MSE 599/498 Electrochemical Material Systems

Syllabus and Schedule

Instructor: Bruce Hinds (bjhinds@uw.edu)

Class time: TTh 1-2:20p (Remote learning, Zoom)

Office Hours: Th 3:30p-5p (Zoom) and by appointment (e-mail)

Course Description: Electrochemical systems have broad societal applications ranging from medical sensors, analytical tools, electro-catalytic synthesis, and energy storage. Performance is limited by both complex device design transport and material limitations such as corrosion, surface states and over-potential. This course will cover electrochemical fundamentals (~6wks) including electrochemical thermodynamics, kinetic effects, mass transport (convective, diffusive and electrophoretic), electrode geometry, electric double layer interface, cell design, and experimental electrochemical measurement techniques. With fundamental electrochemical knowledge, contemporary applications (~4wks) in batteries, flow cells, sensors, and electrochemical transformations will be surveyed at the operational level to identify technological limitations and opportunities.

Course Outline

Week 1	Introduction to Electrochemistry
	-Basic ungraduated concept review
Week 2	Electrochemical cells
	-non-ideal ionic solutions
	-Thermodynamic prediction
	-Cell design and electrosynthesis
Week 3	Electrodes
	-Electrode potentials (working, counter, reference
	-Pourbaix diagrams
	-Ion selective electrodes
	-Electrode reactions
Week 4	Polarization and transport
	-Polarization (non-equilibrium, ohmic, activation, mixed, concentration)
	-Transport mechanism (diffusion, convective, electrophoretic)
Week 5	Electrochemical techniques
	-Voltammetry (steady state, permeation cells, micro electrodes)
	-Electrode interface (Gouy-Chapman model, electrokinetic effects)
	-Cyclic, pulsed, step voltammetry
Week 6	Dynamic electrochemical techniques
	-Impedance spectroscopy
	-MIDTERM 5/7 (Thurs)

Week 7 Battery design
-Basic battery design principals
-Failure modes and material challenges
Week 8 Flow batteries and electrosynthesis
-Basic flow battery design principals
-Survey of electrosynthesis processes
Week 9 Sensors and biomedical applications
-Selective sensor mechanisms and Chem-FET design
-Membranes and electrochemical drug delivery
Week 10 Current topics in electrochemical materials
-Literature review techniques and resources
-Literature critical assessment exercises

Required text: Fundamentals of Electrochemical Science, Keith B Oldham, Jan C. Myland Academic Press 1994. San Diego ISBN 0-12-52545-4

Supplemental handouts will be provided using "Canvas" system.

Course announcements, handouts, lecture notes and syllabus will be available on "Canvas" and is the student's responsibility to check for changes in schedules or assignments.

Due to COVID-19 lectures and assignments will all be given remotely

Grading

Homework/projects 35%, Midterm 30%, Final 35%

Midterm Fri.4/30

Final Take home Due Wed June 10

Homework will be assigned on Fridays and turned in the following Friday (electronically) ***. Late homework will not be graded.***

Plagiarism is a serious academic violation. In particular homework solutions are commonly available and copying the solution and presenting as your work is a form of plagiarism. If solution key is used to help, cite this fact in the homework and self-grade the % that is your effort.

Other expectations: Active participation in class asking/answering questions. Group activities. Reading assigned material before lecture.

MSE599 vs 498 requirements: For graduate 599 credit, independent projects will be longer and have higher critical analysis expectations. Project grading 'curve' is different than those enrolled in 498.

Educational Outcomes: By completing this course you will be able to: A) Identify, recall, and explain important electrochemical techniques and key physical phenomena. B) Propose electrochemical experimental designs. C) Quantitatively describe electrochemical process and applications. D) Identify and analyze current electrochemical applications.

Course Lecture Schedule (subject to change)

Lecture	Date	Topic	Assignment
Week1			
	3/31	Introduction and Undergraduate review	Handouts
	4/2	Conduction & Ionic Solutions	Ch 1&2
Week 2			
	4/7	Electrochemical cells	Ch 2&3
	4/9	Cell design and electrosynthesis	Ch 3&4
Week 3			
	4/14	Electrode reactions	Ch 5
	4/16	Polarization	Ch 6
Week 4			
	4/21	Polarization and transport	Ch 6&7
	4/23	Electrochemical techniques	Ch 8&Handouts
Week 5			
	4/28	Voltammetry	Ch 8 &Handouts
	4/30	Electrode Interface	Ch 9
Week 6			
	5/5	Impedance Spectroscopy	Ch 10
	5/7	**MIDTERM (April 30)**	
Week 7			
	5/12	Battery Design	Handouts
	5/14	Failure Modes and material challenges	Handouts
Week 8			
	5/19	Flow Batteries	Handouts
	5/21	Other energy storage approaches	Handouts
Week 9			
	5/26	Sensors and biomedical applications	Handouts
	5/28	Chem FETs	Handouts
Week 10			
	6/2	Current topics in electrochemical materials	Handouts
	6/4	Literature analysis excercises	Handouts
Week 11			
	6/10	**Final (take home return by June 11)**	Final