Nanoscale Chemistry and materials Design

The total curriculum include 45 hours of lectures and 10 hours of optional tours and hand-on lab experience.

Catalytic Nanomaterials for Chemical Manipulation (Prof. Peter Crozier, 3hours)
Introduction to heterogeneous catalysis, performance parameter for nanocatalysts – surface area, activity, selectivity, chemical kinetics, active sites, chemisoption, adsorption isotherms, activity, kinetics, Sabatier principle, molecular activation and interaction with surfaces, d-band model, dissociation and activation barriers, designer catalysts.

Production and Application of Nanporous Materials (Prof. Don Seo, 3 hours)
Synthesis and characterization of novel solid-state inorganic materials and composites, rational design of target nanoporous material with desired morphology, nanostructured transition-metal chalcogenides; II-IV semiconducting quantum dots and their composites, clays and geopolymers.

Chemically Programmed Design and Assembly of Biologically Inspired Nanomaterials
(Prof. Hao Yan, 3 hours)
Macromolecular interactions and biosensing, design of novel DNA nanostructures, implementation of the designed structure in the construction of patterned DNA arrays and nanomechanical devices, DNA based functional nanodevices, self-assembly of 2D and 3D protein arrays, biomolecular imaging by Atomic Force Microscopy and Electron Microscopy, DNA/RNA/Protein manipulation, gel electrophoresis, labeling, hybridization, PCR and footprinting, cloning.

Single Molecule Biophysics: (Prof. Stuart Lindsay, 9 hours)
DNA sequencing, genes and protein functionality, chemistry and physics of the liquid-solid interface, electrochemical and charge transfer processes at the single-molecule level. Instrumentation for biomolecular research. Molecular visualization

Chemical and Bio Sensors (Prof. NJ Tao, 3 hours)
Microfabricated tuning fork sensor arrays,nanosensors, hybrid electrochemical and conductimetric sensors, wireless sensors, micro- and nano-fluidic devices with integrated protein detection and separation,new label-free biomolecular detection and imaging techniques, coded particles

Nanomaterials Characterization with Electron Microscopy (Prof. Peter Crozier, 3 hours)
Introduction to Electron Microscopy– Introduction to electron-solid interactions and scattering theory, elementary electron optical concepts for the TEM and SEM, examples of high resolution structural and chemical information from modern (S)TEM – an overview of some of the techniques available within TEM, theory and practice electron imaging and diffraction – basic theory of diffraction and imaging for SEM, TEM and STEM, aberration correction. high spatial resolution chemical analysis of nanoparticles, electron energy loss spectroscopy, energy dispersive x-ray spectroscopy.

NMR Characterization of Nanostructures and Their Functions: (Prof. Jeff Yarger, 3 hours)

Ligand capped nanoparticles, nanostructured biopolymers, protein clusters, polyamorphic materials, hydrogen storage complexes, inorganic liquid-crystals, nano-particles and quantum dots, battery and fuel cell materials. MRI contrast nanomaterials.

Nanostructures on Surface and Surface Microscopy (Prof. Robert Nemanich, 9 hours)
Modern electronic devices based on surface nanostructured materials, biological and chemical sensors, molecular scale integration, dynamics of nanometer scale structures at the surfaces, advanced microscopy and spectroscopy techniques in growth and characterization of thin film interfaces and nanostructures. Photo electron emission microscopy (PEEM) with tunable UV light. Imaging of polar materials with STM, nanopatterning in assembling of molecular, biological and electronic nanostructures.

Computational Design of Nanomaterials (Profs. Vladimiro Mujica and Dmitry Matyshov, 9 hours)
Modeling behavior of complex physical and chemical systems, quantum effects in systems of nanoscopic dimensions, optical, magnetic, chemical and electrical properties of thin films, nanowires and quantum dots, electron transport in molecule-electrode interfaces, energy transfer in molecular assemblies, kinetics and energetics of elementary electron, computer simulations and experimental data.

Optional:

Tour of NMR facility (Prof. Jeff Yarger, 1 hour)
Lab tour (Prof. Robert Nemanich, 1 hour)
Lab tour (Prof. Ha Yan, 1 hour)
Tour of TEM facility (Prof. Peter Crozier, 1 hour)
Hands-on training in computational chemistry tools (Profs Vladimiro Mujica and Dmitry Matyushov, up to 6 hours)

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