Curriculum Vitae

SUBHASISH BASU MAJUMDER, Ph.D.

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Cell: +91 9433611775 **Date of Birth : April 21, 1966**

PROFESSOR

He is a B. Tech in Ceramic Engineering and Master and Ph.D in Materials Science. Seasoned researcher with **25** years of electro-ceramic materials research experience in the USA, Germany and India. Demonstrated the ability to build state of the art experimental lab from scratch. Translated various lab based research to patented technologies and built relevant prototypes for probable technology transfer. To trigger innovative material research ideas in young minds, judiciously integrate relevant research demonstrations while teaching various graduate level courses on materials science and engineering. Designed two NPTEL (National Program on Technology Enhanced Learning) courses namely Non – Metallic Materials, and Electrochemical Energy Storage. Till date, **21** Ph.Ds. and **32** MTechs, graduated from his laboratories, are all well placed in various academic institutes and industries both in India and abroad. He has scientific presence with **203** peer-reviewed journal, **35** reviewed publications in various conference proceedings, and **100+** presentations (**31** invited) in scientific forums. Areas of his present research includes Li/Na ion rechargeable batteries, supercapacitor – battery hybrid electrodes for Li ion batteries, Li – S battery, chemi-resistive gas sensors, fly – ash based ceramics, engineered cementitious composites, and fiber reinforced concretes. Completed several research and consultancy projects including several National Mission Projects (IMPRINT, NNetRA, INUP i2i, UAY) of Government of India. Collaborate with broad spectrum of researchers in major universities in India, USA, Germany, Taiwan, and Australia. Editorial board member of Scientific Reports – Nature and Journal of Physics D: Applied Physics. He is a fellow of the West Bengal Academy of Science and Technology and received several National and International accolades including but not limited to prestigious Materials Research Society of India (MRSI) medal, Fulbright – Kalam Climate Fellow of Academic and Professional Excellence, Alexander von Humboldt Research Fellowship for experienced researchers etc. Excellent communication and interpersonal skills with fluency in English, Hindi and Bengali.

PROFESSIONAL APPOINTMENTS

KANSAS STATE UNIVERSITY August 28 2022 – May 28 2023
Manhattan, KS, United States
Visiting Professor
(Fulbright Kalam Academic and Professional Excellence)

INDIAN INSTITUTE of TECHNOLOGY May 2015-present
Kharagpur, India
Professor

INDIAN INSTITUTE of TECHNOLOGY June 2010-April 2015
Kharagpur, India
Associate Professor

INDIAN INSTITUTE of TECHNOLOGY January 2006-May 2010
Kharagpur, India
Assistant Professor

RWTH AACHEN UNIVERSITY OF TECHNOLOGY, May 2005-December 2005
Aachen, Germany

Humboldt renewed research fellowship14th May – 10th Aug. 2007
Humboldt renewed research fellowship15th May – 15th July. 2011
Humboldt renewed research fellowship1st May – 31st July. 2016

Humboldt Research Fellow

UNIVERSITY OF PUERTO RICO, San Juan, Puerto Rico 1998 - 2005
Asst. Professor (non tenured) (August 2002 – April 2005)
Post Doctoral Fellow (April 1998 – July 2002)

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, New Delhi, India 1996 - 1998
Senior Research Associate

- Earned *CSIR Research Associate* award from Government of India.

RECENT RESEARCH ACTIVITIES

RECHARGEABLE LITHIUM AND SODIUM ION BATTERIES*

- **Electrode material synthesis and upscaling** – Upscaling of auto – combustion, soft solution synthesised powders, and fundamental understanding on the structure property relationship of several Li ion battery cathodes [viz. $LiMn_2O_4$, $LiMn_{1.5}Ni_{0.5}O_4$, $Li(Ni_{0.8}Co_{0.15}Al_{0.05})$, $LiFePO_4$ and lithium manganese rich (LMR) $xLi_2MnO_3–(1−x)Li(Mn_{0.375}Ni_{0.375}Co_{0.25})O_2$ $(0.0 \leq x \leq 1.0)$], and anodes, including but not limited to, $Li_4Ti_5O_{12}$, $NiTiO_3$, $ZnFe_2O_4$ – carbonaceous composites, $NiFe_2O_4$, SnSnSb sandwiched between N-rGO sheet etc. Na ion battery cathode [viz. $Na_3V_2(PO_4)_3$, $Na_2VTi\ (PO_4)_3$] and anode such as $NiSb_2O_6$ and $Na_2Ti_3O_7$. Recent activities include battery supercapacitor (BATCAP) hybrid positive electrodes especially the use of polyanionic $Na_3V_2(PO_4)_3$ and its modified counterparts for Li ion intercalation.
- **Material characterization** – X-ray diffraction and Rietveld refinement, thermal analyses (TGA, DTA/DSC), FTIR and microRaman spectroscopy, X-ray photoelectron spectroscopy, BET, scanning and transmission electron microscopy etc
- **Cell fabrication and characterization** – Developed or augmented 2032 type coin cell and 18650 cylindrical cell fabrication facilities. Undertaken electrochemical characterizations including cyclic voltammetry, charge-discharge, differential capacity analyses, cycleability, rate performance, PITT, GITT analyses, and elecetrochemical impedance spectroscopy (EIS) analyses. Electrochemical characteristics of cyclindrical cells in a wide temperature range -10°C to + 180°C. Safety testing of the oprimized cylindrical cells (nail penetration, impact and crush test)
- **Development of Li ion battery prototype** – As IMPRINT mission project of the Government of India, laboratory development of 28V 16 Ah Li ion battery prototype for underwater applications. The battery module, battery management system (BMS) and water sealed battery pack was designed and fabricated in collaboration with colleagues from Electrical and Mechanical Engineering departments at IIT Kharagpur.
- **Development of Li – S rechargeable cells** – Facile synthesis of composite S cathode to simultaneously arrest polysulfide (PS) dissolution, buffer volumetric strain during lithiation and de-lithiation of S, improve electronic as well as Li^+ ion conductivity in composite cathode. Use of electrocatalyst to expedite the long-chain PS to short chain PS liquid to solid phase transition.

* See my complete publication list. Publications of interest are available on request

OXIDE (Chemi-resistive) GAS SENSOR*

- **Sensor material synthesis** - Synthesis of nanostructured ceramic oxides (binary oxide, hetero-structures, spinel, perovskite type etc) by self patterning and template growth technique to improve the sensitivity and selectivity of toxic gases.
- **Modeling of sensor characteristics -** Modeling of resistance transients, concentration and operating temperature dependent sensor response, understanding on reversible and irreversible sensing characteristics. Understanding on the selectivity of resistive gas sensor.

- **Development of MEMs microheater and Taguchi based sensing elements** – MEMs microheater based thin film sensors are under development. Selective VOC, CO, NH_3, NO_x, and H_2 Taguchi sensors are developed in his laboratory.
- **Development of Air Quality Monitoring (AQM) Prototype** – As NNetRA mission project of Government of India development of portable AQM system for VOC, NH_3, CO, NO_2, PM (2.5µm and 10µm), ambient humidity and temperature sensing. The system is equipped with rechargeable power source, electronic module for, system control, data acquisition, display, local and cloud storage.

* See my complete patent and publication list. Publications of interest are available on request.

NATURAL AND MAN MADE FIBER REINFORCED CEMENT MORTAR AND CONCRETE*

- The influence of addition of fibrillated and monofilament polypropylene fibers to a cementitious composite mix on the tensile strength, flexural strength and ductility characteristics of the sample.
- Use of chemically modified chopped jute fiber as secondary reinforcement to grossly improve the bending strength of prestressed concrete.
- Substantial improvement of the physical and mechanical properties of cement mortar mix (mix design :: cement:sand:fibre:water::1:3:0.01:0.6.) using polymer modified alkali treated jute fibre as a reinforcing agent.
- Formulation of concrete mix using chemically – modified jute fibre (reinforcing agent), polymer latex (surface modifier both for fiber and matrix) and tannin (water reducing admixture) to grossly improve the load bearing capacity of underground sewage pipe.
- A dry process route was developed to make wear resistant fly-ash based glazed ceramic wall tile. In collaboration with IMMT Bhubaneswar, the technology is translated to make a fly-ash based glazed ceramic tile pilot plant at NALCO, Bhubaneswar, India.

* See my complete patent and publication list. Publications of interest are available on request.

MULTI-FERROIC THIN FILMS and COMPOSITES*

- Solution synthesis of perovskite multiferroic thin films, crystal chemistry modification of thin film electrical properties through isovalent/aliovalent cation doping.
- Synthesis of nano-crystalline ferrite and ferroelectric powders by reverse micelle technique.
- Synthesis of novel flexible magnetoelectric composites

*See my complete publication list. Publications of interest are available on request.

RESEARCH EXPERIENCE

INFRASTRUCTURE DEVELOPMENT (For details see Annexure – I)

- Dynamic and static flow semi-automated gas sensing measurement set up and automated custom built gas sensor calibration system
- Li and Na ion rechargeable cell fabrication and characterization facilities
- Augmentation of Li and Na ion rechargeable 18650 cell fabrication and characterization facilities
- Wet chemical synthesis of thin films (for Li ion rechargeable cell, ferroelectric multiferroic composite etc) and their electrical characterization facilities
- Fabrication and characterization facilities of natural/artificial fiber reinforced cementitious composite
- Fly-ash based wear resistant ceramic tile fabrication facility

MATERIAL SYNTHESIS*

- Auto – combustion, microwave assisted hydrothermal, wet chemical synthesis, sol – gel and solid state synthesis of a wide variety of Li ion and Na ion rechargeable cell electrode materials. Nano-crystalline S, host materials and water soluble binder for Li – S rechargeable cell.
- Soft solution processing of a wide variety of nano-structured (nano- tube, hollow sphere, porous sphere etc) oxide gas sensing materials. Synthesis of carbonaceous materials.

- Grew wide variety of nano-structured thin films and powders for magnetoelectric/ Multiferroic (eg. CFO/PZT, PFN) NVRAM (e.g. PZT), DRAM (e.g. BST), tunable dielectric devices (BST), and pyroelectric (PLT) applications.
- Synthesized conducting oxides (RuO_2, $SrRuO_3$, doped ZnO), epitaxial/highly textured films by sol-gel technique.
  * For details of synthesized materials see my list of publications

CHARACTERIZATION

Thermal analysis (DTA, DSC, TGA), XRD (Rietveld refinement), SEM/AFM, TEM, micro-Raman spectroscopy, XPS, Rutherford backscattering, ferroelectric and dielectric properties (hysteresis, CV loop, dielectric dispersion etc), leakage current measurements (I-V and time dependent dielectric breakdown), ferroelectric fatigue and imprint characteristics, pyroelectric properties, UV-VIS spectrometry, cyclic voltammetry, charge-discharge measurements, rate performance and cycleability. PITT and GITT analyses, Electrochemical impedance spectroscopy (EIS) measurement and analyses.

DEVELOPMENT OF FUNCTIONAL PROTOTYPE (For details see Annexure – II)

- Dry route based technology to fabricate wear resistant glazed ceramic wall tiles using NALCO coal ash (Indian Patent No. 287533)
- Jute fiber reinforced cement concrete composites (Indian Patent No. 381157)
- Economic air quality monitoring prototype (Indian Patent No. 352616)
- Development of 28V 16 Ah Li ion rechargeable battery module for underwater application

TEACHING EXPERIENCE

INDIAN INSTITUTE of TECHNOLOGY, Kharagpur, India 2006 -

- MS 31005 Ceramic Fabrication and Processing
- MS 31007 Ceramics for Structural Applications
- MS 61003 Science and Technology of Ceramics
- MS 60058 Technology of Ceramics for Electronic Applications
- MS 60002 Techniques of Materials Characterization -I
- MS 69005 Laboratory
- MS 69004 Advanced Laboratory
- MS 69001 Seminar
- MS 60009 Fundamentals of Electronic Materials

NPTEL COURSE OFFERED 2020 – 2022

National Programme on Technology Enhanced Learning (NPTEL), is a joint venture of the IITs and IISc, funded by the Ministry of Education (MoE) Government of India, and was launched in 2003. Initially started as a project to take quality education to all corners of the country, NPTEL now offers close to 600+ courses for certification every semester in about 22 disciplines.

- Non – metallic materials (https://archive.nptel.ac.in/courses/113/105/113105099/)
- Electrochemical energy storage (https://archive.nptel.ac.in/courses/113/105/113105102/)

UNIVERSITY OF PUERTO RICO, San Juan, Puerto Rico 1998 - 2005

Instructor / Graduate Student Supervisor

- Taught Physics 8992 Science and Engineering of Materials, Parts I & II.
- Designed experiments and trained students to handle instruments, perform measurements, analyze data and write research papers.

AWARDS AND EDUCATION

Awards

- FULBRIGHT – KALAM CLIMATE FELLOWSHIP FOR ACADEMIC AND PROFESSIONAL EXCELLENCE (2022)
- FELLOW, WEST BENGAL ACADEMY OF SCIENCE AND TECHNOLOGY (2017)
- MRSI MEDAL (awarded by Materials Research Society of India) (2010)
- ALEXANDER VON HUMBOLDT RESEARCH FELLOWSHIP FOR EXPERIENCED RESEARCHERS (2004) (Alexander von Humboldt Research Foundation, Bonn, Germany)

Education

INDIAN INSTITUTE OF TECHNOLOGY, Kanpur, India

- ***Ph.D. in Materials Science,*** 1997
- ***Master of Technology in Materials Science,*** 1990
  ~ Indian Institute of Technology Fellowship, 1988 - 1996.
  ~ CSIR Research Associate Fellowship, 1996 - 1997

COLLEGE OF CERAMIC TECHNOLOGY (now Government College of Engineering and Ceramic Technology) UNIVERSITY OF CALCUTTA, Kolkata, India

- ***Bachelor of Technology in Ceramic Technology,*** 1988
  ~ National Scholarship from Government of India, 1982 - 1988

OUTREACH

- Mentor and subject expert in the area of Energy Materials for the open innovation event 'MaterialNext' organized by Tata Steel Limted during the period January– April 2023.
- Honorary member of Board of Studies at the Department of Ceramic Technology in The Government College of Engineering and Ceramic Technology, Kolkata.
- External experts in CSIR Assessment Committee constituted in the area of Material Science & Technology.
- Expert committee member for development and application of Li-ion battery technology at NSTL (DRDO), Vizag
- Member of the Board of Post Graduate Studies (BPGS) of the Department of Materials Science and Engineering, Tripura University
- Editorial Board Member: Journal of Physics D: Applied Physics: IOP
- Editorial Board Member: Scientific Reports, Published by: Nature Publishing Groups
- Ex - Editorial Board Member: ISRN Materials Science, Published by: International Scholarly Research Network
- Ex- Editorial Board Member: Transaction of the Indian Ceramic Society, Published by: The Indian Ceramic Society
- Renewed Research Stay at Rheinisch Westfalische Technische Hochschule Aachen, Institut fur Werkstoffe und Elektrotechnik II, Electrokeramische Materialien 52074 Aachen, May 1-July 31 2016: Sponsored by Alexander von Humboldt Foundation, Germany.
- Renewed Research Stay at Rheinisch Westfalische Technische Hochschule Aachen, Institut fur Werkstoffe und Elektrotechnik II, Electrokeramische Materialien 52074 Aachen, May 1-June 30 2011: Sponsored by Alexander von Humboldt Foundation, Germany.
- Session Chair: 6th International Symposium on Integrated Functionalities (ISIF), 2017 held at Shangri - La's Eros Hotel, New Delhi December 10-13, 2017.
- Session Chair: "Lithium Ion Batteries - Cathodes I" in the B1 Energy Technology/Battery - Joint General Session Symposium held at the 223rd Electrochemical Society (ECS) Meeting in Toronto, Canada, during May 12 – 17, 2013.

PROFESSIONAL AFFILIATIONS

- Indian Ceramic Society, Life Member
- Materials Research Society of India, Life Member
- Indian National Science Congress, Life Member

PHD THESIS SUPERVISED

21 Completed **6** ongoing **(**See **Annexure – III** for complete list**)**

M.TECH THESIS SUPERVISED

32 Completed **3** ongoing **(**See **Annexure – III** for complete list**)**

SELECTIVE RECENT PUBLICATIONS (2021-2022)

See Annexure – IV for complete peer reviewed publications and conference presentation list (1991 -)

Also see the following links for citation report

https://scholar.google.co.in/citations?user=TT2ILuAAAAAJ&hl=en (Citation 7179, h index 47)
https://www.webofscience.com/wos/author/record/1970718,25166347,25372154,25812322
https://www.scopus.com/authid/detail.uri?authorId=57210240036

1. The generalized solubility limit approach for vanadium-based cathode materials for lithium-ion batteries, A. Mitra, A. Gilankar, S. Das, S. Jena, D. Das, S.B. Majumder, S. Das, **Journal of Materials Chemistry A**, (2022).
2. High-Performance and Safe Hybrid Li-Ion Batteries Based on $Li_4Ti_5O_{12}$ – TiO_2(A) – TiO_2 (R)@C Anode and $Na_3V_2O_2(PO_4)_2F$–$Na_3V_2(PO_4)_3$@C Cathode, M. Akhtar, T. Majumder, J. K. Chang, S.B. Majumder, **ACS Sustainable Chemistry & Engineering** 10, 4, 1390-1397 (2022).
3. High-Power and Long-Life $Na_3V_2O_2(PO_4)_2F$–$Na_3V_2(PO_4)_3$@C/AC Bimaterial Electrodes for Hybrid Battery–Capacitor Energy Storage Devices, M. Akhtar, A. Mitra, J. K. Chang, S.B. Majumder, **ACS Applied Energy Materials** 5, 4, 4070-4084 (2022).
4. Hierarchical Carbon Composites for High-Energy/Power-Density and High-Reliability Supercapacitors with Low Aging Rate, C.C. Chen, N. Kirana, D.F. Puspita, J. Patra, C.T. Hsieh, Y.A. Gandomi, H.Z. Lai, T.L. Chang, C.J. Tseng, S.B. Majumder, C.Y. Wang, J.K. Chang, **ChemSusChem**, e202200345 (2022).
5. Sensitive and selective CO_2 gas sensor based on CuO/ZnO bilayer thin film architecture, T. Bhowmick, A. Ghosh, S. Nag and S.B. Majumder, **Journal of Alloys and Compounds**, 903, 163871 (2022)
6. Effect of Nickel Doping on the Electrochemical Performances of Carbon-Coated $Na_3V_2(PO_4)_3$ Cathodes for Hybrid Lithium-Ion Batteries, M. Akhtar, S.B. Majumder, **ACS Applied Energy Materials** 4, 12, 13538-13549 (2021).
7. Understanding on the effect of morphology towards the hydrogen and carbon monoxide sensing characteristics of tin oxide sensing elements, V. Ambardekar, T. Bhowmick, P.P. Bandyopadhyay, S.B. Majumder, **International Journal of Hydrogen Energy 46**, 23113 (2021).

8. Plasma sprayed CuO coatings for gas sensing and catalytic conversion applications, V. Ambardekar, S. Sahoo, D. K. Srivastava, S.B. Majumder, P.P. Bandyopadhyay, **Sensors and Actuators B: Chemical**, 331, 129404 (2021).
9. Cetrimonium bromide assisted formation of antimony alloy nanorods for use as an anode in lithium-ion and sodium-ion full-cells, S. Jena, A. Mitra, S. Das, D. Das, K. Das, S.B. Majumder, S. Das, **Applied Surface Science**, 542, 148756 (2021).
10. High-Li^+-fraction ether-side-chain pyrrolidinium–asymmetric imide ionic liquid electrolyte for high-energy-density Si//Ni-rich layered oxide Li-ion batteries, U. Bharath, P.C. Rath, J. Patra, R.F.H. Hernandha, S.B. Majumder, X. Gao, D. Bresser, **Chemical Engineering Journal** 430, 132693 (2021).

EXTRAMURAL RESEARCH GRANT ONGOING/COMPLETED (2007-2022)

See **Annexure – V** for the list of projects awarded. **7** projects are ongoing and **26** are completed.

LIST OF PATENT GRANTED/FILED

1. A low cost, portable and drift corrected semi-conducting metal oxide gas sensor device and process for domestic for domestic and industrial applications, **S.B. Majumder** and Arnab Maity (Reference 500/KOL/2013), **Patent No. 352616**
2. Process for chemically modified jute fiber reinforced high performance cement sheet, B. Adhikari, **S.B. Majumder**, Sumit Chakraborty, Sarada Prasad Kundu (Reference 68/Kol/2013)
3. A process for the production of wear resistant tiles from low carbon fly ash , B. Adhikari and **S.B. Majumder** (Reference- 253/KOL/2012), **Patent No. 287533**
4. Chemically modified jute fiber reinforced high strength concrete and process thereof, **S.B. Majumder**, B. Adhikari (Reference 425/KOL/2011 PBB 1185), **Patent No. 381157**
5. Casting of concrete pipe reinforced with chemically modified jute fiber and method of casting such fiber reinforced concrete pipe, **S.B. Majumder**, B. Adhikari (Reference 426/KOL/2011 PBB 1186)

INTRA AND INTER INSTITUTIONAL COLLABORATION

1. Materials and Metallurgical Engineering, IIT Kharagpur (Joint project and publication)
2. Mechanical Engineering, IIT Kharagpur (Joint Ph.D guidance)
3. IIT Kanpur (Joint project and publication)
4. CSIR - CG&CRI, Kolkata (Joint Ph.D guidance)
5. CSIR – NEERI, Nagpur (Joint publication)
6. CSIR – IMMT, Bhubaneswar (Joint project)
7. IISc Bangalore (Joint project)

ABROAD COLLABORATION

1. NCU and ITRI, Taiwan (Joint Project)
2. RWTH, Aachen, Germany (AvH research work and DAAD Sandwich Program)
3. University of Capetown , South Africa (Joint project)
4. Helmholtz Institute Ulm and Karlsruhe Institute of Technology (DAAD Sandwich Program)

VISIT TO ABROAD

1. Visit as Fulbright – Kalam Climate Fellow of Academic and Professional Excellence, Department of Industrial and Manufacturing Systems Engineering,Kansas State University; Manhattan, KS 66506, 28th August 2022 to 28th May (2023).
2. Visit as visiting scientist to RWTH, IWE-II, Aachen, Germany, May 1 to July 31, (2016)
3. Visit to Industrial Training Research Institute, Hsinchu, and National Central University, Taiwan (as Co-PI of our collaborative project) to carry out project work and discussion, 1st December to 31st December (2013)
4. Visit to Center of Materials Engineering and iThemba Labs (Laboratory for Accelerator based Science), University of Cape Town, South Africa, as PI of IBSA-DST collaborative project, 1st March to 7th March (2012)
5. Visit to attend and deliver talks in the Nature Conference: Frontier in Electronic Materials at Aachen, Germany, June 16 to June 22, (2012)
6. Visit as visiting scientist to RWTH, IWE-II, Aachen, Germany, May 15 to July 15, (2011)
7. Visit to National Central University, Taiwan to attend and deliver seminar talk at "Taiwan-India Bilateral Workshop on Energy Storage Devices", November 28 to 30 (2010)
8. Visit as visiting scientist to the University of Puerto Rico, San Juan, USA, June 9 to July 4, (2008)
9. Visit as visiting scientist to RWTH, IWE-II, Aachen, Germany, May 9 to August 10, (2007)

RESEARCH IN NEWS

Research on fiber reinforced concrete is covered in several printed media (see attached Research Coverage on concrete).

1. Our jute reinforced cementitious composite work has been highlighted in **ACS News Service Weekly PressPac** dated January 16, 2013.
2. The work on jute fiber reinforced cement has been featured in the article "**Matrix reloaded**" in the magazine "Down to Earth", Feb 28, 2013
3. The research work on jute reinforced cementitious composite is also featured in an article titled "**The jute way**" in the magazine Construction World on November 2013

Annexure – I

Infrastructure development*

1. Dynamic and static flow semi-automated gas sensing measurement set up and automated custom built gas sensor calibration system

*Agencies sponsored these developments (logos shown in left margin) are gratefully acknowledged

Objective: Gas sensing research is important for air quality monitoring in automotive cabin, toxic gas detection in industrial ambient (eg. steel and mining industries), health care (eg. diabetics), monitoring auto-gas exhaust etc. We have developed dynamic and static flow gas sensing measurement set up to investigate the sensing characteristics (response%, response/recovery time, sensitivity, stability, and selectivity) of a wide variety of ceramic oxide gas sensors in the form of nano-powder, nano-tube, thin film and bulk ceramic configurations (Not shown here).

User: The gas sensing facilities are not only used for our research, but also it serves several other users both in our Institute as well as researchers from other Institutions. Our user list consist researcher from Metallurgical and Materials Engg., Department of Physics and Meteorology, Department of Mechanical Engg. Chemistry, and Materials Science Centre of IIT Kgp. Researchers from IIT Kanpur (Chemical Engg. and Mechanical Engg.) also collaborate with us in gas sensing research.

Deliverables: We synthesize a wide variety of nano-structured binary oxide, spinel and perovskite ceramics and demonstrated that nano-structuring immensely improve gas sensing characteristics. Using electrophoretic deposition, we have also fabricated Taguchi – type gas sensing elements in our laboratory (See Fig.1). In a custom-built sensor calibration system (see Fig. 1), we can directly plug – in the Taguchi (and also MEMs microheater based) sensing elements and calibrate the sensor response at fixed known gas concentration with variable operating temperature, or at a fixed temperature with variable gas concentration of a known gas. The system is also equipped with the capability of making gas mixture with known gas concentration and humidity. The developed sensor can also be calibrated in such mixed gas environment. The gas calibration system is computer controlled and the resistance transient data can be stored for further analyses.

Glimpses of the facilities custom built by Excel Instrument, Pune, India

The developed selective NO_2 Taguchi sensor is shown in the left panel of Fig.1. The sensing element can directly be plugged into the measurement chamber (middle panel of Fig.1). The gas distribution line is equipped with mass flow controllers. By controlling the test and carrier gas flow rates, the gas concentration is precisely controlled in the test chamber. The sensor heater temperature can also be precisely measured. For mixed gas calibration, up to 4 gases can be mixed and flow to the chamber. Humidity inside the chamber can also be controlled.

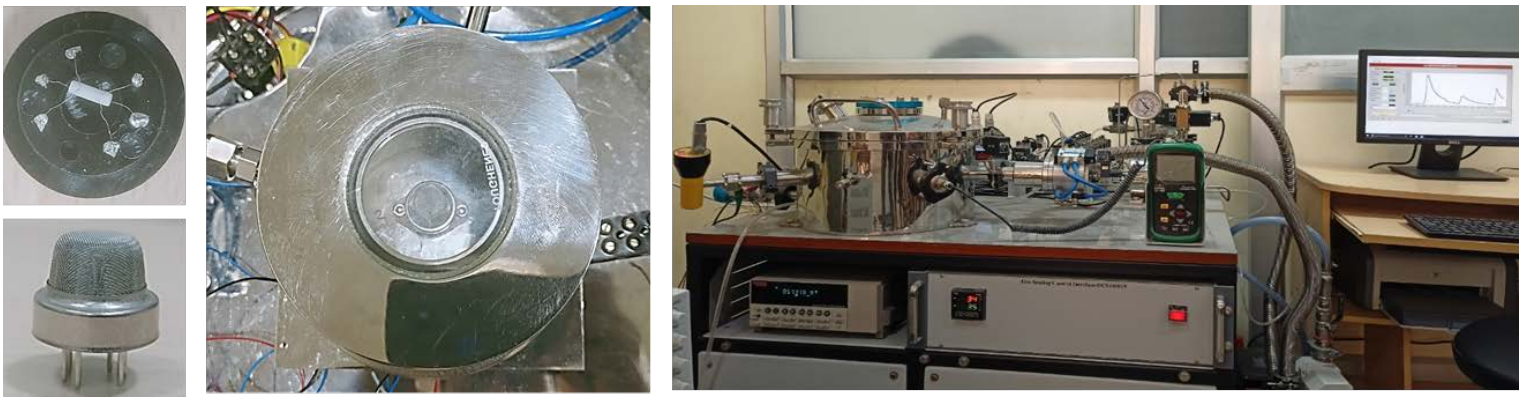


Figure 1 Left panel : Fabricated Taguchi sensors, middle panel: sensor fitted in calibration chamber, right panel: dynamic flow gas calibration unit

2. Li and Na ion rechargeable cell fabrication and characterization facilities

Objective: Lithium-ion rechargeable batteries are one of the most attractive candidates to power portable electronics, electric vehicles and storage for non-renewable as well as renewable energy sources. Our group also works on Na ion rechargeable cells useful for the storage of renewable energies. We have developed facilities to synthesize high energy as well as high power density electrode materials (anode and cathode) for Li and Na ion rechargeable cells. Facilities are also developed to characterize these coin cells in terms of their charge-discharge, cycleability, rate capability and electrochemical impedance spectroscopy (EIS) characteristics. Our laboratory is also equipped with thermal and safety testing equipment for rechargeable cells.

User: Apart from our uses the Li ion rechargeable coin cell fabrication facilities are also regularly used by researchers from the Materials Science Center, Metallurgical and Materials Engg., Physics and Chemistry departments of IIT Kgp. We also collaborate with researchers from IIT Kanpur (Chemical Engg. department), IISc Bangalore, IMMT Bhubaneswar etc. to characterize novel nano-structured electrode materials for Li and Na ion cells.

Deliverable: We have developed high energy density $LiMn_2O_3$-$LiMO_2$ (M = Ni, Co, Mn) composite and $LiNi_{0.5}Mn_{1.5}O_4$ based novel cathode materials and demonstrated their superior electrochemical characteristics in coin cell configuration. As a part of DST-Taiwan collaborative project the electrochemical characteristics of these materials have also been cross checked at one of the leading National laboratories in Taiwan (ITRI) in pouch cell configuration. We have successfully completed IMPRINT project to develop a 28V 16 Ah battery module of underwater application. In recent time we have developed several electrode materials for Na ion rechargeable cells. Also, we have initiated research on Li – S rechargeable cells in coin cell fabrication.

Glimpses of the facilities developed: Left panel (up) is the microwave assisted hydrothermal unit to synthesize nano-structured electrode materials. Left panel bottom is the vacuum mixer used to make electrode ink. Middle panel shows the glove box equipped with disc cutter, crimping tool etc. Right panel up shows the ambient control furnace to calcine the electrode materials. Right panel bottom shows the 16 channel battery channel analyzers.

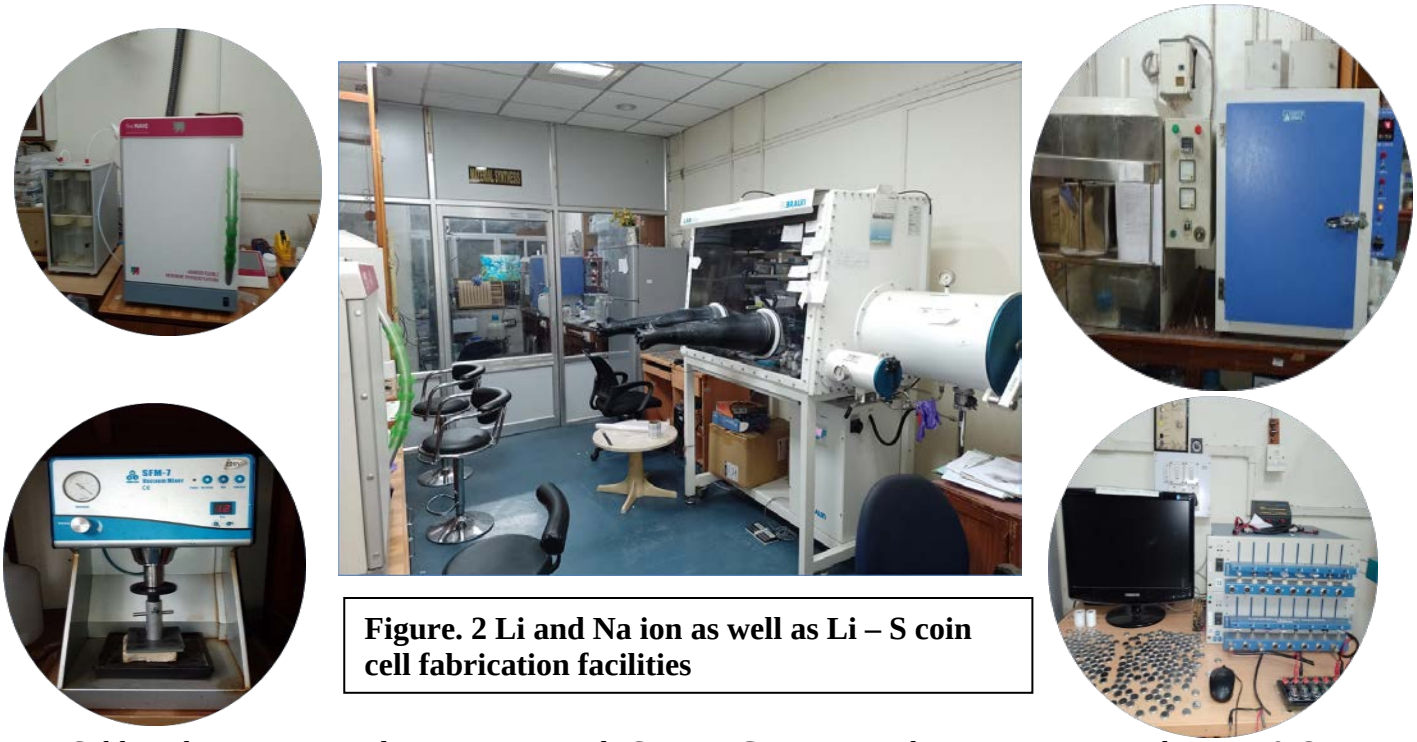


Figure. 2 Li and Na ion as well as Li – S coin cell fabrication facilities

3. Augmentation of Li and Na ion rechargeable 18650 cell fabrication and characterization facilities

Fabricating and testing coin cells we optimize the electrochemical performance of the synthesized electrode materials for Li and Na ion rechargeable cells. The optimized electrode materials are upscaled using auto-combustion synthesis. Roll to roll tape casting unit is used to coat Al (positive) and Cu (negative) current collector with respective electrode materials both sides. Figure 3(a) shows the slitting machine to properly cut the dried electrode in accordance to the Ah requirement of 18650 cells. Figure 3(b) shows the semi-automatic winding machine. After grooving and tab welding, electrolyte is filled in the cells and finally cells are crimped using an automatic crimping tool. Our battery testing lab is shown in Figure 3(c). It is equipped with 9V 15 A 8 channel battery analyzer. Each channel is equipped with EIS facilities. Apart from that we have two other 8 channel battery analyzer. The electrochemical characteristics of the fabricated cells can be measured in a wide temperature range (-10^{o}C - + 180^{o}C). In addition, we also have a battery safety testing unit for nail penetration, crush and impact testing. Either we procured these equipment through private or Government funding of various National Mission Projects.

Figure 3 (a) The slitting machine

Figure 3(b) The semi-automatic winding machine

Figure 3 (c) Battery testing laboratory

4. Wet chemical synthesis of thin films (for Li ion rechargeable cell, ferroelectric multiferroic composite etc) and their electrical characterization facilities

Objective: We have developed chemical solution deposition (CSD) facilities to synthesize electro-ceramic thin film in our laboratory. These films were synthesized for electrodes of Li ion thin film micro-batteries, toxic gas sensing application. In addition we have also synthesized dielectric, ferroelectric and multiferroic thin films for various micro-electronic devices. A wide array or characterization facilities are developed to characterize these films in terms of their electrical properties. This includes but not limited to leakage current and resistivity measurements, dielectric breakdown, frequency dispersion of capacitance and lost tangent, impedance spectroscopy, polarization hysteresis, fatigue, retention, and pulse hysteresis measurement characteristics.

User: Apart from our own use, the developed facilities are also used by other faculty members at the Materials Science Center

Deliverable: We have developed (Pb,La)TiO_3- $CoFe_2O_4$ multiferroic composite thin films. These films exhibit excellent magneto-electric coupling coefficient. Also, we have synthesized $LiMn_2O_3$-$LiMO_2$ (M = Ni, Co, Mn) composite thin films which proved to be excellent cathode for Li ion rechargeable micro-batteries. Moreover, we have also synthesized WO_3 and indium doped ZnO thin films for excellent NO_2 and reducing gas sensing characteristics.

Glimpses of the facilities developed

The photograph of the instruments for electrical measurements and the temperature controlled probe station are shown below.

Figure 4 *left panel* shows I – V, and impedance spectroscopy measurement facilities. Right panel shows probe station for the measurement of dielectric and ferroelectric characteristics of thin films

5. Fabrication and characterization facilities of natural/artificial fiber reinforced cementitious composite

National Jute Board

Objective: Cementitious composites (mortar, concrete etc), reinforced by natural or man-made fiber (viz. jute or polypropylene (PP)), dramatically increase their flexural and compressive strength. Our aim was to devise a fabrication recipe to homogeneously disperse chopped fibers in concrete matrix. For this we had chemically treated the jute fibers by dilute alkali and subsequently modified their surface using sika latex solution. Additionally, we used tannin as water reducing admixture to improve the dispersion of jute fibers. The superior mechanical properties of the jute fiber reinforced concrete are demonstrated through the fabrication of various commercial products such as sewer pipe, electrical pole, pavers block, and railway sleeper. PP fibers were also used in cementitious mixture to develop engineered cementitious composites (ECC) to impart ductility in fabricated structures.

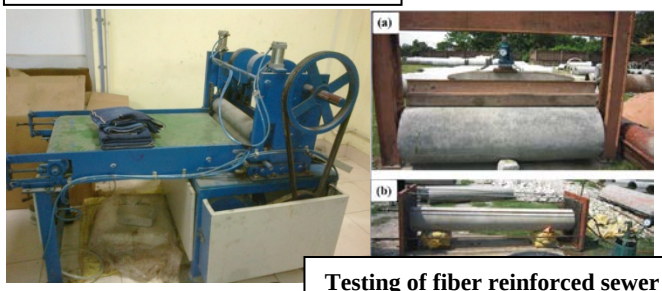
User: Apart from our own use, the developed facilities are going to be utilized by several local Industries to test their products. Also, we use this laboratory for training of our M. Tech students.

Deliverable: We have used jute fiber reinforced cement mortar and concrete to make various structural products in local industries. As for example, we have made pavers block using fiber reinforced concrete, sewer pipe using fiber reinforced RCC, electric pole and concrete railway sleeper using fiber reinforced pre-stressed cement concrete. Research work has also been conducted to make product out of process optimized ECC.

Glimpses of the facilities and product developed

We have shown the photographs of jute cutting machine designed by us, CCS and MOR measurement equipment and fabricated sewer pipe, electric pole and railway sleeper using jute fiber reinforced concrete.

Fabricated fiber cutting machine



Testing of fiber reinforced concrete pole

Testing of fiber reinforced sewer pipe

Testing of fiber reinforced railway sleeper

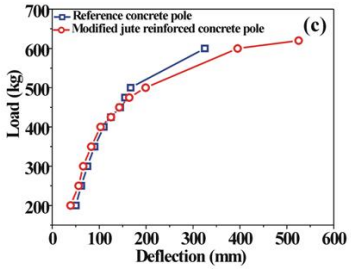


Figure 5 Jute fiber chopping machine, Flexural and compressive strength measurement units.

Objective: A ceramic waste utilization laboratory has been developed to make wear resistant ceramic tiles using NALCO fly-ash. We have used more than 50 wt% NALCO fly/pond ash as well as red mud in making wear resistant ceramic tiles. Our laboratory is fully equipped to make 1′ x 1′ x 8 mm wear resistant fly-ash based ceramic tiles. Presently, in collaboration with IMMT, Bhubaneswar, we are working to commission a fly ash based glazed ceramic tile making pilot plant at the R&D facility premises of NALCO, Bhubaneswar.

User: At present this facility is mostly been used to perform sponsored research work funded by NALCO, Bhubaneswar. Occasionally, we use this laboratory for training of our M. Tech students.

Deliverable: We formulate the process recipe to fabricate 1′ x 1′ x 8 mm wear resistant ceramic tiles using NALCO fly/pond ash, kaolinite, pyrophyllite clay and red mud. Apart from commercial clays the other precursor materials are waste generated by NALCO. We have gotten one patent for the process recipe and no student but only the project personnel are working in this project. These wear resistant tiles will be commercialized in collaboration with NALCO.

Glimpses of the facilities and product developed

In the following we have shown the photographs of fluidized bed mixing unit, hydraulic press, furnace and fabricated 1′ x 1′ x 8 mm wear resistant ceramic tiles using NALCO fly ash.

Figure 6 Clockwise from top: Fluidized bed mixer, 160 MT hydraulic press, furnace and biscuit fired fly-ash tile.

Annexure – II

Prototype development

(i) **Dry route based technology to fabricate wear resistant glazed ceramic wall tiles using NALCO coal ash (Patent No.287533):** Captive power plant (CPP), NALCO, Angul, Odisa, India has been making continuous efforts to increase fly ash utilization (especially the ash dumped in pond, known as pond ash) in an environment friendly manner through various methods (https://nalcoindia.com/sustainability/waste-utilization). We have developed a patented dry-route based technology to fabricate wear resistant glazed wall tile using NALCO coal ash. Three field trials at *Dakhshinamurthy Tiles, Mansa Gujrat, India* have been conducted to validate the developed technology. Subsequently NALCO floated expression of interest (EOI) for commercialization of this technology. It is one of the four projects NALCO decided to commercialize. In collaboration with CSIR IMMT, Prof. Majumder is now working to set up a demonstration/pilot plat to make fly-ash based ceramic tiles at Bhubaneswar. Recently we have submitted the Basic Engineering Package (BEP) for 100 kg/day fly ash mix pilot/demonstration plant to produce wear-resistant ceramic tiles from fly ash/ pond ash. The process flow-sheet for producing tiles has been prepared based on the process developed by Prof. Majumder's laboratory at IIT Kharagpur. The flowsheet also includes unit operations practiced in modern tiles plant such as wet homogenization, filter press/spray drying for removal of moisture followed by size reduction and size separation, among others. Assuming the capacity of the pilot plant between 50 kg and 100 kg tiles/day; based on the equipment available in the market, cost and feasibility of operating the pilot plant is included in the report. The specification and indicative cost of the equipment available for operating 100 kg per day mix (which was selected as the pilot plant capacity) has been detailed in the report with flexibility in the equipment specifications for improvising the operational parameters during the testing in the pilot plant, if required. The estimated equipment cost and operating cost of the plant has also been listed. The report includes the mass balance and the consumables required for three months operation. Process description explains the flow of materials in the plant between the various equipment and the unit operations being carried out under the different sections namely feed preparation, firing, and glazing. The basic equipment specification including capacity, type of equipment, material of construction, number of equipment etc., are detailed in the equipment specification section. Drawings such as Equipment Flow Diagram (EFD), Process and Instrumentation Diagram (PID), Plant Layout, Electrical Single Line Diagram (SLD) and Quality Control Lab (QCL) drawings are included in the annexure of the BEP. The list of suppliers for equipment and raw materials is also attached in the report. Demonstrating this technology to the entrepreneur of eastern Indian region, NALCO would take the initiative to encourage them to set up fly-ash based tile plants.

Figure 1 Left: Prof. Majumder at Naroda plant during field trial. Right : Picture of glazed fly-ash wall tile fabricated at Dakhshinamurthy tiles factory at Mansa, Gujrat

(ii) **Jute fiber reinforced cement concrete composites (Patent No 381157)** We have developed a technology to use jute, a natural fiber, as effective reinforcement in cement mortar, cement concrete, reinforced as well as pre-stressed cement concrete (another patent filed 426/KOL/2011, PBB 1186). The details of this technology may be accessed in the website of sponsor, National Jute Board, using the link https://www.jute.com/documents/10437/0/JFR_FINAL_PROJECT_REPORT.pdf/971388b6-640a-44db-8465-bea71f9244a4 The technology involves the treatment of chopped jute fiber with mild alkali solution to remove hemicellulose, waxes and impurities from jute fiber to modify its surface and increase its crystallinity. The alkali treated fiber surface was coated by SBR to reduce the hydrophobicity of jute fiber. A novel processing technique was developed to distribute coated jute fiber homogeneously in cement matrix. The polymer modification reduces the fiber-cement incompatibility leading to stronger bonding between jute fiber and cementitious matrix. The combined alkali and polymer modified jute fiber reinforcement is demonstrated to be very effective in improving compressive and flexural strength of the concrete product as compared to control concrete sample without jute reinforcement. Using the developed technology, we have fabricated several prototype products including concrete paver block, non-pressure sewer pipes, pre-stressed concrete electric pole, and pre-stressed railway concrete sleepers. Figure 2 shows the fabrication of pre – stressed electric pole using jute fiber reinforced concrete composition. Significant deflection during cantilever beam testing was observed in fiber reinforced concrete as compared to ordinary commercial pre – stressed concrete. Figure 2 also shows the water leak test of fiber reinforced RCC pipes kept filled with pressurized water. Much higher water pressure was withstand by fiber reinforced pipes as compared to ordinary RCC sewer pipes.

Figure 2 Left: Inspecting the fabrication of jute fiber reinforced pre-stressed electric pole. Right: Prof. Majumder inspecting the water leak testing of fabricated jute fiber reinforced sewer pipes

(iii) **Economic air quality monitoring prototype** Air quality has significant impact on the public health. Trace concentration of pollutants [viz. nitrogen oxide (NO_2), ammonia (NH_3), carbon mono oxide (CO), sulphur di oxide (SO_2), various volatile organic components (VOCs), and suspended particulate matters (PM) (10 µm and 2.5µm)] in ambient air need to be continuously monitored at different outdoor locations.

We have developed chemi-resistive type NO_2 and NH_3 sensors using nano-crystalline oxide materials. As compared to available commercial sensing systems of similar type; the developed air quality monitoring (AQM) systems exhibit higher sensitivity, faster response and can detect trace amount (in ppb level) of these pollutants among other pollutants in ambient air. The functionality of an economic, portable air quality monitoring (AQM) system has been demonstrated. A patent namely "A low cost, portable and drift corrected semi-conducting metal oxide gas sensor device and process for domestic and industrial applications" (**Patent No. 352616**) has recently been granted.

As shown in Figure 3 below, the developed prototype can detect CO, VOC, particulate matters (10µm and 2.5µm) along with ambient temperature and humidity. The project work has been sponsored by DST, MeiTy and MoE under NNetRA mission. The project work involves development of nano-materials for selective gas sensing, indigenous development of sensing elements, development of electronic circuit module for gas detection, development of software for process control, data acquisition and storage. Development of suitable GUI for system operation and IoT. We are working on the packaging of the developed prototype. Field test is undergoing to detect VOC, NO_x, CO and particulate matter present in air along with the ambient temperature and humidity.

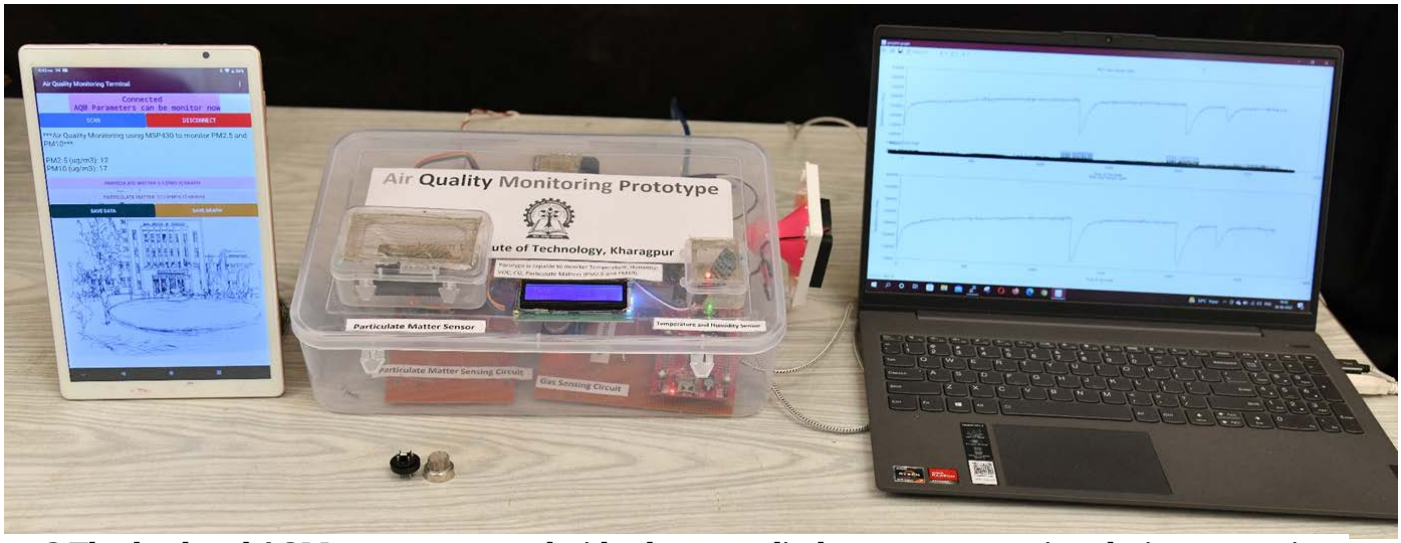


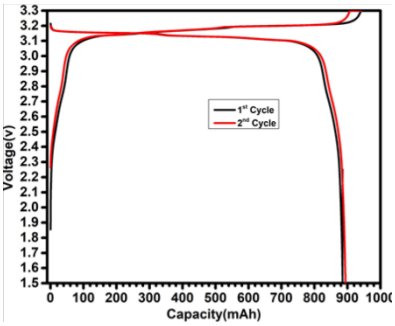
Figure 3 The developed AQM system connected with a laptop to display response transient during gas sensing and with a Tab (through blue tooth) for PM sensing. The LCD screen displays the temperature and ambient humidity. The developed Taguchi type sensing elements are shown separately.

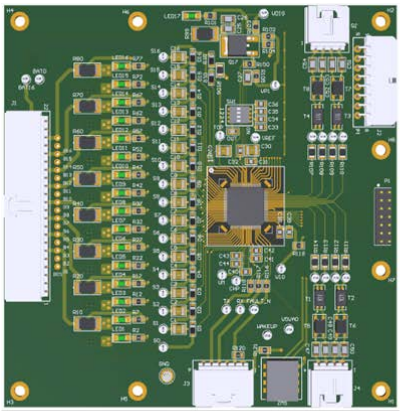
(iv) Development of 28V 16 Ah Li ion rechargeable battery module for underwater application

Under IMPRINT – I initiative for Security and Defense vertical, a group led by Prof. Majumder has developed 28V 16 Ah Li ion rechargeable battery module for underwater defense application. The recently concluded project was jointly funded by DRDO and MoE. A spinel based chemistry (lithium titanium oxide anode and lithium manganese nickel oxide cathode) is used to make 18650 type cylindrical cells. We developed lithium-ion batteries with acceptable energy/power densities (~110Whkg^{-1}/300Wkg^{-1}), rate capabilities (0.2C – 1C discharge) and longer cycle life for various applications relevant to Indian defense laboratories. Also, we fabricated 28V, 16Ah battery module prototypes for underwater application relevant to Indian defense laboratory (see **Figure 4**: cell, cell characteristics, cell assembly, BMS, pack, pack discharge characteristics measured by BMS). Some of the specific deliverables are,

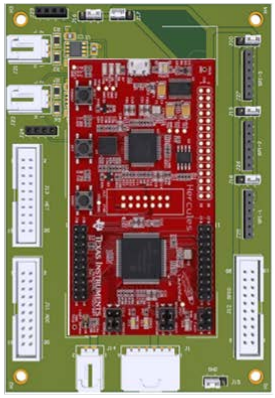
1) Scale up the synthesis and optimize the performance of doped $Li_4Ti_5O_{12}$ anode and activated carbon-doped $LiMn_{1.5}Ni_{0.5}O_4$ spinel hybrid cathode.
2) Fabricate 18650 type cell using optimized electrodes.
3) Develop battery module (28V, 16Ah) along with protection circuit and BMS.
4) Real field testing and benchmarking of the indigenous battery developed.

fabricated 18650 cells

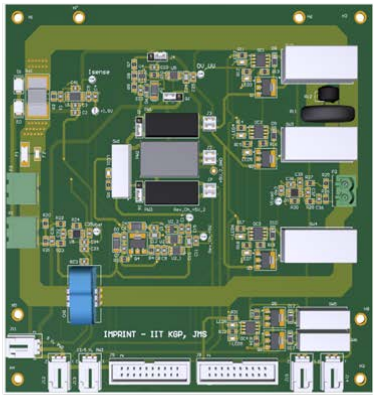




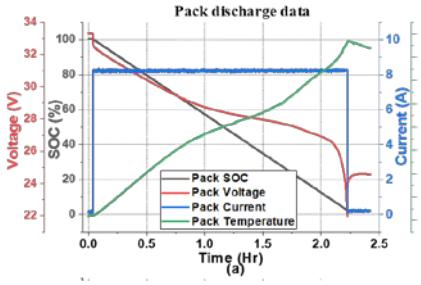
Slave Unit



Master Control Unit



Protection Unit



Annexure – III

Ph.D Thesis Supervised

List of Ph. D Thesis (Awarded)

1. High energy density layered oxide cathode materials for lithium rechargeable batteries, **S. Sivaprakash, October 2009** (SBM). Presently Senior Scientist and SIC at CECRI, Mandapam unit, Tamilnadu, India
2. Synthesis and characterization of multiferroic composite thin films, **Subhasis Roy**, **September 2011** (SBM). Presently Asst. Professor, at Science College, Kolkata University
3. Gas sensing characteristics of wet chemical synthesized spinel ferrites, **Kalisadhan Mukherjee**, **July 2012** (SBM). Presently Asst. Professor at Pandit Deendayal Energy University, Gandhinagar
4. Chemical modification of jute fiber and its potential application for novel adsorptive bioremediation of hazardous dyes from wastewater, **Aprana Roy**, **December 2012** (B. Adhikari and SBM) No information about her affiliation
5. Combustible gas sensing characteristics of undoped and indium doped zinc oxide thin films, **Sumati Pati**, **April 2013** (SBM and P Banerji) (QIP candidate) Asst. Professor at a College at Bhadrak, Orissa.
6. Investigations on the reinforcing behavior of jute fibre in cement mortar, **Sumit Chakraborty**, **May 2013** (SBM and B Adhikari). Presently Assistant Professor, Centre for Interdisciplinary Sciences, JIS Institute of Advanced Studies and Research, Kolkata
7. Novel high energy density composite cathode materials for lithium rechargeable batteries, **Chandan Ghanty**, **October 2013** (SBM and R N Basu, CG&CRI). Presently 2nd Principal Researcher at Tata Steel, Tata Nagar, Jharkhand, India.
8. Jute Fibre Reinforced Cement Concrete for Structural Applications, **Sarada Prasad Kundu**, **March 2014** (SBM and B Adhikari) Entrepreneur
9. Nanocrystalline lanthanum-iron-oxide based perovskites with gas sensing and other multifunctional properties, **Krishna Kumar Bhargav,** December 2014 (SBM and S. Ram) Current affiliation is not known.
10. Development of nano-structured ceramic oxide gas sensing system for air quality monitoring, **Arnab Maity** June, 2015 (SBM). Presently working as post-doctoral researcher in Prof Haick's group in the Department of Chemical Engineering, Technion. Israel
11. Gas sensing characteristics of zinc oxide – copper oxide hetero – composite thin films, **Abhishek Ghosh, September 2017** (SBM). Presently working as Senior Researcher at H2Scan, USA
12. Engineered lithium and manganese rich cathode materials for high energy density lithium ion rechargeable batteries, **Prem Prakash Dahiya, September 2018** (SBM). Presently working as Senior Engineer at Himadri Speciality Chemical Limited, Kolkata, India
13. Spinel oxide based electrode materials for high energy and high power density rechargeable lithium ion cells, **Kirtan Sahoo July 2019** (SBM and A.S. Kumar, NSTL, Vizag) (DRDO sponsored candidate). Presently working as scientist at NSTL, Vizag, India.
14. Investigations on the multifunctional characteristics of bismuth iron oxide, **Moumita Dewan, January 2020** (SBM). Presently at Netherland.
15. Atmospheric plasma sprayed metal oxide coatings: Understanding on their sensing and catalytic conversion characteristics of toxic gases relevant to air quality monitoring,

Ambardekar Vibhav Shriram Shruti, August 2020 (PPB (ME) and SBM). Presently working as PDF at State University at New York, Stony Brook.

16. Surface and bulk modified $Na_3V_2(PO_4)_3$ electrode materials for rechargeable sodium ion battery, **Amalendu Das** (QIP candidate), **October 2020** (ARC and SBM). Presently working as Asst. Professor at Sikkim Manipal University.
17. Tin and antimony alloy based nanocomposites as anode materials for secondary lithium – ion and sodium ion battery, **Sambedan Jena**, **August 2021** (SD (MME) and SBM). Presently working as a PDF at the Department of Polymer Nano Science and Technology, Jeonbuk National University, Korea.
18. Lithium ion battery and supercapacitor hybrid for high performance energy storage device, **Mainul Akhtar, December 2021** (SBM) Presently working as a PDF at Bavarian Center for Battery Technology (BayBatt), University of Bayreuth, Germany.
19. Investigations on thin film sensing elements for air quality monitoring, **Tynee Bhowmick, June 2022** (SBM and SN (ECE). Presently working as a PDF at the University of Cambridge, UK.
20. Investigations on the electrochemical characteristics of electrophoretically deposited anode materials for lithium and sodium ion batteries, **Tania Majumder**, October 2022 (SBM).
21. Layered and polyanion based electrode materials for sodium rechargeable cells **Anwesa Mukherjee**, December 2022 (SBM and SB). Now in Sweden

Post-doctoral fellow

1. **Dr Debasish Das** working as Senior Research Associate in a project entitled "Air quality monitoring prototype" sponsored by Department of Science and Technology, Technology Bhavan, New Mehrauli Road, New Delhi – 110016.
2. **Dr Thiruppathi KP** working as Senior Project Assistant – Technical in a project entitled "Indian Nanoelectronics Users Program-Idea to Innovation (INUP I2I)", sponsored by Ministry of Electronics and Information Technology (R and D in Electronics Group, Nanotechnology Initiatives Division, Government of India

List of ongoing Ph. D thesis (Thesis titles are tentative)

1. Amorphous electrodes for alkali ion rechargeable cells, **Arijit Mitra** (Prime Minister Research Fellow) (SD (MME) and SBM)
2. Electrode materials for alkali ion rechargeable cells: Understanding on alkali ion insertion behavior, **Unmesha Roy** (SD (MME) and SBM)
3. Nano network integrated to sensor nodes, **Sharmistha Nayak** (SM (CSE) and SBM)
4. Development of air quality monitoring prototype, **Subhadip Mandal** (SBM)
5. Development of Li ion rechargeable battery module fabricating 18650 cells, **Pawar Rajwardhan Madhukar Aruna** (SBM and AB (MME)
6. Lithium sulphur rechargeable cell, **Debayan Chatterjee** (SBM)

M. Tech Thesis Supervised

List of M. Tech/MS Thesis Awarded

1. Studies on the process optimization of cobalt iron oxide nano-powder to synthesize polymer ferrite composite, **Bulbul Biswas**, **April 2007** (SBM and S. Ram)
2. Microemulsion mediated synthesis of nano-crystalline barium titanate based thin films for miniaturized multilayered ceramic capacitors, **N. Vyshnavi**, **June 2007** (SBM and R Waser, RWTH, Aachen, Germany) (DAAD Sandwich Fellow)
3. Wet chemical synthesis and structural refinement studies on magnesium zinc ferrite solid solution powders, **Dinesh Chand Bharti**, **April 2008** (SBM)
4. Solution synthesis and characterization of (1-x)Li($Li_{1/3}Mn_{2/3}$)O_2-xLi($Ni_{0.8}Co_{0.15}Mg_{0.05}$)$O_2$ solid-solution cathodes for Li-ion rechargeable batteries, **Aparajita Pramanik** , **April 2008,** (SBM)
5. Towards the development of a prototype CO gas sensor using Al doped ZnO sensing elements, **Anand Prakash Singh Gaur**, **April 2009** (SBM)
6. Chemically modified jute used for soil strengthening under national highways, **Siva T**, **May 2010** (BA and SBM)
7. Wet chemical synthesis and hydrogen sensing characteristics of nano-crystalline iron oxide particles, **Kiran Kumar Atyam**, **May 2010** (SBM)
8. Wet chemical synthesis and characterization of calcium doped lanthanum manganite ceramics, **Atma Prasad Rai**, **April 2011** (DB and SBM)
9. Sol-gel synthesis and characterization of cation co-doped lead titanate thin films, **Ravi Kumar Bhadram, April 2011** (SBM)
10. Development of a test gas chamber and electronic circuit module to evaluate the gas sensing characteristics of wet chemical synthesized nano-crystalline tungsten oxide sensing elements, **Subhash Singh**, **April 2011** (SBM)
11. Synthesis and electrochemical characteristics of xLi2MnO3-(1-x)LiNi0.5Mn1.5O4 ($0.0 \leq x \leq 1.0$) integrated cathodes for rechargeable lithium batteries, **Aniruddha Mukund Dive**, **April 2012** (SBM)
12. Synthesis and electrochemical characteristics of xLi_2MnO_3-(1-x)Li($Mn_{0.375}Ni_{0.375}Co_{0.25}$)$O_2$ ($0.0 \leq x \leq 1.0$) thin film cathode for lithium rechargeable batteries, **Abhinav Sharma**, **April 2012** (SBM)
13. Synthesis and combustible gas sensing characteristics of spinel: perovskite composites, **Sneha Kandapal, April 2012** (SBM)
14. Electrochemical performance of $LiNi_{0.5}Mn_{1.5}O_4$-multiwall carbon nanotube composite cathode for li-rechargeable batteries, **Mainul Akhtar**, **April 2014** (SBM)
15. Use of LD Slag in making high strength paver block, **Sk. Abdul Moyez**, **April 2014** (DB and SBM)
16. Development of thermally sprayed sensors, **Rajat Kanti Kuila April 2015** (P.P. Bandopadhyay (ME), SBM)
17. Wet chemical synthesis and hydrogen sensing characteristics of nickel doped zinc oxide thin films, **Lalitesh Meena** April 2016 (SBM)
18. Fabrication and electrochemical characteristics of rechargeable lithium ion coin cells with flat discharge profile, **Pankaj Kumar April 2016** (SBM)

19. Newly designed cathode materials for lithium sulfur battery, **Lalit Kumar Singh April 2017** (Joint Supervisor, with ARC, MS)
20. Microwave assisted hydrothermal synthesis and characterization of $Na_3V_2(PO_4)_3$@C cathode for Na and hybrid Li-ion rechargeable batteries, **Sunil Kumar Pradhan April 2017** (SBM)
21. Fabrication of lithium ion battery for application in solar energy storage, **Abhinav Sharma April 2017** (SBM)
22. Development of a sol-gel based coating on steel as an alternative means for rust prevention and phosphating, **Tuhin Das April 2017** (Supervisor, with Dr Monojit Dutta, Tata Steel) **(Intern Tata Steel)**
23. Investigations on jute fiber reinforced engineered cementitious composites, **Ravi Shankar Godara April 2017** (SBM)
24. Electrochemical characteristics of auto-combustion synthesized layered and spinel oxide electrode materials for Li ion batteries, **Arun Kumar April 2018** (SBM)
25. Cathode material modification using metal organic framework in lithium sulfur battery, **Aditi Saha April 2019** (SBM)
26. Investigation of the anode – electrolyte interface in full cell rechargeable magnesium ion batteries by using fluorinated alkoxyborate based electrolyte and transition metal disulfide cathodes, **Ananyo Roy May 2019** (SBM and Z. Li, B.B. Parambath, and M. Fichtner, Helmholtz Institute Ulm and Karlsruhe Institute of Technology) (DAAD Sandwich M. Tech Program)
27. Electrophoretic deposition of metal – organic framework derived copper oxide thick film for enhanced volatile organic component sensing, **Kamalika Mandal, May 2019** (SBM)
28. WO_{3-x} thin films for low concentration NO_x sensing, **Samanta Pal, May 2020** (ARC and SBM)
29. The development of lithium sulphur battery, **Bapan Dhara, May 2020** (SBM, ARC and S. Ghosh, Tata Steel Limited) **(Intern Tata Steel)**
30. Understanding on ethanol sensing characteristics of wet chemical and metal organic framework derived electrophoretic deposited copper oxide thick film sensors, **Anisha Bandyopadhyay, April 2021** (SBM)
31. Electrophoretic deposition of transition metal oxide based negative electrodes for superior electrochemical performance of lithium ion rechargeable cells, **Saptarshi Das, July 2021** (SBM and A. Bhattacharyya (ME)). **(MS Thesis)**
32. Electrochemical performance of industrial graphite as negative electrode for Li – ion rechargeable cell, **Dhruv Virpariya, April 2022** (C. Jacob and SBM)

List of ongoing M.Tech thesis (Thesis titles are tentative)

1. Development of catalyst to expedite polysulphide phase transformation in Li – S rechargeable cell, **Purbasha Kundu** (SBM)
2. Optimization of process parameters to fabricate 18650 type Li ion rechargeable cell, **Ankur Hazra** (SBM)
3. Microwave hydrothermal synthesis of electroceramic materials with engineered surface morphology, **Amit Chatterjee** (SBM)

Annexure – IV

List of Publications

Book Chapters

1. Electrode Materials for Sodium Ion Rechargeable Batteries, T. Majumder, A. Mukherjee, D. Das, **S.B. Majumder**, Oxide Electronics, *Oxide Electronics*, 397-422 (2021).

2. Multilayered and Chemiresistive Thin and Thick Film Gas Sensors for Air Quality Monitoring, T. Bhowmick, V. Ambardekar, A. Ghosh, M. Dewan, P. P. Bandyopadhyay, S. Nag, **S.B. Majumder**, *Multilayer Thin Films*, 127 (2020).

3. Hybrid Supercapacitor- Battery Energy Storage, M. Akhtar, **S.B. Majumder**, *Handbook of Advanced Ceramics and Composites: Defense, Security, Aerospace and Energy Applications*, 1259-1296 (2020).

4. Composite film processing, R. Dorey, S. Roy, A. Sharma, C. Ghanty, **S.B. Majumder**, *In Chemical Solution Deposition of Functional Oxide Thin Films*, 445-482 (2013).

5. Conductance transient analyses in metal oxide gas sensors on the example of spinel ferrite gas sensors, K. Mukherjee, **S.B. Majumder**, *Chemical Sensors-Simulation and Modeling*, 1826-1832 (2012).

6. Synthesis and characterization of active-inactive layered oxide composite cathode materials for lithium rechargeable batteries, S. Sivaprakash, **S.B. Majumder**, *Advances in Energy Research*, Volume 8 (2012).

7. Ceramic thin films, T. Schneller, **S.B. Majumder**, R. Waser, *Ceramics Science and Technology*, Volume 1 (2008).

Papers Published in Peer Reviewed Journals

1. Potential of copper oxide thin film-based sensor probe for carbon dioxide gas monitoring, T. Bhowmick, A. Ghosh, V. Ambedkar, S. Nag, **S.B. Majumder**, *Journal of Materials Science: Materials in Electronics* **33**, 26286-26298 (2022).

2. The generalized solubility limit approach for vanadium-based cathode materials for lithium-ion batteries, A. Mitra, A. Gilankar, S. Das, S. Jena, D. Das, **S.B. Majumder,** S. Das, *Journal of Materials Chemistry A*, **10**, 11636-11650 (2022).

3. High-Performance and Safe Hybrid Li-Ion Batteries Based on $Li_4Ti_5O_{12}$ – TiO_2(A) – TiO_2 (R)@C Anode and $Na_3V_2O_2(PO_4)_2F$–$Na_3V_2(PO_4)_3$@ C Cathode,

M. Akhtar, T. Majumder, J. K. Chang, **S.B. Majumder**, *ACS Sustainable Chemistry & Engineering* **10**, 1390-1397 (2022).

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34. Mechanisms Controlling Phase Formation in PZT Thin Films, S.B. Majumder, D.C. Agrawal, Y.N. Mohapatra and V.N. Kulkarni. ***Proceedings of the Ninth IEEE***

International Symposium on Application of Ferroelectrics. Catalogue No. 94CH3416-5, pp.454-456 (1994).

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Invited lectures delivered (National and International)

1. Li ion battery and supercapacitor for hybrid energy storage Keynote lecture at the 2022 ICGET – TW National Tsing – Hua University, Taiwan, November 10 – 12 (2022)
2. Novel bat – cap hybrid electrodes for next generation lithium ion rechargeable cells at the Third International Conference on Advanced Materials (ICAM 2019) Kottayam, Kerala, India, organized by Inter University Centre for Nanoscience and Nanotechnology (IIUCNN), Mahatma Gandhi University, Kottayam, Kerala, India & Wroclaw University of Technology Faculty of Electrical Engineering Wroclaw, Poland, 9-11 August (2019).
3. Status of EV research in Regional Mobility Summit organized by Govt. of West Bengal in association with NITI Aayog at WBTC Maidan Tent, Duffrin Road 10th August (2018).
4. Battery supercapacitor hybrid electrodes for lithium ion rechargeable cells in 81st annual session of Indian Ceramic Society and international conference on "Expanding horizons of technological applications of ceramics and glasses (EH-TACAG'17) at College of Engineering Pune, December 14-16 (2017).
5. Flexible and Printed rechargeable batteries: An introduction, in the Indian Institute of Chemical Engineers, Kharagpur Chapter to commemorate the birth anniversary of Bharat Ratna, Dr. A.P.J. Abdul Kalam, IIT Kharagpur, October 16 (2017).
6. Science and technology of lithium ion rechargeable batteries and Introduction to flexible and printed batteries, Guest lectures at the short course entitle “Flexible Electronics” at IIT Kanpur, June 3-8 (2017).
7. Nano-crystalline composite cathode materials for high energy density lithium ion batteries at Institute of Micro and Nano Materials, University of Ulm Germany, July 13-15 (2016).
8. Materials science aspect of chemi-resistive gas sensor at IWE-II, RWTH, .Aachen, Germany, July 6 (2016).
9. Lithium and manganese rich composite cathodes: Investigations on the materials aspects *in* Center for Solid State Chemistry and New Materials, at Leibniz University of Hannover, Germany, June 13-14 (2016).
10. Lithium and manganese rich composite cathodes for high energy density lithium ion batteries *at* International Conference on Advances in Energy Research IIT Bombay, December 15-17 (2015).
11. Development of Engineered Ceramic Oxide Gas Sensing System for Air Quality Monitoring *in* Workshop on Indian Innovations in Materials Research: New Materials Research: New Materials and Processes (IIMR-15)at CSIR-CG&CRI, Kolkata, June 25-27 (2015).

12. Ceramic Tiles from NALCO Fly ash *at* Nalco, Angul Plant Odisha (Technology Day Lecture) May 11 (2015).
13. Layered-layered type composite cathodes for lithium ion rechargeable batteries *at* National Central University, Taiwan, December 26 (2013).
14. Ceramic oxide gas sensor: Laboratory research to commercialization *at* PricolLimited, Coimbatore, Tamil Nadu, March 18-19 (2013).
15. Fabrication and performance evaluation of a microprocessor controlled VOC monitoring system *in* Sensory Systems for Environmental Monitoring of Obnoxious Odors and VOC in Industries, at National Environmental Engineering Research Institute, February 7-8 (2013).
16. Nano-composite electro-ceramic thin films *at* University of Kolkata, Salt Lake, Kolkata, January 3-7 (2013).
17. Science and technology of high energy density composite cathodes for lithium rechargeable batteries *in* Taiwan-India bilateral workshop on energy storage devices, at IISc, Bangalore.
18. Environment friendly gas sensors: A journey from material synthesis to prototype development *at* Kolkata, January 21-23 (2012).
19. Improvement of the electrochemical properties of nanocomposite cathode materials *at* IIT Bombay, December 9-11 (2011).
20. The Science and Technology of Nano-structured gas sensor *at* Vidyasagar University, Midnapur, W.B, November 29-30 (2011).
21. Science and Technology of Li Rechargeable Batteries *at* ITER Bhubaneswar, November 26-27 (2011).
22. Nano-structured ceramic oxide gas sensors: A journey from laboratory research to prototype development in International Symposium on Materials Education (ISME-2011) *at* IISER, Pune, March 26-28 (2011).
23. Analyses of the conductance transients of oxide gas sensors *in* National Conference on Sensor and Actuators, at Central Glass and Ceramic Research Institute, Kolkata March 11-12 (2011).
24. Our experience in working with high energy density composite cathodes for Li rechargeable batteries *at* Central Glass and Ceramic Research Institute, March 1-2 (2011).
25. Environ friendly nano-structured gas sensors: A journey to laboratory research to prototype development *in* National Symposium on 'Ceramics: Energy and Environment' organized by The Indian Ceramic Society & Central Glass and Ceramic Research Institute (CG&CRI), at Hotel Taj Bengal, Kolkata, January 11-13 (2011).
26. Soft-solution synthesis of nano-structured ceramics: An economic approach *at* National Institute of Technology, Hamirpur, H.P, May 31st to June 4(2010)
27. Development of prototype ceramic oxide combustible gas sensors, in 21st Annual General Meeting of Materials Research Society of India, Sardar Patel University, Vallabh Vidyanagar, February 9-11, (2010) **(MRSI medal lecture).**
28. Current Research Trends in Ceramic Oxide Gas Sensors, *in* the International workshop on tailor made nanomaterials and applications in chemical and biosensors, at CSIR-CG&CRI, Kolkata, March 2-3 (2009).

29. Wet Chemical Synthesis of Electro-ceramic Thin Films, in the National Conference on Recent Advances in Innovative Materials (RAIM-08), NIT, Hamirpur HP, Feb 16-17 (2008).
30. Investigations on flexible multiferroic composites, *in* the International Workshop on Mesoscopic Nanoscopic and Microscopic Materials (IWMNMM), Bhubaneswar, January 2-4 (2008).

Presentation in International conferences

1. Electrochemical performance of electrophoretically deposited nickel/cobalt antimony oxide carbon black negative electrodes for alkali ion batteries, U Ray, D. Das, S. Jena, A. Mitra, S.B. Majumder and S. Das, 241st ECS Meeting, Vancouver BC, May 29 – June 02, (2022)
2. Structural and electrochemical characterization of Zr doped Li_2MnO_3-(1-x)$LiMn_{0.375}Ni_{0.375}Co_{0.25}O_2$ (x = 0.25 and 0.5) layered-layered composite, P.P. Dahiya and S.B. Majumder, European Material Research Society-2016 spring Meeting, European Material Research Society, Lille, France, May 2-6 (2016).
3. Selective hydrogen sensing by cobalt doped ZnO thin films: A study on carrier reversal conductivity, Abhisek Ghosh and S.B. Majumder, 14th IEEE SENSORS Conference, IEEE Sensors, Busan, South Korea, November 1-4 (2015).
4. Development of a nano-structured ceramic gas sensor prototype for air quality monitoring of automotive cabin, A. Maity and S.B. Majumder, 4th Molecular Materials Meeting, A*STAR's Institute of Materials Research and Engineering (IMRE), Singapore, January 14-16 (2014).
5. Anomalous gas sensing characteristics of embedded and isolated $Mg_{0.5}Zn_{0.5}Fe_2O_4$ nanotubes, S.B. Majumder, K. Mukherjee, A. Maity and, S. Basu, C. Lang, and M. Topic, Frontiers in Electronic Materials: Correlation Effects and Memristive Phenomena, Nature conference, Aachen, Germany, June 17-20 (2012).
6. A journey towards the development of prototype gas sensors, S. Pati, P. Banerji and S. B. Majumder, 2nd molecular materials meeting (M3), An International conference on Frontiers in materials science, chemistry & Physics, Biopolis, Singapore, January 9-12 (2012).
7. Kinetic and statistical analysis of the conductance transient to address the selectivity issue of the wet chemically synthesized tailored nano-structured ferrite gas sensors, K. Mukherjee, A. Maity and S.B. Majumder, International Symposium on olfaction and Electronic Nose, Rockefeller University, New York, USA, May 2-5 (2011).
8. Electrochemical and Structural Investigation on $Li(Ni_{0.375}Mn_{0.375}Co_{0.25})O_2$-$Li(Li_{1/3}Mn_{2/3})O_2$ Composite Cathode Material for Lithium Rechargeable Batteries (poster), S. Sivaprakash and S.B. Majumder, 15th International Meeting on Lithium Batteries, Electrochemical Society, Montrial, Canada, June 27-July 2 (2010).
9. Investigation on Highly Potential Layered-oxide Cathode Material for Lithium Rechargeable Batteries, S. Sivaprakash and S.B. Majumder, International Conference in Chemical & Biomolecular Engineering (ChemBiotech 09-10), National University of Singapore, Singapore, January 28-29 (2010).

10. Synthesis and Electrochemical Characterization of $0.5Li_2MnO_3$-$0.5Li(Mn_{0.375}Ni_{0.375}Co_{0.25})O_2$ Cathode Materials for Li Rechargeable Batteries (poster), S. Sivaprakash and S.B. Majumder, MRS Fall Meeting, Material Research Society, Boston, MA, USA, November 30-December 4 (2009)
11. Synthesis and Electrochemical Characteristics of $0.67Li_2MnO_3$-$0.33Li(Mn_{0.375}Ni_{0.375}Co_{0.25})O_2$ Cathode Materials for Lithium Rechargeable Batteries, S. Sivaprakash and S.B. Majumder, 215th Electrochemical Society Meeting, Electrochemical Society, San Francisco, California, USA, May 24-29 (2009).
12. Electrochemical and Structural Investigations of $xLi[Li_{0.33}Mn_{0.66}]O_2(1-x)Li[Ni_{0.8}Co_{0.15}Zr_{0.05}]O_2$ ($0.3 \leq x \leq 0.7$) Composite Layered Oxide Cathode for Rechargeable Lithium Ion Batteries, S. Sivaprakash, R.S. Katiyar and S.B. Majumder, 213th ECS Meeting, Electrochemical Society, Phoenix, Arizona, USA, May 18-23 (2008).
13. Electrochemical and Structural investigations of $xLi[Li_{0.33}Mn_{0.66}]O_2$ $(1-x)Li[Ni_{0.8}Co_{0.15}Zr_{0.05}]O_2$ ($0.0 \leq x \leq 1.0$) composite layered oxide cathode for rechargeable lithium ion batteries, S. Sivaprakash, J. Saavedra, R.S. Katiyar and S.B. Majumder, 213th Electrochemical Society Meeting, Electrochemical Society, Phoenix, Arizona, USA, May 18-22 (2008).

Student's Presentations in National Conferences

1. Electrochemical performance of zinc antimony oxide – carbon black anode for alkali ion batteries (poster), Unmesha Roy, S.B. Majumder, S. Das, International Conference on Energy Conversion and Storage, organized by the Advanced Center for Energy Storage and Conversion of the Energy Consortium, Indian Institute of Technology, Madras, 18 – 20 January (2023) **(best presentation)**

2. Superior alkali ion rechargeable cells for e-mobility and renewable energy storage: Investigations on the hybridization of supercapacitors with rechargeable battery materials (poster), Mainul Akhtar, and S.B. Majumder, Workshop on Battery Technology and Electric Mobility, H.P. Green R&D Center, HPCL, Bengaluru, March 8-9 (2018) (**2nd best presentation**).

3. Electrophoretic deposition: An effective alternative to tape casting for making electrodes for lithium ion rechargeable cells (poster), Debasish Das, and S.B. Majumder, Workshop on Battery Technology and Electric Mobility, H.P. Green R&D Center, HPCL, Bengaluru, March 8-9 (2018).

4. Lithium manganese rich (LMR) layered oxides: Excellent material candidates for high energy density lithium ion rechargeable cells, Premprakash Dahiya, and S.B. Majumder, Workshop on Battery Technology and Electric Mobility, H.P. Green R&D Center, HPCL, Bengaluru, March 8-9 (2018).

5. Graphene-scaffolded $Na_3V_2(PO_4)_3$ high rate and long life cathode for sodium ion batteries with excellent cycling stability (oral), Amalendu Das and S.B. Majumder, International Conference on Current Trends in Materials Science and Engineering,

Institute of Engineering and Management, Kolkata and S.N. Bose National Centre for Basic Sciences, Kolkata, India, January 19-20 (2018).

6. Synthesis and characterization of nickel titanate: A novel electrode for rechargeable lithium ion batteries (oral), Tania Majumder and S.B. Majumder, International Conference On Current Trends In Materials Science And Engineering (IEM CTMSE 2018) Institute of Engineering & Management Kolkata and S.N Bose National Centre of Basic Sciences, Kolkata, India, January 19-20 (2018).
7. An experimental analysis of electrode matching utilizing $LiNi_{0.5}Mn_{1.5}O_4$ //AC hybrid electrochemical capacitor (poster), Mainul Akhtar and S.B. Majumder, 81st Annual session of Indian Ceramic Society and International conference, Department of Metallurgy and Materials Science, College Of Engineering, Pune, India, December 14-16 (2017) (**2nd best presentation**).
8. Electrophoretic deposition: An attractive fabrication technique for electrochemical energy conversion devices (oral), Debasish Das and S.B. Majumder, Young Scientists' Colloquium 2017, Material Research Society of India, Indian Institute of Engineering Science and Technology (IIEST), Shibpur, India, October 11 (2017).
9. Nanostructured spinel $LiNi_{0.5}Mn_{1.5}O_4$ as insertion cathode for non-aqueous hybrid supercapacitors (poster), Mainul Akhtar and S.B. Majumder, International Conference on Functional Materials (ICFM), Materials Science Centre, IIT Kharagpur, India, December 12–14 (2016).
10. Structural and electrochemical characterization of $0.5Li_2Mn_{0.98}Zr_{0.02}O_3$-$0.5LiMn_{0.375}Ni_{0.375}Co_{0.25}O_2$ layered-layered composite (poster), P.P. Dahiya and S.B. Majumder, International Conference on Functional Materials, Materials Science Centre, IIT Kharagpur, December 12-14 (2016).
11. Lanthanum iron cobalt oxide thin film sensor for selective carbon monoxide sensing (poster), Tynee Bhowmick and S.B. Majumder, International Conference on Functional Materials (ICFM), Materials Science Centre, IIT Kharagpur, December 12-14 (2016).
12. Structural and electrochemical characterization of Zr doped xLi_2MnO_3-$(1-x)LiMn_{0.375}Ni_{0.375}Co_{0.25}O_2$ ($x = 0.5$) layered-layered composite (poster), P.P. Dahiya and S.B. Majumder, 4th International Conference on Advances in Materials and Materials Processing, Department of Metallurgical and Materials Engineering, IIT Kharagpur, November 5-7 (2016).
13. Electrochemical Performance of $LiNi_{0.5}Mn_{1.5}O_4$–MWCNT Composite Cathodes for Li-Rechargeable Batteries (poster), Mainul Akhtar and S.B. Majumder, 4th International Conference on Advances in Materials and Materials Processing (ICAMMP-IV), Department of Metallurgical and Materials Engineering, IIT Kharagpur, India, November 5-7 (2016).
14. Microwave Assisted Hydrothermal Synthesis of Engineered $LiNi_{0.5}Mn_{1.5}O_4$Cathode Particles with improved electrochemical performance (poster), Tania Majumder and S.B. Majumder, 4th International Conference On Advances in Materials & Materials Processing (ICAMMP-IV), Department of Metallurgical and Materials Engineering, IIT Kharagpur, India, November 5-7, (2016).

15. Gas sensing characteristics of Composite oxide thin films (oral), Abhisek Ghosh and S.B. Majumder, Indian Innovations in Materials Research: New Materials and Processes, CSIR-CGCRI and IAPQR, Kolkata, India, June 25-27 (2015).

16. Structural and Electrochemical characterization of Mo doped Li_2MnO_3 cathode material for Li-ion batteries (poster), P.P. Dahiya and S.B. Majumder, Indian Innovations in Materials Research: New Materials and Processes, CSIR-CGCRI and IAPQR, Kolkata, India, June 25-27 (2015).

17. Enhancement of VOC sensing by doping Zinc Oxide thin film (poster), Abhisek Ghosh and S.B. Majumder, National Conference on Current Trends in Advanced Materials, Variable Energy Cyclotron Centre, Kolkata, India, November 19-21 (2014).

18. Effect of electrode fabrication process on the performance of $LiMn_{1.5}Ni_{0.5}O_4$ cathode material for Li-ion battery (poster), P.P. Dahiya and S.B. Majumder, National Conference on Current Trends in Advanced Materials, Variable Energy Cyclotron Centre, Kolkata, India, November 19-21 (2014).

19. Investigation on gas sensing characteristics of textured ZnO thin films grown by wet chemical synthesis, S. Pati, P. Banerji and S. B. Majumder, National seminar on Recent trends in condensed matter Physics (RTCMP-2014), , Institute of Technical Education & research, Siskha 'O' Anusandhan University, Bhubaneswar, India, February 8-9 (2014).

20. Doping effect of semiconducting metal oxides for gas sensing application, S. Pati, P. Banerji and S. B. Majumder, International conference on advanced functional materials (ICAFM-2014), IIT Kharagpur, February 5-7 (2014).

21. Carbon Dioxide Gas Detection by Mixed Metal Oxide (poster), Abhisek Ghosh and S.B. Majumder, International Conference on Functional Materials, Materials Science Centre, IIT Kharagpur, February 5-7 (2014).

22. MOCVD grown nanograin ZnO thin films for gas sensor application, S. Pati, P. Banerji and S. B. Majumder, National seminar on Recent trends of nanotechnology in chemical sciences (RTNCS-13), Synergy Institute of Technology, Fulnakhara, Bhubaneswar, Odisha, December 20-21 (2013).

23. Investigations on CO, CH_4, and NO_2 sensing characteristics with spinel: perovskite nano-composite materials to monitor air quality of automobile cabin (oral), A. Maity and S.B. Majumder, International Union of Materials Research Society - International Conference in Asia 2013, International Union of Materials Research Societies – International Conference in Asia, Indian Institute of Science, Bangalore, India, December 16-20 (2013).

24. Carbon Dioxide Gas Detection by Metal Oxide Heterojunction, Thin Film (oral), Abhisek Ghosh and S.B. Majumder, International Union of Materials Research Societies – International Conference in Asia, Indian Institute of Science, Bangalore, India, December 16-20 (2013).

25. Development of nano-structured intelligent economic ceramic gas analyzer prototype for air quality monitoring in automotive cabin (oral), A. Maity and S.B. Majumder, Young Scientist colloquium, Jadavpur University, Kolkata, August 28 (2013).

26. ZnO nanostructures for sensing application, S. Pati, P. Banerji and S. B. Majumder, National Seminar-cum-Workshop on Sensor and Sensing System for Taste Characterization of Food and Agro Produces, IIT Kharagpur, May 9-10 (2013).

27. Wet chemical tailoring of spinel ferrite nano-structures and study on their chemi-resistive type hydrogen sensing characteristics, K. Mukherjee and S. B. Majumder, Third National Seminar on Recent Trends in Condensed Matter Physics including Laser Applications, Department of Physics, University of Burdwan, Burdwan, West Bengal, March 5-7 (2013).

28. Combustible Gas Sensing Characteristics of Undoped and Indium Doped Zinc Oxide Thin Films, S. Pati, P. Banerji and S. B. Majumder, India Singapore joint Physics symposium (ISJPS), IIT Kharagpur, February 25-27, (2013).

29. Investigation of highly selective NO_x gas sensing using WO_3 thin film (poster), A. Maity and S.B. Majumder, 6th India-Singapore Joint Physics symposium on physics of advanced Materials, IIT Kharagpur, India, February 25-27 (2013) (**best presentation award**).

30. Fabrication and performance evaluation of a microprocessor controlled VOC monitoring system (oral), A. Maity, A. Ghosh S. B. Majumder, Sensory Systems for Environmental Monitoring of Obnoxious Odors and VOC in Industries, CSIR NEERI, Nagpur, India, February 7-8 (2013).

31. Portable microprocessor based tungsten oxide thin film gas sensor as a breath analyzer: early diabetic detection as a case study (poster), A. Maity and S.B. Majumder, National Seminar on Advanced Functional Materials (NSAFM-2013), CSIR-CMERI, Durgapur, India, January 23-24, (2013) (**best presentation award**).

32. Volatile organic compounds sensing properties of sol-gel prepared copper oxide thin film, Abhisek Ghosh and S.B. Majumder, National Seminar on Advanced Functional Materials (poster), CSIR-CMERI, Durgapur, India, January 23-24 (2013).

33. ZnO thin film gas sensors, S. Pati, P. Banerji and S. B. Majumder, Seminar on progress in Materials Science and Engineering, Materials Science Centre, IIT Kharagpur, January 20-21 (2012).

34. Metal Organic Chemical Vapor Deposition and Investigation of Structural, Optical and Gas Sensing Characteristics of ZnO Thin Films Grown on Quartz, S. Pati, P. Banerji and S. B. Majumder, Sixteenth international workshop on the physics of semiconductor devices (IWPSD), IIT Kanpur, December 19-22 (2011).

35. ZnO Thin film as selective LPG sensor, S. Pati, P. Banerji and S. B. Majumder, International Conference on Theoretical and Applied Physics(ICTAP), Department of Physics, IIT-Kharagpur, December 01-02 (2011).

36. A Comparison Study of Two Different Techniques to Grow ZnO Thin Films for Gas Sensor Application, S. Pati, P. Banerji and S. B. Majumder, Indian Vacuum Society Symposium on Thin Films: Science & Technology, Bhabha Atomic Research Center, Trombay, Mumbai, November 09-12 (2011) (**best presentation award**).

37. Discrimination of inflammable gases by pattern recognition techniques using magnesium zinc ferrite gas sensors, K. Mukherjee, A. Maity and S. B. Majumder, National Conference on Sensor and Actuators, CSIR-CGCRI, Kolkata, March 11-12 (2011).

38. Toxic and inflammable gas sensing characteristics of solution synthesized $Mg_{0.5}Zn_{0.5}Fe_2O_4$ nano-tubes, K. Mukherjee and S. B. Majumder, National Symposium

on ‘Ceramics: Energy and Environment’, Indian Ceramic Society & CSIR-CGCRI, Hotel Taj Bengal, Kolkata, January 11-13 (2011).

39. Process induced modification of the gas sensing characteristics of ZnO thin films, S. Pati, P. Banerji and S. B. Majumder, National Symposium on Ceramics: Energy and Environment, CSIR-CGCRI, Kolkata, January 11-13 (2011).

40. Statistical Analysis of Volatile Gas Sensing Properties of Nickel Ferrite Nano- Structure for Industrial Air Quality Monitoring (poster), A. Maity, I Banerjee and S.B. Majumder, National Conference on Solid State Ionics, IIT Kharagpur, India, December 21-23 (2010) (**best presentation award**).

41. Statistical analyses of the conductance transients to address the selectivity issue of nano-crystalline magnesium zinc ferrite gas sensors (poster), A. Maity and S.B. Majumder, International Symposium on Advances in Nanomaterials, CSIR-CGCRI, Kolkata, India, December 6-7 (2010) (**best presentation award**).

42. Structural Investigation on $Li(Ni_{0.375}Mn_{0.375}Co_{0.25})O_2$-$Li(Li_{1/3}Mn_{2/3})O_2$ Composite Cathode Material for Lithium Rechargeable Batteries (oral), S. Sivaprakash and S.B. Majumder, 9th International Symposium on Advances in Electrochemical Science and Technology (ISAEST-9), SAEST & CECRI, Karaikudi, hotel Green Park, Chennai, Tamil nadu, India, December 02-04 (2010).

43. Investigations on Layered-Oxide Composite Cathode Material for Lithium Rechargeable Batteries (oral), S. Sivaprakash and S.B. Majumder, 15th National Convention of Electrochemists, VIT University, Tamil nadu, India, February 18-19 (2010).

44. Active: Inactive Nano Composites as High Energy Density Cathode Material for Li-Ion Rechargeable Batteries (poster), S. Sivaprakash and S.B. Majumder, International Conference on Nano Science and Technology, Indian Institute of Technology Bombay, Mumbai, India, February 17-20 (2010).

45. Ferroelectric and Magnetic Behaviors of $CoFe_2O_4/Pb_{0.85}La_{0.15}TiO_3$ nano-Composite Thin Films Synthesized By Sol-Gel Precursor Hybrid Processing Route (poster), Subhasish Roy and S.B. Majumder, International Conference on Nano Science and Technology (ICONSAT), IIT Bombay, Mumbai, India, February 17-20 (2010).

46. Design and fabrication of next generation mobile phone with health checkup facility (oral), A. Maity and S.B. Majumder, ENVISION product design competition, MICROSOFT and E-Cell, IIT Kharagpur, India, (2010).

47. Synthesis and Characterization of $CoFe_2O_4/Pb_{0.85}La_{0.15}TiO_3$Composite Thin Films (poster), Subhasish Roy and S.B. Majumder, International Symposium on Microwave and Optical Technology (ISMOT), University of Delhi, Hotel Ashok, New Delhi, December 16 – 19 (2009).

48. Electrical and Magnetic Properties of Sol-Gel Synthesized CoFe2O4/Pb0.85La0.15 TiO3 Composite Thin Films (poster), Subhasish Roy and S.B. Majumder, International Conference on Electro-ceramics (ICE), University of Delhi, New Delhi, December13-17 (2009).

49. Studies on the gas sensing behavior of nano crystalline $Mg_{0.5}Zn_{0.5}Fe_2O_4$ towards reducing gases,K. Mukherjee, and S. B. Majumder, Material Research Society of India-Kolkata chapter, Saha Institute of Nuclear Physics, Kolkata, October 30 (2009).

50. Grain Size Effect on the Electrochemical Properties of Mo Doped $Li(Ni_{0.80}Co_{0.2}-XMo_x)O_2$ (X=0.025) Cathodes for Li Ion Rechargeable Batteries (oral), S. Sivaprakash and S. Majumder, International Workshop on Nanotechnology and Advanced Functional Materials, National Chemical Laboratory, Pune, Maharashtra, India, July 9-11 (2009).

51. Synthesis and gas sensing characterization of nano-crystalline $ZnFe_2O_4$, K. Mukherjee and S. B. Majumder, Tailor made nanomaterials and applications in chemical and biosensors, CSIR-CGCRI, Kolkata, March 2-3 (2009).

52. Overcapacity in Active: Inactive Composite Cathode for Li Rechargeable Batteries (oral), S. Sivaprakash and S.B. Majumder, International Conference on Hi-Tech Materials, IIT Kharagpur, West Bengal, India, February 11-13 (2009).

53. Development of a gas sensing measurement system using semiconducting oxides as gas sensing materials, K. Mukherjee and S. B. Majumder, International Conference on High Tech Materials (ICHTM-09), IIT Kharagpur, India, February 10-12 (2009).

54. Unconventional Lithium Intercalation in Active: Inactive Composite Cathode for Li Rechargeable Batteries, S. Sivaprakash and S.B. Majumder, International Symposium for Research Scholars on Metallurgy, Materials Science and Engineering, Proceedings, IIT Madras, India, December 10-12 (2008).

55. Dielectric and Magnetic Properties of Flexible PVDF: $CoFe_2O_4$ Composites (poster), Subhasish Roy and S.B. Majumder, National Seminar on Ferroelectric & Dielectrics (NSFD-15), Thapar University, Patiala, India, November 6-8 (2008).

56. Wet chemical synthesis of electro-ceramic thin films (poster), Subhasish Roy and S.B. Majumder, National Conference on Recent Advances in Innovative Materials (RAIM), NIT, Hamirpur, India, February 16-17 (2008).

57. Structural Investigation on Active-inactive Composite Layered Oxide Cathode for Lithium-ion Rechargeable Batteries (oral), S. Sivaprakash and S.B. Majumder, Millennium Energy Summit-2007, CSIR-CGCRI Kolkata, West Bengal, India, September 27-29 (2007).

58. Crystal Chemistry Modification of Lithium Nickel Cobalt Oxide Cathodes for Lithium Ion Rechargeable Batteries (oral), S. Sivaprakash and S.B. Majumder, National Conference on Emerging Trend in Engineering Materials, Thapar University, Patiala, Punjab, India, February 1-3 (2007).

Annexure – V

Extramural Research Grant Ongoing/Completed

List of Projects

1. **Preparation of basic engineering package (BEP) for setting up of pilot/demonstration plant on use of fly/pond ash for production of wear resistant ceramic tiles**, CSIR – IMMT 1 – 5 – 2022 to 01 – 11 – 2022, S.B. Majumder (PI) (Consultancy project) 9.44 lakh

2. **Evaluation of the suitability of Tata Steel provided graphite flake as negative electrode for Li ion rechargeable cells,** Tata Steel Limited, 01 – 12 – 2021 to 31 – 08 – 2022, S.B. Majumder (PI) (Consultancy project) 6.136 lakh.

3. **Indian Nanoelectronics users' program – Idea to Innovation (INUP I2I initiative),** MeiTy, Govt. of India, 23 – 09 – 2021 to 22 – 09 – 2024, S.B. Majumder (one of the PIs out of six PIs) 700 lakhs.

4. **Nano – electronics network for research and applications** (NNetRA Parent project), IIT, DST, and MeiTy, Govt. of India, 01 – 04 – 2018 to 30 – 04 – 2023, S.B. Majumder (Co – PI), 2966 lakh

5. **Thermal modelling and cell characterization of batteries for electric vehicles,** Math Works, Inc. USA, 01 – 05 – 2022 to 30 – 04 – 2025, Anandaroop Bhattacharyya (ME) (PI) and S.B. Majumder (Co – PI) 44.3 lakh

6. **Evaluation of Suitability of Nano Iron/Iron Oxide Powders for Energy and Sensor Applications,** CSIR – IMMT 02 – 04 – 2019 to 31 – 12 – 2022, S.B. Majumder (PI) 15.00 lakh

7. **Air Quality Monitoring Prototype,** MeiTy 01 – 04 – 2018 to 30 – 04 – 2023, S.B. Majumder (PI) 101 lakh (NNetRA initiative, individual)

8. **Air Quality Monitoring Prototype,** DST 01 – 04 – 2018 to 30 – 04 – 2023, S.B. Majumder (PI) 62.24 lakh (NNetRA initiative, individual)

9. **Development of Nanoparticle Incorporated Polymeric High Flux Hollow Fiber Nanofilteration Prototype for Desalination of Brackish Water**, MeiTy 01 – 04 – 2018 to 30 – 04 – 2023, S.De (PI), S.B. Majumder (Co-PI) 101 lakh (NNetRA initiative, individual)

10.**Development of Nanoparticle Incorporated Polymeric High Flux Hollow Fiber Nanofilteration Prototype for Desalination of Brackish Water,** DST, 01 – 04 – 2018 to 30 – 04 – 2023, S.De (PI), S.B. Majumder (Co-PI) 45.36 lakh (NNetRA initiative, individual)

11. **Development of Sodium Ion Rechargeable Coin Cell Micro-Batteries for Consumer Electronic Devices,** SERB – DST,19 – 03 – 2018 to 30 – 11 – 2021, S.B. Majumder (PI) 41.55861 lakh

12. **Development of Cheap and High Energy Density Alkali Metal - Ion Rechargeable Batteries for Renewable Energy Storage,** MHRD and Accurate Industrial Control Private Limited, Pune, 24 – 02 – 2018 to 30 – 04 – 2023 , S.Das (PI), S.B. Majumder (Co-PI), 120.9 lakh (**UAY initiative**)

13. **Development of High Energy and High Power Density Lithium Ion Battery for Under Water Application** (Project No. 5469), MHRD and DRDO, 19 – 08 – 2017 to 30 – 06 – 2022 S.B. Majumder (PI), 160.6176 lakh (**IMPRINT initiative**)

14**. Hybrid Sodium - ion Cell/Super Capacitor Packs for Light Electric Vehicles,** MHRD, Ministry of Road Transport and Highways, 08 – 02 – 2017 to 31 – 03 – 2022, S.Ghosh (PI), S.B. Majumder (Co-PI), 318.58 lakh (**IMPRINT initiative**)

15**. Sodium ion battery for energy storage: Novel electrode materials and battery management system development for integration to photo – voltaic modules,** MPV_ICG_2017_SGCIR, IIT Kharagpur, 15 – 07 – 2018 to 14 -07 – 2021, S.B. Majumder (PI) 25.0 lakh (competitive institutional funding)

16. **Development of high energy density lithium-ion rechargeable batteries for Indian Navy's relevance,** SGIRG, IIT Kharagpur, 19-06-2014 to 18-06-2017, S.B. Majumder (PI)- 25.0 lakh (competitive institutional funding)

17. **Capacity Fade and Prognostics of Advanced Li-ion Battery,** Samsung R&D Institute India, Bengaluru, Limited, 4-5-2018 to 31-3-2020, S.B. Majumder (PI), 19.68 lakh

18. **Development of Ionic Liquid Electrolyte for 5V Lithium Ion Rechargeable Cell**, NSTL, Vizag (DRDO), S.B. Majumder (PI), 9.5 lakh

19. **Development of Carbon Dioxide Sensing Module for Environmental Monitoring**, CSIR, 16-08-2016 to 30-9-2020, S.B. Majumder (PI) 21.77650 lakh.

20. **Engineered cementitious composites- A replacement of conventional concrete for sustainable infrastructure**, MHRD, 02-05-2014 to 01-05-2019, S.B. Majumder (Co-PI), Prof. Nilanjan Mitra (Civil. Engg.) (PI) 73.24 lakh

21**. Development of membrane electrode based portable e-tongue device for rapid characterization of tea,** CDAC, Kolkata, S.B. Majumder (Co-PI), Prof. B. Adhikari (PI) 40.0 Lakh

22. **Integrated project on jute ramie blended technical textiles,** National Jute Board, Kolkata, 25-10-2013 to 24-10-2015, S.B. Majumder (Co-PI), PI: Prof. B. Adhikari (Materials Science) 24.0 Lakh

23. **Development of advanced multifunctional materials for electrochemical energy devices** DST, Govt. of India, 10-07-2013 to 09-07-2016 S.B. Majumder (Co-PI) PI: Prof. A.J. Bhattacharyya (IISc. Bangalore) 36.00 lakh

24. **Industrial scale investigation for the fabrication of wear resistant ceramic tiles using NALCO coal ash** NALCO, Bhubaneswar 11-07-2013 to 10-07-2015 S.B. Majumder (PI) 50.40 lakh

25. **Development of high energy density lithium ion prismatic batteries for laptops, solar, and electric vehicles Future Hi-tech batteries limted,** Mohali 01-04-2013 to 31-3-2016, S.B. Majumder (Co-PI) PI: Prof. Sudipto Ghosh (Met. Engg.) 3.98 lakh

26. **Development of sensing element and alarm circuit module for hydrogen detection from rechargeable batteries** Naval Science and Technology Laboratory, Vizag 01-02-2012 to 31-03-2014 , S.B. Majumder (P.I) 10.00 lakh

27. **Development of novel palladium gas sensors** DST, IBSA, Govt. of India 27-04-2011 to 26-04-2014, S.B. Majumder (P.I) 16.28 lakh

28. **Development of a low cost ceramic gas sensor system prototype for monitoring the air quality of automotive cabin** NPMASS-ADA, Bangalore 1-7-2010 to 30-06-2012, S.B. Majumder (P.I) 50.00 lakh

29. **Development and production of wear resistant ceramic tiles from NALCO fly ash: An economic approach** NALCO, Bhubaneswar 12-08-2010 to 11-02-2012, S.B. Majumder (Co-PI), PI. Prof. B. Adhikari, 24.24 lakh

30. **Development of jute fibre reinforcement cement concrete** National Jute Board, Kolkata 24-03-2008 to 23-03-2011, S.B. Majumder (Co-PI), PI. Prof. B. Adhikari, 75.60 lakh

31. **Novel nano-structured ceramics for gas sensing applications** Department of Information Technology 07-08-2007 to 06-08-2010, S.B. Majumder (P.I) 30.78 lakh

32. **Wet chemical synthesis of novel cathode materials for lithium ion rechargeable batteries** CSIR, Govt. of India 01-12-2007 to 30-09-2010, S.B. Majumder (P.I) 10.46 lakh

33. **Bulk and surface modified layered-layered and layered-spinel composite cathodes for lithium rechargeable batteries** Alexander von Humboldt Foundation, Germany 01-11-2010 to 31-10-2011, S.B. Majumder (P.I) EUR 14330

Sustainable reinforcement for concrete has newly discovered benefits

January 16 2013

Fashionable people may turn up their noses at jute—the cheap fiber used to make burlap, gunny sacks, twine and other common products—but new research is enhancing jute's appeal as an inexpensive, sustainable reinforcement for mortar and concrete. The study appears in ACS' journal *Industrial & Engineering Chemistry Research*.

Subhasish B Majumder and colleagues note that there has been a resurgence of interest in using economical, sustainable natural fibers, rather than steel or synthetic fibers, to reinforce the cement compositions used to make concrete and mortar, the world's most widely used building materials. That reinforcement makes cement compositions stronger and more resistant to cracks. Their previous research showed that jute works as a reinforcement fiber.

The new study discovered another advantage of jute, which is second only to cotton as the most widely used natural fiber. The addition of jute fibers also delays the hardening of concrete and mortar, which must be trucked to construction sites. "The prolonged setting of these fiber-reinforced cement composites would be beneficial for applications where the pre-mixed cement aggregates are required to be transported from a distant place to construction site," the report states.

More information: "Effect of Jute as Fibre Reinforcement Controlling the Hydration Characteristics of Cement Matrix" *Ind. Eng. Chem. Res.*, Article ASAP. DOI: 10.1021/ie300607r

Abstract

The present investigation deals with the effect of jute as a natural fiber reinforcement on the setting and hydration behavior of cement. The addition of jute fiber in cement matrix increases the setting time and standard water consistency value. The hydration characteristics of fiber reinforced cement were investigated using a variety of analytical techniques including thermal, infrared spectroscopy, X-ray diffraction, and free lime estimation by titration. Through these analyses it was demonstrated that the hydration kinetics of cement is retarded with the increase in jute contents in cement matrix. A model has been proposed to explain the retarded hydration kinetics of jute fiber reinforced cement composites. The prolonged setting of these fiber reinforced cement composites would be beneficial for applications where the premixed cement aggregates are required to be transported from a distant place to the construction site.

Provided by American Chemical Society

Matrix reloaded

Author(s): Vibha Varshney

Issue Date: Feb 28, 2013

Adding jute fiber to cement mix can make buildings stronger

JUTE is the latest fad. It is used in everything from delicate jewellery to hardy bags. Researchers have now found one more use of the omnipresent golden fiber: as an additive in cement to strengthen it by delaying its setting. “During construction, roofs are flooded with water for as long as 28 days to strengthen the structure. Water is also sprinkled on walls for the same purpose. Addition of jute strengthens the structure further,” says Subhasish B Majumder of IIT, Kharagpur.

Majumder and his team investigated the impact of adding jute to cement and found it significantly delays hardening. According to their study, published in Industrial and Engineering Chemistry Research on January 23, this delay in hardening can allow for transport of the mixed mortar and concrete over long distances. The study shows that depending on the amount of jute in the mix, delay in setting could be as long as eight hours. This would allow for a transport of around 200 km, says Majumder.

The group had earlier shown that jute is a sustainable reinforcement material and has the potential to replace steel or synthetic fibers in cement, the most widely used building material. The fiber makes cement compositions resistant to cracks. By reinforcing cement matrix with jute fiber, the compressive and flexural strengths of the resultant mortar was increased to 9 per cent and 16 per cent respectively, as compared to the mortar specimen without jute reinforcement. This comes as an advantage in quake-prone areas, says Majumder.

The study was done to investigate how adding jute to cement mix could change its properties. This is imperative before the material can be used widely in construction. While the researchers are yet to figure out the increase in cost due to this addition of jute, their preliminary studies have shown the addition would cost Rs 40 per cubic metre of concrete.

“This natural fiber is a fantastic reinforcement material for concrete,” says one of the researchers, Basudam Adhikari. “We used the material in sewer pipes, lamp posts and railway sleepers and found that the addition of jute leads to substantial improvement in properties.”

The research work on jute reinforced cementitious composite is also featured in an article titled “**The jute way**” in the magazine Construction World on November 2013