TECHNISCHE UNIVERSITÄT MÜNCHEN

1. Syllabus NanoSCI

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.

Required texts:
Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio: Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications, Cambridge University Press, 2008.
Additional course-packet provided in class.

Reference texts:
Rainer Waser: Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, Wiley-VCH, 2003.

Edward L. Wolf: Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, 2nd ed., Wiley-VCH, 2006.

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

Course coordinator (TUM):
Dr. José A. Garrido, Prof. Gerhard Abstreiter, Prof. 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 discussed in this course. The scientific lecture will consist of 30 total lecture hours. A list of the topics include electronic transport in 1, 2, and 3 dimension, nanofabrication technology, scanning probe techniques, semiconductor superlattices and quantum dots, nanoparticles, nanotubes, nanowires, and molecular electronics.

Prerequisites:
Electrical Engineering: Quantum Electronics
Materials Science: Quantum Materials
Physics: Quantum Mechanics
Chemistry, Chemical Engineering: Quantum Chemistry

Detailed course topics:

Week 1 & 2: 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 3: Compound semiconductor nanostructures: growth of compound semiconductors, superlattices, self-assembled quantum dots.

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

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

Week 6: Nanofabrication and nanopatterning: Optical, X-ray, and electron beam lithography, self-assembled organic layers, scanning tunnelling microscopy, atomic force microscopy.

Computer usage: None

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

Grades:

Homework	40%
Final test	60%

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.

2. Syllabus NanoTECH

Course title: NanoTECH – Nanotechnology in Germany: Implementing Science, Research and Technology in Germany Today

Catalog description: Technology and research in Germany and Europe today, direct on-site contact with German research centres, direct conversations with leading scientists around Germany in charge of planning today's research agenda, direct hands-on experience with several laboratory projects themed along nanotechnology.

Required texts: Course-packet provided in class.

Reference texts: (none)

Course coordinator:
Dr. Matthew Grayson (Northwestern Univ.), Prof. Martin Stutzmann, Dr. Beate Rattay-Förstl (TUM)

Course goals: Nanotechnology:
This course will give students an overview of the technological landscape of Germany, with an emphasis on nanotechnology centres. Laboratory projects related to nanotechnology will be performed in groups with German students. Excursions to industrial sites and research laboratories will lead to a deeper understanding of Germany's position in the technological world. An introduction to German academic and research environments will deepen awareness of international industrial and scientific collaboration in the modern market. Lectures on intercultural communication and project management will be combined with first-hand visits to technology centres like General Electric Renewable Energy, the EU Patent Office, and Attocube, as well as visits to academic research centres such as the Max-Planck-Institute for Solid State Research in Stuttgart and the Center for NanoScience at the Ludwig-Maximilians-Universität München. Such visits will be highlight topics covered in the lecture course, NanoSCI. (Specific site visit locations are subject to change each year.)

Prerequisites:
Electrical Engineering: Quantum Electronics
Materials Science: Quantum Materials
Physics: Quantum Mechanics
Chemistry, Chemical Engineering: Quantum Chemistry

Computer usage: None

Homework assignments: Lab assignments, written research reports on site visits.

Projects:
The students will work with groups of German students on one laboratory project relevant to the fabrication and/or characterization of nanostructures. Students will be able to choose from a variety of lab topics, such as quantum transport through antidots, electron spin resonance, molecular motors, lasers, field effect transistors, electron spectroscopy, atomic force microscopy, diamond field effect transistors. Each laboratory project will be written up as a lab report for evaluation. In addition, the students will also write reports on technology practises observed at several of the sites in Germany visited during this course.

SYLLABUS FINDING NANO 2010

DISCOVERING NANOTECHNOLOGY AND CULTURE IN GERMANY

Grades:
Lab reports – 40%
Site visit research reports – 40%
Site visit attendance and course participation – 20%

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

- Perform laboratory tasks related to fabrication and characterization in the field of nanotechnology based on direct experience.
- Be specialized in a specific subfield of technology or nanotechnology as demonstrated by written and oral report
- List centres of modern technological development in Germany, and name leading scientists and research programs at those institutions.
- Describe areas of focused activity relating to state-of-the-art technology and nanotechnology.
- Describe how developments subfields in nanotechnology are interrelated.
- Explain and take advantage of career opportunities in technological centres in Germany and Europe.