RUTGERS, THE STATE UNIVERSITY OF NEW JERSEY
School of Engineering
Department of Materials Science and Engineering
14:635:322

Photonic, Electronic and Magnetic Applications of Nanomaterials and Nanostructures

Prerequisite:	**14:635:330**	**Fall 2011**
Lecture:	**3 hours**	**8.40 – 10 am, Tues & Friday**
Instructors:	**D. O'Carroll and M. Chhowalla**	**SEC 206, BUSCH**
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Description:

This course has been formulated to complement the other nanomaterials-related classes currently being offered within the Department (Introduction to Nanomaterials (330) and Nanomaterials: Structural, Mechanical and Chemical Properties (492). The emerging fields of nanoscale science, engineering and technology are fundamentally based on the ability to develop new materials at the atomic and molecular level and to employ them to achieve novel properties for next generation devices and systems. The breadth and vastness of the exploding field of nanotechnology makes it essential to limit the materials covered in a one semester course offering. The focus here will be nanomaterials synthesis, characterization and application "by design" for optical, electronic, optoelectronic and magnetic materials. The basic physics and fundamental mechanisms responsible for nanoscale-induced changes in properties will be stressed. Representative advances in each of the targeted topical areas will be discussed and examined to provide students with some insight with regard to the potential future impact of nanotechnology on materials science and engineering. A term paper is also included to provide students with an opportunity to explore in-depth, a nanotechnology topic of their choice.

Objective:

This course is designed to introduce students to the fundamental changes in photonic, electronic and magnetic properties which occur when particle sizes approach atomic and molecular dimensions. It provides students with linkages between, for example, changes in electronic band structure of materials as more atoms reside near the surface of a nanoparticles and the modification of physical properties that takes place. A goal is to provide students with a design tool based on nanotechnology that will allow them to engineer next generation materials and devices. It is designed to give students an appreciation of the different properties offered by nanostructured materials, particularly when it comes to their interactions with light, electric and magnetic fields.

Prerequisites: **14:635:330**

Projects:

A term paper is required. It will represent 25% of a student's final grade. The goal is to select a journal paper or set of papers that describe a recent advance in nanotechnology as outlined in the context of this course. The selected topic accompanied by a one page outline must be submitted to the instructors prior to final approval to proceed. This paper serves both as a mechanism to acquaint students with the recent literature in the nano field, as well as an opportunity to improve their written communication skills as required by ABET.

Texts: (Not required)

Nanotechnology, ed. By Gregory Timp, Springer-Verlag, New York 1999

Nanomaterials: Synthesis, Properties and Applications, ed. By A. S. Edelstein and R. C. Cammarata, Institute of Physics, UK, 1966

Nanophotonics by Paras N. Prasad, Wiley-Interscience, 2004

Class notes and handouts will be provided in conjunction with syllabus topics

Topics Covered:

Week	**Topic**
#1 (9/2)	Course introduction: syllabus.
#2 (9/6,9)	Optical Properties of Nanostructures: absorption; emission; the diffraction limit; sub-wavelength nanostructures; Mie scattering; Rayleigh scattering; waveguiding.
#3 (9/13,16)	Basic Photophysics of Nanomaterials: quantum confinement, molecular assembly, surface alignment, size effects.
#4 (9/20,23)	Synthesis and Characterization of Photonic Nanostructures: synthesis techniques; nanocomposites; thin films; nanowires; nanoparticles; sizing; composition; microscopy; photodegradation.
#5 (9/27,30)	Plasmonics: metallic nanostructures; localized surface plasmon resonances; propagating surface plasmon polaritons; loss; spectral dispersion.
#6 (10/4,7)	Nanophotonic and Plasmonic Device Applications: nanolasers; nanoantennas; photonic crystals; optical communications; sensing.
#7 (10/11,14)	Nanophotonic and Plasmonic Device Applications Continued:

negative refraction; metamaterials; cloaking; correlation of properties with size; nanostructures for large-area opto-electronics.

#8 (10/18,21) Review class, Mid-Term Examination (Oct. 21st).

#9 (10/25,28) Electronic properties of nanomaterials and emerging device applications

#10 (11/1,4) Processing of electronic nanomaterials, some examples, quantum dots, nanotubes, quantum wires and junctions

#11 (11/8,11) Nanoelectronic devices, molecular electronics, quantum antennas, terahertz devices, nano transistors

#12 (11/15,18) Nanomagnetic materials, synthesis and characterization

#13 (11/22) Nanomagnetic devices, molecular memories, sensors, nanodetectors, robotics (Term Paper due)

#14 (12/6,9) Nanotechnology systems

#15 (12/13,16) Review session. Final Examination

Grade: The grade is based on the following:

Mid-term examination	(2 hour)	25 %
Mid-term examination	(2 hour)	25 %
Final examination	(3 hours)	25 %
Term Paper		25 %
Term Paper 1 page outline due		0 %

Examinations are based on class lectures, reading assignments, homework problems and class hand-outs.

Contributions of Course to Meeting the Professional Component:

This is the third of three courses available to students in the area of nanomaterials. It facilitates student development and growth in areas related to nanomaterials design, synthesis, manufacturing, economic impact, environmental impact and serves as the basis for both follow-on capstone senior level projects and/or cooperative experiences.

Relationship of Course to Program Objectives:

This course meets all six of the educational objectives set forth by the Rutgers Program in Materials Science and Engineering. It is of value both for students seeking an engineering or manufacturing career in nanomaterials as well as to those students seeking to go on into graduate school in areas related to photonics, optics or electro-optics. With respect to ABET Program proficiencies, this course contributes to (a), (b), (c), (d) and (e) as well as (g), (j) and (k).