Physics 243A--Surface and Interface Physics of Materials: Basic Concepts and Spectroscopy—CRN 46760 Fall Quarter, 2016

Surface and interface physics has had a dramatic growth in importance in recent years due to the increased interest in nanometer-scale structures and materials, which may have a majority of their atoms at the surface or at buried interfaces between two phases. Such surface and interface structures are crucial in a wide variety of technological applications, including very large scale integrated circuits, magnetic storage media, photovoltaic cells, batteries and fuel cells, chemical catalysis, corrosion inhibition, tribology (friction and lubrication), environmental science, and biological science. Such surface/interface systems often exhibit markedly different properties from those of the constituent bulk materials, as for example surface composition alterations, surface relaxations or distortions of atomic positions relative to the underlying lattice, and unusual surface electronic or magnetic properties (e.g., superconductivity or ferromagnetism). Buried surfaces or interfaces are ubiquitous in technology and are similarly varied in properties. Beyond this, the component bulk materials are often complex mixtures of several elements, which also can exhibit surprising "emergent" properties that require detailed characterization.

A number of experimental techniques, theoretical models, and computational methods have thus been developed in order to better understand and control such surfaces, interfaces, and complex materials. Synchrotron radiation has also become an indispensible tool for such systems, with about 50 such facilities worldwide, and the number growing steadily.

Physics 243A will introduce these subjects as the first of a two-quarter A/B sequence that will be offered in 2016-2017. 243A will first consider some basic properties of surfaces, including their thermodynamics, their electronic structure, and the theoretical approaches that are used to model them, and then turn to the principal spectroscopic probes of surfaces, interfaces, and complex multi-element materials. Special emphasis will be on photoelectron spectroscopy (photoemission) and the complementary Auger electron spectroscopy, using both laboratory excitation sources and synchrotron radiation, and the various other spectroscopies and techniques provided by synchrotron radiation: x-ray absorption and x-ray emission spectroscopies, as enhanced by standing-wave excitation. This course is designed to be complementary in subject matter to the subsequent quarters of Physics 243. 243B will probably be taught in 2016-17 by Prof. Chiang, and will stress surface atomic structure and microscopy.

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Some recommended prior course experience:

- **Introduction to quantum mechanics (Physics 115A and/or 215A) and/or quantum chemistry (Chemistry 210A)**
- **Introduction to solid state physics or materials science (Physics 140A and/or Physics 240A)**
- **Introduction to surface analytical chemistry (Chemistry 241A)**
- **Introduction to structure and properties of materials (Chem. Eng. And Mat. Sci. 162 and/or 272)**

Course website: **http://243a.physics.ucdavis.edu/ , to be updated regularly from the current 2014 version**

Time and place: **Tuesdays, Thursdays, 12:10-1:30, Physics 185, plus possible supplementary lectures to be arranged to compensate for some instructor absence during the quarter.**

Textbooks:

Required:

- ***"Modern Techniques of Surface Science",*** **D.P. Woodruff and T.A. Delchar, 2nd Edition (Cambridge University Press, 1994)—a readable text on experimental methods in surface science**
- ***"Physics at Surfaces"*****, A. Zangwill (Cambridge University Press, 1988)--a thorough treatment of the various aspects of surface physics, including concise theoretical discussions of many topics, free download from course website**
- ***"Physics of Surfaces and Interfaces"*****, H. Ibach (Springer, 2006)--a thorough treatment of the various aspects of surface physics, and available for free download from course website**
- **Copies of current review articles on photoelectron spectroscopy and diffraction, synchrotron radiation, and other topics, to be handed out in class**

Recommended for additional theoretical background:

- ***"Concepts in Surface Physics"*****, M.C. Desjonqueres and D. Spanjaard, 2nd Edition (Springer Verlag, 1996, corrected printing 1998)-- contains much more detail concerning the theoretical methods of surface physics, and a useful general reference, e.g. to augment the two textbooks. Derivations are done in detail. Excerpts from this book will be handed out in class.**

--*Course assessment:* *Grading in the course will be based on the following:*

Graded problem sets	**40%**
Midterm exam-Tuesday, 1 Nov.	**20% (Open books and notes, calculators allowed, but not computers/phones)**
Comprehensive final	**40% (Open books and notes, calculators allowed, but not computers/phones)**
	100%

--*Final examination:* Tuesday, December 6th, 10:30-12:30 PM, Physics 185, or, if desirable, another timeslot by unanimous agreement.