THE BOSTON UNIVERSITY PHOTONICS CENTER

Annual Report 2006-2007

July 1, 2006 - June 30, 2007

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I. Introduction and Overview

A. Letter from the Director

It has been a productive and exciting year at the Boston University Photonics Center, marked by changes both within and outside the Center. In September, I was appointed Center Director, the second person to have held that post. Advised by my academic peers and the Center staff, my first job as director was to articulate a clear, shared vision for integrating our four missions in research, education, technology development, and commercialization. Over the past year, we have seen significant early signs of success. Our strong faculty research programs have been enhanced by collaborative engagement through Center initiatives, fellowships, undergraduate internships, joint symposia, as well as fast paced defense prototyping and commercialization.

New faculty and laboratories anchored rapid growth in our emerging, multidisciplinary programs in biophotonics and nanophotonics. Boston University's president Brown engaged the wider community in a strategic planning effort that will set the course of the institution for years to come. The Photonics Center features prominently in that plan, and its continued success can be depended upon to provide a foundation for the University's pioneering efforts to advance academic research in the service of society. We remain mindful of our charge to work on important, hard problems, and to provide education and training consistent with the resources that are uniquely available to us.

The work reported in this document represents collaboration among dozens of faculty members, more than a hundred students spanning nine science and engineering departments, eleven full-time staff members and almost twenty partner companies. I appreciate your interest in our Center's activities, and welcome your feedback.

B. Executive Summary

The 2006-2007 fiscal year was the most productive in the Boston University Photonics Center's (BUPC) history.

This annual report summarizes activities of the BUPC over the period of July, 2006 through June, 2007, corresponding to the University's fiscal year. These activities span the Center's complementary missions in research, education, technology development, and commercialization. This reporting period included a milestone, as BUPC completed its tenth year of operation in its landmark building in the heart of the University's Charles River Campus.

Faculty research activity reached an all time high when evaluated by the usual metrics of external funding, scholarly publications, honors and awards. The Center's educational programs were bolstered by two summer programs hosting more than 40 undergraduate interns, and by the launch of a competitive graduate fellowship program sponsoring ten BUPC graduate fellowships. In technology development, the prototype RedOwl sniper detection system pioneered by Center faculty, staff, and industry partners was field-tested by the US Department of Defense, and has been handed off to industry partners for further pre-commercial development. Three new defense/security prototypes were developed by BUPC to address critical national defense needs in the past year and 13 faculty development projects were supported in collaboration with the Army Research Laboratory to fill the technology pipeline for our future defense-related prototyping efforts. The Center's business incubator had a transformative year. After revising its core mission and operational strategy in the summer of 2006, the incubator generated significant demand for the intellectual environment, facilities, and expertise available to participating companies. New companies attracted by this revised value proposition now occupy all available space.

Highlights of BUPC activities for the 2006-2007 fiscal year include:

External grant funding nearly doubled from the previous year, to $20M. This includes more than $12M in grant and contract support of fundamental photonics research conducted by the Center's 31 faculty members and $8M through a Cooperative Agreement with the Army Research Laboratory's Sensors and Electron Devices Directorate (ARL-SEDD) for photonics technology research and development in areas of critical national need.

Significant new research thrusts were launched in nanophotonics and biophotonics, including the construction of three new faculty laboratories in BUPC for recently hired professors Dal Negro, Swan, and Altug, and supported by a complementary laboratory in the Life Sciences Building for BUPC professor Amit Meller. Professor Altug was also supported by the Center's *New Faculty Initiation Award*, which provided equipment, startup funds, and research funding for collaboration with ARL SEDD. Nanophotonics and Biophotonics have emerged as areas of strategic importance to the Center and to the University, and they build on complementary, interdisciplinary strengths of Center faculty.

Eleven new companies joined the incubator. These companies represent the leading edge of emerging photonics and biotechnology industries, and their proximity to the academic community and to BUPC's unparalleled facilities gives them substantial leverage for growth. In a strategic realignment, the BUPC incubator program has

expanded its connections to the University's core educational missions through its affiliation with the new Boston University Institute for Technology Entrepreneurship and Commercialization (ITEC) and revision of its model for cooperative business acceleration. Veteran incubator companies also prospered. A highlight: Solx Corporation was acquired by OccuLogix after producing profound and effective photonic treatments for glaucoma in partnership with BUPC.

Two professors joined the BUPC faculty. Professor Theodore Fritz, has a primary appointment in Astronomy and a secondary appointment in Electrical and Computer Engineering. His research involves development of instruments to study space plasma physics. Also joining BUPC was Assistant Professor Richard Averitt who has a primary appointment in Physics. His work centers on nanophotonics, plasmonics, and metamaterials for Terahertz systems.

Ten Photonics Center Graduate Fellows were supported in a pilot program. These students initiated wide-ranging activities linking scholarship, education, and community. Fellows were selected competitively, and spanned five university departments. Working with faculty mentors and BUPC staff advisors, they engaged in equipment training, shared laboratory support, event planning, and the creation of a lively "Faculty Forum" seminar series highlighting emerging interdisciplinary research at the Center. Based on the success of the program, ten new fellows were selected for the coming year.

The "BUPC Future of Light Symposium" anchored a variety of scientific conferences hosted by the Center. Professor Larry Ziegler organized the symposium with help from BUPC staff. In celebration of the BUPC's decadal anniversary, the symposium program provided a retrospective of the Center's collective achievements in its first ten years, and a forward looking perspective of research strengths that will guide its achievements in the coming ten years. Other significant conferences hosted by the Center included the spring annual meeting of the Army Science Board, and a well-attended conference on Nanophotonics that was co-hosted by the Center for Nanoscience and Nanobiotechnology (CNN).

Three new pipeline development projects were introduced for defense and security applications following the prototype development model that delivered the successful RedOwl system. The first is a compact biothreat detection system based on surface enhanced Raman spectroscopy (SERS). The COBRA (Compact Optical Bio-threat Rapid Analyzer) prototype is the first field-portable system of its kind. It owes its performance advantage to nanostructured substrates developed at Boston University, under the direction of Professor Larry Ziegler. The second is a point-to-point laser system that combines already-fielded soldier hardware with inexpensive optical modulators to improve battlefield situational awareness, prevent friendly fire and allow secure communication. The SCOUT (Secure Communicating Optical Ultra-light Transponder) prototype is enabled by deformable micromachined mirrors developed at Boston University under the direction of Professor Thomas Bifano. The third is a soldier worn sniper detection system EAGLE (Enhanced Acoustic Gear for Locating Enemies). It translates biomimetic processing algorithms for gunshot source location that were pioneered by Professor Allyn Hubbard and postdoctoral researcher Socrates Deligeorges (now president of Biomimetic Systems) into a compact, helmet-based system that can be integrated with the soldier systems being developed by the Army.

The RedOwl robotically mounted sniper detection system was field tested in the current year, after the third generation prototype was completed. Tests were conducted in the Army Airborne Expeditionary Force (AAEF) exercise at Fort Benning, GA in the fall 2006 and at Aberdeen Proving Grounds in MD in the following spring and summer. This

generation of the system will be transferred in 2007 to industry partners for continued development and commercialization. Based on direct feedback from end users in response to current needs, a vehicle mounted system for HMMWV installation has been developed in the past year and is already beginning field tests.

The Center co-sponsored two summer internship programs for undergraduates led by Center faculty. With support from the National Science Foundation Research Experiences for Undergraduates (NSF-REU) program, Professor Michael Ruane hosted 16 summer interns at the Center in 2007 on the subject of biophotonics. With support from the US Air Force Nanosatellite Program, Professor Ted Fritz hosted 30 summer interns in 2007 in an effort to design and build space-based weather sensing equipment.

The Photonics Center at a Glance

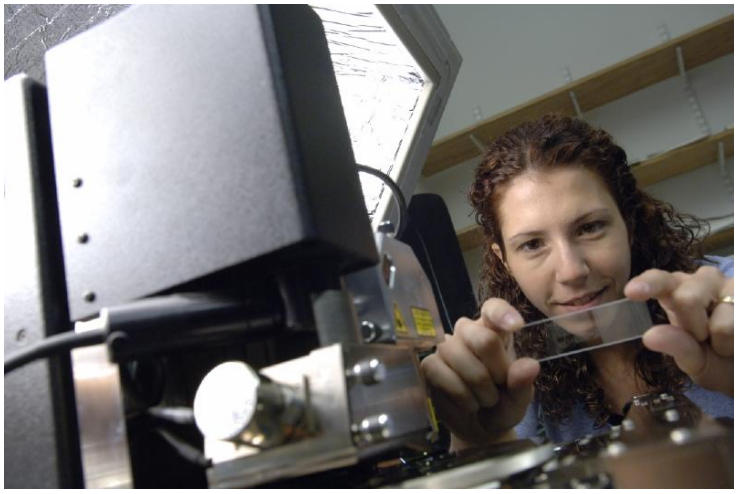
Faculty Members	31
Graduate Students & Post-Docs	49
Staff Members	11
Funded R&D Projects	78
Funding for R&D (Current Year)	$20.1M
Photonics Related Courses	20
Publications in Archival Journals	53
Faculty Patents	6
Shared Facilities	3
Photonics Center Square Footage	235,000
Incubator Square Footage	23,000
Year of Building Opening	1997

C. Mission Statement

The Boston University Photonics Center will pioneer fundamental knowledge and innovative technology in the field of photonics. We aim to work on important and basic problems, to translate enabling discoveries into useful applications and to educate future leaders in the field.

This mission is executed through:

- Basic research and scholarship in photonics
- Academic and entrepreneurial programs and initiatives for students
- Development for defense/security applications utilizing photonics
- Incubation of photonics technology companies



II. Faculty & Staff

From its inception, the Center has attracted scholarly pioneers to lead our academic program in Photonics. A vibrant multi-disciplinary environment is achieved through faculty contributions from various schools and colleges within Boston University. The Center is supported by a dedicated technical and administrative staff. Working with the faculty, the staff is focused on advancing the mission of the Center in the areas of basic research in photonics, academic and entrepreneurial programs for students, development of defense applications utilizing photonics and the incubation of photonics technology companies.

A. Photonics Center Faculty Members

Richard Averitt
Physics

Enrico Bellotti
ECE

Thomas G. Bifano
MFG/AME

Irving Bigio
BME/ECE

Supriya Chakrabarti
Astronomy

Luca Dal Negro
ECE

Kamil Ekinci
AME

Shyamsunder Erramilli
Physics

Theodore Fritz
Astronomy

Rosina Georgiadis
Chemistry

Bennett Goldberg
Physics

Allyn Hubbard
ECE

Guilford Jones
Chemistry

James Jackson
Astronomy

Amit Meller
BME

Michael Mendillo
Astronomy

Jerome Mertz
BME

Theodore Morse
ECE

Theodore
Moustakas
ECE

Todd W. Murray
AME

Roberto Paiella
ECE

Kenneth J Rothschild
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Michael Ruane
ECE

Bahaa E A Saleh
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Alexander V Sergienko
ECE

Andre Sharon
MFG

Anna Swan
ECE

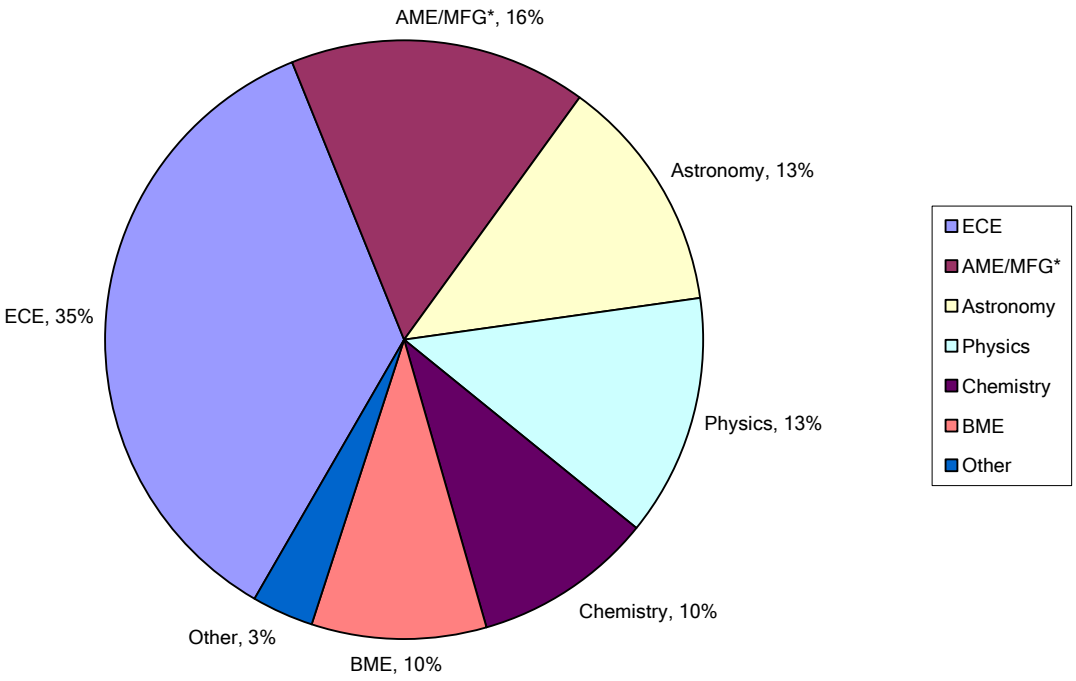
Malvin C Teich
ECE

Selim Ünlü
ECE

Xin Zhang
MFG

Lawrence Ziegler
Chemistry

Photonics Faculty Core Department
Total Number of Faculty: 31



AME & MFG will merge in 2007

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2. Faculty Committees

This year the Photonics Center established six committees supported by Photonics staff and faculty members:

Space Allocation Committee: Chair - Theodore Moustakas
Generates policy guidelines for the space management.

Equipment Committee: Chair - Xin Zhang
Recommends equipment upgrades or new equipment purchases that will enhance the research and development of faculty and students at the Center.

Education Committee: Chair - Shyam Erramilli
Awards fellowships to Photonics Center graduate students. Fellows selected for support provide assistance to the Photonics Center community in shared lab upkeep and training, and in scholarly events and community building activities.

Distinguished Seminar Series Committee: Chair - Malvin Teich
Invites distinguished leaders in the field of Photonics to visit the Photonics Center and to give talks on subjects of importance in the field.

Symposium Committee: Chair - Lawrence Ziegler
Organizes the annual "Future of Light" symposium with a focus on research and development in area relevant to the Photonics Center community. The symposium includes limited outside speakers and a majority of internal faculty speakers. The symposium also includes a student poster session for Photonics Center students to participate in a technical conference where their research can be discussed with distinguished members of the community. Selim Unlu will be chair for the coming year.

Executive Advisory Committee: Chair - Bennett Goldberg.
Comprised of the Chairs of the seven affiliated Departments, advises the Director on educational and academic issues.

B. Photonics Center Staff

1. Staff Directory

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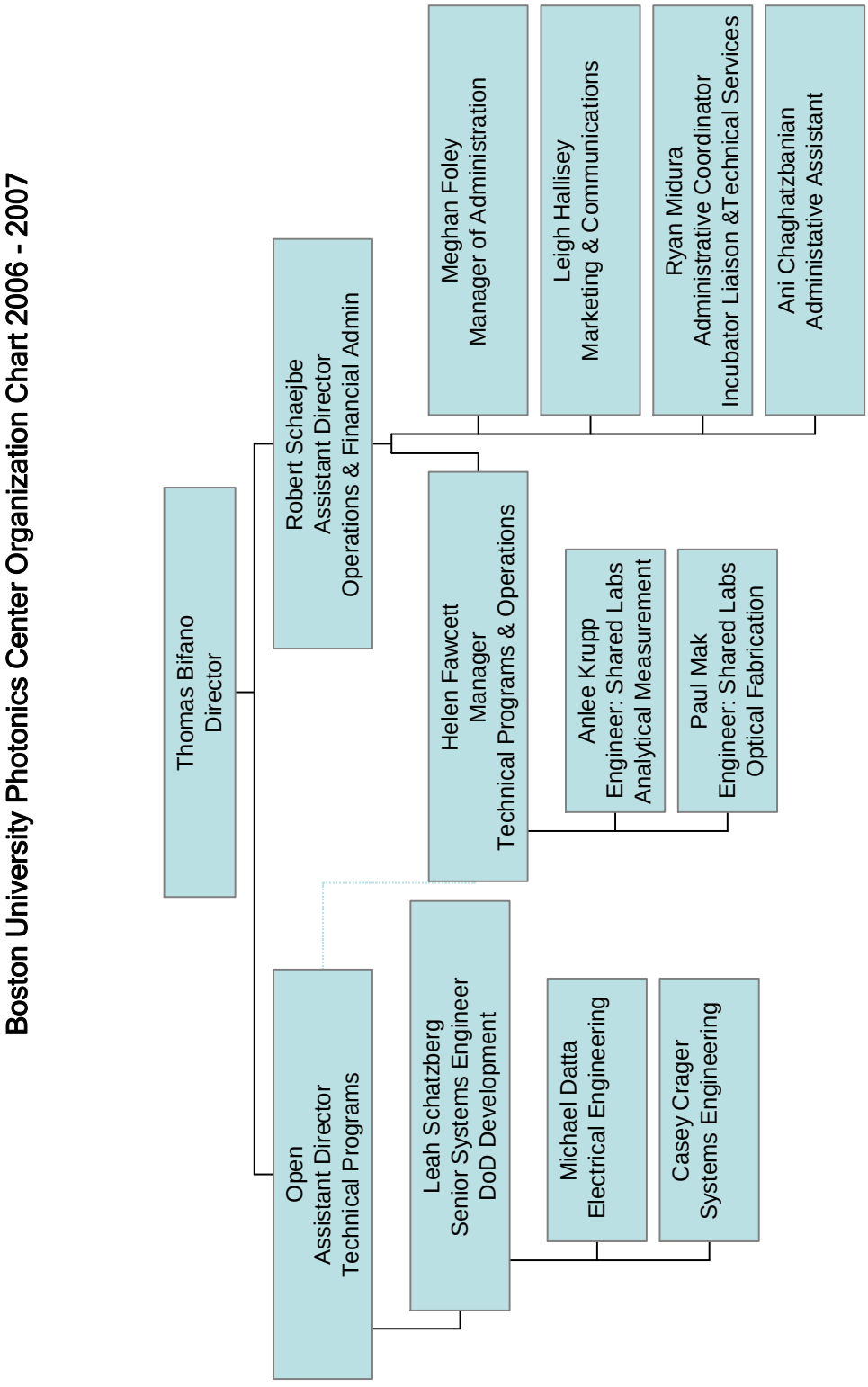
Tel: (617) 353-8899

2. Organizational Chart



III. Research & Development

A. Overview

Scientific discovery, fundamental research and innovative development form a continuous intellectual pipeline at the Boston University Photonics Center. Our scholarly research spans the traditional disciplines of our faculty members' host academic departments: Astronomy, Biology, Chemistry, Physics, Aerospace and Mechanical Engineering, Biomedical Engineering, Electrical and Computer Engineering, and Manufacturing Engineering.

On the following pages, outcomes from our efforts in research and development for the past year are detailed. Photonics-focused grants (i.e. new funds received in the current fiscal year) are listed, as are archival journal publications.

The Photonics Center has become well known for its program of defense-related technology transfer through targeted prototype development. In the past year, we have continued to develop and field-test our successful RedOwl acoustic-optical direction finding robotic system. We have also introduced three new prototype systems based on enabling outcomes from our faculty's research.

Our cooperative agreement with the Army Research Laboratory (ARL) offers us a way to accelerate some of our more applied research, particularly in areas that might lead toward development of prototype systems associated with our defense and security mission. In the year covered by this annual report, $7.9M was awarded to Boston University for this important work. In the coming year, an additional $6.9M has been allocated to Boston University.

Through this summary, we hope to convey the broad range of R&D activities that occur in the Photonics Center, and to portray the pride that our faculty have in their academic achievements and their team-based development projects.

B. Faculty/Staff Research

The Center's research laboratories have pioneered breakthrough photonic devices that include blue light lasers, quantum cryptography systems, deformable mirrors that improve telescope and microscope resolution, high-speed photodetectors and biophotonic sensors. Photonics faculty and staff receive support from industry and federal agencies including the National Science Foundation, the Department of Energy, the National Institutes of Health and the Department of Defense. This year Photonics faculty members and students published more than 50 articles in archival journals, were issued six patents for novel intellectual property and received more than $20.1M in external funding distributed among over 60 photonics related projects. The following table lists new funds that arrived at Boston University in the fiscal year, as reported by the Office of Sponsored Programs.

1. Externally Funded Research (New funds for 2006-2007)

PI	Dept.	Title of Project	Agency	Period	Amount
Averitt	CSP	Metamaterials for Threat Reduction Applications: Imaging, Signal Processing and Cloaking (Subcontract via Los Alamos National Laboratory)	DOE	05/08/07-09/30/07	$67,477
Bellotti	ECE	SBIR: Development of Low Stress Ohmic Contacts to HgCdTe (Subcontract via Photronix, Inc.)	DOD	09/22/06-12/14/08	$120,000
Bellotti	ECE	Deep UV Semiconductor Laser for in-situ Organic and Biological Exploration	NASA	01/01/06-12/31/07	$25,000
Bifano	MFG	High Resolution Silicon Deformable Mirrors (SBIR) (Subcontract via Boston Micromachines Corporation)	NASA	02/13/06-02/12/08	$29,236
Bifano	MFG	High Resolution Silicon Deformable Mirrors (SBIR) (Subcontract via Boston Micromachines Corporation)	NASA	02/13/06-02/12/08	$42,105
Bifano	MFG	SBIR Phase II: Ultraflat Tip Tilt Piston MEMS Deformable Mirror (in conjuction with Photonics Center) (Subcontract via Boston Micromachines Corporation)	NASA	12/03/06-12/03/08	$25,000
Bifano	PHO	Photonics Research and Technology Insertion	DOD	07/01/06-06/30/07	$7,940,000
Bigio	BME	Polarized Probes for Fiberoptic in-vivo Spectroscopy (SBIR) (Subcontract via Optimum Technologies, Inc.)	HHS/NIH/NCI	05/01/06-04/30/07	$53,935
Bigio	BME	Optical Measurement of Fast Drug Kinetics in Tumors	HHS/NIH/NCI	09/01/06-08/31/07	$303,858
Bigio	BME	NRSA: Optical Pharmacokinetics System (R. Reif)	HHS/NIH/NCI	09/01/06-08/31/07	$27,373
Bigio	BME	Optical Spectroscopy for Management of Cancer Treatment	HHS/NIH/NCI	09/01/06-08/31/07	$1,201,187
Bigio	BME	Graduate Student Stipend (S. Gioux) (Subcontract via Beth Israel Deaconess Medical Center)	HHS/NIH/NCI	01/01/07-06/30/07	$18,310
Bigio	BME	Ultra-operative Fluorescence Imaging (S. Gioux) (Subcontract via Beth Israel Deaconess Medical Center)	HHS/NIH/NCI	07/01/07-07/31/08	$43,111

PI	Dept.	Title of Project	Agency	Period	Amount
Chakrabarti	CSP	Planet Imaging Concept Testbed Using a Rocket Experiment (PICTURE)	NASA	11/01/04-01/31/08	$230,000
Chakrabarti	CSP	Planet Imaging Concept Testbed Using a Rocket Experiment (PICTURE)	NASA	11/01/04-01/31/08	$40,000
Chakrabarti	CSP	Planet Imaging Concept Testbed Using a Rocket Experiment (PICTURE)	NASA	11/01/04-01/31/08	$343,097
Chakrabarti	CSP	Planet Imaging Concept Testbed Using a Rocket Experiment (PICTURE)	NASA	11/01/04-01/31/08	$150,000
Dal Negro	ECE	MURI: Electrically-Pumped, Silicon-Based Lasers for Chip-Scale Nanophotonic Systems (Subcontract via MIT)	DOD	07/01/06-11/30/06	$41,667
Dal Negro	ECE	MURI: Electrically-Pumped, Silicon-Based Lasers for Chip-Scale Nanophotonic Systems (Subcontract via MIT)	DOD	07/01/06-11/30/07	$100,000
Ekinci	AME	CAREER: Photonic Integration of Silicon Nanoelectromechanical Systems	NSF	03/01/07-02/29/08	$73,916
Erramilli	PHY	Graduate Student Support (L. Qiu) (Subcontract via Beth Israel Deaconess Medical Center)	HHS/NIH/ NIBIB	05/01/06-04/30/07	$33,022
Fritz	CSP	POLAR/CAMMICE Effort at Boston University	NASA	02/01/05-01/31/07	$1,979
Fritz	CSP	The POLAR CAMMICE Effort at Boston University	NASA	02/01/05-01/31/08	$82,167
Fritz	CSP	The Loss Cone Imager (LCI)	DOD	03/24/05-06/30/10	$212,000
Fritz	CSP	The Loss Cone Imager (LCI)	DOD	03/24/05-06/30/10	$316,000
Fritz	CSP	The Loss Cone Imager (LCI)	DOD	03/24/05-06/30/10	$300,000
Fritz	CSP	The Cluster RAPID On-Orbit Operations and Data Verification	NASA	04/01/05-03/31/08	$100,000
Fritz	CSP	The Cluster RAPID On-Orbit Operations and Data Verification	NASA	04/01/05-03/31/08	$80,200
Fritz	CSP	The Cluster RAPID On-Orbit Operations and Data Verification	NASA	04/01/05-03/31/08	$310,000
Fritz	CSP	The Loss Cone Imager (LCI) – HST Supplement	DOD	03/24/06-06/30/10	$84,000
Fritz	CSP	POLAR/CAMMICE Effort at Boston University	NASA	02/01/05-01/31/08	$200,000

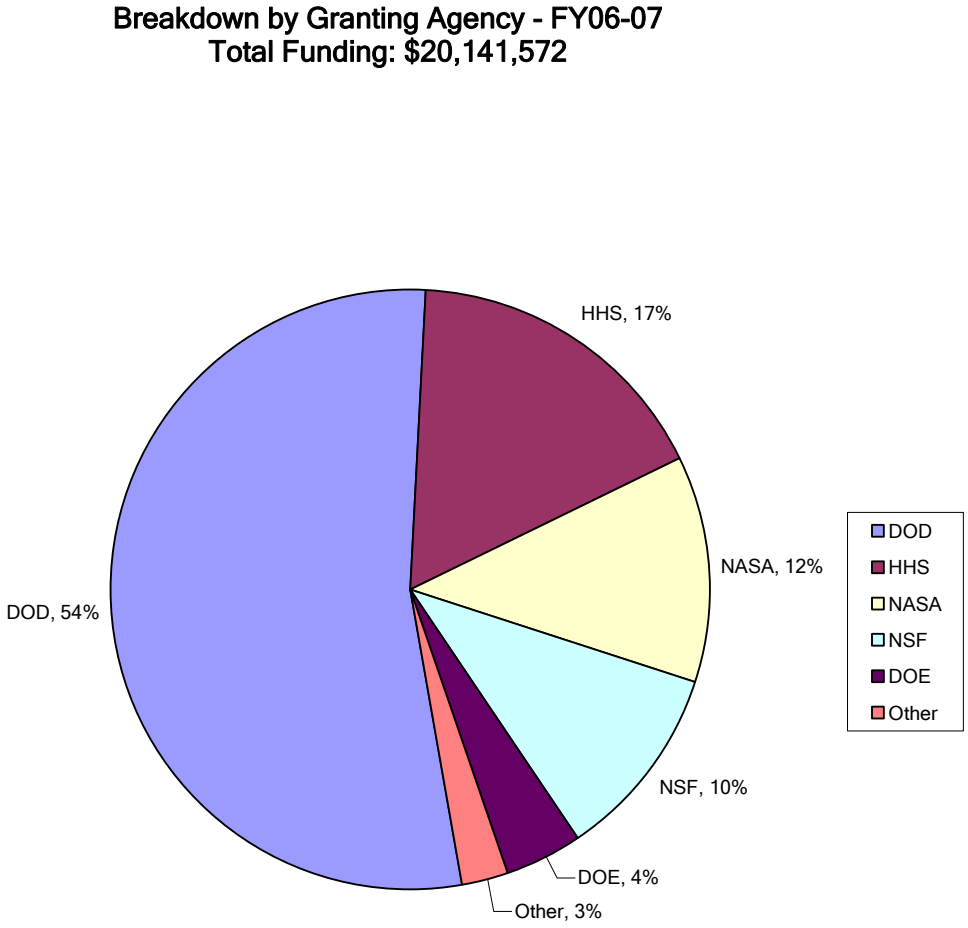
PI	Dept.	Title of Project	Agency	Period	Amount
Fritz	CSP	The Loss Cone Imager (LCI)	DOD	03/24/05-06/30/10	$35,000
Fritz	CSP	The Cluster RAPID On-Orbit Operations and Data Verification	NASA	04/01/05-03/31/08	$200,000
Fritz	CSP	BUSAT: The Boston University Student Satellite for Applications and Training (NANOSAT FY07)	DOD	02/15/07-11/30/07	$55,000
Georgiadis	CHEM	DNA Lattices for the Study of Biological Processes (Subcontract via Boston College)	HHS/NIH/ NIGMS	05/01/06-04/30/07	$57,511
Georgiadis	CHEM	Optimization of Adhesive Coatings for Surface Plasmon Resonance and Surface Plasmon Enhanced Fluorescence	Draper Laboratory	07/01/06-06/30/07	$100,000
Goldberg Unlu	PHY	MURI: New Instrumentation for Nanoscale Subsurface Spectroscopy and Tomography (Subcontract via University of Rochester)	DOD	06/15/03-01/14/08	$72,846
Goldberg Stevens	PHY	Summer Immersion Institutes	Bechtel	12/13/06-12/12/07	$125,000
Goldberg Stanley	PHY	Boston University Urban Fellows Project (in conjunction with Science and Math Education Center)	NSF	06/01/07-05/31/08	$372,853
Goldberg DeRosa Naram Meller	PHY	PROSTARS: Programs for Science and Technology Academic Retention and Success (additional co-p.i.: J. Snyder)	NSF	01/01/07-12/31/07	$318,027
Hubbard	ECE	Photonics Technology Development and Insertion/Task 25: Acoustic Sniper Detection	DOD	07/01/06-06/30/07	$150,000
Jackson	IAR	Spitzer Cycle 3 Funding: Active Star Formation in Infrared Dark Clouds (Subcontract via Jet Propulsion Laboratory)	NASA	09/21/06-09/30/08	$155,345
Jackson	IAR	GBT Student Support Program (E.Chambers) (Subcontract via National Radio Astronomy Observatory)	NSF	03/01/07-02/28/08	$18,001
Jackson	IAR	Protostars in Infrared Dark Clouds (Subcontract via California Institute of Technology/Jet Propulsion Laboratory)	NASA	10/26/06-09/30/08	$125,771

PI	Dept.	Title of Project	Agency	Period	Amount
Jones	CHEM	Development of Dye-Doped Polymer-Filled Nanoporous Glass Optical Materials (in conjunction with Photonics Center)(Subcontract via Physical Sciences, Inc.)	DOD	08/01/05-01/31/07	$50,000
Meller	BME	Folding Kinetics and Stability Studies of Individual RNA Molecules, Application to RNA Interference	Human Frontier Science Program (France)	07/01/06-06/30/07	$119,000
Meller	BME	Nanopore-FRET Instrument for RNA Folding Analysis	HHS/NIH/ NIGMS	07/01/06-01/31/07	$137,680
Meller	BME	Ultra Fast Nanopore Readout Platform for Designed DNAs	HHS/NIH/ WHGRI	07/01/06-09/30/06	$131,749
Meller	BME	Folding Kinetics and Stability Studies of Individual RNA Molecules, Application to RNA Interference	Human Frontier Science Program (France)	07/01/06-06/30/07	$74,367
Meller	BME	Nanopore-FRET Instrument for RNA Folding Analysis	HHS/NIH/ NIGMS	07/01/06-01/31/07	$74,643
Meller	BME	Ultra Fast Nanopore Readout Platform for Designed DNAs	HHS/NIH/ NHGRI	07/01/06-09/30/07	$200,460
Meller	BME	DNA Bubble Formation and Kinetics Studies by Single-Molecule FRET	NSF	07/01/06-07/31/08-	$91,028
Meller	BME	NIRT: DNA Sequencing and Translocation Studies Using Electrically-Addressable Nanopore Arrays (Subcontract via Brown University)	NSF	08/01/06 07/31/08	$162,766
Meller	BME	High Throughput DNA Sequencing Using Design Polymers and Nanopore Arrays	HHS/NIH/ NHGRI	09/29/06-08/31/07	$302,390
Meller	BME	Nanopore-FRET Instrument for RNA Folding Analysis	HHS/NIH/ NIGMS	02/01/07-01/31/08	$192,600
Meller	BME	Electronic Recognition of Gene Regulatory Proteins Bound to DNA	HHS	08/01/07-07/31/08	$195,000
Mendillo	CSP	Studies of Variability Patterns and Their Causes in Mars' Upper Atmosphere	NASA	06/01/04-05/31/08	$104,857
Mendillo	CSP	Saturn Thermosphere-Ionosphere Model (STIM)	NASA	09/01/05-08/31/08	$75,000
Mendillo	CSP	Multiple Characteristics of Ionospheric Variability Patterns	DOD/NAVY	01/01/06-12/31/08	$155,000

PI	Dept.	Title of Project	Agency	Period	Amount
Mendillo	CSP	GSRP - Saturn's Ionosphere and Plasmasphere (L. Moore)	NASA	12/01/06-06/30/07	$24,000
Mendillo	CSP	CEDAR Post-Doc: Imaging Studies of Ionospheric Instabilities (C. Martinis)	NSF	12/01/06-11/30/07	$80,944
Morse	ECE	Specialty Fibers for Clinical Applications	DOD	02/01/07-01/31/08	$150,000
Morse	ECE	Doped Silica Preforms and Tubes: OVD Process	OFS Labs	05/21/07-05/20/08	$30,000
Morse	ECE	Aerosol Combustion Synthesis of Unaglommerated Yttria Nanoparticles	DOD	04/30/07-01/31/08	$70,000
Moustakas	ECE	Photonics Technology Development and Insertion/Task 6: Development of GaN Substrates by HVPE to be Used by Both BU and ARL Groups for Fabrication of UV-LEDs for Biological and Chemical Detection	DOD	05/01/05-10/31/06	$273,000
Moustakas	ECE	Photonics Research and Development (Subcontract via University of Nevada/Las Vegas Research Foundation)	DOE	08/01/06-07/31/07	$350,000
Moustakas	ECE	Low-Cost Blue/UV LEDs with Very High Photon Conversion and Extraction Efficiency for White Lighting	DOE	10/01/06-09/30/07	$85,000
Moustakas	ECE	Low-Cost Blue/UV LEDs with Very High Photon Conversion and Extraction Efficiency for White Lighting	DOE	10/01/06-09/30/07	$80,000
Moustakas	ECE	Nitridation Studies of Sapphire Wafers	Saint-Gobain	12/12/06-06/30/07	$10,000
Moustakas	ECE	Low Cost Blue/UV LEDs with Very High Photon Conversion and Extraction Efficiency for White Lighting	DOE	10/01/06-09/30/07	$154,995
Moustakas	ECE	Deep UV Semiconductor Laser for in situ Organic and Biological Exploration	NASA	01/01/06-12/31/08	$125,000
Paiella	ECE	Plasmonic Band-Structure Engineering for Light-Emission Efficiency Enhancement	DOE	08/15/06-08/14/07	$104,897
Paiella	ECE	Intersubband All-Optical Switching and Optically-Pumped Light Emission with III-Nitride Quantum Wells	NSF	09/01/06-08/31/07	$95,649

PI	Dept.	Title of Project	Agency	Period	Amount
Paiella	ECE	Intersubband All-Optical Switching and Optically-Pumped Light Emission with III-Nitride Quantum Wells	NSF	09/01/06-08/31/07	$90,426
Rothschild	PHY	FTIR Study of Signal Transduction in Sensory Rhodopsins	HHS/NIH/NIGMS	02/01/07-01/31/08	$189,246
Rothschild	PHY	FTIR Study of Signal Transduction in Sensory Rhodopsins	HHS/NIH/NIGMS	02/01/07-01/31/08	$40,451
Ruane	ECE	Center for Subsurface Sensing and Imaging Systems (CenSSIS) – Education Program (Subcontract via Northeastern Univ.)	NSF	09/01/06-08/31/07	$58,942
Ruane	ECE	REU Site: Research Experience for Undergraduate Students in Photonics	NSF	05/01/07-04/30/08	$114,053
Saleh Teich	ECE	Quantum Optical Coherence Tomography (CenSSIS Supplement) (Subcontract via Northeastern University)	NSF	02/01/03-08/31/07	$35,000
Saleh Teich Sergienko	ECE	Quantum Imaging: New Methods and Applications (MURI) (Subcontract via University of Rochester)	DOD	05/01/05-09/30/07	$210,673
Saleh	ECE	Center for Subsurface Sensing and Imaging Systems (CenSSIS) – Research Thrust 1-Photonics (Subcontract via Northeastern Univ.)	NSF	09/01/06-08/31/07	$124,865
Sharon	MFG	Graduate Student Research Support	Fraunhofer USA	01/01/07-04/30/07	$13,962
Teich	ECE	Free Space Quantum Key Distribution (T. Yarnall) (Subcontract via MIT/Lincoln Laboratory)	DOD	09/01/06-12/31/06	$15,358
Teich	ECE	Free Space Quantum Key Distribution (T. Yarnall) (Subcontract via MIT/Lincoln Laboratory)	DOD	01/01/07-05/31/07	$19,198
Unlu Goldberg	ECE	New Instrumentation for Nanoscale Subsurface Spectroscopy and Tomography	DOD	06/15/03-01/14/07	$72,500
Unlu	ECE	New Instrumentation for Nanoscale Subsurface Spectroscopy and Tomography (Subcontract via University of Rochester)	DOD/Airforce	06/15/03-01/14/08	$107,154

PI	Dept.	Title of Project	Agency	Period	Amount
Unlu	ECE	Design, Fabrication and Bench Testing of the FLAMES (in conjunction with Center for Nanoscience and Nanobiotechnology) (Subcontract via New Jersey Institute of Technology)	HHS/NIH/ NIGMS	09/20/05-08/31/07	$53,216
Zhang	MFG	CAREER: Creating Nanostructured Gratings on Microstructures for Residual Strain/Stress Measurement in NEMS/MEMS and Traction Force Measurement in Cells (REU Supplement)	NSF	02/13/04-02/29/08	$12,000
Zhang	MFG	NER - A Digital Bio/Nanoelectronics Interface for Single Cell Study	NSF	09/15/06-08/31/07	$100,000
Zhang	MFG	Uncooled Cantilever Microbolometer Focal Plane Arrays with MK Temperature Resolution: Engineering Mechanics for the Next Generation	DOD	12/01/06-11/30/07	$99,580
Zhang	MFG	Mechanical Behavior of Amorphous Plasma-Enhanced Chemical Vapor Deposited Silicon Oxide Films for MEMS Applications	NSF	06/01/07-05/31/10	$150,000
				Total	**$20,141,572**


Breakdown by Granting Agency - FY06-07
Total Funding: $20,141,572
HHS, 17%
NASA, 12%
DOD, 54%
NSF, 10%
DOE, 4%
Other, 3%
DOD
HHS
NASA
NSF
DOE
Other

2. Publications and Patents

Journal Articles

E. Bellotti and D. D'Orsogna, "Numerical analysis of HgCdTe simultaneous two-color photovoltaic infrared detectors," IEEE Journal of Quantum Electronics, Vol. 42, pp. 418-426, April 2006.

M. H. Miller, J. A. Perrault, G. G. Parker, B. P. Bettig, and **T. G. Bifano**, "Simple models for piston-type micromirror behavior," J. Micromech. Microeng. [16] pp. 303–313, 2006.

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Jean Luc Castagner and **Irving J Bigio**, Polar nephelometer based on a rotational confocal imaging setup, *Applied Optics* **45**, 2232-2239 (April 2006).

LB Lovat, K Johnson, GD Mackenzie, BR Clark, MR Novelli, S Davies, M O'Donovan, C Selvasekar, SM Thorpe, D Pickard, R Fitzgerald, T Fearn, **IJ Bigio**, SG Bown, Elastic scattering spectroscopy accurately detects high grade dysplasia and cancer in Barrett's esophagus, *GUT*, (May, 2006)

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L. B. Lovat, K Johnson, G.D. Mackenzie, B.R. Clark, M.R. Novelli, S. Davies, M. O'Donovan, C. Selvasekar, S.M. Thorpe, D. Pickard, R. Fitzgerald, T. Fearn, **I.J. Bigio**, and S.G. Bown, "Elastic scattering spectroscopy accurately detects high grade dysplasia and cancer in Barrett's esophagus," Gut, May 2006.

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L. Zhou, T. Xu, D. J. Smith, and **T. D. Moustakas**, "Microstructure of relaxed InN quantum dots grown on GaN buffer layers by Molecular Beam Epitaxy," Applied Physics Letters, Vol. 88, p. 231906, June 2006.

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M. Yang and **X. Zhang**, "Electrical Assisted Patterning of Cardiac Myocytes with Controlled Macroscopic Anisotropy using a Microfluidic Dielectrophoresis Chip," Accepted for Publication in Sensors and Actuators A: Physical, June 2006.

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Patents

Spectral imaging for vertical sectioning

Unlu; Selim M. (Jamaica Plain, MA), **Swan; Anna** (Cambridge, MA), **Goldberg; Bennett B.** (Newton, MA), Ippolito; Stephen (Tampa, FL), Moiseev; Lev (Brighton, MA), Lipolf; Samuel (Newton, MA), Tong; Yunjie (Allston, MA) September 19, 2006 United States Patent 7,7110,118

Detection of disease related genes

Rothschild; Kenneth J. (Newton, MA), Sonar; Sanjay M. (Mumbai, IN), Olejnik; Jerzy (Allston, MA) January 20, 2007 United States Patent 7,169,558

Detecting targets in heterologous mixtures

Rothschild; Kenneth J. (Newton, MA), Sonar; Sanjay M. (Mumbai, IN), Olejnik; Jerzy (Brookline, MA) March 27, 2007 United States Patent 7,195,874

Detection of markers in nascent proteins

Rothschild; Kenneth J. (Newton, MA), Olejnik; Jerzy (Brookline, MA) Sonar; Sanjay M. (Thane, IN),May 1, 2007 United States Patent 7,211,394

Semiconductor device having group III nitride buffer layer and growth layers

Moustakas; Theodore D. (Dover, MA) June 26, 2007 United States Patent 7,235,819

Tunable current-mode integrator for low-frequency filters

Yang; Zibling (Natick, MA), Hinck; Todd A. (Arlington, MA), **Cohen; Howard I.** (Waltham, MA), **Hubbard; Allyn** (Medfield, MA) August 29, 2006 United States Patent 7,098,718

C. Development

Since its inception, the Boston University Photonics Center has worked jointly with the Department of Defense to develop photonics technologies. Much of the original funding for the construction of the Center came from a grant from the Office of Naval Research. The Department of Defense requires rapid access to advanced technologies to solve critical operational needs such as sniper detection, improvised explosive device (IED) detection and disarmament, and chemical and biological threat detection. Many potential solutions have emerged from the research efforts within Boston University. A core mission of the Photonics Center is to accelerate the development of new technology for use in defense and security applications. When the results of research are rapidly converted into useful prototype equipment and devices for these applications, the security of the nation is better protected. The proven ability to develop promising defense technology is a critical differentiator for the Photonics Center. To that end, the pipeline model has been developed at the Center with RedOwl being the initial project. From this model, the Center has developed a phased program: Phase I is prototype development, Phase II is prototype enhancement and integration with a spin-off company or outside commercial entity (preferably a defense contractor) and Phase III is an effort to transfer the technology and prototype to production (outside the hands of the University), thus resulting in insertion. As RedOwl is heading to Phase III, several new pipeline projects began the process as Phase I technologies: Enhanced Acoustic Gear for Locating Enemy, Compact Bio-threat Rapid Analyzer and Secure Community Ultra-light Transporter.

1. The RedOwl Development Project

Robot Enhanced Detection Outpost with Lasers (RedOwl)
(Acoustic direction finding: sound localization)

Task Manager: Professor Hubbard / Leah Ziph-Schatzberg

Objective: Develop Boston University acoustic direction finding (ADF) technology to maturity. Integrate the ADF with an optical sensor suite developed for the military and currently deployed (Insight). The system is a sniper detection, gun fire/mortar locator that responds after the first shot and is able to image the source from which the shot originated, illuminate it and identify the source's range. RedOwl provides early warning information, intelligence, surveillance and targeting capabilities.

BU Technology Basis: Researchers at Boston University have developed acoustic localization enabling technology based on mammalian hearing apparatus. This biomimetic technology enables sound localization with significantly smaller microphone separation than traditional sound localization systems. This technology has been integrated with a suite of optical sensors built for military use and mounted on an iRobot PackBot. RedOwl's integrated optical sensor suite includes: laser range finder, laser illuminators/pointer, ADF and classifier with acoustic sensors, zoom thermal imager, low light/day light color 300x zoom camera, digital compass with

GPS integrated positioning, communications link connection and two wide angle cameras.

As the RedOwl system enters Phase III funding in the Photonics Center pipeline model, it has been tested in various military excursions as well as at local firing ranges to collect data on accuracy and capabilities. The RedOwl system was tested extensively at local firing ranges including Fort Devens, both on iRobot's PackBot as well as mounted onto the top of a High Mobility Multipurpose Wheeled Vehicle (HMMWV)

Four PackBot RedOwl systems were tested and characterized at Fort Devens and local firing ranges in preparation for them to be tested at Air Assault Expeditionary Force (AAEF). In September 2006, three systems were sent to Fort Benning to participate in the 10 week AAEF tests where warfighters were trained on how to use the system and then were able to test it in various scenarios for ruggedness, ease of use, etc. The systems were integrated to the network constructed for the exercise. The RedOwl was tested alongside many other gunfire detection systems and the final report stated that the PackBot RedOwl was one of the two most desirable systems which participated (out of 36 systems). The other most desirable system was an unmanned aerial vehicle (UAV).

In an effort to demonstrate versatility of the RedOwl system and in response to currently deployed sensors that are mounted on moving vehicles, a (HMMWV) mounted RedOwl system has been developed and tested on a moving and stationary HMMWV. In addition, a stand-alone ADF system, identical to the RedOwl system without the optical suite was mounted on a HMMWV and tested. Through data analysis, further improvements to the system performance will be adopted as system upgrades. The data collected demonstrated the system's operation in ranges of up to 300 meters, with high angular accuracy of 1-2 degrees.

As the year progressed, the RedOwl and ADF (without optical suite) were tested alongside established gunfire detection systems at various military testing facilities. The systems were tested by Picatinny Arsenal in Aberdeen Proving Grounds as well as at Fort Benning, GA, to determine the system's acoustic performance with respect to other participants. In these tests, the ADF system was tested on HMMWV and Stryker and the RedOwl was tested on iRobot's PackBot. Test results have not yet been published.

Army Research Laboratories (ARL) has a RedOwl head that they are connecting to their network as a sensor node. The technology platform was tested at Aberdeen and at Ft. Benning as a PackBot system as well as the ADF-only on vehicles.

Timeline:

- Proof of concept of Acoustic Direction Finding on a PackBot / 2005
- Integrated Optics and acoustic suite / April 2006
- System test at AAEF – ruggedized / September 2006
- HMMWV system / March 2007
- AAEF test on R-Gator / September 2007
- ADF only technology and system improvements / Through 2008
- Transfer to production / July 2008

2. Pipeline Projects

Enhanced Acoustic Gear for Locating Enemy (EAGLE)
(wearable acoustic direction finding: sound localization)

Task Manager: Professor Allyn Hubbard / Dr. Helen Fawcett

Objective: Transition RedOwl acoustics system to a warfighter wearable format in support of Future Force Warrior (FFW) program, with the first target being a helmet mounted system.

BU Technology Basis: Researchers at Boston University have developed acoustic localization enabling technology based on mammalian hearing apparatus. This biomimetic technology enables sound localization with significantly smaller microphone separation than traditional sound localization systems. It is also far more accurate and immune to other noise sources and echoes and is designed to provide early warning information, gunshot/sniper detection and localization, intelligence, surveillance and targeting capabilities to military forces and government agencies. This technology has been integrated with the Future Force Warrior (FFW) helmet design to demonstrate the versatility of the technology base.

The Boston University Photonics Center has been invited to participate in the Side Excursion at Fort Dix, New Jersey and the On-the-move C4ISR VIP Day. We have been working with Natick Labs to demonstrate the technology on a FFW platform alongside several other technologies that have been developed specifically for sniper detection. We have generated a helmet platform that integrates onto the FFW helmet. This technology basis is being displayed as a proof-of-concept (lap top for leader display or command post, hand-held PDA or integrated optical display) promising integrability with FFW plans. This technology addresses a critical need for soldier-worn acoustic sensors as protection against snipers and to improve situational awareness in urban warfare environments.

Timeline:

- Proof of concept on a helmet / June 2005
- Tests in Aberdeen Proving Ground and Medfield / March 2006
- Demonstration of a wearable unit / March 2007
- Supplying the army with a mobile test unit / July 2007
- Wearable system with <2 oz. on helmet, <1 lb. in pack / April 2008
- Prototypes to meet Army requirements / October 2008
- Army tests, additional capabilities / December 2008 – January 2009
- Insertion / June 2010

Compact Optical Bio-threat Rapid Analyzer (COBRA)
(Spectroscopy: identification of biological contaminants)

Task Manager: Professor Lawrence Ziegler/Dr. Helen Fawcett

Objective: Transition an evolving optical and nano-technology SERS to a portable, field ready platform that will assist in battlefield and homeland hospitals for bacterial detection in blood and sputum as well as detection of bacteria in water testing.

BU Technology Basis: Researchers at Boston University Photonics Center have been developing surface enhanced Raman spectroscopy (SERS) technology that was mostly supported through the cooperative agreement with ARL. A variety of nanoscale structured metal substrates have been utilized for the observation of SERS. A Boston University Photonics Center research team had developed a new in-situ grown aggregated Au or Ag nanoparticle covered SiO_2 matrix and demonstrated exceptionally strong and reproducible signal enhancements for bacteria and spores. Patent applications for this technology and for the SERS substrate are pending.

The team has been moving forward to address some technology challenges. The software interface is one of the most important aspects of this project. The information from a post optical scan must run through mathematical computations and provide an accurate result of what material was just tested by the system. This information must be accurately and clearly displayed for the end user of the system. The team is also working toward a methodology to transfer a sample of bodily fluid to the substrate through the use of micro-fluidics. Sample processing to take a swab, vial of bodily fluid, etc. and process it to a sub-micro-liter volume that is then deposited onto the substrate is also of being demonstrated. With the compact system, the team is demonstrating repeatability and exercising the portable system.

Timeline:

- Proof of concept on commercially available spectrometer / October 2005
- Diagnostic capabilities through data analysis / June 2006
- Portable Raman Microscope Station / March 2007
- Sample manipulation and preparation / October 2008
- Collaboration/Insertion / March 2009

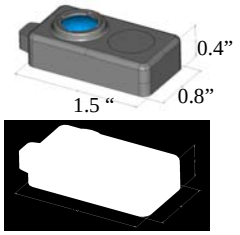
Secure Communicating Optical Ultra-light Transponder (SCOUT)
(MEMs low power battlefield communications)

Task Manager: Professor Thomas Bifano / Leah Ziph-Schatzberg

Objective: Enable a new class of communications and combat ID to assist in situational awareness using an existing optical system and innovative micro-mirrors.

BU Technology Basis: Researchers at the Boston University Photonics Center have developed an enabling technology creating low power integrated performance MEMs microcircuits. The silicon based MEMs circuits will be low cost, rugged and sufficiently high performance to add secure combat identification capability to thousands of soldiers and pieces of equipment in the field. The Boston University project team is continuing to perfect the enabling technology to provide further enhancement capabilities for prototypes to be applied to a variety of platforms and imaging sensors.

Source/Receiver



Transponder

The first system prototype, integrating a modified Insight Technology transceiver, was built. The system's modules and performance characteristics have been tested and analyzed. A plan and system specifications to improve the performance and demonstrate the technology will be in place in July. We have had communications with Natick SSC encouraging us to work on the optical communication for a convoy situation. Natick SSC is also interested in a combat ID system.

Timeline:

- Proof of concept / T. Bifano, BU / June 2005
- STTR award / BMC & BU / September 2006
- Development input PM soldier / December 2006
- Prototype: March 2007
- Technology demonstration / March 2008
- Full system integration with Insight Technology sight system / July 2008
- Work with Natick SSC and other potential customers / December 2008

3. ARL Cooperative Faculty Technology Development Awards

Through the ARL Cooperative Agreement Grants program, Boston University and the Army Research Laboratory have established a broad-based, effective, and productive mesh of collaborative, interdisciplinary research projects. Over the past year, the Photonics Center faculty received more than $1.3M in funding from the Center's Army Research Lab Cooperative Agreement. The supported research spanned a wide variety of photonics disciplines with a concentration on research applicable to solving Department of Defense issues such as chemical and biological detection and novel detectors. Below is a summary of the awards that were selected for support.

Prof. Bellotti – "Theoretical study of the optical and transport properties of III-Nitrides Quantum Wells and superlattices." This project is part of the collaboration between Boston University and the Army Research Laboratories to develop UV-LEDs as well as novel detectors for the detection of biological and chemical agents. This theoretical work supports the design effort for these devices. **Award total $71,969**

Prof. Bifano – "Secure, optical data transfer using modulated retro-reflection for autonomous robot communication." This project will develop a compact, low-power device to detect and modulate an incoming laser beam, and then return the modulated signal back to the location of the sender. This system can be adapted to the RedOwl acoustic sensing robot platform for covert communication. **Award total $105,499**

Prof. Bigio – "Polar nephelometer for rapid measurement of the scattering phase function of particulates." This project will build an instrument for identification of particulates (bacteria, spores or other forms) from aerosols or from aqueous suspension, as in water supply. **Award Total $39,315**

Profs. Dal Negro, Saleh and **Teich** – "Fully silicon based sources for military and biomedical applications." The purpose of this project is to investigate the feasibility of efficient light sources based on CMOS compatible silicon nano-materials and to evaluate their potential for stimulated emission and optical gain. **Award Total $102,015**

Prof. Erramilli – "Nanomechanical and gate controlled nanoelectrical sensors for airborne and waterborne threat detection." The goal of this project is to develop methods for enhancing the sensitivity and specificity of nanosensors for sensing airborne and waterborne pathogens. **Award Total $72,836**

Prof. Jones – "Rapid fluorescence assay for bacterial endospores." The goal of this project is the delivery of a prototype of a field deployable mini-laboratory to be used in military or counter-terrorism missions. **Award Total $96,592**

Prof. Morse – "An ultra sensitive bio-sensor." The final goal of this project is a new sensor that can act as a general platform for ultrasensitive measurements of the change of refractive index associated with surface binding. This sensor can be used for biological as well as other measurements. **Award Total $106,635**

Prof. Moustakas – "Development of free standing GaN substrates by HVPE method". These substrates will be used by both BU and the ARL groups for fabrication of UV-LEDs for biological and chemical detection." This project is part of collaboration between Boston University and the Army Research Laboratories to develop UV-LEDs for the detection of biological and complete infrastructure required for fabrication and characterization of nanotubes. **Award Total $150,656**

Profs. Paiella and **Moustakas** – "III-Nitride quantum cascade lasers for the 3-5 μm atmospheric window".. This project is a development of quantum cascade lasers for the 3-5 μm atmospheric window for counter measures applications (confusing heat-seeking missiles and IR detectors) **Award Total $111,960**

Prof. Swan – "Individual carbon nanotubes devices; fabrication and optical characterization." The goal of this project is to gain full understanding of carbon nanotube optical properties and pursue new applications for them. The PI will pursue industrial collaborations and complete infrastructure required for fabrication and characterization of this nanotubes. **Award Total $65,467**

Prof. Unlu – "Development and deployment of compact integrated biosensor platforms." The overall goal of this project is to develop and deploy compact integrated biosensor platforms based on resonant cavity imaging biosensors and microring resonator biosensors. **Award Total $162,305**

Prof. Zhang – "Uncooled double cantilever microbolometer focal plane arrays with mK NETD." This project is developing uncooled miniaturized IR detectors which will have performance comparable to state of the art cooled detectors. Therefore, IR cameras will require much less power, will be significantly smaller in size and cost significantly less than the cameras using cooled detectors. **Award Total $99,531**

Prof. Ziegler – "Vibrational fingerprinting of bacterial spores by surface enhanced Raman microscopy." This project's goal is to develop in-field analysis tools using SERS to analyze potentially lethal environmental samples containing bacterial spores and vegetative cells. **Award Total $116,022**

4. Faculty and Students Supported through ARL Cooperative Faculty Awards

Prof. Hatice Altug, ECE
Amin Sharooz

Prof. Enrico Bellotti, ECE
Nuno Sucena Almeida
Danilo D'Orsogna
Michele Moresco

Prof. Thomas Bifano, MFG
Alioune Diouf
Michael Gingris
Jin Hong Kim
Wen Lu
Oleg Shatrovoy
Yaopeng Zhou

Prof. Irving Bigio, BME
Kurt Schoener
Chao Shen
Alon Singer

Prof. David Castanon, ECE
Rohit Kumar
Manqi Zhao

Prof. Luca Dal Negro, ECE
Roman Shugayev
Joe Warga
David Harrah

Prof. Shyam Erramilli, PHY
Yu Chen
Xihua Wang

Prof. John Gershoni, PHY

Prof. Bennett Goldberg, PHY
Sebastian Remi
Ayca Yalcin

Prof. Allyn Hubbard, ECE
Cassandra Browning
Shihchin Chiu
David Freeman
Sarah Kelsall
Marianne Nourzad
Yirong Pu
Matthew Sandifer

Prof. Guilford Jones, CHEM

Prof. Theodore Morse, ECE
Andrea Rosales Gardica

Prof. Theodore Moustakas, ECE
Josh Abell
Ramya Chandrasekaran
Adam Moldawer
Adrian Williams

Prof. Roberto Paiella, ECE
Anirban Bhattacharyya, Post-doc
Kristina Driscoll

Prof. Anna Swan, ECE
Svetlana Anissimova
Nick Vamivakas

Prof. Selim Unlu, ECE
James Needham
Ismail Emre Ozkumar
Philipp Spuhler

Prof. Xin Zhang, MFG
Ping Du
Axel Gonzales
Shusen Huang
Hu Tao

Prof. Lawrence Ziegler, CHEM
Logan Chieffo

Prof. David Mountain, BME

5. Awards Selected in FY2006 for Support FY2007 (next fiscal year)

In support of the pipeline development program, a formal Faculty Technology Development Awards Program (FTDA) was initiated in FY2006 with the first awards to be made in FY2007. After a general solicitation, proposals were rated by peers from industry, academia, and government. Written evaluations were provided by the committee and a video-conference meeting was held with the Director of the Center to select awards. Three interdisciplinary groups were granted $250K awards.

FTDA 1:
Compact Label-Free Multiplexed Immunosensor (Optical based molecular detection: identification of biological toxins) Task Manager: Professor Selim Unlu / Dr. Helen Fawcett

Team: Principal Investigators: Dr. Selim Ünlü, Electrical and Computer Engineering Department, Dr. Rostem Irani, Center for Advanced Genomic Technology, Dr. Masoud Sharif, Electrical and Computer Engineering Department, Dr. David Bergstein, ECE postdoctoral researcher

Graduate students: James Needham (BME), Ajay Bangla (ECE), Allison Squire (AME)

BU Technology Basis: The researchers have been developing over the past few years two primary label-free molecular detection technologies. The resonant cavity imaging biosensor (RCIB) consists of two highly reflecting low-loss reflectors that are positioned with their reflecting surfaces facing one another to form the cavity. Spectral reflectance Imaging Biosensor (SRIB) works similar to RCIB except that the resonant signals are collected in reflection and the cavity is simply formed within an oxide layer on a silicon substrate. The benefit of a monolithic design is a significant one. The simpler instrument can be made more compact, inexpensive and robust. Most importantly, the achievable sensitivity should be sufficient for most immunosensing applications.

Applications: Such a technology can be used for in the field identification to battlefield hospital unit diagnostics using a disposable cartridge in a portable unit in antibody detection in blood samples and “first-response” bio-detection capability.

Milestones:
- Characterize system performance using etched SiO_2 features
- Demonstrate specific binding of IgG to samples at multiple sites on one substrate
- Demonstrate the use of a cartridge for delivering the IgG solution to the sensor surface

FTDA 2:
Development of Efficient SERS Substrates via "Rationally" Designed Novel Nanofabrication Strategies (Spectroscopy: substrate surface enhancement) Task Manager: Professor Lawrence Ziegler / Dr. Helen Fawcett

Team: Principal Investigators: Professor L. D. Ziegler, Department of Chemistry, Professor L. Dal Negro, Department of Electrical and Computer Engineering, Professor B. Reinhard, Department of Chemistry

Graduate students: A. Gopinath (ECE), R. A. Shugayev (ECE), L. Skewis (CH),

BU Technology Basis: The researchers will support the ongoing efforts at the BU Photonics Center to implement SERS-based instrumentation for the detection and identification of potential bio-threat agents by developing and evaluating SERS substrates produced by two novel nanofabrication-based techniques. The substrates resulting from these "rationally" designed procedures offer the possibility of improved reproducibility, large enhancement factors and increased shelf life as compared to the SERS substrates currently in use at BU produced by an *in situ* sol gel growth procedure (patent pending). The strategies in both of these approaches will be to create a high density of field enhancing "hot spots" at controllable, fixed sites on the SERS active substrate. These substrates will be tested and compared with the current BU SERS chips and a popular commercially available SERS substrate (Mesophotonics, Ltd.) using both test molecular and bacterial samples.

Applications: Such a technology can be used to support the further growth of the SERS program at Boston University's Photonics Center in the areas of improved process and prediction for generating reproducible substrates as well as adding DNA nano-particle dimers assist in creating high localized field enhancements

Milestones:

- Engineering giant field enhancement and field localization
- Localized hot-spots: top down nanofabrication and bottom up chemical synthetic approaches

FDTA 3:
Development of III-Nitrides Based Optoelectronics Devices from the UV to the THz for Biochemical Threat Detection (Optoelectronics: materials development) Task Manager: Professor Theodore Moustakas / Leah Ziph-Schatzberg

Team: Principal Investigators: Theodore D. Moustakas, Roberto Paiella, Enrico Bellotti, Department of Electrical Engineering

Graduate Students: Adam Moldawer (ECE), Kristina Driscoll (ECE), Nuno Almeida (ECE)

BU Technology Basis: The researchers propose to develop III-Nitride semiconductors emitters and detectors from the UV region of the electromagnetic spectrum for biochemical threats detection. The project will address the development of UV-LEDs emitting at 280 nm and UV-detectors responding at 280 nm. These detectors will be designed to operate as avalanche photodetectors (APDs) in the Geiger mode. The proposed devices will be grown by the MOCVD method at ARL in collaboration with ARL personnel.

Applications: Improved 280 nm LEDs and detectors for biological applications can be used to support the further growth of the bio-threat detection for applications related to fluorescence emission and detection of biological and chemical compounds.

Milestones:

- Develop UV-LEDs emitting at 280 nm
- UV-Detector will be fabricated by the MOCVD method at ARL to respond at 280 nm.

IV. Initiatives

A. Overview

The shared vision and mutual support that forms the foundation of the Photonics Center has engendered a host of Center-based initiatives intended to accelerate and invigorate our collective activities. These initiatives are intended to catalyze new avenues of research and development while strengthening our interdisciplinary efforts. In the past year, three such initiatives were launched.

B. Photonics Center New Faculty Initiative Program

The Photonics Center has made a strategic decision to strengthen its already well-known program in biophotonics. This growth will exploit the powerful integration of "biology and light" at the Photonics Center, in collaboration with the Boston University Medical Center, to create applications and build devices in medicine, genetics, environmental science, for defense and non-defense applications. A particular emphasis will be on translational biophotonics that exploits the Center's pipeline of innovation in this field.

This highly interdisciplinary area draws on combined basic research in the physical sciences, life sciences, medical, and engineering fields focused on defense applications. The Center's specific plans include FY07 ARL Cooperative Agreement project support to assist with academic equipment and program startup costs for a new tenured or tenure-track faculty position complementary to our core intellectual and academic strengths at Boston University. These areas of strength are classified broadly to include:

- **Biophotonic imaging**, the study of optical imaging and how it is used to understand biological problems, including microscopy, subsurface probing of tissue, adaptive optics for retinal and neurobiological imaging.

- **Biomedical photonics**, the study of light-based systems for applications including detecting and treating disease, probing molecules and cells, sensing pathogens, microsurgery and wound healing. Efforts in this category will have the discriminating leverage the new BL4 (Biohazard Level 4) facility being developed with federal funding at Boston University to reinforce our position as a national leader in biophotonics as applied to defense.

The Center's leadership in this important area of research and development will be leveraged by an unparalleled geographic concentration of biophotonics-related academic and commercial activities in the Boston area. The success of our program will depend on our ability to attract, support, and retain the field's most promising academic researchers.

To that end, the Center has established a New Faculty Initiative Program. To help accelerate the scholarly career of a new biophotonics faculty member hired by one of the Center's cognate departments, the Center will allocate funds to support major research equipment for the new faculty member. For FY2007, we will provide $250,000 to support major shared research instrumentation as part of the startup support for a new biophotonics faculty member hired in one of the Center's seven cognate departments (Astronomy, Physics, Chemistry, Aerospace and Mechanical Engineering, Electrical and

Computer Systems Engineering, Manufacturing Engineering and Biomedical Engineering). The equipment, which will be specified collaboratively by the new faculty member, the hiring department's chairman, the director of the Photonics Center, and the ARL program manager, will be housed either in the Photonics Center laboratory designated for use by the new faculty member or in one of the Center's three shared laboratory facilities. In either case, the equipment must be designated in a way that allows it to be shared with other Photonics Center faculty. Moreover, the request should be for equipment that will demonstrably benefit the Photonics Center community.

C. Photonics Center PhD Fellowship Awards Program

The need for greater interdisciplinary research and education in photonics will require the very best students in the graduate pipeline. At the same time, we want our advanced graduate students to develop their research communication skills, and become engaged with the greater scientific society in photonics.

Therefore, we have established a new two-tiered program funding photonics graduate students in the sciences and engineering to simultaneously fill the pipeline, and also create the best possible photonics practitioners. Participating departments in the Photonics Center community are eligible to compete for these fellowships. Awardees are selected from a pool of nominees provided by those departments' graduate program coordinators. Final selections are made by an appointed committee of Photonics Center faculty and staff members.

Three First-Year Graduate Fellowships in Photonics: The first component of our program included three first-year Photonics research fellowships in FY 2006 (September 2006 - May 2007) for which the fellows had support for their first year (salary and tuition), participated in Photonics Center seminars, and were required to do a rotation through a Photonics Center laboratory during the summer following their first two semesters.

Seven Advanced Graduate Research Fellowships in Photonics: The second component of our program included seven additional fellowships for senior graduate students already engaged in photonics research with a Center faculty advisor. These fellowships sponsored one academic year of support for graduate students immersed in research laboratories and projects funded through the Photonics Center programs. These fellows were charged with a range of activities including: self-organizing a graduate student journal club and weekly afternoon tea, meeting with seminar speakers and distinguished visitors, attending national and international photonics meetings to present their work, assisting with workshop organization and being ambassadors for Boston University's Photonics Center.

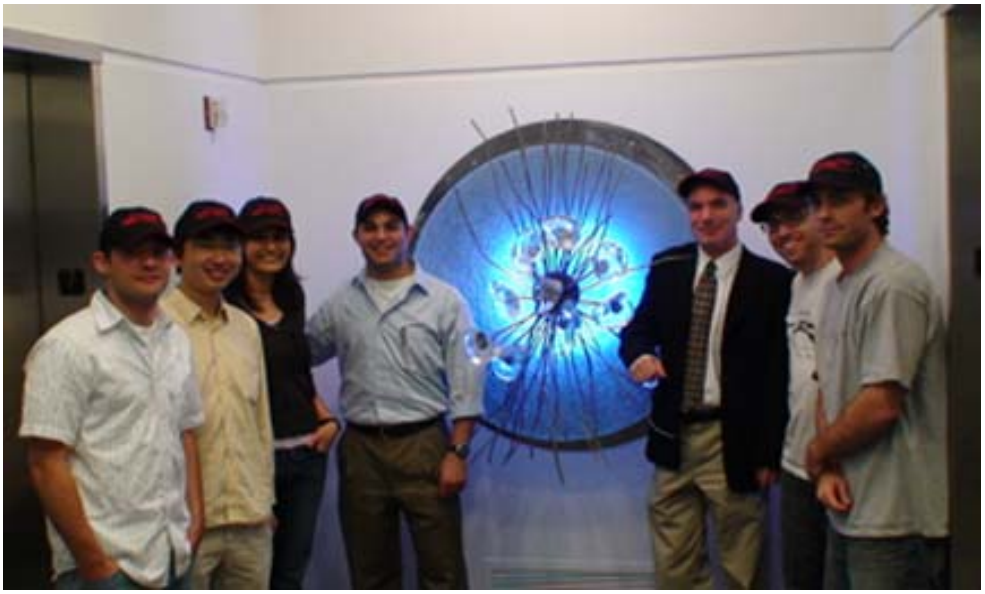
For FY06, the Photonics Center Fellowship Committee was comprised of three Photonics Center faculty members: Irving Bigio, Selim Unlu [Chair] and Shyam Erramilli. In the first year of this program, students were able to work alongside faculty and staff mentors to complete their fellowship duties. Students assigned to work in shared laboratory facilities received first-hand training on new capital equipment including: the Heidelberg Direct Write System, the Cary 5000 Spectrophotometer and the ZYGO New View 6300. Students also assisted in creating video-training sessions for equipment in conjunction with training other users and determining calibration routines and accessories for new equipment. Being a critical component to the shared laboratories

and the success of researchers using advanced tools, these students assisted in community building in a technical and hands-on approach.

The students assigned to community activities were instrumental in organizing and hosting cafes and the Faculty Forum. The students worked together with Photonics staff members to select faculty speakers to discuss photonics research. The Faculty Forum was set in the Colloquium Room with lunch served during the discussion sessions.

2006 Research Fellowships Awardees

Student	Dept.	Advisor	Pho Contact	Service
David Harrah	ECE	Junior Research Assistant		
Alon Singer	BME	Junior Research Assistant		
Sebastian Remi	Physics	Junior Research Assistant		
Ayca Yalcin	ECE	Goldberg	Paul Mak	OPF Photolithography
Nick Vamivakas	ECE	Swan	Leigh Hallisey	Seminars
Josh Abell	ECE	Moustakas	Paul Mak	OPF Processing
Kurt Schoener	BME	Bigio	Leigh Hallisey	Seminars
Logan Chieffo	Chemistry	Ziegler	Helen Fawcett	Spectrometer
"Forest" Huang	MFG	Zhang	Leigh Hallisey	Seminars
Xihua Wang	Physics	Erammilli	Anlee Krupp	PML ZYGO/AFM

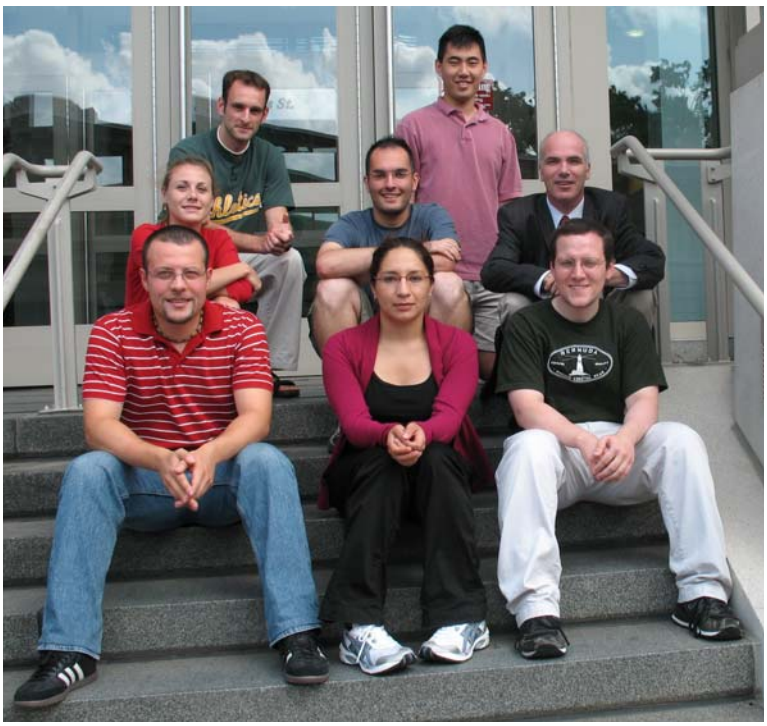


(Pictured L-R) Josh Abell; Xihua Wang; Ayca Yalcin; Kurt Schoener; Professor Thomas Bifano, Photonics Center Director; Logan Chieffo; Nick Vamivakas

For FY07, the Photonics Center Educational Committee, comprised of three Photonics faculty members: Anna Swan, Jerome Mertz, Shyam Erramilli [Chair], made their recommendations to the Director. Thirteen students were nominated. Ten were recommended for selection four from CAS and six from Engineering. These senior fellows will be supported for the academic year (8 months) and will be expected to provide research and service support to the Photonics Center at a rate of 10 hours/per week for their designated services.

2007 Research Assistantship Awardees

Student	Dept.	Advisor
Kengyeh Chu	BME	Mertz
Kristina Driscoll	ECE	Paiella
Andrea Garcia	ECE	Morse
Joel Kralj	Physics	Rothschild
Xiaoyu "Rayne" Zheng	MFG	Zhang
Jude Schneck	Chemistry	Ziegler
Andy Walsh	Physics	Swan
Onur Basarir	AME	Ekinci
Emre Ozkumur	ECE	Unlu
Nico DiFiori	Physics	Meller



(Pictured L-R):
Top Row: Joel Kralj and Kengyeh Chu

Center Row: Kristina Driscoll, Onur Basarir, Director Thomas Bifano

Bottom Row: Emre Ozkumur, Andrea Garcia, Jude Schneck

Missing from Photo: Xiaoyu "Rayne" Zheng, Andy Walsh, and Nico DiFiori

D. Photonics Center Visiting Professorship Program

The Photonics center has become well-known for its innovative work in photonics system development. Its core faculty has established leadership positions in their field, and has earned a reputation for interdisciplinary endeavors. To promote and maintain these qualities in Center-led research, it is important that the Center creates a scholarly environment rich with new ideas, new interactions across disciplines and continuous sharing of recently generated fundamental knowledge.

To that end, the Center has established a Visiting Professor Program, intended to attract pioneers, leading scientists and engineers for year-long residency in the Center. A visiting professor will be expected to interact with many of the Center's faculty and staff and will be charged with participating broadly in its academic, educational, and translational activities.

While each visiting professorship will be customized to suit the particular synergies that can best be exploited by the selected recipient, it is expected that at a minimum the visiting professor will:

- Participate in educational activities, via short courses, topical seminars, workshops, or special topics courses taught to Photonics Center faculty and students.

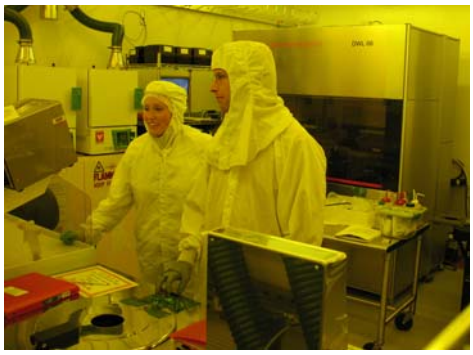
- Interact with two or more of the Center's existing faculty research programs, bringing scholarly or practical expertise that is not well represented in the Center's current faculty.

- Catalyze new or interdisciplinary work that will expand the Center's impact and/or contribution to the field.

In FY07, we supported one full-year, half-salary appointment in this program. Visiting Professor Jonathan Gershoni, from Tel Aviv University, received this year's support. He was additionally supported through a grant on sub-cellular imaging in the Physics Department.

Professor Gershoni received his PhD. from The Hebrew University of Jerusalem, Israel in Biochemistry (1980). Professor Gershoni is an expert on biological systems, immunology and microbiology, with special expertise in phages. He came to the Boston University Photonics Center to match his knowledge in biological systems with our technology in optical sensing and nanoscale position determination. Professor Gershoni collaborated closely with Professors Selim Ünlü and Bennett Goldberg, who have invented a new label-free sensing platform. This platform was subsequently granted a development award through the ARL program. Professor Gershoni was instrumental in designing and implementing a wide variety of biological and surface chemistry protocols that have allowed the optical science done by Professors Goldberg and Unlu to move forward into applications at an accelerated rate. In particular, he led the group to instituting a new surface chemistry approach which out-performed the prior chemistry by an order of magnitude in selectivity. He designed the antigen-antibody binding experiments that first demonstrated the high-throughput multiplexed assay capabilities and he has planned a significant number of future avenues that are already bearing fruit among discussions with clinicians. Professor Gershoni will continue to collaborate with Boston University and will be returning in October to write a proposal to NIH for associated funding in the civilian medical application space.

V. Education



At the core of the Photonics Center's mission is the education of future leaders in the field of photonics.

As an academic pillar for a leading large, private, urban university, the Boston University Photonics Center offers students an unparalleled educational experience. Our program gives students the opportunity to develop their research and communication skills, and to engage with world-leading scholars in photonics.

The Center immerses its students in an environment that fosters collaboration, mentorship, and the unique opportunity to work with photonics companies and staff on prototype development through its partnership with BU's technology entrepreneurship program. As part of our commitment to education, we sponsor annual tours of the facilities to high school students participating in the Science Olympiad as well as undergraduate students from universities all over the country who participate in our yearly Research Experience for Undergraduates (REU) program.

A. Selected Photonics Related Courses

CAS AS 441: Observational Astronomy
Astronomical techniques. Photometry, spectroscopy, photography, CCD imaging, and interferometry. Statistical methods for data reduction and analysis.

ENG SC 560 Introduction to Photonics (Teich)
Prereq: CAS PY 313. Introduction to ray optics, wave optics, Fourier optics and holography, absorption, dispersion. Polarization, anisotropic media, and crystal optics. Guided-wave and fiber optics. Elements of photon optics. Laboratory experiments: interference; diffraction and spatial filtering; polarizers, retarders, and liquid-crystal displays; fiber-optic communication links. 4 cr.

ENG SC 563 Fiber-Optic Communication Systems (Morse)
Prereq: ENG SC 410, SC 311, SC 415, and SC 560 or consent of instructor. Introduction to fiber optics; components, concepts, and systems design techniques required for the planning, design, and installation of fiber-optic communication systems. Single- and multi-mode LED and semiconductor lasers, detectors, connectors and splicers, terminal and repeater electronics, wavelength division multiplexing optical amplifiers and solitons, and systems architecture for point-to-point and local area networks. Laboratory work on fiber and electronic measurements. 4 cr.

ENG SC 568 Optical Fiber Sensors (Morse)
Prereq: ENG SC 455. This course will cover the theory and practice of optical fiber sensors. This course will meet twice a week for two hours. In addition, there will be a three-hour laboratory each week. The focus of the course will be on laboratories involving various types of optical fiber sensors. Grades will be based on laboratory reports as well as a significant laboratory project. 4 cr.

ENG SC 569 Introduction to Subsurface Imaging (Saleh)
Prereq: Senior or graduate standing in ENG, PY, CH, MA, or CS. Introduction to subsurface imaging using electromagnetic, optical, X-ray, and acoustic waves. Transverse and axial imaging using localized probes (confocal scanning, time of flight, and interferometric techniques). Multiview tomographic imaging: computed axial tomography, diffraction tomography, diffuse optical tomography, electrical impedance tomography, and magnetic resonance imaging. Image reconstruction and inverse problems. Hyperspectral and multisensor imaging. 4 cr.

ENG SC 570 Lasers (Unlu)
Prereq: CAS PY313. Review of wave optics. Gaussian and Hermite-Gaussian optical beams. Planar-and spherical-mirror resonators. Photon streams. Absorption, spontaneous emission, and simulated emission. Laser amplification and gain saturation. Laser oscillation; pulsed lasers. Photon interactions in semiconductors. LEDs and semiconductor injection lasers. Photon detectors. Laboratory experiments: beams; divergence and collimation; electroluminescence; semiconductor injection lasers. 4 cr.

ENG SC 574 Physics of semiconductor materials (Bellotti)
Prereq: CAS PY 313 or PY 354 or equivalent. Study the fundamentals of quantum mechanics necessary to understand the properties of semiconductor materials. Study of the electrical and optical properties of materials, including crystal structure and bonding, free electron theory, band theory of solids and semiconductors. Carrier transport properties, dielectric, ferroelectric and magnetic properties. Cannot be taken for credit in addition to CAS PY 543. 4 cr.

ENG SC 575 Semiconductor Devices (Paiella)
Prereq: ENG SC 410, SC 455, and CAS PY 313 or PY 354, or equivalent. Fundamentals of carrier generation, transport, recombination, and storage in semiconductors. Physical principles of operation of the PN junction, metal-semiconductor contact, MOS capacitor, MOSFET (Metal Oxide Semiconductor Field Effect Transistor), JFET (Junction Field Effect Transistor) and bipolar junction transistor. Develops physical principles and models that are useful in the analysis and design of integrated circuits. 4 cr.

ENG SC 591 Photonics Lab I (Paiella)
Prereq: CAS PY313 or equivalent. Corequisite: ENG SC 560. Introduction to optical measurements. Laser safety issues. Laboratory experiments: introduction to lasers and optical alignment; interference; diffraction and Fourier optics; polarization components; fiber optics; optical communications; beam optics; longitudinal laser modes. Optical simulation software tools. 2 cr.

ENG SC 760 Advanced Topics in Photonics (Saleh)
This is an advanced special topics course in photonics; topics will vary from year to year. It will be offered in the spring term when there is no other 700-level course in the photonics area. Students who take the course on two different topics would be able to receive credit for it twice. Some of these offerings may become a permanent part of the curriculum in the future. 4 cr.

ENG SC 762 Quantum Optics (Saleh)
Prereq: ENG SC 560, or equivalent, or consent of instructor. Review of the postulates of quantum mechanics. Quantization of the electromagnetic field. Coherent, thermal, squeezed, and entangled states, and their associated photon statistics. Interaction of light with matter. Spontaneous and stimulated transitions. Theory of optical detection. Quantum theory of the laser. Interaction of light with two-level atoms, including photon echo and self-induced transparency. Quantum theory of parametric interactions. 4 cr.

ENG SC 763 Nonlinear and Ultrafast Optics (Teich)
Prereq: ENG SC 560. Tensor theory of linear anisotropic optical media. Second- and third-order nonlinear optics. Three-wave mixing and parametric interaction devices, including second-harmonic generation and parametric amplifiers and oscillators. Four-wave mixing and phase conjugation optics. Electro optics and photorefractive optics. Generation, compression, and detection of ultra short optical pulses. Femtosecond optics. Pulse propagation in dispersive linear media. Optical solitons. 4 cr.

ENG SC 764 Optical Measurement (Sergienko)
Prereq: ENG SC 560. Detailed discussion of basic principles of major optical effects such as interference, diffraction, and polarization. Analysis of practical applications of interferometry, ellipsometry, photometry, and laser spectroscopy in modern optical measurement such as characterization of industrial processes, environmental control, communication, and laboratory research. 4 cr.

ENG SC 765/BE 765 Biomedical Optics and Biophotonics (Bigio)
This course surveys the applications of optical science and engineering to a variety of biomedical problems, with emphasis on optical and photonics technologies that enable real, minimally-invasive clinical applications. The course teaches only those aspects of biology itself that are necessary to understand the purpose of the application. The first weeks introduce the optical properties of tissue, and following lectures cover a range of topics in three general areas: 1) Optical spectroscopy applied to diagnosis of cancer and other tissue diseases; 2) Photon migration and optical imaging of subsurface structures in tissue; and 3) Laser-tissue interactions and other applications of light for therapeutic purposes. In addition to formal lectures, recent publications from the literature will be selected as illustrative of various topical areas, and for each publication one student will be assigned to prepare an informal presentation (with overhead slides or PowerPoint) reviewing for the class the underlying principles of that paper and outlining the research results. Same as ENG BE 765; students may not receive credit for both. 4 cr.

ENG SC 770 Guided-wave Optoelectronics (Dal-Negro)
Discussion of physics and engineering aspects of integrated optics and optoelectronic devices. Semiconductor waveguides, lasers, and photodetectors. Layered semiconductor structures, quantum wells, and superlattices. QW detectors, emitters, and modulators. OEICs. Photonic switching. 4 cr.

ENG SC 771 Physics of Compound Semiconductor Devices (Bellotti)
Prereq: ENG SC 577 or SC 575 or CAS PY 543. Physics of present-day compound devices, and emerging devices based on quantum mechanical phenomena. MESFETs, Transferred Electron Devices, avalanche diodes, photodetectors, and light emitters. Quantum mechanical devices based on low dimensionality confinement through the formation of heterojunctions, quantum wells, and superlattices. High electron mobility transistors, resonant tunneling diodes, quantum detectors, and lasers. Materials growth and characterization are integral to the course. 4 cr.

SC 700 Nano-photonics (Dal Negro)
Fundamentals of electrodynamics, diffraction theory and optical response theory; Strongly confined fields and near-field optics: optics below the diffraction limit; Light-matter interactions in confined systems: quantum dots, wires and nanotubes, energy coupling phenomena, introductory concepts on plasmonics, photonic crystals structures; Applications to optical devices: nano-lasers, random lasers, photonic crystals LEDs, plasmon waveguides, micro-ring and ultra high Q resonators, principles of near-field optical microscopy, optical antennas and optical tweezers.

SC 700 Semiconductor Quantum Structures in Photonic Devices (Paiella)
Optical properties of semiconductors: interband optical transitions; excitons. Low-dimensional structures: quantum wells, superlattices, quantum wires, quantum dots, and their optical properties; intersubband transitions. Lasers: double-heterojunction, quantum-well, quantum-dot, and quantum-cascade lasers; high-speed laser dynamics. Electro-optical properties of bulk and low-dimensional semiconductors; electroabsorption modulators. Detectors: photoconductors and photodiodes; quantum-well infrared photodetectors.

ENG MN 555 MEMS: Fabrication and Materials (Zhang)
Prereq: graduate status or consent of instructor. This course will explore the world of microelectromechanical devices and systems (MEMS). This requires an awareness of design, fabrication, and materials issues involved in MEMS. The material will be covered through a combination of lectures, case studies, and individual homework assignments. The course will cover design, fabrication technologies, material properties, structural mechanics, basic sensing and actuation principles, packaging, and MEMS markets and applications. The course will emphasize MEMS fabrication and materials. 4 cr.

ENG MN 777 Micromachined Transducers (Zhang)
Prereq: ENG MN 555 or consent of instructor. The field of microelectromechanical devices and systems (MEMS) has been growing at an exciting pace in recent years. The interdisciplinary nature of both micromachining techniques and their applications can and does lead to exciting synergies. This course will explore the world of mostly silicon-based micromachined transducers, i.e., microsensors and microactuators. This requires an awareness of material properties, fabrication technologies, basic structural mechanics, sensing and actuation principles, circuit and system issues, packaging, calibration, and testing. The material will be covered through a combination of lectures, case studies, individual homework assignments, and design projects carried out in teams. 4 cr.

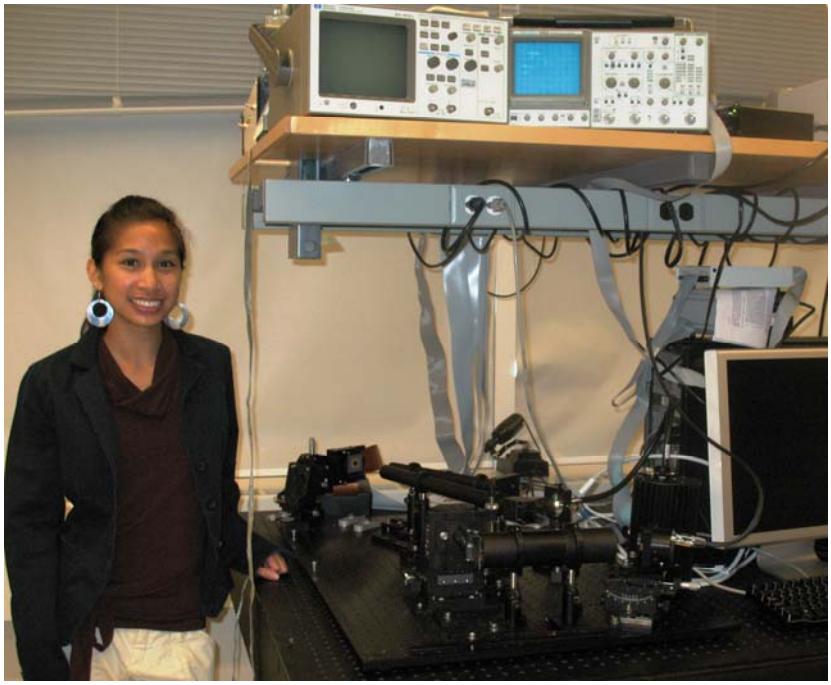
B. Photonics Microscope Instrumentation Educational Laboratory

THOR Labs donates large area microscope

To initiate this program, the Center was fortunate to have attracted the support of Alex Cable, founder and CEO of Thorlabs, Inc., and a pioneer of advanced photonic instrumentation.

One of the several innovative commercial microscopy products introduced by Thorlabs over the past year was the Adaptive Scanning Optical Microscope, (ASOM). It is based on technology developed by Rensselaer Polytechnic Institute's Center for Automation Technologies and Systems. At the heart of the ASOM is a deformable mirror pioneered at BUPC. The ASOM provides the ability to view extraordinarily large fields using a biomicroscope, without sacrificing image resolution. Thorlabs donated an ASOM to BUPC in 2007 as its first educational test bed and platform for biophotonic instrumentation research.

Currently, BUPC graduate student Janice Castillo is pursuing an MS degree in Electrical Engineering based on this instrumentation concept. The instrument first in a series of planned workstations for study of advanced biomicroscopy techniques, is housed in the Photonics teaching laboratory in BUPC.



VI. Facilities & Equipment

The Photonics Center's 235,000 net sq. ft. facility opened in June of 1997. Its ten floors house state-of-the-art research laboratories, laboratory support space, a business incubator, and instructional and seminar facilities specially designed for photonics research.

The building's structural steel frame is built on a reinforced concrete mat, as much as six feet deep, to minimize vibration. The basement level houses laboratories requiring low vibration and a light-free environment. Above-ground laboratories feature large windows, with a 1" airspace between the panes of glass to reduce the sound from the abutting Mass Pike.

The Center has a number of shared facilities for use by Center members and affiliated partners. In addition to these shared laboratories, the Center contains four floors (100,000 sq. ft.) of academic research laboratories and office space dedicated to its faculty researchers.

The Center's sixth floor houses a business incubator that provides 23,000 sq. ft. of "greenhouse" space that can be flexibly configured to house up to 14 photonics start-up companies.

A. Shared Laboratory Facilities

The Photonics Center operates three large shared laboratories. The Optoelectronic Processing Facility is a cleanroom facility that encompasses a wide range of equipment to aid in the research and processing from wafer to die level devices. The Integrated Optics Laboratory is sectioned into two main areas, a Class 100 cleanroom for bonding and sealing processes and a laboratory space for spectroscopy measurements and research. The Precision Measurement Laboratory encompasses analytical analysis of surfaces and materials with industry and research tools to enhance the research and scholarship of faculty and students.

The equipment in these labs is available for use by all faculty and students who are trained on the equipment or with the help of the laboratory manager. Outside industrial users of the shared labs can contact the appropriate lab manager to discuss rate schedules and training for use on the equipment of interest. Multi-usage or separate lab agreements can be put into place for companies interested in using the processing, metrology, and packaging capabilities.

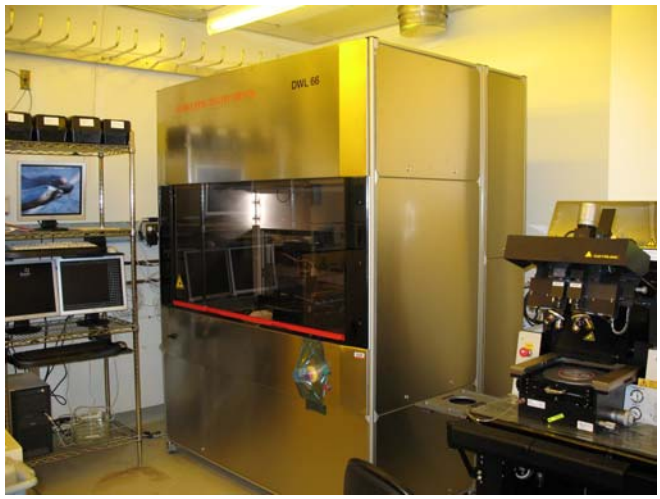
Optoelectronic Processing Facility

The Optoelectronic Processing Facility, comprising 2500 sq. ft. on the 8th floor of the Boston University Photonics Center, is a multi-user facility equipped with state-of-the-art equipment for fabricating semiconductor and other optoelectronic devices. The facility includes: both class 100 and 1000 clean rooms and equipment necessary for photolithography, wet chemical processing, thin film depositions, plasma etching and cleaning, thermal oxidation, thermal annealing, electrical characterization and device packaging.

The Class 100 cleanroom is established as a photolithography room. As part of this year's capital equipment committee, this photolithography room has been upgraded to include a stand-alone Headway Research photoresist spinner with a programmable controller for spin-curves. This system complements the Suss Microtech Delta 80 photoreisist spinner used for large wafers and mask blanks. These spinners provide students with hands-on experience running a piece of equipment commonly found in

industry and research labs. By removing the photoresist spin coater from the processing hood, the equipment committee was able to upgrade the existing hood to a five foot flat decked hood that will allow "clean" processing. A new programmable soft bake and hard bake oven were also included in the upgrades to OPF's Class 100 cleanroom. The photolithography room also has Suss Microtech MJB3 and MA6 exposure tools for UV exposure of photoresist using masks that are purchased from outside vendors or fabricated on the Heidelberg direct write system.

The Heidelberg direct write system has become a standard tool at Boston University. This tool will not only allow students and professors to write their own photomasks (glass on chrome), but rather than spend for a costly mask to try a pattern for research, researchers can either directly write onto a wafer or a mask with the one pattern to verify their theories. Another exceptional aspect of the direct write system is the grayscale capability. Any researchers with micro-lens arrays, specific patterns for surface roughening or blazed gratings can directly write these grayscale features into the photoresist and post process as necessary. This is an exciting field that most students are not exposed to even in industry. The ability to eliminate the need, cost, and errors from multi-layer mask designs and exposures can be explored with the grayscale capability. In one step, the errors and costs for multiple photomasks are eliminated writing directly onto one mask and completing one processing step. Once completed with the spinning and exposures, students learn to develop their wafers and then can move on to the Class 1000 cleanroom to complete etching or deposition process steps.



In the Class 1000 cleanroom, a wide variety of options are available. With a Tencor surface profilometer, students learn how to measure the step height of features that they make on wafers. The capabilities and issues with stylus profilers become apparent when students can either create sharp profiles or find that the tip is too large to measure the shapes accurately. At that point, students must investigate other methods for measurement of step height and incorporate test structures in their wafers.

Many processes are available for student and faculty research. A plasma asher, reactive ion etcher and a deep reactive ion etcher are all available for etching features into a substrate or cleaning a substrate prior to further processing. The STS deep reactive ion etcher is an excellent piece of equipment that few, if any, students are

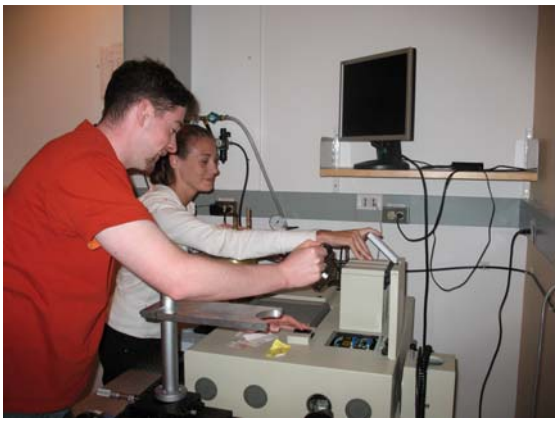
exposed to during their college career. It is a standard piece of equipment that many industrial users cannot accommodate in their fabrication facilities. Thin film coatings are another area of processing in the Optoelectronic Processing Facility. Thermal oxide furnaces, ion assisted deposition, evaporators and sputtering systems all provide students with the capability to learn various coating processes and how to measure the films deposited after processing. Once the wafer processing is complete, a dicing saw can be used to cut the wafer into smaller die and then wirebonding, wedgebonding, or testing can be completed. As part of the OPF probe station upgrades, high-frequency probes, a platen computer controlled lock-in amplifier, frequency generator, and impedance measurements were added. This system will be used by many faculty members and students, allowing them to create wire-bond and test devices in the same location.

Integrated Optics Laboratory

The Integrated Optics Laboratory, comprising 400 sq. ft. Class 100 cleanroom and 2000 sq. ft. laboratory on the 5th floor of the Boston University Photonics Center, is a multi-user facility equipped with state-of-the-art equipment for bonding, testing, and analysis of components that were processed in the Optoelectronic Processing Facility or purchased from outside vendors as part of a research project.

In the Class 100 cleanroom, the door opens to a Miyachi Unitek benchmark lid seal machine and projection welding machine for coaxial welding of TO-Can style units. The lid seal system is commonly used in the packaging industry. An environment of dry nitrogen is infused into the gold-plated package and a welding operation fused the metal lid to the package for hermetic sealing of the unit. A Suss Microtech FC-150, flip chip bonder is the next piece of equipment that is utilized by various researchers to seal and create eutectic bonds either through thermo-compression or soldering processes. This is a precise pick and place system that uses fiducials to aid in placement accuracy. To determine if the bonding will pass MIL-Standard testing, a DAGE die shear machine is used to die shear to failure bonded parts. A pull tester adaptor is also available to determine wire bond pull strengths and verify that they are within the specifications for the part that is bonded. An ESEC automated wire bonder is available for use and is especially helpful if repetitive bonds are required for devices. The equipment in the Class 100 cleanroom is equipment that is typically found in industry. Boston University is one of the only universities in the country to have such a unique set of equipment. The students at Boston University have the ability to learn how to use the equipment and to become more experienced workers in industry or research labs.

The second portion of the Integrated Optics Laboratory is the testing area. A newly created spectroscopy room allows researchers to make use of several spectroscopy tools. The Bruker FTIR along with the Hyperion allows users to try various techniques to measure absorption, reflection, transmittance, and diffuse reflectance of materials to help determine what the composition is or the light penetration. An upgrade to the terahertz region with the addition of a silicon bolometer puts Boston University at the forefront of technology. Very few institutions have this technology available to students and faculty. Another new purchase for the spectroscopy room is the Varian Cary 5000 UV-VIS-NIR spectrometer. Wavelength ranges from 175 – 3300 nm and multiple accessories make this spectrometer an essential tool to multiple users and researchers in the Photonics Center and the BU Community. Test equipment is also available in the Integrate Optics Laboratory along with multiple optical tables for positioning of fibers, lenses, and other optical components.

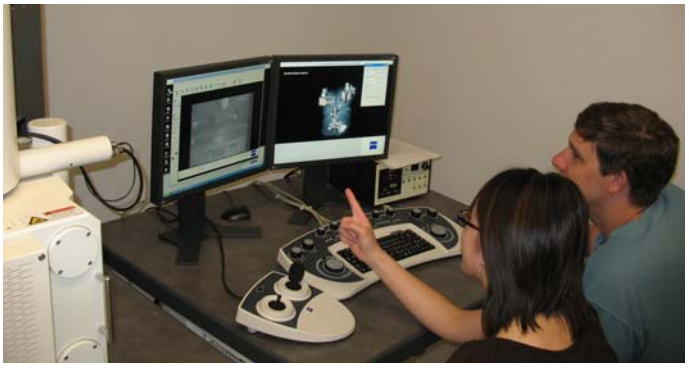


Precision Measurement Laboratory

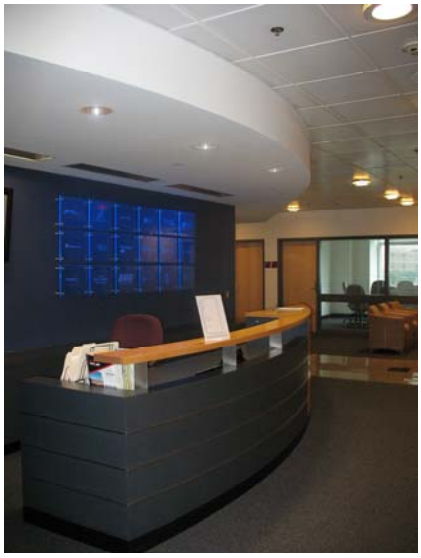
The Precision Measurement Laboratory, comprising of several laboratories, provides capabilities to measure material composition as well as surface morphology. In one of the lab spaces, a JEOL SEM is available for use to view the surface of samples. An equipment upgrade to the Oxford energy dispersive spectrometer (EDS) allows users to evaluate elemental composition, surface contaminants, and analyze samples in a variety of locations for surface composition uniformity. Also upgraded on the JEOL is the Gatan cathode luminescence (CL). The capability allows the detection of energy released in the visible spectrum from electrons in an atom returning to their original energy level after being excited by the bombardment of electrons from the e-beam in the SEM. From the spectrum, elements within the sample can be determined.

A larger extension of the PML laboratory found in the basement has a Digital Instruments (Veeco) atomic force microscope (AFM) and a multi-mode Pico force scanning probe microscope. These two instruments allow the surface profiles in three-dimensional space to be acquired and measured. The Pico-force system allows polymers and samples in solution to be analyzed as the force is monitored, not the attraction of the tip to the sample.

The Zeiss field emission scanning electron microscope (FESEM) is a great acquisition for the university. The FESEM allows polymers and plastics to be viewed without coatings or destructive analysis, and also allows non-conductive samples to be viewed without gold coating the samples. This addition to the analytical toolbox allows viewing of devices in-situ without destroying the unit with a coating. As an upgrade and in response to an overwhelming need for creation of nano-structures, the equipment committee added an e-beam upgrade to the Zeiss FESEM this year. As an added benefit, this will be for the exclusive use of Photonics members. The system can be retro-fitted onto a stand-alone SEM if usage of the e-beam lithography taxes the system. A chamber cleaner was ordered to prevent contamination from the e-beam writing process to the imaging aspect of the SEM. A new addition to the Precision Measurement Laboratory is a heating and cooling stage for the ZYGO NewView 6300 with dynamic MEMs capability. This instrument can be used to optically measure features on a sample, radius of curvature of lenses or slope of MEMs devices. With the dynamic MEMs capability, test stations can be set up to deflect or move MEMs devices and the entire sequence can be captured from the software. Surface roughness and flatness can also be measured on this system. The addition of the heating and cooling stage allows the user to evaluate, measure, and observe modifications to devices and surfaces during controlled heating and cooling of the sample.



B. Incubator Facilities



Located on the sixth floor of the Photonics Center building, Boston University's Business Incubator (The BU Discovery and Innovation Center) is currently 90% occupied and host to twelve technology start-up companies. The mix of companies includes life sciences, bio-tech, medical devices, photonics, clean energy and engineering. Five of the companies originate from within BU and seven originate from outside of BU. All companies are engaged in the commercialization of new technologies of importance to society and all are supportive of BU's educational mission to train students.

Companies in the incubator, which originate externally to BU, are held to the highest professional standards in the industry of new technology ventures. They represent the benchmark by which BU internal spin-out companies may be compared and act as exemplary living case studies for the teaching of entrepreneurship to our students. All are professionally managed by seasoned and credentialed CEO's and founders. All are professionally funded by reputable institutional investors. All have undergone external professional due diligence by their investors. All are commercializing revolutionary technologies developed at many of the region's leading research institutions, e.g. Dana-Faber Cancer Institute, Massachusetts General Hospital, Draper Laboratories, other universities as well as government agencies.

Earlier this year, we began partnering students with incubator companies. Since that time a total of eighteen BU students have worked directly with incubator companies as interns. The Norway Entrepreneurship Program and the Institute of Technology Entrepreneurship and Commercialization (ITEC) in SMG have been valuable partners in providing student interns, while other students have come from the College of Engineering. One Ph.D. ENG student has been hired full time by an incubator company. Collaboration between OTD and ITEC has resulted in the first BU company to be established as part of the Entrepreneurial Research Laboratory within ITEC and located in the incubator.

In addition to twelve technology companies, the incubator also includes First Founders Limited, a non-profit venture mentoring service company founded by Alec Dingee, the founder of MIT's Venture Mentoring Service. First Founders brings to BU a valuable resource and growing network of experienced executives who volunteer their time and expertise to assist young entrepreneurs in growing their businesses.

Current Incubator Companies

Company	Origin	Technology	Market Sector	Funding
Block MEMS	Company Spin-Out Block Engineering	Optical MEMS Micro Chemical Sensors	Military, Industrial *(Photonics)*	DoD, Corporate
Cambridge Devices	MGH	Fluorescent microscopy Tissue spectroscopy Smart data analysis	Medical Devices *(Photonics)*	Venture Capital
DNAR	Dana-Farber Cancer Institute	BioMarkers for Cancer Diagnostics	BioTechnology Personalized Medicine	Venture Capital
LightKey	Company Spin-Out	Secure communications Optical data encryption	Optical Communications *(Photonics)*	Angel
MTPV	Draper Laboratories	Microgap Thermo PhotoVoltaics	Clean Energy *(Photonics)*	Angel
Progenika	Company Spin-Out Progenika BioPharma, Spain	DNA Microarrays, Targeted Diagnostics	BioTechnology Personalized Medicine	Venture Capital Institutional, Private
SonoMedica	DoD, U.S. Navy	Cardiac Disease Diagnosis Acoustics	Medical Devices	Angel, Private
First Founders Ltd	MIT	Venture Mentoring Service	Not for Profit	
PatientFlow Technologies	BU, Management of Variability in Healthcare	Software RFID	Hospital Management	Contracts, Sales
Sand-9	BU Physics Dept.	NanoTechnology Micro Resonators	Wireless Communications	Venture Capital
Cyber Materials	BU MFG	Process Control Thin film deposition	Industrial Manufacturing	SBIR, Sales
Boston Microfluidics	BU BMG BU, SMG - ITEC	Rapid Point of Care Diagnostics for STD's	Medical	BU Sponsored
Biomimetic Systems	BU BME	Bio-Acoustics Sniper Detection	Homeland Security, DoD	DoD, Industry contracts

C. Building Projects

This year, the Photonics Center continued a building-wide safety audit as part of our ongoing operational theme of continuous improvement. The Photonics Center community has joined forces with the Office of Environmental Health and Safety (OEHS) to ensure that the building is operating safely and effectively for all researchers.

Safety Walk-Through

With the help of the Office of Environmental Health and Safety, the Photonics Center staff conducted a walk-through of the building to determine building deficiencies with regards to general laboratory safety and laser safety.

The walk-through was part of our Annual "Laboratory Spring Cleaning Day." As part of this building-wide activity, the Photonics Center hired Triumvirate Environmental to visit each lab in the Center, complete a satellite accumulation area check, retrieve and dispose of unused chemicals and chemical waste, and conduct laboratory inspections.

Below are some of the immediate outcomes of the safety walk-through:

- **Laser Safety Eyeglasses and Accessories:** OEHS and Center staff brought in the laser safety vendor to meet with faculty and students and identify their laser safety needs. In conjunction with the eye wear, laser glasses holders are being placed in each laser laboratory to keep the glasses scratch free and in a labeled space.

- **Laser Safety Electrical Upgrades:** Safety upgrades included electrical interconnects for laser warning signage, lock-outs to alert occupants of the potential danger (laser light on) and EPO verification and labeling.

- **Safety Showers and Drench Hose to Eye Wash Upgrades:** Some safety showers were found to have been improperly placed in the original laboratory build-outs. Approximately seven showers on various floors of the building were not far enough from the wall and were relocated. As part of this year's building upgrades, the Center also repaired drench hoses with eyewash stations. While this is not a code-violation, the OEHS requested that these upgrades be made.

Laboratory Upgrades

New Faculty Laser and Biological Level II Construction (PHO808, 809, 810, and 903B): Three new faculty members have completed the architectural, equipment and building layout of their new lab facilities in the Photonics Center. The laboratories are currently ready for final inspection and occupation by the faculty members. The Photonics Center assisted the Department of Electrical and Computer Engineering in safety, building capabilities, and laboratory design for functionality during this process.

Profs. Swan and Dal Negro (shared lab): PHO808: Luminescence Lab

Prof. Dal Negro: PHO809:
Ultrafast Nanostructures Optics Lab

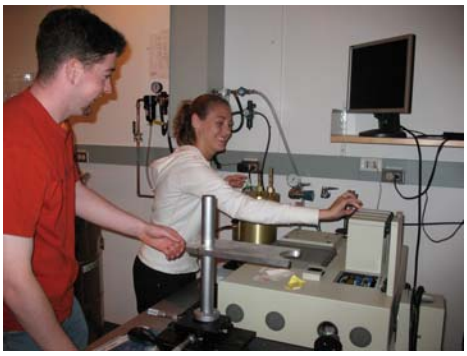
Prof. Swan: PHO810:
Nano-Spectroscopy Lab

Prof. Altug: PHO903B: Nanoscale Optics and Biophotonics Lab

- **Temporary Class IV Laser Laboratory – PHO701A:** One of the new faculty members, whose lab was under construction, needed a location to begin and complete research for grants that would soon be lost as a result of not being able to complete experiments in a timely fashion. The Photonics Center was able to find a temporary location, bring his optical tables in house and establish all electrical and safety requirements to convert this room into a lab space for his research group to make forward progress while construction was on-going.

- **Laser Laboratory Construction – PHO512:** Another long-standing Photonics faculty member had a laser laboratory that was established for Class IIIa lasers. The Photonics Center, in collaboration with the Electrical and Computer Engineering and Biomedical Engineering Departments, established this laboratory as a Class IIIb or IV laser facility complete with curtains, electrical, and other safety requirements and designated it to a localized work area.

- **Spectroscopy Room – PHO503B:** With the equipment committee purchase of a Cary 5000 spectrophotometer and the silicon bolometer upgrade to the FTIR, a light-tight room was established so that sample measurements could be taken in the dark, if required. Sample compartment chambers were not designed to allow light-tight measurements. In the future, if external lasers were to be characterized, the light-tight room could be prepared for laser in use.



Other Facilities Upgrades

- **Common Areas:** In response to the need for more student areas, the Photonics Center added new chairs, tables, and rugs to common areas in the 7th floor atrium as well as the first floor lounge area.

- **Carpet Installations:** After ten years of use, many of the rugs in the common areas of the 1st, 6th and 9th floors needed to be replaced. This year, the carpeting was upgraded in all of these locations.

D. Equipment Projects

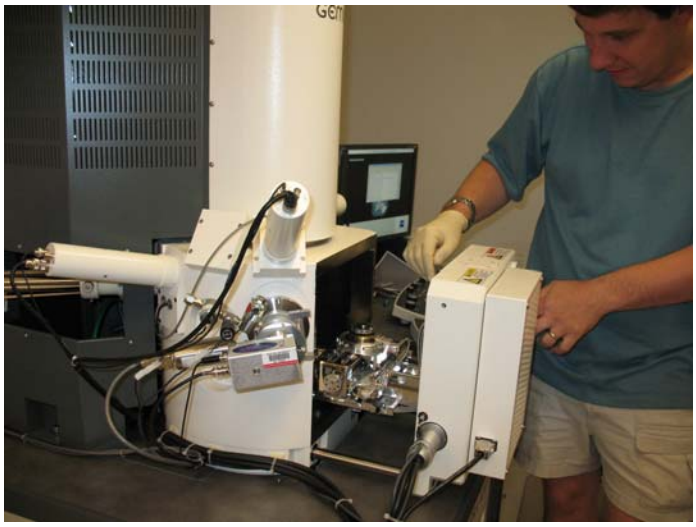
The Center was able to purchase and upgrade capital equipment critical to its research and development efforts. This year's equipment committee was formed by appointment by the Center's Director. The committee was comprised of Photonics faculty (Profs. Dal Negro and Paiella), staff (Helen Fawcett, Anlee Krupp, and Paul Mak) and chaired by a Photonics faculty member (Prof. Zhang). This committee rated equipment upgrades based on the following criteria:

- The instrument will be widely usable as a shared resource in the Photonics Center to enhance the research and development programs
- The instrument will provide critical leverage for attracting additional support to the Center for research and development
- The instrument will enhance the careers and photonics-related research of junior faculty members of the Photonics Center
- The instrument will attract additional support for research and development

Using the same basis for identification and ranking of equipment improvements, the committee determined that the best use of capital equipment money was to upgrade existing equipment in the shared facilities. These upgrades include:

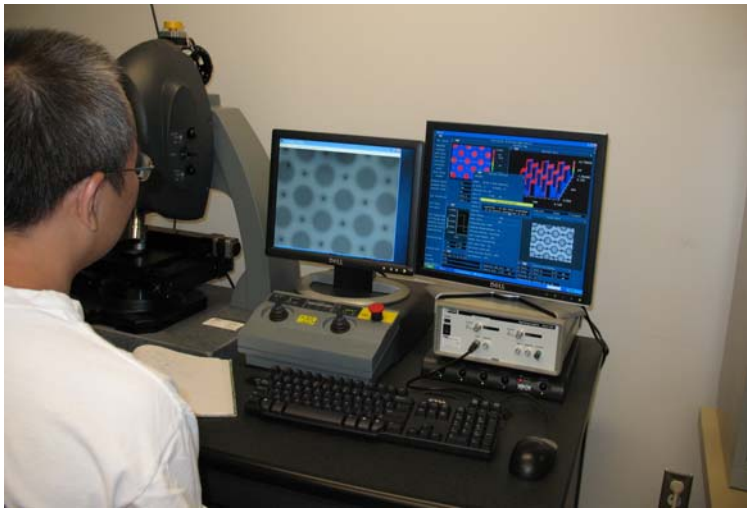
Zeiss E-beam Writer Upgrade

The Zeiss e-beam lithography upgrade provides capabilities within the Photonics Center's shared facilities that were not currently available in the Center. As part of the Photonics Centers future directions, nano-photonics and nano-structures are essential to maintaining faculty research on the cutting edge of technology. An additional vacuum system can be ordered and the e-beam system re-installed on another base SEM model if usage becomes too heavy. This versatile system will allow research in multiple disciplines to utilize the same tool for a variety of nano-technology applications.



ZYGO / WYKO Heating Stage Upgrade

The ZYGO and WYKO optical surface profilometers are a non-contact optical probe for three dimensional surface height measurements. This tool measures topography, optical surface quality, and surface features. It can quantitatively identify the surface characteristics evaluate nanometer-scale changes in the surface. The dynamic MEMS option allows real-time evaluation and data recording of high speed motion. After using the system, many users expressed an interest in identifying the effect of thermal conditions and changes to surface characteristics during measurements on the profilometers. This system allows controlled heating and cooling so that samples can undergo thermal changes, reach equilibrium, have measurements taking during the thermal cycle and at steady state and then allow the sample to run through a different set of parameters. This upgrade will allow controlled experiments to be completed in a calibrated and safe chamber.



Optoelectronic Processing Facility (OPF) Probe Station Upgrade

The upgrades to the current Optoelectronic Processing Facility (OPF) probe station allow further measurement capabilities to 40 GHz. This system has been heavily utilized by Center members. The upgrade allows faculty and students to use this equipment rather than duplicate costly set-ups in their own laboratories. Other items in this upgrade include a lock-in amplifier, impedance analyzer and function generator that are all controllable via a new PC system.

Optoelectronic Processing Facility (OPF) Class 100 Cleanroom Upgrades

The OPF is one of the most utilized shared facilities at the Photonics Center. In reviewing what users need to do in the photolithography room, the committee identified the need for an upgraded photoresist spinner and controller. This allowed the committee a unique opportunity to move the spinner out of the hood and provide a new hood with a flat deck to improve the processing area for cleaning and developing in the photolithography room. Eliminating the spinner from the hood provides a clean work area and allows students an opportunity to use an upgraded spinner with automated controller that is typical of what is found in industry and research laboratories. Bake ovens with controllers were also added to allow soft and hard bakes to be completed outside of the former photoresist spin hood. These additions create a cleaner, safer environment and improved the work-flow within the Class 100 cleanroom.

VII. Community & Public Outreach

A. Activities Committee

As part of the effort to bring the Photonics community together, an activities committee was established with Photonics faculty and staff members. The committee's charter was to plan events and activities that foster collegial discussion and regular interactions among the Center's community members.

Based on the success of last year's Photonics Café, monthly cafés were hosted in the seventh floor atrium. The cafés have successfully drawn the community together and has become an important venue for Center-based collegial engagement. Future planning and execution of these events will be conducted in collaboration with the Photonics Center fellows.

The fellow also successfully implemented the Faculty Forum series. This series highlighted two faculty members each month who provide a twenty minute discussion on their current and future research projects.

On July 31st, we held our second annual summer BBQ on the BU Beach. More than 150 students, faculty and staff enjoyed barbequed beef, grilled chicken, veggie kebobs, accompanying side dishes and desserts. Miniature beach balls and sun screen rounded out the BBQ experience. Everyone enjoyed the sun, good food and fun times.

B. Laboratory Spring Cleaning Day

In an effort to make "Laboratory Spring Cleaning Day" an annual event, the Photonics Center, and ECE Department teamed up with the Office of Environmental Safety to address laser waste and safety as part of the clean up day.

The morning of the event, each lab received a bucket filled with cleaning supplies. Triumvirate Environmental completed satellite accumulation inspections, general chemical waste pickup and general lab "cleanliness" inspections. During the walk-through, the Office of Environmental Health and Safety (OEHS) conducted annual Laboratory Inspections as part of laser safety month. Kentek Corporation, the vendor of laser safety accessories and products, had a table and stayed at the event for the entire day. The OEHS sponsored lab, laser, and machine shop safety training sessions.

The day wrapped up with gift cards that were handed out to the award winning labs. The awards ceremony included well deserved ice cream treats for all participants. Prizes for the event were sponsored by Triumvirate Environmental. The Office of Environmental Health and Safety provided informational booths, ECE provided sealed top water bottles. T-shirts and ice cream were provided by the Photonics Center.

C. Seminars and Special Event Highlights

1. Symposium 2007

The 10th Annual Boston University Photonics Center Symposium: Illuminating the Future of Light, was held on Friday June 8, 2007. Nearly 200 people from both inside and outside of the university registered. This Conference celebrated the Boston University Photonics Center's achievements in photonics research, education, technology development, and incubation in the last decade.

This year's technically focused agenda featured presentations by Photonics Center faculty, as well as leading photonics researchers from outside institutions and industrial development partners. We explored the Photonics Center's role in the continuing evolution of the field by focusing on key areas including bioimaging, biophotonics, nanophotonics, and photonics materials.

This was an exciting event that celebrated a decade of incubation and defense related projects. President Brown kicked off the day by speaking of the importance of the Center and its interdisciplinary nature. We had five guest speakers, including:

- Celia Merzbacher, Assistant Director for Technology R&D, Office of Science and Technology Policy: Research to Innovation: A Federal Policymaker's Perspective
- Richard Clarke, Raman Systems: The Journey from Photonics Center to Marketplace
- David AB Miller, Co-Director of Stanford Photonics Research Center: Directions in Photonics
- Sunney Xie, Harvard University, Department of Chemistry and Chemical Biology: Single Molecule and CARS Imaging
- Ching W. Tang, University of Rochester, Chemical Engineering Department: Organic Light Emitting Diodes

A student poster session, with over 30 posters on display, assisted in linking the research and education aspects of the Photonics Center mission and provided an opportunity for students to interact with speakers and outside visitors during breaks.

Photonics Center 10th Annual Symposium Agenda

8:00 - 9:00 AM **Registration and Continental Breakfast 2nd floor**

Session I: Reflection and Projection: Celebrating a Decade of Light and Beyond – Session/Conference Chairman Lawrence Ziegler, Boston University, Chemistry Department

9:00 - 9:10 AM Welcome to the 10th Annual Symposium
9:10 - 9:25 AM Boston University President Robert A. Brown: The Importance and Impact of Photonics at Boston University
9:25 - 9:45 AM Thomas Bifano, Photonics Center Director: 40,000 ft Looking Down
9:45 - 10:10 AM Guest Speaker: Celia Merzbacher, Assistant Director for Technology R&D, Office of Science and Technology Policy: Research to Innovation: A Federal Policy-maker's Perspective

10:10 - 10:30 AM **BREAK AND STUDENT POSTER VIEWING: 2nd floor outside PHO206**

Session II: From the Laboratory to Industry - Session Chair Allyn Hubbard, Boston University, Electrical Computer Engineering (ECE) Department

10:30 - 10:55 AM Doug Adams, SOLX/Occulogix: External Company Incubation at Boston University
11:00 - 11:20 AM Socrates Deligeorges, BioMimetic Systems: The Long Road from Lab to Product: Innovation, Incubation, Industry
11:25 - 11:45 AM Guest Speaker: Richard Clarke, Raman Systems: The Journey from Photonics Center to Marketplace

12:00 - 1:30 PM **LUNCH: Colloquium Room: Guest Speaker: David AB Miller, Co-Director of Stanford Photonics Research Center:** Directions in Photonics

STUDENT POSTER VIEWING

Session III: BioImaging – Session Chair Anna Swan, Boston University, ECE Department

1:30 - 1:55 PM Guest Speaker: Sunney Xie, Harvard University, Department of Chemistry and Chemical Biology: Single Molecule and CARS Imaging
2:00 - 2:20 PM Irving Bigio, Boston University, Biomedical Engineering (BME) Department: Elastic light scattering spectroscopy for the detection of early cancer and pre-cancer
2:25 - 2:45 PM Jerome Mertz, Boston University, BME Department: New approaches to fluorescence background rejection
2:50 - 3:10 PM Amit Meller, Boston University, BME Department: Developing ultra fast DNA sequencing method using nanopore arrays and optical readout

3:10 - 3:30 PM **BREAK AND STUDENT POSTER VIEWING: 2nd floor outside PHO206**

Session IV: Leading Edge Photonics Materials and Future Directions Session Chair: Hatice Altug, Boston University, ECE Department

3:30 - 3:55 PM Theodore Moustakas, Boston University, ECE Department: GaN R&D at Boston University with emphasis on Solid State Lighting
4:00 - 4:20 PM Alexander Sergienko, Boston University ECE Department: Secure Communication and Quantum Cryptography
4:25 - 4:45 PM Guest Speaker: Ching W. Tang, University of Rochester, Chemical Engineering Department: Organic Light emitting Diodes
4:50 - 5:00 PM Thomas Bifano, Photonics Center Director: Conference Conclusions

Reception 9th floor – Colloquium Room

2. Center for Nanoscience and Nanobiotechnology Symposium

The Photonics Center co-hosted the Center for Nanoscience and Nanobiotechnology Symposium on Nanophotonics on Wednesday, May 16th. The symposium was well attended and provided a strong sense of research in the field of nanotechnology.

BOSTON UNIVERSITY
CENTER FOR NANOSCIENCE AND NANOBIOTECHNOLOGY

Nanophotonics Symposium

Wednesday, May 16th 2007 **8:00am - 5:30pm**

Photonics Center, 9th Floor Colloquium Room · 8 St. Mary's Street · Boston, MA 02215

The field of Nanophotonics is exploding, with tremendous potential impact on basic science, technology, and medicine. This one-day Symposium will focus on recent innovations and breakthrough technologies in Nanophotonics – from the fundamental interaction of light with matter to specific applications in plasmonics and metamaterials. World-renowned faculty from leading institutions in the US, as well as the two IEEE Laser and Electro-Optics Society Distinguished Lecturers for 2007, will present their latest work and technical findings. Academic researchers, industrial and professional scientists, students, and anyone with an interest in this exciting field should plan to attend.

Confirmed speakers for this event include:

Prof. **Hatice Altug**, Boston University
Prof. **Toshihiko Baba**,* Yokohama National University
Prof. **Vladimir Bulovic**, MIT
Prof. **Ken Crozier**, Harvard University
Prof. **Luca Dal Negro**, Boston University
Prof. **Philippe Fauchet**, University of Rochester
Prof. **Bennett Goldberg**, Boston University
Dr. **Masaya Notomi**,* NTT Basic Research Laboratories
Prof. **Srinivas Sridhar**, Northeastern University
Prof. **Francesco Stellacci**, MIT
Prof. **Rashid Zia**, Brown University

** IEEE-LEOS Distinguished Lecturer*

REGISTER ONLINE
http://nanoscience.bu.edu/nanophotonics07/

LIMITED SEATING, PRE-REGISTRATION REQUIRED

SYMPOSIUM AGENDA

MAPS & DIRECTIONS

Topics addressed in the seminar will include:

Photonic Crystals - Silicon Nanophotonics - Plasmonics – Metamaterials - Nanofabrication

Co -hosted by:

CENTER FOR NANOSCIENCE AND NANOBIOTECHNOLOGY

The Boston University photonics center

IEEE LEOS THE SOCIETY FOR PHOTONICS CENTRAL NEW ENGLAND CHAPTER

This Symposium is the annual Spring event for the Boston University Center for Nanoscience and Nanobiotechnology. The annual Symposium alternates between Nanophotonics and Nanomedicine.

3. Army Science Board

In April, the Boston University Photonics Center hosted the Army Sciences Board meeting where faculty and staff members were able to participate in and discuss technology challenges facing the military. This was an invaluable experience for researchers to obtain first hand knowledge of how their research can benefit the military. Also, many surrounding centers supported by the military joined in the discussions to assist in collaborations for future research and development endeavors.

AGENDA 23-24 April 2007
Plenary, Army Science Board Photonics Center, Boston MA

Monday, 23 April 2007

0800-0805	Welcome/Admin	Dr. Akers, Chairman ASB
0805- 0915	Photonics Center Overview	Dr. Bifano, Director, BUPC
0915-1015	Army Posture Statement	COL Rocke, EOH Staff Group
1015-1030	Break	
1030-1200	Resource Posture of the Army	LTG Speakes, G-8
1200-1300	Lunch	
1300-1400	Business Transformation	Mr. Michael Kirby, DUSA-BT
1400-1700	Study Breakouts	
1700-1830	Mixer w/ BU Photonics Center faculty	

Note: from 1030 to 1200, BU Photonics Center faculty and staff members meet with Dr. Killion for an overview of Army Science and Technology.

Tuesday, 24 April 2007

0800- 0915	Dr. Eric D. Evans Director, MIT Lincoln Labs
0915-0930	Break
0930-1045	Dr. J. Joannopoulas Director, Institute for Soldier Nanotechnologies
1045-1200	Root Cause Panel Out-brief
1200-1300	Lunch
1300-1700	Study Breakouts

4. Annual Photonics Center Artwork Commission

Photonics, a technology based on the essential elements of light, is a natural partner with art which communicates to its viewer primarily through the medium of light.

Throughout the Center, there are several permanent installations that reflect the theme of light. Some are by nationally recognized artists, including First Light by Boston University Professor Hugh O'Donnell.

Shortly after the Center opened in June of 1997, Director Donald Fraser worked with Professor O'Donnell and the College of Fine Arts to develop a program that would invite students to develop proposals for light based art projects. These unique pieces allowed the students to integrate their artistic vision with photonics materials and technology applications, creating unique and visually stunning results.

Each year, the winning proposal is installed in the building, giving student artists their first commissioned piece before they even graduate from the University and adding to the Center's impressive and exciting gallery of light.

We are pleased to announce the winners of this year's commission, Adamo Maisano, CFA 2008, and Laura Marotta, CFA 2008 and their piece entitled "Drawing with Light: A Collaboration of Art and Science."

The concept of these images utilizes laser technology to extend traditional drawing methods. Using a laser as a drawing tool, the movement of light was captured with long-exposure photographs. This unique methodology enabled the realization of both figurative and abstract imagery.

This artwork can be seen in the second floor atrium at The Photonics Center.