Boston University Photonics Center

Annual Report | 2024

BOSTON UNIVERSITY

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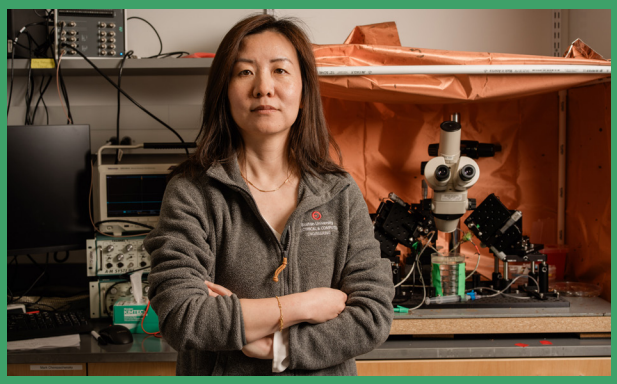
Photonics Center
Annual Report
2024



28

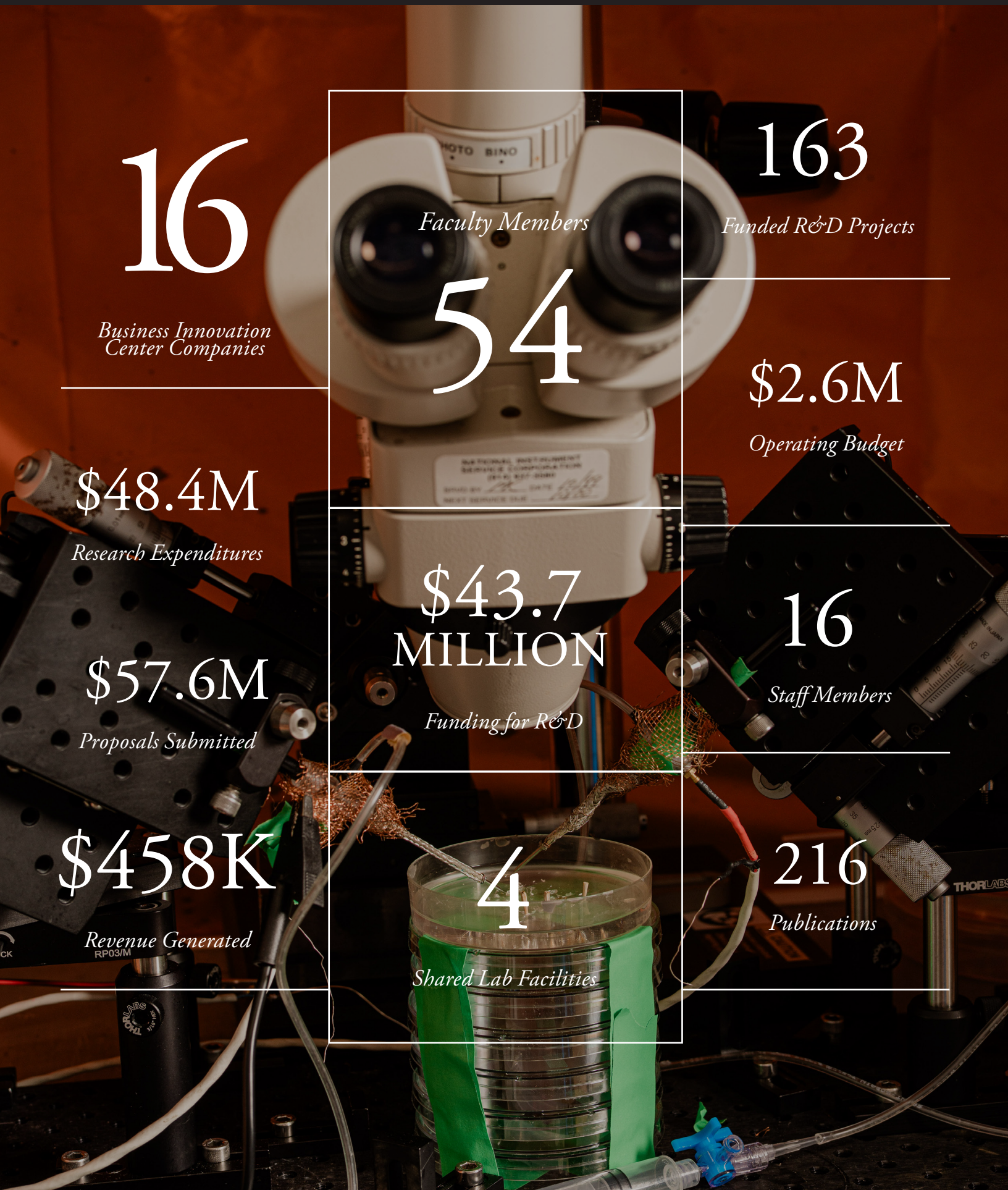
For recently promoted Professor Chen Yang, ECE, Chem, MSE making a societal impact through her work—utilizing nanotechnology to research, understand, and develop retinal and neurostimulative devices—is everything.

32

After taking classes in physical chemistry and quantum mechanics, Assistant Professor Minjung Son joined a research group where she got the chance to work with laser spectroscopy on small molecules, like porphyrins, for the first time.

Front cover art "Ganglion" (2023) provided by alumna Maria Jose-Ayuso through the Photonics Center Arts Initiative

PHOTONICS CENTER AT A GLANCE



16
Business Innovation Center Companies

54
Faculty Members

163
Funded R&D Projects

$2.6M
Operating Budget

$48.4M
Research Expenditures

$43.7 MILLION
Funding for R&D

16
Staff Members

$57.6M
Proposals Submitted

4
Shared Lab Facilities

216
Publications

$458K
Revenue Generated

Letter from the Center Director

"Our [research] efforts are enhanced by a highly collaborative environment in which the ten academic disciplines contributing to our membership join in convergent problem solving."

THIS ANNUAL REPORT SUMMARIZES ACTIVITIES OF THE PHOTONICS CENTER FOR THE 2023-2024 ACADEMIC YEAR. In it, you will find quantitative and descriptive information regarding our photonics programs in research, education, and business innovation.

Located at the heart of Boston University's urban campus, the Photonics Center is an interdisciplinary hub for education, research, scholarship, innovation, and technology development associated with practical uses of light. Our nine-story building houses world-class research facilities and shared laboratories dedicated to photonics research, and sustains the work of faculty, staff, students, and affiliate companies.

Grant expenditures for **Photonics Center faculty totaled $48.4M** this year, with considerable support from the Center through proposal development, project management, access to fee-free core laboratories, and efforts to support research infrastructure. Center staff engagement was particularly impactful this year, through our administration and management of multiple large, multi-institution awards, our substantial overhaul and upgrading of shared facilities, our leadership of several summer internship programs for undergraduates and K-12 Teachers, and our packed schedule of Center-hosted events, symposia, workshops, and training activities.

We welcomed two new members to our faculty: Assistant Professor **Minjung Son** and Assistant Professor **Wanzheng Hu**. Collectively, our 54 faculty were awarded $43.7M in new grant funds this year. They authored 216 archival publications in many of the leading journals in our field. Our students defended 57 successful doctoral dissertations.

We continued to develop our research themes, which include biophotonics; bioimaging; neurophotonics, nanophotonics, photonic materials and devices, metamaterials; and lasers nonlinear optics, and quantum systems. Our programs of research continue to focus on problems of importance to society. Our efforts are enhanced by a highly collaborative environment in which the ten academic disciplines contributing to our membership join in convergent problem solving.

In addition to supporting our core research, we provided critical resources to allied units across the university, supporting research and training projects that catalyzed transformative growth in areas such as biological design, precision diagnostics, and neuroscience. Recently, the Neurophotonics Center (NPC) received a T32 grant from the National Institutes of Health (NIH), led by Professor **Michelle Sander**, Professor **Jerry Chen**, and NPC director Professor **David Boas**, in close alliance with the Photonics Center.

The Business Innovation Center, which has always been a hub for industry/university engagement, houses sixteen tenants, including several BU spinouts, returning innovators, and strategic optics/photonics industry partners. These affiliates support many BU student interns and engage in Center innovation and training workshops, becoming an important part of our community.

This year we strengthened our administrative support of the prestigious Center for Semiconductor Materials and Device Modeling (CSM), led by Professor **Enrico Bellotti**. This program is a cooperative agreement with DOD/ARL that brings together government, academia, and industry in collaboration to advance the nationally strategic field of semiconductor design and manufacturing. CSM was funded in the fall of 2023 for $6.25M over 5 years and continues to broadly focus on six technology areas: Infrared Sensors, Photonic Devices, RF and Power, Persistent

*Photonics Center faculty at Ji-Xin Cheng's 2024 DeLisi Lecture, Credit: Danny Gianciopp*o

Power Sources, and Neuromorphic Devices.

For the seventh year, the Photonics Center led programming, administration, budgeting, and community building for the 10-year, $40M NSF Nanoengineering Research Center on Cellular Metamaterials (CELL-MET), led by Professor **Dave Bishop**.

This past summer saw another successful year of programming led by Professor **Xin Zhang**, supported by staff member **Brenda Hugot**, for our Summer Internship Programs; three Research Experiences for Teachers (RET) members returned from last summer's programming to further develop their curricula for East Boston and Revere high schools; Professor Zhang's Research Experiences for Undergraduates (REU) proposal was funded by NSF, promising another three years of vibrant summer experience that has been a longstanding component of our work to develop STEM career pathways for underrepresented and first generation students. Finally, we substantially increased the scale of our Photonics Undergraduate Research Summer Experience (PURSuE) program that brings outstanding students from optics and photonics programs at peer institutions to BU, where they engage in research internships and receive mentoring about graduate training opportunities.

We hosted multiple symposia and events, including "Boston Photonics Day," organized by the student-led SPIE/Optica/IEEE Student Chapter. That event focused on career development and pathways in the optics and photonics industry. Our annual symposium was a highlight of the year, hosted by Professor **Miloš Popović** and exploring the topic of Photonic Chips in Everything.

I am delighted to be associated with the faculty, staff, students, and industry affiliates of the Photonics Center, and appreciate your continued interest in our programs.

Mission

The Photonics Center is a university-wide center reporting to the Vice President for Research with a mission to generate fundamental knowledge and develop innovative technology in the field of photonics. We work on challenging problems that are important to society, translate enabling research discoveries into useful prototypes, and train future leaders in the field. The Photonics Center community of faculty, staff, students and postdocs engages in interdisciplinary collaborations to advance the frontiers of optics and photonics science and engineering. This mission is executed through:

- Basic research and academic scholarship in photonics, including support of major proposals and awards
- Training programs and immersive research experiences for students and teachers
- Technology development for defense, security, and healthcare applications
- Business incubation and commercialization of photonics technology

In support of its overall mission, the Center maintains a 9-story building at the heart of Boston University's Charles River Campus. The Center supports 30 faculty laboratories in its facility as well as research infrastructure needs for additional faculty laboratories housed in other academic units. The staff manage four large, shared core laboratories with state-of-the-art equipment and assume responsibility for providing training, maintenance, technical support, and capital equipment purchases associated with those facilities. The Business Innovation Center is composed of about 16 small technology companies, university spinout companies, and large company satellites for engagement with academia. The Photonics Center provides administrative, technical, and logistical support for large, complex, multi-institutional proposals and awards. Its resources are allocated primarily to accelerate research outcomes, train graduate students, and foster a robust and engaged community. BUPC membership includes 62 faculty, including 54 active faculty and their associated groups of graduate students and postdoctoral researchers. Affiliates include the Materials Science and Engineering Division of the College of Engineering, for which BUPC manages faculty labs and shared facility space, and the Neurophotonics Center, which BUPC supports with core funding and shared administrative support. BUPC's membership includes faculty from academic departments across the Charles River and Medical Campuses, including: College of Engineering Biomedical Engineering; Electrical and Computer Engineering; Mechanical Engineering; College of Arts and Sciences Biology; Chemistry; Physics; Psychological and Brain Sciences; School of Medicine Departments of Medicine; Microbiology; Physiology and Biophysics; Psychiatry; and Radiology. The chairs of these departments comprise the BUPC Academic Advisory Committee.

Over the past 10 years, our membership has increased by 29%, from 38 members to 54 active members and eight emeritus faculty.

Assistant Professor Minjung Son, who joined the Chemistry Department in September 2023 and was appointed as a Photonics Center faculty member, has been located in temporary lab space in the Photonics Center during her first year while her new lab is renovated. Her research sits at the crossroads of several interdisciplinary topics, including photonics and optics, chemistry, and physics. Focusing on understanding and producing light-harvesting molecular systems via ultrafast spectroscopy, the goal of Professor Son's research is to extend to material scientists in the industry sector for design principles and advancement, as well as combatting worldwide food and energy crises.

Assistant Professor Wanzheng Hu (MSE, Physics) was also appointed as a Photonics Center faculty member this year. Her research is focused on dynamical materials control with light, utilizing pump-probe spectroscopy to advance the study on novel quantum phases, including transient disentangling competing/coexisting orders in correlated electron systems; ultrafast manipulating topological phases in Weyl semimetals; and optically accessing and dynamical control low-dimensional materials.

Highlights of 2024

Basic Research and Scholarship in Photonics

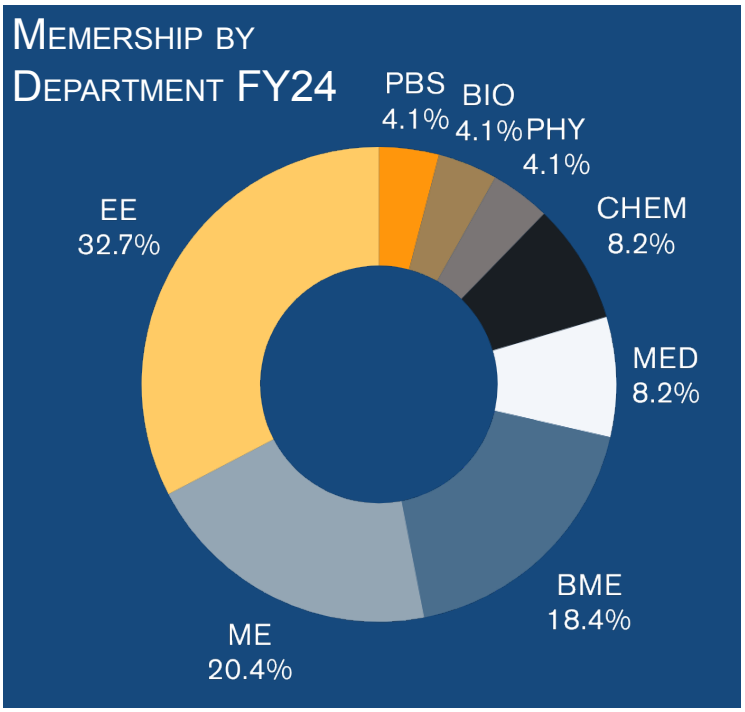
Photonics Center research is distributed broadly across all areas of optics and photonics; however, areas of particularly cohesive research strength and national prominence include biophotonics and bioimaging, biosensing, nanophotonics, neurophotonics, photonic materials and devices, photonic metamaterials, lasers, nonlinear optics, and quantum photonics.

In addition to its core faculty-led research program, the Photonics Center is also closely associated with two distinct scholarly units within BU: the Neurophotonics Center (NPC) and the Materials Science and Engineering Division (MSE). Our affiliation with NPC is the direct result of the Photonics Center's previous strategic plan, through which we deliberately and successfully built a neurophotonics program at BU in collaboration with the Center for Systems Neuroscience. Led by David Boas and housed in BU's Kilachand Center for Integrated Life Sciences and Engineering, NPC continues to receive technical, financial, communications, proposal and post-award support, and doctoral training support from the Photonics Center, and shares substantial overlap with our mission. Our strong collaborative relationship with the MSE derives in part from the fact that MSE's facilities and core faculty research labs are housed in the Photonics Center, and in part from MSE's scholarly focus on photonic-related materials research. The Photonics Center also maintains, staffs, and shares costs related to a large complement of MSE shared laboratory facilities.

Training and Student Initiatives

While the Photonics Center does not offer a degree program, its faculty teach a broad array of graduate and undergraduate courses that cut across traditional departmental curricula, and the foundation of its research program is interdisciplinary doctoral education. Our most direct programs for training and student-focused initiatives are associated with Photonics Center led, externally supported, photonics-themed research experience programs. The three main training programs are all funded by NSF: our combined REU, RET, and REM immersive summer experience programs that have supported ~110 undergraduate and HS teacher participants in the past five years. While the 5-year NSF funded NRT-UtB: Neurophotonics ended last year,

the Photonics Center continues to provide support to the Neurophotonics Center to sustain the vibrant community created through that doctoral training program, including support for one graduate student stipend annually. We also collaborated with the NPC Director David Boas to submit a successful proposal for the NIH T32 grant, entitled "Graduate Training at the Interface of Neuroscience, Optical Engineering and Data Science," to continue to build on the successful training and community outcomes of the NRT.



Beginning in 2021, the Photonics Center added a new summer research experience opportunity to its summer programming. The Photonics Undergraduate Research Summer Experience (PURSuE) aims to recruit academically talented undergraduates from leading photonics and optics programs at peer institutions for immersive summer experiences in the labs of our leading researchers, with the goal of attracting these students to the doctoral programs of our cognate departments. The Photonics Center supported three PURSuE students in 2021, two in 2022, and three in 2023. PURSuE students are able to select faculty labs for their summer research experience. To date, Professors Ji-Xin Cheng, Jerome Mertz, Lei Tian, John White, Siddharth Ramachandran, and Darren Roblyer have hosted PURSuE students. Two students from the 2022 PURSuE cohort are now graduate students in BU's ECE and BME departments, and all three students from the 2023 PURSuE cohort plan to apply to doctoral programs at BU.

The Center also organizes and sponsors professional development for its graduate students and postdocs, sponsoring student chapters of the leading optics and photonics professional societies (Optica, formerly OSA, SPIE, and IEEE) and paying student fees for memberships; providing travel awards to doctoral students who have a paper accepted for presentation at a national optics or photonics symposium; and hosting student-led booths at conferences. This year we worked closely with a new Graduate Student Leadership Council to launch a monthly Lunch & Learn speaker series, which has consistently been standing room only at the events. In collaboration with the Photonics Center Graduate Education Committee, our student chapter of SPIE/Optica/IEEE led a Boston Photonics day on October 4, 2023, held at the Photonics Center. The event featured invited external speakers, Photonics student alumni speakers, an Optics and Photonics company fair, and a student research poster session.

Students also organize and run the Photonics Center's Distinguished Seminar Series, through which they select and invite nationally and internationally renowned speakers to BU for a day-long visit that includes a plenary talk and multiple small group meetings with students and faculty.

Finally, the Center supports several Journal Clubs in which faculty and students within thematic areas (e.g., microscopy) meet regularly for student-led discussion of current seminal publications.

Business Innovation and Photonics Technology Development

The Photonics Center is a leader in the commercialization of photonics technology, an activity that is anchored by the Business Innovation Center (BIC). The BIC ended last year matching its all-time high-record number of tenants with 16 member companies, two of which serve as said anchors for the center as multi-national leaders in opto-electronics and optical tools. The BIC companies continue to be valued participants in the Photonics Center community, collaborating with faculty, training students, and creating career options for engineering graduates. Preferential selection

of prospective tenants that work in areas aligned with the research and scholarship activities of Photonic Center faculty supports this environment of collaboration and fosters potential for growth in sponsored research.

CELL-MET Engineering Research Center

Our National Science Foundation Engineering Research Center (ERC) on Cellular Metamaterials (CELL-MET), administered by the Photonics Center, continues to make significant advances toward our 10-year vision to build cardiac patches capable of repairing damaged hearts and cardiac tissue platforms that can serve as clinically relevant models for heart physiology and disease research; preparing the next generation of engineers; attracting young learners to engineering and other STEM disciplines through outreach; promoting diverse and inclusive perspectives within and outside our community; and impacting society through a thriving CELL-MET innovation ecosystem.

Now in its 7th year, Photonics Center faculty and staff continue to play a prominent role in all aspects of the ERC, led by PI David Bishop. Professor Thomas Bifano, Photonics Center Director, leads Budget and Strategy in addition to the imaging work; Cara Ellis McCarthy, Executive Director, serves as the Administrative Director; and a fully dedicated admin team including Maria Harlow, Associate Director of Administration and Lisa Tanrikulu, Administrative Coordinator. Nozomi Ito, Associate Director of Grants Administration, continues to manage budgets, compliance, and supplemental programs for the ERC; Meghan Foley, Assistant Director of Finance and Administration, works across the team for purchasing, expense tracking, and compiling financial data for reporting. John Hartnett from the BU Industry Engagement Office leads the Innovation Ecosystem. Partners and domestic collaborators in CELL-MET include University of Michigan (UM), Florida International University (FIU), Harvard Medical School, Harvard/Wyss Institute, Columbia University, North Carolina State University, and Brown University.

CELL-MET was awarded an NSF INCLUDES Research Experience and Mentoring supplement for $250K to support a program in 2024-2025 entitled the Engineering and Science Exploration INCLUDES/REM (EASE-IN). This program will support six high performing underrepresented and first-generation students, who have matriculated as freshman into BU's College of Engineering in the fall of 2024. The main aim of the program is to provide learning and research opportunities designed to develop participants' skills, readiness, and confidence, affirming their STEM identities, and including them in the thriving CELL-MET community. The program will begin with mentoring by CELL-MET doctoral students and a postdoctoral associate throughout the academic year, and lead into a six-week summer research and training component in CELL-MET labs in summer 2025.

Dr. Thomas Bifano at East Boston High School, Credit: Kelly Peña

Faculty Scholarly Works

Scholarship by Photonics Center faculty included 216 publications of prominent articles in high-impact journals. Some highlights include:

"Attention hybrid variational net for accelerated MRI reconstruction."
Stephan Anderson, Xin Zhang, ***et al.*** | *APL Machine Learning, 1*(4)

"Short-separation regression incorporated diffuse optical tomography image reconstruction modeling for high-density functional near-infrared spectroscopy."
David Boas ***et al.*** | *Neurophotonics, 10*(2)

"High throughput detection of capillary stalling events with Bessel beam two- photon microscopy."
David Boas ***et al.*** | *Neurophotonics, 10*(3)

"Special Section Guest Editorial: Thirty Years of Functional Near-Infrared Spectroscopy."
David Boas ***et al.*** | *Neurophotonics, 10*(02)

"Optical coherence tomography-based design for a real-time motion corrected scanning microscope."
David Boas ***et al.*** | *Optics Letters, 48*(14)

"Pupil engineering for extended depth-of-field imaging in a fluorescence miniscope."
Ian Davison, Lei Tian, ***et al.*** | *Neurophotonics, 10*(4)

"The Ten Commandments of Everyday Leadership."
Anna Devor ***et al.*** | *Neurophotonics, 10*(4)

"The stop and go of glymphatic flow."
Anna Devor ***et al.*** | *Nat Neurosci, 26*(6)

"Parvalbumin neurons enhance temporal coding and reduce cortical noise in complex auditory scenes."
Xue Han ***et al.*** | *Commun Biol, 6*(1)

"High-speed multiplane confocal microscopy for voltage imaging in densely labeled neuronal populations."
Michael Economo, Jerome Mertz, ***et al.*** | *Nat Neurosci, 26*(9)

"Multiplane HiLo microscopy with speckle illumination and non-local means denoising."
Jerome Mertz ***et al.*** | *J. Biomed. Opt. 28*(11)

"Crystal ribcage: a platform for probing real-time lung function at cellular resolution."
Hadi Nia ***et al.*** | *Nat Methods, 20*(11)

"Scaling information pathways in optical fibers by topological confinement."
Siddharth Ramachandran ***et al.*** | *Science, 380*(6642)

"Intravital measurements of solid stresses in tumours reveal length-scale and microenvironmentally dependent force transmission."
Hadi Nia, Darren Roblyer, ***et al.*** | *Nat Biomed Eng, 7*(11)

"Real-time evolution dynamics during transitions between different dissipative soliton states in a single fiber laser."
Michelle Sander ***et al.*** | *Optics Express, 31*(16)

"Advances in cellular resolution microscopy for brain imaging in rats."
Benjamin Scott ***et al.*** | *Neurophotonics, 10*(4)

"Single virus fingerprinting by widefield interferometric defocus-enhanced mid- infrared photothermal microscopy."
Ji-Xin Cheng, Selim Ünlü, ***et al.*** | *Nat Commun, 14*(1)

"PRIME: a probabilistic neural network approach to solar wind propagation from L1."
Brian Walsh ***et al.*** | *Frontiers in Astronomy and Space Sciences, 10*

"Quantifying the global solar wind-magnetosphere interaction with the Solar-Terrestrial Observer for the Response of the Magnetosphere (STORM) mission concept."
Brian Walsh ***et al.*** |*Frontiers in Astronomy and Space Sciences, 10*

For more faculty awards and grants, scan or go to bu.edu/photonics/category/faculty-awards/

Faculty Awards and Promotions

Among the awards and promotions received by Photonics Center faculty for their scholarly and academic achievements, some highlights include:

Professor and Center Director **Thomas Bifano** was awarded BU's 2024 Innovator of the Year Award

Professor **Ji-Xin Cheng** won SPIE Biophotonics Technology Innovator Award

Professor **Ji-Xin Cheng** delivered the 2023 DeLisi Lecture at the College of Engineering

Professor **Ji-Xin Cheng** won the American Chemical Society Division of Analytical Chemistry's Spectrochemical Analysis Award, 2024

Assistant Professors **Michael Economo** and **Hadi Nia** won respective Kilachand Fund Awards, 2023

Assistant Professor **Sean Lubner** received the 2024 Young Investigator Program (YIP) award from the Air Force Office of Scientific Research

Assistant Professor **Hadi Nia** was named a 2024 Sloan Research Fellow

Professor Emeritus **Theodore Moustakas** was named Optica's 2024 Nick Holonyak Jr Award Recipient

Professor **Roberto Paiella** was named Optica Society Fellow, 2024

Professor **Miloš Popović** named NAI Fellow, 2024

Professor **Siddharth Ramachandran** was named a 2024 AAAS fellow

Assistant Professor **Lei Tian** won the Scialog Award for Advanced Bioimaging, 2023

Chen Yang was promoted to full Professor, 2024

Professor **Xin Zhang** won Sigma Xi's Chubb award, 2023

Grant Support

In another productive year for external grant support, the Photonics Center faculty were awarded $43.7 in new annual-year funding. Highlights among new grants funded include ($ amounts for total anticipated funding):

Renewal of the Center for Semiconductor Materials and Devices Modeling (CSM), an ARL/BU Initiative, **Enrico Bellotti**, DOD/ARL $6.25M

Engineering and Science Exploration INCLUDES/Research Experience and Mentoring (REM), **Dave Bishop**, NSF supplement, $250K

T32 Graduate Training at the Interface of Neuroscience, Optical Engineering and Data Science, **David Boas**, NIH $1.29M

Super-sensitive Vibrational Imaging by Synergic Development of Instruments and Probes, **Ji-Xin Cheng**, NIH, $1.66M

Metabolic and Neural Activity Normalization by Cerebral Blood Flow Increase in AD/ADRD Models, **Anna Devor**, NIH (subaward through Cornell), $2.44M

Optogenetic Selection for Dynamic Phenotypes in Bacteria, **Mary Dunlop**, NSF $796K.

Metrology and Fundamental Science with Magnetic Resonance at its Quantum Limits, **Alexander Sushkov**, Gordon and Betty Moore Foundation, $1.25M

Discovering Principles of Memory Storage, Retrieval, and Restoration, **Steve Ramirez**, Department of Defense/AFOSR, $1.38M.

UV Plasmon-Enhanced Chiroptical Spectroscopy of Membrane Binding Proteins, **Björn Reinhard**, NIH, $1.45M

Research Experience for Undergraduates (REU) Site: Integrated Nanomanufacturing, **Xin Zhang**, NSF $465K

Strategic Goals

The Photonics Center operational plan is driven by five major strategic goals:

1) Catalyze and support major research projects
2) Lead training and educational enrichment programs
3) Promote technology development through the Business Innovation Center
4) Foster a cohesive community through events and programming
5) Provide an enabling infrastructure of shared facilities and individual faculty labs for research

Major Research Projects

The Photonics Center continues to serve the University as a leader in proposing, winning, administering, and managing large research grants. Currently supported major awards include the following:

NSF ERC (CELL-MET)

Now in its 7th year with a renewal in place through Year 10, the $40M NSF ERC, Directed Multiscale Assembly of Cellular Metamaterials with Nanoscale Precision (CELL-MET) has a vision to develop cell and tissue engineering technologies with the goal of delivering therapeutics to restore normal function to diseased or damage hearts. This is a comprehensive program that involves research in biomaterials, nano-engineering, imaging, optogenetics and fundamental research in cell and tissue engineering. CELL-MET will drive these technologies to the clinical environment by its innovation ecosystem of industry, medical and regulatory stakeholders, and training a pipeline of skilled engineers and scientists. This workforce will be diverse and inclusive, and engagement of future leaders will begin at the K-12 and continue through post-doctoral levels. Photonics Center staff play significant leadership roles in the research, inclusiveness, training, administration, and technology transfer efforts of CELL-MET.

Over the life of CELL-MET, it has been awarded six supplements for Research Experience and Mentoring Programs, which we run alongside our NSF REU and RET summer programs. In Year 7, we were awarded an NSF INCLUDES Research Experience and Mentoring supplement for $250K to support a program in 2024-2025 entitled “the Engineering and Science Exploration INCLUDES/REM” (EASE-IN). This year-long program, designed to build research skills and provide mentoring, will support six high-performing, underrepresented, and first-generation students, who have matriculated as freshman into BU’s College of Engineering in the fall of 2024; the Photonics Center will also support an additional student for a total of seven. The main aim of the program is to provide learning and research opportunities designed to develop participants’ skills, readiness, and confidence, affirming their STEM identities, and including them in the thriving CELL-MET community. This will begin with mentoring by CELL-MET doctoral students and a postdoctoral associate throughout the academic year and lead into a six-week summer research experience in CELL-MET labs in summer 2025.

More information about the NSF CELL-MET ERC can be found on the program website: https://www.bu.edu/cell-met/

NIH U19 BRAIN Initiative Award

This multi-university, five-year, $14M project to study Local Neuronal Drive and Neuromodulatory Control of Activity in the Pial Neurovascular Circuit is led by Professor Anna Devor with BU faculty Michael Economo and Lei Tian, and administered through the Photonics Center. The project furthermore involves partners from Massachusetts General Hospital, MIT, University of California San Diego, and University of Illinois Chicago. The goal is to develop a method for extracting information about neuronal circuit activity from functional Magnetic Resonance Imaging (fMRI) scans.

The 2024 REU Program members, Credit: Kelly Peña

Kilachand Fund for Integrated Life Sciences and Engineering
Now in its 3rd year. this project, led by Professor Xin Zhang with BU faculty Stephan Anderson and Ioannis Paschalidis, and administered through the Photonics Center, aims to develop an ultra-low field (ULF) MRI system with much smaller magnets, developing a metamaterial-enhanced hardware to physically boost the signal received by the imaging system. Their metamaterials—materials engineered to have properties which don't occur naturally—will be optimized by using a specifically developed computational material designer. In addition, an artificially intelligent image reconstruction algorithm will be developed to achieve optimal image quality for clinical diagnosis. Their proposed ULF-MRI technology would disrupt existing limitations in MRI and lead to low-cost technology that is readily portable and mobile, and could mitigate financial constraints that prevent MRI from being used prevalently throughout the world.

Center for Semiconductor Materials and Device Modeling (CSM)
This program is a cooperative agreement with DOD/ARL that brings together government, academia, and industry in collaboration to fund research through subcontracts and industry contracts. The CSM, led by Professor Enrico Bellotti, leverages combined core competencies of partner organizations through a consortium of industry and academic partners; broad knowledge base in modeling, and its validation; sharing of computational, characterization, materials growth and device processing resources; project continuity; and "extension of the bench" via exchange of researchers between affiliated entities. Phase II of the CSM was funded for $6.25M over 5 years and will broadly focus on six technology areas: Infrared Sensors, Photonic Devices, RF and Power, Persistent Power Sources, and Neuromorphic Devices.

NIH T32 Graduate Training at the Interface of Neuroscience, Optical Engineering and Data Science
This new neurophotonics training program, launched in August 2024, will produce the next generation of

investigators capable of rigorously and creatively developing and applying photonics methods across a wide array of neuroscience subfields, advancing our understanding of the brain in health and disease. Its trainees will gain the foundational knowledge of the field that will permit them to continue to grow with the field after their training, and efficiently translate their breakthroughs from the academic lab to real world applications and fully support the broad range of exciting careers open to scientists today. They will be advancing the knowledge of two-photon microscopy, prelimbic decision-making, and neurodegeneration, respectively. In addition to building a field-defining neurophotonics curriculum, combining technical training, computational/data analysis, and critical thinking skills, this program will provide robust training in the professional and operational skills required for success in this highly interdisciplinary field.

Research Summer Programs
The Photonics Center's summer research experience programs continue to energize our research community. Our 2024 cohort consisted of 15 participants (3 teachers and 12 undergraduates) with a range of funding, including:

- 3 teachers (via NSF CELL-MET RET Supplement)
- 2 undergraduates (via Photonics Center in anticipation of renewal (for summer 2025) of our NSF Research Experiences for Undergraduates (REU) Site led by Xin Zhang)
- 3 undergraduates (via CELL MET REU Supplement)
- 5 undergraduates (via PURSuE)
- 2 undergraduates (via collaborative research experience program with the Materials Science and Engineering Division (MSE))

The Photonics Center's primary aim for our summer programs is to provide immersive interdisciplinary research experiences that promote graduate study in our field by talented students from diverse backgrounds, filling an important graduate recruitment pipeline. Our 2024 teacher and undergraduate participants' self-identified race/ethnicities include:

- Four (27%) Black participants
- Three (20%) Asian participants
- Two (13%) Indigenous American participants
- Six (40%) Hispanic participants

Eight (53%) participants self-identified as women or non-binary. Three undergraduate participants (25%) participants identified as first-generation college students.

The Photonics Center's summer research experience programs engage students and teachers in meaningful and authentic research, with the shared aim of supporting individuals from historically excluded groups and broadening participation in science and engineering to build a pipeline which inspires STEM careers. This summer's programming culminated with a joint poster event for Photonics, Chemistry, and Physics REU and RET programs, attended by more than 120 BU students and faculty.

Training Programs and Initiatives
In training and education, the Photonics Center administers the NSF REU and RET Sites in Integrated Nanomanufacturing and NSF REM, REU, and RET Supplements to the ERC in Cellular Metamaterials. At the K12 level, the Photonics Center works with partner schools in East Boston to offer opportunities for BU students to interact with and mentor high school students and help lead STEM outreach activities for students in grades 3 and 6. In 2023, our East Boston outreach program engaged approximately 12 BU student volunteers including three former REU participants and six CELL-MET students, 20 high school students, and 80 elementary students.

Photonics Center Research Training (PRT) and Community
The Photonics Center Graduate Education Committee, led by Professor Ji-Xin Cheng and comprised of faculty and staff (Professors Darren Roblyer and Björn Reinhard, and staff Cara McCarthy, Beth Mathisen and Hossein Alizadeh) continues to focus on supporting cognate departments in recruiting competitive and diverse students with a particular focus on the use of optics and photonics in their research; increasing efforts to apply for external funding for doctoral students, such as training grants and external fellowships; and to promote a thriving and interconnected community of Photonics students from across schools and departments at BU along with unique opportunities for their professional development. The PRT initiative is largely student-directed by a Student Leadership Committee, along with advisement by the Graduate Education Committee. The student leaders were elected to this role and are also active in the professional organizations SPIE and Optica. The current leadership includes President Daniel Shahar, Vice President Chinmayee Vallabh Prabhu Dessai, Secretary Vineetha Ashok, and Treasurer Anna Novoseltseva.

As part of the Committee's recruitment efforts, the Photonics Center supported matriculation bonuses of $2,000 per student, which were offered in coordination with the cognate department offers, to prospective doctoral students with a particular interest in working with Photonics Center faculty. In total, 51 recruitment bonuses were offered to students accepted into doctoral programs in BME, ME, ECE and Chemistry, and 18 bonus offers were accepted for fall 2024.

Photonics Center K-12 Outreach Initiative
In support of its mission to promote engineering and photonics-themed educational pathways and careers, particularly for students from racial and ethnic minority groups, the Photonics Center leads a robust outreach program with K-12 partner schools. The Photonics Center partners with STEM program leaders and teachers in primarily Hispanic East Boston and Revere, to engage in spirited multi-grade level student interactions.

With East Boston High School (EBHS), the Photonics Center continued its engineering outreach program with near-peer mentoring in which EBHS students are coached and mentored by their teachers and BU Photonics Center students to prepare them to teach and mentor 3rd and 6th grade students at a nearby elementary school, inspiring their younger peers with hands-on learning activities in STEM topics.

During Spring 2024, seven BU graduate students visited East Boston High School and Otis Elementary School to mentor approximately 25 AP Biology students from EBHS, and assist them in leading STEM lessons and activities for 3rd and 6th grade classes at the Otis School. BU and EBHS students visited the Otis School five times this past spring, whereafter all participants (3rd grade, 6th grade, high school, and BU students) met for a final field trip to the Museum of Science. The topics covered were:

- **March 7-8** – Gr 3&6: *What is an Engineer?*
- **March 21-22** – Gr 3&6: *Graphite Circuits*
- **April 4-5** – Gr 3&6: *Monomers and Polymers*
- **May 2-3** – Gr 3: *Engineering Design Process,* Gr 6: *Feel the Beat (Heart Rates and Cardiovascular Disease)*
- **May 23-24** – Gr 3&6: *UV Light*
- **June 7** – ALL: *Museum of Science Field Trip*

In addition, the Photonics Center faculty and students engage with partner K-12 schools by helping with science fairs and after school clubs, engaging with local families at school community events such as STEAM Day, visiting RET classrooms to help with lesson activities and talk with students about career paths, and by supporting our K-12 partners in their efforts to expose all students to future career possibilities.

Business Innovation Center

The BIC is a facility located at the Photonics Center that houses industry tenants engaged in commercial activities that are complementary to the Center's mission. Currently, the BIC is comprised of about 6000sf of space that includes large and small office suites, multi-company shared office spaces, common areas, and dedicated shared laboratory spaces including a biosafety level 2 (BSL2) space built with funding from the Massachusetts Life Sciences Center. The BIC now hosts 16 companies, matching the record for an all-time high number of tenants from last year.

The goal of the BIC is to accelerate innovation by encouraging industry collaboration with faculty and to provide educational opportunities for graduate and undergraduate students. Innovation occurs at large companies as well as at start-ups, so the BIC is comprised of start-up and mid to large-size business enterprises in life sciences, biotechnology, photonics, and materials technologies. The two large companies in the BIC are AEMtec and Thorlabs. The other eight outside (non-BU) entities are smaller companies and there are four BU faculty spinout companies.

Professors Stephan Anderson and Xin Zhang have one faculty spinout in the BIC, Primetaz, which makes materials that increase the signal of MRI machines. Their company Acoulent departed the BIC this past year and was working on a metamaterial-based noise cancellation product. The value proposition for a hospital is higher throughput (less time per session). iRiS Kinetics is the third BU spinout, founded by Professor Selim Ünlü. iRiS Kinetics develops and markets imaging biosensor platforms for applications ranging from molecular binding affinity measurements to single biological particle detection. Additionally, iRiS Kinetics was a recipient of the EU Transition Grant – NEXUS. Virex Health LLC is new to the BIC this year and is a subsidiary of Sorrento Therapeutics Inc. BU faculty Scott Schaus and Mark Grinstaff are participating faculty. They are developing a rapid diagnostic that leverages the expertise of Sorrento Therapeutics in the production of highly specific antibodies targeting viral antigens, and the existing infrastructure of the glucometer industry. Virex Health has developed a proprietary technology for electrochemical detection of bioanalytes (virus, proteins, small molecules) using the same electronic device requirements employed in glucometers and has reformulated the chemistry contained on the test strip to detect pathogens. In so doing, Virex Health will leverage an existing infrastructure that produces tens of millions of devices per year; an infrastructure that is orthogonal to current infrastructure needed for PCR, another highly sensitive method of detection.

- **Everest Biolabs (EBL)** is new to the BIC this year. They are a startup spun out of David Walt's Lab at the Harvard Wyss Institute. Everest Biolabs is a life science tools company developing sample preparation workflows and analytical techniques to power the next generation of exosome-based diagnostics and therapeutics.
- **Diametryx** is also new to the BIC this year and is developing new-to-the-world color-changing particles in response to magnetic fields and mechanical actuations based on IP-protected technologies. Specifically, they are developing a reversible/erasable tattoo.
- **AEMtec GmbH** is a German company based in Berlin who joined us in September 2019. They chose the BIC after surveying several other facilities in the Boston area; the BIC's operational and spatial flexibility made it an attractive location for their first U.S. office and a hub to support their salespeople in the field. When they joined the BIC in 2019, they made a substantial investment in their space to upgrade and customize it for their needs. Their strength is the high accuracy die placement of components like chips, optics, and lenses.
- **Thorlabs**, a long-time supporter of the Photonics Center, made BIC the hub of their outreach to other universities and businesses in the Boston area tech community. The Boston location of Thorlabs seeks partnerships with Boston area universities and researchers for (1) accelerating research through offering early access to Thorlabs prototype technologies, (2) licensing startup or university owned patents, (3) increasing

federal funding through letters of support and collaborative research, and (4) providing research opportunities for current students and career paths to graduating students while facilitating recruitment to Thorlabs of highly trained and skilled workers.

- **Leuko Labs**, an MIT spinout, is developing their PointCheck™ device, used for non-invasive white cell monitoring. The value proposition of their device is to improve clinical outcomes for more than 2 million cancer chemotherapy patients a year in the US and Europe, reduce their chemotherapy-related hospital readmissions by 50% and save over $6 billion annually in healthcare cost.
- **Quantum Network Technologies (Qunett)** is developing a full stack of hardware and software solutions for the quantum internet. Qunett has secured two government contracts to develop their Mega-Qubit Quantum Router and Deterministic Entangled Photon Source technologies. Qunett moved into lab and office space at the BIC in May 2023 and has been busily installing cryogenic infrastructure to build out a quantum networking test bed with a high-capacity quantum memory.
- **Stata Dx** is a spinout from Harvard's Wyss Institute. They are building a next-generation blood diagnostic platform. Their first product will be a portable "liquid MRI" for the brain enabling at-home monitoring of neurodegenerative conditions such as Multiple Sclerosis and Alzheimer's as well as rapid triage for acute neurological conditions like Traumatic Brain Injury.
- **PlenOptika** makes technology that frees vision exams from the clinic, unlocking the regulated eyeglass prescription market. The value proposition is to break the prescription bottleneck with technology that democratizes eyeglass prescriptions.
- **Coalesenz** is a company that creates low-cost solutions to detect clotting disorders and prevent life-threatening hemmorhage and thrombosis in patients. They joined the BIC in July of 2021.
- **Nuceptive** labs are transforming sexual health through next-generation contraception in a post-Roe world. Nuceptive is a consumer products company that provides novel condoms and associated accessories that enhance user experience and provide preferable alternatives to traditional birth control. They joined the BIC in April of 2023.

FY24 Business Innovation Center Tenants

Company Name	Origin	Idea	Market Sector	Funding
Acoulent	Boston University	Metamaterials	Healthcare	Grants
AEMtec	Corporate	Optoelectronic Circuits	Medical Technology, Telecomm, Other	Corporate
*Analog Devices	Corporate	MEMS	Healthcare	Corporate
*BioVirtus	Private	Rx	Healthcare	Grants
Coalesenz	MGH: Wellman Center	Optical Sensor	Healthcare	Grants
Diametryx	Private	Color Changing Particles	Color changing materials	Privately Funded
Everest Biolabs	Harvard Wyss Institute	Exosome Isolation	Life Sciences Tools	Privately Funded and Angel Investors
*FLEXcon	Corporate	Mfg	Adhesives	Corporate
iRis Kinetics	Boston University	Instrument to characterize molecular kinetics	Healthcare	Grants
Leuko Labs	MIT	Non-Invasive White Blood Cell Monitor	Healthcare	Grants and Venture

FY24 Business Innovation Center Tenants				
*Neural Dynamics Technologies	MIT	Micro-Electrodes and Implantable Devices	Healthcare	Grants
Nuceptive	Private	Male Contraceptive	Healthcare	Angel
NXTEC Corporation	Corporate	Software as a Service (SaaS)	Multiple	Grants and Venture
PlenOptika	MIT	Autorefractor Using Wavefront Aberrometry	Healthcare	Grants and Angel
Primetaz	Boston University	Metamaterials	Healthcare	Grants
Quantum Network Technologies	MIT	Quantum Internet	Telecom	Grants
Stata Dx	Harvard University	Diagnostics for neruodegenerative	Healthcare	Grants
Thorlabs	Corporate	Optical Tools	Multiple	Corporate
Virex Health	Sorrento Therapeutics Inc.	Electrochemical Detection of Bioanalytes	Healthcare	Corporate

Companies marked with "" have left the BIC within FY 2024.*

CELL-MET Innovation Ecosystem

One of the main broader impacts goals of an NSF Engineering Research Center is to create a thriving innovation ecosystem with corporate members who bring industry perspective and facilitate and accelerate technology development and transfer to clinical use. These members form an Industry and Practitioner Advisory Board (IPAB) who regularly interact with the ERC, including engagement with trainees for workshops, Perfect Pitch competitions, professional development, and mentorship. John Hartnett, Director of Industry Engagement in the BU IE Office, leads this effort as the Industry Liaison Officer.

The NSF prescribes levels of membership and corresponding fees which can include both cash and in-kind contributions. Over the course of the 10-year ERC, one of the key elements to sustainability of the center's work beyond the NSF funding is through industry participation and support. John Hartnett developed a sustainability plan with the Senior Leadership Team as part of the ongoing strategic plan of CELL-MET.

Highlights over the first seven years of the CELL-MET ERC include the establishment of an Industry Practitioner Advisory Board whose members have contributed funds, equipment, mentoring, and internship/research opportunities. In the first seven years members have contributed $1,182,686 to the center consisting of $711,834 in cash membership dues and $470,772 of in-kind contributions. These funds have been used to support nine seed projects for commercialization from cash contributions totaling $650K. CELL MET has submitted 24 patent filings to date with two licenses granted. In addition, CELL MET industrial affiliates have supported four sponsored research projects directly with CELL MET participants, including projects with Boston Micromachines Corporation, Imagion, Analog Devices, and IBM. As part of its Innovation Ecosystem activity, CELL MET hosted an "Industry Engagement" workshop in October 2023 with its Industry Affiliates.

A summary of support received by CELL MET from its industrial affiliates is shown in the adjacent Table.

CELL-MET Industrial Affiliate Support			
Total Oct 2017– Sept 2024			
Company	**Cash**	**In-Kind**	**Total**
Bayer	$0	$25,000	$25,000
BioMetrix	$1,667	$0	$1,667
Bioventus	$39,583	$0	$39,583
Boston Micromachines Corp	$6,667	$0	$6,667
Boston Scientific	$68,750	$19,750	$88,500
Corning	$60,417	$0	$60,417
Hamamatsu	$175,000	$0	$175,000
Imagion	$50,000	$0	$50,000
K&L Gates	$0	$26,785	$26,785
Lightwave Advisors	$0	$160,000	$160,000
Nanoscribe/BICO	$6,667	$0	$6,667
Poly6	$2,583	$0	$2,583
Stembiosys	$3,000	$0	$3,000
Sublime	$5,000	$0	$5,000
Thorlabs	$287,500	$239,147	$526,647
Valo/Tara	$5,000	$0	$5,000
TOTAL	$711,834	$470,772	$1,182,606

Photonics Center Articles

INNOCENT MOLE OR SKIN CANCER? FDA CLEARS DEVICE WITH BU-DEVELOPED TECHNOLOGY THAT MAKES DETECTION EASIER

DERMASENSOR USES OPTICAL TECHNIQUE PIONEERED BY BU BIOMEDICAL ENGINEER IRVING J. BIGIO AND COULD CUT NUMBER OF MISSED CANCERS BY HALF

by Andrew Thurston for *The Brink*

Maybe it's just a funky-looking, unique-to-you mole. But that irregular patch or evolving mark could signal bad news: skin cancer, the most common form of cancer in the United States. Although spotting skin cancer early could save your life, it can be tough for even some medical professionals to judge if a mark is benign or potentially harmful. A new noninvasive skin cancer detection device—powered by technology pioneered by a professor at Boston University's College of Engineering—aims to make telling the difference easier and faster.

The US Food & Drug Administration recently cleared for US markets DermaSensor, which uses light and artificial intelligence to examine skin lesions and assess whether a patient should be referred to a specialist. The company bringing the handheld device to market says it has the potential to slash the number of missed skin cancers by half. DermaSensor's underlying sensing technology, elastic scattering spectroscopy (ESS), was developed and refined by Irving J. Bigio, an ENG professor of biomedical engineering and of electrical and computer engineering. He's a scientific advisor to the eponymous company behind the device, which also licensed patents from Bigio and BU.

"The FDA had designated this as a breakthrough technology, which means they gave it higher priority for review because they see it as having a real impact," says Bigio. "And the trials showed that it actually does work."

Bigio says DermaSensor's clearance doesn't just reflect well on his Biomedical Optics Lab, but also

The DermaSensor uses technology developed by BU's Iriving J. Bigio. Photo courtesy of BU College of Engineering

on BU's cross-disciplinary approach to fostering new technologies.

The DermaSensor uses technology developed by BU's Irving J. Bigio. Courtesy of BU College of Engineering

"It's a positive statement about BU's commitment to interdisciplinary research that involves the engineering and physical sciences, as well as the medical school," says Bigio, who also holds positions in BU's Chobanian & Avedisian School of Medicine and College of Arts & Sciences physics department. "They are supportive of collaborative research across schools."

According to the American Academy of Dermatology Association, one in five of us will grapple with skin cancer at some point in our lives, which is why it recommends regular skin exams. In its pivotal FDA study—the research that makes or breaks a new clinical technology—DermaSensor says researchers found the device had "a sensitivity of 96 percent across all 224

skin cancers." It can detect the most frequent forms of skin cancer—basal cell carcinoma and squamous cell carcinoma—and the less common, but more deadly, melanoma.

Bigio first began working on ESS as a senior research scientist in New Mexico at Los Alamos National Laboratory, and continued to advance it when he joined BU in 2001. An optical technique, ESS involves directing pulses of light at tissue, then scrutinizing which colors of light bounce back to reveal important information about cellular and subcellular structures. In the case of DermaSensor, the light can reveal whether tissue is potentially cancerous, as malignant and benign lesions scatter light differently. Bigio says it works equally well on different skin tones.

"The word elastic means that the light scatters but doesn't change its wavelength; on the other hand, how efficiently it scatters and in what direction it scatters does depend on the wavelength," says Bigio. "And that wavelength dependence is informative about the size and density of the microscopic structures in the tissue."

In the clinic, a physician or nurse puts the tip of the DermaSensor on a lesion. The device then fires off a pulse of light and analyzes the spectral information of the backscattered light using an AI-powered algorithm. Eladio Rodriguez-Diaz (ENG'09), a former PhD student in Bigio's lab, developed much of the sensor's machine learning and data analysis technology; he's a coinventor on some of the patents.

"It's incredibly gratifying to see Dr. Bigio's innovative research incorporated into an FDA-cleared medical device, especially one with the potential to noninvasively detect skin cancer," says Frances Forrester, director of business development in BU Technology Development. "Early detection is known to save lives, and now a new tool is available to US-based primary care providers and their patients through BU research."

According to Bigio, many potentially cancerous lesions are currently missed in primary care clinics—something DermaSensor could help change. He gives the scenario of a patient who spots a concerning mark on their body and asks their doctor to take a look.

The DermaSensor was given a priority review by the FDA because "They see it as having a real impact," says BU's Irving J. Bigio. Photo courtesy of DermaSensor/Business Wire

"If it looks suspicious, they'll send the patient to the dermatologist, but of patients who are referred to the dermatologist, only one out of 18 to 20 actually have cancer, or precancer," says Bigio. "But of the patients who present in the primary care setting who actually have skin cancer, only half are currently being referred."

Bigio says the device is the first consumer-facing medical product using ESS to hit the market, but that he and his clinical collaborators have spent decades testing the technology's potential in other fields. In multiple National Institutes of Health–funded studies, they've shown it could help pinpoint the locations of tumors, measure the effectiveness of cancer medications, detect malignant thyroid nodules, and differentiate normal from abnormal polyps during a colonoscopy. In some cases, he says, that research is ready to make the jump from the bench to the bedside—they just need to find the right commercial partners to take things to the next level, as DermaSensor has done.

"I think the DermaSensor success in getting FDA clearance, and some initial commercial success that I'm quite confident is going to come now, will be the rising tide that floats other boats," says Bigio. "Once investors or med tech companies see this, they're going to take a stronger interest. And we're already starting to see that in what we've been doing for interventional radiology and intravital measurements in various organs."

Michael Albro (right), an ENG assistant professor of mechanical engineering, and postdoctoral researcher Masumeh Kazemi using the Raman needle probe on an excised bovine cartilage specimen.

NEW NONINVASIVE LIGHT-BASED DEVICE COULD HELP DIAGNOSE OSTEOARTHRITIS EARLY

KNEE AND OTHER JOINT CARTILAGE HEALTH COULD BE ASSESSED WITH CLICK OF A BUTTON; MAY HELP PREVENT FURTHER DAMAGE—AND PAINFUL JOINT REPLACEMENT SURGERY

by Patrick Kennedy for *The Brink*, Photos by Chris McIntosh

It's a disease that causes pain, can't be cured right now, and can't be diagnosed until it's too late. Osteoarthritis afflicts 32.5 million Americans, making it the most common type of arthritis, according to the Centers for Disease Control and Prevention. A degenerative joint disease, it occurs when articular cartilage—the tissue that cushions the ends of bones at the joint—wears away. It leads to pains and aches and even disability. The tissue loss is irreversible, so eventually an artificial joint is required. That's a problem when the sufferer is a young adult or a teenager, because artificial joints last for only a couple of decades.

"When you think of osteoarthritis, you think of older individuals, but the reality is that 24 percent of adults are afflicted with osteoarthritis," says Boston University orthopedics researcher Michael Albro. "The burden can at times fall even heavier on younger patients."

Every year, hundreds of thousands of adolescents and young adults suffer sports injuries that can lead to post-traumatic osteoarthritis, says Albro, a BU College of Engineering assistant professor of mechanical engineering. "And they're not yet eligible for a joint replacement procedure."

Albro is leading a team of BU researchers—along with clinicians and other experts around the world—developing a groundbreaking weapon in the fight against osteoarthritis. Their noninvasive light-based arthroscope, which uses a technique called Raman spectroscopy, could be used to gauge the health of cartilage in the knees and other joints with the click of a button. The work recently received a $3 million boost from the National Institutes of Health.

"We keep getting contacted by orthopedic surgeons in the area who really want to use this in the clinic as soon as possible," says Albro, who's also affiliated with the BU Photonics Center. "This NIH grant will essentially enable us to prove that Raman diagnostic

Albro and his team say their arthroscope can take what they call an "optical biopsy."

measurements can outperform MRI."

Dating Fossils, Busting Art Forgers, and Now Saving Knees?

Soft tissue doesn't show up very well in radiography scans, and MRI—the gold standard for fractures and other diagnoses—doesn't have quite the granular resolution needed for imaging cartilage. That means no method currently in use can detect osteoarthritis early, when there might still be time to intervene.

The alternative that Albro and colleagues have crafted uses the principle of Raman scattering. Long used to date fossils and bust art forgers, a Raman spectroscope shines light on a specimen, counts the tiny number of light particles that undergo a shift in wavelength, and uses that data to assess the specimen's chemical composition.

Applying this process to articular cartilage, Albro's team figured out that Raman scattering would pick up on key biomarkers, measuring the tissue's composition and mechanical function. With a grant from the Arthritis Foundation, they successfully tested their device—the first-ever Raman arthroscope—on donor cartilage in 2021. Now, with the NIH grant, they are testing it in live large animal models, bringing the technology another step closer to the clinic.

Albro and his team say their arthroscope can take what they call an "optical biopsy."

Why build a better arthroscope if cartilage loss can't be reversed? Two good reasons, says Albro. First, many scientists are in fact working on methods that might stop osteoarthritis in its tracks—and some even hope to reverse it—so if the disease could be detected early enough, that would prevent a lot of damage from ever occurring.

Second, many researchers are working on engineering or regenerating tissue to replace the cartilage. Indeed, Albro and many of his colleagues on the Raman arthroscope project are also involved in such efforts, as part of a two-pronged approach. Their arthroscope can take what they call an "optical biopsy," which can be used to assess the quality of the replacement tissue that they and others engineer, just as well as it can assess natural tissue.

"Ultimately, one of the key benefits of the [Raman] technology is going to be, for the first time ever, to examine the efficacy of some of these exciting emerging therapies," says Albro.

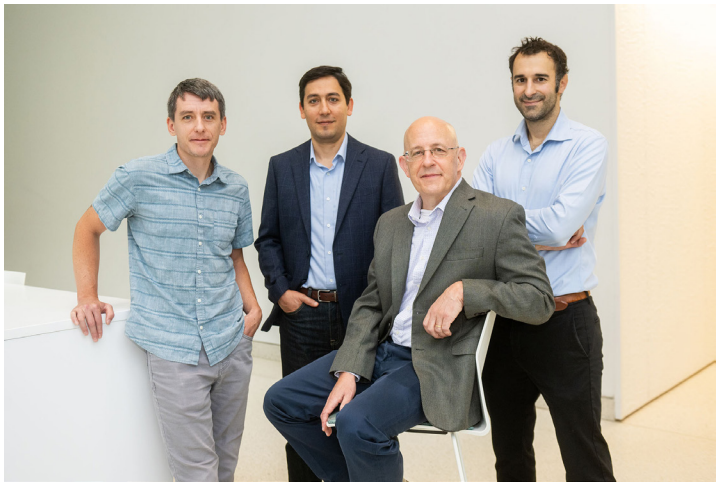
"That's the main utility of this whole coordinated effort," says Brian Snyder, one of Albro's collaborators. An ENG research professor of biomedical engineering, he's also an orthopedic surgeon at Boston Children's Hospital. "We're developing the diagnostic tools, as well as minimally invasive interventions to repair the tissue. My partners in sports medicine at Children's are anxious to start using [the Raman arthroscope] immediately."

Others working on the project include Mark Grinstaff, BU's Distinguished Professor of Translational Research and a William Fairfield Warren Distinguished Professor, and biophotonics expert Mads Bergholt from King's College London, United Kingdom—as well as "just terrific, talented students" from across ENG, says Albro.

"These are challenging problems that any one of us sitting alone would really not be able to tackle," he says. "These international interdisciplinary collaborations are wonderful—but they can also be precarious, given the distance and everyone's busy schedules. So, the magic formula is, you have to really like working together. And we seem to have found this really nice team that's just enthusiastic to work together on these projects."

KILACHAND FUND AWARDS GO TO CRYSTAL RIB CAGE AND BRAIN CONNECTION PROJECTS

by Chuck Leddy for *the Brink*, photos by Cydney Scott



The 2023 Kilachand Fund award winners are Brian Cleary (CDS) (from left), Hadi Nia (ENG), Joseph Mizgerd (CAMED), Michael Economo (ENG), and Jerry Chen (CAS) (not pictured).

When infection or disease strikes the lung—cancer, pneumonia, COVID-19—it's tough for researchers to see what's going on inside the organ. Even if they simulate in a lab the disease in a lung, they can't recreate the forces the rib cage places on it without blocking their view of what's happening. That's about to change.

A crystal rib cage, developed by a Boston University engineer—and being refined in collaboration with a BU medical researcher specializing in pneumonia—will enable scientists to visualize in real time how the lung develops immunity against infection.

"This innovation will enable us to visualize the entire lung with an optical microscope at different scales, from cell level all the way to the entire organ," says Hadi T. Nia, a BU College of Engineering assistant professor of biomedical engineering.

The crystal rib cage is one of two projects to win a 2023 Rajen Kilachand Fund for Integrated Life Sciences & Engineering award.

Since its launch in 2017, the fund has awarded $14 million to support projects that have advanced science, built collaborative structures for interdisciplinary research, and expanded funding opportunities. Past Kilachand award winners have made important scientific breakthroughs, secured patents, founded companies, and sparked important spin-off research.

"Our research is exactly the type of interdisciplinary work the Kilachand Fund was designed to support," says Joseph Mizgerd, a BU Chobanian & Avedisian School of Medicine professor of medicine, who is leading the crystal rib cage project with Nia. "Hadi can engineer systems that allow us to study lungs in ways that nobody else on Earth can. And I have immunological and respiratory infection expertise from decades of work on this topic. Working together, we can potentially transform how pneumonia is treated, and possibly other respiratory diseases and cancer." They were awarded $500,000 per year for up to three years.

BU trustee Rajen Kilachand (Questrom'74, Hon.'14) established the fund with a historic gift of $115 million with the aim of driving solutions to some of the biggest challenges in the life sciences, including heart disease, cancer, and degenerative brain diseases. The second 2023 winning project will investigate genetic and neuronal networks of healthy and diseased brains.

Nia (left) and Mizgerd won an award to advance research into pneumonia using a crystal rib cage.

Defending Against Pneumonia

A result of respiratory infection, pneumonia is a massive public health concern and more common among the elderly and in children. "Pneumonia is the number one cause of death globally for children under

five," says Mizgerd. "In the US, it's the top cause of hospitalization for children under 9, as well as the top cause of death for hospitalized people over 65 years of age." A person's age and history of prior infection are two key factors contributing to the incidence and severity of pneumonia.

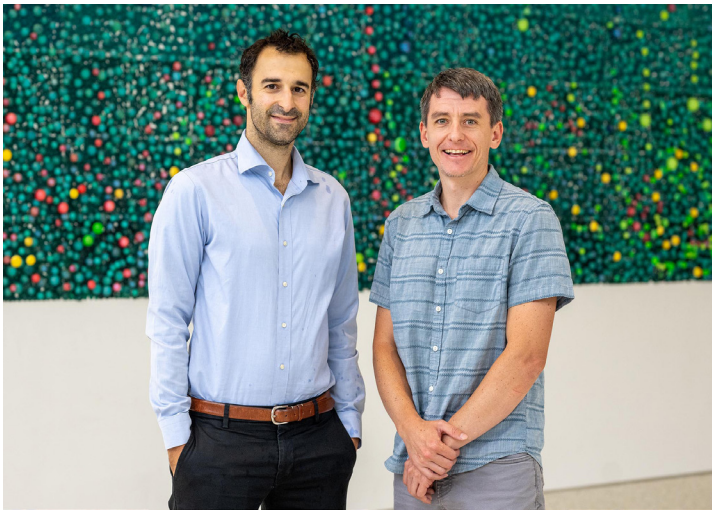
But scientists aren't sure why some people have immunity when others don't. Mizgerd says that understanding the impacts of age and prior respiratory infections on someone's immune response to pneumonia has been a long-standing challenge. People can be exposed to the same microbe and have vastly different outcomes—a phenomenon also seen with COVID-19. "There's something different within us that determines the outcome of these respiratory infections," says Mizgerd, "and we're trying to understand exactly what those differences might be."

The crystal rib cage "will allow us to visualize every step of disease progression in real time," says Nia. The researchers will also test how changes in the bloodstream and within the lung itself impact immunity. "In addition, we can evaluate the role of cells that are resident in the lungs and those circulating inside the bloodstream in order to evaluate how differences in age and infection experience affect immunity." That deeper understanding of exactly how immunity against pneumonia works could help inform further studies on prevention and treatment, from improving vaccines to developing new therapeutics.

Understanding Connections in the Brain

The brain is a complex network made up of thousands of cell types, each expressing a different set of genes. While these patterns of gene expression are associated with cellular connectivity, information processing, and susceptibility to disease, scientists still don't fully understand how they work. This year's other Kilachand Fund award winners intend to change that with a new approach to exploring how genes express themselves in the brain.

The traditional way of defining the impact of genetic expression on brain development and disease involves taking out one gene at a time from an animal and then seeing what happens. Does its brain wire up correctly or does it end up with a disease? "The downside of



Economo (left) and Cleary are working with Chen (not pictured) to give researchers a new tool kit for studying connections in the brain.

this classic approach is that it's just very, very slow," says Michael Economo (ENG'12), an ENG assistant professor of biomedical engineering. "And disease states often have multigenic sources, so isolating just one gene is limiting."

Instead, Economo and his colleagues are trying a novel investigative approach, building upon a technique called Perturb-Seq, which allows researchers to perturb (in other words, to prevent from working) multiple genes at once in a bunch of cells. The team's goal is to pool technologies developed in their respective labs to create a new toolkit—a platform they call Spatial Interrogation of Neurons and Genes, or SING—for better understanding connections in the brain.

The investigators will work to interpret not just how the manipulation of genes changes gene expression, but also how these changes impact cell connection and disease progression. "This is a very enabling technology that builds upon new developments across a number of different domains, including in experimental neuroscience, molecular genetics, virology, and more," says Economo, who is leading the project with Jerry Chen, a BU College of Arts & Sciences associate professor of biology, and Brian Cleary, a Faculty of Computing & Data Sciences assistant professor.

The trio views its work as potentially applicable "for investigating a large number of problems across domains, including the development of the normal functioning of the brain, how the brain wires its connectivity, and what happens in disorders of the

nervous system," says Economo. "We're trying to attack those problems in a way that hasn't been possible before."

The research being done by Economo, Chen, and Cleary is high risk, but has the potential for big rewards—it's very new, highly interdisciplinary, and could open up lots of fresh ground for other researchers. The team has been awarded $250,000 per year for up to two years.

"Federal funding agencies are so often hesitant to support this kind of research," says Economo, "but funding from the Kilachand award has been vital for seeding so many new ideas across multidisciplinary interests and expertise. We couldn't do this work without the fund's help."

BU'S INNOVATOR OF THE YEAR HAS PIONEERED DEVICES TO ADVANCE ASTRONOMY, MICROSCOPY, EYE EXAMS

PHOTONICS CENTER DIRECTOR THOMAS BIFANO RECOGNIZED FOR HELPING OTHERS NURTURE THEIR IDEAS AND FOR "ALWAYS TRYING TO SOLVE PROBLEMS"

by Andrew Thurston for *The Brink*, Photos by Jackie Ricciardi

Thomas Bifano, an ENG professor of mechanical engineering, is the cofounder of Boston Micromachines Corporation, a company specializing in deformable mirrors that he spun out of his BU lab 25 years ago.

The light from the stars filling the sky travels mind-boggling distances to reach us: the nearest star, beyond our own, is about 25 trillion miles from Earth. For most of its journey to our planet, that light is undisturbed, flying parallel and unimpeded through the vacuum of space. But then, in the very last microseconds, our atmosphere gets in the way, and the light bends.

If you're looking through a telescope, "the result is that the image is blurry, because not all of the light is getting to the right focus," says Boston University mechanical engineer Thomas Bifano.

For astronomers studying distant stars, blurry just won't cut it.

But Bifano created a solution: a mirror that can shift its surface as quickly as every millisecond to compensate for the atmosphere's fluctuating effect, pulling the image into focus. It's a technology, called MEMS (micro-electro-mechanical systems) deformable mirrors, that he's also used to improve eye exams, satellite communications, and imaging research—and that has now helped earn Bifano BU's Innovator of the Year award.

The director of the University's cross-disciplinary Photonics Center, Bifano is the 14th winner of the award, given to an "outstanding faculty member who has translated world-class research into an invention or innovation that benefits humankind." A holder of 10 patents, he's also chief technology officer of Boston Micromachines Corporation, a company he cofounded to develop and market deformable mirrors and other optics products.

"I'm deeply, deeply honored by the award," says Bifano, a BU College of Engineering professor of mechanical engineering. "But I'm also aware that my advocacy for others is partly responsible for why I've been chosen."

As head of the Photonics Center—which is a hub for the study of light and development of technologies utilizing it—Bifano has helped many others nurture their own innovations. The center is home to 70 faculty research labs and the Business Innovation Center, which hosts

tech, biotech, manufacturing, and medical devices start-ups and corporations.

"Tom's leadership at Boston Micromachines, where he solves real optics problems, and his role in connecting innovative research groups across the University via the Photonics Center, demonstrate his ability to think creatively and foster interdisciplinary collaboration," says biotech entrepreneur David Freedman (ENG'10), whose first company, NanoView Biosciences, was incubated and funded through the Photonics Center. Freedman is now back on campus, using the Business Innovation Center to cultivate his latest start-up, Everest Biolabs.

"Tom's ability to balance risk-taking with practicality and his commitment to fostering innovation make him a role model for success," he says. "He has his own innovative track record, but also creates an ecosystem of innovation."

Playing, Discovering, Failing, Solving

Before Bifano's MEMS deformable mirrors, existing peer technologies for bending light were big, expensive, and drained lots of power. That meant they were mostly only viable in large instruments—think a hulking telescope in a desert rather than a small microscope in a lab. His innovation was leveraging microfabrication techniques used for making microscopic objects—like inkjet printer nozzles—to develop tiny mirrors moved by electrostatic actuators. By creating deformable mirrors that were smaller, faster, cheaper, and more efficient, Bifano vastly opened up their range of applications.

He spun Boston Micromachines out of his lab in 1999 and says the company hitting its quarter of a century mark is gratifying—and not just because of the impact its technologies have had on astronomy, healthcare, and more.

"I've watched the employees there grow and raise their children, put them through college," says Bifano. "And the reason they've been able to do all those things, to have lives that are meaningful and useful, is a direct result of the innovations that we made here at BU."

One of those who has been at Boston Micromachines from the start is Paul Bierden, its president and CEO. A former student in Bifano's lab, Bierden (ENG'92,'94) helped him found the company.

"I have known Tom since I was 18 years old. He has been a teacher, a mentor, a business partner, and a friend," says Bierden. "He is a true engineer, which in my opinion, is that he is always trying to solve problems.

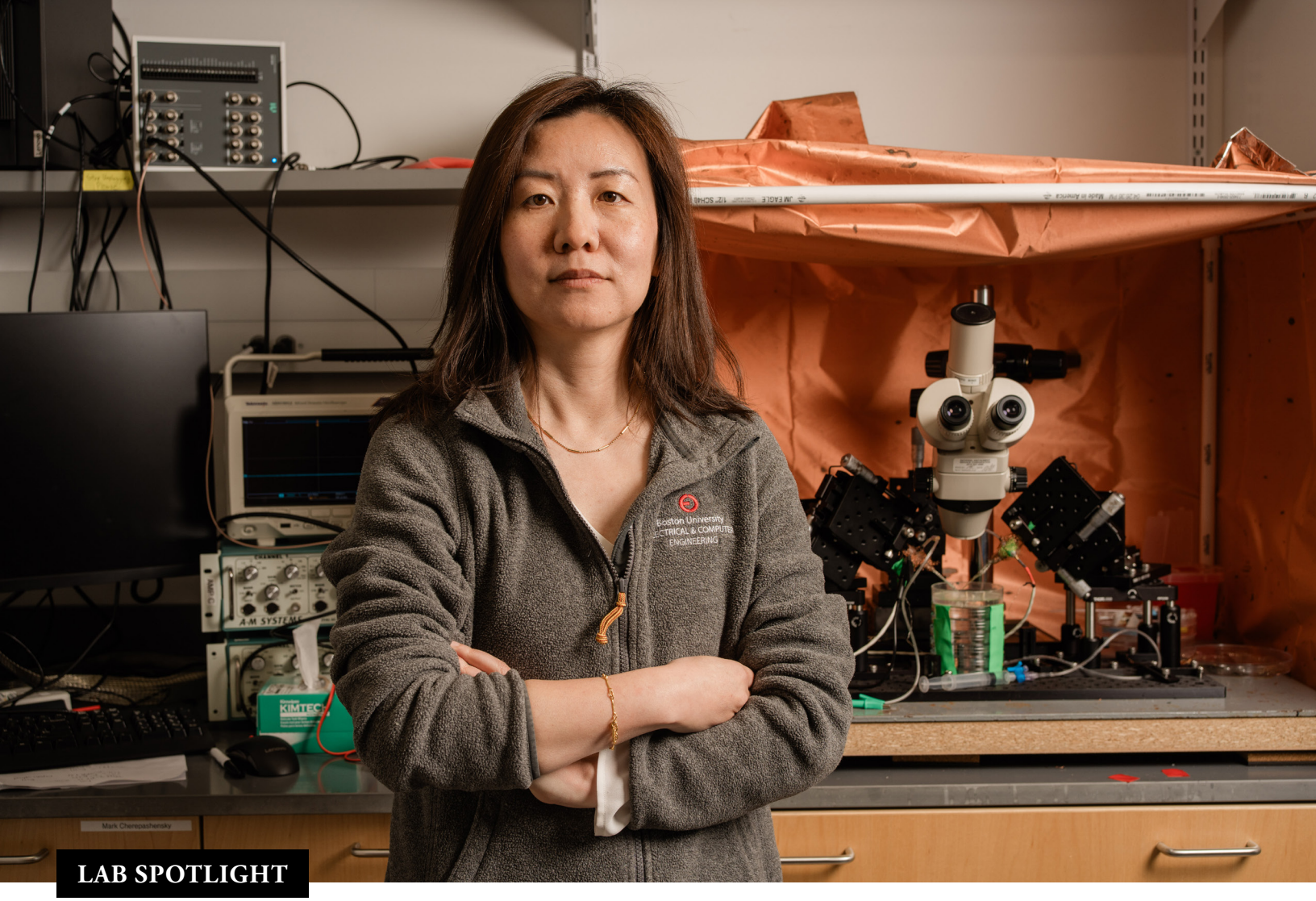
"Tom has always instilled in me to not be afraid to try something new. Dive into a problem, break things, flip switches, turn knobs, learn from your mistakes, and try again."

Those lessons in innovation are ones Bifano continues to share today, encouraging students to roll with the failures, to keep playing and discovering—but to also focus on the end goal.

"I tell my students early on—and the ones who grasp it do much better than the ones who don't—that you need to own the problems you're working on," he says. "You're not working on it because somebody assigned it to you, you own it, it's yours. The motivation is not to satisfy me or your doctoral committee, it's to knock down the problem.

"You're not really a good engineer unless the things you do turn into helpful benefits for society."

For more faculty news and articles, scan or go to bu.edu/photonics/category/faculty-news/



LAB SPOTLIGHT

DESIGNING A BETTER WORLD FOR THE PEOPLE SAT BESIDE YOU – PROFESSOR CHEN YANG'S LAB WORKS TO ENHANCE RETINAL AND BRAIN IMPLANTS

by Danny Giancioppo, Photos by Christopher McIntosh

Nanomaterials & Interdisciplinary Research

For recently promoted Professor Chen Yang, ECE, Chem, MSE making a societal impact through her work—utilizing nanotechnology to research, understand, and develop retinal and neurostimulative devices—is everything. The interdisciplinary nature of her research, meanwhile, is a natural part of the process.

"It's interdisciplinary because the goal, interest, and mission that we're pursuing is really focused on developing novel materials and making innovative devices as a neural interface, in particular for neurostimulation," Professor Yang says. "We like to not only record the neuroactivity—for example, you record brain waves to understand how the brain responds to different stimuli: light, language, behavior—but develop technology using those devices to control brain activity. To stimulate it or to inhibit it."

This multitude of goals allows Professor Yang and her team of graduate researchers to bring significant developments to the field of neurostimulation. Taking advantage of carbon- and polymer-based nanomaterials brings forth not only an enhanced understanding of stimulation in brains and eyes with damaged or suboptimal function, for example, but new and non-invasive means of studying, perhaps even improving said functionality.

The use of nanomaterials in optical and photonic devices helps to develop brain and retinal implants, taking advantage of the materials to contain strong absorption within optimal wavelengths, thereby producing clearer readouts of data, and offering solutions by way of improved visual and neural stimulation. And it's not only research like this that's so interdisciplinary in the Yang group.

"Our group members are actually very interdisciplinary," Yang says. "I have students from Chemistry, from Mechanical Engineering, from ECE (Electrical and Computer Engineering), from MSE (Materials Science & Engineering). And we also collaborate with groups and students with BME (Biomedical Engineering)."

Graduate students in Professor Yang's laboratory share a collaborative and varying list of responsibilities, from developing injectable solutions—that is, non-surgical implants—which can still be used as means to help restore vision, to developing electronic and photonics-based devices for

capturing neurostimulation data, to performing applications for non-drug pain reduction strategies via neural inhibitors. To be a successful student in Professor Yang's lab, she explains, a researcher must value teamwork, shared responsibility, and a willingness to share in both triumphs and defeats.

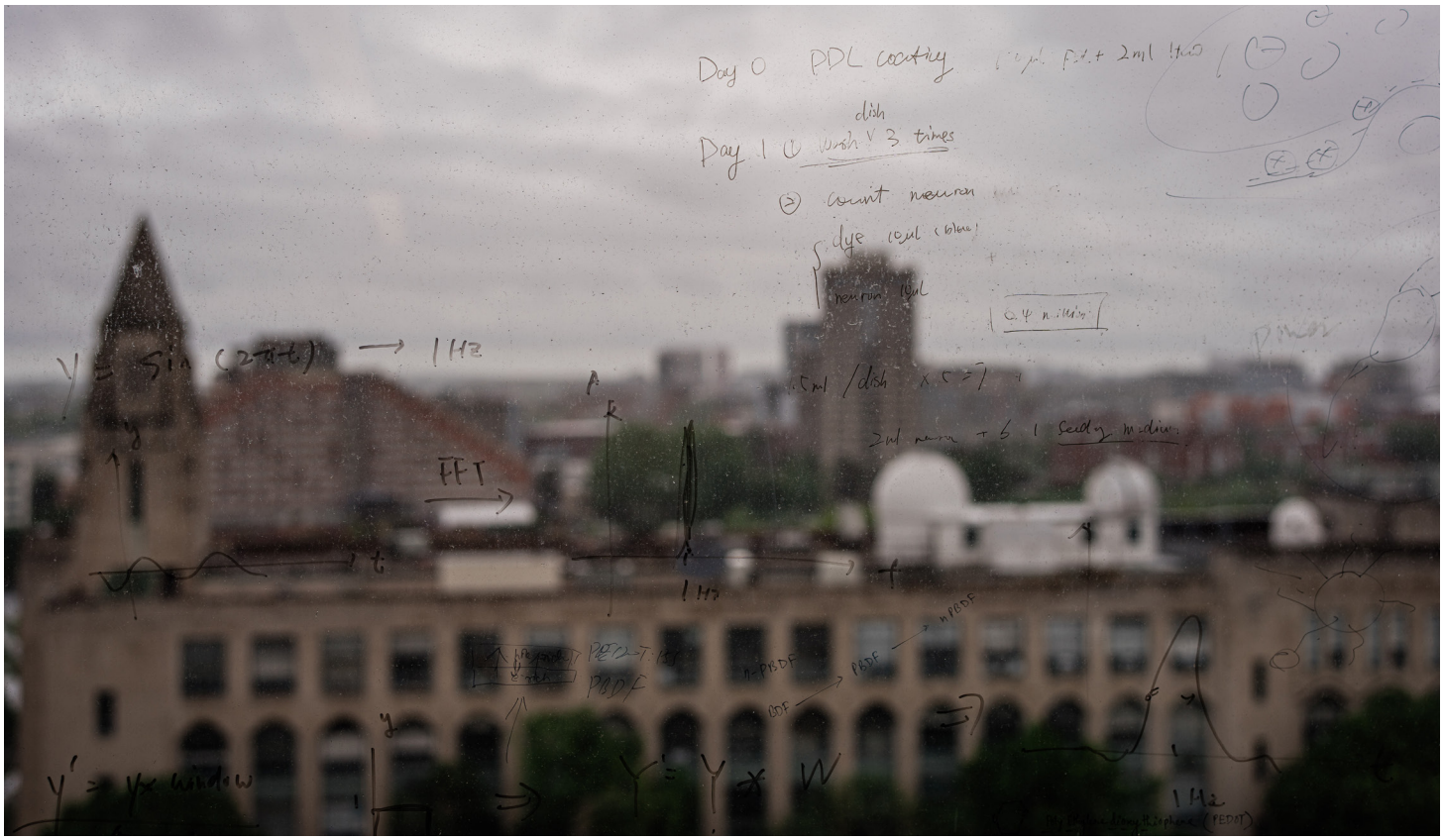
Professor Yang explains what successful students are to her: "Number one: they're not afraid of learning new things, taking new projects that they never touched on. In fact, all my students, when they joined my group—nobody knew how to culture neurons. They all learned from that first step […] When you are in research, every project you're solving is a new project. So you must be fearlessly interested in doing that."

"My students are brave. They are fearless. They believe 'as long as I learn, I'll be able to solve this problem.'"

Photoacoustics & Societal Impact

For anyone who hasn't heard of photoacoustics, it's as cool as it sounds, but perhaps simpler than you'd think. Described by Professor Yang as a "physics" or "energy-conversion process," photoacoustics is similar to wearing a black article of clothing in the summer; that black clothing soaks in a high amount of light and converts the energy into heat. In photoacoustics, the captured light is instead transferred into sound waves (ultrasound) to elicit a neuronal response. In other words, turning light into sound to study and improve brain and retinal function.

Professor Yang explains, "What's happening is, we deliver light to the device, the device will convert the



light energy into mechanical waves, and those produced mechanical waves will actually activate the neurons in the brain or in the retina."

Where this research method has a wide breadth of application, including treating disease models where drugs aren't helping. To elaborate, by using mechanical waves, neurons can be activated, meaning they will respond to the mechanical waves, to trigger neuronal activity in the brain. In some cases, this can be used to control the neuronal activity of a subject, thereby mitigating deviation or improper function, such as with epilepsy. It has even been shown to improve vision for the seeing-impaired.

"In retina application where photoreceptor cells are damaged, those generated mechanical waves can actually activate the healthy part of the retina and generate vision perception in the patient's brain," Professor Yang says.

If it seems like this particular research has the potential to change lives, that's because it has been precisely what Professor Yang has kept in mind since working at Boston University. While she hadn't begun as a researcher focusing on societal impact, "it's [been] a journey," for her.

"When I was a graduate student, or junior faculty, I worked on different types of projects," Yang says. "Some of them were more focused on science. Trying to discover new findings, to understand what exists and how it works. But I think BU is a great place that's allowed me to think that, when we work as engineers, it is possible to develop technology that can eventually become a product."

These products are eventually disseminated among other research labs worldwide—with such collaborators in California, Paris, and beyond. The ultimate goal being to not only enhance the understanding of brain and retina stimulation, but put it into practice as a commercialized product. Namely, practices like their high-precision, non-genetic stimulation project.

On a pixel level, using high-precision stimulation within the retina can aid blindness with non-invasive technology, offering a potential two- to three-times larger retinal implant than what's currently offered. By using a thin film to generate mechanical waves which stimulate the retina—with materials developed by her students—the healthy sections

of otherwise damaged retina are effectively perceiving restored vision. Her team of graduate researchers has even been looking at injectable solutions as an alternative to surgical implants. With all these advancements, Yang is hopeful that in five to ten years, the technology may be ready for human trials. And not a moment too soon, at that.

"The reason why I'm inspired to do this is because I know that it's needed," Yang says.

She and her graduate researchers closely collaborate with Professor Serge Picaud at the Institut de la Vision in Paris. When Yang was visiting with a graduate researcher, she says it was outside the lab that they shared a moment which emphasized the importance of their work.

"[Picaud's group] is in a building next to a hospital that specializes in treating blind patients. I saw more blind patients [there] than in the rest of my life." In a nearby café when the team went for a lunch, Yang explains, she and her colleagues saw a large group of vision-impaired patients sitting alongside them, eating lunch. "You know those French restaurants—they have very tiny tables, very narrow. [The patients] couldn't use their sticks, they had to put their hands on the [patient] in front of them. They formed one single line to come into the restaurant and sit down."

"That was a really inspiring moment for me. What we're discussing at this table eventually can benefit the people sitting next to us in the same restaurant. That's how close we can be socially impactful, and I think that's really, really exciting."

> "WHEN YOU ARE IN RESEARCH, EVERY PROJECT YOU'RE SOLVING IS A NEW PROJECT. IT'S A SOLVABLE NEW PROBLEM."
>
> *– Chen Yang*

Promotion to Full Professor & Prospective Students

Throughout her time at BU, Professor Yang has strived to make an impact not only in her university work, but society at large. When she was promoted to a full professor in March of 2024, she considered it recognition for the hard work she and her team started and enabled at BU, and a direct result of the resources and assistance enabled by her colleagues.

Yang describes the support from the Photonics Center community as "immediate" and "the most collaborative environment" she had seen while she and her research group transitioned onto campus in 2017. This included other BU faculty and colleagues teaching her and her students how to perform neuron culture studies, which they had little knowledge of beforehand—and now they're able to perform live animal experiments.

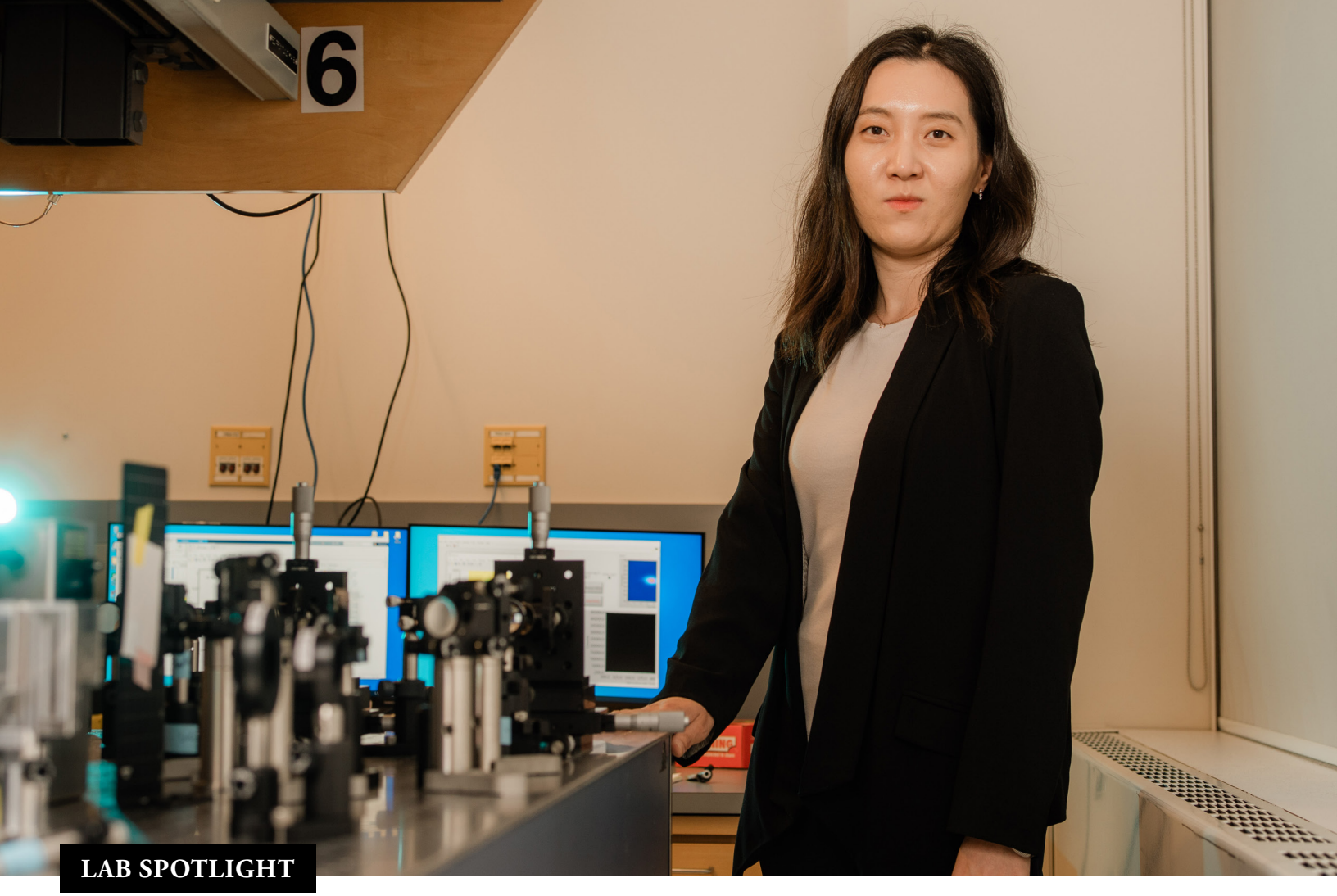
"Everyone is sincerely interested in the problem that we're solving and how we solve it," Yang explains. "They are willing to spend time looking at our work, our results, to help us. I don't have a neuroscience background at all—so we have to learn!"

Looking ahead, Yang wants any and all prospective students to be just as "fearlessly interested" in solving new tasks and learning new solutions. As an interdisciplinary team, she's more interested in a student's drive to advance their group's projects than the particular field of study they may be coming from.

"You really have to be willing to learn," she says. "To me, I feel that's a very general perspective we look for in a successful graduate student. You have to realize, when you are in research, every project you're solving is a new project. It's a solvable new problem." During this process, Yang goes on, students have to pick up new skill sets, and have an excitement for it.

Students, and indeed Professor Yang, herself, are deemed successful due to their confidence, their collaborative studies, and unending hunger to keep learning and adapting to new hurdles along the path to greater and wider-spread solutions.

Bravery, to Professor Yang, drives the confidence that has led to so much success in her research. "They believe, 'as long as I learn, I'll be able to solve this problem.'"



LAB SPOTLIGHT

LASER-FOCUSED: HOW MINJUNG SON'S RESEARCH BRINGS TOGETHER PHOTONICS AND CHEMISTRY FOR A BRIGHTER FUTURE

by Jack Osmond, Photos by Christopher McIntosh

Assistant Professor of Chemistry Minjung Son loves shooting lasers at things for a living—just check her Twitter bio for proof. She stumbled upon her passion for lasers, or ultrafast spectroscopy, as an undergraduate. After taking classes in physical chemistry and quantum mechanics, she joined a research group where she got the chance to work with laser spectroscopy on small molecules, like porphyrins, for the first time.

"I learned how to get my hands dirty. I just loved it. All these different colors in a dark lab, and we can actually measure some super fast processes that our eyes can't capture. I just got fascinated by that aspect." From that point on, she knew she wanted to pursue a graduate degree to further her research in the field.

While doing her PhD at MIT, Son fell in love with Boston and decided she wanted to continue doing research in the city. That led her to the BU Photonics center, where she's continuing her work with spectroscopy and physical chemistry. While she'll remain as a permanent faculty member at the center, her lab space is temporary – she is currently waiting for her permanent lab space to be finished in the Life Science and Engineering Building. Despite the temporary arrangement, Son jokes that she doesn't want to leave: "I

really like being here, and I kind of want to stay here forever if I can."

"This is such a nice place where I can interface with a lot of engineers and scientists who are all working on optics and photonics," Son continues. "Being here and interacting with other faculty and students who are similarly minded and excited about optics, spectroscopy, and photonics is really great."

Where Son differs from other faculty at the Photonics Center, however, is in her focus on chemistry. Yet Son's main focus on physical chemistry lies at the intersection of the Photonics Center's disciplines. "It's really interdisciplinary by definition […] We can talk to physicists like we're physicists, but we can talk to chemists making molecules." Son describes how her team uses "physical tools from physics and optics, but we actually apply those tools to study interesting molecular systems, which is more like a chemist."

Much of Son's research focuses on understanding light-harvesting molecular systems. Such systems can be both natural, like a plant photosynthesizing sunlight, or artificial, like a solar panel. These light-harvesting molecular reactions happen on the femtosecond timescale—that's one quadrillionth of a second. These light-harvesting systems absorb energy from the sun and put it towards functional work, making these reactions essential to understanding how humans can better capture and use energy from the sun. The only way to capture these reactions is to use ultrafast spectroscopy, which Son describes as, "using lasers or super short laser pulses to take snapshots of the pathways of those processes, energy transfer and electron transfer, so we can actually time-resolve the mechanism and the time scales of those processes."

> "WE'RE PROVIDING THE INDUSTRY PEOPLE, OR THE MATERIAL SCIENTISTS, WITH THE DESIGN PRINCIPLES OF HOW TO OPTIMIZE THOSE DEVICE STRUCTURES SO THAT THEY CAN BE BUILDING BLOC BLOCKS FOR REAL WORLD APPLICATIONS"
>
> *– Minjung Son*

Despite the small scale of these reactions, Professor Son's research understanding how they work makes a big impact on society. For example, the engineers and scientists in charge of making artificial light-harvesting systems (like solar cells) need to understand these molecular systems to enhance the utility of said systems. "They're not going to know [the systems] without the photophysical parameters that we measure."

"We're providing the industry people, or the material scientists, with the design principles of how to optimize those device structures," Son explains, "so that [the molecular structures] can be building blocks for real world applications and devices for things like LEDs."

Professor Son's research doesn't just influence industry, however. Her research is also critical for optimizing natural photosynthetic systems, most commonly found in plants. According to Son, these "are

actually the most efficient light-harvesters on this planet," and hold potential to combat worldwide food and energy crises.

"If you think about the ever growing demand for energy and food globally, photosynthesis has been proposed as a way to maybe address the problem, or the demand, because if you can figure out how to optimize the molecular-level photosynthetic mechanism, then people who are doing field studies have found that we can increase crop yields by 30% [...] so for that we have to delve into the molecular level stuff, which only we can do."

With all the talk of harvesting light, Professor Son is thrilled to be based in the Photonics Center, as she describes her current research as "really, really photonics-y." Presently, her team is working on polaritons: pairs of reflective gold or silver mirrors that trap light inside of them. When Son and her team put natural photosynthetic proteins inside of these mirror pairs, they interact with the intense light bouncing back and forth between the mirrors. Son and her team then use spectroscopy to gain further insight into how the interaction alters the photophysical pathways of the light-harvesting molecular system. This knowledge is essential in both optimizing natural systems and creating artificial ones.

"This is the prime example of how photonics can be interfaced with traditional physical chemistry research," Son says, "I'm super excited to see what actually comes out of this research."

Son's two undergraduate research assistants, Gabe Russo and Christopher Kretschman, are essential to her work. Russo, a chemistry major, works on actually building these polaritons. "He's doing a lot of the material science stuff," Son explains, such as making the mirrors and gluing them together. Part of this work includes finding the optimal distance between the two mirrors to create the strongest interactions.

Chris Kretschman, a physics and chemistry major, "is naturally really interested in working with lasers," much like Son. Kretschman spends a lot of time in the laser lab, helping Professor Son align the optics and measuring the pulse diagnostics, putting together a white-light generation setup. Compared to Russo, Kretschman's work relies more heavily on optics and photonics related research. If these two roles seem different, it only aligns with Son's philosophy as a mentor.

"I just want to be a mentor who lets people do what they're most excited about," she says. "I typically ask them and they pick two or three things, then I give each person an individual project that isn't the same as everyone else. But they're all broadly related under the same umbrella project, so they can always talk to each other."

In addition to her "really terrific" undergraduate students, Son is also recruiting graduate students. To Son, the most important aspect she looks for in research assistants is passion.

"You'll find something you love about research because our work is so interdisciplinary," she says. Including chemistry, physics, biophysics, programming, and coding. "If you have passion, and if you look at my website and that kind of stuff is what you're excited about, you can talk to me and we can go from there."

Events & Programs

THE PHOTONICS CENTER offers an exciting array of events and programs throughout the year to engage the community and offer enriching opportunities to Boston University, Boston area universities, and local companies. These events foster interdisciplinary discussion and encourage faculty and students to collaborate with a variety of professionals on fundamental research. A list of events organized by Photonics Center Staff is listed below. The Photonics Center Lunch and Learns were co-organized by the BU Student Chapter of Optica/SPIE.

Additionally, the Photonics Center CELL-MET staff supported a Perfect Pitch competition, monthly Trainee Journal Clubs, monthly Community Technical meetings, monthly Community Training meetings, professional development workshops for students and postdocs, team calls, numerous trainee socials, annual advisory board meetings, inclusion Thursday events, community visioning workshops and various community outreach events on campus and at collaborating institutions and schools.

INCLUDING...

Boston Photonics Day

Organized by the BU SPIE/Optica Student Chapter

Photonics Center Symposium 2023:

Photonic Chips in Everything

Chaired by Associate Professor Miloš Popović

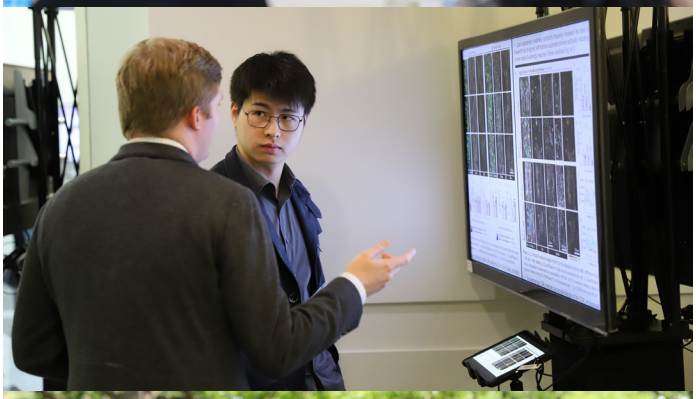
CELL-MET Materials Day 2023:

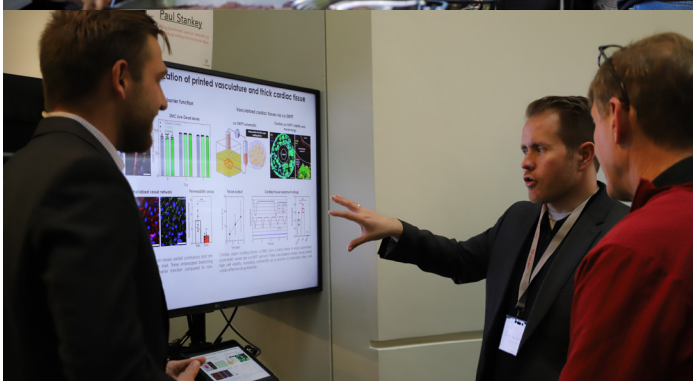
Cardiac Bioengineering: Approaches to Advance Study and Treatment of Cardiac Disease

CELL-MET NSF Site Visit 2024

6 Lunch & Learns

Co-Organized by the BU SPIE/ Optica Student Chapter





"Photonic Chips in Everything" Draws Hundreds of International Guests, *by Danny Giancioppo | Photonics Center Symposium 2023*

November 30th, 2023 marked the 25th annual Photonics Center symposium, which every year invites members of the photonics and optics fields to learn, present, and connect with colleagues from around the educational and industrial world. This year, Associate Professor Miloš Popović (ECE) hosted the event, with an industry focus on "Photonic Chips in Everything: Emerging Applications and Materials in Silicon Photonics Integrated Circuits."

What are Silicon PICs? Photonics Integrated Circuits are likely something everyone owns in some technology or other: smartphones, laptops, microwaves—the everyday amenities of modern day life. Using light over electricity as a form of power, the application of photonics chip is one with a wide variety.

Starting off with opening remarks from Dean Elise Morgan, the Photonic Center's 25th annual symposium featured ten speakers, as well as a panel discussion featuring said speakers, the Photonics Center symposium shed light on a number of these varying topics within the field of integrated circuits. Some topics included: "Scaling Photonic Quantum Computers" from Zachary Vernon of Xandau; "Going Beyond Moore's Law: Electronic-Photonic Systems-on-Chip for Compute, Communications and Sensing" from Vladimir Stojanovic of UC Berkeley and Ayar Labs; "Broadening the Spectrum: Silicon Photonics Beyond the Telecom Wavelengths" from Joyce Poon of the Max Planck Institute and University of Toronto; and "Silicon Photonics, A Foundry Perspective" from Ted Letavic of GlobalFoundries.

Additionally, special guest Chris Miller, economic historian and author of Chip War: The Fight for the World's Most Critical Technology, gave a brief presentation during lunch to discuss the contents of his book and how it related to the larger discussion of photonic integrated circuits. Namely, how several countries around the world are vying for chip building and import superiority. These chip risks, as well achievements, blended well into the conversation topics of the other presenters, as well as the panel session that ran later on.

Following the panel discussion, there was a reception and poster presentation shared on the seventh floor atrium of the Photonics Center building. There, student researchers were able to share their progress and goals as future leaders of the field, and connect with the many industry professionals in attendance.

With a packed house of international guests and aspiring industry change-makers in STEM, the Photonics Center's 25th annual symposium proved to be yet another success in bringing together learners and leaders in optics and photonics, and the world of photonic chips.

Scan or visit bu.edu/photonics/newsevents for more information on past and upcoming events

Shared Facilities for Research

A CORE COMMITMENT OF THE PHOTONICS CENTER is to provide its researchers with an advantageous research environment through establishment and continuous improvement of critical research infrastructure. Over the past year, we have realized this commitment through our financial and technical contributions in several key areas:

Faculty Startups & Laboratory Upgrades – We have facilitated new faculty startups with equipment and renovations for research labs, alongside regular lab enhancements and repairs.

Shared Laboratory Facilities – Our major shared lab facilities have been maintained and operated with the assistance of our dedicated technical personnel, ensuring seamless student training and optimal daily operations.

Equipment Acquisition – In our continued pursuit to elevate the standards of our shared laboratories and enhance their inventory, we have successfully acquired a diverse array of research equipment. This year has seen significant improvements in the Photonics Center shared labs, building upon the foundation of major capital purchases made in 2022 and early 2023.

Among our new additions are three pieces of capital equipment that significantly augment our shared labs' capabilities in micro/nano fabrication:

- Oxford DRIE
- ICP RIE
- Heidelberg MLA 150

The **Oxford DRIE** and **ICP RIE** machines are state-of-the-art pieces of equipment, bringing cutting-edge etching capabilities to our campus. The **Heidelberg MLA 150** is a maskless aligner with direct laser writing capabilities. This advanced lithography system eliminates the need for masks in optical lithography, dramatically reducing the prototyping turnaround in micro- and nanofabrication processes from weeks to minutes.

Beyond these major acquisitions, we have made several important upgrades to the shared labs:

- A new **Allwin21 Rapid Thermal Annealer** was acquired to replace the existing legacy RTA. This system is capable of reaching high temperatures within seconds, making it ideal for applications such as dopant activation, oxidation, silicidation, and other annealing processes.
- A new **Thermal Evaporator from Angstrom Engineering** was purchased to replace the aging Edwards Thermal Evaporator. This system is known for its precision in controlling deposition rates and thicknesses, allowing for high-quality, uniform thin film deposition in matieral science and semiconductor research.
- A new **Thermo-Fisher Desktop SEM with EDS capability** was comissioned, expanding our micro- and nano-imaging accessibility. The Phenom ProX G6 is an advanced desktop scanning electron microscope (SEM) designed for high-resolution imaging and analysis, featuring an integrated energy-dispersive X-ray spectroscopy (EDS) system, and enabling detailed elemental analysis and compositional mapping of samples.
- Substantial repairs and improvements were carried out to our existing **SEM, SEM-converted EBL, TEM, and FIB systems**, ensuring that these critical pieces of equipment continue to meet the evolving needs of our research community.

New scheduling platform – We continuously evaluate our shared labs' functionality to eliminate operational bottlenecks and enhance efficiency. This ongoing initiative aims to improve service delivery and better meet our researchers' needs.

After a thorough analysis of our long-standing Google Calendar-based equipment scheduling system, we identified inefficiencies leading to time waste and inequitable instrument usage. Consequently, we have adopted FOM Networks, a new scheduling platform that offers live-usage tracking, real-time instrument breakdown reporting, and integration with hardware access control. This new system not only streamlines scheduling, but helps safeguard the functionality and integrity of our instruments through improved monitoring and management.

The Photonics Center's Shared Labs

Boston University's Photonics Center operates four shared laboratories, which serve as the nexus for the fabrication and characterization of micro/nano structures. These laboratories have emerged as indispensable elements of BUPC's research pursuits for various reasons, including their accessibility, free-of-charge availability for BUPC's faculty and students, and the provision of staff support and training, among other factors.

The Optoelectronic Processing Facility (OPF) is a multi-user laboratory spanning over 2500sf and dedicated to the fabrication of optoelectronic and photonic devices. It encompasses processing and testing equipment for thin film deposition, photolithography, wet and dry chemical processing, plasma etching and cleaning, metallization, thermal oxidation, thermal annealing, wire bonding, electrical characterization, test, and assembly. Following the recent acquisition of three significant pieces of capital equipment, OPF is poised to undergo a substantial improvement in its etching and optical lithography capabilities. The OPF is managed by Paul Mak.

The Precision Measurement Laboratory (PML) is dedicated to measurement and analysis of micro/nano structures, and to e-beam lithography of nanostructures. It consists of two laboratory spaces with equipment for field-emission scanning electron microscopy, atomic force microscopy, surface mapping interferometry, Fourier-transform infrared spectroscopy, and scanning electron beam lithography. The PML is managed by Alexey Nikiforov and Arthur Shih, who joined the Photonics Center in August 2024.

The Focused Ion Beam/Transmission Electron Microscope Facility (FTF) is dedicated to nanometric and sub-nanometric machining and characterization of material composition, image surface morphology, and micro/nano machined materials. It consists of a laboratory with a focused ion beam tool and a transmission electron microscope, along with facilities for sample preparation and characterization. The FTF is managed by Alexey Nikiforov.

The Materials Science Core Facility (MSCF) is dedicated to materials science characterization. It consists of processing hoods for materials preparation and equipment for X-ray crystallography, atomic force microscopy, and Raman Spectroscopy. It is managed collectively by staff from the BUPC with support from the Materials Science and Engineering Division of the College of Engineering.

Scientific and Technical Themes

The Photonics Center research themes are:

- Biophotonics & Bioimaging
- Lasers, Nonlinear Optics, and Quantum Photonics
- Neurophotonics
- Nanophotonics
- Photonic Materials and Devices
- Photonic Metamaterials

These research themes are not all-encompassing of our members' areas of interest, but they represent areas in which we have substantial activity and reputation, and in which we have made significant investments in research infrastructure through shared lab facilities and other infrastructural support.

The outcomes of research in these thematic areas have an impact on society through applications in such fields as medical imaging systems, diagnostics, laser communication, chemical and biological material synthesis, laser system development, automation, and defense. In general, research at the Center focuses on practical uses of light-based technologies.

If/How Priorities and Strategic Goals Were Met this Year

Central to the Photonics Center strategic plan is an operational model where the Center functions as a university resource – promoting, supporting, and sustaining allied research centers and interdisciplinary programs across BU. The Center has been conducting business as an institute, leading on several activities such as the BIC, managing and equipping shared laboratories, and administering/supporting major grants and supporting affiliated units.

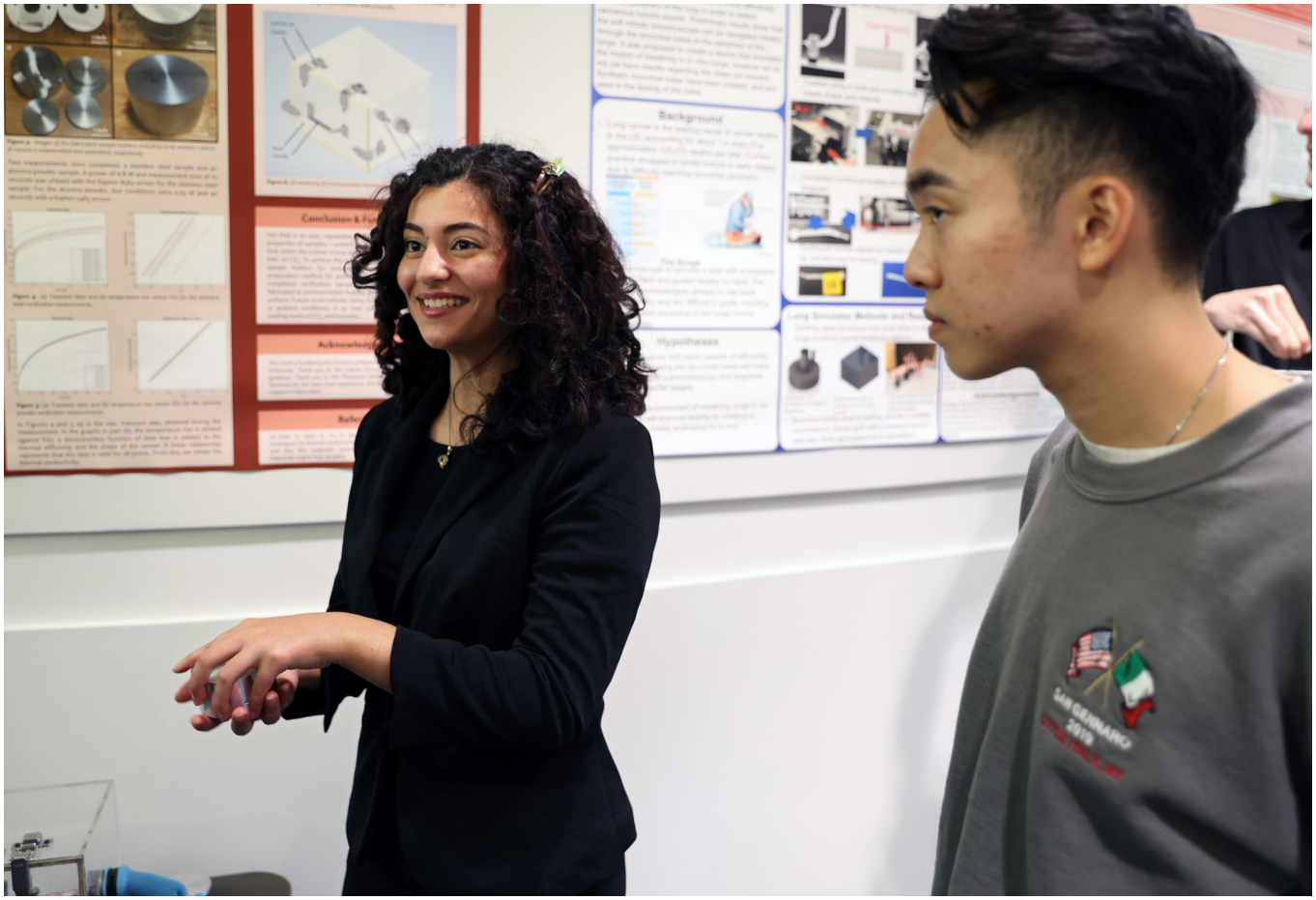
Some of the affiliated units include the Materials Science and Engineering Division, the Neurophotonics Center, and the CELL-MET ERC. With respect to the Materials Division, the Photonics Center has managed substantial renovations for the Materials Division and co-manages its shared facilities.

In support of its strategic goal of expanding core programs for research support, the Photonics Center provides strategic advice, critical review, management, and logistical support for large scale, complex collaborations proposed for external sponsorship, including research and educational projects. Major successes include the award of two training grants including the NSF NRT grant on Understanding the Brain (UtB) in FY17, which led to the new NIH T32 Graduate Training at the Interface of Neuroscience, Optical Engineering and Data Science with David Boas as PI and co-PIs Jerry Chen and Michelle Sander; the CELL-MET ERC in FY18 and subsequent successful five-year renewal in FY23; the award of an NSF MRI in FY23 for the acquisition of a Spinning Disk Confocal Super-Resolution Microscope for Transcriptomics Research now installed in LSEB; multiple NSF REU, RET and REM programs and supplements; the recent approval of an endowment award to establish a $1M fellowship support for graduate students and postdocs. Our support for research extends to post-award activities, including project administration, communications, and financial tracking and reporting. The Photonics Center provides outsized support for the CELL-MET ERC, assuming leadership roles in Administration, Innovation Ecosystems, Imaging research and Budget and Strategy leadership. The Photonics Center also took on the implementation and management of the multi-institutional NIH U19: Local Neuronal Drive and Neuromodulatory Control of Activity in the Pial Neurovascular Circuit, which is starting its fourth year of five years, with Professor Anna Devor as PI through the NIH BRAIN Initiative; the Kilachand Award for Professors Xin Zhang, Stephan Anderson and Yannis Paschilidis entitled Metamaterial and AI-Enabled Ultra-Low Field MRI for Low-Cost, Portable Brain Imaging, as well as Professor Enrico Bellotti's DOD/ARL funded Center for Semiconductor Materials and Device Modeling (CSM), which renewed last fall for $6.25M for five years and which includes a consortium of six industry and two academic partners.

The Center has expanded its research administration service to a full-cycle model, streamlining the transactional flow and supporting the interdisciplinary, multi-institution programs from proposals to final reporting. Our team

worked closely with the Photonics research community to prepare 16 grant, scholarship and endowment-matching proposals in FY24 totaling $13.8M in requested funding, and receiving $7.2M in awards over the same period. In support of our three largest awards, CELL-MET (NSF Engineering Research Center), USArhythms (NIH U19) and the Center for Semiconductor Materials and Devices Modeling (ARL CSM), we processed subawards for 16 sites encompassing 34 individual accounts that support the complex configuration of these project-based interdisciplinary programs. Among the proposals submitted during this fiscal year, Professor Xin Zhang's REU Site: Integrated Nanomanufacturing, part of NSF's prestigious Research Experiences for Undergraduates program, was awarded a renewal after nine years of successful run at the Photonics Center. Dr. Marshall Ma, a former BU Ph.D. student and postdoctoral researcher, received a residency scholarship to conduct research at FDA under the mentorship of Professor Christopher Chen.

In summary, the Center has had an exceptional year of continued progress toward our primary strategic goal of building and maintaining a major university hub for interdisciplinary research and training in the convergent area of Photonics.



2024 REU/RET Poster Session, Credit: Jack Osmond

Faculty Committees

The Photonics Center has five standing committees that support and serve its faculty and staff. The Photonics Center Director appoints the committee chairs.

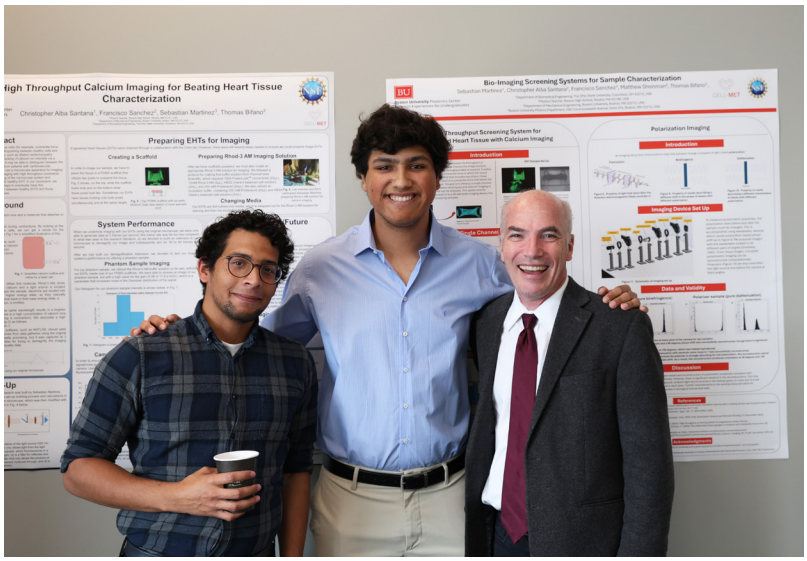
Photonics Center Guest Speakers: 2023-2024 Chair – Carolyn Marar
The Distinguished Speaker Seminar Series is managed by student leaders of the BU student chapters of the Optica, SPIE, and IEEE. With support by the Photonics Center for travel and seminar expenses, students host a distinguished speaker of their choice each semester as well as monthly Lunch and Learns.

Academic Advisory: 2023-2024 Chair – Professor Thomas Bifano
The Academic Advisory Committee advises the Director of the Photonics Center on educational and academic issues, as well as membership, and is comprised of the chairs from the Center's cognate departments.

Space Allocation: 2023-2024 Chair – Professor Thomas Bifano
This committee chair generates policy guidelines for space management.

Symposium: 2023-2024 Chair – Professor Miloš Popović
The Photonics Center Symposium was held on November 30, 2023, chaired by Associate Professor Miloš Popović, and entitled, "Photonic Chips in Everything: Emerging Applications and Materials in Silicon Photonics Integrated Circuits." Starting off with opening remarks from Dean Elise Morgan, "Photonic Chips in Everything" featured ten speakers, as well as a panel discussion. The Photonics Center symposium shed light on a number of topics within the field of integrated circuits.

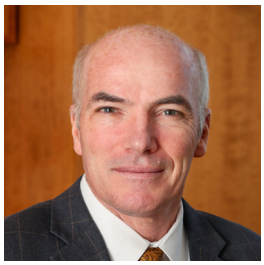
Education Committee: 2023-2024 Chair – Professor Ji-Xin Cheng
This committee focuses on three areas in particular. 1) recruitment of graduate students with a particular interest in photonics or optics to graduate programs in the Photonics Center's cognate departments, 2) creating a vibrant, distinctive community for our students and postdocs which highlights professional development, student-led communal scholarly activities, and shared resources, 3) applying for training grants and fellowships. Faculty members on the committee are Darren Roblyer and Björn Reinhard and staff members are Cara Ellis McCarthy, Beth Mathisen, and Hossein Alizadeh.



From top to bottom: 2023 REU/RET Poster Session, 2024 Poster session, 2023 Symposium, Credit: Kelly Peña, Jack Osmond, Danny Giancioppo

Center Leadership & Staff

Hossein Alizadeh, Ph.D.
Technical Director



Thomas Bifano, Ph.D.
Center Director

Meghan Foley
Assistant Director of Finance & Administration

Danny Giancioppo
Communications Manager

Maria Harlow
Associate Director of Administration, ERC

Brenda Hugot
Associate Director of Summer Programs & Outreach

Nozomi Ito
Associate Director of Grants Administration

Paul Mak
Laboratory Manager

Beth Mathisen
Assistant Director of BIC, Grants, & Initiatives

Cara Ellis McCarthy
Executive Director

Alexey Nikiforov, Ph.D.
Laboratory Manager

Kelly Peña
Multimedia Manager

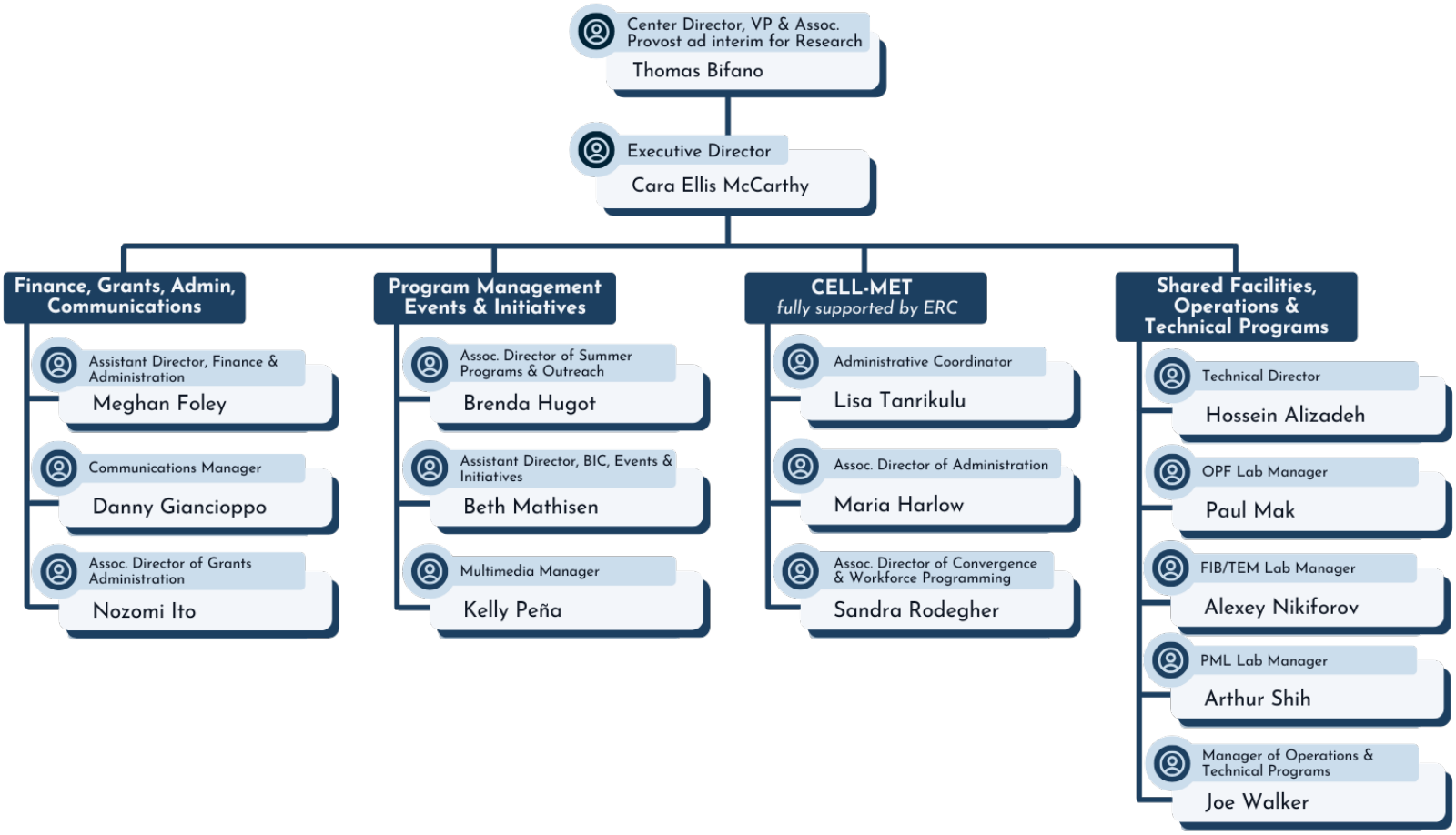
Sandra Rodegher, Ph.D.
Associate Director of Convergence and Workforce Planning

Arthur Shih, Ph.D.
Laboratory Manager

Lisa Tanrikulu
Administrative Coordinator, ERC

Joe Walker
Manager of Operations & Technical Programs

Organizational Chart



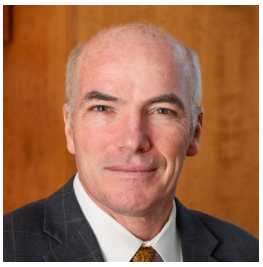
Photonics Center Faculty

Michael Albro
Assistant Professor,
BME, ME, MSE

Stephan Anderson
Professor,
ME, Medicine

Soumendra Basu
Professor,
ME, MSE

Enrico Bellotti
Professor,
ECE, MSE



Thomas Bifano
Professor,
BME, ME, MSE

Iriving Bigio
Professor,
BME, ECE, Medicine, Physics

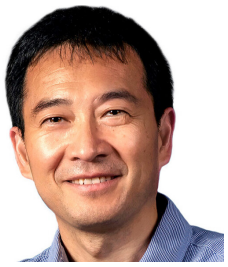
David Bishop
Professor,
BME, ECE, ME, MSE, Physics

David Boas
Professor,
BME, ECE

Keith Brown
Associate Professor,
ME, MSE, Physics

Scott Bunch
Associate Professor,
ME, MSE

Jerry Chen
Associate Professor,
Biology, BME



Ji-Xin Cheng
Professor,
BME, ECE, MSE

John Connor
Associate Professor,
Medicine

Luca Dal Negro
Professor, ECE, MSE,
Physics

Ian Davison
Associate Professor,
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Anna Devor
Professor,
BME

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BME

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Photonics Center Faculty

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ECE

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Steve Ramirez
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Benjamin Scott
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Alexander Sergienko
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Tianyu Wang
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ECE

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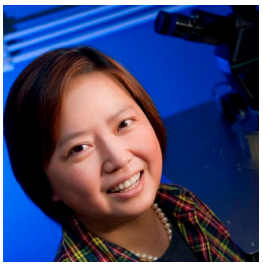
John White
Professor,
BME

Chen Yang,
Professor,
Chemistry, ECE



Xin Zhang,
Professor,
BME, ECE, ME, MSE

Lawrence Ziegler,
Professor,
Chemistry, MSE

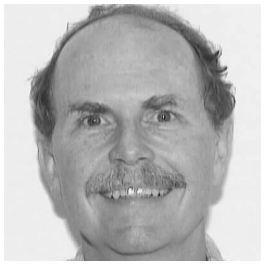
Bennett Goldberg
Professor Emeritus,
Physics

Allyn Hubbard
Professor Emeritus,
BME, ECE

Theodore Morse
Professor Emeritus,
ECE, MSE

Theodore Moustakas
Professor Emeritus,
ECE, MSE

Kenneth Rothschild
Professor Emeritus,
Physics



Michael Ruane
Professor Emeritus,
ECE

Malvin Teich
Professor Emeritus,
BME, ECE, Physics

Barry Unger
Associate Professor Emeritus,
MET

Photonics Center PhD Students and their Dissertation Titles

Photonics Center Faculty Member	Academic Year 2023-2024 PhD Graduates and Dissertation Titles
Michael Albro	**Sedat Dogru** *"Transport of Transforming Growth Factor-Beta in Native and Engineered Articular Cartilage"*
Michael Albro	**Tinbai Wang** *"Bio-Inspired Latent Transforming Growth Factor Beta Scaffolds for Cartilage Regeneration"*
Soumendra Basu	**Jillian Rix Mulligan** *"Relating Microstructure and Performance of Solid Oxide Cells for Improving Performance and Mitigating Degradation"*
Soumendra Basu	**Rohan Soni** *"Surface Nitridation o fAluminum Alloys for Protective Nitride Coating"*
Enrico Bellotti	**Mike Zhu** *"Simulation of Advanced Semiconductor Devices with 3D Monte Carlo"*
Thomas Bifano	**Wenkuan Man** *"Stress-Resilient Electromagnetically Actuated Deformable Mirror"*
Irving Bigio	**Nathan Blanke** *"Birefringence Microscopy for High-Resolution Imaging of Myelinated Axons and Myelin Pathology in the Postmortem Brain"*
David Bishop	**Zelin Ma** *"Light Transport by Topological Confinement"*
David Boas	**Shuaibin Chang** *"Serial Sectioning PSOCT and 2PM for Imaging Post-Mortem Human Brain and Neurodegeneration"*
David Boas	**John Giblin** *"Quantifying the Effects of Cerebral Capillary Flow Disruptions with Two Photon Microscopy"*
David Boas	**Sharvari Zilpelwar** *"Laser Speckle Based Techniques for Blood Flow Estimation in Small Animal and Human Brain"*
Keith Brown	**Kelsey Lawrence Snapp** *"Discovering Tough and Impact-Resistant Structures Using a Self-Driving Lab"*
Scott Bunch	**Fartash Samie Yousefi** *"Dynamics of Molybdenum Disulfide Resonators Coupled to Acoustic and Mechanical Systems"*
Jerry Chen	**Mitchell Clough** *"A Wide Field-of-View Multi-Are Two-Photon Microscope for Simultaneous Imaging of Sensory and Motor Cortex in the Mouse Brain"*

Photonics Center Faculty Member	Academic Year 2023-2024 PhD Graduates and Dissertation Titles
Jerry Chen	**David Lee** *"Investigating the Functional Roles of Perirhinal Cortex in Goal-Directed Learning at*
Jerry Chen	**Caroline McLachlan** *"Functional and Molecular Properties of Learning-Related Neuroplasticity in Perirhinal Cortex"*
Ji-Xin Cheng	**Yueming Li** *"Optically-Generated Ultrasound for Non-Invasive Brain Stimulation"*
Ji-Xin Cheng	**Jiaze Yin** *"High-Speed Mid-Infrared Photothermal Microscope for Dynamic and Spectroscopic Imaging"*
Ji-Xin Cheng	**Jing Zhang** *"High-Throughput Single-Cell Imaging and Sorting by Stimulated Raman Scattering*
Ji-Xin Cheng	**Haonan Zong** *"Wide-Field Mid-Infrared Photothermal Microscopy: From Wide-Field to Volumetric*
John Connor	**Jacquelyn Turcinovic** *"Host Responses to Viral Infection and Genomic Variation During Pandemic*
Luca Dal Negro	**Yilin Zhu** *"Design and Characterization of Advanced Diffractive Devices for Imaging and Spectroscopy"*
Mary Dunlop	**Caroline Margret Blassick** *"Characterizing Heterogeneity in Escherichia coli Gene Expression and Its Consequences for Antimicrobial Tolerance"*
Mary Dunlop	**Michael Brian Sheets** *"Light-Inducible Tools for Control of Bacterial Gene Expression and Antibiotic Resistance"*
Kamil Ekinci	**M. Çağatay Karakan** *"A Direct-Laser-Written Heart-on-a-Chip Platform for Generation and Stimulation of Engineered Heart Tissues"*
Xue Han	**Emma P. Bortz** *"Noninvasive Ultrasound Alters Neuronal Activity in the Awake Mammalian Brain"*
Xue Han	**Sudiksha Sridhar** *"Neural Network Processing of External Cues During Learning and Locomotion Across Brain Regions"*
Ajay Joshi	**Zahra Azad** *"On Designing Hardware Accelerator-Based Systems: Interfaces, Taxes and Benefits"*
Ajay Joshi	**Cansu Demirkiran** *"Building Next-Generation Deep Learning Hardware Using Photonic Computing"*

Photonics Center Faculty Member	Academic Year 2023-2024 PhD Graduates and Dissertation Titles
Maria Kamenetska	**Brent Lawson** *"Strategies for Molecular Junctions with Expanded Degrees of Freedom"*
Xi Ling	**Lu Ping** *"2D Wide Bandgap Transition Metal Oxides: Synthesis and Photoelectron Spectroscopic Studies"*
Jerome Mertz	**Shuqi Zheng** *"Speckle Applications for Volumetric Imaging of Biological Dynamics"*
Abdoulaye Ndao	**Guang Yang** *"Exceptional Points and Adiabatic Evolution in Optical Coupled Mode Systems"*
Hadi Nia	**Sue Shuyi Zhang** *"Quantification of Solid Stress and Subcellular Structures Using Imaging-Based Techniques"*
Roberto Paiella	**Jianing Liu** *"Directional Photodetectors Based on Plasmonic Metasurfaces for Advanced Imaging Capabilities"*
Miloš Popović	**Kenaish Al Qubaisi** *"Toward an Active CMOS Electronics-Photonics Platform Based on Subwavelength Structured Devices"*
Miloš Popović	**Dorde Gluhovic** *"Towards Scalable Quantum Technologies: Monolithically Integrated Electronic-Photonics Light Sources"*
Miloš Popović	**Deniz Onural** *"Silicon CMOS Electronic and Photonic Integrated Circuit Platforms for Photonic Superconducting Circuit Interfaces and Microwave Signal Processing"*
Miloš Popović	**Manuj Kumar Singh** *"Electronic-Photonic Millimeter-Wave Systems-On-Chip and Passive Devices in Silicon CMOs Photonics"*
Siddharth Ramachandran	**Zelin Ma** *"Light Transport by Topological Confinement"*
Steve Ramirez	**Kaitlyn Dorst** *"Hippocampal Engrams Generate Flexible Behavioral Responses and Brain-Wide Network States"*
Steve Ramirez	**Rebecca Suthard** *"Neuron-Astrocyte Calcium Dynamics in Fear Learning and Memory"*
Darren Roblyer	**Carlos A. Gomez** *"Non-Invasive Monitoring of the Respiratory Muscles via Diffuse Optical Modalities"*
Darren Roblyer	**Samuel S. Spink** *"Next Generation near Infrared (NIR) and Shortwave Infrared (SWIR) Wearables for Breast Cancer Imaging"*

Photonics Center Faculty Member	Academic Year 2023-2024 PhD Graduates and Dissertation Titles
Darren Roblyer	**Anahita Pilvar** *"Shortwave Infrared Spatial Frequency Domain Imaging to Quantify Blood Lipids"*
Darren Roblyer	**Kuan Cheng Wu** *"Critical Closing Pressure with Pulsatile Diffuse Optical Signals"*
Michelle Sander	**Panagis Samolis** *"Thermal Diffusion Dynamics as a Contrast Mechanism in Mid-Infrared Photothermal Microscopy"*
Michelle Sander	**Shutao Xu** *"Thulium-Doped Ultrafast Fiber Laser System Designs and Dynamics"*
Benjamin Scott	**Rifqi Affan** *"Neural Mechanism of Planning"*
Joshua Semeter	**Joaquín Díaz Peña** *"High Latitude Ionospheric Flow Channels: Effects on the Polar and Subauroral Region Dynamics"*
Joshua Semeter	**Meghan LeMay** *"High-Rate Electron Density and Temperature of Ionospheric E-Region Derived Through GNSS-Optical Sensor Fusion"*
Lei Tian	**Joseph Greene** *"Computational Extended Depth of Field Fluorescence Microscopy in Miniaturized and Tabletop Platforms"*
Lei Tian	**Shiyi Cheng** *"Augmenting Label-Free Imaging Modalities with Deep Learning Based Digital Staining"*
Brian Walsh	**Emil A. Atz** *"Satellite Instrumentation Methods to Probe the Spatial Extent of Magnetopause Magnetic*
John White	**Jacob Frederick Norman** *"Investigating the Neural Activity Elicited by Induced Memory Recall"*
Chen Yang	**Nan Zheng** *"Multifunctional Photoacoustic Materials for Neural Engineering"*
Xin Zhang	**Yuwei Huang** *"Dynamic Metamaterials Towards Terahertz Applications"*

Scholarly Work of the Photonics Center Faculty

BOOKS [2]

Argwal, R. & **Joshi, A.** (2023). *On Architecting Fully Homomorphic Encryption-based Computing Systems.* Springer Nature.

BOOK CHAPTERS

Argwal, R. & **Joshi, A.** (2023). *On Architecting Fully Homomorphic Encryption-based Computing Systems.* Springer Nature.

Ma, Y., Joardar, B., Pande, P., & **Joshi, A.** (2023). "Interconnect and Integration Technology." In A. Chattopadhyay, & M. Sabry (Eds.), *Emerging Computing: From Devices to Systems – Looking Beyond Moore and Von Neumann*. Springer Nature.

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Liu, X., Halvorsen, S., Blanke, N., Downs, M., Stein, T. D., **Bigio, I. J.**, . . . Zhang, Y. (2023). "Progressive Mechanical and Structural Changes in Anterior Cerebral Arteries with Alzheimer's Disease." *Res Sq.* doi:10.21203/rs.3.rs-3283587/v1

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[2]Scholarly publications are reported for Calendar Year 2023. Publications with "**" indicate two or more faculty contributors.

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Chang, S., Yang, J., Novoseltseva, A., Abdelhakeem, A., Hyman, M., Fu, X., . . . **Boas, D. A.**, Wang, H. (2023). "Multi-Scale Label-Free Human Brain Imaging with Integrated Serial Sectioning Polarization Sensitive Optical Coherence Tomography and Two-Photon Microscopy." *Adv Sci (Weinh), 10*(35), e2303381. doi:10.1002/advs.202303381

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FACULTY AWARDS

- Professor **Soumendra Basu** was elected as Vice Chair, Functional Materials Division, TMS, Functional Materials Division, 2023
- Professor **Enrico Bellotti** was honored as an IEEE Senior Member, IEEE, 2023
- Professor and Center Director **Thomas Bifano** was awarded BU's 2024 Innovator of the Year
- Professor **David Boas** delivered the 2023 DeLisi Lecture at the College of Engineering
- Professor **Ji-Xin Cheng** was awarded BU's 2023 Innovator of the Year
- Professor **Ji-Xin Cheng** won SPIE Biophotonics Technology Innovator Award
- Professor **Ji-Xin Cheng** delivered the 2024 DeLisi Lecture at the College of Engineering
- Professor **Ji-Xin Cheng** won the American Chemical Society Division of Analytical Chemistry's Spectrochemical Analysis Award, 2024
- Associate Professor **Mary Dunlop** was elected as an American Institute for Medical and Biological Engineering (AIMBE) Fellow, 2023
- Assistant Professor **Michael Economo** was elected a Scialog Fellow, Research Corporation for Science Advancement, Tuscon, United States, 2023
- Assistant Professors **Michael Economo** and **Hadi T. Nia** won respective Kilachand Fund Awards for Integrated Life Sciences and Engineering, 2023
- Professor **Ajay Joshi** won the Best Paper Award, IEEE, International Symposium on Hardware Oriented Security and Trust (HOST), 2023
- Assistant Professor **Maria Kamenetska** was featured in the Chemical Science Reviewer Spotlight, Chemical Science Journal, Royal Society of Chemistry, 2023
- Professor **Catherine Klapperich** was elected as a fellow for the International Academy of Medical and Biological Engineering, 2023
- Assistant Professor **Sean Lubner** received the Dean's Catalyst Award, 2023
- Assistant Professor **Sean Lubner** received the 2024 Young Investigator Program (YIP) award from the Air Force Office of Scientific Research
- Assistant Professor **Hadi T. Nia** won the Early Career Excellence Award, College of Engineering, 2023
- Assistant Professor **Hadi T. Nia** won the American Thoracic Society Science and Innovation Center Award, American Thoracic Society, 2023
- Assistant Professor **Hadi T. Nia** won the NSF Career award, 2023
- Assistant Professor **Hadi T. Nia** was named a 2024 Sloan Research Fellow
- Professor Emeritus **Theodore Moustakas** was named Optica's 2024 Nick Holonyak Jr Award Recipient
- Professor **Roberto Paiella** was named Optica Society Fellow, 2024
- Professor **Miloš Popović** named an NAI Fellow, 2024
- Professor **Siddharth Ramachandran's** "Topological confimenet" paper highlighted as one of 30 significant articles in 2023 by Optics and Photonics News, 2023
- Professor **Siddharth Ramachandran** was named a 2024 AAAS fellow
- Assistant Professor **Lei Tian** won the Scialog Award for Advancing Bioimaging, and was named a Scialog Fellow, Advancing BioImaging, Research Corporation for Science Advancement 2023
- Professor **Selim Ünlü** was named an NSF Distinguished Lecturer, 2023
- Professor **John A. White** received the Herbert F. Voigt Science Award, Biomedical Engineering Society, 2023
- Professor **Chen Yang** was elected as an American Institute for Medical and Biological Engineering (AIMBE) Fellow, 2023
- **Chen Yang** was promoted to full Professor, 2024
- Professor **Xin Zhang** won Sigma Xi's Walston Chubb Award for Innovation, 2023

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Sponsored Research Awards, Proposals, and Expenditures and Sources of Funding

LIST OF NEW GRANTS AWARDED IN FY24 (total: $43.7M)
Photonics faculty members received $43.7M in external funding. The following table lists funds in the fiscal year (July 1, 2023 – June 30, 2024), as reported by the BU Sponsored Programs office. Grants shaded in blue represent grants which were led by the Photonics Center, and grants shaded in yellow represent grants which were catalyzed by the Photonics Center.

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
CAREER: REACTION-DIFFUSION MODELING OF GROWTH FACTOR EXPOSURE PROFILES IN TISSUE ENGINEERING	ALBRO MICHAEL	National Science Foundation	5/1/2024	4/30/2029	$476,886
DEVELOPMENT OF AN ADVANCED SHOWERHEAD FOR PECVD	BASU N SOUMENDRA	Lam Research Corporation	5/10/2017	12/31/2024	$50,000
AI/ML-MADE: AI/ML AUGMENTED MATERIALS AND DEVICE EXPLORATION	BELLOTTI ENRICO	Department of Defense/ Army Contracting Command/Aberdeen Prov	9/30/2022	9/29/2025	$72,480
AI/ML-MADE: AI/ML AUGMENTED MATERIALS AND DEVICE EXPLORATION	BELLOTTI ENRICO	Department of Defense/ Army Contracting Command/Aberdeen Prov	9/30/2022	9/29/2025	$250,000
AI/ML-MADE: AI/ML AUGMENTED MATERIALS AND DEVICE EXPLORATION	BELLOTTI ENRICO	Department of Defense/ Army Contracting Command/Aberdeen Prov	9/30/2022	9/29/2025	$177,520
AI/ML-MADE: AI/ML AUGMENTED MATERIALS AND DEVICE EXPLORATION	BELLOTTI ENRICO	Department of Defense/ Army Contracting Command/Aberdeen Prov	9/30/2022	9/29/2024	$500,000
BROADBAND OPTICAL ATTENUATOR VIA AMPLIFIED FREE CARRIER ABSORPTION	BELLOTTI ENRICO	Physical Sciences, Inc.	1/1/2024	11/30/2024	$171,625
SIMULATION OF SEMICONDUCTOR DEVICES AND MATERIALS ARL/BU INITIATIVE	BELLOTTI ENRICO	Department of Defense/ ARL	9/26/2023	9/25/2028	$1,259,392
OPTIMIZATION AND VALIDATION OF QUANTITATIVE BIREFRINGENCE MICROSCOPY FOR ASSESSMENT OF MYELIN PATHOLOGIES ASSOCIATED WITH COGNITIVE IMPAIRMENTS AND MOTOR DEFICITS IN YOUNG AND OLD AGING MONKEY BRAIN	BIGIO J IRVING	NIH/National Institute on Aging	1/1/2022	11/30/2026	$503,149
OPTIMIZATION AND VALIDATION OF QUANTITATIVE BIREFRINGENCE MICROSCOPY FOR ASSESSMENT OF MYELIN PATHOLOGIES ASSOCIATED WITH COGNITIVE IMPAIRMENTS AND MOTOR DEFICITS IN YOUNG AND OLD AGING MONKEY BRAIN	BIGIO J IRVING	NIH/National Institute on Aging	1/1/2022	11/30/2026	$55,906

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
OPTIMIZATION AND VALIDATION OF QUANTITATIVE BIREFRINGENCE MICROSCOPY FOR ASSESSMENT OF MYELIN PATHOLOGIES ASSOCIATED WITH COGNITIVE IMPAIRMENTS AND MOTOR DEFICITS IN YOUNG AND OLD AGING MONKEY BRAIN	BIGIO J IRVING	NIH/National Institute on Aging	1/1/2022	11/30/2026	$55,906
OPTIMIZATION AND VALIDATION OF QUANTITATIVE BIREFRINGENCE MICROSCOPY FOR ASSESSMENT OF MYELIN PATHOLOGIES ASSOCIATED WITH COGNITIVE IMPAIRMENTS AND MOTOR DEFICITS IN YOUNG AND OLD AGING MONKEY BRAIN	BIGIO J IRVING	NIH/National Institute on Aging	1/1/2022	11/30/2026	$(55,906)
VALIDATION OF LIGHT SCATTERING SPECTROSCOPY FOR INTRA-OPERATIVE MARGIN GUIDANCE DURING ORAL CANCER RESECTION	BIGIO J IRVING	Boston Medical Center Corporation	7/7/2020	6/30/2025	$180,322
NANOSYSTEMS ENGINEERING RESEARCH CENTER FOR DIRECTED MULTISCALE ASSEMBLY OF CELLULAR METAMATERIALS WITH NANOSCALE PRECISION: CELL-MET	BISHOP DAVID	National Science Foundation	10/1/2017	9/30/2027	$3,219,519
TIME-GATED DIFFUSE CORRELATION SPECTROSCOPY FOR FUNCTIONAL IMAGING OF THE HUMAN BRAIN	BOAS DAVID	Massachusetts General Hospital	9/21/2019	6/30/2024	$102,424
THE NEUROSCIENCE OF EVERYDAY WORLD- A NOVEL WEARABLE SYSTEM FOR CONTINUOUS MEASUREMENT OF BRAIN FUNCTION	BOAS DAVID	NIH/National Institute of Biomedical Imaging & Bioengineerin	9/22/2020	5/31/2025	$980,087
THE NEUROSCIENCE OF EVERYDAY WORLD- A NOVEL WEARABLE SYSTEM FOR CONTINUOUS MEASUREMENT OF BRAIN FUNCTION	BOAS DAVID	NIH/National Institute of Biomedical Imaging & Bioengineerin	9/22/2020	5/31/2025	$1,597,493
NEUROPHOTONIC ADVANCES FOR MECHANISTIC INVESTIGATION OF THE ROLE OF CAPILLARY DYSFUNCTION IN STROKE RECOVERY	BOAS DAVID	NIH/National Institute of Neurological Disorders & Stroke	9/27/2022	8/31/2027	$662,228
BILLING AGREEMENT FOR AYMAN ABDELHAKEEM	BOAS DAVID	The General Hospital Corporation d/b/a Massachusetts General	6/5/2023	6/2/2024	$23,055
BILLING AGREEMENT FOR MACKENZIE HYMAN	BOAS DAVID	The General Hospital Corporation d/b/a Massachusetts General	6/5/2023	8/27/2023	$10,252
BRAIN CONNECTS: MAPPING CONNECTIVITY OF THE HUMAN BRAINSTEM IN A NUCLEAR COORDINATE SYSTEM	BOAS DAVID	The General Hospital Corporation d/b/a Massachusetts General	9/1/2023	8/31/2026	$105,255
A FIELD-DEPLOYABLE MAGNETIC RESONANCE IMAGING RHIZOTRON FOR MODELING AND ENHANCING ROOT GROWTH AND BIOGEOCHEMICAL FUNCTION	BOAS DAVID	The General Hospital Corporation d/b/a Massachusetts General	5/29/2023	6/30/2024	$24,416

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
A FIELD-DEPLOYABLE MAGNETIC RESONANCE IMAGING RHIZOTRON FOR MODELING AND ENHANCING ROOT GROWTH AND BIOGEOCHEMICAL FUNCTION	BOAS DAVID	The General Hospital Corporation d/b/a Massachusetts General	5/29/2023	12/29/2023	$28,397
BRAIN CONNECTS: THE CENTER FOR LARGE-SCALE IMAGING OF NEURAL CIRCUITS (LINC)	BOAS DAVID	The General Hospital Corporation d/b/a Massachusetts General	8/28/2023	6/2/2024	$17,929
LOW-COST HIGH-PERFORMANCE NIRS-SCOS DEVICE FOR NON-INVASIVE MONITORING OF CEREBRAL BLOOD FLOW AND INTRACRANIAL PRESSURE IN TRAUMATIC BRAIN INJURY	BOAS DAVID	The General Hospital Corporation d/b/a Massachusetts General	6/1/2024	5/31/2029	$114,927
EXPLORATION OF FLEXOELECTRIC MATERIALS PRODUCED USING ADDITIVE MANUFACTURING	BROWN KEITH	Honeywell Federal Manufacturing & Technologies, LLC	4/24/2023	11/30/2023	$15,000
COLLABORATIVE RESEARCH: DMREF: CLOSED-LOOP DESIGN OF POLYMERS WITH ADAPTIVE NETWORKS FOR EXTREME MECHANICS	BROWN KEITH	National Science Foundation	10/1/2023	9/30/2027	$400,000
UNCOVERING A FINGERPRINT OF METAL-ORGANIC FRAMEWORK (MOF)-POLYMER INTERACTIONS	BROWN KEITH	Department of Defense/ Army Contracting Command/Aberdeen Prov	3/29/2024	3/28/2027	$50,000
A SCANNING PROBE FOUNDATION FOR FEMTOLITER-SCALE SYNTHETIC AND ANALYTICAL CHEMISTRY	BROWN KEITH	Department of Defense/ Army Contracting Command/Aberdeen Prov	3/1/2024	11/30/2024	$60,000
DATA-DRIVEN ADVANCEMENT OF ADDITIVE MANUFACTURING OF FUNCTIONAL POLYMERS	BROWN KEITH	Honeywell Federal Manufacturing & Technologies, LLC	4/10/2024	8/31/2024	$105,871
BRIDGING FUNCTION, CONNECTIVITY, AND TRANSCRIPTOMICS OF MOUSE CORTICAL NEURONS	CHEN JERRY	Allen Institute, d/b/a Allen Institute for Cell Science	9/1/2022	6/30/2027	$13,604
BRIDGING FUNCTION, CONNECTIVITY, AND TRANSCRIPTOMICS OF MOUSE CORTICAL NEURONS	CHEN JERRY	Allen Institute, d/b/a Allen Institute for Cell Science	9/1/2022	6/30/2027	$27,883
BRIDGING FUNCTION, CONNECTIVITY, AND TRANSCRIPTOMICS OF MOUSE CORTICAL NEURONS	CHEN JERRY	Allen Institute, d/b/a Allen Institute for Cell Science	9/1/2022	6/30/2027	$237,397
SENSING VULNERABLE PLAQUE IN VIVO BY AN ALL-OPTICAL INTRAVASCULAR ULTRASOUND AND PHOTOACOUSTIC CATHETER	CHENG JI-XIN	NIH/National Heart, Lung, and Blood Institute	9/1/2020	8/31/2024	$1
SENSING VULNERABLE PLAQUE IN VIVO BY AN ALL-OPTICAL INTRAVASCULAR ULTRASOUND AND PHOTOACOUSTIC CATHETER	CHENG JI-XIN	NIH/National Heart, Lung, and Blood Institute	9/1/2020	8/31/2024	$589,576
MAPPING CANCER METABOLISM BY MID-INFRARED PHOTOTHERMAL MICROSCOPY	CHENG JI-XIN	NIH/National Cancer Institute	9/20/2021	8/31/2024	$390,792

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
HIGH-CONTENT HIGH-SPEED CHEMICAL IMAGING OF METABOLIC REPROGRAMMING BY INTEGRATION OF ADVANCED INSTRUMENTATION AND DATA SCIENCE	CHENG JI-XIN	NIH/National Institute of Biomedical Imaging & Bioengineerin	4/1/2022	12/31/2025	$454,378
HIGH-CONTENT HIGH-SPEED CHEMICAL IMAGING OF METABOLIC REPROGRAMMING BY INTEGRATION OF ADVANCED INSTRUMENTATION AND DATA SCIENCE	CHENG JI-XIN	NIH/National Institute of Biomedical Imaging & Bioengineerin	4/1/2022	12/31/2025	$40,390
SUB-MILLIMETER PRECISION WIRELESS NEUROMODULATION USING A MICROWAVE SPLIT RING RESONATOR	CHENG JI-XIN	NIH/National Eye Institute	8/1/2022	7/31/2025	$206,250
IPA FOR CHENG JI-XIN	CHENG JI-XIN	Jesse Brown VA Medical Center	1/1/2023	12/31/2024	$23,887
PERSONNEL AGREEMENT FOR RESEARCH SERVICES OF HONGJIAN HE	CHENG JI-XIN	Jesse Brown VA Medical Center	1/1/2023	12/31/2024	$90,580
FLUORESCENCE ENHANCED PHOTOTHERMAL INFRARED SPECTROSCOPY (FE-PTIR) BREAKTHROUGH FOR SIMULTANEOUS FLUORESCENCE MICROSCOPY AND SUB-MICRON IR SPECTROSCOPY	CHENG JI-XIN	Photothermal Spectroscopy Corp.	11/1/2022	8/31/2024	$146,591
RAPID AST THROUGH METABOLIC IMAGING AT SINGLE CELL LEVEL	CHENG JI-XIN	NIH/National Institute of Allergy & Infectious Diseases	7/7/2023	6/30/2027	$621,858
RAPID AST THROUGH METABOLIC IMAGING AT SINGLE CELL LEVEL	CHENG JI-XIN	NIH/National Institute of Allergy & Infectious Diseases	7/7/2023	6/30/2027	$718,052
SUPER-SENSITIVE VIBRATIONAL IMAGING BY SYNERGIC DEVELOPMENT OF INSTRUMENTS AND PROBES	CHENG JI-XIN	NIH/National Institute of Biomedical Imaging & Bioengineerin	1/1/2024	12/21/2027	$41,354
SUPER-SENSITIVE VIBRATIONAL IMAGING BY SYNERGIC DEVELOPMENT OF INSTRUMENTS AND PROBES	CHENG JI-XIN	NIH/National Institute of Biomedical Imaging & Bioengineerin	1/1/2024	12/21/2027	$514,946
HIGH-CONTENT SRS IMAGING OF METABOLISM IN MULTICELLULAR BIOLOGICAL SYSTEMS	CHENG JI-XIN	Howard Hughes Medical Institute	2/19/2024	2/18/2025	$7,107
ADVANCEMENT OF A POXVIRUS INHIBITOR	CONNOR H JOHN	NIH/National Institute of Allergy & Infectious Diseases	3/12/2020	2/28/2025	$74,512
ADVANCEMENT OF A POXVIRUS INHIBITOR	CONNOR H JOHN	NIH/National Institute of Allergy & Infectious Diseases	3/12/2020	2/28/2025	$670,610
DETERMINANTS OF COVID19-INDUCED VENOUS THROMBOSIS AND TARGETED THERAPY ASSESSED WITH BIOENGINEERED VEIN-CHIP	CONNOR H JOHN	NIH/National Heart, Lung, and Blood Institute	5/1/2021	4/30/2025	$647,897

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DETERMINANTS OF COVID19-INDUCED VENOUS THROMBOSIS AND TARGETED THERAPY ASSESSED WITH BIOENGINEERED VEIN-CHIP	CONNOR H JOHN	NIH/National Heart, Lung, and Blood Institute	5/1/2021	4/30/2025	$57,591
DEVELOPMENT OF A RVSV VECTORED VACCINE FOR LASSA VIRUS: NONHUMAN PRIMATE EFFICACY AND IMMUNOGENICITY STUDIES	CONNOR H JOHN	University of Texas Medical Branch at Galveston	9/1/2021	8/31/2026	$516,377
NEW ENGLAND PATHOGEN GENOMICS CENTER OF EXCELLENCE	CONNOR H JOHN	Comm. of Mass./ Department of Public Health	7/1/2023	9/29/2024	$393,044
NEW ENGLAND PATHOGEN GENOMICS CENTER OF EXCELLENCE	CONNOR H JOHN	Comm. of Mass./ Department of Public Health	7/1/2023	9/29/2024	$287,566
NEW ENGLAND PATHOGEN GENOMICS CENTER OF EXCELLENCE	CONNOR H JOHN	Comm. of Mass./ Department of Public Health	7/1/2023	9/29/2024	$95,862
MODULAR POINT-OF-CARE PLATFORM FOR DIFFERENTIAL DIAGNOSIS OF VIRAL HEMORRHAGIC FEVERS	CONNOR H JOHN	RedBud Labs	10/1/2023	9/30/2025	$119,174
RFQ 7063-016 BIOINFORMATICS SUB-2021-7063-0008	CONNOR H JOHN	Mapp Biopharmaceutical, Inc.	12/14/2023	12/31/2024	$221,884
RFQ 7063-016 BIOINFORMATICS SUB-2021-7063-0008	CONNOR H JOHN	Mapp Biopharmaceutical, Inc.	12/14/2023	6/30/2024	$40,708
RESTRICTED_RFQ 7063-016 BIOINFORMATICS SUB-2021-7063-0008	CONNOR H JOHN	Mapp Biopharmaceutical, Inc.	12/14/2023	6/30/2024	$3,053
RESTRICTED_RFQ 7063-016 BIOINFORMATICS SUB-2021-7063-0008	CONNOR H JOHN	Mapp Biopharmaceutical, Inc.	12/14/2023	12/31/2024	$16,642
RFQ 7080-008 BIOINFORMATICS	CONNOR H JOHN	Mapp Biopharmaceutical, Inc.	1/1/2024	8/31/2028	$90,584
RFQ 7063-016 BIOINFORMATICS SUB-2022-7080-0003	CONNOR H JOHN	Mapp Biopharmaceutical, Inc.	1/1/2024	6/30/2028	$40,708
RESTRICTED: RFQ 7080-008 BIOINFORMATICS	CONNOR H JOHN	Mapp Biopharmaceutical, Inc.	1/1/2024	8/31/2028	$6,794
RESTRICTED_RFQ 7063-016 BIOINFORMATICS SUB-2022-7080-0003	CONNOR H JOHN	Mapp Biopharmaceutical, Inc.	1/1/2024	6/30/2028	$3,053
NOVEL ULTRAFAST NONLINEAR MATERIALS AND HYBRID PHOTONICPLASMONIC NANOSTRUCTURES FOR IR MULTIBAND IMAGING AND DETECTION	DAL NEGRO LUCA	Department of Defense/ Army Contracting Command/Aberdeen Prov	8/1/2022	7/31/2025	$126,753
EFFECTS OF INTRINSIC AND DRUG-INDUCED NEUROMODULATION ON FUNCTIONAL BRAIN IMAGING	DEVOR ANNA	NIH/National Institute on Drug Abuse	8/1/2020	5/31/2025	$370,026
LOCAL NEURONAL DRIVE AND NEUROMODULATORY CONTROL OF ACTIVITY IN THE PIAL NEUROVASCULAR CIRCUIT	DEVOR ANNA	NIH/National Institute of Neurological Disorders & Stroke	8/16/2021	5/31/2026	$2,520,076

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METABOLIC AND NEURAL ACTIVITY NORMALIZATION BY CEREBRAL BLOOD FLOW INCREASE IN AD/ADRD MODELS	DEVOR ANNA	Cornell University	4/15/2023	1/31/2028	$475,500
OPTOGENETIC SELECTION FOR DYNAMIC PHENOTYPES IN BACTERIA	DUNLOP MARY	National Science Foundation	8/1/2023	7/31/2026	$796,158
REVERSE ENGINEERING THE BRAIN STEM CIRCUITS THAT GOVERN EXPLORATORY BEHAVIOR	ECONOMO NICHOLAS MICHAEL	University of California, San Diego	6/1/2020	5/31/2024	$86,613
LINKING MOTOR CORTEX ACTIVITY AND MOVEMENT IN THE MOUSE OROFACIAL SYSTEM.	ECONOMO NICHOLAS MICHAEL	NIH/National Institute of Neurological Disorders & Stroke	2/1/2022	1/31/2027	$28,875
LINKING MOTOR CORTEX ACTIVITY AND MOVEMENT IN THE MOUSE OROFACIAL SYSTEM.	ECONOMO NICHOLAS MICHAEL	NIH/National Institute of Neurological Disorders & Stroke	2/1/2022	1/31/2027	$371,251
THE DESCENDING CONTROL OF MOVEMENT INITIATION BY THE MOTOR CORTEX	ECONOMO NICHOLAS MICHAEL	The Esther A. & Joseph Klingenstein Fund, Inc.	7/1/2020	7/1/2025	$75,000
FLEX: FLUORESCENT LIGHT EXAMINATION OF EXTENSORS (AND OTHER MUSCLES)	ECONOMO NICHOLAS MICHAEL	Research Corporation for Science Advancement	2/1/2024	1/31/2025	$55,000
ILLUMINATING THE MOLECULAR MECHANISMS OF MEMORY FORMATION DURING BEHAVIOR	ECONOMO NICHOLAS MICHAEL	The Kavli Foundation	2/1/2024	1/31/2025	$55,000
COLLABORATIVE RESEARCH: THE NONLINEAR STOCHASTIC DYNAMICS OF MICRO AND NANOMECHANICAL SYSTEMS	EKINCI KAMIL	National Science Foundation	6/15/2020	11/30/2025	$8,000
COLLABORATIVE RESEARCH: WAVE ENGINEERING IN 2D USING HIERARCHICAL NANOSTRUCTURED DYNAMICAL SYSTEMS	EKINCI KAMIL	National Science Foundation	3/1/2024	2/28/2027	$375,000
MODULATION OF CELLULAR METABOLISM TO MAXIMIZE NEURONAL REGENERATION	GABEL V CHRISTOPHER	Comm. of Mass./ Department of Public Health	7/17/2019	6/30/2024	$180,045
VALIDATION OF LENS BETA-AMYLOID AS A NOVEL BIOMARKER FOR EARLY DETECTION OF ALZHEIMER'S DISEASE AT THE BOSTON UNIVERSITY ALZHEIMER'S DISEASE RESEARCH	GOLDSTEIN E LEE	NIH/National Institute on Aging	9/30/2023	6/30/2028	$-
VALIDATION OF LENS BETA-AMYLOID AS A NOVEL BIOMARKER FOR EARLY DETECTION OF ALZHEIMER'S DISEASE AT THE BOSTON UNIVERSITY ALZHEIMER'S DISEASE RESEARCH	GOLDSTEIN E LEE	NIH/National Institute on Aging	9/30/2023	6/30/2028	$824,998
IMPACT OF TOXIC METAL EXPOSURES IN NOVEL GENETIC MOUSE MODELS OF LATE-ONSET ALZHEIMER'S DISEASE	GOLDSTEIN E LEE	NIH/National Institute on Aging	9/15/2023	8/31/2024	$822,643
IU/JAX/PITT MODEL-AD CENTER	GOLDSTEIN E LEE	Trustees of Indiana University	9/1/2023	8/31/2024	$206,250

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ICP-TOF MASS SPECTROMETER FOR ULTRAFAST ELEMENTAL MAPPING OF CLINICAL AND PRECLINICAL BIOSPECIMENS	GOLDSTEIN E LEE	NIH/National Institutes of Health	5/1/2024	4/30/2025	$582,750
VOLTAGE IMAGING ANALYSIS OF STRIATAL NETWORK DYNAMICS RELATED TO VOLUNTARY MOVEMENT AND PARKINSONS DISEASE	HAN XUE	NIH/National Institute of Neurological Disorders & Stroke	4/1/2020	3/31/2025	$478,131
VOLTAGE IMAGING ANALYSIS OF STRIATAL NETWORK DYNAMICS RELATED TO VOLUNTARY MOVEMENT AND PARKINSONS DISEASE	HAN XUE	NIH/National Institute of Neurological Disorders & Stroke	4/1/2020	3/31/2025	$89,789
MULTIDIMENSIONAL OPTIMIZATION OF VOLTAGE INDICATORS FOR IN VIVO NEURAL ACTIVITY IMAGING	HAN XUE	NIH/National Institute of Mental Health	3/1/2020	1/31/2025	$598,022
COLLABORATIVE RESEARCH: DYNAMIC INTERACTIONS OF INDIVIDUAL NEURONS IN SUPPORTING HIPPOCAMPAL NETWORK OSCILLATIONS DURING BEHAVIOR	HAN XUE	National Science Foundation	10/1/2020	9/30/2025	$75,849
DESIGNING LOW-COST, CUSTOMIZABLE HIGH-DENSITY PROBES FOR ACUTE AND CHRONIC NEURAL RECORDINGS IN RODENTS	HAN XUE	Neural Dynamics Technologies	9/1/2023	8/31/2024	$113,606
CAREER: COHERENT PHONON CONTROL IN IRON-BASED SUPERCONDUCTORS	HU WANZHENG	National Science Foundation	3/1/2020	2/28/2025	$129,141
BIDIRECTIONAL MANUPULATION OF PHASE TRANSITIONS BY LASER EXCITATION OF OPTICAL PHONONS	HU WANZHENG	Department of Energy	9/1/2020	8/31/2024	$153,447
COLLABORATIVE RESEARCH: CSR: MEDIUM: ARCHITECTING GPUS FOR PRACTICAL HOMOMORPHIC ENCRYPTION-BASED COMPUTING	JOSHI JAYANT AJAY	National Science Foundation	8/1/2023	7/31/2026	$396,988
I-CORPS: TRANSLATION POTENTIAL OF PRACTICAL PRIVACY-PRESERVING COMPUTING USING FULLY HOMOMORPHIC ENCRYPTION	JOSHI JAYANT AJAY	National Science Foundation	5/1/2024	4/30/2025	$50,000
CLINICAL EVALUATION OF A NOVEL DIGITAL HEALTH INTERVENTION FOR NUTRITIONAL ANEMIAS	KLAPPERICH M CATHERINE	Massachusetts Life Sciences Center	7/1/2023	6/30/2026	$805,660
EQUIPMENT: MRI: TRACK 1 ACQUISITION OF AN ILLUMINA NEXTSEQ 2000 SEQUENCING INSTRUMENT	KLAPPERICH M CATHERINE	National Science Foundation	9/1/2023	8/31/2026	$-
EQUIPMENT: MRI: TRACK 1 ACQUISITION OF AN ILLUMINA NEXTSEQ 2000 SEQUENCING INSTRUMENT	KLAPPERICH M CATHERINE	National Science Foundation	9/1/2023	8/31/2026	$-

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EQUIPMENT: MRI: TRACK 1 ACQUISITION OF AN ILLUMINA NEXTSEQ 2000 SEQUENCING INSTRUMENT	KLAPPERICH M CATHERINE	National Science Foundation	9/1/2023	8/31/2026	$639,794
EQUIPMENT: MRI: TRACK 1 ACQUISITION OF AN ILLUMINA NEXTSEQ 2000 SEQUENCING INSTRUMENT	KLAPPERICH M CATHERINE	National Science Foundation	9/1/2023	8/31/2026	$-
CLARE BOOTHE LUCE FELLOWSHIP FOR MADISON FLETCHER	KLAPPERICH M CATHERINE	The Henry Luce Foundation, Inc.	9/1/2023	8/31/2025	$65,244
SYNTHESIS OF NEW 2D CRYSTALS VIA SELECTIVE ATOMIC SUBSTITUTION	LING XI	Department of Energy	8/1/2020	7/31/2024	$150,000
NEW COOPERATIVE ADSORBENTS AND REGENERATION METHODS FOR THE EFFICIENT REMOVAL OF CARBON DIOXIDE FROM AIR	LUBNER SEAN	Lawrence Berkeley National Laboratory	4/20/2023	8/31/2024	$80,000
PHONON CONTROL FOR NEXT-GENERATION SUPERCONDUCTING SYSTEMS AND SENSORS	LUBNER SEAN	Lawrence Berkeley National Laboratory	10/12/2023	8/31/2025	$200,000
INVESTIGATING COUPLED THERMAL, MECHANICAL, AND ELECTRICAL PHENOMENA IN HIGH-TEMPERATURE MATERIALS USING THERMAL WAVE SENSORS	LUBNER SEAN	Department of Defense/ AFOSR	6/1/2024	5/31/2027	$147,970
MULTI-LAYER NEURONAL IMAGING WITH REVERBERATION MULTIPHOTON MICROSCOPY	MERTZ JEROME	NIH/National Institute of Neurological Disorders & Stroke	3/15/2020	12/31/2024	$28,036
MULTI-LAYER NEURONAL IMAGING WITH REVERBERATION MULTIPHOTON MICROSCOPY	MERTZ JEROME	NIH/National Institute of Neurological Disorders & Stroke	3/15/2020	12/31/2024	$360,465
UNCOVERING CELL INTRINSIC AND EXTRINSIC FACTORS GOVERNING MELANOMA DORMANCY AT SINGLE-CELL RESOLUTION	NIA HADI	Department of Defense/ Army Medical Research Acquisition Acti	6/1/2024	5/31/2027	$646,252
DEVELOPMENT OF CRYSTAL RIBCAGE FOR IMAGING OF FUNCTIONING LUNG AT HIGH SPATIOTEMPORAL RESOLUTION	NIA HADI	The Arnold and Mabel Beckman Foundation	9/1/2022	8/31/2026	$150,000
SLOAN RESEARCH FELLOWSHIP	NIA HADI	Alfred P. Sloan Foundation	9/15/2024	9/14/2026	$75,000
SOPAIPILLA: SERPENTINE OPTICAL PHASED ARRAY FOR IMAGING BY PAIRWISE INTERFERENCE FROM A LARGE LIDAR APERTURE	POPOVIC MILOS	The Regents of the University of Colorado dba University of	1/17/2023	1/16/2024	$15,000
COLLABORATIVE OPTICALLY DISAGGREGATED ARRAYS OF EXTREME-MIMO RADIO UNITS (CODAEMIMO)	POPOVIC MILOS	National Science Foundation	10/1/2023	9/30/2026	$151,766
PROPERTIES OF FERROMAGNETIC NEMATIC LIQUID CRYSTAL MATERIALS FOR INTEGRATED PHOTONICS	POPOVIC MILOS	Polaris Electro-Optics, Inc.	1/1/2023	12/31/2023	$152,023
LIGHT-MATTER INTERACTIONS WITH A TWIST	RAMACHANDRAN SIDDHARTH	Department of Defense/ ONR	9/1/2019	8/31/2024	$598,775

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LOW SWAP SOURCES FOR HIGH-POWER BLUE COMMUNICATIONS	RAMACHANDRAN SIDDHARTH	Department of Defense/ ONR	5/1/2020	7/31/2024	$72,830
SINGLE-CELL AND TARGET SPECIFIC RESOLUTION OF MULTIPLE MEMORIES ACROSS THE BRAIN	RAMIREZ STEVE	Research Foundation for Mental Hygiene	9/13/2019	8/31/2024	$385,494
THE EFFECT OF ADOLESCENT DRUG-INDUCED NEUROIMMUNE SIGNALING IN SEX-SPECIFIC SOCIAL DEVELOPMENT AND REWARD LEARNING	RAMIREZ STEVE	Albany Medical College	7/1/2022	3/31/2027	$12,198
DISCOVERING PRINCIPLES OF MEMORY STORAGE, RETRIEVAL, AND RESTORATION	RAMIREZ STEVE	Department of Defense/ AFOSR	10/1/2023	9/30/2024	$1,378,172
PLASMONIC INACTIVATION OF VIRUS AND MYCOPLASMA CONTAMINANTS	REINHARD M BJOERN	NIH/National Institute of General Medical Sciences	8/1/2021	5/31/2025	$330,000
IMPROVED NANOPARTICLE TARGETING OF TISSUE MYELOID CELLS FOR HIV-1 LONG-ACTING PRE-EXPOSURE PROPHYLAXIS	REINHARD M BJOERN	NIH/National Institute of Allergy & Infectious Diseases	3/17/2023	2/28/2027	$710,093
IMPROVED NANOPARTICLE TARGETING OF TISSUE MYELOID CELLS FOR HIV-1 LONG-ACTING PRE-EXPOSURE PROPHYLAXIS	REINHARD M BJOERN	NIH/National Institute of Allergy & Infectious Diseases	3/17/2023	2/28/2027	$78,899
ILLUMINATING DYNAMIC RECEPTOR CLUSTERING IN THE EPIDERMAL GROWTH FACTOR RECEPTOR SIGNAL TRANSDUCTION PATHWAY USING PLASMON COUPLING	REINHARD M BJOERN	NIH/National Cancer Institute	4/1/2020	3/31/2025	$372,281
INTERFEROMETRIC PLASMON RULER FOR ELUCIDATING STRUCTURAL DYNAMICS ON THE SINGLEMOLECULE LEVEL	REINHARD M BJOERN	NIH/National Institute of General Medical Sciences	9/20/2022	8/31/2024	$206,250
UV PLASMON-ENHANCED CHIROPTICAL SPECTROSCOPY OF MEMBRANE-BINDING PROTEINS	REINHARD M BJOERN	NIH/National Institute of General Medical Sciences	9/23/2023	7/31/2027	$412,032
NEXT GENERATION PLASMON COUPLING NANOSENSORS	REINHARD M BJOERN	National Science Foundation	3/1/2024	2/28/2027	$447,747
MULTIPLEXED IMAGING IN THE NEAR INFRARED WITH INDIUM PHOSPHIDE QUANTUM SHELLS	ROBLYER DARREN	Northeastern University	8/1/2022	7/31/2024	$160,116
PHOTOTHERMAL LABEL-FREE DYNAMIC PROBING AND MODULATION OF ASTROCYTES AND FIBROBLAST CELL MODELS	SANDER MICHELLE	Department of Defense/ AFOSR	12/1/2022	11/30/2025	$169,069
INVESTIGATING MECHANISMS UNDERLYING PERCEPTUAL INTEGRATION IN AUTISM	SCOTT BENJAMIN	Simons Foundation	12/1/2021	11/30/2024	$-
INVESTIGATING MECHANISMS UNDERLYING PERCEPTUAL INTEGRATION IN AUTISM	SCOTT BENJAMIN	Simons Foundation	12/1/2021	11/30/2024	$250,000
THE ROLE OF THE LOCUS COERULEUS-NOREPINEPHRINE SYSTEM IN FLEXIBLE DECISION-MAKING	SCOTT BENJAMIN	NIH/National Institute of Mental Health	4/13/2023	3/31/2025	$371,250

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UNDERSTANDING THE MULTIPLE TIMESCALES OF NEUROMODULATION USING THREE PHOTON INSTANT FILM	SCOTT BENJAMIN	Research Corporation for Science Advancement	2/1/2024	1/31/2025	$55,000
COMPREHENSIVE MINIMALLY/ NON-INVASIVE MULTIFACETED ASSESSMENT OF NANO-/ MICROELECTRONIC DEVICES (COMMAND)	SERGIENKO V ALEXANDER	State University of New York at Buffalo	5/1/2022	6/14/2027	$200,000
COMPREHENSIVE MINIMALLY/ NON-INVASIVE MULTIFACETED ASSESSMENT OF NANO-/ MICROELECTRONIC DEVICES (COMMAND)	SERGIENKO V ALEXANDER	State University of New York at Buffalo	5/1/2022	6/14/2027	$200,000
CAREER: FUNDAMENTAL DISCOVERY WITH SOLID SATE SPIN ENSEMBLES	SUSHKOV ALEXANDER	National Science Foundation	12/15/2021	11/30/2026	$164,548
QUANTUM SENSING AND SIMULATION FOR FUNDAMENTAL DISCOVERY	SUSHKOV ALEXANDER	Stanford National Accelerator Laboratory	3/10/2022	8/31/2025	$370,100
METROLOGY AND FUNDAMENTAL SCIENCE WITH MAGNETIC RESONANCE AT ITS QUANTUM LIMITS	SUSHKOV ALEXANDER	Gordon and Betty Moore Foundation	7/18/2023	8/1/2028	$1,250,000
COMPUTATIONAL MINIATURE MESOSCOPE FOR CORTEX-WIDE, CELLULAR RESOLUTION CA2+ IMAGING IN FREELY BEHAVING MICE	TIAN LEI	NIH/National Institute of Neurological Disorders & Stroke	4/1/2022	3/31/2027	$400,125
REFLECTION-MODE COMPUTATIONAL 3D PHASE AND POLARIZATION IMAGING FOR SEMICONDUCTOR WAFER METROLOGY AND INSPECTION	TIAN LEI	Samsung USA	12/15/2021	2/1/2025	$150,000
3D QUANTIFICATION WITH DIFFERENTIAL DYNAMIC LIGHT-FIELD MICROSCOPY	TIAN LEI	Silicon Valley Community Foundation	10/1/2023	9/30/2024	$57,500
PFI-TT: HIGH-THROUGHPUT DIGITAL BIOSENSING: FUTURE OF MOLECULAR DIAGNOSTICS	UNLU SELIM M	National Science Foundation	9/1/2023	8/31/2025	$275,437
PFI-TT: HIGH-THROUGHPUT DIGITAL BIOSENSING: FUTURE OF MOLECULAR DIAGNOSTICS	UNLU SELIM M	National Science Foundation	9/1/2023	8/31/2025	$274,558
EFFECTS OF FORESHOCK AND MAGNETOSHEATH KINETIC STRUCTURES ON THE GLOBAL MAGNETOSPHERE	WALSH MICHAEL BRIAN	Johns Hopkins University	11/1/2023	8/7/2027	$151,998
CAREER: SPREADING OF 3D MAGNETIC RECONNECTION	WALSH MICHAEL BRIAN	National Science Foundation	6/1/2019	5/31/2024	$132,581
REFINING PREDICTIONS OF RECONNECTION X-LINES AT EARTH'S MAGNETOPAUSE	WALSH MICHAEL BRIAN	NASA	7/22/2020	7/21/2024	$115,945
SINGLE-SOURCE, SOLAR WIND MAGNETOSPHERE IONOSPHERE LINK EXPLORER (SMILE)	WALSH MICHAEL BRIAN	NASA	10/1/2023	9/30/2026	$44,001

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AN AI/ML READY OMNI DATASET WITH IMPROVED PROPAGATED SOLAR WIND PARAMETERS	WALSH MICHAEL BRIAN	NASA	10/27/2023	10/26/2024	$110,608
PROTOTYPING A CHARGED PARTICLE MAGNETIC SWEEPER FOR AN X-RAY INSTRUMENT (FELLOWSHIP FOR AADARSH ARASU)	WALSH MICHAEL BRIAN	Massachusetts Institute of Technology	3/1/2024	5/31/2024	$2,500
CORRELATION ENGINEERING OF DEEP MULTIPHOTON MICROSCOPY	WANG TIANYU	Yale University	3/1/2024	2/28/2028	$203,478
TRAINING PROGRAM IN QUANTITATIVE BIOLOGY & PHYSIOLOGY (QBP)	WHITE A JOHN	NIH/National Institute of General Medical Sciences	7/1/2022	6/30/2027	$549,359
UNDERSTANDING THE MECHANISM OF MICROWAVE NEURON INHIBITION	YANG CHEN	Department of Defense/ ARO	5/9/2022	5/8/2025	$45,000
UNDERSTANDING THE MECHANISM OF MICROWAVE NEURON INHIBITION	YANG CHEN	Department of Defense/ ARO	5/9/2022	5/8/2024	$80,000
MASSIVELY PARALLEL OPTOACOUSTIC RETINAL STIMULATION AT MICROMETER-RESOLUTION	YANG CHEN	NIH/National Eye Institute	9/1/2023	8/31/2026	$265,150
DEVELOPING NEXT GENERATION PHOTOACOUSTIC IMPLANT FOR RETINAL STIMULATION	YANG CHEN	Axorus	9/1/2023	9/1/2025	$300,000

TOTAL: $43,690,053

Boston University Photonics Center

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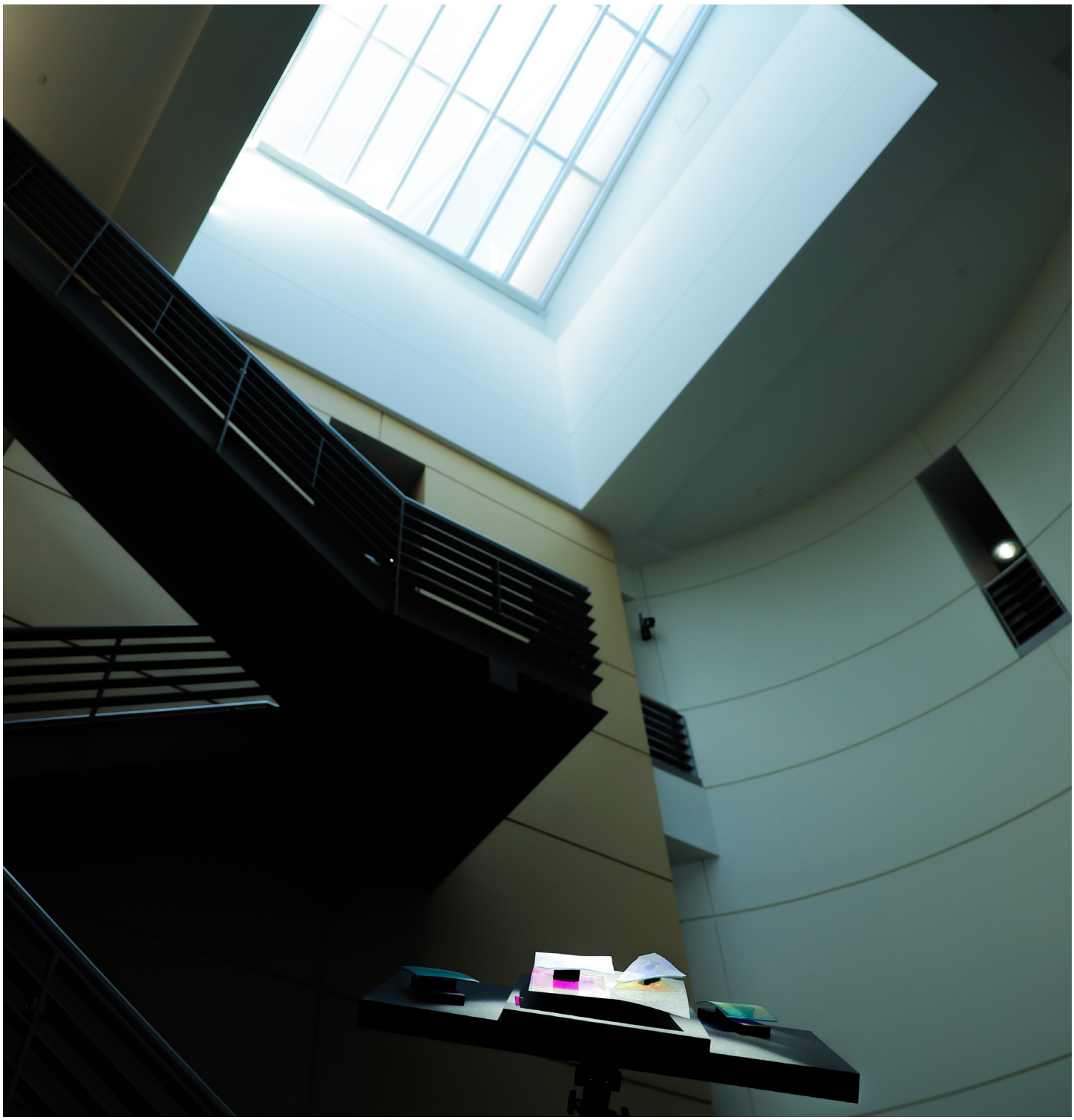

Back Cover: Photo taken in the Photonics Center 9th Floor
Credit: Kelly Peña