COURSE TITLE: NanoSCI - Electronic Properties of Nanoengineered Materials

CATALOG DESCRIPTION: Physics and technology of nanoengineered materials and devices. Semiconductor nanostructures. Nanotubes and nanowires. Molecular electronics. Bioelectronics.

REQUIRED TEXTS:

Edward L. Wolf, *Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience*, 2nd ed., WILEY-VCH, 2006, ISBN: 3-527-40651-4, and additional course-packet provided in class.

REFERENCE TEXTS:

John H. Davies, *The Physics of Low Dimensional Semiconductors: An Introduction,* Cambridge University Press, 1998.

COURSE COORDINATOR: (Tech. Univ. Munich) Jose Garrido, Gerhard Abstreiter, Martin Stutzmann

COURSE GOALS: Nanoscience; This course will introduce students to the rapidly developing field of nanoengineered materials with special focus on their electronic properties. The course is expected to appeal to electrical engineers, materials scientists, physicists and alike. Therefore, fundamental aspects of the electronic properties of these materials, as well as fabrication processes and applications will be equally discussed in this course. The scientific lecture will consist of 30 total lecture hours. An additional laboratory part of the course will introduce students to several different characterization methods relevant to nanomaterials in a laboratory setting with German students. Research topics relevant to technological sites visited in the companion course NANO 301-2 course will be emphasized. A list of the topics covered in this lecture includes:

- Electronic transport in 1, 2, and 3 dimensions
- Nanofabrication technology (including molecular beam epitaxy, self assembly of nanostructures, scanning probe techniques)
- Semiconductor superlattices and quantum dots
- Nanoparticles, nanotubes, and nanowires
- Molecular electronics
- Bioelectronics

PREREQUISITES: Electrical Engineering: EECS 223 or consent of instructor
Materials Science: MATSCI 351-1, MATSCI 351-2 or consent of instruct.
Physics: PHYS 339-1, PHYS 339-2 or consent of instructor
Chem, Chem Eng: CHEM 342-2 or consent of instructor

DETAILED COURSE TOPICS:

WEEK 1: Electronic transport in 1,2 and 3 dimensions: Quantum confinement, energy subbands, quantum wells, quantum wires, quantum dots. Effective mass, Drude conduction and mean free path in 3D, ballistic conduction, phase coherence length, and quantized conductance in 1D.

WEEK 2: Compound semiconductor nanostructures: growth of compound semiconductors, superlattices, self-assembled quantum dots.

WEEK 3: Nanofabrication and nanopatterning: Optical, X-ray, and electron beam lithography, self-assembled organic layers, scanning tunneling microscopy, atomic force microscopy

WEEK 4: Nanoparticles, nanotubes and nanowires, fullerenes (buckyballs, graphene)

WEEK 5: Molecular electronics**:** optoelectronic properties of molecular materials, nanotechnology, devices: OLEDs, OTFTs.

WEEK 6: Bioelectronics and biosensors: charge transport, DNA and protein functional systems, electronic noses and biosensors

COMPUTER USAGE: None.

HOMEWORK ASSIGNMENTS: Homework is assigned weekly to reinforce concepts learned in class.

PROJECTS: None

GRADES:

Homework - 60%

Final - 40%

COURSE OBJECTIVES: When a student completes this course, s/he should understand nanotechnology by being able to:

- Recognize state of the art developments in the field of nanotechnology, be knowledgeable in common themes across nanotechnology, as well as be able to distinguish various individual nanotech implementations.

- Understand the basic concepts of quantum mechanics and be able to solve the quantum confinement equations which lead to reduced dimensionality.

- Be knowledgeable in the various modern technologies used in nanotechnology to grow bulk crystals, thin films, and nanoscale quantum structures, including the epitaxy of semiconductors.

- Be knowledgeable in optical and electronic properties of semiconductor nanostructures such as quantum wells and quantum dots.

- Manipulate and calculate physical parameters related to nanotechnology, such as mean free paths and phase coherence lengths.

- Explain the effect of the reduced dimensionality on the electronic charge transport

- Explain the operating principle of various nanofabrication techniques, such as lithography patterning, self assembling, single atom manipulation, etc

- Explain the main properties of nanoobjects such as nanotubes, nanowires, and nanoparticles.

- Be knowledgeable in basic optical and electronic properties of organic/molecular-based materials, as well as main applications.

- Be knowledgeable in concepts related to bioelectronics and biosensors, such as charge transport in proteins and DNA, and operating principle of biosensors.

ABET:

50 % Science , 50 % Engineering