink (Bi-luminescent and CSI Ink)
- Development of novel inorganic/organic/perovskite materials for optoelectronics application
- Size and composition dependent TiO_2 nanoparticles for pigments, paints and coating
- Ultrafast Optoelectronics & Terahertz Photonics

The highlights of the achievements of the sub divisions are as follows:

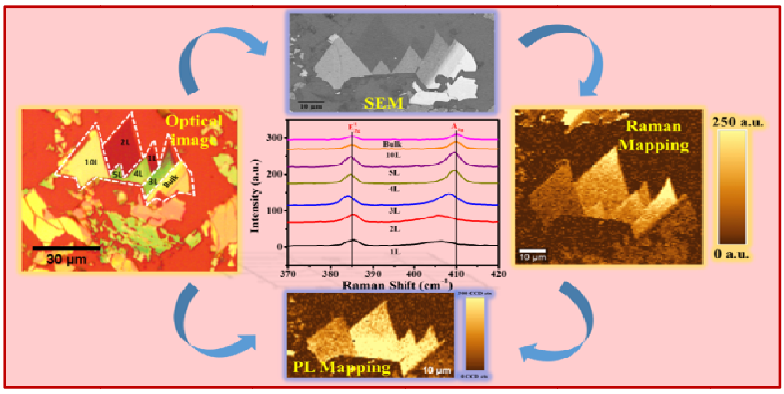
- **Development of High Power Laser-Driven YAG: Ce Phosphor Incorporated Sapphire Disc For Outstanding White Light Conversion Efficiency:**CSIR-NPL has designed a facile synthesis method for the development of $Y_{3-x}Al_5O_{12}:xCe^{3+}$ ($x = 0.03–0.24$) yellow phosphor via an auto-combustion method and fabrication of phosphor-incorporated sapphire disc (PISD) of various dimensions is reported. The photoluminescence (PL) intensity for the optimized concentration of Ce^{3+}-doped yttrium aluminum garnet (YAG) phosphor is recorded at 550 nm wavelength under the excitation wavelength of 445 nm from a high power blue laser diode. The developed

PISD exhibits high stability and luminescence. The blue laser diode is a promising candidate to revolutionize the luminous intensity of the white light by several orders of magnitude as compared with the existing blue light-emitting diodes as shown in the following figure. This emerging technology has an extremely bright future with endless uses of tunable power of the laser that controls the intensity of the emitted white light. Hence, this new approach provides a paradigm shift to produce highly efficient white light based on PISD integrated with a blue laser diode as compared with the conventional technology.



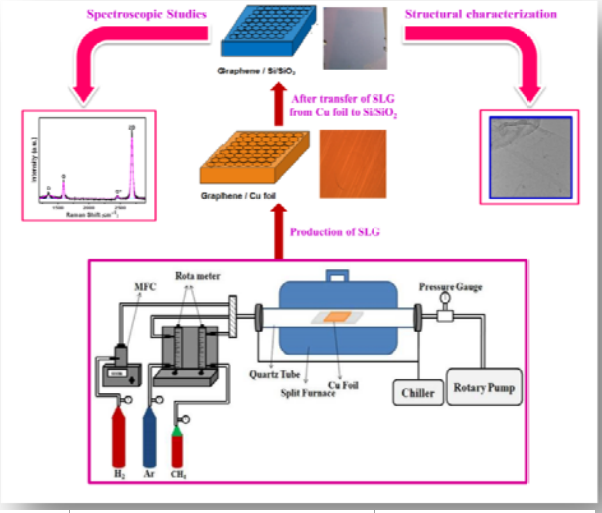
a) Schematic Geometry of the Reflection Mode. b) Reflection Mode Geometry Arrangement in Normal Light. c) Laser-induced White Light in the Reflection Mode. d) PL Spectrum of the Blue Laser. e) PL Spectrum of Laser-induced White Light through the Reflection Mode. f) Laser-induced White Light Spectrum at Different Hours in the Reflection Mode

- **Development of a Strategy for the Qualitative Analysis of Mechanically Exfoliated MoS_2 Nanosheets using Spectroscopic Probes:** CSIR-NPL presents various spectroscopic probes such as optical, Raman, and photoluminescence (PL) to quantify the number of layers in mechanically exfoliated MoS_2 nanosheets as shown in the figure. The obtained results legitimize that these spectroscopic probes are the metrological tool to identify the number of layers of MoS_2 nanosheets to design the emerging next-generation 2D devices.



Demonstration of Different Layers of MoS_2: Microscopic and Spectroscopic Importance during Layer Identification

- **Development of Continuous Growth of Highly Reproducible Single-Layer Graphene Deposition on Cu Foil by Indigenously Developed LPCVD Setup:** CSIR-NPL proposed a low-cost, highly reproducible high-quality SLG synthesized by indigenously developed low-pressure chemical vapor deposition (LPCVD) setup as shown in the figure. The quality of SLG is examined by Raman spectroscopy, where we have probed the I_{2D}/I_G ratio for continuous 30 runs to assess the reproducibility and quality of single-layer using proposed indigenous LPCVD setup for device fabrication. The highest I_{2D}/I_G ratio of SLG (5.82) was found with a full width at half maximum values of 2D peak and G peak of ~30.10 cm^{-1} and ~20.86 cm^{-1}, respectively. Further, high-resolution transmission electron microscopy. Thus, this new indigenously developed low-cost setup provides a novel alternative method to produce highly reproduciblemetrology-grade continuous SLG on Cu substrate for next-generation quantum devices.



Schematic of Low Cost Indigenously Developed CVD System for Growth of SLG on Copper Foil

- **Photocatalytic Degradation of Hazardous Organic Pollutants and Industrial Waste using Hydrophilic CZTS (Cu_2ZnSnS_4):** In this work, CZTS is prepared by a simple, cost-effective, and colloidal route using the 'hot injection' method. Different ligands such as trioctylphosphine (TOP), trioctylphosphine oxide (TOPO), butylamine and octadecene are studied in respect of quality formation i.e. size, shape, and ease of synthesis of CZTS nanoparticles. The contact angle shows the hydrophobic nature of these nanoparticles which was further ligand exchanged with L-cysteine hydrochloride to make it hydrophilic to study the photocatalytic degradation activity of organic pollutants and industrial waste in the water. The photocatalytic efficiencies were studied for different CZTS nanoparticles with different ligands. The photocatalysis experiments were performed under bare sunlight (Intensity ~ 900W/m2) and the best photocatalytic efficiency achieved under sunlight was ~ 98.1% for organic pollutants and ~ 73% for an industrial waste respectively.

Advanced Carbon Products and Metrology

The subdivision is engaged in the development of advanced carbon materials, magnetic materials and thermoelectric materials catering to the need of the country in the Industrial, Health, Energy as well as Strategic sectors like Defense, Aerospace and Nuclear power. The major focus area of projects activities are as listed below:

- Establishing centre for ballistic material testing and MWCNTs based armour materials
- Development of high density isotropic nuclear grade graphite

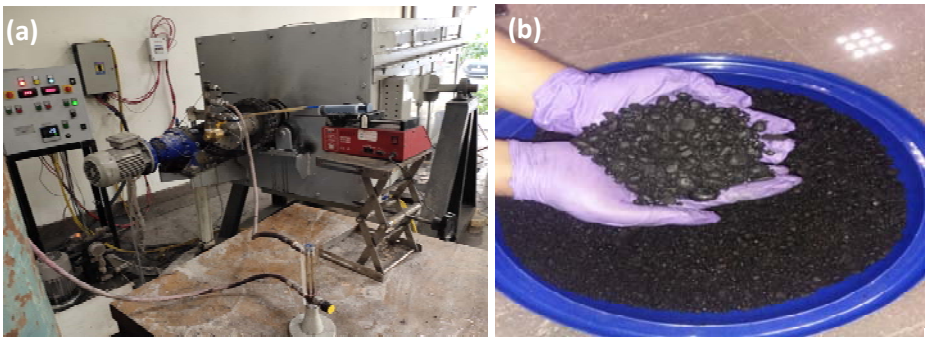
- Demonstration and validation of a 5 KW HT-PEMFC based on combined cooling and power system
- Characterization of coal tar, their conversion into coal tar pitch and zero Q.I. pitch, and characterization
- Carbon fiber composite limbs for recurve archery bow
- Conversion of crop stubble and municipal solid waste (MSW) in to bio coal by Torrefaction as useful raw material for co-firing in thermal power plants
- Development of Lithium titanate-graphene based battery chemistry for EVs anode for LiB
- Creation of National Center for Battery Evaluation & Safety Test
- CSIR Young Scientist Research Grant on "Direct Synthesis of Carbon Nanotube Yarn by Chemical Vapor Deposition.
- Development of Efficient and Economically viable Carbon Nano Materials for Water Purification
- Development of BND of Graphitized petroleum Coke and Calcined Petroleum Coke
- Development of fiberboards and panel from agricultural waste and polymers

The highlights of the achievements of the subdivision during the last year are as follows:

- **Development of Carbon Fiber Polymer Composite Archery Bow:**To support MSME-Technology Development Centre (PPDC) sport complex, Meerut, UP, CSIR-NPL with MSME, PPDC is developing cost effective archery recurve bow. CSIR NPL has developed CFRP based recurve bow limb of 20 inch as shown in the figure. Further upscaling of the size to actual size is under process. The indigenous production of the professional composite recurve bow and alloy or metal based riser will make the archery sport quite affordable in the country. Considering the fact that riser and limbs are main part in functioning on a recurve bow.

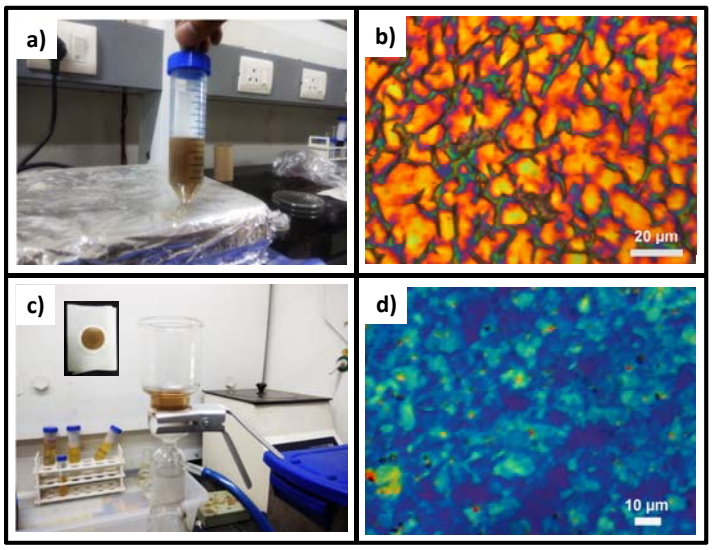
Small Scale Down Size Carbon Fiber Composite Archery Bow Limb

- **Development of Activated Carbon from Waste Jute Sticks Biomass:** A scaled up process with rotary furnace consisting 90 liter volume Inconel reactor which can sustain a temperature upto 900°C in strong acidic medium has been established. The parameters for development of activated carbon from waste jute stick biomass by physical and chemical activation method have been optimized and activated carbon produced is shown in the following figure. A technological solution for the development of activated carbon from waste jute sticks biomass which can help in improving socio economic status of jute growing farmers in north eastern state.



Rotary Furnace for Production of Activated Carbon Acid based Activated Carbon

- **VAMAS, TWA-33:**Under TWA 33, Project 1, the main objective is to determine the shape, size and size distribution of nano-filler particles which is graphene oxide (GO) in this case.As per Good Practice guide No: 145 of NPL UK there are several methods like drop casting, dispersing and deposition on TEM grid for size analysis of graphene and graphene oxide flakes. For the present study drop casting technique was employed. The sample is easily dispersible in water as shown in figure-a. But we found that the dilution and filtration is required to remove excess surfactant as seen in figure-b which is an optical microscope image. As shown in figure-c, filtration using whatman filter paper of 0.5 um pore size is employed to remove excess surfactant and the sample is re-dispersed in water for preparing samples by drop casting. Figure-d shows optical microscope image of widely dispersed flakes for very low dilution of dispersed solution.



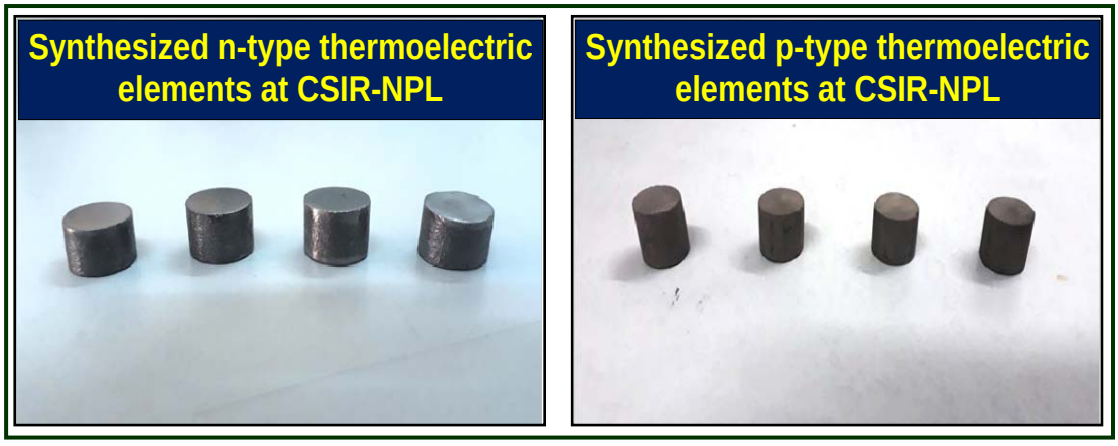
a) As Received GO Flakes Diluted and Dispersed in Water b) Optical Microscope Image of GO Flakes Dispersed as Received on SiO_2 Substrate c) Centrifugation and Filtration of GO Flakes and Redispersion in Water d) Dispersion of Flakes on SiO_2 Substrate after Filtration

- **Torrefied Agriculture Waste Biomass as Sustainable Renewable Energy Source:**CSIR-NPL has taken initiative to convert waste agricultural biomass in to biocoal by torrefaction process. Torrefaction is defined as mild pyrolysis of biomass in protective atmosphere which alters the physical and chemical composition of biomass. Different types of biomass such as rice straw, rice husk, mustered stalk, wheat straw, almond shell etc. is converted in to biocoal. After torrefaction, there are significant reductions in the volume of biomass that can solve the problem of transportation and their heating properties are equivalent to that of bituminous coal.

India is committed as per Paris agreement to reduce green house gases emission. Green house gases such as CO2, NOx, and SOx emissions can be reduced by replacing a portion of coal with torrefied biomass in the thermal power plant. Also, an exploitation of agricultural residues helps in sinking the process of deforestation by reducing our dependence on forest woody bio-mass. Also, crops residues have short harvest periods that adds up to their accessibility on more consistent basis as compared to woody bio-mass. Thus, use of torrefied agriculture biomass can reduce the dependency on the fossil fuel and hence the energy security.

Torrefied Product at Different Stage from Raw Biomass to Torrefied

- **Thermoelectric Materials:** The thermoelectric power generator has been fabricated using half Heuslers alloys (p-type TiCoSb and n-type ZrNiSn). The p-type TiCoSb and n-type ZrNiSn pellets (dia: 10 mm for each p- & n-type, height: 7 mm for all pellets) were synthesized employing spark plasma sintering via optimized processing conditions at CSIR-NPL. A 2 × 2 p-n legs device was successfully fabricated by using these pellets at TPD/BARC. The pellets were mounted in a zircar (Al_2O_3-SiO_2 composite) housing and interconnected using a silver stripe. The following figure shows the photographs of device scaled n- & p-type half-Heusler alloys developed at CSIR-NPL. The optimum loading conditions, the fabricated module delivered a maximum power output of ~ 361 mW, for a temperature difference of 553K.



Photograph shows the Device Scaled SPS Processed n- & p-Type HH TE Elements at CSIR-NPL

BhartiyaNirdeshakDravya(BND®): Division 5

The Certified Reference Materials are important for calibrating analytical equipments for accurate and precise measurement of data. In this context, CSIR-NPL as the National Metrology Institute of the country (NPLI) has recently started a program for indigenous production and certification of Indian Reference Materials (BNDs) in different areas such as food, fuel, ores, and minerals etc. to ensure better quality control of processes and products made in the country. Indian Reference Materials (Bharatiya Nirdeshak Dravya®) developed at CSIR-NPL is thus the key to quality control on local manufacturing by establishing its traceability through the SI unit at CSIR-NPL. It will strengthen industrial advancement and international competitiveness of our nation in the days to come. This Divisions' strength is also in the various analytical equipments for characterization of materials that it maintains. The major activities of different units of the BND Division over the last one year are given below.

- **Involvement in the PTB-NMCG Project for Clean Ganga:**BND Group involved in the project "Strengthening Quality Infrastructure for Water Monitoring of the Ganges River", implemented by the PTB, the National Metrology Institute of Germany; and National Mission for Clean Ganga (NMCG), India. The aim of the project is to improve the quality of data used to monitor the Ganges River. An assessment of the concerned Regional Laboratory of SPCB situated at Prayagraj, UP has been conducted during 17th to 19th February 2020. The data of SPCB, will be utilized for the society under the "Namami Ganga" project.

- **Aatmanirbhar Bharat and Make in India Initiative:** BND Division of CSIR-NPL has started producing and/ or certifying Indian Reference Materials in various sectors like cement, water, petroleum etc. for import substitutions in different sector like Environmental, Food & Agriculture, Petroleum Products etc. As on today, India imports CRMs worth more than Rs 10,000 crore. Related MoUs has been signed with various Reference Material Producers (RMPs) such as M/s AASHVI Technology LLP, Ahmedabad, NCCBM, Faridabad, HPCL Ltd, Visakhapatnam, M/S Sigma Aldrich, USA, M/s Global PT Provider (P) Limited, New Delhi, M/S SUM Tech. Pvt. Ltd., M/S. BPCL, Mumbai, CSIR-IITR, Lucknow etc.

- **Production of In-House Indian Reference Materials (Bharatiya Nirdeshak Dravya:BND):**Two BNDs were developed viz. $K_2Cr_2O_7$ solution (BND2021) and Ho_2O_2 (BND 2022) solution for UV-VIS-NIR spectrophotometer Absorbance and wavelength calibration respectively.

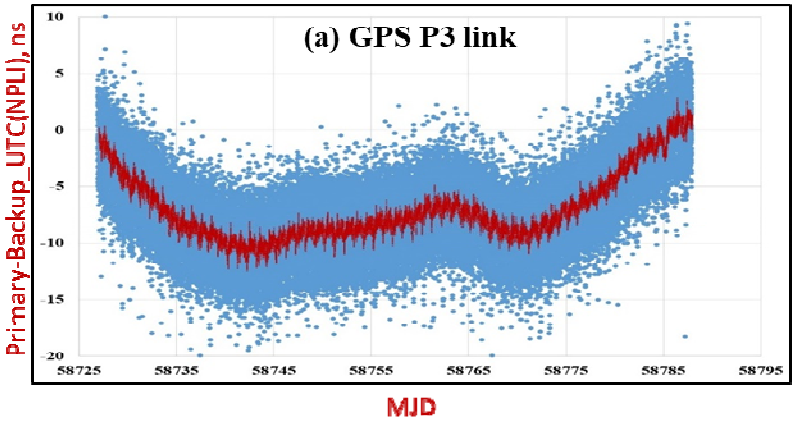
- **Other Activities**:
  BND is working and progressing on development of specific Seebeck coefficient-"a parameter of thermoelectric properties" to establish thermoelectric metrology and hence optimizing the precise and accurate measurement of thermoelectric parameters.
  BND is also working on standardizing sand for construction industry using zero calcium carbonate as a parameter. They are also working on inter-comparing alloy content using surface analysis tehcniques and on standardizing materials for reducing radar

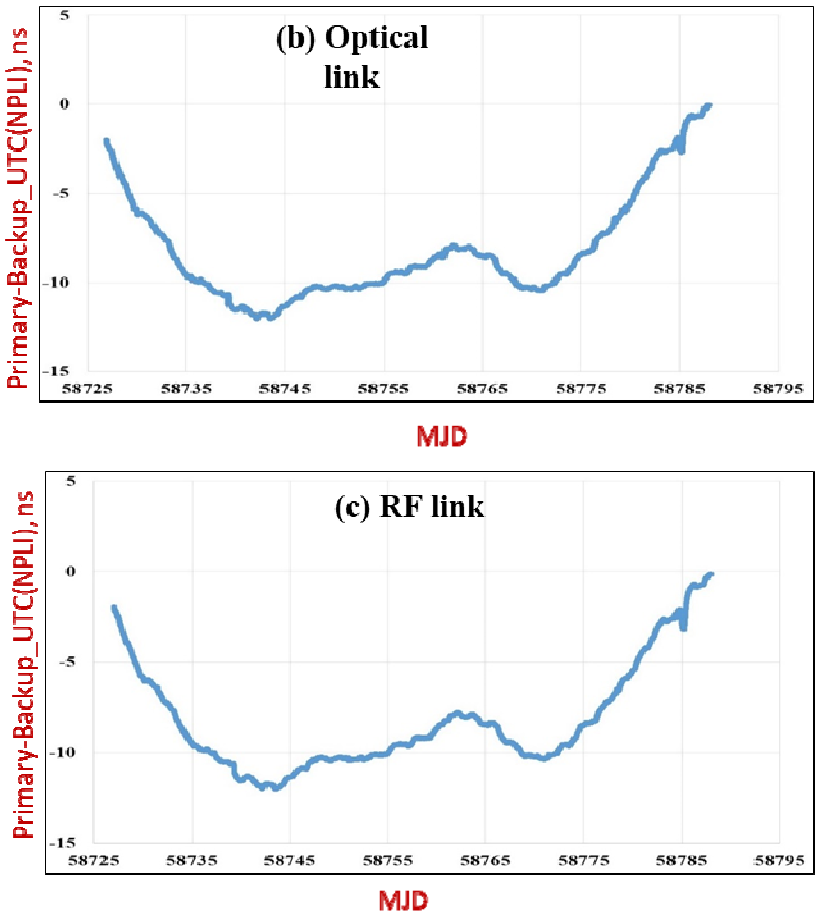
cross section. They are also liaising to develop tools to reduce man-animal conflict and for developing a few simple agri- technologies available nationally as well. BND staff has also been working towards maintenance and upkeep of their hi-tech equipments and assets.

Indian Standard Time Metrology: Division 6

Indian Standard Time (IST) is generated by the Primary Time Scale Ensemble at CSIR-NPL. As the time keeper of the nation, the realization, maintenance and dissemination of Indian Standard Time (IST), is the key responsibility of CSIR-NPL. During the year, CSIR-NPL undertook regular maintenance and upgradation of Time Scale systems, and its environmental conditions for realization of the National Time. The dissemination of IST was provided through Two-way Time and Frequency Transfer (TWSTFT) System and Global Navigation Satellite system (GNSS) to ISRO; and through NTP service to all types of e-services in the country. For the contribution of CSIR-NPL's atomic clocks in the development of international time scale - TAI, and for providing the global visibility to the CSIR-NPL's efforts in time and frequency metrology at the international platform, CSIR-NPL participated in the APMP meetings held at Sydney. The efforts helped in maintaining the time scale uncertainty around ±3 ns and provided the support to the existing CMCs.

For fail-safe 24×7 dissemination of IST, a backup Time Scale Ensemble was commissioned and linked to Primary Time Scale. Two new atomic frequency standards (Active Hydrogen Masers) have started contributing to BIPM's time scale, TAI. For uninterrupted dissemination of IST, backup time scale ensemble was calibrated against the primary time scale. For this purpose, a traceability link was created between backup Time Scale ensemble and Primary Time Scale ensemble. For the first time, optical fibres were used to transmit standard time and frequency signals. This has been done to transport standard time and frequency signals (1 PPS and 5 or 10 MHz) from Primary Time Scale to the Backup Time Scale. The use of Optical Fibres as a transmission medium is preferred over the conventional RF cable transmission medium as it provides the low attenuation (~ 0.2 dB/Km), electrical isolation, low power loss, and cost-effectiveness. The clocks of backup time scale were compared with those at primary time scale using a dedicated fiber optic link along with a RF link and the GNSS link as shown inthe following figure. Backup time scale was tightly coupled with primary time scale so that it stays as close to UTC (NPLI) as possible. Backup time scale provided traceability of UTC(NPLI) to the labs of Length, Microwave and Voltage Standards in the Metrology Building of CSIR-NPL.R&D work was undertaken on the transmission of electrical signals over the Optical Fiber.





Traceability Links between Primary and Backup Timescale using GNSS Common View, Optical Fibre and RF link has been Established using (a) GPS Common View-PolaRx3 and GTR51 Receivers used for GPS P3 Results. (b) Optical Link-Optical Source and Termination are used for Time Transfer over Optical Fiber. (c) RF link-LDF4 Cable is used for RF Link. Time Transfer Uncertainty (u_a) is Better than 5E-15/Day

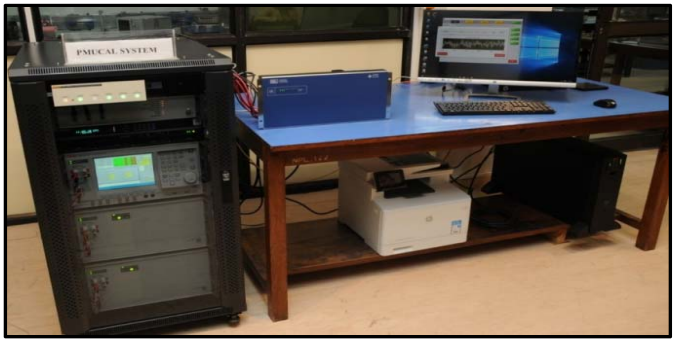
To strengthen the time dissemination in the country and to synchronize the telecommunication network of the country, establishment of the timing laboratories of Legal Metrology Department (LM) in five cities, namely, Guwahati, Bangalore, Faridabad, Ahmedabad, and Bhubaneswar, has been taken up. A laboratory has been also built to create a disaster recovery center, a copy of Primary Time Scale Ensemble, in Bangalore. The conceptualization of the secondary time scales has been completed during the year. CSIR-NPL provided technical, infrastructural and manpower inputs to the Department of Legal Metrology(LM) to establish the secondary timing systems under a Consultancy Project. Based on NPL's design and specifications, the building infrastructure has been prepared at five Regional Reference Standards Laboratory (RRSL) located at Guwahati, Bangalore, Faridabad, Ahmedabad, and Bhubaneswar. Each RRSL is now having state of the art laboratory with round the clock power supply and well controlled temperature and humidity environment. The effort will help all the telecom operators to synchronize their network to the secondary time scales being established at each RRSL. This will help the country to make rapid progress towards the establishment of 5G networks. Another secondary time scale is being created at IIT Kanpur for the National Project on Very Long

Baseline Interferometry (VLBI) for Geodetic Applications in India. The significant contributions of Time and Frequency Metrology are listed below:

- Two new standards (Active Hydrogen Masers) started contributing to BIPM's International Time Scale (TAI).
- Backup Time Scale laboratory was established. The laboratory provided time traceability to length, voltage and microwave standards.
- Collaboration with BIPM was maintained. The CSIR-NPL's clock data was regularly uploaded to the BIPM for generation of international time Scale, TAI and UTC.
- Time and Frequency Traceability service provided to ISRO.
- The existing Antenna structure was difficult to service and was having security issues. The new antenna structure and reception area of Primary Time was planned, designed and developed for additional security as well as for periodic maintenance of antennas.
- Participated in international inter-comparison of Stopwatch to enhance our measurement capabilities and support our existing CMCs. Held meetings with NMIs during the APMP 2019 in Australia.
- Trained 30 International Scientists and Government Officers of the UN Centre for Space Science and Technology Education for Asia Pacific (CSSTEAP).
- Time and Frequency Calibration services provided to the Indian Industry and maintained the Quality System.
- The layout, design and specifications of civil and electrical systems at Regional Reference Standards Laboratory (RRSL) located at Guwahati, Bangalore, Faridabad, Ahmedabad and Bhubaneswar were prepared. Strategic meetings held with Principal Scientific Advisor, Secretary and Joint Secretary of Ministry of Consumer Affairs, ISRO and DG-CSIR for the timing infrastructure in the country.
- The new traceability laboratory at CSIR-NPL was planned and developed for providing traceability services to the secondary time scales.
- Technological guidance given to DRDO's laboratory, ITR Chandipur (Odisha), and IIT Kanpur for the development of timing systems.
- Formulated national time synchronization requirement in telecom networks and Generic Requirement for Primary Reference Clock, Precision Timing Protocol (PTP) GM Clock and PTP Slave Clock along with the Department of Telecommunications.

LF & HF Voltage, Current and Microwave Metrology

- **PMU Calibration System:** This system shown in the figure is basically a monitoring device that captures data at a very high speed and each measurement is time stamped to a common time reference. PMU Calibration System is used to test/calibrate PMUs and report the errors, as the difference between the systems reported 'True' values and the measured output. Errors are reported in the form of Total Vector Error (TVE), Frequency Error (FE) and Rate of Change of

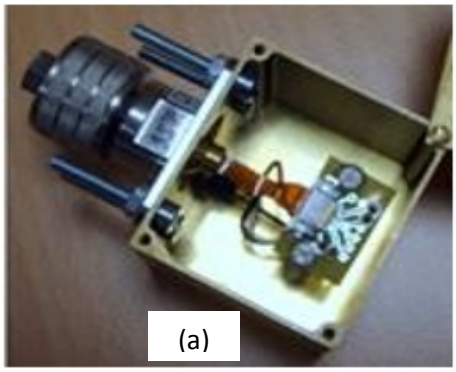


CSIR-NPL PMU CAL System

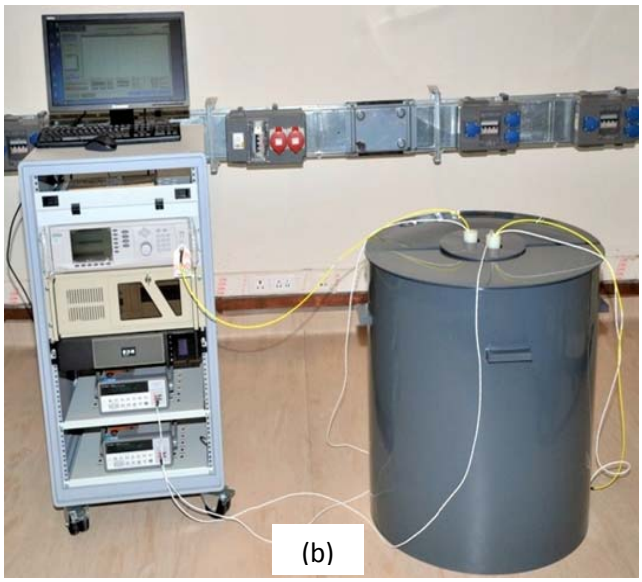
Frequency Error (RFE) as per IEEE C.37.118.1a-2014 standard. CSIR-NPL PMU CAL System traceability has been established against the primary standards of CSIR-NPL.

- **Coaxial Microcalorimeter System up to 50 GHz:** Coaxial Microcalorimeter system in 2.4mm connector, established as the primary standard of Microwave Power in the frequency range of 1 MHz to 50 GHz is an absolute method based on thermocouple principle for the determination of effective efficiency to the thermocouple sensor as shown in the following figure (a). Coaxial thermocouple sensors, which are assigned calibration factors using coaxial microcalorimeter system, are used as reference standards to calibrate power sensors / thermistor mounts using direct comparison technique. The basic components are shown the following figure (b). VSWR is measured at all the desired frequencies with the help of Vector Network Analyzer based technique.

Measurement Capabilities:
Frequency: **1MHz-50GHz**
Parameter: Effective Efficiency
Uncertainty: ±0.4% to ±1.5%



2.4mm Coaxial Microcalorimeter



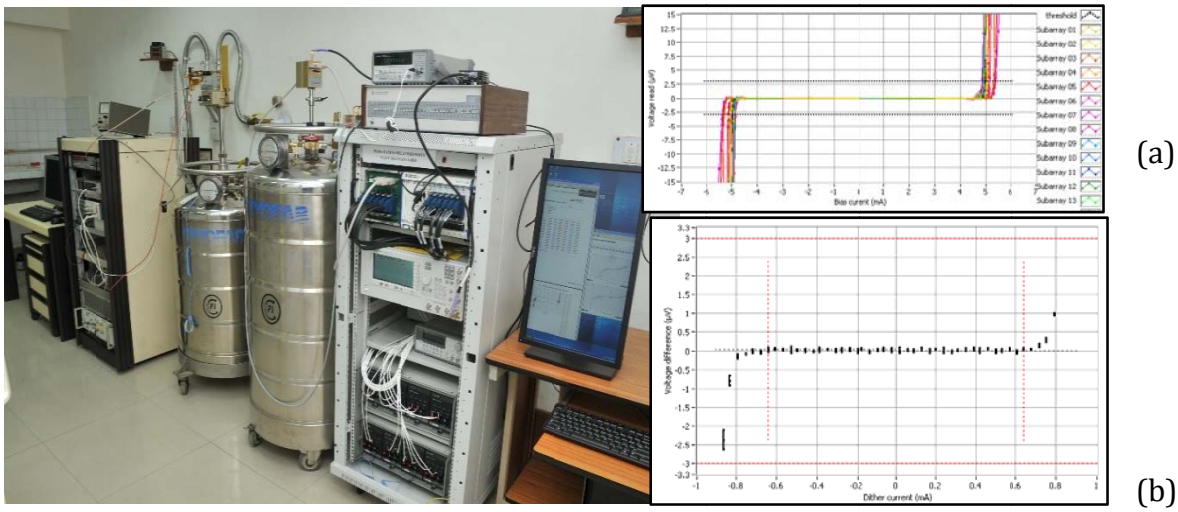
Coaxial Thermocouple Sensor

- **Vector Specific Absorption Rate Metrology:** In the current age of fast evolving communication and being present online virtually always, has made us surrounded by communication equipment everywhere, be it mobile phones, tablet and other wireless devices and the upcoming IoT (Internet of Things) based wearable devices, smart homes, household equipment to smart sensors. We are dependent on these devices for all our day to day work and these are always radiating microwave of other RF radiation. International Standards require that each of these wireless devices to be tested individually, so as to ensure its radiation is within the specified and internationally accepted “safe limit”. For this these devicesneed to be tested at each individual frequency on which it operates and for all possible configurations in which the devices may be used. However, this is a tedious and time consuming task to test all these devices, as per existing standard namely IEEE-1528 (2013) and ICNRP guidelines. Also, with continuously upgrading communication technology and increasing number of devices, the task becomes more complex.

Regularity bodies have been working to upgrade these standards and trying to come up with faster assessments methods to accommodate these multiple tests and such large number of devices. Suggested methodology is to make use of time domain probes and arrays which map the amplitude and phase simultaneously and then map the E-field generated by the device. These method uses time-domain Vector probes and MIMO antennas for faster measurements by employing simultaneous amplitude and phase measurements. However, before making these measurements acceptable worldwide the standard for calibration of these probes needs to be established. CSIR-NPL has joined the EURAMET Program 2017 as member in collaboration with LNE, France and other participating NMIs. This program is launched by NPL, UK to address these issues and finally come up with guidelines, procedures and methodologies for SAR assessment using vector probes and their calibration schemes. CSIR-NPL, India has collaborated with coordinator (LNE) to validate their individual measurements and procedures. This collaboration will lead towards comprehensive methods, software tools and datasets required for traceable calibration and uncertainty analysis of vector probe array systems. It will also help incorporate new SAR assessment procedures in the upcoming standards (IEC 62209-1528/D5 2019 and the latest IEEE Std. C95.1 2019). These upgradations of existing SAR standards are essential to address the technological change upcoming with smart wireless technologies.

The project aims to address this issue and establish national facility for vector SAR measurement (1st of its kind in country) with measurement equivalence to world's leading NMI for IEC 62209-3 TC. This will serve as a precise calibration system for the Vector SAR assessment systems proposed. With India emerging as 2nd largest producer of mobile equipment in recent 2-3 years, there is huge scope to provide SAR assessment to the manufacturers in country itself and save lot of time and cost by having testing at par with new international standards. Microwave Metrology has taken this opportunity and responsibility, being the NMI of India.

- **Programmable Josephson Voltage Standard (PJVS)**: The PJVS system is based on 'Quantum Phenomena' (Josephson effect) given by the relation $2eV_n = nhf$, where $n = 0, \pm 1, \pm 2, \pm 3..$, V_n = quantized voltage, f = frequency of irradiation, h = Planck's constant, e = electron charge. The salient features of the system, shown in the following figure are:
  - The non-hysteretic Josephson tunnel junctions made up of Nb electrodes and Nb_xSi_{1-x} barriers.
  - The 10 V chip contains a total of 256,116 Josephson junctions organised in stacks of three junctions and distributed into 32 microwave coplanar waveguide lines.
  - The voltage steps are stable, have superior immunity to noise and have rapid settling time.



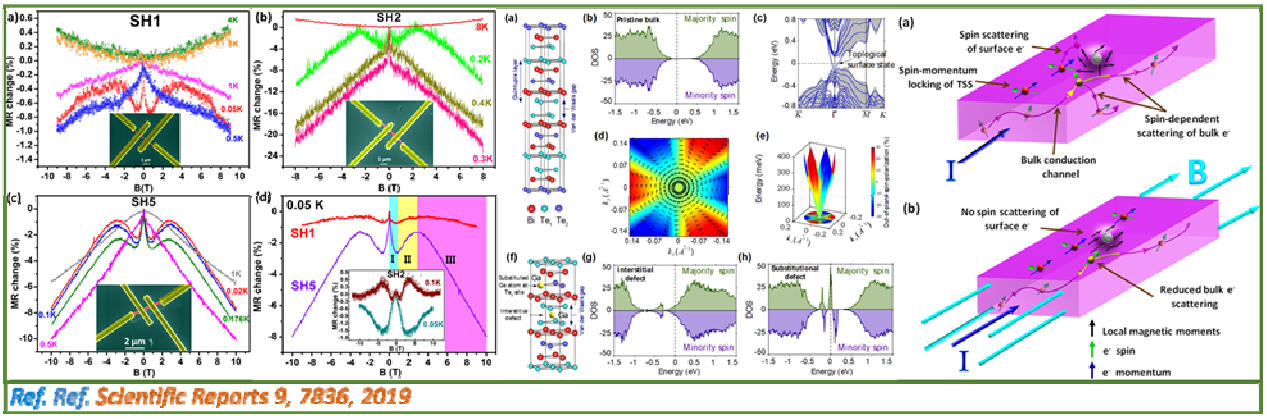
(a)

(b)

(a) 10 V - PJVS at NPL-India, (b) I-V Curves for 23 Sub arrays and Step Flatness Test at 18.645 GHz and 0.00 dBm

PJVS forms the basis for standard of the unit 'Volt' in India at par to the international level. The uncertainty in measurement of Zener Reference Standards are provided at 1.018V and 10V levels as per the ISO/IEC 17025:2005.

- **Focused Ion Beam Activity:**The spin-dependent scattering induced negative magnetoresistance measurements in topological insulator Bi2Te3 nanowires were carried out. The large longitudinal negative magnetoresistance (LNMR) in TIs nanowires at ultralow temperatures (Scientific Reports 2019, 9 (1), 7836) were studied, where it was found that the interplay between negative and positive magnetoresistance can be understood in terms of the competition between dephasing and spin-orbit scattering time scales. First time it was shown that Ga doping induces local magnetic moments which leads to spin-dependent scattering of surface and bulk electrons which can be exploited further for spintronic applications.



Magnetic Metrology

This activity is responsible for maintaining and upgrading National Standard related to magnetic parameter like magnetic flux density, magnetic flux, turn area of search coil, power loss measurement of electrical steel, through continuous development and providing calibration/test services (as per ISO/IEC: 17025 guidelines) to more than 100 customers (MSME sectors, Large scale industries and Govt. R & D organizations including Indian Air Force, Air India, Power Grid, CPRI, IDEMI, ERTL, ABB, Siemens, Samsung, GE Healthcare, L&T, etc.) to improve the quality infrastructure of India. The group provides solution to industrial problems and also offers industrial consultancy. The group is also continuously working to develop the new test/calibration methods (as per the current demand of industries) to facilitate the users. The group has also initiated to develop calibration facility for AC Magnetic field measurement up to 400 Hz (Magnetic field range: 10mG-20G). The section is also involved in Material R & D for Magnetic Metrological Applications.

Directorate

This division comprises of Planning, Monitoring Evaluation and Outreach; IndustrialLiaison Group; Centre for Calibration & Testing; Workshop; International Science andTechnology Affairs Group; Human Resource Development Group; AdministrationQuality Management System; Rajbhasha Unit; Knowledge Resource Centre; Finance &Accounts Store & Purchase Section; Works & Services.

Planning, Monitoring Evaluation and Outreach

CSIR-NPL undertakes projects sponsored by various external agencies such as Ministry of Science & Technology, MNRE, DST, etc. The department is involved in the planning, monitoring and evaluation of the various types of GAP, TLP, FTT, SPP, CNP & Mission Mode, etc, projects. The details of External Cash Flow i.e., money received from these agencies to carry out specified project is regularly recorded and monitored by PME against the target established by the Institute. Registration of all projects and allotment of specific identity in terms of a Project No. is made at PME, soon after the money for the project is received along with In-Principle approval. Projects are registered in different modes viz FTT, mission mode, Sponsored research, Grant-in-Aid, Collaborative and CNP. The total number of projects registered in different modes during **2019-20 is 42**. In the year 2019-20, **ten** new GAP projects have started worth **Rs. 8.12 Crores**, while three new MLP-CSIR funded projects have taken off, costing Rs**. 15.12 Crores**. A grant of Rs **13.78** Crores in the **fifty two** continuing GAP projects was received.

Apart from this, PME also attends to technical queries, Parliament Questions and Technical Audit as well as assist Director in liasioning with CSIR-HQ, Management Council (MC) and Research Council (RC) on project related matters. In 2019-20, **PME has successfully conducted 15 NPL Council Meetings, 3 Apex Review Committee (ARC) Meetings, 02 Research Council and 28 Institutional Scientific Review Meetings.** PME has processed **1916 indents** worth **Rs 55.25 Crores**.

PME has developed and implemented barcode enabled **Online File Tracking System (FTS)** across CSIR-NPL, to enable tracking of file movement using web based software. All the departments across CSIR-NPL are using the software for their in and out dak entries. From April 2019 – March 2020, **14,846 files have been generated and 28964 files have been processed** across various departments.

In 2019-20, PME assisted in the design of the new CSIR-NPL logo, advanced image editing, photo collages for the walls, cover and back pages for various events and publications.

Industrial Liaison Group

The Industrial Liaison Group (ILG) of CSIR-NPL has been actively involved in providing scientific solutions to the Indian Industries in many verticals ranging from licensing of CSIR-NPL technologies/know-how to provide scientific and technical support to the Industry. ILG acts as an interface between the Industry and CSIR-NPL with a mandate to bridge the gaps between the Industrial requirements and the expertise available within CSIR-NPL. Several industries and research institutes contact ILG to get the solutions for their technical problems. Depending upon the requirements of the Industry, several new projects have been undertaken by ILG in this period in consultancy, technical services and

sponsored project modes. In order to promote CSIR-NPL, ILG has been actively involved in showcasing the Technologies/know-how and expertise available with CSIR-NPL at various platforms and forums. Further to publicize the technologies/know-how, ILG is maintaining "technology transfer" web page on the CSIR-NPL website. This web page holds the list of all the technologies/know-hows etc available with CSIR-NPL which are ready for commercialization along with their basic details. The Industrial Liaison Group (ILG) also plays a very important role by facilitating the formulation of the Memorandum of Understanding/Agreement/NDAs etc between CSIR-NPL and the concerned Industry/Institute.

Apart from that, ILG is also involved with the registration of new Bharatiya Nirdeshak Dravya (BNDs). The details of the technology/know-how transferred, MoUs signed, dissemination of traceability through BNDs and consultancy/sponsored/technical services projects undertaken during this period has been given below;

- **Consultancy Projects**

Sl No	Project Title	Client	Project cost including GST@18%	Money Received
1	Recommendation based on evaluation of absorbing characteristics of Interior Materials for better NRC value	Annutone Acoustics Limited, 3A Visvesvaraya Industrial Area, Bengaluru 560 048	Rs 5,90,000	Rs 5,90,000
2	Feasibility studies on selected Fluorescent dyes for Nonenzymatic Glucose sensing	Mr. Anirudh Jain, West Delhi, Delhi, 110085	Rs 2,89,100	Rs 2,89,100

- **Sponsored Projects**

Sl No	Project Title	Client	Project cost (including GST)	Money Received (Rs)
1	Indigenous development of Colour Shift Intaglio Ink (CSII)	Security Printing and Minting Corporation of India Limited, (SPMCIL), Janpath, New Delhi-110001	Rs 236 Lakh	Rs 151.04 Lakh

- **Technical Services Projects**

Sl No	Project Title	Client	Project cost (including GST)	Money Received (Rs)
1	Technical services for evaluation of Metrological Characteristics of 32 t Weighing Scale	Micro Precision Products Private Limited; Palwal; Haryana – 121 102	Rs 2,95,000	Rs 2,95,000

- **Registration of Bharatiya Nirdeshak Dravya (BND), Indian Reference Material with Reference Material Producers (RMPs)**

Sl No	Project title	Funding agency	Money received @Rs10,000/BND + GST@18%
1	Dissemination of Metrological traceability through Cement BNDs	National Council for Cement and Building Materials (NCCBM), Ballabgarh, Haryana	Rs 35,400
2	Dissemination of Metrological Traceability through Chemical BNDs	Aashvi Technology LLP, Ahmedabad, Gujarat-380004	Rs 59,000
3	Dissemination of Metrological Traceability through Chemical BNDs	Aashvi Technology LLP, Ahmedabad, Gujarat-380004	Rs 23,600
4.	Dissemination of Metrological Traceability through Chemical BNDs	Aashvi Technology LLP, Ahmedabad, Gujarat-380004	Rs 35,400
5.	Dissemination of Metrological Traceability through Chemical BNDs	Quality Control Laboratory, HPCL Visakha New White Oil Terminal, Visakhapatnam	Rs 35,400

- **Licensing of Technology/Know-How**

Sl. No.	Name of the technology/Know-how	Name of the client	Date of transfer
1.	Recycling of Plastic Wastes into Tiles for Structure Designing for Societal Usage), Lumpsum: Rs 17.64 Lakh including GST; Non exclusive (through NRDC)	Bengal One Enviro Infra LLP, Kolkata, West Bengal	14-05-2019
2.	Recycling of Plastic Wastes into Tiles for Structure Designing for Societal Usage), Lumpsum: Rs 17.64 Lakh including GST; Non exclusive (through NRDC)	Ayasya Infrastructure LLP, Hyderabad, Telangana	17-07-2019
3.	Noise Absorptive barrier for Metro/Railway /Highway/Airport Noise Abatement, Lumpsum : Rs 5.60 Lakh including GST, Non exclusive	Reliable Diesel Engineers (P) Ltd, Faridabad, Haryana	04-09-2019
4.	Recycling of Plastic Wastes into Tiles for Structure Designing for Societal Usage), Lumpsum: Rs 17.64 Lakh including GST; Non exclusive (through NRDC)	NAS Industries, Panchpakhadi, Thane, Maharashtra	21-02-2020

- **Agreements/MoUs/NDA etc signed by CSIR-NPL**

Sl. No.	Name of the company/Industry/Firm	Signing date
1.	Tripartite License Agreement amongst CSIR-NPL, National Research Development Corporation (NRDC), New Delhi and Bengal One Enviro Infra LLP, Kolkata, West Bengal for licensing of technology "Recycling of Plastic waste into useful Tiles".	14-05-2019
2.	Signing of project proposal (sponsored project) with Security Printing and Minting Corporation of India Limited (SPMCIL), New Delhi for "Development of Colour Shift Intaglio Ink (CSII)".	09-07-2019
3.	Memorandum of Understanding (MoU) with Reference Material Producer, Bharat Petroleum Corporation Limited (BPCL), Ballard Estate, Mumbai, for "Production of Bhartiya Nirdeshak Dravyas (BND)".	12-07-2019
4.	Scientific MoU with Indian Institute of Technology, Delhi (IITD), for "collaborative Research, PhD and training for M.E./M.Tech, B.E./B.Tech. Students of IITD in CSIR-NPL",	16-07-2019
5.	Tripartite License Agreement amongst CSIR-NPL, National Research Development Corporation (NRDC), New Delhi and Ayasya Infrastructure LLP, Hyderabad for licensing of technology "Recycling of Plastic waste into useful Tiles".	17-07-2019
6.	Memorandum of Understanding (MoU) with Reliable Diesel Engineers (P) Ltd, Faridabad, Haryana for licensing of know-how "Noise Absorptive Barrier for Metro/Railway/ Highway/airport/ Noise Abetment".	04-09-2019
7.	Agreement between CSIR & SUMS Techno Labs Private Ltd (Reference Material Producer) Ballari Road, Hosapete, Ballari, Karnataka, for "Production of Bhartiya Nirdeshak Dravyas (BND)".	17-01-2020
8.	Tripartite License Agreement amongst CSIR-NPL, National Research Development Corporation (NRDC), New Delhi and NAS Industries, Thane, Maharashtra, for licensing of technology "Recycling of Plastic waste into useful Tiles".	21-02-2020
9.	Agreement with CSIR-IITR, Lucknow, UP. (Reference Material Producer) for "Production of Bhartiya Nirdeshak Dravyas (BND)".	13-03-2020

Centre for Calibration and Testing

Centre for Calibration and Testing Centre for calibration and testing has been setup to promote calibration and testing services of NPL. It acts as an interface between customers and all calibration and testing groups. CFCT is responsible for accepting the applications, generating case files and sending calibration certificates and testing reports to the customers. It maintains a customer database of more than 4050 customers. During the year

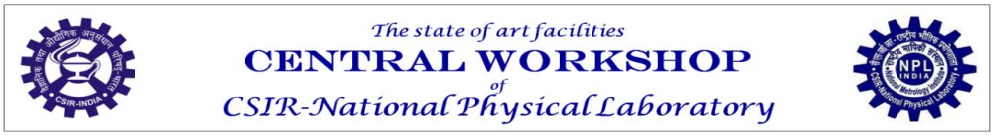
the revenue generated from calibration and testing is11.4 crore out of 2350 for the year 2019-20. This centre follows/maintains the Laboratory Quality System ISO 17025.

Central Workshop

Central Workshop of the CSIR-National Physical Laboratory provides technical services related to design, drawing, modeling and development of new experimental set up/instruments, fabrication of high precision components, repair and maintenance of existing instruments/setup required by the various section of the laboratory. In addition to that this facility also provides inside campus mechanical maintenance and other related work etc.

The central workshop is equipped with the following state-of-the-art facilities:

- 4-Axis Deckle Make CNC Milling Machine with FANUC Controller
- Precision Lathe Machines
- Micro Milling Machines
- Tool and Cutter Grinder
- Precision Surface Grinder
- Sheet Metal and Fitting Shop
- Welding and Glass Technology Workshop




Micro Milling Machine


CNC Milling Machine


Precision Lathe Machine


Welding Shop


Precision Surface Grinder


Tool and Cutter Grinder


Sheet Metal Shop


Glass Technology Section


Fitting & Assembling Shop

A Number of Instruments/components has been fabricated in the workshop such as High Precision OFHC Dilution Refrigeration Sample Holders, High Density Graphite Crucible and Cooling Module for Graphene Growth experiment for Quantum Hall Resistance Standard Metrology. Low temperature sample stage probe for transport measurement which covers the temperature range from 300K to 4.2K, sophisticated components for the indigenous development of PID system and fully Signal sound card cabinet and Horn Transducer connecters used in fabrication of Sodar Antenna etc.

Beside this, the central workshop helps in the maintenance of Apex level standards and establishment of new facility/Instrument and other site mechanical works of the laboratory in several manners. The central workshop facility also involves in the fabrication of the accessories and components using for calibration and testing in the different standards lab and approximate notional earning was Rs. 65.0 Lakhs for the year 2019-20.

International Science and Technology Affairs Group

International Scientific Collaborations are assisting the scientists to share their ideas & papers for developing new technologies & bridging the gap between them for the service of mankind. The group facilitates the overseas visits of scientific and technical personnel of the laboratory to get acquaintance & learn new techniques. It advises the scientists to participate in International Conferences, Seminars and Summer Schools. The group helps the scientists to get prestigious international fellowships. This group also advises the scientists to avail bilateral exchange programme. The total numbers of visits conducted by the CSIR-NPL scientists/technologists during the period were 18. The group also encourages and facilitates the visits of young students to abroad. This year total 22 students visited abroad for attending International conferences/seminars/ workshops and others for research oriented programmes. It also organizes the visit of foreign delegations at CSIR-NPL. International experts are also invited to deliver talks and lectures at CSIR-NPL. During 2019-20, eight foreign delegations have visited the CSIR-NPL. The scientific staff is also motivated to avail sabbatical leave/study leave. Arranging training programmes for international candidates is also the job of this group. International collaborative projects, bilateral exchange programme and MOU are also handled by this group.

Human Resource Development Group

During the period major activities of the group are as follows:

- **Organisation of Industrial Training Courses:**Organisation of training courses on various physical parameters in the area of Metrology / Standards, as well as on other specialized 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 organizations and CSIR-NPL staff.

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

  Total Training Programme till 31/03/2020 = 6 Non Residential

Total No. of Participant = 190
Total ECF Generated: Rs.11,70,560/-

- **Ph.D. Registration and other Support to Research Fellows:**One of the most prominent activities of the CSIR-NPL is to provide help and support to Research Fellows (JRFs / SRFs), starting from the time they join the institute till the time they leave the CSIR-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 /up-gradation, deputation to attend conferences, etc.

  During the period from 1st April, 2019 to 31st March, 2020, 51 research fellows (JRFs/SRFs) joined CSIR-NPL and AcSIR Ph.D. Programme, resulting in a total strength of Research Fellows (JRFs+SRFs) in CSIR-NPL is 289 as on 31.03.2020.

- **Organization of Institutional Visits to CSIR-NPL:**Organization of institutional visits involving students / teachers / faculty members / personnel belonging to schools / colleges / universities / technical institutes / S&T organisations is an important activity of the CSIR-NPL. The basic objective is to provide the visitors a glimpse of the CSIR-NPL activities and achievements, and thus enhance visibility of the institute in the society.

  During the period from 1st April, 2019 to 31st March ,2020, one(01) institutional visit was organized by CSIR-NPL for 50 School children alongwith their teachers.

  Total ECF: Rs. 10,000/-

- **Organization of Student's training at CSIR-NPL:**CSIR-NPL provides training to the students pursuing M.Sc./M.Tech./MCA, or their equivalent degree programmes at different educational institutions spread all across the country, in the areas of research activities being carried out at CSIR-NPL. The basic objective is to provide the students a feel and importance of the various activities, as well as to motivate them towards scientific research as the career.

  During the period from 1st April, 2019 to 31st March, 2020, 115 students were provided training oriented towards the fulfillment of their academic degree requirements in different areas of research under the guidance of senior scientists.

  ECF Generated:Rs. 7,10,120/-

- **Deputation of CSIR-NPL Staff Members to Attend Conferences / Similar Events:**CSIR-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 CSIR-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.

During the period from 1st April, 2019 to 31st March, 2020, 245 cases of CSIR-NPL scientists and other staff members including research scholars, were nominated to participate in various conferences / similar events and different training courses held across the country.

- **Skill Development Programme in CSIR-NPL:**Precision Measurement and Quality Control Certification Course (PMQC) batch 2018-19, Placement interview were organized by inviting interested organization. This year, 45 students have joined the PMQC programme.

  ECF Generated: 7,60,000/- (2nd Installment)

- **Jigyasha Programme with Kendriya Vidhyalaya Sangathan**

  Total Programme:**6** Student : **200**

Quality Management System

The Quality Management System (QMS) of CSIR-NPL is responsible for implementing and fulfilling the requirements of IS/ISO/IEC 17025: 2005 at CSIR-NPL. At present, there are 28 sub-divisions covered under QMS. However, many other activities are in the process of adopting quality system and QMS is providing necessary guidance to them. QMS coordinated the internal audits of sub-divisions, follow up of corrective actions and closure of NCs. Integrated Quality Manual based on IS/ISO/IEC 17025: 2017 and IS/ISO 17034: 2016 is under preparation by a committee.

Annual report (November 2018 - October 2019) of QMS of CSIR-NPL was prepared by taking the necessary inputs from the respective sub-division and submitted to Technical Committee for Quality System (TCQS) of Asia Pacific Metrology Programme (APMP) for APMP GA 2019. QMS has also provided the necessary inputs and information as required by APMP TCQS from time to time.

QMS conducted the course on "Quality Management and Control" as a part of curriculum of the one-year Certificate Course on "Precision Measurement and Quality Control (PMQC)".

Dy. Quality Manager imparted 04 days training on "IS/ISO/IEC 17025: 2017" as a Faculty Member at CSIR-NPL during May 21-24, 2019 under Integrated Skill Development Initiative of CSIR.

Quality Manager delivered invited talks on Quality System in the training programme on Mass Metrology at CSIR-NPL during August 28-30, 2019.

Quality Manager and Dy. Quality Manager delivered lectures in the training programme on "IS/ISO/IEC 17025: 2017" held during February 25-28, 2020 at CSIR-HRDC, Ghaziabad.

Approx. 80 nos. of participants from accredited laboratories, industries, etc. participated in these training programmes.

Knowledge Resource Centre

In CSIR-NPL, the umbrella term 'Knowledge Resource Centre (KRC)' comprised of Library and IT related activities under its domain.

As far as library and information support is concerned, KRC over the years has developed a rich collection of scholarly books and journals, especially in the field of physics and related sciences. During the current year, KRC subscribed to numerous scholarly journals and added a variety of books both in English and Hindi languages to enrich its textual collection. Regarding the services offered, KRC serves the CSIR-NPL community with services like Electronic Document Delivery service, Inter Library Loan service, Reference service, Literature Search service etc. Further, towards improving the quality of science produced by the lab in terms of research publications, NPL-KRC offers content similarity check with the help of the recommended software 'iThenticate'.

In addition to the printed content, the centre also offers online access to more than 6000+ full text journals under the e-consortium project of NKRC (CSIR+DST). The project facilitates access to the electronic content from various publishers such as, ACS (American Chemical Society), AGU (American Geophysical Union), AIP (American Institute of Physics), APS (American Physical Society), IOP (Institute of Physics), OSA (Optical Society of America), Oxford University Press, RSC (Royal Society of Chemistry), Springer, Wiley etc. KRC also provides access to the Indian Standards.

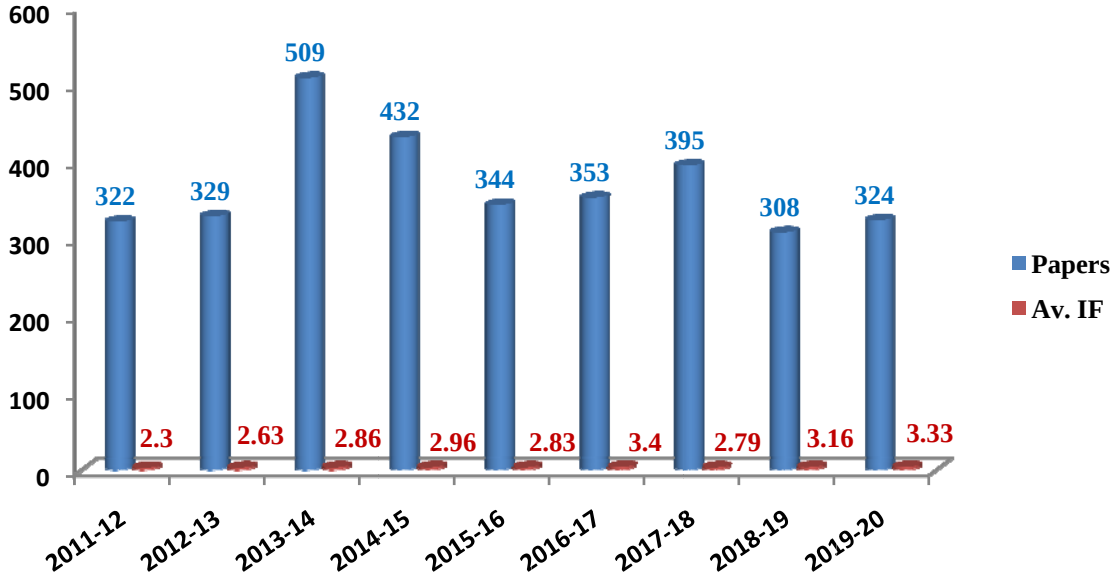
The shift in technology achieved with the automation of KRC activities and installation of improved routers helped in attracting the R & D personnel in large number to optimize the use of the available resources. Further, to promote free worldwide access to the intellectual outputs of CSIR-NPL in form of journals articles, research papers, conference papers, technical reports, preprints, and other scholarly communication, NPL-KRC has established the Institutional Repository (IR@NPL) http://npl.csircentral.net/ and till date, around 3600 records have been added. Further, to enhance the use of licensed scientific software(s) available in CSIR-NPL, a central facility 'eZone' for such applications has been created in the NPL-KRC.

Apart from the library related activities, NPL-KRC also contributes towards maintaining the CSIR-NPL website (http://www.nplindia.in) on the Internet. This is to inform others about the activities of the institute, such as its role towards the society, thrust area of research, facilities, services and achievements.

KRC also provides IT facilities to cater to the computing and communication needs of the laboratory. Data Center services are running 24x7 with in-house set up of various Linux based servers. Internet connectivity has been implemented using 100Mbps through National Knowledge Network (NKN). A gigabit fiber optics backbone network solution is running at various locations across the CSIR-NPL campus and providing CAT6 based ethernet LAN to connect approximately one thousand network based devices i.e. computers, servers, laptops, IP cameras, attendance machines. The gateway security solution has been setup, which includes a Unified Threat Management (UTM) system for multi-level firewall, anti-virus etc. A Radio Link is established between NPL-Campus and NPL-Colony for JRF Hostel Network. JRF hostel is equipped with complete wireless technology solution and devices such as Omni Directional/Directional antennas and

various Wi-Fi devices in different modes and configuration. Email services of the laboratory are facilitated using NIC mail services at mail.gov.in.

Papers Published by the CSIR-NPL in SCI Journals



राजभाषा यूनिट

राजभाषा यूनिट दिन-प्रति-दिन के सरकारी कार्यों में राजभाषा हिन्दी के प्रगामी प्रयोग को बढ़ाने का कार्य करती है । राजभाषा यूनिट का मुख्य उत्तरदायित्व संघ सरकार की राजभाषा नीति, राजभाषा अधिनियम के उपबंधों तथा आदेशों से प्रयोगशाला के वैज्ञानिकों/अधिकारियों/कर्मचारियों को अवगत कराना, अनुपालन कराना एवं अनुपालन हेतु सहायता प्रदान करना है ।

राजभाषा यूनिट के उत्तरदायित्व:

❖ कार्यान्वयन

- संघ सरकार की राजभाषा नीति, राजभाषा अधिनियम के उपबन्धों तथा आदेशों से प्रयोगशाला के वैज्ञानिकों/ अधिकारियों/कर्मचारियों को अवगत कराना, अनुपालन कराना एवं अनुपालन हेतु सहायता प्रदान करना ।
- प्रत्येक तिमाही में निदेशक, एन पी एल की अध्यक्षता में राजभाषा कार्यान्वयन समिति की बैठक का आयोजन, कार्य सूची एवं कार्यवृत्त तैयार करना । बैठक में लिए गए निर्णयों पर अनुवर्ती कार्रवाई करना ।
- हिन्दी दिवस/ हिन्दी मास तथा प्रत्येक तिमाही में हिन्दी कार्यशालाओं/व्याख्यानों का आयोजन करना ।

- राजभाषा विभाग, गृह मंत्रालय, भारत सरकार से प्राप्त वार्षिक कार्यक्रम में निर्धारित लक्ष्यों को प्राप्त करने हेतु उचित कार्रवाई करना ।
- संसदीय राजभाषा समिति के निरीक्षण सम्बन्धी कार्य तथा समिति को दिए गए आश्वासनों को पूरा करने हेतु कार्रवाई करना ।
- प्रत्येक वर्ष विज्ञान विषयों पर हिन्दी में राष्ट्रीय संगोष्ठी का आयोजन ।

❖ प्रशिक्षण एवं प्रकाशन

- हिन्दी प्रशिक्षण (प्रबोध, प्रवीण एवं प्राज्ञ पाठ्यक्रम) ।
- हिन्दी टंकण/आशुलिपि एवं कम्प्यूटर पर हिन्दी में कार्य करने का प्रशिक्षण दिलाना ।
- प्रत्येक छःमाही में हिन्दी समीक्षा पत्रिका का प्रकाशन ।
- प्रयोगशाला की वार्षिक रिपोर्ट तथा अन्य महत्वपूर्ण प्रकाशनों में हिन्दी अंश का संपादन ।

❖ अनुवाद

- प्रयोगशाला में प्रयुक्त सभी प्रपत्रों (फार्मों), मानक मसौदों का द्विभाषीकरण ।
- हिन्दी अनुवाद कार्य ।
- राष्ट्रीय भौतिक प्रयोगशाला के वार्शिक प्रतिवेदन के महत्वपूर्ण अंशों का हिन्दी अनुवाद ।
- प्रयोगशाला की वेबसाइट का हिन्दी अनुवाद ।

❖ प्रयोगशाला द्वारा राजभाषा की प्रगति के लिए उठाए गए कदम एवं प्रयास

- प्रत्येक तिमाही में निदेशक, एन पी एल की अध्यक्षता में राजभाषा कार्यान्वयन समिति की बैठक में वार्षिक कार्यक्रम में निर्धारित लक्ष्यों को प्राप्त करने हेतु चर्चा एवं उनकी समीक्षा की जाती है तथा बैठक में लिए गए निर्णयों पर अनुवर्ती कार्रवाई की जाती है ।
- संघ सरकार की राजभाषा नीति, राजभाषा अधिनियम के उपबन्धों तथा आदेशों से प्रयोगशाला के वैज्ञानिकों/अधिकारियों/कर्मचारियों को अवगत कराया जाता है, अनुपालन कराया जाता है एवं अनुपालन हेतु सहायता प्रदान की जाती है ।
- हिन्दी दिवस/हिन्दी सप्ताह/हिन्दी पखवाड़ा/हिन्दी मास मनाया जाता है । इस दौरान विभिन्न प्रतियोगिताओं का आयोजन किया जाता है, जिसमें प्रयोगशाला के सभी अधिकारी/कर्मचारी भाग लेते हैं और उन्हें नकद पुरस्कार द्वारा प्रोत्साहित किया जाता है ।
- प्रत्येक तिमाही में प्रयोगशाला के अधिकारियों/कर्मचारियों हेतु हिन्दी कार्यशालाओं/व्याख्यानों का आयोजन किया जाता है । इन कार्यशालाओं के माध्यम से स्टाफ सदस्यों को हिन्दी में अधिक से अधिक कार्य करने हेतु प्रेरित एवं प्रोत्साहित किया जाता है । टेबल-वर्कशाप के माध्यम से व्यक्तिगत रूप से चर्चा की जाती है एवं कठिनाइयों का समाधान किया जाता है ।
- प्रत्येक वर्ष विज्ञान विषयों पर हिन्दी में दो दिवसीय राष्ट्रीय संगोष्ठी का आयोजन किया जाता है।

वैज्ञानिकों द्वारा शोध पत्र हिन्दी में प्रस्तुत किए जाते हैं। राष्ट्रीय संगोष्ठी की सारांश पुस्तिका हिन्दी में प्रकाशित की जाती है, जिससे विज्ञान शोध सम्बन्धित जानकारी हिन्दी में आम जन तक पहुंचती है ।

- प्रयोगशाला के अधिकारियों/कर्मचारियों को केन्द्रीय हिन्दी प्रशिक्षण संस्थान से हिन्दी प्रशिक्षण (प्रबोध, प्रवीण एवं प्राज्ञ पाठ्यक्रम) दिलाया जाता है। कम्प्यूटर पर हिन्दी में कार्य करने का प्रशिक्षण दिलाने हेतु कार्यक्रम आयोजित किए जाते हैं।

❖ हिन्दी माह, 2019

राजभाषा विभाग, गृह मंत्रालय, भारत सरकार की हिन्दी दिवस / पखवाड़ा के आयोजन सम्बन्धी निर्देशों को ध्यान में रखते हुए प्रयोगशाला में दिनांक 06 अगस्त,2019 से 14 सितम्बर,2019 तक हिन्दी माह मनाया गया।13 सितम्बर, 2019 को हिन्दी दिवस समारोह का आयोजन किया गया। प्रयोगशाला में स्टाफ सदस्यों को हिन्दी में अधिक से अधिक कार्य करने के लिए प्रोत्साहित एवं प्रेरित करने के उद्देश्य से हिन्दी माह के दौरान विभिन्न प्रतियोगिताओं का आयोजन किया गया । प्रत्येक वर्ष की भाँति इस वर्ष भी जो प्रतियोगताएं आयोजित की गयी वे इस प्रकार से हैं :-

क्रम सं.	प्रतियोगिताएं	दिनांक
1.	लोकोक्ति पल्लवन प्रतियोगिता	06 अगस्त, 2019
2.	शब्दावली एवं अनुवाद प्रतियोगिता	08 अगस्त, 2019
3.	वाद-विवाद प्रतियोगिता	20 अगस्त, 2019
4.	सामान्य ज्ञान-विज्ञान प्रतियोगिता	22 अगस्त, 2019
5.	वर्ष के दौरान हिन्दी में किया गया अधिकतम कार्य एवं हिन्दी डिक्टेशन	28 अगस्त, 2019
6.	गीत एवं काव्य पाठ प्रतियोगिता	03 सितम्बर, 2019

इन सभी प्रतियोगिताओं में प्रयोगशाला के स्टाफ सदस्यों ने अत्यधिक रूचि प्रदर्शित करते हुए उत्साहपूर्वक भाग लिया। प्रयोगशाला के सभागार में दिनांक 13.09.2019 को मुख्य समारोह आयोजित किया गया । इस अवसर पर व्याख्यान देने के लिए प्रो. मोहन, विभागाध्यक्ष, हिन्दी विभाग ,दिल्ली विश्वविद्यालय को आमंत्रित किया गया था । प्रो. मोहन ने हिन्दी दिवस के अवसर पर प्रयोगशाला के सभागार में उपस्थित स्टाफ सदस्यों को दैनिक सरकारी कामकाज में हिन्दी का प्रयोग करने के लिए प्रेरित एवं प्रोत्साहित करते हुए 'वैश्विक संदर्भ में हिन्दी' विषय पर अत्यन्त सारगर्भित एवं विवेचनात्मक व्याख्यान प्रस्तुत किया। निदेशक महोदय ने कार्यक्रम का शुभारंभ किया । इस अवसर पर उन्होंने प्रयोगशाला के स्टाफ सदस्यों को हिन्दी में अधिक से अधिक कार्य करने के लिए प्रेरित करते हुए अपना संदेश दिया । समारोह के अंत में हिन्दी माह के दौरान आयोजित की गयी प्रतियोगिताओं में भाग लेने वाले 43 विजेता प्रतिभागियों को पुरस्कार प्रदान किए गए ।

हिन्दी दिवस पर व्यख्यान देते हुये प्रो. मोहन,
विभागाध्यक्ष, हिन्दी विभाग ,दिल्ली विश्वविद्यालय

हिन्दी दिवस पर संबोधित करते हए निदेशक

सामान्य ज्ञान-विज्ञान प्रतियोगिता

वाद-विवाद प्रतियोगिता

हिन्दी माह का शुभारंभ उद्बोधन देते हुए निदेशक,एनपीएल

लोकोक्ति पल्लवन

गीत एवं काव्य पाठ प्रतियोगिता में काव्य
पाठ करते हुये प्रसिद्ध कवयित्री डॉ. बलजीत

गीत एवं काव्य पाठ प्रतियोगिता में काव्य पाठ करते प्रतिभागी

❖ प्रयोगशाला के वैज्ञानिकों/तकनीकी अधिकारियों/अधिकारियों/कर्मचारियों के लिए कार्यशाला

राजभाषा विभाग, गृह मंत्रालय, भारत सरकार के दिशा—निर्देशों का अनुपालन सुनिश्चित करते हुए हिन्दी के प्रगामी प्रयोग में उत्तरोत्तर वृद्धि हेतु दिनांक 19 जून, 2019 को हिन्दी कार्यशाला आयोजित की गयी।

श्री गुंजन गांधी, उप—निदेशक, रक्षा मुख्यालय, प्रशिक्षण संस्थान, नई दिल्ली ने 'केन्द्रीय सिविल सेवा आचरण नियमावली' विषय पर व्याख्यान देकर प्रयोगशाला के अधिकारियों/कर्मचारियों को बेहतर निष्पादन हेतु प्रेरित एवं प्रोत्साहित किया । इस कार्यशाला में प्रयोगशाला के लगभग 38 वैज्ञानिकों/अधिकारियों/कर्मचारियों ने भाग लिया । यह कार्यशाला अपने उद्देश्य में पूर्णत: सफल रही।

हिन्दी कार्यशाला को संबोधित करते श्री गुंजन गाँधी

हिन्दी कार्यशाला में उपस्थित प्रतिभागीगण

❖ प्रयोगशाला के वैज्ञानिकों/तकनीकी अधिकारियों/अधिकारियों/कर्मचारियों के लिए कार्यशाला

राजभाषा विभाग, गृह मंत्रालय, भारत सरकार के दिशा–निर्देशों का अनुपालन सुनिश्चित करते हुए हिन्दी के प्रगामी प्रयोग में उत्तरोत्तर वृद्धि हेतु प्रयोगशाला के स्टाफ सदस्यों के लिए हिन्दी कार्यशाला आयोजित की गयी । टेक्नोलॉजी ट्रांसफर के संदर्भ में डा. नाहर सिंह, प्रधान वैज्ञानिक ने दिनांक 18 दिसम्बर, 2019 को 'औद्योगिक संपर्क सूमह : देश भर में

गुणवत्तापूर्ण जीवन को बढ़ाने के लिए उद्योगों और सी एस आई आर – एन पी एल के बीच एक पुल' विषय पर व्याख्यान दिया ।

साथ ही, इसी कड़ी में प्रयोगशाला के श्री सुधांशु कुमार, प्रशासनिक अधिकारी(प्रभारी) ने 'कर्मचारियों के अधिकार और प्रशासन का उत्तरदायित्व' विषय पर व्याख्यान दिया। प्रयोगशाला के लगभग 40 वैज्ञानिकों/अधिकारियों/कर्मचारियों ने भाग लिया । यह कार्यशाला अपने उद्देश्य में पूर्णत: सफल रही ।

Annexure

Annexure I

Major R & D Projects during 2019-20

The major projects of value >50 Lakhs are listed below

Sl. No	Project Title	Funding Agency	Contract Value (in lakhs)	Amount Received during 2019-20
1	A system to generate a common synchronised clocks using CVGNSS with an uncertainty of few ns at geographically disturbed sensor nodes	Defence Electronics Research Laboratory (DERL) Ministry of Defence	95	NIL
2	Implementation of IST service using NPL controlled remote oscillator system for national knowledge Network at National Informatics	National Informatics Centre Services Inc. (NICSI)	94.34	NIL
3	Quality Checks of the Data and Instruments working at Air Quality Monitoring Stations in Raipur City	Chhattisgarh Environmental Conservation Board (CECB)	89.53	NIL
4	Carbonaceous Aerosols Emissions, Source Apportioment and climate effects	Ministry of Environment & Forest (MoEF)	274.67	50.00
5	National Primary Standard facility for cell calibration	Ministry of New and Renewable Energy (MNRE)	1788.50	-
6	Development of new Interfacial layers for efficient and stable excitonic solar cells	Department of Science & Technology (DST)	92.80	10.00
7	Growth and study of highly conducting delafossite single crystal: Device application in metrology	Department of Science & Technology (DST)	89.00	4.40

8	Megacity Delhi atmospheric emission quantification assessment and impacts (Delhi Flux)	Ministry of Earth Sciences (MoES)	198.28	NIL
9	Buried contacts high efficiency crystalline radial p-n junction Si Nanocord Solar Cell	Department of Science & Technology (DST)	89.00	17.18
10	Chemical Composition and source apportionment of Aerosols using Receptor Models at urban sites of the Himalayan Region of India	Department of Science & Technology (DST)	71.72	5.30
11	Creation of Testing and Calibration Facility for LED and LED based Lighting at NPL India as per National/International Standards	BEE (Bureau of Energy Efficiency)	2025.00	NIL
12	Production of Certified Reference Materials-Bharatiya Nirdeshak Dravya® (BND)	Ministry of Commerce & Industry, Department of Commerce	1627.00	NIL
13	Delineation of Airshed for Air Quality Management in Delhi-NCR	CPCB (CSIR-NEERI)	193.80	NIL
14	Establishment of type testing calibration and certification facility for online continuous Emission Monitoring System (OCEMS) and Continuous Ambient Air Quality Monitoring System (CAAQMS)	Ministry of Environment, Forest & Climate Change (MoEF)	5660.00	NIL
15	Advanced Single Photon Detector & Establishment of Single Photon Defection Based Quantum Standard for QuEST	DST	578.14	104.50

Annexure II

Awards & Achievements

- Research work of Dr. Bipin Kumar Guptaon "Single-layer graphene deposition using indigenously developed LPCVD set-up at CSIR –NPL" news was covered by Rajya Sabha TV in Gyan Vigyan (Hindi) &Science Monitor (English) and telecasted on June 01,2019.

- Research work of Dr. Bipin Kumar Gupta on luminescent security ink is covered by the Nature India podcast interview entitled "What will it take to make currency notes hard to counterfeit" on July26,2019.

- Dr. GirijaMoona, R.S. Walia, Mr. VikasRastogi and Dr. Rina Sharma of Length and Dimension Metrology have received Best Paper Award in International Conference on Emerging Trends in Electromechanical Technologies and Management, organized at HMRIT, Delhi (July 26-27, 2019).

- Ms. Sumedha Gupta has been conferred with the Young Scientist Award of the International Union of Radio Science (*URSI) for* XXXIII General Assembly and Scientific Symposium (GASS) held in Rome from 29 August to 05 September 2020. She was selected based on the paper entitled "Sources of Ionospheric F2 region variability at low-mid latitude station, Delhi" by Sumedha Gupta and A.K Upadhayaya.

- Dr. Bipin Kumar Gupta is recognized as the top 10% highly cited author in Materials portfolio for the year 2018 of RSC journals on September21,2019.

- Dr. Manju Singh and Dr. Rajib K. Rakshit received the TRIL Fellowship during October 01, 2019 to November 30, 2019.

- Mr. Sushant Sharma, Dr. S.R. Dhakate,Mr. B.P. Singh received Best Poster Awardon Electromagnetic shielding behaviour of structurally strong bucky paper interleaved Kevlar fiber reinforced composites, Conference on Carbon Materials (CCM2019), India Habitat Centre, New Delhi (November20-22, 2019).

- Mr. Ravi Kumar, Dr. Dilip K. Singh, Mr. Rajkumar, Dr. Sanjay R. Dhakatereceived Best Poster Award on Effect of high temperature annealing on the concentration of Nitrogen Vacancy Centers in Nanodiamonds, Conference on Carbon Materials (CCM2019), India Habitat Centre, New Delhi(November20-22, 2019).

- Research work of Dr. Bipin Kumar Gupta on luminescent security ink is recognized and selected for invited speaker in 64th DAE Solid State Physics Symposium (DAE-SSPS 2019) organized by Bhabha Atomic Research Centre, Mumbai and venue of the conference at Indian Institute of Technology Jodhpur, Rajasthan, India,*"Multifold*

*excitable novel luminescent pigment to generate unbreakable advanced security features for anti-counterfeiting applications." (*December18-22, 2019*).*

- Research work of Dr. Bipin Kumar Gupta on development of "Single excitable dual emissive novel luminescent pigment to generate advanced security features for anti-counterfeiting applications" is recognized as List of Science and Technology 2020 & 2019: Inventions and Discoveries, 03 February,2020 and 31December,2019.

- Mr. Ashish Bhatt, Mr. Umesh Pant, Mr. Gaurav Gupta, Mr. Hansraj Meena, Dr. Komal Bapna, Dr. D.D. Shivagan from Temperature and Humidity Metrology received "Springer Best Poster Award" at AdMET-2020 held at CSIR-NPL, New Delhi (January 04- 06, 2020).

- Ms. Sonali Mehra received Best Poster Award in International Conference on Advances in Smart Materials & Emerging Technologies (ASMET- 2020); Indira Gandhi Delhi Technical University for Women (IGDTUW), Delhi (January 23-24, 2020).

- Ms. Naina Lohia awarded with DST Woman Scientist (WOS-A) (January, 2020).

- Ms. Naina Lohia received Best Poster Award in 2nd National Conference on "New Trends in Nanotechnology & Applications "(NTNA-2020); ARSD College, University of Delhi (February 06-07, 2020).

- Mr. Kishor Kumar Johari won Young Scientist Award in 4th International Conference on Recent Advances in Science (ICRAS-2020), organized byFaculty of Science, Invertis University, Bareilly (February 28-29, 2020).

- Dr. S. Swarupa Tripathy was made a Fellow of Academy of Environmental Biology (FAEB) for her outstanding contribution in the field of environmental sciences. (February 2020).

- Research work of Dr. Bipin Kumar Gupta on bi-luminescent security ink for anti-counterfeiting applications for the protection of currency and passport was appreciated in a written statement on, "Discovery of Ink to Curb Fake Printing of Passports and Counterfeiting of Currency Notes" in Rajya Sabha on 03 March,2020 by Honorable Dr. Harsh Vardhan, Minister of Science and Technology, India.

- Mr. Dheeraj Sah, Ms. Chitra, Ms. Kalpana Lodhi, Mr. Chander Kant, Dr. Sanjay K. Srivastava, Dr. Vandana and Dr. Sushil Kumar received Best Poster Award on the paper entitled "Analysis of Extracted Silicon Wafer from Waste Silicon Solar Cells" in the International Conference on Purification and Recycling of Electronic Materials (ICPREM - 2020) held at C-MET Hyderabad (March 08 -10, 2020).

- Research work of Dr. Bipin Kumar Gupta on bi-luminescent security ink for anti-counterfeiting applications for the protection of currency and passport was covered by Rajya Sabha TV (Science Monitor & Gyan Vigyan) and was telecast on March15,2020.

- Ms. Kalpana Agarwal awarded with DST Woman Scientist (WOS-A) (March, 2020).

- Mr. H.S. Rawat received Young Scientist Award at URSI General Assembly and Scientific Symposium 2020 for the work "E-Field Strength Measurement using Rydberg Atom Based sensor for Microwave Metrology".

- Mr. Goutam Mandal reviewed CMCs on liquid volume of five countries (Bosnia, Macedonia, Montenegro, Slovenia and Sweden) under EURAMET.M.65.2019 as member of inter-RMO CMC review team for APMP TCFF.

- Dr. Govind Gupta has been elected as Associate Academician of Asia-Pacific Academy of Materials (APAM) (2019).

- Dr. Bipin Kumar Gupta has received a Reviewer award by ACS in recognition of ACS's mission of service to the global community of Chemists.

- Dr. Yudhisther Kumar Yadav received Best Poster Award for NSU-2019, for the paper entitled, "Ultrasonic transducer selection for Non-Destructive Testing of materials".

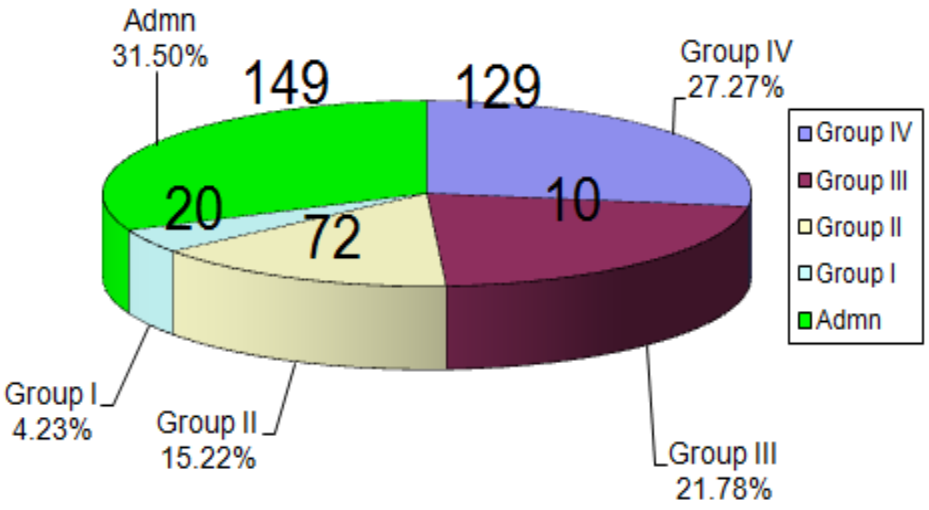
Annexure III

Staff, Patents, Reports and Financial Outflow

Regular Staff in Position

TOTAL NUMBER= 473

Average Age 46.53



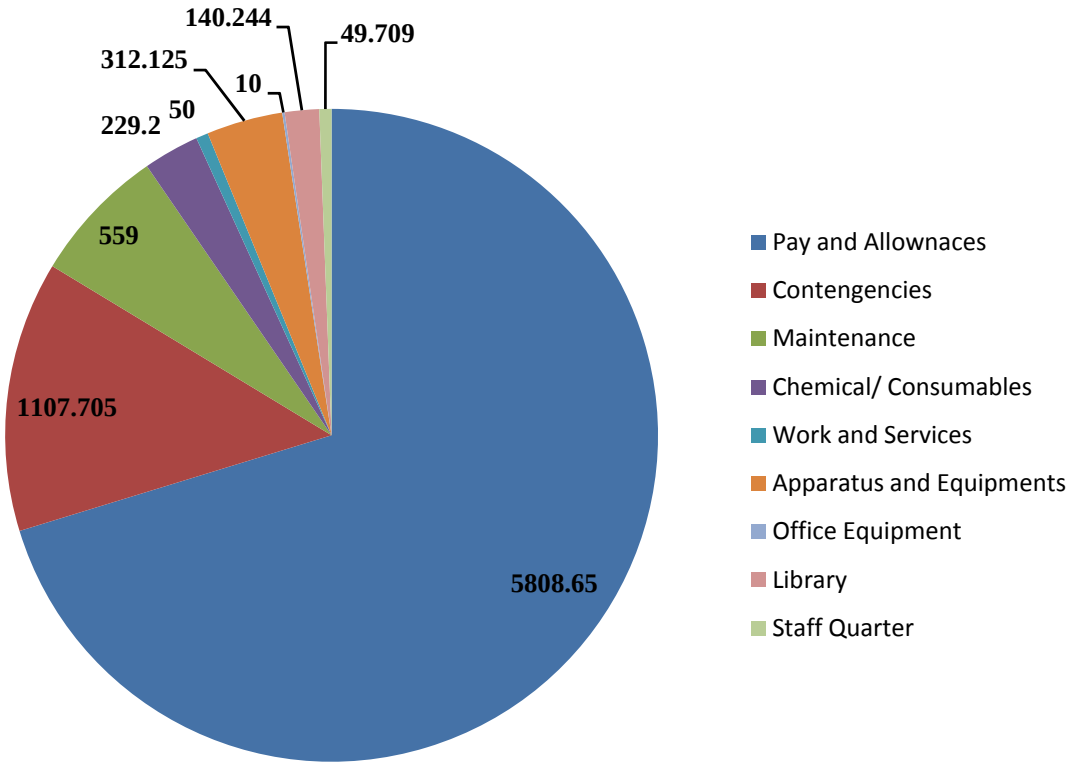
New Recruitments (2019-20)

S. No.	Name	Designation	Date of Joining
1	Ms Sarita Bhardwaj	Junior Secretariat Asstt.(JSA), (G)	12-Apr-2019
2	Sh Sanjay	Junior Secretariat Asstt.(JSA), (G)	12-Apr-2019
3	Dr Manoj Kumar	Scientist	26-Jun-2019
4	Sh Mansingh Meena	Junior Secretariat Asstt.(JSA), (G)	2-Sep-2019
5	Sh Mohit Kumar	Multi Tasking Staff	30-Sep-2019
6	Smt. Vidyawati	Multi Tasking Staff	30-Sep-2019

Patents and Reports

- Patents filed in India: 01
- Patents granted in India: 08
- Patents granted abroad: 02
- Test and Calibration Reports generated: Non-notional - 2324; Notional –473

Budget flow
(in Lakh)



Dr. D.K. Aswal
Tel.: +91-11-45609201, 45609301
Email: director@nplindia.org, dnpl@nplindia.org

Editing, Compiling and Publication

Mr. Ashish Ranjan, Senior Principal Scientist	(Chairman)
Dr. Abhishek Sharma, Senior Scientist	(Convener)
Dr. Dilip Dhondiram Shivagan, Principal Scientist	(Member)
Dr. Sunil Singh Kushvaha, Senior Scientist	(Member)
Dr. Arun Kumar Upadhayaya, Principal Scientist	(Member)
Dr. Bipin Kumar Gupta, Principal Scientist	(Member)
Dr. Sanjay Kumar Srivastava, Principal Scientist	(Member)
Dr. Nirmalya Karar, Principal Scientist	(Member)
Ms. Sandhya Malikar Patel, Senior Scientist	(Member)
Dr. Rajesh, Senior Principal Scientist	(Member)
Mrs. Deepti Chaddha, Principal Scientist	(Member)
Mr. Ashok Kumar, Principal Technical Officer	(Member)
Mr. Abhishek Kumar Yadav, Technical Officer	(Member)

वार्षिक प्रतिवेदन

राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली

CSIR-National Physical Laboratory

Dr. K. S. Krishnan Road, New Delhi

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