

MINISTRY OF EDUCATION SPONSORED GIAN COURSE



शिक्षा मंत्रालय
MINISTRY OF
EDUCATION



INTRODUCTION TO CHARACTERIZATION OF MATERIALS (Online Mode)

Organized by
Department of Chemistry,
Maulana Azad National Institute of Technology (MANIT)
Bhopal 462 003

Overview

Materials – and the science and technology that allow us to understand them - are increasingly central to human society. Whether these are the **structural materials** – metal alloys, ceramics, plastics, composites – employed in the buildings, vehicles and consumer goods that surround us or **functional materials**, whose specific optical, magnetic, electrical or chemical properties are designed for specific applications in e.g. information technology, lighting, electric vehicles or renewable energy systems, it is essential that we understand the link between the nature of these materials and their intended use. The **characterization of materials** is key to allow us to do this.

When we synthesise a new material or analyse an existing one we need to ask “What is it?”. The answer has many parts on many levels. Is the material a single phase or a mixture of phases? Are these phases crystalline or amorphous? Are they composed of atoms, ions or molecules? What crystal structures do the crystalline phases have? What is the spatial relationship between the different phases? Is the material made up of crystalline particles or is it a dense material made up of grains? What size and shape (morphology) are these particles and grains? Which elements - and how much of each - are present in each phase (i.e. what are their chemical compositions)? In which oxidation state are these elements? What kind of bonding are they involved in? What are their coordination numbers? Which atoms or ions are their nearest neighbours (i.e. what is their local chemical environment)? Are the structure and composition of the material the same at the surface as in the “bulk”? We can use a wide range of characterisation techniques to provide the different parts of the answer. In this course we will look at the most important of these, learn about their operating principles, how they are used in practise and what useful information can be obtained from them. They will include **Diffraction Techniques** (X-ray, Neutron and Electron); **Spectroscopy** (Electronic, Magnetic, X-ray, Vibrational); **Microscopy** (Scanning and Transmission Electron, Scanning Probe Atomic Force); **Thermal Techniques** (Changes in mass, length, energy *etc.* with changing temperature).

Objectives

Participants will gain a detailed understanding of the underlying principles, operating procedures, benefits and limitations of a large number of key materials characterization techniques. Case studies will be shared to illustrate the lecture and stimulate research motivation of the participants. After taking the course, participants should have a good understanding of which technique or set of techniques is most appropriate for gaining the information they need about the materials they synthesise or analyse in their studies or professional work.

Program Dates: 4th December (Monday) to 8th December (Friday) 2023

Participant's Eligibility

The course will be suitable for undergraduate, postgraduate and research students, postdoctoral researchers, academic faculty, industrial scientists and engineers of any discipline.

How to Apply

All interested applicants must register themselves on GIAN portal (<https://gian.iitkgp.ac.in/GREGN/index>) before **15th November 2023**. An e-mail for the interest in participation may also be sent to ijalmittal@gmail.com.

There is no participation fee to attend the course.

The course shall be held through the online mode. Total number of seats are limited to 225 (Two Hundred Twenty Five Only). The communication platform, accessing details etc. will be intimated to all selected applicants by **25th November 2023**.

Lecture Overview (Timings 01.30 PM to 5.00 PM)

Day 1	Opening Ceremony	
04.12.2023 (Monday)	Lecture – 1	Introduction to Materials
	Lecture – 2	Review of Solid State Structure and Principles Of Diffraction
Day 2 05.12.2023 (Tuesday)	Lecture – 3	Powder and Single Crystal X-Ray Diffraction
	Lecture – 4	Neutron Diffraction
	Lecture – 5	Scanning Electron Microscopy (SEM)
Day 3 06.12.2023 (Wednesday)	Lecture – 6	Transmission Electron Microscopy (TEM) and Electron Diffraction
	Lecture – 7	X-Ray Emission and Absorption Spectroscopies [X-Ray Fluorescence Spectroscopy (XRF), Energy Dispersive & Wavelength Dispersive Spectroscopy (EDS, WDS)]
	Lecture – 8	X-Ray Absorption Near Edge Spectroscopy (XANES), Extended X-Ray Absorption Fine Structure (EXAFS); Electron Spectroscopies [X-Ray Photoelectron Spectroscopy (XPS), Electron Energy Loss Spectroscopy (EELS)]
Day 4 07.12.2023 (Thursday)	Lecture – 9	Solid State Nuclear Magnetic Resonance (NMR) Spectroscopy
	Lecture – 10	Infra-Red, Raman And UV-Visible Spectroscopy Applied To Materials Analysis
	Lecture – 11	Thermal Analysis Methods: Dilatometry, Thermogravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC)
Day 5 08.12.2023 (Friday)	Lecture – 12	Differential Thermal Analysis (DTA); Atomic Force Microscopy (AFM)
	Q & A Session	Discussion on the course with participants Participant's Feedback & Closing Ceremony
	Meetings with interested faculty to explore collaborative opportunities	

*15/30 minutes break between lectures

Guest Faculty



Dr Richard Baker is a member of faculty at the University of St Andrews, where he has worked since 2005. He holds a PhD in Chemical Engineering and Chemical Technology from Imperial College, London. He has published over 70 research articles, reviewed for a dozen international journals and made over 25 keynote or invited presentations. He was Editor, Secretary/Treasurer and then Chair of the Electron Microscopy and Analysis Group of the Institute of Physics.

He has very considerable experience, over 25 years, of teaching and research in fuel cell science and technology. His research has focused on Solid Oxide Fuel Cells (SOFCs) which are completely solid state devices based on ceramic electrolytes which are good conductors of O^{2-} ions. SOFCs are able to use a wide range of fuels, including biofuels, and, if the excess heat from the SOFC is utilised, efficiencies of up to 80% can be attained (cf. internal combustion engine: 25%). Recent projects have improved conductivity of ceria-based electrolytes, developed new anode materials for use with challenging biofuels and studied proton-conducting ceramics in a novel electrochemical reactor for combined chemicals synthesis and electrical power generation. Dr. Baker has already conducted a GIAN course on the Fuel Cells. He is also Principal Investigator of a Government of India funded SPARC project with Dr. Jyoti Mittal and her colleagues at MANIT, Bhopal.

Host Faculty



Dr. Jyoti Mittal is working as Assistant Professor in the Department of Chemistry at Maulana Azad National Institute of Technology, Bhopal and possesses a long academic and research experience. She has received distinction to become 'Clarivate Analytics Highly Cited Researchers of the Year 2018' and amongst only 10 Indian Researchers out of top 4000 most influential Scientists of the World IN THE YEAR 2018. She has published more than 60 research papers in the journals of high impact and authored several books. Her papers have been cited more than 10800 times and her present h-index is 41. Dr. Mittal obtained Ph.D. degree from RGPV, Bhopal in the thesis related to environmental issues.

She has also been an alumnus of the University of Roorkee (Presently, I.I.T., Roorkee) and obtained M.Sc. (Analytical Chemistry) and M.Phil. (Industrial Methods of Chemical Analysis) degrees from there. She also contributes her expertise as reviewer for many international journals of environmental field and has guided/guiding Ph.D.s on the topics related to environmental problems. Her research field focuses on the removal of various inorganic and organic pollutants, like metal ions, dyes etc. from wastewater through adsorption and photocatalytic degradation.

For any information contact: Dr. Jyoti Mittal, e-Mail: jyalmittal@gmail.com