ME/MS 781: ADVANCED ELECTROCERAMICS

Course Description:

This course will explore the structure property relationships and phenomena in ceramic materials used in electronic, dielectric, ferroelectric, magnetic, and electrochemical applications. In particular we will discover how to functionalize a component for a particular application - a capacitor, a thermistor, actuator, or a fuel cell. Such a discovery process demands an in-depth understanding of the roles and interrelationships between the crystal structure, point defect chemistry, microstructure, and texture in such materials. Statistical thermodynamics, quantum mechanics, and solid mechanics principles will be used as and when necessary in the course. The course is intended to fit in the space and act as a bridge between solid state theory where the emphasis is largely on theory, and a ceramic materials course where the emphasis is largely on processing.

Course Schedule:

Mon, Wed 10 AM – 12 PM @ EPC 204

Instructor Information:

Prof. Srikanth Gopalan
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Division of materials Science and Engineering
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(617) 358-2297

Instructor Office Hours: Tue 1- 3 PM

Textbooks:

No textbooks required but the following books will be used as references for many of the topics; written handouts will be provided from time to time. Much of the material will be directly from seminal papers in the field.

1. L.L.Hench and J.K.West, "Principles of Electronic Ceramics", 1990, John Wiley & Sons

2. A.J.Moulson and J.M.Herbert, "Electroceramics", 2008, John Wiley & Sons

3. D.M.Smyth, “The Defect Chemistry of Metal Oxides”, Oxford University Press 2000.

Pre-requisites:

MS/ME 505 and MS/ME 503 or equivalent.
It might be useful to have taken MS/ME 545 and/or MS/EE 577 but not essential.

Goals:

The goals of the course are to provide an in depth exploration into the electrochemical, electronic and magnetic properties of ceramic materials and to discuss the wide range of conduction, polarization, and multiferroic phenomena exhibited by ceramic materials. Another goal of the course if to show how these rich variety of phenomena can be exploited in useful devices like fuel cells, sensors, piezoelectric transducers and actuators.

Course Outcomes:

1) Know the relationships between ceramic structure (structure encompasses electronic, microstructural, and defect structure) and the wide variety of phenomena they display.
2) Learn how these variety of phenomena can be exploited in useful applications like fuel cells, sensors, and piezoelectric transducers.
3) Be able to access current research in electrochemical, electronic, and magnetic ceramics.

Course Topics:

1) Defects Chemistry in Ceramics
2) Electrical Conduction
3) Charge Displacement and Polarization Processes
4) Ceramic Varistors and Capacitors for Energy Storage
5) Electrochemical Ceramics: Fuel Cells and Potentiometric and Amperometric Sensors
6) Piezoelectric Phenomena
7) Ferroelectricity and Ferroelasticity
8) Electro-optic Phenomena in Ceramics
9) Magnetic Phenomena in Ceramics

Assessment:

1) 4 assignments worth a total of 20%
2) One midterm take home exam worth 35%
3) One final (in class) worth 35%
4) Class participation 10%