**Nazwa przedmiotu:**

Batteries

**Koordynator przedmiotu:**

Leszek Niedzicki, PhD, DSc, Eng.

**Status przedmiotu:**

Obowiązkowy

**Poziom kształcenia:**

Studia I stopnia

**Program:**

Electric and Hybrid Vehicles Engineering

**Grupa przedmiotów:**

Obowiązkowe

**Kod przedmiotu:**

1150-00000-ISA-0349

**Semestr nominalny:**

5 / rok ak. 2022/2023

**Liczba punktów ECTS:**

2

**Liczba godzin pracy studenta związanych z osiągnięciem efektów uczenia się:**

1. Contact hours - 30h, including: a) lectures – 30h; b) consultations – 1h;
2. Student's own work - 25h, including: a) preparation for the lectures – 10h; b) preparation for the tests – 15h.
Total student’s effort: 30h+1h+15h+10h=56h.

**Liczba punktów ECTS na zajęciach wymagających bezpośredniego udziału nauczycieli akademickich:**

1.2 ECTS points - contact hours - 31h, including: a) presence at lectures – 30h; b) consultations – 1h

**Język prowadzenia zajęć:**

angielski

**Liczba punktów ECTS, którą student uzyskuje w ramach zajęć o charakterze praktycznym:**

-

**Formy zajęć i ich wymiar w semestrze:**

|  |  |
| --- | --- |
| Wykład: | 30h |
| Ćwiczenia: | 0h |
| Laboratorium: | 0h |
| Projekt: | 0h |
| Lekcje komputerowe: | 0h |

**Wymagania wstępne:**

-

**Limit liczby studentów:**

Brak

**Cel przedmiotu:**

After completion of the course student should have acquired:
- detailed knowledge on different types of rechargeable galvanic cells and electrodic materials, electrolytes and other necessary components of the cell;
- knowledge on possibilities of modification and choice of electroactive materials to obtain required parameters for the intended goal;
- ability to assess composition and structure of the existing cell and propose modifications for adjusting its parameters to the given application;
- ability to design cell for the application including economic and environmental requirements;
- ability to predict cause of potential cell failure and propose required modifications in the cell structure or requirements for the battery management system to avoid or minimize the risk of the failure;
- ability to cooperate and communicate in the interdisciplinary team for the choice of component materials of the cell for the given application.

**Treści kształcenia:**

The aim of the lecture is to familiarize students with the following topics:
rechargeable cells review; lead-acid batteries - types, construction, principles of work; nickel-hydride and nickel-cadmium cells - construction, materials for components, environmental hazards; high-temperature batteries; anodes for lithium-ion cells - parameters, materials, manufacturing, modifications; intercalation phenomenon; nanometric structures; cathodes for lithium-ion cells - polymeric, oxide, silicate, phosphate materials - parameters, manufacturing methods, modifications; fundamentals of ions building into crystal structure; lithium salts for lithium-ion cells' electrolytes; chemical, electrochemical and thermal properties, toxicity, recyclability; liquid electrolytes for lithium-ion cells; choosing proper solvents or solvent mixtures for the cell application; economy of manufacturing vs electrolyte parameters; electrolyte stability and impurities; separators - their properties and modifications; polyelectrolytes, gel, polymer, solid and solid polymer electrolytes in lithium-ion cells - manufacturing/synthesis and parameters; thin-film cells; ionic liquids in lithium-ion cells; modifications of ionic liquids, material modification possibilities with ionic liquids; modifications of electrolytes; functional additives changing properties or increasing parameters; materials selection and parameters optimization for lithium-ion cell application; maximizing parameters for specialized applications; lithium-ion cell and battery manufacturing in small and industrial scale; components of the cell that are necessary but not taking part in energy storage; construction types; methods of assembly; casings and protections/safeguards; design and technological issues in cell manufacturing; batteries' future; lithium-air and zinc-air rechargeable batteries; sodium-ion batteries and beyond; current-voltage characteristics; cycling, cell's wear and work regime; cell diagnostics; damage and risks of using lithium-ion batteries; types of protections on chemical and electronics level; recycling of batteries; abundance of materials and other limitations.

**Metody oceny:**

Two written tests during the lecture

**Egzamin:**

nie

**Literatura:**

G.A. Nazri, G. Pistoia – „Lithium Batteries”
M. Winter, Chem. Rev. 104 (2004) 4245.
M.S. Whittingham, Chem. Rev. 104 (2004) 4271.
K. Xu, Chem. Rev. 104 (2004) 4303.
K. Xu, Chem. Rev. 114 (2014) 11504.

**Witryna www przedmiotu:**

http://lniedzicki.ch.pw.edu.pl

**Uwagi:**

Brak

## Efekty przedmiotowe

### Profil ogólnoakademicki - wiedza

**Efekt 1150-00000-ISA-0349\_W1:**

Student knows battery types as well as electrodic, electrolytic and other components required to manufacture cell adequate for the given application type.

Weryfikacja:

written exam.

**Powiązane efekty kierunkowe:** K\_W05, K\_W09, K\_W11, K\_W16, K\_W17, K\_W19

**Powiązane efekty obszarowe:** T1A\_W03, T1A\_W07, T1A\_W06, T1A\_W08, T1A\_W02, T1A\_W03, T1A\_W04, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W07, T1A\_W05

**Efekt 1150-00000-ISA-0349\_W2:**

Student knows set of modifications and mixtures of electroactive materials that fit parameters required for the given application.

Weryfikacja:

written exam

**Powiązane efekty kierunkowe:** K\_W05, K\_W11, K\_W16, K\_W17, K\_W19, K\_W20

**Powiązane efekty obszarowe:** T1A\_W03, T1A\_W07, T1A\_W02, T1A\_W03, T1A\_W04, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W07, T1A\_W05, T1A\_W06

### Profil ogólnoakademicki - umiejętności

**Efekt 1150-00000-ISA-0349\_U3:**

Student is able to predict cause of the potential cell failure and design necessary modifications in the cell composition or requirements of the powered device to minimize the chance for this failure to occur.

Weryfikacja:

written exam

**Powiązane efekty kierunkowe:** K\_U13, K\_U14, K\_U16, K\_U24

**Powiązane efekty obszarowe:** T1A\_U08, T1A\_U13, T1A\_U14, T1A\_U12, T1A\_U16, T1A\_U15

**Efekt 1150-00000-ISA-0349\_U2:**

Student potrafi zaprojektować ogniwo pod konkretne zastosowanie przy uwzględnieniu aspektów ekonomicznych i środowiskowych.

Weryfikacja:

written exam

**Powiązane efekty kierunkowe:** K\_U09, K\_U14, K\_U16, K\_U22

**Powiązane efekty obszarowe:** T1A\_U09, T1A\_U12, T1A\_U14, T1A\_U12, T1A\_U16, T1A\_U10

**Efekt 1150-00000-ISA-0349\_U01:**

Student potrafi krytycznie ocenić skład i strukturę istniejącego ogniwa i zaproponować jego modyfikacje w celu dopasowania parametrów ogniwa do konkretnej aplikacji.

Weryfikacja:

written exam

**Powiązane efekty kierunkowe:** K\_U14, K\_U16, K\_U22

**Powiązane efekty obszarowe:** T1A\_U14, T1A\_U12, T1A\_U16, T1A\_U10

### Profil ogólnoakademicki - kompetencje społeczne

**Efekt 1150-00000-ISA-0349\_K1:**

Student is aware of the need for cooperation and efficient communication with other specialists in the interdisciplinary team in order to choose cell components for the given application thanks to the ability to use professional vocabulary for phenomena, materials and processes.

Weryfikacja:

written exam

**Powiązane efekty kierunkowe:** K\_K02, K\_K04

**Powiązane efekty obszarowe:** T1A\_K02, T1A\_K03, T1A\_K04