

Spring 2008

MSE 608
CHEMICAL AND ELECTROCHEMICAL PROPERTIES
OF SOLID MATERIALS

Instructor: Giovanni Zangari
E-mail: gz3e@virginia.edu
Office: Wilsdorf Hall 320
Phone: (434) 243-5474

OBJECTIVES:

The goal of this class is to teach the fundamental principles associated with the phenomena of electrochemical and chemical processing/fabrication of solid material as well as chemically and electrochemically driven degradation of solid materials. The course will first cover the fundamentals associated with electrochemical phenomena, then discuss their applications, with particular attention to corrosion, electroplating, and energy conversion. An underlying theme during the course will be the materials science paradigm; that is, how microstructure, composition, defects and processing can affect properties such as corrosion behavior and performance of electrodeposits.

The class is also designed to prepare students for more advanced classes in electrochemistry and surface science as well as to aid students in their research. Students will be prepared for careers in industry that require knowledge of chemical and electrochemical aspects of materials science.

PREREQUISITES: MSE 601 Materials Structures and Defects
MSE 623 Thermodynamics
MSE 624 Kinetics

The requirements above are only indicative. Graduate students should be able to study the required fundamental concepts on their own without negatively affecting outcomes.

TEXTBOOK: V.S. Bagotsky "Fundamentals of electrochemistry" 2nd Ed. Wiley. ISBN 0-471-70058-4

REFERENCES (in reserve in the Brown S&E Library):

C.H. Hamann, A. Hamnett, W. Vielstich *Electrochemistry* Wiley-VCH, 1998 – ISBN 3-527-29096-6

D.A. Jones, *Principles and Prevention of Corrosion* 2nd Ed., Prentice Hall 1996 – ISBN 0-13-359993-0

M. Paunovic, M. Schlesinger, *Fundamentals of Electrochemical Deposition* Wiley 1998

A.J. Bard, L.R. Faulkner, *Electrochemical Methods* Wiley 1998

Southampton Group, *Instrumental methods in electrochemistry* Horwood Pubs.

J. O'M. Bockris, A.K.N. Reddy *Modern Electrochemistry* Plenum Press

E. Gileadi *Electrode Kinetics* Wiley-VCH

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J. Newman *Electrochemical Systems* Wiley-Interscience

Other texts, articles and notes will be distributed to the students as needed

TOOLKIT:

A web site for this course exists on the UVA Instructional Toolkit (<http://toolkit.virginia.edu>). Information on this course as well as supplementary material, assignments etc. will be available on this website.

SYLLABUS:

1. Introduction to the course

2. Electrochemical Thermodynamics

Electrode potentials

The connection between electromotive force and free energy change

Nernst equation

Reference electrodes, measurement of electrode potentials and cell voltages

The electrochemical series

3. The Electrolytic Double Layer

Mechanistic models for the double layer and double layer capacitance

Ion activity in solution: theory of Debye-Huckel

Conducting, semiconducting and insulating electrodes

4. Electrochemical Kinetics

Absolute reaction rate theory: Butler-Volmer Reaction

Single and multi-step charge transfer reactions

Ohmic, mass transport, mixed control

Evans' diagrams

5. Corrosion

Pourbaix Diagrams

Cathodic protection

Anodic protection

Uniform and galvanic corrosion

Metallurgical aspects of corrosion

6. Electrodeposition

7. Energy conversion

MSE 608 GRADING CRITERIA:

a) Two in-class quizzes	20% each
b) Homework	20%
c) Comprehensive Final	40%

Homework will be assigned approximately weekly. Interaction between peers in solving the homework encourages discussion and is generally regarded as beneficial. However, I strongly encourage each student to solve and write down the problem solution individually.

Problems in the quizzes and the final will consist of questions similar to those assigned in the homework assignments.