Syllabus

Physics 243B
Surface Physics of Materials: Structure and Microscopy

CRN 63265, 3 Units

Time: Tues., Thurs. 2:10-3:30 p.m.
First class: Thurs. Sept. 28, 2017
Place: 414 Physics

Instructor: Shirley Chiang, 235 Physics Geology, tel: 530-402-7113
e-mail: chiang@physics.ucdavis.edu
Class Web page: http://chiang.physics.ucdavis.edu/Physics243B.html
Lecture Notes, Resources, and Problem Set Solutions will be posted on https://canvas.ucdavis.edu
Chiang group web page: http://chiang.physics.ucdavis.edu
Office Hours: Tuesday, 11:00-12:00 and Thursday 1:10-2:00 p.m., 235 Physics
Also by appointment.

Textbooks:

- "Modern Techniques of Surface Science--Second Edition," D.P. Woodruff and T.A. Delchar, (Cambridge Univ. Press, 1994).
- "Physics at Surfaces," A. Zangwill (Cambridge Univ. Press, 1988).
- Reprints of review articles to be posted on Canvas.

First Reading Assignment:

Woodruff & Delchar, Chapters 1 and 2
Zangwill, Chapters 2 and 3

Other Reference Books (will be on reserve at Shields Library)

1. M. Prutton, Introduction to Surface Physics, Oxford University Press (1994).
2. T. A. Delchar, Vacuum Physics and Techniques, Chapman and Hall (1993).
3. John F. O'Hanlon, A User's Guide to Vacuum Technology,2nd Edition, John Wiley & Sons (1989).
4. G. Ertl and J. Küppers,. Low Energy Electrons and Surface Chemistry, Weinheim, Germany (1985).
5. M. A. Van Hove, W.H. Weinberg, C.-M. Chan, Low-Energy Electron Diffraction : Experiment, Theory, and Surface Structure Determination, Springer-Verlag, Berlin, (1986).
6. G. A. Somorjai, Chemistry in Two Dimensions : Surfaces, Cornell University Press, Ithaca (1981).
7. G. A. Somorjai, Introduction to Surface Chemistry and Catalysis, Wiley, New York (1994).
8. C. J. Chen, Introduction to Scanning Tunneling Microscopy, Oxford University Press, New York (1993).

9. Joseph A. Stroscio and William J. Kaiser, editors, Scanning Tunneling Microscopy, Academic Press, Boston (1993).
10. H.-J. Güntherodt, R. Wiesendanger, eds., Scanning tunneling microscopy I, II, III, Springer-Verlag, New York (1992,1994,1995)
11. Dror Sarid, Scanning Force Microscopy : With Applications to Electric, Magnetic, and Atomic Forces, Oxford University Press, New York (1991).
12. John A. Venables, "Introduction to Surface and Thin Film Processes," (Cambridge Univ. Press, 2000). See also http://venables.asu.edu/
13. Harald Ibach, Physics of Surfaces and Interfaces, Springer, Berlin and New York, (2006). Entire book available online through UCD library.
14. Hans Lüth, Solid Surfaces, Interfaces, and Thin Films, 6th Edition, Springer, (2015). Entire book available online through UCD library.
15. Ernst Bauer, Surface Microscopy with Low Energy Electrons, Springer, (2014). Entire book available online through UCD library.

Performance Assessment:

- Graded problem sets (3 total) 40%
- One midterm exam 20%
- Final term paper 30%
- Final oral presentation 10%

Term Paper and Oral Presentation:
*Term paper suggested length 10-20 pages, double spaced, plus references in addition.
*Oral Presentation: 20 minutes, using viewgraphs and figures, followed by questions from other students, typically 5-10 minutes.

Topic for term paper and oral (same topic for both):
Pick a surface science system and look for papers in the original literature describing how several different surface analytical techniques were used to determine the surface structure and properties. If there are any theoretical papers on the topic, discuss their connection to the experimental ones. Explain why this particular system is of scientific interest.
Please consult instructor before you choose a topic. You are welcome to pick a topic relevant to your research.

Examples of possible topics:

Si(111) 7x7 reconstruction

Au(111) $23x\sqrt{3}$ reconstruction

Ag/Si(111) $\left(\sqrt{3}x\sqrt{3}\right)R30°$ overlayer

O/W(110) 2x1, 2x2, 1x1 overlayers

Topics Covered in Course

Introduction to Surface Science
- Rationale for studying surfaces
- Production of ultrahigh vacuum
- Methods for cleaning surfaces

Brief overview of several surface analytical techniques
- X-ray photoemission spectroscopy (XPS)
- Auger spectroscopy
- Low energy electron diffraction (LEED)
- Secondary Ion Mass Spectometry (SIMS)
- Thermal Desorption Spectorscopy (TDS)

Surface structure
- 2D Bravais lattices
- Reciprocal lattices
- Overlayer structures and nomenclature
- Diffraction patterns

Low energy electron diffraction –(LEED)
- General kinematic theory
- Surface reconstructions
- Adsorbate overlayers
- Antiphase domain boundaries
- Stepped and kinked surfaces
- Dynamical LEED theory

Other surface scattering techniques for determining structure
- Reflection high energy electron diffraction (RHEED)
- Helium atom scattering (HAS)

X-ray techniques for surface structure
- Surface X-ray diffraction
- X-ray standing waves
- Extended X-ray absorption fine structure (EXAFS), NEXAFS (near-edge EXAFS)

Incident ion techniques
- Ion scattering techniques—low energy ion scattering (LEIS), medium energy ion scattering (MEIS), high energy ion scattering (HEIS)
- Sputtering and depth profiling
- Secondary ion mass spectroscopy (SIMS)

Vibrational spectroscopy as a structural analysis technique
- RAIRS—reflection-absorption infrared spectroscopy
- HREELS—high resolution electron energy loss spectroscopy
- IETS—inelastic tunneling spectroscopy
- SERS—surface enhanced Raman spectroscopy

Desorption spectroscopies
- Thermal desorption spectroscopy (TDS)
- Laser-induced thermal desorption (LITD)
- Electron stimulated desorption ion angular distribution (ESDIAD)

Surface Microscopies

- Field emission microscopy (FEM)
- Field ion microscopy (FIM)
- Scanning tunneling microscopy (STM)
- Atomic force microscopy (AFM)
- Transmission electron microscopy (TEM)
- Scanning electron microscopy (SEM)
- Low energy electron microscopy (LEEM)
- Photoemission electron microscopy (PEEM)
- Variations of the above combined with spectroscopy

Epitaxy

- Growth modes—effects of surface free energies
- Surface alloys
- Effects of orientation and strain
- Effect of surfactants

Chemical Reactions at Surfaces

- Chemisorbed adsorbates
- Catalytic reactions
- Molecular beam techniques for determination of energy transfer, state selection

Surface Phase Transitions

- Adsorbate structure of physisorbed and chemisorbed systems
- Surface magnetism
- Critical exponents