Nanomaterials – Chem 648 (Fall 2002 Instructor: Z. Iqbal)

Synopsis and Syllabus

The course on Nanomaterials is designed to introduce advanced undergraduates and graduate students in chemistry, materials science, physics and bio-engineering to the emerging area of nanotechnology that has the potential to revolutionize techniques by which materials and products will be created in the future with new and superior properties and functionalities. Nanotechnology refers to the world as it works on the nanometer scale from about a nanometer to a few hundred nanometers. The synthesis and control of nanomaterials will involve "bottom up" strategies of self-assembly starting with the smallest possible entities, such as atoms and molecules, much in the same way as synthesis is conducted in natural biological systems. The goal of the course will be to prepare and train students in this evolving technology which lies at the interfaces of chemistry, physics and biology. The course will start with fundamental concepts and then proceed to nanoscale phenomena, properties and characterization. This will be followed by discussions on the synthesis and self-assembly of nanomaterials, and potential applications.

Weeks 1-4

I. Introduction
   1. Definitions and course organization
   2. Classification of functional nanomaterials
   3. Historical development

II. Fundamental Principles
   1. Size & Scale
      - Units
      - Scaling Laws
      - Atoms, Molecules, & Clusters
      - Supramolecules
   2. Nanoscale Phenomena
      - Tunneling
      - Chemical Bonds (types and strength)
      - Intermolecular Forces
      - Molecular and Crystalline Structures
      - Hierarchical Structures and Functionality
      - Surfaces and Interfaces
      - Bulk to Surface transition
      - Self-Assembly and surface reconstruction

Weeks 5-9

III. Properties of NanoMaterials
   - Size dependence of properties
     - Phenomena and Properties at Nanoscale
     - Brief introduction to calculational approaches
   - Mechanical / Frictional
   - Optical

Electrical Transport
Magnetic

IV. Nanomaterial characterization

Electron Microscopy
Scanning Probe Microscopies
Near field microscopy
Micro- and near field Raman spectroscopy
Surface-enhanced Raman spectroscopy
X-ray photoelectron spectroscopy

Week 9

Mid Term (Open Book)

Weeks 10-14

V. Synthesis of Nanomaterials

Fabrication techniques: Self-Assembly, Self-Replication, Sol-Gels, Langmuir-Blodgett thin films, Nanolithography, Bio-inspired syntheses, Microfluidic processes, Chemical Vapor Deposition
Metals
Colloidal gold, Silver and other metals clusters
Semiconductors
Cadmium Sulfide, silicon
Fullerenes / Carbon nanotubes
Nano-composites
Nanoporous Materials
Biological Materials

VI. Applications of Nanomaterials

Nanoelectronics
Nanosensors
Environmental
Biological
Energy storage and fuel cells

Week 15

Final Exam (Open Book)

Textbook

Nanomaterials- Synthesis, Properties and Applications, Edited by A.S. Edelstein and R.C. Cammarata, Institute of Physics Publishing, London, 1998 (paper back edition)

Reference Books

Handbook of Nanostructured Materials and Nanotechnology, Edited by H.S. Nalwa Vols. 1-5, Academic Press (2000).
Science of Fullerenes and Nanotubes, by M.S. Dresselhaus, G. Dresselhaus and P. Eklund, Academic Press (1996).
Nanostructured Carbon for Advanced Applications, Edited by G. Benedek et al, Kluwer Academic Publishers (2001).