Warsaw University of Technology | Doctoral School No. 1

Course offered in the Doctoral School No. 1 – Spring semester of the 2021/2022 academic year

TITLE
Electrochemical Impedance Spectroscopy – Principles and Applications
CONDUCTING UNIT
Doctoral School No. 1
SCIENTIFIC DISCIPLINE
Chemical sciences
IMPLEMENTING UNIT
102000 - Faculty of Chemistry
FULL DESCRIPTION
Electrochemical Impedance Spectroscopy (EIS) has been playing an important role in fundamental and applied electrochemistry and material science since decades and the scope of its applications is still widening with development of novel and smart materials in chemical technology, energy storage and conversion, electronics and other branches of modern science and technology. With current availability of high-quality impedance analyzers and deeper understanding of impedance phenomena EIS studies become more and more popular and versatile tool for electrochemists, material engineers and related specialists. The scope of possible applications varies from determination of basic electrical parameters of materials (conductivity) to electrochemical kinetics and structural subtleties of materials as revealed by impedance components, hints for technological processes and improvements. This class is aimed at leading the students from the basic principles of EIS method over the understanding of application and correlation between measured parameters and physicochemical properties of materials studied to the final practical laboratory skills. (Lecture + lab unit) Electrochemical Impedance Spectroscopy (EIS) has been playing an important role in fundamental and applied electrochemistry and material science since decades and the scope of its applications is still widening with development of novel and smart materials in chemical technology, energy storage and conversion, electronics and other branches of modern science and technology. With current availability of high-quality impedance analyzers and deeper understanding of impedance phenomena EIS studies become more and more popular and versatile tool for electrochemists, material engineers and related specialists. The scope of possible applications varies from determination of basic electrical parameters of materials (conductivity) to electrochemical kinetics and

structural subtleties of materials as revealed by impedance components, hints for technological processes and improvements.
This class is aimed at leading the students from the basic principles of EIS method over the understanding of application and correlation between measured parameters and physicochemical properties of materials studied to the final practical laboratory skills.
The lecture part will start with recapitulation of basic physics of AC circuits, with hints and explanation towards more sophisticated computational procedures, that are sometimes used in advanced analysis of experimental data. Graphical presentation of impedance of simple and complex R, L and C containing circuits will be discussed.
Next part will deal with interpretation of electrochemical AC measurements. The crucial concept of how electrical elements might represent physical objects, physical and chemical (electrochemical) reactions will be covered in detail. Virtual components of impedance – like Constant Phase Element and other diffusion- and structure-related parameters will be introduced and incorporated into equivalent circuits for electrode-electrolyte systems.
After this theoretical part more practical topics will follow – principles of measuring technique, characteristics of modern measuring devices, design of experiments, data acquisition and processing. Typical approach to data analysis (simulation procedures combined with critical discussion of data fitting results) will be presented, with hints for further evolution of combined electrochemical and structural studies.
The laboratory part will instruct the students on practical aspects of EIS technique. Design and assembly of experimental set-ups will be mastered, and finally students will execute their own experiments and work on the results, formulating research conclusions.
Performance of the students will be controlled twofold – with written test at the end of the lecture and laboratory reports.

LITERATURE

1. Impedance Spectroscopy , E.Barsoukov, J. Ross Macdonald, Wiley Interscience 2005
2.
2. https://www.ntnu.edu/documents/140124/0/EIS+Literature/cd116109-3fbf-4db5-9f99-ff5ab68cf950
3.
3. Electrochemical Methods, A Bard. L. Faulkner , Wiley&Sons 2001
4.
4. http://www.chem.uw.edu.pl/wp-content/uploads/2017/03/p1.pdf

LEARNING OUTCOMES

W zakresie wiedzy: doktorant zna i rozumie najnowsze osiągnięcia nauki w obszarze podstaw elektrochemii, układów pomiarowych, interpretacji wyników EIS
- w zakresie umiejętności: doktorant umie efektywnie pozyskiwać informacje związane z EIS z różnych źródeł, także w językach obcych, oraz dokonywać właściwej selekcji i interpretacji tych informacji, prezentować i uzasadniać wyniki swoich badań
- w zakresie kompetencji społecznych: doktorant jest gotowy do uznawania znaczenia wiedzy w rozwiązywaniu problemów poznawczych i praktycznych, ciągłe podnoszenia kompetencji zawodowych i osobowych, w szczególności poprzez śledzenie i analizowania najnowszych osiągnięć w dziedzinie elektrochemicznych badań materiałów i procesów

LANGUAGE OF THE COURSE	ECTS CREDITS
English	2

TYPE OF CLASSES	NUMBER OF HOURS	COURSE INSTRUCTOR
Lecture	8	Regina Borkowska, dr inż.
Laboratory	8	Regina Borkowska, dr inż.