102780/2020/R&D-E

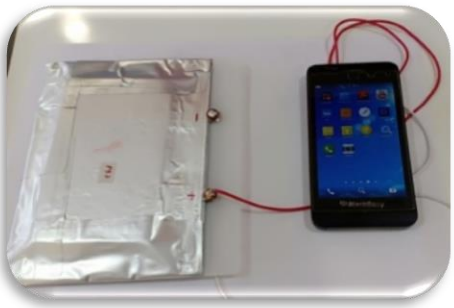
Four Years of Digital India

29th Year

C-MET

ANNUAL REPORT

2018-19



Flexible Lithium ion battery

Silicon carbide single crystal

Aerogel Carbon (Monolith)

CENTRE FOR MATERIALS FOR ELECTRONICS TECHNOLOGY (C-MET)
Scientific society under Ministry of Electronics and Information Technology (MeitY)
Government of India

Governing Council of C-MET (2018-2019)

Shri Ravi Shankar Prasad — **Chairman**
Hon'ble Minister
Ministry of Electronics & Information Technology
Electronics Niketan, 6, CGO Complex
New Delhi-110 003

Shri S. S. Ahluwalia — **Deputy- Chairman**
Hon'ble Minister of State
Ministry of Electronics & Information Technology
Electronics Niketan, 6, CGO Complex
New Delhi-110 003(From 25.05.2018 onwards)

Shri Ajay Prakash Sawhney — **Executive Vice-Chairman**
Secretary to the Govt. of India
Ministry of Electronics & Information Technology
Electronics Niketan, 6, CGO Complex,
New Delhi-110 003

Dr. V. K. Saraswat — **Member**
Former secretary, Defence R&D
Member NITI Aayog, NITI Aayog building
Parliament street, New Delhi-110 001

Shri Pankaj Kumar — **Member**
Additional Secretary,
Ministry of Electronics & Information Technology
Electronics Niketan, 6, CGO Complex,
New Delhi-110 003

Ms. Anuradha Mitra — **Member**
Additional Secretary & Financial Advisor,
Ministry of Electronics & Information Technology
Electronics Niketan, 6, CGO Complex,
New Delhi-110 003 (Upto 21.09.2018)

Smt. Kiran Soni Gupta — **Member**
Additional Secretary & Financial Advisor,
Ministry of Electronics & Information Technology
Electronics Niketan, 6, CGO Complex,
New Delhi-110 003 (From 23.09.2018 onwards)

Shri Rajiv Kumar — **Member**
Joint Secretary (Societies),
Ministry of Electronics & Information Technology
Electronics Niketan, 6, CGO Complex,
New Delhi-110 003

Shri. Arvind Kumar — **Member**
Group Coordinator (R&D Electronics),
Ministry of Electronics & Information Technology
Electronics Niketan, 6, CGO Complex,
New Delhi-110 003

Prof. T. R. N. Kutty — **Member**
No. 48, HMT Layout, 7th Cross/ 7th Main
Rebindranath Tagore Nagar (PO)
Bangalore-560 012, Karnataka

Shri P. Sudhakar — **Member**
Ex-Chairman & Managing Director
and OSD to DAE
Electronics Corporation of India Ltd. (ECIL), Moula-Ali, ECIL post
Hyderabad-500 062, Telangana

Dr. A. K. Bhaduri — **Member**
Distinguished Scientist &Director,
Indira Gandhi Centre for Atomic Research (IGCAR),
Kalpakkam-603 102, Tamil Nadu

Prof. (Dr.) Sanjay K. Nayak — **Member**
Director General, CIPET
Dept of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilizers
T.V.K. Industrial Estate,
Guindy, Chennai -600 032, Tamil Nadu

Dr. Hemant Darbari — **Member**
Director General
Center for Development of Advanced Computing
(C-DAC), Pune University Campus
Pune-411 007, Maharashtra

Dr. N. R. Munirathnam — **Member-Secretary**
Director General
Centre for Materials for Electronics Technology
Panchawati, Off Pashan Road
Pune-411 008, Maharashtra

ANNUAL REPORT
2018-2019

CENTRE FOR MATERIALS FOR ELECTRONICS TECHNOLOGY (C-MET)
Scientific Society under
Ministry of Electronics and Information Technology (MeitY)
Government of India

Vision& Mission

Vision

C-MET will become a premier R&D organization known all over the world for its knowledge base, innovations and expertise in Electronic materials.

Mission

To develop knowledge base in electronic materials and their processing technology for Indian industries and to become a source of critical electronic materials, know-how and technical services for the industry and other sectors of economy.

CONTENTS

Executive Summary

Centre for Materials for Electronics Technology (C-MET) has been developing viable technologies in the area of niche materials mainly for electronics since its inception in 1990. C-MET is working closely with industry and premier academic institutions in the country to develop advanced materials and devices for strategic as well as commercial applications.

C-MET has been working in the area of electronic packaging to design and produce packages for integrated circuits, sensors, sensor packages, microwave communication circuits and biomedical applications. Electrolyte baths for binary Sn-Ag, Sn-Cu and ternary Sn-Ag-Cu systems for surface finishing in PCBs. Two dimensional ReS_2 films for photo transistors and graphene for radio frequency switches.

C-MET has realized silicon nanoparticles coated on MoS_2 nano-sheets for water splitting applications, developed layered nanostructured vanadium oxide for detection of ammonia with swift response and silver paste for photovoltaic cell application with sheet resistance in the range of 4-5 (mΩ/sq) which are very well accepted by Indian industry.

Materials for renewable energy is another area of research, focused on zero emission of CO_2 while generating and storage energy. C-MET has developed ZnO, TiO_2, Nb_2O_5 nanomaterials based Dye Sensitized Solar Cells (DSSC) with efficiency in the range of 6-7%. Demonstrated fabrication of Li-ion flexible batteries using commercial Lithium Cobalt Oxide (LCO) and Graphite on carbon cloth. C-MET has developed electrodes like MoS_2 (Capacity: 120 $mAh^{-1}g^{-1}$), nanoporous carbon, nanoporous N-doped hard carbon (Capacity: 162 $mAh^{-1}g^{-1}$) for sodium ion batteries. Battery pack of capacity 2000 mAh using indigenous LCO and LTO materials were realized for mobile applications.

High purity electronic materials and their compound semiconductors are used mostly in opto-electronic, space engineering and defense applications. Refractory materials are related to the development of high stability, long life time electronic devices with high capacity and high power density for harsh environment uses. C-MET has developed high pure tellurium, cadmium and zinc (> 7N purity) and made granules around 3 mm dia without scarifying their purity. Hafnium metal of 98% purity is being supplied to Vikram Sarabhai Space Center (VSSC) for high temperature alloy applications.

India has missed the silicon revolution in electronics. The next era is predicted to be silicon carbide based electronics. C-MET has grown for the first time in the country the silicon carbide single crystals, which are used as substrates for variety of high temperature and high current electronic devices. This has paved a way to seed indigenous development in silicon carbide electronics.

India produces around 2.2 million metric tonnes of electronic waste every year and it is growing at the rate of 25% CAGR. Nearly 3% share of Printable Circuit Boards (PCBs) in electronic waste can produce around 7-8 metric tonne gold after processing. The

technology for processing of PCBs upto 100 kg per batch has been established at C-MET. In addition, the NABL accreditation facility for analysis of electronic products for the compliance of e-waste (management) rule 2016 is being successfully run to support Indian industry.

Microwave dielectric and packaging is the need of the hour for miniaturization of electric circuits. As part of this an antenna has been fabricated using Z type hexa ferrite (CoZ) magneto dielectric filler which showed 35% miniaturization and 4% enhancement of bandwidth. Similarly, Y-type hexa ferrite (CoY) magneto dielectric filler has shown 30% miniaturization and 4% enhancement of bandwidth.

Sensors and actuators are essential elements required for the country primarily in remote systems. These are used in several real-life applications such as flight control system in an aircraft, process control systems in nuclear reactors, power plants that require to be operated on an auto-control mode. C-MET has developed nano Negative Temperature Coefficient (NTC) compositions for low temperature (-100 ^{0}C to +50 ^{0}C) sensing and submillimeter sized chip thermistors for weather balloon applications.

Supercapacitors are devices with high power density. According to the Global market report (IDTech's Global supercapacitor market 2014-25), it is predicted that there will be substantial demand for supercapacitor worth $ 8.30 billion by 2025, out of which $ 3.80 billion would be for power & energy sector and $ 877 million for smart power grid applications. C-MET designed and fabricated indigenous facility for making aerogel carbon at pilot plant level and demonstrated the process of making supercapacitors in the range of 10F & 25F.

Plasmonic materials are metamaterials which uses surface plasmons to achieve unusual optical properties used for various optoelectronic applications. C-MET has developed new and cost effective materials based on transparent conducting oxide thin films with carrier density (>10^{21}/cc) for plasmonic applications in near Infrared (IR) region.

The Annual Report 2018-19 of C-MET is prepared with the objectives to disseminate and propagate the achievements and other initiatives of C-MET among citizens of the country. It highlights major success stories of technologies developed at C-MET and transferred to industry for productization. The report also includes the ongoing projects and their progress as well as new initiatives during the year 2018-19. Indigenous development and import substitute of critical materials will play a major role in achieving self-sufficiency.

Foreword

It is my profound pleasure to present the Annual Report of C-MET for the year 2018-2019. The salient purpose of this annual report is to accentuate the consolidated scientific activities, R & D inputs, accomplishments and overall impact of technologies developed and transferred by C-MET during the period.

C-MET is a unique R&D institution under the Ministry of Electronics and Information Technology (MeitY), deliberating on materials for electronics, energy and allied applications for the past 29 years. As directed by the members of honourable Governing Council (GC) and Steering Committee (SC), C-MET has been consciously taking rapid strides into R&D for strategic, commercial and societal applications with the demands of the modern era. The multidisciplinary R&D from materials to electronic devices, practicing them from laboratory to industrial use being engaged by C-MET demonstrates our commitment towards commensurate products with high quality to quantity that could build upto pilot plant level.

At this juncture, it is indeed my pleasure to recapitulate a few notable achievements of C-MET during the year 2018-19. C-MET has transferred two technologies to private industries and efforts are being made to transfer more technologies to interested entrepreneurs/start-ups. This year, 09 sponsored projects were successfully completed, and 13 new projects have been initiated and 18 sponsored projects are ongoing from previous year. During the year, research performance indicators of C-MET continued to be impressive in terms of 03 national/international patent applications, 68 research papers in peer-reviewed international journals, 29 contributory papers at various National/ International conferences, and 80 invited talks at various National/ International scientific events. All these awards and honours are testimony to the research excellence of C-MET research fraternity. This could be possible due to MeitY's unstinting support, budgetary resources from external sponsoring agencies and passionate scientific personnel of C-MET.

This year C-MET scientists were appeared in the national news by receiving several prestigious awards such as "**Nari Shakti Puraskar**" presented honourable president of India and National award for women's development through application of science and technology (NAWD) from Secretary DST, for outstanding

achievements in science & technology. On scientific merit basis, in line to previous years, this year also scientists and students from C-MET has received awards for the inventive research in International and National conferences/symposia.

This year also C-MET has blended the 29thAnnual Foundation Day (AFD 2019) celebrations with "International Conference on Supercapacitors, Energy storage and Applications (ICSEA-2019)"organized during 08-10thMarch 2019 at C-MET Thrissur .Dr. Vijayamohanan K Pillai, outstanding Scientist & former Director of CSIR-CECRI, Karaikudi has delivered foundation day lecture on the theme subject. Prof. Roberto Gunnella from University of Camerino, Italy, Shri P Sudhakar, former CMD, ECIL and presently OSD to DAE and Prof. OM Hussain, Physics department, SV University, Tirupati have delivered the Plenary lectures. In addition, 20 invited lectures by eminent scientists from India and abroad have been presented. More than 120 posters were displayed and discussed in ICSEA-2019 through 10 different technical sessions with lots of new trends and concepts by the participants. Nearly 250 world renowned researchers and experts from industry attended and discussed the current status of developments and future trends on the energy storage technology around the globe. Such international events highlight recognition of C-MET across the world.

International workshop on Q -glass for water purification was also held on 20-21st Feb 2019 at C-MET, Pune. Prof Animesh Jha from University of Leeds gave a plenary talk. Almost 65 participants including scientist from UK have participated. Such international events highlight recognition of C-MET across the world.

I must emphasize the accomplishments and achievements by C-MET reflecting the vibrant atmosphere induced by the researchers and innovative R&D projects. There are significant achievements in sensors, compounds semiconductors and energy storage devices during this year. In a similar fashion, we anticipate that C-MET will embark cutting edge technologies in materials development.

I earnestly anticipate that the reading material in this report is interesting to researchers and Indian industries to embark upon our ideas and technologies developed to nurture the progress and progressively advanced technology findings in to the next era and augment the "Make in India" programme a grand success.I welcome your precious suggestions and feedback on this report.

Dr. N. R. Munirathnam
Director General
rathnam@cmet.gov.in

1. Overview: vision, mission, objectives, structure and functions of C-MET

1.1 Introduction

Centre for Materials for Electronics Technology (C-MET) has been set up as a registered scientific society in March 1990 under Ministry of Electronics and Information Technology (MeitY), (formerly known as Department of Electronics (DOE)) as a unique concept for development of viable technologies in the area of materials mainly for electronics. C-MET is operating with its three laboratories located at Pune, Hyderabad and Thrissur with specialized research mandate at each place.

1.2 Objectives

The objectives of C-MET are:

- To establish the technology up to pilot-plant scale for a range of electronic materials and transfer the same to industry for commercialization.
- To establish relevant characterization facilities.
- To undertake applied research activities in the area of its operation.

C-MET has set up its vision, mission and strategy to achieve its objectives.

1.3 C-MET organization structure

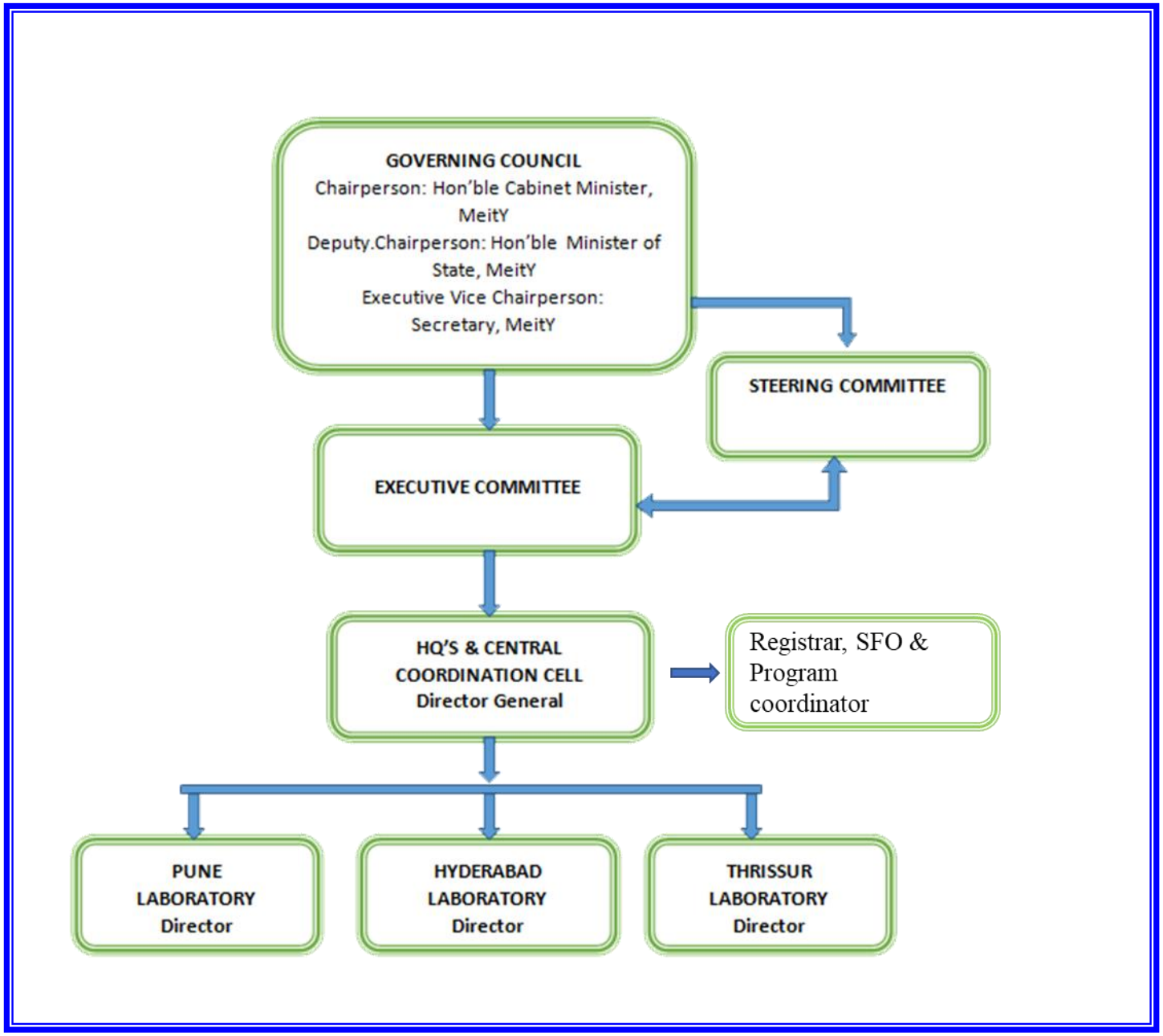


Figure 1. Organization chart of C-MET

1.4 Human resource indicators (as on 31.03.2019)

C-MET team consists of 45 S&T officers, 31 S&T supporting staff and 40 administrative staff.Among S&T staff,43staff are having Ph.D. degrees. Additionally, there are 95 Project staff/Ph.D. students, DST Inspire/Young scientistand women scientists working at three laboratories of C-MET.

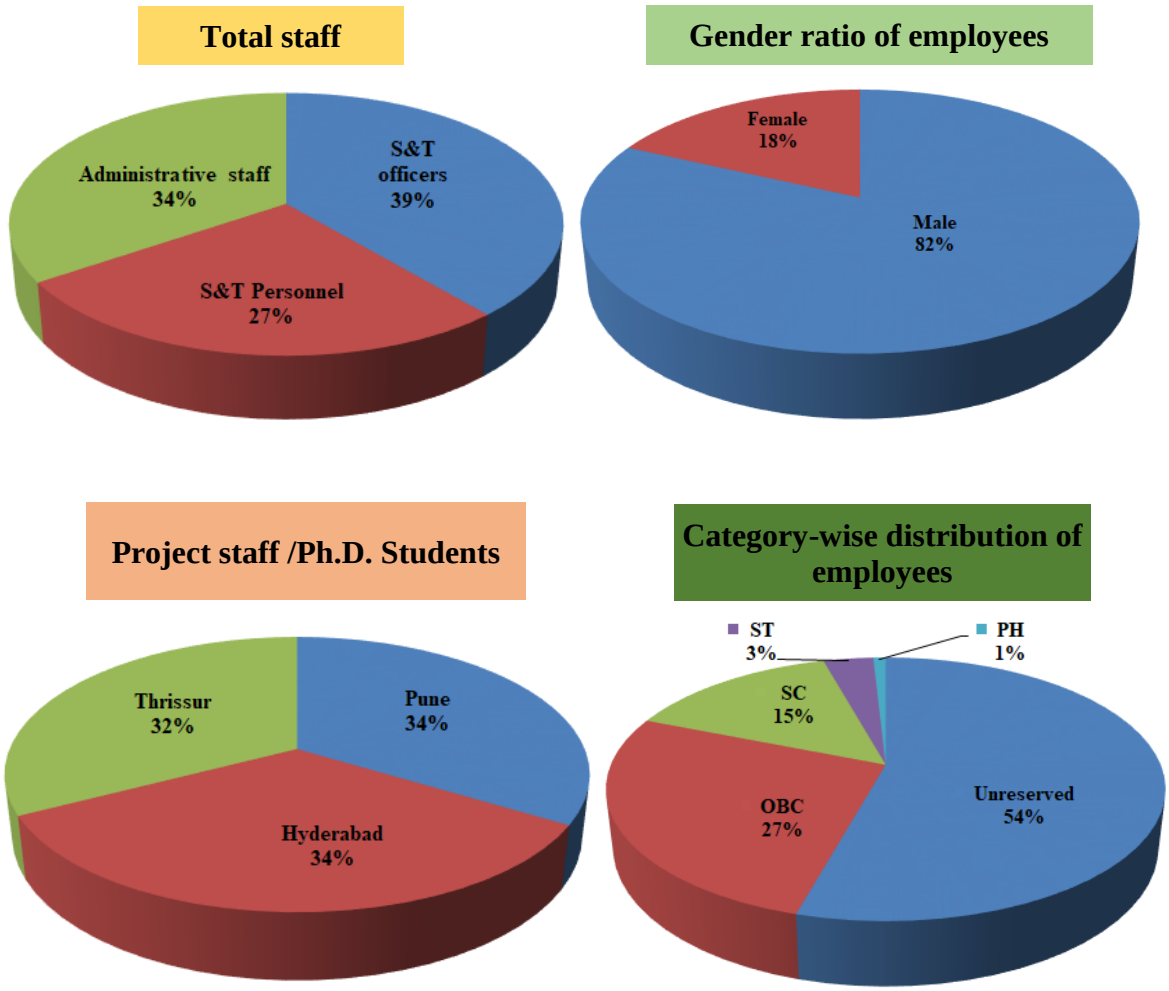


Figure 2. Human resource indicators of C-MET

Sexual harassment of women at work place (prevention, prohibition and redressal):

No such cases are reported at C-MET during the year 2018-19.

2. C-MET's Core Competency in Electronic Materials

2.1 R & D in electronic materials & significance of C-MET

Electronic materials are the materials used in electrical, electronics and microelectronic industries and are core substances for the development of integrated circuits, substrates for circuit boards, energy storage systems, packaging materials, communication systems, optical fibres, displays, and various sensing, detecting, controlling and monitoring devices. Electronic materials form an important segment of advanced materials.

Presently, Information Technology (IT) is one of the premier global technologies. IT comprises data (or information) generation, categorization, transmission, retrieval, processing, and propagation to the benefit of society. Microelectronics is the keystone of IT. A strong IT network needs supporting system, which has the roots in the advanced electronic materials. Although electronic materials are primarily associated with computers, the internet and mobile technologies; they are used in many applications which help to improve overall quality of life. The latest progress made in traditional scientific field often depends upon emerging developments in electronic materials. Advanced electronic materials have been identified as one of the critical technology areas worldwide. Overall development of any nation has its roots in the advancement of defence, agriculture, education, medicine, space and other relevant fields. New heterostructure device concepts will be the basis for further improvements in micro and optoelectronics. High-k permittivity materials play an important role in down-scaling Metal Oxide semiconductor Field Effect Transistors (MOSFET) and Dynamic Random-Access Memories (DRAMs). The high frequency signals receiving, transmitting, modulating demands innovative materials for operation as well as miniaturization. If the present trend is an indication, advancement in electronic materials technology may become the base of the total technology strength of a nation in future.

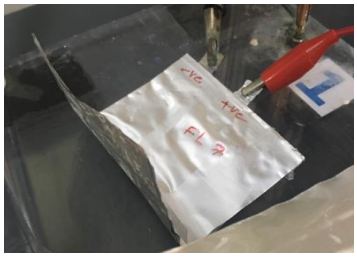
Research and development activities on the electronic materials domain have been pursued by various institutions in the country. However, focussed approach to undertake requirement driven R&D activities lies only with C-MET. This uniqueness of C-MET can be judged through its objectives laid down during its establishment vis-à-vis deliverables. All the developmental programmes undertaken and carried out during previous years and currently are in accordance with these objectives. Various process and product technologies were developed in the area of electronic materials through all these years, but a major stumbling block was the after effects of globalization and open market scenario immediately after the formation of C-MET. Understanding this scenario, new knowledge-based methodologies have been evolved to enhance the partnership of end users like industries, service and strategic sectors in C-MET's technical program.

2.2 Core competence at C-MET laboratories

C-MET's R & D activities have been implemented in three laboratories at Pune, Hyderabad and Thrissur. The laboratory at Pune functions as headquarters also and extends central coordination support. Each of these laboratories has its own area of specialization with requisite infrastructure and expertise. This approach has proven to be successful in creating core competence at each laboratory.

❖ **Pune laboratory**

Materials for electronic packaging, Materials for renewable energy, energy storage and sensors, Nano-materials/composites



Flexible Lithium ion full cell

❖ **Hyderabad laboratory**

Highpure (HP) materials, Compound semiconductors, Refractory metals, alloys, RoHS and e-waste recycling

Silicon carbide single crystal

❖ **Thrissur laboratory**

Microwave dielectrics, Super-capacitors, Multilayer ceramics, Actuators and sensors

Graphene for supercapacitors

2.3 C-MET's approach and current strategy

2.3.1 Our approach

- Majority of Indian electronic materials related industries do not have adequate in-house R&D facilities and are not in a position to set up new production line for new technologies. At the same time, after the globalization, it has become imperative for them to improve their production with respect to quality, quantity and delivery time to compete with their counterparts. To achieve this, they have to depend on either foreign collaborators or identify a suitable Indian partner. Industry had faced immense problems with absorption and up-gradation of imported technologies. Therefore, it has become essential for the industry to interact with an R&D laboratory having a strong knowledge base and expertise in their desired

field of interest. C-MET has identified this situation, as a right opportunity to shake hand with the industry. The paradigm shifts from the research and development to technology development & transfer and providing timely services to industry are important in the changed scenario.

- Strategic sector has been routinely facing uphill task to procure the requisite materials, components and systems for their critical operations from various countries. Indian industries are lacking expertise in realising fully the cutting-edge technologies. Identification of a right agency in both these cases is very important and C-MET has a major role to play in terms of bridging the gaps. C-MET's expertise, infrastructure and long experience suit to take up this challenging responsibility. Hence, the total system has been mobilized and geared up to utilize the present situation in favour of C-MET. Accordingly, C-MET has signed MoUs with DRDO, ISRO and DAE institutes.
- Growing trend in the volumes of electronic waste related informal sectors and difficulties in collection mechanism of electronic waste is necessitating looking towards the eminence digital India programme to estimate the electronic waste dismantling mechanisms and studying the viability of process technologies. Each C-MET centre will give adequate publicity to these discussions, secure wide participation and showcase these discussions in live using social media.

2.3.2 Current strategy

In order to accomplish the set objectives, C-MET has adopted the following strategy for project execution based on available expertise, competence and infrastructure to maximize the participation in strategic and industrial sectors.

- To develop indigenous technologies in the area of Electronic materials to support strategic sector

The salient features of achievements in the year 2018-19 are as follows:

- Nitrogen doped Lithium Titanium Oxide (LTO) have been developed for the first time and shown the capacity of 150 mAh/g at 1C rate.
- Single flexible cell has been fabricated using Lithium-Cobalt Oxide (LCO) and graphite which conferred the capacity of 100 mAh/g at C/20.
- Fabricated aerogel supercapacitor packs of 350F (2.5 V) and delivered to ECIL for conducting experimentson VVPAT for EVM application.
- Developed sub-millimetre sized chip thermistors for weather balloon applications.
- 7N pure Cd and Te have been prepared through zone refining technique and delivered the same to SSPL for night vision camera applications

- To implement projects which are expected to generate technologies which would be commercialized in near future and the products/processes which are required for critical areas covering space, atomic energy, defence, industry, etc., that are essentially small volume but high value products.

- A demonstration plant for processing of 100 Kg PCB /day of electronic waste has been established

- Developed titanium nitride films with carrier density (1022/CC) for plasmonic applications in visible region.
- A pilot plant for production of carbon aerogel for aerogel based supercapacitors has been established and demonstrated carbon aerogel production in 3-5 kg/batch.
- Graphene supercapacitors (<50F) having ESR as low as 40 mΩ have been achieved.
- Higher thickness 6H hexagonal type SiC single crystal bowls were grown.
- Nanosized $MnFeO_4$ ferrite has been synthesized using $MnSO_4$ waste supplied by MOIL, India Ltd., Nagpur.
- Formulated screen printable conductible thick film inks curable at room temperature for polyethylene terephthalate (PET) as well as paper substrate.

- **Electronic Waste, RoHS and Thermal sensor for societal applications**

- First government owned “Restriction of Hazardous Substances (RoHS)” analytical facility is successfully running towards self-sustainability.
- High pure (99.99999%) Tellurium and Cadmium with 60 mm dia ingots were purified, tested at NRC, Canada and delivered to SSPL/DRDO.
- One metre long Germanium ingot was prepared and purified by inductive zone refining.
- Hafnium yield improvement from 28-35% has been achieved by recycling of residual coke briquette and hafnium chloride.
- Developed Negative Temperature Coefficient (NTC)nano compositions for low temperature applications (-100 °C to +50 °C)
- Up-scaled the preparation of aerogel carbon (AGC) to 2 kg/batch by adopting a new and cost-effective technique.
- Supercapacitors of values 5F, 15F, 25F & 35F were fabricated and delivered to IIT-Bombay for further testing in Supercapacitor power packs.
- Sizeable quantity of high pure cathode copper, gold and silver have been processed using electronic waste.
- Acid leaching experimental set-up was up-graded from 0.5 kg batch to 1 kg batch level and prepared 0.3 kg of mixed rare earth oxides.

- **Develop strong knowledge base**

The technology development and pilot plant activities can be sustained for longer period with the backing of scientific capability and expertise of requisite standards. This could be generated by various means, e.g., by undertaking research& development in the relevant areas, hands on training to young scientists and providing services to the industry. Strong R&D knowledge base is essential in developing specialized electronic materials, such as, materials for energy conversion & storage, microwave materials, technologies for recycling of electronic waste, Wide Band Gap (WBG) compound semiconductors, technologies to purify electronic materials, packaging technologies, sensors for smart cities and Internet of Things (IOT), high accuracy sensors and actuators, Transparent Conducting Oxides (TCO), ultrasonic transducer probes for medical imaging and cost-effective solution for early breast cancer detection and X-ray shielding medical apron. C-MET has strong expertise in nanostructured semiconductors, Quantum dot semiconductor glasses, nanocomposites for optical and energy applications.

3. R&D activities and S&T contribution

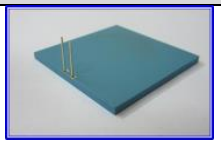
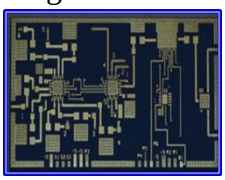
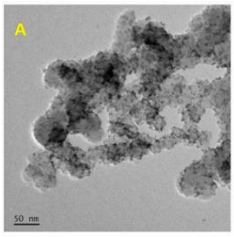
During the year 2018-19, the main technical activities of C-MET are the following:

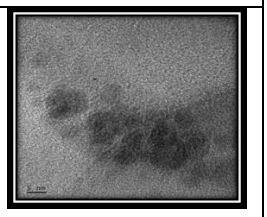
- Implementation of supplementary grant-in-aid projects from MeitY as well as various government funding agencies like DST, ISRO, BARC, BRNS, DRDO, DAE, private industry and public sector,etc.
- Technical and materials characterization services

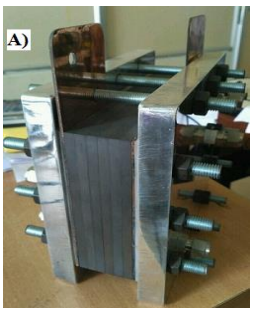
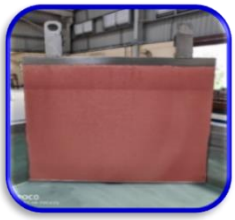
3.1 Core program:

It was proposed to have more coordinated and focused approach to the R & D areathrough inter-laboratory research interactions, where C-MET can deliver by exploiting its expertise gained hitherto in the development of traditional and advanced electronic materials.

In this context, six major core programs listed in the following table are selected for implementation.

S.No.	Core program	Selection criteria	Broad objectives	Products developed
1	Integrated electronic packaging	• Strategic Requirement • Electronics packaging solutions	• Development of LTCC materials for integrated passive components • Fabrication of LTCC devices • Growth of high-density interconnects	 Magnetic sensors  Microwave circuits for SAC
2.	Nano-materials and devices	• Advanced research leading to cutting-edge technologies	• Development of low loss transparent conducting oxide based plasmonic materials and devices. • Large scale synthesis of metals, nanostructured compounds by thermal plasma. • Synthesis of nanomaterials and fabrication	 Stacked (24 Cells) Li-ion mobile battery 

			& testing of sensors for smart cities and agro-electronics.	TEM images of Sn@C nanoparticles
3.	Highpurity materials &compound semiconductors	• Indigenization of critical materials for electronic devices for defence	• Development of the technology and product up to pilot plant level and supply the materials to meet the input materials requirement of strategic sector, e.g. DoS, DRDO and DAE • Development of process technology for refractory metals. • Development of process technology for Silicon Carbide (SiC)single crystals	 Purified tellurium  Purified cadmium  SiC seed crystal
4.	Materials for renewable energy	• Indigenous development of materials, devices and systems for energy storage/conversion for strategic and commercial applications	• Development of process technology and supply of materials for solar energy and other renewal energy industries. • Development of semiconductor nanostructures for photocatalytic H_2 generation	 2% CdS doped Glass

			by water and H_2S splitting • Development of nanoscale cathode, anode and allied materials for battery applications • Fuel cell materials and devices	Fuel cell 
5.	Sensors and actuators	• For strategic and allied applications	• Development of nano material based thick film sensors • Development of textured ceramics for micro actuators	 Photopatternable Thick Film photosensors
6.	Electronic waste and RoHS	• Recycling of hazardous waste to reduce environmental pollution • Extraction of precious metals from electronic waste • E-waste (Management) Rules 2016 compliance by testing	• E-waste recycling: development of pilot plant technology for environmentally safe recycling of E-waste and extraction and recovery of precious metals • ROHS: characterization of electronic and allied products using NABL accredited analytical facility for the compliance of e-waste (management)	 Black copper rods after smelting  Electro refined copper cathode  Extracted gold & silver metals from anode mud

			rules 2016 RoHS directive.	

All these programs are supplemented/complimented by grant-in-aid sponsored projects.

3.2 Products developed for Strategic sector

3.2.1. Hafnium sponge for strategic applications

The first indigenous Hafnium Plant in India, with production capacity of 320 kg /annum of hafnium metal sponge to meet the Vikram Sarabhai Space Centre (VSSC) for their applications in rocket nozzles and thrusters due to its superior mechanical stability at high temperature range of 1500 °C, has been established at C-MET, Hyderabad laboratory. Hafnium is a costly rare metal with a world production of only 70 metric tonnes per annum. Hafnium oxide is also future high dielectric gate oxide material for silicon based MOSFETs due to combination of high dielectric constant (k), thermal stability, large heat of formation and large band gap. Input material for hafnium production is zirconium raffinate which is an effluent generated during the production of zirconium.

Indigenously produced Hafnium Sponge

3.2.2. 7N purity zinc prepared and converted into less than 3 mm diameter shots

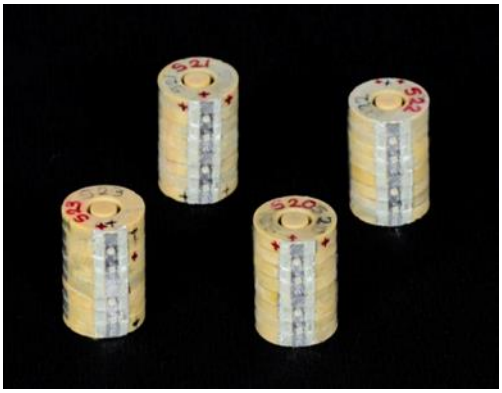
High purity zinc (7N purity) is used in compound semiconductor production such as CdZnTe, ZnSe for γ-ray detectors and electro-optic modulators, respectively. IGCAR, Kalpakkam is in the process of developing cadmium zinc telluride based detectors as an alternative to germanium detectors for which 7N purity zinc granules or shots of less than 3mm diameter.

Ultra High Pure Zinc ingot

Ultra high pure granules

3.2.3. Ring type actuators for MEMS based Microvalves

A MEMS based valve is effectively used for micro-propulsion of a micro-spacecraft, essentially for formation or maintenance of altitude control, such as pointing an RF antenna to earth for data transmission or aiming a camera for optical observations or for very low impulse bit operation. The major advantage of using an multilayer design is the low voltage of operation, absolutely low power consumption and maximum generated force which ensures a very tight leak proof closure during off state under very low reverse voltage and more than enough force during operation to pass the pressurized fluid.



Multilayer Ring type Piezo Actuator

3.2.4. Cystobalite for re-entry launch vehicle

Modified silica filler is a high temperature crystalline polymorph for space application. Modified silica filler is used as reinforcement filler in the adhesive used for bonding e-glass, strain isolation pads and ceramic tiles to space vehicles. C-MET has developed a technology for the production of space qualified phase pure modified silica filler in pilot plant scale with indigenous input material. Indian Space Research Organization (ISRO) used modified silica filler supplied by C-MET in their Space capsule recovery experiments.

Modified Silica Filler material

3.2.5. Medium and low dielectric ultralow loss microwave substrates

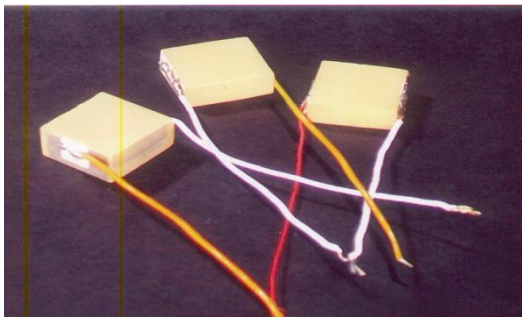
The demand for high frequency circuit design is rapidly increasing because of the high frequency communication explosion for civilian applications. As the low frequency bands are getting over crowded, for meeting the increasing demand, turning into high frequency has become essential which necessitates circuit materials with low dielectric constant. Such substrates have the advantages like fast signal propagation, better signal integrity and low power loss. In order to accomplish aforementioned objectives, C-MET has developed low dielectric constant flexible microwave substrates. The drift in operating frequency with respect to temperature is a serious problem while using flexible microwave substrates for outdoor wireless communication. C- MET has successfully designed, fabricated and tested ceramic filled polymer substrates with temperature stable microwave dielectric properties using single filler material for the first time in the country. The temperature coefficient of dielectric constant of C-MET substrates is less than 30 ppm/°C in the temperature range of 0 to 120 ^{o}C.

Ultralow loss dielectric microwave substrates

3.2.6. Multilayer actuators for robotics

The major advantages of Multi-layer actuators are maximum force (3-5 kN for 10 x 10 mm area), reasonable displacement maximum energy conversion of 70% and low operating voltage $\leqslant$ 150 V. ML actuators in general find applications in variety of fields such as precise positioning for optics/

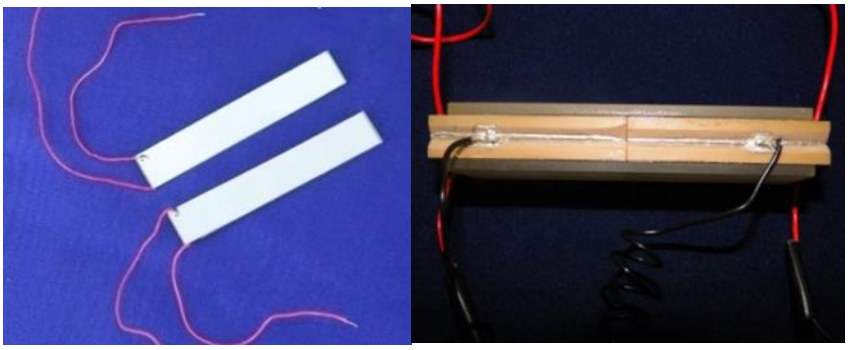
microscopes, automobile multipoint fuel injection, ultrasound, underwater transducer applications etc.



Multilayer Piezo Actuator

3.2.7. Bimorph actuator based mirror for X-ray focusing for RR CAT, Indore

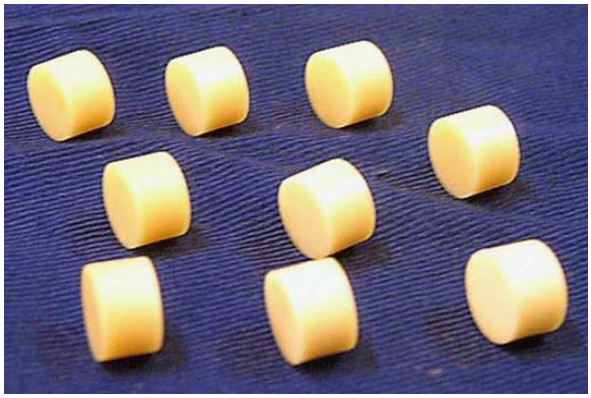
For focusing of x-rays emanating from linear accelerator Bimorph based mirrors of length 100 – 300 mm were developed. In general bimorph actuators are useful for large displacement where the force required is very low.



Bimorph Actuator and Bimorph Actuator based mirror

3.2.8. BMT resonance for space communications

Dielectric resonator (DR) is a ceramic compact, which can confine electromagnetic energy at very high frequencies through total internal reflection by virtue of its high dielectric constant. High frequency devices such as satellite phones, global positioning systems, low noise oscillators, filters etc. require DR as the frequency-determining component. Barium Magnesium Tantalate (BMT) has attractive microwave dielectric properties. However, the processing of these materials currently is difficult and results in wider variation in their unloaded quality factors. C-MET has succeeded in developing super high quality BMT microwave resonators through a patented and cost-effective processing route. The sintered BMT compacts exhibited an unloaded quality factor of 25000. This technology has been transferred to an industry for commecialization.

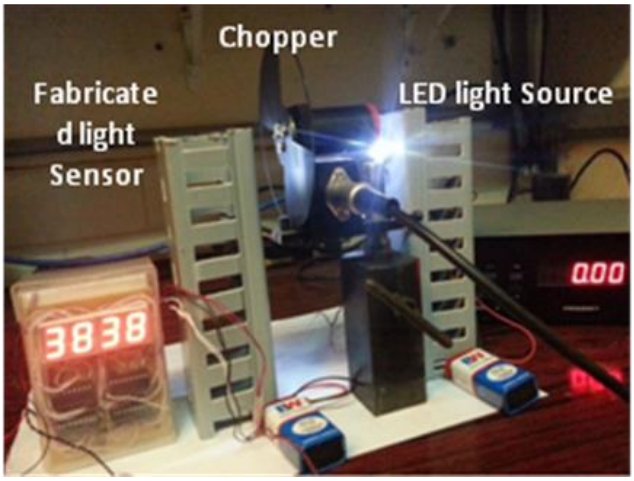


Barium Magnesium Tantalate (BMT) based resonators

3.3 Technologies transferred

Two technologies have been transferred to the Indian industries during 2018-19.

1. The technology entitled “Photo patternable silver and photoconductor (CdS) thick film pastes for photo sensors” was transferred to M/S. Ants innovation Pvt. Ltd, Palghar, Mumbai on 05.07.2018.



Testing of photoconductor (CdS) thick film

Properties	**Values**
Application	**Counter (Object detector)**
Type	Resistive
Material	Activated semi conductor
Fabrication Process	Photopatterned electrode
Electrode spacing	~100 micron
Device dimension	12mm X14 mm
Spectral range	Visible (550nm peak)
Dark resistance	1.8Mohm ±10k
Light resistance	100kOhm±10k
Sensitivity	Three order
Response time	4.5ms
Light source	LED (1. 5 Volt x 2 AAA battery
Sensor and Circuit Power supply	9V volt battery

Distance	5 cm to 1000 cm
Speed	From 1Hz to 220 Hz
Long distance / remote application	Laser as a source (tested at distance100 meter)

2. The technology entitled “Wearable device and analysis system for early detection and screening of breast cancer” has been transferred to M/s Murata business engineering India private limited, Hyderabad on 22.01.2019.

Features

- Privacy of the women is ensured
- Highly trained man power is not required.
- Portable, works on battery power. Ideal for rural India
- Economical
- Do not inflict any pain to the women and suitable for younger women also
- No radiation exposure
- Early detection of breast cancer- decrease mortality rate

Technologies ready for transfer

The following are ready for transfer to the Indian industries. The glimpses of these technologies are given below.

3.4 Technologies ready for transfer

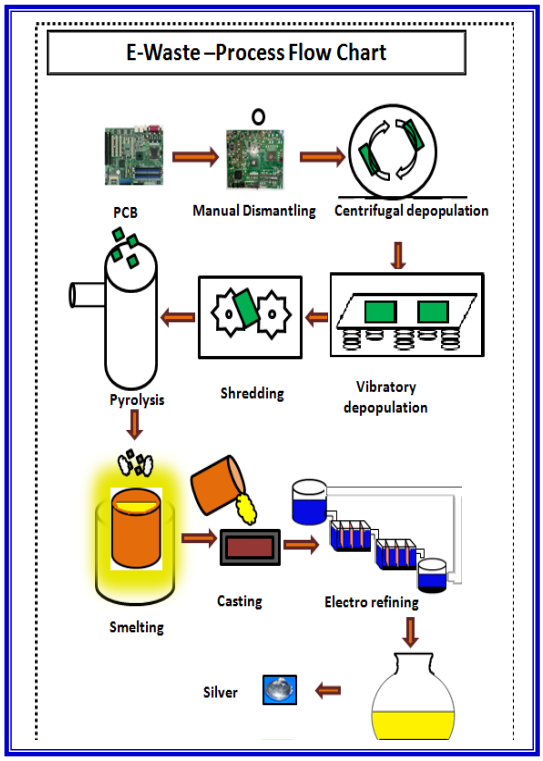
3.4.1 Digital thermometer

The body temperature monitoring market was valued at USD 828.69 million in 2018, and it is expected to reach USD 1,132.06 million by 2024, with an anticipated CAGR of 5.38%, during the forecast period, 2019-2024. In addition, the growing preference of digital thermometer helps in giving more accurate and faster result, when compared to a mercury thermometer. Furthermore, it is safe, as mercury is a neurotoxic metal than can adversely affect the human body. C-MET has developed a low-cost indigenous technology for fast response digital thermometer with a response time of <1s to 3s (depending on type of encapsulation). The sensor part can be designed in such a way that the sensor alone can be disposed after each use and the electronic part can be reused to make the system more cost effective. This will be specifically useful in situations such as detection of contagious disease like swineflu in airports, etc. The level of technology readiness at C-MET: TRL 6.

3.4.2. Graphene through chemical route

It is projected that the Global Graphene (GNP) Market will collect $151.4 million and post a 47.7 percent CAGR by 2021. The demand for GNP is attributed primarily to its low price and wide application. C-MET has developed a technology for the synthesis of graphene through chemical route from natural graphite flakes. India is having second largest deposition of natural graphite flakes and hence graphene can be made in a cost-effective way. Using this graphene, C-MET has developed supercapacitors, actuators and transparent electrodes. The level of technology readiness at C-MET:TRL 4.

3.4.3. E-waste recycling: from printed circuit boards (PCBs) to precious metals



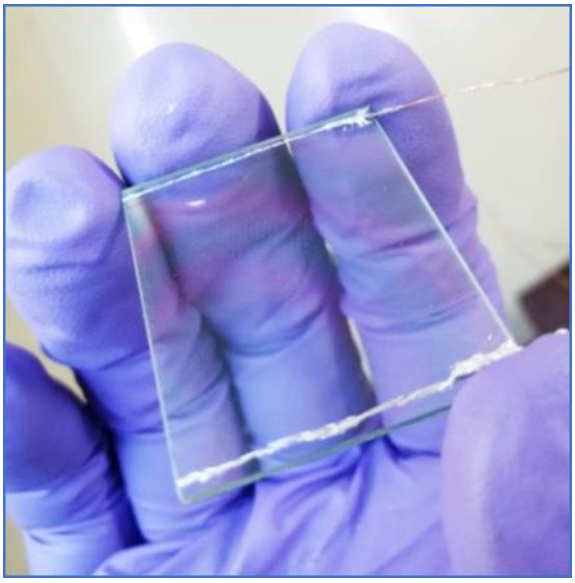
Electronic waste disposal is a grave concern for the country due to hazardous and toxic substances. Currently about 90% of the e-waste generated in the country is ending up in informal sector. On the hand, formal recyclers export spent PCBs to foreign countries, which leads to loss of precious metals. C-MET has developed an environmental friendly process complying with Central Pollution Control Board (CPCB) norms for spent PCB recycling@ 100 kg/day. The expected recovery of precious metals from 100 kg of PCB is: Gold: 15 to 20 gms (99.9% purity) Silver: 30 to 40 gms (99% Purity) Copper: 15 to 20 Kgs (99.9% purity). The metal and chemical segment accounted for the largest market share and is expected to register highest CAGR of 14.02% till 2024. The level of technology readiness at C-MET: TRL 5.

3.4.4. Microwave substrates with dielectric constant 3.5

The global Ceramic Substrates Market size was valued at USD 5.97 Billion in 2016 and is projected to reach USD 8.68 Billion by 2022, at a CAGR of 6.44% during the forecast period from 2017 to 2022. C-MET has developed low dielectric constant (εr = 3.5) and ultra-low loss tangent (tan δ= 0.0018) ceramic filled PTFE substrates for microwave circuit design. These copper cladded microwave substrates are suitable for solid state amplifier design with an output power of 750 watts and is ready for technology transfer. Since the development project is funded by BRNS, the technology will be transferred by Department of Atomic Energy (DAE). Flexible microwave substrates known under the trade name RT/duroid is a proprietary product of M/s. Rogers Corporation, USA. RT/duriod is extensively used by our strategic sectors. It is also required for cellular base stations, military radar communications, global positioning systems. Approximately 250 numbers of 5880 and 6010 substrates per year is required for space applications. The

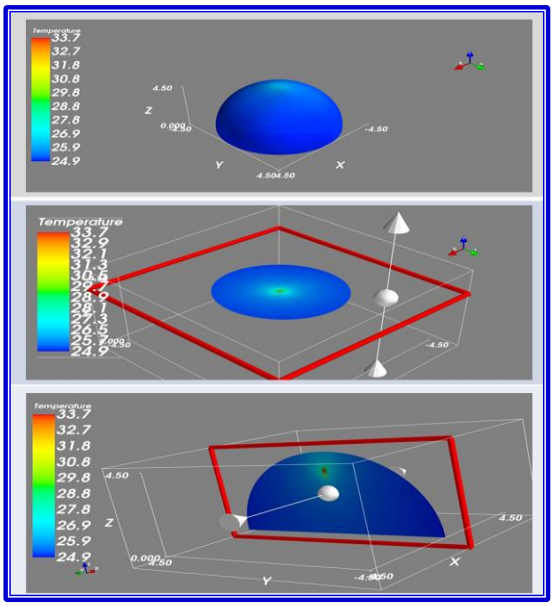
approximate cost of 12” x 12” substrate is around US$ 220. The level of technology readiness at C-MET: TRL 6.

3.4.5. Transparent heater



C-MET has developed optically transparent heater film on glass substrates for defrosting applications through a simple and cost-effective process technology. The heater film provides uniform heating on its surface by applying a small electric power and can be employed in cold environments and for defrosting and anti-icing applications in automobile and consumer industries. Demonstrated on 2"×1" size and the technology can be easily up-scaled to any size. Typical specifications of the product are (i) optical transparency >90% (in visible region),(ii)sheet resistance ~100 Ω/sq, (iii) heater film thickness 200 nm and (iv) substrate: standard soda lime glass. As this new spin off technology has potential applications in many fields including automobile and consumer industries, this product has huge market potential and estimation of the same at this stage is difficult as unexplored wider areas of applications are also feasible. The level of technology readiness at C-MET: TRL 4

3.4.6. Wearable device and analysis system for early detection and screening of Breast Cancer



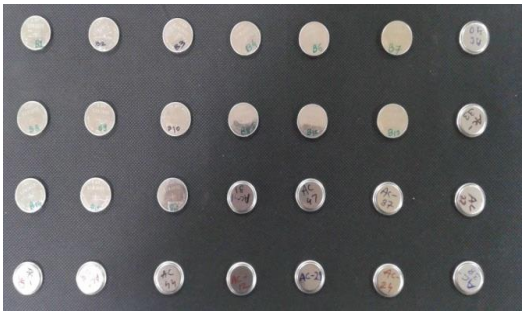
For a country like India with over 1.3 billion population and limited human resources and infrastructure, early detection of cancer is the solution for improving the cure rates of breast cancer and save a large number of cancer patients. C-MET has developed a wearable device using high sensitivity thermal sensors for the early detection and screening of breast cancer. The first phase of the project was successfully completed. The results obtained from the wearable device are very much in conformity with the standard diagnostic tools. C-MET has developed its own 2D analysis system which works on open source platform. C-MET is in the process of developing 3D thermal tomography for finding out location and size of the cancerous tissue. This is shown in the figure as 3D surface and sliced plots for a phantom experiment with a heater position at 3.5 cm. C-MET has filed two Indian patent applications (No.: 201741017186 and No.: 201711047118) and one US patent (No. 15/926,935) for this technology. The level of technology readiness at C-MET: TRL 7.

3.4.7. Aerogel based supercapacitors

The global Supercapacitors market was valued at USD 685 million in 2018, and it is expected to reach USD 2187 million by 2024, registering a CAGR of 21.8%, during the period of 2019-2024. With the ability of quick charging and temperature stability, supercapacitors are replacing traditional electric car batteries. Additionally, supercapacitors are flexible than normal batteries, and high demand for stable power supply for applications, such as GPS, portable media players, laptops, mobile devices, etc., is an emerging trend in the market. C-MET has developed a complete indigenous technology for production of aerogel supercapacitor (with assorted capacitance from 0.47 F to 50.0 F) in cylindrical radial lead forms, for electronics, automobile, power electronics and energy

storage applications. This technology comprises (a) production of carbon aerogel in pilot scale, (b) fabrication of electrodes for supercapacitor and (c) production of aerogel supercapacitors of assorted capacitance values are offered either tone of the above or combination of them on non-exclusive basis. Aerogel supercapacitor: cell capacitance: 0.5 to 50F; Specific capacitance: 60-75 F/g; Cell ESR: 15-800 mΩ; Op. Volt: 2.50 V (surge: upto 2.80 V); Power density: 3-5 kW/kg; Energy density: 6-10 Wh/kg; Working Temp range: -25 ^{o}C ~ + 85 ^{o}C. The level of technology readiness at C-MET: TRL 5.

3.4.8. Li-ion battery



The global lithium ion (Li-ion) battery market is expected to reach 100.4 billion U.S. dollars by 2025, compared to a market size of 30.2 billion U.S. dollars in 2017. C-MET, Pune established whole fabrication facility by taking into account the growing demand of the indigenous Li-ion battery technology for the country. The synthesis and scale up of active materials for electrodes had been started. C-MET developed a full battery fabrication and testing provision for the button/coin type and pouch / rectangular cells under single roof.

3.4.9. Piezoelectric compositions and components

C-MET Thrissur has developed piezoceramic compositions which are engineered for enhanced electromechanical properties. C-MET has the capability to fabricate Components of various shapes like rings, rods ad discs. Typical dimensions and some of the important properties of piezoceramic components offered by C-MET.

3.4.10. Graphene supercapacitors technology

Supercapacitor can be used in a wide range of energy capture and storage applications and are used either by themselves as the primary power source or in combination with batteries or fuel cells. C-MET has developed the technology for "Graphene supercapacitors". Graphene supercapacitors have applications in hybrid/ electric vehicle, renewable energy field in power sector, electronics sector, etc. with cumulative growth rate of 30% as predicted by Elcina. The technology of **"Graphene supercapacitors"** consists of fabrication of graphene supercapacitors from graphene. In this technology, fabrication of graphene upto 100F is included. Capacitance: 100 F to 1F, ESR: 10 mΩ to 100 mΩ. Testing standard: IEC62391-1. An Indian patent has been filed vide application number. 293/CHE/2015. The level of technology readiness at C-MET: TRL 5

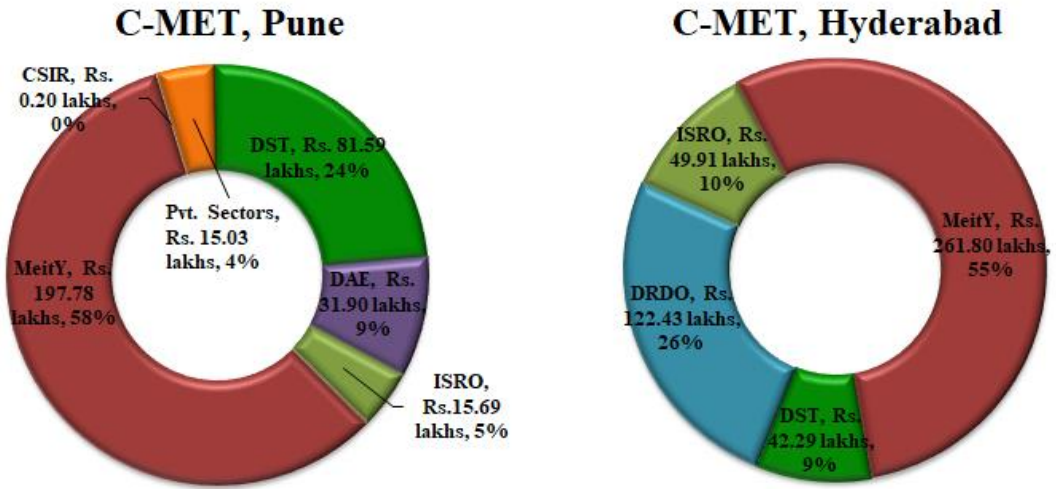
3.4.11. Lead free X-Ray absorbing material & medical apron technology

C-MET developed nanomaterials-based apron

There is always a slight risk of damage to cells or tissue from being exposed to any radiation, including the low levels of radiation. X-rays are harmful to the tissues under long time exposure. C-MET has developed lead free X-ray shielding material as well as fabricated medical apron using these materials. Salient features of the indigenously developed Lead-free aprons compared to commercially available ones are, light weight, lead Free (Non-toxic) and hence eco-friendly and low cost. Specifications of the product are nanostructured hexagonal BiBa Shaving average diameter of around 100 nm and the X-ray absorption /attenuation provide the protection level greater than 0.25 mm thick lead equivalence at 80 kVp. The preparation cost is about **Rs. 6500 per piece** at laboratory. The level of technology readiness at C-MET: 4.

3.5 Externally funded projects

During this year, C-MET has initiated 13 new grant-in-aid and technical services projects, in addition to 19 ongoing grant-in-aid projects from previous year. Also, 08 projects have been successfully completed during the year. C-MET has earned Internal and Extra Budgetary Resources (IEBR) to the tune of Rs. 1292.20lakhs during the year 2018-19. The laboratory wise sponsored projects funding pattern is depicted in Figure 3 below.



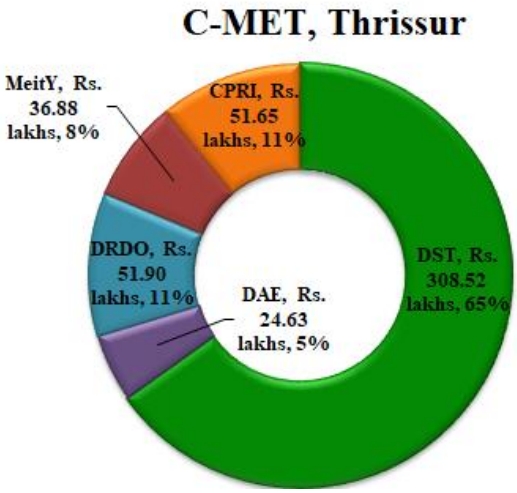


Figure 3. Sponsored projects at C-MET Pune, Hyderabad and Thrissur

The growth in IEBR is graphically shown in Figure 4.

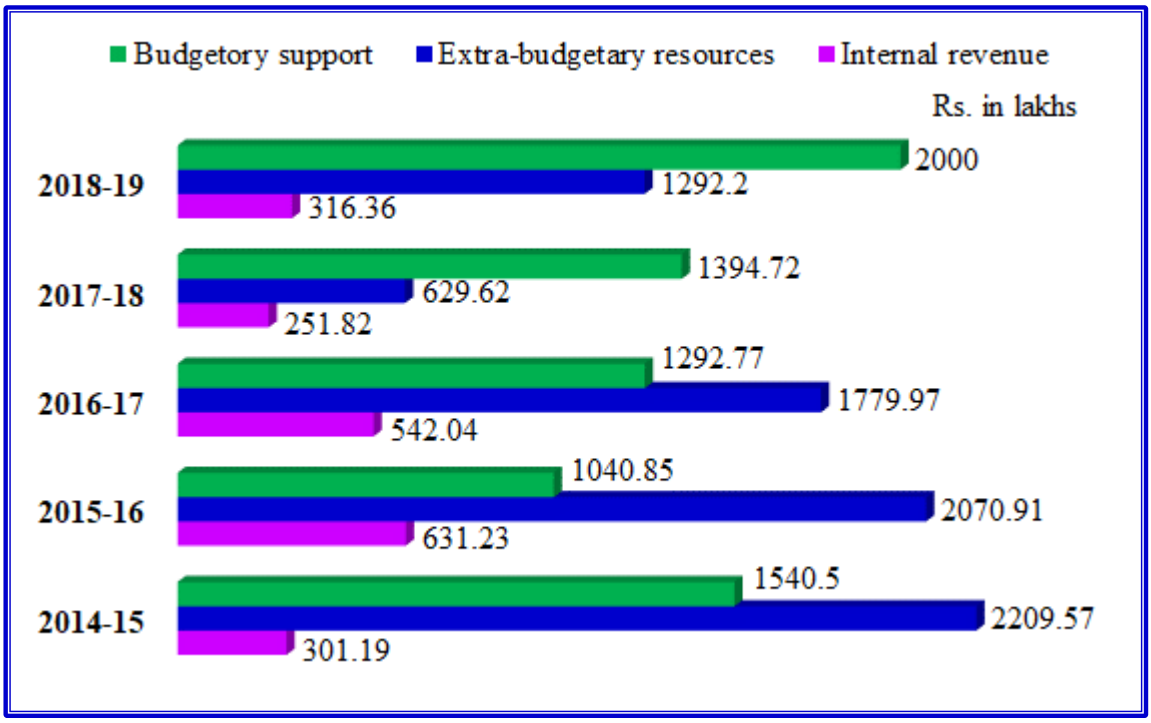


Figure 4. Budgetary support (BS), Internal Revenue (IR) and Extra-Budgetary Resources (EBR)of C-MET since 2014-2015

C-MET has also been enhancing its intellectual outputs in terms of journal publications, conference papers, Indian and foreign patents and invited talks as seen in Figure 5. The trend clearly evidences better scientific recognition of the R&D capability of C-MET scientists.

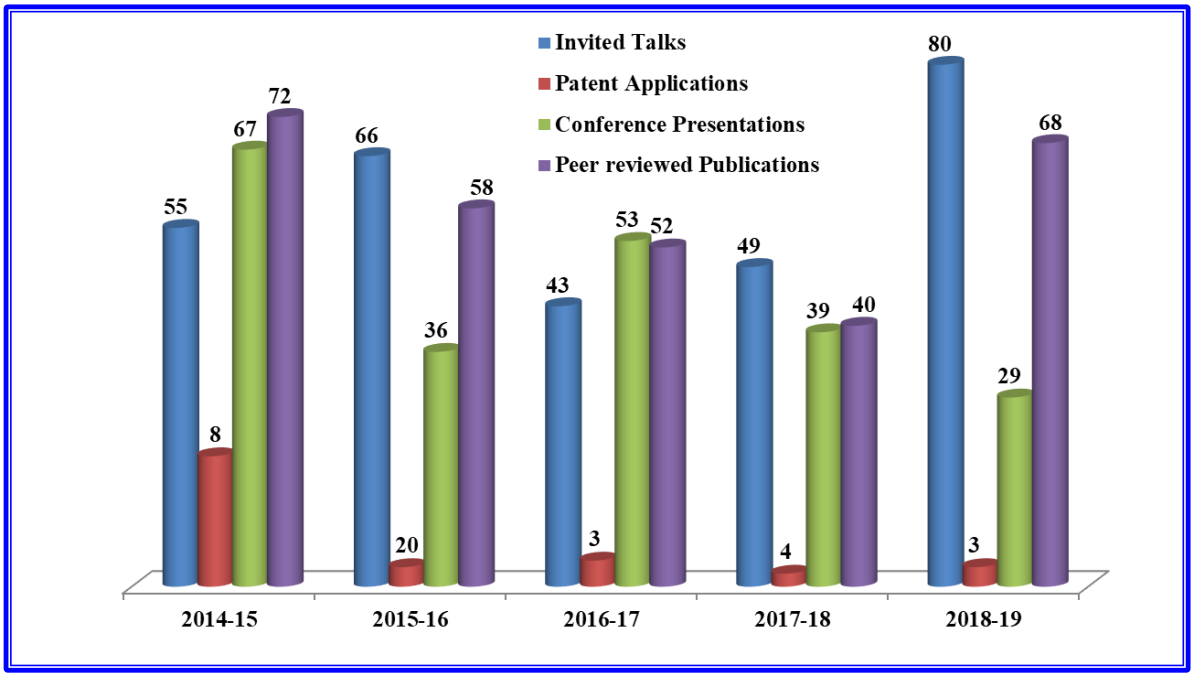
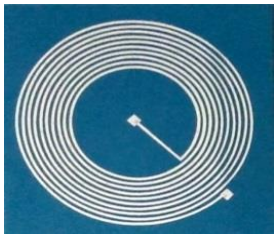
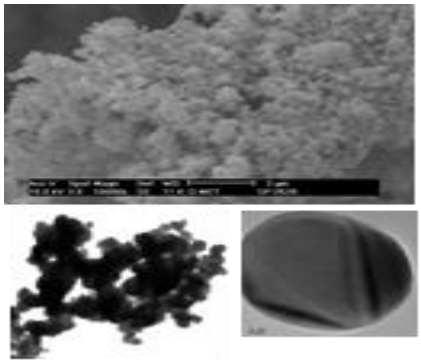


Figure 5. Intellectual output of C-MET since 2014-15

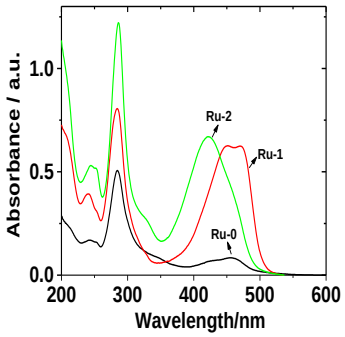
3.5.1 Completed grant-in-aid projects

The major achievements in respect of completed grant-in-aid projects are furnished below:

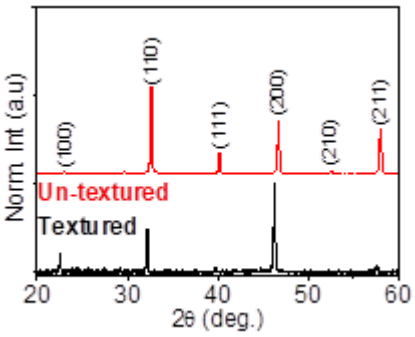
S. No.	Title of the project	Funding agency &duration	Total outlay (Rs. lakhs)	Achievements for 2018-19
C-MET, Pune				
1	Development and testing of LTCC based induction coil magnetic sensors (PN/TS/013)	BARC 19.01.2015 to 18.06.2018	148.5 + taxes	• 10 Nos of 40 layers Magnetic coil sensors fabricated, delivered and accepted by users.  Magnetic coil sensor
2	Development of microcrystalline silver powder for photovoltaic cells and EMI shielding applications (PN/TS/015)	Modison Metals Ltd. Vapi 01.01.2017 to 30.06.2018	26.44	• Silver powder 20-50 g batch with spherical morphology and particle size around 200-300nm, Specific surface area in the range of 1.63-2.57m^2/g and tap density of 1.4-1.5 g/cm^3 was synthesized.

				• Silver paste for photovoltaic cells application with sheet resistance in the range of 4-5 mΩ/sq has been prepared. • EMI shielding of thick film paste in the range of 30-55dB was achieved at 9- 11 GHz frequency. • Prepared silver paste compositions using different batch of powders and also glass frit composition. Electrical properties such as sheet resistance and sheet resistivity of the prepared samples were measured and sheet resistance was found to be in the range of 1-6 mΩ/sq. • Sample submitted to sponsoring agency which are accepted.  Achieved specification: Colour- Greyish/metallic silver Purity: 99.99 % Shape: Spherical as well as flake Size: ≤ 2 μm; more precisely (200-300nm). Surface area: 1.63-2.57 m^2/gm (depend on environmental / drying conditions) Tap density: 1.4-1.5 g/cm^3
3	Sealing of sodium ion cells for automotive applications (PN/TS/016)	KPIT, Pune 06.04.2018 to 05.08.2018	18.40	• Sealing of sodium ion cells were completed and supplied to funding agency.

				 Na ion pouch cells
C-MET, Hyderabad				
4	Development of ultra high pure Zinc for detector applications (HD/SP/38)	BRNS 05.12.2016 to 04.12.2018 (6 months project extension requested)	32.44	• 7N Zinc prepared and converted into less than 3 mm diameter shots.  7N Zinc shots
5	Development of ultra purification process for high scale production of 7N grade Te& Cd. (HD/SP/33)	DRDO 08.12.2015 to 31.03.2019	76.93	• Studies on batch enhancement to produce ultrapure Te& Cd on higher batch scale were done. Optimized process parameters to prepare UHP Te& Cd @4 Kg/batch. • 9.0 Kg each of high pure tellurium & cadmium certified by NRC, Canada was supplied to SSPL as part of project deliverables.  Ultra pure Tellurium
6	Ru(II)&Ir(III)-polypyridine dyads complexes with long-lived 3IL excited state as photosensitizers for visible light switches photocatalytic applications (HD/SP/34)	SERB, New Delhi 01.04.2016 to 31.03.2019	37.00	• Tetradentate Schiff-base ligand have been interacted with Ru(II) and Ir(III) salts in the presence of polypyridine ligands and isolated 1:1:1 ternary metal complexes with good yields. • Biological application studies of polypyridine dyads complexes were carried out by UV-Vis, fluorescence spectroscopy.

				 UV-Vis absorption spectra of Ru-0, Ru-1 and Ru-2
C-MET, Thrissur				
7	Development & Setting-up of pilot scale production of aerogel super capacitors for electronics applications (TH/SP/054 A&B)	MeitY& DST 01.08.2014 to 31.07.2018	2210.66	• Developed indigenous process for production of carbon aerogel and demonstrated production of carbon aerogel in pilot scale (upto 5 kg/batch). • Developed suitable compositions for supercapacitor electrodes using CAG & organic binder of appropriate combinations and fabricated aerogel electrodes in spool form using set of machines designed and fabricated indigenously.  • Developed unique process for Fab. of aerogel supercapacitor (AGSC) of values 0.5–50F using the aerogel electrode, thus produced. Also upscaled the process of making aerogel supercapacitors of selected values (10F, 25F & 40F) to 100 nos./batch by using the machines, designed/fabricated indigenously.

				 • Also fabricated prototype AGSC packs of 300F and performed trails with VVPAT of EVM, which showed encouraging performances.
8	Design & Dev. of Supercapacitor for supercapacitor based Powerpacks for applications in power electronics (TH/SP/056)	BRNS 02.07.2015 to 31.03.2019	190.61	• Upscaled the preparation of aerogel carbon (AGC) upto 2 kg/batch by new cost-effective gel drying technique. • Fabricated more than 250 nos. of supercapacitors of 5-35F using the indigenous aerogel carbon thus developed and they were tested by using SCTS & EWS. The sp. capacitance and cell ESR of ASC were found to be in the range of 55-60 F/g and 200-350 mΩ respectively, which are better than the spec targeted for.  • More than 200 nos. of ASC of different values were delivered to IIT Bombay for testing and further exploration in making the supercapacitor based-power packs.
9	Textured PMN-PT based Piezoceramics (TH/SP/057)	DST-SERB 16.12.2015 to 15.12.2018	31.13	• Synthesized PMN-PT single phase perovskite structure through columbite route and the piezoelectric properties of PMN-PT ceramics around the MPB

				(Morphotropic Phase Boundary) were optimized. • Growth of tabular ST7 through Molten Salt Synthesis (MSS) was carried out and confirmed the formation of ST particles from ST7 through Molten Salt Synthesis (MSS). Prepared ST particle through hydrothermal method also. • Formation of ST platelets from Aurivillius $SrBi_4Ti_4O_{15}$. • Influence of ST seed particle phase on the piezoelectric properties were evaluated. • Optimization of tape casting process and alignment of <001> templates in PMN-PT matrix through tape casting process and properties evaluated.  XRD of PMN-PT ceramics

3.5.2 On-going grant-in-aid Projects

The consolidated progress in respect of on-going grant-in-aid projects is furnished below:

S. No.	Title of the project	Funding agency &duration	Total outlay (Rs. lakhs)	Achievements for 2018-19
C-MET, Pune				

1	Nanostructure NMC as a cathode material for rechargeable lithium ion batteries (PN/SP/072)	ISRO 08.11.2018 to 08.11.2020	25.54	• Trial runs are conducted for the synthesis of NMC (811) and NMC (111). • Physico-chemical characterization is in progress.
2	Development of Sn-Ag-Cu based binary and ternary lead-free electrolyte system for PCB applications (PN/SP/060)	DST 11.05.2016 to 10.11.2019	68.16	• Developed binary Sn-Cu, Sn-Ag and ternary Sn-Ag-Cu electrolyte systems for electroplating of lead – free solders. • Industrial trials for Sn-Cu system is in progress.
3	Fabrication of 2D heterostructures by chemical vapor deposition (PN/SP/061)	BRNS 01.04.2017 to 31.03.2020	34.99	• Successfully fabricated and testedReS_2 few layer continuous films. • Films are being supplied to other collaborators for device fabrication.
4	Plasmonic ionic liquid crystal stabilized nano-clusters for optical devices (PN/SP/062)	DST-SERB 01.04.2017 to 02.04.2020	32.72	• Successfully synthesized the different stable gold, silver nanoparticles (AuNPs) using imidazolium ionic liquids as a stabilizer as well as surfactant to give size of 5nm. • These nanoparticles have been characterized by using different characterization techniques. • Optical properties of these nanoparticles were studied in different molecular solvents. The correlation of surface plasmon resonance of these nanoparticles with solvent properties were investigated. • The phase transfer behaviour of these nanoparticles was also studied without any change in its behaviour. • Finally, the catalytic activity of these nanoparticles for different chemical processes has been investigated.
5	Flexible solid-state supercapacitor devi ce. (Project in	DST	60.64	• Successful optimization of aerogel synthesis has been completed and characterizes.

	collaboration with NIT, Nagpur) (PN/SP/063)	01.07.2017 to 29.07.2020		• The film of porous carbon on stainless steel substrates has been fabricated and sent to NIT-Nagpur • The trial synthesis of V_2O_5 @ C is completed. • Asymmetric supercapacitor has been fabricated using V_2O_5@C and aerogel carbon with stainless steel substrates.
6	Novel nanostructured high-Performance anode materials for high energy Na-ion batteries (PN/SP/064)	DST 30.11.2017 to 29.11.2020	68.27	• The nanostructured SnO_2 has been prepared using combustion technique. • In-situ coating of carbon has been performed. Optimization with reference to electrochemical performance is in progress. • The SnO_2/C has been synthesized and porous structure is obtained. • The electrochemical study was performed and the results show the specific capacity of 200 mAh/g at C/20 current rate.
7	Synthesis of nanosized AlN ceramic powder by transferred arc plasma reactor for electronic packaging applications (PN/SP/065)	ISRO 12.12.2017 to 11.12.2019	28.64	• Nano sized AlN powder using transferred arc thermal plasma reactor has been prepared. The XRD shows the formation of AlN and traces of Al. EDAX show the negligible oxygen.
8	Development of nanostructured manganese ferrite ($MnFe_2O_4$) (PN/SP/066)	MOIL Ltd., Nagpur 01.02.2018 to 31.01. 2020	24.77	• Synthesized and optimized process for $MnFe_2O_4$ (10 and 20 g scale) by hydrothermal and co-precipitation method using $MnSO_4$ solution obtained from MOIL. • The materials showed highly crystalline cubic spinel structure with the particles size distribution in the range of 20-30 nm.
C-MET, Hyderabad				
9	Processing and supply of hafnium sponge	VSSC, DoS,	633.08	• 100 KL Hf-containing Zr scrub raffinate processed for the recovery of HfO_2.

		01.07. 2016 to 30.03.2020		• 75 kg Hf oxide, 80 kg Hf chloride, 40 kg reduced mass prepared • Preparation of another 100 kg of Hf oxide is under progress • 20 Kg Hf sponge supplied to VSSC
10	Process development for recovery of rare earths from CFLs & FLs. (HD/SP/036)	DST 02.09.2016 to 01.09.2019	39.36	• 1kg/batch acid leaching experimental set-up designed and conducted 3 experiments. • ICP-OES analysis of acid leached and solvent extracted samples contain Yttrium (Y) more than 85 %.
11	Recycling of scrap germanium to ultra high pure germanium (HD/SP/037)	DRDO 17.10.2016 to 16.10.2019	122.073	• Installation and commissioning of induction zone refining system and resistive zone refining system completed successfully. • Induction zone refining experiments conducted on three shift basis, >6N Ge prepared. • Analysis of germanium samples by HR – ICMPS at NGRI completed.
12	Environmentally sound methods for recovery of metals from PCB's: phase – II (HD/SP/32)	MeitY 22.08.14 to 31.12.2019	1229.80	• Installed and commissioned indigenously devolved smelting furnace (FFRTF) and conducted three demonstration trials. • Processed 55 kg of calcined PCB and obtained 9.5 kg black copper. • Scaled up electro-refining facility from 1kg/day capacity to 5kg/day capacity. Augmented 500A rectifier, fabricated 0.6kL electrolytic tank and erected overhead circulation tank. • Analysis of gases evolved during calcination of PCB like furans, dioxins, SOx, NOx, CO, CO_2 etc. have been conducted by vimtalabs, and found that all the pollutants are within limits as per CPCB norms. • Established 20 L volume chemical reactor for anode mud processing. • 54 kg cathode copper, 24 g gold and 40g silver have been recovered. • EOI advertised for extending

				services to informal sector for recovery of metal from PCBs on payment basis.
13	SiC single crystal bulk growth process development (HD/SP/35)	DRDO 27.07.2016 to 26.07.2020	998.47	• Physical vapour transport reactor with optimized recipes was used for the growth of SiC single crystal boules with targeted properties. • Characterization of grown SiC boule confirms 100 % 6H polytypes with flat top surface. • FWHM of DoE 6 found to be average < 50 arc-secs against deliverable target of 100 arc-sec. • Completed class 100000 clean room facility for the growth of semi-insulating SiC single crystals
C-MET, Thrissur				
14	Magneto-dielectric substrates for miniaturized antenna application (TH/SP/058)	MeitY 23.08.2016 to 07.02.2020	80.51	• Prepared phase pure Cu substituted analogue of Y-type hexaferrite and Z-type hexaferrite magneto-dielectric fillers through conventional solid state route. • Fabricated polymer YHF & ZHF composite MD substrate for antenna application • The MD substrate exhibited μr=4.7, $\tan\delta_m$<0.03, εr=5.8, $\tan\delta_{\varepsilon r}$<0.01. • Antenna fabricated using the substrate showed miniaturization of 30% and bandwidth enhancement of 4%.
15	Development of transparent conducting oxide and metal nitrides as low loss plasmonic materials in near IR and visible frequencies (TH/SP/059)	BRNS + C-MET 28.08.2017 to 27.08.2020	31.83	• Fabricated Al doped ZnO thin film with carrier density >10^{20}/cc on various substrates for plasmonic applications in near IR frequencies. • Prepared titanium nitride thin films with carrier concentration >10^{22}/cc by DC sputtering on glass substrates for plasmonic applications in visible region
16	Development of transparent conducting oxide	SERB + C-MET	44.85	• Prepared indium doped zinc oxide with a carrier concentration >10^{21}

	based fibre optic plasmonic hydrogen and ammonia sensors (TH/SP/060)	20.10.2017 to 19.10.2020		cm^{-3} by thermal coating for fiber optic sensor applications • Fabricated polyaniline thin films by thermal evaporation for ammonia sensor applications
17	Development of nano NTC composition based sub millimeter sized thermal sensors for low temperature applications (TH/SP/061)	SERB 15.03.2018 to 14.03.2021	47.37	• Developed nano NTC low temperature compositions through SHS route • Disc thermistors were prepared and evaluated for sensors characteristics • Aging characteristics of the thermistors were studied • Tape casting slurries were prepared to make defect free tapes.
18	Supply of amplified linear piezoactuator for use in breathing regulators for aircrew (TH/TS/31)	DEBEL 04.7.2018 to 03.7.2019	43.49	• Piezomaterial identification and tape formation has been completed. • Initiated multilayer ceramic processing is initiated.

3.5.3 Newly initiated Projects

The consolidated progress in respect of newly initiated grant-in-aid projects is furnished below:

S. No.	Title of the project	Funding agency &duration	Total outlay (Rs. lakhs)	Achievements for 2018-19
C-MET, Pune				
1	Development of hybrid battery power module with indigenously developed super capacitor and Li-ion Cell (PN/SP/074)	MeitY – CSIR NEIST 26.12.2018 to 25.12.2021	69.70	• Project has just been initiated.
2	Three-Dimensional nanostructure based miniaturized and flexible rechargeable lithium batteries for flexible electronics (PN/SP/ 068)	MeitY 05.06.2018 to 04.06.2021	454.10	• Performed trial experiments for the synthesis of solid-State Gel Polymer Electrolyte (GPE) for flexible batteries. The ionic conductivity I found to be in range of 10^{-3}S/cm.
3	Engineering of a Q-dot based solar radiation harvestor for enhanced water evaporation and nano filtration (PN/SP/070)	Royal Society of Chemistry (RSC), London 06.08.2018 to 05.08.2020	25.85	• Few glass trials have been performed and glass samples have been sent to University of Leeds, UK for optical characterization. • The heat absorption by the water from glasses have been performed at UK during the visit.
4	Integrated low-cost water sensors for real-time river water monitoring and decision-making (PN/SP/067)	DST 07.06.2018 to 06.06.2021	36.97	• C-MET has discussed the serpentine channel PCR design with users at IIT-Delhi and has finalized the design concept. • A new, well-type PCR design was fabricated for similar applications. • A few fabricated well-type PCR samples with temperature controller electronics and sensor, have been submitted to IIT-Delhi for trials.

5	Development of robust metal supported Micro proton conducting solid oxide fuel cells for portable power applications (PN/SP/071)	DST 13.09.2018 to 12.09.2023	35.00	• Synthesis of proton conducting oxide materials has been carried out. • The sintering behavior of the electrolytes and study of electrochemical properties are underway.
6	Development of printable silver thick film ink for Radio Frequency Identification (RFID) Tags on environment friendly, flexible substrate for smart applications (PN/SP/073)	MeitY 13.12.2018 to 12.12.2021	108.84	• Silver paste formulation with different organics compatible to PET and paper substrate has been initiated. • Procurement of vector network analyzer (300 KHz to 20 GHZ) is initiated.
C-MET, Hyderabad				
7	Development of Indigenous Antennas for Navigation with Indian Constellation (NavIC) (HD/SP/39)	MeitY 29.09.2018 to 28.09.2021	267.02	• Simulation studies performed using High Frequency Structure Simulator (HFSS) for the design of L5 antenna for NavIC module • Copper cladded substrates with high dielectric constant (ε_r=10.2) and loss tangent (tan δ =0.002) at 10 GHz have been fabricated through SMECH process. • L5 antenna is fabricated using photolithography technique and system level evaluation is under progress
8	Design and fabrication of MEMS bionic sensors for Autonomous Underwater Vehicles (AUVs)(HD/SP/40)	DST-SERB 22.03.2019 to 31.03.2022	43.19	• Sanction order received on 22.03.2019 • Literature survey and design of MEMS bionic sensor are under progress
C-MET, Thrissur				

9	Development of supercapacitor bank for electronic time fuse application (TH/SP/062)	ARMREB 10.05.2018 to 09.05.2021	53.115	• Graphene material was synthesized and electrodes were fabricated. • Graphene coin Cell supercapacitors were developed • Electrochemical characteristics of graphene coin cell supercapacitors were studied. The capacities in the range of 0.1 to 0.8 F for different applications have been fabricated and ESR values are in the range of 12 to 4Ω.
10	Development of thermal tomography for the detection of breast cancer and to predict the Size and location of the cancerous tissue (TH/SP/063)	MeitY 12.06.2018 to 11.06.2020	55.67 (for C-MET: 39.70)	• Algorithm for finite element analysis of bio heat transfer equation was developed. • Python was identified as the open source platform for developing the thermal image analysis software. • 2D imaging system was converted to open source. • In order to reduce the computing time and to increase mesh size sparse matrix was introduced in both 2D and 3D programmes. • Coding of 3D programme in Python is in progress.
11	Development of a new and cost effective biosensor based on transparent conducting oxide thin films working in near IR frequency (TH/SP/064)	DST + C-MET 31.10.2018 to 30.10.2020	48.20 (C-MET contribution)	• Prepared TCO film on BK7 glass for device applications. • Initiated the prism coupling experiments with the film coated on BK7 glass. • Delivered samples to the collaborating institute for immobilization studies
12	Dev. of aerogel Supercapacitor based Power Module (SCPM) for application in Voter Verifiable Paper Audit Trail of EVM (TH/SP/065)	MeitY + ECIL 25.10.2018 to 24.10.2021	660.35	• Prepared two batch of organic gels for making require input materials (carbon aerogel). Both the gel batches were cured with TFA for additional cross-linking, and they are now under stage of exchange of pore-liquid.

13	High capacitance (50F to 200F) graphene supercapacitors for storage of power from Renewable energy sources (TH/SP/066)	CPRI (MoP) 20.11.2018 to 31.03.2020	64.80	• Increased the batch size of graphene synthesis at laboratory level.

4. Major pilot plant and infrastructure facilities

4.1.1. Low Temperature Co-fired Ceramic (LTCC) based packaging facility

C-MET, Pune has established a state-of-the-art Low Temperature Co-fired Ceramic (LTCC) facility for research and development in a widerange of applications. LTCC finds applications in microwave circuits, IC packaging, micro-sensor packaging, actuators and integrated microsystems. The facility not only possess high quality machines required for standard LTCC process, but also specialized process machines, such as LASER micromachining, CNC milling and dicing.

C-MET has developed products like low dielectric loss (10^{-4} @ 13 GHz), ferromagnetic materials with resistivity 10^{11} Ω.cm, electrolyte with ionic conductivity 0.035 $S.cm^{-1}$ for LTSOFC and magnetic sensors and magnetic coils for strategic applications.

Clean room of class 10000 and LTCC facility at C-MET, Pune

LTCC Screen Printer **In-house developed Dilatometer**

Figure 6. LTCC facility at C-MET Pune

4.1.2. Li-ion batteries: facility for synthesis of active materials, single cell fabrication and testing of prototype cells

C-MET, Pune has Li-ion battery facility which can be used for the preparation of coin cells upto 2032 and punches of size 120x75 mm (manually) 45x58 mm (automatic mode) C-MET Pune developed 24 cell stacked battery for mobile with conventional circuit. The battery has shown the capacity of around 1200 mAh at C/20 rate.

Lithium ion cell fabrication and testing facility

Spray Pyrolyzer for cathode material preparation

Figure 7. Battery fabrication facility at C-MET, Pune

4.1.3. E-waste plant: recycling demonstration facility

A demonstration plant is established at CMET Hyderabad for the recovery of valuable metals such as copper, silver and gold from obsolete printed circuit boards (100 kg PCBs/day capacity) in environmentally friendly way. Processing facilities such as depopulation, shredding, smelting, re-melting, electro refining and leaching units have been established with gas cleaning systems complying to CPCB norms. A front fired rotary tilting furnace is designed and fabricated indigenously with a view to mechanize the smelting process and thereby improving the yield as well as cost reduction. In order to promote environmentally recycling practices among informal sector, e-waste recycling facilities are extended to informal sector on chargeable basis. Silver 2N pure, copper ~ 90% pure and gold 99.9% pure are extracted using C-MET developed process.

Front Firing rotary tilting furnace Calciner

Gas cleaning system Secondary burner chamber

Figure 8(a). E-waste plant facility at C-MET, Hyderabad**.**

4.1.4. Silicon carbide single crystal facility

Silicon carbide (SiC), an indirect wide bandgap compound semiconductor, has very fascinating and extraordinary electronic properties due to its high thermal conductivity and high power handling capacity at high frequency for advance applications. C-MET has established a state-of-the-art facility for the growth of 2" diameter SiC single crystal boule using physical vapor transport technique – first time in the country, sponsored by DRDO and in collaboration with DMRL and SSPL.

Figure 9. Class 100000 Clean room facility created at SiC laboratory, growth chamber.

As per the MoU signed between C-MET and DMRL, C-MET shall deliver 30 Nos of high resistive 2" SiC boule (10-12 mm thick) with targeted specifications for bandgap, polytypes area, FWHM, MPD, resistivity to be used as a substrate for GaN devices. Single crystal growth process parameters were optimized using Design of Experiments (DoE), simulation through Virtual reactor (VR) software and found excellent properties for DoE-6 (Temperature-2325 ^{o}C, Pressure-12 mbar, SSD – 10.5 mm, coil position – 35 mm). polytype area, FWHM and micropipe density in the grown 6H SiCboule were found to be 100%, average 50 arc-sec, and 70 cm^{-2} respectively against targeted specification of > 60%, < 50 arc-sec and <100 cm^{-2}.

4.1.5. High Pure (HP) materials facility

The impurities in the starting materials used for synthesis, growth of crystals for fabrication of devices are responsible for deterioration of optoelectronic properties of materials and hence the device performance. The properties of electronic devices depend heavily on the quantity and type of impurities contained in the materials. During the last few years, high purity tellurium and cadmium have received great attention due to their role as starting component of several important compound semiconductors such as CdTe, etc. C-MET, Hyderabad has evolved as a unique facility for high pure materials in the country, where in the process technology development for tellurium and cadmium purification is one of the major activities.C-MET has been supplying these materials for the R&D needs for the development of optoelectronic devices. The state-of-the-art facility can meet complete demand in the country.

Figure 10. Resistive zone refining system and purified tellurium and cadmium

Recycling of ultra-high pure materials

An indigenous induction zone refining system has been designed and fabricated for Germanium (Ge) purification. Further, the process technology was developed for the recycling of scrap germanium to ultra high pure germanium. Samples analyzed by GDMS at NRC Canada found to be >6N (99.9999 at.%) Ge. 5 kg of 7N Ge will be supplied to SSPL, DRDO at the end of the project.

Figure 11. Induction zone refining system

4.1.6. Hafnium sponge for strategic applications

C-MET, Hyderabad has established first indigenous Hafnium (Hf) metal sponge plant to meet ISRO requirement. The input material used is scrub raffinate from nuclear fuel complex containing 3-4 gpl of Hf %, which is further processed through solvent extraction to obtain HfO_2. Chlorination, Kroll reduction and vacuum distillation have been employed to get 99% pure Hf sponge with respect zirconium. Hf sponge will also cater to the needs of Department of Atomic Energy (DAE) in control rods of nuclear reactors. C-MET is also working on developing novel spin off products based on the indigenous availability of Hf in different forms.

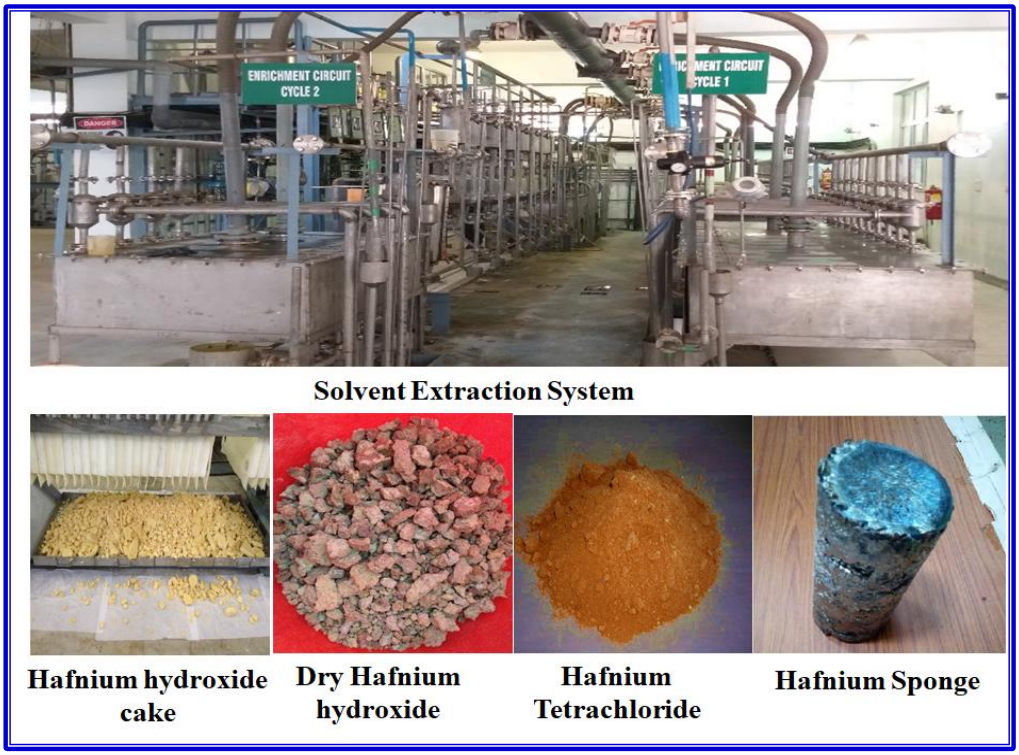


Figure 12. Solvent extraction system, wet & dry hafnium hydroxide, hafnium tetra chloride and hafnium sponge.

4.1.7. Restriction of Hazardous Substances (RoHS) test facility

C-MET, Hyderabad laboratory has established a state-of-the-art and NABL accredited chemical testing facility (bearing no. T-1780) for the analysis of electrical, electronic equipment and related products to help the industries and developed a mechanism to identify and quantify the banned hazardous substances such as Pb, Cd, Hg, Cr^{6+}, polybrominated compounds, under e-waste (management) rules 2016 in the area of polymers, metals. This is the only government owned testing facility in India established with the financial support of Ministry of Electronics & IT (MeitY), Government of India. In addition to NABL accreditation, C-MET is also having Bureau of Indian Standards (BIS), Govt. of India recognition for testing of mercury levels in CFLs and Fluorescent Lamps (FLs) as per standard methods. More details can be found at http://cmet.gov.in/rohs-services.

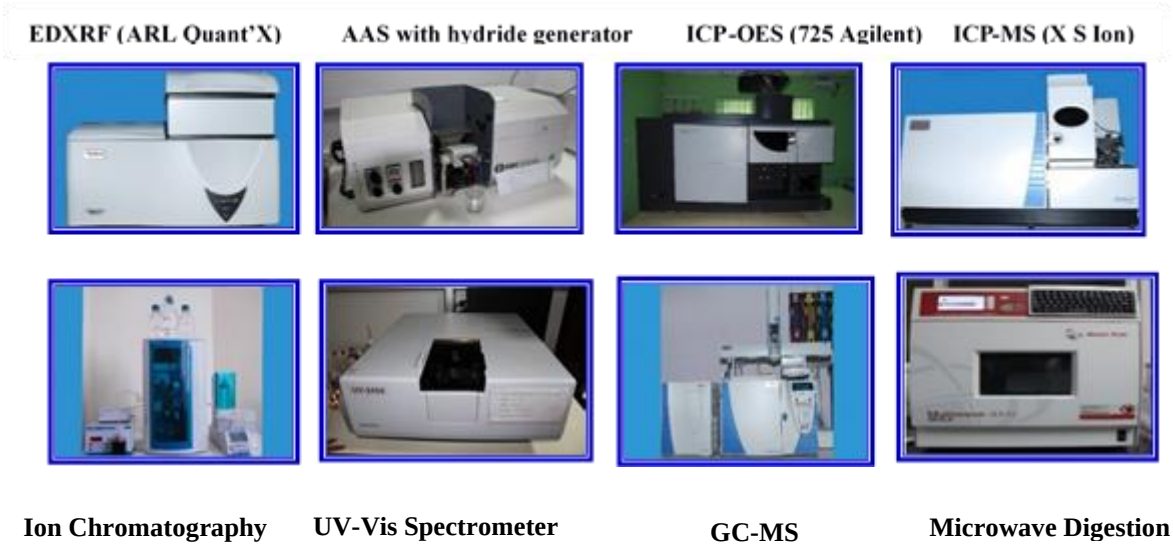


Figure 13. RoHS laboratory facility for the detection of hazardous materials

4.1.8. Carbon aerogel and graphene-based supercapacitors

4.1.8 (a) New infrastructure &machineries for fabrication of aerogel supercapacitors:

A new laboratory building of 12,300 sq. ft has been made for housing the machineries for fabrication of aerogel supercapacitors of different values upto 50F. Also a dehumidified clean room of class 1000 with RH<15% has been designed and set-up at C-MET Thrissur laboratory for sealing of supercapacitors under low RH conditions.

Pilot plant facilities for the prototype development of supercapacitors

4.1.8 (b) Pilot plant for production of carbon aerogel:

Aerogel production plant is the unique facility, which has been set-up/established at C-MET, Thrissur for the first time in India. The plant has the capacity of producing aerogels upto 5 kg per day per batch, which is capable of making 25,000 pcs of aerogel supercapacitor (1F). This aerogel production plant was established with the financial support of DST, Govt. of India and fabricated indigenously.

Figure 14. Aerogel tape forming machine, Gel reactor

4.1.9. Flexible microwave substrates for high power microwave applications

Flexible microwave substrates are extensively used for variety of high-end microwave circuit applications such as high-power solid-state amplifiers, patch antennas, missile guidance, mobile base stations, etc. C-MET, Thrissur has developed a patented SMECH process, which comprises of sigma mixing, extrusion, calendaring followed by hot pressing for the fabrication of planar and dimensionally stable microwave substrates. Copper cladded microwave substrates with dielectric constant values 2.9 to 14.8 were developed indigenously for the first time. In this year, 250 nos of circuit boards suitable for high-power solid-state amplifier and 50nos of copper cladded substrates of size 200 mm (L) x 200 mm (B) x 0.762 mm (T) were delivered to RRCAT, Indore and to BARC respectively.

Figure 15. Processing facility for microwave materials, processing equipment and deliverable products

4.1.10. Indigenous facility for making chip thermal sensors

NTC Chip thermistors are extensively used for accurate temperature measurement and control in automobiles, medical field and electronic appliances. To meet the challenging demands in the latest thermal devices high accuracy, close tolerance and high sensitivity thermistors are required. The thermistor-based temperature sensors market is estimated at $0.84 billion by 2018 at a compound annual growth rate (CAGR) of 3.93% over the period 2014-2020. The inclination of growth towards

vehicle production, availability of a strong aftermarket, and rising trends of security and surveillance are the key drivers which are making the thermistor temperature sensors market to grow lucratively.

Fast response chip in glass NTC thermistor, an alternative to glass sealed bead and epoxy coated chip NTC thermistors combine the best characteristics of both devices. C-MET has developed different NTC compositions, chip thermistors and chip in glass fast response thermal sensors suitable for various temperature ranges of sensing applications. C-MET has even developed sub-millimeter sized chip thermal sensors for weather balloons and low temperature applications. Using chip thermal sensors, a wearable device was developed for early detection and screening of breast cancer.

Figure 16. Processing facility for making thermal sensors

4.2 Major characterization and testing equipment available at C-MET

Name of the equipment	Model	Manufacturer	Applications
Pune laboratory			
UV-VIS Spectrometer	UV 3600	Hitachi, Japan	Spectroscopic chemical analysis
Spectrofluorometer	JOBIN YVON F3	Horiba, Japan	Defects in semiconducting materials
Photo Luminescence Spectrometer	RF-5301	Shimadzu, Japan	Luminescence studies of organic, inorganic and polymeric compounds
Potentiostat/Galvanostat	PG-100	Autolab, Netherlands	Electrochemical synthesis and characterization
TGA/SDTA/DSC/DPA	Toledo 821, 851	Mettler, Switzerland	Thermal characterization of organic, inorganic and polymeric samples
TMA/DMA	Perkin Elmer 7e	Perkin Elmer, USA,	Thermomechanical analysis of polymers
Fourier Transform Infrared Spectrometer (FT-IR)	PE Spectrum 2000	Perkin Elmer, USA	Spectroscopic chemical analysis
Scanning Electron Microscope (SEM) with EDAX	Philips XL-30	Philips, Netherlands	Surface morphology and related microanalysis

Graphite furnace Atomic Absorption Spectrometer	Avanta-sigma	Nulab, USA	Trace impurity analysis
Hot Stage Microscope	FP-900, Lica DMLP	Mettler- Toledo, Switzerland	Characterisation of liquid crystalline polymers
Scanning Probe Microscope (SPM)	Pico plus	Agilent Technologies Inc., USA	Examination of topological features at atomic scale
Field Emission Scanning Electron Microscope (FE-SEM)	S-4800 II	Hitachi, Japan	Surface morphology and related microanalysis
Field Emission Transmission Electron Microscopy (FE-TEM)	JSM 2200FS	Jeol, Japan	Surface morphology and related microanalysis
Broadband Impedance Spectrometer	C80	Nova Control	Frequency sweep measurements of dielectric properties and conductivity of materials
BET Surface Area Analyser	Nova Touch LX	Quantachrome Instruments	For surface area measurement of nanomaterial powders
Name of the equipment	**Model**	**Manufacturer**	**Applications**
Thickness measurement Unit (TMU)	Talysurf CLI 2000	Taylor Hobson	For surface profiling, thickness measurement of coatings and deposits, roughness parameter
Particle size analysis	380	Nicomp	To measure the particle size and real time particle size distribution.
X-Ray tomography	MICRO XCT-400	Carl Zeiss	For ultra-fine analysis of the microstructure, in-situ experimentations such as tensile/ compression and temperature variation tests while imaging
Hyderabad laboratory			
Inductively coupled Plasma Mass spectrometer (ICP-MS)	X-Series II	Thermo Fisher Scientific, Germany	Elemental analysis in liquid (ppb/ppt level)
Inductively coupled plasma optical emission spectrometer (ICP-OES)	iCAP 6500 series	Thermo Fisher Scientific, Germany	Elemental analysis in liquid to ppm level at Hafnium facility
X-Ray diffractometer (XRD)	Xpert PRO	Panalytical, Netherlands	Phase and impurities detection in materials
Inductively coupled plasma optical emission spectrometer (ICP-OES)	Agilent 725	Agilent Technologies India Pvt. Ltd., Bangalore	Elemental analysis in liquid to ppm level at RoHS facility

Gas chromatography-mass spectrometer (GC-MS)	DSQ II	Thermo Fisher Scientific, USA	Analysis of poly brominated compounds in electronic materials
Energy dispersive X-ray fluorescence (ED XRF)	ARL Quanta X	Thermo Fisher Scientific, USA	Screening of elemental analysis down to ppm level
Ion chromatography (IC)	850 IC Professional	METROHM, Switzerland	Estimation of anions/ cations
Atomic absorption spectrometer (AAS)	932AA	GBC, Australia	Elemental analysis at ppm/ ppb level in liquids
Microwave digestion system for RoHS facility	Multiwave -3000	ANTON PAAR, Vienna	Closed digestion of samples by Microwave
Microwave digestion system for Hafnium facility	Star D	Milestone, Italy	Closed digestion of samples by Microwave
Carbon sulphur analyzer	EMIA-920V2	Horiba, Japan	Estimation of carbon, sulphur in metal samples
Name of the equipment	**Model**	**Manufacturer**	**Applications**
ONH analyser	ONH-836	LECO, USA	Estimation of oxygen, nitrogen and hydrogen in materials
UV visible spectrophotometer	UV 2450	Shimadzu, Japan	Organic &inorganic analysis of elements in liquids (micro level)
TGA/DTA	S-II 7300	S-II, Nano Technology, Japan	Thermal characterization of organic, inorganic and polymeric samples ≤ 1400 ˚C
ED-XRF	EPSILON I	Panalytical, Holland	Elemental analysis from Na to U, in PCB, intermediates and slag
Fire assay system	CF-15	Carbolite UK	Estimation of precious metal
Fluorescence Spectrometer	L565	Perkin Elmer, USA	Measurement of fluorescence
Optical microscope	DSX 510	Olympus, Japan	Microstructural analysis
Gas chromatograph	Trace 1110	Thermofisher, India	Estimation of volatile compounds in organic molecules
Thrissur laboratory			

DSC/TGA	SDTQ600	TA Instruments, USA	To study physicochemical changes with respect to temperature up to 1500 ˚C
Supercapacitor testing systems (SCTS)	BT-2000	Arbin Instruments, USA	To measure charge-discharge cycles, cell capacitance and ESR of supercapacitor test cells at under V=0-10V & I=0.01~1.0A.
Multichannel high current supercapacitor testing module	BT-ML-4CH-20A	Arbin Instruments, USA	For testing of supercapacitors (charge-discharge cycle, cell capacitance, ESR) under voltage & current in the range of 0-40 V & 0.1~20 A.
Gain phase analyser	Model 4294A	Agilent Technologies, USA	For impedance analysis of materials in the frequency range 40 Hz to 110 MHz
Name of the equipment	**Model**	**Manufacturer**	**Applications**
Electrometer	6517A	Keithley, USA	Measurement of electrical resistivity (10 Ω to 210 TΩ) voltage/current, RH, etc.
Vector network analyzer	E8263 B	Agilent Technologies, USA	Microwave characterization of dielectric resonators, composite substrates, ferrites, tunable dielectrics etc.
Piezo evaluation system	FE 2000	AixACCT, Germany	For piezoelectric property evaluation
Thermo mechanical analyzer	TMA/SS6 100, SII	Japan	Measurement of thermal expansion coefficient of materials
UV-Visible spectrophotometer	Lambda 35	Perkin Elmer, USA	For measuring the absorbance in the UV-visible region
Surface Area & Pore size Analyser	Quadrasorb- Evo-KR/MP	M/s Quantachrome Instruments, USA	To analyze Surface area and pore size distribution of porous materials
Helium pycnometer	Ultrapyc1 200E	M/s Quantachrome Instruments, USA	To determine skeletal density of porous materials
FT-IR	Spectrum 10	M/s Perkin Elmer, USA	IR spectroscopy to study the chemical environments of species
SEM with EDS	EVO 18	M/s Carl Zeiss	Microstructural and elemental analysis of materials

Electrochemical workstation (EWS)	Aut302N	M/s AutoLab Inc., Netherlands	To study electrochemical behaviour of samples by the CV & FRA technique.
Hall measurement system	HMS-3000	M/s ECOPIA	Measurement of resistivity, carrier density, mobility and P/N type
X-ray diffractometer	Ultima IV	Rigaku, Japan	Phase identification of crystalline materials, crystalline phase evaluation, structure studies etc.

The detailed information of equipments available at C-MET are available at website http://www.cmet.gov.in/equipments-list .

5. Important events

5.1. ToT function of photopatternable silver and photoconductor (CdS) thick film pastes for photo sensors application, Ants Innovation Pvt. Ltd., Paghar, Mumbai.

C-MET, Pune has transferred the technology entitled "Photopatternable silver and photoconductor (CdS) thick film pastes for photo sensors application" to M/s. Ants Innovation Pvt. Ltd. Paghar, Mumbai on 05th July 2018. The certificate of permission was handed over to Shri. Ashwini Jain, Director, Ants Innovation Pvt. Ltd by the hands of Dr. Sandip Chatterjee, Director and head, EMCD, MeitY, New Delhi at C-MET, Pune.

5.2. C-MET, Pune organized a workshop on "Q-dot and nanostructured materials, characterizations, processing and device Fabrication (Q-dot-NMat-2019)"

C-MET, Pune has organized two days workshop on "Q-dot and nanostructured materials, characterizations, processing and device Fabrication (Q-dot-NMat-2019)" at C-MET, Pune during 20-21st February 2019. This workshop was jointly organized by the University of Leeds, UK

sponsored by Royal Society Chemistry (RSC), London under the International Collaboration Scheme for “Drinking water for all” (a Sustainable Development Goal of UN, under which several grand challenges are defined.

5.3. DST Subject Expert Committee Meeting (SEC) organized at C-MET, Pune

C-MET, Pune have organized Subject Expert Committee meeting (SEC) of Department of Science and Technology (DST)- for woman scientists during06-07 April 2018.

5.4. One day C-MET - VSSC joint workshop at VSSC, Thiruvananthapuram

One day C-MET – Vikram Sarabhai Space Center (VSSC) workshop on “development of advanced materials for space applications” was held on 21st November 2018 at VSSC, Thiruvananthapuram. VSSC, Director Dr. S. Somnath and C-MET, Director General, Dr. N. R. Munirathnam had addressed scientists about possible scientific and technology exchange between two centers.

5.5. Hafnium production facility inauguration at Hyderabad

Hafnium production facility was formally inaugurated on 07thSeptember 2018 by Shri S. Somanath, Director, VSSC (Dept. of Space, Govt. of India). Dr. Dinesh Srivastava, CEO, NFC (Dept. of Atomic Energy, Govt. of India) was guest of honour. Dignitaries from VSSC and heads of other local research organizations, veterans of C-MET fraternity and collaborating industries participated in the event.

Inauguration of Hf plant by Director, VSSC & DG, C-MET facilitating Director, VSSC

5.6. Vigilance awareness week

C-MET, Hyderabad was observed vigilance awareness week from 29th October 2018 to 03rd November 2018. The theme of vigilance awareness week was “Eradicate Corruption – Build a New India”.

5.7. National science day celebrations

In connection with National science day celebrations, many students from nearby colleges/schools visited C-MET, Hyderabad research facility and interacted with C-MET scientists on 28th February 2019. Various research activities being carried out by scientists at C-MET, Hyderabad have been presented and students were encouraged to ask questions with a view to spur their research interests. Prof. B.R. Sant, Scientist (Rtd.), CSIR delivered a lecture on "pursuit of excellence" in the occasion of science day celebrations.

In similar way, National science day celebrations were held at C-MET Thrissur on 28th February 2019. The laboratory was opened to visit by the public and students. Around 500 students from various colleges visited the laboratory and scientists have explained about the technologies/products developed at C-MET. The National Science day lecture was delivered by Dr. Dr. G. Suresh, senior scientist, Naval Physical Oceanographic laboratory, Kochi, on 'MEMS Sensors'. He highlighted the importance of MEMS based sensors and presented the recent developments in this area. Dr.S. N. Potty and Dr. N. C. Pramanik spoke on the occasion.

5.8. International Conference on Supercapacitors, Energy Storage and Applications (ICSEA-2019) and 29th Annual Foundation Day - 2019

C-MET Thrissur conducted an International Conference on Supercapacitors, Energy storage and Applications (ICSEA-2019) during 08-10 March 2019 as part of the celebration of its 29thannual foundation day. More than 250 researchers, renowned speakers, and experts/leading specialists in various parts of the country and abroad, especially those are actively engaged in supercapacitor

technology, particularly on development of novel electrode/electrolyte materials, novel concepts & designs, attended ICSEA-2019 and discussed the current status of developments and future trends towards the energy storage technology across the world. Dr. Vijayamohanan K Pillai, the outstanding scientist & former Director of CSIR-CECRI laboratory has delivered foundation day lecture on "Electrochemical energy storage: role of 2D materials for enabling a sustainable future" in ICSEA-2019. Prof. Roberto Gunnella from University of Camerino, Italy, Shri P Sudhakar of former CMD, ECIL and Prof. OM Hussain from SV University, Tirupati delivered the plenary lectures. In addition, 20 invited lectures were also delivered by eminent scientists from all over the globe. More than 120 posters were presented in this ICSEA-2019 through 10 different technical sessions. ICSEA-2019 is a grand successful event with lots of new ideas and concepts shared by the participants.

5.9. National workshop on RoHS compliance and environment-friendly e- waste recycling

As a part of Swachhtapakhwada (01-15 February 2019), MeitY, Govt. of India program, a national work shop on "RoHS compliance and environment-friendly e-waste recycling" was organised by C-MET, Hyderabad on 01st February 2019at gurukul seminar hall, NFC Guest House. Rear admiral (Retd.) Sanjay Choubey, CMD, Electronics Corporation of India (ECIL), Hyderabad was the chief guest. Invited talks on e-waste and RoHS were delivered by top officials and scientists from MeitY, other research institutions, e-waste industries and corporate world. Dignitaries from NFC, CCCM, ECIL, ETDC, and other local organizations, industries, and C-MET fraternity were also participated in the event.

5.10. Swachhta pakhwada at C-MET &Secretary, MeitY visit

As per the guidelines of MeitY, Govt. of India and C-MET, Headquarters, C-MET, Pune, Hyderabad and Thrissur laboratories were observed Swachhta pakhwada from 01st to 15thFebruary 2019. During this period, all scientific, administrative, supporting staff and students were actively participated in cleaning of the campus.

Shri Ajay Prakash Sawhney, Secretary, MeitY visited C-MET Hyderabad laboratory in connection with Swachhta pakhwada on 09th February 2019 and evaluated the environmental friendly e-waste recycling process and the pilot plant facility established by C-MET through MeitY sponsored project. A detailed presentation on various features of e-waste technology has been made by scientists and future programmes envisaged to roll out the technology for supporting informal sector in the country was appraised. Secretary appreciated the efforts made so far by C-MET and urged the need to augment the facility to meet country's requirement. The first Government owned Restriction of Hazardous Substances (RoHS) facility at C-MET campus also visited by the secretary and reviewed the testing and certification procedures followed by C-MET as per IEC 17025. The other major facilities such as hafnium sponge production plant, SiC single crystal growth facility, ultra high purity materials laboratory etc. were shown to secretary, MeitY. He was impressed with the technological achievements of C-MET and advised C-MET scientists to focus on identified thrust areas in a larger perspective.

The activities of Swachhta pakhwada 2019 includes disposal/weeding out of old records, segregation & removing of unserviceable items from the work-place, and cleaning of grasses/weeds from various places of C-MET premise, etc. Following are the actions taken on the said special drive

5.11. Inauguration of silicon carbide single crystal research facility at C-MET, Hyderabad

The silicon carbide single crystal research facility was inaugurated jointly by Director DMRL; Dr. Vikas Kumar and Director SSPL; Dr. Seema Vinayak on 27th February 2019 at C-MET, Hyderabad. Senior scientists from SSPL, Dr. A. K. Garg, Dr. Renu Tyagi, Dr. O.P. Thakur and Dr. T. K. Nandy, Dr. Venugopal and Dr. Sreedhar from DMRL were present. Both DMRL as well as SSPL Directors appreciated the progress made by C-MET so far and opined to complete the project deliverables in time. They also offered all support for the continuation of SiC activity such as high purity SiC powder preparation, augmentation of the size of SiC single crystal size etc.

Inauguration of the SiC clean room facility felicitating Director, DMRL by DG C-MET

5.12. ToT function of wearable device and analysis system for early detection and screening of breast cancer technology

The technology entitled “Wearable device and analysis system for early detection and screening of breast cancer” has been transferred to M/s Murata business engineering India private limited, Hyderabad on 22nd January 2019. This technology was developed at C-MET, Thrissur.

Figure 17. Technology transfer of wearable device and analysis system for early detection and screening of breast cancer to M/s Murata Business Engineering India Pvt. Ltd., Hyderabad

5.13. National renowned awards to C-MET scientist for outstanding achievements in science & technology

Figure 18. Dr. A. Seema received Nari Shakti Puraskar from hon'ble President of India.

Figure 19. Dr. A. Seema along with award recipients with Prime Minister after receiving Nari Shakti Puraskar award.

Figure 20. Dr. A. Seema receiving National Award for Women's Development through application of Science and Technology (NAWD) from secretary DST, GoI.

6. Collaborative research activities

6.1. Memorandum of Understandings (MoUs)

1. C-MET, Pune signed an MOU with Tata chemicals, on 03rd January 2019 to facilitate academic and research for mutual benefit and knowledge enhancement particularly to develop the collaborative technology for the recovery and purification of cathode and anode active ingredients from spent lithium ion batteries.

2. C-MET signed an MOU with IIT-Bhilai, on 23rdJuly 2018 to facilitate academic and research for mutual benefit and knowledge enhancement. IIT-Bhilai is working in line with the C-MET trust areas opening many opportunities of collaboration.

3. C-MET signed an MOU with Kalam Institute of Health Technology (KIHT),on 06thSeptember 2018 to facilitate innovation in healthcare technology commercialization thereof, and work towards promoting the growth of the sector by creating necessary eco-systems.
4. C-MET, Hyderabad signed an MOU with Manjeera Digital Pvt.Ltd., on 21stDecember2018 to collaborate in design and fabrication of chips for navigation systems and to evaluate antennas for NavIC module.

5. C-MET, Thrissur signed an MOU with Electronics Corporation of India Limited (ECIL), on 04thOctober 2018 towards collaborative R&D on development and fabrication of aerogel supercapacitor based power modules for application in VVPAT of EVM on national interest.
6. C-MET, Thrissur signed a non-disclosure agreement with M/s Saint-Gobain India private limited (Research and Development), Chennai on 19thSeptember 2018 to engage in discussions concerning expression of interest for transfer of technology of transparent heater.
7. C-MET, Thrissur signed an agreement with Government Engineering college (GEC), Thrissur, Kerala, on 18thJuly 2018 to facilitate the implementation of the joint project entitled "development of thermal tomography for the detection of breast cancer and to predict the size and location of the cancerous tissue" funded by MeitY.
8. C-MET, Thrissur signed an MoU with Central Power Research Institute (CPRI), Bangalore on 20thNovember 2018 for implementing the CPRI funded project on "high capacitance (50F to 200F) graphene supercapacitors for storage of power from renewable energy sources" at C-MET Thrissur.

6.2. Distinguished Visitors

1. **Dr. Rajiv Soman**, Director, Purity Survey Analysis, EAG labs, USA delivered a lecture on "Glow Discharge Mass Spectroscopy (GDMS) as an analytical tool, at C-MET, Pune on 05th December 2018.
2. **Dr. Jijeesh Ravi Nair** from Helmholtz Institute Munster, IEK-12, Germany delivered a lecture on "Cross-linked polymer electrolytes for safe and durable Lithium metal batteries" at C-MET, Pune on 21st December 2018.
3. **Dr. Nilima S. Rajukar** from SPP University delivered a talk on "We and the Environment" at C-MET, Pune on 01st February 2019.
4. **Dr. Peng Zou** from Princeton instruments presented a talk on "Raman Spectroscopy Instrumentational" at C-MET, Pune on 19th February 2019.
5. **Dr. R. L. Sharma**, managing Director, SPEL technology Pvt. Ltd., has delivered an invited lecture on "supercapacitors "at C-MET, Pune on 28th February 2019.
6. **Dr. S. K. Kulkarni** from C-MET, Pune has delivered a special lecture on woman's day celebration at C-MET, Pune on 08th March 2019.
7. **Shri. Ajay Prakash Sawhney** IAS, secretary, MeitY visited C-MET, Hyderabad on 09th February 2019.

Secretary, MeitY welcomed by DG, C-MET

8. **Dr. Sudhir Kamat**, Director General, MED &CoS, DRDO and Dr. Shiv Kumar, Director, MED, DRDO had visited C-MET, Hyderabad laboratory on 15th March 2019.

DG, C-MET with DG, DRDO (MED & CoS)

9. **Prof. Rajan Jose**, nano structured renewable energy materials laboratory, University of Malaysia Pahang, Kuantan, Malaysia visited C-MET, Hyderabad on 18thDecember 2018 and delivered a lecture on "Future of materials research: renewable materials &smart processes".
10. **Prof. Thoshiaki Enoki,** emeritus professor, Tokyo Institute of Technology, Japan visited C-MET, Thrissur on 18th December 2018 and delivered a lecture on "Molecular science of nanographene where he discussed the functionalisation of graphene for various device applications" and interacted with the scientists, students and research scholars.

9. **Prof. Roberto Gunnella** from University of Camerino, Italy visited aerogel lab of C-MET, Thrissur on 07th March 2019. He also delivered the plenary lecture on "Physics of lithiation &delithiation process in metal oxide nanoparticles", in ICSEA-2019 conducted by C-MET, Thrissur.

10. **Prof. Manikam Minakshi** from Murdoch University, Australia visited the aerogel lab of C-MET, Thrissur on 7th March 2019. He also delivered talk on "Ma-molybdate hierarchical architectures for high performance energy devices", in ICSEA-2019 conducted by C-MET, Thrissur.
11. **Dr. Patrick Glynn**, from Queensland University, Australia the aerogel lab of C-MET, Thrissur on 7th March 2019. He also delivered a lecture on "High density thermal energy storage and application", in ICSEA-2019 conducted by C-MET, Thrissur.

12. **Dr. Vinod C. Prabhakaran**, principal scientist, catalysis division and centre of excellence on surface science CSIR-National Chemical Laboratory, Pune visited C-MET, Thrissur on 28th December 2018 and delivered a talk on X-ray photoelectron spectroscopy.

6.3.International research activities

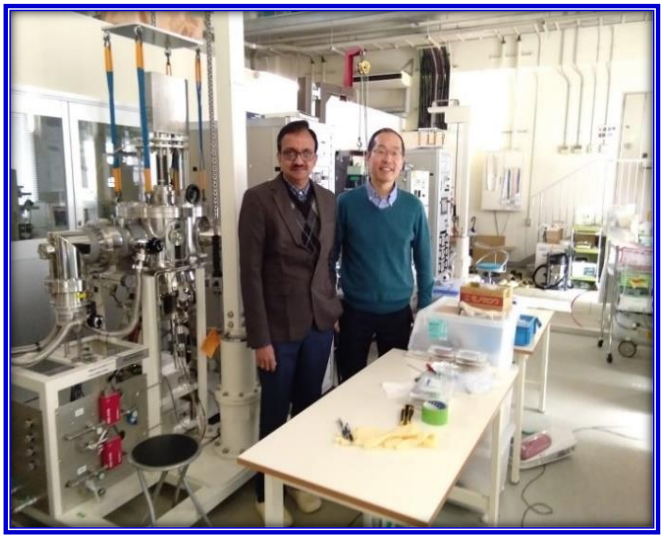
1. Dr. B.B. Kale from C-MET, Pune has visited the University of Leeds under the royal society UK project during 10 -19th October 2018.

2. Dr. R.P. Panmand from C-MET, Pune has visited the University of Leeds under the royal society UK project during05-10th December 2018.

3. Dr. S. Rajesh Kumar from C-MET, Hyderabad visited Italimpianti Orafi Italy to work with top blown rotary furnace (TBRF) from 24th December 2018 to 02nd January 2019.

4. Dr. N.C.Pramanik from C-MET, Thrissur visited University of Camerino, Italy during 16-21stSeptember 2018 as the Indian delegate to review progress of Indo-Italy bilateral program on renewable energy technology.

5. Dr. V. Kumar from C-MET, Thrissur visited Kobe University, Japan during 11-17th January 2019 on invitation from Prof. Isaku Kanno, Department of Mechanical Engineering to discuss the collaborative projects on piezo MEMS devices.



7. IPR & publications

7.1 National/ International patents awarded

1. "Layered tough ceramics for armour applications", K.Akella and G.Phatak, Indian Patent (No. 304258)date of granting: 10.12.2018.
2. "X-ray shielding material and method of preparation thereof", B. B. Kale, M. V. Kulkarni, R.P. Panmand, U.V. Kawade, S.K. Apte, S.D. Naik, J.D. Ambekar, R.S. Sonawane, D.P. Amalnerkar, N. Shroff, S. Chatterjee, US Patent 988170730.01.2018.
3. "Synthesis of nanostructures of metal doped cadmium sulphide" Indian patent application no. 3235/MUM/2010, M. Shinde, S.B. Rane and D.Amalnerkar, patent no. 297804 granted on 19.06.2018 patentee, secretary, MeitY and Executive Director, C-MET.

7.2 National/ International patents filed

1. Novel metal-carbon aerogel composite electrode, aerogel supercapacitors, process of the same and application thereof, N.C. Pramanik, K.S. Jacob, R.Panicker, P.A. Abraham, S. Das, Indian patent filed on 27.03.2019 application No. 201921012033.

7.3 Publications in peer-reviewed journals

1. In situ preparation of N doped orthorhombic Nb_2O_5 nanoplates/rGO composites for photocatalytic hydrogen generation under sunlight, A.K. Kulkarni, R.P. Panmand, Y.A. Sethi, S.R. Kadam, S.P. Tekale, G.H. Baeg, A.V. Ghule, B. B. Kale, *Intern. J. Hydrogen Energy*, **2018**, *43*, 19873-19884 (IF-4.22)
2. Facilitated lithium storage in hierarchical microsphere of Cu_2S-MoS_2 ultrathin nanosheets, S.R. Kadam, R.S. Kalubarme, S.P. Deshmukh, R.P. Panmand, U.V. Kawade, M.V. Kulkarni, S.S. Deo, S.W. Gosavi, B.B. Kale, *Chem. Select*, **2018**, *3*, 11020-11026 (IF-1.55)
3. Ethoxy-ester functionalized imidazolium based ionic liquids for lithium ion batteries, T. Nirmale, N. Khupse, R. Gore, J.D. Ambekar, M.V. Kulkarni, A.Varma, B.B. Kale, *Chem. Select*, **2018**, *3*, 6255-6261 (IF-1.55)
4. Porous Mn-doped cobalt oxide@ C nanocomposite: a stable anode material for Li-ion rechargeable batteries, R.S. Kalubarme, S.M. Jadhav, B.B. Kale, S.W. Gosavi, C. Terashima, A. Fujishima, *Nanotech*. **2018**, *29*, 285705 (IF-3.4)
5. Hierarchical nanostructures of nitrogen-doped molybdenum sulphide for supercapacitors, C. Kanade, S. Arbuj, K. Kanade, K. S. Kim, G. Y. Yeom, T. Kim, B. B. Kale, *RSC Adv*., **2018**, *8*, 39749-39755 (IF-2.9)
6. Surface modified $Li_4Ti_5O_{12}$ by paper templated approach for enhanced interfacial Li^+, charge transfer in Li-ion batteries, U.V. Kawade, M.S. Jayswal, A.A. Ambalkar, S.R. Kadam, R.P. Panmand, J.D. Ambekar, M.V. Kulkarni, B. B. Kale, *RSC Adv*., **2018**, *8*, 38391-38399 (IF-2.9)
7. Unique perforated graphene derived from bougainvillea flowers for high-power supercapacitors: a green approach, R.P. Panmand, P. Patil, Y. Sethi, S.R. Kadam, M.V. Kulkarni, S.W. Gosavi, N.R. Munirathnam, B.B. Kale, *Nanoscale*, **2018**, *10*, 22065-22065 (IF-7.2)
8. 3D Hierarchical heterostructures of $Bi_2W_{1-x}Mo_xO_6$ with enhanced oxygen evolution reaction from water under natural sunlight, A.K. Kulkarni, R.P. Panmand, Y.A. Sethi, S.R. Kadam, D.R. Patil, A.V. Ghule, B.B. Kale, *New J. Chem*., **2018**, *42*, 17597-17605 (IF-3.27)

9. Interstitial charge transfer pathways in a $TiO_2/CdIn_2S_4$ heterojunction photocatalyst for direct conversion of sunlight into fuel, M.A. Mahadadalkar, S.W. Gosavi, B B. Kale, *J. Mater. Chem. A*, **2018**, *6*, 16064-16073 (IF-6.6)
10. Photodegradation of spent wash, a sugar industry waste, using vanadium-doped TiO_2 nanoparticles, S.P. Takle, S.D. Naik, S.K. Khore, S.A. Ohwal, N.M. Bhujbal, S.L. Landge, B.B. Kale, R.S. Sonawane, *RSC Adv*., **2018**, *8*, 20394-20405 (IF-2.9)
11. Solar light active plasmonic Au@ TiO_2 nanocomposite with superior photocatalytic performance for H_2 production and pollutant degradation, S.K. Khore, S.R. Kadam, S.D. Naik, B.B. Kale, R.S. Sonawane, *New J. Chem*., **2018**, *42*, 10958-10968 (IF-3.27)
12. Perforated N-doped monoclinic $ZnWO_4$ nanorods for efficient photocatalytic hydrogen generation and RhB degradation under natural sunlight, Y.A. Sethi, C.S. Praveen, R.P. Panmand, A. Ambalkar, A.K. Kulkarni, S.W. Gosavi, M.V. Kulkarni, B.B. Kale, *Catal. Sci. & Tech*., **2018**, *8*, 2909-2919 (IF-5.36)
13. Hierarchical $CdMoO_4$ nanowire–graphene composite for photocatalytic hydrogen generation under natural sunlight, S.R. Kadam, R.P. Panmand, S. Tekale, S. Khore, C. Terashima, S.W. Gosavi, A. Fujishima, B.B. Kale, *RSC Adv*., **2018**, *8*, 13764-13771 (IF-2.9)
14. Synthesis of porous nitrogen doped zinc oxide nanostructures using a novel paper mediated template method and their photocatalytic study for dye degradation under natural sunlight, G. Kale, S. Arbuj, U. Kawade, S.B. Rane, J.D. Ambekar, B.B. Kale, *Mater. Chem. Front*., **2018**, *2*, 163-170 (IF-NA)
15. Thickness-dependent humidity sensing by poly (vinyl alcohol) stabilized Au–Ag and Ag–Au core–shell bimetallic nanomorph resistors, P.V. Adhyapak, R. Aiyer, S. Reddy Dugasani, H.-U. Kim, C.K. Song, A. Vinu, V. Renugopalakrishnan, S. H. Park, T. Kim, H. Lee, D. Amalnerkar, *Royal Society open science*, **2018**, *5*, 171986. (IF: 2.5)
16. Nanostructured WO_3/graphene composites for sensing NOx at room temperature, P.V. Adhyapak, A.D. Bang, P. More, N.R. Munirathnam, *RSC Adv.*, **2018**,*8*, 34035–34040. (IF: 2.9)
17. Sunlight driven highly efficient degradation of methylene blue by CuO-ZnO nanoflowers, S.P. Mardikar, S. Kulkarni, P.V. Adhyapak, *J. Environ. Chem. Engn*.,**2018**, https://doi.org/10.1016/j.jece.2018.11.033. (IF: 4.01)
18. 1, 1′-Bis (diphenylphosphino) ferrocene-appended nickel (ii) dithiolates as sensitizers in dye-sensitized solar cells, A. Singh, P. Singh, G. Kociok-Köhn, M. Trivedi, A. Kumar, R. Chauhan, S.B. Rane, C. Terashima, S.W.Gosavi, A. Fujishima, *New J. Chem*., **2018**, *42*, 9306-9316. (IF-3.277**)**
19. Effect of firing temperature on microstructure and dielectric properties of chromium oxide based glass composite thick films on stainless steel substrate, G.D.Shirke, G.G.Umarji, A.R.Tarale, V.L.Mathe, U.P.Mulik, S.B. Rane, *J. Mater Sci: Mater Electron*., **2018**, *29*, 9871-9878. (IF-2.324)
20. Highly efficient dye-sensitized solar cells by $TiCl_4$ surface modification of ZnO nano-flower thin film, Y. Waghadkar, S. Arbuj, M. Shinde, R. Ballal, S. B Rane, S. Gosavi, H Fouad, R. Chauhan, *J. Sol. State Electrochem*., **2018**, *22*, 3621-3630. (IF-2.509)
21. Hydrothermally synthesized zinc sulphide microspheres for solar light-driven photocatalytic properties, Y. Waghadkar, S. Arbuj, M. Shinde, R. Ballal, S.B. Rane, S. Gosavi, H. Fouad, R. Chauhan, *J. Electron Mater*., **2018**, *47*, 2687-2693. (IF. 1.566)
22. Template-free hydrothermal synthesis of beaded nanochain bundles of ZnO and their application as photoanode in dye-sensitized solar cells, R. Ballal, M. Shinde, Y. Waghadkar, S. Arbuj, S.B. Rane, R. Chauhan, *Appl. Phys. A*,**2018**, *124* ,203. (IF-1.455)

23. Morphological evolution of nanorod to submicron brick-like cobalt oxide structures under microwave solvothermal regime, M. Shinde, N. Qureshi, S.B. Rane, C. Ahn, T. Kim, D. Amalnerkar, *Sci. Adv Mater*., **2018**, *10*, 144-148. (IF-1.318)

24. Hierarchical nanostructures of nitrogen-doped molybdenum sulphide for supercapacitors, C. Kanade, S. Arbuj, K. Kanade, K. S. Kim, G. Y. Yeom, T. Kim, B. B. Kale, *RSC Adv*., **2018**, 8, 39749-39755 (IF-2.936)

25. Synthesis of porous nitrogen doped zinc oxide nanostructures using a novel paper mediated template method and their photocatalytic study for dye degradation under natural sunlight, G. Kale, S. Arbuj, U. Kawade, S.B. Rane, J.D. Ambekar and B.B. Kale, *Mater. Chem. Fron*., **2018**, *2*, 163-170 (IF-5.45)

26. Paper templated synthesis of nanostructured Cu-ZnO and its enhanced photocatalytic activity under sunlight. G. Kale, S. Arbuj, U. Kawade, S. Kadam, L. Nikam, B.B. Kale, *J. Mater. Sci.: Mater. Electron*., **2019** https://doi.org/10.1007/s10854-019-01020-w, (IF-2.324)

27. Bioinspired carbon quantum dots: an antibiofilm agents, A. F. Shaikh, M. S. Tamboli, R. H. Patil, A. Bhan, J.D. Ambekar, B.B. Kale, *J. Nanosci. Nanotech*., **2019**, *19*, 2339-2345 (IF-1.35)

28. Manganese dioxide/reduced graphene oxide composite an electrode material for high-performance solid-state supercapacitor, S. Jadhav, R. S. Kalubarme, C. Terashima, B.B. Kale, V. Godbole, A. Fujishima, S.W. Gosavi, *Electrochim. Acta*., **2019**, *299*, 34-44 (IF-5.11)

29. Silicon nanoparticles sandwiched ultrathin MoS_2-graphene layers as an anode material for Li-ion battery, U.V. Kawade, A.A. Ambalkar, R.P. Panmand, R.S. Kalubarme, S.R. Kadam, S. D. Naik, M. V. Kulkarni, B. B. Kale, *Mater. Chem. Front*., **2019** ,*4*, 587-596 (IF-5.45)

30. In situ preparation of CdS decorated $ZnWO_4$ nanorods as a photocatalyst for direct conversion of sunlight into fuel and RhB degradation, Y. A. Sethi, R. P. Panmand, A. A. Ambalkar, A.K. Kulkarni, D.R. Patil, S.W. Gosavi, M.V. Kulkarni, B.B. Kale, *Sustain. Energy & Fuels*, **2019**,3, 793-800 (IF- NA)

31. Paper templated synthesis of nanostructured Cu–ZnO and its enhanced photocatalytic activity under sunlight, G. Kale, S. Arbuj, U. Kawade, S. Kadam, L. Nikam, B.B. Kale, *Journal of Materials Science: Mater. Electron*., **2019**, 1-12 (IF-2.32)

32. Enhanced performance of PTB7-Th: PCBM based active layers in ternary organic solar cells G. Lakhotiya, N. Belsare, S. Arbuj, B.B. Kale, A. Rana, *RSC Adv*., **2019**, *9*, 7457-7463 (IF-2.96)

33. Solar-light-active mesoporous Cr–TiO_2 for photodegradation of spent wash: an in-depth study using QTOF LC-MS, S. P. Takle, O. A. Apine, J. D. Ambekar, S. L. Landge, N. N. Bhujbal, B.B. Kale, R.S. Sonawane, *RSC Adv*., **2019**, *9*, 4226-4238 (IF-2.96)

34. Nanocomposite of polypyrrol and silica rods-gold nanoparticles core-shell as an ammonia sensor, V. Khambalkar, S. Birajdar, P. Adhyapak, S. Kulkarni, *Nanotech*, **2019**, *10*:105501. (IF: 3.4)

35. catalyst for hydrogen generation and degradation of phenol under solar light irradiation, S. Balgude, Y. Sethi, B.B. Kale, D. Amalnerkar, P. Adhyapak, *Materials Chemistry and Physics*, **2019**, *221*, 493-500. (IF: 2.21)

36. Fragmented lignin-assisted synthesis of a hierarchical ZnO nanostructure for ammonia gas sensing, K.M. Joshi, D.R. Shinde, L.K. Nikam, R.P.Panmand, Y.A. Sethi, B.B. Kale, MG Chaskar, *RSC Adv*., **2019**, *9*, 2484-2492 (IF-2.96)

37. Nickel nanoparticles grown by successive ionic layer adsorption and reaction method for ethanol electrooxidation and electrochemical quartz crystal microbalance study, A.N. Vyas, M.A. Desai, D.M. Phase, R.G. Saratale, J.D. Ambekar, B.B. Kale, H.M. Pathan, S.D. Sartale, *New J. Chem*., **2019**, *43*, 2955-2965 (IF-3.2)

38. Green synthetic methodology: an evaluative study for impact of surface basicity of MnO_2 doped MgO nanocomposites in wittig reaction, M.H. Moulavi, B.B. Kale, D.Bankar, D.P. Amalnerkar, A. Vinu, K.G. Kanade, *J. Solid State Chem*., **2019**, *269*, 167-174 (IF-2.17)
39. Sn_3O_4microballs as highly efficient photocatalyst for hydrogen generation and degradation of phenol under solar light irradiation, S. Balgude, Y. Sethi, B.B. Kale, D. Amalnerkar, P. Adhyapak, *Mater. Chem. Phys*., **2019**, *221*, 493-500 (IF-2.08)
40. High performance tellurium-reduced graphene oxide pseudocapacitor electrodes, A.P. Alegaonkar, M.A. Mahadadalkar, P.S. Alegaonkar, B.B. Kale, S.K. Pardeshi, *Electrochim. Acta*., **2019**, *291*, 225-233 (IF-5.11)
41. Sol–gel assisted isotropic morphological progression in nanostructured MoO_3 and allied investigations on photocatalytic dye-degradation, N. Qureshi, M. Shinde, S. Arbuj, S.B. Rane, A. Bhalerao, H.U. Kim, T. Kim, D. Amalnerkar, *J. Nanosci. Nanotech*., **2019**, *19*, 3479-3486 (IF: 1.354)
42. Hierarchical MoS_2-based onion-flower-like nanostructures with and without seedpods via hydrothermal route exhibiting low turn-on field emission, N. Qureshi, K. Harpale, M. Shinde, K. Vutova, M. More, T. Kim, D. Amalnerkar, *J. Electron. Mater*., **2019**, *48*, 1590-1598 (IF:1.566)
43. Nanocrystalline Cu–ZnO as an green catalyst for onepot synthesis of 4,4-((phenyl)methylene)bis(3-methyl1-phenyl-1H-pyrazol-5-ol) derivatives, S. Shinde, , B. Karale, D. Bankar, S. Arbuj, M. Moulavi, D. Amalnerkar, T. Kim, and K. Kanade, *J. Nanosci. Nanotech*., **2019**, *19*, 4623-4631(IF-1.354)
44. Enhanced performance of PTB7-Th:PCBM based active layers in ternary organic solar cells,G. Lakhotiya, N. Belsare, S. Arbuj, B. B. Kale and A. Rana, *RSC Adv*., **2019**, *9*, 7457-7463 (IF-2.936)
45. Role of defect structures in stabilization of ferroelectric phase in tin-substituted lead zirconatetitanate, A.Anil, K.Vani and V.Kumar, *J.Amer.Ceram.Soc.*,**2018**,*101*,3377-3382.(IF-2.96)
46. Influence of fillers on the re-crystallization and dielectric properties of $60ZnO\text{-}30B_2O_3\text{-}10SiO_2$ glass, M. Vincent, P. M. Afsal, K. G Vasanthakumari, S. Susanth, T. Radhika, N. Raghu1, *J. of Electroceram.*, **2018**,*40*, 219–224. (IF-1.4)
47. Factors influencing rheological characteristics of silver thick film paste and its correlation to multilayer ceramic processing, M. Vincent, V.K. Gopalakrishnan, S.Sivanandan, T. Radhika and N. Raghu, *Adv. Appl. Ceram.,***2018.**DOI: 10.1080/17436753.2018.1526435 (IF-1.09)
48. Optimization studies on nanocrystalline NTC thermistor compositions by a self propagated high temperature synthesis route, P.P.Deepak, M.Parokkaran, K.R. Ranjith, M.N. Muralidharan, Seema Ansari, *Ceram. Int.*, **2018,***44*, 4360–4366. **(**IF - 2.98)
49. Self-discharge and voltage recovery in graphene supercapacitors, S. Subramanian, M. A.Johny, M.N. Muralidharan,A. Seema,*IEEE Transactions on Power Electronics*, **2018**, *33(12)*, 10410-10418 (IF - 6.812)
50. Transverse piezoelectric properties of {110}-oriented PLZT Thin films, S.Laxmipriya, V.Kumar, T.Teramoto, I.Kanno, Integr. Ferroelectrics, **2018**, 192, 113(I.F. 0.375)
51. Manganese doped BaTiO3 nanotube arrays for enhanced visible-light photocatalytic applications, N.Manoj, V.Kumar, Mat.Chem.Phys.: **2018**, 213, 400-405 (I.F. 2.210).

52. Engineering Nanocrystalline Titania thin films for high photocatalytic activity, K.Vijila, K.V.Baiju, V.Kmar, Materials Today Proceedings, **2019**, 9, 621(I.F. 1.09)

53. Influence of synthesis parameters on the physicochemical and electrochemical properties of $LiFePO_4$ for Li-ion battery, J.R. Swapnil, L.D. Jadhav, R.S. Kalubarme, N.Y. Sanket, *J. Alloys and Compounds*,**2019**, *774*, 841-847 (IF- 3.78)

54. Silicon nanoparticle-sandwiched ultrathin MoS_2–graphene layers as an anode material for Li-ion batteries, V.K. Ujjwala, A.A. Anuradha, R.P. Panmand., R. S. Kalubarme., R.K. Sunil, S.D. Nayak, M.V. Kulkarni, B.B. Kale., *Mater. Chem. Front.*, **2019**, (DOI:10.1039/C8QM00568K) (IF-Pending)

55. CZTS films from three different routes: Crystallite size-dependent properties, P. Prabeesh,I.P. Selvam, S.N. Potty, *Mater. Res. Express*,**2019**, *6*, 065509 (IF-1.51)

56. Cu_2ZnSnS_4 thin films by dip coating from metal-thiourea precursor solution: effect of sulphurization temperature on the formation and structural, optical and electrical properties, P. Prabeesh, K.V. Vysakh, I. P. Selvam, S. N. Potty, *J. Electron. Mater.***2018**, *47*, 5396. (IF-1.566)

57. Enhanced photocatalytic activity of ternary $CuInS_2$ nanocrystals synthesized from the combination of a binary Cu(I)S precursor and $InCl_3$, G. Mondal, A. Santra, S. Jana, N.C. Pramanik, A Mondal, P. Bera,*J. Nanoparticle Research*, **2018**, *20*, 108. (IF- 2.127)

58. Study of fluorine content in some commercial phosphate fertilizers,L.P. Ramteke, A.C. Sahayam, A. Ghosh, U. Rambabu, M.R.P. Reddy, K.M. Popat, B. Rebary, D.Kubavat, K.V. Marathe, P.K. Ghosh**,** *J. of Fluorine Chemistry*; **2018**, *210*, 149-155.(I.F-1.87)

59. RoHS regulation – challenges in the measurement of substances of concern in industrial products by analytical techniques, V. Balaram, U. Rambabu, M.R.P. Reddy, S. Chatterjee, N. R. Munirathnam, *MAPAN – J. of Metrology Society of India*, **2018**, *33(1)*, 329- 346. (I.F-0.6)

60. Solid solution limits and electrical properties of scheelite $Sr_yLa_{1-y}Nb_{1-x}V_xO_{4-\delta}$ materials for x = 0.25 and 0.30, A. Brandao, N. Nasani, A. Yaremchenko, A. Kavaleuski, D.P. Fagg. *Int. J. Hydrogen Energy*,**2018**, *43*, 18682-18690. (IF-4.23)

61. Chemically transformed additive phases in Mg_2TiO_4 and $MgTiO_3$ loaded hydrogen storage system MgH_2, D. Pukazhselvan, N. Nasani, T. Yang, D. Ramasamy, A. Shaula and D.P. Fagg. *Appl. Surf. Sci.*,**2019**, *472*, 99-104. (IF-4.44)

62. Synthesis of organic semiconductor bearing B ← N bridged thienylthiazole and diketopyrrolopyrrole for the application of high open-circuit voltage organic photovoltaics, K.Y. Ryu, D.-BSung, S.-Y Won, A. Jo, K.Ahn, H.Y Kim, A.A. Kashmir, K. Kwak, C. Lee, W.-S Kim, K. Kim, *Dyes Pigm.*, **2018**, *149*, 858-866. (IF-3.767)

63. Performance enhancement of lithium-polysulphide batteries by atomic layer deposition of lithium tantalate on sulphide solid electrolytes, R.P. Rao, S. Adams, *Solid State Ionics*, **2018**, *323*, 97-104. (IF-2.751)

64. Cubic sodium cobalt metaphosphate $[NaCo(PO_3)_3]$ as a cathode material for sodium ion batteries, R. Gond, R.P. Rao, V. Pralong, OI. Lebedev, S. Adams and P. Barpanda, *Inorg. Chem.*, **2018**, *57 (11)*, 6324-6332. (IF-4.70)

65. Electrochemical and diffusional insights of combustion synthesized $SrLi_2Ti_6O_{14}$ negative insertion material for Li-ion Batteries, A Dayamani, G.S. Shinde, A.Chaupatnaik, R.P. Rao, S. Adams, P Barpanda, *J. Power Sources*, **2018**, *385*, 122-129. (IF-6.945)

66. Preparation and Microwave Dielectric Properties of $Ba_3A(V_2O_7)_2$ (A = Mg, Zn) Ceramics for ULTCC Applications, R. Naveenraj, E.K. Suresh,J. Dhanya and R Ratheesh, Euro. J. Inorg. Chem, 2019(7), 949-955, 2019 (IF-2.57)

67. Structure and microwave dielectric properties of low temperature sinterable $NaR_5(MoO_4)_8$ (R= La, Pr, Nd, Sm) ceramics, J. Dhanya, E. K. Suresh, R. Naveenraj, R. Ratheesh, *J. of Electr. Materials*, 48(6), pp 4040-4049, 2019 (IF-1.57)

68. Structure and microwave dielectric properties of $ALn_4(MoO_4)_7$ (A = Ba, Sr, Ca, Ln = La, Pr, Nd, and Sm) ceramics**,** *Int. J. of Appl. Cer. Techn*.,J. Dhanya, P. V. Sarika, R. Naveenraj, E. K. Suresh, R. Ratheesh, 16(3), pp 1150-1158, 2019 (IF-1.07)

7.4 Books and Book Chapters

1. Glassy photocatalysts: new trend in solar photocatalysis, B.B. Kale, M.A. Mahadadalkar, A.P.Bhirud, Chapter-7, in the book *Visible Light-Active Photocatalysis: Nanostructured Catalyst Design, Mechanisms, and Applications*, Wiley-VCH Verlag GmbH & Co. KGaA. DOI:10.1002/9783527808175, **2018**

2. Metal oxide additives incorporated hydrogen storage systems: formation of in situ catalysts and mechanistic understanding, in the book emerging nanostructured materials for energy and environmental science Chapter 5, D. Pukazhselvan, N. Nasani, S.K. Singh, and D.P. Fagg, Springer Nature, **2019**, ISBN: 978-3-030-04473-2.

7.5 Presentations in Conferences and Symposia

1. Flexible and integrated sensors for biological process monitoring, A.A. Kashmir, Mumbai Pune Semiconductor Meet (MPSM-2019) held at IIT-Bombay, on 03rdMarch **2019**.

2. Bioelectronic devices to detect the neuron related mental disorder, A.A. Kashmir, National Conference on Recent Trends in Chemistry, held at VPMM Arts and Science College for Women, Krishnan Koil, Tamil Nadu, during 11-12thFebruary **2019**.

3. Development of protonic ceramic fuel cells-current status and challenges, N. Narendar, International Meeting on Energy Storage Devices (IMESD-2018) held at IIT, Roorkee, 10-12thDecember**2018**.

4. Co-deposited Sn-Ag-Cu films for Fine Pitch surface finishes in PCBs, P. Varsha, S.Rakshe, S. Joseph, G.Phatak, Raman Memorial Conference, Savitri Bai Phule University of Pune, during 14-15thFebruary **2019**.

5. Ferrocenylethenyl-substituted oxadiazoles with phenolic and nitro anchors as sensitizers in dye sensitized solar cells, R. Chauhan, S.W. Gosavi,S.B. Rane, International Conference on Supercapicitors, Energy storage and Applications (ICSEA-2019), C-MET Thrissur during 8-10thMarch **2019**.

6. Electrochemical performance of layered V_2O_5 for energy storage application, S.Birajdar, A.Kasabe, S. Kulkarni, B.B. Kale, P.Adhyapak, International conference on supercapacitor and energy storage applications (ICSEA-2019) held at TMCAA, Govt. Medical College, Thrissur during 8-10thMarch **2019**.

7. Synthesis and characterization of manganese ferrite nanoparticles by hydrothermal method for energy storage application, R.Ghuge, K.Patole, S.Arbuj, M. Shinde, P.V. V. Patnaik, B.B. Kale,

S.B. Rane, International Conference on Supercapicitors, Energy storage and Applications (ICSEA-2019), C-MET Thrissur during 8-10thMarch **2019**.

8. Hydrothermal synthesis of anatase tio_2 and study of photocatalytic properties for dye degradation and DSSC applications, N.Jawale, S.Arbuj, S.B. Rane, International Conference on Supercapicitors, Energy storage and Applications (ICSEA-2019, C-MET Trissur during 8-10thMarch **2019**.
9. Tuning of morphology, optical property and photocatalytic activity of cds nanostructures, S.Arbuj, S.B. Rane, National Conference on Chalcogenide compounds (Materials, Chemistry and Physics (NC^3-2019-MCP), DIAT, Pune during 14-15thMarch **2019**.
10. Studies on extraction of Hafnium and Zirconium from solid zirconium frit disposed off after recovery of nitric acid, A. Kumar, M.R.P. Reddy, N.R.Mandre, T. Sharma, XVII International Seminaron Mineral Processing Technology (MPT) held at Indian Institute of Technology (ISM), Dhanbad during 10-12thOctober **2018**.
11. Effect of distillation temperature on purification of Zinc, Y. Purushotham and S.T. Ali, Telangana State Science Congress (TSSC-2018) held at NIT Warangal during 22-24th December **2018**.
12. Design and fabrication of aerogel supercapacitor based solar energy harvesting device for application in embedded systems, K.S. Swathy, S. Suresh, D.Denny, E. K. Sunny, P.A. Abraham, R.Paniker, S. Jacob, and N.C.Pramanik, in International Conference on "Chemistry & Physics of Materials 2018" (ICCPM-2018), held at St. Thomas College, Thrissur during 19-21th December **2018**.
13. Performance enhancement of carbon-based supercapacitor using redox electrolyte, A. A.Babu, .K.S. Swathy, E.K. Sunny, P.A. Abraham, P.N. Rani, N.C.Pramanik and K.S. Jacob, International Conference on "Chemistry & Physics of Materials 2018" (ICCPM-2018), held at St. Thomas College, Thrissur during19-21thDecember **2018**.
14. Structural, electrical and optical properties of spray coated indium doped zinc oxide films for nanophotonic applications in near IR, K. Soumya, I.P. Selvam, S N Potty, National photonics symposium (NPS 2019) held at International School of Photonics, Cochin University of Science & Technology (CUSAT) during 27 thFebruary to 01March **2019**.
15. Preparation porous aerogel carbon for supercapacitor's electrode applications by cost-effective successive pore-liquid exchange technique, K.S. Swathy, N. Ranipanicker, C. D. Denny C, P.A. Abraham, K. S. Jacob and N.C. Pramanik, in International Conference on Supercapacitors, Energy Storage and Applications (ICSEA-2019), held at TMCAA Academic Complex, Thrissur during 08-10thMarch **2019**(Best Paper Award).
16. Preparation of novel aerogel-graphene for application as electrode material for Supercapacitors,N. Ranipanicker,K.S.Swathy, M. P. Bhaskar, H.Venu, P.A. Abraham and N.C. Pramanik, in International Conference on Supercapacitors, Energy Storage and Applications (ICSEA-2019), held at TMCAA Academic Complex, Thrissur during 08-10thMarch **2019**.
17. Study the feasibility of use of aerogel supercapacitor packs for applications in VVPAT of EVM, O.Sahu, A. Kumar, V.V. Prasad, S.R.C. Reddy, M. Madhury, N. Ahmed, P.A. Abraham, K.S. Jacob, S. Das, and N.C.Pramanik, in International Conference on Supercapacitors, Energy Storage and Applications (ICSEA-2019), held at TMCAA Academic Complex, Thrissur during 08-10thMarch **2019**.

18. Study the effect of conductive interlayer (CIL) on cell capacitance & ESR of Aerogel Supercapacitors, K.S. Swathy, J. Vigneswaran, D. C Deny, P.A. Abraham, N. R.Panicker, K. S. Jacob, S. Das and N.C.Pramanik, in International Conference on Supercapacitors, Energy Storage and Applications (ICSEA-2019), held at TMCAA Academic Complex, Thrissur during 08-10thMarch **2019**.

19. Synthesis of carbon spheres by emulsion technique for supercapacitor electrode application, K.S. Jacob, P.A. Abraham, N. Ranipanickerand N.C. Pramanik, in International Conference on Supercapacitors, Energy Storage and Applications (ICSEA-2019), held at TMCAA Academic Complex, Thrissur during 08-10thMarch **2019**.

20. Preparation and characterization of high surface area porous lithium titanate aerogel, suitable for hybrid supercapacitor electrode,K. S. Jacob, N.R.Panicker, P.A. Abraham and N.C.Pramanik, in International Conference on Supercapacitors, Energy Storage and Applications (ICSEA-2019), held at TMCAA Academic Complex, Thrissur during 08-10thMarch **2019**.

21. Design and fabrication of Aerogel supercapacitor-based energy storage device with load equalization circuits for powering electronic devices, E.K. Sunny, A.K.Athira, A.Madanan, P.A. Abraham, N.R. Panicker, S. Das and N.C.Pramani, in International Conference on Supercapacitors, Energy Storage and Applications (ICSEA-2019), held at TMCAA Academic Complex, Thrissur during 08-10thMarch **2019**.

22. Design & Setting-up of safe, recyclable and indigenous plant for production of carbon aerogel in pilot scale for Supercapacitor applications, P.A. Abraham, N. Ranipanicker, A.Choudhuri, K.R.Sumesh, V. Mohan, E.K. Sunny, K.S. Jacob and N.C. Pramanik, in International Conference on Supercapacitors, Energy Storage and Applications (ICSEA-2019), held at TMCAA Academic Complex, Thrissur during 08-10thMarch **2019**.

23. Carbon encapsulated manganese doped cobalt oxide nanostructures as electrode materials for energy storage devices, R.S. Kalubarme, B.B. Kale, S.W. Gosavi, International Conference on Supercapacitor, Energy Storage and Application, (ICSEA 2019) held at C-MET, Thrissur during 08-10th March **2019**.

24. Cu_2ZnSnS_4 thin films by spray coating from thiourea - free solution for photovoltaic applications, P. Prabeesh, V.G. Sajeesh, I.P. Selvam, S.N. Potty, in the International Conference on super capacitor and energy storage applications (ICSEA-2019) held at Centre for Materials for Electronics Technology (C-MET) during 8-10thMarch**2019**.

25. Dielectric characteristics of Thermoplastic polyurethane/CCTO composites, Lakshmi Variar C. V, M. N. Muralidharan, Sunil K. Narayanankutty, A. Seema in the National Conference on Current Trends in Polymer Science (CTPS'2019) organized by Department of Polymer Science and Rubber Technology, CUSAT on 22nd March 2019.

26. PMN-PT/Polymer composite thin films for energy harvesting applications, Lakshmi Variar C.V, M.N.Muralidharan, S..K.Narayanankutty, A. Seema in the International Conference on Supercapacitors and Energy Storage Applications (ICSEA2019) organized by C-MET, Thrissur during 8-10thMarch 2019.

27. Graphene electrode based coincell supercapacitors, Jimmy Joy, Alastin, R. Sridharkrishna, M.N. Muralidharan, A.Seema in the International Conference on Supercapacitors and Energy Storage

Applications (ICSEA-2019) held at Centre for Materials for Electronics Technology (C-MET) during 8-10thMarch 2019.

28. Voltage recovery phenomenon in graphene supercapacitors, M.N. Muralidharan, R. Sridharkrishna, A.Seema in the International Conference on Supercapacitors and Energy Storage Applications (ICSEA-2019) held at Centre for Materials for Electronics Technology (C-MET) during 8-10thMarch 2019.
29. Synthesis and characterization of high dielectric constant PMN-PT for embedded capacitor application, Lakshmi Variar C.V, M.N.Muralidharan, S.K.Narayanankutty, A.Seema in the National Conference on Advanced Materials and Techniques for Emerging Applications(AMTEA-2019) organised by Post Graduate Department of Physics, Ansar women's college, Perumpilavu during 13-14thFebruary 2019.

7.6 Invited Lectures by C-MET Scientists

1. **Dr. N.R. Munirathnam** has delivered an invited talk on "Rare earth based Ceramics and composites for microwave circuit applications" in the "International Conference on Science, Technology and Application of Rare Earths (ICSTAR - 2018)" held at Tirupati, AP, India during 23-25thSeptember 2018.
2. **Dr. N.R. Munirathnam** has delivered a key note address on "Modern Sensors - Challenges and Innovations" in "National conference on novel materials for devices and applications (NCNMDA-2018)" held at physics department, S V University, Tirupathi, AP, India during 04-05thNovember 2018.

3. **Dr. N.R. Munirathnam** has delivered an Inaugural address on the topic entitled "Ultra- high pure materials processing and characterization for preparation of radio-isotopes in nuclear medicine in "The national workshop on "Application of Radiation and Radio-isotopes in industry and Materials Science (ARRIM-2018) held at NIT Warangal, Telangana, India during 26-30th November 2018.
4. **Dr. N.R. Munirathnam** has delivered an invited talk on "Innovation in some of the indigenous sensor techniques" in the Telangana State Science Congress (TSSC) organized by Telangana Academy of Sciences (TAS) at NIT, Warangal during 22-24th December 2018.
5. **Dr. N.R. Munirathnam** has delivered an invited talk entitled "Achievements in E-waste recycling & RoHS compliance: way forward" in the National work Shop entitled "RoHS compliance &environment-friendly e-waste recycling" organized by C-MET at Hyderabad on the occasion of swachhta pakhwada of Ministry of Electronics & IT (MeitY), 2019 during 1st February 2019.

6. **Dr. N.R. Munirathnam** has delivered an invited talk on "Indigenization of Advanced functional ceramics for strategic applications" in an International Conference on Advanced Functional Materials and Devices (ICAFMD-2019) held at National Institute of Technology, Warangal, Telangana, held during 26-28thFebruary 2019.
7. **Dr. N.R. Munirathnam** has delivered an invited talk entitled "Future electronic materials can meet the environmental concerns in India" in the conference namely "India International E-waste 2019" held at Shangri-La Hotel Bangalore, India during 28th February to 01st March 2019.
8. **Dr. B.B. Kale** has delivered a talk on "Development of Lithium ion pack" at Science Technology Park, Pune University on 31st October 2018.
9. **Dr. B.B. Kale** has delivered a talk on"Energy and environment" at RayatShikshan Sanstha Maharaja Jivajirao Shinde Mahavidyalaya, Shrigonda on 22nd December 2018.
10. **Dr. B.B. Kale** has delivered a talk on "environment and Energy" at Radhabai College Ahemdangar on 04th January 2019.
11. **Dr. B.B. Kale** has delivered a talk on "Nanostructured materials and environment" at C.T Bora College Shirur on 19th January 2019.
12. **Dr. B.B. Kale** has delivered a talk on "Battery materials and technology" at Eknath Sitaram Divekar Art's, Science & Commerce College, Varvand on 19th January 2019.
13. **Dr. B.B. Kale** has delivered a talk on "Nanostructured materials in Batteries" in workshop on nanoscience and nanotechnology at Sinhgad college of Engineering Ambegaon, Pune on 25th January 2019.
14. **Dr. B.B. Kale** has delivered a talk on "Nanomaterials synthesis strategies", at Machar College on 02nd February 2019.
15. **Dr. B.B. Kale** has delivered a talk on "Energy and Environment" at B.G. College Sangavi on 05th February 2019.
16. **Dr. B.B. Kale** has delivered a talk on "Quantum dot glass for optical and energy applications" in First Indian Materials Conclave and the 30th Annual General Meeting of MRSI held at the Indian Institute of Science, Bangalore, India during 12-15thFebruary 2019.
17. **Dr. B.B. Kale** has delivered a talk on "New Frontiers in Environmental and Allied Sciences" on 15th and 16th February 2019 at Yashada, Pune.
18. **Dr. B.B. Kale** has delivered a talk on "Quantum dot glasses for water purification" at C-MET Pune workshop at C-MET, Pune on 21st February 2019.
19. **Dr. B.B. Kale** has delivered a talk on "Strategies in Energy storage" in National Seminar on Communicating Recent Developments in Science-2019, (NSCRDS-2019)" at Institute of science on 27-28thFebruary 2019.
20. **Dr. B.B. Kale** has delivered a talk on "Strategies of nanostructured materials for energy storage" at C-MET, Trissur on 10th March 2019.
21. **Dr. B. B. Kale** has delivered a Chief Guest lecture on "IP protection" at Zeal Engineering college Ambegaon on 26th March 2019.
22. **Dr. G.J. Phatak** has delivered a talk on "Electronic Packaging Overview", at Refresher course entitled "Recent Trends in MEMS, Power Sources and Electronic Packaging" organized by All India Shri Shivaji Memorial Society's Institute of Information Technology, Pune, between 25-30th June 2018.
23. **Dr. G.J. Phatak** has delivered a talk on "LTCC: Processes and Applications", "Recent trends in MEMS, power sources and electronic packaging" organized by All India Shri Shivaji Memorial Society's Institute of Information Technology, Pune, between 25-30th June 2018.

24. **Dr. G.J. Phatak** has delivered a talk on "Materials for LTCC", "Recent trends in MEMS, power sources and electronic packaging" organized by All India Shri Shivaji Memorial Society's Institute of Information Technology, Pune, between 25-30th June 2018.
25. **Dr. G.J. Phatak** has delivered a talk on "Advanced packaging concepts and recent practices", "Recent trends in MEMS, power sources and electronic packaging" organized by All India Shri Shivaji Memorial Society's Institute of Information Technology, Pune, between 25-30th June 2018.
26. **Dr. G.J. Phatak** has delivered a talk on "LTCC: Process, applications and materials at C-MET" Dept of Electrical Engineering, IIT Bombay, 13th July 2018.
27. **Dr. G.J. Phatak** has delivered a talk on "Electronics Technology", as Resource person for induction programme of Dept. of Electronic-Science, Savitribai Phule Pune University, 18th July 2018.
28. **Dr. G.J. Phatak** has delivered a talk on "Present and future of LTCC and electronic packaging", 9th*ISSS* National Conference on MEMS, Smart Materials, Structures and Systems, 4-6th October 2018.
29. **Dr. G.J. Phatak** has delivered a talk on "C-MET and LTCC packaging", DIAT, 15th February 2019.
30. **Dr. G.J. Phatak** has delivered a talk on "Changing face of (Micro) electronics and C-MET", Foundation day lecture, C-MET, Pune, 8th March 2019.
31. **Dr. S.B. Rane** has delivered a talk on "Research/Technical paper writing" at orientation program for faculty on 'Modern pedagogy and recent technological development' AISSMS College of Engineering, Pune on 11th December 2018.
32. **Dr. S.B. Rane** has delivered a talk on "New approaches in hybrid microelectronics: development of 'Green' Materials" at national conference on emerging materials and nanotechnology (EMAN-2019), C.T. Bora College, Shirur, Pune on 19th January 2019.
33. **Dr. S.B. Rane** has delivered a talk on "Harvesting solar (light) energy through dye-sensitized photo-electrochemical cells (solar cells)" at National Conference on Advance Perspectives in Chemical, Materials and Life Science, E.S.D. College, Varvand, Pune on 19th January 2019.
34. **Dr. M.V. Kulkarni** has delivered invited talk on "Polymer nanocomposites and Li-ion batteries in the refresher programme" in recent trends in MEMS, Power source and Electronic Packaging by AICTE-ISTE organized by Department of Electronics and Telecommunication AISSMS Institute of Information Technology, Pune, 25-30th June 2018.
35. **Dr. M.V. Kulkarni** has delivered an Invited talk as a resource person on "Solid State Batteries" in Two days state level workshop on "Electrical Vehicles: Technologies and Challenges in India" organized by D.Y. Patil Institute of Engineering and Technology, Ambi, Talegaon, Pune, 29 - 30thJanuary 2019.
36. **Dr. M.V. Kulkarni** has delivered an Invited talk as a resource person on "Nanomaterials and Nanocomposites for Multifunctional Applications" in National conference on Applications of Nanomaterials in Chemical & Physical Sciences (ANCPS-2019) organized by Annasaheb Awate Arts, Commerce, & Hutatma Babu Genu Science College, Manchar, Pune, 1-2 February 2019.
37. **Dr. M.V. Kulkarni** has delivered an Invited talk as a resource person on "Nano materials and Polymer Nanocomposites for Biomedical applications" in National conference on Integration of Biological Data for Transformation of Science organized by Vidya Pratishthan's Arts, Science and Commerce College, Baramati, Pune, 22-23 February 2019.

38. **Dr. P. Adhyapak** has delivered invited talk on "Recent innovative trends of nanomaterials in Chemical, Biological and Physical sciences" held at Modern college of Arts, Science and Commerce, Pune on 12th October 2018.
39. **Dr S. Joseph** has delivered an invited lecture on "Interconnects and solder Bumping", "Recent Trends in MEMS, Power Sources and Electronic Packaging" organized by All India Shri Shivaji Memorial Society's Institute of Information Technology, Pune, between 25th-30th June 2018.
40. **Dr. R. Hawaldar** has delivered a talk on "Materials and manufacturing a bird view prospect" at ICSEE-2019, Hindustan University, Chennai on 22nd February 2019.
41. **Dr. R. Hawaldar** delivered a guest lecture on "Synthesis of nanomaterials" at Birla college Kalyan during one day National conference on "Recent Trends in Photonics, Smart and Nanomaterials", 21st February 2019.
42. **Dr. S. Arbuj**hasdelivered an Invited talk entitled 'Semiconductor nanomaterials and it's applications' as resource person in state level conference on "Frontiers in Basic and Applied Sciences" on 22nd December 2018, organized by Amruteshwar Arts, Commerce and Science College, Vinzar, Tal-Velhe, Pune.
43. **Dr. M.D. Shinde** has delivered a talk on Instrumental Analysis, Data Analysis and Interpretation of Spectra at Prof.Ramkrushna More Arts, Commerce and Science College, Akurdi, Pune organized under Lecture Series for MSc-II students on 18th August 2018.
44. **Dr. M.D. Shinde** has delivered a talk on Present status and future scope of renewable Energy at H. V. Desai College, Pune organized under Skill Development Course II on 09th March 2019.
45. **Dr. M.D. Shinde** has delivered a talk on Introduction to renewable energy at H. V. Desai College, Pune organized under Skill Development Course I on 29th September 2018.
46. **Mr. A. Kumar** has delivered an invited talk on "Extraction, Properties and Applications of Tantalum, Niobium and Hafnium" on 05th February 2019 at Nuclear fuel Complex (NFC, Dept. of Atomic Energy), Hyderabad.
47. **Dr. U. Rambabu** has delivered a lecture on "Restriction of Hazardous Substances (RoHS) - Awareness, Compliance, Testing & Certification as per MoEF & CC, E-waste (Management) Rules - 2016" at an oriental course to academicians, conducted by Dept. of Physics, Osmania University, Hyderabad on 21st December 2018.
48. **Dr. U. Rambabu** has delivered an invited talk on "Awareness on RoHS" in a seminar entitled "Management of Hazardous waste" conducted by Engineering Exports Policy Council of India (EEPCINDIA) and Federation of Telangana and Andhra Pradesh Chamber of Commerce and Industry (FTAPCCI), at Federation House, Hyderabad on 24thJanuary 2019.
49. **Dr. Y. Purushotham** has delivered a talk on "Ultra purification of Zinc by vacuum distillation" at Vasavi College of Engineering, Hyderabad on 08th September 2018.
50. **Dr. R. Ratheesh** has delivered an invited lecture on "Ceramic and composite materials for wireless communication applications" in the National Photonic Symposium at Cochin University of Science & Technology, Kochi on 01st March 2019.
51. **Dr. N.C.Pramanik** has delivered the invited lecture on "Supercapacitors & Nanostructured materials for energy storage" at University of Camerino, Camerino, Italy on 18th September 2018.
52. **Dr. N.C.Pramanik** has delivered invited lecture on "Aerogel supercapacitor for energy storage- The technology for Pilot scale production & achievements" at Royal Norwegian Embassy, New Delhi in c/w Indo-Norway Collaboration on "Emerging Energy Ecosystem – Levering Norwegian Expertise", on 14th November 2018.

53. **Dr. A. Seema** has delivered a talk on "Supercapacitors: Challenges of material design &system fabrication", National Seminar on recent trends in Material Science and Technology (RTMST-2018), 27-28th November 2018 at Sree Neelakanta Government Sanskrit college, Pattambi, Palakkad.
54. **Dr. S.N. Potty** has delivered an invited talk on 'X-ray diffraction studies' at the Department of Chemistry, Government Engineering College, Thrissur on 27th November 2018.
55. **Dr. N.C.Pramanik** has delivered invited lecture on "3D Nanostructured Materials & Energy storage devices for high power electronic applications" at Dept. of Instrumentation Science, Jadavpur University, Kolkata on 06th December 2018 before the One day 'National Seminar on Energy Storage & Conversions (NSESC-2018)".
56. **Dr. A. Seema** has delivered a talk on Modern sensors- challenges and innovations in refresher course in Nano science for college/University teachers at UGC-Human Resource Development Centre (HRDC), University of Calicut on 07th December 2018.
57. **Dr. A. Seema** has delivered a talk on Supercapacitors and Batteries: Material challenges and system design in Nano Science for college/University teachers at UGC-Human Resource Development Centre (HRDC), University of Calicut on 07thDecember 2018.
58. **Dr. T. Radhika** has delivered a talk in an International conference-biopolymer-ceramics nanocomposite flexible films for Rewritable Printing Applications, INCP-2018, M. G. University, Kerala on 07-09thDecember 2018.
59. **Dr. V. Kumar** has delivered invited lecture on "Local structural rearrangements in complex perovskites- A Raman perspective" in International conference on chemistry and physics of materials, organized by St. Thomas College, Thrissur, 19th-21st December 2018.
60. **Dr. T. Radhika** has delivered a talk in a National Seminar on Advanced Materials Research: next Generation Applications, T. M. Jacob Memorial Govt. College, Manimalakunnu, Kothamangalam, Kerala, 17-18th January 2019.
61. **Dr. N. Raghu** has delivered a talk in the National seminar on Artificial Intelligence and Robotics organized by Department of Electronics St. Thomas' college, Thrissur on 29th January 2019.
62. **Dr. S.N. Potty** has delivered an invited talk on' Smart Materials' in the national science day and silver jubilee celebration of K. G. College, Pampady, Kottayam on 14th February 2019.
63. **Dr. A. Seema** was the chief guest and delivered a talk on "Sensors: A Success Story from C-MET" in national science day 2019 celebration (under the theme "Communicating Scienec to All") of Vidya Academy of Science and Technology, Thrissur, Kerala on 22nd February 2019.
64. **Dr. T. Karthik** has delivered a talk on "Importance of electric field driven studies on piezoelectrics" at SRM Institute of Science and Technology in 7th National Conference on Hierarchically Structured Materials, NCHSM 2019., Chennai on 22-23rdFebruary 2019.
65. **Dr. V. Kumar** has delivered an invited lecture on "Ferroelectric glass - ceramics" at Department of Mechanical engineering, Kobe university, Japan on 15th February, 2019.
66. **Dr. N.C.Pramanik** has delivered invited lecture on "Indigenization of aerogel supercapacitor for energy storage Applications" on 09th March 2019 before the International Conference on Supercapacitors, Energy storage and Applications (ICSEA-2019), held at TMCAA Academic Complex, Thrissur during 08-10 March2019.
67. **Dr. N.C.Pramanik**h as delivered an invited lecture on "Chemistry of aerogel and the indigenous development of aerogel supercapacitors for energy storage application" on 21st March 2019 at Calicut University in c/w National Seminar on "Frontier in Chemical Sciences (ACS 2019)", held at Dept. of Chemistry, University of Calicut University during 19-21thMarch 2019.

68. **Dr. N.C.Pramanik** has delivered an invited lecture on “Materials for hybrid supercapacitors-technological aspects &achievements” on 17th March 2018 at Dept. of Physics, CUSAT in c/w National Workshop on “Recent Trends on Photovoltaics 2018’, held at CUSAT (Cochin) during 16-17thMar 2018.
69. **Dr. R. Prasada Rao** has delivered an Invited talk on “Solid electrolytes for Li and Na sulfur batteries” at International Meeting on Energy Storage Devices (IMESD-2018) held at IIT, Roorkee, 10-12thDecember 2018.
70. **Dr. R. Prasada Rao** has delivered an Invited talk on “Development of solid electrolytes for Lithium rechargeable all-solid-state batteries” at Advanced Functional Materials and Devices (ICAFMD-2019) held at NITW, Warangal, 26-28th February 2019.
71. **Dr. R. Prasada Rao** has delivered an Invited talk on “Studies of Sodium ion conducting electrolytes for rechargeable all-solid-state batteries” at International Conference on supercapacitors and Energy Storage Applications, (ICSEA-2019) held at C-MET, Thrissur, 8-10th March 2019.
72. **Dr. S.N. Potty** has delivered an invited talk on "How to choose final year projects which are interdisciplinary in nature" in the Orientation Program conducted by Government Engineering College, Thrissuron 27th June 2018.
73. **Dr. A. Seema** has delivered an invited talk on Technology Development & Commercialization: Impediments and Intricacies, in National Conference on "Current Trends in Polymer Science" (CTPS'2019) at Department of Polymer Science and Rubber Technology, Cochin University of Science and Technology, Kerala on 22nd March 2019.
74. **Dr. A. Seema** has delivered an invited talk on Electronic Materials to Devices-Technological Challenges, in Prof. Dr. Jose Mechery Endowment lecture at St. Thomas College, Thrissur on 28th March 2019.
75. **Mr. A. Kumar** has delivered an invited lecture entitled “E-waste processing: present scenario and way ahead” on 04th August 2018 at CVSR Engineering College (Anurag Group of Institutions), Hyderabad.
76. **Dr. R. C. Reddy** has delivered an invited entitled lecture entitled, “Recovery of rare metals from Zirconium plant effluents – Waste to Wealth”, on 28th September 2018 at an event Organized by Indian Institute of Metals held at M/S Navabharath Ventures Ltd., Paloncha, Telangana.
77. **Dr. R. C. Reddy** has delivered an invited lecture, entitled, “Indigenization of Hafnium for space and atomic energy applications - from Ore to Metal”, on 06th October 2018 at an event Organized by Indian Institute of Metals held at M/S Navabharath Ventures Ltd., Paloncha, Telangana.
78. **Dr. R. Ratheesh** has delivered an invited lecture titled “Novel ceramics and composites for microwave circuit applications” at Functional Materials and Applications Symposium organized by IIT, Hyderabad on 16th August 2018.
79. **Dr. R. Ratheesh** has delivered an invited lecture titled “Strategy need for developing special materials for electronics industry” on 19th December 2018 at an event organized by Electrical and Electronics summit in Aerospace and Defence at HAL, Hyderabad.
80. **Dr. Tanay Seth** delivered an Invited Lecture in "Recent trends in MEMS, power source and electronic packaging" at Institute of Information Technology, Pune, during 25-30thJune 2018.

7.7 Awards and honours

1. **Dr. B.B. Kale**have been nominated as Board of Studies (BoS) Member for Physics, SPPU, Pune, Maharashtra from 01.01.2019 onwards.
2. **Dr. G.J. Phatak** have been nominated as Board of Studies (BoS) Member for Electronics Science, SPPU, Pune, Maharashtra from 01.01.2019 onwards.
3. **Dr.S.B. Rane** have been nominated as executive council member, Maharashtra Academy of Science (MASc), Pune from 31.12.2018 onwards.
4. **Dr. S.B. Rane**have been nominated as Research and Recognition (RRC) Member, instrumentation science, Savitribai Phule Pune University (SPPU), Pune from 06.11.2017 to 06.11.2019.
5. **Dr. S.B. Rane**have been nominated as Board of Studies (BoS) Member for Energy Studies, Savitribai Phule Pune University (SPPU), Pune. From 28.05.2018 to 27.05.2020.
6. **Dr. S.B. Rane**have been nominated as Board of Studies (BoS) Member for Physics, Solapur University, Solapur, Maharashtra. From 23.11.2017 to 31.08.2022.
7. **Dr. M.V. Kulkarni** have been nominated as Board of Studies (BOS) Member for chemistry, Fergusson College, Pune, Maharashtra from 01.01.2018 to 01.01.2021.
8. **Dr. M.D. Shinde** has been selected as the Young Associate of the Maharashtra Academy of Science (MASC) in the field on physical sciences for the year 2018.
9. **Dr. N.C. Pramanik** has been awarded as ‘Member of expert Indian delegate’ for the India-Italy bilateral program on ‘Renewable Energy Technology’ and visited university of camerio, Italy during September 16-20, 2018
10. **Dr. N.C. Pramanik** recognized as the expert by Dept. of Science & Technology (Govt. of India) for screening & selection of new R&D proposals to be considered for financial support from DST-MES.
11. **Dr. N.R. Munirathnam**, Director General, C-MET has been inducted as a fellow of Telangana Academy of Sciences (TAS) on 15.03.2019 for his contribution in science and technology.

12. **Dr. A. Seema** has received Nari Shakti Puraskar, the highest Civilian honour for Women in India for her outstanding contributions in science and technology for the benefit of women in India, awarded by the President of India on 08.03.2019 at Rashtrapati Bhavan, New Delhi.

13. **Dr. A. Seema** has received national award for women's development through the application of science and technology, constituted by Department of Science and Technology (DST), government of India, awarded by the secretary, DST on 28.02.2019 at JNU, New Delhi.
14. **Dr. N. Narendar** selected for Visiting scientist program 2019, Indian National Science Academy (INSA), New Delhito carry out research work at IIT-Hyderabad for the period of 02 months between 01.06.2019 to 31.01.2020.
15. **Dr. N. Narendar** has awarded International travel grant (ITS) by DST-SERB on 16.08.2018 to attend European Materials Research Society (E-MRS) 2018 fall meeting, held at Warsaw, Poland.
16. **Dr. Y. Purushotham** elected as Hon. Treasurer, Telangana Academy of Sciences and Hon Treasurer, IIM, Hyderabad chapter for the year 2018-2020 and organizing Secretary for the Telangana State Science Congress 2018, held at NIT Warangal during December 22-24, 2018.
17. **Shri Abhisek Choudhary** has been conferred with the Degree of Philosophy (Ph.D) by National Institute of Technology, Rourkela during the XVI convocation held at NIT Rourkela during 18-19th January, 2019.

8. C-MET's future area of research

8.1. Future area of research

The following activities are planned to explore the cutting edge technologies in advanced electronic materials;

- High energy storage devices by researching on active materials for batteries for e-vehicle applications (supercapacitors, lithium ion battery).
- Development of 3-D printing inks and microwave devices for strategic and commercial applications.
- Indigenous sensors for internet of things (IoT) and smart cities applications.
- Microwave substrates, terahertz and milli meter wave materials.
- Cost effective and environmental friendly recycling technologies and RoHS testing.
- Silicon carbide electronic device grade substrates for strategic applications.
- NTC materials for low temperature applications for airport weather monitoring system (-90^{o}C to +50^{o}C).
- EMI-shielding materials, nanopowders of aluminum, iron, boran, Boran nitride, boran carbide, aluminium nitride for strategic applications.
- Graphene based electrical, optical and acoustic attenuators for medical, consumer and strategic applications.
- LTCC integrated PZT sensors for defense.
- Plasmonic for photostable nanoparticles to in medical applications.
- Medical electronics
- Stretchable electronic devices.
- COE on rechargeable batteries
- Additive manufacturing.

9. Others

9.1 Plans and prospects

C-MET implemented the projects in accordance with its approach and strategy. The key features of plans and prospects are:

1. To enhance the competency in advanced areas of science and technology in order to keep pace with the world scenario of electronic materials through in-house and grant-in-aid projects with inter and intra laboratory involvement.
2. Continue the interactive/working relation with strategic sector for development of critical materials and products through sponsored projects.
3. Continue the technical and materials characterization services to industries for creating more scope for consultancy projects, chemical analysis and certification for the compliance of RoHS directive and e-waste rules 2016.
4. Be a front runner in R&D of electronic materials and collaborate with esteemed international and national institutes/universities for creating common platform on knowledge sharing basis.
5. Development of impactful products and technologies through exploratory and requirement driven applied research.

9.2 Acknowledgment

C-MET is grateful to the Ministry of Electronics & Information Technology (MeitY), Govt. of India for its whole-hearted support and guidance during the entire year. It is my pleasure to acknowledge the support to C-MET in the form of specific sponsored projects for the technology/product development from the government and private organizations such as MeitY, ISRO (VSSC), DST, DRDO, DAE (BRNS, BARC), CPRI, EATON Pvt. Ltd., and MOIL, India Ltd., Nagpur.

The guidance and proactive support of the honourable Chairman, Deputy Chairman, Executive vice-Chairman and members of the Governing Council of C-MET have been invaluable for effective functioning. The advice of the Steering and Executive Committee of C-MET in carrying out the programmes effectively and efficiently requires special mention. I sincerely thank all of them.

I place on record very special thanks to all the officers and staff members of Electronic Materials and Components Development (EMCD) division, finance division, Autonomous Bodies Coordination Division (ABCD) and the other divisions of MeitY, for their extraordinary support and prompt co-operation in implementing C-MET´s programs. I am also obliged to our bankers, Punjab National Bank, Canara Bank, State Bank of India, Indian Overseas Bank, Andhra Bank and Bank of India at Pune, Hyderabad and Thrissur for rendering timely services.

I earnestly owe all the staff members and project staff working in various projects of C-MET for their dedicated professional efforts in the R&D activities, administrative services and financial support in achieving the overall progress of C-MET during the year.

Dr. N. R. Munirathnam

Director General

On behalf of C-MET staff

C-MET, PUNE

10. Auditor´s Report and Annual Accounts

FOR THE YEAR 2018-19

M/S. VDA Associates,
Chartered Accountants
10, Satsnag Society, Near Vaikuntha, Opp. L B Shashtri Road,
977, Navi Peth, Pune - 411030.

INDEPENDENT AUDITORS' REPORT TO THE CENTRE FOR MATERIALS FOR ELECTRONICS TECHNOLOGY (C-MET)

Report on the Financial Statements

We have audited the accompanying financial statements of **Centre for Materials for Electronics Technology, C-MET**, which comprise the Balance Sheet as at 31st March, 2019, and Income & Expenditure Account for the year then ended, and a summary of the significant accounting policies and other explanatory information.

Management's Responsibility for the Financial Statements

The Management of Centre for Materials for Electronics Technology, is responsible for the preparation of these financial statements that give a true and fair view of the financial position and financial performance in accordance with the Accounting Standards applicable to non corporate entities issued by Institute of Chartered Accountants of India in accordance with the accounting principles generally accepted in India. This responsibility includes the design, implementation and maintenance of internal control relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatement, whether due to fraud or error.

Auditors' Responsibility

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and the disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error.

In making those risk assessments, the auditor considers internal control relevant to the Society's preparation and presentation of the financial statements that give a true and fair view in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of the accounting policies used and the reasonableness of the accounting estimates made by the Management as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Opinion

In our opinion and to the best of our information and according to the explanations given to us, the aforesaid financial statements read with Annexure to Audit Report and Notes to Accounts (schedule 6) annexed herewith give a true and fair view in conformity with the accounting principles to the extent applicable to the Society:

a) in the case of the Balance Sheet, of the state of affairs of the Society as at 31st March, 2019; and
b) in the case of the Income & Expenditure Account, of the surplus of the Society for the year ended on that date;

For M/s VDA Associates
Chartered Accountants
Firm Registration No. 119179W

CA Pavan Sharma
Membership No. 170497
(Partner)

Place : Pune.
Date : 21.08.2019

ANNEXURE forming part of Audit Report of
Centre for Materials for Electronics Technology
for the Year ended 31st March 2019.

1) Fixed Assets pertaining to projects:
At present, the fixed assets pertaining to projects are shown in the books as project expenses. As suggested, project fixed assets are shown separately in the Balance Sheet.

In respect of those assets, which relate to the projects that are completed and the fixed assets which are not likely to be returned to the sponsors, feasibility to dispose off such assets may be assessed.

2) Statutory Dues:

1. GST on Reverse Charge Mechanism is not followed in FY 2018-19 in case of Hyderabad and Thrissur units.
2. Income Tax Refunds of previous years to be followed up and if not receivable then it should be written off in next financial year.

For M/s VDA Associates
Chartered Accountants
Firm Registration No. 119179W

CA Pavan Sharma
Membership No. 170497
(Partner)

Place : Pune.
Date : 21.08.2019

102780/2020/R&D-E

Centre for Materials for Electronics Technology, Pune.

BALANCE SHEET AS AT 31st MARCH, 2019

(Amount ₹)

CORPUS / CAPITAL FUND AND LIABILITIES :	**Schedule**	**As at 31.3.2019**	**As at 31.3.2018**
CORPUS/ CAPITAL FUND	*1*	496,312,552	420,908,360
CURRENT LIABILITIES ANDPROVISIONS (Including sponsored project)	*2*	307,181,432	334,040,454
TOTAL		**803,493,984**	**754,948,814**
ASSETS :			
FIXED ASSETS	*3*	151,203,160	147,464,069
CURRENT ASSETS, LOANS AND ADVANCES	*4*	652,290,824	607,484,745
MISCELLANEOUS EXPENDITURE (to the extent not written off or adjusted)		-	-
TOTAL		**803,493,984**	**754,948,814**
SIGNIFICANT ACCOUNTING POLICIES	*5*		
NOTES TO ACCOUNTS AND CONTINGENT LIABILITIES	*6*		

We hereby certify the above balance sheet to be true and correct to the best of our knowledge and belief, subject to notes to accounts and schedules attached hereto.

Sd/-
Dr. N. R. Munirathnam
Director General

Sd/-
G. B. Rao
Sr. Finance Officer

As per our report of even date attached.
For M/s VDA & Associates
Chartered Accountants
F.R. No. 119179W

Sd/-
CA Pavan Sharma
(M.No.: 170497)
(PARTNER)

PLACE: PUNE
DATE : 21.08.2019

Centre for Materials for Electronics Technology, Pune.

Income and expenditure account for the year ended 31st march, 2019

(Amount ₹)

Income:	**Schedule**	**Current year 2018-19**	**Previous year 2017-18**
Revenue grants	7	21,93,26,538	13,24,25,687
Income from services	8	1,11,45,728	59,17,325
Interest earned	9	3,04,32,485	2,82,54,588
Other income	10	1,41,85,840	21,80,903
Total (A)		**275,090,591**	**168,778,503**
Expenditure:			17,89,59,332
Establishment expenses	11	16,26,51,947	
Laboratory and administrative expenses etc.	12	40,773,543	33,716,174
Depreciation		24,034,371	23,869,991
Total (B)		**227,459,861**	**236,545,497.00**
Surplus / (Deficit) for the year (A - B)		(47,630,730)	(66,766,994)
Balance transferred to / from Corpus/Capital Fund		(47,630,730)	(67,766,994)

We hereby certify the above Income & Expenditure account to be true and correct to the best of our knowledge and belief, subject to notes to accounts and schedules attached hereto.

Sd/-
Dr. N. R. Munirathnam
Director General

Sd/-
G. B. Rao
Sr. Finance officer

As per our report of even date attached.
For M/s VDA & Associates
Chartered Accountants
F.R. No. 119179W

Sd/-
CA Pavan Sharma
(M.No.: 170497)
(PARTNER)

PLACE: PUNE,
DATE: 21.08.2019

Centre for Materials for Electronics Technology, Pune.

Schedules forming part of balance sheet as at 31st march, 2019

(Amount ₹)

Schedule 1 - corpus / capital fund:	**as at 31.3.2019**		**as at 31.3.2018**	
Balance as at the beginning of the year	**44,21,86,697**		434,612,384	
Add: Contribution towards Corpus / Capital Fund	2,77,73,462		7,574,313	
	469,960,159		**442,186,696**	
Add / (Less): Balance of net income / Expenditure transferred from income and expenditure account:				
As per last year	**21,278,337**		43,126,481	
Add: Surplus / (deficit) for the year	(47,630,730)		(64,404,818)	
	(26,352,393)	496,312,552	**21,278,337**	420,908,360
Balance at the year end		**496,312,552**		**420,908,360**

Centre for Materials for Electronics Technology, Pune.

Schedule 2 - current liabilities and provisions:

(Schedules forming part of Balance Sheet as at 31st March, 2019)

(Amount ₹)

	as at 31.3.2019		as at 31.3.2018	
A. Current liabilities:				
1.Sundry creditors:				
a) For goods & others	97,671		1,897,986	
b) For E.M.D and deposits	4,140,308	4,237,979	3,657,809	5,555,795
2.Statutory liabilities:				
Profession tax / ITDS / GST/ Service tax / GIS		1,039,308		2,176,799
3.Other current liabilities:				
Sponsored projects	138,546,291		174,465,061	
Other liabilities	43,276,150	181,822,441	38,663,841	213,128,902
Total (A)		**187,099,728**		**220,861,496**
B. Provisions:				
1.Gratuity payable	66,367,265		63,226,248	
2.Leave encashment payable	52,050,395		46,626,024	
3.C-MET CPF trust	-		-	
4.Expenses payable	3,464,044	120,081,704	3,326,686	113,178,958
Total (B)		**120,081,704**		**113,178,958**
Total (A + B)		**307,181,432**		**334,040,454**

Centre for Materials for Electronics Technology, Pune.
Schedules forming part of balance sheet as at 31st march, 2018

Schedule 3 - fixed assets: *(Amount ₹)*

Description	**Gross block**				**Depreciation**				**Net block**	
	as at 1.4.2018	additions during the year	deletions / Adj. during the year	**as at 31.03.2019**	as at the beginning of the year	for the year	deletions/ Adj. during the year	**Total upto 31.03.2019**	**as at 31.03.2019**	as at 31.3.2018
1. Buildings on freehold land	**127,373,897**	2,158,143	-	**129,532,040**	**67,375,013**	6,264,736		**73,639,749**	**55,892,291**	59,998,885
2. Lab equipment	**288,406,449**	23,642,971	-	**312,049,420**	**210,293,601**	16,138,615	-----	**226,432,216**	**85,617,204**	78,112,849
3. Furniture, fixtures	**13,157,662**	216,008	-	**13,373,670**	**9,635,439**	363,023	-----	**9,998,462**	**3,375,208**	3,522,222
4. Office equipment	**16,498,867**	1,048,975	-	**17,547,842**	**13,094,803**	607,730	-----	**13,702,533**	**3,845,309**	3,404,063
5. Computer/peripherals	**12,277,112**	707,365	-	**12,984,477**	**11,648,220**	442,558	-----	**12,090,778**	**893,699**	628,892
6. Electric fittings	**1,765,724**	-	-	**1,765,724**	**763,275**	100,245	-----	**863,520**	**902,204**	1,002,449
7. Electric substation	**3,689,196**	-	-	**3,689,196**	**3,098,533**	88,599	-----	**3,187,132**	**502,064**	590,663
8. Air conditioners	**813,174**	-	-	**813,174**	**643,951**	25,383	-----	**669,334**	**143,840**	169,223
9. Tubewell	**95,494**	-	-	**95,494**	**60,671**	3,482	-----	**64,153**	**31,341**	34,823
Total of current year	**464,077,575**	**27,773,462**	-	**491,851,037**	**316,613,506**	24,034,371	-----	**34,0647,877**	**151,203,160**	**147,464,069**

Centre for Materials for Electronics Technology, Pune.

Schedule 4 - current assets, loans & advances :

(Schedules forming part of Balance Sheet as at 31st March, 2019)

(Amount ₹)

	as at 31.3.2019		as at 31.3.2018	
A.Current assets:				
1.Cash balances in hand		-		1,373
2.Bank balances with scheduled banks:				
- On deposit accounts	36,15,00,448		28,05,10,473	
- On savings accounts	2,72,45,414		7,43,63,022	
- Project deposits (including flc margin money)	18,74,52,980	57,61,98,842	18,74,65,762	54,23,39,257
Total (A)		**57,61,98,842**		**54,23,40,630**
B. Loans, advances and other assets				
Loans and advances to staff	2,64,556		5,25,796	
Loans and advances to others	56,87,513		3,66,04,296	
Amount recoverable	78,19,810		25,16,032	
Advance to suppliers	45,04,095		34,38,633	
Security and other deposits	5,03,78,733		1,37,93,623	
Prepaid expenses	3,155		9,622	
Interest Accrued on FDRs	74,34,120	7,60,91,982	82,56,113	6,51,44,115
Total (B)		**7,60,91,982**		**6,51,44,115**
Total (A + B)		**65,22,90,824**		**60,74,84,745**

Centre for Materials for Electronics Technology (C-MET)
Schedules forming part of the accounts for the year ended 31st March 2019.

Schedule: 5 significant accounting policies

1. Accounting conventions:

   The financial statements are prepared on *historical cost convention*, going concern, and accrual basis and the same are followed consistently, except for bonus, which is accounted for on cash basis.

2. Revenue recognition:

   - Income from operation includes, income from analysis receipts, overhead receipts and professional/consultancy services. Income from these activities is accounted for as and when services are rendered.
   - Grants are recognized when there is a reasonable assurance that, the grants will be received.
   - C-MET being research body, its entire expenditure relates to *research activity*. The expenditure incurred is debited to the appropriate accounts.
   - All significant items of incomes and expenses are accounted on accrual basis unless otherwise stated.

3. Fixed assets:

   - Fixed assets stated in the balance sheet are valued at their cost of acquisition inclusive of freight, octroi and other direct and indirect cost in respect thereof.
   - Society has been directed to charge depreciation on its assets on the written down value basis vide instructions issued by Ministry of Electronics & Information Technology. Accordingly, depreciation has been charged as per rates prescribed under the income tax act, 1961.
   - Fixed assets procured under the sponsored projects, being the property of the respective sponsoring agency, are not accounted under the head C-MET fixed assets.

4. Inventory:

   As per the policy consistently followed by the centre, expenditure incurred on consumable stores and spares is charged to revenue account.

5. Foreign currency transaction:

Transactions in foreign currency are recorded at the exchange rates prevailing on the date of transactions.

Foreign currency assets / liabilities are restated at the rates prevailing at the year end.

Exchange differences relating to fixed assets are adjusted to the cost of the assets.

Any other exchange difference is dealt with in the income & expenditure account.

6. Prior period and extraordinary items:

Prior period income and expenses and extraordinary items, wherever material are disclosed separately. Prior period items include material items of income or expenses which arise in the current period as a result of error or omission in the preparation of financial statements of one or more prior periods. It does not include items, which are ascertained and determined during the year.

7. Retirement benefits:

C- MET has set up contributory provident fund separately. Leave encashment and gratuity is accounted for as per the actuarial valuation, liability whereof is as below:

a) Gratuity - Rs. 66,367,265/- (Previous year Rs. 63,226,248/-)

b) Leave Encashment - Rs. 50,210,045/- (Previous year Rs. 46,626,024/-)

8. Amount equal to capital expenditure is credited to capital fund. Grants for sponsored projects are shown separately. Unspent amount of the sponsored projects is shown as liability.

For**Centre for Materials for Electronics Technology**

Sd/- Sd/-

Dr. N. R. Munirathnam **G. B. Rao**

Director General Sr. Finance Officer

As per our report of even date attached.
For M/s VDA & Associates
Chartered Accountants
F.R. No. 119179W

Sd/-
CA Pavan Sharma
(M.No.: 170497)
(PARTNER)

As per our report of even date attached.
For M/s VDA & Associates

PLACE: PUNE
DATE: 21.08.2019

Centre for Materials for Electronics Technology (C-MET)

Schedules forming part of the accounts for the year ended 31st March 2019.

Schedule: 6 notes on accounts

1. Current assets, loans & advances: In the opinion of the management, the current assets, loans and advances have a value on realization in the ordinary course of business equal at least to the aggregate amount shown in the balance sheet.
2. Foreign currency transactions:

a) Value of imports (FOB basis):
Capital Goods: Rs. 11,784,429/- (Previous Year Rs. 3,41,47,192/-)

b) Expenditure in foreign currency: Rs. 4,065,434/- (Previous Year Rs. 1,11,88,529/-)

As the information of CIF basis for import of capital goods is not available, values are taken on FOB basis.

3. The society is an approved institution in terms of sub-section (21) of section 10 of the income tax act, 1961 and is exempt from tax.
4. Since most of the materials/equipments are of technical nature, their allocation between equipments, stores and projects is taken as certified by the management.
5. C-MET, being a scientific Society and not a commercial, industrial or a business entity, the management is of the opinion that reporting requirements as per AS-17 "Segment Reporting" are not mandatory.
6. The management of C-MET is of the opinion that being a scientific society under Ministry of Electronics and Information Technology, Govt. of India and societies registration act, the disclosure requirements as per AS-18 "Related Party Disclosure" are not applicable.
7. In the opinion of the Management, Accounting Standard 22 for "Accounting for taxes on income" is not applicable to the society as it is exempt from payment of income tax.
8. Debit and Credit Balances of Personal Accounts are subject to confirmation.
9. Previous year's figures have been regrouped and rearranged wherever necessary.
10. Schedules 1 to 11 are annexed to and form an integral part of the balance sheet as at 31st March, 2019 and the Income & Expenditure Account for the year ended on that date.
11. The Financial statements are prepared in accordance with the **Accounting standard 21- consolidated financial statement** of 3 operational units i.e. Pune, Hyderabad and Thrissur.
12. Contingent liability not provided in the books of account:-

Particulars	**Current year (Rs.)**	**Previous year (Rs.)**
For capital goods	Nil	Nil
For others	8,69,760/- TDS Defaults	81,533/- Court Case

a) The TDS notices Unit wise are issued by the Income Tax Department and the dues are yet to be finalized and settled.

The details of the TDS Defaults of all the 3 sections are as follows:

Sr	Unit Name	Amount
1	Pune	6,32,250/-
2	Hyderabad	2,37,010/-
3	Thrissur	500/-
Total		**8,69,760/-**

b) The amount of contingent liability carried forward towards pending court judgement for medical reimbursement of Thrissur laboratory staff is Nil as all the dues have been paid in FY 2018-19. (Previous Year Rs. 81,533/-)

ForCentre for Materials for Electronics Technology

sd/- sd/-

Dr. N. R. Munirathnam **G. B. Rao**

Director General Sr. Finance Officer

For VDA & Associates,
Chartered Accountants
Firm Registration No. 119179W

CA Pavan Sharma
Membership No.: 170497
(Partner)

Place : Pune.
Date : 21.08.2019

Centre for Materials for Electronics Technology, Pune.

Schedules forming part of Income & Expenditure A/c for the year ended 31st March, 2019

(Amount ₹)

Schedule 7 - revenue grants:	**Current year 2018-19**	**Previous Year 2017-18**
Grants for Revenue Expenditure	219,326,538	132,425,687
TOTAL	**219,326,538**	**132,425,687**

Schedule 8 - income from services:	**Current year 2018-19**	**Previous Year 2017-18**
Income from Services:		
Analysis receipts	89,053	111,431
Overhead/Consultancy services/Intellectual Fee	9,254,175	4,997,394
ToT Fee	1,802,500	808,500
TOTAL	**11,145,728**	**5,917,325**

Schedule 9 - interest earned:	**CURRENT YEAR 2018-19**	**Previous Year 2017-18**
On Savings account and Term Deposits:		
a) With Scheduled Banks	30,424,925	28,249,548
b) On Advance to Staff	7,560	5,040
TOTAL	**30,432,485**	**28,254,588**

Schedule 10 - other income:	**CURRENT YEAR 2018-19**	**Previous Year 2017-18**
Miscellaneous Income	2,180,903	2,180,903
TOTAL	**2,180,903**	**2,180,903**

Centre for Materials for Electronics Technology, Pune.

Schedules forming part of Income & Expenditure A/c for the year ended 31st March, 2019.

(Amount ₹)

Schedule 11 - establishment expenses:	**Current year 2018-19**	**Previous yar 2017-18**
Salaries and allowances	130,610,952	127,142,830
Training	150,729	28,930
Leave travel concession	2,927,760	389,843
Medical reimbursement	6,285,568	5,551,884
Leave encashment	6,453,700	11,499,209
Gratuity	5,136,997	17,856,661
Employer contribution to cpf	4,673,475	7,879,689
Nps contribution	4,207,827	6,632,509
Honorarium	58,000	120,500
Canteen reimbursement	959,200	905,720
Newspaper & periodicals	115,993	111,067
Cea reimbursement	835,697	470,731
Membership fees	48,894	18,954
Recruitment expenses	76,119	68,793
Transfer TA	111,036	282,012
Total	**162,651,947**	**178,959,332**

Centre for Materials for Electronics Technology, Pune.

Schedule 12 - laboratory and administrative expenses:

(Schedules forming part of Income & Expenditure A/c for the year ended 31st March, 2019)

(Amount ₹)

Particulars	**Current year 2018-19**	**Previous year 2017-18**
Laboratory general expenses	2,176,019	2,423,271
Electricity charges	11,342,886	10,965,704
Water charges	10,845	50,289
Repairs and maintenance:		
On buildings	2,037,751	116,876
On electricals	453,029	323,688
On laboratory equipments	1,232,123	232,559
On office equipments	633,837	313,001
On furniture & fittings	5,745	9,380
Rates and taxes	1,597,686	2,587,025
Postage & telegram charges	81,301	88,952
Telephone, Telex & Fax charges	359,834	365,714
Printing and Stationary	764,501	550,516
Conveyance	19,732	19,802
Vehicle hire	1,676,664	1,925,360
Ta & da	2,137,702	1,709,461
Security expenses	6,309,570	4,693,218
Office & general expenses	5,057,689	3,128,148
Diesel for Gensets	288,405	297,569
Auditor's remuneration	149,770	132,750
Audit expenses	59,348	54,910
Meeting expenses	759,795	733,851
Gardening expenses	1368,356	1,079,781
Bank charges	31,094	37,108
Advertisement and Publicity	148,923	348,278
Professional & consultancy expenses	433,150	1,020,508
Prior period Expenses	1133,228	805
Workshop/symposia	300,000	-
Contribution to Sponsored project	-	200,000
Assets written off	-	307,650
Legal expenses	204,560	-
TOTAL	**4,07,73,543**	**33,716,174**

Centre for Materials for Electronics Technology - Pune

Bifurcation of Grants for the year 2018-19

(Amount ₹)

Total Grants received during the year 2018-19				**2,407,100,000**
Particulars	Date / voucher no.	Plan	Non-plan	Total
Grants received for the year 2017-18				
1. Sanction letter no.2(4)/2018-EMCD dtd. 12.6.2018	20.6.2018 / BRV-33	15,00,00,000	-	15,00,00,000
2. Sanction letter no.2(4)/2018-EMCD dtd. 31.7.2018	27.8.18 / BRV-72	5,00,00,000	-	5,00,00,000
3. Sanction letter no.2(4)/2018-EMCD dtd. 25.2.2019	28.2.19 / BRV-152	2,00,00,000	-	2,00,00,000
Total Grants receipts		**237,100,000**	**-**	**247,100,000**
Expenditure for the year 2018-19				
Capital Expenditure.				
Revenue Expenditure.		27,773,462	-	27,773,462
		219,326,538	-	219,326,538
	Total	**247,100,000**	**-**	**247,100,000**

Centre for Materials for Electronics Technology, Pune.

Details of project balances as on 31st march 2019

(Amount ₹)

S. No.	Name of Project		Opening balance as on 1.4.2018	Receipts during 2018-19	Payments during the year 2018-19			Closing balance as on 31.3.2018
					Fixed assets	Other expenses	Total	
	1		2	3	4	5	6 = (4+5)	7 = (2+3-6)
	PUNE:							
1	SP28	Solar light photocatalyst	(2,11,501)	2,11,501	-	-	-	-
2	SP41	UGC-JRF- JM Malli	63,629	-	-	-	-	63,629
3	SP45	Devp of LTCC Materials for GPA	11,64,508		-	6,00,027	6,00,027	5,64,481
4	SP46	CSIR-SRF-Ms. Bhirud	36,518				-	36,518
5	SP47	CSIR-JRF-Mr. Pandit	2,01,026			-	-	2,01,026
6	SP48	INSPIRE FACULTY AWARD-Dr.Chauhan	(2,776)	14,79,920		13,81,558	13,81,558	95,586
7	SP49	Devp. Of Active Material	(84,138)		-	(84,138)	(84,138)	-
8	SP50	CSIR-JRF-MS A F Shaikh	-	20,000		20,000	20,000	-
9	SP52	Fab. Of Microwave Components	3,78,141			3,78,141	3,78,141	-
10	SP54	Prototype Devp of Fuel Cell	(3,140)	-		(3,140)	(3,140)	-
11	SP55	Inspired Faculty Award-D R Patil	3,39,496	16,57,920	-	13,55,658	13,55,658	6,41,758
12	SP57	Devp of Nanostructured PdTe	(9,600)	1,00,000		90,400	90,400	-
13	SP59	Proof of Patternable Thick film	12,92,475	-	-	5,900	5,900	12,86,575
14	SP60	Devp. Of Electrolyte systems	19,61,288	15,40,000	20,68,802	13,26,911	33,95,713	1,05,575
15	SP61	FAB of 2D Heterostructures	16,88,515	1,19,702	13,97,306	2,03,142	16,00,448	2,07,769
16	SP62	SERB Young Scientist Dr Khupse	3,80,048	10,00,000	-	9,53,489	9,53,489	4,26,559
17	SP63	Flexible Solidstate supercapacitor	2,80,707	-		2,87,368	2,87,368	(6,661)
18	SP64	Novel nanosthong perf anode mat	35,74,039	-		8,32,309	8,32,309	27,41,730
19	SP65	Synth of Nanosized ANI Ceramic	13,91,390	-	69,800	7,03,567	7,73,367	6,18,023
20	SP66	Dev. Of NanostrMng Ferrite	10,23,781	-		8,67,169	8,67,169	1,56,612
21	SP67	Integrated low-cost water sensors	5,45,400	-		5,43,170	5,43,170	2,230
22	SP68	3D Nano St. Lithium battery	-	1,00,00,000	-	20,18,554	20,18,554	79,81,446
23	SP69	WOS Nano St. Layered MOS 2	-	7,35,000		5,74,754	5,74,754	1,60,246
24	SP70	Engg. Of Q Dot based Solar Radiation		9,98,951		4,57,598	4,57,598	5,41,353
25	SP71	Inspire Faculty award Dr Nasani		7,00,000	9,818	2,34,621	2,44,439	4,55,561

26	SP72	Dev of Nano St. NMC Cathode Mt		13,57,000		3,43,867	3,43,867	10,13,133
27	SP73	Dev. Of Print Silver ink for RFID		50,00,000		1,74,476	1,74,476	48,25,524
28	SP74	Dev. Of Hybrid Battery		45,00,000		2,37,241	2,37,241	42,62,759
29	TS12	LTCC Based Circuits Fittings	(11,714)				-	(11,714)
30	TS13	LTCC Based Magnectic Sensors	30,40,504	29,70,000	-	18,29,945	18,29,945	41,80,559
31	TS15	Devp of Microcrystaliine	8,51,294	-		2,31,642	2,31,642	6,19,652
32	TS16	Sealing of Na Ion Battery cells		15,02,824		6,39,875	6,39,875	8,62,949
33	-	CSIR SRF D Kajale		18,356		18,270	18,270	86
34	-	CSIR SRF Y. Sethi	5	20,000		19,891	19,891	114
35	-	INSA Sr Sci. Dr. S Kulkarni	363	4,59,637		4,28,394	4,28,394	31,606
36	-	DST Sub expert com. on Engg& Tech Dev.	8,50,000	-		8,50,000	8,50,000	-
37	-	Workshop Q Dot Nmat 2019	-	2,32,043	-	1,57,009	1,57,009	75,034
		TOTAL (a)	**1,87,40,258**	**3,46,22,854**	**35,45,726**	**1,76,77,668**	**2,12,23,394**	**3,21,39,718**
	HYDERABAD:							
38	SP31	GALLIUM-DST	48,56,144				-	48,56,144
39	SP32	E-WASTE-PCBs-DeitY	1,97,23,498	1,71,80,000	40,52,575	1,39,51,853	1,80,04,428	1,88,99,070
40	SP33	DRDO/SSPL/CARS/Cd & Te	14,37,162	19,00,000	12,90,462	22,43,394	35,33,856	(1,96,694)
41	SP34	Photosensitizers for visible light -SERB	8,80,595	9,50,000	5,88,088	11,90,130	17,78,218	52,377
42	SP35	SiC / DMRL	3,72,66,044	92,74,978	8,57,808	1,55,58,145	1,64,15,953	3,01,25,069
43	SP36	CFLs & FLs / DST	1,53,317	8,83,143		7,11,539	7,11,539	3,24,921
44	SP37	Recycling scrap Germanium DRDO SSPL	39,48,150	10,68,520	24,39,000	23,07,789	47,46,789	2,69,881
45	SP38	Ultra High Pure Zn BRNS IGCAR	18,10,520		9,33,978	4,96,078	14,30,056	3,80,464
46	SP39	NaviCMeity		90,00,000	2,33,877	11,59,039	13,92,916	76,07,084
47	SP40	Design & Fab. MEMS Bionic Sensors		23,96,310				23,96,310
48	TS-01	Hafnium VSSC	39,02,804	97,58,878		92,36,784	92,36,784	44,24,898
		TOTAL (b)	**7,39,78,234**	**5,24,11,829**	**1,03,95,788**	**4,68,54,751**	**5,72,50,539**	**6,91,39,524**
	THRISSUR:							
49	SP45	DST (NR)	(1,52,634)	-		1,180	1,180	(1,53,814)
50	SP51	DEITY (NR)	(1,30,410)	6,33,395		4,62,550	4,62,550	40,435
51	SP52	BRNS (RT)	24,792	72,106		96,898	96,898	-
52	SP53	BRNS (RR)	8,555	3,318		38,360	38,360	(26,487)
53	SP54A	DEITY (NCP)	5,68,74,513	20,366	13,82,693	5,55,04,289	5,68,86,982	7,897

54	SP54B	DST (NCP)	68,46,882		1,70,100	66,75,602	68,45,702	1,180
55	SP55	BRNS (NR)	(29,853)	43,023		618	618	12,552
56	SP56	BRNS (NR)	1,05,50,254	19,31,819	60,80,433	48,48,009	1,09,28,442	15,53,631
57	SP57	SERB (NR)	5,05,554	6,00,000	1,18,530	9,22,833	10,41,363	64,191
58	SP58	MEITY (KPM)	2,83,460	10,42,000	20,208	8,05,012	8,25,220	5,00,240
59	SP59	BRNS (SNP)	13,07,452	4,58,756	8,94,234	7,17,180	16,11,414	1,54,794
60	SP60	DST (SNP)	26,39,487	4,00,000	6,09,659	25,25,625	31,35,284	(95,797)
61	SP61	DST (AS)	25,00,000			9,33,739	9,33,739	15,66,261
62	SP62	ARMREB (AS)		32,31,000	3,50,272	10,47,644	13,97,916	18,33,084
63	SP63	MEITY (AS)		30,96,000	2,76,700	22,42,516	25,19,216	5,76,784
64	SP64	DST (SNP)		35,60,000	1,51,000	2,45,442	3,96,442	31,63,558
65	SP65	DIT (NCP)		2,47,50,000		27,72,084	27,72,084	2,19,77,916
66	SP66	CPRI (SEEMA)		51,65,000		6,99,651	6,99,651	44,65,349
67	TS-31	DEBEL - TR		18,50,500		3,44,590	3,44,590	15,05,910
68	DISHA	Ferroelectric Ceramic-Polymer Composite	4,70,832	5,00,000		9,50,800	9,50,800	20,032
69	JRF/PDF	JRF Grant in aid	47,685	32,511		39,060	39,060	41,136
70	-	ICSEA 2019		18,99,515		18,41,318	18,41,318	58,197
		TOTAL (c)	**8,17,46,569**	**4,92,89,309**	**1,00,53,829**	**8,37,15,000**	**9,37,68,829**	**3,72,67,049**
		GRAND TOTAL (a+b+c)	**17,44,65,061**	**13,63,23,992**	**2,39,95,343**	**14,82,47,419**	**17,22,42,762**	**13,85,46,291**

Statement showing comments of statutory auditors on the accounts of C-MET for the year 2018-19 and C-MET's replies thereto.

Sr. No	Brief subject	Auditor's comments	C-MET Reply
1.	**Fixed assets pertaining to projects:**	At present, the fixed assets pertaining to projects are shown in the books as project expenses. As suggested project fixed assets are shown separately in the Balance Sheet. In respect of those assets, which relate to the projects that are completed and the fixed assets which are not likely to be returned to the sponsors, feasibility to dispose off such assets may be assessed.	Actual amount of Fixed Assets procured out of the projects is separately accounted for & indicated in the schedule. Also, individual head-wise expenditure is separately maintained and sent to Sponsoring Agency. In addition, project Fixed Assets register is also maintained. Ownership and title of project fixed assets rests with the project sponsoring agency. Fixed Assets pertaining to completed projects are disposed off as soon as sponsoring agency consents their disposal.
2.	**Statutory Dues:**	GST on Reverse Charge Mechanism is not followed in FY 2018-19 in case of Hyderabad and Thrissur units. Income Tax Refunds of previous years to be followed up and if not receivable then it should be written off in next financial year.	Services of GST and income tax consultants shall be availed to clear out both the issues. Necessary entries will be passed in the books of accounts.

Steering and Executive Committee of C-MET (2018-2019)

STEERING COMMITTEE

Dr.V.K. Saraswat — **Chairman**
Former secretary, Defence R&D
Member Niti Aayog, Room no.113,
Niti Aayog building
Parliament street, New Delhi-110 001

Prof. T. R.N. Kutty — **Member**
Emeritus Professor, IISc
No. 48, HMT Layout, 7thCross/ 7thMain
Rebindranath Tagore Nagar (PO)
Bangalore- 560 012

Shri.ArvindKumar — **Member**
Group Coordinator (R& D Electronics),
Ministry of Electronics & Information Technology
Electronics Niketan, 6, CGO Complex,
New Delhi-110 003

Dr. ArunKumarBhaduri — **Member**
Distinguished Scientist and Director
Indira Gandhi Centre for Atomic Research (IGCAR)
Kalpakkam- 603102,
Tamil Nadu

ShriP.Sudhakar — **Member**
OSD to DAE & Former CEO, ECIL
ECIL admin. building
Electronics Corporation of India Ltd (ECIL)
Hyderabad-500 062

Prof. (Dr.) SanjayK.Nayak — **Member**
Director General
Central Institute of Plastics Eng.and Technology (CIPET)
Chennai – 600 032

Dr.HemanthDarbari — **Member**
Director General
Centre for Development of Advanced Computing
Pune University Campus, GaneshKhind, Pune- 411 008

Dr. N.R.Munirathnam — **Member-Convener**
Director General
Centre for Materials for Electronics Technology
Panchawati, Off Pashan Road, Pune-411 008

EXECUTIVE COMMITTEE

Dr. N.R.Munirathnam — **Chairman**
Director General
Centre for Materials
for Electronics Technology
Panchawati, Off Pashan Road, Pune-411 008

Smt. SwarnaLata — **Member**
Scientist G/HOD,
Ministry of Electronics & Information Technology
Electronics Niketan, 6 CGO Complex
New Delhi - 110 003 (Up to 03.09.2018)

Dr. Sandip Chatterjee — **Member**
Director, Scientist F
Ministry of Electronics & Information Technology
Electronics Niketan, 6, CGO Complex,
New Delhi-110 003 (from 04.09.2018 onwards)

Shri Trilok Chandra — **Member**
Director, Personnel Group
Ministry of Electronics & InformationTechnology
Electronics Niketan, 6, CGOComplex,
New Delhi-110 003 (Up to20.05.2018)

Shri Roop Kishor — **Member**
Director, Personnel Group
Ministry of Electronics & Information Technology
Electronics Niketan, 6, CGO Complex,
New Delhi-110 003 (from 21.05.2018 onwards)

Shri B.D. Sharma — **Member**
Joint Director, Integrated Finance Division
Ministry of Electronics & InformationTechnology
Electronics Niketan, 6, CGOComplex,
New Delhi-110 003 (Up to13.01.2019)

Smt Revathi Kumar — **Member**
Joint Director, Integrated Finance Division
Ministry of Electronics & Information Technology
Electronics Niketan, 6, CGO Complex,
New Delhi-110 003 (from 14.01.2019 onwards)

Dr. B. B. Kale — **Member**
Director (A)
Centre for Materials for Electronics Technology
Panchawati, Off Pashan Road, Pune-411 008

Dr. R. Ratheesh — **Member**
Director
Centre for Materials for Electronics Technology
Hyderabad- 500 051

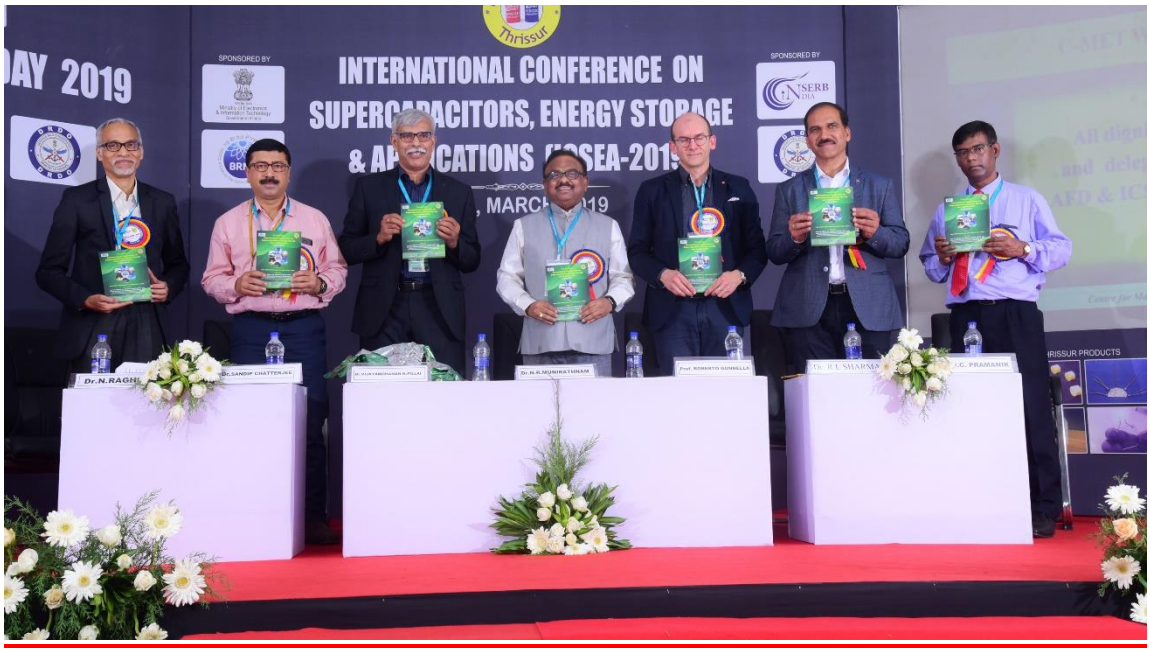
Dr. N. Raghu — **Member**
Director
Centre for Materials for Electronics Technology
Thrissur-680 771

Dr. R. Prasada Rao — **Member**
Programme Co-ordinator
Centre for Materials for Electronics Technology
Panchawati, Off Pashan Road, Pune-411 008

Shri G. B. Rao — **Member**
SFO
Centre for Materials for Electronics Technology
Panchawati, Off Pashan Road, Pune-411 008

Smt. Radha Jaisimha — **MemberSecretary**
Registrar
Centre for Materials for Electronics Technology
Panchawati, Off Pashan Road,
Pune-411 008

Inaugural Function of the Annual Foundation Day 2019



From Left: Dr. N. Raghu, Director, C-MET, Thrissur; Dr. Sandip Chatterjee, Director, EMCDMeitY; Dr.Vijayamohanan K Pillai, the former Director of CSIR-CECRI; Dr. N. R. Munirathnam, Director General, C-MET; Prof. Roberto Gunnella from University of Camerino, Italy; Mr. Rajendra Kumar Sharma, SPEL, Technologies Pvt. Ltd, Pune; Dr. N. C. Pramanik,

CENTRE FOR MATERIALS FOR ELECTRONICS TECHNOLOGY (C-MET)

Website: www.cmet.gov.in

Headquarters
Panchawati, Off Pashan Road, Pune – 411 008
Tel: +91(20) 25898141, 25899273
Fax: +91(20) 25898180
Email: **rathnam@cmet.gov.in**

Pune Laboratory
Panchawati, Off Pashan Road, Pune – 411 008
Tel: +91(20) 25898390, 25899273
Fax: +91(20) 25898180
Email: **cmetp@cmet.gov.in**

Hyderabad Laboratory
IDA Phase III, Cherlapally, HCL (PO), Hyderabad – 500 051
Tel: +91(40) 27265673, 27262437, 27260327
Fax: +91(40) 27261658
Email: **cmeth@cmet.gov.in**

Thrissur Laboratory
MulangunnathKavu, Athani (PO), Thrissur- 680 581
Tel: +91(487) 2201156-59, 2201757
Fax: +91(487) 2201347
Email: **cmett@cmet.gov.in**