



Nanotechnology Research and Education Center

Briefing to NREC Affiliated Faculty Members

Dr. Ashok Kumar, Director (NREC)







Topics

- NREC Mission & Goals
- Research, Education, and Outreach Activities
- Collaboration with USF Research Centers
- National Context (AAU aspiration)
- NREC Budget
- Critical Issues with NREC
- Accomplishments
- Future Initiatives





Context for Nanotechnology

- Nano-structures are 1000 times smaller that micro-structures
- Nearly \$1.5 Billion/yr in federal support
- Spans biology, medicine, electronics, materials, etc
- "The next big thing"
- Hot Job market predicted by Wall Street Journal 2010

Human hair is approximately 30,000 nanometers in diameter







"The Future Has No Walls"

Nanoscience and Nanotechnology

Bioengineering & Health Care Engineering

• Environmental, Energy, and Transportation

• Information Technology



NREC Goals

- Nurturing and enabling multidisciplinary micro/nano related research projects for all interested faculty at the University of South Florida.
- Providing **professionally managed** state-of-the-art fabrication facilities, analytical instruments and metrology tools for the characterization of materials.
- Providing <u>training programs</u> for all interested faculty and students who wish to use the facility.
- Providing a facility for industrial users working collaboratively with USF faculty to develop competitive processes and products for <u>commercialization of</u> <u>technology</u>.



NREC: Prologue

- Although NREC housed in College of Engineering, it provides state of the art tools and expertise to enable research from many disciplines and colleges in a single facility
- Provide tools that are too expensive (purchase and operational) to be duplicated by individual faculty, but are critical for innovation and new grants
- Critical Issues with NREC
 - Annual Service Contracts for instruments
 - Historically first in line to be considered for budget cut priority
 - Need support from the administration to operate and maintain expensive core facility
- Get your valuable feedback about NREC ☺



NREC Snapshot

• Users

• 10 Departments (over 60 Faculty) from 5 Colleges

- Anthropology
- Chemical and Biomedical Engineering
- Chemistry
- Civil and Environmental Engineering
- College of Medicine
- College of Marine Science
- College of Pharmacy
- Electrical Engineering
- Industrial & Management Systems Engr.
- Mechanical Engineering
- Physics
- 41 Industrial Client Users and growing
- Over 250 student and Post-doc users
- 357 Users total in current database
- Staff
 - 5 Full time staff
 - 15 Student assistants (FWS & OPS)

Helping to bring \$22.3 Million in NSF Research Grants over the last 7 years (\$3.18 M/year)





NREC Affiliated Faculty Members

- Anthropology:
- Chemical and Biomedical Engineering:
- Chemistry:
- Civil and Environmental Engineering:
- College of Medicine:
- Electrical Engineering:
- Industrial & Management Systems Engr.:
- Mechanical Engineering:
- Physics:
- College of Pharmacy:

Approx. 60 Faculty from different Colleges are using NREC facilities.

1 Faculty 9 Faculty 4 Faculty **5** Faculty **3** Faculty **14 Faculty** 4 Faculty **11 Faculty 12** Faculty **1** Faculty

Academic Advisory Board

My Lien Dao, Ph.D.



Wilfrido Moreno, Ph.D.



Shyam S. Mohapatra, Ph.D, MBA



Vinay Gupta, Ph.D.



Daniel H. Yeh, Ph.D., P.E., LEED AP



David Fries, Ph.D.



Bernard L. Batson



Andrew Hoff, Ph.D.



Delcie Durham, Ph.D.



Robert J. Gillies, Ph.D.



Nagarajan Ranganathan, Ph.D.



O. Geoffrey Okogbaa, Ph.D.



Edward Turos, Ph.D.



Sarath Withanachchi, Ph.D.



Elias (Lee) Stefanakos, Ph.D., P.E.



Edwin J. Weeber, Ph.D.



Industrial Advisory Board

John Bumgarner, Ph.D. Director Micro Science and Engineering Laboratories SRI International

Joseph D. Cuiffi, Ph. D. Principal Investigator Draper Laboratory - Bioengineering Center at USF

Ronald J. Guttmann, Ph.D. Consultant and Professor Emeritus, RPI

Ken Heffner, Ph.D. Honeywell Aerospace Engineering Fellow Electronic Systems and Engineering Applications Damon Hooten Constellation Technology Corp. Systems Development Lead

Thomas J. Koob, Ph.D. Chief Scientific Officer MiMedx, Inc.

Sergei Ostapenko, Ph.D. Ultrasonic Technologies:

Penelope T. Salmons, MPA General Manager Rosseter Nano Composites

Xueji Zhang, EMBA, Ph.D. Sr. Vice President of Science World Precision Instruments, Inc.



Role of the Advisory Board

Provides Counsel on topics including:

- Long term objectives of NREC
- Strategic acquisition of multi-user equipment
- Recommendations for benchmarking of NREC performance
- Other relevant issues for long-term sustainability of facilities





Advisory Board Feedback Spring 2010 Meeting

- Enhance the nurturing and enabling role for <u>multidisciplinary research</u> at USF, for both campus and off-campus users.
- Promote and take a leadership role of a newly approved Interdisciplinary Graduate Program in Materials Science and Engineering.
- Try to become a member of the <u>National Nanotechnology Infrastructure</u> <u>Network (NNIN)</u>.
- The NREC should form a <u>regional consortium</u> with the <u>USF Nanomedicine</u> <u>Center</u>.
- Explore <u>collaborative research funding</u> with medical school, industries (SRI/Draper), and other Florida Nanotech Center proposals (ERC, Materials Research Science and Engineering Center, MURI).
- Establish an <u>International Nanotechnology Network</u> with Latin and South American countries (Ibero-American Nanotechnology Centers Network, coordinated by USF Faculty, Dr. Moreno).



Nanotech1 Facility

The Nanotechnology and Research Education Center (NREC) housed in the 15,000 square foot Nanotech1 building at the University of South Florida has <u>five laboratories</u> available for user access.





Cleanroom Process Tools





Class 1000 Cleanroom

More than 50 instruments in NREC

Alcatel Deep Reactive Ion Etcher Several Contact Mask Aligners Plasma Etch PECVD Chamber Several Ellipsometers Dektak D150 Profilometer DI Atomic Force Microscope Bruce Furnace (Two Banks 8 Tubes) Several Vacuum Evaporators Several Sputter Tools CV/IV Test Equipment Microautomation Dicing Saw Several Probe Stations and Wire Bonders

Material Characterization Tools





HRTEM



XRD



E-Beam Lithography







Recent Equipment Acquisitions

Spring 2011 Installed and Operational

Nanotechnology Research & Education Center

 Establishment of an HR-SEM capability to support state-of-the-art imaging capability for current and future funded research activities including for education purposes <u>NSF-MRI 2009</u> Award (Kumar, Batzill, Li, Gupta, Schlaf, and 10 other faculty from both COE and CAS)



• Optical Profilometer

- Noncontact three-dimensional surface metrology
- Sub-nanometer vertical resolution at all magnifications
- For advanced applications in MEMS, thick films, optical coatings, solar cells, ceramics, and advanced materials research





Users (Faculty, Student, Industry) Involved with NREC

The NREC has seen a major increase in its user base in the past two years from:

Physics, Biology, Chemistry, Medicine, Public Health, and all six departments in the College of Engineering.

Students and Post Docs Faculty Industry Total

Industrial Users of NREC

Tampa Electric Company Ortho Technology, Inc. Naval Research Lab Environmental Consulting Group, Inc. Unaxis USA Inc. Valenzuela & Stern, P.A. Constellation Technology Corporation American Water Chemicals, Inc. Mustang Vacuum Systems HSA Engineers & Scientists Xcelience, Llc South Gate Technology Semiconductor Diagnostics, Inc. Eclipse Energy Systems, Inc. **SRI** International J. C. Newman Cigar Co. Aviation Engineering Consultants, Inc. **Rosseter Nanocomposites**

Modelithics Inc. Applied Research and Development Inc **Ocean Optics Inc** VSEA, Inc. - Gloucester Intelligent Micro Patterning, LL Doosan HydroTechnology Nano CVD Co Ultrasonic Technologies, inc. **Global System International General Atomics** CUBE Technology, Inc. Ascent Healthcare Solutions Howard Kay, Lilly, O'Toole & Brown LLP COMMERCE ONE BPO, LLC WAKONDA TECHNOLOGIES Draper Lab (Tampa) Alliant Tech Systems Inc. PrimeStar Solar, Inc. Chromalloy Casting, Inc.



NREC Training

In the past **18 months NREC has provided**:

- Training sessions(#) 300
- Training Hours 700
- Individuals trained 125



Student researchers fabricate micro-electromechanical devices and sensors using process tools.



Education

NREC Staff support education with lectures and demonstrations

• The NREC staff supports the activities of the following courses:

CRS#	Course Title	Professor	Department	Activity
EEL 6935	Micro Electro Mechanical Systems (MEMS II)	Dr. Wang	Electrical Engineering	Series of many lab sessions to build and test a MEMS pressure sensor.
ECH 6931	Characterization of Materials	Dr. Wolan	Chemical Engineering	Guest Lectures in XRD, SEM, EDS, TEM, FIB, Vacuum technology plus labs.
ANG 6100	Archaeological Science	Dr. Tykot	Anthropology	Demonstration of EDS and SEM techniques.
EEL 6935	Integrated Circuit Processing II	Dr. Hoff	Electrical Engineering	Help with certain process steps and test IC capacitors.
EML 6930	Micro & Nano Manufacturing	Dr. Kumar	Mechanical Engineering	Series of Lab Sessions to build a pressure sensor device.



Interdisciplinary Graduate Program in Materials Science & Engineering

 College of Engineering and College of Arts and Sciences Graduate Program

http://mse.usf.edu

Four students in INTO program





Materials Science & Engineering

A Joint Interdisiplinary Program between College of Engineering & College of Arts & Sciences



Ibero-American Nanotechnology Centers Network

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UNM

Researc







Search NREC @ USF NREC @ USF Facı, Ed. VINORIE UL Faculty/Student Exchange **Educational Initiatives Research Collaborations Community Engagement Equipment & Supplies Acquisitions**







Instituto Nacional de Astrofísica, Óptica y Electrónica

www.inaoe.gob.mx



NREC Working with Affiliated Centers

<u>UNRC</u> - USF Nanomedicine Research Center

UNRC and NREC hosted Nano-Bio Collaborative 2010 Symposium

- <u>USF-CDDI</u> Center for Drug Discovery and Innovation
- CERC Clean Energy Research Center
- <u>Moffitt Cancer Center</u>
- <u>Byrd Altzheimers Institute</u>
- <u>FLATE</u> Florida Advanced Technological Information Center (NSF ATE activities)



National Context (AAU Aspiration)



- UC Berkeley
- Georgia Tech* (63 AAU member)
- Stanford
- MIT
- U Michigan
- UCLA
- Princeton
- Yale
- Cornell
- UT Austin
- Purdue

National Peer Institutions

- U Cincinnati
- Rutgers
- U Illinois, Chicago
- U Buffalo, SUNY

All Top 75 ranked Engineering schools invest in Nanotechnology Research Centers

USF is one of Florida's top three research universities



NREC (CMR) Budget History





NREC ENG Budget

Expenses

Approx.\$375K for 2009/2010



Staff Salary

OPS 🛯

Supplies

Service Contracts

Maintenance and Repairs

* Not including \$110K service contract for TEM/FIB

Allotment for Maintenance, Repairs, and Supplies spent within 2-3 months



NREC Users Billed for Cost Recovery (estimated 2009/2010)

- Student Users
 - \$96,000 (48 students on flat rate, \$2000 each per year) + time billed users (approx \$20k)
- Industrial Users
 - \$98,489
- Spent on
 - Operating expenses for the remaining approx. 10 months of the year
 - Soft money salary (1 employee+OPS students)
 - Equipment repairs not covered by service contract
 - Materials and Supplies



Critical **ISSUES** with NREC

- Annual Service Contracts for instruments
- Investment in new tools for the future
 80% of tools over 20 yrs. Old
- Historically first in line to be considered for budget cut priority
- Lack of Institutional Policy or practice in terms of University Core Facility
- For a productive center, a model and investment has to be decided and supported
- Limited staff number to serve large user base and tool set



Investment in Core Facilities

- Major core facilities are an integral part of major Universities
 - Consider them like Library Services, Athletic Facilities
 - Enable an "Unfair Advantage" to Faculty to win Research Grants
- Intellectual powerhouse for collaborative research
 - Discovery happens when people have access to modern, cutting edge research facility
- Industry
 - Basic R & D Investment is needed to remain competitive

NREC plays a key role in retention and recruiting of some of USF's most active researchers.



NREC fulfilling USF Vision/Values/Goals

- Recruiting high quality faculty & graduate students
- Promoting inter-disciplinary research and education
- Increasing interactions with start-up companies and wellestablished industries for technology transfer and job opportunities to promote economic development
- Provides resources to compete for external research grants
- State of the art facility to facilitate researchers to publish in high-impact journals
- Provides a highly trained work force (academic and industry)

NREC is the best center in the USF campus in terms of fulfilling the University goals as a premier research University with a State, National and Global impact, positioned for membership in AAU.



- Form Advisory Board to obtain feedback
- Education and Outreach effort with major national reach in teaching, training, promotion, and diversity building
- Center promotion via print and electronic media (newsletter, brochures, etc.) to increase networking with Florida industries
- Technical workforce development with Community Colleges (Plan underway)



Academic Impact

• A large number of Ph.D. users of NREC facilities





Industrial Impact

• Increase industrial users 10-20% each year





Small Company Impact

- Ultrasonic Technologies Inc. (spin-off NREC)
 - Dr. Sergei Ostapenko (CEO)
 - Associate professor working at CMR/NNRC/NREC in the CoE since 1993
 - Crack detection in Si solar cells and solid oxide fuel cell (SOFC) substrates using Resonance Ultrasonic Vibration (RUV) Technology







• Awards

- **NSF CAREER** Awards
 - Dr. Nathan Gallant
 - Dr. Craig Lusk



- Fellow of American Assoc. for Advancement of Science (FAAAS)
 - Dr. Ashok Kumar
 - Dr. Salvatore Morgera





Scientific Contributions

Publications

- 32 approx. in 2010 (Applied physics letters, Nature Nanotechnology, IEEE journals)
- 384 approx. since 2000
- Patents
 - 24 approx. from Faculty users (1995-2011)



• Grant winning impact



NREC Accomplishments Diversity and Outreach Impact









Recruitment, Education & Research Training

- Supported USF <u>PhD recruitment initiatives</u> via tours for potential students from Latin American (Mexico, Columbia, Venezuela) and US minority serving intuition.
- Since 2004, <u>33 graduate fellows have been NREC users</u>. These students have received over \$1.5 million in federal (NSF, DHS, etc), state, and private fellowships.
- <u>Education and career development</u>: State-of-the art research training for PhD internships and postdoctoral and industry employment (Argonne, BNL, Sandia, PNNL, Naval Research Lab, etc.)
- Student outcomes: Since 2004, <u>50+ conference presentations</u>, <u>40+ conference/journal papers</u> from graduate fellows.

K-12 Outreach

- USF campus tours (Moffitt Nano Days, Engineering Expo, Stampede for Success, etc.)
- Fostered expanded engagement of USF faculty, students, and staff with the public – "The Great American Teach-In", Hillsborough Regional Science Fair, Introduce A Girl to Engineering, MOSI lectures, etc.
- NSF and USF Research Experiences for Teachers Research-training of K-12 teachers and faculty from community colleges and minority-serving institutions



- Alumni NREC Student users
 - Faculty in Academia
 - Leading Research Scientists in National Labs
 - Processing Engineers (Intel, IBM, AMD)
 - REU students, trained in NREC, admitted in top 25 engineering schools





- Local Activities
 - Engineering EXPO
 - Tours
 - Industrial visitors, New hire at USF, prospective faculty & students
 - Seminars
 - Over 10 research and education talks in conjunction with faculty host
 - Workshops
 - Materials Characterization (FIB and TEM) Dr. Giannuzzui
 - Rheology Mr. Metzger, Anton-Paar

NREC Future Initiatives



 Become a member of NSF Nanotechnology, Infrastructure Network (NNIN)

(solicitation due in 2013, possible \$1 million support per year)



<u>College of Marine Science (Oceanographic Sensing)</u>

NREC Future Initiatives



- Initiate for Center Proposals
 - Materials Science & Engineering Research Center (Center for Functional Materials, submitted by Dr. Venkat Bhethanabotla)
 - Engineering Research Center (ERC)
 - DOD MURI grant
- Florida Center of Excellence Proposal (in Nano-Bio topic)
- Promote Interdisciplinary Research and Education Activities
- Promote Industry/University Research Collaboration
- Establish Collaborative Research Partnership with other Florida Nano Centers (UF and UCF)

NREC 2010



NREC Future 2011-2016





Responsible Research in Action

"We are taking nanotechnology in a direction we can be proud of."



For more information, go to sei.nnin.org

1 st to

NREC Staff



Ashok Kumar, Ph.D. Director



Robert Tufts, Assistant Director



Yusuf Emirov, Ph.D. Metrology Scientist



Richard Everly, Cleanroom Research Engineer



Jay Bieber, Metrology Engineer



Sclafani Louis-Jeune, Office Assistant



Thank You.

