The Boston University photonics center

ANNUAL REPORT 2010-2011

LETTER FROM THE DIRECTOR

This annual report summarizes activities of the Boston University Photonics Center in the 2010-2011 academic year. In it, you will find quantitative and descriptive information regarding our photonics educational programs, our interdisciplinary research efforts, and our photonics business incubator.

Located at the heart of Boston University's large urban Campus, the Photonics Center is an interdisciplinary hub for education, research, scholarship, innovation, and technology development associated with practical uses of light. Our iconic building houses world-class research facilities and shared laboratories dedicated to photonics research, and sustains the work of forty faculty members, eight staff members, and more than one hundred graduate students and postdoctoral fellows.

This has been a transformational year for the Photonics Center, marked by the end of our extraordinarily successful technology development grant with the Army Research Laboratory (ARL), and by the beginning of a new industry collaborative research center grant that is a centerpiece of our recently expanded translational biophotonics program.

In the six years I have served as Director of the Photonics Center, that ARL grant brought more than $30M to the Photonics Center for our defense-related technology development and prototyping program. Those funds resulted in critical new hardware for US defense needs, including most prominently the RedOWL sniper detection system and the COBRA bacterial infection diagnosis system, and the ROVR viral pathogen detection system, each of which established a new state-of-the-art in fielded defense hardware. They also led to substantial expansion of Boston University's photonics-related research infrastructure. Over the past three years alone we allocated:

- $14.3M toward defense-focused research grants for twenty faculty members,
- $1.5M toward startup costs for four new faculty members,
- $1.3M toward laboratory renovations for eleven faculty members,
- $0.6M toward new equipment installed in our three shared laboratories, and
- $0.8M toward photonics graduate research fellowships.

Perhaps more importantly, the Photonics Center has emerged as a preeminent national resource for applied research and technology development in the field of photonics. We are among the nation's leading academic institutions in photonics scholarship, and have an unparalleled record of success in photonic system prototyping.

The new collaborative research center grant, a National Science Foundation (NSF) Industrial University Cooperative Research Center (I/UCRC) five-year grant on biophotonic sensors and systems, will challenges us to extend our prior success in defense-focused technology development to a broader set of problems that focus on industry and medicine.

In the following pages, you will see that the Center's faculty received prodigious honors and awards, attracted $21M in new research funds for the year, and generated scholarly publications at an unprecedented rate in all of the leading journals in our field. Faculty and staff also expanded their efforts in education and training, building on prior successes in the Research Experiences for Undergraduates (REU) and Research Experiences for Teachers (RET) programs with continued funding from the National Science Foundation. As a community, we hosted a compelling series of distinguished invited speakers, and emphasized our research theme on novel electromagnetic materials at the Annual Future of Light Symposium.

On behalf of the Photonics Center's faculty, staff, and students, I thank you for your interest in our annual report.

Thomas Bifano
Director

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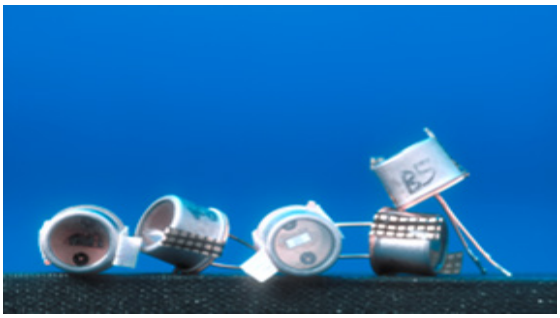
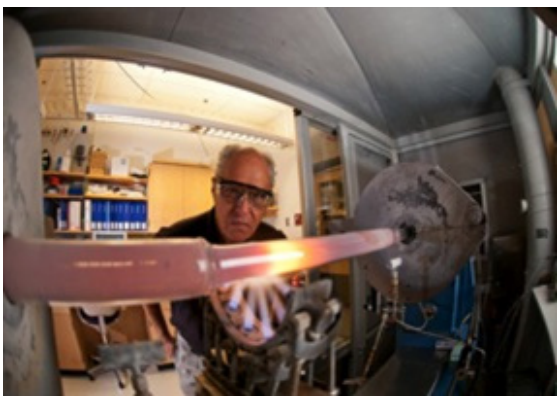
SUMMARY FY 2010-2011

This report summarizes activities of the Boston University Photonics Center (BUPC) during the period July 2010 through June 2011. These activities span the Center's complementary missions in education, research, technology development, and commercialization.



In education, 21BUPC graduate students received Ph.D. diplomas. BUPC faculty taught 20 photonics courses. One graduate student was funded through the Photonics Center Dean's Fellowship Program. BUPC supported the Research Experiences for Teachers (RET) in Biophotonic Sensors and Systems. In addition to working in the laboratories and heading to Northeastern University for shared seminars, the eight teachers split into two groups to participate in cleanroom activities. The University hosted its annual Science and Engineering Day, where the Photonics Center sponsored the Herbert J. Berman "Future of Light" Prize. Professor Goldberg's Boston Urban Fellows Project started its sixth year. For more on our education programs, turn to the Education section on page 62.

In research, BUPC faculty published journal papers spanning the field of photonics. Eleven patents were awarded to faculty this year for new innovations in the field. A number of awards for outstanding achievement in education and research were presented to BUPC faculty members. These honors include the NSF CAREER Award for Professors Altug, the 2010 R&D 100 Award for Professor Bifano, and the Dean's Catalyst Award for Professor Joshi. New external grant funding for the 2010-2010 fiscal year totaled $20.9M. For more information on our research activities, turn to the Research section on page 24.



In technology development, this year was the beginning of a transitional period at the Photonics Center as ARL pipeline programs were completed and new research projects were proposed as part of the newly funded National Science Foundation (NSF) Industrial

University Cooperative Research Center (I/UCRC) on Biophotonic Sensors and Systems. As researchers finished programs for ARL development, many successfully presented programs at the first annual I/UCRC meeting in April 2011. In the I/UCRC model, industry members of the Center provide the market vision and orient research to solve urgent market needs – in an extension of the successful ARL pipeline model in which the Department of Defense's urgent needs motivated our research goals. For more information on our technology development pipeline and projects, turn to the Technology Development section on page 49.

In commercialization, the business incubator continues to operate at capacity. Its tenants include ten technology companies with a majority having core business interests primarily in photonics and life sciences. It houses several companies founded by current and former BU faculty and students and provides students with an opportunity to assist, observe, and learn from start-up companies. For more information about business incubator activities, turn to the Business Incubation chapter in the Facilities and Equipment section on page 74.

In early 2010, the BUPC unveiled a five-year strategic plan as part of the University's comprehensive review of centers and institutes. The BUPC strategic plan will enhance the Center's position as an international leader in photonics research. For more information about the strategic plan, turn to the BUPC Strategic Plan section on page 11.

Highlights for FY 2010-2011

External Grant Funding for the 2010-2011 Fiscal Year: $20.9M
External Grant Funding for the 2010-2011 fiscal year was over $20.9M. Included in this figure is more than 37% of funding from DoD and 22% of funding from Health and Human Services (HHS). The most significant change relates to the "other category", which predominately includes industrial and private grants. This category reflects a 200% increase over FY10 levels and covers 21% of the FY11 research funding.

Three New Photonics Center Faculty Members
This year, the Photonics Center welcomed Professors Daniel Ehrlich (BME), Xue Han (BME), and Aaron Schmidt (ME) to the community. The new faculty members' research is focused on cell-based assays, neurotechnology, and optical tools, respectively.

Five Companies Graduate from the Business Incubator
The University's Business Incubator is host to ten technology start-up companies. This past year, five incubator companies, First Founder, Good Start Genetics, Lumenz, Ninth Sense and Zoiray, exited the incubation program as they expanded and grew their business or re-evaluated their business plans. Four new companies joined the incubator and one current company increased their floor space. The mix of companies includes: life sciences, biotechnology, medical devices, photonics, clean energy and engineering.

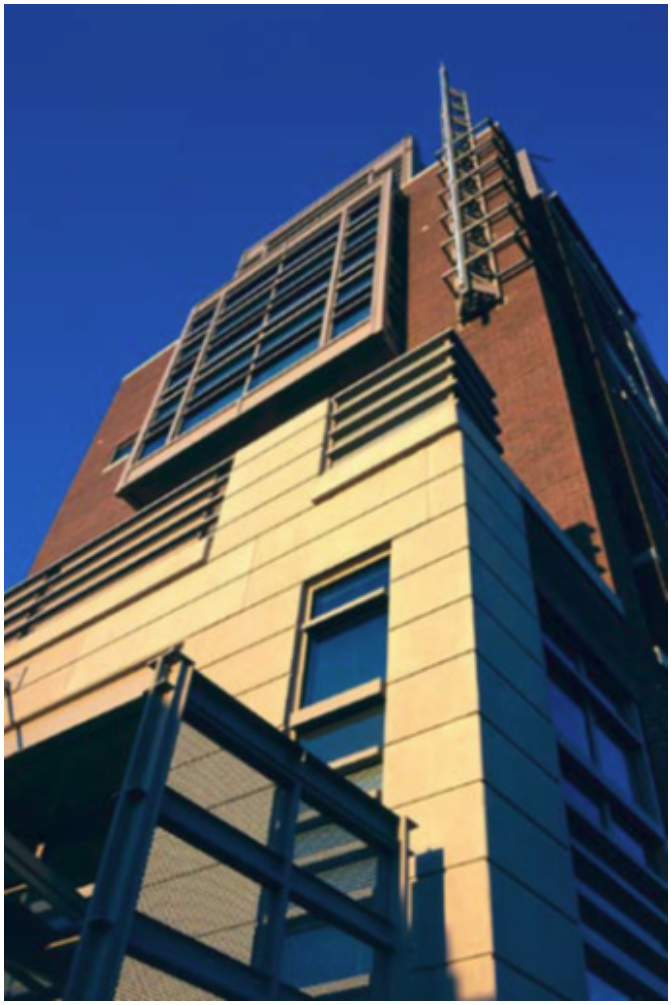
The 14th Annual Future of Light Symposium: Novel Electromagnetic Materials
This year, the 14th Annual Future of Light Symposium focused on novel electromagnetic materials. Nearly 200 people from Boston University, other academic institutions and industry attended the event. The agenda for this year's symposium featured a tutorial by Comsol the day before the symposium, and presentations from Photonics faculty members and researchers from leading photonics research institutions. The conference explored the applications of novel electromagnetic materials as well as current research endeavors utilizing these materials in a variety of settings.

Boston University Satellite for Applications and Student (BUSAT2): A New Beginning
The scientific mission BUSAT2 is to perform measurements of the precipitating energetic electron fluxes from low Earth orbit over the high latitude auroral zones and to simultaneously image the auroral emissions caused by these electrons. The summer team for this year includes 24 BU students, most of who are being paid for a 10 week summer effort from funding provided by a number of administrative centers at BU. The seventh cycle of the University Nanosat Program (UNP#7) involves a competition involving 10 universities each of whom have two years to develop a functioning satellite that will be judged by the US Air Force in January 2013 to determine a winner. The winning satellite will then be flown by the USAF after an additional two years of flight fabrication, testing, and qualification. A satellite ground station is being installed on the roof of the Photonics Building to permit the command and control of the satellite on-orbit and mission communications.

Photonics Center at a Glance

Faculty Members	40
Students Funded by BUPC- ARL Cooperative Research Grant	23
Staff Members	9
Funded R&D Projects	106
Funding for R&D (New funds for current year)	$21M
Graduate Courses taught by Photonics Faculty Members	20
Publications in Archival Journals	179
Shared Laboratory Facilities	3
Photonics Center Square Footage	235,000
Incubator Square Footage	23,000
Year of Building Opening	1997

Mission and Highlights



The Boston University Photonics Center generates fundamental knowledge and develops innovative technology in the field of photonics. We work on challenging problems that are important to society, we translate enabling research discoveries into useful prototypes, and we 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
- Technology development for defense, security, and healthcare applications
- Business incubation and commercialization of photonics technology

The BUPC community of faculty, students and staff engage in numerous interdisciplinary collaborations to further the field. Below are examples of how the Photonics Center and its diverse community execute our four-pillar mission.

Basic Research and Scholarship in Photonics
Neurophotonics research is an emerging area of strategic importance to the Photonics Center. In neurophotonics, light is used in the study, diagnosis and treatment of neurologicial disease/disorders/injury such as traumatic brain injury and post-traumatic stress disorder. This field is becoming a highlight of BU research and several newly appointed faculty members to the Center align with photonics based neurology research. In alignment with the new area of photonics research, a NSF IGERT proposal was submitted this summer on the topic of Neurophotonics.

Academic and Entrepreneurial Programs and Initiatives for Students
The NSF Industrial/University Cooperative Research Center on Biophotonic Sensors and Systems provides a direct academically motivated program of research. Students and faculty work on one year projects that will address the urgent market needs of our industrial partners. The expectation is that faculty members will propose projects that address these needs and a consensus of the industrial membership will rally behind proposals that best provides a path to a market solution. This Center allows an opportunity for students to interact with industrial members and to see what issues or research is done in industry. More information on the I/UCRC can be found in the Technology Development Section of the Annual Report.

Technology Development for Defense, Security, and Healthcare Applications
This year, the Resonant Optical Virus Reader (ROVR) project exited Phase II with the delivery of an instrument to the virology department at USAMRIID. The collaboration between Professor John Connor and USAMRIID and the photonics based research collaboration between Professors Connor and Altug led to this successful insertion. More information about ROVR and other development projects can be found in the Technology Development Section of this Annual Report.

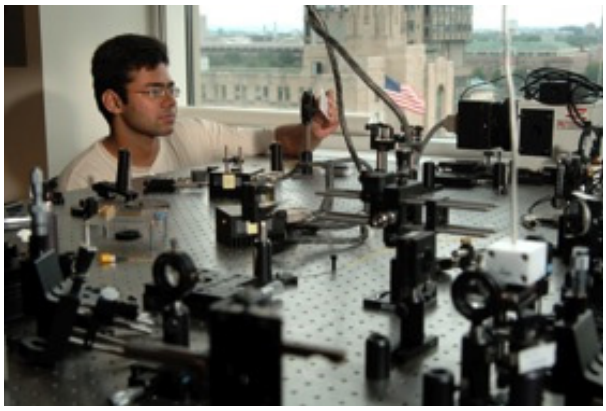
Business Incubation and Commercialization of Photonics Technology

Zoiray Technologies, Inc., led by Dr. David Bergstein, a former BU post-doctoral fellow, continued its efforts in viral antibody detection. This BU spin-off company is based upon the research and technology developed in Professor Selim Unlu's laboratory. The technology features on-board, efficient processing of serum from a symptomatic patient for multiplexed, label-free virus detection and diagnosis. The technology developed by Professor Unlu and Zoiray officially exited from the BUPC Prototype Development Pipeline last year.

Ninth Sense was a faculty spin out company founded by CAS physics professors, Shyamsunder Erramilli and Raj Mohanty. The premise for the company was to create a diagnostic and monitoring tool with patient-specific protein biomarker–based therapies. Applications under investigation are those with well-defined biomarkers and those with tests that require them to be sent to larger laboratory facilities rather than at point of care locations. There is more information about incubator companies at the Photonics Center in the Facilities and Equipment section of this Annual Report.

BUPC STRATEGIC PLAN

Last year's (FY10) annual report outlined a five-year strategic plan for the Center. This plan was intended to provide a roadmap for the Center to remain a leader in photonics research and technology transfer while delivering on its four pillar mission. In this section, you will find highlights that relate to continuing progress in implementing our strategic plan.



A key component of strategic plan is a new operational model for the Photonics Center that allow it to operate as a centralized institute – promoting, supporting, and sustaining allied research centers and programs across Boston University.

In order to document the operational configuration as an institute, the Academic Advisory Board approved a Charter and new Bylaws which reiterate the mission and vision of the Photonics Center and outlines structure and purpose, membership policies, administration, organization, reporting, and budget and governance guidelines for the Center.

As part of our roadmap to land a major competitive research center grant by 2014, we have pursued a number of smaller grant opportunities. Our first success was the award of the I/UCRC on Biophotonic Sensors and Systems in March 2011. This is one of about fifty NSF I/UCRC centers across the country and the only one focused on Biophotonic Sensors. We have pursued several opportunities for supplemental funding against this grant and have also submitted proposals for a five-year graduate education program (IGERT – Integrative Graduate Education and Research Traineeship) on Neurophotonics and a three-year Research Experience for Undergraduates (REU) on Biophotonics.

The Army Research Laboratory (ARL) Photonics Technology Development grant was completed in the past year. However, the Photonics Center staff remained engaged with the Program Director at ARL and continued to pursue new opportunities for collaboration.

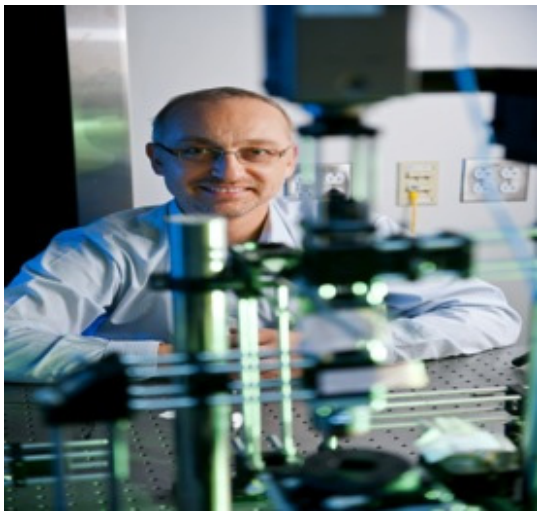
BUPC has also pursued collaborations, including international collaborations, beyond the university. Laval University in Quebec City was a significant partner in our IGERT proposal on neurophotonics and this collaboration will be further developed by BUPC faculty members. BUPC also continues to cultivate collaborations in Department of Defense research laboratories (i.e. US Army Medical Research Institute for Infectious Diseases) and university photonics centers across the country including Lehigh University, U.S. Military Academy and Delaware State University, a historically black university.

With respect to the business incubator located on the 6th floor of the Photonics Center, BUPC staff has taken a leading role in setting the strategy and managing the operations of this longstanding program. We are aiming to implement strategic changes that align the business incubator more closely with ongoing BUPC member research and educational activities and with the activities of the new I/UCRC and its member companies.

BUPC staff continued to pursue high value, multi-investigator grants in the areas of terahertz devices, quantum communications, energy conservation and adaptive optics for space or ground surveillance. Staff contributions to support proposal preparation and networking with government, academic and industrial partners have become increasingly important to BUPC's strategic mission, and that role will be expanded in the coming year.

FACULTY AND STAFF

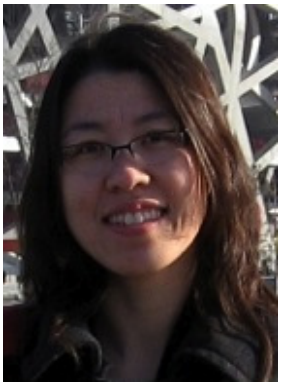
From its inception, the Photonics Center has attracted scholarly pioneers to lead our academic program in photonics. A vibrant, multidisciplinary environment is achieved through immersion of faculty from various schools and colleges within Boston University to have one location, the Photonics Center, as a base for research, teaching and collaborating. A dedicated technical and administrative staff supports the Center. Working with the faculty, the staff is focused on advancing the mission of the Center and its faculty, students and industrial and U. S. Department of Defense partners.



New Faculty Members

Professor Daniel Ehrlich

Professor Daniel Ehrlich is a Research Professor of Biomedical Engineering. Professor Ehrlich earned his Ph.D. in Optics from the University of Rochester. His research interests include: new instrumentation and methods for cell-based assays, deep-UV microscopy, microfluidics for assay of DNA, RNA and protein.



Professor Xue Han

Dr. Xue Han is an Assistant Professor of Biomedical Engineering. Professor Han earned her B.S. in Biophysics at Beijing University in China, and her Ph.D. in Physiology at the University of Wisconsin-Madison. Her research interests include: neurotechnology, optical neural modulation, optogenetics, neural prosthetics, neural network dynamics, brain rhythms, neurological and psychiatric diseases, and cognition.

Professor Aaron Schmidt

Dr. Aaron Schmidt is an Assistant Professor of Mechanical Engineering. He leads the Thermo-Optics Lab. Professor Schmidt earned his Ph.D. at the Massachusetts Institute of Technology. His research focus is on the development and application of the latest optical tools to study and manipulate transport of energy in solids and liquids from the nanoscale to the macroscale, with applications in developing new materials, energy conversion, thermal management, and furthering fundamental understanding of nanoscale transport phenomena.

Faculty Member Listing

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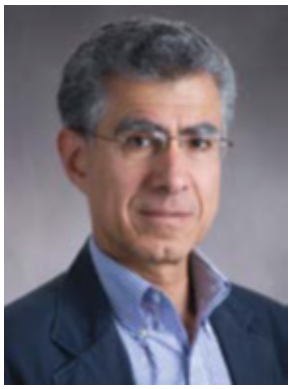
- Adaptive optics



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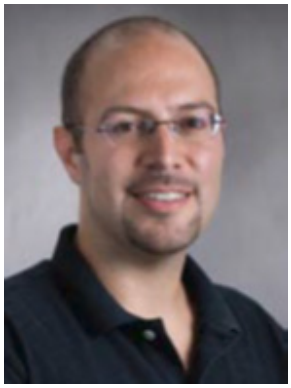

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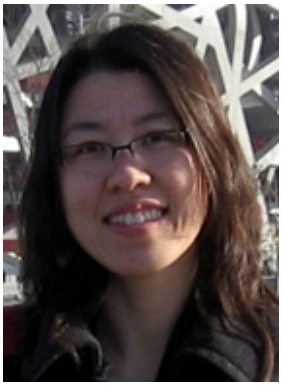

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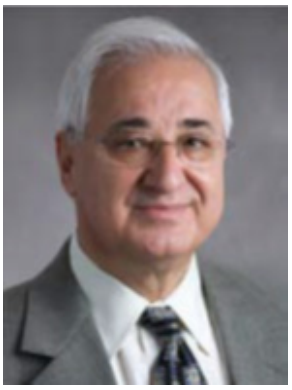

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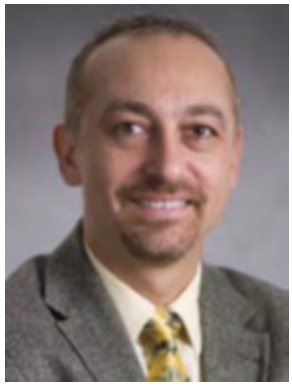
- Product design process
- MIT Tech. Enterprise Forum



Selim Unlu
Professor, ECE

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Research interests:
- Optical characterization
- Nanophotonics
- Nanoscale biological imaging

Xin Zhang
Assistant Professor, ME

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Research interests:
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- Microelectromechanical sys.
- Nanoelectromechanical sys.

Lawrence Ziegler
Professor, Chemistry

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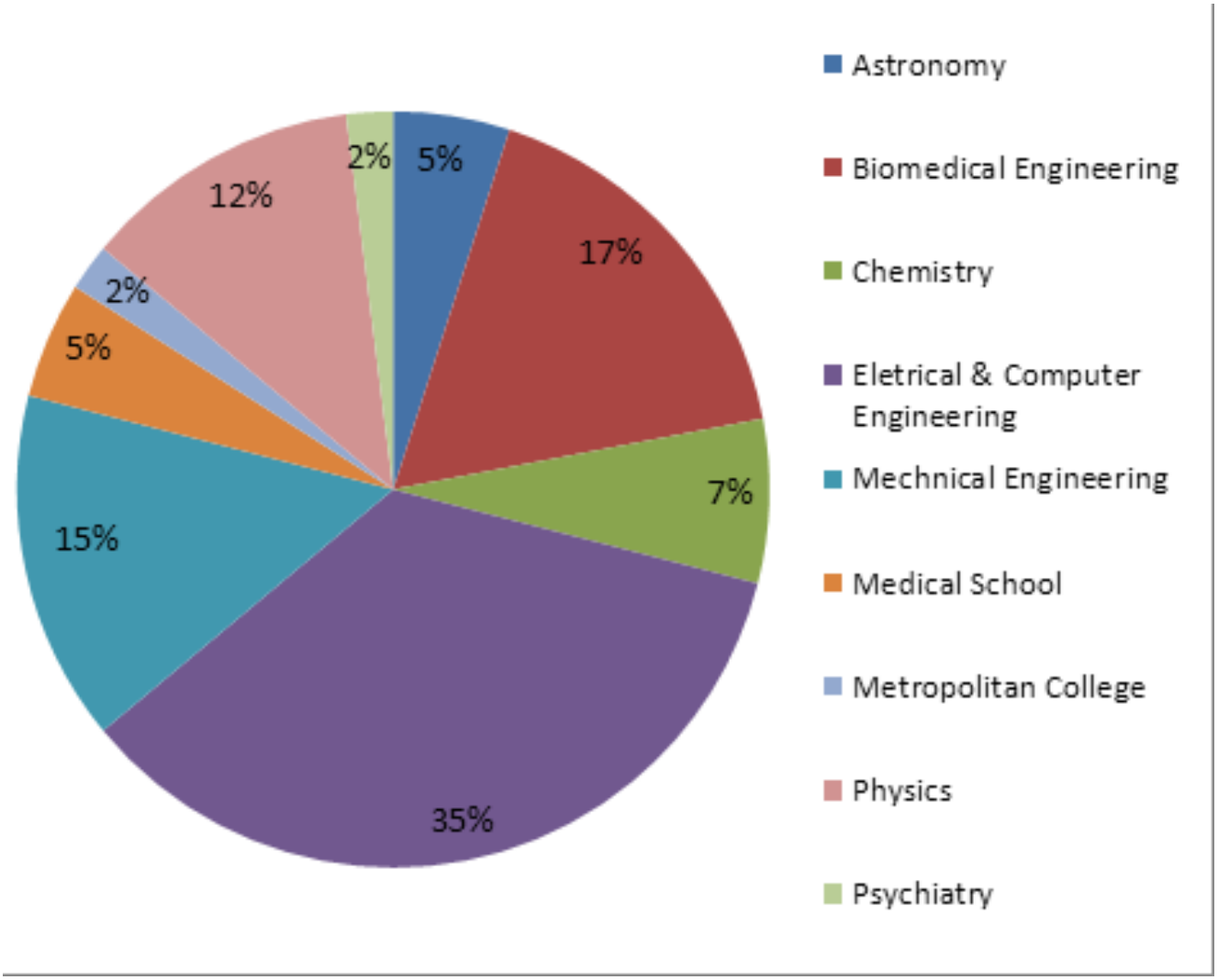
Research interests:
- Spontaneous resonance raman studies of photodissociative and biological chromophores

Primary Faculty Departments



Faculty Committees

The Photonics Center has six committees that support and serve its faculty and staff. In the spirit of continuous improvement and community involvement, the BUPC Director appoints committee chairs each year.

Distinguished Lecturer Series:
Chair – Thomas Bifano
The distinguished lecture series committee invited distinguished leaders in the field of photonics to visit the Photonics Center and give seminars on subjects of importance in the field. The lecturers also meet with individual faculty members and students.

Education:
Chair – Open
The education committee investigated methods for applying and enriching education of photonics within the community and BU programs.

Equipment:
Chair – Open
The equipment committee recommended equipment upgrades or new equipment purchases that would enhance the research and development of faculty and students at the Center.

Executive Advisory:
Chair – John Straub
The executive advisory board advised the Director of the Photonics Center on educational and academic issues and was comprised of the chairs from the Center's affiliated departments.

Space Allocation:
Chair – Thomas Bifano
This committee chair generated policy guidelines for space management.

Symposium:
Chair – Richard Averitt
This committee chair organized the 14th annual "Future of Light" symposium that focuses on research and development of novel electromagnetic materials, an area relevant to the Photonics Center community. The symposium includes external and internal faculty speakers. This past year's symposium also included a student poster session for students conducting research in meta-materials as well as a simulation software package training session by Comsol.

Staff Member Listing

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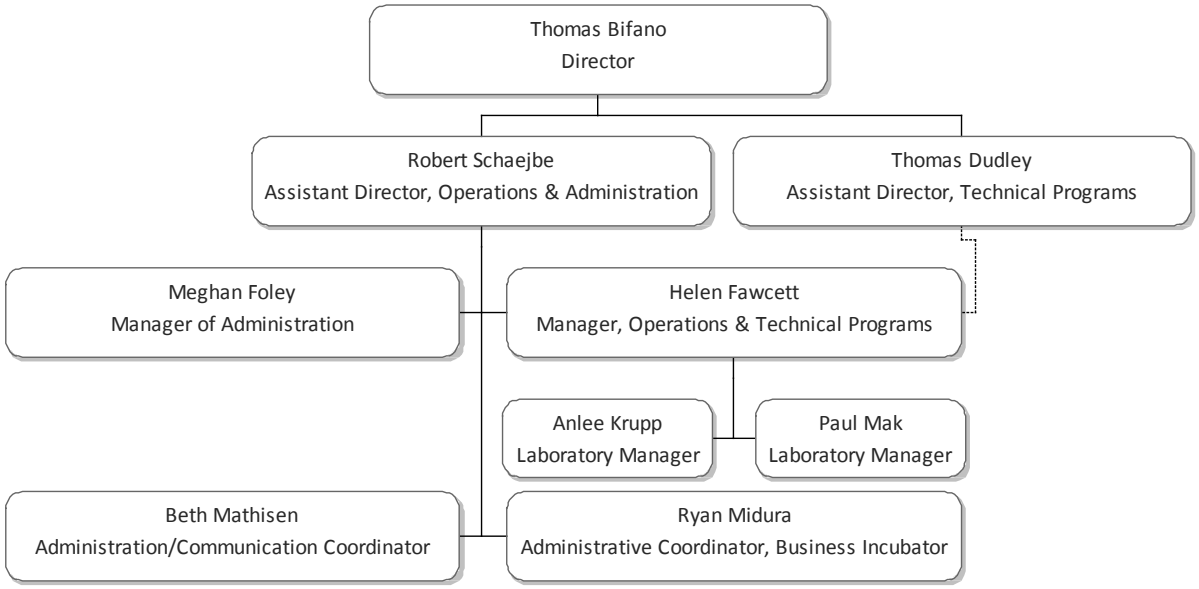
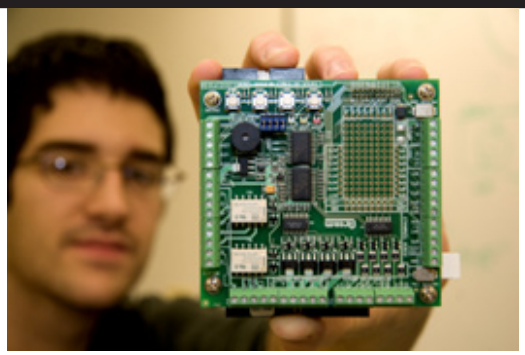
Staff Organizational Chart

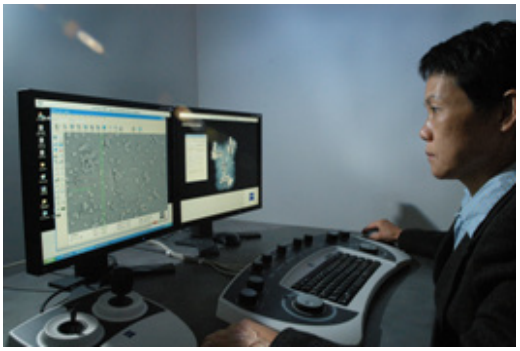


Research

Basic research and scholarship in photonics is a core mission for the Boston University Photonics Center. This commitment to academic research provides the foundation for further innovation in technology development. Scholarly research conducted at the Photonics Center originates from the traditional disciplines of the faculty members' host departments: Astronomy, Chemistry, Physics, Mechanical Engineering, Biomedical Engineering, Electrical and Computer Engineering, and the School of Medicine.

The BUPC individual faculty laboratories have pioneered breakthrough photonic devices that include UV LED's, quantum cryptography systems, deformable mirrors, high-speed photodetectors, and metamaterial devices. Photonics faculty members receive support from industry and federal agencies including, but not limited to, the National Science Foundation (NSF), the Department of Energy (DoE), the National Institutes of Health (NIH) and the Department of Defense (DoD). In addition, faculty and students associated with the Photonics Center published more than 179 journal papers.





Externally Funded Research

Photonics faculty members received more than $20.9M in external funding. The following table lists funds in the fiscal year (July 1, 2010-June 30, 2011), as reported by the Office of Sponsored Programs.

P.I.	Dept.	Title of Project	Agency	Period	Amount
Altug	ECE	High-Performance NanoPlasmonic Sensors for Biological Warfare Detection	Department of Defense/Navy	05/01/10 -- 04/30/13	42,082
Altug	ECE	Development of Multiplexed, Ultra-Sensitive, Label-Free and Rapid Biosensing Technologies for Proteomics and Virus Detection Applications	National Science-Foundation	05/16/11 -- 01/31/15	10,000
Altug	ECE	NSF Engineering Research Center for Smart Lighting - Administration (In conjunction with Center for Information and Systems Engineering) (Subcontract via Rensselaer Polytechnic Institute)	National Science-Foundation	09/01/08 -- 08/31/11	678,000
Averitt	PHY	SISGR: Multifunctional Materials Research Using Ultrafast Optical Spectroscopy (In conjunction with Photonics Center)	Department of Energy	09/01/09 -- 09/14/11	149,999
Averitt	PHY	Photonics Research and Technology Insertion - Active Metamaterial Based Terahertz Polarimeter for Spectroscopic. Detection of Chemical and Biological Hazards (Topic R). In conjunction with Photonics Center) (Subcontract via Department of Defense/ARL)	Department of Defense/ARO/ DTRA	08/01/10 -- 06/30/11	198,100
Averitt	PHY	High Performance THz Detector Arrays Using Planar Metamaterial Absorbers (Subcontract via DOLCE Technologies, LLC)	Department of Defense/Air Force	09/08/10 -- 04/01/11	34,539
Averitt	PHY	Photonics Research and Technology Insertion - Active Metamaterial Based Terahertz Polarimeter for Spectroscopic Detection of Chemical and Biological Hazards (Topic R) (In conjunction with Photonics Center) (Subcontract via Department of Defense/ARL)	Department of Defense/ARO/ DTRA	05/25/11 -- 06/30/12	201,766
Bellotti	ECE	Photon-Trap Structures for Quantum Advanced Detectors (PT-SQUAD) (In conjunction with Photonics Center) (Subcontract via BAE Systems)	Department of Defense/DARPA	08/18/09 -- 09/01/11	85,158
Bellotti	ECE	Theoretical Study of Carrier Transport, Impact Ionization and Radiative Recombination in Si/SiGe Nanostructures	University of Pretoria, South Africa	07/01/10 -- 06/30/12	119,310
Bellotti	ECE	SBIR Phase II - Advanced Space Sensor Components and Concepts (In conjunction with Photonics Center) (Subcontract via Photronix, Inc.)	Department of Defense/AFOSR	09/20/10 -- 09/20/12	119,993

P.I.	Dept.	Title of Project	Agency	Period	Amount
Bifano	ME	Scalable, Cost-Effective, High-Actuator-Count Deformable Mirrors for Astronomical Adaptive Optics	National Science Foundation	07/01/11 -- 06/30/12	423,166
Bifano	ME	Industry-University Cooperative Research Center: Biophotonic Sensors and Systems	National Science Foundation	03/01/11 -- 02/29/12	80,000
Bifano	ME	Industry-University Cooperative Research: Center for Biophotonic Sensors and Systems	National Science Foundation	03/01/11 -- 02/29/12	8,000
Bigio	BME, ECE	Validation of Colon Cancer Screening by Optical Sensing of Field Effect in Rectal Mucosa (Subcontract via Massachusetts General Hospital/CIMIT)	Department of Defense/Army/ Medical Research Acquisition Activity	05/26/10 -- 03/21/11	140,000
Bigio	BME, ECE	Enhanced Intraarterial Delivery of Chemotherapeutic Drugs to the Brain (Subcontract via Columbia University)	HHS/NIH/NCI	08/01/10 -- 07/31/11	88,668
Bigio	BME, ECE	Optical Imaging of Chemotherapy for Brain Tumors (Subcontract via Columbia University)	HHS/NIH/NCI	04/01/11 -- 03/31/12	83,448
Connor	MED	Stage Specific Inhibitors of Orthopoxviruses	HHS/NIH/NIMH	04/15/11 -- 03/31/12	40,812
Connor	MED	Miroarray and Viral Genome Sample Processing and Analysis Supporting USAMRID TMTI Development and-Characterization of Animal Models for Arenaviruses (Subcontract via Harvard University)	Department of Defense	07/01/10 -- 03/09/12	314,090
Connor	MED	Identification of Therapeutic Targets for Viral Hemorrhagic Fever Viruses	Department of Defense	07/19/10 -- 08/18/11	225,903
Connor	MED	Microarray Analysis in Support of Development of the Cynomolgus Macaque Model for Filoviruses	Department of Defense/Army/ Medical Research Acquisition Activity	03/10/11 -- 04/09/12	200,484
Connor	MED	Microarray Processing and Analysis of Biological Samples from Non-Human Primate Models of Viral Infections and Human Clinical Samples (Subcontract via Harvard University)	Department of Defense	12/30/10 -- 12/29/11	45,847
Connor	MED	Multivariant Vaccine for Viral Hemorrhagic Fever (Subcontract via University of Texas Medical Branch)	HHS/NIH/CC	08/01/10 -- 07/31/11	260,296
Connor	MED	Development and Characterization of Animal Models for Filoviruses	Department of Defense/Army	09/01/10 -- 08/31/11	391,979

P.I.	Dept.	Title of Project	Agency	Period	Amount
Dal Negro	ECE	Deterministic Aperiodic Structures for On-Chip Nanophotonics and Nanoplasmonics Device Applications	Department of Defense/AFOSR	12/01/10 -- 11/30/11	159,999
Dal Negro	ECE	MURI: Electrically-Pumped, Silicon-Based Lasers for Chip-Scale Nanophotonic Systems Subcontract via MIT)	Department of Defense/AFOSR/ AFRL	07/01/06 -- 06/30/11	55,166
Dal Negro	ECE	Engineering Structural Color in Metal Films	APIC Corporation	07/01/11 -- 06/30/12	150,000
Ehrlich	BME, ECE	High-Throughput BioMEMS	HHS/NIH/NHGRI	09/01/10 -- 06/30/11	710,176
Ehrlich	BME, ECE	High-Throughput BioMEMS	HHS/NIH/NHGRI	07/01/11 -- 06/30/12	709,603
Ekinci	ME	Tailor-Made Superhydrophobic Surfaces for MEMS and NEMS (REU Supplement)	National Science Foundation	05/01/10 -- 04/30/13	6,000
Erramilli	PHY	Nanowire Wheatstone Bridge	Battelle Memorial Institute	01/18/11 -- 01/31/12	50,333
Erramilli	PHY	Nanoplasmonic Rectenna (In conjunction with Photonics Center)	Battelle Memorial Institute	01/06/11 -- 01/31/12	195,333
Erramilli	PHY, BME	Nanowire Wheatstone Bridge (In conjunction with Center for Nanoscience and Nanobiotechnology)	Battelle Memorial Institute	07/01/10 -- 09/15/10	25,000
Erramilli	PHY, BME	Nanoplasmonic Rectanna (In conjunction with Center for Nanoscience and Nanobiotechnology)	Battelle Memorial Institute	05/31/10 -- 09/15/10	60,000
Erramilli	PHY, BME	Nanoplasmonic Infrared QCL/SEIRA-Biochemical Detection (Subcontract via MIT/Lincoln Laboratory)	Department of Defense/Air Force	04/01/10 -- 06/30/12	60,500
Fritz	AST	The Loss Cone Imager (LCI) for the DSX Program (Task 1)	Department of Defense/Air Force	04/01/10 -- 09/30/11	30,000
Fritz	AST	The Loss Cone Imager (LCI) for the DSX Program (Task 1)	Department of Defense/Air Force	04/01/10 -- 09/30/11	85,604
Fritz	AST	The Loss Cone Imager (LCI) for the DSX Program (Task 1)	Department of Defense/Air Force	04/01/10 -- 09/30/11	75,000
Fritz	AST	The Loss Cone Imager (LCI) for the DSX Program (Task 1)	Department of Defense/Air Force	04/01/10 -- 09/30/11	8,528
Fritz	AST	The Loss Cone Imager (LCI) for the DSX Program (Task 1)	Department of Defense/Air Force	04/01/10 -- 09/30/11	30,000

P.I.	Dept.	Title of Project	Agency	Period	Amount
Fritz	AST	The Loss Cone Imager (LCI) for the DSX Program (Task 1)	Department of Defense/Air Force	04/01/10 -- 09/30/11	50,000
Fritz	AST	The Cluster RAPID Investigation 2008-2011	NASA	07/01/08 -- 10/16/11	40,000
Fritz	AST	The Loss Cone Imager (LCI) for the DSX Program (Task 1)	Department of Defense/Air Force	04/01/10 -- 09/30/11	100,000
Gabel	MED	The Study of Neural Regeneration in C. Elegans using Femtosecond Laser Surgery and Advanced Optical Neurophysiology	Massachusetts Life Sciences Center	09/01/10 -- 08/31/11	100,000
Goldberg	PHY	Logic Analysis Tool (Subcontract via DCG Systems, Inc.)	Office of the Director of National Intelligence/IARPA	12/08/10 -- 12/07/11	365,275
Goldberg	PHY	Summer Immersion Institutes	Stephen Bechtel Fund	12/04/09 -- 10/01/11	100,000
Goldberg	PHY	Boston University Cross-Disciplinary Training in Nanotechnology for Cancer	HHS/NIH/NCI	09/01/10 -- 07/31/11	280,532
Goldberg	PHY	Inquiring Minds (STEM Grant)	Comm. of Mass./ Department of Higher Education	03/13/09 -- 09/30/10	560
Goldberg	PHY	Graphene Membranes as Micro- and Nano-Pressure Sensors (In conjunction with Center for Nanoscience and Nanobiotechnology and Photonics Center)(Subcontract via University of Texas/Austin)	Advanced Energy Consortium	03/01/09 -- 12/31/11	198,179
Goldberg	PHY	Next Generation Solid Immersion Microscopy for Fault Isolation in Back-Side Analysis (In conjunction with Center for Nanoscience and Nanobiotechnology and Photonics Center))	Office of the Director of National Intelligence/IARPA	11/10/10 -- 06/15/12	2,071,000
Han	BME	Alfred P. Sloan Research Fellowship	Alfred P. Sloan-Foundation	09/15/11 -- 09/15/13	50,000
Han	BME	Cross Region Neural Computation Subserving Attention	HHS/NIH/NIMH	07/01/10 -- 04/30/11	249,000
Han	BME	Cross Region Neural Computation Subserving Attention	HHS/NIH/NIMH	05/01/11 -- 04/30/12	246,311

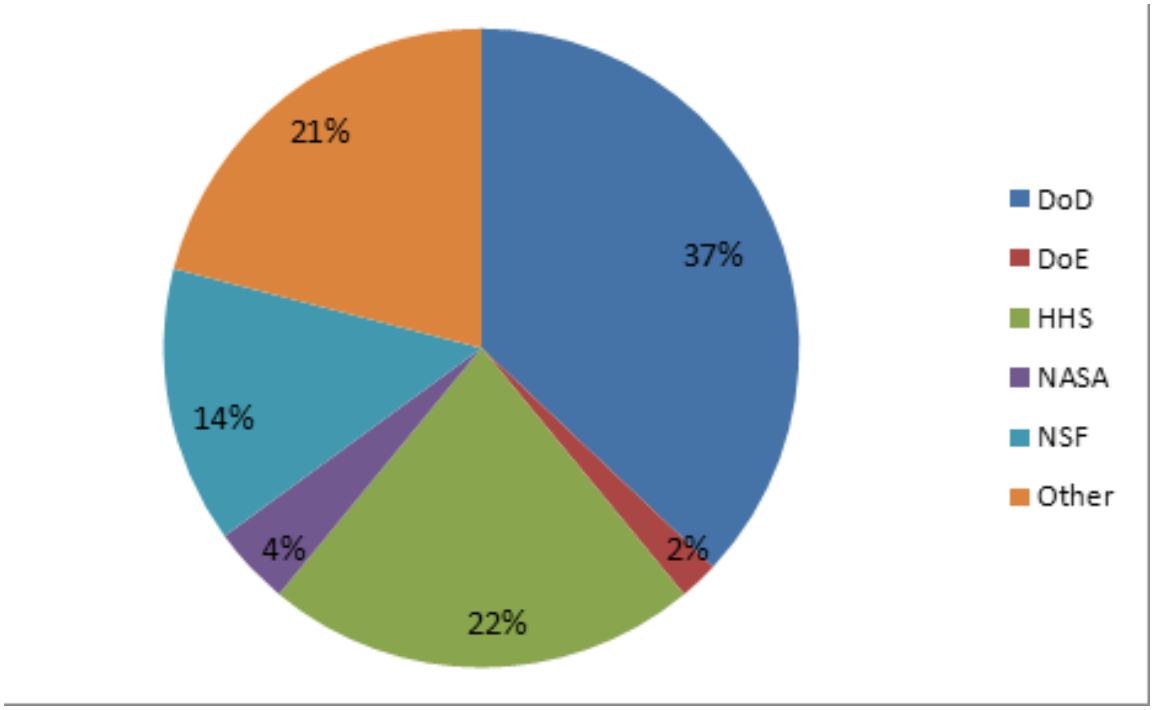
P.I.	Dept.	Title of Project	Agency	Period	Amount
Hubbard	ECE, BME	Active Filtering in the Cochlea (In conjunction with Hearing Research Center)	HHS/NIH/NIDCD	09/01/10 -- 08/31/11	713,343
Hubbard	ECE, BME	Advanced Auditory Modeling for Acoustic Analysis (STTR Phase 1) (In conjunction with Hearing Research Center) (Subcontract via BioMimetic Systems, Inc.)	Department of Defense/Air Force	05/01/10 -- 01/31/11	34,785
Klapperich	ME, BME	Bacterial Drug Susceptibility Identification by Surface Enhanced Raman Microscopy (Subcontract via Fraunhofer USA)	HHS/NIH/NIAID	07/01/10 -- 06/30/11	162,500
Klapperich	ME, BME	Portable Low Power Nucleic Acid Extraction Module (In conjunction with Center for Nanoscience and Nanobiotechnology) (Subcontract via Program for Appropriate Technology in Health)	HHS/NIH/NIBIB	09/01/10 -- 08/31/11	109,660
Meller	BME	Single-Molecule DNA Sequencing with Engineered Nanopores (Subcontract via The Scripps Research Institute)	HHS/NIH/NHGRI	09/01/10 -- 06/30/11	99,999
Meller	BME	Single Molecule Sequencing by Nanopore Induced Proton Emission (SM-SNIPE)	HHS/NIH/NHGRI	07/20/10 -- 06/30/11	998,656
Meller	BME	Single Molecule Sequencing by Nanopore Induced Proton Emission (SM-SNIPE)	HHS/NIH/NHGRI	07/01/11 -- 06/30/12	1,019,398
Mendillo	AST	A Comprehensive Multi-Process Saturn- Thermosphere-Ionosphere-Model (STIM)	NASA	03/01/09 -- 02/29/12	99,526
Mendillo	AST	Inter-Hemispheric Studies of Ionospheric Irregularities	Department of Defense/Navy	12/12/08 -- 12/31/11	87,443
Mendillo	AST	Imaging Science and Modeling Investigations of the Upper Atmosphere	National Science-Foundation	12/01/10 -- 11/30/11	295,000
Mendillo	AST	NASA Fellowship: Mercury's Escaping Atmosphere (Carl Schmidt)	NASA	09/01/10 -- 08/31/11	30,000
Mendillo	AST	Inter-Hemispheric Studies of Ionospheric Irregularities	Department of Defense/Navy	12/12/08 -- 12/31/11	83,557
Mertz	BME	Ultrasound-Enabled Two-Photon FRET Microscopy	HHS/NIH/NIBIB	04/01/11 -- 03/31/12	81,626
Mertz	BME	Sponsored Research Agreement with Karl Storz	Karl Storz GmbH & Co. KG	12/01/10 -- 12/31/11	65,000
Mertz	BME	Development of Photothermal Microscopy for Biomedical Applications	HHS/NIH/NIBIB	04/01/11 -- 03/31/12	244,876

P.I.	Dept.	Title of Project	Agency	Period	Amount
Mertz	BME	The Development of Hybrid Widefield Imaging for Out-of-Focus Background Rejection	HHS/NIH/NIBIB	07/01/11 -- 06/30/12	350,709
Moustakas	ECE	Sub-250 nm Electron-Beam Pumped Semiconductor Laser (SBIR) (Subcontract via Photon Systems, Inc.)	Department of Defense/DARPA	12/20/10 -- 12/19/12	1,521,034
Moustakas	ECE	Investigation of Rapid Thermal Annealing of Oxide Semiconductor Samples (In conjunction with Photonics Center) (Subcontract via Osram Sylvania, Inc.)	NASA	01/01/11 -- 06/30/11	19,656
Paiella	ECE	Plasmonic Nanostructures Integrated with Semiconductor Light Emitting Materials for Enhanced Efficiency and Functionality	Department of Energy	01/01/11 -- 12/31/12	155,000
Paiella	ECE	Collaborative Research: Quantum-Cascade-Laser Active Materials Based on Silicon-Germanium Nanomembranes	National Science-Foundation	07/01/10 -- 06/30/12	80,849
Ramachandran	ECE	Higher Dimensional Information Encoding with Vortex Fibers	Department of Defense/DARPA	04/29/11 -- 04/28/12	224,784
Ramachandran	ECE	High-Power Blue-Green Lasers for Communications	Department of Defense/ONR	11/01/10 -- 04/30/13	120,000
Ramachandran	ECE	Power-Scalable Blue-Green Bessel Beams	Department of Defense/ONR	01/01/11 -- 12/31/11	255,818
Ramachandran	ECE	High-Power Blue-Green Lasers for Communications	Department of Defense/ONR	11/01/10 -- 04/30/13	120,000
Ramachandran	ECE	High-Power Blue-Green Lasers for Communications	Department of Defense/ONR	11/01/10 -- 04/30/13	100,000
Ramachandran	ECE	High-Power Blue-Green Lasers for Communications	Department of Defense/ONR	11/01/10 -- 04/30/13	130,000
Reinhard	CHEM	Bioavailability and Toxicity of Engineered Nanomaterials (Lynell Skewis)	HHS/NIH/NIMH	08/01/10 -- 07/31/11	28,295
Reinhard	CHEM	Illuminating Dynamic Receptor Clustering in the Epidermal Growth Factor Receptor (In conjunction with Center for Nanoscience and Nanobiotechnology)	HHS/NIH/NCI	05/01/11 -- 04/30/12	23,603
Ritt		Career Award at the Scientific Interface	Burroughs Wellcome Fund	01/01/11 -- 12/31/11	60,000
Rothschild	PHY	FTIR Study of Signal Transduction in Sensory Rhodopsins	HHS/NIH/NIGMS	09/01/10 -- 08/31/11	309,375
Rothschild	PHY	Melanopsin Signal Transduction Studied by FTIR Spectroscopy	HHS/NIH/NEI	09/01/10 -- 05/31/11	213,381
Rothschild	PHY	Melanopsin Signal Transduction Studied by FTIR Spectroscopy	HHS/NIH/NEI	09/01/10 -- 05/31/12	298,540

P.I.	Dept.	Title of Project	Agency	Period	Amount
Ruane	ECE	TRIPSS - RET Site in Biophotonics Sensors and Systems (In conjunction with Photonics Center)	National Science-Foundation	06/01/10 -- 06/30/12	274,970
Sergienko	ECE	High Information Capacity Quantum Imaging (In conjunction with Photonics Center) (Subcontract via University of Rochester)	Department of Defense	09/01/10 -- 09/30/11	100,000
Sergienko	ECE	High Information Capacity Quantum Imaging (In conjunction with Photonics Center) (Subcontract via University of Rochester)	Department of Defense	09/01/10 -- 08/31/11	16,667
Unlu	ECE, BME	BU/CIMIT Applied Healthcare Engineering Fellowship (Subcontract via Massachusetts General Hospital)	Department of Defense/Army/ Medical Research Acquisition Activity	01/01/10 -- 12/31/10	125,000
Unlu	ECE, BME	High Throughput Quantification of Conformation and Kinetics of DNAProtein Complexes (In conjunction with Center for Nanoscience and Nanobiotechnology)	National Science-Foundation	09/15/09 -- 08/31/11	110,000
Unlu	ECE, BME	Floating Light-Activated Micro-Electrical Stimulators for Neural Prosthetics (Subcontract via New Jersey Institute of Technology)	HHS/NIH/NIBIB	08/01/10 -- 05/31/11	156,411
Unlu	ECE, BME	STTR Phase II: High Speed Diagnostic of Temperature and Intensity Variation of Diode-Laser Facets (Subcontract via Science Research Laboratory)	Department of Defense/Army Aviation and Missile Command	08/01/10 -- 06/30/12	110,879
Unlu	ECE, BME	MITRE Research Agreement (In conjunction with Center for Nanoscience and Nanobiotechnology and Photonics Center)	The MITRE Corporation	10/01/10 -- 09/30/11	85,000
Unlu	ECE, BME	BU/CIMIT Applied Healthcare Engineering Fellowships (Subcontract via Massachusetts General Hospital/ CIMIT)	Department of Defense/USAMRAA	01/01/11 -- 12/31/11	125,000
Unlu	ECE, BME	Floating Light-Activated Micro-Electrical Stimulators for Neural Prosthetics (Subcontract via New Jersey Institute of Technology)	HHS/NIH/NIBIB	06/01/11 -- 05/31/12	108,730
Zhang	ME	Draper Laboratory Fellow (Aleksander Jonca)	Charles Stark Draper Laboratory, Inc.	09/01/10 -- 08/31/11	38,162

P.I.	Dept.	Title of Project	Agency	Period	Amount
Zhang	ME	Draper Laboratory Fellow (Else Frohlich)	Charles Stark Draper Laboratory, Inc.	09/01/10 -- 08/31/11	38,162
Zhang	ME	An Impedance-Based Assay Microsystem for Real-Time High Throughput Study of Single Cells (In conjunction with Photonics Center)	National Science Foundation	10/01/10 -- 09/30/11	92,932
Zhang	ME	An Impedance-Based Assay Microsystem for Real-Time High Throughput Study of Single Cells (In conjunction with Photonics Center)	National Science Foundation	10/01/10 -- 09/30/12	89,620
Zhang	ME	Mechanical Behavior of Amorphous Plasma-Enhanced Chemical Vapor Deposited Silicon Oxide Films for MEMS Applications (REU Supplement) (In conjunction with Photonics Center)	National Science Foundation	06/01/09 -- 05/31/11	6,000
Zhang	ME	Coupled Evanescent Field Micro-Resonators for Downhole Data Relay (In conjunction with Photonics Center) (Subcontract via University of Texas, Austin)	Advanced Energy Consortium	07/01/11 -- 06/30/12	208,209
Zhang	ME	Materials and Mechanics of Metamaterial Enhanced MEMS for Terahertz Technology (In conjunction with Photonics Center)	Department of Defense/AFOSR	04/01/11 -- 03/31/12	130,000
Ziegler	CHEM	Reporter Based SERS Testing of Biothreat Simulants (In conjunction with Photonics Center)	Intevac Photonics: Delta Nu Business Unit	07/08/10 -- 09/08/10	8,515
Ziegler	CHEM	Assessment of SERS Bacterial Specificity and Culture Growth Dependence (In conjunction with Photonics Center)	Becton, Dickinson and Company	07/01/10 -- 12/31/10	110,368
Ziegler	CHEM	Bacterial Drug Susceptibility Identification by Surface Enhanced Raman Microscopy (In conjunction with Photonics Center) (Subcontract via Fraunhofer USA)	HHS/NIH/NIAID	07/01/10 -- 06/30/11	248,410
Ziegler	CHEM	Effects of Immediate Biochemical Environments on the Structure and Function of Aortic Elastin	National Science-Foundation	05/01/11 -- 04/30/14	370,000
				TOTAL	20,986,512

Breakdown by Granting Agency FY 2010-2011



In FY11, DoD funding sources accounted for 37% or the largest percentage of the Photonics Center's overall research funding and an increase of 20% over FY10 funding levels. The most significant change in overall funding relates to the "other category", which predominately includes industrial and private grants. This category reflects a 200% increase over FY10 levels and covers 21% of the FY11 research funding. The increases in DoD and other categories compensated for an approximate $3 million year-over-year reduction in research funding from NIH and NSF sources.

Looking forward, FY12 is likely to see reductions in DoD funding, but overall research dollars are still expected to be holding at around $20 million, as NSF and NIH funding rebounds and commercial sponsored research is expected to hold steady or grow.

Publications and Patents

Books

H. Altug, D. Englund, and J. Vuckovic, "Photonic Crystal Microcavity Light Sources," in Comprehensive Semiconductor Science and Technology, P. Bhattacharya, R. Fornari, and H. Kamimura (editors), Elsevier Science, March 29, 2011.

R. Paiella, "Quantum Cascade Lasers," in Comprehensive Semiconductor Science and Technology, P. Bhattacharya, R. Fornari, and H. Kamimura (editors), Elsevier Science, March 29, 2011.

Book Chapters

"Photonic Crystal Microcavity Light Sources". **H. Altug**, in "Comprehensive Semiconductor Science and Technology", Elsiver in Calendar Year 2010.

Elastic-scattering spectroscopy for optical biopsy: probe designs and analytical methods for clinical applications," Roberto Reif and **Irving J. Bigio**, in Biomedical Applications of Light Scattering, Backman, Wax, Eds., McGraw-Hill, (Jan. 2010).

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Awards of Note

Hatice Altug won the NSF Career Award. She also won the ONR Young Investigator Award, the Boston University College of Engineering Early Career Award, and the IEEE Photonics Society Young Investigator Award.

Enrico Bellotti won the 2010 Nusod Best Paper Award.

Thomas Bifano won the 2010 R&D 100 Award for (MEMS)-based Adaptive-Optics Optical Coherence Tomography. He won this prestigious award acknowledging the top-100 technology innovations in R&D for the year in collaboration with Lawrence Livermore National Laboratory.

Irving Bigio was elected Fellow of SPIE, 2010.

Kamil Ekinci was named the College of Engineering Distinguished Faculty Fellow.

Allyn Hubbard was made a Kern Fellow in recognition of the companies he has started.

Ajay Joshi was awarded the Dean's Catalyst Award (2011) for the project on "Application-Specific Noisy Processors: Weaving Nearly Reliable Circuits from an Unreliable Fabric"

Theodore Moustakas was given the 2010 Molecular Beam Epitaxy Innovator Award. He was also named the 2011 Distinguished Scholar of the BU College of Engineering.

Siddharth Ramachandran was named a Fellow of the Optical Society of America.

Bjoern Reinhard was awarded the National Science Foundation Career Award.

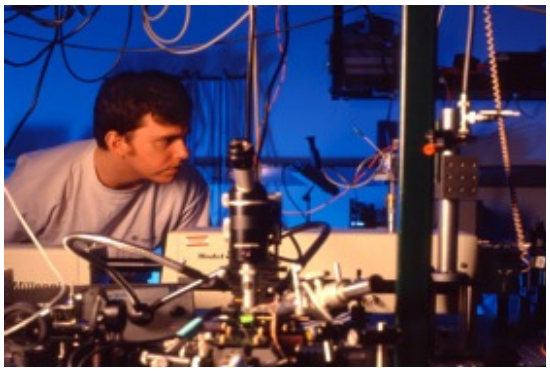
Anna Swan's mentee Samir Ahmed won the best poster award at the UROP 13th Annual undergraduate research Symposium. The subject of the poster was the Fabrication of Durable Graphene Based Passive Pressure Sensors.

Selim Unlu was selected as Editor-in-Chief for IEEE Journal of Quantum Electronics.

Xin Zhang was named the Inaugural Distinguished Faculty Fellow (2009-2013). She also received the Advanced Energy Consortium (AEC) Award, the Schlumberger Award for Excellence and Leadership in MEMS/NEMS Research, the K-L2 Fellowship, the Nanomedicine Phase II Award, and the Best Paper Award in IEEE Sensors.

Technology Development

The Boston University Photonics Center (BUPC) working through a Cooperative Research Agreement with the U.S. Army Research Laboratory (ARL) has been at the forefront of groundbreaking research and technology development that directly addresses critical national defense needs. The program's success depends on the ability to understand Department of Defense (DoD) priorities and quickly bring promising research to bear against those priorities. This involves iterative interactions with end users and other stakeholders in the development process, an objective assessment of technology potential and a methodical approach to managing complex multi-disciplinary projects involving faculty from multiple departments and schools.



BUPC has established a record of achievement in delivering critical-need prototypes to the DoD including projects such as bio-inspired sniper detection, MEMS based secure communication systems and viral and bacterial detection systems. Each of these programs resulted in an alignment with an industrial partner, execution of a technology transfer and company positioning as a DoD procurement source.

The most recently completed prototypes on viral and bacterial pathogen detection have been run under a program referred to as COBRA and involved collaborative research with the US Army Medical Research Institute of Infectious Diseases (USAMRIID). The output of these programs has resulted in instrumentation, currently deployed at Fort Detrick, which has proven particularly useful in forensic biology work being conducted at USAMRIID where species, sub-species and lab of origin information needs to be accurately and rapidly identified. The instrument for viral detection is now being refined on an NIH grant, in close collaboration with BD Technologies, a worldwide leader in diagnostic technologies.

The Photonics Center intends to build on the integration and project management skills successfully utilized on DoD programs and further leverage our expertise at the intersection of life sciences and photonic engineering to drive research and prototyping opportunities in the healthcare sector. The Industry/University Cooperative Research Center (I/UCRC) on Biophotonic Systems and Sensors led by BUPC and launched on July 1, 2011 will focus development efforts in the field of biophotonics going forward.

ARL funds are utilized on two categories of projects. The first and most significant use of funds is designated for "pipeline projects" or research that has progressed enough to be considered for technology transfer and eventual deployment by the defense/security sector. A much smaller area of funding relates to seeding research innovation that may lead to breakthrough advancements in warfighter capabilities or care, but which is still too early in the research stage to foresee a possible commercial outcome. The section immediately following will outline the "pipeline programs" funded through the ARL Cooperative Research agreement for the fiscal year ending June 30, 2011.

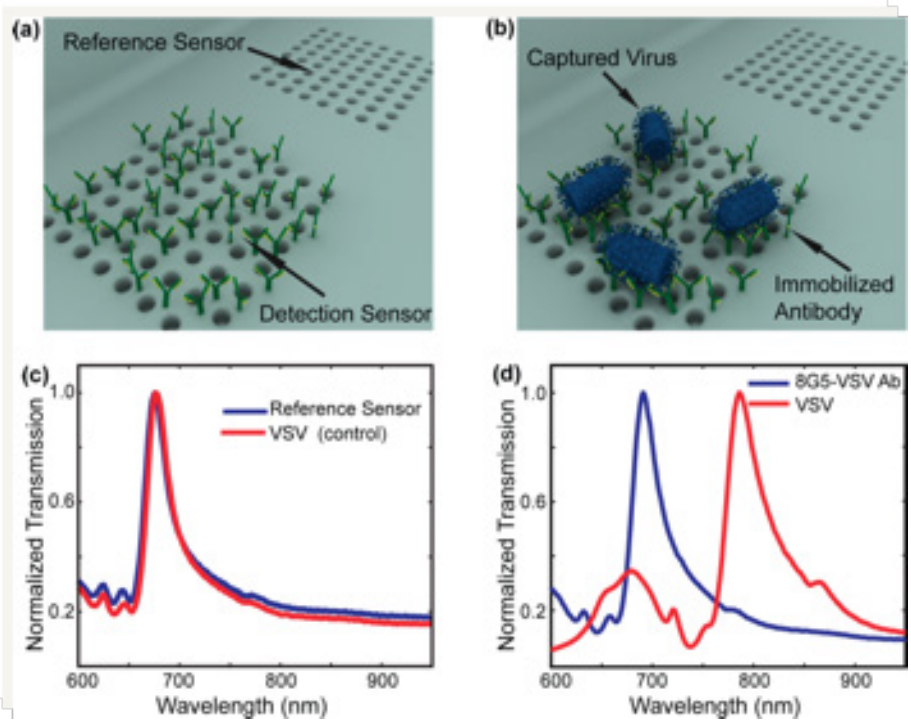
Phase II Pipeline Project: Resonant Optical Virus Reader (ROVR)

Task Leader: Hatice Altug Collaborator: John Connor

Project Objective:
The intended objective of the ROVR project was to deliver a dual-function virus reader and microscope for bona-fide virus detection in a BL-4 laboratory environment.

Project Approach:
The team focused on prototype fabrication of a virus reader/microscope instrument and on new designs and methods of substrate fabrication. More aggressive tasks to integrate microfluidics were attempted but could not be realized in a BL4 laboratory. The team worked through several design iterations for the add-on virus reader and selected an outside company to develop the prototype and integrate with a lab microscope. Once fabricated, the system was verified, a post-doctoral associate was trained on use and analysis of the system in the BL-2 facility at BU. The post-doctoral associate then conducted system validation studies at USAMRIID. The substrate used in the reader for the virus detection is an integral part of the system. Several substrate design iterations were initiated and a final design was chosen. Concurrently, fabrication facilities were identified for eventual full-wafer processing. A facility was chosen and chips were produced from wafer level processing.

Project Outcome:
The team worked to deliver a prototype and has a duplicate set up at the medical campus. Testing and sensitivity experiments continue and valuable data was collected and became instrumental in follow-on funding awards from NIH. Publically traded diagnostic companies have become aware of the technology and ultimately may initiate a technology transfer.



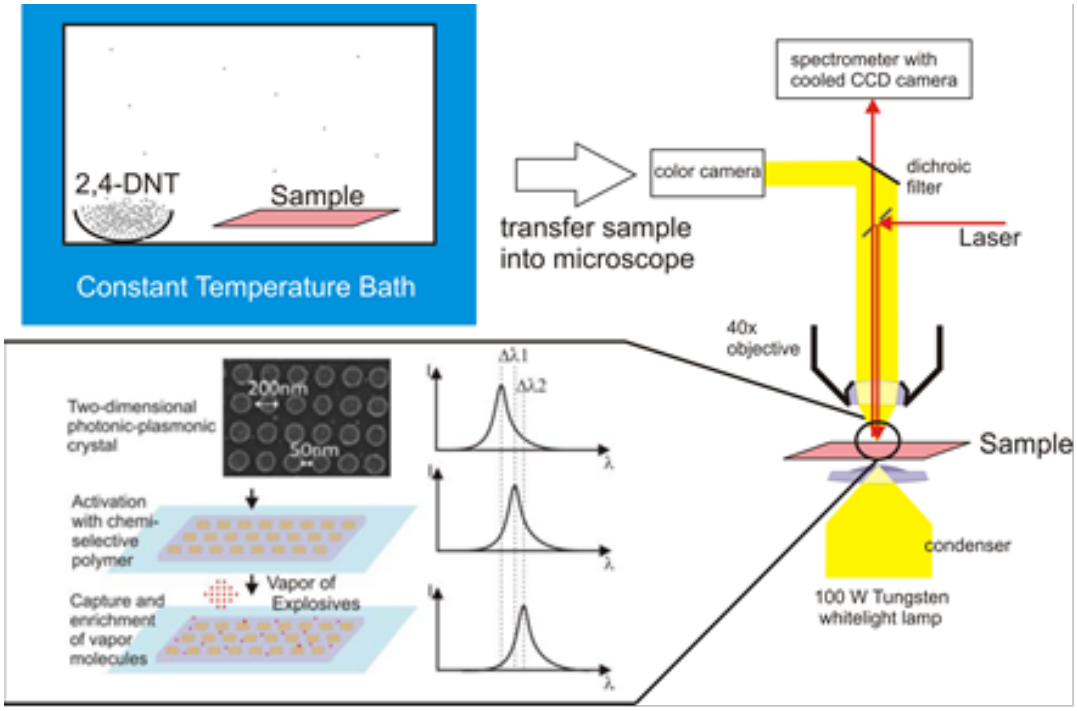
Phase II Pipeline Project: Chemically Enhanced Photonic-Plasmonic Crystals for Explosive Vapor Detection

Task Leader: Bjoern Reinhard Collaborator: Luca Dal Negro

Project Objective:
This team developed a chemically enhanced photonic plasmonic sensor for explosive vapor detection. This technology, also known as the Photonic Sniffer, utilized chemically functionalized photonic plasmonic crystals for the selective and sensitive detection of specific threat molecules.

Project Approach:
The development team worked with two different technology platforms: chemioselective absorption through capture polymers and use of photonic plasmonic crystals for capture of explosive vapor molecules. Both technologies were developed in parallel while continued testing of standard chips with absorption capture polymers were tested in multi-chemical environments. For example, detection of the chemical of interest was successfully completed in an environment rich in other commonly found materials such as diesel fuel. The sensitivity of the chip was determined and the incubation time required for reproducibly and with repeatability was validated.

Project Outcome:
The team worked to identify the sensitivity of the chip in a multi-faceted environment and shared some of this data with interested industrial partners. The selective enrichment and detection approaches represented a promising approach for the selective and sensitive detection of explosive vapors. The Photonic Sniffer technology was demonstrated to potential industrial supporters for the detection of explosive vapors with high fidelity, low false-alarm rate and detection sensitivity comparable to that of explosive detection dogs.



Experimental Set up. Photonic sniffer provides colorimetric and SERS read-out.

Phase II Pipeline Project: Plasmon-enhanced Stimulated Coherent Raman: A New Spectroscopic Technique for Highly Specific and Sensitive Standoff Detection

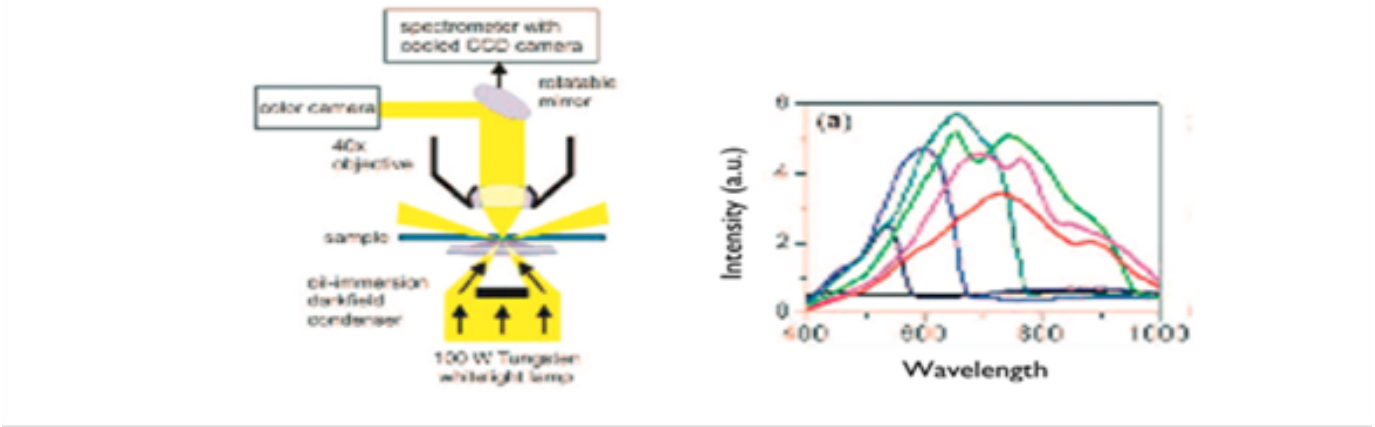
Task Leader: Lawrence Ziegler

Collaborator: Bjoern Reinhard

Project Objective:
The team proposed to develop a new spectroscopic technique, plasmon-enhanced stimulated coherent Raman spectroscopic (PESCRS), that combines plasmonic local field amplification effects and Raman signal acquisition derived from stimulated coherent Raman emission. The combined technologies provide a rapid, specific, sensitive, optical approach for standoff detection and identification of biological and chemical agents.

Project Approach:
The ability to rapidly detect and identify chemical and biological agents which constitute potential warfare or terrorist threats at a distance offers considerable advantages in terms of safety and minimizing exposure risks. The team proposed use of a novel optical technique similar to SERS methodology. PESCRS resulted from the "marriage" of two highly active research areas: SERS and femtosecond spectroscopy. The coherent Raman approach utilized a picosecond and femtosecond laser beam that interacted with the sample creating the Raman excitation. The further enhancement of local electric fields by resonant plasmonic effects, amplified the local optical fields associated with these two-beam interaction. Enhanced sensitivity resulted from the larger intensities of the stimulating laser fields and the directionality of the coherent Raman signal as compared to the corresponding spontaneous emission "field".

Project Outcome:
The successful development of this optical approach was applied to the detection and identification of volatile energetic materials and chemical agents (nerve agents, e.g. sarin) which adsorb to plasmonic substrate from the environment. Potential application for detection use in BSL 3/4 facilities where serviceable apparatus (lasers, detectors, etc.) remains outside the BSL 3/4 footprint in readily accessible area, was explored.



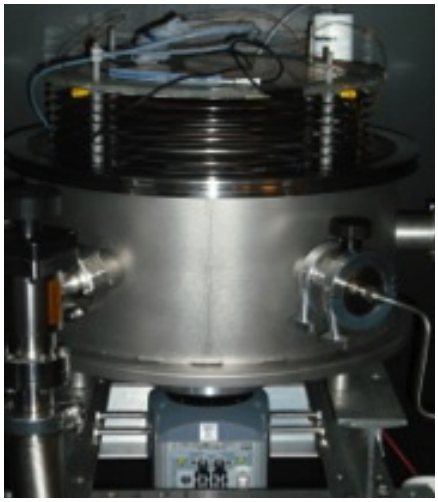
Phase I Pipeline Project: A Thermal Neutron Detector Using Lithium Film in an Optical Time-Projection-Chamber

Task Leader: Steven Ahlen

Project Objective:
The detection of thermal neutrons has many applications in national defense, homeland security, nuclear non-proliferation, nuclear treaty verification, and for monitoring operations and personnel dosimetry at nuclear facilities. Currently, the most effective detectors of thermal neutrons use the by-product of the nuclear weapons programs, isotope 3He. There is currently a severe shortage of 3He in the world and a new technology is required to identify thermal neutrons. As an alternative to 3He based detectors, the Ahlen laboratory proposed to develop a detector that would use thin films of enriched lithium or lithium fluoride as the neutron detecting material.

Project Approach:
The proposed detection mechanism relies on the identification of daughter products following the absorption of thermal neutrons by 6Li. This method uses a time-projection-chamber (TPC) with a gas of CF4, with a wire mesh/anode amplification gap, and with a photomultiplier tube (PMT) readout. This technique had several advantages over designs that utilize charge readout of gas proportional tubes or TPCs: 1) the proportional tubes suffer from space charge saturation effects and ion-electron recombination that limit detector size and gain; 2) the geometry of proportional tubes makes it much more difficult to coat the walls of the detector with neutron detecting materials than is possible with TPCs; 3) the charge readout of TPCs is less effective than PMT readout at determining the arrival time distribution of electrons at the amplification plane, making it more difficult to discriminate against gamma rays.

Project Outcome:
The team worked to design a large area detector with neutron detection efficiency, response time, and gamma ray detection efficiency that met or exceeded the current requirements for replacement of existing neutron detectors that use 3He. This development effort will help define a new technology to assist in the replacement of detectors, a market totaling approximately one billion dollars.



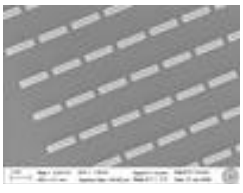
Phase I Pipeline Project: Nanoplasmonic Infrared Chemical Imaging Spectrometer

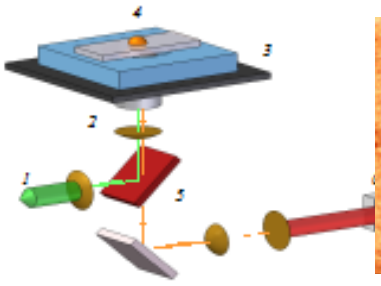
Task Leader: Shyamsunder Erramilli Collaborators: Hatice Altug, Kenneth J. Rothschild

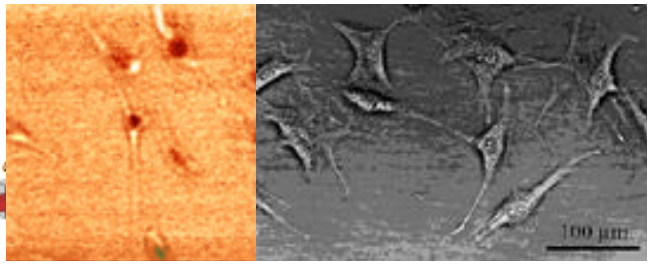
Project Objective:
The team proposed to build a prototype of a nanoplasmonic mid-infrared spectrometer for rapid screening of fluids and for chemical imaging of single cells and tissue.

Project Approach:
The development of novel infrared plasmonic structures has provided unprecedented enhancement factors in mid-infrared spectral molecular fingerprints of biomolecules. The prototype instrument consisted of a nanoplasmonic sensor array, coupled to a tunable infrared source in the epi-illumination reflection microscope geometry. The instrument was optimized to Chemical Warfare Agents (CWA) and pathogens in solutions, with specifications to meet defense priorities for the detection of chemical and biological threats, and for ensuring safe food and water supply. The instrument could operate in several modes, in back reflection studies for both widefield and narrowfield toxicology studies on living cells using the infrared spectral fingerprints for functional assays. The prototype consists of: (i) a super-array of nanoplasmonic structures, with each element designed for Surface Enhanced Infrared Absorption (SEIRA) of a selected infrared absorption band; (ii) an infrared microscope for wave coupling to the plasmonic structures to perform absorbance measurements in liquid water; (iii) a single element detector in scanning mode to interrogate each element in the sensor array. The chemical imager overcomes obstacles that have plagued portable IR spectrometers, such as the difficulty in working with water due to strong absorption and relatively low sensitivity.

Project Outcome:
The Phase I prototype demonstration was performed with a single element infrared detector. The modular design of the instrument allowed for adapting to an infrared hyperspectral imaging system with a digital Focal Plane Array invented at MIT Lincoln Labs in a potential Phase II instrument. This would be a new class of infrared chemical imaging systems for both defense and medical use in infrared pathology. Dual use studies included the ability to measure functional changes in an array of cells subjected to toxic agents without requiring perturbing labels, by directly measuring protein and nucleic acid conformation changes, and molecular studies in fixed tissue.







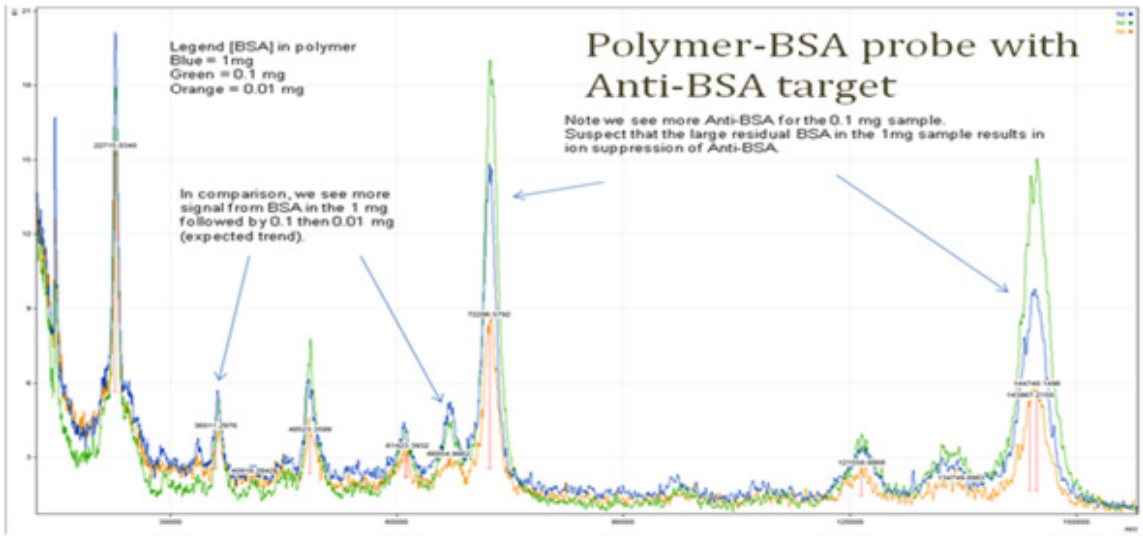
Phase I Pipeline Project: Quantified High-Throughput Biomarker Discovery by Mass Spectrometry on Label-free Arrays

Task Leader: Bennett Goldberg Collaborator: Mark McComb

Project Objective:
Develop high throughput, label-free, and high sensitivity biosensing arrays that can be applied to the discovery of new viral agents.

Project Approach:
The team worked to develop the technology to couple the quantified, high-throughput label-free microarray platform of Spectral Reflectance Biosensing (SRB) developed at BU to mass spectroscopy to demonstrate quantified, high-throughput biomarker discovery relevant for defense needs. As part of the development of the technique, the team designed and optimized protocols for direct verification of the SRB system for existing defense-related applications. Two technologies were combined – SRB for label-free, high-throughput affinity assays and mass spectroscopy. The combined technologies, referred to as matrix assisted laser desorption ionization time-of-flight (MALDI-TOF), provides for sensitive and accurate determination of the target material itself without the need to design the probe-target sets. After determining the binding affinity to the probes as well as the amount of material through the SRB, a final step of MADLI-TOF determined the specific molecular weight of the one or several species bound to each probe. For defense applications, the team envisioned using this technology for host response to viral infection for both virology and immunology.

Project Outcome:
This development project demonstrated relative and absolute quantitation with SRB and MADLI in single element target. In addition, high profile success using a known marker with low level concentration in plasma or urine, possibly PSA or a peptide marker will be demonstrated. Finally, a set of novel markers were used to measure in a high-throughput array protocols for direct verification of the SRB system.



Demonstration of clear target recognition (anti-BSA) with very little probe contamination (BSA).

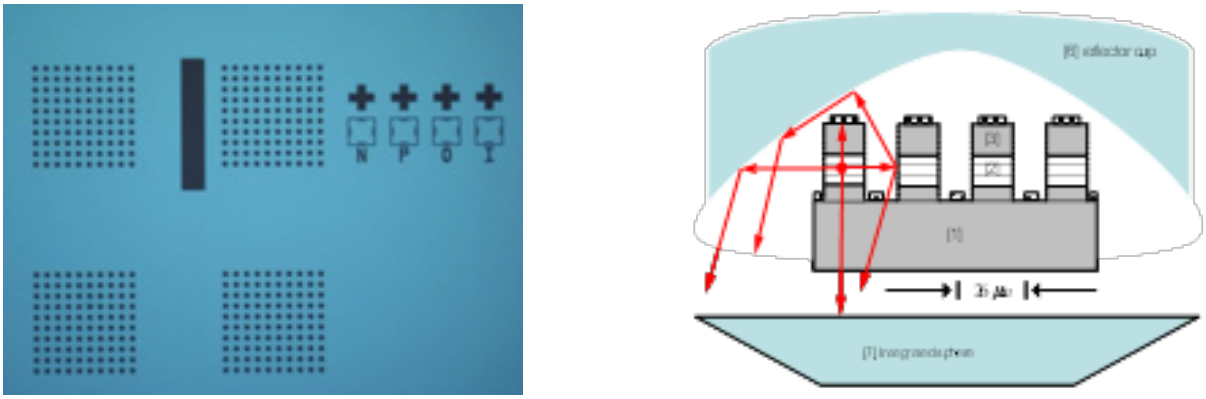
Phase I Pipeline Project: Development of Packaged UV LED and Lamps Emitting at 266nm for Water-Air Purification and Surface Sterilization

Task Leader: Theodore D. Moustakas

Project Objective:
The team's objective was to demonstrate 260 nm UV-LED's with higher efficiency than what is currently being offered in the marketplace. The team would also package UV LED's emitting at 266 nm for demonstration of proof-of-concept.

Project Approach:
The team has previously addressed the important materials issues required to produce efficient deep UV LEDs and fabricated prototype devices, which when measured at the bare die level without packaging were found to have equivalent performance as those of the state of the art. New device design and packaging schemes were employed to improve the light extraction and thus increase the EQE of these devices. The packaging of the devices was done in an external packaging house. The team proposed to build on progress in deep UV LEDs in order to develop packaged UV LEDs and lamps emitting at 266 nm with External Quantum Efficiency at least an order of magnitude better than the current state of the art. The main application of these devices was for water-air purification and surface sterilization, important needs for the Army during deployment.

Project Outcome:
Once the UV LED's were packaged, the team could further develop an UV light at 266 nm that acts on microbiological contaminants in water and air through a process by which adjacent thymine nuclei acids on DNA are dimerized, preventing replication of the microorganisms. This process was shown to be effective for E. coli, giardia, and even more resistant virus strains such as adenovirus. Such robust and non-toxic solid state devices were designed and intended to replace the present low-pressure mercury lamps emitting at 254 nm.



Mask used for the fabrication of multi-pixel deep UV LEDs (left image) Schematic indicating the light extraction from such LEDs (right image)

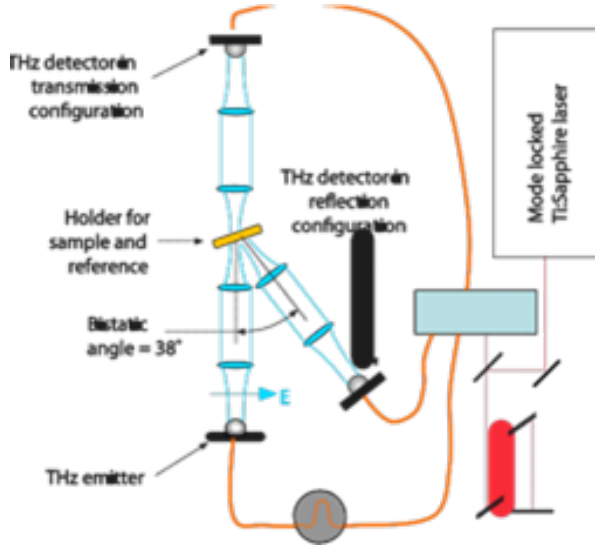
Phase I Pipeline Project: A Flexible, Lightweight, Remotely-Accessible THz Source and Detector

Task Leader: Siddharth Ramachandran Collaborator: Richard Averitt

Project Objective:
Fiber delivery of THz radiation has been attempted before, but nonlinear distortions in a fiber significantly broaden the pulses at the fiber output, severely limiting the efficiency of THz generation. The key enabler for this development project was an optical fiber that utilized a new spatial mode of propagation, recently invented by the task leader, which could carry/deliver, in a distortion-free manner, ultrafast optical pulses that were an order-of-magnitude greater in power than that possible with conventional optical fibers.

Project Approach:
THz radiation has attracted attention in the field of security and threat detection because of: (a) the ability to "see" through materials commonly used for packaging and clothing; and (b) the prevalence of absorption spectrum signatures in the THz frequency range for many compounds used in improvised explosive devices (IEDs). Unfortunately, this part of the electromagnetic spectrum is also the least developed, primarily due to a paucity of sources, large footprint and a lack of flexibility in deployment at the desired physical location. The team developed a THz generator/receiver that was based on a specialty optical fiber, and provided two key advantages of a light-weight, long, flexible medium: (a) the ability to physically separate the "bulky," expensive, and alignment-sensitive ultrafast laser from the THz antenna-head, thus enabling deploying the THz radiation capability in previously inaccessible spaces, such as, for example, from a robotic arm of a mobile unit searching for IEDs; (b) the ability to "broadcast" THz radiation to several physically separated antennae from a single ultra-fast laser, with the use of multiple fiber arms to, for example, deploy multiple body scanners at airports.

Project Outcome:
The team demonstrated the feasibility of this concept by designing and fabricating a fiber device capable of high-energy ultra-short pulse delivery at 800 nm. In addition, they tested the THz generation and detection capability of this system using an existing THz setup in which the free-space optical paths were replaced by optical fibers.



Schematic showing THz generation via fiber-optic ultra-short pulse delivery using HOM fibers. Only free-space optical component used is the dispersion compensator, which can be integrated with the ultrafast laser and hence separated from the region of deployment.

Innovative Research Seed Funding

The funds from the ARL Cooperative Agreement are intended to support BUPC's congressionally funded mission to develop advanced photonics based technologies to address critical defense and security applications. As part of the mission, the BUPC staff is tasked with identifying enabling research produced by faculty members and matching this research to end user needs in the defense and security communities. Often, all parties may have a difficult time comprehending the benefits of new technologies or have not yet formulated a need sufficiently to solicit for new technology approaches. The approach used by BUPC staff to position possible groundbreaking research for future and as yet undefined needs is to allocate a small amount of funding to "research seed funding" opportunities.

The following projects were initiated as seed research projects:

- Development of High Resolution Laser Ablation Metallomic Imaging Mass and Optical Spectrometry (MI MOS) to Assess Microvascular Pathology in Traumatic Brain Injury (TBI) and Chronic Traumatic Encepha lopathy (CTE) – Lee Goldstein.

- Development of Light-activated Viruses and Rhodopsin Proteins for Selectively Engineering of Individual Nerve Cells in Complex Neuronal Circuits – Ken Rothschild.

- Development of Microfluidic Platform for Virus Concentration, Delivery, and Lysing for Integration with Bio photonic Sensors – Catherine Klapperich.

- Reflectance Spectroscopy for Discriminative Valiation of Hemorrhagic Fever Virus – John Connor

Two of the four seed research projects are in the emerging field of Neurophotonics (the use of light in the diagnosis, study and treatment of neurological disease/injury). This is a promising field of research that may provide the key for diagnosis and treatment of conditions such as those caused by severe or repetitive mild head injuries. In June, BUPC followed up on the seed research activities with the submission of a proposal to an NSF program to establish a graduate training program in this new field.

This year was also the beginning of a transitional period at the Photonics Center as ARL pipeline programs were completed and new research projects were proposed as part of the newly funded National Science Foundation (NSF) Industrial University Cooperative Research Center (I/UCRC) on Biophotonic Sensors and Systems.

NSF I/UCRC on Biophotonic Sensors and Systems

In February 2011, NSF announced the award of the NSF I/UCRC for Biophotonic Sensors and Systems (CBSS) for Boston University and partner institution, the University of California at Davis (UC Davis). The new CBSS is one of about 50 such cooperative research centers across the country and the only center focused on biophotonic sensors. The concept is a long-running NSF program designed to foster university-industry collaborations and is jointly supported by the foundation and industry. Working at the intersection of photonics engineering and the life sciences, research at the new center will focus on improving tools and techniques for disease diagnosis, drug-efficacy testing, patient monitoring and food and water safety.

CBSS will focus on translational research where photonics provides the enabling technologies for advances in methods to detect/sense and identify biological properties, conditions, or changes at the molecular and cellular/sub-cellular level. BUPC envisions photonics will be a driver for early disease detection, reduction of health care costs, speedier and more effective treatment through personalized care and better patient outcomes.

The first program formulation meeting of the I/UCRC was held on April 28 – 29, 2011. In attendance were nearly forty business and engineering leaders from over twenty companies who had signed or had expressed interest in signing the membership agreement. Over the two, days various faculty members from both Boston University and UC Davis presented their research that was then ranked and evaluated by the industrial participants. The day was marked with presentations from twelve faculty members and a poster presentation session where more than thirty more research programs were presented to the industrial participants. The breadth of research programs that both institutes presented provided the industrial participants with dozens of final projects of which they had to narrow the choices to a handful. To-date, there are five companies who have joined the CBSS; they include ThorLabs; Lincoln Labs; Becton, Dickinson, and Company; the Fraunhofer Institute; and Applied Precision, Inc. The April meeting also marked the first meeting of CBSS's industrial advisory board (IAB), which is comprised of one representative from each paying member. The IAB reached a consensus around three projects that would be funded and these recommendations were approved by the CBSS Director (Dr. Bifano) and the Site Director at Davis. A unique feature of I/UCRC centers is that the member companies have an option to exercise a non-exclusive royalty free license to any inventions that may result from the CBSS approved projects, so members tend to select projects that would have potential commercial success.

As the lead, BUPC will be responsible for managing projects and disseminating reports and notices. The start date for the selected projects, which follow, is July 1, 2011 and the period of each project will be one year.

Project	**Lead Researcher**	**University Site**
Label-free Nanofluidic-nanoplasmonic Biosensor	H. Altug	BU
Photothermal Microscopy	S. Erramilli	BU
Live Cell Superresolution Microscopy	T. Huser	UCD

Students Supported by ARL Cooperative Agreement

Luca Dal Negro (ECE)
Alyssa Pasquale

Shyamsunder Erramilli (PHY)
Alket Mertiri
Vidal Guerra

Bennett Goldberg (PHY)
Julian Anding
Vivek Bhatia
Aaron Berliner

Xue Han (BME)
Xuan Gu

Catherine Klapperich (BME)
Jane Zhang
Xirui Zhang

Theodore Moustakas (ECE)
Yitao Liao
Dipesh Bhattarai
Chen-Kai Kao

Siddharth Ramachandran (ECE)
Roman Barankov
Mark Moosburner

Kenneth Rothschild (PHY)
Asma Al-Rawi
Jeffrey Markowitz
John Ogren

Selim Unlu (ECE)
Gultekin Tasdirek
Aaron Larocque

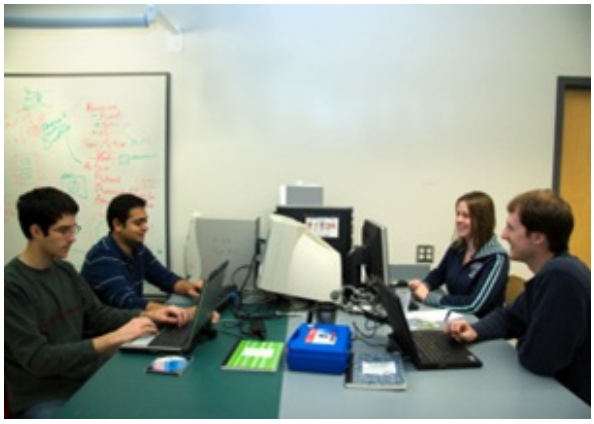
Lawrence Ziegler (CHEM)
Yan Hong
Tianhong Chen
Jeffrey Shattuck
Jude Schneck

Education

One of the most important missions of the Boston University Photonics Center is education. Center faculty members teach many photonics related courses in addition to their core area of expertise. BUPC faculty members also mentor undergraduate, graduate, and post-doctoral student and fellows working in their research laboratories.

The Center encourages collaboration and mentorship through its Fellowship program. The program recruits top incoming graduate students to the university while helping support those graduate students currently immersed in Photonics Center faculty laboratories. Through these programs, students participate in Photonics Center activities and work with the community in our shared laboratories. In the laboratories, students help train users and also assist lab managers with equipment troubleshooting and maintenance.

Each year, Center students participate in a variety of educational opportunities supported by Photonics Center staff. Students present during research poster sessions at the university-wide Science and Engineering Day and the Boston University Photonics Center Future of Light Symposium. These events give students the opportunity to highlight their cutting edge research and collaborations with the various departments. To further highlight the Center's commitment to supporting a variety of student opportunities, the Center continued its support of the Research Experiences for Undergraduates (REU) in Photonics program. The Center also supported the formation of student Society of Photo-optical Instrumentation Engineers (SPIE) and Optical Society of America (OSA) chapters.



Graduated Doctoral Students 2010-2011

PhD Graduate	Advisor	Primary Major
Onur Basarir	Kamil Ekinci	Mechanical Engineering
Shihchin Chiu	Allyn Hubbard	Electrical and Computer Engineering
Kengyeh Chu	Jerome Mertz	Biomedical Engineering
Andrea Garcia	Theodore Morse	Electrical and Computer Engineering
Xiang He	Theodore Fritz	Electrical and Computer Engineering
Bradley Kaanta	Xin Zhang	Mechanical Engineering
Michael Klida	Theodore Fritz	Electrical and Computer Engineering
Yitao Liao	Theodore Moustakas	Electrical and Computer Engineering
Daryl Rong Lim	Jerome Mertz	Biomedical Engineering
I-Kuan Lin	Xin Zhang	Mechanical Engineering
Michele Moresco	Enrico Bellotti	Electrical and Computer Engineering
Christine Mulvey	Irving Bigio	Biomedical Engineering
Jonathan Niehof	Theodore FritZ	Astronomy
Charles Parker	Theodore Fritz; Michael Ruane; Alexander Sergienko	Electrical and Computer Engineering
Eric Pinnick	Shyam Erramilli	Physics
Yirong Pu	Allyn Hubbard	Electrical and Computer Engineering
Armin Rahmanisisan	Shyam Erramilli	Physics
Gilberto Sanchez	Theodore Morse	Electrical and Computer Engineering
David Simon	Alexander Sergienko	Electrical and Computer Engineering
Selcuk Yerci	Luca Dal Negro	Electrical and Computer Engineering
Xiaoyu Zheng	Xin Zhang	Mechanical Engineering

Selected Photonics Related Courses

ENG EC 560 (Altug)
Introduction to Photonics
Introduction to ray optics; matrix optics; wave optics; Fourier optics; electromagnetic optics including absorption and dispersion. Polarization, reflection and refraction, anisotropic media, liquid crystals, and polarization devices. Guided-wave and fiber optics. Nanophotonics. Laboratory experiments: interference; diffraction and Fourier optics; polarization; fiber optics.

ENG EC 575 (Bellotti)
Semiconductor Devices
Fundamentals of carrier generation, transport, recombination, and storage in semiconductors. Physical principles of operation of the PN junction, metal-semiconductor contact, bipolar junction transistor, 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.

ENG EC 771 (Bellotti)
Physics of Compound Semiconductor Devices
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.

ENG EC 574 (Bellotti)
Physics of Semiconductor Materials
This course teaches the relevant notions of quantum mechanics and solid state physics necessary to understand the operation and the design of modern semiconductor devices. Specifically, this course focuses on the engineering aspects of solid state physics that are important to study the electrical and optical properties of semiconductor materials and devices. Particular emphasis is placed on the analysis of the electronic structure of semiconductor bulk systems and low-dimensional structures, the study of the carrier transport properties and the calculation of the optical response that are relevant to the design and optimization of electronics and photonics semiconductor devices. The students will learn to apply the quantum mechanical formalism to the solution of basic engineering device problems (quantum wells, wires, and dots, 2D electron gas) and to perform numerical calculation on more complex systems (band structure calculation of bulk and low dimensional systems).

ENG EC 777 (Dal Negro)
Nanostructure Optics
Discussion of the fundamental physical aspects and device applications of optical fields confined and generated in nanoscale environments. Review of classical electrodynamics and angular spectrum representation of optical fields, classical and quantum models for light-matter interaction, light emission from semiconductor quantum dots and wires, surface-plasmon polaritons and sub-wavelength light transport/localization in metal nanostructures, slot waveguide structures, surface-enhanced Raman scattering (SERS) and SERS-based sensors, light scattering in complex photonic structures such as: metal-dielectric photonic crystals, fractal structrures, random lasers.

ENG EK 131 (Dal Negro)
Introduction to Engineering
Introduction to engineering analysis and/or design through a sequence of two modules or minicourses chosen from a selection of modules offered by participating engineering faculty. Each module presents students with key concepts and techniques relevant to an applied area of engineering. Limited to freshmen and sophomores (students with less than 64 credits toward degree requirements).

ENG EK 132 (Dal Negro)
Introduction to Engineering
Introduction to engineering analysis and/or design through a sequence of two modules or minicourses chosen from a selection of modules offered by participating engineering faculty. Each module presents students with key concepts and techniques relevant to an applied area of engineering. Limited to freshmen and sophomores (students with less than 64 credits toward degree requirements).

ENG EC 560 (Dal Negro)
Introduction to Photonics
Introduction to ray optics; matrix optics; wave optics; Fourier optics; electromagnetic optics including absorption and dispersion. Polarization, reflection and refraction, anisotropic media, liquid crystals, and polarization devices. Guided-wave and fiber optics. Nanophotonics. Laboratory experiments: interference; diffraction and Fourier optics; polarization; fiber optics.

ENG EC 470 (Fritz)
Sensors in Space
This course provides a practical introduction to the development, integration, and deployment of instrumentation on spacecraft platforms. Students are introduced to the physical concepts and practical designs of sensors that measure particles, magnetic fields, and electric fields over a range of energies and frequencies. Particular attention is given to special constraints presented by the space environment. In addition to established designs, the course will also cover new and emerging sensor technologies. The course includes a lab component in which students will learn about small satellite development through design and implementation of a high-altitude balloon ("balloonsat") experiment.

ENG EC 772 (Joshi)
VLSI Graduate Design Project
Students working in a group of one to four people design and simulate a microchip, and create a fabrication file. Students submit the design for fabrication. When the chip is returned, students test and if necessary redesign the circuitry. A project write-up is required. Students must take an I-grade until testing of the chip is completed.

ENG EC 311 (Joshi)
Introduction to Logic Design
Introduction to hardware building blocks used in digital computers. Boolean algebra, combinatorial and sequential circuits: analysis and design. Adders, multipliers, decoders, encoders, multiplexors. Programmable logic devices: read-only memory, programmable arrays, FRGAs, Verilog. Counters and registers.

ENG EC 471 (Moustakas)
Physics of Semiconductor Devices
Study of solid state electronic devices, including growth and structure of semiconductors, energy bands and charge carriers in semiconductors, junctions, diodes, bipolar junction transistors, field effect transistors and devices.

ENG EC 577 (Moustakas)
Electronic Optical and Magnetic Properties of Materials
This course in intended to develop an in depth knowledge of solid state concepts that are important for students in the areas of material science and electrical engineering. Specifically, this course focuses on the study of different apsect of solid state physics necessary to study technologically relevant crytalline and amorphous systems. Particular enphasis is placed on the study of the crystal structure, crystal diffraction and the related techniques used as diagnostic tools; the electronic, thermal, optical and magnetic properties of material systems important for electronics and photonics device applications. Furthermore the course will also consider the theory of superconductivity, the chemistry aspcts of solid state materials and will provide an introduction to solid state biophysics. This course complements EC 574 (Physics of semiconductor material) and EC575 (semiconductor devices) with its focus on technologically relevant structural, optical, thermal and magnetic material properties. Meets with ENG MS 577.

ENG EC 591 (Paiella)
Photonics Lab I
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.

ENG EC 563 (Ramachandran)
Fiber Optics and Communications Systems
This course will cover the theory light propagation and manipulation in an optical fiber both in the linear and nonlinear regimes. This theory will be used to introduce design, both of optical fibers for transmission as well as for devices and components. The latter part of the course will use these concepts to illustrate applications in which fibers and fiber devices are used. The emphasis will be on telecommunications systems, but the course will also touch upon other emerging applications such as lasers, sensors, biomedical systems and astrophotonics.

ENG EC 568 (Ramachandran)
Optical Fibers and WaveGuides
Whether it be the FiOS™ internet connection at our homes, or fiber lasers powerful enough to cut metals (many automobile chassis are now made using fiber lasers), or the ability to perform endoscopic surgery and imaging, or doing frequency metrology with super-continuum sources (the basis of a few recent Nobel prizes)... the optical fiber has played a central, often dominant, role in many applications that impact the way we live. The main function of an optical fiber is to carry an electromagnetic (in the optical frequency) pulse over distances ranging from meters to greater than ten thousand kilometers without distortions. Fibers can also become smart light-pipes when they are intentionally designed to alter, temporally shape or amplify light pulses. Moreover, new developments in this field such as photonic bandgap fibers, fiber nanowires and higher-order mode fibers, are opening up new directions in science and technology. This course will introduce the optical fiber waveguide and its theory of operation. Specifically, the design and impact of the two most important properties in optical fibers -- dispersion and nonlinearity -- that govern the evolution of light in optical fibers, will be covered in detail. The latter part of the course will describe new fibers and fiber-structures that are active research topics today. One lecture of the course will include a tour of an actual, industrial-scale fiber fabrication facility.

ENG EK 131 (Swan)
Introduction to Engineering
Introduction to engineering analysis and/or design through a sequence of two modules or minicourses chosen from a selection of modules offered by participating engineering faculty. Each module presents students with key concepts and techniques relevant to an applied area of engineering. Limited to freshmen and sophomores (students with less than 64 credits toward degree requirements).

ENG EK 307 (Swan)
Electric Circuit Theory
Introduction to electric circuit analysis and design; voltage, current, and power, circuit laws and theorems; element I-V curves, linear and nonlinear circuit concepts; operational amplifier circuits; transient response of capacitor and inductor circuits, sinusoidal-steady-state response, frequency response, transfer functions; Includes design-oriented laboratory. (MET EK 317 and EK 318 fulfill this requirement; however, only 4 credits can be applied toward the graduation requirement.)

ENG EC 570 (Teich)
Lasers
Review of wave optics. Gaussian, Hermite-Gaussian, Laguerre-Gaussian, and Bessel optical beams. Planar- and spherical-mirror resonators; microresonators. Photons and photon streams. Energy levels; absorption, spontaneous emission, and simulated emission. Thermal and scattered light. Laser amplification and gain saturation. Laser oscillation. Common lasers and introduction to pulsed lasers. Photon interactions in semiconductors. LEDs, laser diodes, quantum-confined lasers, and microcavity lasers. Introductoin to photon detectors. Laboratory experiments: beam optics; longitudinal laser modes; laser-diode output characteristics.

ENG EC 763 (Teich)
Nonlinear and Ultrafast Optics
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 photo-refractive optics. Generation, compression, and detection of ultra short optical pulses. Femtosecond optics. Pulse propagation in dispersive linear media. Optical solitons.

Photonics Center Dean's Fellowship Program

Based on the success of our initial year of Photonics Center Dean's Fellowships, the Photonics Center will continue this fellowship program for the 2011 - 2012 academic year. The Photonics Center Dean's Fellowship process aligned with the standard Dean's Fellowship program supported by the Graduate School of Arts and Sciences (GRS) and the College of Engineering. Below are the requirements for fellowship candidates:

Fellowship Candidates must be from Photonics Center Affiliated Departments:

Graduate School of Arts and Sciences (GRS):
- Physics
- Chemistry
- Astronomy/Space Physics

College of Engineering (ENG):
- Biomedical Engineering
- Electrical and Computer Engineering
- Mechanical Engineering

School of Medicine:
- Microbiology
- Psychiatry

Photonics Center Dean's Fellowships require research alignment with Photonics Center faculty members. Graduate applications must identify:
- Interest in working with a Photonics Center faculty member or group.
- Interest in specific graduate research topics in photonics.

Responsibilities of Photonics Center Dean's Fellowship recipients include:
- Completing at least one rotation or research program in a Photonics Center faculty laboratory.
- Participating in Photonics Center community activities.

The Photonics Center Engineering Dean's Fellowship recipient for the 2011-2012 academic year is Christopher Hwang who is being mentored by Professor Siddharth Ramachandran in the ECE Department. Christopher came to Boston University from a position in industry at Q-Peak, Inc. Prior to working at Q-Peak, Christopher earned his Bachelor of Science in Applied Physics and Master of Science in Mechanical Engineering both from Columbia University School of Engineering.

Science and Engineering Day

On March 23, 2011, the University hosted its annual Science and Engineering Day. This event is held each year in the George Sherman Union and gives students from all science and engineering disciplines the opportunity to share their current research endeavors. Each year, the Photonics Center sponsors a prize for this event, the Herbert J. Berman "Future of Light" Prize.

The Photonics Center would like to congratulate the Photonics Center graduate students who won prizes at this year's event:

College of Engineering Dean's Award
Winner: John Henson
Advisor: Roberto Paiella

Center for Nanoscience and Nanobiotechnology Award
Winner: Terence Ta
Advisor: Tyrone Porter

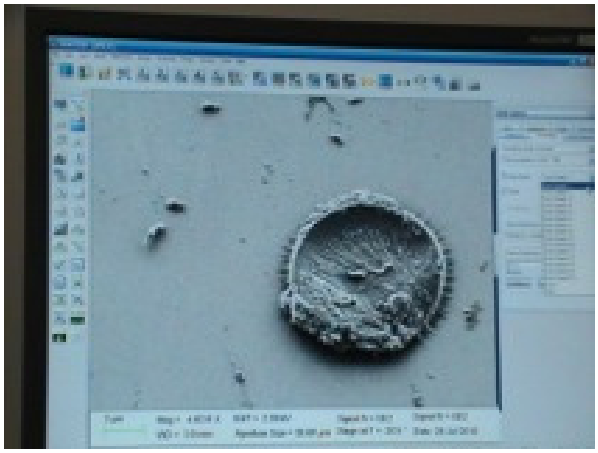
Office of Technology Development Award
Winner: Philipp Spuhler
Advisor: Selim Unlu

Gordon CenSSIS and Smart Lighting Center Award
Winner: Margo Monroe
Advisor: Selim Unlu

Photonics Center Berman "Future of Light" Award
Winner: Cicek Boztug
Advisor: Roberto Paiella

Teachers (RET) in Biophotonic Sensors and Systems

Professor Michael Ruane submitted the NSF RET proposal along with Cynthia Brossman from LEARNet. The proposal was awarded as Professor Ruane was preparing to retire, so he requested support and assistance from Photonics Center staff member Helen Fawcett. This first year of three, four teacher teams were paired (middle school with a high school teacher, or pre-service with a high school teacher) and ready to start working in the laboratories. The first year of the program, the BU RET participants teamed with the Northeastern University participants to meet during their Friday seminars. The expectation is that for year 2, BU will hold its own training and pedagogy sessions. The faculty members who mentored these teachers included Professors Irving Bigio, Lawrence Ziegler, Selim Unlu, and Hatice Altug. In addition to working in the laboratories and heading to Northeastern for shared seminars, the 8 teachers split into two groups to participate in cleanroom activities, where the teachers worked on photolithography equipment in the Class 100 cleanroom to spin wafers, expose them with a mask they helped to create, and develop the final wafers. The teachers took their wafers home and a replica of their wafer with a polymer material commonly used for first generation prototype evaluation. More information about the projects and the teachers can be found at http://www.bu.edu/lernet/ret/index.html.



Boston Urban Fellows Project

Professor Bennett Goldberg continued work as principal investigator this year with the Boston Urban Fellows Project. The Boston University Urban Fellows Project is a 10-year NSF supported program to institute a sustainable model of immersing K-12 teaching partnerships within urban school systems for graduate fellows in sciences and engineering.

This project has further strengthened the existing relationships between Boston University and the Chelsea, Quincy, and Boston urban school districts. The Boston Urban Fellows Project has trained 67 K-12 fellows in urban schools and worked with more than 200 classrooms since it was established 6 years ago.

The project's support staff provides content support, curriculum materials, and role models for more than 5,000 children.

OSA and SPIE Student Chapters

After forming in October 2009, the student chapters affiliated with the OSA and with SPIE continued to encourage membership and community activities centered on technologies associated with photonics. SPIE is an international society advancing an interdisciplinary approach to the science and application of light. OSA promotes the generation, application and archiving of knowledge in optics and photonics. Both organizations provided student chapter members with networking opportunities for students with an interest in optics and photonics. They also provided startup funds and travel grants for chapter members to attend conferences. The chapters had organized a student dinner for networking and community building as well as a Code V and Light Tools tutorial. The chapters continue to be busy and more information can be found on their website: http://www.bu.edu/osa_spie/.

Boston University Satellite for Applications and Student Training (BUSAT2): A New Beginning

In December of 2010, AS/ECE Professor Ted Fritz was notified that his latest submission to the Air Force University Nanosatellite program, called "BUSAT2," was selected for funding. The scientific mission BUSAT2 is to perform measurements of the precipitating energetic electron fluxes from low Earth orbit over the high latitude auroral zones and to simultaneously image the auroral emissions caused by these electrons. The Boston University Center for Space Physics is a leading space weather research institution and is involved in the study of auroral emissions with ground-based radars, optical instruments, and magnetometers. Present efforts to characterize the electron energy spectrum from the information obtained by these ground based instruments is a main thrust of this research but these efforts are limited by lack of the measured electron precipitating fluxes directly. The proposed satellite will permit this loop to be effectively closed. The needed auroral imager, magnetometer, and imaging electron spectrometer (IES) will also be fabricated by student teams relying on the in-depth experience with such instruments by BU faculty. Additional experiments are being incorporated into the modular satellite bus to measure VLF noise and the local plasma density. The new mission leverages heavily on Boston University's previous student-run satellite project, called BUSAT. Funded under the AFOSR University Nanosatellite Program #5, BUSAT involved over 70 undergraduate students, 15 graduate students, and 4 faculty members from 3 departments at Boston University.

BUSAT2 mission seeks to build upon this highly successful and virtuous program and to continue the student training in satellite development at BU. The BUSAT management plan fosters a strong link between student teams and their faculty mentors. Mentors range from senior to junior status, thus providing the important cross-generation ties which are critical to the vitality of any technical discipline. The summer team for this year includes 24 BU students, most of whom are being paid for a 10 week summer effort from funding provided by a number of administrative centers at BU. Their work has used the Senior Design rooms in PHO113 for the summer effort. The summer team also includes three students from the BU Academy who have been very important to the progress made during the summer effort. The UNP#7 program involves a competition involving 10 universities each of whom have two years to develop a functioning satellite that will be judged by the US Air Force in January 2013 to determine a winner. The winning satellite will then be flown by the USAF after an additional two years of flight fabrication, testing, and qualification. A satellite ground station is being installed on the roof of the Photonics Building to permit the command and control of the satellite on-orbit and the reception of data from the satellite. The PI (Ted Fritz) brings to the project nearly 50 years of experience in spacecraft and satellite instrument design.

As part of the BUSAT effort an outreach program to the local MATCH school was conducted. The high school students involved in the program learned about of the near-Earth space environment as well as how to build sensor systems to measure temperature and pressure at high altitudes. A launch of a weather balloon with these instruments from Mt. Greylock in western Mass will be planned later during the Summer. The web site with further pictures of the outreach program is available at http://people.bu.edu/bwalsh/BUSAT/NearSpace.html.

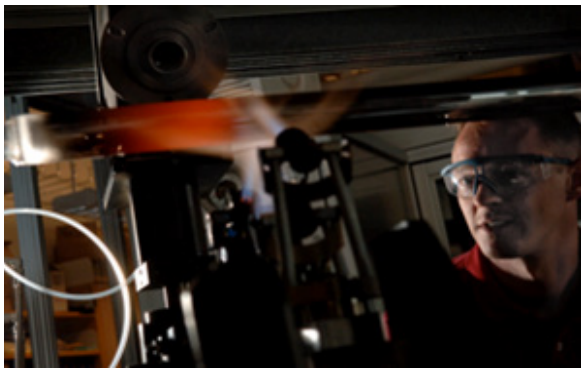
BU undergrads from AS, PY, ECE, and ME working on BUSAT2 project during the Summer 2011 using the Senior Design facility in PHO113.

Facilities and Equipment

The Boston University Photonics Center first opened in June 1997 as a unique structure with superior vibration stability while being centered between the Mass Pike and a MBTA rail line. The facility boasts ten floors consisting of 235,000 net square feet of space including: classrooms, conference rooms, faculty offices, educational laboratories, faculty research laboratories and three shared laboratories managed by the Photonics Center.

The Center's faculty, students, and incubator companies utilize these core-shared facilities. The Photonics Center also offers collaborators from industry and other universities use of the facilities when time is available. Every year upgrades are made to the three-shared laboratories to ensure faculty and student research is being supported and maintained at exceptional levels.

The business incubator is another unique aspect of the Photonics Center. Located on the 6th floor, the incubator provides 23,000 square feet of flexible space that can be configured to house up to 14 start-up companies. This space offers start-up companies state-of-the-art facilities and a collaborative environment with faculty and students.



As an added benefit to Center membership, new and existing faculty members of the Photonics Center are provided with Photonics staff assistance in laboratory design. This year, Professors Selim Unlu, Luca Dal Negro, Bennett Goldberg, Anna Swan, Aaron Schmidt, and Xin Chen moved into their newly designed and/or redesigned laboratories in the Photonics Center. Minor renovations to the Precision Measurement Laboratory were also completed to make room for the new Scanning Electron Microscope that was added to the suite of measurement equipment in the shared laboratory.

Shared Laboratory Facilities

The Optoelectronic Processing Facility (OPF) includes a Class 100 photolithography cleanroom and an exterior Class 1000 cleanroom with processing and test equipment for die and wafer level processing. The Integrated Optics Laboratory (IOL) includes a flip chip bonding system in the Class 100 cleanroom and a standard laboratory space next door for spectroscopy measurements. The Precision Measurement Laboratory (PML) spans two laboratory spaces with scanning electron and atomic force microscopy among other analytical surface characterization tools.

Optoelectronic Processing Facility (OPF)

OPF is a multi-user facility located on the 8th floor of the Photonics Center. Within its 2500 sq. ft., is equipment for semiconductor and optoelectronic fabrication from bare chip to fully populated components. The facility includes: both Class 100 and 1000 cleanrooms and equipment facilitating photolithography, wet chemical processing, thin film depositions, plasma etching and cleaning, thermal oxidation, thermal annealing, and electrical characterization.

The Class 100 cleanroom is a photolithography and mask-making laboratory. Two types of photoresist spinners are available for use by all self-users in OPF. The standard Headway Research spinner is designed to accommodate small chip level to six inch wafers, while the Suss Microtech Delta 80 is used to spin chrome on glass masters that can be written using the Heidelberg Direct Write Laser System. Ovens and a hood for bakes and development are readily available. Two UV exposure tools, the MJB3 (for three inch masks or smaller) and the MA6 (up to a 6 inch square mask) are fully utilized for chip and wafer exposure. A high-powered optical microscope provides higher resolution imaging.

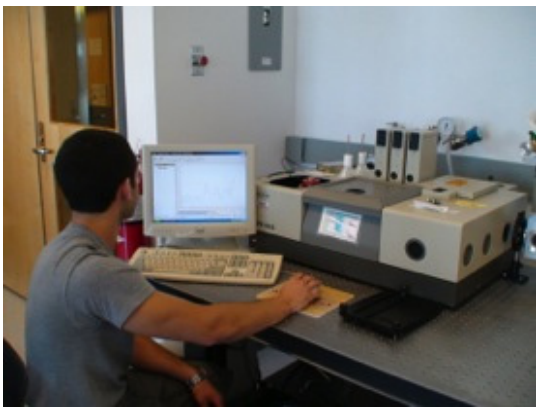
In the Class 1000 cleanroom, wafer processing from the photolithography room can include cleaning, etching, or characterization. With a Tencor surface profilometer, students learn how to measure the step height of features that they make on wafers. This contact profilometer requires students to either create measurement fiducials on their structure or work with large features into which the stylus can drop down, reach base surface, and then run back up to the top of the structure. The high powered microscope has alleviated the congestion in OPF's photolithography room and allows users to capture still or video images from the sample.

Dry etching processes are readily available and used in the OPF cleanroom, including but not limited to plasma etching, reactive ion etching and a deep reactive ion etching. As an upgrade, the piping system has been completely renovated and an end-point detection system installed onto the RIE system. Although not a full solution to over-etching or a replacement for inductively coupled plasma etching, this tool will assist in variations to the system caused by such a variety of users and materials. In addition to dry etching, both acid and separate solvent hoods are available to complete wet chemical etching. In addition, the HF vapor etch system has addressed safety issues for students or faculty so that they do not have to handle liquid HF, but rather use the vapor system to release oxide

films. This system accommodates small pieces of wafers as well as 4 and 6-inch full wafers.

A majority of the research laboratories at Boston University use thin film deposition systems. Thermal oxide furnaces, ion assisted deposition, evaporators and sputtering systems all provide students with the capability to learn about different coating process methodologies and how to measure the films deposited after processing. The CHA thermal and e-beam evaporator has been instrumental in complementing the standard Sharon vacuum and Edward's thermal, ion-assisted, and the e-beam evaporators. The J.A. Woollam Co., Inc V-VASE spectroscopic ellipsometer has allowed students to evaluate coatings for uniformity and composition as well as index of refraction information. The new Disco dicing saw with programmable features has been highly utilized by many research groups who use OPF. The scriber is also utilized by faculty and students processing larger scale repeated patterns on wafers or chips that they then want to make into smaller foot-prints to complete a series of experiments with the same base substrate. Wirebonding, wedgebonding, or testing can also be done inside the cleanroom in OPF. The IV characterization test set up is used to evaluate devices post wirebonding and pre-integration into test set ups on the lab bench.

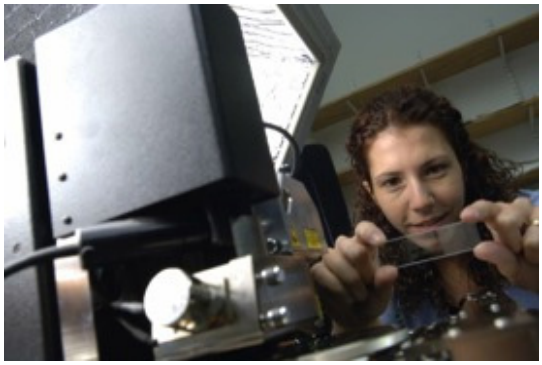
Integrated Optics Laboratory (IOL)



Within its 900 sq. ft, the IOL houses a Class 100 cleanroom and a standard laboratory space. It is a multi-user facility on the 5th floor of the Center and is equipped with state-of-the-art equipment for bonding and spectroscopic analysis of components.

In the Class 100 cleanroom, a Suss Microtech FC-150 flip chip bonder is used to seal and create eutectic bonds either through thermocompression or soldering processes. This is a precise pick and place system that uses fiducials to aid in placement accuracy. Several researchers in device packaging (LED's) use this piece of equipment and many outside collaborators also use the system for alignment and bonding of devices. The IOL standard laboratory space includes a soft lithography area and spectroscopic tools. The soft lithography station uses PDMS to make replicas from masters created through photolithography or e-beam writing. The upgraded Bruker FTIR allows users to evaluate the role of polarization in response to excitation through the FTIR. The Varian Cary 5000 UV-VIS-NIR spectrometer covers wavelength ranges from 175 – 3300 nm. In addition to measuring reflectance and transmission at a particular wavelength, it can also measure absorption.

Precision Measurement Laboratory (PML)



PML is comprised of two laboratories located in the basement of the Photonics Center. The PML allows the measurement of features and surface morphology. In one of the lab spaces, a JEOL SEM with imaging, cathode luminescence (CL), and energy dispersive spectrometer (EDS) is available for use. The EDS allows validation of elemental composition and surface contaminants in selected locations over the surface of the sample. The JEOL, with gatan cathode luminescence (CL), 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 also be determined and emission spectrum can be evaluated.

Also available in the PML are: a Veeco (formerly Digital Instruments) atomic force microscope (AFM) a Pico-Force System, a Zeiss field emission scanning electron microscope (FESEM) and a Zygo NewView 6300. The AFM was upgraded previously with a closed-loop scanner. This assisted in nanoscale structural measurements. 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 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, thus a non-destructive way to view a sample. The beam blanker added to the Zeiss FESEM for the exclusive use of Photonics members allows e-beam writing of nanoscale structures. This year's capital equipment purchase was a Zeiss Supra55 VP FESEM. In addition to imaging using secondary electron detectors, this SEM is also capable of imaging thin TEM samples using a STEM detector, providing atomic contrast information using a backscattered electron detector and chemical composition using EDS (energy dispersive spectrometer). It is also equipped with an EBSD (electron backscatter diffraction) detector which gives information on the crystalline structure and grain boundary misorientations on polished materials. A hot and cold stage is also available for in-situ work in the SEM chamber. The ZYGO NewView 6300 with dynamic MEM's capability also has a heating and cooling stage that allows testing under controlled temperature and the viewing and measurement in-situ. Surface roughness, morphology, and displacement can all be measured using this instrument.

Equipment Committee

This year's capital equipment purchase fulfilled an emerging need, identified in a poll of faculty members, to enable further research in nanofabrication and nanoscale imaging, and there was overwhelming support for procurement of a new SEM to off-load the imaging use on the existing Supra 40.

The following criteria was considered in making the decision to support the new equipment purchase:

- The instrument will be widely usable as a shared resource in the Photonics Center to enhance the re search and development programs.

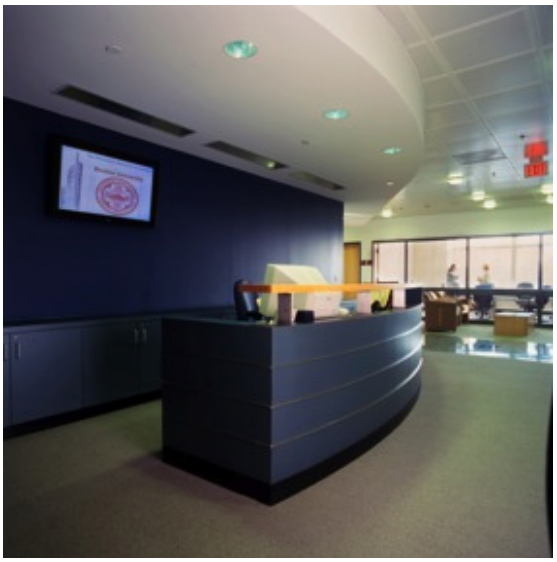
- The instrument will provide critical leverage for attracting additional support to the Center for research and development.

- The instrument will enhance the careers and photonics-related research of junior faculty members of the Photonics Center.

Using these guidelines for identification and ranking of equipment improvements, the majority of Photonics Faculty users supported the purchase of an additional SEM. A specific instrument, a used Zeiss Supra 55 VP was evaluated, purchased and installed before the start of the new year. The Supra 55 has more capabilities than just imaging. In addition to imaging using secondary electron detectors, the SEM is capable of imaging thin TEM samples using a STEM detector, providing atomic contrast information using a backscattered electron detector and chemical composition using EDS (energy dispersive spectrometer). It is also equipped with an EBSD (electron backscatter diffraction) detector which gives information on the crystalline structure and grain boundary misorientations on polished materials. A hot and cold stage is also available for in-situ work in the SEM chamber and a load-lock for sample insertion provides another layer of cleanliness and performance to the main chamber. The system was installed and certified by Zeiss before the end of the calendar year.

New Zeiss Supra 55VPFESEM

Incubator Facilities



Located on the sixth floor of the Photonics Center building, Boston University's Business Incubator currently hosts ten technology start-up companies. This past year, five incubator companies graduated from the incubation program. As these companies exited, four new companies joined the incubator and one current company increased their floor space. The mix of companies includes: life sciences, biotechnology, medical devices, photonics, clean energy and engineering. Currently four of the companies originate from within BU and the other six from outside of BU. All companies are engaged in the commercialization of new technologies of importance to society and all are engaged in BU's educational mission to train students in entrepreneurial management.

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 spinout 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 and 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 such as: Dana-Farber Cancer Institute, Massachusetts General Hospital, Draper Laboratories, MIT and other universities and government agencies.

Total financing for all the companies in the Business Incubation Program is approximately $35 million, mostly from established venture capital funds. About seventy employees work with the incubator companies on the Charles River Campus. In total, this represents a substantial concentration of entrepreneurial business activity on campus at Boston University.

In 2006, we began partnering students with incubator companies. Since that time, approximately sixty-five BU students have worked directly with incubator companies as interns. The Institute of Technology Entrepreneurship and Commercialization (ITEC) in the Graduate School of Management has provided student interns through numerous entrepreneurial programs while other students have come from the College of Engineering. To date, incubator companies have hired two Ph.D. students full time. In addition, ITEC is currently supporting three new student startup companies that entered the incubator this year: Mobilife, Bytelight, Inc. and Zipcents, Inc.

Incubator Companies That Exited During July 2010 – June 2011

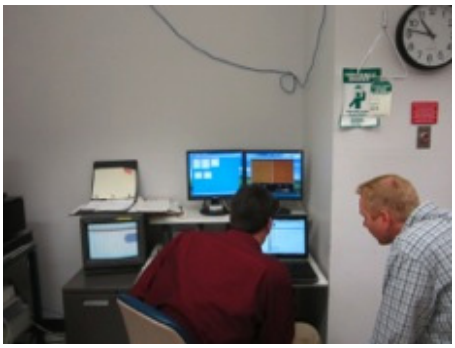
Company Name	External Origin	Technology	Market Sector	Funding
First Founders LTd	MIT	Venture Mentoring Service	Not for Profit	N/A
Good Start Genetics	Harvard	DNA Sequencing	Pre-pregnancy Genetic Testing	MLSC/Venture Capital
Lumenz	MIT	Opto-electronic Materials	Blue/UV LEDsq	Venture Capital
Ninth Sense	BU, BME and Physics	Protein Biomarkers	Medical Diagnostics	Launch Award OTD
Zoiray	BU, BME, and ECE Depts.	Immunoassay Instrumentation	Medical Diagnostics	Technology Award Photonics

Current Incubator Companies

Company Name	External Origin	Technology	Market Sector	Funding
Block MEMS	Compqany Spin-Out Block Engineering	Optical MEMS Micro Chemical Sensors	Military, Industrial	DoD, Corporate
ByteLight	Student Start-up	Receiveres for Intelligent Lighting Systems	Energy, Lighting	Bootstrap
CoSMo Systems	Individual Research	S/W for Predictive Modeling	Healthcare, Energy	Bootstrap
Cyber Materials	BU, Manufacturing Engineering	Process Congrol Thin Film Deposition	Industrial Manufacturing	SBIR, Sales
Mass Medical Devices Journal	De Novo Start-up	N/A	Medical Device Journalism	Sales/Advertising
mobiLIFE	Student Start-up	Bluetooth CGM	Healthcare, Medical Devices	Bootstrap
MTPV	Draper Laboratories	Microgap Thermo Photo Voltaics	Clean Energy	Angel
Nano Surfaces	Cornell University	Nano Structured Surfaces	Anitfouling Coatings	Angel
Spring Leaf Therapeutics (formerly Entra Pharmaceuticals)	MIT	Microelectronics	Drug Delivery	Venture Capital
Zipcents	Student Start-up	S/W Algorithms for Secure Online Payment	On-Line Financial Transactions	Bootstrap

Building Projects

PHO B19



Construction in PHO B19, the Precision Measurement Laboratory, was completed at the end of October, 2010. This renovation was required for the installation of the new SEM. In addition to adding power and exhaust to the existing laboratory, the decision was made to localize the supply of nitrogen gas to a remote manifold system. This saves space and allows distribution of nitrogen to various tools in the lab from one central point.

PHO714/715

Construction in PHO714 715 was completed at the end of November, 2010. Professor Selim Unlu's laboratory was split into two separate labs. PHO714, the Laboratory for Enhanced Nano/Bio Sensors (LENS), was designed specifically for the laboratory to work with BL2 viruses. IBC approval must be granted prior to the use of BL2 viruses in their laboratory. PHO715 was designed to provide a dry optical space. This laboratory is now known as Photonic Imaging and Neural Stimulation Lab (PINS). Both spaces came on-line before the first of the calendar year and are fully operational at this time.

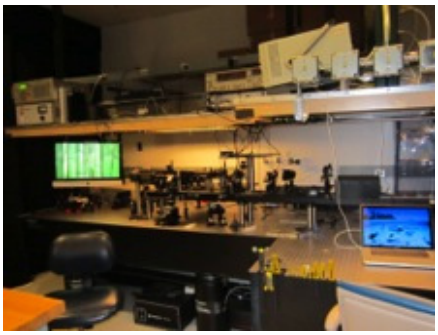
PHO 808/809

Construction on PHO 808/809 was completed in January, 2011. Professor Luca Dal Negro's Laboratory was re-structured to accommodate several needs. First, a doorway was cut between the two labs to allow students to take samples from the wet chemistry lab to laser tables in either 808 or 809. This prevents the need to leave the main lab 809 to enter lab 808 with samples in hand. In addition, the laboratory wanted to be able to use the laser from the far bay of 809 at the first optical table in 808. In order to accomplish this task within laser safety guidelines, a tube with mirrors encapsulated in the pipe ends was put together and aligned by the students.

PHO B11

With the transition of shared space in PHO808 and construction in PHO714/715, faculty members Anna Swan and Bennett Goldberg's laboratory Optical Characterization and Nanophotonics Lab, was reconfigured to accommodate their needs, and to provide space for a new smaller laboratory for future use. As equipment moved to the newly renovated 7th floor laboratory and B21 Nanophotonics & Nanosystems Integration Lab, this allowed for an enlarged space to accommodate a new grant and new equipment as well as to redesign the Raman Laboratory so that is was better suited to accommodate the current and future research plans. This construction was completed and the laboratory was move in ready in February, 2011.

PHO 503D



Construction on PHO 503D, Professor Aaron Schmidt's Thermo-Optics Lab began in February, 2011 and was completed in April. His laboratory included a Class IIIb/IV laser bay as well as wet chemistry and general chemistry area. In his laser bay, there is a thermally contained clean environment that was designed into the space to keep laser optics clean and damage-free. His laboratory includes student work space as well.

PHO 708

Construction on PHO 708, new faculty member Professor Xin Chen's Soft Services and Interfaces Lab began in June and was completed mid-July 2011. This laboratory includes a wet chemistry area, a Faraday box area, a microscope dark room, and a Class IIIb/IV laser bay. Being a new faculty member, Xin Chen's laboratory is expected to come on-line before the end of the calendar year.

Community Outreach

The community within the Photonics Center spans several colleges and schools on both Boston University campuses. As the community expands, the role of community events and outreach becomes even more essential to further the center's collaborative mission.

The Photonics Center opens its doors each year to outside academic institutions, industrial partners and to the greater BU Community through symposia, seminars and building activities. These events foster interdisciplinary discussion and encourage faculty and students to collaborate with a variety of professionals on fundamental research.

Community Events

Photonics Cafes and Forums

The Photonics Center hosted two monthly events: The Photonics Café and the Photonics Forum. The cafés bring together the faculty, students, staff and incubator company employees in an informal setting for conversation and collaboration. The cafés are hosted on the second Friday of each month from September through April in the West End Lounge.

The Photonics Forum, held on the fourth Wednesday of each month throughout the academic year, give the community opportunities to participate in technical discussions in an open forum over lunch. A Photonics Faculty member along with one of their graduate students is selected to discuss their current research endeavors and the real-world applications of their research.

2010-2011 Forum Schedule
September
Presenter: Professor Hatice Altug
Presentation: Integrated Plasmonic Systems for Ultrasensitive Spectroscopy and Detection

October
Presenter: Professor Christopher Gabel and Samuel Chung, Ph.D.
Presentation: Worm Neurosurgery: Using Femtosecond Lasers to Study Neuronal Damage in C. Elegans

November
Presenter: Professor Nandita Singh
Presentation: Journal of Visualized Experiments

January
Presenter: Boston University Environmental Health and Safety
Presentation: Annual Laboratory Safety Training

February
Presenter: John Kurkomelis, Boston University Radiation Specialist
Presentation: Annual Laser Safety Training

March
Presenter: Professor Daniel Ehrlich
Presentation: New Instruments for High Information Content Measurements on Biological Cells

April
Presenter: Professor Xue Han
Presentation: Advances in Optical Neurotechnologies

14th Annual Future of Light Symposium: Novel Electromagnetic Materials

This year, the 14th Annual Future of Light Symposium focused on novel electromagnetic materials. Nearly 200 people from Boston University, outside academic institutions and industry attended the event.

The agenda for this year's symposium featured a tutorial by Comsol the day before the symposium, presentations from Photonics faculty members and researchers from leading photonics research institutions. The conference explored the applications of novel electromagnetic materials as well as current research endeavors utilizing these materials in a variety of settings.

Our speakers included:

Richard Averitt, Boston University
Keith Nelson, MIT
Hatice Altug, Boston University
Dai Sik Kim, Seoul National University

Willie Padilla, Boston College
David Smith, Duke University
Bjoern Reinhard, Boston University
Fiorenzo Omenetto, Tufts University

The symposium also included a lunch speaker, Tim Birks from the University of Bath.

To conclude this year's conference, a poster session was held for graduate students, post-doctoral researchers, and research staff members to present their current investigations. Twenty posters were submitted to the poster session. The poster session gives outside guests the opportunity to gain further insight into the Center's education and research missions by giving students and researchers the opportunity to share their results.

Spring Cleaning Day 2011

The Boston University Photonics Center, Electrical and Computer Engineering Department and the Environmental Health and Safety Department combined forces to host Laboratory Spring Cleaning Day on Tuesday, April 19, 2011. Several of our safety and specialty gas vendors set up tables with their latest technology. AirGas revealed a new refillable lecture size bottle, Kentek had new laser safety Personal Protective Equipment (PPE), Triumvirate Environmental had safety caps for waste stream bottles, and Fisher had new items for BL2 PPE.

In addition to learning about safety and supplies, the students, faculty, researchers, and staff enjoyed breakfast and a carnival style lunch complete with corn dogs and ice cream party.

Each of the vendors contributed gift cards or vendor certificates for purchase of supplies.

This year's winners included:

Most Community Involvement – Reinhard Laboratory. Prize sponsored by AirGas.

Most Improved – Moustakas Laboratory. Prize sponsored by Triumvirate Environmental.

Most Sparkling – Goldberg/Swan Laboratory. Prize sponsored by Kentek.

Safest Lab – Bifano Laboratory. Prize sponsored by Fisher Scientific.

Seminar Series

Over the year, the Boston University Photonics Center hosted several seminars by leading experts in the field. The following list includes the seminars for 2010 – 2011.

August
Presenter: Professor Patrick Koelsch from Karlsruhe and Heidelberg in Germany
Title of Presentation: In Vitro Characterization of Surface Properties Through Living Cells Using Sum-frequency-Generation Spectroscopy

September
Presenter: Paul Pellegrino from Army Research Laboratory
Title of Presentation: Development of a Quantum Cascade Laser-Based Photoacoustic Chemical Sensor for Trace Vapor Detection

February
Presenter: Professor Jason Fleischer from Princeton University
Title of Presentation: Dynamical Imaging Using Spatial Nonlinearity

April
Presenter: Professor Lukas Novotony from The Institute of Optics, University of Rochester
Title of Presentation: Optical Antennas for Enhanced Light-Matter Interaction