

ANNUAL PLAN

2019-2020

OF



**CENTRE FOR MATERIALS
FOR ELECTRONICS TECHNOLOGY
(C-MET)**

www.cmet.gov.in

Annual Plan 2019-20

STATUS OF THE PROJECT

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 laboratories located at Pune, Hyderabad and Thrissur. C-MET's mission is to develop knowledge base in electronics 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.

PROGRESS ACCOMPLISHED DURING 2017-2018

During the year 2017-2018, C-MET has implemented 32 sponsored projects and technical services in the following core programs viz.

- Integrated Electronics Packaging
- Nanomaterials, Thin & Thick films and Nano Composites
- Materials for Renewable Energy
- Ultra High Purity Materials and Compound Semiconductors
- E-Waste management
- NABL accredited RoHS facilities
- Microwave Dielectrics and Multilayer Ceramics
- Actuators and sensors
- Aerogel and Graphene based components / devices
- Plasmonic materials and devices

During the year, 16 projects were completed and 8 new projects were initiated and 17 projects ongoing. The characterization and allied services were extended to outside organization on chargeable basis, overheads and assorted income other sources generated revenue to the tune of nearly Rs. 250 lakhs.

SUMMARY OF UNITWISE TECHNICAL PROGRESS

i) Pune Laboratory

Developmental activities at C-MET, Pune consist of **Electronics Packaging, Nanomaterials/ Nano composites and Materials for Renewable Energy**. The salient features of the progress

made during the year 2017-18 are as follows:

a) Electronics Packaging

- Development of Ag and Ag-Pd pastes at pilot scale for screen printing and via filling, compatible with C-MET LTCC has been completed.
- Completed development of LTCC tapes for general purpose applications at pilot scale.
- Completed development of LC tank based and FP based LYCC pressure sensor for M/S Eaton Technology Pvt Ltd.
- Completed development of Mark 1.5 (intermediate samples) of magnetic sensors for BARC and submitted for testing. All samples are acceptable.

b) Nanomaterials/ Nano composites

- Nanostructured PdTe, PbTe and Bi₂Te₃ thermoelectric materials has been synthesized successfully. The Seebeck coefficient of these materials was measured at BARC, Mumbai. The Seebeck values at room temperature varied from 2.5 to -5 μ volt/Kelvin.
- Pt@C, Pt-Ni@C, Pt-Co@C and Pd-Ni@C nanocomposites have been developed as electrocatalyst. The prototype PEM fuel cell has been developed using Pt-Co@C electrocatalyst by NIT Warangal. The maximum power obtained is 188 W. Completion report writing is in progress.
- Nitrogen doped TiO₂ catalyst has been used efficiently for waste water purification. The completion report has been submitted to DST (INDO-UKRIE bilateral).
- The development of WO₃ nanostructured based NO_x sensor has been developed and completion report has been submitted to ISRO.
- The ferrite based low temperature and yttria based high temperature sensors for DRDO have been developed and completion report writing is in progress.
- Optical emission spectroscopy 200-1000 nm has been procured and installed.
- CuO and Fe nanopowder (100 nm) were synthesized under different reaction conditions.
- The thermoelectric cooler for automotive shock absorber oil cooling is in progress (with TATA motors).
- The Pt-Ni based catalytic convertor for automotive application is in progress (TATA motors).
- Manganese ferrite nanopowders have been synthesized using solvothermal, co-precipitation and spray drying methods. Structural and magnetic characterizations are in progress.
- Prepared silver powder (100 gm scale) for EMI shielding and solar cell applications and silver paste (10 gm scale) for solar cell applications and submitted to Modison Metals Limited, Mumbai for testing.

- Synthesized ZnO and TiO₂ nanopowders using solvothermal method by varying reaction parameters for dye sensitized solar cell (DSSC) applications and efficiencies up to 6 % have been obtained. Further efforts in efficiency improvement are in progress.

c) Materials for Renewable Energy and storage

- The synthesis process for N doped Ta₂O₅ and TiO₂ has been up scaled (10 gm) and optimized successfully. The H₂ production process from H₂O using these catalysts has been optimized. The application study shows promising results. The project is completed successfully and final report is submitted to DRDO
- Full coin cells (~60 Nos) and pouch cells (~30 Nos) using in-house developed and commercial active materials have been fabricated. Temperature dependent battery performance testing of the fabricated cells has been performed in collaboration with Bharat Electronics Limited (BEL), Pune. The project has been completed successfully. The power bank of 250 mAh using in house developed cells has been developed and demonstrated to GC.
- The mesoporous carbon has been synthesized using RF aerogel. The optimization of process parameters is in progress w. r. t. surface area is in progress report.
- Biomass based carbon as anode materials for Na-ion batteries has been developed and electrochemical studies is in progress.
- Cellulose based polymer electrolyte has been developed. The battery cell has been fabricated and demonstrated using in-house polymer electrolyte.

ii) Hyderabad Laboratory

Developmental activities at C-MET, Hyderabad consist of **Ultra Pure & Special Materials (Metals, Alloys and Refractory Materials), Compound Semiconductors, MEMS based acoustic sensors, flexible electronics, E-waste and RoHS compliance.** The salient features of the progress made during the year 2017-18 are as follows:

a) Ultra-Pure & Special Materials (Metals, Alloys and Refractory Materials)

- 4 Kg of high pure 7N grade cadmium with 60 mm dia ingots were prepared, tested at NRC, Canada and delivered to SSPL/DRDO as a part of project deliverables.
- Installation and commissioning of induction zone refining system completed successfully. Two zone refining experiments conducted for Ge.
- Total impurities level came down from 1540 ppb to 380 ppb
- Six Vacuum distillation experiments conducted, ~ 1Kg of high purity Zn prepared.
- Zone refinement experiment carried out. One cycle (15 passes) completed, second cycle is under progress.
- Prototype synthesis chamber for the preparation of GaN powder through fluxing approach was fabricated

- 20 Kgs of Hf sponge delivered to VSSC as a part of MoU and 2 Kg against monthly minimum charges for the month of April 2017.
- Order for 70 Kg Hafnium order received from VSSC and Rs. 66.55 lakhs (40% of the total order value) has also been received.
- Hafnium sponge supplied to VSSC is processed at MIDHANI by EB melting and found to be qualified for Atomic Energy Applications.

b) Compound Semiconductors

- 15 Nos. of 6H SiC single crystal bowls were grown under Design of Experiments for optimization of process parameters. Out of these 9 bowls were handed over to DMRL/SSPL for characterization.
- Targeted diameter, polytype and micropipe density have been achieved
- Resistivity is being optimized

c) E-Waste management

- 800 Sq.Mt. E-waste mechanical shed completed for processing of 100 Kg PCB /day
- 600 Kg of PCBs were processed; 120 kg copper prepared and collected 6 Kg Anode mud for further processing.
- Prototype leaching unit (30 L capacity) established for anode mud processing
- Augmented electrorefining facility from 100 Amp to 500 Amp for processing of 5 Kg copper per day
- Process equipment such as Depopulation system, Shredding system, cupellation system and fire assay system relocated to E-waste plant
- Prototype gas cleaning system suitable for 30 Kg PCB/ hour designed and fabricated for removing dioxins and furans from the flue gases.
- P.O released for TBRF

d) Re-Cycling of Rare-earth from waste CFLs

- 500 gms batch scale of acid leaching including second leaching using nitric acid experiments have been optimized for the recovery of mixed rare earths.
- Solvent extraction experiments carried out using DoDGAA solvent and ionic liquids for separating Yttrium and Europium.

e) NABL accredited facilities

- ~22.82 lakhs revenue generated from RoHS test facilities
- 1300 samples analyzed during the review period
- NABL accreditation has been renewed until June 26, 2020 for RoHS test facilities as per IEC 62321-2018

iii) Thrissur Laboratory

Developmental activities at C-MET, Thrissur consist of Microwave Dielectrics, Multilayer Ceramics, Actuators and Sensors, Nanomaterials & Thin films and Aerogel and graphene based supercapacitors. The salient features of the progress made during the year 2017-2018 are as follows:

a) Microwave Dielectrics & Packaging

- 150 Nos. of copper cladded microwave substrates having $\epsilon_r = 3.5$ and $\tan \delta = 0.0018$ were fabricated through SMECH process followed by vacuum lamination
- Gold finished microwave printed circuit boards suitable for the fabrication of 750 W solid state amplifiers were realized through photolithographic technique and ready for delivery to user agency viz. RRCAT, Indore
- Microwave substrates of augmented size: 200 x 200 mm have been prepared and sent to RF & Microwave Division, BARC for system level evaluation
- Prepared phase pure MD filler (CoZ type hexaferrite). Composite MD substrate and the antenna fabricated using the substrate showed miniaturization of 23% and bandwidth enhancement of 4%.
- Developed PMN-PT composition with high dielectric constant ($\sim 29,000$ at 1 kHz) for embedded capacitor applications.
- Prepared and sent ~ 8 Kgs of LTCC powder to C-MET, Pune for tape casting trials. LTCC tapes were casted on new mylar and sent to C-MET, Pune for evaluation.
- Developed Aluminium based internal electrode paste and confirmed the dielectric properties using Al paste.

b) Actuators and Sensors

- Developed thermal sensor based wearable device and an analysis system for the early detection and screening of breast cancer. ToT process was initiated. Obtained approval for ToT from 70th EC, 39th SC and 37th GC.
- Confirmed the formation of tabular SrTiO_3 particles from $\text{Sr}_4\text{Ti}_3\text{O}_7$ through Molten Salt Synthesis (MSS) for texturing of PMN-PT ceramics.

c) Aerogel, Graphene based Supercapacitors & other Energy materials

- Designed and fabricated indigenous machines for making Aerogel electrodes (AG-E) in spool forms and demonstrated the process for making Aerogel Electrodes of $W=10-25$ mm, $T=200-300$ μm , and $L= 10-100$ m per spool. AG-E thus made have been tested by Keltron Component Complex Ltd. (KCCL) and confirmed its suitability for use in high speed automatic capacitor manufacturing machines.
- Developed the indigenous process for fabrication of Aerogel Supercapacitor (AGSC) using AG-E thus produced at C-MET and fabricated Aerogel Supercapacitors/packs of diff sizes /

values in the range of **0.47F to 50F** (AGSC cells) and **250-350F** (AGSC packs). Also designed and fabricated several indigenous machines including dehumidified clean room for fabrication of Aerogel supercapacitors of different sizes/values.

- Also developed a new and versatile method of making aerogel carbon (AGC) by cost effective technique, which have been optimized and up-scaled to 2 kg/batch. Materials were characterized and evaluated their properties, which showed suitability for use as supercapacitor electrode applications. Also fabricated several numbers prototype Supercapacitor cells (cell capacitances, 5, 10, 15 & 25 F, as per target) using the AGC thus produced, and prototypes were tested at IIT-Bombay and making supercapacitor packs are in progress.
- Developed graphene supercapacitors having capacitance up to 70F. Developed and demonstrated supercapacitor banks using graphene supercapacitors.
- Transferred the technology of quickly rechargeable emergency lamp to a startup company M/s. Aessar at Thrissur in a function held at C-MET, Thrissur on 16.02.2018.
- Plasmonic Materials and Devices
- Developed optically transparent heater film on glass substrates for defrosting applications through a simple and cost effective process technology

RESEARCH PERFORMANCE INDICATORS DURING 2017-18

S.No	Activity	Total (actual)
1.	Research publications in peer-reviewed journals	40
2.	Conference presentations	39
3.	Invited talks	49
4.	Awards and Honors	09
5.	Patents awarded	02
6.	Patents Applied	07
7.	Fellowships/visits (Abroad)	02
8.	International/ National conferences organized	04
9.	Books / Book Chapters	00
10.	Technologies ready for transfer	05
11.	Technology transferred	02

LIKELY EXPENDITURE FOR 2018-19

S.No.	Head of Accounts	2018-19	
		Budgetary Estimates (Rs. in lakhs)	Revised Estimates (Rs. in lakhs)
1.	Grant-in-aid (Salaries)	1710.00	1710.00
2.	Grant-in-aid (Capital Assets)	1590.00	490.00
3.	Grant-in-aid (General/Revenue)	670.00	500.00
	TOTAL	3970.00	2700.00
	BUDGETARY SUPPORT	3970.00	2700.00

S.No.	Description	Targets for 2018-19 (Rs. in lakhs)
1.	IR	360.00
2.	EBR	2700.00
	Total	3060.00

PROJECTS PLANNED FOR 2019-2020

C-MET will continue its program on development of advanced electronic materials and technology through intra-inter laboratory research integration. Based on their importance and role in the future electronics technology vis-à-vis C-MET's capability to execute them and produce the desired end-results, it is proposed to implement programs viz.

1. Integrated Electronics Packaging.
2. Nanomaterials, Thick films and Nano Composites.
3. Materials for Renewable Energy and Sensors.
4. Ultra High Purity Materials and Compound Semiconductors.
5. E-Waste management.
6. NABL accredited RoHS facilities.
7. Microwave Dielectrics and Multilayer Ceramics
8. Actuators and sensors
9. Aerogel and Graphene based Supercapacitors
10. Plasmonic materials and devices

C-MET has prepared plan to execute the projects during 2019-2020 are given below.

C-MET, PUNE

It is proposed to initiate/continue the development work on:

- Development of materials and sensors including RFID for smart cities.
- Development of Ink jet printable conducting inks for flexible Electronics.
- LTCC Based Packaging including sensors, fuel cells etc.
- Nano-composite for gamma ray shielding.
- Development of visible light Active stable Photocatalyst for H₂O Splitting.
- Synthesis of high technology materials for Hydrogen Storage Applications.
- Aluminium Nitride (AlN) nanopowders for electronic applications.
- Development of Na-ion, Li-flexible batteries and Solar Cells.
- Development NMC cathode for ISRO.
- Process technology for Spent Lithium ion battery recycling
- Development of NPK optical sensors for agriculture applications
- Development of thermoelectric cooling materials and devices for agriculture applications.
- Thermoelectric micro-generator materials and devices for energy generation.
- Development of magnetic materials for Industry specific project applications.
- Development and processing of magnetic alloy materials for strategic applications.
- Development of materials for solar cells applications.
- Development of nanostructured materials by using spray pyrolysis, Transferred Arc Thermal Plasma Reactor (TAPR) for strategic sector.

C-MET, HYDERABAD

It is proposed to initiate/continue the developmental work on:

- Development of technology for recovery of Lithium from spent Li-ion batteries.
- Six inch Semi Insulating (SI) SiC Single Crystals Processing Technology
- Continuous Preparation of Hf sponge at pilot scale and fine-tuning of process parameters
- Development of Germanene for Terahertz applications
- Development of beta gallium oxide single crystals substrates for LED applications
- Development of Silicon carbide powder through CVD method for single crystal growth
- Development of polycrystalline silicon through metallurgical route
- Development of ZnTe single crystals
- Development of Fe-Al-Si flaky powders for microwave absorber applications
- Development of antennas for NaViC system
- Augmentation and setting up of 1 T/day E-waste processing facility with PSU

- Development of rare earth free permanent magnetic materials
- Development of HfO₂ doped gate oxide materials
- Edge defined Sapphire single crystal growth for LED applications
- Development of Carbide derived Carbon for Energy Storage Applications
- Development of MEMS bionic sensors

C-MET, THRISSUR

It is proposed to initiate/continue the developmental work on.

- Development of RF/Microwave absorber for high power solid state amplifier
- Composite Dielectric materials for High Power Radio frequency components
- Development of Supercapacitor based power module (SCPM) for application in EVM-VVPAT
- Development of Power packs with aerogel supercapacitors for power electronics
- ToT of Development of thermal sensor based monitoring system for the early detection and screening of breast cancer
- Automated production process for wireless thermography wearable device and multicentric clinical trials for early detection and mass screening of breast cancer.
- Technical Service: Supply of thermal sensors and calibration of sensors
- Development of Nano NTC composition based sub- millimeter sized thermal sensors for low temperature applications
- Development of Thermal Tomography for the Detection of breast cancer and to predict the Size and Location of the Cancerous Tissue
- High capacitance (50F to 200F) graphene supercapacitors for storage of power from Renewable energy sources
- Development of supercapacitor bank for electronic time fuse application
- Graphene Supercapacitor Modules for Long Life and High Power UPS/Solar Inverters
- Development of transparent conducting oxide based plasmonic materials and devices
- Development of ULTCC materials for multilayer circuits
- Development of LTCC materials and tape for electronic packaging
- Aluminium internal electrode based ULTCC material for electronic packaging
- Development of TCO based plasmonic biosensors
- Development of ultrasound probe for medical imaging
- development and supply of piezo-micro actuator
- Development of Lithium ion capacitor using graphite/carbon aerogel

**Budget Estimates, Budget sanctioned & Actual Expenditure for 2017-18,
Budget & Revised Estimates for 2018-19 and Proposed Estimates for 2019-20**

(Rs. in lakhs)									
S. No.	Head of Accounts	2017-18			2018- 2019				2019-2020
		Budget Estimates	Budget sanctioned	Actual Expenditure (From 1.4.2017 to 31.03.2018)	Budget Estimates	BE approved by MeitY	Actual Expenditure (1.4.2018 to 30.06.2018)	RE 2018-19 by C-MET	Proposed Estimates
1.	Grant-in-aid (Salaries)	1260.00	1600.00	1446.17	1710.00	1500.00	342.66	1710.00	2010.00
2.	Grant-in-aid (Capital Assets)	1710.00	350.00	155.68	1590.00	500.00	01.11	490.00	1740.00
3.	Grant-in-aid (General/ Revenue)	580.00	450.00	342.34	670.00	0.00	105.06	500.00	700.00
	Total	3550.00	1400.00	1944.19	3970.00	2000.00	448.83	2700.00	4450.00
	BUDGETARY SUPPORT	3550.00	1400.00		3970.00	2000.00	448.83	2700.00	4450.00

(Rs. in lakhs)						
S No.	Description	Targets for				
		2017-2018		2018-2019		2019-2020
		Target	Actual (From 1.4.2017 to 31.03.2018)	Target	Actual (From 1.4.2018 to 30.06.2018)	
1.	IR	300.00	251.82	360.00	103.14	425.00
2.	EBR	2400.00	629.62	2700.00	165.93	2700.00
	Total	2700.00	881.44	3060.00	269.07	3100.00
