155:555 **Chemical Engineering of Advanced Materials** Fall 2018

Lectures: Monday, 5 p.m.- 8 p.m., Eng-C115

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Office Hour: Mon. 3:00-4:00 pm

Course Description: Students will learn advanced materials, i.e., materials utilized in high technology applications. Emphasis is placed on the relationships between the structure, which is controlled by processing, and the properties of advanced materials. Both soft matter, cutting-edge materials evolving daily, and traditional hard matter will be covered.

Course Objectives: In this course, students learn how to apply knowledge of the laws of chemistry, physics, and engineering to analyze and solve physical and chemical problems encountered in advanced materials. The course gives the student the opportunity to analyze and interpret data, to identify, formulate, and solve engineering problems, and to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Students will be introduced to the advanced materials and will learn the microstructures of advanced materials. Students will learn properties of advanced materials made under the given processing conditions. Students will be introduced to soft matter, cutting-edge materials, in addition to hard matter, widely used for high-tech applications.

Goals: The objective of this course is to introduce students advanced materials, both traditional and modern, which have been utilized in high-tech areas.

Knowledge, Abilities, and Skills Students Should Gain From This Course: 1. The students should understand the ordered (crystalline) structures and apply them to understand the structure and properties of advanced materials. 2. The students should be able to apply thermodynamics and kinetics to understand the structure of advanced materials produced under the given processing conditions. 3. They should understand the disordered (amorphous) structures and apply them to understand some advanced materials, such as amorphous metals and polymer melts. 4. They should be able to derive diffusion relationships using Fick's laws and a random walk model.

Impact on Subsequent Courses in Curriculum: This is the first in a sequence of material courses for obtaining a Certificate in Advanced Materials, offered by the Chemical and Biochemical Engineering Graduate Program. Students completing 155:555 will be able to take various material courses, both in CBE and other departments, to satisfy the requirements for the Certificate.

Reference Books (also review articles in professional journals)

Introduction to Soft Matter: Polymers, Colloids, Amphiphiles, and Liquid Crystals, I.W. Hamley, John Wiley, New York (2000).

An Introduction to Transport Phenomena in Materials Engineering, D.R. Gaskell, Macmillan (1992).

Advanced Materials: Manufacturing, Physics, Mechanics and Applications, I.A. Parinov, S. Chang, V.Y. Topolov, Springer (2016).

Chemistry of Advanced Materials, L.V. Interrante, M. J. Hampden-Smith, Wiley-VCH (1998).

Springer Handbook of Electronic and Photonic Materials, S. Kasap, P. Capper, Springer (2006).

Nanostructured Materials and Nanotechnology, H.S. Nalwa, Academic Press (2002).

Nanostructures and Nanomaterials, 2nd edition, G. Cao, Y. Wang, World Scientific (2011).

Physical Chemistry of Semiconductor Materials and Processes, S. Pizzini, Wiley (2015).

Smart Materials and Structures, E. Carrera, M. Cinefra, F. Miglioretti, Trans Tech Publishers (2013).

Polymer Liquid Crystals: from Structures to Applications, A.A. Collyer, Elsevier Applied Science (1992).

Assessment:

First Exam (10/22): 35 %
Term Paper (Presentation) (12/3): 30 %
Second Exam (12/10): 35 %

Course Contents:

0. Introduction and Overview

1. Traditional Advanced Materials

   Crystalline and Amorphous Structures
   Metals and Ceramics
   Elastic and Plastic Behavior of Crystalline Materials
   Polymers and Composites (rubber elasticity)

2. Transport Properties of Materials

   Diffusion in Materials [Macroscopic view]
   Random Walk and Brownian Motion [Microscopic view]

3. Modern (Newly developed) Advanced Materials

Modern Polymer Synthesis (Living Radical Polymerization)
Novel Metals (Amorphous Metals) and Viscoelasticity/rheology
Nanomaterials made from Colloids
Nanomaterials made from Block Copolymers and Amphiphiles
Advanced Carbon Materials (Carbon Nanotubes, Graphene)

4. Mis.

Smart Materials
Plasmonic and Photonic Materials
Compound and Wide Band Gap Semiconductors