AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name: Physical Chemistry of Surfaces and Surface Analytical Techniques

Academic year: 2019/2020 Code: CIMT-2-418-s ECTS credits: 3

Faculty of: Materials Science and Ceramics

Field of study: Materials Science Specialty: —

Study level: Second-cycle studies Form and type of study: Full-time studies

Lecture language: English Profile of education: Academic (A) Semester: 4

Course homepage: —

Responsible teacher: prof. nadzw. dr hab. inż. Jedliński Jerzy (jedlinsk@agh.edu.pl)

## Module summary

Part I focuses on description of surfaces (physical and chemical), surface processes and surface-affected properties of materials, while part II deals with surface analytical methods

# Description of learning outcomes for module

| MLO code | Student after module completion has the knowledge/ knows how to/is able to | Connections with FLO | Method of learning outcomes verification (form of completion) |
|---|---|---|---|
| Social competence: is able to | | | |
| M_K001 | The student is able to work on scientific issues and engineering tasks./ Student potrafi pracować nad problematyką naukową i zadaniami inżynierskimi | IMT2A_K01 | Activity during classes |
| Skills: he can | | | |
| M_U001 | The student is able to choose a research methodology for a problem related to surface properties./ Student potrafi wybrać metodykę badawczą do problemu związanego z właściwościami powierzchni | IMT2A_U04, IMT2A_U01 | Activity during classes |
| Knowledge: he knows and understands | | | |
| M_W001 | The student learns about the properties of materials under the influence or control of their surface layer./ Student poznaje właściwości materiałów pozostające pod wpływem lub kontrolą ich warstwy powierzchniowej | IMT2A_W04, IMT2A_W03 | Activity during classes |

| | | | |
|---|---|---|---|
| M_W002 | The student learns the description of the structure of real areas./ Student poznaje opis struktury powierzchni rzeczywistych | IMT2A_W01 | Activity during classes |
| M_W003 | The student learns the description of the surface on the basis of formalism of thermodynamics./ Student poznaje opis powierzchni na gruncie formalizmu termodynamiki | IMT2A_W01 | Activity during classes |
| M_W004 | Student learns about specific processes and phenomena occurring on the surface and their correlations with the properties of materials./ Student poznaje konkretne procesy i zjawiska zachodzące na powierzchni i ich korelacje z właściwościami materiałów | IMT2A_W01, IMT2A_W03 | |

## Number of hours for each form of classes

| | Form of classes | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Suma | Lectures | Auditorium classes | Laboratory classes | Project classes | Conversation seminar | Seminar classes | Practical classes | Fieldwork classes | Workshops | Prace kontrolne i przejściowe | Lektorat |
| 30 | 0 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 | 0 |

## FLO matrix in relation to forms of classes

| MLO code | Student after module completion has the knowledge/ knows how to/is able to | Form of classes | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lectures | Auditorium classes | Laboratory classes | Project classes | Conversation seminar | Seminar classes | Practical classes | Fieldwork classes | Workshops | Prace kontrolne i przejściowe | Lektorat |
| Social competence: is able to | | | | | | | | | | | | |
| M_K001 | The student is able to work on scientific issues and engineering tasks./ Student potrafi pracować nad problematyką naukową i zadaniami inżynierskimi | - | - | - | - | - | + | - | - | - | - | - |
| Skills: he can | | | | | | | | | | | | |
| M_U001 | The student is able to choose a research methodology for a problem related to surface properties./ Student potrafi wybrać metodykę badawczą do problemu związanego z właściwościami powierzchni | - | - | - | - | - | + | - | - | - | - | - |
| Knowledge: he knows and understands | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M_W001 | The student learns about the properties of materials under the influence or control of their surface layer./ Student poznaje właściwości materiałów pozostające pod wpływem lub kontrolą ich warstwy powierzchniowej | - | - | - | - | - | + | - | - | - | - | - |
| M_W002 | The student learns the description of the structure of real areas./ Student poznaje opis struktury powierzchni rzeczywistych | - | - | - | - | - | + | - | - | - | - | - |
| M_W003 | The student learns the description of the surface on the basis of formalism of thermodynamics./ Student poznaje opis powierzchni na gruncie formalizmu termodynamiki | - | - | - | - | - | + | - | - | - | - | - |
| M_W004 | Student learns about specific processes and phenomena occurring on the surface and their correlations with the properties of materials./ Student poznaje konkretne procesy i zjawiska zachodzące na powierzchni i ich korelacje z właściwościami materiałów | - | - | - | - | - | + | - | - | - | - | - |

## Student workload (ECTS credits balance)

| Student activity form | Student workload |
|---|---|
| Udział w zajęciach dydaktycznych/praktyka | 30 h |
| Preparation for classes | 15 h |
| Realization of independently performed tasks | 30 h |
| Examination or Final test | 2 h |
| Summary student workload | 77 h |
| Module ECTS credits | 3 ECTS |

## Additional information

## Module content

**Seminar classes**

Physical chemistry of surfaces and surface analytical techniques
Content is divided into two following parts

Part I: Physical chemistry of surfaces:
1. Ideal and real surfaces
2. Thermodynamics of surfaces

3. The structure of surfaces.
4. Crystal thermodynamics (with relevance to surface)
5. Molecular and mechanical description of surfaces
6. Surface dynamics
7. Electrical properties of surfaces
8. Surface processes and properties (clean surface structure, reconstruction, solid-gas interface-general considerations, adsorption, catalysis by surfaces, mechanical properties of surfaces, friction, lubrication and adhesion, wetting, floating, detergency, growth of surface layers, catalytic growth of nanotubes and nanowires, structure formation by etching, various processes on solid surfaces, colloids and relevant processes)

Part II: Surface analytical techniques
9. Concept of selvedge
10. General description of the concept  of surface analysis and approach
9. Interaction of the particles/radiation with matter: application to surface investigation
10. Parameters of surface methods
11. Electron spectroscopies: XPS (X-ray Photoelectron Spectroscopy), AES (Auger Electron Spectroscopy, SAM (Scanning Electron Microscopy)
12. Scattered Ion Mass Spectrometry of light ions: RBS (Rutherford Backscattering Spectrometry), ISS (Ion Scattered Spectrometry)
13. Ion-Beam Mass Spectrometry – emitted ions: SIMS (Secondary Ion Mass Spectrometry), SNMS (Sputtered Neutrals Mass Spectrometry)
14. Scanning Probe Microscopy (SPM): STM (Scanning Tunnelling Microscopy), AFM (Atomic Force Microscopy), other
15. Electron microscopies: SEM (Scanning Electron Microscopy), TEM (Transmission Electron Microscopy), Sample preparation methods to electron microscopy studies (FIB, ion-beam thinning, ...)
16. Glow Discharge Optical Emission Spectroscopy (GDOES)
27. Grazing Incidence X-Ray Methods

## Teaching methods and techniques:

Seminar classes: Na zajęciach seminaryjnych podstawą jest prezentacja multimedialna oraz ustna prowadzona przez studentów. Kolejnym ważnym elementem kształcenia są odpowiedzi na powstałe pytania, a także dyskusja studentów nad prezentowanymi treściami.

## Warunki i sposób zaliczenia poszczególnych form zajęć, w tym zasady zaliczeń poprawkowych, a także warunki dopuszczenia do egzaminu:

Egzamin nie jest przewidziany.
Zaliczenie zajęć seminaryjnych: ocena z prezentacji.
Zaliczenie poprawkowe: dodatkowe prezentacje, a w przypadku nieobecności – kolokwium z całości materiału.

## Zasady udziału w poszczególnych zajęciach, ze wskazaniem, czy obecność studenta na zajęciach jest obowiązkowa:

Seminar classes:
– Attendance is mandatory: Yes
– Participation rules in classes: Studenci prezentują na forum grupy temat wskazany przez

prowadzącego oraz uczestniczą w dyskusji nad tym tematem. Ocenie podlega zarówno wartość merytoryczna prezentacji, jak i tzw. kompetencje miękkie.

## Method of calculating the final grade

Prezentacja/Presentation (50%) + Kolokwium końcowe/Final test (50%)

## Sposób i tryb wyrównywania zaległości powstałych wskutek nieobecności studenta na zajęciach:

1. W przypadku usprawiedliwionej nieobecności na własnej prezentacji – dodatkowy termin prezentacji.
2. W przypadku nieusprawiedliwionych nieobecności na więcej niż dwóch zajęciach – kolokwium zaliczeniowe z całości (student uzyskuje dostęp do materiałów dydaktycznych z zajęć na których nie był obecny)..

## Prerequisites and additional requirements

Prerequisites and additional requirements not specified

## Recommended literature and teaching resources

K.W. Kolasinski, Surface Science, 2nd Edition, Wiley & Sons, 2008
G.A. Somorjai, Introduction to Surface Chemistry and Catalysis, Wiley & Sons, 1994 or later
A.W. Adamson, A.P. Gast, Physical Chemistry of Surfaces 6th Edition, Wiley & Sons, 1997 or later
J.A. Venables, Introduction to surface and thin film processes, Cambridge University Press, 2000
G. Friedbacher, H. Bubert (Ed.), Surface and Thin Films Analysis, Wiley-VCH Verlag GmbH KGaA,Weinheim, 2011
S. Myhra, J.C. Rivere, Characterization of Nanostructures, CRC Press, Taylor & Francis Group, Bova Raton, 2012
D.J. O'Connor, B.A. Sexton, R.St.C. Smart, Surface Analysis Methods in Materials Science, Springer, Berlin-Heidelberg, 2nd Ed., 2003
Y. Leng, Materials Characterization, Wiley & Sons (Asia), Singapore, 2008
D. Brandon, W.D. Kaplan, Microstructural Characterization of Materials, 2nd Edition, John Wiley & Sons Ltd., Chichester, 2008
D.P. Woodruff, Modern Techniques of Surface Science, 3rd edition, Cambridge University Press, 2016

## Scientific publications of module course instructors related to the topic of the module

1. J. Jedliński, J.L. Grosseau Poussard, G. Smoła, G. Bonnet, M. Nocuń, K. Kowalski, and J. Dąbek, "The effect of alloyed and/or implanted yttrium on the mechanism of the scale development on β-NiAl at 1100oC", Materials at High Temperatures, 29 (2), 59-69 (2012)
2. J. Jedlinski, J.L. Grosseau-Poussard, M. Nocuń, G. Smoła, K. Kowalski, J. Dąbek, A. Rakowska, G. Bonnet "The Early Stages of the Scale Growth on FeCrAl(RE)-Type Alumina Formers"
Materials Science Forum, 696, 70-75 (2011)
3. H.J. Choi, J. Jedlinski, B. Yao, Y.H. Sohn
"Transmission electron microscopy observations on the phase composition and microstructure of the oxidation scale grown on as-polished and yttrium-implanted β-NiAl"
Surface & Coatings Technology, 205 (2010) 1206–1210
4. J. Jedlinski
"Application of 18O2 Exposure–Based Approach to Study the Failure Mechanisms of Oxide Scales on Alumina Formers"
Materials Science Forum, 513 (2006) 149-164
5. J. Jedliński, A. Bernasik, K. Kowalski and M. Nocun
"On the Application of SIMS to Study the Oxidation Behaviour of Alumina Formers"
Materials at High Temperatures, 22 (2005) 505-520
6. J. Jedliński
"Local and Microstructure-related Effects Affecting the High Temperature Oxidation of Alumina Formers: A Brief Survey"
Materials at High Temperatures, 22 (2005) 485-496
7. M. Nocuń, J. Jedliński, E. Leja
"Spectroscopic studies of hybrid glasses based on TEOS-cyclosiloxane systems"
Proc. XXth International Congress on Glass, Kyoto, 27.09-1.10.2004, Paper : P-11-031

8. J. Jedliński, M. Konopka, M. Goebel, A. Glazkov, A. Bernasik, M. Nocun, J. Camra, G. Borchardt
“The Use of XPS and SIMS in Studying the Early Oxidation Stages of FeCrAl-Based High Temperature Alloys”
Proc. 7th European Conference on Applications of Surface and Interface Analysis, ECASIA’97, Göteborg, 1997, Ed. I. Olefjord, L. Nyborg, D. Briggs, J. Wiley & Sons, Chichester, 1997, p. 259 – 262
9. K. Kowalski, A. Bernasik, A. Sadowski, J. Janowski, M. Radecka, J. Jedliński
“SIMS Investigation of Titanium Diffusion in Yttria Stabilised Zirconia”
Proc. 7th European Conference on Applications of Surface and Interface Analysis, ECASIA’97, Göteborg, 1997, Ed. I. Olefjord, L. Nyborg, D. Briggs, J. Wiley & Sons, Chichester, 1997, p. 259 – 262
10. A. Bernasik, K. Kowalski, A. Sadowski, J. Janowski, J. Jedliński
“XPS Study of the Surface Segregation in Yttria Stabilised Zirconia”
Proc. 7th European Conference on Applications of Surface and Interface Analysis, ECASIA’97, Göteborg, 1997, Ed. I. Olefjord, L. Nyborg, D. Briggs, J. Wiley & Sons, Chichester, 1997, p. 255 – 258
11. J. Jedliński, A. Glazkov, M. Konopka, G. Borchardt, E. Tscherkasova, M. Bronfin, M. Nocun
“An XPS/SEM/EDX study of the early oxidation stages of Fe19Cr5Al (Y) alumina-forming alloys at 1173 K"
Applied Surface Science, 103, 205 – 216 (1996)

## Additional information

None