

**Center for Optoelectronics and Optical Communications**  
**Publications, Presentations, Patents and Grants**  
**2005 –2006**

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**Books and Book Chapters**

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**R. Tsu**, *Superlattice to Nanoelectronics*, Pub. Elsevier Science 2005, ISBN 0 08 044377

**R. Tsu**, Chapter: *Nanostructured Electronics and Optoelectronic Materials in Nanostructured Materials*, Ed. Carl C. Koch, Noyes Pub., Norwich NY 2002, prepared 2<sup>nd</sup> ed.

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**Journals and Conference Proceedings**

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**R. Tsu**, "Stability issues in tunneling via quantum systems", *Microelectronics Journal*, Volume 36, Issues 3-6, March-June 2005, pp. 212-215

**K. Daneshvar**, **K.Kang** and **R. Tsu**, "Three-dimensional quantum dot array ", *Microelectronics Journal*, Volume 36, Issues 3-6, March-June 2005, pp. 250 – 252

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**E.C.H. Sykes**, Aja Andreu, **K. Daneshvar** and **M. El-Kouedi**, "Synthesis and Characterization of Nanowire Based Anisotropic Conductors", submitted for publication in *Journal of Nanotechnology*, 2006

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- K.E. Gonsalves**, M. Thiyagarajan, K. Dean, "New resists for nanometer scale patterning by extreme ultraviolet lithography", *Journal of Microlithography, Microfabrication, and Microsystems* 2005, 4(2), 029701/1-029701/6.
- M. Thiyagarajan, K. Dean, **K.E. Gonsalves**, "Improved lithographic performance for EUV resists based on polymers having a photoacid generator (PAG) in the backbone", *Journal of Photopolymer Science and Technology* 2005, 18(6), 737-741.
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- W. Gou and **M. Y. A. Raja**, "Far-field and near-field analysis of light reflected from a photonic crystal", Accepted in *J. Optics Commun.* Editor ref paper # OPTICS\_2179, (2006).
- M. U. Wasim, S. M. H. Zaidi, **M. Y. A. Raja**, N. Ghani, and R. Ahmad, "Survivable Passive Access Network (SPAN)", accepted *Proc Globecom-NGN 2006*.
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- R. Muzaffar, U. Younis, S. M. H. Zaidi, and **M. Y. A. Raja**, "Priority Swapping Intra-ONU Bandwidth Allocation Algorithm Supporting Differentiated Services" accepted in *Proc, ICCCN 2006*.

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- M.E. Testorf, **T.J. Suleski**, and Y.-C. Chuang, "Optimization of diffractive elements for fabricating 3-D photonic crystals with interference lithography," (accepted for publication and presentation, Optical Society of America *Nanophotonics* meeting) (April 2006).
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- M.A. Fiddy**, **T.J. Suleski**, D.J. Brady, and N. Pitsianis, "Compressive sampling for feature-specific compact imagers," in *Frontiers in Optics 2005/Laser Science XXI* (Optical Society of America, Washington, DC, 2005), Paper FWU4.
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- K. Patel C. Burkhart, P. Batoni, **S. Bobbio**, and **E.B. Stokes**, “Optimization of Gallium Nitride Reactive Ion Etch in CCl<sub>2</sub>F<sub>2</sub> Environment”, Optics in the Southeast, Atlanta, Oct. 2005.
- B.A. Martin, **E.C. Sykes**, M.R. Sardela, Jr., and **M-A Hasan**, “Epitaxial Growth and Doping of GaN(001) on Si(111) Using Surface Reconstruction Induced Epitaxy”, 208<sup>th</sup> Meeting of the Electrochemical Society, Los Angeles, October 2005.
- M-A Hasan**, K. Cherukuvada, and M.R. Sardela, Jr., “Growth of Single Crystalline Cubic SiC on Si Using Compliant Nanoscale Seed Crystals”, 208<sup>th</sup> Meeting of the Electrochemical Society, Los Angeles, October 2005.
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- B.A. Martin, **E. C. Sykes**, M.R. Sardela, Jr., M. Jenkins and **M-A Hasan**, “Epitaxial growth of Hexagonal AlN (100) and GaN(100) on Si(111) Using Surface Reconstruction Induced Epitaxy”, Fifth Annual Fitzpatrick Center Symposium, Durham NC, May 2005.
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- J.C. Poler, T.D. DuBois**, "Modeling of Supramolecular Systems, Mechanically Docked to Carbon Nanotubes", Materials Research Society Symposium Z, San Francisco, CA April 18<sup>th</sup> 2006
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- K. M. Medicus, J. Snyder, **A. Davies**, "Gaussian Beam Modeling of the Radius of Curvature", ASPE 2005 Summer Topical Meeting, Precision Interferometric Metrology, Middletown, Connecticut, July (2005).
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- M. Y. A. Raja**, N. Ghani, K. Acharya, and S. M. H. Zaidi, "Passive Optical Networks: Propellers of FTTH", Keynote-paper in HONET'05, Proc. US-Pak International Symposium on 'High-capacity Optical Networks & Enabling Technologies" Dec. 19-21, 2005.†
- M. U. Wasim, S. M. H. Zaidi, **M. Y. A. Raja**, N. Ghani, R. Ahmad, and A. Choudhery, "WDM based PON: An Overview", in HONET'05, Proc. US-Pak International Symposium on 'High-capacity Optical Networks & Enabling Technologies" Dec. 19-21, 2005.

- N. Ghani, **M. Y. A. Raja**, S. M. H. Zaidi, and A. Ali, "Optical Internet Technologies and Emergent Cyber-Infrastructures" invited paper in HONET'04, Proc. US-Pak International Workshop on High-capacity Optical Networks & Enabling Technologies" Dec. 19-21, 2005.†
- N. Ghani, Q. Liu, V. M. Muthalaly, and **M. Y.A. Raja**, "Inter-domain Routing in DWDM Optical Networks", contributed paper in HONET'05, Proc. US-Pak International Workshop on High-capacity Optical Networks & Enabling Technologies" Dec. 19-21, 2005
- M. Y. A. Raja**, "Optical Networking Technologies and Passive Optical Networks (PON)", 3<sup>rd</sup> International Workshop on Frontiers of, Information Technology (FIT), Islamabad, PK Dec. 28-29, 2005
- K. Hamid, K. Acharya, and **M. Y. A. Raja**, "Development of Optical Access Network Testbed at UNC Charlotte", presented and extended abstract in OISE'05, Charlotte NC, Oct. 6-8, 2005.
- J. C. West, K. Acharya, and **M. Y. A. Raja**, "Design and Simulations of Chirped VCSELs", presented and extended abstract in OISE'05, Charlotte NC, Oct. 6-8, 2005.
- W. Guo and **M. Y. A. Raja**, "Far-field and Near-field Analysis of Light Reflected from Photonic Crystals", PDP-2 OSA Topical Meeting on "Nano-Photonics for Information Systems (NPIS)" San Diego, CA, April 13-15, 2005.
- R. K. Tyson**, "Laser communications and other applications available for low-cost adaptive optics research," SPIE Visiting Lecturer Program, Université Laval, Quebec, Canada, November 2005.†
- R. K. Tyson**, "Our changing view of the universe," Charlotte Dilworth South End Rotary Club, Charlotte, NC, September 2005.†
- V.N. Astratov**, "Integrated complex networks of coupled microspheres for optoelectronics applications", International Conference: ICTON 2006 Special session on: Microresonators and Photonic Molecules: trapping, harnessing and releasing light, Nottingham, UK, June 19-20, 2006†
- V.N. Astratov**, "Circuits of Microspheres for Applications in Integrated Optoelectronics and Controllable Delay Lines", Frontiers in Optics, 89<sup>th</sup> OSA Annual Meeting, Tucson, Arizona, October 2005, †
- V.N. Astratov**, "Photonic Integrated Circuits Formed by Coupled Ultra High-Q Spherical Cavities" Material Science Research Seminar Series, Norfolk State University, Virginia, September 2, 2005.†
- V.N. Astratov, A.V. Kanaev**, S.P. Ashili, J.P. Franchak and **W. Cai**, "Optical Delay Lines formed by Circuits of Spherical Cavities with Coupled Whispering Gallery Modes" Topical Meeting of OSA "Information Photonics", Charlotte, June 6-8, 2005
- V.N. Astratov, A.V. Kanaev**, S.P. Ashili, J.P. Franchak and **W. Cai**, "Optical Coupling between Spherical Dielectric Atoms" CLEO/IQEC 2005 Conference of OSA, Baltimore, May 22-27, 2005
- V.N. Astratov, A.V. Kanaev**, "Evanescent Whispering Gallery Mode Coupling between Spherical Dielectric Atoms", Optics in the Southeast 2005 OSA Meeting, 6-8 October 2005, Atlanta, Georgia

† Denotes invited talk

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## **Patents/Inventions**

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*US Patent #6,764,368*, "Method of fabricating a cathodo-electro-luminescent device using a porous silicon/porous silicon carbide as an electron emitter", **M-A Hasan** and D.H. Elqag, Issued 7/20/04

*US Patent #6,917,057*, "Layered phosphor coating for LED devices", **E.B. Stokes**, D. Buckley Jr., T. McNulty, and D. Doxsee, Issued 7/12/05

*US Patent #6,945,262*, "Analysis equipment for determining physical properties of an organic solution", H.J. Farr, K.H. Betscher, R.R. Worthing Jr., D. Sangeeta, H.B. Vakil, C.A. Johnson, T.J. Cartier Jr., **E.B. Stokes**, H. Jaster, and A.S. Alexander. Issued 9/20/05

*US Patent #6,952,507*, "Multi-mode fiber coupler, system and associated methods," **E.G. Johnson**, M.R. Feldman, and **T.J. Suleski** (2005).

*U.S. Patent # 6,980,710*, **Farahi, Moyer**, Benrashid, and **Leilabady**, "Process for efficient light extraction from light emitting chips", issued December 27, 2005

*Application #2004967831* "Biomaterials for cell adhesion." **K.E. Gonsalves** (USA). U.S. Pat. Appl. Publ. (2005), 17 pp., Cont.-in-part of U.S. Ser. No. 835,757. CODEN: USXXCO US 2005244452 A1 20051103 Patent written in English. Priority: US 2004-835757 20040430. CAN 143:427444 AN 2005:

*Application #20050087884*, "Flip-chip light emitting diode", **E.B. Stokes**, M.P. D'Evelyn, S.E. Weaver, P.M. Sandvik, A.U. Ebong, X-A Cao, S.F. LeBoeuf, and N.R. Tasker, 4/28/05.

*Application # 20050098796*, "Methods and apparatus for a semiconductor device", **E.B. Stokes**, D.M. Walker, X-A Cao, and S.F. LeBoeuf, 5/12/05.

*Application #20050268942*, "Method for removing ceramic coatings from component surfaces". H.J. Farr, K.H. Betscher, R.R. Worthing Jr., D. Sangeeta, H.B. Vakil, C.A. Johnson, T.J. Cartier Jr., **E.B. Stokes**, H. Jaster, and A.S. Alexander., 12/8/05,

*Application #20050287770*, "Alternative methods for fabrication of substrates and heterostructures made of silicon compounds and alloys", **M-A Hasan**, Published 12/29/05

"Synthesis and Characterization of Nanowire based Anisotropic Conductors", **Mahnaz El-Kouedi**, (#UNCC IR 2005-037) *Invention Disclosure*

"Optical field enhancement device at ir and visible frequencies", **Suleski, Cao** and **Deguzman**, [invention reported Dec 2005]

"Structural Extending Member", **Stephen Bobbio**, Filed 2/13/06

"Solar Cell Formed from Black Silicon", **M.A. Hasan** and **S.M. Bobbio**, Disclosed 4/2006

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**Grants (FY 2005 and 2006)**

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<b>Intel Corp</b>	<b>\$79,662</b>
KENNETH GONSALVES	Chemistry
Kinetics & Diffusion Studies in Polymer-bound PAG Resists for EUVL	
<b>Intel Corp</b>	<b>\$30,000</b>
KENNETH GONSALVES	Chemistry
Kinetics & Diffusion Studies in Polymer-bound PAG Resists for EUVL	
<b>National Science Foundation</b>	<b>\$99,933</b>
JORDAN POLER	Chemistry
NER: Diameter Specific Separations of Carbon Nanotubes for 3D Nanoassembling	
<b>National Science Foundation</b>	<b>\$231,673</b>
WEI CAI	Mathematics and Statistics
Numerical Methods for Maxwell Equations in Dispersive and Loss in Homogeneous Media	
<b>Dept of Energy</b>	<b>\$180,049</b>
WEI CAI	Mathematics and Statistics
Algorithms for Nonlinear Maxwell Equations in Nonhomogeneous Media and Photonic Resonant Waveguides with Coupled Microspheres	
<b>North Atlantic Treaty Organization</b>	<b>\$12,182</b>
MICHAEL KLIBANOV	Mathematics and Statistics
Methods of Optimization of Layered Structures for Protection of the Personnel	
<b>DOD/Army/Army Research Office</b>	<b>\$45,000</b>
MICHAEL KLIBANOV	Mathematics and Statistics
Globally Convergent Numerical Methods for Coefficient Inverse Problems	
<b>National Science Foundation</b>	<b>\$156,378</b>
STANISLAV MOLCHANOV	Mathematics and Statistics
BORIS VAINBERG	Mathematics and Statistics
Wave Propagation and Scattering for Periodic and Randomly Perturbed Periodic media	
<b>Northrop Grumman Corp</b>	<b>\$5,619</b>
ANGELA DAVIES	Physics and Optical Science
Characterization of Optical Materials with a Zygo MST Interferometer	
<b>Eastman Kodak Co</b>	<b>\$192,736</b>
ANGELA DAVIES	Physics and Optical Science
ROBERT HOCKEN	Mechanical Engineering & Engineering Science
Ultra Precision Coordinate Measuring Machine	
<b>National Science Foundation</b>	<b>\$12,000</b>
ANGELA DAVIES	Physics and Optical Science
REU Supplemental Request for CAREER: Self-Calibration Metrology Advances for Micro-Optics Manufacturing, award No.0348142	

<b>Duke University</b>	<b>\$74,091</b>
MICHAEL FIDDY	Physics and Optical Science
TOM SULESKI	Physics and Optical Science
Compressive Optical MONTAGE Photography Initiative	
<b>UNC Office of the President</b>	<b>\$20,000</b>
MICHAEL FIDDY	Physics and Optical Science
MICHAEL FIDDY	Electrical & Computer Engineering
North Carolina Photonics Initiative Phase II	
<b>Duke University</b>	<b>\$74,091</b>
MICHAEL FIDDY	Physics and Optical Science
TOM SULESKI	Physics and Optical Science
Compressive Optical MONTAGE Photography Initiative	
<b>DOD/Air Force/Office of Scientific Research</b>	<b>\$35,232</b>
GREGORY GBUR	Physics and Optical Science
Developing 'superbeams' for improved propagation through turbulence	
<b>National Science Foundation</b>	<b>\$32,000</b>
M YASIN RAJA	Physics and Optical Science
International Workshop on High Capacity Optical Networks and Enabling Technologies	
<b>Brashear LP</b>	<b>\$55,720</b>
ROBERT TYSON	Physics and Optical Science
Adaptive Optics Tool Development	
<b>DOD/Air Force/Office of Scientific Research</b>	<b>\$3,000</b>
MICHAEL FIDDY	Electrical & Computer Engineering
MICHAEL FIDDY	Physics and Optical Science
Support for workshop on Inverse Scattering	
<b>Dot Metrics Technologies</b>	<b>\$27,764</b>
EDWARD STOKES	Electrical & Computer Engineering
MOHAMMED-ALI HASAN	Electrical & Computer Engineering
Novel Active Layer Nanostructures for White Light Emitting Diodes	
<b>Dot Metrics Technologies</b>	<b>\$57,000</b>
EDWARD STOKES	Electrical & Computer Engineering
MOHAMMED-ALI HASAN	Electrical & Computer Engineering
Phase 2 SBIR: Nanostructured active layers for deep-green light emitting diodes(LEDs)	
<b>Dept of Commerce/NIST</b>	<b>\$20,382</b>
EDWARD STOKES	Electrical & Computer Engineering
2005 NIST Summer Undergraduate Research Fellowship Maryland	
<b>RF Micro Devices</b>	<b>\$363,517</b>
EDWARD STOKES	Electrical & Computer Engineering
Metal organic chemical vapor deposition (MOCVD) reactor donation	
<b>Northrop Grumman Corp</b>	<b>\$149,916</b>
RAPHAEL TSU	Electrical & Computer Engineering
SiC Superlattice Nano Science for Military Electronics Applications	

<b>DOD/Army/Army Research Office</b>	<b>\$35,000</b>
RAPHAEL TSU	Electrical & Computer Engineering
Structural and Electrical - Optical Characterizations of Semiconductor - Atomic Superlattice	
<b>Northrop Grumman Corp</b>	<b>\$568,856</b>
RAPHAEL TSU	Electrical & Computer Engineering
KASRA DANESHVAR	Electrical & Computer Engineering
JOHN HUDAK	Electrical & Computer Engineering
Silicon-Carbide Superlattice Device Development	
<b>DOD/Army/Corps of Engineers</b>	<b>\$67,174</b>
FALIH AHMAD	Engineering Technology
Investigations in MI, SAR, ISAR, and InSAR Systems: Techniques, Measurements and Algorithms for Composite Materials	
<b>DOD/Army/Corps of Engineers</b>	<b>\$32,825</b>
FALIH AHMAD	Engineering Technology
Analysis of SAR Measurement Techniques	
<b>National Science Foundation</b>	<b>\$430,501</b>
MATTHEW DAVIES	Mechanical Engineering & Engineering Science
ANGELA DAVIES	Physics and Optical Science
MICHAEL FIDDY	Physics and Optical Science
PATRICK MOYER	Physics and Optical Science
MRI: Nano-solid Freeform Generator for Micro-Optics Replication	
<b>University of California at Los Angeles</b>	<b>\$30,000</b>
ROBERT HOCKEN	Mechanical Engineering & Engineering Science
Nano-Linear Optical Encoder	
<b>University of California at Los Angeles</b>	<b>\$56,960</b>
ROBERT HOCKEN	Mechanical Engineering & Engineering Science
Nano-Linear Optical Encoder	
<b>NC Biotechnology Ctr</b>	<b>\$1,500</b>
KENNETH GONSALVES	Chemistry
Nanoscale Science and Engineering Conference	
<b>DOD/Army</b>	<b>\$5,000</b>
KENNETH GONSALVES	Chemistry
Nanoscale science and engineering conference at UNCC-partial support	
<b>Rohm &amp; Haas</b>	<b>\$71,050</b>
KENNETH GONSALVES	Chemistry
Prototype Resists for 193 nm and EUVL	
<b>Intel Corp</b>	<b>\$109,662</b>
KENNETH GONSALVES	Chemistry
Kinetics & Diffusion Studies in Polymer-bound PAG Resists for EUVL	
<b>Carolinas Healthcare System</b>	<b>\$27,000</b>
KENNETH GONSALVES	Chemistry
MICHAEL HUDSON	Biology
Utilizing nanospheres to transport antibiotics	

<b>Dot Metrics Technologies</b>	<b>\$24,200</b>
THOMAS SCHMEDAKE	Chemistry
EDWARD STOKES	Electrical & Computer Engineering
SBIR: Colloidal Quantum Dot Emitters for Deep UV LEDs	
<b>American Chemical Society/Petroleum Research Fund</b>	<b>\$35,000</b>
THOMAS SCHMEDAKE	Chemistry
Synthesis and Photochemical Characterization of Hexacoordinate	
<b>American Chemical Society/Petroleum Research Fund</b>	<b>\$50,000</b>
WADE SISK	Chemistry
Luminescence and Photodegradation of Near-infrared Ionic Dye Solutions and Polymer-Dispersed Films	
<b>National Science Foundation</b>	<b>\$180,000</b>
WEI CAI	Mathematics and Statistics
VASILY ASTRATOV	Physics and Optical Science
High Order Numerical Methods for Light Propagation in Micro-Photonics	
<b>Dept of Energy</b>	<b>\$183,317</b>
WEI CAI	Mathematics and Statistics
Algorithms for Nonlinear Maxwell Equations in Nonhomogeneous Media and Photonic Resonant Waveguides with Coupled Microspheres	
<b>DOD/Army/Army Research Office</b>	<b>\$95,306</b>
MICHAEL KLIBANOV	Mathematics and Statistics
Globally Convergent Numerical Methods for Coefficient Inverse Problems	
<b>DOD/Army/Army Research Office</b>	<b>\$85,000</b>
VASILY ASTRATOV	Physics and Optical Science
WEI CAI	Mathematics and Statistics
MOHAMMED-ALI HASAN	Electrical & Computer Engineering
Optical Circuits Based on Coupling Between Whispering Gallery Modes in Dielectric Microresonators	
<b>Fizeau Electro-Optic Systems</b>	<b>\$10,000</b>
FARAMARZ FARAH	Physics and Optical Science
Optical Waveguide Device for Frequency Stabilized Laser Diodes	
<b>DOD/Army/Army Research Office</b>	<b>\$4,450,000</b>
MICHAEL FIDDY	Physics and Optical Science
MICHAEL FIDDY	Electrical & Computer Engineering
Advanced Integrated Technologies: a collaborative agreement with ARL for research into sources and sensors	
<b>UNC Office of the President</b>	<b>\$25,000</b>
MICHAEL FIDDY	Physics and Optical Science
MICHAEL FIDDY	Electrical & Computer Engineering
North Carolina Photonics Initiative Phase II	
<b>Duke University</b>	<b>\$104,425</b>
MICHAEL FIDDY	Physics and Optical Science
TOM SULESKI	Physics and Optical Science
Compressive Optical MONTAGE Photography Initiative	

<b>UNC Office of the President</b>	<b>\$5,500</b>
MICHAEL FIDDY	Physics and Optical Science
MICHAEL FIDDY	Electrical & Computer Engineering
North Carolina Photonics Initiative Phase II	
<b>DOD/Air Force/Office of Scientific Research</b>	<b>\$35,953</b>
GREGORY GBUR	Physics and Optical Science
Developing 'superbeams' for improved propagation through turbulence	
<b>Clemson University</b>	<b>\$225,000</b>
TSING-HUA HER	Physics and Optical Science
WEI CAI	Mathematics and Statistics
High Power Fiber Lasers	
<b>National Science Foundation</b>	<b>\$31,500</b>
M YASIN RAJA	Physics and Optical Science
High-Capacity Optical Networks & Enabling Technologies (HONET 2005 )	
<b>University of California at Los Angeles</b>	<b>\$30,000</b>
TOM SULESKI	Physics and Optical Science
Compact Scatterometer for Integrated Process Control on the UMIL System	
<b>UNC General Administration</b>	<b>\$1,500</b>
ROBERT TYSON	Physics and Optical Science
Professional Science Master's Degree Planning Grant: Medical Physics	
<b>Oak Ridge Associated Universities</b>	<b>\$600</b>
MICHAEL FIDDY	Electrical & Computer Engineering
MICHAEL FIDDY	Physics and Optical Science
Oak Ridge Visiting Industry Grant	
<b>Dot Metrics Technologies</b>	<b>\$120,905</b>
EDWARD STOKES	Electrical & Computer Engineering
MOHAMMED-ALI HASAN	Electrical & Computer Engineering
Phase 2 SBIR: Nanostructured active layers for deep-green light emitting diodes(LEDs)	
<b>National Science Foundation</b>	<b>\$1,500,000</b>
ROBERT HOCKEN	Mechanical Engineering & Engineering Science
NIRT: Nanometrology for Nanoscale Science and Engineering	
<b>National Science Foundation</b>	<b>\$43,000</b>
ROBERT HOCKEN	Mechanical Engineering & Engineering Science
ANGELA DAVIES	Physics and Optical Science
EDWARD MORSE	Mechanical Engineering & Engineering Science
ROBERT WILHELM	Mechanical Engineering & Engineering Science
Industry/University Cooperative Research Center for Precision Metrology	
<b>University of California at Los Angeles</b>	<b>\$2,400</b>
ROBERT HOCKEN	Mechanical Engineering & Engineering Science
NSEC: Center for Scalable and Integrated Nano Manufacturing (SINAM)	
<b>University of California at Los Angeles</b>	<b>\$50,000</b>
ROBERT HOCKEN	Mechanical Engineering & Engineering Science
NSEC: Center for Scalable and Integrated Nano Manufacturing (SINAM)	

**University of California at Los Angeles**

**\$8,000**

ROBERT HOCKEN

Mechanical Engineering & Engineering Science

NSEC: Center for Scalable and Integrated Nano Manufacturing (SINAM)

**Dept of Commerce/ Economic Development Administration**

**\$1,270,000**

ROBERT WILHELM

Mechanical Engineering & Engineering Science

MICHAEL FIDDY

Physics and Optical Science

MICHAEL FIDDY

Electrical & Computer Engineering

UNC Charlotte/Charlotte Research Institute Applied Optics Regional Economic Support Project