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6. AUTHORS
Thomas Bifano

5d. PROJECT NUMBER

5e. TASK NUMBER

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Boston University
Office of Sponsored Program
881 Commonwealth Avenue
Boston, MA 02215 -1300

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14. ABSTRACT
Boston University Photonics Center (BUPC) conducted a project in collaboration with colleagues at the Army Research Laboratory (ARL) on the subject of advancing photonics technologies, converting photonics technologies into prototypes that serve Army needs, and testing photonics technology prototypes with support from ARL partners. BUPC performed a series of high-level R&D projects and developed hardware prototypes for sniper detection, bacterial and viral detection, laser communication, blue light and UV light source development, and nanophotonic detection systems.

15. SUBJECT TERMS
Photonics research technology inseriion

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a. REPORT	b. ABSTRACT	c. THIS PAGE			Thomas Bifano
UU	UU	UU	UU		19b. TELEPHONE NUMBER 617-353-8908

Report Title

Final Report: Photonics Research and Technology Insertion

ABSTRACT

Boston University Photonics Center (BUPC) conducted a project in collaboration with colleagues at the Army Research Laboratory (ARL) on the subject of advancing photonics technologies, converting photonics technologies into prototypes that serve Army needs, and testing photonics technology prototypes with support from ARL partners. BUPC performed a series of high-level R&D projects and developed hardware prototypes for sniper detection, bacterial and viral detection, laser communication, blue light and UV light source development, and nanophotonic detection systems.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received		Paper
05/28/2015	6.00	T. D. Moustakas, Tao Xu, C. Thomidis, A. Yu Nikiforov, Lin Zhou, David J. Smith. Growth of III-nitride quantum dots and their applications to blue-green LEDs, physica status solidi (a), (11 2008): 0. doi: 10.1002/pssa.200880222
05/28/2015	7.00	Hu Tao, Nathan I. Landy, Christopher M. Bingham, Xin Zhang, Richard D. Averitt, Willie J. Padilla. A metamaterial absorber for the terahertz regime: design, fabrication and characterization, Optics Express, (05 2008): 0. doi: 10.1364/OE.16.007181
05/29/2015	11.00	Alp Artar, Ahmet Ali Yanik, Hatice Altug. Fabry–Pe?rot nanocavities in multilayered plasmonic crystals for enhanced biosensing, Applied Physics Letters, (10 2009): 0. doi: 10.1063/1.3202391
05/29/2015	8.00	Yitao Liao, Christos Thomidis, Chen-kai Kao, Adam Moldawer, Wei Zhang, Yi-chung Chang, A. Yu. Nikiforov, Enrico Bellotti, Theodore D. Moustakas. Milliwatt power AlGaN-based deep ultraviolet light emitting diodes by plasma-assisted molecular beam epitaxy, physica status solidi (RRL) - Rapid Research Letters, (02 2010): 0. doi: 10.1002/pssr.200903400
TOTAL:		**4**

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received		Paper
TOTAL:		

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received	Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received	Paper	
05/29/2015	9.00	Leah Ziph-Schatzberg, Thomas Bifano, Steven Cornelissen, Jason Stewart, Zvi Bleier, Scot S. Olivier, Thomas G. Bifano, Joel A. Kubby. <title>Secure optical communication system utilizing deformable MEMS mirrors</title>, SPIE MOEMS-MEMS: Micro- and Nanofabrication. 24-JAN-09, San Jose, CA. : ,

TOTAL: **1**

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received		Paper
05/22/2015	2.00	Ashwin Gopinath, Svetlana V. Boriskina, W. Ranjith Premasiri, Lawrence Ziegler, Bjo?rn M. Reinhard, Luca Dal Negro. Plasmonic Nanogalaxies: Multiscale Aperiodic Arrays for Surface-Enhanced Raman Sensing, Nano Letters (11 2009)
05/22/2015	3.00	G. G. Daaboul, A. Yurt, X. Zhang, G. M. Hwang, B. B. Goldberg, M. S. U?nlu?. High-Throughput Detection and Sizing of Individual Low-Index Nanoparticles and Viruses for Pathogen Identification, Nano Letters (11 2010)
05/22/2015	4.00	Emre O?zkumur, Carlos A Lopez, Ayça Yalc?n, John H Connor, Marcella Chiari, M Selim U?nlu?. Spectral Reflectance Imaging for a Multiplexed, High-Throughput, Label-Free, and Dynamic Biosensing Platform, IEEE Journal of Selected Topics in Quantum Electronics (2010)
05/22/2015	1.00	Bo Yan, Anupama Thubagere, W. Ranjith Premasiri, Lawrence D. Ziegler, Luca Dal Negro, Bjo?rn M. Reinhard. Engineered SERS Substrates with Multiscale Signal Enhancement: Nanoparticle Cluster Arrays, ACS Nano (05 2009)
05/28/2015	5.00	Jason J. Amsden, Hannah Perry, Svetlana V. Boriskina, Ashwin Gopinath, David L. Kaplan, Luca Dal Negro, Fiorenzo G. Omenetto. Spectral analysis of induced color change on periodically nanopatterned silk films, Optics Express (11 2009)
TOTAL:		**5**

Number of Manuscripts:

Books

Received		Book
TOTAL:		

Received	Book Chapter

TOTAL:

Patents Submitted

Biomimetic acoustic detection and localization system
~~MEMS-Based Retroreflector~~
Optical Devices featuring textured semiconductor layers
Semiconductor device having group III nitride buffer layer and growth layers

Patents Awarded

Biomimetic acoustic detection and localization system
~~MEMS-Based Retroreflector~~
Optical Devices featuring textured semiconductor layers
Semiconductor device having group III nitride buffer layer and growth layers

Awards

None

Graduate Students

NAME	PERCENT_SUPPORTED	Discipline
Joshua Abell	0.20	
Sunmin Ahn	0.00	
Nuno Almeida	0.23	
Asma Al-Rawi	0.10	
M. Shahrooz Amin	0.10	
Svetlana Anissimova	0.03	
Roman Barnkov	0.15	
Vivek Bhatia	0.07	
Dipesh Bhattarai	0.07	
Saban Bilek	0.07	
Nenad Bozinovic	0.02	
Cassandra Browning	0.23	
Gordon Brummer	0.02	
Thomas Butler	0.03	
Ramya Chadrasekaran	0.05	
Tianhong Chen	0.17	
Yu Chen	0.07	
Logan Chieffo	0.55	
Shihchin Chiu	0.07	
Alioune Diouf	0.27	
Danilo D'orsogna	0.02	
Kristina Driscoll	0.22	
Kebin Fan	0.17	
David Freedman	0.43	
Michael Gingras	0.13	
Ashwin Gopinath	0.40	
Xuan Gu	0.17	
Diego Guerra Vidal	0.03	
David Harrah	0.28	
Yan Hong	0.03	
Shusen Huang	0.15	
Chen-Kai Kao	0.23	
Craig Keasler	0.08	
Sarah Kelsall	0.43	
Jin-Hong Kim	0.10	
Joel Mark Kralj	0.10	
Rohit Kumar	0.40	
Yuk Kwan Lee	0.33	
Andrew Legendre	0.02	
Jing Li	0.18	
Yitao Liao	0.23	
I-Kuan Lin	0.07	
Wen Lu	0.07	
Yang Lu	0.03	
Jeffrey Markowitz	0.10	
Alket Mertiri	0.17	
Adam Moldawer	0.43	
Michele Moresco	0.05	
James Needham	0.13	
Marianne Nourzad	0.30	
New Entry	0.00	
John Ogren	0.03	
Ismail Ozkumur	0.40	
Alyssa Pasquale	0.25	
Eric Pinnick	0.07	

Yirong Pu	0.50
Erica Raber	0.07
Sebastian Remi	0.20
Andrea Rosales Garcia	0.10
Matthew Sandifer	0.12
Jude Schneck	0.25
Kurt Schoener	0.13
Jeffre Shattuck	0.30
Roman Shugayev	0.07
Alon Singer	0.20
Lynell Skewis	0.22
Philipp Spuhler	0.20
Andrew Strikwerda	0.17
Hu Tao	0.43
Gultek Tasdirek	0.10
Hidefumi Tomita	0.08
Anthony Vamivakas	0.13
Kyle Vigil	0.07
Xihua Wang	0.27
Joseph Warga	0.33
Adrian Williams	0.08
Jeffrey Woodward	0.02
Ayca Yalcin	0.37
Bo Yan	0.17
Abdulkadir Yur	0.08
Jane Yuqi Zhang	0.10
Xirui Zhang	0.10
Yaopeng Zhou	0.02
FTE Equivalent:	**13.61**
Total Number:	**83**

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

NAME	PERCENT_SUPPORTED	National Academy Member
Lawrence Ziegler	0.05	
Richard Averitt	0.05	
Xin Zhang	0.00	
Lee Goldstein	0.02	
Theodore Moustakas	0.04	
Steve Ahlen	0.03	
Allyn Hubbard	0.10	
Selim Unlu	0.02	
Bjoern Reinhard	0.01	
John Connor	0.02	
Thomas Bifano	0.04	
New Entry	0.00	
FTE Equivalent:	**0.38**	
Total Number:	**12**	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period:	0.00
The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:.....	0.00
The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:.....	0.00
Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):.....	0.00
Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:.....	0.00
The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense	0.00
The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:	0.00

Names of Personnel receiving masters degrees

NAME	
Cassandra Browning	
Wen Lu	
Matthew Sandifer	
Roman Shugayev	
Joseph Warga	
Total Number:	**5**

Names of personnel receiving PHDs

NAME	
Joshua Abell	
Nenad Bozinovic	
Ramya Chandrasekaran	
Shihchin Chiu	
Alioune Diouf	
Danilo D'orsogna	
Kristina Driscoll	
David Freedman	
Ashwin Gopinath	
Yitao Liao	
I-Kuan Lin	
Michaele Moresco	
James Needham	
Marianna Nourzad	
Ismail Ozkumur	
Eric Pinnick	
Yirong Pu	
Kurt Schoener	
Hu Tao	
Ayca Yalcin	
Bo Yan	
Zaopeng Zhou	
Total Number:	**22**

Names of other research staff

NAME	PERCENT_SUPPORTED
Keith Crook	0.05
Meghan Foley	0.12
Thomas Dudley	0.15
Helen Fawcett	0.60
Mark Harney	0.06
Chad Demurs	0.10
Anlee Krupp	0.75
Paul Mak	0.76
Elizabeth McCaffrey	0.12
Jay Morong	0.17
Deborah Powers	0.07
Robert Schaejbe	0.25
Leah Schatzberg	0.75
Glenn Thoren	0.31
Justin Zavislak	0.06
FTE Equivalent:	**4.32**
Total Number:	**15**

Sub Contractors (DD882)

1 a. iRobot Corporation

1 b. iRobot Corporation
8 Crosby Drive
Bedford MA 017301402

Sub Contractor Numbers (c):
Patent Clause Number (d-1):
Patent Date (d-2):
Work Description (e): Helped manufacture RedOWL sniper detection prototype
Sub Contract Award Date (f-1):
Sub Contract Est Completion Date(f-2):

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1 a. iRobot Corporation

1 b. iRobot Corporation
8 Crosby Drive
Bedford MA 017301402

Sub Contractor Numbers (c):
Patent Clause Number (d-1):
Patent Date (d-2):
Work Description (e): Helped manufacture RedOWL sniper detection prototype
Sub Contract Award Date (f-1):
Sub Contract Est Completion Date(f-2):

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1 a. Insight Technologies

1 b. 9 Akira Way
Londonderry NH 03053

Sub Contractor Numbers (c):
Patent Clause Number (d-1):
Patent Date (d-2):
Work Description (e): Helped develop optical components for RedOwl
Sub Contract Award Date (f-1):
Sub Contract Est Completion Date(f-2):

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1 a. BioMimetic Systems

1 b. 810 Memorial Drive, Suite 106
Cambridge MA 021394662

Sub Contractor Numbers (c):
Patent Clause Number (d-1):
Patent Date (d-2):
Work Description (e): Developed software for RedOwl prototype
Sub Contract Award Date (f-1):
Sub Contract Est Completion Date(f-2):

1 a. BioMimetic Systems

1 b. 810 Memorial Drive
STE 106
Cambridge MA 021394662

Sub Contractor Numbers (c):

Patent Clause Number (d-1):

Patent Date (d-2):

Work Description (e): Developed software for RedOwl prototype

Sub Contract Award Date (f-1):

Sub Contract Est Completion Date(f-2):

Inventions (DD882)

5 **Biomimetic acoustic detection and localization system**

Patent Filed in US? (5d-1) Y

Patent Filed in Foreign Countries? (5d-2) N

Was the assignment forwarded to the contracting officer? (5e) Y

Foreign Countries of application (5g-2):

5a: David Mountain

5f-1a: Boston University

5f-c: 881 Commonwealth Avenue

Boston MA 02215

5a: Socrates Deligeorges

5f-1a: Boston University

5f-c: 881 Commonwealth Avenue

Boston MA 02215

5a: Allyn Hubbard

5f-1a: Boston University

5f-c: 881 Commonwealth Avenue

Boston MA 02215

5 **MEMS-Based Retroreflector**

Patent Filed in US? (5d-1) Y

Patent Filed in Foreign Countries? (5d-2) N

Was the assignment forwarded to the contracting officer? (5e) Y

Foreign Countries of application (5g-2):

5a: Thomas Bifanoi

5f-1a: Boston University

5f-c: 881 Commonwealth Avenue

Boston MA 02215

5 **Optical Devices featuring textured semiconductor layers**

Patent Filed in US? (5d-1) Y

Patent Filed in Foreign Countries? (5d-2) N

Was the assignment forwarded to the contracting officer? (5e) Y

Foreign Countries of application (5g-2):

5a: Theodore Moustakas

5f-1a: Boston University

5f-c: 881 Commonwealth Avenue

Boston MA 02215

5a: Jasper Calabu

5f-1a: Boston University

5f-c: 881 Commonwealth Avenue

Boston MA 02215

5 **Semiconductor device having group III nitride buffer layer and growth layers**

Patent Filed in US? (5d-1) Y

Patent Filed in Foreign Countries? (5d-2) N

Was the assignment forwarded to the contracting officer? (5e) Y

Foreign Countries of application (5g-2):

5a: Theodore Moustakas

5f-1a: Boston University

5f-c: 881 Commonwealth Avenue

Boston MA 02215

Scientific Progress

Working with the Department of the Army, the Photonics Center has become a national resource for biophotonics, nanophotonics, and photonic materials development through this five-year program in technology development aimed toward addressing critical defense needs.

The program created a pipeline for photonics technology development and insertion at the Boston University Photonics Center. The essential elements of that pipeline are described in Figure 1.

Support in this grant was used primarily for Phases I-III. Funds were divided between two principal cost elements:

1. An infrastructural element that supported Photonics Center centralized resources for technology development, prototyping, program management, and Army field testing.
2. A programmatic element that supported more than thirty Faculty Technology Development Awards (FTDA) over five years to provide candidate technologies for prototyping and insertion.

Following is a list of three major pipeline projects, their objectives, their BU technology basis, and their timelines. After that, a number of other supported pipeline projects are highlighted and summarized.

A. Major Pipeline Projects

A.1 Robot Enhanced Detection Outpost with Lasers (RedOwl)

Main theme: Acoustic direction finding: sound localization

Task Managers:¿Professor Allyn Hubbard / Leah Ziph-Schatzberg
Objective:¿Transition Boston University acoustic direction finding (ADF) technology to industrial partners. The system responds after the first shot and is able to image the firing source and identify the range to it. RedOwl provides early warning information, situational awareness, intelligence, surveillance and targeting capabilities.

BU Technology Basis: Researchers at Boston University have developed acoustic localization enabling¿technology based on the mammalian auditory system. This biomimetic technology is capable of accurate sound localization with a significantly smaller microphone separation than traditional sound localization systems. This technology has been integrated with a suite of optical sensors built for military use and mounted on an iRobot PackBot. RedOwl's integrated optical sensor suite includes: laser range finder, laser illuminators/pointer, ADF and classifier with acoustic sensors, zoom thermal imager, low light/day light color 300x zoom camera, digital compass with integrated GPS positioning, communications link and two wide angle driving cameras.

Transition: RedOwl was transitioned to production by the industrial partners that participated in the project: Biomimetic Systems, Inc., Insight Technologies and iRobot. The system was tested extensively at local firing ranges. Special Operations Command (SOCOM) requested three systems be sent to Afghanistan for further testing. The RedOwl was also tested by Soldier Battle Lab in Fort Benning, GA. Initial reports from this test were very favorable. Army Research Laboratories (ARL) integrated a RedOwl head in their network as a sensor node.

Timeline:
• Proof of concept of ADF on a PackBot - 2005¿
• Integrated optics and acoustic suite - April 2006¿
• System test at AAEF - September 2006¿
• HMMWV mounted system - March 2007¿
• ADF technology and system improvements - Through 2008
• SOCOM deployment - Fall 2008¿
• Insertion to industry partner - Fall 2008

A.2 Enhanced Acoustic Gear for Locating Enemies (EAGLE)

Main Theme: Wearable acoustic direction finding: sound localization

Task Managers: Professor Allyn Hubbard / Dr. Helen Fawcett

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

BU Technology Basis: Researchers at Boston University have developed acoustic localization enabling technology based on

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

Transition: The Boston University Photonics Center, in partnership with Biomimetic Systems, participated in the Side Excursion at Fort Dix, New Jersey and the On-the-move C4ISR VIP Day in July successfully locating 12 test rounds for the demonstration. From the success at the VIP Day, the team met with groups from ARDEC and PM Soldier, Systems, and Lasers to gain feedback on the relevance and acceptance of the platform integrated onto the FFW helmet. This technology basis was displayed as a proof-of-concept (lap top for leader display or command post, hand-held PDA or integrated optical display for field soldiers) promising integrability with FFW plans. This technology addresses a critical need for soldier-worn acoustic sensors as protection against snipers and to improve situational awareness in urban warfare environments. EAGLE was transferred directly to BioMimetic Systems, Inc. for pursuit in SWAT/ Homeland Security applications and other soldier wearable platforms. The last demonstration of the technology was in December 2007 at Fort Benning for a data collection opportunity.

Timeline:¿
• Prototypes to meet VIP FFW platform - July 2007¿
• Army tests, additional capabilities - December 2007
• Insertion to industrial partner - June 2008

A.3 Compact Optical Biothreat Rapid Analyzer (COBRA)

Task Managers: Professor Lawrence Ziegler/Dr. Helen Fawcett

Objective: Final data collection and determination of performance and identification of engineered substrates when compared to the sol-gel chemically manufactured nanostructured metal substrates. Based on this data, the team developed a manufacturing protocol that can transferred to a manufacturing partner.

BU Technology Basis: A¿BU Photonics Center¿research team developed a new in-situ¿grown aggregated Au or Ag nanoparticle¿covered SiO_2 matrix that demonstrated¿exceptionally strong and reproducible signal¿enhancements for surface enhanced Raman¿spectroscopy (SERS) detection of bacteria and spores.

Transition: Several compact instruments were developed using these enhanced substrates with a goal of producing instruments that could be used at Army medical and research facilities for rapid detection of bacterial infections. Transition involved collaborative research with the US Army Medical Research Institute of Infectious Diseases (USAMRIID). The output of these programs has resulted in instrumentation 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. A second instrument for viral detection was developed in collaboration with BD Technologies, a worldwide leader in diagnostic technologies.

Timeline:¿
• Proof of concept – June 2006
• COBRA I, compact instrument for USAMRIID evaluation - June 2008
• COBRA III insertion at USAMRIID – January 2010
• Translation to industrial partner – December 2010

B. Additional Pipeline Projects

B.1 Spectral Reflectance Imaging Biosensor (SRIB)

Task Managers: Professor Selim Unlu/Dr. Helen Fawcett

Objective: Develop a label-free antigen detection platform for virus biothreats. The team was challenged with developing a detection platform for antigen as opposed to antibody detection to fulfill the general concept of detection prior to infection.

Approach: SRIB, a label free process,¿can be used to diagnose and detect¿numerous distinct molecular biomarkers¿in a multiplexed format when compared¿to individual single Enzyme-Linked¿Immunsorbent Assay (ELISA) test¿protocols. In this pipeline project, BU developed an antigen¿based capture technology. The main¿purpose was detection of clinically¿relevant quantities (10^6 PFU) of a virus¿within the sample.

Transition: The technology was transitioned to Zoiray Technologies, Inc., a BU spin off.

B.2 Portable IR Laser Bio-Dosimetry Radiation Scanner (RADSCAN)

Task Managers: Professor Lee Goldstein/Leah Ziph-Schatzberg
Objective: Develop an instrument to detect radiation exposure by imaging cross-linked structures in the cornea.

Approach: The team developed a corneal imaging instrument using Quasielastic light scattering to determine detectible protein aggregates in the periphery of the cornea resulting from radiation exposure.

Transition: Performed data analysis and bio-dosimetry research at Armed Forces Radiology Research Institute (AFRRI) and Lawrence Berkley National Laboratory (LBNL), to which instruments were delivered.

B.3 Chemically Enhanced Photonic-Plasmonic Crystals for Explosive Vapor Detection (Photonic Sniffer)

Task Leaders: Bjoern Reinhard, Luca Dal Negro

Objective: Develop a chemically enhanced photonic plasmonic sensor for explosive vapor detection. This technology utilized chemically functionalized plasmonic crystals for the selective and sensitive detection of specific threat molecules.

Transition: 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.

B.4 Thermal Neutron Detector Using Lithium Film in an Optical Time-Projection-Chamber
Task Leaders: Steven Ahlen, Helen Fawcett

Objective:¿ Develop a compact neutron detection system that does not use rare 3He gas, but instead uses thin films of enriched lithium or lithium fluoride as the neutron detecting material.

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.

Transition:¿The instrument's neutron detection efficiency, response time, and gamma ray detection efficiency 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.

B.5 Secure Communicating Optical Ultra-light Transponder (SCOUT)

Task Managers: Thomas Bifano / Leah Ziph-Schatzberg

Objective: Enable a new class of communications to assist in situational awareness using a military issued optical laser system already in theater and integrating innovative micro-mirrors to transmit sound securely.

Approach: Using BU low power deformable microelectromechanical (MEMs) devices as facets of a corner cube retroreflector, develop a secure laser communication system.

Transition: A system prototype was integrated into a modified Insight Technology fielded weapon. The system's modules and performance characteristics have been tested and analyzed. Clear communication was demonstrated at ranges over 200 meters. In addition, NRL tested SCOUT at in an underwater application. The test determined that the assemblies are suitable for underwater communication application at higher modulation frequencies.

B.6 Resonant Optical Virus Reader (ROVR)

Task Managers: Hatice Altug/John Connor/Dr. Helen Fawcett

Objective: Validate detection of clinically relevant concentrations of whole virus in serum using Vesicular Stomatitis Virus (VSV) and well developed antibodies against VSV.

Approach: Optical resonances are among the most sensitive optical phenomena to
small refractive index modulations in their near-environment. In this project we used photonic crystal (PhC) structures to manipulate light on a chip. By changing the size of one or more holes, we can created nano-scale optical resonators (also

known as photonic crystal nanocavities or defects) that localize light. Employing enhanced resonance effects, namely small mode volume and high Q, dramatically reduces the detection limit of optical resonance based biosensors while increasing their multiplexing capability.

Transition: The team demonstrated virus detection (clinically relevant amounts
in serum).

B.7 Development of UV LEDs Emitting at 250-260 nm for Water-Air Purification and Surface Sterilization

Task Manager: Professors Enrico Bellotti, Theodore Moustakas and Roberto Paiella/Leah Ziph-Schatzberg

Objective: The team set out to develop electrically pumped UV LEDs emitting at 250-260 nm for water-air purification and surface sterilization applications. UV light at these wavelengths acts on microbiological contaminants in water and air through a process by which adjacent thymine nucleic acids on DNA are dimerized, preventing replication of the microorganisms. This process has been shown to be effective for E. coli, Giardia and even more resistant virus strains such as Adenovirus. The developed robust and non-toxic solid state devices are intended to replace the present low-pressure mercury lamp emitting at 254nm.

Approach: The BU team is a leader in UV LED material development. We developed high quality AlN templates, heavily doped contact layers and high IQE quantum wells. The group demonstrated state of the art devices emitting at 273 nm and then initial devices emitting a 265 nm.

Transition: The technology has been licensed to a BU spinout that has received venture funding for further development.

Technology Transfer

Semi-annual meetings with ARL SEDD director for technical program management and dissemination of technical results

Startup company generated for sniper detection prototype (Biomimetic Systems Inc., Boston, MA)

Startup company licensed to develop SERS bacterial detection prototype (Raman Systems Inc, Boston, MA)

Collaborative efforts with USAMRIID for development of bacterial and viral front end detection systems for use at government BSL4 facility

Collaborative efforts with iRobot and Insight Technology for development of RedOWL sniper detection system.

Transfer of technology to NRL for underwater modulated retroreflector system (SCOUT).

Participation in Air Assault Expeditionary Force (AAEF) field trials at Fort Benning for RedOWL.

Prototypes for Neutron detection, laser communication by modulated retroflection, and single virus microscopy were constructed and demonstrated to military end-users.