

SYLLABUS MSE 4055 – Nanoscale Science and Technology

I. Nanoscale systems – challenges and properties at the nanoscale

- Electronic and mechanical systems
- Dimensionality and confinement
- Reactivity and Synthesis

II. Scanning tunneling (STM) and atomic force microscopy (AFM) as essential tools for nanomaterials analysis

- AFM as a micromechanical system: cantilever and tip-surface interaction
- Tunneling – concepts and quantum mechanics (note: tunneling is also a critical concept to understand interactions between nano-particles)
- Imaging and Manipulation at the atomic scale

III. Semiconductor Nanowires

- Circuits made from and on nanowires
- Synthesis of Nanowires: Growth, structure and crystallography
- Electronic structure, dimensionality and confinement: applications
- Device example: single electron transistor
- Device example: measuring cell activity

IV. Carbon Based Nanomaterials

- Bonding, dimensionality and density of states (connects to MSE 3670)
- Fullerenes, Nanotubes and Graphene – applications
- Fullerenes: geometry and doping
- How to modify Carbon nanotube properties: crystallography and electronic structure, metals and insulators by wrapping

V. 2D materials

- Graphene: why is it the new wonder material?
- Transition Metal Dichalcogenides and their relatives
- Devices with 2D materials, Chemistry with 2D materials

VI. Quantum Dots

- Quantum dots - artificial atoms
- Synthesis: chemistry and physics – reactivity and strain
- Optical properties: absorption, and emission, photovoltaic applications.

VII. Self Assembly, and Nanomachines