Train-the-Trainers

Abstract Book

CONTENTS

TECHNOLOGY, SYNTHESIS, FABRICATION

MATERIALS PROPERTIES AND PERFORMANCE

CHARACTERISATION TECHNIQUES

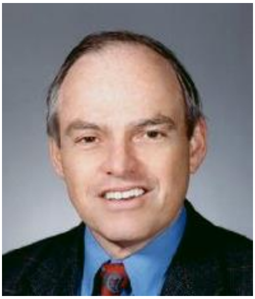
NANOELECTRONICS AND OTHER APPLICATIONS

USEFUL TOOLS

Technology, synthesis, fabrication

The World of Nanotechnology: An Introduction (2011),

http://elluminate.mesacc.edu/play_recording.html?recordingId=1311874532750_1317397089706



Presenter

Stephen J. Fonash

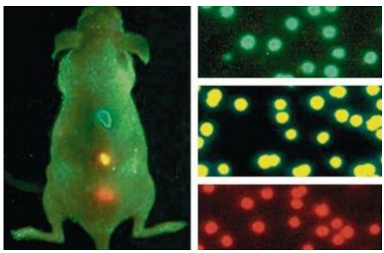
Bayard D. Kunkle Chair in Engineering Sciences, Director Center for Nano-technology Education and Utilization

The Pennsylvania State University

Abstract

The emerging fields of nano technology affords the ability to work at the molecular level to create structures with fundamentally new properties and functions, essentially providing unforeseen powers to understand and control the basic building blocks of all natural and man-made things. Nanotechnology is often cast as an enabling technology that is helping to create a vast array of opportunities in a broad range of industries and disciplines. Nanotechnology is one area of research and development that is truly multidisciplinary. It encompasses a wide range of disciplines, including physics, biology and materials science which are briefly presented on the webinar.

Better plastics and polymers



Fluorescent nanoparticles

Intro to Nanofabrication: Top Down to Bottom Up (2011), http://elluminate.mesacc.edu/play_recording.html?recordingId=1280849478020_1298653927868

Presenter

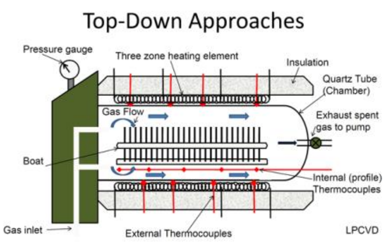
Dave Johnson

Research Assistant

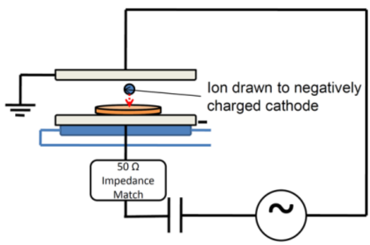
The Pennsylvania State University - Center for Nanotechnology Education and Utilization

Abstract

The interactions between light and matter are modified appreciably when the material dimensions are shrunk to a nanometre scale. The materials in nanometre dimensions can be realized by a variety of nanofabrication methods. These methods, in general, can be divided into two groups: top-down and bottom-up. In a typical top-down approach, the dimensions of materials are shrunk from bulk to a nanometre scale by either lithographic or non-lithographic tools. The bottom-up approach, on the other hand, involves the synthesis of materials by clustering of atoms, molecules or their groups.



Chemical Vapour Deposition



Reactive Ion Etching

"ECET 499N: Introduction to Nanotechnology" (2009),
https://nanohub.org/resources/6583

Presenter

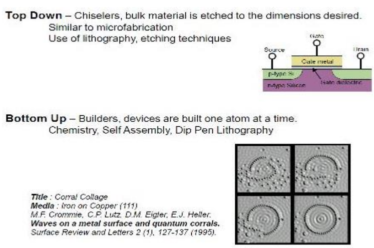
Helen McNally

Dr. McNally is an assistant Professor of Electrical and Computer Engineering Technology at Purdue University. She is a member of the Birck Nanotechnology Center and the Bindley Bioscience Center (BBC) at Purdue's Discovery Park. Dr. McNally currently directs the BBC Biological Atomic Force Microscopy (BioAFM) Facility.

Abstract

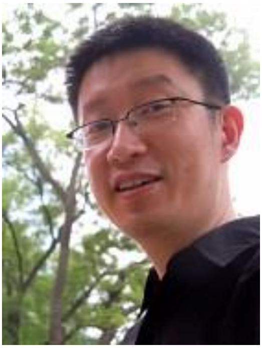
An introduction to the emerging area of nanotechnology is studied. The primary focus is on the technologies of nanotechnology, with specific emphasis on electronics and electrical measurements. Instruments and techniques used in nanotechnology are described and explored which include but are not limited to scanning probe microscopy, surface analysis and electron microscopy. Nanomaterials such as carbon nanotubes and nanoparticles are covered. Applications of nanotechnologies in various disciplines are introduced along with social implications of this exciting new area.

What is nanotechnology?



Approaches to Nanotechnology

"Illinois ME 498NF: Introduction of Nano Science and Technology" (2009), https://nanohub.org/resources/7313



Presenter

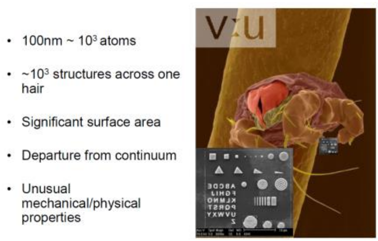
Nick Fang

Nicholas X. Fang is the d'Arbeloff Career Development Associate Professor of Mechanical Engineering at the Massachusetts Institute of Technology. He teaches and conducts research in the area of micro/nanotechnology.

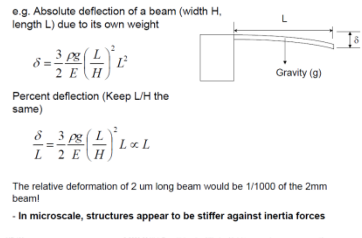
Abstract

Part I: Concepts in Nanoscale Science; Below the continuum: quantum mechanics; Statistics of small ensembles: molecular transport and thermodynamics; Constitutive description of materials: continuum solid mechanics; Nanoscale momentum and energy transfer: ballistic and diffusive transport; Surface and interface interactions: adhesion, surface tension, lubrication; Collective phenomena and temporal-spatial scales.

Part II: Primer on Nanotechnology; Nanophase materials: design, synthesis and characterization; Nanodevice thermal and fluidic management; Nanoscale sensing, nanometrology and actuation; Nanosystem energy conversion; Nanomanufacturing: challenges and opportunities; Nanoscale biomimetic devices and systems

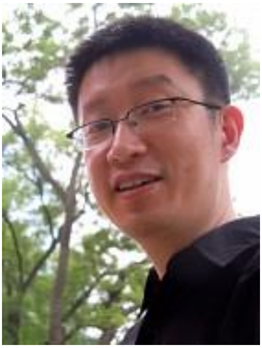


What is and why nanoscale?



Relative significance of forces

"Illinois ME 498 Introduction of Nano Science and Technology, Lecture 3: Thinking at the Nanoscale – Departure from continuum" (2009), https://nanohub.org/resources/7385



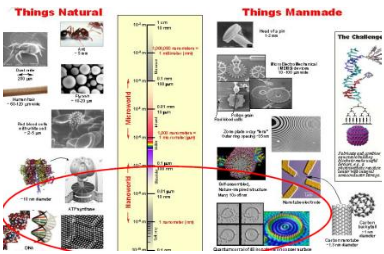
Presenter

Nick X. Fang

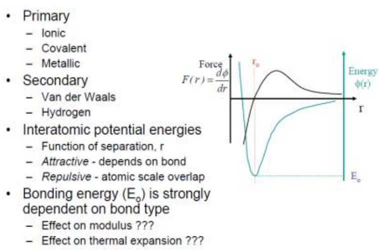
Nicholas X. Fang is the d'Arbeloff Career Development Associate Professor of Mechanical Engineering at the Massachusetts Institute of Technology. He teaches and conducts research in the area of micro/nanotechnology.

Abstract/Topics:

- The Scale of Things
- Nanoscale Friction
- Departure from continuum
- Constitutive Equations Revisited
- Microscopic origins of Physical Law
- Constructionist Approach
- Mechanics at Atomic Scale
- Atomic Bonding in Solids
- Van der Waals Bonding
- Material Waves and Energy Quantization



Scale of things



Atomic bonding in solids

"ECET 499N Lecture 2: Nanotechnology Background Information" (2010), https://nanohub.org/resources/8460

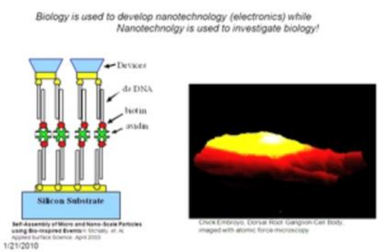
Presenter

Helen McNally

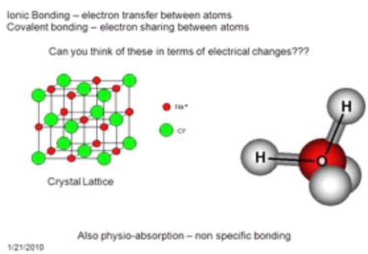
Dr. McNally is an assistant Professor of Electrical and Computer Engineering Technology at Purdue University. She is a member of the Birck Nanotechnology Center and the Bindley Bioscience Center (BBC) at Purdue's Discovery Park. Dr. McNally currently directs the BBC Biological Atomic Force Microscopy (BioAFM) Facility.

Abstract

- Basic Sciences
    - Biology
    - Chemistry
    - Physics
    - Math
- Concepts
    - Resonators
    - Particle Wave Duality
    - Fermi Levels



A win-win relationship



Chemical bonding

From Labs-on-Chips to Cellular Machines: Interfacing Engineering and Biology at the Micro and Nanoscale (2012),

http://event.on24.com/eventRegistration/EventLobbyServlet?target=lobby.jsp&eventid=544564&sessionid=1&partnerref=&key=E021373275E558E537AFDB01C8607DF2&eventuserid=7796813

Presenter

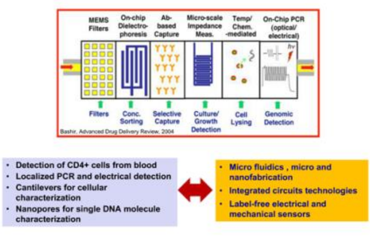
Rashid Bashir

Abel Bliss Professor of Electrical and Computer Engineering, Co-Director of Micro- and Nano-Technology Laboratory

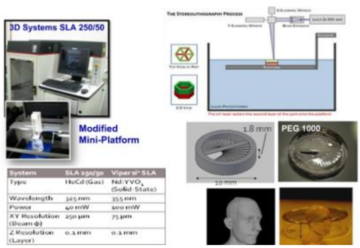
University of Illinois, Urbana-Champaign

Abstract

The lab-on-a-chip and bionanomachines (devices in the size range of 80 nm that perform useful, medical tasks) are two of science's most exciting frontiers, and engineers are racing to make them everyday realities. (The Tricorder X Prize, for example, aims to produce a real-world version of the Star Trek device by the end of the decade.) The effort, though, demands that engineers integrate a wide array of increasingly complex systems—microfluidic, electronic, biologic, and BioMEMS—to produce fast, ultra-accurate, and ultimately low-cost devices to diagnose diseases, to simulate living systems, and to stimulate basic life-science research.



Integrated lab-on-a-chip



3D stereo lithography

The Silent Industrial Revolution:
Additive Layer Manufacturing and its Transition into Nanomanufacturing (2012),

http://youtu.be/1ZAoW7kApFs

Presenter

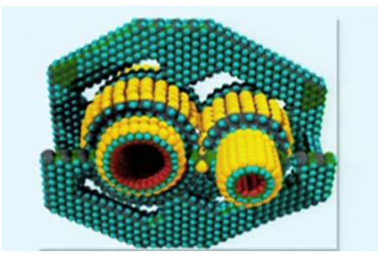
Boris Fritz

Engineer Senior Technical Specialist

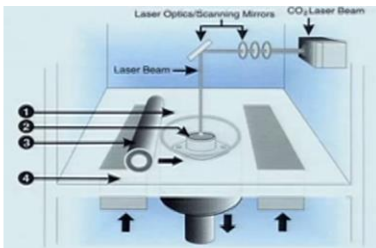
Northrop Grumman Corporation Air Combat Systems

Abstract

Learn more about the rapidly changing, relatively new field of 3-D printing/rapid prototyping/additive manufacturing and how it is being used at Northrop Grumman. You'll learn about some of NGC's in-house equipment and how it is used for tooling, assembly fit checks, unique applications and first-flight articles. You'll also find out about the remarkable future of this technology and its transition into nanomanufacturing. You've heard about nanotechnology, but here's your chance to learn a unique approach to this technology from an additive manufacturing perspective that you won't find in books, or anywhere else for that matter!



CAD system for Nanodesign



The SLS process

MATERIALS PROPERTIES AND PERFORMANCE

Nanotechnology and Materials: Nanotechnology Impact on Materials Properties and Performance (2012), http://elluminate.msacc.edu/play_recording.html?recordingId=1311875023430_1335458131773

Presenter

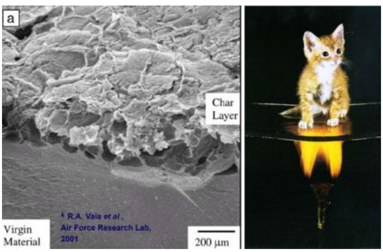
Allen Kimel

Assistant Professor, Associate Head for Undergraduate Studies

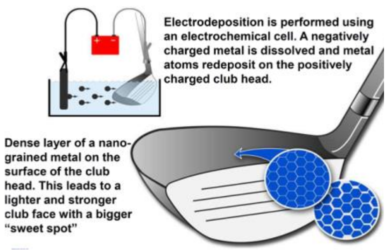
The Pennsylvania State University – Materials Science and Engineering

Abstract

By using structure at nanoscale as a tuneable physical variable, we can greatly expand the range of performance of existing chemicals and materials. For example, ceramics, which normally are brittle, can easily be made deformable when their grain size is reduced to the low nanometre range. Switching devices and functional units at nanoscale can improve computer storage and operation capacity by a factor of a million, while nanostructured metals have greatly improved mechanical properties, both in ductility and strength. That is the reason why nanotechnology has attracted large amounts of funding, research activity and media attention.



Thermal properties improvement



Nanotechnology in golf

Thermal Energy at the Nanoscale (2013),
https://nanohub.org/groups/u/spring2013_thermal_energy_at_the_nanoscale

Presenter

Timothy S. Fisher

He joined Purdue University's School of Mechanical Engineering and Birck Nano-technology Center in 2002. His research has included studies of nanoscale heat transfer, coupled electro-thermal effects in electron emission and semiconductor devices, energy conversion and storage materials and devices, and related computational methods.

Abstract

Thermal Energy at the Nanoscale is a five-week online course that develops a unified framework for understanding essential physics of nanoscale thermal energy and its important applications, trends, and directions. The course is taught at the level of a Purdue graduate course for first-year students, but there are no admission requirements and no need to travel to Purdue. The online course can be taken from anywhere in the world from March through April 2013. Each week contains six 20-minute video lectures covering essential physics, practical considerations, models for simulation, and fundamental limits.

Week 1: Lattice Structure, Phonons, and Electrons (available free)
L1.1: Introduction and Atomic Bonding
L1.2: Mathematical Description of the Lattice
L1.3: Lattice Vibrations and Phonons
L1.4: Free Electrons
L1.5: Example 1D Atomic Chain with a Diatomic Basis
L1.6: Week 1 Wrap Up

From Atoms to Materials: Predictive Theory and Simulations (2010),

https://nanohub.org/groups/u/spring2013_from_atoms_to_materials

Presenter

Alejandro Strachan

He is an associate professor of materials engineering at Purdue University and the deputy director of NNSA's Center for the Prediction of Reliability, Integrity and Survivability of Microsystems. His research focuses on the development of predictive atomistic and molecular simulation methodologies to describe materials from first principles, their application to problems of technological importance and quantification of associated uncertainties.

Abstract

From Atoms to Materials: Predictive Theory and Simulations is a five-week online course that develops a unified framework for understanding essential physics that govern materials at atomic scales and relate these processes to the macroscopic world. The course will cover important applications, trends, and directions. The course is taught at the level of a Purdue graduate course for first-year students, but there are no admission requirements and no need to travel to Purdue. The online course can be taken from anywhere in the world from May 13 through June 14, 2013. Each week contains six 20-minute video lectures.

"Lecture 4: Graphene: An Experimentalist's Perspective" (2010),

https://nanohub.org/resources/7421

Presenter

Joerg Appenzeller

Since 2007 he is Professor of Electrical and Computer Engineering at Purdue University and Scientific Director of Nanoelectronics in the Birck Nanotechnology Center. His current interests include novel devices based on low-dimensional nano-materials as nanowires, nanotubes and graphene.

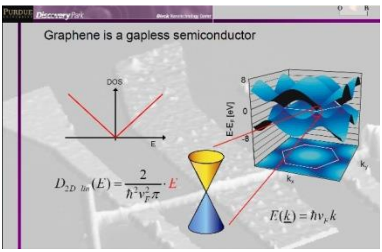
Abstract/Conclusions

Graphene has been proposed as a promising material for future nanoelectronics because of its unique electronic properties.

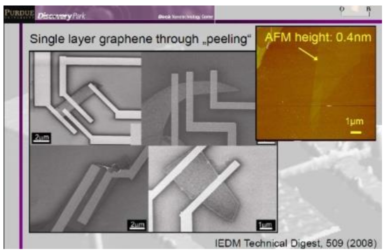
- Graphene offers a number of intrinsic materials related properties that make it particularly suited for electronic applications

- Graphene devices can operate in the quantum capacitance regime

- Contact effects need to be considered in graphene even in the absence of a bandgap.



The material impact



Sample fabrication

CHARACTERISATION TECHNIQUES

"ECET 499N Lecture 12: Scanning Probe Microscopy Applications (in Neuroscience and Beyond)" (2010), https://nanohub.org/resources/8837

Presenter

Helen McNally

Dr. McNally is an assistant Professor of Electrical and Computer Engineering Technology at Purdue University. She is a member of the Birck Nanotechnology Center and the Bindley Bioscience Center (BBC) at Purdue's Discovery Park. Dr. McNally currently directs the BBC Biological Atomic Force Microscopy (BioAFM) Facility.

Abstract

Scanning Probe Microscopy (SPM)

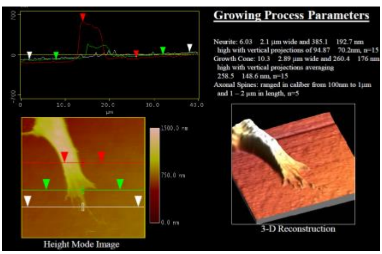
- Scanning Tunneling Microscopy – Rohrer and Binnig 1982
- Atomic Force Microscopy (AFM/SFM) – Binnig et al 1986

Resolution:

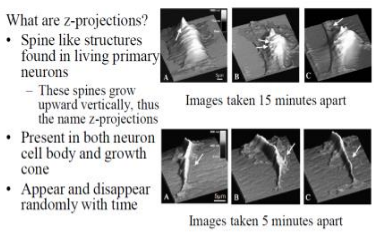
- Optical: 200nm
- AFM: atomic resolution possible, depending on tip dimension, detection system, operating conditions & controls

Measurement capabilities: topography and material characteristics

Operating conditions: vacuum, air (gas), liquid, and hyperbaric



Growing process



Z-projections

"ECET 499N Lecture 8: Electron Microscopy" (2010), https://nanohub.org/resources/8587

Presenter

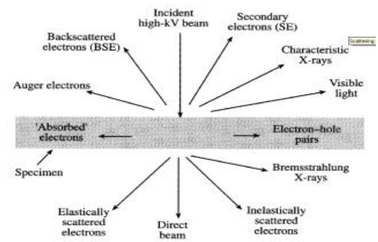
Eric Stach

Professor, School of Materials Engineering, West Lafayette, Purdue, IN

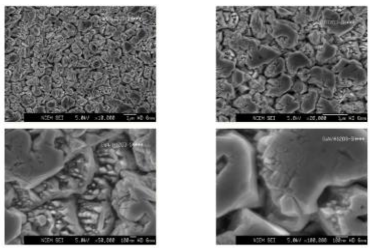
He began his career at Purdue in the School of Materials Engineering in 2005. His research interests include high-resolution in-situ electron microscopy techniques.

Abstract

- Scanning electron microscopy
    - Electron-specimen interactions
    - How do you make a microscope?
    - Typical images from composites/nanotube composites, as an example
- Focused ion beam microscopy
- Transmission electron microscopy
    - Operation modes: diffraction & imaging
    - More 'typical' images …



Electron-specimen interaction



Scanning electron microscopy

In-Situ Nanomechanical Testing Techniques (2009),

http://hysitron.com/resources/webinars/webinar-1-in-situ-nanomech.-testing-techniques

Presenter

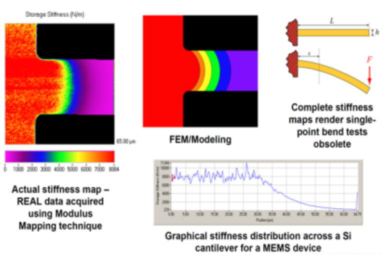
Oden Warren

President
Chief Technology Officer

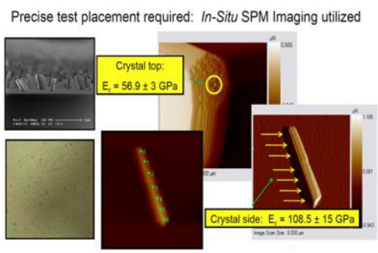
Hysitron

Abstract

Next generation materials research is highly dependent on the development and application of innovative nanomechanical testing techniques. This webinar will cover the background and future of advanced in-situ nanomechanical characterization techniques that are becoming increasingly pertinent to research institutions and industries around the world. These quantitative in-situ testing techniques serve as a cornerstone to an exceptionally wide array of research fields and quality control applications. Complex applications will be discussed in the areas of: ultra-thin films; nanostructures; MEMS devices and soft materials.



Stiffness mapping: Si cantilever



In-situ SPM imaging

Novel Techniques for In-Situ Nanomechanical Testing in the Electron Microscope (2009), http://hysitron.com/resources/webinars/webinar-2-in-situ-nanomech.-testing-in-the-em

Presenter

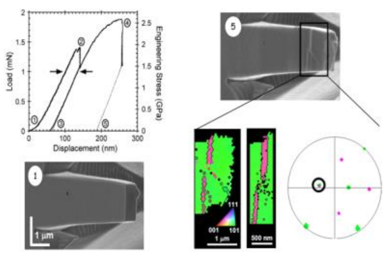
Johann Michler

Head of the Materials and Nanomechanics Laboratory

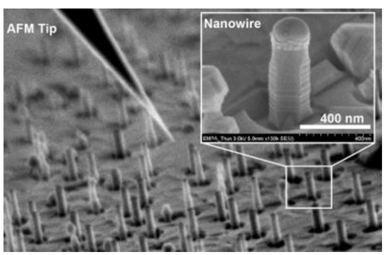
EMPA – Swiss Federal Laboratories for Materials Science and Technology

Abstract

The combination of traditional nanomechanical test instruments with complementary techniques has generated innovative ways to characterize nanoscale materials. In particular, simultaneously pairing the high sensitivity of nanoindentation with the high spatial resolution of electron microscopy creates a powerful tool for studying nanoscale structures. Recent developments in compact vacuum-compatible instruments which are capable of quantitative nanomechanical testing with synchronized SEM or TEM observation have spurred a number of in situ studies of nanoscale structures and helped to create a more complete understanding of their behaviour.



EBSD compression of GaAs



SEM image of AFM tip

Tools & Techniques for Nanomechanical Testing of Bio-materials (2010), http://hysitron.com/resources/webinars/webinar-3-nanomech.-testing-of-biomaterials

Presenter

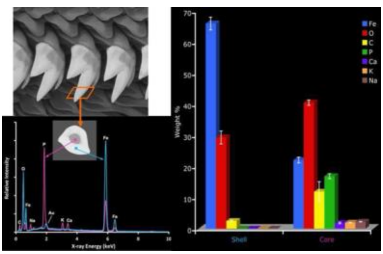
Shefford P. Baker

Associate Professor, Dept. of Materials Science and Engineering

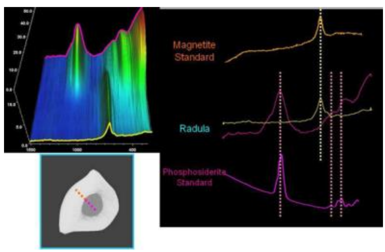
Cornell University

Abstract

As biomaterials research continues to advance and enhance the overall quality of life, the methods by which researchers achieve such new heights must also be continuously developed and optimized. This webinar will cover established and recently developed tools and techniques for nano-characterization of biomaterials. Key points to be covered with regards to testing of biomaterials include: testing in vitro, nano matters when studying biomaterials, fluorescence microscopy combined with nanomechanical testing, and research fields for which the tools and techniques presented have been well-established.



High res. elemental mapping



Raman spectroscopy

Nanomechanical Characterization in Irradiated Materials (2011), http://www.hysitron.com/resources/webinars/webinar-7-irradiated-materials

Presenter

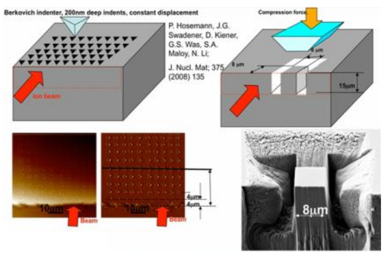
Peter Hosemann

Assistant Professor, Department of Nuclear Engineering

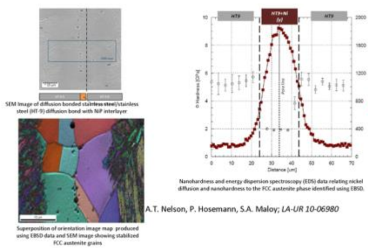
University of California-Berkeley

Abstract

The world continues to increase its demand for innovation in energy research, which is supported by increased government spending on energy and a rising number of worldwide researchers focusing efforts in this area. Many energy-related research initiatives inherently require small-scale material analysis due to the micro- and nano-scale feature sizes in new and improved materials for energy innovation. Key energy-related topics include: photovoltaics, solar cells, batteries, fuel cells, lightweight materials (steels, aluminium, alloys, etc.), fuel rods, nuclear materials, and irradiated materials.



Cross-section material testing



SEM image of diffusion bonding

High-Temperature Nanoindentation (2011),

http://hysitron.com/resources/webinars/webinar-8-high-temperature-nanoindentation

Presenter

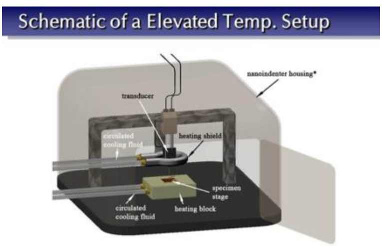
Andrea Hodge

Assistant Professor

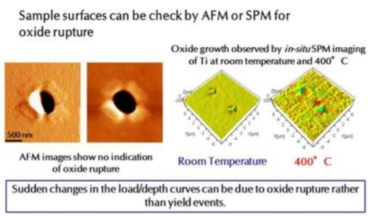
University of Southern California

Abstract

Next-generation materials research is highly dependent on the development and application of innovative nanomechanical testing techniques. The utilization of nanoindentation at elevated temperatures is a growing area of research used to accurately determine nanoscale mechanical or tribological behaviour at, or near, a material's operating or processing temperatures. These hybrid techniques are extremely valuable for quantitatively determining temperature-dependent mechanical properties and conducting incipient plasticity, creep, phase transformation and glass transition studies.



Schematic of elevated temp. setup



AFM check of oxide formation

Nanoscale Dynamic Mechanical Testing (2011),

http://hysitron.com/resources/webinars/new-innovations-in-materials-characterization-i

Presenter

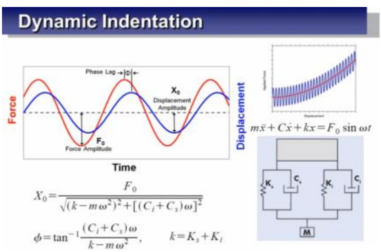
Douglas Stauffer

Researcher

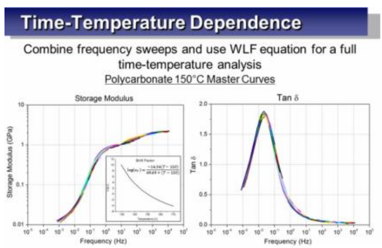
Hysitron

Abstract

As materials technology advances, greater performance is often achieved by controlling the structure of a material at smaller and smaller scales. Development of materials with smaller constituents, thinner films or coatings, and increasing microstructural complexity require characterization techniques to advance accordingly. The webinar deals with the following areas: overview of nanomechanical characterization and dynamic testing at the nanoscale; current challenges facing traditional dynamic testing; quantitative mechanical property measurements at the nano to micro scale.



Dynamic indentation



Time-temp. analysis of polyC

Advanced High Temperature Mechanical Testing (2012),

http://hysitron.com/resources/webinars/new-innovations-in-materials-characterization-ii

Presenter

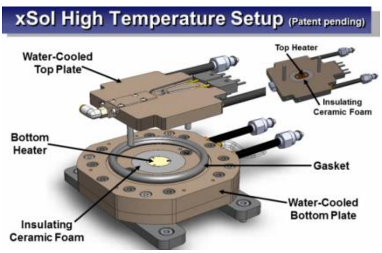
S.A. Syed Asif

Director of R&D

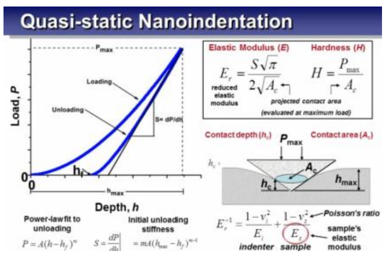
Hysitron

Abstract

Researchers in many industries face significant issues in studying mechanical properties of a broad range of materials at high temperatures that represent operating or processing conditions. Accurate quantitative data adds significantly to the process of materials property modelling. Oxidation, thermal drift, sample/tip temperature gradients, and many other issues make it difficult to acquire accurate nanomechanical data at elevated, high temperatures. Recent developments have resulted in a new solution for highly accurate nano-mechanical testing over a broad temperature range.



High temperature setup



Quasi-static nanoindentation

Innovations in High Precision Thin Film Mechanical Property Characterization (2013), http://www.hysitron.com/resources/webinars/high-precision-thin-film-characterization

Presenter

Jeremiah Vieregge

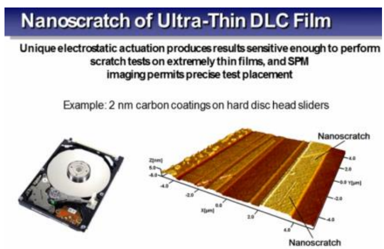
Researcher

Hysitron

Abstract

Advances in thin film deposition technologies and material development have enabled innovations in a wide range of industries. Examples of this are evident in microelectronics, display, energy, optoelectronics, bio-medical, and many other industries. Decreasing film thicknesses and manufacturing complexities pose increasing challenges for academic and industrial researchers. As coatings become thinner, material properties such as elastic modulus, hardness, adhesion, friction, and electrical behavior become increasingly difficult to measure. These difficulties are particularly relevant for industrial process and quality control.

Studying tribological properties



Nano scratch of ultra-thin DLC film

Fundamentals of Atomic Force Microscopy, Part 1: Fundamental Aspects of AFM (2012),

https://nanohub.org/courses/afm1

Presenter

Arvind Raman

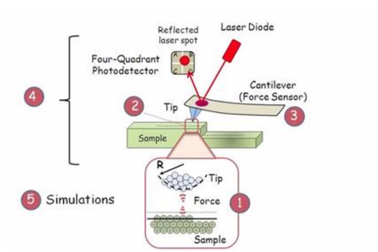
Professor

School of Mechanical Engineering

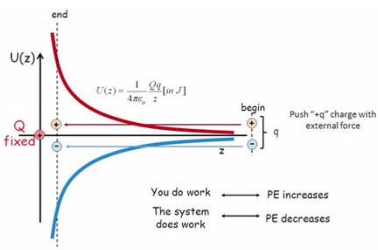
Purdue University

Abstract

The atomic force microscope (AFM) is a key enabler of nanotechnology, and a proper understanding of how this instrument operates requires a broad-based background in many disciplines. Few users of AFM have the opportunity or resources to rapidly acquire the interdisciplinary knowledge that allows an intelligent operation of this instrument. Fundamentals of Atomic Force Microscopy, Part 1: Fundamental Aspects of AFM is designed to develop many key concepts – both theoretical and experimental – which allow a better understanding of the principles underlying the AFM.



Atomic Force Microscopy



Electrostatic potential energy

Fundamentals of Atomic Force Microscopy, Part 2: Dynamic AFM Methods (2012),

https://nanohub.org/courses/AFM2

Presenter

Arvind Raman

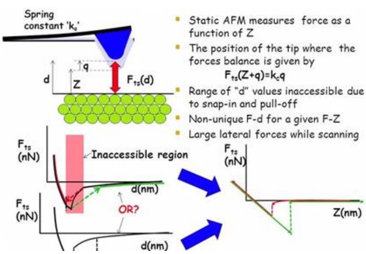
Professor

School of Mechanical Engineering

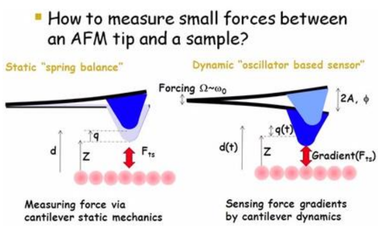
Purdue University

Abstract

The atomic force microscope (AFM) is a key enabler of nanotechnology, and a proper understanding of how this instrument operates requires a broad-based background in many disciplines. Few users of AFM have the opportunity or resources to rapidly acquire the interdisciplinary knowledge that allows an intelligent operation of this instrument. This focused, in-depth course solves this problem by presenting a unified discussion of the fundamentals of atomic force microscopy. Part 2 deals with Dynamic AFM Methods, an in-depth treatment of dynamic mode AFM.



Disadvantages of static AFM

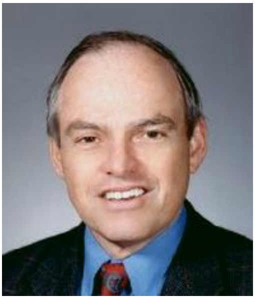


Static vs. dynamic AFM

NANOELECTRONICS AND OTHER APPLICATIONS

Nanotechnology Applications in Today's World (2010),

http://elluminate.mesacc.edu/play_recording.html?recordingId=1277836648560_1285344098830



Presenter

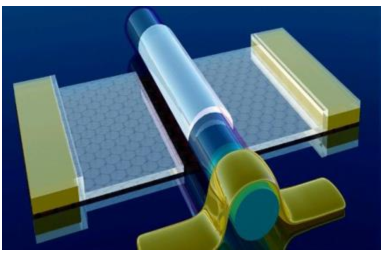
Stephen J. Fonash

Bayard D. Kunkle Chair in Engineering Sciences, Director Center for Nano-technology Education and Utilization

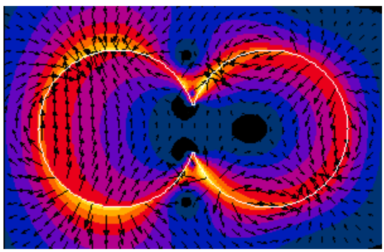
The Pennsylvania State University

Abstract

Before taking a quick tour through some of today's applications of Nanotechnology, we must ask "what is so different about the nano-scale"? The answer is: small size – can get a lot of nano-things in an area or volume; most atoms are at the surface and their electron distributions are different than that of an isolated atom or that of the atoms in a bulk solid; wave properties of light become important for the small structures and nature allows some unusual chemical bonding for nano-scale structures. These opportunities available at the nano-scale should be and are used by engineers and scientists to make new materials and, from these new materials, come new devices and structures.



High-speed graphene transistor



Wave properties of light

Trends in Nanoelectronics: Microchips and More (2013),

https://sas.elluminate.com/site/external/launch/nativeplayback.jnlp?sid=2012302&psid=2013-01-25.1007.M.13BC40C9350636C02C7F877AFA0927.vcr

Presenter

Tom Morrow

Executive Vice President of Global Emerging Markets and Officer of Chief Marketing

SEMI global industry association

Abstract

The penetration of semiconductors into our everyday lives is accelerating, being driven by Moore's Law and Haitz's Law, the two most powerful economic and social forces of our time. Many of the same technologies and processes developed to make today's most advanced microchips are now being utilized in solar energy, LEDs (including Smart Lightning), MEMS, displays, printed, and large area electronics. Discover how nanotechnology and nanoelectronic innovations are driving today's commercial or high-reliability automotive electronics revolution and how they will shape our future.

LEDs, adaptive lightning

Printed electronics in action

How is Nanotechnology Changing the Electronics Industry? (2012), http://elluminate.mesacc.edu/play_recording.html?recordingId =1311874826010_1330102989559

Presenter

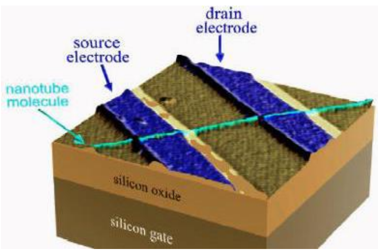
Osama Awadelkarim

Associate Director, NACK

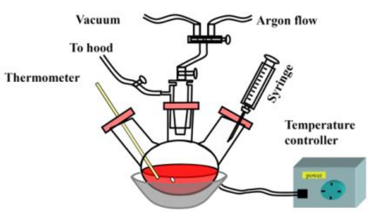
Professor of Engineering Science and Mechanics, The Pennsylvania State University

Abstract

For 50 years, electronics have run on silicon transistor technology. Over those years, that technology has continually been scaled down to the point now further shrinkage is difficult. Continuing evolution of electronics beyond the limits of the conventional silicon technology (top-down approach, lithography technology) requires innovative approaches for solving heat dissipation, speed and scaling issues. Many people have suggested that the microelectronics industry has to stop using top-down nanofabrication and must move to bottom-up or hybrid nanofabrication. If this worked, it would stop the spiralling costs of producing nano-scale transistors.



Carbon Nanotube Transistor



Synthesis of Quantum Dots

"Nanoelectronics 101" (2006),
https://nanohub.org/resources/1737

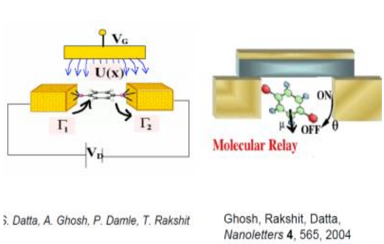
Presenter

Mark Lundstrom

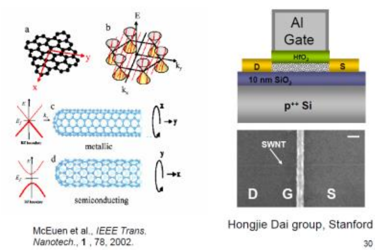
Mark Lundstrom is the Don and Carol Scifres Distinguished Professor of Electrical and Computer Engineering at Purdue University. He has worked on solar cells, heterostructure devices, carrier transport physics, the physics and simulation of nanoscale transistors, and currently on the technology of energy conversion devices.

Abstract

Semiconductor device technology has transformed our world with supercomputers, personal computers, cell phones, ipods, and much more that we now take for granted. Moore's Law states that the number of transistors per chip doubles each technology generation. This doubling has led to an exponential growth in the capability of electronic systems and an exponential decrease in their cost. The microelectronic technology of the 1960's has evolved into today's nanoelectronics technology. This talk gives a brief overview of the history of electronics, a look at where it stands today, and some thoughts about where electronics is heading.



Molecular transistor



Carbon nanotube transistor

"ECET 499N Lecture 3: Nanoelectronics 1" (2010),
https://nanohub.org/resources/8473

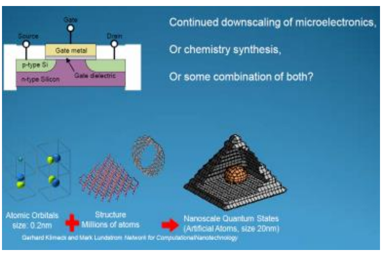
Presenter

Helen McNally

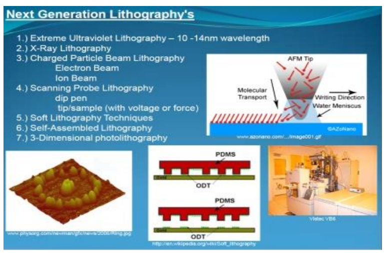
Dr. McNally is an assistant Professor of Electrical and Computer Engineering Technology at Purdue University. She is a member of the Birck Nanotechnology Center and the Bindley Bioscience Center (BBC) at Purdue's Discovery Park. Dr. McNally currently directs the BBC Biological Atomic Force Microscopy (BioAFM) Facility.

Abstract

- Challenges and examples
- Top down Processing
- Bottoms Up Approach
- A combination of Methods
- Measurements



Nanoelectronics



Next generation lithography

"ECET 499N Lecture 4: Nanoelectronics 2" (2010)

https://nanohub.org/resources/8474

Presenter

Helen McNally

Dr. McNally is an assistant Professor of Electrical and Computer Engineering Technology at Purdue University. She is a member of the Birck Nanotechnology Center and the Bindley Bioscience Center (BBC) at Purdue's Discovery Park. Dr. McNally currently directs the BBC Biological Atomic Force Microscopy (BioAFM) Facility.

Abstract

Etching (Chiseling) Techniques

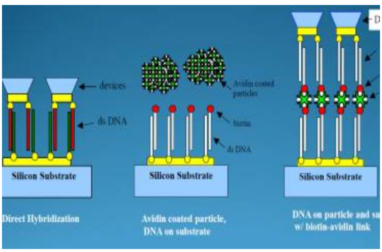
- Dry Etching
- Wet Etching

Additive Technologies (Building)

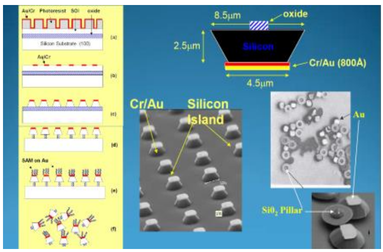
- Thermal Processing
- Physical Vapor Deposition
- Molecular Beam Epitaxy
- Chemical Vapor Deposition (CVD) - Plasma enhanced CVD (e.g. for CNs)
- Silk-Screening or Screen Printing
- Sol-Gel or PDMS
- Self-Assembled Monolayers.

Enabling Technologies

- Nanofabrication – "chiseling"
- Scanning Probe Microscopy – imaging and manipulation
- Chemical Synthesis – bottom-up assembly



Bio-inspired assembly



Silicon island fabrication

"ECET 499N Lecture 5: Nanoelectronics 3" (2010)

https://nanohub.org/resources/8475

Presenter

Helen McNally

Dr. McNally is an assistant Professor of Electrical and Computer Engineering Technology at Purdue University. She is a member of the Birck Nanotechnology Center and the Bindley Bioscience Center (BBC) at Purdue's Discovery Park. Dr. McNally currently directs the BBC Biological Atomic Force Microscopy (BioAFM) Facility.

Abstract

How do you test these devices?

How do you interact with a single molecule?

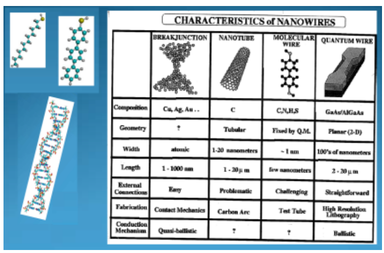
What is the resistance of a molecule?

What is the capacitance?

Is there any inductance?

Can you measure anything below the noise level?

What does the contact look like?



Characteristics of nanowires

"ECET 499N: Nanoelectronics" (2009),

https://nanohub.org/resources/6580

Presenter

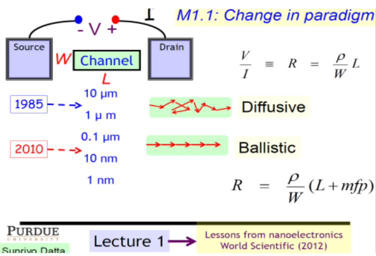
Supriyo Datta

Professor

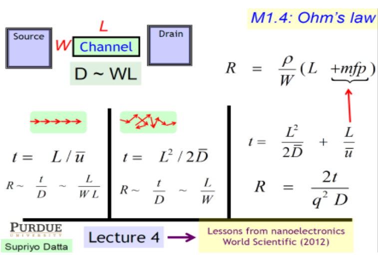
Supriyo Datta is the Thomas Duncan Distinguished Professor in the School of Electrical and Computer Engineering.

Abstract

Nanoelectronics: How does the resistance of a conductor change as we shrink its length all the way down to a few atoms? This is a question that has intrigued scientists for a long time, but it is only during the last twenty years that it has become possible for experimentalists to provide clear answers, leading to enormous progress in our understanding. There is also great applied interest in this question at this time, since every computer we buy has about a billion transistors that rely on controlling the flow of electrons through a conductor a few hundred atoms in length. This lecture is designed as an introduction for the beginner who will hopefully feel sufficiently intrigued to look at more in-depth lectures.



Change in paradigm



Ohm's law

Nanotechnology: Applications in Energy –Solar (2010),

http://elluminate.mesacc.edu/play_recording.html?recordingId=1256858367380_1274976824902

Presenter

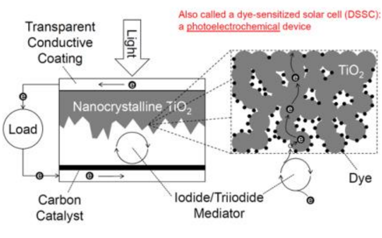
Travis Benanti

Research Associate

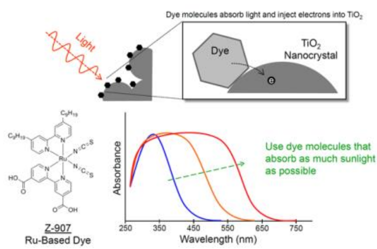
Center for Nanotechnology Education and Utilization (CNEU) Regional Center, The Pennsylvania State University

Abstract

Energy is one of the major challenges faced by our society, while being a complex problem involving many facets of technology, social, economy and environmental. Solar energy is often cited as a green alternative to fossil fuel energy. However, the cost and maintenance requirements of traditional cells are prohibitive. Currently available nanotechnology solar cells are not as efficient as traditional ones; however their lower cost offsets this. In the long term nanotechnology versions should both be lower cost and, using quantum dots, should be able to reach higher efficiency levels than conventional ones.



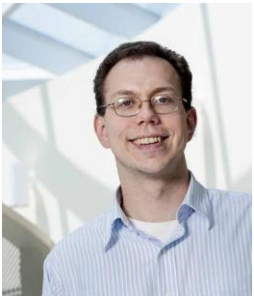
Dye-sensitised solar cell



Improving light absorption

Nanophotonic Modeling (2014),

http://nanohub.org/courses/NPM/overview



Presenter

Peter Bermel

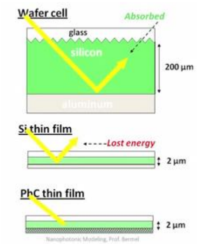
Assistant professor

Electrical and Computer Engineering at Purdue University.

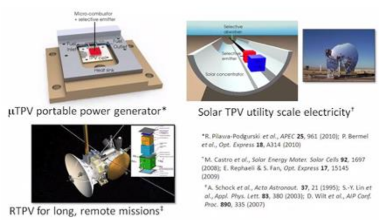
Abstract

Classic ray optics played a crucial role in the development of early photonic technology, where components such as glass spheres, thin lenses, and conventional mirrors control the propagation of light. Over time, limitations of these components in terms of size, and flexibility have become increasingly clear.

Fortunately, new optical and opto-electronic systems utilizing components whose size is at the wavelength scale or smaller stand ready to enable these new applications. This course will cover advanced methods of simulating nanophotonic, plasmonic, and metamaterial structures. Related applications in thermal radiation will also be discussed.



Light management - Photovoltaics



Thermophotovoltaics

Principles of Electronic Nanobiosensors (2014),

http://nanohub.org/courses/pen

Presenter

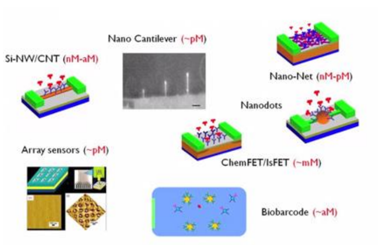
Muhammad A. Alam

Professor

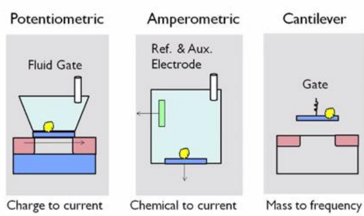
Electrical and Computer Engineering at Purdue University.

Abstract

This course will provide an in-depth analysis of the origin of the extra-ordinary sensitivity, fundamental limits, and operating principles of modern nanobiosensors. The primary focus will be the physics of biomolecule detection in terms of three elementary concepts: response time, sensitivity, and selectivity. And, we will use potentiometric, amperometric, and cantilever-based mass sensors to illustrate the application of these concepts to specific sensor technologies. Students of this course will not learn how to fabricate a sensor, but will be able to decide what sensor to make, appreciate their design principles, interpret measured results, and spot emerging research trends.



Diversity of Biosensors



Main types of nano-biosensors

From Atoms to Materials: Predictive Theory and Simulations (2013), http://nanohub.org/courses/FATM

Presenter

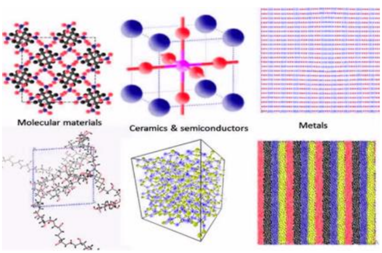
Alejandro Strachan

Professor

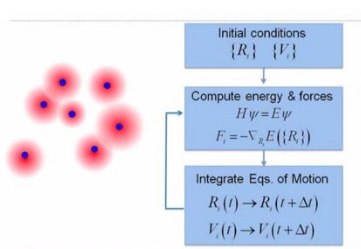
Alejandro Strachan: Materials Engineering, Purdue University; Deputy Director, NNSA - PRISM

Abstract

From Atoms to Materials: Predictive Theory and Simulations is a five-unit online course that develops a unified framework for understanding essential physics that govern materials at atomic scales and relate these processes to the macroscopic world. This short course will teach the basic physics that govern materials at atomic scales and relate these processes to the macroscopic world. The course will cover important applications, trends, and directions. The course is taught at the level of a Purdue graduate course for first-year students, but there are no admission requirements and no need to travel to Purdue. The online course can be taken from anywhere in the world.



Structures of materials



Molecular dynamics

Nanoscale Transistors (2013),
http://nanohub.org/courses/NT

Presenter

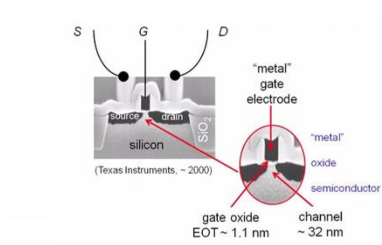
Mark Lundstrom

Professor

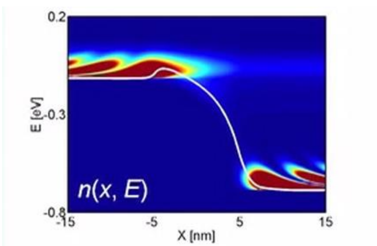
Electrical and Computer Engineering at Purdue University.

Abstract

The transistor is the key enabler of modern electronics. Progress in transistor scaling has pushed channel lengths to the nanometer regime where traditional approaches to device physics are less suitable. Surprisingly, the final result looks much like the traditional, textbook, MOSFET model, but the parameters in the equations have simple, clear interpretations at the nanoscale. My objective for this course is to provide students with an understanding of the essential physics of nanoscale transistors as well as some of the practical technological considerations and fundamental limits. The goal is to do this in a way that is broadly accessible to students with only a basic knowledge of semiconductor physics and electronic circuits.



Nanoscale MOSFETs



Quantum transport

Fundamentals of Nanoelectronics, Part 1: Basic Concepts (2012), http://nanohub.org/courses/FON1

Presenter

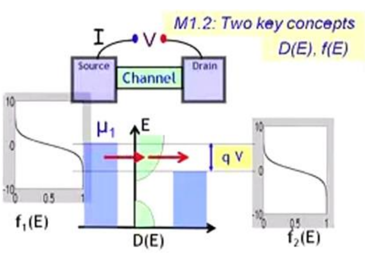
Supriyo Datta

Professor

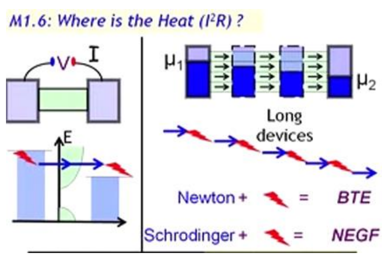
Supriyo Datta is the Thomas Duncan Distinguished Professor in the School of Electrical and Computer Engineering.

Abstract

Nanoelectronic devices are an integral part of our life, including the billion-plus transistors in every smartphone, each of which has an active region that is only a few hundred atoms in length. First in a two part series, Part 1: Basic Concepts is designed to convey the key concepts developed in the last 20 years, which constitute the fundamentals of nanoelectronics and mesoscopic physics. Part 2 will deal with Quantum models. This course is intended to be broadly accessible to students in any branch of science or engineering. Basic Concepts assumes basic familiarity with calculus and elementary differential equations. No prior acquaintance with quantum mechanics is assumed.



Two key concepts



Effect of heat

Fundamentals of Nanoelectronics, Part 2: Quantum Models (2012), http://nanohub.org/courses/FON2

Presenter

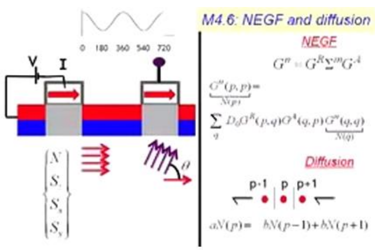
Supriyo Datta

Professor

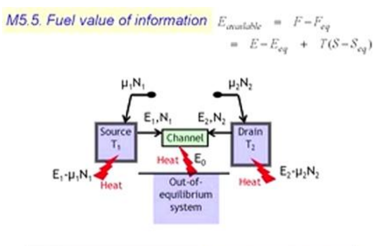
Supriyo Datta is the Thomas Duncan Distinguished Professor in the School of Electrical and Computer Engineering.

Abstract

Nanoelectronic devices are an integral part of our life, including the billion-plus transistors in every smartphone, each of which has an active region that is only a few hundred atoms in length. First in a two part series, Part 1 dealt with the basic concepts, whereas Part 2, Quantum Models provides an introduction to more advanced topics, including the Non-Equilibrium Green's Function (NEGF) method widely used to analyse quantum transport in nanoscale devices. This course is intended to be broadly accessible to students in any branch of science or engineering. Basic Concepts assumes basic familiarity with calculus and elementary differential equations. No prior acquaintance with quantum mechanics is assumed.



NEGF and diffusion



Fuel value of information

USEFUL TOOLS

Nanotechnology Demos and Simulations (2013),

https://sas.elluminate.com/site/external/launch/nativeplayback.jnlp?sid=2012302&psid=2013-02-22.1012.M.EC234DFC079F0F5B83A1B62B10204D.vcr

Presenter

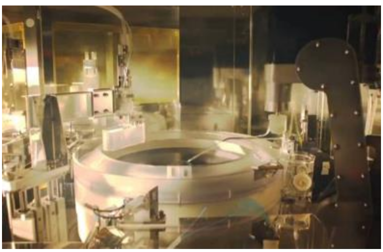
Michael Lesiecki

Director

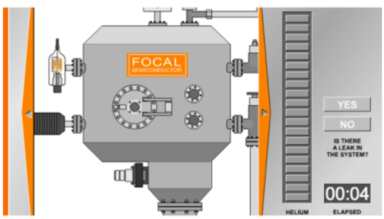
Maricopa Advanced Technology Education Center (MATEC) at the Maricopa Community Colleges

Abstract

To engage today's learners we need to present content and information in different ways and to provide multiple means of engagement. Sometimes, a system is too complex and hard to visualize, analyse and explain it or it is variable with respect to time or process and has multiple inter-dependent variables. And sometimes… you just want to show something in a different way. The possibilities of multimedia are so diverse that it would be unfortunate to ignore it since one can present animations, interactives, videos and can do simple and complex simulations, emulations. The presentation shows how to incorporate these visual tools to expose students to nanotechnology concepts.



Inside a 22nm 3D chip



Simulation: vacuum leak detection

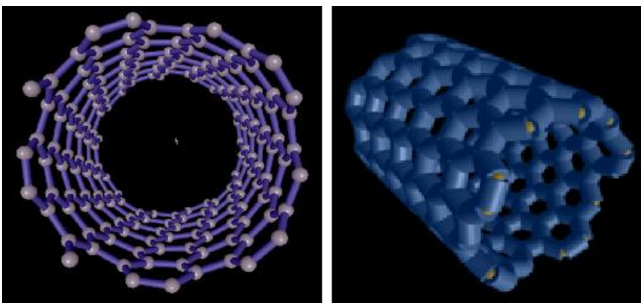
Chanaka Suranjith Rupasinghe; Mufthas Rasikim (2010), "ninithi", https://nanohub.org/resources/8987

Developers

Chanaka Suranjith Rupasinghe completed BSc in Electronic and Telecommunications Engineering at University of Moratuwa, Sri Lanka in 2009. He is a PhD student at Monash University, Australia. He works on open-source simulation and modelling softwares.

Ninithi is a free and open-source modelling software to visualize and analyze carbon allotropes used in nanotechnology. You can generate 3-D visualization of carbon nanotubes, fullerenes, graphene and carbon nano-ribbons; and analyze the band structures of nanotubes and graphene. For more information visit http://ninithi.sourceforge.net and download the software free.

Carbon nanotube is an allotrope of carbon. It is a nano-scale tube formed of carbon atoms that can have different geometries depending on a parameter known as 'Chirality', which is a vector represented by a pair of integers (n,m). In the figure you can see screenshots of nanotubes in different views. User is also capable of changing the sizes and colours of atoms and bonds to customize the visualization.



Chanaka Suranjith Rupasinghe; Mufthas Rasikim (2010), "ninithi", https://nanohub.org/resources/8987

Developers

Mufthas Rasikim specialized in Electronic and Telecommunication Engineering from University of Moratuwa, Sri Lanka. Currently he is working for Lanka Software Foundation and together with scientists in Sri Lanka Institute of Nanotechnology to develop open-source software for nanotechnology.

Graphene, the two-dimensional (2D) monolayer of carbon atoms is the basic building block for all other graphitic materials with different dimensionalities. It can be wrapped up into 0D fullerene, rolled into 1D nanotube or stacked into 3D graphite. Structure of the graphene layer is a honeycomb lattice where each carbon atom is bonded to three other ones in the plane. Nano-ribbon is a cut along the graphene layer according to given parameters, m,n integer pair and the length. Ninithi can be used to visualize graphene, nanoribbons and fullerenes (see the screenshots below), and their electrical properties, as well.