Chemistry of Surfaces and Interfaces

Dr. Giulia Fioravanti

Course Schedule (a.a. 2013-2014)

Chemistry of Surfaces and Interfaces		CFU	**6**
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Consulting hours	**Monday 17-18; Thursday 14-15 in room B 0.1**		

Time table (room B0.1)

Monday	Wednesday	Thursday
15-17	**15-17**	**15-17**

Program:

Introduction. Introduction to surface science.

The states of matter. The gaseous state: Equation of state of ideal gases. Kinetic theory of gases. Maxwell-Boltzmann equation.
The condensed states. Solid state: types of solids, geometric classification. Packaging and crystal lattices. The energetic classification: Lennard-Jones potential. Classification according to the physico-chemical properties: conductors, semiconductors and insulators.
The liquid state. Properties of liquids. Viscosity. Surface Tension. Capillarity. Vapour tension.

The technique of vacuum. Vacuum levels; Ultra High Vacuum (UHV) Parameters to set in UHV.

Physical chemistry of interfaces. Phenomenological aspects. Definition of interphases, type of interphases (solid-gas, solid-liquid, liquid-gas, liquid-liquid) and its features. Practical examples on surface phenomena.

Fundamentals of surface phenomena. Discontinuity at the interface. Excess surface. Surface tension: determination in liquids and solids. Elements of thermodynamics of interfacial systems. Surface free energy and stability. Surface free energy and surface tension. Model case: fluid-solid interfacial systems. Phenomena of adhesion and cohesion. Wettability: Contact angle and Young's equation. Spreading.

Effect of the surfaces. Model case: three-phase system (liquid, gas and interphase). The curvature of a surface. The Young-Laplace Equation and its applications. The Kelvin effect.

Models of interphase. The surface phase approach: three-phase system (interphase). The excess surface approach. The Gibbs dividing surface. Model case: vapor-liquid two-phase system. Liquid-liquid system. Three-phase system. Liquid-vapor two-components system: effect of the composition in a binary system.

Adsorption. Phenomena of absorption and adsorption. Liquid-vapor two-components system. The Gibbs Adsorption Equation. Interaction of gas to the surface: physical and chemical adsorption. Adsorption models: isotherms (BET). Chemisorption. Adsorption from solution. Amphiphilic adsorption. Surfactants: classification. Surface tension and surfactants.

Solid-liquid interaction. Contact angle and wettability. Young-Dupré equation. Surface tension and contact angle: pure substances. Zisman method: critical surface tension. Surface tension measurements (Fowkes, Neumann, Owens- Wendt, Wu, Van Oss - Chaudhury -Good). Microscopic and macroscopic contact angle. Hysteresis. Surface roughness. Wenzel and Cassie-Baxter wetting regime.

Dispersed systems. Colloids. Optical, kinetic and electrical properties. Intermolecular forces and stability of dispersed systems. Phenomena of flocculation and coagulation. Nanoparticles (notes). Detergents.
Interaction between solid surfaces. Tribology: friction, wear and lubrication. Surfaces texture: roughness. Surface treatments.

Surfaces Characterization Techniques. Structural characterization: morphology, structure, defects, thickness, chemical composition. Profilometer. Confocal microscopy (notes).

Microscopic Characterization. Optical Microscopy. Birefringence (notes). Fluorescence microscopy. Electron microscopy (TEM, SEM). Scanning Probe Microscopy (STM). Atomic force microscopy (AFM).

Spectroscopic characterization. UV-Visible Spectroscopy. IR-Raman spectroscopy. X-ray photoemission spectroscopy (XPS). Auger electron spectroscopy (AES).

Modification of surfaces. Thin and thick films deposition: methods, properties, and characterization. Physical and chemical methods. Physical Vapor Deposition (PVD: Thermal evaporation, Electron gun, Sputtering, Arc deposition) and Chemical Vapor Deposition (CVD, thermal CVD; Assisted Photo -CVD, plasma - enhanced CVD).

Deposition from solution. Drop casting, Spin coating, Dip coating and Langmuir- Blodgett films. Spray coating.

Surface patterning techniques. Lithographic techniques. Photolithography. Soft- lithography (Replica molding RM, Micromoulding in capillaries MIMIC, Microtransfer μTM molding, Microcontact printingm μCP).

Self -assembled monolayers (SAM). Formation and properties. Approach SAM (Self- Assembling Monolayer). Issues related to the SAM: order, stability, reproducibility, defects. SAM of thiols and silanes. Cleaning and activation protocols of surfaces. SAMs modification. Technological applications of SAMs. Chemical gradients on surface: properties and applications. Wettability gradients.

Reference Books:

- Slides and other material from the professor.
- "An Introduction to Interfaces & Colloids: The Bridge to Nanoscience" - J. C. Berg, Publisher: World Scientific (ISBN: 978-981-4299-82-4).
- The characterization techniques should be integrate with material of other courses.

Skills required:
Mathematics, Physics, Thermodynamics, Kinetics, Catalysis, Light-matter interaction.

Pre-requisites specified by the teacher:
Chemistry I and II, Science and Technology of Materials and Applied Chemistry.

Assessment:
The exam consists of an oral examination.
During the exam, the student must also analyze and discuss a scientific article related to a topic of the course (recent literature).
The student must contact the professor at least 10 days before the oral exam and propose a list of at least 3 items from which only one will be chosen for the examination.
For the bibliographic research, you can use the university databases (http://www.univaq.it/section.php?id=1247), and in particular:
- ACS, America Chemical Society: http://pubs.acs.org/
- Science Direct: http://www.sciencedirect.com/
- Pubmed: http://www.ncbi.nlm.nih.gov/pubmed/advanced
- Scopus: http://www.scopus.com/

If you connect to a computer network at the university, you can directly download the pdf of articles from the pages of the publishers.
Students who have followed the laboratory experiences organized during the course is required a brief written report describing the activities carried out in the laboratory, with a brief theoretical introduction to the topic, the description of the experience, taken together with the data, and finally a brief discussion on the results obtained.