AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name:	Surface engineering and mechanics
Academic year:	2019/2020
Code:	ZSDA-3-0253-s
ECTS credits:	3
Faculty of:	Szkoła Doktorska AGH
Field of study:	Szkoła Doktorska AGH
Specialty:	—
Study level:	Third-cycle studies
Form and type of study:	Full-time studies
Lecture language:	English
Profile of education:	Academic (A)
Semester:	0
Course homepage:	—
Responsible teacher:	prof. Vignal Vincent (vincent.vignal@u-bourgogne.fr)

Module summary

Fundamental principles of mechanics of solids, solid surfaces and surface engineering. Description of useful experimental techniques for characterizing the structure and mechanical properties of surfaces at different scales.

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 motivates to solve the problems in industry, on practical systems	SDA3A_K01, SDA3A_K03	Presentation
Skills: he can			
M_U001	The student is able to select appropriate techniques and methods to study solid surfaces and engineering materials	SDA3A_U01	Presentation
Knowledge: he knows and understands			
M_W001	Understanding the fundamental principles of surface mechanics and surface engineering	SDA3A_W03, SDA3A_W01	Examination
M_W002	The student know the different experimental techniques used for surface characterization.	SDA3A_W03, SDA3A_W01	Examination

Number of hours for each form of classes

Suma	Form of classes										
	Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
30	30	0	0	0	0	0	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 motivates to solve the problems in industry, on practical systems	+	-	-	-	-	-	-	-	-	-	-
Skills: he can												
M_U001	The student is able to select appropriate techniques and methods to study solid surfaces and engineering materials	+	-	-	-	-	-	-	-	-	-	-
Knowledge: he knows and understands												
M_W001	Understanding the fundamental principles of surface mechanics and surface engineering	+	-	-	-	-	-	-	-	-	-	-
M_W002	The student know the different experimental techniques used for surface characterization.	-	-	-	-	-	-	-	-	-	-	-

Student workload (ECTS credits balance)

Student activity form	Student workload
Udział w zajęciach dydaktycznych/praktyka	30 h
Preparation for classes	2 h
przygotowanie projektu, prezentacji, pracy pisemnej, sprawozdania	4 h
Realization of independently performed tasks	15 h
Examination or Final test	2 h
Contact hours	2 h
Summary student workload	55 h
Module ECTS credits	3 ECTS

Additional information

Module content

Lectures

Surface engineering and mechanics
PART I
-Generalities on engineering systems, engineering materials and surface engineering
- Generalities on the surface
-Environmental degradation of engineering surfaces (machining, tribology)
-Surface treatment for protection (Burnishing, laser shock processing)
- Experimental methods for coating of engineering surfaces
(Welding, surfacing by welding, electrodeposition, electroless plating, chemical and electrochemical conversion, chemical vapor deposition, physical vapor deposition, Hot-dip galvanizing, Powder painting)

PART II: Mechanics of deformable solids and surface mechanics (basics)
strain and stress, definitions
strain-stress curves
Damage mechanics
stress-strain laws in elasticity
stress-strain laws in plasticity

PART III
Experimental techniques to measure the mechanical properties and the surface stress/strain fields, to evaluate damages
X-ray diffraction methods (XRD)
Image analysis and Digital Image Correlation (DIC)
Lithography and microstrain gauges
Indentation tests (micro and nano)
Split Hopkinson pressure bar (SHPB) test
Experimental techniques to characterize engineering surfaces
SEM, TEM,...

PART IV: Fudamentals of the finite element method
Introduction
Advantages
Modeling and discretization errors
Numerical errors
general procedure
different steps

PART V: Examples

Teaching methods and techniques:

Lectures: multimedia presentation

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

If students want to pass the exam, they must attend at least 70% of the lectures

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

Lectures:
– Attendance is mandatory: Yes
– Participation rules in classes: 70% of presence at the lectures is obligatory

Method of calculating the final grade

Final grade will be average grade calculated from an exam and a presentation.

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

The students must write additional report on a subject given by the teacher

Prerequisites and additional requirements

no

Recommended literature and teaching resources

1. A.F. Bower, Applied mechanics of Solids, ed. by CRC Press 2009
2. C. Suryanarayana, Experimental Techniques in Materials and Mechanics, ed. by CRC Press 2011
3. O.C. Zienkiewicz, R.L. Taylor, The Finite Element Method: Solid Mechanics, Volume 2, 5th edition, ed; by MPG bokks Ltd 2002

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

1) H. Krawiec, V. Vignal, A. Krystianiak, Y. Gaillard and S. Zimowski, Mechanical properties and corrosion behaviour after scratch and tribological tests of electrodeposited Co-Mo/TiO2 nano-composite coatings, Applied Surface Science, 475, pp. 162-174 (2019).
2) L.A. Denguir, J.C. Outeiro, G. Fromentin, V. Vignal and R. Besnard, A physical-based constitutive model for surface integrity prediction in machining of OFHC copper, Journal of Materials Processing Technology, 248, pp. 143-160 (2017).
3) L.A. Denguir, J.C. Outeiro, J. Rech, G. Fromentin, V. Vignal, R. Besnard, Friction model for tool / material contact applied to surface integrity prediction in orthogonal cutting simulation, Procedia CIRP, 58, pp. 578-583 (2017).
4) L.A. Denguir, J.C. Outeiro, G. Fromentin, V. Vignal, R. Besnard, Orthogonal cutting simulation of OFHC

copper using a new constitutive model considering the state of stress and the microstructure effects, Procedia CIRP, 46, pp. 238-241 (2016).
5) J.C. Outeiro, S. Campocasso, L. Denguir, G. Fromentin, V. Vignal and G. Poulachon, Experimental and numerical assessment of the severe plastic deformation induced by OFHC copper machining, CIRP Annals Manufacturing Technology, 64, pp. 53-56 (2015).
5B) V. Rault, V. Vignal, H. Krawiec and F. Dufour, Quantitative assessment of local misorientations and pitting corrosion behaviour of pearlitic steel using electron backscattered diffraction and microcapillary techniques, Corrosion Science, 100, pp. 667-671 (2015).
5C) H. Krawiec, Z. Szklarz and V. Vignal, Influence of applied strain on the microstructural corrosion of AlMg2 as-cast aluminium alloy in sodium chloride solution, Corrosion Science, 65, pp. 387-396 (2012).
6) A. Clair, M. Foucault, O. Calonne, Y. Lacroute, L. Markey, M. Salazar, V. Vignal and E. Finot, Strain mapping near a triple alloy junction under tensile loading using EBSD and biaxial nano-gauges, Acta Materialia, 59(8), 3116-3123 (2011).
7) N. Hfaiedh, P. Peyre, I. Popa, V. Vignal, W. Seiler, V. Ji, Experimental and Numerical Analysis of the Distribution of Residual Stresses Induced by Laser Shock Peening in a 2050-T8 Aluminium Alloy, Materials Science Forum, 681, pp. 296-302, (2011).
8) J. Breuils, H. Pelletier, J. Krier, V. Vignal, Determination of elastoplastic properties of TiO2 thin films deposited on dual phase stainless steel using nanoindentation tests, Surface and Coatings Technology, 204(12-13), pp. 2068-2072 (2010).
9) A. Claire, M. Foucault, J.M. Salazar, V. Vignal, E. Finot and L. Markey, A methodology to deduce the microstructural spatial deformation of polycrystalline structures: application to the alloy 600, Defect and Diffusion Forum, 289-292, pp. 137-144 (2009).
10) D. Kempf, V. Vignal, N. Martin and S. Virtanen, Relationships between strain, microstructure and oxide growth at the nano- and microscale, Surface and Interface Analysis, 40(1), pp. 43-50 (2008).
11) D. Kempf, V. Vignal, G. Cailletaud, R. Oltra, J.C. Weeber and E. Finot, High spatial resolution strain measurements at the surface of duplex stainless steels, Philosophical Magazine, 87(8-9), pp. 1379-1399 (2007).
12) N. Mary, V. Vignal, R. Oltra and L. Coudreuse, Finite-element and XRD methods for the determination of the residual surface stress field and the elastic-plastic behaviour of duplex stainless steels, Philosophical Magazine, 85(12), pp. 1227-1242 (2005).
13) V. Vignal, R. Oltra and C. Josse, Local analysis of the mechanical behaviour of inclusions-containing stainless steels under straining conditions, Scripta Materialia, 49(8), pp. 779-784 (2003).

Additional information

no