Advanced Nanomaterials for Li-ion Batteries, Supercapacitors and Fuel Cells: Fundamentals and Applications

MHRD
Govt. of India
सत्यमेव जयते

Overview:

Increasing worldwide concerns about global warming, environmental pollution and the need for renewable energy sources motivates the application of new materials for energy conversion and storage. The understanding of the related operation mechanisms in different scales is the precondition for application and further development materials and systems. Atomistic processes must be understood and tailored to improve the efficiency and stability of materials. Moreover, sophisticated system concepts are required to ensure proper and sustainable operation of these materials.

Most promising and complementary systems for mobile and stationary applications include fuel cells, Li-ion-batteries and super capacitors. Despite having already numerous applications, these systems require a more detailed understanding for further improvements. Key issues of emerging energy conversion and storage materials include:

- High capacity and efficiency
- Materials stability, compatibility and durability
- Scalability and availability of raw materials

These issues define the objective of the course.

Objectives:

Within the proposed course, the following objectives are prioritized:

- Provision of adequate background information on the atomistic transport mechanisms in emerging materials for fuel cells, Li-ion-batteries and super capacitors which includes fundamentals on structure, electrochemical and physical properties.
- Correlation of energy conversion and storage principles with specific materials systems.
- Identification of operation limits and unsolved problems to enable further improvement of the materials for the energy conversion and storage systems.
- Discussion of scalability and of size effects upon application of nanomaterials.
- Brief presentation of state-of-the art techniques for the preparation and characterization of the above mentioned materials and of application examples for the energy conversion and storage systems.

MODULES/BRIEF SYLLABUS

A: Duration : 19th February – 28th February, 2018

B: Venue : CENTRE FOR NANOSCIENCE AND NANOTECHNOLOGY, JAMIA MILLIA ISLAMIA, NEW DELHI-110025.

NO. OF PARTICIPANTS FOR THE COURSE WILL BE LIMITED TO FIFTY.

DAY-1
(MONDAY, 19 FEBRUARY 2018)

SECTION 1: INTRODUCTION

MODULE A: FUNDAMENTALS: FUNCTIONAL MATERIALS AND NANOMATERIALS	• References: Textbooks and publications • Classification of the materials for batteries, super capacitors and fuel cells • Nanomaterials: Size effects • Materials requirements, raw materials and energy resources • Basic operation principles of batteries, super capacitors and fuel cells • Types of batteries, super capacitors and fuel cells
	DAY- 2 | Tuesday, 20 February, 2018
MODULE B: MATERIALS OVERVIEW AND KEY MATERIALS PROPERTIES	• Atomistic transport: Ionic and electronic conductivity • Reaction mechanisms and kinetics • Transport paths and mechanisms • Defect models • Materials stability and energy density

DAY-3
(WEDNESDAY, 21 FEBRUARY 2018)

SECTION 2: LITHIUM ION BATTERIES

MODULE A: THIN-FILM ALL-SOLID-STATE BATTERIES	• Layer sequences and size effects • Preparation methods • Reactions and electrochemical potentials • Brain storming session: Application fields of thin-film batteries
	Day 4 | Thursday, 22 February,2018
MODULE B: REACTION MECHANISMS IN DIFFERENT SCALES	• Solid Electrolyte Interphase • Intercalation mechanisms • Limiting transport steps • Problem solving session: Theoretical storage efficiency and ways to approach the theoretical value
	Day 5 | Friday, 23 February, 2018
MODULE C: POSITIVE ELECTRODE MATERIALS	• Layered crystal structures • Spinel structure • Olivine structure
MODULE D: NEGATIVE ELECTRODE MATERIALS	• Metallic lithium • Graphite, silicon

	• Tantalate • Molybdenum disulphide
	Day 6 | Saturday, 24 February, 2018
MODULE E: ELECTROLYTES	• Types of electrolytes • Solid electrolytes for thin film batteries
MODULE F: CHARACTERIZATION METHODS	• Calorimetry including thin-film calorimetry for nanoscaled films • Cyclovoltammetrie • Galvanic cycling

DAY 7
(SUNDAY, 25 FEBRUARY, 2018)

LABORATORY VISIT

DAY 8
(MONDAY, 26TH FEBRUARY, 2018)

SECTION 3: SUPER CAPACITORS

MODULE A: TYPES AND MATERIALS FUNDAMENTALS	• Types of super capacitors • Key materials properties and requirements • Operation concepts, materials systems and fabrication technologies • Space charge and double layers
MODULE B: MATERIALS	• Electrolyte and electrode materials • Carbon, carbon fibres and graphene • Metal oxides • Brain storming session: Applications of different super capacitor materials and research directions

DAY 9
(TUESDAY, 27 FEBRUARY, 2018)

SECTION 4: FUEL CELLS

MODULE A: TYPES, CONCEPTS AND MATERIALS	• Types of fuel cells: Solid oxide fuel cells, polymer electrolyte fuel cells etc. • Nanoscaled components • Fuel reforming • Fabrication technologies • Characterization methods
MODULE B: REACTIONS AND LOSSES	• Triple phase boundary • Transport mechanisms and losses

	• Efficiency
MODULE C: ELECTROLYTES	• ZrO_2 based materials • Dopants and transport mechanisms • Alternative electrolytes: Fluorite structure, perovskites • Problem solving session: Operation limits of the electrolytes
MODULE D: CATHODES AND ANODES	**Day 10 | Wednesday, 28th February, 2018** • Mixed ionic-electronic conductors • Cermets • Nanoscaled electrode layer sequences
YOU SHOULD ATTEND IF	• You are an engineer or researchers from manufacturing, service and government organizations including R&D laboratories. • You are a materials scientist, physicist or chemist interested in the basics and applications of new energy technologies. • You are a student or faculty from academic institution interested in learning how to do research in the fields of Li-ion batteries, supercapacitors and fuel cells.
FEES	The participation fees for taking the course is as follows: Participants from abroad : US $500 Industry/ Research Organizations: Rs.25000/- Academic Institutions: Rs.5000/- Students/Scholars: Rs. 2000/- The above fee include all instructional materials, computer use for tutorials and assignments, laboratory equipment usage charges, 24 hour free internet facility. The participants will be provided with accommodation on payment basis.
REGISTRATION	The participants should register on the following link: http://www.gian.iitkgp.ac.in/GREGN/index

The Faculty:

Prof. Holger Fritze is in the faculty of Clausthal University of Technology (TUC), Germany. His research interests include high-temperature functional materials for fuel cells, gas sensors and micro-sensors as well as active materials for batteries.

Prof. Dr. habil. Holger Fritze
Technische Universität Clausthal (TUC)
Institut für Energieforschung und
Physikalische Technologien
and Energie-Forschungszentrum
Niedersachsen
Am Stollen 19B, 38640 Goslar, Germany
E-mail: holger.fritze@tu-clausthal.de

Dr. Manika Khnauja has obtained her M.Sc (Physics) and Ph.D. (Physics) from Indian Institute of Technology Delhi, India. She worked as a Guest-Scientist in University of Duisburg-Essen, Germany. Her area of research includes thin film deposition, nanomaterials synthesis by physical and chemical routes for various applications including photocatalysis, photocatalytic water splitting, hydrogen sensors and fuel cells.

Course Coordinator:

Dr. Manika Khanuja (Assistant Professor)
Centre for Nanoscience and Nanotechnology
Jamia Millia Islamia, Jamia Nagar,
New Delhi-110025

E-mail: manikakhanuja@gmail.com
mkhanuja@gmail.com
Mobile: 91-9810076796