MSE 8803 E– Materials for Energy Storage and Conversion

School of Materials Science and Engineering
Georgia Institute of Technology

Fall Semester 2021

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 design of new materials for a clean and secure energy future
Lecture	**3:30-4:45** pm Tu Th in **MRDC 3403**
Instructor	Meilin Liu, Zhitao Kang, Chaitanya Deo
Office	Love 258
Phone	894-6114
E-mail	meilin.liu@mse.gatech.edu;
Office Hour	Tu Th 5-6:00 pm
TA	TBD
Homework	Homework problems will be assigned periodically and solutions to homework will be posted later. While homework may not be collected or graded, doing homework is very important to your learning and an effective way to get prepared for exams.
Exam/Assignment	Grades are based on points earned from two exams and a term paper Two Exams **Exam 1** – Electro-physical energy storage/conversion **Exam 2** – Electro-chemical energy storage/conversion **Term Paper**–Novel energy storage/conversion devices/system

Grading

Assignment	**Points**
Exam 1	100
Exam 2	100
Term Paper	100
Total	**300**

Grading Scale
A: 270-300 pts
B: 240-269 pts
C: 210-239 pts
D: 180-209 pts

Final grades may be curved.

Academic Integrity	Students are reminded of the obligations and expectations associated with the Georgia Tech Academic Honor Code and Student Code of Conduct, available online at www.honor.gatech.edu. Academic dishonesty will not be tolerated, including cheating, lying about course matters, plagiarism, or helping others commit a violation of the Honor Code. Academic misconduct refers to any act that may improperly distort student grades or other student academic records. Such acts include but are not limited to the following: • Possessing, using or exchanging improperly acquired written or verbal information in the preparation of term paper, examination, or other assignment • Submission of material that is wholly or substantially identical to that created or published by another person or persons, without adequate credit notations indicating authorship (plagiarism); • Obtaining details/help on tests and assignments from students previously enrolled in the course Scholastic dishonesty by a few is unfair to the students who are honest. Please help us keep the grading fair and the learning opportunity in this course as equitable as possible.
Learning Accommodations:	Please let me know if you have a documented disability or special need that requires accommodation. We will make proper accommodations in accordance with the ADAPTS office (http://www.adapts.gatech.edu). However, this must be arranged in advance (within the first two weeks).
Electronic Devices	All electronic devices (cell phones, smartphones, laptops, tablets and similar devices) that can be used to view Internet web pages, or to communicate voice, data, text or graphic messages, must be turned off and put away during class. The only electronic device that you may have out and available for use during an exam is a commercially available calculator.

References

1. Lecture notes – to be posted on Canvas
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.

Website

Lecture notes, assignments of homework problems, homework solutions, announcements and other materials relevant to the course will be posted on Canvas. It is the student's responsibility to check their e-mail and Canvas on a regular basis.

Attendance and Tardiness

While there is no formal attendance policy, it is hoped that you feel attending class is important to your learning and for success in this class. Even for an excused absence, it is your responsibility to find out what was missed. There may be test questions based on material that is exclusively covered in class; thus, missing class could have some effect on your grade in the course.

It is disruptive to the class when someone arrives late (or leave early). Try to come to class on time or a few minutes early to get prepared for class.

Seeking Assistance

I would be more than happy to meet with students to provide assistance with course material and/or other school and career related issues. Please feel free to stop by during my office hours or email me to arrange a time to meet. While I can usually be flexible on arranging a meeting time, I may be unavailable to meet with students without an appointment.

Please give yourself sufficient time to study for exams. If you have a specific question or need clarification of a topic, please discuss it with me at least one day before the scheduled exam. Questions regarding test material will NOT be answered or discussed the day of the exam.

MSE 8803E: Topical Outline

# of weeks	Date	Topics	Ref
		Introduction	1,2
1 wk	**Aug 24-26**	Global energy issues; Materials science to transcend energy challenges; Materials for energy transformation processes Introduction to Thermodynamics/Kinetics/Crystallography	
		Electro-physical Energy Storage & Conversion	*,1,3,4,5
3 wks	Aug 31 to Sept 21	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	
2 wk	Sept 23 to Sept 30 **Oct 14**	Thermoelectricity: Transport of Charge and heat Thermoelectric Phenomena Materials challenges for thermoelectric generators **Exam 1: Electro-physical energy storage/conversion (100 pts)**	1,3,4,5
		Electrochemical Energy Storage & Conversion	1,6,7,8
6 wks	Oct 5 to Nov 16 **Nov 23**	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 (100pts)**	
		Materials for Nuclear & Solar Energy Conversion	1
2 wks	Nov18 to Dec 7	Nuclear systems and materials challenges Materials degradation under radiation Fundamentals of photovoltaic materials Thin-film, multijunction photovoltaic cells Materials challenges for high-efficiency solar cells Latest development in new materials	
	Dec 2	**Term Paper Due (100 pts)**	

Guidelines for Term Paper

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Objective	To acquaint students with a specific topic of current research in energy storage, conversion, or harvesting and to inspire student's creativity in developing novel materials, processes, or devices for *clean* and *sustainable* energy.
Topic	Any topic which is closely related to the materials covered in the lectures may be chosen. Appropriate topics include processing, characterizations, or applications of materials for energy storage, conversion, or harvesting. It is critical, however, to select a topic in which you have a strong interest so that your creativity can be demonstrated. Feel free to ask me if you need some suggestions.
Format	The term paper should consist of • Title, author, and affiliation • Abstract (less than 150 words) • Introduction (significance of the topic) • Critical review of current literature • Identification of **critical challenges/new directions** • **Novel approaches/solutions** • References • Figures with captions Length: about 10 pages (double-spaced) or 2,000 to 2,500 words excluding references and figures
Due Dates	**Oct 19:** A title and a short abstract (50-150 words description of the proposed term paper) **Dec 2:** This is will give me enough time to read and grade the term papers.
Reference Source	**Journals** related to materials for energy applications **Proceedings Volumes** of recent meetings on related topics