1.	**Nazwa kierunku**	**biofizyka**
2.	Wydział	Wydział Nauk Ścisłych i Technicznych
3.	Cykl rozpoczęcia	2021/2022 (semestr zimowy)
4.	Poziom kształcenia	studia drugiego stopnia
5.	Profil kształcenia	ogólnoakademicki
6.	Forma prowadzenia studiów	stacjonarna

Moduł kształcenia: Surface Science

Kod modułu: W4-2BF-MB-21-09

1. Liczba punktów ECTS: 3

2. Zakładane efekty uczenia się modułu

kod	opis	efekty uczenia się kierunku	stopień realizacji (skala 1-5)
MB_09_1	the student can be introduced to the physics of surfaces and interfaces, focusing on basic concepts rather than specific details	KBF_W01 KBF_W07	4 3
MB_09_2	the student is able to know the physical phenomena underlying some of the most important techniques and methods for surface analysis	KBF_W01 KBF_W10	4 4

3. Opis modułu

Opis

PART I: Phenomenology of surfaces and interfaces
Introduction to the course. Introduction to surfaces and interfaces. Surface/volume ratio. Microscopic interpretation of intermolecular forces. Interaction energy between ions, frozen and mobile permanent dipoles. Keesom energy.
Interaction energy with induced dipoles: Debye induction energy, London dispersive energy. Frequency dependence of atomic polarizability. Ionization energy. Van der Waals energy.
Additivity of Van der Waals interaction. VdW forces between macroscopic bodies: adsorption, adhesion, cohesion. Hamaker constant. Liquid surfaces. Interfacial thickness. Surface free energy and surface energy. Surface tension. Thermodynamics of
interfaces in equilibrium: Gibbs theory. Definition of interface and Gibbs dividing plane. Interfacial excess.
Thermodynamic potentials at the interface. Thermodynamic definition of surface tension. Euler relation and Gibbs-Duhem relation. Surface tension and interfacial excess. Mixing entropy and mixing chemical potential. Surface activity: case of ionic, apolar, and amphiphilic solutes. Colloidal aggregates. Critical micellar concentration. Thermodynamics of colloidal aggregation.
Pressure difference across a curved surface: Young-Laplace equation. Vapor pressure at a curved surface: Kelvin equation.
Supersaturation pressure. Theory of homogeneous nucleation. Heterogeneous nucleation. Wetting. Wetting line and contact angle. Young equation. Cases of partial, complete, and no wetting. Capillarity phenomena. Thin film formation.
Dewetting. Pseudo partial wetting and wetting layer. Thin film deposition: dip coating and spin coating.

	PART II: Surface characterization techniques Scanning probe microscopy. Beam vs local probes. Atomic force microscope. Working principle: typical setup. Piezoelectric scanners and raster scan. Constant height mode and constant force mode. Interaction steepness and atomic resolution. Cantilever force sensors. Optical lever deflection detection method. Static mode of operation: contact mode. Jump-in-contact and jump-off-contact points. Lateral force and local friction coefficient measurement. Bidirectional optical lever. Dynamic modes of AFM. Problems arising in static mode: thermal noise. Response function of the cantilever as a simple harmonic oscillator. Tapping mode. Phase sensitive coherent detection and lock-in detection. Effect of conservative and dissipative interactions on resonance curve. Frequency-modulation mode. Piezoelectric resonant force sensors: quartz tuning fork. Combined scanning probes. Auxiliary distance control. Electrostatic Force Microscopy. Dependence of electric force on distance and electric properties of dielectrics. Voltage-modulated force detection. Dielectric constant, surface charge and contact potential measurement. Kelvin probe method. Kelvin probe force microscopy. Nanotribology. Friction at a contact point measured by AFM. Stick-slip model for dissipation by dynamical friction. Friction of atomic layers. Quartz crystal microbalance (QCM). Gravimetric and non-gravimetric QCM. Interfacial viscosity and slip time.
Wymagania wstępne	

4. Sposoby weryfikacji efektów uczenia się modułu

kod	nazwa (typ)	opis	efekty uczenia się modułu
MB_09_w_1	egzamin	oral exam, or presentation, in seminar form, of a detailed study concerning one of the topics of the course	MB_09_1, MB_09_2

5. Rodzaje prowadzonych zajęć

kod	rodzaj prowadzonych zajęć			praca własna studenta		sposoby weryfikacji efektów uczenia się
	nazwa	opis (z uwzględnieniem metod dydaktycznych)	liczba godzin	opis	liczba godzin	
MB_09_fs_1	wykład	Detailed discussion by the lecturer of the issues listed in the table "module description" using the table and/or multimedia presentations	18	Supplementary reading, working with the textbook	41	MB_09_w_1
MB_09_fs_2	laboratorium	One visit to research laboratories where experiments of surface physics using scanning probe microscopy are performed	6	Supplementary reading, working with the textbook	10	MB_09_w_1