Approved in 44th BoA Meeting (24-11-2021)

Course number : EN 512
Course Name : Structure-Property Correlations for Energy Applications
Credit Distribution: *1-0-4-3*
Intended for : UG/PG (Compulsory for MTech. in Materials and Energy Engineering, and Elective for others)
Prerequisite : IC241 (Materials Science for Engineers)/ Instructor Consent
Mutual Exclusion: None

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1. Preamble:

The goal of this course is to understand the structure of materials at different scales and correlate the observed properties particularly in the context of design of materials for application in energy systems. The introduction of various characterization tools will play instrumental role in understanding and application of materials for energy domains. The course will provide a basic overview of materials characterization techniques employed for structural, microstructural, thermal, mechanical, and electrical property determination. Suitable preparation and processing method /heat treatment will be employed to bring out the effect of processing on structure-property correlation in energy materials. Finally, students will be made to use computational tools (such as origin / gnuplot / matlab) for dealing with raw data and doing the analysis themselves to strengthen their understanding and skills.

2. Course Modules with quantitative lecture hours: [14 Hours]

Module – 1: Introduction to energy materials; photovoltaics, electrochemical systems, thermoelectrics, solar thermal systems. Importance of materials characterization (2 hours).

Module – 1: Structure of Materials – Crystal structure, micro-structure, and macrostructure; Determination of crystal structure by diffraction, X ray diffraction and electron and neutron diffraction; Vibrational spectroscopy (IR and Raman spectroscopy) for structural characterization of materials. (4 Hours)

Module – 2: Microstructure determination by light, and electron microscopy (SEM and TEM); binary alloys and distribution of phases in microstructure. (2 Hours)

Module – 3: Thermal analysis by TGA-DSC; Determination of enthalpy, melting, decomposition and phase transition temperatures. (2 Hours)

Module – 4: Mechanical property determination by indentation and tensile test, Stress-Strain diagram (2 Hours)

Module-5: Basics of electronic band structure, Electrical and optical properties of energy materials, determination of bandgap, Absorption (UV-Vis), emission (Photoluminescence)

(2 Hours)

Laboratory/practical/tutorial Modules: [42 Hours]

Structural Characterization (Module-1):

1. Preparation and processing of specimen and structural characterization using XRD,Determination of crystal structure by X-ray diffraction in a diffractometer
2. Preparation and processing of specimen and structural characterization using FT-IR,and Raman spectroscopy

Microstructural Characterization (Module-2):

3. Preparation and processing of specimen and observation of microstructure in singlephase alloy under optical microscope, scanning electron microscope
4. Preparation and processing of specimen and observation of microstructure and electrondiffraction using transmission electron microscope

Thermal Characterization: (Module-3):

5. Preparation and processing of specimen and thermal characterization using TGA-DSC
6. Thermal conductivity measurement

Mechanical Characterization (Module-4):

7. Preparation and processing of specimen and characterization of mechanical propertyusing tensile test UTM
8. Preparation and processing of specimen and elastic modulus as well as hardnessmeasurements by indentation method.

Electrical and Optical Characterization (Module 5):

9. Preparation and processing of specimen and characterization of Current voltage measurement, electrical conductivity, opto-electrical property.
10. Preparation and processing of specimen for Absorption (UV-Vis), emission (Photoluminescence/fluorescence) spectroscopy and determination of band gap.

3. Text books:

- Robert E Reed-Hill and Reza Abbaschian, Physical Metallurgy Principles, Thomson, 2003reprint.
- R. E. Hummel, Electronic Properties of Materials, Springer, 4th ed. 2011

4. References:

- Mauro Sardela, Practical Materials Characterization, Springer New York, 2014
- A.R. West, Solid-State Chemistry and Its Applications, Wiley, 2014

5. Similarity with the existing courses:

(Similarity content is declared as per the number of lecture hours on similar topics)

S. No.		Course Code	Similarity Content	Approx. % of Content
1.	Structure - Property correlation inmaterials for Energy Application s	EN612	Crystal structure,micro-structure andmacrostructure; Determination ofcrystal structure by X-ray diffraction and Determination ofcrystal structure by X-ray diffraction in a diffractometer	<10%

6. Justification of new course proposal if cumulative similarity content is >30%: None