

Nurturing a new-born Ph.D. program in the PREM environment



Mikhail A. Noginov

Partnership for Research and Education in Materials (PREM)

*Norfolk State University,
Cornell University, Purdue University*



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The goals and the mission of the Partnership

The **goals** of the Partnership:

Research. To advance NSU's CMR to the level of world-leading institutions in the areas of photonics and nanoplasmonics.

Education. To make NSU's CMR one of top five producers of *African-American* Ph.D. graduates in Materials Science in the nation.

The Partnership's **mission** is to increase the number of underrepresented minorities in the STEM disciplines and, particularly, Materials Science, *via* recruitment, mentoring, education, and training *African-American* students in cutting-edge research programs.



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Partnership for Research and Education in Materials *Photonic Metamaterials*

Norfolk State University, Cornell University MRSEC, Purdue University Birck Nanotechnology Center and Network for Computational Nanotechnology

NSF funding: \$2.8 M for five years total

Starting date: July 1, 2006

Director: Mikhail Noginov

Thursday, September 07,
2006

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Welcome to PREM

PREM Mission

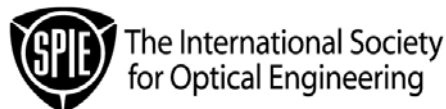
The Partnership's mission is to increase the number of underrepresented minorities in the STEM disciplines and, particularly, Materials Science, via recruitment, mentoring, education, and training African-American students in cutting-edge research programs.

The Partnership for Photonic Metamaterials, includes investigators from the Center for Materials Research at Norfolk State University; the Center for Materials Research at Cornell University; and both the Birck Nanotechnology Center and the Network for Computational Nanotechnology at Purdue University.

Its central research theme is mutual enhancement of (1) optical gain and other optical responses in dielectric media and (2) surface plasmons in metallic particles and aggregates.

The PREM's education program seeks to establish a complete academic pipeline for underrepresented minority groups, starting with efforts to attract high-school students into the science, technology, engineering and mathematics disciplines. Then, through specially developed educational materials, class work, research training, mentoring and exchange programs within the partnership, the pipeline will carry the students through to become Ph.D. candidates for careers in materials science in academic, industry, and

Broader Impact: From Photonics Metamaterials PREM to Photonic Metamaterials Conference



SPIE Optics & Photonics

26-30 August 2007

San Diego, California USA

Call for Papers and Announcement

Photonic Metamaterials

Conference Chairs: **Mikhail A. Noginov**, Norfolk State Univ.; **Nikolay I. Zheludev**, Univ. of Southampton (United Kingdom) **Allan D. Boardman**, Univ. of Salford (United Kingdom); **Nader Engheta**, Univ. of Pennsylvania

Program Committee: **David L. Andrews**, Univ. of East Anglia Norwich (United Kingdom); **Hui Cao**, Northwestern Univ; **Larry R. Dalton**, Univ. of Washington; **Graeme Dewar**, Univ. of North Dakota; **Ildar Gabitov**, University of Arizona; **Alexander L. Gaeta**, Cornell Univ.; **Javier Garcia de Abajo**, Consejo Superior de Investigaciones Científicas (Spain); **Jakob B. Khurgin**, Johns Hopkins Univ., **Joachim R. Krenn**, Karl-Franzens-Univ. Graz (Austria); **Akhlesh Lakhtakia**, The Pennsylvania State Univ.; **Martin W. McCall**, Imperial College London (United Kingdom); **Martin Moskovits**, The Univ. of California at Santa Barbara; **Evgenii Narimanov**, Princeton Univ.; **Andrey K. Sarychev**, Ethertronics Inc.; **Vladimir M. Shalaev**, Purdue Univ.; **Mark I. Stockman**, Georgia State Univ.; **Gennady Shvets**, The Univ. of Texas at Austin, **Din Ping Tsai**, National Taiwan Univ. (Taiwan).

The Photonic Metamaterials conference will be devoted to papers reporting new and challenging results in the burgeoning field of nano-structured photonics media. The topics to be covered will include, but are not limited to:

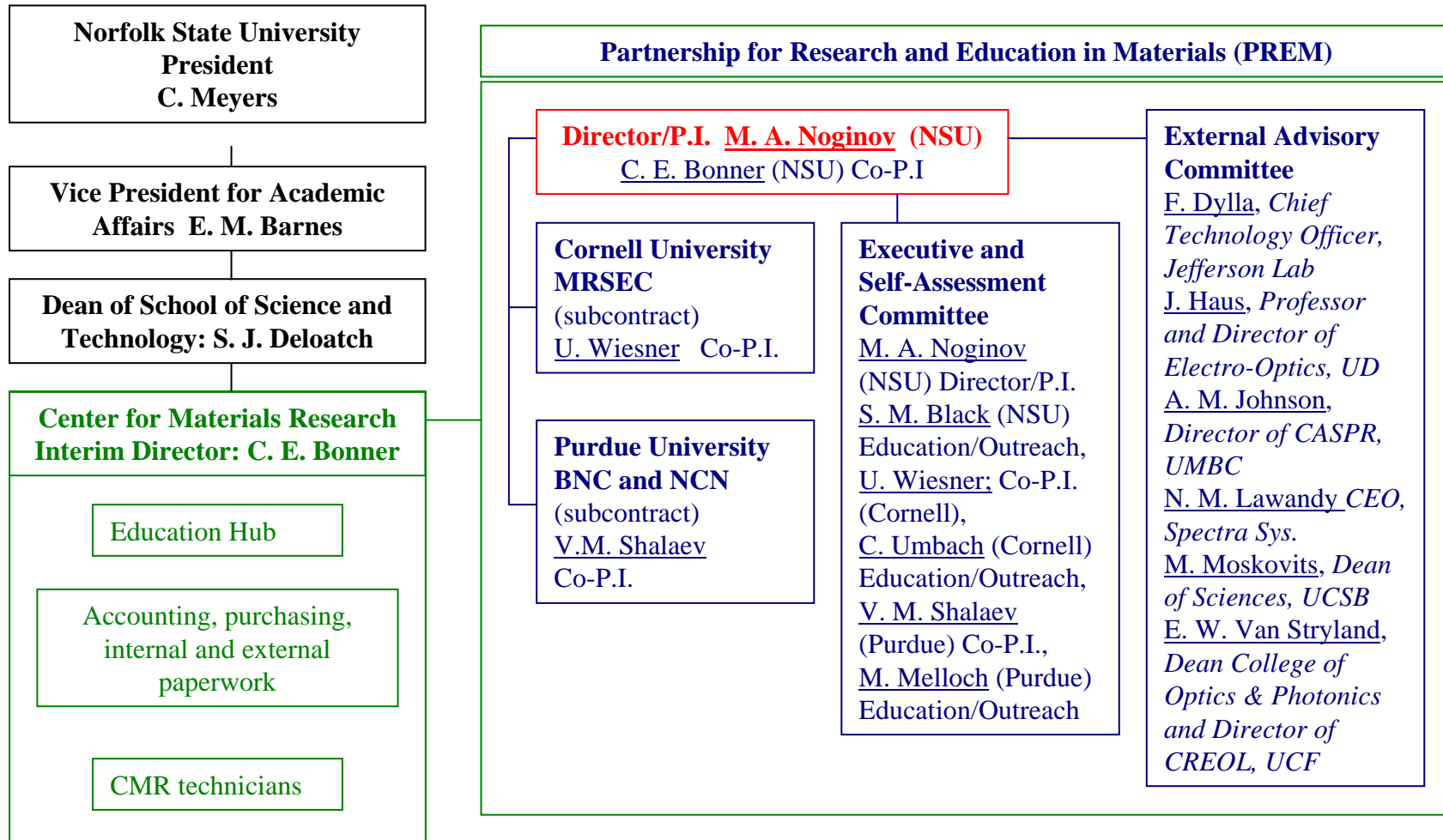
- negative index metamaterials
- applications of microwave metamaterials concepts to optics
- plasmonic materials and waveguides
- nano-structured metallic and dielectric surfaces
- nano-particles and nano-wires



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Management Scheme



Participants

Norfolk State University

Mikhail A. Noginov, Partnership Director, [Spectroscopic and laser studies, nanoplasmonics, random lasers].

Carl E. Bonner, Co-P.I., [Synthesis and spectroscopic studies, nonlinear optical nanoplasmonic materials].

Suely M. Black, [Education and Outreach].

Vladimir I. Gavrilenko, [*Ab initio* theory].

Particia Mead, [Laser studies].

Natalia Noginova, [Magnetic and optical studies].

Devin Pugh-Thomas, [Luminescent and laser materials].

Shirleigh F. Wood [Accounting management, clerical support]

Messaoud Bahoura [Education and Outreach, Spectroscopic studies]

Guohua Zhu [Spectroscopic studies]

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Ulrich Wiesner, Co-P.I., [Particle synthesis and characterization, nanostructured polymer-inorganic hybrids].

Alexander Gaeta, [Optical and laser studies].

Emmanuel Giannelis, [Materials synthesis, structure and dynamics of nanoparticles and nanocomposites].

Christopher Umbach, Education and Outreach].

Purdue University

Vladimir M. Shalaev, Co-P.I., [Gain-enhanced Negative Index Materials, Optical studies].

Michael R. Melloch, [Education and Outreach].

Mark Lundstrom, NCN Director

Gerhard Klimeck, NCN Technical Director



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Collaboration with Cornell and Purdue

Research: Most of research tasks are executed in a highly collaborative manner. Students and faculty involved in the project visit labs of partner institutions to conduct joint experiments and discuss results (first long-term visit is planned for May-July).

Education: Cornell and Purdue teams help to “jump start” the new-born Ph.D. program in Materials Science at NSU *via* co-advisement of students and guiding NSU faculty on the management and development of the program.

The partners will enrich graduate and undergraduate Materials Science curricula and research culture at NSU *via* offering courses, development of “informal learning” educational materials, seminars, *etc.*



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Management

PREM meetings

All participants meeting: Monthly, non-NSU participants participate via BREEZE/ conference call (*first Friday of the month, 4:00 p.m., one-hour long*)

Executive committee: three times per year: in the end of each semester and end of the summer program

External Advisory Board : Annually

PREM Annual Meeting for all participants and students: Annually

PREM workshop for undergraduates (this year - FutureTech)

combined 2-day or 3-day event, beginning of June

Major management problem of the year: issuing subcontracts

Research Tasks

Research Program. The central theme of the proposed research is *mutual* enhancement of (i) optical gain and other optical responses in dielectric media and (ii) surface plasmons (SPs) in metallic particles and aggregates.

Task 1. Study of enhancement of optical responses by SPs

Task 2. Study of enhancement of SPs and SPPs by optical gain

Task 3. Study of nonlinear magneto-optical effects enhanced by SPs

Task 4. Study of lasers, which properties are enhanced by SPs

Task 5. Study of negative index materials with metallic loss

Task 6. Fabrication of nano-sized C-dots with metallic cores or shells as well as fluorophore-doped microspheres

Task 7. Theoretical studies

Optical gain conquers surface plasmon loss

Surface plasmons (SP's), oscillations of free electrons in metallic particles, and surface plasmon polaritons, electromagnetic waves propagating along metal/dielectric interfaces, are important to the development of nanoantennae, nanocircuits, chemical and biological sensors, high resolution imaging and many other applications. However, future development of nanoplasmonics is limited by metallic absorption of SPs.

The team of PREM researchers from Norfolk State University (the group of M. A. Noginov) and Purdue University (the group of V. M. Shalaev) was able to experimentally demonstrate that optical gain in a dielectric medium can compensate for loss in a metal and enhance SP resonance. This accomplishment paves the road to many practical applications of nanoplasmonics and photonic metamaterials.

nature
photonics

Research Highlights
Surface plasmons:
Enhanced nanoplasmonics

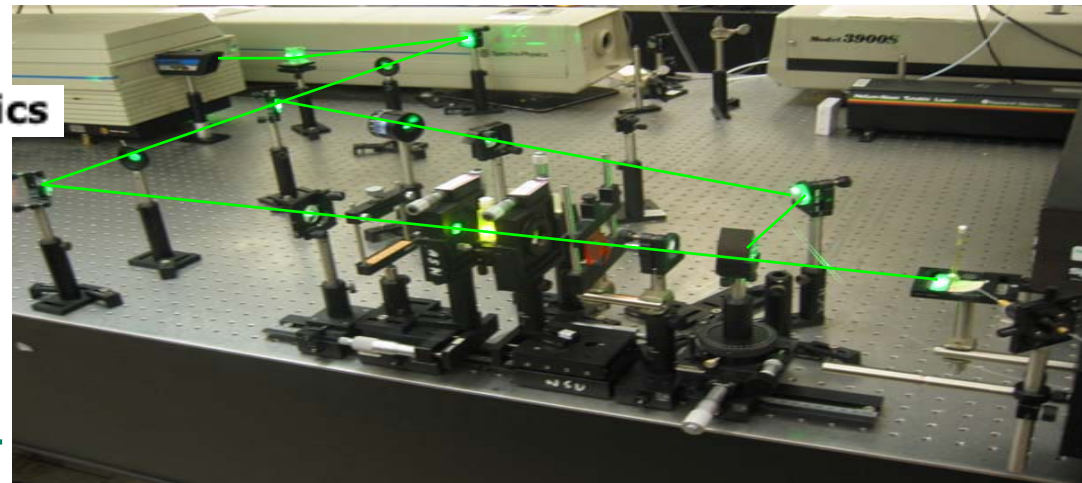
LaserFocusWorld®
NOVEMBER 2006 WWW.LASERFOCUSWORLD.COM

newsbreaks

Optical gain enhances
surface-plasmon resonance

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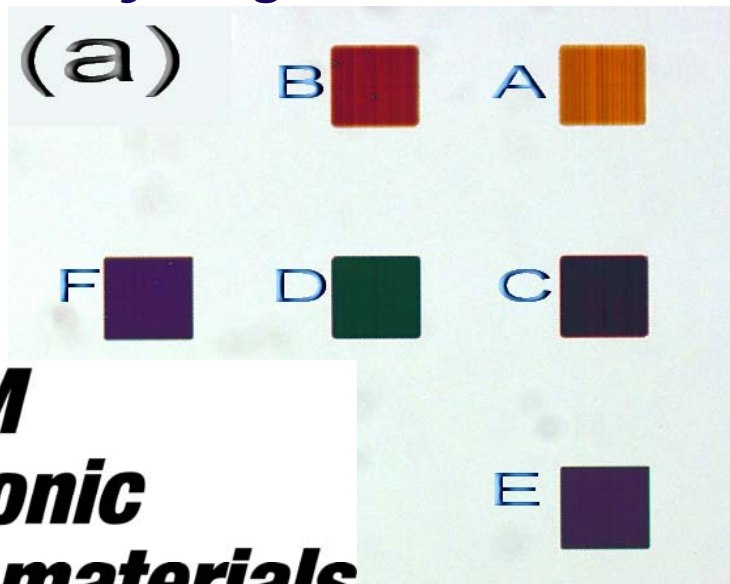


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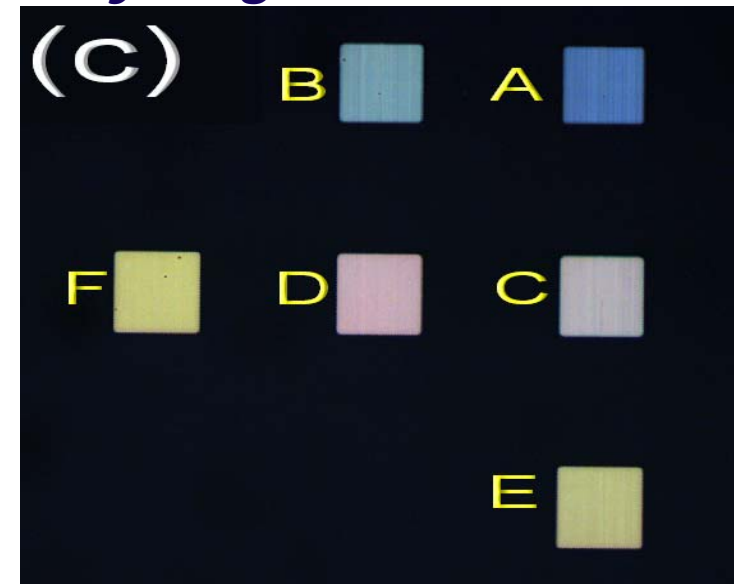
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Metamagnetics with Rainbow Colors: Magnetism from Red to Blue

*Transmittance
by magnetic resonators*



*Reflectance
by magnetic resonators*



PREM
Photonic
Metamaterials

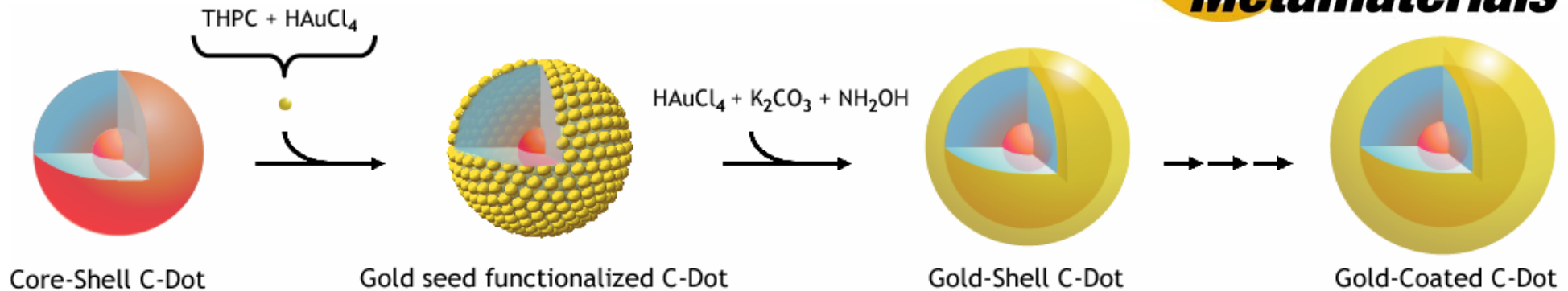
A family of coupled nanostrips with varying dimensions is demonstrated exhibiting optical magnetic responses across the whole visible spectrum, from red to blue. *This is the first demonstration of magnetism in the visible range.* We refer to such a phenomenon as rainbow magnetism. The experimental and analytical studies of such structures provide us with a universal building block and a general recipe for producing controllable optical magnetism for various practical implementations.



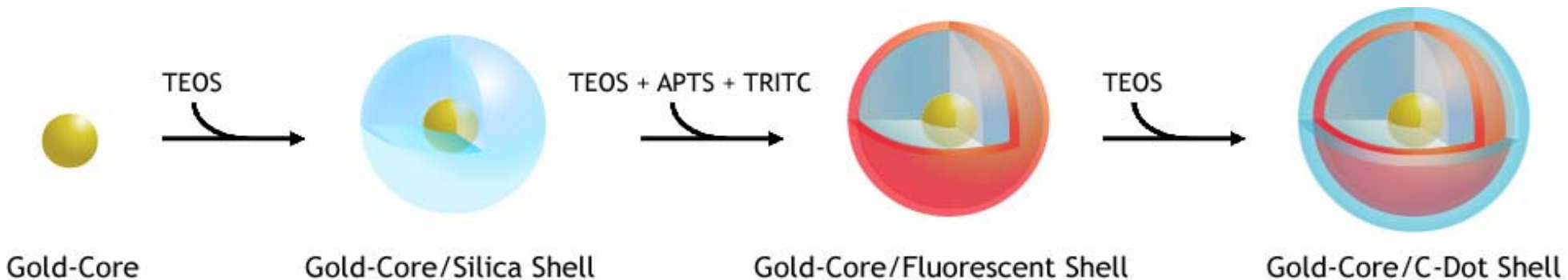
Goal: To incorporate organic dyes within silica-metal nanoparticles to systematically tailor the interaction between the encapsulated dye and the surface plasmon, thereby maximizing fluorescence enhancement

Proposed Architectures:

Gold-Coated C-Dots:



Gold-Core/C-Dot Shell:



Education

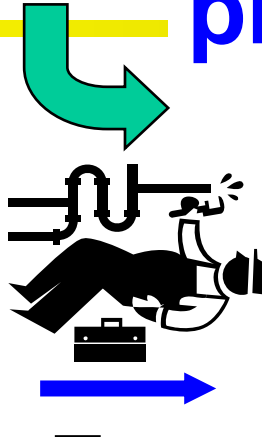
Accepting (new)
graduate students

Professional workforce
and leadership

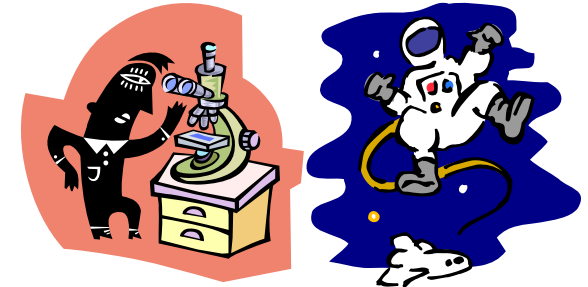
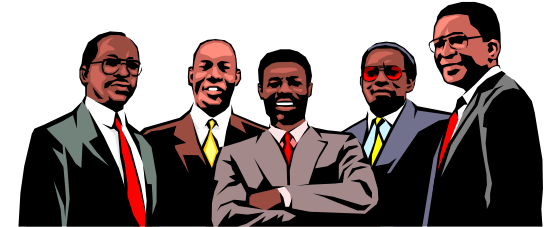
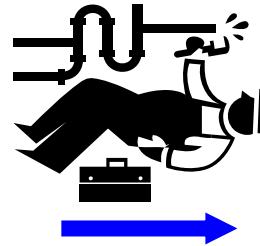
pipeline



Undergraduate,
K-12



Graduate studies,
Ph.D.
*MIT, Princeton,
Stanford, etc.*



The goal of the ambitious education program of the Partnership is to establish a pipeline starting from attracting high school students from the underrepresented minority groups to the Science, Technology, Engineering and Mathematics (STEM) disciplines (especially Materials Science), and finishing with preparation of the PhD candidates for careers in Materials Science in academia, industry, and government.

Education



Ph.D. program

Ph.D. program in Materials Science and Engineering has been established at NSU (officially approved in October 2006)

First Ph.D. students will start their studies from August 2007 and graduate by the end of the 5th year of PREM.

A lot of work has been done by the PREM team before PREM has officially started (PREM proposal and Ph.D. proposal were written at the same time).

Much more work has to be done.



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Education Tasks

Greater Participation – Reaching out to STEM students

- 1 *PREM Workshop (FutureTech 2006)*
- 2 *Adopting Undergraduate M.S. Courses from Cornell and Purdue*
- 3 *PREM and PREM/NCN Scholars Program (6 scholars now)*
- 4 *Cooperative Summer Program (NSU 6 new slots; this summer one student goes to Cornell and two to Purdue)*

Greater Depth – Effective Ph.D. Program

- 1 *Implementation of Ph.D. Program at NSU (practical advises on hundreds of big and small issues)*
- 2 *Adopting Graduate Courses*
- 3 *Research Culture and Communication: Graduate Student Co-Advising and Seminars (by the end of the semester: 4 seminars at NSU, 2 seminars at Cornell, 2 seminars at Purdue; the exchange started before PREM was funded.)*
- 4 *Professional Training*

PREM Workshop and NSF-STC 2nd Annual Hands-On Future Tech at Norfolk State University co-located with the Ph.D. program recruitment workshop



Exciting the next generation about Science and Technology – the hands-on learning experience workshop primarily targeting undergraduate students.

Attended by 118 students from 22 colleges and universities. Most of them belong to underrepresented minority groups.

Organized and sponsored by six NSF funded programs: NSU PREM Photonic Metamaterials, STC on Materials and Devices for Information Technology Research, STC for Biophotonics Science & Technology, STC for Embedded Network Systems, MRSEC at Cornell University, NCN at Purdue University.



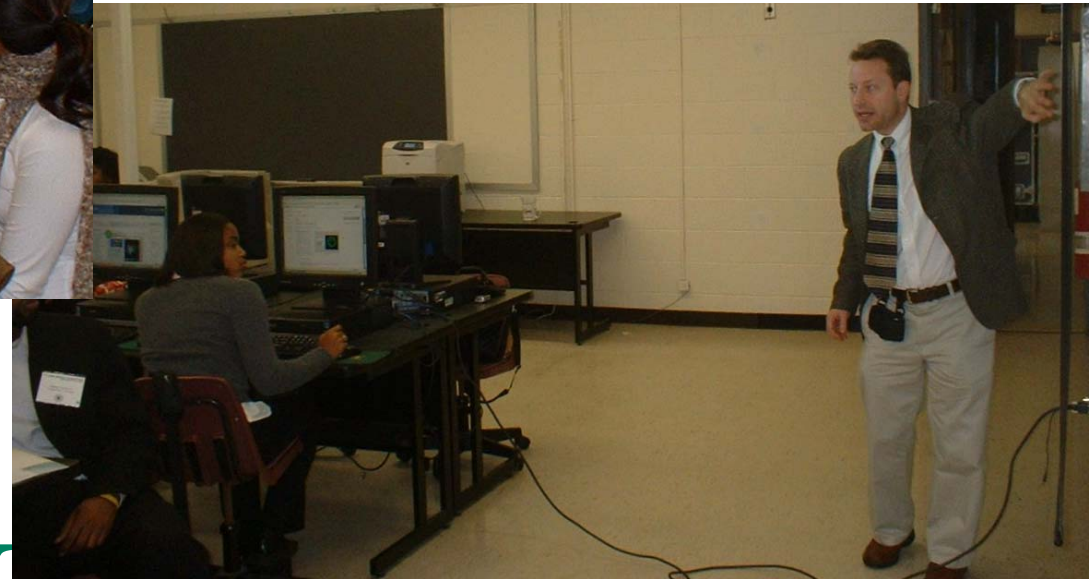
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PREM Workshop and
NSF-STC 2nd Annual Hands-On Future Tech at
Norfolk State University
co-located with the Ph.D. program recruitment workshop



Michael McLennan
Purdue NCN



Christopher Umbach
Cornell CCMR



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Teaching and learning resources available at the NCN's nanoHUB

<http://nanohub.org/>

The screenshot shows the nanoHUB website interface. At the top, the nanoHUB logo is displayed with the tagline 'online simulation and more' and 'an NCN project'. A navigation bar includes links for Home, my nanoHUB, Resources, Contributors, Events, About, and Support. A search bar and a 'Help!' button are also visible. The main content area is divided into three columns: Simulate, Research, and Contribute. The 'Teach & Learn' menu is highlighted with a red border and contains the following items:

- [Nano 101 / Nano 501](#)
Introductory tutorials
- [Nanocurriculum](#)
Curriculum on Nanoelectronics
- [Learning Modules](#)
Self-paced web instruction
- [Teaching Materials](#)
Graduate, Undergrad, K-12

The 'Simulate' column lists tools for Nanoelectronics, NEMS/Nanofluidics, and Nano-bio, with a 'More >' link to browse all available tools. The 'Research' column lists Seminars, Collaborate, Web Meetings, and User Groups. The 'Contribute' column lists options to contribute content, give feedback, take a poll, and make donations.



MATERIALS FOR NANOTECHNOLOGY

(draft of the developed curriculum by N. Noginova)

Recommended textbook Charles P. Poole, J and Frank J. Owens. *INTRODUCTION TO NANOTECHNOLOGY*. Wiley-Interscience, 2003 or later

COURSE OUTLINE, ASSESSMENTS AND TESTS

Introduction and Basics. Physics of the Solid State. Effects of Size

Lecture 1. What is Nanoscience? Why the physics of nanoscience is so interesting. Historical perspectives. Current applications and future trends. Chapter 1 and <https://www.nanohub.org/resources/179/> (“Introduction to Nanometer Scale Science & Technology”, Mark Hersam. Nanotechnology 101)

Lecture 2. Basic concepts of physics of the solid state. Crystal structures. Energy bands. Size dependence of properties

Lecture 3. Energy bands. Semiconductors. Excitons. Chapter 2

Methods of Measuring Properties

Lecture 4. X-ray crystallography. Particle size determination. Surface structure. Magnetic resonance and Spectroscopy. Chapter 3

- We are currently working on similar courses with Cornell University
- Smaller number of resources available on-line
- This requires a lot of manual curriculum-sorting by the Cornell colleagues