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 2016**
Lecture:	**3 hours**	**8.40 – 10 am, Tues & Friday**
Instructors:	**M. Chhowalla, CCR103/206**	**SEC 206, BUSCH**
	manish1@rci.rutgers.edu	

Office Hours:
I am committed to being available for discussions outside the classroom. I typically arrive to class 5-10 mins early. Brief or informal questions can be addressed at this time. I will also remain 5-10 mins after class to address any questions on issues encountered during class. More detailed discussions can be conducted during office hours that are scheduled on Tuesdays and Fridays ~ 10:00 – 10:30. If office hours clash with other commitments, then an appointment can be scheduled via email.

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 levels 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 the introduction of unique optical and electronic phenomena that arise in nanomaterials. 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**

Attendance (10% of the grade):
The students are urged to arrive to class on time. I start the lectures promptly at 8:40AM. I usually start the class with important announcements and although I endeavor to repeat them at the end of class, this may not always happen causing tardy students to miss important information. Attendance is essential for this class in lieu of the fact that there is no required textbook. Attendance will be taken at every class and will count towards 5% of your final grade.

Topical Paper (25% of the grade):
A term paper is required for the course. Individual students will choose the topic of the term paper. The term paper topic should relate to aspects of nanotechnology. The due date for the term paper is ***<u>Friday November 18</u>***.

Length: 1800 – 2000 words (not counting the references or the figure captions).
Font: New Times Roman or Arial (12point).
Spacing: 1.5

Each student will present their term paper to the class. The presentations will be prepared and presented using power point. The presentation grade will depend on the clarity of the presentation (i.e. are the slides readable, coherency of the explanations, competency in answering audience questions, and finishing on time).

Term paper grade: The written portion of the term paper will count for 20% of the grade. The oral presentation will account for 5% of the grade. 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.

Journal Club Presentation (10% of the grade):
The fields of nanoelectronics and nanophotonics are moving at a rapid pace. New discoveries are reported on a weekly basis. To keep up with the latest findings, each student will be asked to choose a published paper and summarize this paper in the form of a 20 minute presentation to the class. The class will then ask questions about the paper for ten additional minutes. Acceptable papers for presentations can be found in the following journals: Nature, Science, Nature Nanotechnology, Nature Photonics, Nature Materials, Nano Letters, ACS Nano, Advanced Materials. All of these journal are available from any Rutgers network via the web.

Each student will be required to choose the paper for presentation at least a week in advance, email it to me so that I can post it on Sakai. All class members are required to read the paper and prepare at least one question for the presenter.

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

Class Notes: A complete set of notes will be provided. The notes will be supplemented with additional materials that will be distributed in the course of the semester. *Please note that the notes are for your personal use and should not be redistributed or posted without my explicit written permission.*

Topics Covered:

Week	**Topic**
#1	Course introduction; syllabus; prior knowledge survey. Basics of electronic structure and how it influences the optical and electronic properties. Wave-Particle duality, uncertainty principles
#2	Basics of band structure; Optical and Electronic properties of bulk materials
#3	Optical Properties of Nanostructures: absorption; emission; the diffraction limit; sub-wavelength nanostructures; Mie scattering; Rayleigh scattering; waveguiding.
#4	Synthesis and Characterization of Photonic Nanostructures: synthesis techniques; nanocomposites; thin films; nanowires; nanoparticles; sizing; composition; microscopy; photodegradation.
#5	Plasmonics: metallic nanostructures; localized surface plasmon resonances; propagating surface plasmon polaritons; loss; spectral dispersion.
Oct 11	**Examination 1**
#6	Electronic properties of bulk materials and how they vary at nanoscale. Band structure, p-n junctions, diodes and field effect transistors and bulk heterojunction solar cells.

Oct 18	**Term Paper Due Date**
#7	Tunneling and single electron devices
#8	Carbon nanotubes devices and Graphene based electronics
#9	Other 2D Materials and exotic effects such as Valleytronics
Nov 15	**Examination 2.**

No Class (Thanksgiving Break)

#10	**Term Paper Presentations**

Date Dec. 20 8:00 – 11 AM: Final Examination: Covering all course topics.

Grade: The grade is based on the following:

Section 1 examination	20 %
Section 2 examination	20 %
Final examination	20 %
Term Paper	20 %
Journal Club Presentations	10%
Term paper presentations	5 %
Attendance	5 %

Examinations will be based on class lectures, reading assignments, 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).