DOCTORAL SCHOOL OF WROCŁAW UNIVERSITY OF SCIENCE AND TECHNOLOGY

SUPERVISOR DECLARING/CONDUCTING COURSE: Włodzimierz Tylus
DEPARTMENT: Chemical Department
SCIENTIFIC DISCIPLINE: Chemical Engineering

COURSE CARD

Course name in Polish: Zaawansowane techniki badawcze w inżynierii materiałowej
Course name in English: Advanced research techniques in material engineering
Course language Polish
University-wide general course type*: Yes/ No
1) basic course
~~**2) specialist course**~~
~~**3) seminar**~~
~~**4) humanistic course**~~
~~**5) language**~~

Subject code: CIQ100097W

* delete as applicable

	Lecture	Foreign language course	Seminar	Mixed forms
Number of hours of organized classes in university (ZZU)	30			
Grading	Exam	Exam	Oral presentation	Exam, inspection, evaluation classes

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of atom structure and chemical bonds
2. Fundamentals of optical microscopy and surface morphology

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COURSE OBJECTIVES

C1 Understanding the nature of solids surface in nanotechnology
C2 Introduction to the modern techniques of testing the surface of a solids: XPS / AES, XRD, SEM, TEM, EIS microhardness / nanohardness, adhesion of the coatings and thin films, surface topography, the contact profilometry
C3 Understanding the interaction of the surface of the tested material with the corrosive environment. Understanding the contemporary laboratory methods of testing of corrosion processes
C4 Acquaintance and use of standards during measurements

PROGRAM CONTENTS

Form of classes – lecture (Lec)		Number of hours
Lec1	Photoelectric process - primary and secondary emission. Basic concepts: nano-surface, spectroscopic and X-ray notation. X-ray photoelectron spectroscopy (XPS / ESCA). Auger electron spectroscopy (AES). 'Depth' in XPS / AES analyzes.	2

Lec2	XPS / AES spectrum and its components. Stages of the analytical process. Basic instrumentals (UHV, energy analyzer, photon source, ion gun, manipulator). Sample preparation techniques	2
Lec3	Application of electron spectroscopy in material engineering. Examples of spectra (XPS / AES) and their interpretation: in microelectronics, semiconductor and polymer materials, metallurgy, corrosion of materials, ceramics, catalysis	2
Lec4	Depth profiling (destructive and non-destructive methods). Surface nanomorphology in XPS studies. 3D models. Typical problems in XPS tests. Using XPS databases	2
Lec5	Introduction to X-ray crystallography. Laboratory radiation sources and types of diffractometers. Research on the crystal structure of metals and ceramics using powder diffractometry	2
Lec6	Research on the crystal structure and phase composition of polymers using one- and two-dimensional wide-angle X-ray diffractometry (WAXS)	2
Lec7	Nanostructure analysis of heterogeneous multicomponent materials using small angle X-ray diffractometry (SAXS)	2
Lec8	The use of synchrotron radiation in materials research. Time-resolved studies of phase transitions, studies of structure changes induced by mechanical deformation and the influence of other external factors	2
Lec9	Fundamentals of electron microscopy (SEM, TEM) and X-ray microanalysis (EDS, WDS). Basic instruments: electron and X-ray detectors, vacuum system. The formulations used in the electron microscopy and their preparation	2
Lec10	Application of electron microscopy (SEM, TEM) and chemical composition microanalysis (EDS, WDS) in material engineering. Study of the structure of materials by means of backscattered electron diffraction (EBSD). Examples of photos (SEM, TEM), spectra and chemical composition (EDS, WDS) and crystallographic orientation maps (EBSD). Fundamentals in interpretation of measurement data.	2
Lec11	Scanning transmission electron microscopy (STEM) - advantages and disadvantages compared to the conventional SEM imaging. Focused ion beam systems and DualBeam ™ systems.	2
Lec12	Application of contact profilometry to determine the geometric parameters of coating surfaces and thin layers	2
Lec13	Determination of micro-hardness and adhesion of coatings and thin films	2
Lec14	Electrochemical impedance spectroscopy (EIS) in corrosion tests. Basic concepts, impedance and methods of its presentation, available measurement techniques, spectra and their analysis, electrical replacement models	2
Lec15	Determination of dielectric materials parameters based on impedance spectroscopy. Basic concepts, available measurement techniques, spectra and their analysis, electrical replacement models	2
	Total hours:	**30**

TEACHING TOOLS USED
N1. Informative lecture with multimedia presentation N2. Problem lecture N3. Database presentations

ACHIEVED SUBJECT LEARNING OUTCOMES		
Type of learning outcome	Code of learning outcome	Assessment of learning outcome
Knowledge	P8S_WG	exam
Skills	P8S_UW	

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] An Introducing to Surface Analysis by XPS and AES; J.F. Watts, J.Wolstenholme, John Wiley&Sons Ltd., 2003
[2] Kelsall R.W., Hamley I.W., Geoghegan M.: Nanotechnologie. Warszawa: Wydawnictwo Naukowe PWN, 2008.
[3] Goldstein J, Newbury D, Joy D, Lyman C, Echlin P, Lifshin E, Sawyer L, Michael J.: Scanning Electron Microscopy and X-Ray Microanalysis. Berlin: Springer-Verlag, 2003.
[4] Chemia Fizyczna, P.W. Atkins, PWN, 2012
[5] K. Nitsch, Zastosowanie spektroskopii impedancyjnej w badaniach materiałów elektronicznych, Oficyna Wydawnicza PWr, 1999

SECONDARY LITERATURE:

[1] Marek Faryna, *Analiza zależności krystalograficznych faz składowych w kompozytach z osnową ceramiczną*, Polska Akademia Nauk. Instytut Metalurgii i Inżynierii Materiałowej, 2003.
[2] Kędzierski Z., Stępiński J.: *Elektronowy mikroskop skaningowy (SEM)*. UWN AGH, 2007
[3] X-ray diffraction, B.E. Warren Dover Publications; Reprint edition (June 1, 1990)
[4] CasaXPS Manual 2.3.15 Rev 1.2, Intrudction to XPS and AES, N. Fairley, Casa Software Ltd, http://www.casaxps.com/ebooks/ebooks.htm
[5] J. Martinem-Vega (ed.), Dielectric Materiale for Electrical Engineering, John Wiley&Sons, Inc., 2010

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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