WM995-15 Battery Electrochemistry, Design and Manufacturing

20/21

Department
WMG
Level
Taught Postgraduate Level
Module leader
Chuan Cheng
Credit value
15
Module duration
1 week
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

This is a Li-ion battery cell focused module for MSc in Sustainable Automotive Electrification (new course). This module consists of face-to-face teaching, hands-on lab sessions, tutorial, online learning, literature review assignment, take home examination assignment and post module assignment, for a total of 150 hours.

Module aims

This module focuses on electrochemical energy storage principles, energy storage materials and chemical engineering processes of lithium-ion batteries, which is the major energy storage solution for automotive electrification. This module will provide students the scientific knowledge inside batteries to understand the fundamental mechanisms for battery operation, design and manufacturing. It will unlock the mysteries of battery cells rather than treating them as black boxes. This module covers batteries up to the cell level to avoid any overlapping with another energy storage module which covers battery systems within the same MSc course.

Moreover, based on the state-of-the-art energy storage research facilities at WMG, four hands-on lab practicals are included in this module, which will give students the first ever experiences on

battery cell manufacturing and characterization.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

1. Battery fundamentals: key terminologies, lithium-ion battery components, functions, and operation principles.
2. Electrochemical principles of energy storage in batteries: thermodynamics, kinetics and mass transport.
3. Energy storage materials: chemistry of cathode and anode active materials
4. Manufacturing processes: synthesis method of energy storage materials; fabrication method of battery cells; recycling processes of lithium-ion battery valuable materials
5. Degradation mechanisms of Lithium-ion batteries
6. Four hands-on lab session: electron microscopy (characterization of energy storage materials); mixing and coating (battery electrode manufacturing); battery cell fabrication; battery forensics.

Learning outcomes

By the end of the module, students should be able to:

- Demonstrate conceptual analysis of electrochemical working principles of Li-ion batteries
- Evaluate different energy storage materials for battery cell design and manufacturing
- Comprehensively interpret battery cell degradation mechanisms and recycling processes
- Practically assemble Li-ion battery cells and interpret the manufacturing processes
- Independently evaluate battery cell testing results

Indicative reading list

Allen J. Bard; Larry R. Faulkner: “Electrochemical methods: fundamentals and applications”, 2nd edition, 2001, ISBN: 0471405213
John Newman and Karen E. Thomas-Alyea: “Energy Storage Systems”, 3rd edition, 2004, ISBN: 9780471477563
J-K. Park: “Principles and Applications of Lithium Secondary Batteries”, (e-book), 2012, ISBN: 9783527650422

View reading list on Talis Aspire

Interdisciplinary

Electrochemistry, Chemistry, Materials Science and Engineering, Chemical Engineering

Subject specific skills

Electrochemical principles of Lithium-ion batteries including thermodynamics, kinetics and mass transport.

Chemistry of energy storage materials and how to evaluate advantages and disadvantages of various anode and cathode materials for applications.
Key battery degradation mechanisms and the safety issues raised from battery degradation.
Recycling methods and processes for battery cells and valuable materials inside cells.
Hands-on battery cell manufacturing from electrode mixing and coating to cell assembly, and battery cell characterization techniques.

Transferable skills

Critical thinking; Problem solving; Self-awareness; Communication; Teamwork and working effectively with others; Information literacy (research skills); Digital literacy; Sustainability; Professionalism;

Study

Study time

Type	Required
Lectures	12 sessions of 2 hours (16%)
Tutorials	1 session of 1 hour 30 minutes (1%)
Supervised practical classes	4 sessions of 4 hours (11%)
Online learning (independent)	4 sessions of 2 hours (5%)
Other activity	30 minutes (0%)
Private study	10 hours (7%)
Assessment	90 hours (60%)
Total	150 hours

Private study description

Pre-work before module starts: to read several review articles on Li-ion batteries; book chapters related with fundamentals of chemistry and electrochemistry to better follow the progress of coming lectures.

Other activity description

Introduction to the module; Introduction to PMA

Costs

Category	Description	Funded by	Cost to student
Other	This module has four hands-on lab sessions which may give	Department	£0.00

Category	Description	Funded by	Cost to student
	rise to cost for lab consumables, facility booking and the time of lab demonstrators.		

Assessment

You do not need to pass all assessment components to pass the module.

Assessment group D

	Weighting	Study time
Post Module Assignment	50%	40 hours

The tasks may include analysing of real battery cell testing data provided to the students, and from which students need to extract useful information to evaluate the performance of batteries; selecting battery materials and design batteries for specific applications; also other tasks related with battery application.

Literature review of batteries for electric vehicles	40%	40 hours

Literature review of the latest research and industrial development of batteries for electric vehicle applications, and use the knowledge that learned from the lectures to discuss advantages and disadvantage of these new developments, and your opinions of the future challenges and development directions. Literatures can include research papers, books, news articles, references from the online data base of the library. Students can select a specific research topic in Li-ion batteries to review; or have a general review of different types of batteries; or have a review of the next generation batteries beyond Li-ion.

Take home examination questions	10%	10 hours

This examination includes a series of numerical calculations related with battery electrochemistry, energy storage and battery materials; discussion and comparison of battery related techniques. It requires students to have an in-depth understanding of the knowledge learned from lectures. To finish these questions, students may need to go back to lecture notes from time to time. Duration 180 minutes

Assessment group R

	Weighting	Study time
Evaluation of tests and technology application	100%	

PMA is comprised of one part. This part covers all ILOs. It is related to discuss a lithium-ion battery design based on given requirements.

Feedback on assessment

Scaled ratings for Comprehension, Effort and Presentation, individual written feedback and overall mark following on from WMG feedback sheet templates.

Past exam papers for WM995

Availability

Pre-requisites

To take this module, you must have passed:

- Any of
  - WM986-15 Energy Storage Systems
  - WM985-15 Automotive Hybridisation and Electrification

Courses

This module is Core option list A for:

- Engineering Competence (Sustainable Automotive Electrification) [New Course]
- MSc in Sustainable Automotive Electrification (FT) [New Course]
- MSc in Sustainable Automotive Electrification (PT) [New Course]