MSE 6010 – Principles of Functional Materials

School of Materials Science and Engineering
Georgia Institute of Technology

Spring 2017

Course Objective	To introduce fundamental principles important to functional materials, including energy band structure, charge and mass transport, electrical polarization, and magnetization; chemical, thermal, electrical, mechanical, and optical interactions in solids; and electrical characterization techniques.
Instructor	Meilin Liu
Lecture	**10:05 – 10:55** MWF
Office	Room 258 Erskine Love Building
Phone	404-894-6114
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Office Hours	4 - 5:00 M W F or by appointment
Teaching assistant	Lei Zhang (Rm 256)
Office Hours	To be determined
e-mail	Lei Zhang <sjtuzhanglei@gmail.com>
Prerequisite	Graduate standing; Basic knowledge of structure and defects of materials
Homework	Homework will be assigned periodically and collected (but not graded) to assess the level of understanding. Solutions will be posted after homework is collected.
Exams/grading	Exam 1 30% Exam 2 30% Final exam 40%

References

1. S. O. Kasap, Principles of Electronic Materials & Devices, McGraw-Hill, 3nd Edition, 2007
2. Y. M. Chiang, D. Birnie, and W. D. Kinggery, Physical Ceramics, Wiley, 1997
3. Kwan Chi Kao, Dielectric Phenomena in Solids, Elsevier, 2004
4. B.N. Figgis & M.A. Hitchman, *Ligand Field Theory and Its Applications*; Wiley-VCH, 2000
5. M. A. White, Properties of Materials, Oxford, 1999
6. R. C. Buchanan, ed., Ceramic Materials for Electronics, M. Dekker, 2nd Edition, 1991
7. T. Ikeda, Fundamentals of piezoelectricity, Oxford, 1990
8. L. Solymar and D. Walsh, Electrical Properties of Materials, 6th Ed., Oxford, 1998
9. Jean-noel Chazalviel, Coulomb Screening by Mobile Charges – Applications to Materials Science, Chemistry, and Biology, Birkhauser, 1999.

* Lecture notes

Class Schedule (MSE 6010)

Lecture #	Date	Topics	Ref
		Point Defects	1,2,4,5
4 weeks	Jan 9 to Feb 3	Defect Notations Equilibrium Defect Concentrations Defect Reactions Mass-Action Law/Electroneutrality approximation Ionic and Electronic Disorders in materials Brouwer's Approximation Non-stoichiometry: Solid-Gas Interactions Effect of Doping: Donors and acceptors Temperature Effect Charged Surfaces & Space Charge Region, Complex Defects	
	Feb-6	**Exam 1: Point Defects**	**??**
		Transport of Mass, Charge, and Energy	*,2,3
4 weeks	Feb 8 to Mar 6	Irreversible Thermodynamics Phenomenological transport Equations Definition of transport properties/coefficients Electrical conduction, The 4-probe measurements, Hall effect Chemical diffusion; Nernst-Planck-Poisson system Relaxation of a single kind of species: Diff. and dielectric relaxation Relaxation of two kinds of species - Ambipolar diffusion Mobility of minority carriers Haynes-Shockley Experiment Microscopic transport mechanisms	
		Thermoelectricity	*,2,3
2 weeks	Mar 8 to Mar 20	Thermal conduction Thermoelectricity Thermoelectric power Peltier heat, Thomason heat Thermoelectric cooler Thermoelectric generator	
	Mar 22	**Exam 2: Transport and Thermoelectricity**	
		Dielectric Properties	*,3,5,6
5 weeks	Mar 24 to Apr 28	Concept of electrical polarization Electrical polarization in a static field Electrical polarization in an alternating field Polarization mechanisms Resonance spectra Relaxation spectra Concept of impedance spectroscopy Impedance functions Equivalent circuit approximation Wagner-Maxwell model Interfacial polarization Piezoelectricity Ferroelectricity & pyroelectricity Ferroelectric materials Applications	
	Apr ??	**Final Examination** (??: **11:30-2:20**)	

* Lecture notes