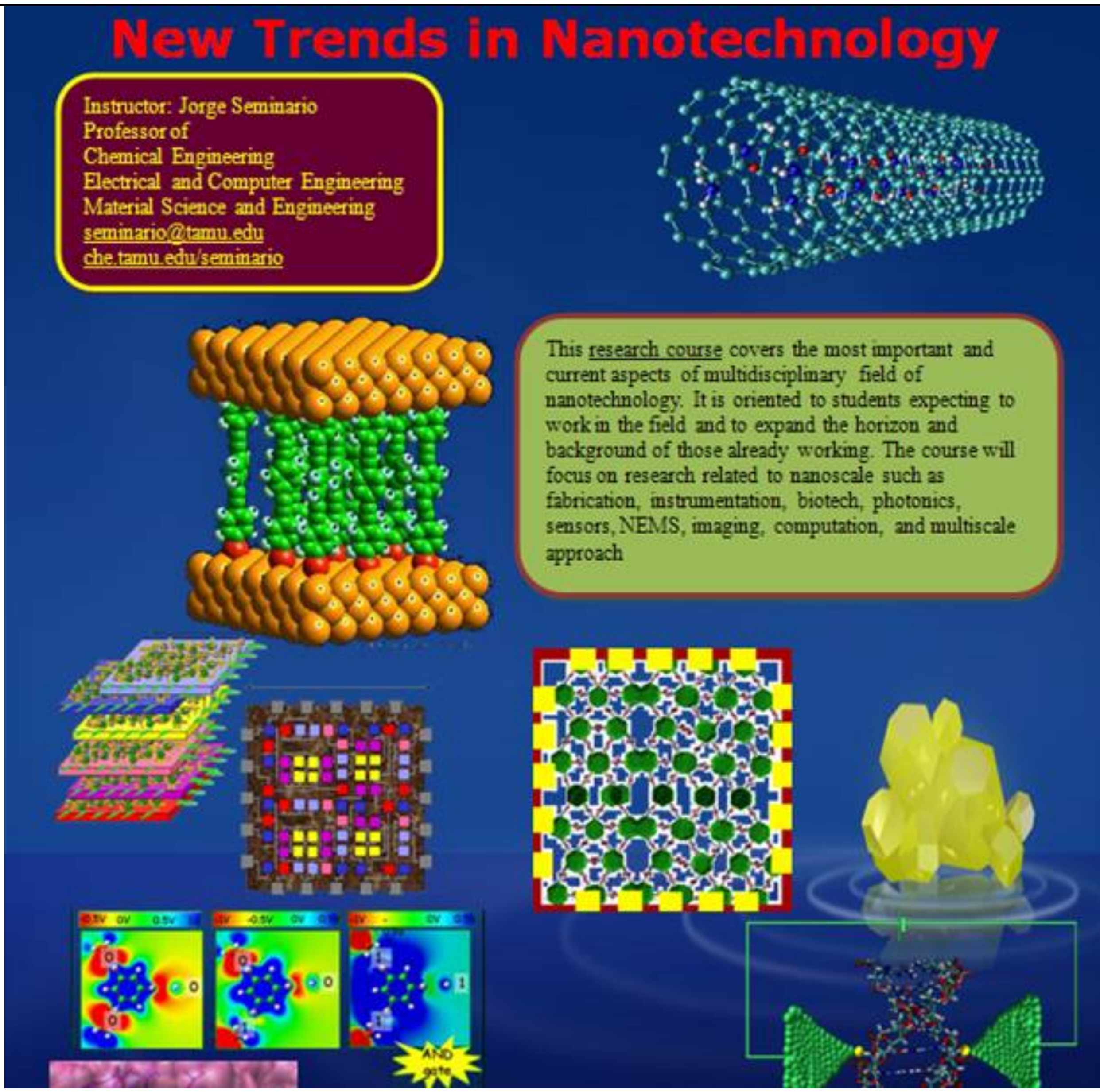
NANOTECHNOLOGY CHEN-689-601 (3 CREDITS)
NANOTECHNOLOGY CHEN-489-501 (3 CREDITS)
NANOTECHNOLOGY SEMINAR CHEN-481 502 (1 CREDIT)

SPRING-2010



NANOTECHNOLOGY: THE PHYSICS, CHEMISTRY, AND ENGINEERING OF NANOTECHNOLOGY

Course Information

Instructor Information:

Name: Jorge M. Seminario
Research URL: http://www.che.tamu.edu/seminario
Course URL: http://www.che.tamu.edu/orgs/groups/Seminario/nanotechnology//index.html
Office: 239 JEB

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Office: 239 JEB
E-mail: seminario@tamu.edu

Class room: 112 JEB

Class time:
CHEN 689&489:
Tuesday and Thursday 2:20-3:35 PM
Student presentations: Thursday 2:45-3:35 PM

CHEN 481:
Fridays 2:05-2:55 PM

Pre-requisite: None

For CHEN689, Introductory quantum mechanics and scientific programming will be provided as needed for specific cases. (See me or e-mail me if you have doubts)

Course Goals

Basically the courses have two main goals:
1) To introduce all students to the basics and tools of the exciting field of nanotechnology. This includes a review of the state of the art as well as discussions of present research such that presently or after graduation the student can be ready to work in this multidisciplinary field; and
2) For students who are not working on nanotechnology: re-orient and re-tool them with nanotechnology approaches and algorithms to analyze, design, and simulate systems of their own interest or of their own research. For students already working in nanotechnology, the effort will focus on developing, modifying, adapting, and creating tools to solve specific problems in the field.

Course Topics 489 and 689 only:

As the course is multidisciplinary, these topics are tentative and focus on the scaling-down problems in microelectronics as the key trigger and example for nanotechnology; solving the scaling down problems requires of a multidisciplinary effort that includes several engineerings, physics, chemistry, materials, and biology.. The list of topics below will be enlarged/adapted/modified considering the background of the registered students. (Numbers inside parentheses indicate the approximated number of weeks that will be dedicated each topic.)

- **Introduction** **(1)**
  Introduction
  Moore's Law
  Challenge facing Si microelectronics
  Nanoelectronics and molecular electronics: "Lab-on-chip"
  Bottom-up and top-down approaches
  Motivation from other fields
  Biological systems
  Other applications based on student interest

- **Practical First Principles Tools (*in silico* instrumentation)** **(3)**
  Molecular and clusters calculations
  Extended Systems calculations
  Time Dependent Methods
  Green Function Approaches
  Applications to Solar Energy
  Applications to Catalysis
  Applications to Genomics
  Other applications based on student interest

- **Empirical and Semi-empirical Techniques** **(2)**
  Classical Molecular Dynamics
  Ab initio based and empirical force fields
  Multiscale simulations
  High performance computing
  Applications to Drug Delivery
- **Molecular Nanotechnology** **(3)**
  Self assembly molecules (SAMs)
  SAMs devices
  Charge transport in a molecule
  Contact junctions: theory and measurement
  Integration issue
  The MoleFET
  The lessons from Schon's incident
  Other applications based on student interest

- **Nanotubes, Nanowires, Nanoribbons** **(2)**
  New forms of carbon
  Growth of carbon structures
  Molecular devices
  Integration issue
  Other applications based on student interest

- **Other Topics, Guest Lectures, and Lab Tours** **(2)**

Grading

MidTerm Exam Project 1	20%
Final Exam Project 2	30%
Presentation discussions	50%

The same formula is used for everyone. No student may obtain extra credit by special arrangement. Final grades are assigned as indicated below. I am not committed to giving a certain percentage of A's or F's to every class.
The following table gives you a precise idea of your grade:

From	90	to	100	A
	80		89	B
	70		79	C
	60		69	D
	Less than 60			F

Only presentations/reports submitted on the due date or before will be able to receive credit (no exceptions).

Make-Up Policy

There are NOT make-ups; if you have a proved emergency (properly documented and submitted to me as soon as possible, i.e., the next class you are able to attend after the emergency) that does not allow you to attend one of the presentations, you will be allowed to submit a late report/presentation. If the emergency does not allow you to report/present your work by the end of the semester and if you have a valid reason, you will be given an incomplete. If you do not have a valid emergency, you will get a zero in the assignment. There are few situations in which a make-up has to be done; if so, please provide the needed information as soon as you can.

The same rules also apply for other cases not explicitly considered as emergencies such as, jury duty, job interviews, or presentations of your research work in meetings; however for all these cases, documentation/data should be submitted in advance. Consistent with University Student Rules, students are required to notify the instructor and provide supporting information if they have a problem to attend the presentations. If no documentation is presented after one week of the end of the emergency, you will receive a zero. If the absence is planned, you will need to provide the documentation in advance.

Please send me an e-mail if you have further questions.

Americans with Disabilities Act (ADA) Policy Statement

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities, in Room 126 of the Koldus Building or call 845-1637.

The Texas A&M University Academic Integrity Statement

"An Aggie does not lie, cheat, or steal or tolerate those who do"

The Aggie Honor Code provides a standard of conduct in which each student promises not to lie, cheat, or steal and not to tolerate violations by others. I support the Aggie code and I assume the students do also. Remember that the honor system can be effective only if everyone supports it! For further information, please see the Academic Integrity Task Force, 2004 at http://www.tamu.edu/aggiehonor/FinalTaskForceReport.pdf. In summary, do not cheat on exams, test, quizzes, or homework. Please spare me the difficulty of seeing those sorts of cases through the prosecution system.

Bibliography

No textbook but current journal articles in the field and lecture notes will be used as well as the following books as reference material
Here are two interesting books edited by the instructor:
Jorge M. Seminario, Molecular and Nano Electronics, Elsevier, 2006
P. B. Balbuena and J. M. Seminario, Nanomaterials: Design and Simulation, Elsevier 2006.

Class and Assignment Schedule

n	*Day*	*Date*	**Applications of technology to**	*Group*	*n*
0	Tue	Jan19	Introduction		0
1	Thu	Jan21	The meaning of nanotechnology		1
2	Fri	Jan22	The meaning of nanotechnology		2
3	Tue	Jan26	Distribution of assignments		3
4	Thu	Jan28	Nanowires	invited	4
5	Fri	Jan 29	Hydrogen Cells	invited	5
6	Tue	Feb02	Process to control nanotubes chirality	G1	6
7	Thu	Feb04	Nanotech applic.: Oil, gas industry	U1	7
8	Fri	Feb05	Solar Cells; Chemistry & Surface chemistry	S1	8
9	Tue	Feb09	electromechanical oscillator	G2	9
10	Thu	Feb11	Reservoir Engineering	U2	10
11	Fri	Feb12	Nano-porous membranes in Gas separation	S2	11
12	Tue	Feb16	Nano-Sensors; Microtubule dynamic instability	G3	12
13	Thu	Feb18	Biodegradable Polymer Nanoparticles for drug delivery through mucosal Membranes	U3	13
14	Fri	Feb19	Deliver chemicals to a specific location	S3	14
15	Tue	Feb23	biomedical sensing- biosensing	G4	15
16	Thu	Feb25	Nano-robots	U4	16
17	Fri	Feb26	Gas & oil industry	S4	17
18	Tue	Mar02	Carbon-nanotubes	G5	18
19	Thu	Mar04	Energy, Food production & sustainability	U5	19
20	Fri	Mar05	Carbon-nanotubes	S5	20
21	Tue	Mar09	mechano-transduction; piezoelecctricity movie (mpg)	G6	21
22	Thu	Mar11	Nano-fabrics, Chemical Eng. Industry at IBM, Intel	U6	22
23	Fri	Mar12	Industrial applications	S6	23
24	Tue	Mar16	Spring Break	-	24
25	Thu	Mar18	Spring Break	-	25
26	Fri	Mar19	Spring Break	-	26
27	Tue	Mar23	Nanowire photonics	G1	27
28	Thu	Mar25	semiconductor manufacturing techniques	U1	28
29	Fri	Mar26	Agriculture	S1	29
30	Tue	Mar30	molec. Circuits using NDR composites	G2	30
31	Thu	Apr01	Solid state Chemistry	U2	31

32	Fri	Apr02	Reading Day; no class	-	32
33	Tue	Apr06	NEMs	G3	33
34	Thu	Apr08	Graphene	U3	34
35	Fri	Apr09	Food/ beverages industry, Consumer products	S3	35
36	Tue	Apr13	Thermal conductivity	G4	36
37	Thu	Apr15	Metal organic frameworks	U4	37
38	Fri	Apr16	Nanotechnology in Daily Life	S4	38
39	Tue	Apr20	Quantum mechanical devices, tunnel FETs	G5	39
40	Thu	Apr22	Nanotech applic. Mechanical	U5	40
41	Fri	Apr23	Nanotechnology in Aerospace Applications	S5	41
42	Tue	Apr27	Self-ordered devices	G6	42
43	Thu	Apr29	Nanotech applic: Pharmaceuticals	U6	43
44	Fri	Apr30	Zeolites in the Petrochemical Industry	S6	44
45	Tue	May04	1) Applications to genomics 2) Sequencing Cancer Genomes (individual work) Students may chose either of the two or the two for their report	S2	45

Review of Basic Stuff from Materials:

1) Atomic and molecular
2) Electrical properties
3) Magnetic properties
4) Optical properties

GROUPS:
S = CHEN481, U = CHEN489; G = CHEN689

Other very important books are,
C. P. Poole and F. J. Owens, Introduction to Nanotechnology, Wiley, 2003.
Jorge Kohanoff, Electronic Structure Calculations for Solids and Molecules, Cambridge, 2006
G. L. Timp (ed.), Nanotechnology, Springer-Verlag, 1998.
A. Aviram, M. Ratner, and V. Mujica (ed.), Molecular Electronics II, NYAS, 2003.
Introduction to Mesoscopic Physics, Yoseph Imry, Oxford University Press (1997)
Molecular Electronics, James M. Tour, World Scientific; (2003)
Modern Quantum Chemistry, A. Szabo and N. S. Ostlund, MacMillan, New York (1982)
Molecular Quantum Mechanics, P. W. Atkins, Second edition, Oxford University, (1983)
Silicon Quantum Integrated Circuits, E. Kasper and D.J. Paul, Springer
Atoms, Molecules and Clusters in Electric Fields, G. Maroulis, Imperial College Press (2006)
Gaussian 2009 Information
Crystal 2006 Information
VASP 2009 Information
LAMMPS Molecular Dynamics Program information
Artificial Intelligence Methods
Monte Carlo Methods

"Always read in advance the material for class"

Class Outline:
Paper Discussions
Progress Reports
Final Projects

Presentations
For the presenters:

1) Chose one or more papers regarding applications of nanotechnology to your assigned topic
2) Prepare a ppt presentation of ~30 minutes.
    a. Title slide (title of your presentation and names of participants)
    b. Introduction (background, etc)
    c. Basic principles
    d. Work performed
    e. Conclusions
    f. Your assessment of the work (how to improve it, follow up, analysis)
    g. What further research would you suggest
    h. References
3) Send me the ppt in advance to get feedback
4) Decide who is(are) presenting for a total of 30 minutes

For the Audience:

1) Listen and take notes on the prepared sheet (individually, attendance required, no make-ups)
2) Send me a one or two slides (ppt) of your review within one week (by groups)

Suggestion: Choose papers from recent issues in Science or Nature

Project Deadlines (only for 489 and 689):

Short Project Abstracts: February 13
Short project due March 11
Project Abstract March 18
Long Project April 27

Hint: Long project can be an extension of the short project
All projects in ppt; abstract could be in word.

Interesting Topics
Solar Energy {this is material I collected for an undergraduate class in petroleum engineering}

See the nanoMaterials page: http://www.che.tamu.edu/orgs/groups/Seminario/nano-materials
Additional Information from the materials class is here: Materials
I strongly advise you to see the 14 topics prepared by the materials class of fall-2009. These presentations will allow you to browse the diverse areas related to nanotechnology. I also included important chapters from the material's class that can help you further to refresh some basics stuff that I am sure you learn before.

FAQ, Suggestions, and the like received/sent from/to the students:
1) About make-ups: There are not make-ups as you should be in class to do the review.
You still can help your group to prepare the ppt review of the presentation.
Presentations are posted in the web site

2) Proper citing: Several of the figures that are not your own are not cited. Please make sure that all material you presented is cited in the same slide.
Also, in several cases, the text size is too big compared to the graphics. Increase the size and quality of the figures and decrease the size of the fonts.
Please send a new version at your earliest convenience

3) I had a few questions about the abstract that is due tomorrow and on the overall project. What topics can we choose from for the project. What are you expecting from the abstract, anything in particular? Is the project supposed to be based off of a paper or just a topic?

You choose the topic from a field of nanotechnology. It could be based on a recent paper but you have to do something or proposed something to improve or go beyond of what was done in the paper.
In simple terms you can chose between (a) do the work to improve the paper topic or (b) make a proposal to improve or go beyond of what was obtained in the paper.

4) is the overall project a presentation or a written paper?

PPT

5) Could you please explain more about the short project? What are the parameters of the short project?
See 3-4

6) Is it based on single paper like the presentation or we have to use multiple sources?

It is up to you

7) The deadline is coming saturday, and do u want the abstract in email as word document?

Word file is OK

Reviews and Project Abstracts

(Forward your e-mail to seminario@tamu.edu if you submitted your reports/abstracts and they do not show up here.)
(Carbon copy ALL your submissions to paola.leon@chemail.tamu.edu)
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U1: Nanocatalyst
Abstract--We intend to research the field of nanoparticle catalysts. Our intended research will include how nanocatalysts work, how they are produced, what separates them from traditional catalysts, the advantages and disadvantages of noncatalysts, current applications, and future applications, and economic feasibility of their use. We intend to find information by reading research papers, talking knowledgeable professors here at Texas A&M, and by searching the internet and library for additional information.
Our preliminary research shows that the much of the nanocatalyst's properties come from its greater surface area when compared to traditional catalysts. The greater surface area leads to more favorable chemical kinetics and thus to a faster rate of reaction. Although they may be more expensive to produce, the increase in reaction rate without an increase in pressure or temperature of the reaction vessel leads to great process safety in addition to increased yields.
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U2: Kyle Demel, Keaton Hamm, Bryan Holekamp, and Rachael Houk
Currently, the separation of gases in industry requires a chemical reaction or a large investment of energy for phase separation. The potential for nano-porous membranes to separate a gas mixture is being researched. The purpose of this report is to investigate non-chemical separation by using nano-porous membranes. The report will discuss the physical concepts that make membrane separation theoretically possible, the experimental tests that demonstrate the viability of membrane separation, and the implications of membrane-separation technology. One potential application of nano-porous membranes is the separation of poisonous hydrogen sulfide from methane gas. Over 30% of the natural gas produced in the United States contains varying amounts of carbon dioxide and hydrogen sulfide. Since the demand for natural gas is expected to increase, gas industries are researching methods to upgrade the low-quality methane. Nano-porous membranes present a feasible alternative to conventional separation because the method is cleanlier and less energy intensive.

Nanotechnology and the Environment
The purpose of this report is to provide the major insights concerning how new developments in nanotechnology will affect the health of humans and the environment. Nanotechnology poses a major scientific and economic growth area for the next fifty or more years. Yet, many scientists and researchers are concerned that nanomaterial residues may present detrimental health risks to humans and to the environment. Little data is available to show the quantitative effect that manufactured nanomaterials may have on the environment. Nanomaterials, which are in the 1 to 100-nm size range, are composed of many different base materials, some of which are toxic in high concentrations. Particles on the nano-scale occur both in nature and as a result of industrial processes. However, the next generation of nanostructures are different because these materials are fabricated starting at the molecular level. These engineered nanomaterials are more reactive than traditional

materials because the atoms in the nanoparticles reside on the surface of the material. The increase in reactivity may lead to different biological effects, which some scientists believe could lead to an increase in the toxicity of chemical pollutants.

Nanotechnology also has the potential to improve current environmental protection measures and our understanding of the environment. Current research could unveil new emission control schemes, develop new "green" technologies that minimize the production of undesirable byproducts, and remediate existing waste sites and polluted water sources. Nanotechnology has the potential to remove the smallest contaminants from the water we drink and from the air we breathe as well as to continuously measure and mitigate pollutants in the environment. This report will examine both the positive and negative aspects that nanotechnology will provide for the environment in the future.

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U3: Krista, Melish, James Kancewick, Phillip Keller, and Mike Jones

Porous Graphene as the Ultimate Membrane for Gas Separation

It was written by De-en Jiang, Valentino R. Cooper, and Sheng Dai from the Chemical Sciences Divison and the Technology Division of Oak Ridge National Laboratory. The article was published in the nano technology journal "Nano Letters" on September 23, 2009, and can be viewed online at the following address: http://pubs.acs.org/doi/full/10.1021/nl9021946. The research presented was focused on adding molecule selective gates to sheets of graphene in order to create super selective molecular sieves. The experiments were designed by using first principles density functional theory calculations to determine poor types that would inhibit the passage of methane while allowing hydrogen to pass through easily. Using electron beams and bottom-up synthesis, the team was able to create sub nanometer pores with nitrogen that effectively inhibited the passage of methane at 1.6 eV, and allowed hydrogen to easily pass through at 0.22 eV. This research shows promise that it can be tailored for pretty much any type of gas separation, which gives it a heavy impact on the future design of molecular separations. The authors state that this technology could readily advance current carbon sequestration efforts, gas sensor technology, and fuel cell design.

Large-Scale Pattern Growth of Graphene Films for Stretchable Transparent Electrodes

Graphene has the potential to revolutionize electronics based on its physical properties, but there are problems associated with the large scale pattern growth that stands as a primary obstacle in using this material in electronic applications. Typically, macroscopic-scale graphene films were prepared by two-dimensional assembly of graphene sheets derived from graphite crystals and graphene oxides. The issue was the sheet resistances were found to be much larger than theoretical values. Methods were conducted to synthesize large scale graphene films directly by using chemical vapour deposition on thin nickel layers, and present two different methods of patterning the films and transferring them. The transferred graphene film shows very low sheet resistance. Calculations imply that the quality of graphene grown by chemical vapour deposition is as high as mechanically cleaved graphene. Employing these properties, the macroscopic use of these highly conducting and transparent electrodes in flexible, stretchable, foldable electronics is possible and desirable.

{refs}

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U4: Nanorobots for Brain Aneurysm

Abstract:

Nanorobotics are of interest in the field of medicine. Advanced medicine technologies are being researched to replace traditional medicine methods. Techniques and equipment design necessary for the effective development of nanorobots are discussed in this report. In special, current studies show that nanobioelectronics and electromagnetic can be used as the basis to advance medical Nanorobotics. These can search for proteins overexpression signals and recognize cerebral aneurysm in its initial stages.

Toxicity of Carbon Nanotubes

Recent advances in nanotechnology have made nanotubes, specifically carbon nanotubes (CTNs), an indispensable element in the technological industry. Since their discovery in 1991, massive investments have been made worldwide to learn more about them, and making them one of the most widely investigated nanoparticles. Due to their physical and chemical properties, CNTs have encountered a wide range of applications in today's technology-craving world. Currently, CNTs are being tested to be used in electrical circuits, batteries, solar cells and capacitors, among others. However, they are not limited to technological uses. It has been proposed that CNTs can also be used in the medical field. This, however, raises increasing concerns regarding their possible effects on the human body. One of the most concerning issues presented is found in recent studies which demonstrate that CNTs are able to cross cell membranes and thus have a potential influence on cell properties. Moreover, CNTs are very light, and may become airborne and inhaled, which is potentially hurtful to the respiratory system. Shockingly, research to proof or disproof these concerns has just recently begun. Current investigations are not sufficient in determining biological hazards acquired by CNTs used in the biomedical field and demonstrate the actual effects of nanotubes in biological systems, in part due to these studies not having complete understanding of the effects and interactions of nanotubes with living organisms.

{it has to be something orthogonal to what is already presented}

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U5: John Pack, Greg Pudewell, Jaynesh Shah, Larry Youmsi

Nanotechnology Applications in the Oil and Gas Industry

We would like to do our project on Nanotechnology Applications in the Oil and Gas Industry, more specifically on enhanced oil recovery methods (EOR) as pertaining to reservoir engineering. We would like to research into carbon dioxide injection techniques and how nanotechnology can help improve oil recovery within this technique. Carbon dioxide injection is becoming a very prevalent form of enhanced oil recovery and many historical oil and gas fields are switching over to carbon dioxide injection such as in North Dakota, Montana, and West Texas. As oil and gas is such a major energy source in our increasingly modern world, the exponential increase in the demand for oil and gas has made it critical for more and more sources of energy - specifically hydrocarbons - to be recovered. This, coupled with the increasing scarcity of oil fields, makes it vital to recover as much oil as possible from our current oil fields. In conclusion, we feel that nanotechnology has a huge potential to assist in increasing the efficiency of oil recovery and help meet the ever-increasing demand for oil and gas.

References:

Igor N. Evdokimov, Nikolaj Yu. Eliseev, Aleksandr P. Losev, & Mikhail A. Novikov "Emerging Petroleum-Oriented Nanotechnologies for Reservoir Engineering" SPE| October 2006| spe102060

Nanotechnology Applications in Biomedical Physics

We would like to do our project on Nanotechnology Applications in Biomedical Physics, more specifically on the bactericidal effect of silver nanoparticles as pertaining to biomedical engineering. We would like to research into the antibacterial properties of metallic nanoparticles which exhibit increased chemical activity due to their large surface to volume ratios and their crystallographic surface structure and how nanotechnology can help improve fighting bacteria using this technique. Silver nanoparticles used in this work exhibit a broad size distribution and morphologies with highly reactive facets. Due to the recent increase of new resistant strains of bacteria to the most potent antibiotics, this study outlining the antibacterial capabilities of silver nanomaterials is particularly timely. The study indicates that the bactericidal properties of the nanoparticles are size dependent since the nanoparticles that present a direct interaction with the bacteria preferentially have a diameter of approximately 1-10 nm. In conclusion, we feel that nanotechnology has a huge potential to assist in increasing the fight against diseases and help improve the quality and quantity of life.

References:

Jose Ruben Morones, Jose Luis Elechiguerra, Alejandra Camacho, Katherine Holt, Juan B Kouri, Jose Tapia Ramirez and Miguel Jose Yacaman "The bactericidal effect of silver nanoparticles" Nature, Vol 16| 26 August 2005| doi:10.1088

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U6: Pavitra Timbalia, Michael Trevathan, Jared Walker

The 5 principles of "Design for Safer Nanotechnology"

Nanoparticles, or particles which are in the range of 1-100nm, are becoming increasingly common in today's society. However, the hazard of nanoparticles is something which has to be investigated further. Certain nanoparticles, such as carbon nanotubes and quantum dots, can be toxic to human health. When nanoparticles enter the human body, either though digestion, inhalation, or injection, they pose a health threat. The smaller the particles, the further they can travel into the lungs, where they are harder for the body to remove. Also redox activity generates reactive oxygen which can damage lipids, proteins, and DNA. Two approaches to developing safer nanotechnology are the design approach and the non-design approach. In the design approach, engineering teams alter the design before the production of the technology, while in the non-design approach aims to change things during the later stages of product lift. When trying to determine ways to make nanotechnology safer, there are five basic design principles to take into account. First of all, the size, surface, and structure of the nanoparticles can be changed in order to make them safer. They would have to be altered in a way which does not damage the intended functionality of the product, but reduces the hazard. Secondly, an alternative material or a combination of alternative materials may be available which is not as harmful. If an alternative material cannot be found, the nanoparticles may have to be eliminated from the product. A third design principle is to use functionalization. This is the technique of bonding atoms to nanoparticles to change the properties of the nanoparticles. This may be a way to keep the product properties, but discard the hazardous potential of the particle. Yet another way to keep reduce the toxicity of a nanoparticle is to encapsulate it in an innate material. This means that less of the nanoparticle is exposed. Finally, reducing the quantity of the nanoparticles used will reduce the toxicity. In many applications, such as the compact fluorescent lamp, this has been successfully done. These design principles need to be tested and developed further as more and more discoveries are being made in the world of nanotechnology.

How Safe is Nanotechnology – A Further Investigation

For the second project, we will perform a further investigation into the safety of nanoparticles. While our first project was a general overview of how to design safer nanotechnology and public perceptions on nanotechnology, this project will go into specific details and current research on the risks. There are specific studies that have shown that there may be health and environmental risks associated with the production and use of nanoparticles. One nanoparticle that is currently being studied is the carbon nanotube and its carcinogenic properties. Researchers are trying to determine whether there is a link between exposure to carbon nanotubes and lung cancer. The magnitude of this risk has to be investigated in order to see if using nanotechnology on a wide scale basis is something which can be implemented. Due to the small size of nanoparticles, specific health risks include their absorption into the lungs, body tissue, cell mucus, or nanoparticles contaminating water supplies. Group U6 will look into current research being conducted on the health hazards of nanoparticles. We will analyze possibilities of future research on the safety of nanotechnology. We will also look into the size and structure of the nanoparticles by using computer analysis tools to determine the magnitude of the risk. In addition, we will analyze the size of tissue pores in the lungs to get a better understanding of the probability of nanoparticle absorption.

References:

"Learning from History: Understanding the Carcinogenic Risks of Nanotechnology -- Carter 100 (23): 1664 -- JNCI Journal of the National Cancer Institute." Oxford Journals | Medicine | JNCI J Natl Cancer Inst. Web. 31 Mar. 2010. <http://jnci.oxfordjournals.org/cgi/content/short/100/23/1664>.

Roller, Markus. "Carcinogenicity of Inhaled Nanoparticles." Inhalation Toxicology 21 (2009): 144-57.

G1: Edson Bellido:

DNA origami

DNA origami is the nanoscale folding of DNA to create arbitrary two and three dimensional structures at the nanoscale. The specificity Watson and Crick interactions between complementary base pairs make DNA a useful construction material. The process of synthesis involves the folding of a long single strand helped by multiple smaller strands called staples. Currently a lot of research is being done to characterize the mechanical, electrical and thermal properties of DNA origami compared with the ones of single or double stranded DNA, Also multiple applications of DNA origami have been proposed, including enzyme immobilization, self-assembly, moletronics, biosensing, DNA based computation and nano-patterning.

Corrugation on Graphene

Graphene is a 2D sheet of carbon just one atom thick with a very high intrinsic mobility (200,000 cm2/Vs) which makes graphene a very good candidate for future electronic applications. However, graphene is normally not perfectly flat but instead has a corrugated appearance and these corrugations vibrate as the graphene warms up. These corrugations serve as scattering sites for electrons reducing the mobility at higher temperatures. These corrugations are caused by a combination of factor including thermal treatment on the device preparation, different oxygen containing addends and substrate roughness. In this project we will discuss how this factor affect the electrical conduction and which one of this factor influences the most on the formation of corrugations.

{References???}

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G2: Alfredo Bobadilla

Electron-Phonon Interactions in a SWCNT

An individual suspended SWCNT is subjected to a variable stress and its vibrational modes are obtained by measuring its current-voltage characteristic. A gate voltage is applied in order to generate an electrostatic force acting on the SWCNT. This methodology allows studying the influence of stress and electron-phonon interaction on molecular conductance.

References:

1) Study of Electron−Phonon Interactions in a Single Molecule Covalently Connected to Two Electrode Nano Lett., 2008, 8 (6), pp 1673–1678 http://pubs.acs.org/doi/abs/10.1021/nl080580e

2) Scaling Law in Carbon Nanotube Electromechanical Devices Phys. Rev. Lett. 95, 185504 (2005) http://prl.aps.org/abstract/PRL/v95/i18/e185504

3) Mechanically controlled binary conductance switching of a single-molecule junction Nature Nanotechnology 4, 230 - 234 (2009) http://www.nature.com/nnano/journal/v4/n4/abs/nnano.2009.10.html

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G3: Mary Coan –Short Abstract Project

As medicine continues to advance more and more people are placed on dialysis as a method of survival. Dialysis is used for patients who have lost kidney function either temporarily or permanently due to acute renal failure, acute kidney injury, or chronic kidney failure. Dialysis treatment is usually 4x a week taking approximately 4 hours for each treatment. The frequency is dependent on the degree of kidney failure while the treatment time is based on separation of waste products from the blood stream through several membranes. Current commercial dialysis membranes have broad pore size distributions and are extremely thick (over 1,000 times thicker than the molecules they are designed to separate) leading to poor size cutoff properties, filtrate loss within the membranes, and slow transport rates. Dr. Striemer reports fabricating an ultra thin, 15nm thick, nanocrystalline silicon (pnc-Si) membrane with average pore sizes ranging from approximately 5nm to 25nm using commercial silicon fabrication techniques. He performed experiments which resulted in the pnc-Si membrane retaining proteins while permitting the transport of small molecules at rates an order of magnitude faster than existing materials, separating differently sized proteins under physiological conditions, and separating similarly sized molecules carrying different charges. Dr. Striemer also tested the physical properties of the membrane and found that the membranes can support a full atmosphere of differential pressure without plastic deformation or fracture.

Further experimental work should include a more robust study of separation not limited to only two proteins at one time and determining the effects of different concentrations of proteins. The integration into microfluidic devices, the effects of large scale production on the physical properties of the device should be studied to determine low-cost feasibility. Environmental effects on the separation and physical properties of the membrane should be determined. The determination of methods to "clean" the membranes if high-cost should be explored.

Based off of the following paper:
Christopher C. Striemer, Thomas R. Gaborski, James L. McGrath & Philippe M. Fauchet "Charge- and size-based separation of macromolecules using ultrathin silicon membranes" Nature, Vol 445| 15 February 2007| doi:10.1038/nature05532
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G4: Diego A. Gómez-Gualdrón - Nanotechnology - CHEN689-601

Potential Applications of Nanoparticles in Medicine

Nanotechnology, just as any other area of science, pursues the application of human knowledge toward the development of new technologies that are ultimately intended to increase the welfare and comfort of the human race. Therefore, the efforts in implementing the use of nanotechnology in fields such as medicine it is not surprising at all. Due to its small size, nanoparticles have potential applications targeting specific sites in the body with cell precision for drug delivery, medical imaging, and diagnostic sensing. Nonetheless, the implementation of nanoparticles in commonplace clinical use is greatly depending on the solution of toxicity and specificity problems, among others. Hence, further research is needed to wisely design the nanoparticles to address these problems. The current work reviews the basic concepts, which the development of this area is based upon, as well as the advances and breakthroughs during the last years. One area that is very promising is the use of nanoparticle in cancer treatment, and it is on this area that this work is focused the most. A nanoparticle properly functionalized has the potential to specifically bind to tumorous cells, and not only facilitate a very detailed imaging of the spread of a tumor, but also selectively kill malign cells.

Nanotoxicology

Despite some claims the take-over of nanotechnology products are still many years away – perhaps decades – it is also true that nanotechnology is moving forward at a fast rate. Hence, we can no longer afford for risks to appear in the workplace or a marketplace before the necessary research is conducted to develop safe and sustainable nanotechnologies. There is always a question asked at the end of nanotechnology seminars. Journalists, environmentalists, scientists, students, and increasingly, the general public ask this question, which turns out to be "Are nanotechnology products safe?". It is noteworthy that the same properties that make nanomaterials so interesting are the same ones that make them show potential, and possibly unknown, risks. This project aims to make a review of the nanotoxicology area. Nanotoxicology studies are intended to find out in what extent nanoproducts may or may not pose a threat to both the human beings and the environment.
{references?}
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G5: Norma L. Rangel

Nanofood as weapons of mass destruction

Nanotechnology derived food products are already available or in the research and development stage and will be in the market soon. "Nanofood" is a new industrial revolution, with innovative applications during cultivation, production, processing and packaging of the food. However, the impact on human health will depend on how the consumer is exposed to such materials; because due to its nano-size, those materials are imperceptible and able to interact with other substances present in food and molecules in the human organism. But the treat can be also used as a terrorist attack, the high surface to volume ratios materials in the denominated "nanofood" have an increased reactivity due to the molecules located at the surface with energetically unstable states, which may cause reactions mainly oxidations that could yield to deadly hazard risks for human health.

Knowledge of the potential toxicity of materials in nano-food, hazard characterization and early detection is still in the early stage. More research is needed in processes of nanofood, defense and security, for example packaging systems able to respond to environmental conditions and alert the costumer if the food is contaminated, dose-response for a faster reaction under an attack, sensing systems able to detect biochemical and biological agents in nano-food, or simply just a better understanding of the human exposure to hazards through oral routes is strongly needed.
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G6: J.H. Woo

Geometric Relief of Strained GaAs on Nano-Scale Growth Area

A compressively strained epitaxially grown GaAs layer on a (110) surface of silicon wafer is used as a tool to understand the strain relaxation phenomenon in nano-scale substrate. The GaAs layer is growth with various thicknesses is simulated using a software. The critical thickness, h_c, of GaAs grown on bulk planar silicon is effectively zero, but due to the relaxation of strain, the growth of a defect-free single crystal GaAs epitaxy may be possible using a long narrow patterned silicon wafer. The simulation results are presented and analyzed. In particular, the relief of the strain in GaAs due to the various geometry of the substrate is investigated.

Designing, modeling and simulation of the III-V high electron mobility tunnel field-effect transistor on silicon substrate

Tunnel field-effect transistors (TFET) are becoming more attractive topic due to their low leakage current and the scalability. Employing the tunneling effect in the high electron mobility transistor device may show a potential improvement in the device performance. Furthermore, the high threshold voltage requirement in TFETs could also be alleviated. The steep subthreshold slope of these transistors will make them suitable for low power applications as well as CMOS integrations. This project includes the novel design of the III-V high electron mobility tunnel field-effect transistor (HEMTFET) based on Si substrate. Such design is modeled for simulation and the simulation results will demonstrate the performance of HEMTFET.

References

1. H. C. Lin, T. Yang, H. Sharifi, S. K. Kim, Y. Xuan, T. Shen, S. Mohammadi and P. D. Yea, Appl Phys Lett 91 (21), - (2007).
2. A. S. Verhulst, B. Soree, D. Leonelli, W. G. Vandenberghe and G. Groeseneken, J Appl Phys 107 (2), - (2010).

The reviews & rebuttals are NOW in the same file as the presentation (Class & Assignments Schedule)

S reviews
G reviews
U reviews

A few changes will take place for the second round of presentations. Such as

a) A new evaluation form. A draft version was already delivered in class. Please read it and get acquainted with the new items to evaluate.

Short Projects

G1: DNA Origami
G2: Electron-Phonon Interactions in a SWCNT
G3: Ultrathin Silicon Membranes
G4: Potential Applications of Nanoparticles in Medicine
G5: Nanofood as weapons of mass destruction
G6: Geometric Relief of Strained GaAs on Nano-Scale Growth Area
U1: Nanocatalyst
U2: Molecular Separation by Nano-porous Membranes

U3: Porous Graphene as the Ultimate Membrane for Gas Separation
U4: Nanorobots for Brain Aneurysm
U5: Emerging Petroleum-oriented nanotechnologies for reservoir
U6: The 5 principles of "Design for Safer Nanotechnology"

Long Projects
G1: Corrugation of graphene
G2: Electrical characteristic of carbon nanowires produced by oxidative shrinking
G3: Biodetoxification Nanocarriers
G4: Nanotoxicology
G5: Plasmonics for improved photovoltaic devices
U1: Nanocatalyst
U2: Nanotechnology and the Environment
U3: Graphene Further Applications and Research
U4: Toxicity of Carbon Nanotubes
U5: The Bactericidal Effect of Silver Nanoparticles
U6: Safer Nanotechnology PartII

Papers related to the presentations
Send me the pdf of the papers you are using for your presentation at least 24 hours in advance. Name the pdf with the title of the paper.

Nanorobot for Brain Aneurysm

U4
3/11/10
Derek Nelson
Aziz Daabash
Amanda Mogollon
Brett Michalk

References

- A. Cavalcanti, B. Shirinzadeh, T. Fukuda, S. Ikeda. Nanorobot for Brain Aneurysm
- A. Ummat et al. Nanorobotics