

PH 487/587 (UAB) & PH 495/595 (UA)
Nanoscale Science and Applications
Spring 2007

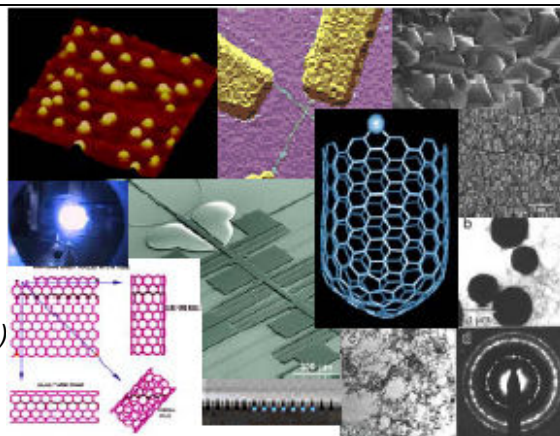
Instructor: Dr. Renato P. Camata (CH306)
camata@uab.edu; (205) 934-8143

UA Contact: Dr. Gary J. Mankey
gmankey@bama.ua.edu

M, W, F: 11:00am-11:50am (UAB: CH394; UA: TBA)

Office Hours: W, F 12:30-1:30pm (CH 394). Other times by appt.

Prerequisite: PH 221/222, CH 115/117, or equivalent.

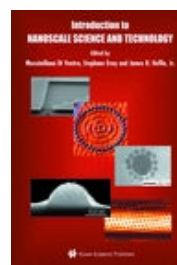


Background. Nanoscale science and technology are based on the study and manipulation of phenomena at length scales approaching one billionth of a meter. Advances in this rapidly changing field are being made across multiple disciplines including Physics, Chemistry, Biology, Materials Science, Engineering, and Medicine with emerging practical applications in areas as varied as energy conversion and storage, manufacturing, telecommunications, information processing and storage, medical diagnostics, and drug delivery to mention just a few.

Goal. The goal of this course is to provide upper level undergraduate and graduate students with a foundational perspective on some of the key scientific principles relevant to the behavior of matter at the nanoscale as well as a review of processes, materials, and systems that derive their properties from nanoscale phenomena.

Course contents include:

- *Nanoscale Fabrication and Characterization*
- *Nanomaterials and Nanostructures*
- *Nanoscale and Molecular Electronics*
- *Integrative Systems (MEMS, NEMS)*
- *Nanoscale Optoelectronics*
- *Nanotechnology in Magnetic Storage*
- *Nanobiotechnology*



Textbook
*Introduction to
Nanoscale
Science and
Technology*

Di Ventra, Evoy, Heflin (Eds.)
Springer-Verlag, 2004
(ISBN: 1-4020-7720-3)

Format and multi-campus offering. Course activities will involve lectures and classroom discussions. Classes will be held at UAB with interactive broadcast to students at the University of Alabama (UA) campus (Tuscaloosa). A faculty member at UA will serve as a local point of contact for the class. Class materials will be available on the class web page. Course grading will be based on assignments and exams. (For enrollment information at UA, please contact Prof. Gary J. Mankey (gmankey@bama.ua.edu))

Catalog Description: Physics of electronic, mechanical, and biological properties of materials at the nanoscale level approaching one billionth of a meter. The applications of nanoscale materials in electronic, mechanical, and biomedical systems will be emphasized. Special tools in synthesis and characterization of nanomaterials will be discussed.

Course Activities: This course will comprise formal lectures integrated with classroom discussions and written essay as well as problem-solving exercises assigned by the instructor. Through these activities, undergraduate students enrolled in **PH 487 (PH 495)** are expected to acquire a foundational perspective on key scientific principles relevant to the behavior of matter at the nanoscale as well as be exposed to a review of processes, materials, and systems that derive their properties from nanoscale phenomena. Students are also expected to acquire reasoning and problem-solving skills in this highly interdisciplinary area. Graduate students enrolled in **PH 587 (PH 595)** will be required to demonstrate this same proficiency of undergraduate students and, in addition, develop an advanced level of understanding in this area by completing an Advanced Project. This Advanced Project will consist in an in-depth study of a current problem in nanoscale science. Students will be allowed to choose their Advanced Project topic from a list of proposed study areas made available by the instructor during the third week of classes. Alternatively, graduate students will also be allowed to work on an Advanced Project investigation inspired by their graduate research, if applicable, or other problem in nanoscale science of their interest. The design and scope of the specific area of study in the Advanced Project requires the approval of the instructor and this decision must be finalized by the end of the third week of classes. Students will have the remainder of the semester to complete their Advanced Project and will be encouraged to integrate the knowledge and skills developed in this course with learning experiences from other courses and/or research activities. The Advanced Project will be presented in two forms: (i) An oral presentation to be given to the class on **Friday, April 6**; and (ii) a brief review-type paper including appropriate diagrams, figures, and references, in the format of a journal manuscript submission due on **Friday, April 20**. The instructor will advise graduate students in the preparation of their oral presentation and an example of the paper to be written will be provided.

Related UAB learning outcomes: Students successfully completing this course will demonstrate knowledge of fundamental concepts in nanoscale science and the ability to apply this knowledge in the description of processes, materials, and systems that derive their properties from nanoscale phenomena.

Course learning objectives:

- Demonstrate knowledge of fundamental concepts in nanoscale science (**UG & Graduate**).
- Demonstrate a broad and interdisciplinary understanding of the scientific issues related to nanoscale science and nanotechnology (**UG & Graduate**).
- Demonstrate an ability to effectively apply fundamental concepts in solving problems involving nanoscale processes, materials, and systems (**UG & Graduate**).
- Demonstrate the ability to describe and communicate an advanced problem in nanoscale science both in oral and written form (**Graduate**).

Measurement of learning objectives: Assignments with quantitative exercises and essay-type questions and exams will be used regularly to measure *understanding of the fundamental concepts* and *reviews* presented as well as students' *abilities to apply this understanding* to select problems in nanoscale science. Prompt grading of the assignments by the instructor will provide feedback to students on their strengths and weaknesses, in preparation for the exams.

Both, assignments and exams also provide an opportunity to evaluate the development of an interdisciplinary perspective of students' perception and understanding of nanoscale phenomena. These two measuring tools will be used for both **undergraduate** and **graduate** students. In addition, students enrolled in **PH 587 (PH 595)** will have an opportunity to develop an advanced knowledge on a selected problem in nanoscale science through the completion of the Advanced Project. This higher knowledge level as well as their *ability to describe and communicate an advanced problem in nanoscale science both orally and in writing* will be achieved through their written report and oral presentation to the class.

Course Grade:

PH 487 (PH 495) (Undergraduate)	PH 587 (PH 595) (Graduate)
50% - Assignments	25% - Assignments
50% - Exams*	50% - Exams*
-	25% - Advanced Project

* Two take-home exams – equal weight

Exam 1: Available Friday, February 23; **Due Wednesday, March 7.**

Exam 2: Available Friday, April 20; **Due Friday, May 4.**

Letter grades will be assigned according to the following scale:
(All calculated grades will be rounded up to the nearest 0.1%.)

88.0% to 100% inclusive	A
76.0% to 87.9% inclusive	B
63.0% to 75.9% inclusive	C
50.0% to 62.9% inclusive	D
0.0% to 49.9% inclusive	F

Assignment & Exam policy:

Group work and discussions on assignments are appropriate.
No collaboration allowed in exams.

Last Day to Withdraw with “W” (UAB Only): March 7 (PH 487); April 25 PH 587).

Special accommodations:

Please contact Dr. Camata for an appointment to discuss special accommodations.

Web Page: <http://www.phy.uab.edu/~rcamata/PH487-587.htm>

(Class information and grades will be posted on this web page)

Tentative Topical Outline

I. Nanoscale Fabrication and Characterization

1. *Nanolithography (Textbook; Chapter 1)*
2. *Self-Assembly and Self-Organization (Textbook; Chapter 2)*
 Featuring Guest Lecturer: Dr. Derrick Dean (UAB, Dept. Mat. Science and Engineering)
 on Polymeric Nanomaterials
3. *Scanning Probe Microscopes (Textbook; Chapter 3)*

II. Nanomaterials and Nanostructures

4. *Nanoscale Carbon (Textbook; Chapters 4-5 – selected portions)*
5. *Quantum Dots (Textbook; Chapter 7)*
6. *Nanocomposites (Textbook; Chapter 8)*
 Featuring Guest Lecturer: Dr. Aaron Catledge (UAB, Dept. of Physics)
 on Nanostructured Biomaterials

III. Nanoscale and Molecular Electronics

7. *Nanoscale Devices (Textbook; Chapter 9)*
8. *Molecular Electronics (Textbook; Chapter 10)*
9. *Single Electron Electronics (Textbook; Chapter 11)*

IV. Nanotechnology in Magnetic Systems

10. *Structures for Quantum Computation (Textbook; Chapter 12)*
11. *Magnetic Storage (Textbook; Chapters 13-14 – selected portions)*

V. Nanotechnology in Integrative Systems

12. *Microelectromechanical Systems (MEMS) (Textbook; Chapter 15)*
13. *Nanoelectromechanical Systems (NEMS) (Textbook; Chapter 16)*
14. *Micromechanical sensors (Textbook; Chapter 17)*

VI. Nanoscale Optoelectronics

15. *Quantum-Confined Optoelectronic Systems (Textbook; Chapter 18)*
16. *Organic Optoelectronic Nanostructures (Textbook; Chapter 19)*
17. *Photonic Crystals (Textbook; Chapter 20)*

VII. Nanobiotechnology

18. *Biomimetic Nanostructures (Textbook; Chapter 21)*
 Featuring Guest Lecturer: Dr. Maaïke Everts (UAB, Dept. of Pathology)
 on Nanobiotechnology Applications in Medicine

 Featuring Guest Lecturer: Dr. Ho-Wook Jun (UAB, Dept. of Biomedical Engineering)
 on Nanotechnology in Tissue Engineering and Regeneration
19. *Biomolecular Motors (Textbook; Chapter 22)*
20. *Nanofluidics (Textbook; Chapter 23)*