TECHMSE-02-Technical Elective 2 Materials for Energy Generation and Storage

Course Syllabus Fall 2020

Description

The goal of **Materials for Energy Generation & Storage** course is to demonstrate the role of materials in solving one of the most critical socio-economic issues of our time; Energy. This course is primarily focused on material uses and issues in different energy conversion, harvesting, and storage systems and devices. Since energy is such a broad field, the course is arranged based on the relative dominance of energy sources in today's use. I will start with a discussion of global energy and related environmental issues. Topics to be covered include: Basic electrochemical thermodynamics and kinetics, with emphasis on electrochemical techniques fuel cells and batteries (electrochemical energy conversion and storage); catalysts and membrane separations (fossil fuel and biomass energy conversion); and nuclear fuels. Then I will focus on electrical, optical, thermal, and mechanically functional materials for energy devices. Solar cells, solar fuel, solar thermal, energy efficient lighting, building energy, thermoelectric and wind energy will be covered. The course will also cover the full range of materials that are relevant to nuclear energy with a focus on materials subject to irradiation (glasses, steels, nickel alloys, and zirconium alloys).

In addition to lectures and homeworks, each student will complete a detailed case study in which they examine a particular material and application for energy generation and storage application.

Course Summary

The availability, accessibility, and affordability of different energy sources are first discussed in each lecture. Energy production processes as well as material uses and performance requirements in fossil, nuclear, solar, bio, wind, hydrothermal, geothermal, and ocean energy systems are covered. In addition, energy harvesting and storage issues (including hydrogen storage) and material needs are addressed. The course generally follows the sequence of energy conversion, harvesting, and storage for easy use. On one hand, it is intended to move beyond the broad, introductory stage of energy courses and give students an in-depth coverage of material-specific issues. On the other hand, the course provides a transition between current energy materials and new energy materials so that the students can view the existing and new fields in a continuous manner. The electrochemical storage of energy has become essential in assisting the development of electrical transport and use of renewable energies. This course assures a connection between basic researches, technological researches and industries. We will cover the technological advances as well as the challenges that must still be resolved mainly in the field of electrochemical storage, taking into account sustainable development.

Learning Outcomes

By the completion of this course, students will be expected to:

- ✓ Understanding the role of materials in solving one of the most critical socio-economic issues of our time; Energy.
- ✓ Familiar with various materials applicable in energy sector.

- ✓ Recognize the need to undertake lifelong learning in materials for energy generation and storage.
- ✓ Demonstrate the ability to work as a team member, plan and make decisions through effective communication.
- ✓ Write a professional engineering report for materials in energy generation and storage applications.

Course Content

- ✓ Word Energy Data
- ✓ Fossil energy and Materials
- ✓ Nuclear energy Conversion and Materials
- ✓ Solar energy and Materials
- ✓ Bioenergy Conversion and Materials
- ✓ Wind energy Conversion and Materials
- ✓ Hydro, Geothermal, ocean energy and Materials
- ✓ Definition and Classification of Energy Storage Systems
- ✓ Electrical Energy Storage
- ✓ Electrochemical Energy Storage Systems
- ✓ Fuel cells and hydrogen energy Materials
- ✓ Lithium batteries and advanced secondary batteries
- ✓ Green energy for a clean environment
- ✓ Photo-Electrocatalysis materials
- ✓ Supercapacitors materials
- ✓ Electrochemical clean energy materials
- ✓ Chemical Energy Storage
- ✓ Mechanical Energy Storage
- ✓ Thermal Energy Storage

Course structure

Delivered through a combination of lectures and case study projects presentation

Reading List

1. Materials in Energy Conversion, Harvesting, and Storage, Kathy Lu, John Wiley & Sons, Inc, ISBN:9781118889107, 2014.
2. Fundamentals of Materials for Energy and Environmental Sustainability, David S. Ginley, David Cahen, Cambridge University Press, ISBN:9780511718786, 2012.
3. Introduction to Materials for Advanced Energy Systems, Colin Tong, ISBN 978-3-319-98002-7, Springer, 2019.
4. Electrochemical Energy Storage for Renewable Sources and Grid Balancing, Patrick T. Moseley Jurgen Garche, ISBN: 9780444626165, Elsevier, 2014.
5. Handbook of Energy Storage, Demand, Technologies, Integration, Sterner, Michael, Stadler, Ingo, ISBN 978-3-662-55504-0, Springer, 2019.
6. Electrochemical Energy Systems, Foundations, Energy Storage and Conversion, Artur Braun, ISBN: 978-3110561821, De Gruyter, 2019.
7. Energy Storage, Fundamentals, Materials and Applications, 2/e, Huggins Robert, Springer, ISBN 978-3-319-21239-5, 2016.

Grading
Homework Assignments 20 %
Project Presentation 30%
Final Exam 50 %

Schedule: Online Lectures: Every Wednesday from 08/09/2020 to 29/12/2020, 18:00-20:35
Final exam date: Tuesday, 18:00-20:35, 07/01/2021
Instructor Associate Professor Ali Davoodi, ali.davoodi@scupi.cn
Teaching Assistant Yuan Bo, mrchenyb@163.com

When emailing the instructor or TA, include "YourName2020F-TECHMSE-02" in the subject field of your message. Use your university email account; mail from other accounts might be stopped by the SCU spam filter.

Web Site

This course uses the Blackboard and Zoom online video conference system; the web site is

https://learn.scupi.cn/

the online course will be arranged by TA on Zoom platform.
(Note: the **https** is important, otherwise it may not load.) There you will find the course syllabus, homework assignments, and other materials. Current announcements and assignments will be posted on the home page. All assignments will be uploaded through the Blackboard system. Please check the class page frequently.

Class Format
This course is taught using a combined lecture, reading, review and discussion format. The lecturer may ask questions to as many students as possible and encouraging critical reading of published papers in related field.
It is imperative that you come to class prepared. This will generally involve reading all posted literature and viewing tutorial videos. This is a three credit hour class, which means you should expect to devote at least 9 to 12 hours of effort outside the scheduled class time every week.

Homework Assignments
Assigned homework problems will be posted on Blackboard with details information. These are to be completed and turned by the following week. You may work with other people on homework, but all write-ups must be individual efforts. Homework will be graded on a 0-100 point scale.
All work will be submitted electronically through the Blackboard system. Late homework will not be accepted.
Unless specifically requested, emailed homework will not be accepted.
Please adhere to these homework guidelines:

- Your assignment must be typeset using Word and submitted electronically through Blackboard.
- Put your name, ID number (last four digits), and class section at the top of the first page, e.g., "YourName2020F-TECHMSE-02"

All the homework scores will be used in your grade computation. Unless otherwise indicated, you can work with your fellow classmates in the class, but you must submit a distinct and independent write-up to receive credit.

If you are sick or have a compelling emergency that prevents you from turning in the homework on time, email Prof. Ali Davoodi.

If you believe an error has been made in the grading of an assignment, bring it to the attention of your TA within one week of its return.

Contact instructor or teaching assistant

If you do not understand something, and talking to your classmates does not help, then you should be seeking help from the instructor or teaching assistant. We are available via email to schedule an online time for discussion.

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Teaching Assistant Yuan Bo, mrchenyb@163.com