MSE 410: Materials Foundations for Energy Applications
MSE 810: Materials for Energy Applications
Spring 2013

Course instructors:

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Course description

The dawn of the 21st Century has starkly illuminated new challenges in the area of energy production and use: a rapidly increasing worldwide demand, dwindling supply, and the overarching threat of environmental damage due to energy utilization. These are not temporary inconveniences but rather harsh realities of a new world: energy reserves whose creation took millions of years are being depleted by an increasingly energy-hungry global society. How can science respond to these new challenges? Materials will play a central role. This course will survey in a seminar-like format the wide field of materials for energy applications. After some introductory discussions of the challenge presented by climate change and energy usage, we will explore a range of materials issues related to the development of new energy technologies and the more efficient utilization of existing energy resources. Topics to be covered include: unconventional geologic fuels and biofuels; photovoltaic materials and solar energy conversion; materials for future wind energy needs; thermoelectric materials for solid state energy conversion; materials for electrical energy storage; materials for hydrogen production, storage, and use; bio-fuel cells solid-state lighting materials; and materials challenges in nuclear energy.

Time and location
Class will meet M/W/F from 10:20 – 11:10 am in Room 1300 Engineering Building

Office hours (Morelli)
M/W 11:30-2:30 pm and by appointment. I will also respond to course-related questions and comments via email.

Grading
Your **c**ourse grade will be determined by a combination of your scores on two take-home exams, homework/attendance, a final presentation, and a final research paper, according the following distribution:

Exam I (take home, mid- to late February)	20%
Exam II (take home, mid-to late April)	20%
Homework/Attendance	10%
Final Research Presentation	25%
Final Research Paper	25%

Research Presentation/Paper
Each student will undertake an independent topic focusing on a particular issue or problem related to materials for energy applications. Selection of the topic will be made in consultation with Professor Morelli. Each student will summarize his or her findings in the form of a research paper and a presentation. Details regarding the expected content of the presentation and paper will follow. Papers will be due at the end of the semester, and presentations will be given the last few days of class.

Course Outline (all dates are tentative)

Date	Topic	Description	Instructor(s)
Jan 7, 9, 11	Introduction	The energy/climate problem: broad view	Morelli
Jan 14,16	Module I: geologic/alternative fuels	Geology and infrastructure of the current hydrocarbon economy. Alternative sources: shale oil, tar sands, methane clathrates	Nicholas
Jan 18,23,25	Module II: thermoelectric materials	Introduction; the design of thermoelectric materials	Morelli
Jan 28,30, Feb 1	Module II: thermoelectric materials	Thermal and electrical transport properties; model systems	Morelli
Feb 4,6,8	Module II: thermoelectric materials	Synthesis of TE materials; aspects of TE devices	Morelli/Sakamoto (Feb 8)
Feb 11,13,15	Module III: inorganic photovoltaic materials	Introduction and design of materials	Morelli
Feb 18,20,22	Module III: inorganic photovoltaic materials	Inorganic semiconductors for solar cell applications	Morelli
Feb 25, 27, Mar 1	Module IV: materials issues for future nuclear energy	Radiation damage, recovery mechanisms, and creep-rupture	Bieler
Mar 4-8	Spring Break		
Mar 11	Module V: organic photovoltaic materials	Dye sensitized and polymer solar cells, POLEDS	Duxbury
Mar 13,15	Module V: organic photovoltaic materials	Small molecule solar, OLEDS, and other organic electronics	Lunt
Mar 18,20,22	Module VI: materials related to hydrogen technologies	Hydrogen production, transportation, storage, and use; fuel cells	Nicholas
Mar 25,27,29	Module VII: inorganic semiconductors for solid state lighting	III-V wide band gap semiconductors, phosphors	Morelli
April 1,3,5,8	Module VIII: materials for electrical energy storage	Batteries, ultracapacitors	Sakamoto, Drzal
April 12,15	Module IX: Bio fuel cells	Bio fuel cells	Barton
Apr 17,19	Module X: Other Energy Technologies	Geothermal, hydro, wind	Morelli
April 22	Module XI: biofuels		Dale
April 24, April 26, and May 2 (final exam day)	Student Presentations		Morelli