

Surface Science

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1. Introduction

- 1.1 Historic development
- 1.2 Definition of the surface
- 1.3 Ideal and real surfaces (intrinsic/extrinsic defects)
- 1.4 Nomenclature (Miller indices)
- 1.5 Ultra-high vacuum (UHV)
- 1.6 Surface cleaning
- 1.7 UHV materials (leaks, contaminants)
- 1.8 Pumps

2. Geometric structure of a surface

- 2.1 Mathematical description
- 2.2 Thermodynamics of surfaces (surface tension)
- 2.3 Facetting
- 2.4 Crystal surfaces
- 2.5 Superlattices and reconstructions (Wood and matrix notation)
- 2.6 Reciprocal lattice
- 2.7 Experimental determination of surface structures (electron diffraction)
- 2.8 I/V curves (Bragg condition)
- 2.9 Adsorption
- 2.10 Diffusion processes
- 2.11 Thin film growth (growth modes, energetics)
- 2.12 Molecular growth processes (self-organization, molecular recognition, binding types)

3. Electronic structure of a surface

- 3.1 Surface states
- 3.2 Work function
- 3.3 Dipole layer
- 3.4 Smoluchowski effect
- 3.5 Image potential states
- 3.6 Experimental determination of electronic structures (Auger electron spectroscopy, photoemission spectroscopy)

4. Microscopy

- 4.1 Optical microscopy (diffraction limit)
- 4.2 Super-resolution fluorescence microscopy
- 4.3 Electron microscopy (TEM and SEM)
- 4.4 Electron generation, electron optics
- 4.5 Elastic/inelastic electron scattering
- 4.6 Secondary electrons, backscattered electrons, Auger electrons, X-rays
- 4.7 Detection
- 4.8 Field ion microscopy (field emission and field evaporation)

5. Scanning tunneling microscopy

- 5.1 Quantum tunneling
- 5.2 Local density of states
- 5.3 Sub-Ångström positioning, piezoelectric effect, feedback control
- 5.4 Vibration isolation
- 5.5 Tip preparation, sample preparation, molecular deposition methods
- 5.6 Imaging modes

6. Atomic force microscopy

- 6.1 Lennard-Jones potential (Pauli repulsion, van der Waals force)
- 6.2 Force sensors (cantilevers, tuning forks)
- 6.3 Contact/Non-contact mode AFM

7. General aspects of scanning probe microscopy

- 7.1 Noise in SPM measurements
- 7.2 Atomic/molecular manipulation
- 7.3 Lateral and vertical manipulation
- 7.4 Single-molecule chemical reactions
- 7.5 Surface probe spectroscopy
- 7.6 Selected examples (inelastic electron tunneling spectroscopy, force spectroscopy)
- 7.7 Spectroscopic mapping
- 7.8 Applications and recent advances in SPM