ESE-904 Synthesis and Analytical Characterization of Advanced Energy Materials/

Educational Objectives

1. The objectives of the course are as under:
   a. To create awareness among students and comprehend their knowledge-base on variety of techniques currently being used by R&D/industrial community for synthesis/development of materials for energy production/conversion, etc.
   b. To mainly focus on intelligent synthesis of energy materials through nanotechnology routes along with blend of conventional processes.
   c. To discuss the instrumentation, working principles, and capabilities of various probes based on photons, electrons, and ions for structural and chemical analyses, etc.
   d. To know and to use various probes for transport properties such as electrical characterization, optoelectronic performance, etc.
   e. To provide the students with the advanced academic background necessary to contribute effectively to technically demanding projects in the field of energy efficient materials.

Course Contents

2. Contents with suggested contact hours

No.	Topics	Contact Hours
a.	Introduction about functional materials used in various energy devices such as solar cells and fuel cells etc.	2
b.	Crystal structures and defects	3

c.	Synthesis of energy materials
	• Solid state reaction method
	• Wet chemistry routes
	  • Sol-gel
	  • Co-precipitation
		10

	• Hydrothermal method • Glycine nitrate process • Deposition based synthesis processes • Physical vapor deposition • Chemical vapor deposition • Plasma spraying • Spray pyrolysis • Dip coating • Spin coating	
d.	Properties of energy materials • Physical • Thermal • Mechanical • Electrical • Chemical	5
e.	Characterization of energy materials • X-ray diffraction • Analytical imaging of energy materials • Optical microscopy • Scanning electron microscopy • Transmission electron microscopy • Focused ion beam microscopy • Chemical characterization and elemental analysis of energy materials • Energy dispersive X-ray spectroscopy • X-ray photoelectron spectroscopy • Auger electron spectroscopy • X-ray fluorescence • Thermal Characterization of energy materials • Differential thermal analysis • Thermal gravimetric analysis	25

	• Dilatometry (Thermal expansion)
	• Electrical Characterization of energy materials
	  • Electrochemical impedance spectroscopy
	  • Cyclic voltammetry
	  • I-V characteristics
	  • Two-probe and four-probe method to determine resistivity/conductivity
	• Raman spectroscopy
	• Spectrophotometry (UV/Visible/IR)
	• Surface area (BET), particle size and porosimetry
	• Measurement of strength, toughness and hardness	

		45

Outcomes

3. The students will be given broad flavor of various analytical and quantitative characterization techniques employed for the study of energy materials.

4. **Recommended Reading (including Textbooks and Reference books).**

No.	Title	Author(s)	Books
a.	The Physical Chemistry of Materials: Energy and Environmental Applications, CRC Press	Rolando M. A. Roque-Malherbe	Text
b.	Fundamentals of Mat. Science and Engineering	Donald Askeland and Pradeep Phule	Text
c.	Fundamentals of Solid	ManijehRazeghi	Text

	State Engineering, 3rd Edition, Published by Springer		
d.	Fundamentals of Semiconductors: Physics and Materials Properties, 4th Edition, Published by Springer	Peter YU, Manuel Cardona	Ref
e.	Ceramic Processing and Sintering, 1995	M. N. Rahaman	Ref
f.	Advanced Characterization Techniques for Thin Film Solar Cells	Daniel Abou-Ras, Thomas Kirchartz, Uwe Rau, Wiley-VCH	Text
g.	Handbook of Physical Vapor Deposition Processing, Published by Elsevier Inc. 2010	Donald M. Mattox	Text
h.	Electronic properties of materials	R.E. Hummel	Ref
i.	Materials Science of thin films	Milton Ohring	Ref
j.	Introduction to physical metallurgy	Avner	Ref
k.	Physical methods in materials characterization	Flewit and Wild	Text
l.	Critical Materials Problems in Energy Production	Stein	Ref