

MSE 410: Materials Foundations for Energy Applications
MSE 810: Materials for Energy Applications
Spring 2012

Course instructors:

Donald Morelli (Lead)
C9E ERC
dmorelli@egr.msu.edu

Phillip Duxbury
4260 BPS
duxbury@pa.msu.edu

Tom Bieler
3527 Engineering Building
bieler@egr.msu.edu

Wei Lai
3524 Engineering Building
laiwei@egr.msu.edu

Bruce Dale
3815 Technology Blvd, Suite A118
bdale@egr.msu.edu

Richard Lunt
4135 Engineering Building
rlunt@egr.msu.edu

Lawrence Drzal
2100 Engineering Building
drzal@egr.msu.edu

Jason Nicholas
C9C ERC
jdnicholas@gmail.com

Jeffrey Sakamoto
3519 Engineering Building
jsakamot@egr.msu.edu

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 T/Th from 3:00 - 4:20 pm in Room 1257 Anthony Hall

Office hours (Morelli)

T/Th 1:30-2:30 pm and by appointment. I will also respond to course-related questions and comments via email.

Grading

Your course 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 to the following distribution:

Exam I (take home, mid- to late February)	15%
Exam II (take home, mid-to late April)	15%
Homework/Attendance	10%
Final Research Presentation	30%
Final Research Paper	30%

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 near 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 10	No Class: Morelli on travel		
Jan 12, 17	Introduction	The energy/climate problem: broad view	Morelli
Jan 19	Module I: geologic/alternative fuels	Geology and infrastructure of the current hydrocarbon economy. Alternative sources: shale oil, tar sands, methane clathrates	Nicholas
Jan 24, 26	Module II: thermoelectric materials	Introduction; the design of thermoelectric materials	Morelli
Jan 31, Feb 2	Module II: thermoelectric materials	Thermal and electrical transport properties; model systems	Morelli
Feb 7, 9	Module II: thermoelectric materials	Synthesis of TE materials; aspects TE devices	Morelli/Sakamoto (Feb 9)
Feb 14, 16	Module III: inorganic photovoltaic materials	Introduction and design of materials	Morelli
Feb 21,23	Module III: inorganic photovoltaic materials	Inorganic semiconductors for solar cell applications	Morelli
Feb 28, Mar 1	Module IV: materials issues for future nuclear energy	Radiation damage, recovery mechanisms, and creep-rupture	Bieler
Mar 5-9	Spring Break		
Mar 15	Module V: organic photovoltaic materials	Dye sensitized and polymer solar cells, POLEDS	Duxbury
Mar 20	Module V: organic photovoltaic materials	Small molecule solar, OLEDS, and other organic electronics	Lunt
Mar 22, 27	Module VI: inorganic solid state lighting and LED's	III-V wide band gap semiconductors, phosphors	Morelli
Mar 29, Apr 3	Module VII: materials related to hydrogen technologies	Hydrogen production, transportation, storage, and use; fuel cells	Nicholas
April 5, 10, 12	Module VIII: materials for electrical energy storage	Batteries, ultracapacitors	Lai, Sakamoto, Drzal
April 17	Module IX: Bio fuel cells	Bio fuel cells	Barton
April 19	Module X: biofuels	Technologies, land use, GHGs and energy return considerations for biofuels	Dale
April 24	Module XI: other energy technologies	Geothermal, hydro, wind,...	Morelli
April 26 and May 3 (final exam day)	Student Presentations		Morelli