MSE 4004 Materials in Electronic Applications (required)

Catalog Description: (3-0-3)

Basics of photolithography, screen printing, tape casting and other film deposition methods. Requirements for fuel cells, magnetic nanocomposites,, flatpanel displays, gas sensors, piezoelectric actuators, photonic crystals, etc.

Suggested References:

1. Marc J. Madou, "Fundamentals of Microfabrication," CRC Press Inc., 2nedition, 2005
2. A.J.Moulson and J.M. Herbert "Electroceramics: Materials-Properties-Applications", Chapman & Hall, 2003;
3. James W. Mayer and S.S. Lau, "Electronic Materials Science: For Integrated Circuits in Si and GaAs" Macmillan Publishing, 1990;
4. S.O. Kasap, "Principles of Electrical Engineering Materials and Devices," McGraw-Hill Book Company, 2nd edition, 2001.

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Topics Covered:

1. Electronic material classes, crystal structures & defects in electronic materials
2. Tape casting, screen printing, single crystal growth methods, combinatorial methods, colloidal synthesis methods, physical and chemical vapor deposition methods, molecular beam epitaxy, pulsed laser deposition, wet and dry chemical etching, FIB, ion milling.
3. Photolithography, mask design and pattern deposition. Soft lithography methods such as microcontact printing, dip pen nanolithography, nano-imprint lithography.
4. Basics of integrated circuit component fabrication and design. To develop an understanding of how materials are integrated into electronic devices.
5. To learn to determine the corresponding structure-property-processing relationships as a function of composition, microstructure and patterning.
6. Materials requirements for gas sensors, fuel cells, solar cells, LEDs and displays for TVs, ssmart phones, etc..Piezoelectric devices and magnetic storage devices.
7. Scaling issues and packaging challenges.

Course Outcomes:

Outcome 1: The student will develop a basic understanding of the importance of nanotechnology in the development of modern electronic devices.
Outcome 2: The student will demonstrate a working knowledge of the different patterning methods for making the majority of electronic devices as well as learn what material types are used with each method.
Outcome 3: The student will become proficient with the basic mechanisms operative in electronic materials and the meaning of band gaps and charge carrier generation, transfer or recombination.

Outcome 4: The student will learn the concepts of bandgap and defect engineering in order to successfully design a desired composition for a given application.
Outcome 5: The student will learn the importance of material interfaces and their effect on the resultant properties of the materials and devices.
Outcome 6: The student will learn the importance of crystalline perfection and the differences between textured films, epitaxial films and polycrystalline films as well as amorphous materials.
Outcome 7: The students will learn about direct and indirect piezoelectric effect and its relationship to ferroelectricity and electrostriction and their use in non-volatile memory devices, actuators and sensors.
Outcome 8: The student will understand the differences between metallic, semiconducting, ionic, superconducting and insulating materials and their use in the appropriate devices.
Outcome 9: The students will learn to draw from the current literature and become quickly proficient on a given contemporary processing, device design or composition and be able to explain it to the rest of the class.

Correlation between Course Outcomes and Student Outcomes:

Course Outcomes	**Student Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1. Nanotechnology impact on our everyday lives	x				x	x			x	x	x
2. Steps needed to deposit a pattern using one of various deposition methods (i.e. photolithography, screen printing, nanoimprint lithography, etc.	x	x	x	x		x				x	x
3. Understand the mechanism differences between an LED and a solar cell.	x		x	x		x					x
4. Effect of composition on the electrical, optical and or magnetic response of a given compound.	x	x	x	x		x			x		
5. Effect of microstructure on the electrical, optical and or magnetic response of a given material or device.	x		x		x			x	x		
6. Describe why single crystals and high quality thin films are needed for fabricating many devices.	x	x	x	x		x			x		x
7. Requirements to achieve piezoelectricity.	x		x	x		x					
8. Be able to determine the difference between an electronic, ionic or mixed conductor	x			x		x				x	
9. Write a term paper and give a presentation on a contemporary topic					x	x	x	x	x	x	
Entire Course	**3**	**2**	**3**	**3**	**1**	**3**	**1**	**1**	**2**	**2**	**2**
0 = None or insignificant; 1 = Some; 2 = Moderate; 3 = Strong											

MSE School of Materials Science and Engineering Student Outcomes:

(a) an ability to apply knowledge of mathematics, science and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.