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http://www.cnf.cornell.edu/cnf_2011cnfra.html
# Table of Contents

2010-2011 CNF Research Accomplishments Reports, by Section .................................................. i-vi
2010-2011 CNF Research Accomplishments Introduction .......................................................... vii-viii
2010-2011 CNF-Research Related Patents, Presentations, and Publications ................................... ix-xxxvi
Commonly Used Abbreviations and Their Meanings................................................................. xxxvii-xl

**Biological Applications** .................................................. 2-63

- Construction of Synthetic Gel Metrics ................................................................. 2
- Retinal Implant Project .................................................................................. 4
- Microfluidic Cell Culture Analog Devices to Mimic Animal Exposures to Toxins and Drugs .... 6
- Nanofluidics for Single Molecule Sorting .................................................................. 8
- An Array of Planar Apertures for Near-Field Fluorescence Correlation Spectroscopy .......... 10
- Microfluidic Device for Extraction of DNA from Selected Cells .................................. 12
- Investigation of Functional Electrospun Bionanofibers in Microfluidic Channels ............. 14
- Ultra-Sensitive Biodetection Using Photonic Crystal Nanocavities ............................... 16
- Electrochemical Detection of Neurotransmitter Using CMOS IC Biosensors ............... 18
- Revealing the Conformational Change of SNAP-25 during Exocytosis using Electrochemical Detectors and TIR-FRET Imaging .............................................. 20
- Microring Resonator Bacteria Sensing ...................................................................... 22
- Microfluidic Materials .......................................................................................... 24
- Effect of CKCL12 on Tumor Cell Migration using a 3D Microfluidic *in vitro* Model ........ 26

Index of Reports by CNF Project Number ................................................................. 271
Index of CNF Principal Investigators and Users ....................................................... 272-276

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**The 2010-2011 Cornell NanoScale Facility Research Accomplishments**

Charles Harrington Photography
### Biology, continued

- Silicon Nitride Cantilevers for Muscle Sarcomere Force Measurements ..........................28
- Nanofountain Probes for the Delivery of Molecular Inks ..........................30
- Single Protein Detection Using a Microfluidic System ...........................................32
- DNA Methylation Profiling in Nanochannels ..................................................34
- Three Dimensional Microscale Niches for Studies of Tumor Angiogenesis ..........36
- Circulating Tumor Cell Release by use of Novel Immunocapture Chemistry in GEDI Microdevices ..........................38
- A Laminar Flow Microfluidic Device for Quantitative Analysis of Electrochemical Activity of Bacteria ..........................40
- Utilizing Micro-Patterned Protein Surfaces to Investigate the Properties of the Lysosomal Synapse .........42
- Microgeometries and Photonics for Studying Cell Mechanics and Cancer Metastasis ..........................44
- Micropatterned Hydrogel Substrates of Tunable Stiffness ..................................46
- Suspended Carbon Nanotube Devices for Single Molecule Sensing ..........48
- Development of Teaching Labs for the New Course Biologically Inspired Microsystems Engineering ..........................52
- X-Ray Lab on a Chip: A Microfluidic Mixing System for Small-Angle X-Ray Solution Scattering ..........................54
- A 3D Microfluidic in vitro Model for Cancer Cell Migration and Invasion Under Flow Effect ............56
- Fabrication of Flexible Microelectrodes for Chronic Implantation ....................58
- Moisture Responsive Artificial Micro-Pores in a PEGDA Membrane with Anisotropic Swelling Properties ....60
- Multichannel Microfluidic Device for Tracking Cell Lineages ..........................62

### Chemistry

- The Investigating of Graphene Chemistry using Scanning Electrochemical Microscopy ..........................64
- Chemical Bonding Across the Periodic Table at High and Ambient Pressures ..........................................66
- Compound-Specific Isotope Analysis of Carbon Using a Micro-Fabricated Micro-Reactor and Cavity Ring-Down Spectrometry ..........................68
- Imaging Reactive Sites on Carbon Materials during Electrochemical Reaction ..................70
- Oriented 2D Covalent Organic Framework Thin Films on Single-Layer Graphene ..........................72
- Mid-Infrared Transparent Substrate for Alkylsiloxane Monolayers ...........................................74
Materials \( \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots}
### Mechanical Devices

- Stress-Based Ethanol Sensing with Functionalized Resonant Microbridge at Critically-Buckled State .......... 134
- Large-Scale Production of Graphene Resonators with Enhanced Performance .......... 136
- Rapid Serial Prototyping of Magnet-Tipped Cantilevers .......... 138
- Towards a Graphene-Based Electromechanical Switch .......... 140
- Graphene Mechanical Resonators .......................................... 142
- A Bio-Inspired Low-Noise Differential Microphone with Optical Detection ....................... 144
- 6.4 GHz Acoustic Sensor for *in situ* Monitoring of AFM Tip Wear ....................... 146
- MEMS-Integrated MRA for use in Multi-Band/Mode Communication Systems Operating within the Public Safety Bands (700-4900 MHz) .............. 150
- Batch Compatible Integration of Nanoscale Samples and MEMS Devices .......... 152
- Non-Linear Dynamics of Coupled MEMS Oscillators .......... 154
- Fabrication of All-Thin-Film Magnetoelectric Devices on Micromachined Silicon Cantilevers .......... 156
- A Microfabricated Low Cost Enzyme-Free Glucose Fuel Cell for Implantable Devices .......... 158

### Optics & Opto-Electronics

- Slow-Light Dispersion in Periodically Patterned Silicon Microrings .......... 160
- Transformation Optics on a Silicon Platform .......... 162
- Non-Blocking Operation of a Silicon Optical Filter with Doubled FSR .......... 164
- Optical Bistability in Etchless Silicon Ring Resonators .......... 166
- Optical Frequency Conversion in Silicon Waveguides at Mid-Infrared Wavelengths .......... 168
- Waveguide-Integrated Telecom-Wavelength Photodiode in Deposited Silicon .......... 170
- 3D Backend CMOS Optics Integration Using Compatible Materials and Processes .......... 172
- Fabrication of Nanofluidic Channels on Fused Silica Wafers .......... 174
- Porous Polymer Waveguides and Ring Resonators .......... 176
- Microring-Based Optical Pulse Train Generator .......... 178
- Reconfigurable Photonic Systems from Optofluidic Waveguides .......... 180
- Advancements in Microfluidically Reconfigurable Photonics .......... 182
- Thermal Characterization of an Opto-Fluidic Photonic Crystal .......... 188
- Highly Sensitive Spectroscopic Interferometers Using Photonic Crystal Structures .......... 190
- Nanoscale Photonic Biosensors from Biological Building Blocks .......... 192
- Three-Dimensional Metallo-Dielectric Photonic Crystal Thermal Emission through Electrical Bias .......... 194
- Antireflective Conductive Metamaterial Films for Silicon Solar Cells .......... 196
- Nanomanipulation using SiN Photonic Crystal Resonators .......... 198
- Creation of Magnetic Janus Particles .......... 200
- Demonstration of an *n-i-p-i* Photovoltaic Device .......... 204
- The Effect of Annealing on the Spin-Transfer Torques of Magnesium Oxide Magnetic Tunneling Junction Nanopillars .......... 206
A Three-Terminal Spin Transfer Torque Device.................. 208
High Voltage Pulse Measurement of Microwave Emission
and Spin-Torque Effects in Magnetic Tunnel Junctions...... 210
Fabrication of Charge-Density-Wave
Conductor Field Effect Devices........................................ 212
Giapor Proximity Effects in Confined Superfluid 4He........ 214
X-Ray Imaging of Magnetic Normal Modes Driven
by Spin Transfer Torque in Magnetic Nanopillar Devices ... 216
Nanoscale Superconducting Microwave
Cavities for Ferromagnetic Resonance Studies .............. 218
Fabrication of Mechanically-Adjustable Devices
with Two Opposing Graphene Electrodes...................... 220
Spin Torque Oscillations in a Hybrid Structure with
both In-Plane and Perpendicular Anisotropy Layers........ 222
Plasmon Resonance in Individual Nanogap Electrodes Studied
Using Graphene Nanooonstrictions as Photodetectors..... 224
Making an Electric-Field-Controlled Giant
Magnetoresistance Device Using Multiferroic Material.... 226
Dissipation in Ultrathin Membranes................................. 228
Vortex Dynamics
in Nanofabricated Superconducting Devices............... 230
Melting Dynamics
of Colloidal Crystals on Patterned Surfaces................. 232
Microfluidic Chambers
for Studies of Confined Superfluid He-3..................... 234
Persistent Currents in Normal Metal Rings...................... 236
Quantum-Limited Measurement
and Entanglement in Superconducting Circuits............ 238
Magnetic Tunnel Junction Based
Orthogonal Spin Transfer Devices............................ 240
Magnetic Fringe Fields Control of Electronic Transport
in Organic Thin Films: Organic Semi-Spin-Valves........ 242
Fabrication of Nanoscale Josephson Junctions
for Quantum Coherent Superconducting Circuits........ 244
Carbon Nanotube p-i-n Diodes of Known Chirality........ 246
Improved Materials for High-Performance
Superconducting Quantum Circuits............................ 248
Dynamical Bifurcation
in a Superfluid 4He Josephson Junction..................... 250
Electronic Structure Calculations for Cr1-xAlx............ 252
Thermoelectric Properties
Measurement of 1D Nanostructures............................ 254
High Resolution Reversible Color Images
on Photonic Crystal Substrates................................. 256
Fabrication of Superconducting Devices
for Quantum Information Science............................. 258
Photonic Crystal Nanocavities
for Solid State Quantum Optics.............................. 260
First-Principles Study of the
Surface Chemistry of Metal-Oxide Nanostructures....... 262
Process & Characterization . . . . 264-270

Fabrication of Field Effect Transistors .................................. 264
Nano-Scale Devices for Biosensor Applications ..................... 266
Characterization of Graphene Obtained by Chemical Vapor Deposition ............................................. 268
Introduction

This Research Accomplishments publication highlights research projects carried out Cornell NanoScale Science and Technology Facility (CNF) in the past year, selected from the work of our approximately 700 new or continuing users.

We wish to thank our users for their contributions to this publication, and we hope that you will find this collection of work to be instructive and impressive, both for the quality of the research and for the range of fields in which the tools of nanotechnology are enabling new breakthroughs.

CNF is supported through funding to the National Nanotechnology Infrastructure Network (NNIN). NNIN is an integrated network of fourteen university-based user facilities established March 2004 and supported by the National Science Foundation to serve the needs of nanoscale science, engineering and technology. NNIN provides users from across the nation—from academia, small and large industry, and government—with open access to leading-edge tools, instrumentation, and capabilities for fabrication, synthesis, characterization, design, simulation, and device integration.

We welcome inquiries from all researchers, especially those with no previous experience in nanofabrication, since the outstanding staff members of the NNIN are highly skilled at teaching new users. The NNIN also conducts extensive education, training and outreach activities for the general public. Additional information about NNIN can be found at www.nnin.org.

CNF News; New Equipment and Capabilities

The CNF has installed many new tools in the past year that are now available to users. Please see the CNF web site for the names of the staff members to contact for training.

- **SUSS Gamma Automatic Spin/Spray Coat/Develop Tool:** automated photoresist and wet processing system designed to meet needs for clean, reliable and high throughput wafer spinning, baking, developing, and spray coating of conformal resists, on 100 mm to 200 mm wafers. Together with the Heidelberg Mask Writer and ASML DUV (248 nm stepper), the Gamma tool gives the CNF the capability for highly reliable and high-throughput DUV lithography.

- **SUSS Substrate Conformal Imprint Lithography (SCIL) System:** improving our capabilities for imprint lithography.
• **FirstNano Graphene and Carbon Nanotube Growth Furnace**: chemical vapor deposition growth on substrates up to four inches in diameter.

• **Primaxx Vapor Phase HF Etching Tool**: designed to make MEMS devices and other released structures without the need for critical point drying.

• **Improved Facilities for Spinning and Baking SU8 and PDMS**: expanding our capabilities for microfluidics users.

• **AJA Sputter Deposition System**: a five-target, single-wafer system designed to eliminate processing bottlenecks associated with CNF’s existing sputter system.

• **Hitachi FB-2000A Focused Ion Beam (FIB) System**: capable of milling a variety of metals, semiconductors and insulators as well as depositing tungsten.

• **Wyko White Light Interferometer**: to modernize our optical profiling capability.

• **Improved Optical Microscopes, Cameras, and Software**: installed throughout the lab, and designed to provide a more consistent software interface.

### Computation and Modeling

In addition to providing cleanroom tools for nano-fabrication, CNF and the NNIN also provide resources and training for high-performance scientific computation. This includes, at CNF, an Intel cluster with 152 Xeon processors comprising 288 computing cores on which users may perform simulations using a wide range of software for electronic structure calculations, nanophotonics simulations, molecular dynamics, modeling of electronic and thermal transport, quantum chemistry, and a “virtual vault” with information about a variety of pseudopotentials. Dr. Derek Stewart serves as CNF’s Scientific Computation Research Liaison, and is available to introduce new users to existing codes, to help modify codes for new applications, or to construct new computational approaches as user needs may require. For more information, please contact Dr. Derek Stewart at stewart@cnf.cornell.edu.

### Educational Outreach

The CNF participates in numerous educational outreach activities, both alone and as part of NNIN. One network-wide program is the NNIN Research Experience for Undergraduates (REU) Program. During the summer of 2011, 85 undergraduate students (selected from over 850 applications) participated in the 10-week NNIN REU internship program of focused research in micro and nanotechnology. Twelve of those interns spent their summer in Ithaca, working with Cornell faculty, graduate students and CNF staff. Graduates of the NNIN REU program are eligible to apply for the NNIN International REU program with placement in nanotechnology labs throughout Europe and Japan. The research accomplishments of the REU students can be viewed at http://www.nnin.org/nnin_reu.html. We are grateful to the National Science Foundation for their continued funding support for the Research Experience for Undergraduates activities, but we also seek corporate funds to augment this program. Please contact Dr. Lynn Rathbun, NNIN Program Manager, to discuss corporate sponsorship (rathbun@cnf.cornell.edu).

CNF continues to host many educational workshops and special events at Cornell. Twice each year (in January and June) we offer a short course, “Technology & Characterization at the Nanoscale” (CNF TCN), open to participants from academia, industry, and government. It includes lectures and demonstrations, and also hands-on lab activities in the cleanroom. Find out about the January 2012 CNF TCN at http://www.cnf.cornell.edu/cnf5_courses.html

Over the past year, CNF has hosted visits and tours for over 1100 people; from prospective graduate students and incoming faculty members, to visiting dignitaries and corporate executives, to school children. These include over 35 distinct visits and events. We particularly enjoy meeting and working with high school students—introducing them to the nano-world we live in and getting them into “bunny” suits for a tour of our cleanroom. We also have events specifically designed for the many elementary school students who visit us. The possibilities of science open to them as they discover vegetable batteries and sound/wave dynamics. Contact Ms. Melanie-Claire Mallison with your visit requests (mallison@cnf.cornell.edu).

**As always, we welcome your comments about CNF and its operations, as well as suggestions for improvements.**

**Dan Ralph**
Lester B. Knight Faculty Director

**Donald Tennant**
Director of Operations


“Ab-Initio Heat Transfer: Predicting Thermal Transport in Nanostructures and Materials from the Atoms Up”; D. A. Stewart (invited talk), Condensed Matter Seminar Series, Case Western Reserve University, Cleveland, Ohio, April 4th, 2011. CNF Staff Computation Project, Cornell


“Advancements in Photonic Crystal Resonators for Optical Trapping”; Serey, X., Chen, Y.-F., and Erickson, D., EOS 1st Conference on Optofluidics, Munich, Germany (May 2011). CNF Project # 1857-10, Cornell


“All-Thin-Film Multiferroic Magnetic Field Sensors”; I. Takeuchi, T. Onuta, et al, Summer Workshop on Oxide Devices, Tokyo, Japan, July 2010. CNF Project # 1840-09, University of Maryland - College Park


2010-2011 Research Accomplishments

Engineering Congress Exposition, Nov 12-18, 2010, Vancouver, British Columbia, Canada. IMECE2010-38179. CNF Project # 1116-03, Binghamton University


“Capture and Analysis of CTCs in Geometrically Enhanced Differential Immunocapture Microdevices”; Kirby BJ; CHI Meeting on Circulating Tumor Cells (CTCs) for Cancer Detection, Diagnosis, Prognosis and Treatment, San Francisco, CA, 23-25 Feb 2011; Leiden, the Netherlands, 7-11 Feb 2011. CNF Project # 1639-08, Cornell


“Carbon Nanotube Placement by Dielectrophoresis: Elucidating the Shutoff Mechanism”; Davis, B; Conley, H; Jones, D; Hustedt, C; Barrett, L; Davis, R; Brigham Young University College of Physical and Mathematical Sciences Spring Research Conference (2011). CNF Project # 1784-09, Brigham Young University

“Carbon Nanotube Transistors for Protein Sensing Applications”; Minot, E. D. SPIE Optics and Photonics Conference Invited Talk, San Diego, CA; (Aug 2010). CNF Project # 1881-10, Cornell


“Cautionary Tale of Two Basis Sets and Graphene, A”; D. A. Stewart, accepted for publication in Computing in Science and Engineering (2011) [http://doi.ieeecomputersociety.org/10.1109/MCSE.2011.54] CNF Staff Computation Project, Cornell


“Characterization of Small Diameter in vitro Endothelial Linings of the Microvasculature”; Esch MB, Shuler M, Stokol T, Annual meeting of the Biomedical Engineering Society, October, Austin, TX (2010). CNF Project # 1465-06, Cornell

“Chemical and Biological Sensing with Photonic Crystal Devices Made of Silicon”; P. Fauchet, Invited Presentation, Workshop on Frontiers in Silicon Photonics, Beijing, China, August 2010. CNF Project # 810-99, University of Rochester


“Controlled Placement of Carbon Nanotubes using Massively Parallel Indirect Dielectrophoresis”; Davis, B; Conley, H; Hustedt, C; Jones, D; Barrett, L; Harb, J; Wheeler, D; Wooley, A; Linford, M; Davis, R; NanoUtah: Utah Statewide Nanotechnology Conference (2010). CNF Project # 1784-09, Brigham Young University

“Controlled Storage of Light in Silicon Cavities”; A.W. Elshaari, A.A. Aboketaf, and S.F. Preble, Optics Express,18, 3014-3022 (2010). CNF Project # 1950-10, Rochester Institute of Technology


“Device for Rapid Identification of Nucleic Acids for Binding to Specific Chemical Targets”; Craighead HG; Patent Application, 4422-03-US, 13/059,223, 2/15/11. CNF Project # 762-99, Cornell


“Does Chaos Unstir Better?”; A. Stroock, van Ness Award Lecture, Department of Chemical and Biomolecular Engineering, Rensselaer Polytechnic Institute, Troy, NY, October 13, 2010. CNF Project # 1119-03, Cornell


“Effects of Interfacial Organic Layers on the Growth of Thin Al2O3, HIO2 and TaNx Films by Atomic Layer Deposition, The”; K.J. Hughes, S. Isaacson and J.R. Engstrom, A VS 57th International Symposium, Albuquerque, NM, October 2010. CNF Project # 1111-08, Cornell

“Effects of Interfacial Organic Layers on the Growth of Thin Al2O3, HIO2 and TaNx Films by Atomic Layer Deposition, The”; K.J. Hughes, S. Isaacson and J.R. Engstrom, A VS 57th International Symposium, Albuquerque, NM, October 2010. CNF Project # 1111-08, Cornell


“Electrostatic Actuation of Silicon Optomechanical Resonators”; S. Sridaran and S.A. Bhave, Optics Express 19 9020-9026 (2011). CNF Project # 1380-05, Cornell


“Engineering 3-D Microscale Niches for Studies of Oxygen Dependent Tumor Angiogenesis”; Verbridge, SS; Choi, NW; Zheng, Y; Williams, RM; Chen; J; Kim, JY; Smeheh, R; Zipfle, WR; Stroock, AD; Fischbach, C; Biomedical Engineering Society Meeting, Austin, TX, 2010. CNF Project # 1540-07, Cornell


Charles Harrington Photography
“Epigenetic Profiling in Nanochannels”; S.F. Lim, A. Karpusenko, J.J. Sakon, J.A. Hook, T.A. Lamar, R. Riehn; March meeting of the APS, Dallas, TX, March 2011. CNF Project # 1483-06, North Carolina State University


“Evanescent Coupling to the Slow Photons in Oxide-Clad Silicon Microcavities”; S.P. Anderson, P.M. Fauchet, Optics Letters, in press. CNF Project # 863-00, Cornell

“Experimental Demonstration of Evanescent Coupling and Photon Confinement in Oxide-Clad Silicon Microcavities”; S.P. Anderson, P.M. Fauchet, in press. CNF Project # 810-99, University of Rochester


“Explaining the semiconducting Behavior in Antiferromagnetic Cr3Al”; Z. Boekelheide, invited talk, NIST Magnetic Materials Group, NIST-Gaithersburg, May 20 2011. CNF Project # 1845-09, University of California-Berkeley

“Explaining the Semiconducting Behavior in Cr3Al”; Z. Boekelheide, invited talk, Materials Research Society Graduate Student Seminar Series, UC-Berkeley, April 5 2011. CNF Project # 1845-09, University of California-Berkeley


“Fabrication of Integrated Nanomagnets Overhanging Batch-Fabricated Attonewton-Sensitivity Cantilevers”; Longenecker, J; Hickman, S; Moore, E; Lee, S; Wright, S; Harrell, L; Marohn, J; AVS 57th International Symposium, Albuquerque, NM (2010). CNF Project # 863-00, Cornell


“FET-Based Biosensors: Capabilities and Challenges”; E. C. Kan (invited talk), Circuits and Systems for Medical and Environmental Applications 2nd Workshop, Merida, Mexico, Dec. 13-15, 2010. CNF Project # 715-98, Cornell

“First Principles Computational Study of Anatase TiO2 and the Three Layered Aurivillius Compound Bi2La2Ti3O12, A”; Koch, R., Thesis submitted to the Faculty of the N.Y.S. College of Ceramics at Alfred University for the Degree of Bachelor of Science in Ceramic Engineering, Advisor: Dr. Alastair Cormack, May 2011. CNF Staff Computation Project, Cornell


“From Traditional MEMS to ‘Hybrid’ MEMS”; S.A. Bhave, Condensed Matter Physics Seminar, Syracuse, October 1, 2010. CNF Project # 1380-05

“From Traditional to Revolutionary NEMS”; S.A. Bhave, Intel, Hillsboro, OR, January 7, 2011; Texas Instruments, Dallas, TX, February 25, 2011. CNF Project # 1380-05


“Giant Coupling Effects in Confined 4He Near Tc”; Gasparini, F; the International Symposium on Quantum Fluids and Solids, (2010). CNF Project # 526-94, University at Buffalo


“Got MEMS?”; S.A. Bhave, Microsoft Research, Redmond, WA, May 23, 2011; Robobees Seminar, Harvard University, June 17, 2011. CNF Project # 1380-05


“Hazardous Waste Concerns and Solutions in a Microelectronics Project # 459 and P.F. Ma, U.S. Patent 7,829,150 (November 9, 2010). CNF Project # 1371

“High Refractive Index and High Transparency HfO2 Applications in the Photonics West, (SPIE, 2010). CNF Project # 980, Cornell


“Hot N’ Cold Gyroscope”; R. Wang and S.A. Bhave, disclosed to CECTC, June 1, 2011. CNF Project # 1380-05, Cornell

“Hybrid MEMS Resonators and Oscillators”; S.A. Bhave, IEEE Frequency Control Symposium (FCS 2011), San Francisco, CA, May 2, 2011. CNF Project # 1380-05, Cornell

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“Information Processing and Sensing with Photonic Crystal Microcavities in SOI”; P. Fauchet, Invited Presentation given at the 2010 International Conference on Solid State Devices and Materials, Tokyo, Japan, September 2010. CNF Project # 810-99, University of Rochester


“Inductive Coupling of Superconducting Qubits to Cloplanar Waveguide Resonators”; Strand, J.: March Meeting of the American Physical Society, Dallas, TX-March 23, 2011. CNF Project # 1314-05, Syracuse University


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“Information Processing and Sensing with Photonic Crystal Microcavities in SOI”; P. Fauchet, Invited Presentation given at the 2010 International Conference on Solid State Devices and Materials, Tokyo, Japan, September 2010. CNF Project # 810-99, University of Rochester


“Integration of Batch-Fabricated Overhanging Magnet Tips on Attonewton-Sensitivity Cantilevers”; Longenecker, J; Moore, E; Lee, S; Hickman, S; Marohn, J; 3rd Nano-MRI Conference, Paris (2010). CNF Project # 863-00, Cornell


“Ion-Nucleic Acid Interactions”; L. Pollock, University of Ottawa Physics Colloq, 10/10. CNF Project # 692-98, Cornell

“Ion-Nucleic Acids: SAXS Studies of Interactions”; L. Pollock, University of Illinois, Urbana-Champaign: Physics Colloquium, 04/11. CNF Project # 692-98, Cornell

“Isotropic Etching of 111 SCS for Wafer-Scale Manufacturing of Perfectly Hemispherical Silicon Molds”; L.C. Fegeley, D.N. Hutchison, and S.A. Bhave, 16th International Conference on Solid-State Sensors, Actuators and Microsystems (Transducers’11), Beijing, China, pp. 2295-2298, June 5-9, 2011. CNF Project # 1380-05, Cornell

“Josephson Junctions formed from Superconducting Nanowires”; Xiao, B.; March Meeting of the American Physical Society, Dallas, TX-March 23, 2011. CNF Project # 1314-05, Syracuse University


“Keeping Nano Cool... a First Principles Approach to Understanding and Potentially Controlling Nanoscale Thermal Transport”; (invited talk) D. A. Stewart, 2010 CNF Annual Meeting, Cornell University, Ithaca, September 16, 2010. CNF Staff Project on Computation, Cornell

“Large Area Flexible SERS Active Substrates using Engineered Nanostructures”; A.J. Chung, Y.S. Huh, and D. Erickson; Nanoscale, 3, 2903-2908, 2011. CNF Project # 1764-09, Cornell


“Large-Scale Arrays of Single Layer Graphene Resonators”; van der Zande, A., Barton, R., Alden, J., Ruiz-Vargas, C., Whitney, W.,


“Learning from Plants about Water at Negative Pressure”; A. Stroock, Department of Mechanical Engineering, Queens University, Kingston, ON, Canada. February 9, 2011. CNF Project # 1119-03, Cornell

“Lens, Methods, and Applications”; M. Lipson, Patent Application, 5399-01-US, 61/446,577, 2/25/11. CNF Project # 980-01, Cornell


“Low-Loss Superconducting Microwave Resonators with NbN Films”; Xiao, B.: March Meeting of the American Physical Society, Dallas, TX-March 24, 2011. CNF Project # 1314-05, Syracuse University


“Massively Scalable and Parallel Activity Screening of Nanocatalysts at the Single-Particle Levels; P. Chen, Disclosure to Cornell; (Docket 5472). CNF Project # 1844-09, Cornell


“Mathematical Modeling and Frequency Gradient Analysis of Cellular and Vascular Invasion into Integra® and Strattice®: Towards Optimal Design of Tissue Regeneration Scaffolds”;

“Measurement of Hard X-Ray Lens Wavefront Aberrations using Phase Retrieval”;

“Mechanical Control of Spin States in Spin-1 Molecules and the Underscreened Kondo Effect”;


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## Commonly Used Abbreviations and Their Meaning

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<thead>
<tr>
<th>Abbreviation</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>&lt;</td>
<td>is less than</td>
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<tr>
<td>&gt;</td>
<td>is greater than</td>
</tr>
<tr>
<td>µL</td>
<td>microliter</td>
</tr>
<tr>
<td>µm</td>
<td>micron, micrometer</td>
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<tr>
<td>1D</td>
<td>one dimensional</td>
</tr>
<tr>
<td>2D</td>
<td>two dimensional</td>
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<tr>
<td>2DEG</td>
<td>two dimensional electron gas</td>
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<tr>
<td>3D</td>
<td>three dimensional</td>
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<tr>
<td>3DOM</td>
<td>three-dimensionally ordered macroporous carbon</td>
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<tr>
<td>4He</td>
<td>helium-4</td>
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<tr>
<td>a-Si</td>
<td>amorphous silicon</td>
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<tr>
<td>A&amp;M</td>
<td>Agricultural &amp; Mechanical</td>
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<tr>
<td>AC</td>
<td>alternating current</td>
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<tr>
<td>AFM</td>
<td>atomic force microscopy/microscope</td>
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<tr>
<td>AFOSR</td>
<td>Air Force Office of Scientific Research</td>
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<tr>
<td>Ag</td>
<td>silver</td>
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<tr>
<td>agLDL</td>
<td>aggregated low-density lipoproteins</td>
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<tr>
<td>AgNO₃</td>
<td>silver nitrate</td>
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<tr>
<td>AgSR</td>
<td>silver-thiolate</td>
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<tr>
<td>AIC</td>
<td>aluminum-induced crystalization</td>
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<tr>
<td>Al</td>
<td>aluminum</td>
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<tr>
<td>Al₂O₃</td>
<td>aluminum oxide</td>
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<td>ALD</td>
<td>atomic layer deposition</td>
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<td>AlGaN</td>
<td>aluminum gallium nitride</td>
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<td>AM</td>
<td>amplitude modulation</td>
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<tr>
<td>APD</td>
<td>avalanche photodiode</td>
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<tr>
<td>APS</td>
<td>advanced photon source</td>
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<tr>
<td>Ar</td>
<td>argon</td>
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<tr>
<td>ArF</td>
<td>argon fluoride</td>
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<td>As</td>
<td>arsenide</td>
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<tr>
<td>AST</td>
<td>aspartic transaminase</td>
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<tr>
<td>atm.</td>
<td>standard atmosphere (as a unit of pressure)</td>
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<tr>
<td>ATRP</td>
<td>atom transfer radical polymerization</td>
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<tr>
<td>Au</td>
<td>gold</td>
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<td>AuNPs</td>
<td>gold nanoparticles</td>
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<td>BAM</td>
<td>bisphenol aminomethyl</td>
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<td>BPB</td>
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<td>C-V</td>
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<td>CCI</td>
<td>Centers for Chemical Innovation</td>
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<td>CCMR</td>
<td>Cornell Center for Materials Research</td>
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<td>CCS</td>
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<td>charge-density-wave</td>
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<td>carbon tetrafluoride</td>
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<td>tetrafluoromethane</td>
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<tr>
<td>cm</td>
<td>centimeter</td>
</tr>
<tr>
<td>CMOS</td>
<td>complementary metal oxide semiconductor</td>
</tr>
<tr>
<td>CMOSFET</td>
<td>complementary metal oxide field effect transistor</td>
</tr>
<tr>
<td>CMP</td>
<td>chemical mechanical polishing</td>
</tr>
<tr>
<td>CNF</td>
<td>Cornell NanoScale Science &amp; Technology Facility</td>
</tr>
<tr>
<td>CNL</td>
<td>charge neutrality level</td>
</tr>
<tr>
<td>CNS</td>
<td>Cornell Center for Nanoscale Systems</td>
</tr>
<tr>
<td>CNTFET</td>
<td>carbon nanotube field-effect transistor</td>
</tr>
<tr>
<td>Co</td>
<td>cobalt</td>
</tr>
<tr>
<td>CO₂</td>
<td>carbon dioxide</td>
</tr>
<tr>
<td>COF</td>
<td>covalent organic framework</td>
</tr>
<tr>
<td>CoFeAl</td>
<td>cobalt iron aluminum</td>
</tr>
<tr>
<td>CoP</td>
<td>cobalt porphyrin</td>
</tr>
<tr>
<td>CPC</td>
<td>colloidal photonic crystal</td>
</tr>
<tr>
<td>CPD</td>
<td>contact potential difference</td>
</tr>
<tr>
<td>Cr</td>
<td>chromium</td>
</tr>
<tr>
<td>CRDS</td>
<td>cavity ring-down spectrometer</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>CTC</td>
<td>circulating tumor cell</td>
</tr>
<tr>
<td>CTL</td>
<td>confinement tuning layer</td>
</tr>
<tr>
<td>Cu</td>
<td>copper</td>
</tr>
<tr>
<td>CuZnSnS4</td>
<td>copper zinc tin sulfide</td>
</tr>
<tr>
<td>CVD</td>
<td>cardiovascular disease</td>
</tr>
<tr>
<td>CVD</td>
<td>chemical vapor deposition</td>
</tr>
<tr>
<td>CW</td>
<td>continuous wave</td>
</tr>
<tr>
<td>CXRF</td>
<td>confocal x-ray fluorescence microscopy</td>
</tr>
<tr>
<td>DARPA</td>
<td>Defense Advanced Research Projects Agency</td>
</tr>
<tr>
<td>DC</td>
<td>direct current</td>
</tr>
<tr>
<td>DCE</td>
<td>1,2-dichloroethane</td>
</tr>
<tr>
<td>DCM</td>
<td>dichloromethane</td>
</tr>
<tr>
<td>DEP</td>
<td>dielectrophoresis</td>
</tr>
<tr>
<td>DFT</td>
<td>density functional theory</td>
</tr>
<tr>
<td>DFT</td>
<td>discrete Fourier transform</td>
</tr>
<tr>
<td>DH-PSF</td>
<td>double helix point spread function</td>
</tr>
<tr>
<td>DI</td>
<td>de-ionized water</td>
</tr>
<tr>
<td>DIC</td>
<td>differential interference contrast</td>
</tr>
<tr>
<td>DMF</td>
<td>dimethyl formamide</td>
</tr>
<tr>
<td>DNA</td>
<td>deoxyribonucleic acid</td>
</tr>
<tr>
<td>DNP</td>
<td>dynamic nuclear polarization</td>
</tr>
<tr>
<td>DODAB</td>
<td>dimethyl dioctadecyl ammonium bromide</td>
</tr>
<tr>
<td>DOE</td>
<td>United States Department of Energy</td>
</tr>
<tr>
<td>DPPC</td>
<td>1,2-dipalmitoyl-sn-glycero-3-phosphocholine</td>
</tr>
<tr>
<td>DPPG</td>
<td>1,2-dimyristoyl-sn-glycero-[phospho-rac-(1-glycerol)]</td>
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<tr>
<td>DRAM</td>
<td>dynamic random access memory</td>
</tr>
<tr>
<td>DRIE</td>
<td>dry reactive ion etch</td>
</tr>
<tr>
<td>DUV</td>
<td>deep ultraviolet</td>
</tr>
<tr>
<td>e-beam</td>
<td>electron beam lithography</td>
</tr>
<tr>
<td>E, coli</td>
<td><em>Escherichia coli</em></td>
</tr>
<tr>
<td>EB</td>
<td>exchange bias</td>
</tr>
<tr>
<td>EBI D</td>
<td>electron beam induced deposition</td>
</tr>
<tr>
<td>EBL</td>
<td>electron beam lithography</td>
</tr>
<tr>
<td>ECD</td>
<td>electrochemical detectors</td>
</tr>
<tr>
<td>ECM</td>
<td>extracellular matrices</td>
</tr>
<tr>
<td>ECM</td>
<td>extracellular matrix</td>
</tr>
<tr>
<td>EDS</td>
<td>energy dispersive spectroscopy</td>
</tr>
<tr>
<td>EDTA</td>
<td>ethylenediaminetetraacetic acid</td>
</tr>
<tr>
<td>EELS</td>
<td>electron energy loss spectroscopy</td>
</tr>
<tr>
<td>EG</td>
<td>ethylene glycol</td>
</tr>
<tr>
<td>EIS</td>
<td>electrochemical impedance spectroscopy</td>
</tr>
<tr>
<td>EMCCD</td>
<td>electron multiplying charge coupled device</td>
</tr>
<tr>
<td>EO</td>
<td>electro-optic</td>
</tr>
<tr>
<td>EOT</td>
<td>equivalent oxide thickness</td>
</tr>
<tr>
<td>EPICs</td>
<td>electronic photonic integrated circuits</td>
</tr>
<tr>
<td>EPR</td>
<td>enhanced permeability &amp; retention</td>
</tr>
<tr>
<td>Er</td>
<td>erbium</td>
</tr>
<tr>
<td>ErAs</td>
<td>erbium arsenide</td>
</tr>
<tr>
<td>ESM</td>
<td>effective screening medium</td>
</tr>
<tr>
<td>EUV</td>
<td>extreme ultraviolet</td>
</tr>
<tr>
<td>ex vivo</td>
<td>Latin for “out of the living” — that which takes place outside an organism</td>
</tr>
<tr>
<td>FcCOOH</td>
<td>ferrocene carboxylic acid</td>
</tr>
<tr>
<td>FDA</td>
<td>United States Food &amp; Drug Administration</td>
</tr>
<tr>
<td>FDMA</td>
<td>fluoroinated perfluorodecyl methacrylate</td>
</tr>
<tr>
<td>FDMNES</td>
<td>finite-difference method approach to predicting spectroscopic transitions</td>
</tr>
<tr>
<td>Fe</td>
<td>iron</td>
</tr>
<tr>
<td>FeDRAM</td>
<td>ferroelectric dynamic random access memory</td>
</tr>
<tr>
<td>FEM</td>
<td>finite element method</td>
</tr>
<tr>
<td>FES</td>
<td>functional electrical stimulation</td>
</tr>
<tr>
<td>FESEM</td>
<td>field-emission scanning electron microscope</td>
</tr>
<tr>
<td>FET</td>
<td>field-effect transistor</td>
</tr>
<tr>
<td>FFTs</td>
<td>fast Fourier transforms</td>
</tr>
<tr>
<td>fg</td>
<td>femto gram</td>
</tr>
<tr>
<td>FIB</td>
<td>focused ion beam</td>
</tr>
<tr>
<td>FIR</td>
<td>far infrared</td>
</tr>
<tr>
<td>fJ</td>
<td>femto Joules</td>
</tr>
<tr>
<td>FLT</td>
<td>field-like torque</td>
</tr>
<tr>
<td>FM</td>
<td>frequency modulation</td>
</tr>
<tr>
<td>FMR</td>
<td>ferromagnetic resonance</td>
</tr>
<tr>
<td>FOTS</td>
<td>fluorosilane, tri-decafluoro-1,1,2,2-tetrahydroxy-trichlorosilane</td>
</tr>
<tr>
<td>FRAP</td>
<td>fluorescence recovery after photobleaching</td>
</tr>
<tr>
<td>FRET</td>
<td>fluorescence resonance energy transfer</td>
</tr>
<tr>
<td>FTIR</td>
<td>Fourier transform infrared spectroscopy</td>
</tr>
<tr>
<td>FWM</td>
<td>four-wave mixing</td>
</tr>
<tr>
<td>Ga</td>
<td>gallium</td>
</tr>
<tr>
<td>GaAs</td>
<td>gallium arsenide</td>
</tr>
<tr>
<td>GaAsN</td>
<td>gallium arsenide nitride</td>
</tr>
<tr>
<td>GaInNAs</td>
<td>gallium indium nitride arsenide</td>
</tr>
<tr>
<td>GaN</td>
<td>gallium nitride</td>
</tr>
<tr>
<td>GaP</td>
<td>gallium phosphate</td>
</tr>
<tr>
<td>GASP</td>
<td>growth advantage in stationary phase</td>
</tr>
<tr>
<td>GB</td>
<td>glass bead</td>
</tr>
<tr>
<td>GBLMA</td>
<td>α-γama butyrolactone methacrylate</td>
</tr>
<tr>
<td>GC</td>
<td>gas chromatograph</td>
</tr>
<tr>
<td>GC-C-IRMS</td>
<td>gas chromatography combustion isotope ratio mass spectrometry</td>
</tr>
<tr>
<td>Ge</td>
<td>germanium</td>
</tr>
<tr>
<td>GEDI μdevices</td>
<td>geometrically enhanced differential immunocapture microdevices</td>
</tr>
<tr>
<td>GHz</td>
<td>gigahertz</td>
</tr>
<tr>
<td>GI</td>
<td>gastrointestinal</td>
</tr>
<tr>
<td>GMR</td>
<td>giant magnetoresistance</td>
</tr>
<tr>
<td>GNR</td>
<td>gold nanorod</td>
</tr>
<tr>
<td>GNR</td>
<td>graphene nanoribbons</td>
</tr>
<tr>
<td>GPa</td>
<td>gigapascal</td>
</tr>
</tbody>
</table>
in vitro. Latin for “within glass” -- refers to studies in experimental biology that are conducted using components of an organism that have been isolated from their usual biological context in order to permit a more detailed or more convenient analysis than can be done with whole organisms.

in vivo. Latin for “within the living” -- experimentation using a whole, living organism

H2O2 hydrogen peroxide
HAMI hydroxyl adamantyl methacrylate
HCl chloroauric acid
hexagonal close packing
HCP1 Heme Carrier Protein 1
HEMTs high electron mobility transistors
HF hydrofluoric acid
HFES hydrogen silsesquioxanes
Hg mercury
high-κ high dielectric constant
HMDS hexamethyldisilazane
HOMO-LUMO highest occupied molecular orbital & lowest unoccupied molecular orbital
HOPG highly oriented pyrolytic graphite
HRS high resistance state
HRTEM high-resolution transmission electron microscopy
HS-ssDNA thiol terminated single stranded deoxyribonucleic acid
HSQ hydrogen silsesquioxane
HSQ/FOX negative electron beam resist hydrogen silsesquioxane
Hz hertz
I-V current-voltage
I/O input/output
IARPA Intelligence Advanced Research Projects Activity
IC integrated circuit
ICP inductively coupled plasma
ICP-RIE inductively coupled plasma reactive ion etcher
IFVD impurity free vacancy diffusion
IGERT Integrative Graduate Education and Research Traineeship
IID impurity induced disordering
IIIEI ion implant enhanced interdiffusion
IJCMSSE International Journal of Computational Materials Science & Surface Engineering
In indium
in situ. Latin phrase which translated literally as ‘in position’ -- to examine the phenomenon exactly in place where it occurs

2010-2011 Research Accomplishments
MD... molecular dynamics
ME... magnetoelectric
MEG... maleimide-ethylene glycol disulfide
MEMs... microelectromechanical systems
MFMR... microfabricated micro-reactors
MgO... magnesium oxide
MGs... molecular glasses
MHz... megahertz
micron... micrometer, aka μm
MIFIS... metal-insulator-ferroelectric-insulator-semiconductor
min... minutes
mL... milliliter
mm... millimeter
mM... millimolar
MMA-MAA... methyl-methacrylate-co-methacrylic acid
MnO₂ NPs... manganese oxide nanoparticles
Mo... molybdenum
MOCVD... metal oxide chemical vapor deposition
MONOS... metal/oxide/nitride/oxide-semiconductor
MOS... metal oxide semiconductor
MOSFET... metal oxide semiconductor field effect transistor
MOVPE... metal organic vapor phase epitaxy
MPM... multiphoton microscopy
MQCA... magnetic quantum-dot cellular automata
MQW... multiple quantum well
MRA... multifunction reconfigurable antenna
MRAM... magnetic random access memory
MRFM... magnetic resonance force microscopy
MRI... magnetic resonance imaging
ms... microsecond
MSM... metal-semiconductor-metal
MTJ... magnetic tunneling junction
mTorr... millitorr
mV... millivolt
MVD... molecular vapor deposition
MWNT... multiwalled carbon nanotube
MΩ... megarhms
N... nitrogen
n-type... negative semiconductor
NaCl... sodium chloride
NASA... National Aeronautics & Space Administration
NBTC... National Nanobioscience Institute, Cornell University
NCRR... National Centers for Research Resources
NEs... nanoelectromechanical systems
NEXAFS... near edge x-ray absorption fine structure
NH₄F... ammonium fluoride
Ni... nickel
NIDCD... National Institute on Deafness & Other Communication Disorders
NIH... National Institutes of Health
nL... nanoliter
nm... nanometer
NMP... n-methyl-2-pyrrolidone
NMR... nuclear magnetic resonance microscopy / spectroscopy
NORIS... nanometrology optical ruler imaging system
NPR... nonlinear polarization rotation
NPs... nanoparticles
NPs... nanopores
ns... nanosecond
NSF... National Science Foundation
NSF-SGER... National Science Foundation Small Grants for Exploratory Research
NSOM... near-field scanning optical microscopy
NSSP... nanostructured semipolar
NVM... non-volatile memory
NW FETS... nanowire field-effect transistors
NYSTAR... New York State Office of Science, Technology & Academic Research
O... oxygen
OFET... organic field effect transistor
Oh number... Ohnesorge number
OLED... organic light-emitting diode
ONO... oxide/nitride/oxide
ONR-MURI... Office of Naval Research Multidisciplinary University Research Initiative
OPV... organic photovoltaic cells
OST-MRAM... orthogonal spin-transfer magnetic random access memory
OTFT... organic thin-film transistor
p-n, p/n... p-type & n-type semiconductors joined together
p-type... positive semiconductor
P/E... program/erase
Pa... pascals
PAB... post-apply bake
PAE... power-added efficiency
PAG... photoacid generator
PANOMs... planarized apertures for near-field optical microscopy
Pb... lead
PBG... photonic bandgap
PBPK... physiologically-based pharmacokinetic
PBS... phosphate-buffered saline
PC... persistent current
PC... photocurrent
PCB... printed circuit board
PCBM ................................ fullerene derivative [6,6]-phenyl-C_{61}-butyric acid methyl ester
PCM ................................ phase change material
PCN .................................. photonic crystal nanocavity
Pd ..................................... palladium
PD ................................... photodetector
PDMS ................................ polydimethylsiloxane
PE-GNR ............................... polyelectrolyte gold nanorod
PEB ................................... post-exposure bake
PEC ................................... photoelectrochemical
PECVD ............................... plasma enhanced chemical vapor deposition
PEDOT:PSS ....................... poly(3,4-ethyleneedioxythiophene):poly(styrene
desulphonate)
PEG ................................ polyethylene glycol
PEI ................................... poly(ethyl imine)
PFM ................................... piezo-response force microscopy
pH ................................... potential of hydrogen
PL ................................... photoluminescence
PLGA ................................. poly(lactic-co-glycolic) acid
PMGI ................................. poly(methyl glutarimide)
PMMA ............................... poly(methyl methacrylate)
Pt ................................... platinum
Pt/Al ................................ platinum/aluminum
PS .................................. polystyrene
PSMO ............................... praseodymium strontium manganite
PSµM ............................... phase separation micro-molding
Pt ................................... platinum
Pt/Ir ................................ platinum/iridium
PV ................................... polyaniline
PVA ................................ poly-vinyl alcohol
PVC ................................ polyvinyl chloride
PVDF ................................ polyvinylidene fluoride
PVP ................................ polyvinylpyrrolidone
Py .................................. Ni81Fe19
Q ..................................... high quality factor
QD ................................... quantum dots
QW ................................... quantum well
QWI ................................ quantum well intermixing
Re number ......................... Reynolds number
RF ................................... radio frequency
RF MEMS ......................... radio frequency microelectromechanical systems
RFID ................................. radio frequency identification
RIE ................................ reactive ion etch
RMS or rms ......................... root mean square
RNA ................................ ribonucleic acid
ROS ................................ reactive oxygen species
RRAM ............................... resistive random access memory
RTA ................................ rapid thermal anneal
RTD ................................ resistance temperature device
s .................................... seconds
SA-MOVPE ......................... selective area metal organic vapor phase epitaxy
SABC ................................ surface active block copolymers
SAED ................................. selected area electron diffraction
SAMs .............................. self-assembled monolayers
Sb ................................... metallic antimony
SBH ................................ Schottky barrier height
Sc ................................... scandium
SCAN ............................... single-chromatin analysis at the nanoscale
sccm ................................ standard cubic centimeters
sccm ................................ standard cubic centimeters per minute
scCO₂ ............................... supercritical carbon dioxide
SEM ................................ scanning electron microscopy
SERS ................................ surface enhanced Raman spectroscopy
Si₂p ................................. sulfur hexafluoride
SH .................................. second harmonic
Si ................................... silicon
Si₅N₃ ................................ silicon nitride
SiAlON .............................. silicon aluminum oxynitride
SiC ................................ silicon carbide
SiN ................................... silicon nitride
SiNWs .............................. silicon nanowires
SiO₂ ................................ silicon dioxide
SICOFET ............................... a single crystal organic field effect transistor
SiO₂ ................................ silicon dioxide
SiO₂ ................. single crystal organic field effect transistor
SiO₂ ....................... single crystal organic field effect transistor
SLG ................................ single-layer graphene
SLUG ............................... superconducting low-inductance undulatory galvanometer
SMS ................................ single molecule spectroscopy
Sn ................................... tin
SNARE ......................... Soluble N-ethylmaleimide-sensitive factor
Attachment Protein Receptor complex
SnO₂ ................................ tin oxide
SNPs ................................ silver nanoparticles
SOFC ................................ solid oxide fuel cells
SOI ................................ silicon-on-insulator
SPCM ............................... scanning photocurrent microscopy
SPD ................................ switching phase diagram
SPR ................................ surface plasmon resonance
Sr₂RuO₃ ............................. strontium ruthenate
The photographs in the table of contents and PPPs were taken by CNF Staff members Donald Tennant and Sam Wright, unless otherwise noted as Charles Harrington Photography. The cover images are:

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Top Image: CNF Project 398-91; Robert Austin and Guillaume Lambert — full report, pages 2-3
Bottom Image: CNF Project 731-98; Michael Shuler and Mandy Esch — full report, pages 6-7