Materials Science / Energy Science and Technology 143

Solid State Electrochemistry for Energy Storage and Conversion

http://addis.caltech.edu/teaching/MS-EST143/MS-EST143.html

Spring Quarter 2009

Instructor:	Prof. Sossina M. Haile 307 Steele Laboratories, x2958, smhaile@caltech.edu
Organizational Meeting:	214 Steele, Monday, Mar. 30, 9-10 am
Class Meetings:	MWF 9-10am, location TBD [214 Steele or NMC]
Teaching Assistant:	Mary Louie, 328 Steele, x2309, mlouie@caltech.edu
TA Office Hours:	TBA (likely Tuesdays)
Required Text:	none
Recommended Text:	"CRC Handbook of Solid State Electrochemistry," Eds. P.J. Gellings & H.J.M. Bouwmeester; "Physical Chemistry of Ionic Materials: Ions and Electrons in Solids," by Joachim Maier
Reserved Texts: (coming to SFL)	The two recommended texts, plus "Electrochemical Impedance Spectroscopy," by Mark E. Orazem and Bernard Tribollet

Course Content:

- Introduction to Electrochemical Energy Technologies
  - The Global Energy Landscape
  - Overview: Fuel Cells, Batteries, Sensors, Permeation Membranes
- Solid State and Physical Chemistry Review
  - Crystalline Structure, Microstructure, Amorphous Structure
  - Gibbs Free Energy and Binary Phase Diagrams
- Bulk Defect Chemistry
  - Point Defects, Kroeger-Vink Notation, Brouwer Diagrams
- Internal Interfaces
  - Grain Boundaries; Secondary Phases
- From Defects to Conductivity
  - Purely Ionic Conductors; Mixed Ionic / Electronic Conductors
  - Atomistics of charge transport (focusing on ionic transport)
  - Conductivity in polymers
- Electrodes
  - Electrochemical equilibrium
  - Electrochemical reactions
- Measurement Techniques
  - Bulk conductivities – partial electronic and ionic; grain boundaries
    - A.C. impedance spectroscopy, D.C. methods with blocking electrodes
  - Electrode kinetics
    - A.C. and D.C. methods

Course Structure:			
	Midterm Exam:	30%	(Apr 29 – May 5)
	Final Exam:	35%	(Jun 3 – Jun 5)
	Written Report:	35%	(May 29)

Grading

Students may take this course either Pass/Fail or for a letter grade

Midterm and Final Exams 30 / 35%

Both the midterm and final be open-book, take-home exams, 3-4 hours in length (TBD). You will be permitted one or two [TBD] 20 minute breaks sometime after the first hour. Further details will be given at the time of the exam.

Written Report 35%

A key component of this course will be a written report on a topic of your choice within the broad field of electrochemical energy storage and conversion. This is to be a 15-20 page report, that identifies a key technological challenge and describes the solutions that researchers are pursuing. For example, why do some lithium ion batteries burst into flames? Another example might be, why is the electrochemical reaction pathway in some particular fuel cell reaction unknown and what are researchers doing to determine it? You should be able to find a recent review article on a relatively broad topic and use it to help you define the narrower area in which you will write your report.

April 10	Select topic
April 17	Read and summarize 2-3 review articles (submit < 3 pages)
April 24	Identify and read primary references; submit list and report theme
May 8	Prepare report outline
May 18	First draft due
May 29	Final draft due

Each step along the way will be graded to determine a final grade for the report, so don't put this off until the end!

Content Delivery

Depending on student interest and enrollment, this course may be held in the New Media Classroom (NMC) and the lectures recorded to enable you to view them at your leisure. In such a case, you would not be required to attend lecture in person, but you would be required to send an email message confirming that you watched the recording (prior to the time of the next lecture). Because this format offers you scheduling flexibility, you will be required to either attend or view all but four lectures for the term, but you are ***not*** to postpone this to the end of the term!

Schedule Modifications

Regrettably, there will be dates on which Prof. Haile will not be able to be on campus to deliver regularly scheduled lectures. Specifically, the dates of conflict are April 27, April 29 and May 1 (the last week of the term). To make up the lost time, we will begin lectures at 8:30 am for the two preceding weeks. I realize this is extremely inconvenient, especially for undergraduates, but 8:30-9am is one of the few times that poses no (or very few) formal conflicts for students.

Date	Change	Date	Change
05/11/09	***begin at 8:30am***	**05/22/09**	***begin at 8:30am***
05/13/09	***begin at 8:30am***	~~05/25/09~~	**no lecture**
05/15/09	***begin at 8:30am***	~~05/27/09~~	**no lecture**
05/18/09	***begin at 8:30am***	~~05/29/09~~	**no lecture**
05/20/09	***begin at 8:30am***	06/01/09	possible review lecture, details TBA

And kindly remember your commitment to the principle that "*No member of the Caltech community shall take unfair advantage of any other member of the Caltech community.*"