Physics of Surfaces

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The aim of the course is to give the basic knowledge of how surfaces of solid materials are built, which special properties they have and which processes take place at surfaces. The course treats the atomic structure of surfaces, the electronic structure of surfaces, metal-semiconductor interfaces, heterostructures, adsorption, chemical reactions and growth on surfaces, as well as the experimental methods used for investigation.

Program

1. Introduction. The role of surface on physico-chemical processes. Physics and techniques of ultra-high vacuum. Preparation of atomically clean surfaces: thermodesorpsion, ion etching, deposition, catalytic reaction, cleavage.

2. 2D crystallography. Two dimensional lattices. Miller indexes of planes and directions. Surface structures. Reciprocal lattice. Relaxation and reconstruction mechanisms. Physical properties and structure. Surface defects. Diffraction on the surface. Low and high energy electron diffraction. Grazing incidence X-ray diffraction. Photoelectron diffraction

3. X-ray photoelectron spectroscopy: physical background and techniques. Ultra-violet photoelectron spectroscopy. Synchrotron studies. Resonant photoemission. Auger electron spectroscopy. Electron energy loss spectroscopy.

4. Principles and methods of ion spectroscopy. Secondary ion mass-spectroscopy, background, and equipments. Thermal desorption spectroscopy.

Scanning probe microscopy and spectroscopy of surface. Scanning tunneling microscopy. Atomic force microscopy.

IR and Raman spectroscopy.

5. Electronic structure and properties of surfaces. Surface states. Space distribution of charge and Friedel oscillations. Surface Plasmon. Work function principle and components. Methods of determination of work function.

Electronic and atomic processes on the surface

6. Adsorption and desorption.

Heterosystems. Interfaces. Surface phenomena on solid/gas interfaces. Physical and chemical adsorption. Intermolecular interaction and physadsorption. Mono- and polymolecular adsorption. Langmuir model. Adsorption/desorption equilibrium. Heat of physadsorption.

Chemical bonding and chemoadsorption. Activation energy and heat of adsorption. Dissociative adsorption. Theory of Brunauer-Emmet-Taylor. Electron states of adatom. Work function changes on adsorption processes, dipole and Lang models. Atomic structure and interaction of adsorbate atoms. Desorption, surface diffusion.

Diffusion on solid surfaces. Diffusion equations (random walk motion and Fick's laws). Tracer, chemical, self- and mass transfer diffusion. Anisotropy of surface diffusion. Atomic mechanisms of surface diffusion. Experimental study of surface diffusion.

7. Growth and structure of Thin Films

Vollmer-Weber (VW, Island) growth. Models of islands nucleation. Kinetics of film growth. Franck van der Merve (FM, Layer-by-layer) growth. Pseudomorphic layer critical thickness, the elastic strain relaxation and structure. Kinetics of layered growth. Schwoebel barrier. Structural transformation on Stransky- Krastanov growth. Amorphous, mono- and polycrystalline films. Defects. Lattice mismatch on the interface. Thin film growth techniques. Molecular beam epitaxy and solid phase epitaxy.