

**Special Topics    PHY 894 (#07177)    Room: Clip 132A**  
**Surfaces and Surface Analytical Techniques**  
**4 credit hours**  
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In this course, we will cover various present-day methods involved in surface-related measurements, including diffraction, spectroscopic methods, and scanning tunneling microscopy, with discussion of the latest methods in spin-polarized STM. We will also discuss various methods related to surface and nanostructure preparation. The course will involve enough theory to get the physical basis of the technique and will discuss applications to current research. The methods are fundamental for condensed matter and nanoscience, particularly at surfaces in vacuum. We will survey a variety of topics, going into as much depth as possible with each.

**Required Text:**

1. H. Luth, "Solid Surfaces, Interfaces and Thin Films", 4th edition, Springer

**additional possible references:**

2. J. F. O'Hanlon, "A User's Guide to Vacuum Technology," John Wiley & Sons.
3. D. B. Chrisey and G. K. Hubler, Eds., "Pulsed Laser Deposition of Thin Films," John Wiley & Sons, Inc., 1994.
4. C. Julian Chen, "Introduction to Scanning Tunneling Microscopy," Oxford University Press, 1993.
5. Roland Wiesendanger, "Scanning Probe Microscopy and Spectroscopy – Methods and Applications," Cambridge University Press, 1994.
6. Roland Wiesendanger, "Scanning Tunneling Microscopy I-III," Springer Series.
7. J. A. Stroscio and W. J. Kaiser, "Scanning Tunneling Microscopy," Academic Press, 1993.
8. D. Bonnel (ed.), "Scanning Probe Microscopy and Spectroscopy, Theory, Techniques, and Applications, 2<sup>nd</sup> edition, Wiley-Vch.
9. T. Sakurai, Y. Watanabe (Eds.), "Advances in Scanning Probe Microscopy," Springer.
10. J. B. Hudson, "Surface Science – an Introduction," Butterworth-Heinemann.

**Course Requirement:**

**Homework:**

Homework problems will be assigned periodically to reinforce material covered in class. Please feel free to work together on the homework but answer all questions for yourself. Homework will count significantly towards your grade. Homework will be due one week after being assigned. Late homework (1-2 days) will be accepted only at the discretion of the instructor.

**Special Topics Project:**

During the first few weeks of the class, you should choose a topic that you are particularly interested in for your special project. You will investigate your topic like a research project. It should not be something that you have written in any previous class or program – for example, do not choose something that you previously wrote a Masters thesis on or a previous research paper. It must be a new topic for you. At mid-quarter, you will be required to turn in a 3-5 page description of your project. This is like a report; it should show that you are making good progress toward the completion of your project.

The topic itself should be experimental in nature. It should be related to some form of surface or nanomaterials on surfaces and/or to some method(s) of investigation of the properties of the surface(s) or nanostructure(s). There could be some theory involved but should not be the focus. For material, you will reference some books or published papers.

The complete project will be due at the end of the quarter, in two forms. First, you will present your project to the class during a 15 minute talk. The talk could be a condensed version of your paper but will offer the opportunity for presenting diagrams and graphics as well as verbal information. Second, you will turn in your full project as a written paper; it should be in the range of 10-20 double spaced pages. It should have an abstract, introduction, experimental methods, results and discussion, summary or conclusion, and references. It can also contain figures. In this case, each figure should have a caption, and the figures should be numbered.

**Grading will be as follows:**

Homework	40%
Mid-quarter Report	10%
End-of-quarter talk	15%
Final Project Paper	35%
<b>Total</b>	<b>100%</b>

**Intended Schedule:**

- 1/3 Introduction, Beginning of Vacuum
- 1/5 Vacuum, Lüth pp 1-18, also can refer to J. F. O'Hanlon
  
- 1/8 Surface Preparation, pp. 33-58
- 1/10 Morphology and Surface Structure, pp. 77-99
- 1/12 Nucleation and Epitaxial Growth, pp. 100-120
  
- 1/15 *No Class – Martin Luther King Day*
- 1/17 Quantum Layers - 'Electronic' Growth
- 1/19 Quantum Wires – Growth by Seeding
  
- 1/22 Quantum Dots – Growth by Self-Assembly
- 1/24 Growth by Pulsed Laser Deposition
- 1/26 Scanning Probe Microscopy
  
- 1/29 Scanning Tunneling Microscopy/Scanning Tunneling Spectroscopy (STM/STS)
- 1/31 STM/STS
- 2/2 Spin-Polarized (SP)-STM

- 2/5 SP-STM **(mid-quarter project reports due)**  
2/7 Low Energy Electron Diffraction (LEED)  
2/9 Reflection High Energy Electron Diffraction (RHEED), Intensity Oscillations
- 2/12 Rutherford Backscattering (RBS)  
2/14 Theory of Electronic Surface States  
2/16 Photoemission & Inverse Photoemission
- 2/19 Auger Electron Spectroscopy (AES)  
2/21 Surfaces of Metals  
2/23 Surfaces of Semiconductors
- 2/26 Electron Counting  
2/28 Group III Nitride Surfaces  
3/2 Transition Metal Nitride Surfaces
- 3/5 Magnetic-doped Nitride Surfaces  
3/7 Student Talks  
3/9 Student Talks
- 3/14 **Final Project Due Date**