E SC 211
Course Syllabus

I. BASIC COURSE INFORMATION

A. Course Title: Material, Safety and Equipment Overview for Nanotechnology

B. Course Number: E SC 211

C. Credit Hours: 3:2:2

D. Prerequisites: CHEM 101, MATH 081; PHYS 150 or PHYS 250 or equivalents

II. COURSE DESCRIPTION

This course overviews basic material properties as well as environment, health, and safety (EHS) issues in equipment operation and materials handling in "top down" and "bottom up" nanofabrication. The chemical and physical materials properties underlying nanotechnology are surveyed. EHS topics arising from the processing and disposal of these materials are addressed including: cleanroom operation, OSHA lab standard safety training, health issues, biosafety levels (BSL) guidelines, and environmental concerns. Specific safety issues dealing with nanofabrication equipment, materials, and processing will also be discussed including those pertinent to wet benches, thermal processing tools, plasma based equipment, optical, e-beam, stamping and embossing lithography tools, vacuum systems and pumps, gas delivery systems and toxic substance handling and detection.

III. RATIONALE OF COURSE

The purpose of this course is to provide an overview of safety, processing equipment, materials properties, and materials handling procedures encountered in the various "top down" and "bottom up" nanofabrication technologies. The focus is on materials properties as well as on materials and processing procedural, safety, environment, and health issues. Students will become familiar with state-of-the-art processing equipment used in nanofabrication and will learn and practice principles of safe materials handling and of safe equipment operation.

IV. SPECIFIC TOPICS INCLUDED

Overview of basic materials properties
Materials handling and disposal
OSHA lab standard safety training
BSL guidelines
Wet bench protocol
Cleanroom protocol
Vacuum processing, operation principles of pumps, gauges and hardware
Wet processing summary and specific safety and environmental issues
Plasmas processing summary and specific safety and environmental issues
Physical vapor deposition summary and specific safety and environmental issues
Chemical Vapor deposition summary and specific safety and environmental issues
Lithography processing summary and specific safety and environmental issues
Characterization tool summary and specific safety and health issues

E SC 212
Course Syllabus

I. BASIC COURSE INFORMATION

A. Course Title: Basic Nanotechnology Processes

B. Course Number: E SC 212

C. Credit Hours: 3:2:2

D. Prerequisites: Concurrent: E SC 211

II. COURSE DESCRIPTION

This course is an overview of the broad spectrum of processing approaches involved in "top down", "bottom up", and hybrid nanofabrication. The majority of the course details a step-by-step description of the equipment, facilities processes and process flow used in today's device and structure fabrication. Students learn to appreciate processing and manufacturing concerns including safety, process control, contamination, yield, and processing interaction. The students design process flows for micro- and nano-scale systems. Students learn the similarities and differences in "top down" and "bottom up" equipment and process flows by undertaking hands-on processing. This hands-on overview exposure covers basic nanofabrication processes including deposition, etching, and pattern transfer.

III. RATIONALE OF COURSE

The purpose of this course is to develop a broad understanding of the range of processing techniques used in nanofabrication. The manufacturing issues of nanofabrication are addressed while giving students an introduction to a wide spectrum of nanofabrication processing approaches.

IV. SPECIFIC TOPICS INCLUDED

Self-assembly
Anisotropic and isotropic etching
Wet and dry etching
Physical deposition
Chemical deposition
Lithography

E SC 213
Course Syllabus

I. BASIC COURSE INFORMATION

A. Course Title: Materials in Nanotechnology

B. Course Number: E SC 213

C. Credit Hours: 3:2:2

D. Prerequisites: Concurrent: E SC 211, E SC 212

II. COURSE DESCRIPTION

This course is an in-depth, hands-on exposure to the producing and tailoring of the materials used in nanofabrication. The course will cover chemical materials production techniques such as colloidal chemistry; atmosphere, low-pressure and plasma enhanced chemical vapor deposition; nebulization; and atomic layer deposition. It will also cover physical techniques such as sputtering; thermal and electron beam evaporation; and spin-on approaches. This course is designed to give students experience in producing a wide variety of materials tailored for their mechanical, electrical, optical, magnetic, and biological properties.

III. RATIONALE OF COURSE

The purpose of this course is to develop a detailed understanding of how materials used in nano-structures are produced. This course emphasizes the understanding of materials production approaches and of the operation of state-of-the-art materials production equipment.

IV. SPECIFIC TOPICS INCLUDED

Molecular films
Nanoparticles
Metal films
Semiconductor films
Dielectric films
Organic materials

E SC 214
Course Syllabus

I. BASIC COURSE INFORMATION

A. Course Title: Patterning for Nanotechnology

B. Course Number: E SC 214

C. Credit Hours: 3:2:2

D. Prerequisites: Concurrent: E SC 211, E SC 212

II. COURSE DESCRIPTION

This course is a hands-on treatment of all aspects of advanced pattern transfer and pattern transfer equipment including probe techniques; stamping and embossing; e-beam; and optical contact and stepper systems. The course is divided into five major sections. The first section is an overview of all pattern generation processes covering aspects from substrate preparation to tool operation. The second section concentrates on photolithography and examines such topics as mask template, and mold generation. Chemical makeup of resists will be discussed including polymers, solvents, sensitizers, and additives. The role or dyes and antireflective coatings will be discussed. In addition, critical dimension (CD) control and profile control of resists will be investigated. The third section will discuss the particle beam lithographic techniques such as e-beam lithography. The fourth section covers probe pattern generation and the fifth section explores imprinting lithography, step-and-flash, stamp lithography, and self-assembled lithography.

III. RATIONALE OF COURSE

Patterning materials on the nanoscale is a challenging but generally required aspect of nanofabrication. Tool and technique selection are key to creating products in the competitive modern workplace. This course addresses these issues and is a detailed study using hands-on applications of state-of-the-art pattern transfer equipment.

IV. SPECIFIC TOPICS INCLUDED

Resists Masks
Developing
Optical lithography
E-beam lithography
Probe lithography
Imprinting lithography
Step-and-flash lithography
Pen dip lithography
Stamp lithography
Lithography and etching for patterning
Lithography and lift-off for patterning

E SC 215
Course Syllabus

I. BASIC COURSE INFORMATION

A. Course Title: Nanotechnology Applications

B. Course Number: E SC 215

C. Credit Hours: 3:2:2

D. Prerequisites: Concurrent: E SC 211, E SC 212

II. COURSE DESCRIPTION

This course covers the applications of nano-scale devices and systems and the material chemical, physical, biological, or multiple-property requirements necessitated in these applications. Material modifications to meet these requirements will be addressed including structure control, composition control, surface property control, strain control, functionalization, and doping.

III. RATIONALE OF COURSE

The purpose of this course is to provide awareness of the broad spectrum of applications of nano-scale devices and systems. The hands-on emphasis of this course is to gain experience in building and evaluating nano-scale devices and systems.

IV. SPECIFIC TOPICS INCLUDED

Survey of nanomaterials and structures applications
Fabricating devices for specific applications
Hydrophobicity/hydrophilicity
Stiction
Barrier layer formation
Doping—conductivity and electro-chemical potential control
Functionalization
Alloying
Tailoring mechanical properties
Tailoring optical properties

E SC 216
Course Syllabus

I. BASIC COURSE INFORMATION

A. Course Title: Characterization, Testing of Nanotechnology Structures and Materials

B. Course Number: E SC 216

C. Credit Hours: 3:2:2

D. Prerequisite: Concurrent: E SC 211, E SC 212

II. COURSE DESCRIPTION

This course examines a variety of techniques and measurements essential for testing and for controlling material fabrication and final device performance. Characterization includes electrical, optical, physical, and chemical approaches. The characterization experience will include hands-on use of tools such as the Atomic Force Microscope (AFM), Scanning Electron Microscope (SEM), 1 nm resolution field emission SEM, fluorescence microscopes, and Fourier transform infrared spectroscopy.

III. RATIONALE OF COURSE

The purpose of this course is to learn about and use a variety of nanotechnology techniques and measurements essential for controlling material and device fabrication. The emphasis will be learning with and using state-of-the-art characterization techniques.

IV. SPECIFIC TOPICS INCLUDED

Electron microscopy (e.g., scanning electron microscopy)
Scanning probe microscopy (e.g., atomic force microscopy)
Fluorescence microscopy
Infrared spectroscopy