SURFACE STRUCTURE & DYNAMICS (6 ECTS)
Prof. M. Sambi

Contents (2017/2018):

1. Introduction to surface chemistry - the need of UHV.
2. Basics of UHV – pumps and pressure measurement.
3. Sample preparation and manipulation in UHV.
4. Surface thermodynamics: surface free energy, surface tension. Ideal epitaxial growth modes.
5. Anisotropy of the surface free energy in crystalline solids.
6. Wulff construction. Surface free energy minimisation: relaxation, reconstruction, faceting.
7. Surface termination of binary compounds: surface dipole minimisation and auto-compensation. Vicinal surfaces.
8. Superstructures: Wood and matrix notation.
9. Simple, coincidence and incommensurate superstructures.
10. A deeper look at coincidence structures. Moiré patterns.

11. Introduction to STM - operating modes (constant height, constant current).
12. Local Work Function measurements, STS. CITS. Nanomanipulation.
13. Ambient and electrochemical STM.
14. AFM.

15. Introduction to surface kinetics - elementary diffusion events.
16. Introduction to mean field nucleation theory. Critical and stable clusters, saturation density, dendrites.
17. Basics of mean field nucleation theory. Dendritic growth at low T. Fractal growth at intermediate T. Compact islands at high T.
18. Size dispersion reduction through Ostwald ripening.
19. Growth on anisotropic substrates. Step decoration on vicinal surfaces. Quantum wires on fcc (110) surfaces. Quantum dots on reconstructions.
20. Quantum dots on dislocation networks. Oxide templating ultrathin films for metal nanocluster growth. 3D semiconductor quantum dots.

21. Bragg diffraction in 2D. 2D reciprocal lattice. Ewald sphere in 2D. Reciprocal lattice rods.
22. LEED - cinematic theory. From the LEED image to real space periodicity. Matrix conversion. The presence of domains.
23. Examples of superstructures resolved by combining STM and

LEED. LEED I-V.

24. RHEED: principles and applications.

25. Adsorption. Physisorption and chemisorption. Desorption. Introduction to heterogeneous catalysis. Pseudo-homogeneous approach. The Langmuir isotherm.
26. Langmuir isotherm for non-dissociative, dissociative and competitive adsorption.
27. The BET isotherm. A brief survey of Temkin, BLK, Freundlich, Fowler-Guggenheim, Hill-De Boer isotherms.
28. The Polanyi-Wigner equation for desorption. Temperature programmed desorption.
29. TPD spectra: zeroth, first and second order desorption spectra.

30. Introduction to organic self-assembly. Deposition methods. Overlayer-substrate and inter-overlayer interactions. A case of strong O-S interactions: C_{60} on Pt(110).
31. Van der Waals O-S interactions: FePc on Ag (110): structure and reactivity with oxygen.
32. Supramolecular vs covalent networks. On-surface synthesis.
33. Case studies: porphyrin-fullerene copolymers; bottom-up synthesis of graphene nanoribbons; porphyrin photopolymerization.
34. Hydrogen-bonded surface supramolecular networks. Nanoporous networks.
35. Metal coordination-based supramolecular networks.

36. Introduction to synchrotron radiation. Light production: LINAC, booster, storage ring, source parameters.
37. Spectral brilliance. Bending magnet radiation: spectral width and collimation.
38. Radiation from insertion devices: ondulators and wigglers.
39. From the storage ring to experimental end stations - the beamline: monochromators and mirrors.

40. Introduction to photo- and Auger emission. The binding energy. Singlets and doublets: spin-orbit coupling. Qualitative analysis.
41. Surface sensitivity. Inelastic attenuation length. Quantitative analysis. Differential photoemission cross sections. The Chemical Shift. Angle-resolved XPS.
42. Applications of synchrotron radiation: high energy, time and spatial resolution. Photoemission spectromicroscopy.
43. Photon energy tunability. Cross sections dependence on photon energy. Use of Cooper minima.

44. Angle- and energy-scanned photoelectron diffraction.
45. Basics of x-ray absorption. Experimental modes: absorption, florescence, secondary electrons.
46. XANES, NEXAFS, with examples.
47. , EXAFS, with examples.
48. Basics of x-ray circular magnetic dichroism (XMCD)

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