

Electrochemical Engineering

Lecture 0 Introduction

Dr. Zhe Cheng

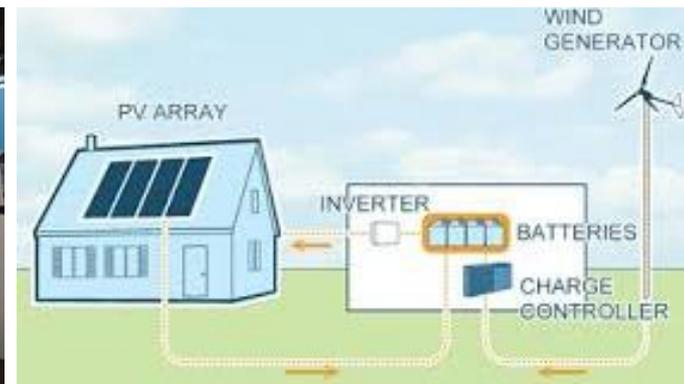


Electrochemical Engineering

□ Basic electrochemistry

□ Electrochemical engineering for

- Energy conversion & storage
 - batteries, fuel cells, capacitors:
 - Transportation (EV & FCV)
 - Clean power generation & storage
 - Mobile devices
- Corrosion and prevention
- Materials/chemicals production or processing
- Sensors & more



<https://www.toppr.com/guides/chemistry/electrochemistry/corrosion-prevention-method/>

<https://bestmetltrade.com/product/aluminium-ingot-99-7-percent/>

<https://www.nisenet.org/catalog/exploring-fabrication-electroplating>

<http://www.tesla.com>

http://www.greencarreports.com/news/1106296_price-cut-and-monthly-sales-spike-for-toyota-mirai-fuel-cell-sedan

<http://www.dailymail.co.uk/sciencetech/article-4003522/New-phone-battery-charge-phones-just-seconds.html>

<http://www.fuelcelltoday.com/analysis/event-reports/2013/19th-group-exhibit-hydrogen-plus-fuel-cells>

<http://www.exponent.com/services/practices/engineering/materials--corrosion-engineering/?servicelD=c9288b2c-d7b1-4ad8-8fc3-1b1ed6f2c8c1&loadAllByPageSize=true&knowledgePageSize=3&knowledgePageNum=0&newseventPageSize=3&newseventPageNum=0>

<https://www.medgadget.com/2014/08/handheld-electrochemical-sensor-detects-diseases-measures-biomarkers-costs-25.html>

Course Materials

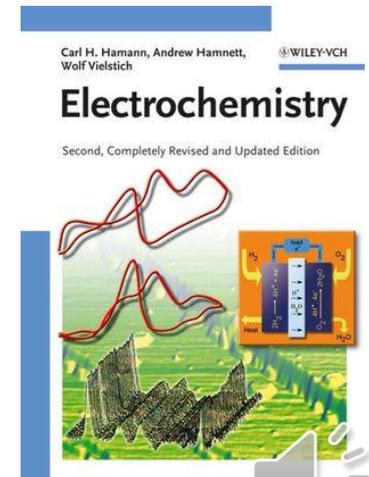
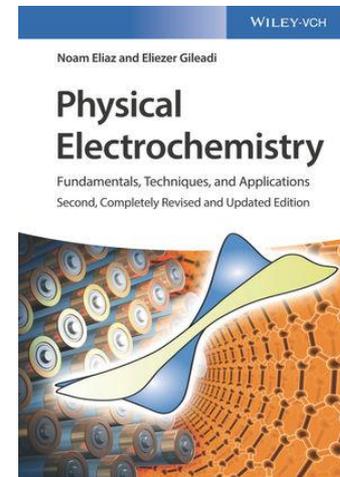
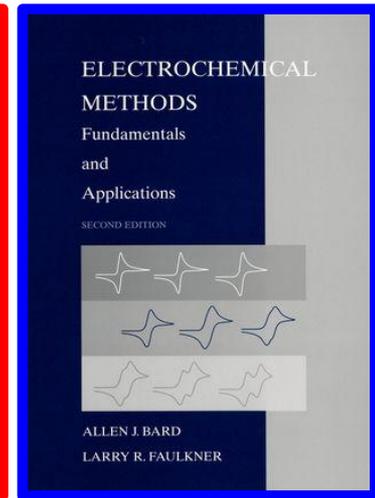
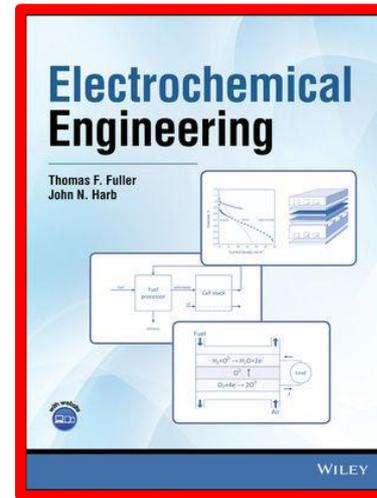
❑ **Text:** *Electrochemical Engineering*, Thomas F Fuller and John Narb, Wiley (2018), ISBN: 978-1-119-00425-7

❑ **Canvas**

- Class notes, Quizzes, Hw & more

❑ **Additional references**

- *Electrochemical Methods: Fundamentals and Applications*, Allen J. Bard, Larry R. Faulkner, Wiley (2001), ISBN: 978-0-471-04372-0
- *Physical Electrochemistry: Fundamentals, Techniques, and Applications*, 2nd Edition, Noam Eliaz, Eliezer Gileadi, Wiley (2019), ISBN: 978-3-527-34139-9
- *Electrochemistry*, 2nd ed., Carl H. Hamann, Andrew Hamnett, Wolf Vielstich, Wiley-VCH (2007), ISBN: 978-3-527-31069-2



Dr. Zhe CHENG & Course Website

□ Dr. Zhe CHENG

- zhe.cheng@colostate.edu

□ Course website

<https://www.engr.colostate.edu/laboratories/ceramics/teaching/ema5305-4303/>

More about Dr. Zhe Cheng

□ Education & Experiences:

- PhD in Materials Science & Engineering, Georgia Tech, 2008
- Research scientist, DuPont, Wilmington DE, 2008-2013
- Florida International University, Miami, FL, 2013-2024

□ Research group website

The screenshot shows a web browser window with the URL enr.colostate.edu/laboratories/ceramics/. The website header features the Colorado State University logo and the text "ADVANCED CERAMICS LABORATORY". A yellow "MENU" button is visible in the top right corner. The main content area is titled "Home" and contains the following text:

The AC group is looking for motivated undergraduates, as well as new MS and Ph.D. applicants with strong interests and backgrounds in materials, physics, chemistry, or related engineering fields to work on novel and challenging science and engineering problems of ceramic materials for various applications. Contact Dr. Z Cheng (zhe.cheng@colostate.edu) if interested.

Welcome to the Advanced Ceramics (AC) group in the Department of Mechanical Engineering at Colorado State University. The group is led by Dr. Zhe Cheng, who joined CSU in the fall of 2024, after 11 years at Florida International University (FIU).

The Advanced Ceramics group's goals include the following:

- Developing advanced functional as well as structural ceramic and ceramics-containing composite materials for different applications with a particular focus on energy conversion (e.g., solid oxide fuel cells, solid oxide electrolysis cells, and solar fuels) and extreme environments where ceramic materials excel over other choices
- Generating new fundamental knowledge about ceramic materials focusing on the interrelationships between composition (chemistry), macro- and micro-structure, synthesis and processing, and properties
- Educating and training next-generation scientists and engineers with expertise in advanced ceramic science and engineering and promoting awareness of ceramics and related fields among undergraduate students and the general South Florida community

Copyright © Zhe Cheng 2025

Course Policy

□ Policy

- Students can discuss homework problems, but must **independently** finish it
- Grade discrepancies – resolve within 24 h
- Accommodate “make-up” quiz, tests, or delayed term paper if proven medical necessity
- Accommodate disability and religious holidays
- NO cheating or plagiarizing in ANY form (Check with me if questions)
 - No excuses will be accepted
 - Will be reported and handled according to policies



Course Objective & Outcome

□ Objective

Introduce to undergraduate and junior graduate students the basic concepts, physical/chemical principles, and engineering practices of electrochemistry and its applications in various electrochemical systems for energy, chemical, biomedical, and electronics industries

□ Learning Outcomes

- a) Understand the concepts of **electrochemical cells** and related components and the basic electrochemical processes
- b) Understand the **thermodynamics** for electrochemical systems and be able to obtain basic information such as cell potential from thermochemical data and vice versa
- c) Understand basic **reaction kinetics** for electrochemical systems including current-voltage relationship and the influences of factors such as transport properties
- d) Understand the principles for basic **electrochemical analysis techniques** including controlled current/voltage measurements & electrochemical impedance spectroscopy
- e) Be able to explain basic operating principles and identify major considerations for various **practical** engineering electrochemical **systems** including corrosion and its prevention, electrolytic production of chemicals and metals, electrodeposition, batteries, fuel cells and biofuel cells, and electrochemical sensors.



Topics & Tentative Schedule

- ❑ Introduction: basic concepts of electrochemical cells and processes
- ❑ Equilibrium and electrochemical thermodynamics
- ❑ Electrochemical kinetics including current-voltage relationships
- ❑ Electrochemical techniques for analysis including impedance spectroscopy and controlled current and voltage techniques
- ❑ Electrochemical energy conversion and storage via batteries and fuel cells
- ❑ If time allows
 - Electrolytic production of chemicals/metals and electro-deposition
 - Corrosion (if time allows)
 - Other: electrochemical sensors (if time allows)



Homework

Pick a **specific topic** centering on electrochemistry or electrochemical engineering and **explain briefly what specific aspect you personally would like to know more** about that topic. Notes:

The topic has to be SPECIFIC and NOT too broad/big:

For example, instead of “**battery**”, one may choose

- “cyclability of solid state lithium battery with ceramic electrolyte”
- “state-of-the-art power density for lead acid battery for automobiles”
- “current status for silicon anode for lithium-ion battery with higher capacity”

Please declare the use of AI tools (e.g., ChatGPT) if applicable - NO points will be deducted, but please share the prompts that was used as well

Less than 100 words

Must be typed