MSE 8803E – Materials for Energy Storage and Conversion

School of Materials Science and Engineering
Georgia Institute of Technology

Spring Semester 2016

Course **Objective**	To provide students with a fundamental understanding of the scientific principles and new strategies to transfer, capture, and store energy derived from various resources (e.g., solar, wind, geothermal, and biomass), the latest developments, and the materials challenges for energy storage, conversion, and harvesting; to emphasize guidelines for rational design of new materials for a clean and secure energy future
Lecture	**4:35-5:55** pm Tuesdays and Thursdays in **Instr. Center 119**
Instructor	Meilin Liu and Chris Summers
Office	Love 258
Phone	894-6114
E-mail	meilin.liu@mse.gatech.edu; chris.summers@mse.gatech.edu
	M W F 2-3
Office Hour	TBD
Teaching assistant	TBD
Homework	Problems will be assigned periodically and solutions will be posted a week later. Homework will not be collected or graded.
Exam/grading	2 Exams*, 30% each Exam 1 – Electro-physical energy storage/conversion Exam 2 – Electro-chemical energy storage/conversion 1 Term Paper 40% Design of a novel energy storage/conversion device *Exams are *optional* for *non-engineering/science* students, whose grade may be based mainly on a Term Paper.

References

1. Lecture notes – to be distributed in class
2. R. A. Hinrichs and M. H. Kleinbach, **Energy: Its Use and the Environment**, 2005
3. D. R. Lovett, **Tensor Properties of Crystals**, 1999; QD 911.L69
4. J.F. Nye, **Physical Properties of Crystals**, Oxford, Third Edition, 2001.
5. T. Ikeda, **Fundamentals of piezoelectricity**, Oxford, 1990.
6. E. Subbarao, ed., **Solid Electrolytes and Their Applications**, Plenum, 2nd Ed., 1991- QD 565. S665
7. R. P. O'Hayre et al., **Fuel Cell Fundamentals**, 2009
8. Robert A. Huggins, **Advanced Batteries: Materials Science Aspects**, 2008
9. Additional references on **solar** energy to be given later

The references with call numbers are available from the library and will be placed on a 2-hour reserve in the Library.

MSE 8803E: Topical Outline

# of Lectures	Date	Topics	Ref
		Introduction	1,2,3
2 wks	**Jan 12-21**	Global energy issues; Materials science to transcend energy challenges; Materials for energy transformation processes Introduction to Thermodynamics/Kinetics/Crystallography	
		Electro-physical Energy Storage & Conversion	*,1,2,3,4
4 wks	Jan 26 to Feb 18	Introduction to anisotropy and tensors Thermodynamic formulation of physical interactions: Thermal, mechanical, electrical, & magnetic interactions Piezo-, pyro-, & ferro-electricity Electro-physical energy transformation processes Materials challenges for piezoelectric generators and capacitors; the latest developments in new materials	
1 wk	Feb 23 to Feb 25 **Mar 1**	Thermoelectricity: Transport of Charge and heat Thermoelectric Phenomena Materials challenges for thermoelectric generators **Exam 1: Electro-physical energy storage/conversion (30%)**	1,2,4,5
		Electrochemical Energy Storage & Conversion	1,6,7
5 wks	Mar 3 to Apr 7 **Apr 12**	Solid-state ionics and ionic conductors Electrode processes and electrode materials **Fuel cells**: SOFCs and PEM fuel cells **Batteries**: Li-ion and Li-air batteries **Electrochemical Capacitors** Mixed ionic-electronic conductors (MIECs) for **hydrogen production** and **fuel reformation** Materials challenges for electrochemical energy **Photo-electrochemical solar cells** Fundamentals of photo-electrochemical processes Materials challenges, Recent developments of novel materials **Exam 2: Electrochemical energy storage/conversion (30%)**	
		Materials for Solar Energy Conversion (CS)	1
2 wks	Apr 14 To Apr 26	Fundamentals of photovoltaic materials Thin-film cells Multijunction photovoltaic cells Materials challenges for high-efficiency solar cells Latest development in new materials	
	Apr 18	**Term Paper (40%)**	