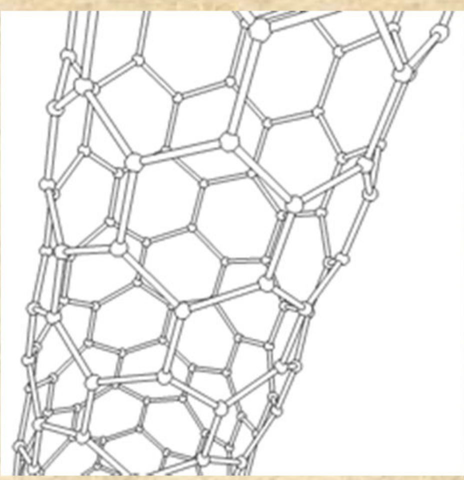
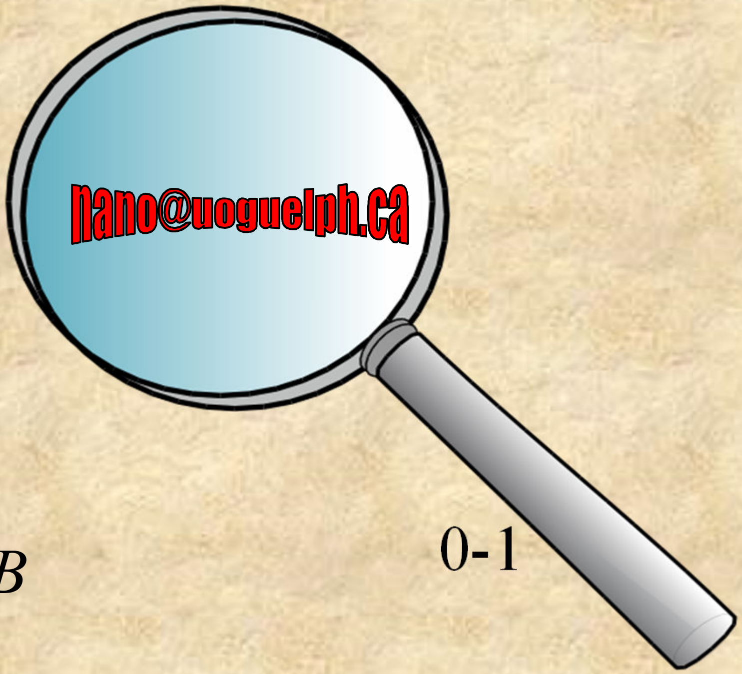
Lecture Zero

Welcome to NANO* 2000



First - the "big picture" of the course
and the COURSE OUTLINE

-grading scheme
- exam schedule
- review paper
- lab (Jay)



last revision August 27 2014: MDB

NANO* 2000


The joy of learning

Course Professor: Mark Baker: MACN 122: Ext. 58637: mbaker@uoguelph.ca

Student Evaluation:

Laboratory: 35% The introductory labs will occur on Sept. 11/12 depending on the section. This lab will be used to pair up students and cover safety as well as reports and important submission dates that are pertinent to the lab portion.

Mid-Term Exam: 20%: Weds 22 Oct (in class)

Final Exam: 25%: Sat. Dec 6th ....2.30-4.30 pm: Cumulative

(Room TBD)- last year's exams will be available

Review Paper 20%

Prerequisites: CHEM* 1050, PHYS* 1010, MATH* 1210, NANO* 1000

Objectives: This course aims to provide an Introduction to the synthesis and properties of Nanomaterials.

Textbook: No book assigned

Lectures: Mon and Weds ROZH 108 10-11.20

The lectures will be presented from both the Adobe files that I will email to you and the whiteboard. Lecture notes were initially designed for MWF so we will cover 30 lectures in about 24 slots.

Some material from CHEM 2060 may be expanded upon in relationship to NANO 2000

Laboratory: Thurs 2.30-5.20 pm and Fri 8:30-11:20 am.

in SSC (formerly SCIE) 2110and 2109

The first week will be check in and safety. Sept 11/12

Research Paper

Each student will prepare a review paper on a topic listed below or on a suitable topic of your choice.
The report must be produced by a word processor and should be between 10 and 15 pages double spaced. The format should adhere to that specified by The American Chemical Society. I will provide details separately.
We will spend part of a lecture looking at this. You must work Individually on the assignment.

Plagiarism will not be tolerated; see http://www.academicintegrity.uoguelph.ca/plagiarism.cfm

Office Hours: Monday 12-2…and other times. My door is usually open! Come by yourself or with others. The more the merrier. email requests for appointments are fine.

Topics: *You cannot choose the same topic as in NANO 1000*

1. Nanotubes
2. Nanomachines
3. Biological Nanostructures
4. Quantum Dots and Nanowires
5. Applications of Nanomaterials
6. NanoGold
7. Supramolecular Chemistry
8. Graphene
9. Molecular Electronics
10. Fullerene Chemistry
11. DNA in nanoscience
12. Labs on a chip
13. Toxicology of Nanostructures
14. A topic of your choice
15. Core-shell nanostructures
16. Nanolithograhy
17. Quantum Computing

Papers due Nov 7: Noon
Late submissions
will be penalized 2 marks/day
Submission MUST be a pdf
PLUS hard copy.

submission after
Nov 11 = zero
(paper is 20% of total
course grade.)

Course Content:

Lecture 1: Introduction to Nano* 2000. Nanostructures in Nature. Nanogold. Types of Nanostructures.

Lecture 2: Characterization. Imaging Methods. Electron Microscopy. Electron Optics. Resolution. Numerical Aperture. Rayleigh. Abbe. Wave-Particle Duality. Electron Waves (STM first look).

Lecture 3: de Broglie. Interaction of electrons with solids. Secondary Electrons. Mean Free Paths. SEM (Scanning Electron Microscopy). Electron optics. EDX. X-Ray Fluorescence.

Lecture 4: X-Ray emission. Mosely. EDX examples. TEM (Transmission Electron Microscopy.

Lecture 5: SPM (Scanning Probe Microscopy) AFM. Contact, Tapping and non-contact modes. Atomic-Resolution AFM (Si{111}). Pros and cons of the three methods. The TARDIS! Rohrer and Binnig.

Lecture 6: STM (Scanning Tunneling Microscopy). Tunneling. STM probe tips. Imaging Modes. Constant height and constant current. Example Images.

Lecture 7: An Introduction to X-Ray Crystallography. Unit Cells. Miller Indices. Single crystal surfaces. Relation to STM.

Lecture 8: Crystal Structures. Close Packing. Diamond and Silicon. Bragg Law. XRD. hkl planes and Indexing. Instrumentation for XRD.

Lecture 9: XRD - more examples. Systematic Absences. Phase purity. Line broadening. Particle size determination. Debye-Scherrer Equation.

Lecture 10: Particle Size Determinations. Dynamic Light Scattering. Adsorption isotherms. BET surface area measurements.

Lecture 11: BET methods continued. Examples. Instrumentation. Mercury Porosimetry. Instrumentation. Quartz Crystal Nanobalance. Sauerbrey Equation. Applications and examples.

Lecture 12: Preparation of Nanostructures. Top-Down and Bottom-Up terminology. Top Down Methods- Carbon Nanotubes. Laser Ablation. Mechanical Methods. Thermal Syntheses. High Energy Methods. Solar Furnaces. Plasma Methods. Electrochemical Techniques.

Lecture 13: Lithography. Contact Printing. Proximity Printing. Projection Printing. Bottom-Up Methods. - CVD. SWCNTs. Epitaxy MBE.

MID-TERM EXAM

Lecture 14: Physical Chemistry of Nanostructures. Importance of Nanostructure Surface. Surface to Volume Ratios. Size and Shape, Bravais Lattices.

Lecture 15: Bravais Lattices for cubic and hexagonal systems. Close Packing. Octahedral and tetrahedral vacancies. Packing Density. Structural magic Numbers. Hollow nanostructures.

Lecture 16: Size-dependent properties of nanostructures. Melting Points. Lattice Energies. Madelung Constants and nanostructures. Ewald's Method.

Lecture 17: Madelung series for various structures as function of size. Surface Madelung Constants. Nanosurface Madelung Maps.

Lecture 18: Synthesis and Modification of nanostructures. Carbon: the four types of carbon.

Lecture 19: Fullerenes: Properties, Synthesis and Purification.

Nanotubes. Armchair Zig-Zag and chiral**.** Vector Notation (review of Nano* 1000).

Lecture 20: Nanotubes**:** Vector Notation (review of NANO* 1000).

Lecture 21: Synthesis of carbon nanotubes. Growth mechanisms. Diamondoid nanostructures (BN and CN).

Lecture 22: BN Nanostructures. Structure, Synthesis and Properties.Diamond this films.

Lecture 23: Thin Films (Intro). Film Growth Methods (Vacuum Methods). Nucleation Mechanisms. Wolmer-Weber , Frank - Van der Merwe, Stranski -Krastonov

Lecture 24: Self assembled monolayers and multilayers. Alkanethiols and sulfides. Nanoparticles captures by assembled mono- and multilayers.

Lecture 25: Electrochemical Methods. Electrodepositon of nanowires and nanorods. Bias potentials. Nernst-Planck equation. Diffusion. Electroless depositions. Electrochemical templates.

Lecture 26: Electrophoretic deposition of nanostructures. Double layer. Stern Layer. Zeta potentials. Dielectric constant. Templates (more detail). Zeolites -first look.

Lecture 27: Silicates. Template ideas. Knudsen diffusion. Molecular sieving. Mesoporos, microporous and macroporous templates. Zeolites - more detail.

Lecture 28: Zeolites as templates for nanostructures. Macroporous templates. Synthesis. Core shell nanostructures.

Lecture 29: Metal Oxide core shell nanostructures. Stabilizers. Metal-polymer core shell nanostructures.

Lecture 30: Wrap up. Recent examples of nanostructures in the literature. Review class.

EVALUATION OF PROFESSOR:

As part of the faculty evaluation process in the Department of Chemistry, students are reminded that written comments on the teaching performance of the lecturer may be sent to the Chair, Department of Chemistry at any time. Such letters must be signed.

Last revision: August 27 2014 MDB