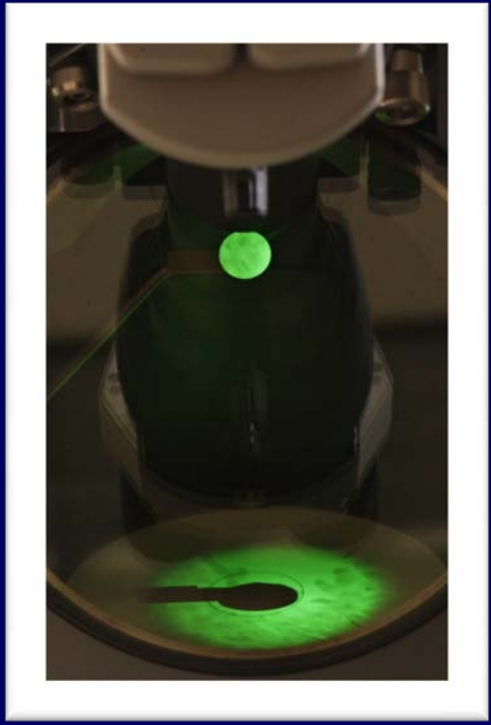
Nanomaterials and Nanomanufacturing Research Center

Nanomaterials and Nanomanufacturing Research Center

Briefing for Advisory Members

Dr. Ashok Kumar, Director (NNRC)



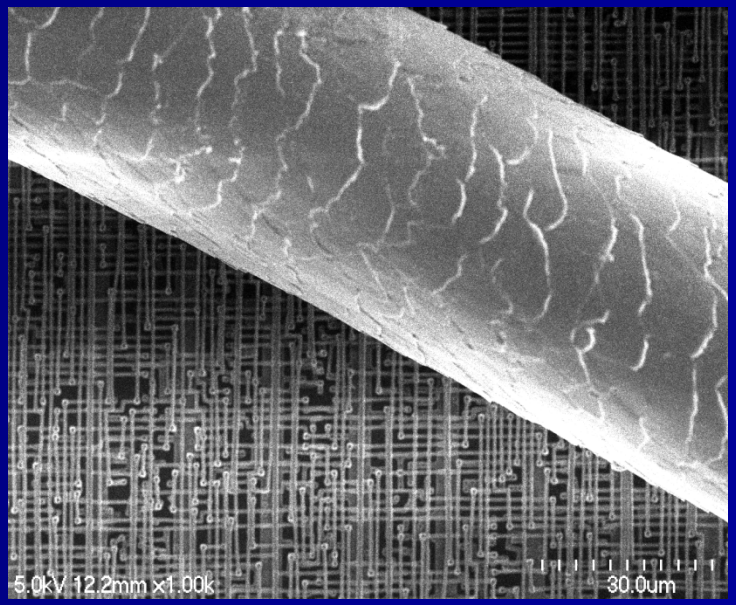
USF UNIVERSITY OF SOUTH FLORIDA COLLEGE OF ENGINEERING

Topics

- Mission / Objectives
- Advisory Board
- Staff
- Overview of Facilities
- Faculty Users-what they do
- Students, Training, and Outreach Activities
- Collaboration with USF Research Centers
- National Context
- Future Initiatives
- Tour of facilities

Context for Nanotechnology

- Nano-structures are 1000 times smaller that micro-structures
- Nearly $1.2 Billion/yr in federal support
- Spans biology, medicine, electronics, materials, etc
- “The next big thing”



Human hair is approximately 30,000 nanometers in diameter

National and Global Factors

NSF, DOE, DOD, DHS, NIH Engineering Priorities (NAE Study):

- Energy & Environment
- Health Care/Life Science
- Information/Computation
- Infrastructure (Includes Transportation)
- Materials
- Manufacturing
- Discovery Sciences (Cyber enabled discovery & innovation)
- Robotics
- DARPA SOC integrating 3D VLSI, MEMS, Microelectronics, Photonics
- Intelligent Systems

Strategic Priorities for Engineering School

The Future Has No Walls

- Bioengineering & Health Care Engineering
- Environmental, Energy, and Transportation
- Information Technology
- Nanoscience and Nanotechnology

NNRC Objectives

- **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 **training programs** 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 **commercialization of technology.**

History of NNRC (CMR)

- In mid 1980s special state appropriation to set up CEDAR (later called CMR) at USF…part of Governor Bob Martinez's High Tech Council
- USF lead State of Florida effort to attract SEMATECH to state of Florida in late 1980s
- Federal Funds (via DARPA) to establish cleanroom and metrology lab by refurbishing several rooms in College of Engineering let to the Center for Microelectronics Research (CMR)
- With support from Lucent/Agere (early 2000's) CMR evolved into the NNRC

Academic Advisory Board

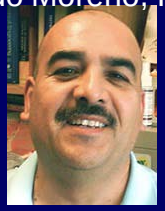
My Lien Dao, Ph.D.

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

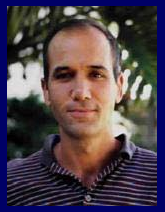
Delcie Durham, Ph.D.

Edward Turos, Ph.D.

Wilfrido Moreno, Ph.D.



David Fries, Ph.D.



Robert J. Gillies, Ph.D.

Sarath Withanachchi, Ph.D.

Shyam S. Mohapatra, Ph.D, MBA

Bernard L. Batson

Nagarajan Ranganathan, Ph.D.

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

Vinay Gupta, Ph.D.

Andrew Hoff, Ph.D.

O. Geoffrey Okogbaa, Ph.D.

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. Gutmann, 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 vision and objectives of NNRC
  - Strategic acquisition of multi-user equipment
  - Recommendations for benchmarking of NNRC performance
  - Other relevant issues for long-term sustainability of facilities

Affiliated Faculty Members

- Anthropology: 1 Faculty
- Chemical and Biomedical Engineering: 9 Faculty
- Chemistry: 4 Faculty
- Civil and Environmental Engineering: 5 Faculty
- College of Medicine: 1 Faculty
- Electrical Engineering: 14 Faculty
- Industrial & Management Systems Engr.: 4 Faculty
- Mechanical Engineering: 11 Faculty
- Physics: 12 Faculty

Approx. 60 Faculties are using NNRC facilities.

NNRC Staff

Ashok Kumar, Ph.D. Director

Robert Tufts, Assistant Director

Yusuf Emirov, Ph.D. Metrology Scientist

Richard Everly, Cleanroom Research Engineer

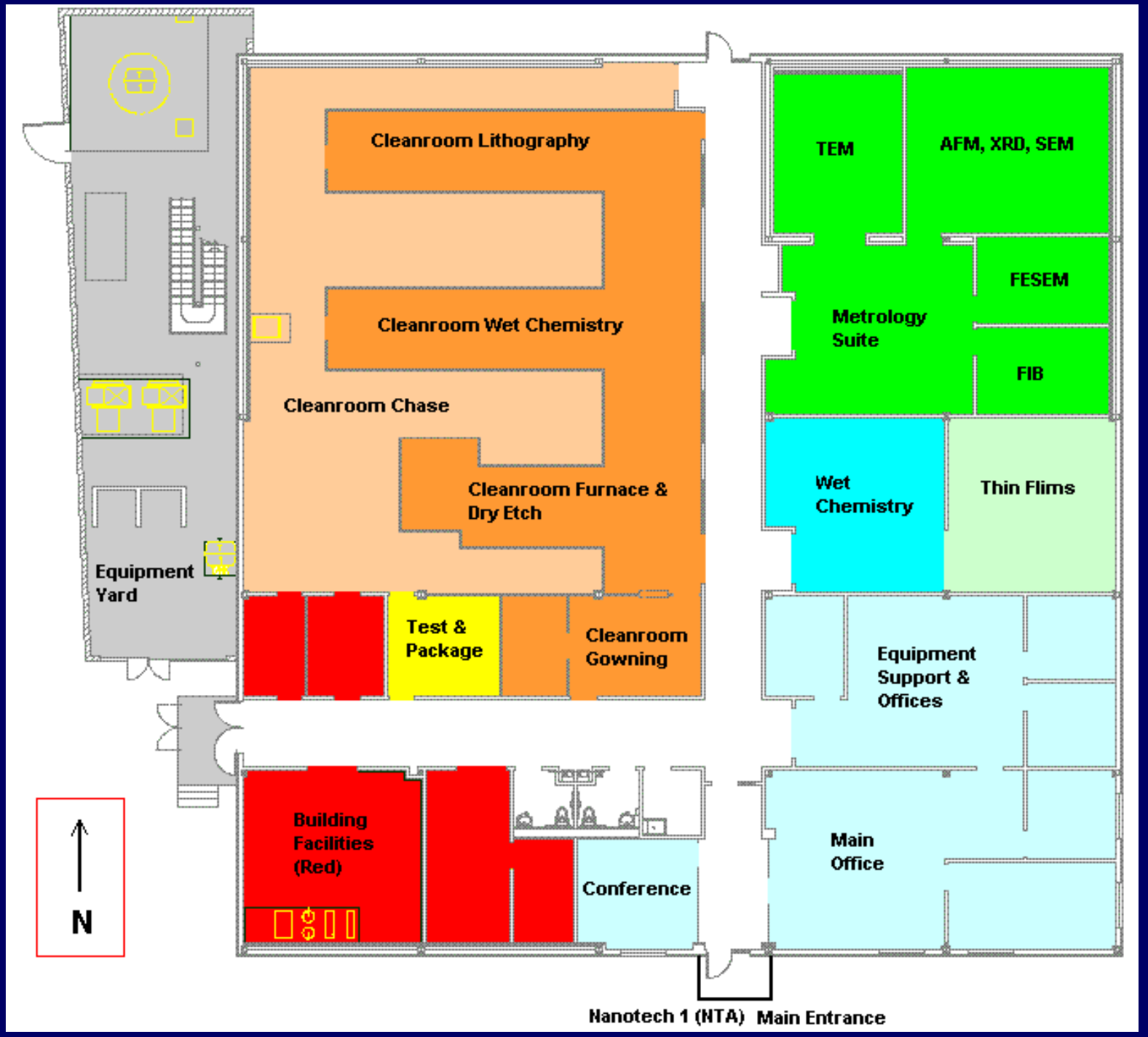
Jay Bieber, Metrology Engineer

Sclafani Louis-Jeune, Office Assistant

Nanotech1 Laboratories

The Nanomaterials and Nanomanufacturing Research Center (NNRC) housed in the15,000 square foot Nanotech1 building at the University of South Florida has five laboratories available for user access.

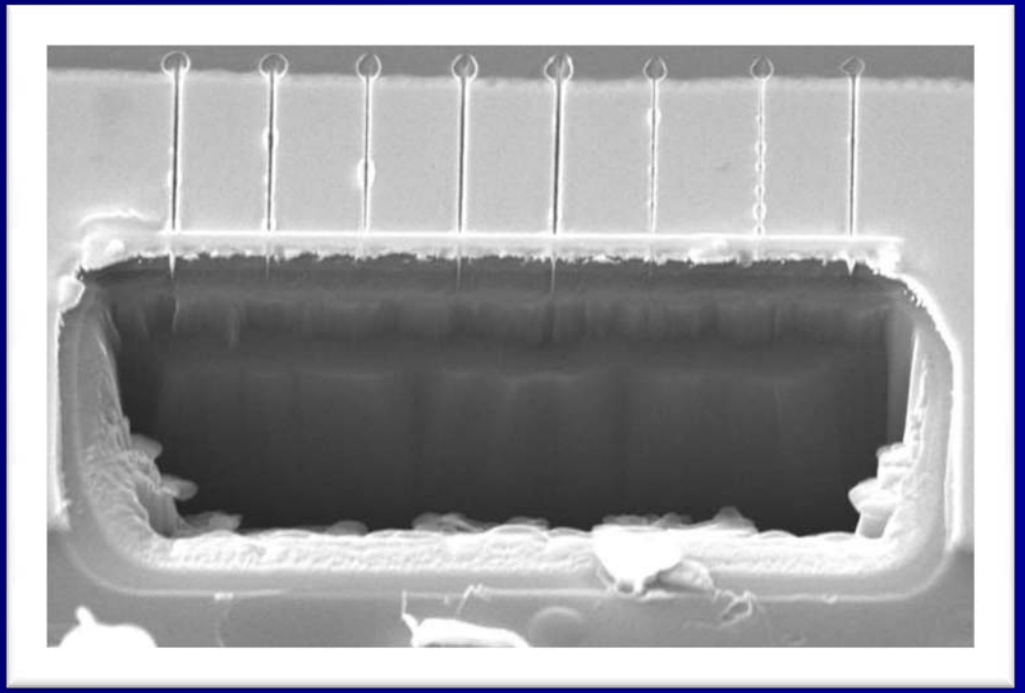
- A Class 1000, 1,800 square foot Cleanroom
- Thin Film Deposition Lab
- Materials Characterization / Metrology Suite
- Electrical Test and Packaging Lab
- Wet Chemistry Lab


Cleanroom Lithography
Cleanroom Wet Chemistry
Cleanroom Chase
Cleanroom Furnace & Dry Etch
Test & Package
Cleanroom Gowning
Equipment Yard
TEM
AFM, XRD, SEM
FESEM
Metrology Suite
FIB
Wet Chemistry
Thin Flims
Equipment Support & Offices
Building Facilities (Red)
Conference
Main Office
N
Nanotech 1 (NTA) Main Entrance

List of Major Instruments

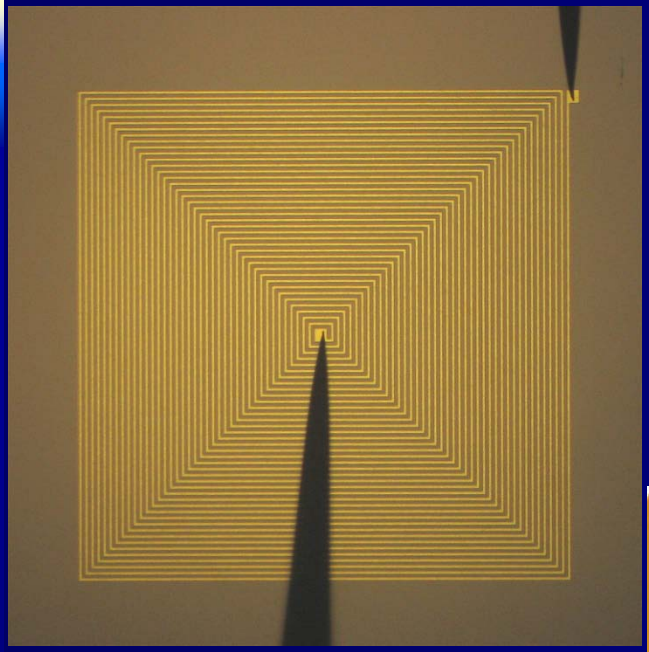
Pananalytical X-Ray Diffractometer
FEI Focused Ion Beam
FEI Transmission Electron Microscope
Hitachi Scanning Electron Microscope
JEOL Scanning Electron Microscope

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
Mask Pattern Generator
Mask Photorepeater

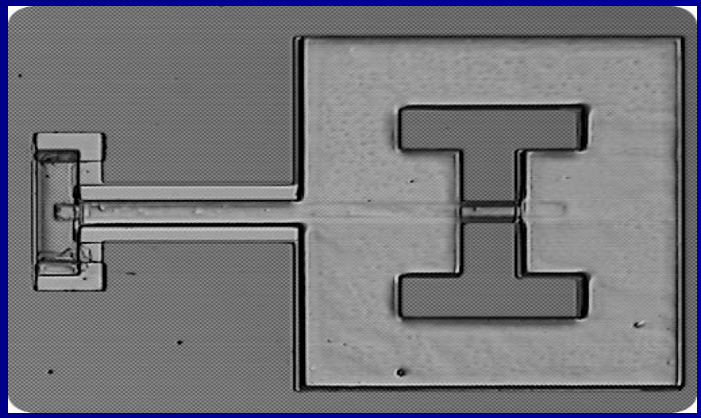


Images of Focus Ion Beam
Milled Structures
(USF NNRC)

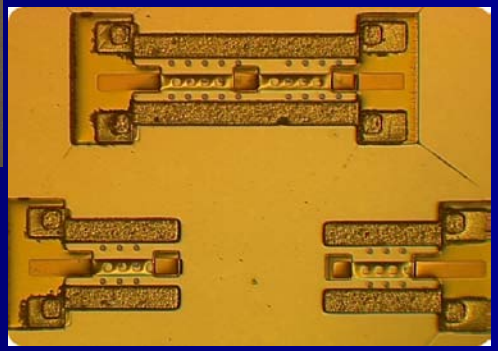
Micro Fabrication



A 40 turn spiral inductor is probed and tested for self inductance measurements. The application for such a device is power grid sensing. The line width on the aluminum conductors is 30 micrometers.

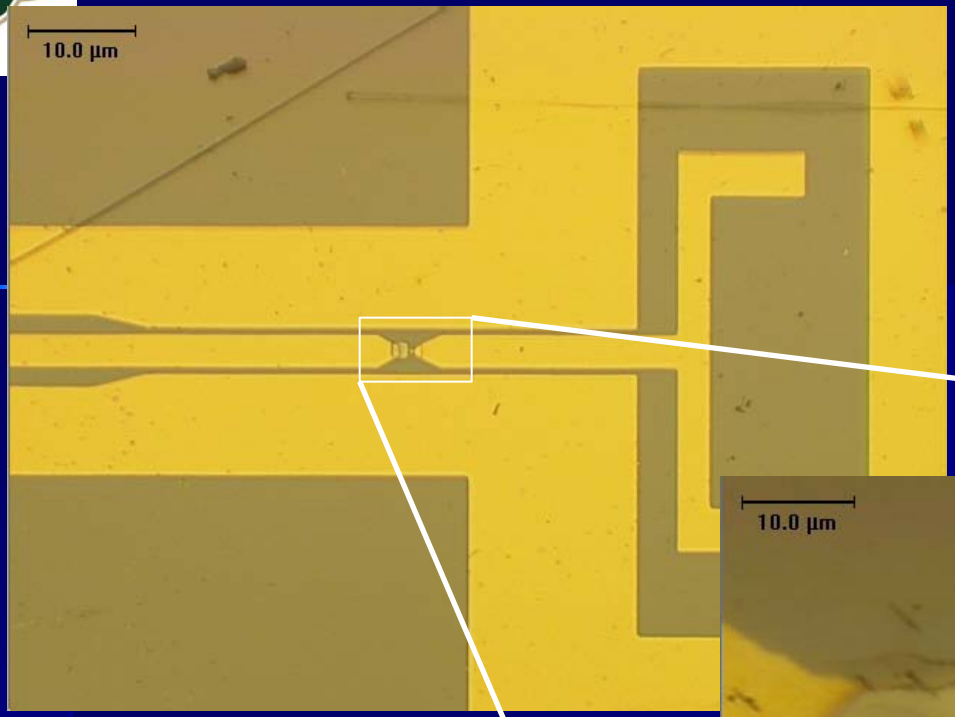


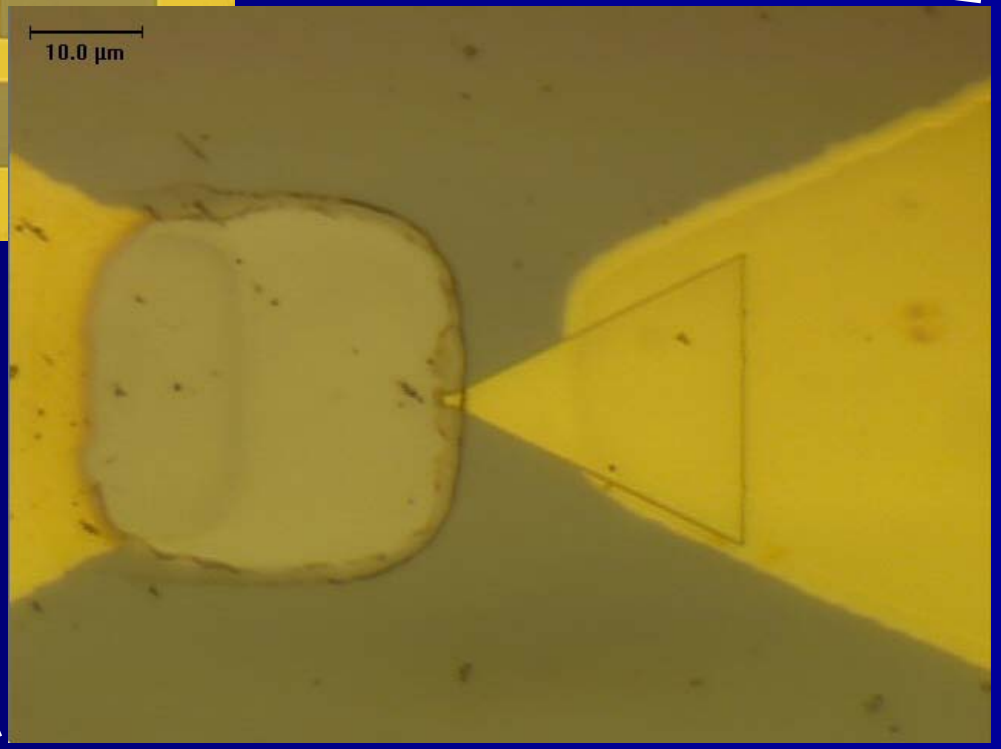
This is an integrated slot antenna fed by a micro coaxial transmission line operating at 55-65 GHz.



Micro coaxial transmission lines fabricated through a fixed-beam MEMs beam topology with a suspended top lid.

Nano Fabrication

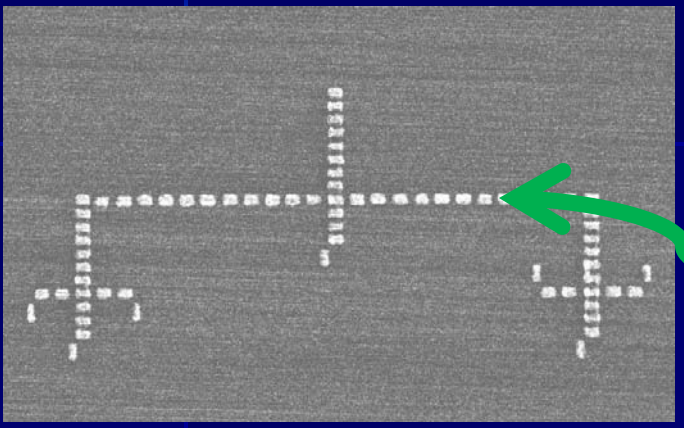


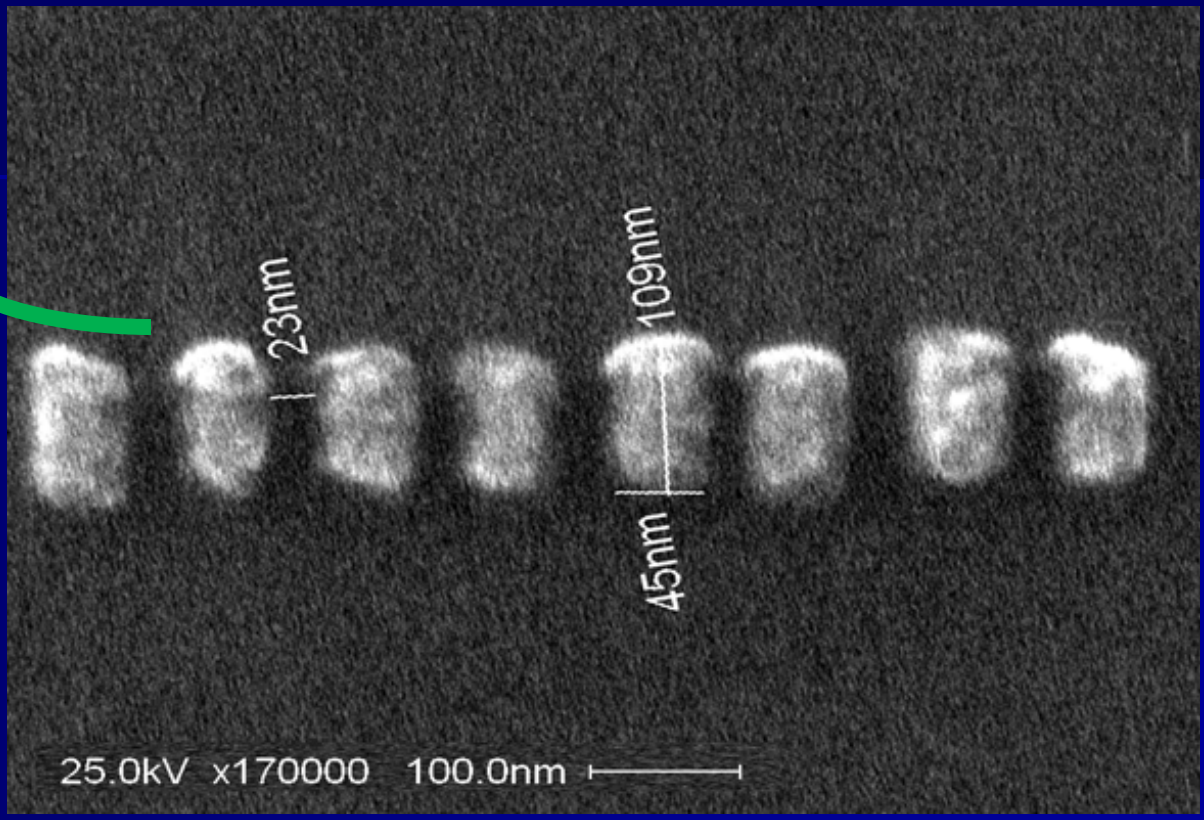


Nano Diode for Energy Harvesting

Drs. S. Krishnan, Shekhar Bhansali,
Lee Stefanakos and Yogi Goswami, & CERC

Nano Fabrication

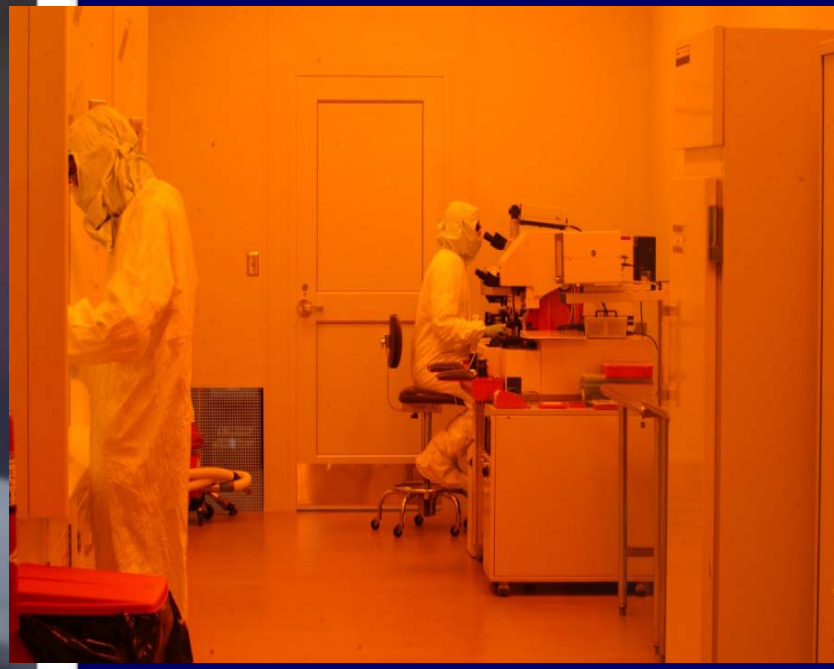




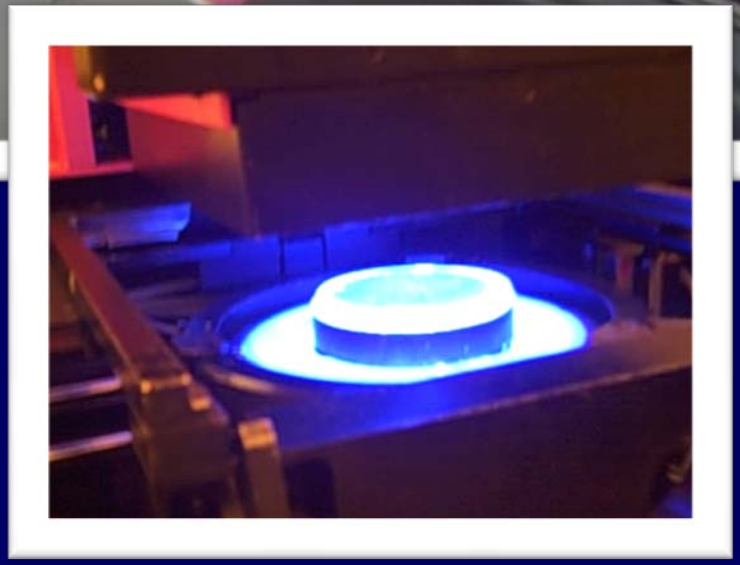
A high resolution Scanning Electron Microscope image taken of permalloy nano-magnetic structures fabricated with nanolithography techniques. An interesting detail to notice is the high resolution lithography capabilities demonstrated by the gap size between each structure, which is about 20 nm.

J. Pulecio & Dr. S. Bhanja

Cleanroom Process Tools



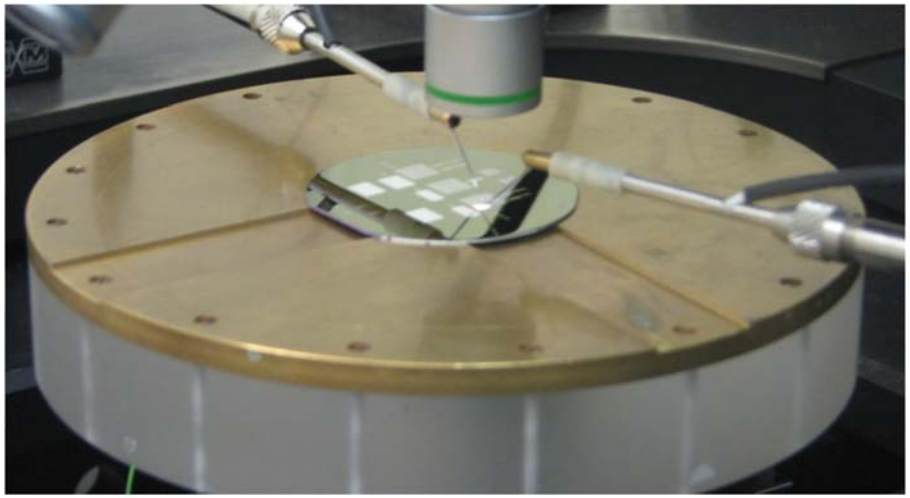
Class 1000 Cleanroom



Cleanroom Major Process Equipment

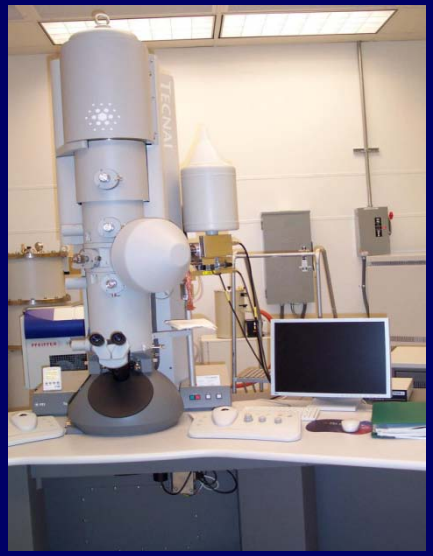
- Six furnace tubes, Wet/Dry Oxidation, n/p doping, TCA, polysilicon, anneal
- Furnace quartzware/loading station hood
- Plasma Therm PT700 (Plasma Etch & PECVD)
- SFI cluster sputter tool
- SDI COCOS tool
- SDI SILC tool
- ATV 8” furnace
- Critical point dryer – MEMs Release
- Rudolph Ellipsometer
- Alphastep Profilometer
- Long working distance microscope with video capture and measurement
- Two cleanroom wet benches with dump rinser capabilities
- One solvent/lithography bench
- Quartz tube cleaning bench
- Afterglow Research Tool
- Karl Suss Mask Aligner
- Quintel Mask Aligner
- Spin Rinse Dryers
- Photoresist Spinners (2)
- Hard/Softbake Oven
- Afterglow System

Test & Packaging Lab



Material Characterization Facility

SEM



HRTEM

XRD

E-Beam Lithography

AFM

FIB

Transmission Electron Microscope

Tecnai F20 is the versatile Nano-Analytical electron microscope what can be used in two different modes:

High resolution conventional transmission electron microscopy (TEM);

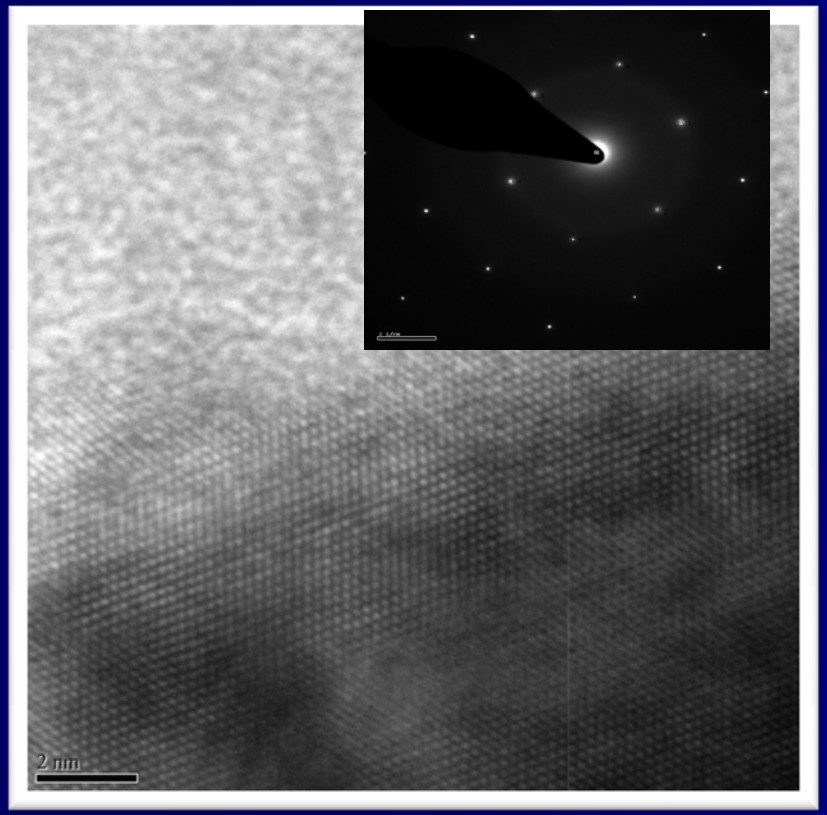
High resolution scanning transmission electron microscopy (STEM) with Bright Field and Dark Field Detectors;

Electron Source is Schottky Field emitter with Small energy spread (0.7 eV or less) and High stability and long life.
Micro- and nano-analysis can be performed by embedded Electron Dispersive X ray (EDX) system

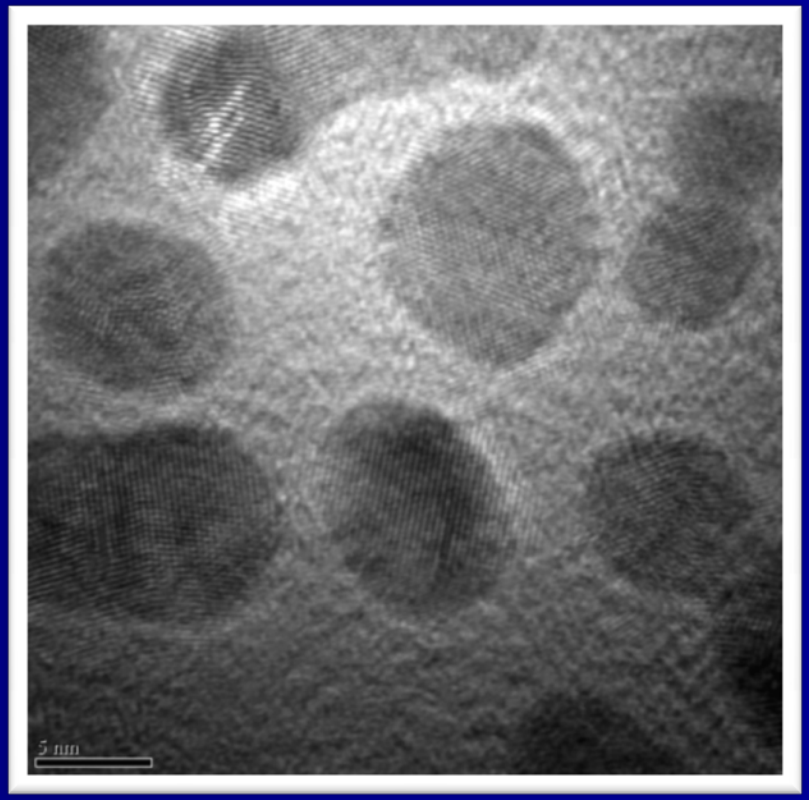
TEM TECNAI F20 basic specification

Point resolution	0.19 nm
Line resolution	0.102 nm
Information limit	0.12 nm
Magnification range in TEM mode	25x – 1000x
Magnification range in STEM mode	150x – 230x
Tilt angle (double tilt specimen holder)	24°
Diffraction angle	32 °

Transmission Electron Microscope



High resolution Transmission Electron Microscopy image and Diffraction pattern of Si-SiO_2. The photo shows ordered atomic planes of silicon atoms. d= 3.15 Å



Transmission Electron microscopy image of gold nanoparticles.

Panalytical X'Pert Pro MRD

The X'Pert PRO diffraction system utilizes a modular system approach to provide no-compromise performance for applications ranging from routine characterization to in-depth research investigations. The Pre-FIX (Pre-aligned Fast-Interchangeable X-ray optics) concept enables the diffraction system to be reconfigured in a few minutes without the need for re-alignment to handle different types of analysis. A suite of data analysis software from Philips is available.

Applications

X-Ray source Cu Ka (1.5405 Å)

- Rocking curves
- Reciprocal space mapping
- Phase identification and quantification
- Stress analysis
- Texture analysis
- Reflectivity

Atomic Force Microscope

Atomic Force Microscope (AFM) Dimension 3100 utilizes standard and advanced AFM imaging modes to measure surface topography and characteristics for semiconductors, lithography masks, magnetic media, CDs/DVDs, biomaterials and other samples up to 200mm in diameter.

The AFM uses a nano-size tip mounted on a flexible cantilever which scans above the surface to be investigated. Interatomic forces between tip and sample surface induce bending of the cantilever. The reflected from cantilever laser beam is detected with a position sensitive detector the output of which provide topographical image of the surface with atomic resolution. The cantilever can be bent not only by far-ranging forces but also electric, magnetic, etc forces. It provides researchers the advanced scanning probe microscopy modes:

- AFM phase image;
- Magnetic Force Microscopy (MFM)
- Electric Force Microscopy (EFM);
- Force Modulation
- Scanning Capacitance Microscopy (SCM)
- Lateral Force Microscopy (LFM)
- Scanning Tunneling Microscopy (STM)

Focused Ion Beam

The combined power of focused ion beam and scanning electron microscope technologies (FIB/SEM) has opened a new world of 3 dimension materials characterization, analysis, manipulation at the nanoscale. It uses an energetic focused beam of ions as a “nano” milling machine.

AutoCad files can be loaded into the FIB computer to mill patterns designs to fabricate any desired device structure. It also has a scanning electron microscope used to inspect the structures after they are made. The two different sources (electrons and ions) enable high-resolution imaging of below-the surface structures and manipulation of samples (by deposition or removal of material), for patterning, repairing or prototyping.

For the material science FIB offer the capability of in-situ dynamic experiments 3 dimension imaging and analysis; TEM sample preparation for more in depth analysis

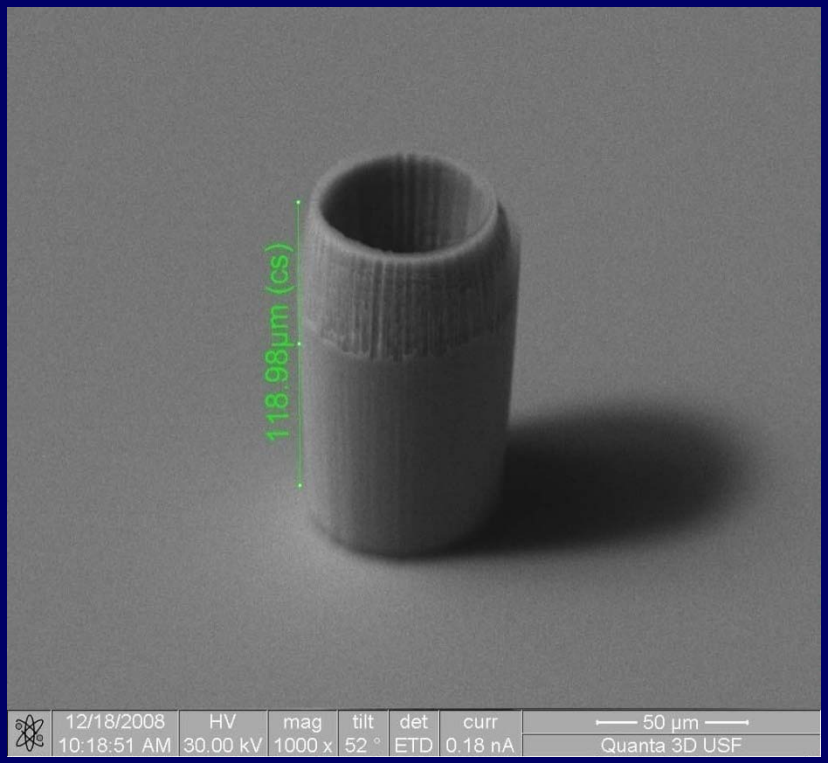
The achievable ion beam resolution is 3 nm (30angstrom)

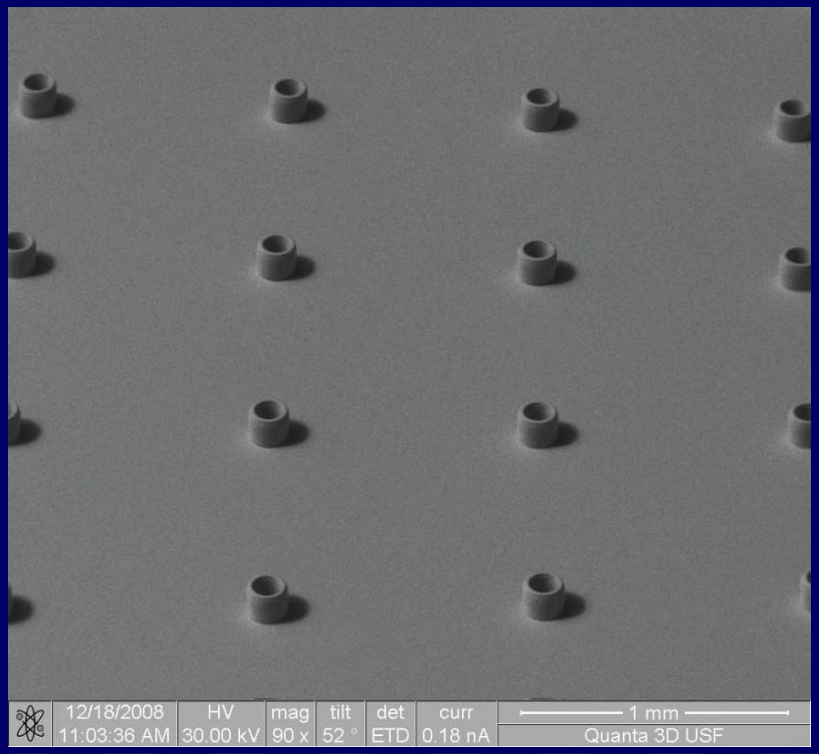
Hitachi S-800
Scanning Electron Microscope

The Hitachi field emission electron microscope or FE-SEM is used for inspection of nanostructures. The SEM has a magnification power of 300,000 times actual size. The image is generated by scanning a very small electron beam over the specimen. These electrons are scattered from the surface, and are then collected to generate an
image.

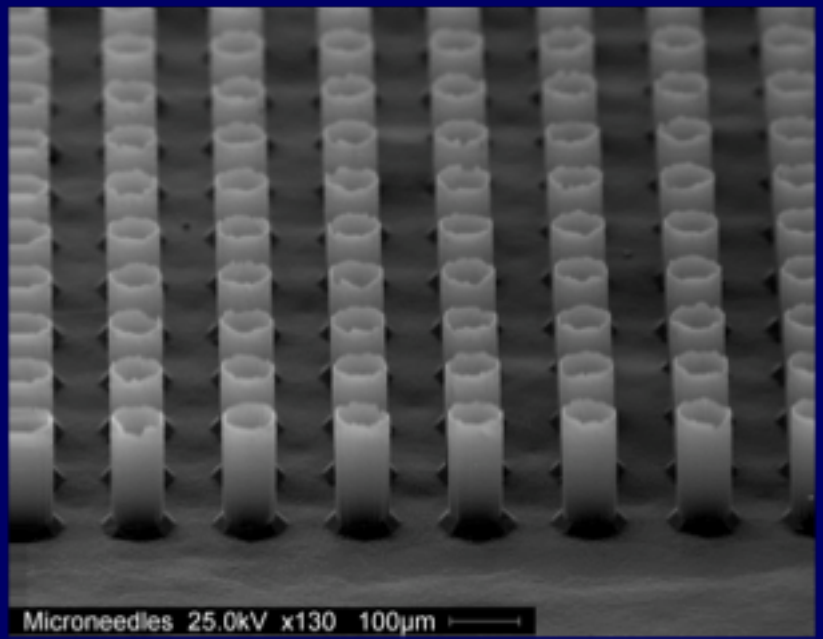
Energy Dispersive Spectroscopy
The electron beam is also used to perform chemical analysis on microstructures below 1 micron in size using an x-ray spectrometer. The spectrometer collects X-rays which are also generated by the electron beam. The x-rays are characteristic of the quantity of each element present in the area scanned by the electron beam.

Specifications
- 2 nm Resolution
- 300,000X magnification
- Cold cathode field emission source
- Accepts specimens up to 25 mm diameter, by 20 mm height
- EDAX-Phoenix EDS System





SEM Images of Bio-MEMs
silicon micro-needles
Fabricated at Nanotech1
by Drs. P. Khanna & Shekhar Bhansali



JEOL 840
Scanning Electron Microscope
(E-beam Lithography)

SEM Description

The JEOL scanning electron microscope or SEM is used for the imaging and creation of nanostructures by electron beam lithography. The SEM has a magnification power of 300000 times actual size. The image is generated by scanning a very small electron beam over the specimen. These electrons are scattered from the surface, and are then collected to generate an image.

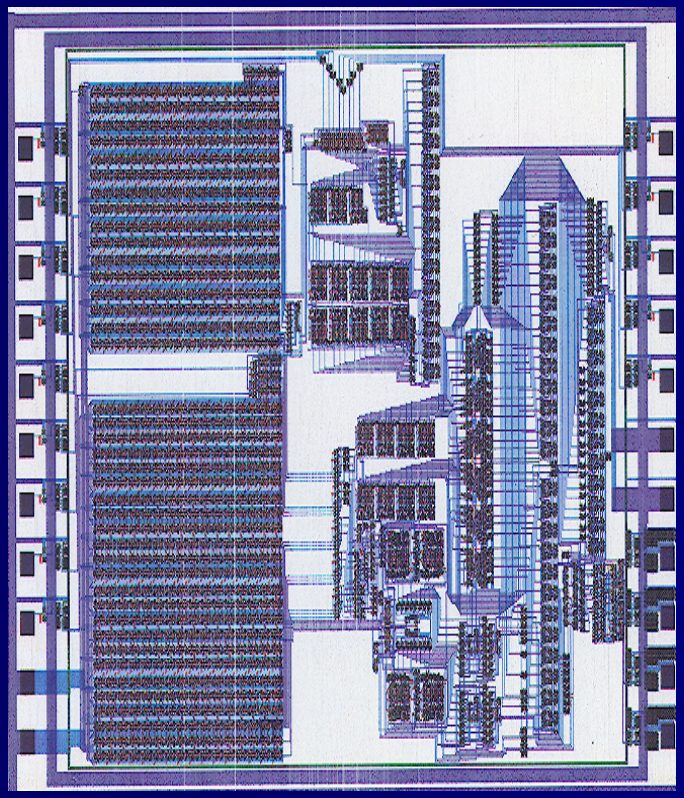
Electron Beam Lithography

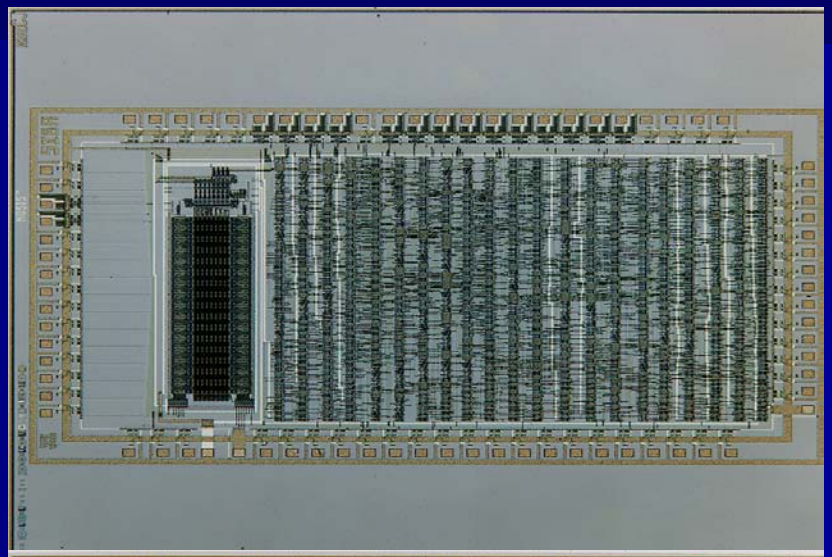
The electron beam is also used to delineated a pattern design on a substrate which has been coated with a thin film of plastic. Areas of the plastic which have been exposed by the electron beam can then be chemically etched away leaving a behind a copy of the pattern in the plastic film. The plastic in the unexposed areas of the pattern protects the substrate during a subsequent plasma etch process. The plasma then etches a copy of the pattern into the substrate material, and the plastic mask is removed.

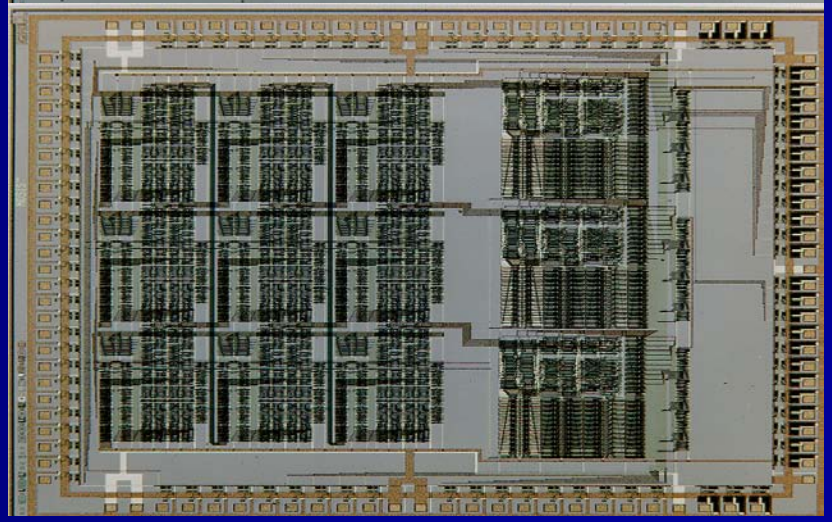
Specifications

- 4 nm Resolution
- 300,000X mag.
- Thermionic emission source
- NPGS Electron Lithography System

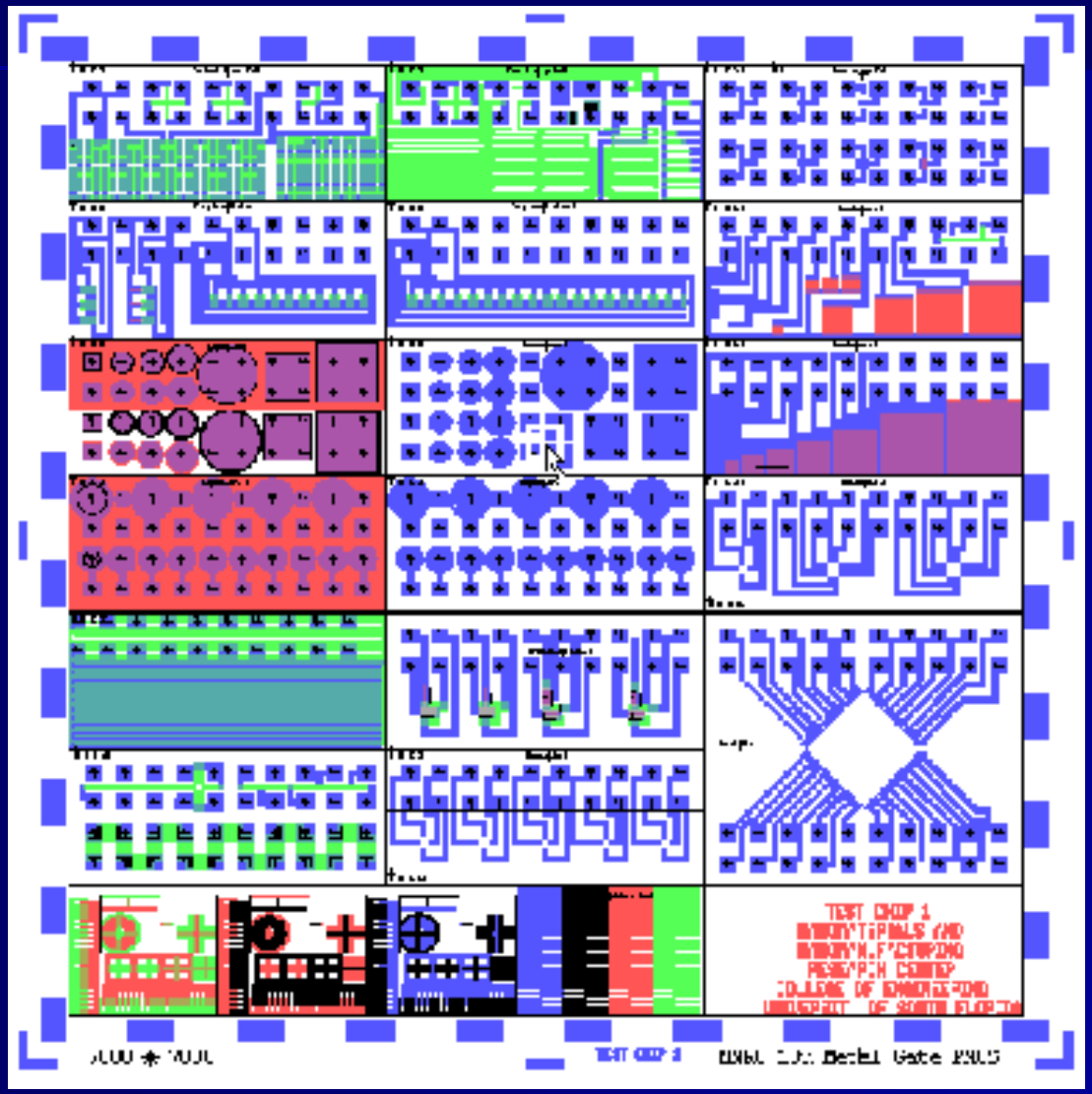
NNRC Design Lab







Computer Aided Design



New State-of-the Art High Resolution Scanning Electron Microscope

Coming to Nanotech1 Summer 2010

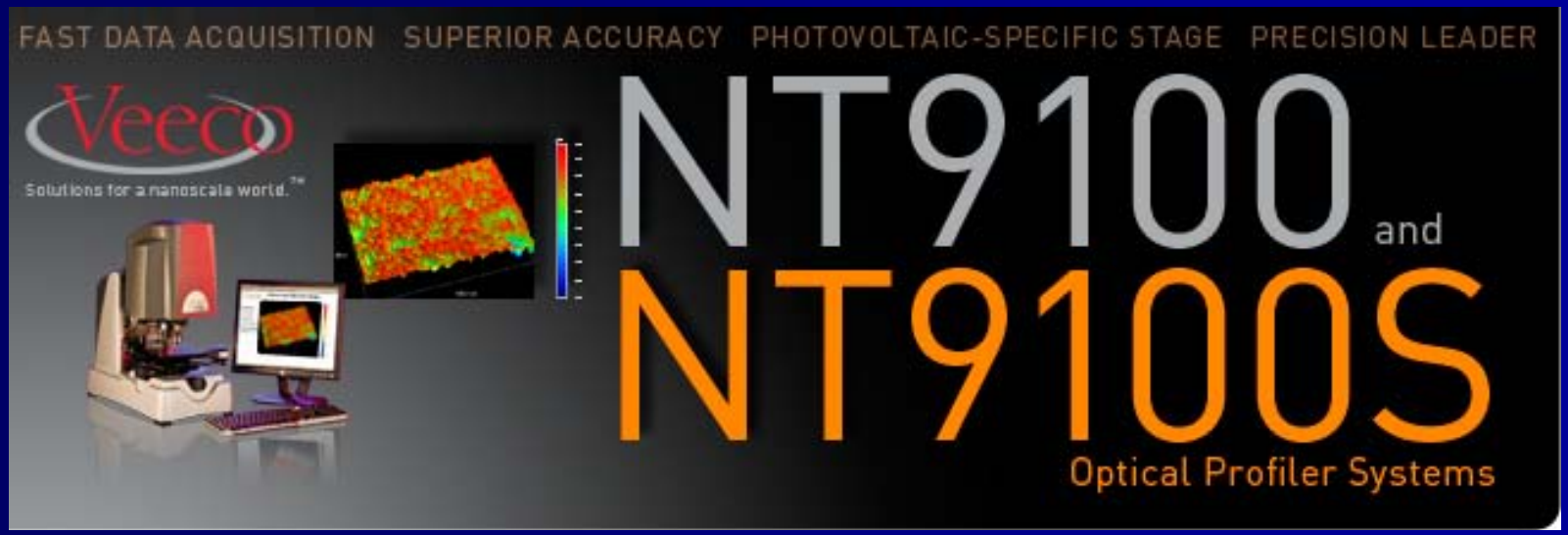
- Establishment of an HRSEM capability to support these activities will leverage current and future funded programs," said **Dr. Ashok Kumar**, Principal Investigator.

- Co-PIs
  - **Matthias Batzill** (Physics)
  - **Xiao Li** (Chemistry)
  - **Vinay Gupta** (Chemical Engineering)
  - **Rudy Schlaf** (Electrical Engineering
  - 10 other faculty participants contributed to win this grant from the NSF as well as the staff research engineers at the NNRC.

Hitachi SU-70 HRSEM

New Optical Profilometer

Installing Now



- 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

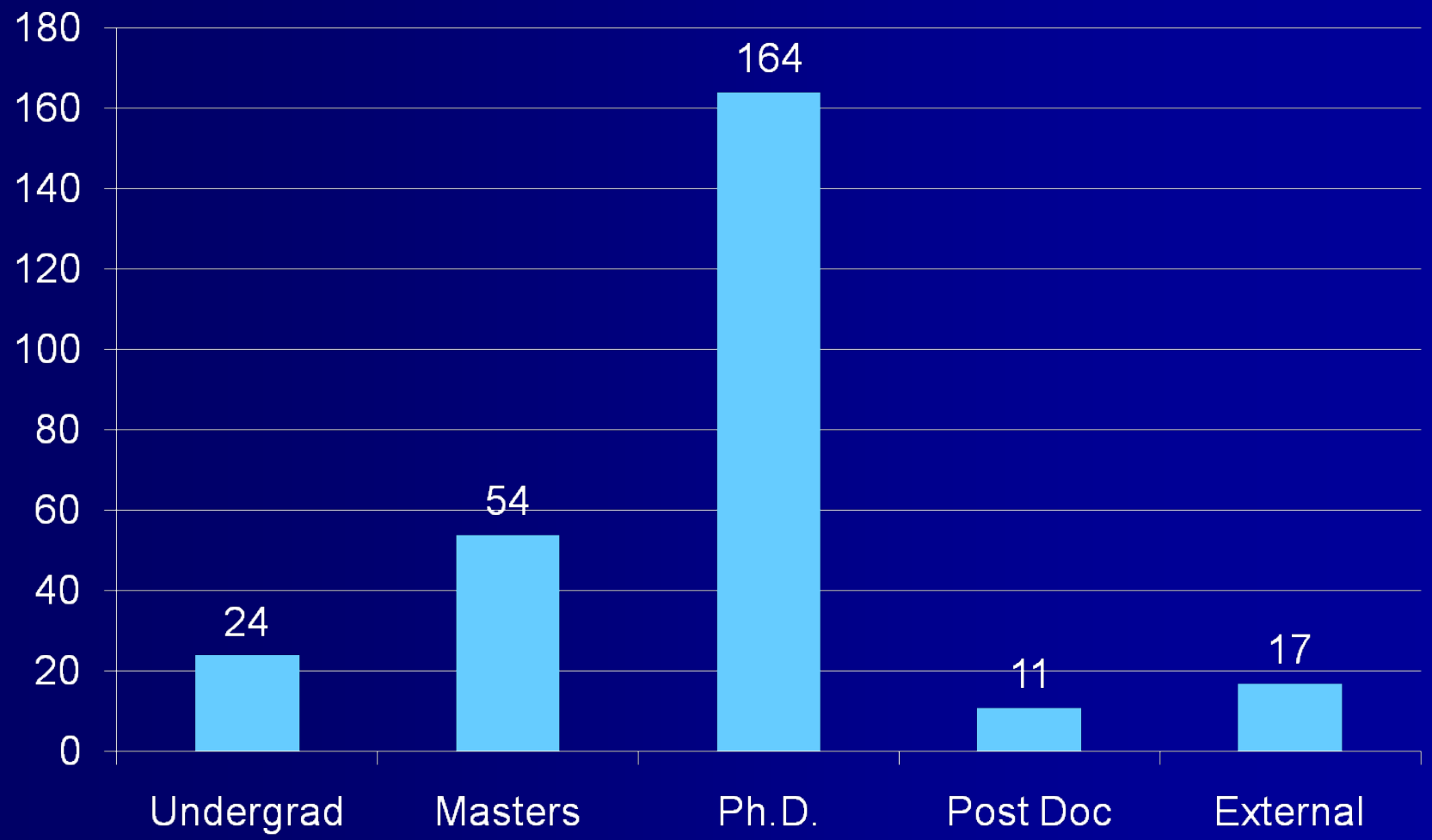
Users (Faculty, Student, Industry) Involved with NNRC

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

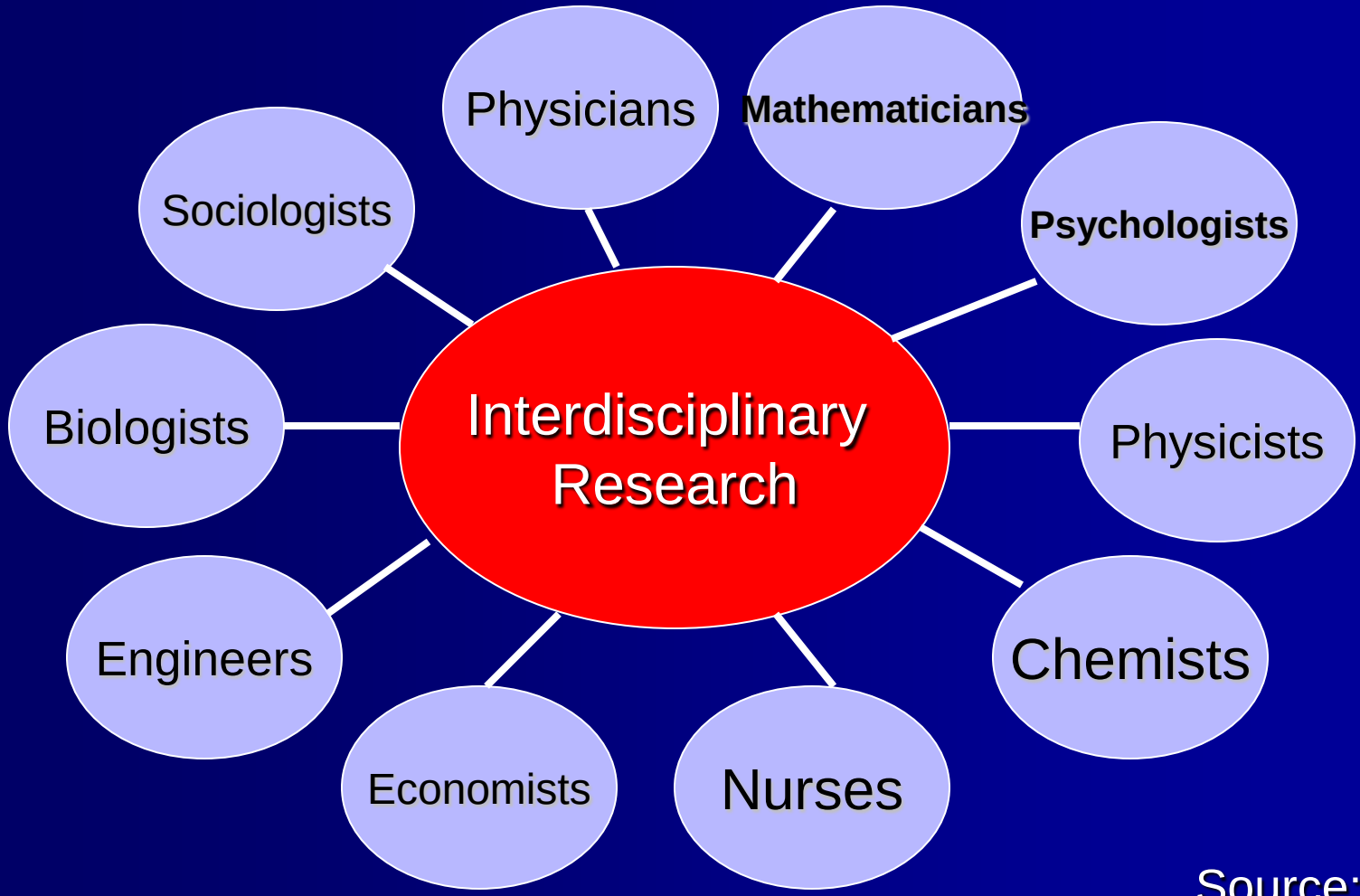
Physics, Biology, Chemistry, Medicine, Public Health, and all six departments in the College of Engineering.

Students and Post Docs	253
Faculty	32
Industry	41
Total	**326**

NNRC Promoting Big Time Graduate Education



Research Team of the Future



Source: NIH

Industrial Users of NNRC

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

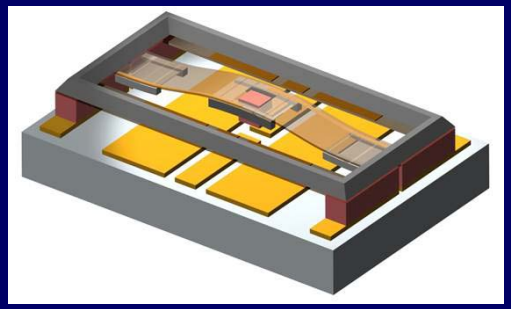
Modelithics Inc.
Applied Research and Development Inc
Ocean Optics Inc
VSEA, Inc. - Gloucester
Intelligent Micro Patterning, LL
Doosan HydroTechnology
Nano CVD Co
Ultrasonic Technologies, inc.
Globbal System International
General Atomics
CUBE Technology, Inc.
Ascent Healthcare Solutions
Howard Kay, Lilly,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

Tom Weller, Ph.D.
Professor, EE Department

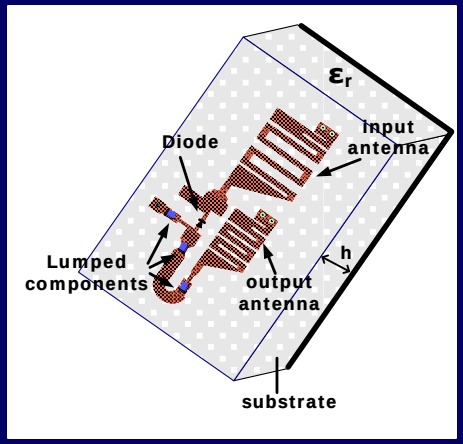
1986-1988	Environ. Res. Inst. Of Mich.
1988-1990	Hughes Space & Comm
1990-1995	University of Michigan
1995-	Univ. of South Florida
2001-	Modelithics, Inc. (co-founder)
B.S.EE	University of Michigan, 1988
M.Sc. EE	University of Michigan, 1991
Ph.D. EE	University of Michigan, 1995

Recent Research Highlights

- Ultra Low Power Electronics for Autonomous Micro-Sensor Applications, Sciperio
- Flexible Ferroelectric-Based Antenna Arrays for Conformal Radiometric Imaging, NSF
- Integrated Microwave Microneedle-Electrode for Fine Scale Material and Device Characterization, NSF
- Passive, Diamagnetic Inertial Sensing Integrated with High-Sensitivity Telemetry, NSF
- Functional Magnetic Polymer Nanocomposite Films for Tunable RF Device Applications, NSF
- Funding as Principal Investigator: $4.2M



Nanocrystalline Diamond RF MEMS Switch



Passive Harmonic Sensor Node

Prof. Jing Wang

EE Department

Research Areas:

Ultra Low Power Wireless Communicators
Sensors & Actuators in Micro-/Nano-Scale
On-Chip Energy Generation or Harvesting

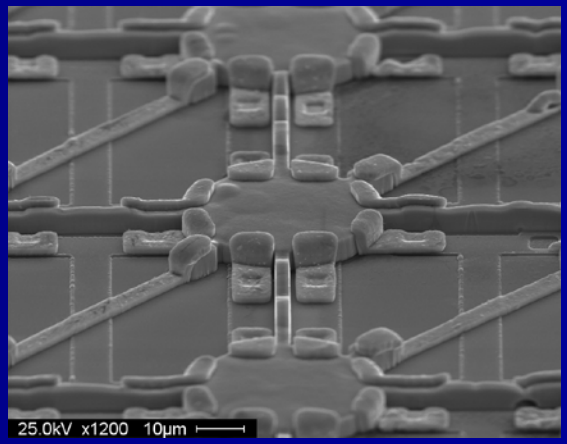
Research Highlights

Miniature On-Chip Filters, Raytheon, $190K (PI)
Passive, Diamagnetic Inertial Sensing Integrated with High-Sensitivity Telemetry, NSF, $270K (PI)
Development of a High-Density Cylindrical Ion Trap Array Mass Spectrometer using Micro-Fabrication Techniques, NSF, $143K (PI)
Uncooled Nanoscale Infrared High-Speed Sensors for Missile Seeker Applications, NanoCVD, $310K (PI)
Functional Magnetic Polymer Nanocomposite Films for Tunable RF Device Applications, NSF, $378K (Co-PI)

NNRC utilization

Oxidation, Photo Lithography, Wet and Dry Etching, Nanolithography Processes SEM, XRD, AFM, C-V measurements

Jing Wang's research group Spring 2010



Capacitively-Transduced On-chip MEMS Resonator Array with ALD high-k Dielectrics

Prof. Shekhar Bhansali

EE Department

Research Areas:

- Micro Bio/Chem/Gas/ impedance Sensors
- Magnetic/acoustic Actuators Nanostructures
- Integrated Systems – Microfluidics

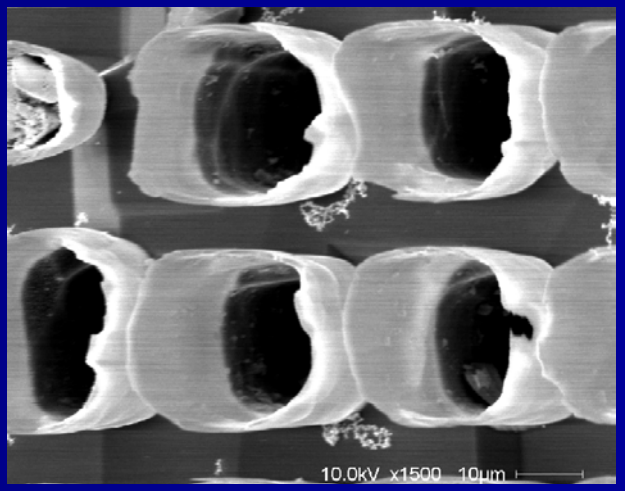
Research Highlights

- Bio-impedance characterization underway
- Interdisciplinary Research Education (IGERT-SKINS)
- Funding from NSF > $4M
- Developing nanometer interconnects at wafer scale

NNRC utilization

- Oxidation, Lithography, Wet and Dry, Processes SEM, XRD, AFM

Bhansali Research Group



Micro needle array

Prof. Rudy Schlaf

EE Department

Research Areas:

- Directed Assembly of Carbon Nanotubes
- Nano-Patterning Techniques
- Bio- and Polymer Interfaces

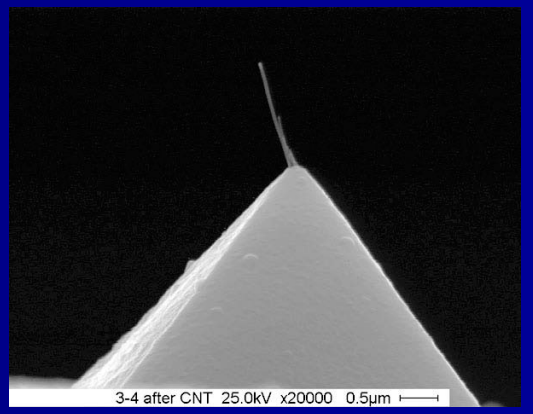
Rudy Schlaf's Group

Research Highlights

- Carbon Nanotube AFM Cantilevers
- First Electrospray Thin Film Deposition System
- Characterization of RNA- and Protein Interfaces

NNRC Utilization

- Electron Beam Lithography
- Suite of Metrology Tools (AFM, SEM)
- Thin film deposition



Single nanotube grown at 10 deg angle on AFM probe

Dr. Nagarajan Ranganathan
Distinguished Univ. Professor
CSE Department

1984-1988 Uni. of Central Florida
1988- Uni. of South Florida

Distinguished Professor
IEEE Fellow

B.S. EEE N.I.T., Uni. of Madras, 1983
Ph.D. CS Uni. of Central Florida, 1988

Recent Research Highlights

- Multi-metric Optimization Considering Process Variations in Deep Submicron and Nanometer Design, SRC
- A New Image Registration Algorithm and Its FPGA Realization for UAV, Tessera and NSF
- VLSI Clock Control Mechanism, Florida High Tech Corridor and EWI Corporation
- IEEE CAS Society VLSI Transactions Best Paper Award, 2009
- Low Power High Level Synthesis for Nanoscale CMOS Circuits, coauthored textbook, Springer, 2008
- 86 journal, 170 conference publications, 4 best paper awards, 3 edited books, 1 textbook, 6 patents & 3 pending

Prof. Venkat Bhethanabotla

Chemical & Biomedical Engineering Department

Research Areas

- Acoustic Wave Sensors
- Molecular Simulation
- Metallic Glass Thin Films
- IT Based Education

Research Highlights

- Demonstrated surface acoustic wave micro sensor for hydrogen
- Funding from NASA-Glenn, NSF, Agere Systems, Liquid Metal Technologies, and FDEP

NNRC Utilization

- Photolithography, SEM, XRD, AFM, and E-beam lithography

Venkat Bhethanabotla, Ph.D.

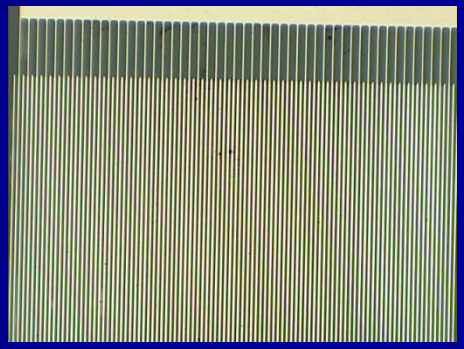


Photo-lithographed Inter-digital Transducer on SAW

Dr. Ashok Kumar

Department of Mechanical Engineering

Research Areas:

- Interconnect technology for microelectronics
- Diamond and carbon nanotubes for MEMS
- Nanostructured superhard coatings for machining applications
- Chemical and biological sensor technology

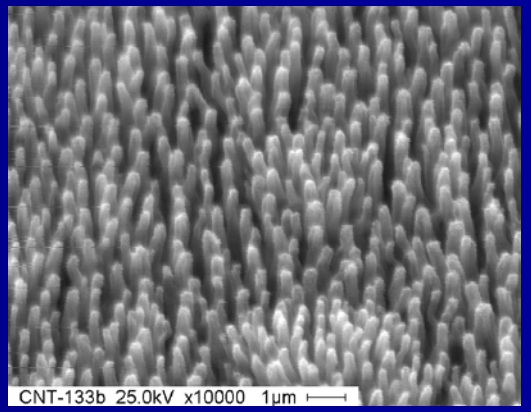
Research Highlights

- NSF CAREER Award
- Various NSF Grants (GOALI, NIRT MRI etc.) > $ 4 million
- Industry Grants (International Sematech, Novellus, General Motors, Agere Systems, Fractal Systems, Psiloquest, Honeywell) > $600K

NNRC Utilization

- SEM, EDAX, XRD, AFM,
- Cleanroom facilities (Oxidations, Lithography, Sputtering, Reactive Ion Etching etc.)

Dr. Ashok Kumar's Team



Carbon Nanotubes

Dr. Pritish Mukherjee & Dr. Sarath Witanachchi

Department of Physics

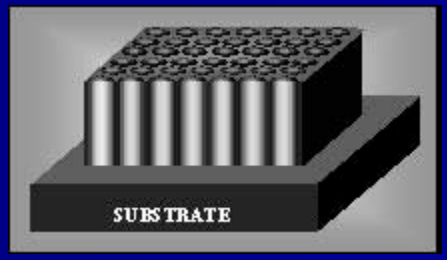
USF
UNIVERSITY OF SOUTH FLORIDA
COLLEGE OF ENGINEERING

Research Areas: (NSF & DOE funded)

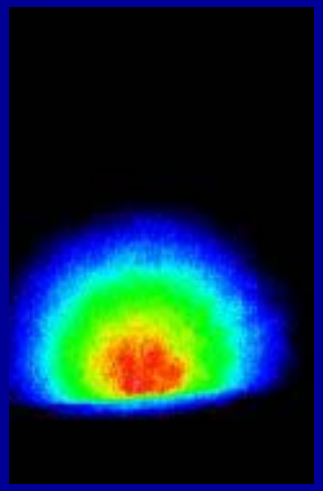
- Self-Assembled Nanotemplates for Manufacturing Dimensionally Controlled Nanostructured Films.
- Laser-triggered hollow-cathode transient plasma for a multi-component film manufacturing process.
- Fabrication of diamond structures for Microelectromechanical systems (MEMS).
- Dual-laser Ablation for Stoichiometric Large-area Multicomponent CuInGaSe2 Film Growth.
- Pulsed Laser Ablation for Manufacturing: A Novel Dual-laser Film Growth Process.

NNRC utilization

Characterization of films by XRD, AFM, SEM, and TEM (in the future)



Nanostructured film



Prof. Srikanth Hariharan

Physics Department

Research Areas:

- Magnetic Materials
- Nanoscience & Nanotechnology
  Thin films

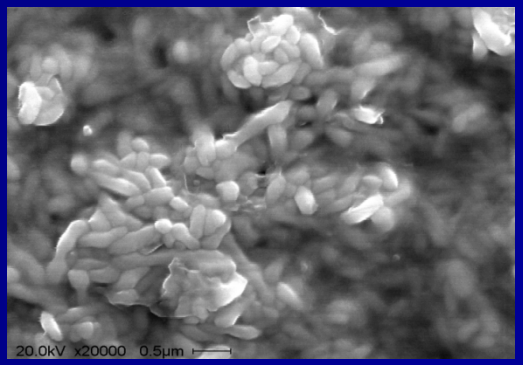
Research Highlights

- Current funding ~ $1.5 M from NSF, DOE and Army Research Office
- Tunable magnetism and RF properties in nanocomposite materials

NNRC utilization

- SEM, XRD, AFM
- TEM (in the future)
- E-beam deposition and lithography

Hariharan group



Platelet Barium ferrite grains imaged with SEM at NNRC

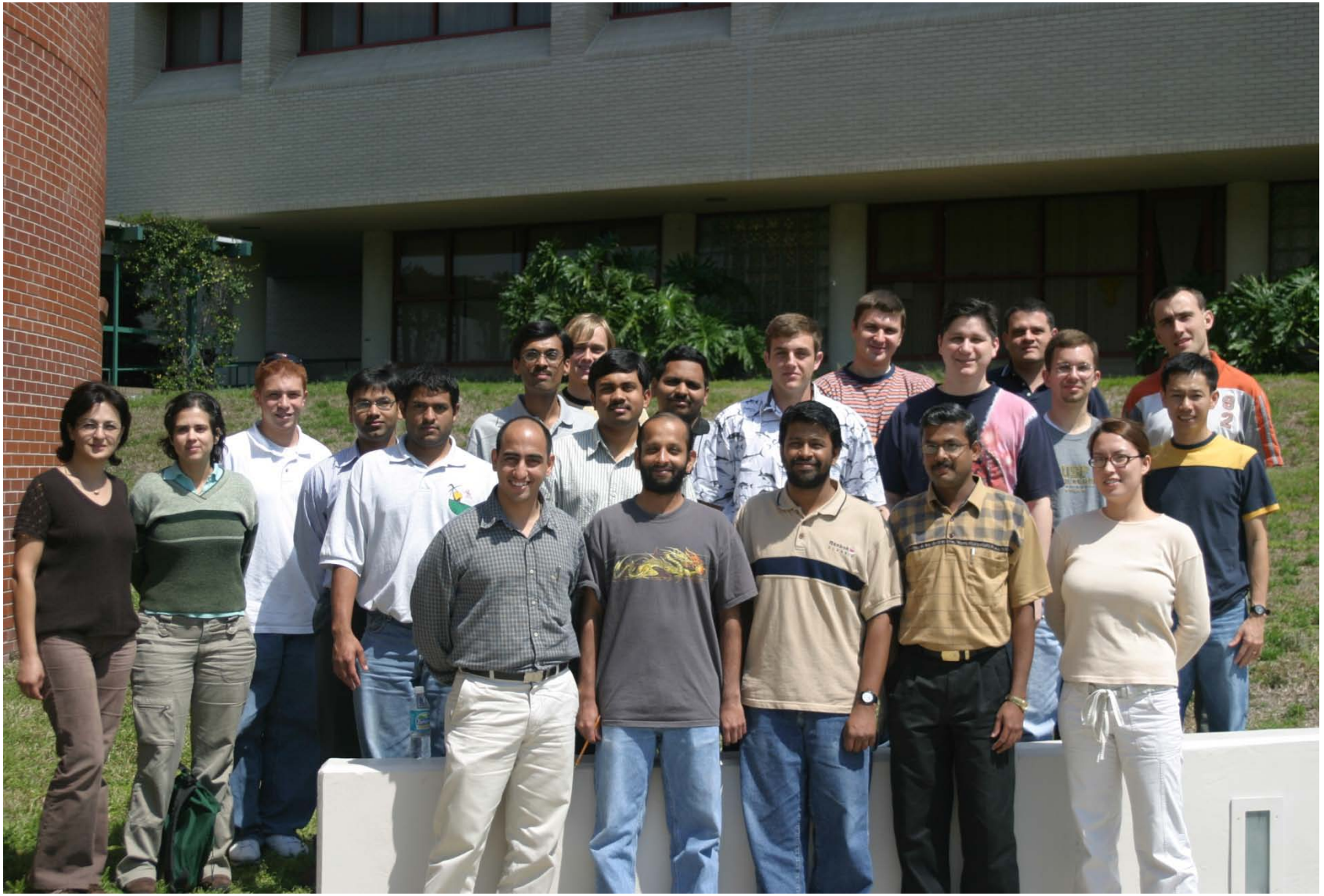
NNRC Trainings

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

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

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

NNRC Training Programs	# Sessions required	# per each Session	Duration of Training	NNRC Certification available-*
Bruce Furnace Training	3	4	2 hr/each	Yes
Cleanroom Safety	1	10	2 hours	Yes
General High Pressure gas bottle safety	1	6	1 hour	Yes
Karl Suss Mask Aligner	1	4	2 hour	Yes
Cleanroom Alphastep, Paxit, Rudolph, Ellipsometer, Profilometer	1	4	1.5 hour	
Plasma Therm Dry Etch	1	4	2 hours	Yes
Bruce Furnace Programming	2	2	2 hours	Yes
Lithography Spinners	1	4	1 hour	Yes
Atomic Force Microscope	3	4	2 hr/each	Yes
Hitachi SEM EDS	3	4	4 hr/each	Yes
Hitachi SEM Imaging	3	4	4 hr/each	Yes
Hummer X sputter	1	4	1 hour	
Jeol SEM Imaging	3	4	4 hr/each	Yes
Jeol SEM Litho	3	4	4 hr/each	Yes
Dektak, Microscope, Sopra, Ellipsometer, Profilometer	1	4	1.5 hour	
TEM	TBA	TBA	TBA	TBA
X-ray Difractometer	TBA	4	TBA	TBA
Aluminum Evaporator	TBA	4	TBA	Yes
CRC Sputter Tool	1	4	1 hour	Yes
E-beam Evaporator	2	6	4 hr/each	Yes
RTP Anneal	1	4	1 hour	Yes
***You must pass the training before you will be allowed to use the equipment/tools**				



NNRC Student Researchers

Impact of the NNRC – College of Engineering Diversity and Outreach Program

Recruitment, Education & Research Training

- Supported USF PhD recruitment initiatives via tours for potential students from Latin American (Mexico, Columbia, Venezuela) and US minority serving intuition.
- Since 2004, 33 graduate fellows have been NNRC users. These students have received over $1.5 million in federal (NSF, DHS, etc), state, and private fellowships.
- Education and career development: 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, 50+ conference presentations, 40+ conference/journal papers 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, etc.
- NSF and USF Research Experiences for Teachers Research-training of K-12 teachers and faculty from community colleges and minority-serving institutions

Education

- NNRC Staff support education with lectures and demonstrations
- This spring, the NNRC 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.

Education and Outreach

- NNRC wins “Best Internal Exhibitor” Award for EXPO
  - Staff and graduate student users gave more than 10 tours over both days
  - Demonstrations of:
    - vacuum technology
    - cryogenic superconductors (magnetic levitation)
  - Presentations on:
    - Cleanroom operations
    - Scanning Electron Microscope (insects, elemental mapping)
    - Transmission Electron Microscope (individual atoms)

Education and Outreach

- NNRC assists 3rd Grader to win science fair
  - Nathaniel Moura, student at W.B. Dickenson Elementary School
  - 1st place in Hillsborough Regional Science and Engineering Fair
  - “Will Nanosilver Leak Out of Socks When They Are Washed?”
    - Socks processed and tested
    - Hitachi Scanning Electron Microscope used for imaging silver nanoparticles

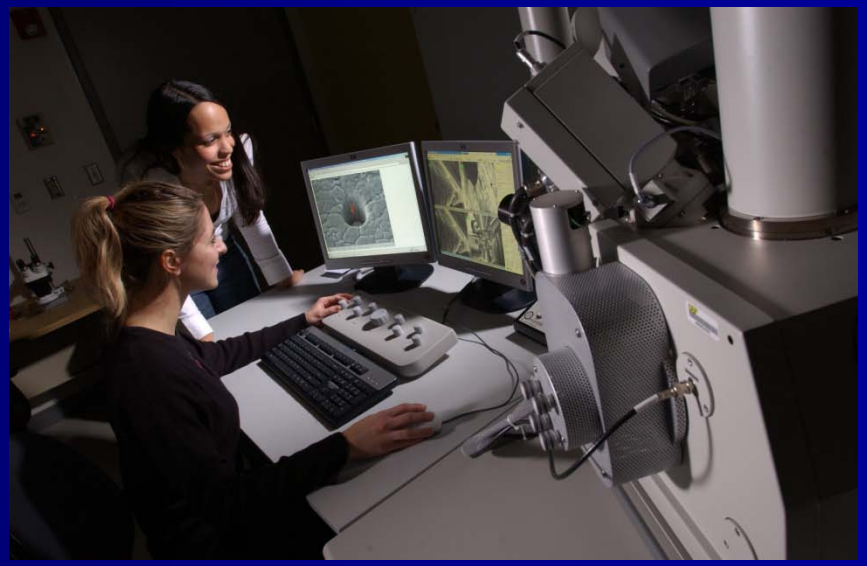
- Principle wrote a letter to Dr. Das, Associate Provost, thanking the NNRC staff for assistance

Interdisciplinary Graduate Program

in Materials Science & Engineering

- College of Engineering and College of Arts and Sciences Graduate Program

http://msc.usf.edu



MSE Materials Science & Engineering

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

Ibero-American Nanotechnology Centers Network

Research Centers / Industry / Funding Agencies / Non-profit Organizations / Universities

ISTEC / INAOE / UV / NNRC @ USF / UNINORTE / ULA / UNM /

- ✓ Faculty/Student Exchange
- ✓ Educational Initiatives
- ✓ Research Collaborations
- ✓ Community Engagement
- ✓ Technical Support
- ✓ Equipment & Supplies Acquisitions

istec
Ibero-American Science & Technology Education Consortium

UNIVERSIDAD DEL NORTE

UNIVERSIDAD VERACRUZANA
LIS DE VERACRUZ ARTE CIENCIA LUZ

The University of New Mexico

Nanomaterials and Nanomanufacturing Research Center

Instituto Nacional de Astrofísica, Óptica y Electrónica
INAOE
www.inaoe.gob.mx

Affiliated Centers

- **UNRC - USF Nanomedicine Research Center**
  The main mission of the UNRC is to bring together a dedicated, creative, interdisciplinary group of faculty and staff to conduct research on the application of nanoengineering methods and materials to the development of novel, highly effective and useful therapies and diagnostic methods for human diseases.

  UNRC and NNRC hosted **Nano-Bio Collaborative 2010 Symposium**

- **USF FCoE-BITT - Florida Center of Excellence for Biomolecular Identification and Targeted Therapeutics**
  A multi-purpose lab providing equipment, custom services, consultation and training for biological and interdisciplinary projects (biology, with chemistry and biomedical, chemical and electrical engineering components).

- **Clean Energy Research Center**
  The USF Clean Energy Research Center's fundamental investigations into new environmentally clean energy sources and systems (hydrogen, fuel cells, solar energy conversion and biomass utilization) meet the needs of power and energy producers and the transportation sector through multi-disciplinary research, technical and infrastructure development and information transfer.

Affiliated Centers

- **FLATE - Florida Advanced Technological Information Center**
  An NSF-ATE Regional Center for Advanced Technological Education. Aims to be the go-to organization for manufacturing and advanced technical education, best practices and resources supporting the high performance skilled workforce for Florida's manufacturing sectors.

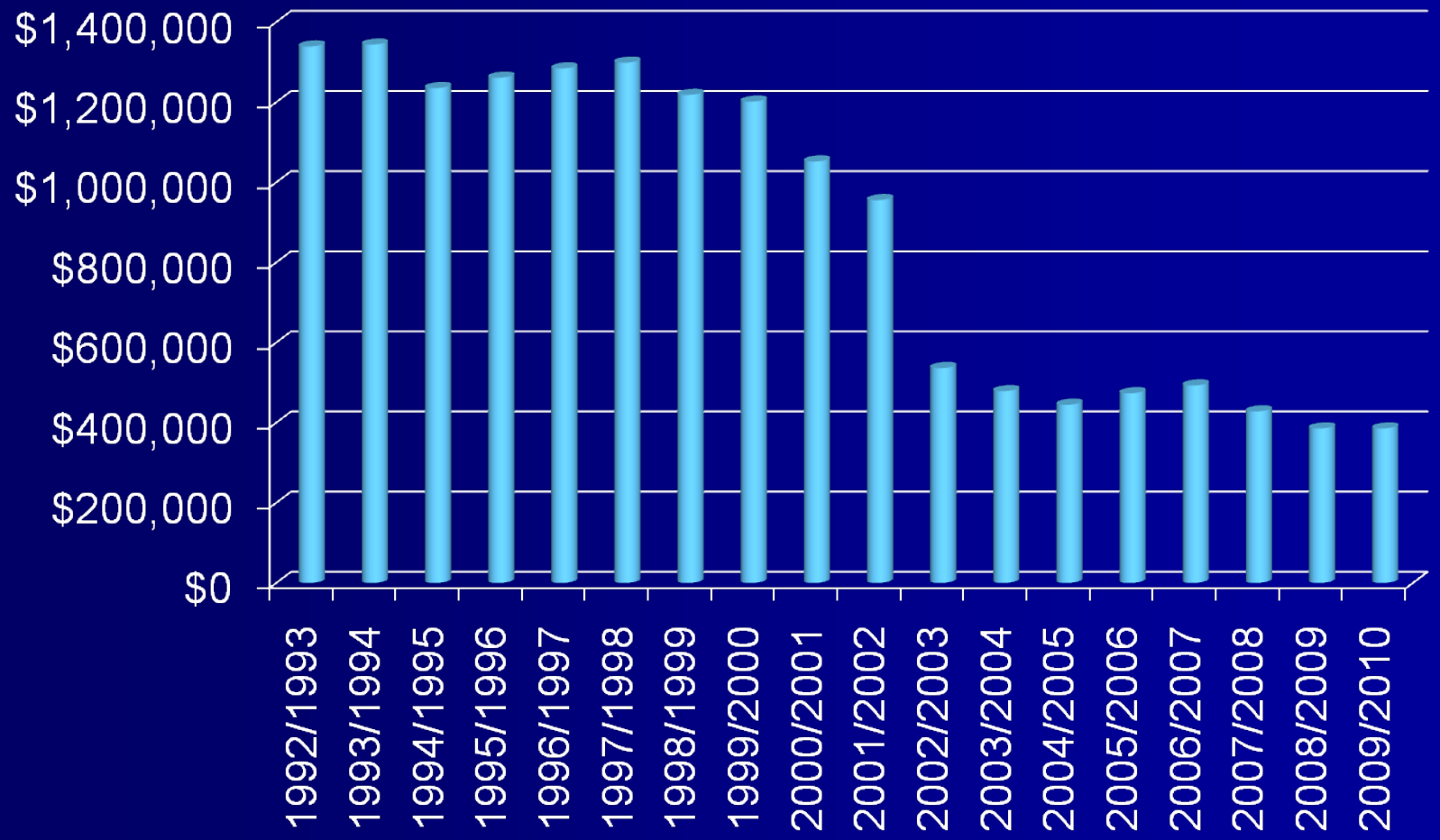
- **Moffitt Cancer Center**
  As part of an elite group of National Cancer Institute (NCI) Comprehensive Cancer Centers, Moffitt focuses on the development of early stage translational research aimed at the rapid translation of scientific discoveries to benefit patient care.

- **Byrd Altzheimers Institute**
  The USF Health Byrd Alzheimer's Institute is dedicated to the prevention, treatment and cure of Alzheimer's disease and related disorders. The Institute is both a physical location that provides state-of-the-art services to persons living with Alzheimer's disease and a coordinating and facilitating agent for all of the state's varied efforts to prevent, diagnose, treat, and support caregivers of persons with Alzheimer's disease.

National Context

- Berkley
- Georgia Tech*
- Stanford
- Albany
- NC State
- Cornell
- Michigan
- Illinois
- UCLA
- Princeton
- Yale
- UT Austin

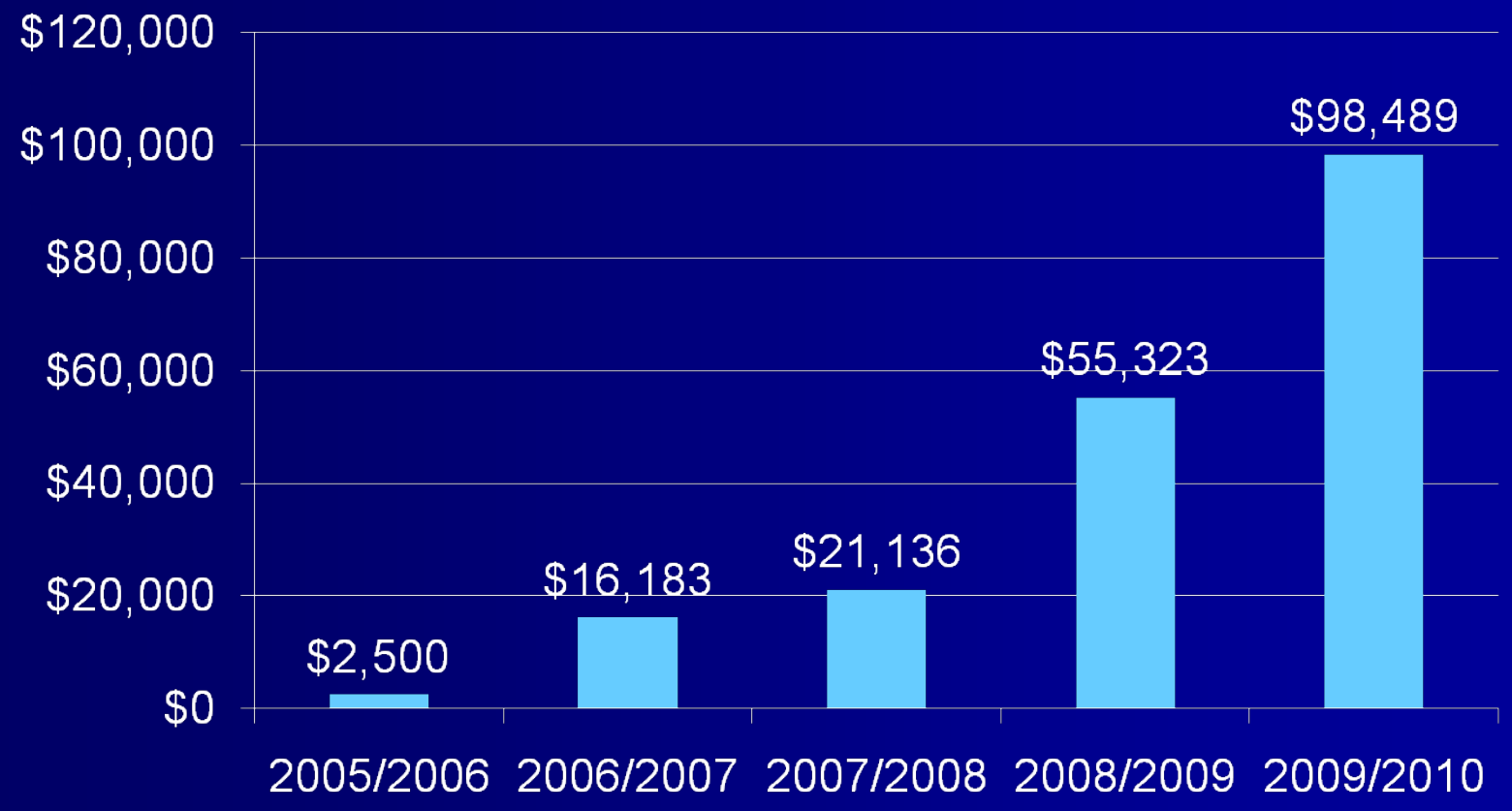
NNRC (CMR) Budget History



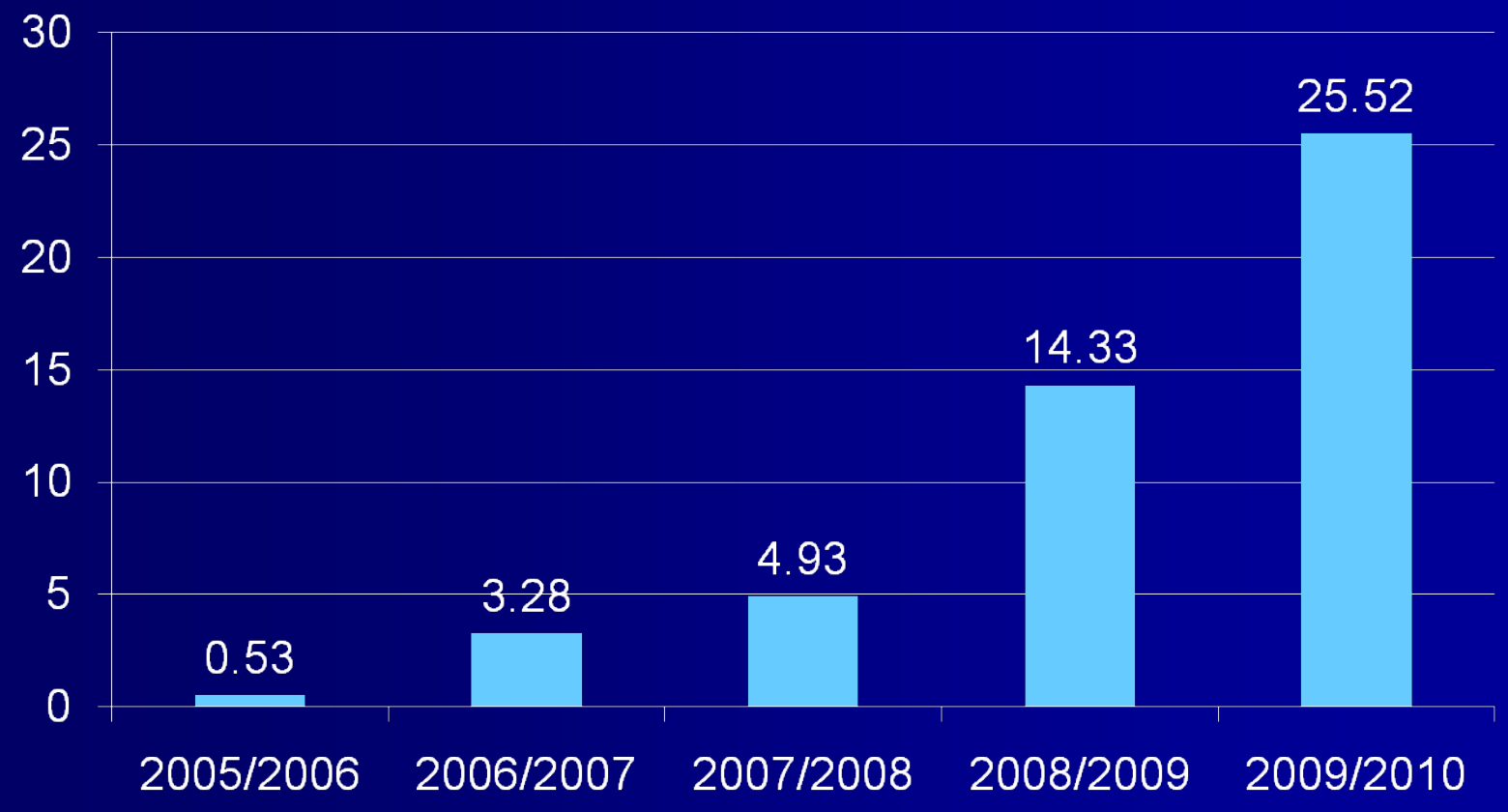
NNRC Users Billed for Cost Recovery (estimated 2009/2010)

- Student Users
  - $96,000 (48 students on flat rate, $2000 each per year) + time billed users (approx $20k)
- Industrial Users
  - $98,489 (billed, to date)

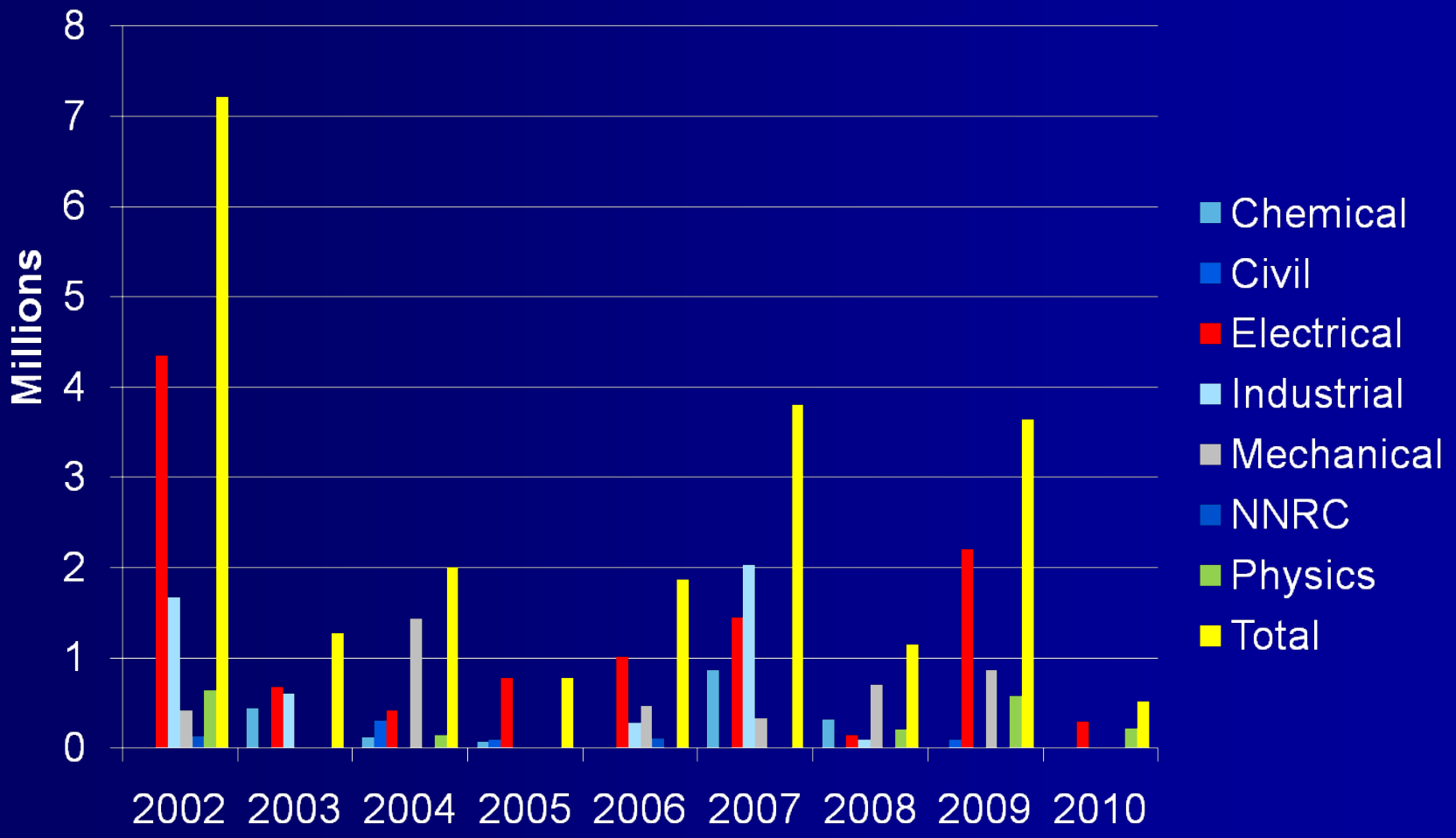
NNRC Cost Recovery (Industry Users)



Cost Recovery Percentage (Industry Users)



NNRC helping to bring Federal Grants (NSF only)



NNRC Future Initiatives

- Become a member of NSF Nanotechnology, Infrastructure Network (NNIN)
- Initiate for Center Proposals
  - Materials Science & Engineering Research Center
  - Engineering Research Center
- 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)


THANK YOU!


USF