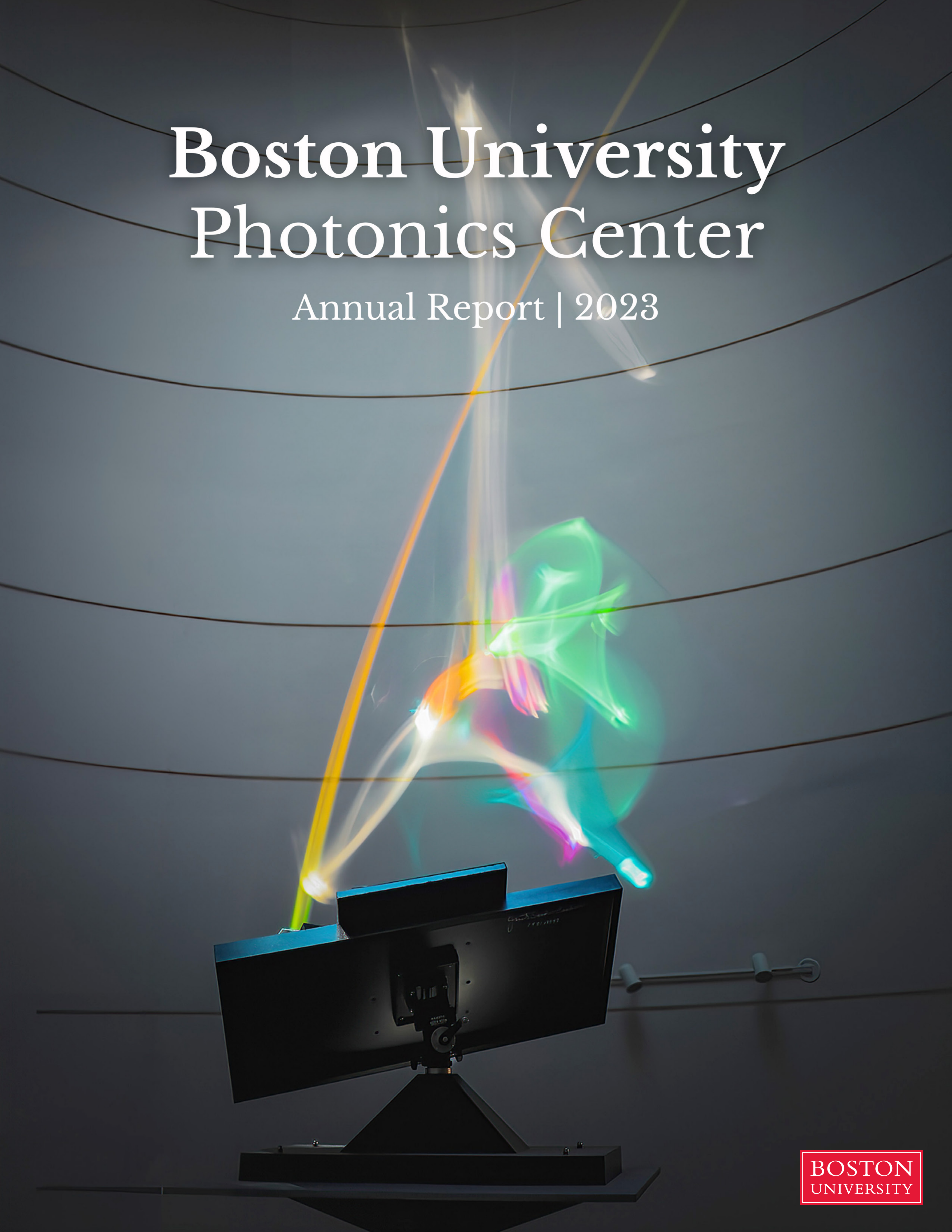
Boston University Photonics Center

Annual Report | 2023



BOSTON UNIVERSITY

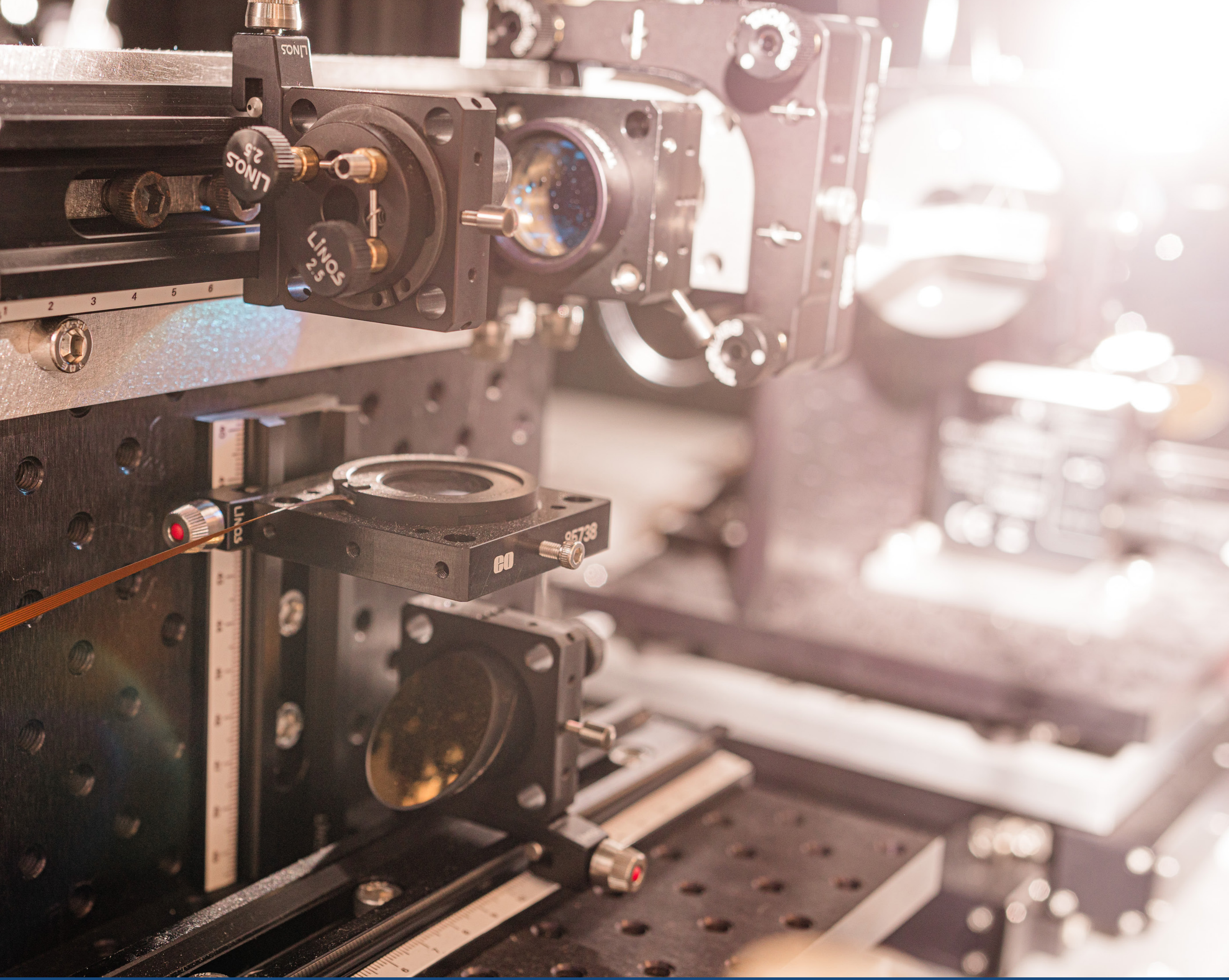


Photo taken in Jerry Chen's lab. Credit: Christopher McIntosh

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

LETTER FROM THE CENTER DIRECTOR

THIS ANNUAL REPORT SUMMARIZES ACTIVITIES OF THE PHOTONICS CENTER for the 2022-2023 academic year. In it, you will find quantitative and descriptive information regarding our photonics programs in research, education, and business innovation.

New grant funding awarded to Photonics Center faculty for this annual year totaled more than **$52.9MM**, another record high, continuing an **impressive growth rate of more than 20% per year over the last five years**. Three factors combine to make such sustained growth possible. First, the Photonics Center's **17 staff members dedicate themselves to our mission** to be a thriving research center of excellence within the University. From identifying strategic research funding opportunities to co-writing and supporting complex, ambitious proposals to administering multi-institution, multi-investigator interdisciplinary awards, our staff tirelessly support our community of **53 active faculty members and more than 250 graduate students distributed among dozens of individual and shared research laboratories.** The innovative ideas emerging from those laboratories comprise the second factor in our formula for success. In imaging, neurophotonics, nanophotonics, photonic materials and metamaterials, our programs of research aim to solve problems of critical importance to society, while training a world-class cohort of doctoral students. Finally, the Photonics Center's sustained growth is made possible by the **extraordinarily collaborative nature of our community of researchers**. As evidenced by the many multi-investigator grants, multi-authored journal publications, and jointly mentored dissertations described in the following pages, the Photonics Center has created a research environment that promotes and supports collaborative work across traditional disciplinary domains.

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.

As a longstanding Boston University institution, the Photonics Center has adopted a mission to help to establish and support newer research centers and university initiatives in allied fields. We routinely provide critical resources, infrastructure, and support for research, and we help win and manage a portfolio of major research and training grants that have catalyzed transformative growth in prominent allied research areas such as biological design, precision diagnostics, and neuroscience. **The Business Innovation Center**, which has always been a hub for industry/university engagement, currently houses an all-time high of sixteen tenants, including many BU spinouts and strategic optics/photonics industry partners. Under **Rana Gupta's** leadership, the BIC has strengthened its connectivity to the Faculty Entrepreneurship program and to Innovate@BU, with a goal of integrating some common aspects of those distinct innovation activities.

"This year, the Photonics Center continued to help our faculty win and administer large, complex, multi-university interdisciplinary grants that aim to impact society through optics and photonics innovation."

This year, the Photonics Center continued to help our faculty win and administer large, complex, multi-university interdisciplinary grants that aim to impact society through optics and photonics innovation. We took on the administration 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 fund research through subcontracts and industry contracts. CSM was funded this fall 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.

Under the leadership of Professor **Xin Zhang**, supported by staff member **Brenda Hugot**, our Summer Internship Programs were again an overwhelming success. We hosted multiple symposia and events, including a workshop on Chemical Imaging hosted by Professor **Ji Xin Cheng** and an Annual Symposium on the topic of Photonics and Artificial Intelligence, hosted by Professor **Luca Dal Negro**.

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.

Dr. Thomas Bifano, Center Director

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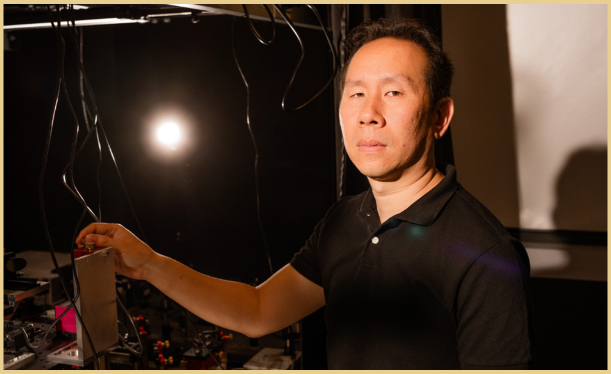

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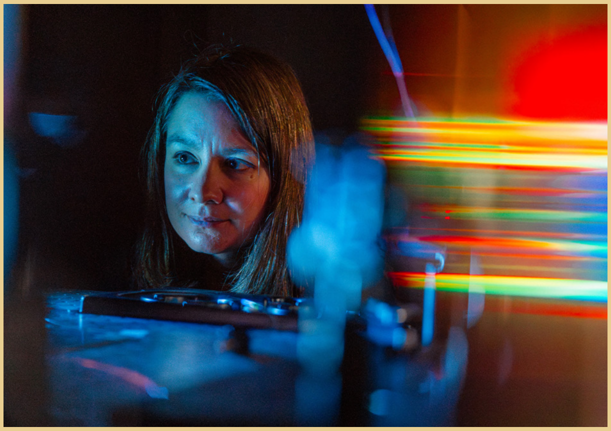
At the crux of Jerry Chen's research are some of the most elemental questions about the cognitive experience. "How do we perceive the world?"



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Michelle Sander and her lab group at Boston University are seeking out new ways to build ultrafast lasers – lasers that emit such short-lasting pulses of light that their duration is difficult to fathom.

PHOTONICS CENTER AT A GLANCE

16
Business Innovation Center Companies

Faculty Members
53

163
Funded R&D Projects

$2.51M
Operating Budget

$45.7M
Research Expenditures

$57M
Proposals Submitted

$52.9 MILLION
Funding for R&D

17
Staff Members

$453K
Revenue Generated

4
Shared Lab Facilities

213
Publications

Photo taken in Michelle Sander's lab. Credit: Christopher McIntosh

HIGHLIGHTS OF FY23

CELL-MET Engineering Research Center

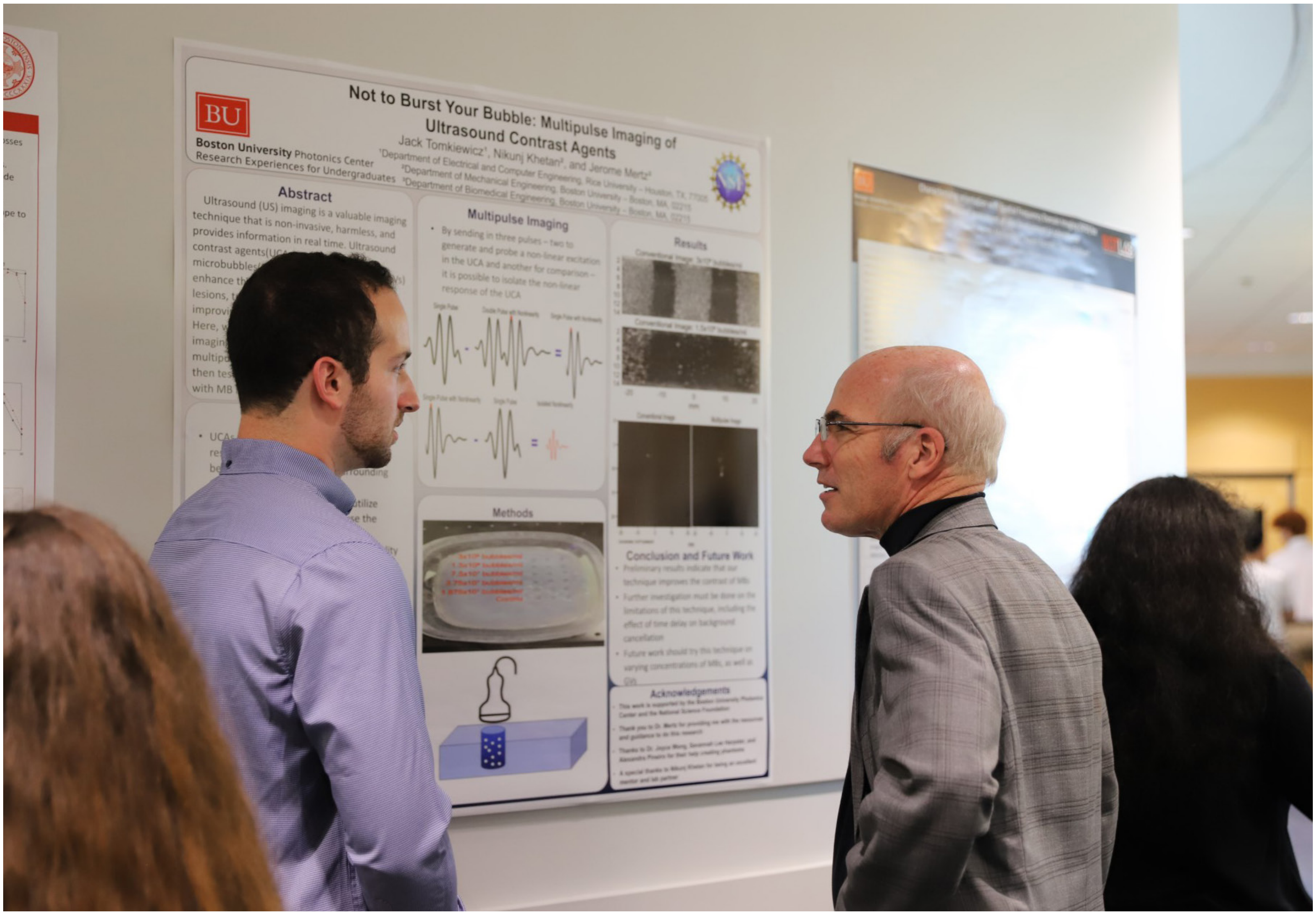
Our National Science Foundation (NSF) Engineering Research Center (ERC) on Cellular Metamaterials (CELL-MET), administered by the Photonics Center, continues to make significant advances toward its overall goal of engineering functional heart tissue for cardiac repair and creating a robust community that advances engineering workforce development, diversity, and culture of inclusion, as well as an innovation ecosystem. After receiving a rating at our renewal site visit in the top tier that noted both remarkable technical progress and exemplary commitment to diversity, equity, and inclusion, and renewal for 5 years for $17.5M, we had another very successful site visit in May 2023 again being rated in the top band.

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 his imaging research; Cara Ellis McCarthy, Executive Director, serves as the Administrative Director. New team members Maria Harlow, Associate Director of Administration and Lisa Tanrikulu, Administrative Coordinator, joined in the fall of 2022 and are fully dedicated to the ERC. Nozomi Ito, in her new role as Associate Director of Grants Administration, manages budgets, compliance, and supplemental programs for the ERC; Meghan Foley, Senior Manager of Finance, 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 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, Fort Valley State University, Nueta Hidatsa Sahnish College, and Brown University.

Most recently, the Director of the NSF EEC Division, which houses the ERC Program, received a priority request from the ENG Directorate for examples of high-impact research advances that the NSF will forward to the White House Office of Science and Technology (S&T) Policy. Such examples will be utilized for an event to be organized for S&T Leaders, Administration and Congressional members, staff, and some public, and will feature exhibits meant to excite attendees about the future of US science. In response, CELL-MET was asked by NSF to send its EEK! materials for inclusion in this event.

EEK!, the Engineering Engagement Kit, was designed in 2018 and 2019 by an interdisciplinary team of 13 CELL-MET trainees, researchers and science museum professionals, including Sandra Rodegher, Associate Director for Convergence and Workforce Programming, for CELL-MET outreach and education in science museums. To date, EEK! has been implemented in more than 100 partner institutions (over 50 science museums and 50 K-12 schools), and seven different spin-off programs have been created which reach several thousands of learners every year. During the pandemic, one such spin-off was developed and implemented in our three CELL-MET partner cities — East Boston K-12 (where many of our NSF RET teachers are located), Detroit, and Miami — as a formal education component of curriculum development.

Dr. Rodegher and two graduate students will attend the event at the White House where EEK! will feature a hands-on component of CELL-MET research, focusing on microbundle creation as an entry point to a more robust discussion of CELL-MET multi-disciplinary technical goals of engineering functional heart tissue. Other EEK! components CELL-MET was asked to include are: EEK! Engineering Lab Notebook, classroom posters and worksheets, a digital game pilot, and pre- and post-tests for engineering identity. The timing aligns perfectly with our latest plans for expanding the EEK! program to



REU Jack Tomkiewicz presenting his poster to Dr. Thomas Bifano, Credit: Kelly Peña

EEK!-A-Million with a three-year implementation plan to reach one million people with our education outreach kit.

Grant Support

In another productive year for external grant support, the Photonics Center faculty were awarded more than $52.9M in new annual-year funding representing a $10M increase over the previous year. Photonics Center faculty annual grant income has risen steadily to a level three times higher than it was a decade ago.

Highlights among new grants funded include ($ amounts for total anticipated funding):

- *Arthroscopic Raman Monitoring of Cartilage Content for PTOA Diagnosis and Chondroregenerative Treatment Response*, **Michael Albro**, NIH, $2.95 million
- *Neurophotonic Advances for Mechanistic Investigation of the Role of Capillary Dysfunction in Stroke Recovery*, **David Boas**, NIH, $3.3 million
- *Improved Nanoparticle Targeting of Tissue Myeloid Cells for HIV-1 Long-Acting Pre-Exposure Prophylaxis*, **Bjoern Reinhard**, NIH, $2.9 million
- *Optical Voltage Imaging Analysis of the Cellular and Network Mechanisms of Deep Brain Stimulation*, **Xue Han**, NIH, $2.02 million
- *Lunar Environment Heliophysics X-Ray Imager (LEXI)*, **Brian Walsh**, NASA, $3.3 million
- *Bond-Selective Intensity Diffraction Tomography*, **Ji-Xin Cheng, Lei Tian**, Silicon Valley Community Foundation, $1.36 million
- *Efficient Two-Photon Voltage Imaging of Neuronal Populations at Behavioral Timescales*, **Jerry Chen, Michelle Sander**, NIH, $1.34 million

Research Summer Programs

The Photonics Center's summer research experience programs continue to energize our research community. Our 2023 cohort consisted of 23 participants (7 teachers and 16 undergraduates), including 4 teachers supported by our NSF Research Experiences for Teachers (RET) Site led by Professor Xin Zhang, 3 teachers supported by CELL-MET RET, 8 undergraduates supported by our NSF Research Experiences for Undergraduates (REU) Site also led by Professor Zhang, 2 undergraduates supported by our CELL MET REU, 1 undergraduate supported by our CELL MET Research Experiences and Mentoring (REM), 3 undergraduates supported by the Photonics Center's Photonics Undergraduate Research Summer Experience (PURSuE), and 2 undergraduates supported by a new 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 2023 teacher and undergraduate participants' self-identified race/ethnicity include 4 (18%) Black participants, 5 (22%) Asian participants, and 11 (48%) Hispanic participants. Fifteen (65%) participants self-identified as women. Three REU participants attend community colleges with the intent to transfer to four-year institutions to pursue bachelor's degrees. In addition, our 2023 cohort was diverse in terms of ability and disability status, sexual orientation, religion, rural and geographic disparities, and family and social status. Fourteen (61%) participants identified as first-generation college students.

We also hosted two Native American teachers from Nueta Hidatsa Sahnish Tribal College in North Dakota as a part of our summer research programming. Here, the two Tribal participants engaged in the study of impactful community interventions, mentored by Center Director Thomas Bifano, with the goal of reducing the prevalence of cardiovascular disease among American Indians and Alaskan Natives. The participants underwent a six-week plan, ending with inclusion at the CELL-MET REU/RET poster session, in direct connection to our RETs.

Faculty Awards and Promotions

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

- Professor **Soumendra Basu** won the TMS LMD and EPD Best Energy Paper Award - Professional, The Materials Society (TMS), LMD and EPD Divisions, 2022
- Professor **David Boas** delivered the 2023 DeLisi Lecture at the College of Engineering
- Professor **David Boas** was named Arthur G.B. Metcalf Chair
- **Jerry Chen** was promoted to Associate Professor and awarded tenure in 2023, and was a Molecular Basis of Cognition Scialog Fellow at the Research Corporation for Science Advancement in 2022
- Professor **Ji-Xin Cheng** was awarded BU's 2022 Innovator of the Year
- Professor **Anna Devor** was promoted to full professor in 2023
- Associate Professor **Mary Dunlop** was awarded the NSF Transitions Award, 2022
- Assistant Professor **Maria "Masha" Kamenetska** won the NSF CAREER Award, CAREER, NSF, Division of Chemistry, CSDM-A, Alexandria, United States, 2022
- Assistant Professor **Michael Economo** won the NSF CAREER Award, CAREER, NSF, Division of Integrative Organismal Systems, United States, 2022
- Assistant Professor **Hadi T. Nia** won the NSF CAREER Award, as well as the NIH Director's New Innovator Award (DP2), and the Beckman Young Investigator award, Beckman Foundation, in 2022
- Associate Professor **Miloš Popović** was awarded the 2022 Boston University Supervisor of the Year
- Professor **Xin Zhang** won the 2023 IEEE EMBS Society Award
- Professor **Xin Zhang** won the 2023 STAT Madness All-Star Award
- Professor **Xin Zhang** won the 2023 ASME Per Bruel Gold Medal

Faculty Scholarly Works

Scholarship by Photonics Center faculty included 213 publications of prominent articles in high-impact journals. Some highlights include the following articles:

- Javor, J., Imboden, M., Stange, A., Yao, Z., Campbell, D. K., and **Bishop, D. J.**, "Zeptometer Metrology Using the Casimir Effect," *Journal of Low*

Temperature Physics, vol. 208, no. 1, pp. 147-159, 2022/07/01 2022, doi: 10.1007/s10909-021-02650-3.
- Ayaz, H., Baker, W. B., Blaney, G., **Boas, D. A.**, Bortfeld, H., Brady, K., Brake, J., Brigadoi, S., Buckley, E. M., Carp, S. A., Cooper, R. J., Cowdrick, K. R., Culver, J. P., Dan, I., Dehghani, H., **Devor, A.**, Durduran, T., Eggebrecht, A. T., Emberson, L. L., Fang, Q., Fantini, S., Franceschini, M. A., Fischer, J. B., Gervain, J., Hirsch, J., Hong, K. S., Horstmeyer, R., Kainerstorfer, J. M., Ko, T. S., Licht, D. J., Liebert, A., Luke, R., Lynch, J. M., Mesquida, J., Mesquita, R. C., Naseer, N., Novi, S. L., Orihuela-Espina, F., O'Sullivan, T. D., Peterka, D. S., Pifferi, A., Pollonini, L., Sassaroli, A., Sato, J. R., Scholkmann, F., Spinelli, L., Srinivasan, V. J., St Lawrence, K., Tachtsidis, I., Tong, Y., Torricelli, A., Urner, T., Wabnitz, H., Wolf, M., Wolf, U., Xu, S., Yang, C., Yodh, A. G., Yücel, M. A., and Zhou, W., "Optical imaging and spectroscopy for the study of the human brain: status report," (in eng), *Neurophotonics*, vol. 9, no. Suppl 2, p. S24001, Aug 2022, doi: 10.1117/1.NPh.9.S2.S24001.
- Ferguson, A. L. and **Brown, K. A.**, "Data-Driven Design and Autonomous Experimentation in Soft and Biological Materials Engineering," *Annual Review of Chemical and Biomolecular Engineering*, vol. 13, no. 1, pp. 25-44, 2022, doi: 10.1146/annurev-chembioeng-092120-020803.
- Kuhfeldt, K., Turcinovic, J., Sullivan, M., Landaverde, L., Doucette-Stamm, L., Hamer, D. H., Platt, J. T., **Klapperich, C.**, Landsberg, H. E., and **Connor, J. H.**, "Examination of SARS-CoV-2 In-Class Transmission at a Large Urban University With Public Health Mandates Using Epidemiological and Genomic Methodology," *JAMA Network Open*, vol. 5, no. 8, pp. e2225430-e2225430, 2022, doi: 10.1001/jamanetworkopen.2022.25430.
- Xia, Q., Yin, J., Guo, Z., and **Cheng, J.-X.**, "Mid-Infrared Photothermal Microscopy: Principle, Instrumentation, and Applications," *The Journal of Physical Chemistry B*, vol. 126, no. 43, pp. 8597-8613, 2022/11/03 2022, doi: 10.1021/acs.jpcb.2c05827.
- Chen, G., Shi, L., Lan, L., Wang, R., Li, Y., Du, Z., Hyman, M., **Cheng, J.-X.**, and **Yang, C.**, "High-precision neural stimulation by a highly efficient candle soot fiber optoacoustic emitter," (in English), *Frontiers in Neuroscience*, Original Research vol. 16, 2022-November-03 2022, doi: 10.3389/fnins.2022.1005810.
- Zhao, J., Matlock, A., Zhu, H., Song, Z., Zhu, J., Wang, B., Chen, F., Zhan, Y., Chen, Z., Xu, Y., **Lin, X.**, **Tian, L.**, and **Cheng, J.-X.**, "Bond-selective intensity diffraction tomography," *Nature Communications*, vol. 13, no. 1, p. 7767, 2022/12/15 2022, doi: 10.1038/s41467-022-35329-8.
- Chen, Y. and **Dal Negro, L.**, "Physics-informed neural networks for imaging and parameter retrieval of photonic nanostructures from near-field data," *APL Photonics*, vol. 7, no. 1, 2022, doi: 10.1063/5.0072969.
- Michas, C., Karakan, M. Ç., Nautiyal, P., Seidman, J. G., Seidman, C. E., Agarwal, A., **Ekinci, K.**, Eyckmans, J., **White, A. E.**, and Chen, C. S., "Engineering a living cardiac pump on a chip using high-precision fabrication," *Science Advances*, vol. 8, no. 16, p. eabm3791, 2022, doi: doi:10.1126/sciadv.abm3791.
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- Zheng, S. and **Mertz, J.**, "Direct characterization of tissue dynamics with laser speckle contrast imaging," *Biomed Opt Express*, vol. 13, no. 8, pp. 4118-4133, 2022/08/01 2022, doi: 10.1364/BOE.462913.
- Li, Y., Krisshnamurthi, M. R., Luo, W., **Swan, A. K.**, **Ling, X.**, and **Paiella, R.**, "Graphene metasurfaces for terahertz wavefront shaping and light emission [Invited]," *Opt. Mater. Express*, vol. 12, no. 12, pp. 4528-4546, 2022/12/01 2022, doi: 10.1364/OME.473110.
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mediated memories during reconsolidation to disrupt fear," *Nature Communications*, vol. 13, no. 1, p. 4733, 2022/09/12 2022, doi: 10.1038/s41467-022-32246-8.
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- Xu, S., Turnali, A., and **Sander, M. Y.**, "Group-velocity-locked vector solitons and dissipative solitons in a single fiber laser with net-anomalous dispersion," *Scientific Reports*, vol. 12, no. 1, p. 6841, 2022/04/27 2022, doi: 10.1038/s41598-022-10818-4.
- Mrak, S., Zhu, Q., Deng, Y., Dammasch, I. E., Dominique, M., Hairston, M. R., Nishimura, Y., and **Semeter, J.**, "Modeling Solar Eclipses at Extreme Ultra Violet Wavelengths and the Effects of Nonuniform Eclipse Shadow on the Ionosphere-Thermosphere System," *Journal of Geophysical Research: Space Physics*, vol. 127, no. 12, p. e2022JA031058, 2022, doi: https://doi.org/10.1029/2022JA031058.
- Xue, Y., Yang, Q., Hu, G., Guo, K., and **Tian, L.**, "Deep-learning-augmented computational miniature mesoscope," *Optica*, vol. 9, no. 9, pp. 1009-1021, 2022/09/20 2022, doi: 10.1364/OPTICA.464700.
- Ekiz Kanik, F., Celebi, I., Sevenler, D., Tanriverdi, K., Lortlar Ünlü, N., Freedman, J. E., and **Ünlü, M. S.**, "Attomolar sensitivity microRNA detection using real-time digital microarrays," *Scientific Reports*, vol. 12, no. 1, p. 16220, 2022/09/28 2022, doi: 10.1038/s41598-022-19912-z.
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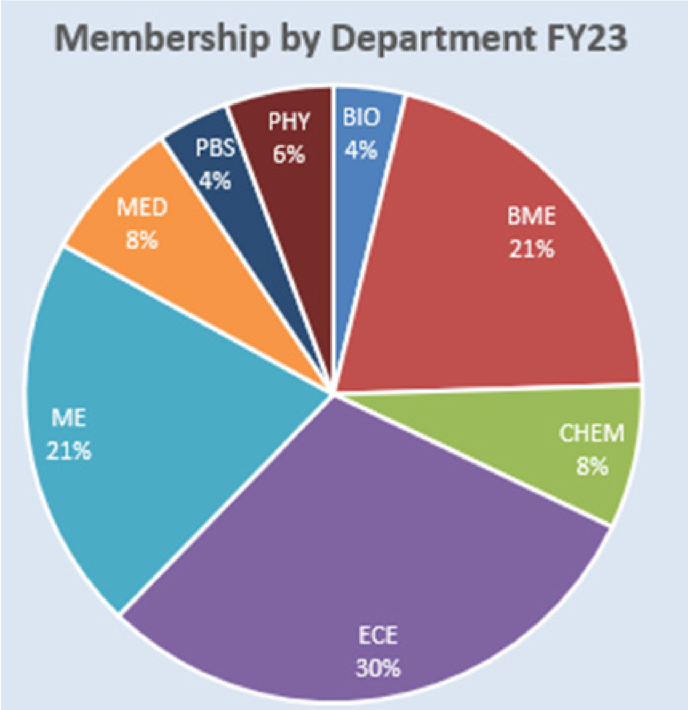
- Huang, Y., Kaj, K., Chen, C., Yang, Z., Ul Haque, S. R., Zhang, Y., Zhao, X., Averitt, R. D., and **Zhang, X.**, "Broadband Terahertz Silicon Membrane Metasurface Absorber," *ACS Photonics*, vol. 9, no. 4, pp. 1150-1156, 2022/04/20 2022, doi: 10.1021/acsphotonics.2c00166.

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, and students engage 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
- 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 thirty faculty laboratories in its facility and supports research infrastructure needs for additional faculty laboratories housed in other academic units. The staff manages four large, shared core laboratories with state-of-the-art equipment and assumes 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 grants. Its resources are allocated primarily to accelerate research outcomes and to train graduate students. BUPC membership includes sixty-one faculty and their associated groups of graduate students and postdoctoral researchers. Affiliates include the Materials Science and Engineering Division of the Boston University 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 eight academic departments across BU's campus. Over the past 10 years, the membership has increased by 29%, from 38 members to 53 active members and 8 emeritus faculty. New Boston University faculty members of the center who were appointed this past year include: Sean Lubner, an assistant professor in ME and MSE who specializes in nano-to-macro energy transport and conversion, and focuses his research on long duration energy storage; Hadi T. Nia, an assistant professor in

BME and MSE, specializing in mechanobiology and mechano-immunity, with a focus on cancer research; Mary Dunlop, an associate professor of BME, as well as the graduate chair for BME, with research interests in metabolic engineering, optogenetics, and more; and Tianyu Wang, who will be joining the Photonics Center through ECE with a research focus on micromirror devices, in-vivo mouse brain imaging, deep physical neural networks, and more. Furthermore, Center space is being renovated for Sean Lubner and Tianyu Wang in rooms 703 and B12, respectively.

Listed below are some of the ways in which the Photonics Center community pursues each of its four mission-specific themes.

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 imaging, biosensing, neurophotonics, photonic materials, metamaterials, lasers, nonlinear optics, and quantum photonics.

In addition to its core, faculty-led research program, the Photonics Center is 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, the NPC continues to receive technical, financial, 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 training 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 an NIH T32 proposal 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 get 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, and SPIE) and paying student fees for memberships; providing travel awards to doctoral students who have a poster 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 Optica/SPIE hosted a Boston Photonics day on October 4, 2023, held at the Photonics Center. Xiaowei Ge, president of the SPIE/OPTICA Student Chapter, hosted the event amongst her peers, introducing keynote speaker from Brown University, Dr. Daniel M. Mittleman, among other presenters. Mittleman spoke on the multimodal nature of "Near-field terahertz networking" and the looming need for wireless systems to kick off the event. The rest of the event featured invited external speakers and Photonics student alumni speakers, ranging from professionals in the academic and research fields, to OPTICA ambassadors, to BU alumni, each providing a new insight into how today's BU students seeking a career in photonics and optics can forge their own path forward. One such example was BU alumnus Peng Li, who used his Ph.D. journal to demonstrate

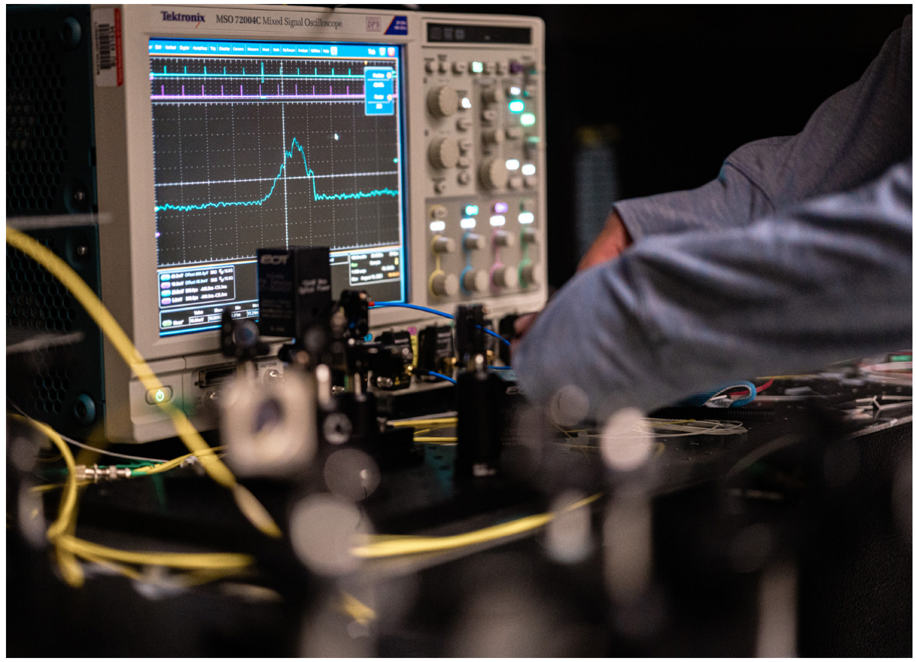


Photo taken in Michelle Sander's lab. Credit: Christopher McIntosh

job preparation strategies for students studying optics and photonics. A student research poster session was also featured at the event, where all attendants and speakers were able to preview some of the latest technological advancements in the field, as supplied by several Boston-based companies such as THORlabs and PlenOptika.

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 with a record 16 member companies. The BIC is anchored by three multi-national leaders in opto-electronics, micro-electromechanical devices, and imaging. The BIC companies continue to be valued participants in the Photonics Center community, collaborating with faculty, training students, and creating a career option 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.

Strategic Goals

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

1) Support and catalyze 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 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 NSF-sponsored CELL-MET Engineering Research Center, now in its 7th year and renewed for years 6-10 for $17.5M, led by Professor David Bishop, that aims to engineer heart tissue for cardiac repair. CELL-MET includes a supplemental grant for a US-Ireland R&D Partnership Collaboration, led by David Bishop, Alice White, and Chris Chen to study Cardiac Organoid Systems, as well as industry contracts and other supplemental funding. We are now in Year 3 of Professor Anna Devor's NIH-sponsored $14M U19 multi-university program, to study Local Neuronal Drive and Neuromodulatory Control, and we organized a successful three-day research retreat and NIH site visit for the program thar took place in late September 2023. We administer the Kilachand Fund award of $1.5M led by professors Xin Zhang, Stephan Anderson, and Ioannis Paschalidis, entitled "Metamaterial and AI-Enabled Ultra-Low Field MRI for Low-Cost, Portable Brian Imaging". Following the award of the NSF MRI: Acquisition of a Spinning Disk Confocal Super-resolution Microscope for Transcriptomics Research with Tom Bifano as PI, we purchased a new Nikon CSU-W1 SoRa microscope and supported the installation. The grant covers partial salary for a Research Technician on the NPC staff to manage the microscope, and we continue to administer the grant. As noted, we also continue to run NSF funded research experience programs for undergraduates (REU), high school and community college teachers (RET), and mentoring in STEM fields (REM), as well as curriculum development outreach in East Boston High school. We are taking over the administration of Professor Enrico Bellotti's DOD/ARL funded Center for Semiconductor Modelling (CSM), which renews this fall for $6.25M for 5 years and includes a consortium of 6 industry and 2 academic partners.

NSF ERC (CELL-MET)

The 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 drives these technologies to the clinical environment by building an innovation ecosystem of industry, medical and regulatory stakeholders, and training a pipeline of skilled engineers and scientists. This workforce is diverse and inclusive, and engagement of future leaders begins at the K-12 level and continues through post-doctoral levels. The Photonics Center staff play significant leadership roles in the research, inclusiveness, training, administration, and technology transfer efforts of CELL-MET.

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

NSF Center to Center (C2C) project

In its third and final year during 2022-23, the C2C project, Cardiac Organoid Systems Partnership (COSP) served as a collaboration between CELL-MET, the SFI Research Center for Medical Devices (CURAM) out of the National University of Ireland, Galway and the Wellcome-Wolfson Institute for

Experimental Medicine (WWIEM) out of Queens University Belfast. These Centers have a common goal to cure heart disease and the complementary skills of this C2C collaboration provide a force multiplier that enhances the opportunity for success. The COSP has pursued development of high-throughput techniques for the fabrication of nanoscale scaffolds and the functionalization of those scaffolds with cardio biosystems. Partnerships like this are possible due to the Photonics Center's reputation and leadership position in the biophotonics sector and established corporate partnerships. One of our BU CELL-MET graduate students, Noelle Pierce, who has been supported by the program in Professor David Bishop's group, spent 10 weeks this past summer working on the project with our collaborators in Galway.

NIH U19 BRAIN Initiative Award

This multi-university $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, Laura Lewis (now at MIT), Lei Tian, and administered through the Photonics Center, involves partners from Massachusetts General Hospital, 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.

Kilachand Fund for Integrated Life Sciences and Engineering

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 that 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 at BU and through subcontracts and industry contracts. The CSM 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 this fall 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.

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 3 former REU participants and 6 CELL-MET students, 20 high school students, and 80 elementary students.

Photonics Center Community & Training

The Photonics Center Graduate Education Committee, led by Professor Ji-Xin Cheng and comprised of faculty and staff (Professors Darren Roblyer and Bjoern 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 of use 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 community building and training program 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.

As part of the Committee's recruitment efforts, the Photonics Center supported recruitment bonuses of $2,000 that 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, 13 recruitment bonuses were offered with 2 BME students and 1 ECE student accepting for fall 2023.

NSF REU/RET/REM Summer Programs

The Photonics Center's summer research experience programs engage students and teachers in meaningful and authentic research, with the aims of supporting individuals from historically excluded groups and broadening participation in science and engineering, to help build a STEM pipeline and inspire STEM careers. The 23 participants in summer 2023 were a diverse and successful group including:

- Three high school science teachers and one community college professor in our RET Site Program on the topic of Integrated Nanomanufacturing and three high school science teachers in our CELL-MET RET program, all of whom teach in schools serving disadvantaged and minority student populations.
- Two Native American teachers from Nueta Hidatsa Sahnish Tribal College in North Dakota as part of a six-week program on the topic of impactful community interventions to reduce heart diseases.
- Eight undergraduates (including 2 from community colleges) in our REU Site Program on the topic of Integrated Nanomanufacturing.
- Two undergraduates in the CELL-MET REU Program at BU (Four additional CELL-MET REU participants are based at partner institutions UM and FIU).
- One undergraduate in our CELL-MET Research Experiences and Mentoring (REM) supplemental program.
- Three undergraduates from top undergraduate optics and photonics programs in our self-funded Photonics Undergraduate Research Summer Experience (PURSuE).
- Two undergraduates in the new Photonics and MSE-funded Materials Science & Engineering REU.

The summer research programs culminate with a joint poster event for Photonics, Chemistry, and Physics REU and RET programs, attended by more than 120 BU students and faculty.

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 schools. The Photonics Center partners with STEM program leaders and teachers in primarily Hispanic East Boston, to engage in spirited multi-grade level student interactions. With East Boston High School (EBHS), the Photonics Center has developed an engineering outreach program with near-peer mentoring in which EBHS students were coached and mentored by their teachers and Photonics Center students to prepare them to teach and mentor 3rd and 6th grade students at partner schools in the Boston area, inspiring their younger peers with hands-on learning activities in STEM topics. The content of the outreach program this past academic year (2022-23) was developed by Photonics RET participants and East Boston High School (EBHS) students with one lesson about heart health, adapted from the highly successful Engineering Engagement Kits (EEK!) that were developed for CELL-MET.

In Spring 2023, 12 BU graduate

and undergraduate students visited East Boston High School and Otis Elementary School, to mentor approximately 20 AP Biology students from EBHS and assist the high school students 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, and then 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 2-3 – Gr 3&6: What is an Engineer?
- March 23-24 – Gr 3&6: Graphite Circuits
- April 12-14 – Gr 3&6: Monomers and Polymers
- May 11-12 – Gr 3: Engineering Design Process; Gr 6: Feel the Beat (Heart Rates and Cardiovascular Disease)
- May 26 – Gr 3&6: UV Light
- June 2 – ALL: Museum of Science Field Trip

The Photonics Center envisions that this Engineering Engagement Program will be replicated and adopted by other schools in and beyond the Boston area. The program provides unique mentoring opportunities for students and visible pathways for younger students to see themselves as future engineers.

Two 3rd-grade Otis Elementary students, Credit: Kelly Peña

The 2023 REU Cohort at Long Wharf in Boston, Credit: Kelly Peña

Business Innovation Center

The BIC is a facility located at the Photonics Center that houses industry tenants engaged in commercial activities 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.

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 four large companies in the BIC are AEMtec, FLEXcon, Analog Devices (ADI), and Thorlabs. The other nine outside (non-BU) entities are smaller companies and there are three BU faculty spinout companies.

Profiles of Select BIC Tenants:

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 but 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.

Analog Devices' BIC team are working on a low-cost, rapid, personal Covid test. Their team at the BIC is a self-named "intrapreneur shop" with a "lab to fab" mindset as part of the Analog Garage which reports to the CTO at ADI headquarters. They're here to engage with startups and look for win-win situations: "we bring the manufacturing, marketing, and distribution. You bring the tech."

Quantum Network Technologies (Qunett), a recent addition to the BIC, is developing a full stack of hardware and software solutions for the quantum internet. Qunett has secured two government contracts to develop their Megaqubit Quantum Router and Deterministic Entangled Photon Source technologies. Qunett moved into lab 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.

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 needed to support continued strong yearly growth of the company.

Three of the 16 BIC tenants are BU faculty spinouts. Professors Stephan Anderson and Xin Zhang have two spinouts in the BIC. ***Acoulent*** is working on a metamaterial-based noise cancellation product. ***Primetaz*** makes materials that increase the signal of MRI machines. 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 who was named 2021 BU Innovator of the Year. iRiS Kinetics develops and markets imaging biosensor platforms for applications ranging from molecular binding affinity measurements to single biological particle detection. They hired three undergraduate interns and two doctoral student interns. iRiS Kinetics was a recipient of the EU Transition Grant – NEXUS.

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.

Neural Dynamics Technologies (NDT) creates implantable high-resolution electrodes for basic research and clinical purposes. For basic research applications, they develop custom high-density electrodes for recording brain activity in the form of local field potentials and single neuron action potentials in any brain region. NDT is collaborating with Professor Xue Han to test device prototypes.

In-Depth Profile:
Leuko Labs, Leuko Labs, an MIT spinout, is developing their PointCheck device, used for non-invasive white cell monitoring, had a big year. 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.

- Financing: in September 2022, Leuko Labs closed a $5M Series A from HTH VC, Good Growth Capital, IAG Capital Partners, Nina Capital, and angel investors.
- Awards: in September 2022, Leuko Labs received the 2nd prize at the RESI Innovators Challenge pitch competition. In March 2023, Leuko received a $50k NIH TABA award to work on our market access and reimbursement strategy.
- Products launched: in January 2023, Leuko Labs signed a pilot agreement with Telefónica, a leading provider of a wide range of communication solutions with operations in Spain, USA, Germany, UK, Brazil, Mexico and seven other Latin American countries. This collaboration is to explore the use of Telefónica's 5G connectivity and Edge computing services in the operation of Leuko's device PointCheckTM. The 5G connected device will be further tested in a clinical trial with a major pharmaceutical company.
- Recognition by a third party: in October 2022,
- Leuko Labs was selected for inclusion in the MIT Museum permanent exhibit "Essential MIT." It is one the first inventions visitors encounter in the newly opened MIT museum. It is a tremendous honor for Leuko to be included amongst the other great inventions made by MIT faculty and scientists.

FY23 Innovation Center Tenants				
Company Name	**Origin**	**Idea**	**Market Sector**	**Funding**
Acoulent	Boston University	Metamaterials	Noise Cancellation	Grants
AEMtec	Corporate	Optoelectronic Circuits	Medical Technology, Telecomm, Other	Corporate
Analog Devices Inc.	Corporate	MEMS	Healthcare	Corporate
BioVirtus	Private	Rx	Healthcare	Grants
Coalesenz	MGH: Wellman Center	Optical Sensor	Healthcare	Grants
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
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	Telecome	Grants
Stata Dx	Harvard University	Diagnostics for neruodegenerative	Healthcare	Grants
Thorlabs	Corporate	Optical Tools	Multiple	Corporate

CELL-MET Innovation Ecosystem

One of the broader impact 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, the key 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 renewal plans for Years 6-10.

Highlights over first six years of the CELL-MET ERC include the establishment of an Industry Practitioner Advisory Board with 13 members contributing funds, equipment, mentoring, and internship/research opportunities; cash membership contributions totaling $658K and in-kind another $403K for a total of $1.061M; and support of 5 seed projects for commercialization from the cash contributions totaling $435K. CELL-MET has submitted 24 patent filings to date with two licenses granted and two potential licenses in early discovery discussions. In addition, CELL-MET industrial affiliates have supported 4 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 a 2.5 day "Industry Engagement" workshop in November, 2022 with its Industry Affiliates.

BU NEUROSCIENTIST STEVE RAMIREZ GIVEN $1.15 MILLION CHAN ZUCKERBERG INITIATIVE SCIENCE DIVERSITY LEADERSHIP AWARD

EXPERT ON MEMORY WILL USE AWARD'S FIVE-YEAR GRANT TO ADVANCE RESEARCH AND TRAIN SCIENTISTS FROM UNDERREPRESENTED BACKGROUNDS

by Andrew Thurston for *The Brink*, photos by Jackie Riccardi

Steve Ramirez, a Boston University neuroscientist studying memory with the goal of improving mental health treatment, has been given an inaugural Science Diversity Leadership Award by the Chan Zuckerberg Initiative. The awards—launched in partnership with the National Academies of Sciences, Engineering, and Medicine—champion early- and mid-career scientists with a proven research record and a commitment to diversifying their field.

In his lab, Ramirez (CAS'10), a BU College of Arts & Sciences assistant professor of psychological and brain sciences, examines the neural circuits controlling memory and looks for ways to modulate them. His goal is to shape memories to help treat depression, post-traumatic stress disorder, and other mental health disorders.

The Chan Zuckerberg Initiative was founded in 2015 by Facebook founder and Meta CEO Mark Zuckerberg and his wife, Priscilla Chan, and its diversity leadership award comes with a five-year, $1.15 million grant. Ramirez will use the funding to advance his research and train the next generation of scientists from underrepresented backgrounds.

The Brink spoke with Ramirez about why this award matters and why it's so important to diversify science.

Q&A WITH STEVE RAMIREZ

***The Brink:* What's the goal of your research?**

Ramirez: The importance of the work is twofold. The first is the idea that we can go in and image memories in the brain, and then go in and see how the memories look, how they change over time as they're formed, and even as they get emotional significance, like positive memories, negative memories. One of the overarching goals of the lab is to look at the physical basis of memories as they change, as they become positive or negative, or even as they enter a pathological space, as the brain begins to break down, or as the brain begins to degenerate. And then the second part is—given that

Steve Ramirez, a CAS assistant professor of psychological and brain sciences, says having a diverse team gives his "lab a different lens through which to view science and view the world"

we can look at memories as they change in the brain over time—can we go and artificially manipulate them? And, if so, can we do so in some kind of therapeutic capacity, so that the idea of artificially manipulating memories becomes part of the toolbox we have for tackling various disorders of the brain.

Why is the Science Diversity Leadership Award important to you?

It's amazing. It really fortifies our plans for training the next generation of neuroscientists, particularly from underrepresented backgrounds. My family's from El Salvador, I'm Hispanic American, and there's a sparsity of neuroscientists that are from Hispanic backgrounds. The significance of the award is that it helps us train the next leaders who will become role models for the subsequent generation. I remember when I was in graduate school, I didn't really have that many, if any, Latino neuroscientists to look up to or to call role models. And it kind of dawned on me way after the fact that if there are no role models around you, it's because you're the one to become that [role model] to help the next generation.

Our outreach plans for training the next generation of Hispanic and Hispanic American scientists can become a possibility thanks to the award. It does require funding and infrastructure for training these students in the lab, and forming these kinds of lifelong mentorship, training dynamics that hopefully will launch their careers. And what they're being trained in is part of the lab's mission of artificially manipulating and imaging memories in the brain. The award enables both the outreach components of our lab's approach to training neuroscientists, and simultaneously enables the research that will be going on.

How do you plan to recruit and train students from underrepresented backgrounds?

I went to public schools in Everett, a town six miles north of Boston, and my classroom in high school was, to this day, the most diverse classroom I've ever been in. I want to make neuroscience look like my high school classroom, where diversity is the norm, not the exception. The first thing would be to start off with recruiting from towns that have large Hispanic populations and representation—for instance, Everett, East Boston, Chelsea, some of the towns that I grew up in or around—to seek out high school students who can partake in a summer internship in the lab, using that to begin their experience in neuroscience and research. We have a lot of undergrads in the lab already that come from underrepresented backgrounds, so the award will also help us maintain those students for a longer period of time and to really start their careers in science and beyond.

"Celebrating is easy, but when life throws its inevitable curveballs at us, having [a] support system is a way of getting back to shore when we're paddling alone out in the stormy ocean."
–Steve Ramirez

How does having a more diverse team help improve your lab, and the science you and BU can do?

When we have students from different perspectives, it grounds the lab, it gives the lab a different lens through which to view science and view the world. We have a couple of undergrads, for instance, from Latin America. Some of the topics that we talk about, that we connect over, are making money to send back home to our families that we're helping out and how many often have to have a second job to help family back home or maintain finances. A lot of people don't relate to that directly, but when I chat with students, we connect about that. I understand that from within, because it's exactly the same trajectory that I went through and it helps me connect with students on a very human level.

Having these different perspectives really helps everybody. It helps everyone connect on a fundamentally deeper level. And that connection is the brick and mortar of teamwork, of groups working well together toward a common goal, such as a set of experiments in the lab. When you get people who understand each other—or respect each other's very different walks of life and where they come from—not only are they doing an experiment and science together, but they're [also] learning from each other, and they're learning from each other in a way that a classroom may not be able to teach you, but life and the experiences you have in the lab can be part of that enriching experience. It helps sculpt the next generation of citizens of the world.

I've seen firsthand how that helps people think creatively, or helps people think out loud without feeling like an imposter or inadequate. It's an environment that accepts and supports you, wants to elevate you. And then, when you work with other people who have that shared goal, everyone wins. Having a diverse set of perspectives with that approach is as enriching as any research experience in science can be.

What message or advice do you have for those students from a background like yours who want to follow in your footsteps?

There's a couple of bits of advice, and the first and foremost is that your values, and who you are as a person, shouldn't come second to work or career, or appeasing the establishment. Your values, who you are, what makes you tick, what makes you excited, those are your nonnegotiables. Ideally, you would be in a work environment that supports that, that elevates that, and that respects what you bring and who you are. Then you bring your whole self to the table.

A piece of advice I was once given was to build an army of people you trust around you, of friends, of colleagues, a support system of people who really do have your back. Celebrating is easy, but when life throws its inevitable curveballs at us, having that support system is a way of getting back to shore when we're paddling alone out in the stormy ocean.

There are multiple ways of succeeding and being happy. It's really embracing that your personal trajectory, like your fingerprint, is yours to own. It doesn't have to be one size fits all, it doesn't have to be the way that anyone else did it.

THE SKY'S THE LIMIT: RAMACHANDRAN TEAM'S LIGHT TRANSMISSION DISCOVERY PUBLISHED BY SCIENCE

RESEARCHERS' NEW METHOD FOR SCALING UP DATA CAPACITY IN OPTICAL FIBERS ECHOES ASTRONOMICAL PHENOMENA - WITH SIGNIFICANT IMPLICATIONS FOR TOMORROW'S INTERNET.

by A.J. Kleber and Millie Zhu for Boston University College of Engineering

Have you ever idly logged into your social media accounts over breakfast, only to be overwhelmed by the sheer number of posts clogging up your feed? So many people sharing a nearly endless stream of articles, memes, personal anecdotes and yes, even essential information. It's hard to take it all in–and not just for our minds.

It's undeniable that the amount of data people are generating in digital spaces is constantly, exponentially growing. We tend to think of information as ephemeral, hovering insubstantially in "the cloud," but in reality there are physical limits to how our data is stored and transmitted, and this continual increase in content is beginning to pose a challenge to the optical fibers that form the infrastructure through which it travels.

Optical fibers are the backbone of long-distance data transmission, whether that's taking place between quantum-computing nodes, between servers in a data center, or across the worldwide internet. The information is sent in the form of beams of light, which can be maintained and relayed over globe-spanning distances using a phenomenon called "total internal reflection," which allows light to bounce off the walls of a fiber "light pipe" with minimal loss. However, the capacity of a given optical fiber is limited–a limit our expanding data generation threatens to exceed. Fresh solutions are needed, which is where Professor Siddharth Ramachandran and ECE PhD candidate Zelin Ma come in.

In a new paper published in Science, Ma and Ramachandran, along with industry collaborator Poul Kristensen of OFS Optics, demonstrate their groundbreaking solution–one which not only cracks the problem of the upcoming capacity crunch, but may also yield a more energy-efficient means of signal transmission.

One existing approach to alleviating capacity crunch involves configuring an optical fiber to support several separate data channels. Light travels down these channels in spatially distinct patterns, each of which carries as much data as a single standard fiber. Ramachandran and his team had previously played a pivotal role in the development of this concept, demonstrating its viability in a publication in Science in June 2013. Ramachandran compares this method to

Professor Siddharth Ramachandran

"expanding the number of lanes in a highway" to allow for increased traffic. Unfortunately, this tends to lead to "crashes"– information leaking between channels. This leakage corrupts every channel within the fiber, thereby rendering information transmitted in all channels irretrievable–making this method a stopgap at best, not an effective solution.

Instead of thinking in terms of cars and roads, Ramachandran suggests a more celestial framework.

"High-topological charge light beams" behave differently from the standard beams used in optical communications today; instead of moving in a straight line, they twist as they travel, generating a "centrifugal barrier" similar to those created by the rotation of binary stars. Just as centrifugal barriers protect such stars from crashing into one another through the sheer force of their respective gravity, they can also operate to keep these unusual light beams contained within an optical fiber over significant distances. These twisted beams do not require total internal reflection, previously thought to be necessary for transmitting light, to remain confined to the optical fiber. This peculiar effect, dubbed "topological confinement" by the authors, also makes high-topological charge light beams significantly more robust than conventional beams. They're able to contain many more data channels without that pesky leakage problem.

As laid out in their paper, Ramachandran's team has successfully demonstrated their new method by packing as many as 50 data channels into a single 1-kilometer optical fiber; 25 times the capacity of conventional fibers. They theorize that this improvement is only the beginning–and if their approach is as scalable as they suspect, it could have a truly global impact.

First author Zelin Ma recently defended his doctoral dissertation, "Light Transport by Topological

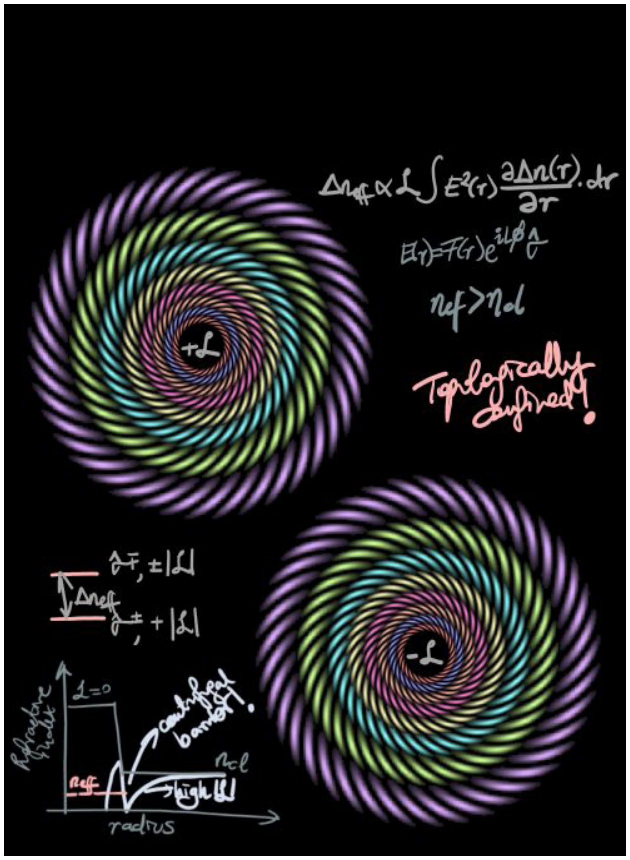


Image credit: Havva Begüm Kabagöz, Aaron P. Greenberg, Zelin Ma.

Confinement," based on the same research. After wrapping up some studies that extend this research, he aims to consider industrial or academic positions in related areas in the fields of classical or quantum communications. Ma's advisor and corresponding author, Distinguished Professor of Engineering Siddharth Ramachandran, directs the High Dimensional Photonics Lab at Boston University. His research centers on nonlinear, ultrafast and quantum photonics, fibers and guided-wave devices, brain imaging, and classical and quantum networks.

■ JI-XIN CHENG IS BU'S 2022 INNOVATOR OF THE YEAR

CHENG WAS CHOSEN FOR HIS INNOVATIONS IN BIOMEDICAL ENGINEERING, INCLUDING INVENTING A TREATMENT FOR MRSA AND IMAGING MOLECULES INSIDE LIVING CELLS

by Jessica Colarossi for *The Brink*, photos by Jackie Riccardi

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Ji-Xin Cheng, the Moustakas Chair Professor in Photonics and Optoelectronics, has been named the 2022 Boston University Innovator of the Year.

Professor Ji-Xin Cheng

Cheng has a long list of trailblazing achievements, including inventing a way to use blue light and hydrogen peroxide to treat a drug-resistant skin infection called MRSA, finding molecular signatures associated with aggressive cancers for treatment and diagnosis, and creating novel imaging techniques using infrared light to see molecules inside living cells. A BU College of Engineering professor of biomedical engineering, electrical and computer engineering, and materials science and engineering, his specialty is bond-selective imaging, which allows scientists to see cells on the molecular level without injecting a visible dye (dye particles are larger than molecules, interfering with their chemical makeup). He recently received funding from the Chan Zuckerberg Initiative to develop a new dye-free technique, called bond-selective intensity diffraction tomography, which can produce a three-dimensional map of a specific chemical inside cells. This has the potential to help scientists unlock knowledge for treating diseases, from cancer to Alzheimer's.

With over 30 patents and multiple companies, like VibroniX and Pulsethera, aimed at bringing his techniques to the market, Cheng's work has measurable impact—and he is far from finished.

"I have been keeping BU's Technology Development office very busy," Cheng says. Each year, Technology Development, which helps faculty commercialize their research, gathers nominations from the BU community to select the Innovator of the Year award. This year's award was announced at an in-person celebration on May 1 and presented to Cheng by Kenneth R. Lutchen, ENG dean and a professor of biomedical engineering.

To learn more about where he gets his inspiration, The Brink sat down with Cheng to talk about his journey as a scientist and inventor.

Q&A WITH JI-XIN CHENG

***The Brink*: Why do we want to see into cells?**

Cheng: To understand the nature of life. The molecules in the cell are highly organized and work together to drive, produce energy, produce membranes, divide, but exactly how so many molecules work inside cells is not clear. If we can understand this, we can understand the fundamentals inside the cells. It is also very important for disease diagnosis and treatment—when a cell becomes a cancer cell, we want to understand if there is new chemistry happening in the cancer cell, which can be a signature for cancer diagnosis.

My team has made many discoveries. For example, using coherent Raman scattering microscopy, of which I am a coinventor, we discovered a molecular signature for aggressive prostate cancer in 2014. It helps distinguish aggressive prostate cancer versus a benign tumor. With label-free imaging, we can directly study the human sample and look into the cell, which is beyond the reach of fluorescence microscopy. We find that the signature is not everywhere, it's localized in one particular position of the cell.

With so many different aspects of your work, what are you focusing on now and hoping to accomplish next?

We do many things—I'm not limiting myself to imaging. In collaboration with my BU colleague Chen Yang and others, I recently started in a new direction called optoacoustic neuromodulation. Scientists want to make new tools to control the behavior of the brain. This happens now with a technique called optogenetics, but it has one problem: it needs a virus to deliver a gene for this technique to work. That means a viral particle delivers a gene to the neuron—this is done in mice, but you don't want to inject a viral particle in a human. So, we're asking, can we do this genetics-free?

Like a safe alternative version for humans?

Right. We had the idea of converting optogenetics—which is optical, using light to stimulate the neuron—to an opto-mechanical technique. That way, we can perturb the neuron membrane and it will fire—this is what we're calling optoacoustic, so it converts an optical wave to an ultrasound wave to produce brain stimulation. One goal is to do this for treatment of human patients. We're working with a Paris-based company, Axorus, to apply this technique for retinal stimulation. It's in the early stages, but the scientific principle works. This can help a lot of people if we can turn this into a real device. It will take another 8 to 10 years.

How did you first get started in this field?

I was trained as a physical chemist as a PhD student and postdoc. I was looking for a job in 2003 and had one offer from the chemistry department at the University of Utah. I then got an offer from Purdue University in biomedical engineering, and I had no idea what biomedical engineers do—I talked to my advisor at Harvard University and he said, "Oh they make artificial bones." So, that was my initial understanding of biomedical engineering. Photonics was still new and eventually became a major direction, but the whole biomedical engineering department at Purdue only had six faculty at the time. It turned out to be a very good decision for me to go there, because I was able to bring my spectroscopy knowledge into the biomedical engineering discipline. I had the fortune of leading an emerging field called chemical imaging. A major goal of my career is to build a special microscope, called a chemical microscope, which allows scientists to map molecules inside a living system without dye labels.

Cheng holds a model of a chemical bond attached to a molecule. He says one of the goals of his work is to "understand the nature of life."

What would you say to early career scientists who want to be innovators? What advice would you give them?

The whole world can be described in one word: change. Innovation means that you do new things, and the whole world is changing every day. If you don't change, you cannot do new things. And embracing change, in my case, is having no fear to enter a new field, or a new discipline. That will create unexpected opportunity. The flip side to my advice is to not change—that's exactly the Chinese philosophy, the yin and yang, change and no change. Here, no change means persistence. Because if you want to have a big impact, you need to have persistence toward a far-reaching goal and never give up. I have a dream to make dye-free bond-selective microscopy extremely sensitive, to be on par with fluorescence microscopy, which has single molecule detection. That way we can really see molecules, since the concentration of most molecules inside cell tissue is very low. We are now very close to that dream, from not giving up and having no fear of trying new ways over the past 20 years.

NANOVIEW | A BU SPINOUT'S STORY OF SUCCESS

by Rana Gupta for the Boston University Photonics Center

George Daaboul, PhD: 2015 (left) and David Freedman, PhD: 2009 (right)

Introduction:
NanoView Biosciences, a venture-backed startup purchased in 2022 by a California-based life science company, was entirely a creation of BU.

The company's founders, David Freedman and George Daaboul, were both PhD students in BU's School of Engineering. Freedman and Daaboul met working at the lab of Professor Selim Ünlü and then incubated NanoView at "the BIC," the Business Innovation Center inside BU's Photonics Center, located at 8 St. Mary's Street in Boston. Rana K Gupta, a lecturer in BU's Questrom School of Management, met Freedman and Daaboul in 2012 and mentored the founders for the next six years. An early investor in NanoView, Parker Cassidy, earned his Bachelor of Science in mechanical engineering at BU. When the time came for Freedman to hand over the CEO reins, the company hired an executive, Jerry Williamson, who had earned his MBA at BU. The people, product, and place of NanoView and its success were all strongly linked to BU.

A core element of NanoView's intellectual property was developed in a lab run by Selim Ünlü, a professor in BU's Department of Electrical and Computer Engineering. "BU did a really fantastic job of encouraging and helping us build our company from the ground up," Freedman said. "It was really a great ecosystem for growing a company." The pair also credit Michael Pratt, the university's managing director of Technology Development, for his guidance. A licensing deal needed to be negotiated with the university, and Pratt "made sure we weren't burdened by the deal," said Freedman.

Grown Inside a BU Lab:
David Freedman had long known he wanted to be an entrepreneur. "My parents had a startup," he said. "I had always been passionate about startups." He arrived on campus in 2005 to start a PhD program in electrical engineering, on the lookout for an idea that might let him build a company.

George Daaboul also arrived at BU in 2005, as an undergraduate majoring in biomedical engineering. As an undergrad, he worked with Prof. Ünlü, who specializes in biophotonics, where biology meets light. That had Daaboul working on biosensors, biological imaging techniques, and digital detection based on a single particle or molecule. (Prof. Ünlü was honored as BU's 2021 Innovator of the Year.)

"I thought I'd go to medical school," Daaboul said, "but, funny story, I didn't get in and so I was like, 'Alright, I might as well do my PhD then.'" Initially, Freedman also thought he would be leaving the campus in 2009. He had earned a PhD in electrical engineering, but the country was going through what economists have dubbed the Great Recession. "I thought it was a bad time to look for a job," Freedman says. Instead, he went to work as a post-doc in the lab of Prof. Ünlü, where Daaboul was also doing research.

Success stories often don't start as we imagine. Some earlier false starts along the journey included the BU Ignition Award program to help professors and other researchers on campus reach a critical milestone in pursuit of a potentially commercial product under development. Daaboul earned an Ignition Award for a product that never found its market and there was also an earlier effort that involved seven graduate students on campus, including Daaboul and Freedman. The group entered several pitch competitions, but ultimately decided the idea was not commercially viable enough to pursue. "Most of the others, they went to California and got jobs," Freedman said. "That left the two of us." Daaboul was working on a project with a second professor, John Connor, in BU's

Dr. Selim Ünlü, BME, ECE, MSE

School of Medicine, on a device that employed biophotonics to do rapid detection of Ebola and other hemorrhagic fever viruses. That was around the time of the outbreak of Ebola in West Africa. “The idea was something we could deploy in Africa, out in the field,” said Daaboul, who earned his PhD in biomedical engineering in 2013. Freedman joined the project to help them create the device they would use for detection.

“Dave was a perfect fit because he had the skill set to build a prototype while I was more on the high-level science of how the technology works,” Daaboul said.

“George is brilliant and understands the science, the optics, the biology, extremely well,” Freedman said. “My expertise was electrical engineering, so software, hardware, and optics is where I played.” Together, they seemed a perfect match for a startup looking to bring a new analytical tool to market. “We were especially strong on the technical side,” Freedman said. “That’s been our secret sauce.”

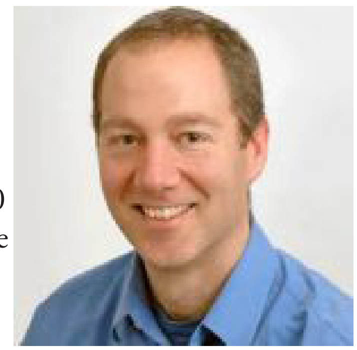
The platform that Daaboul and Prof. Ünlü developed uses interferometry, which “basically took advantage of how we combined the illumination light and the light which interacted with the biomaterial of interest,” Daaboul said — along with a superbright source of light and a silicon chip typically used to make computer chips to detect viruses. With the biophotonics platform that Daaboul and Prof. Ünlü developed, researchers could have the ability to detect things that have traditionally been invisible to them.

“Using traditional technologies, you have to accumulate a certain amount of virus to be able to see them,” Freedman says. “Our technology lets you see individual nano particles, like viruses.”

Founding NanoView:

Freedman and Daaboul formally filed the paperwork to start a company in 2014. The early years were lean ones for Freedman and Daaboul, who survived off grants.

Their first contract was through Professor Connor’s NIH R01 grant that was the primary support of the company for the first three years. They were still developing the product and a long way from customers that might pay them for their creation. One key moment, both Freedman and Daaboul agree, came when they were awarded an Innovation Corps grant, or I-Corps™ grant, from the National Science Foundation (NSF). The I-Corps program had been established to help engineers and scientists build their skills as entrepreneurs. “I don’t think this company would have been successful without that experience,” Freedman said.



Dr. John Connor, Medicine

Under the terms of the I-Corps grant, which they received in 2013, the pair was required to talk to 100 people to learn where there was a need in the market, which in NanoView’s case included doctors, hospital administrators, and people with the insurance companies that would need to pay for such a device. “That’s when we started focusing on commercialization,” Freedman said.

The program also required the pair to team up with a business mentor, which is how they connected with Rana K Gupta. Gupta, who had been the CEO of a successful diagnostic company spun out of Yale University, was teaching a technology transfer class at BU’s Questrom School of Business. Professor John Connor introduced Freedman and Daaboul to Gupta, who today serves as the university’s Director of Faculty Entrepreneurship. The pair also met Parker Cassidy, a BU engineering grad who proved not just a champion of their technology and mentor but also an early investor.

NanoView moved into the BIC at the end of 2014. “We probably moved six times on the sixth floor of that building because we kept growing,” Daaboul said. They leased an optics lab at the BIC and then a private bio-safety level 2 lab—required to work with human blood samples. The university kept reminding the pair that they couldn't stay at the BIC forever, but they remained there for more than three years, moving from a shared cubicle to a pair of large suites and a conference room they used as a manufacturing space.

"We weren't looking to take the easy path," Freedman said. "But the more we looked around for space and the costs, it was very attractive to stay at the BIC."

As part of I-Corps, the pair taught themselves about "product-market fit" – the need to find markets for the device they wanted to sell, Initially, Daaboul and Freedman thought they would focus on a rapid respiratory diagnostic that could tell a parent if their child has RSV or the flu. "We learned that there were already a lot of great technologies for rapid diagnostics, and we were never going to be competitive there," Freedman said. That would be the first of many pivots to alternative markets.

"We were pivoting all over the place for a couple of years there," Freedman said. "We did early detection of Type-1 Diabetes. At one point, we looked at hepatitis diagnostics."

"We had this great hammer, but what's the nail?" Freedman said.

Serendipity had meant the two of them remained on campus in 2009. And in 2016, it meant a fellow researcher and collaborator (she is still paid royalties for helping with the chemistry side of the science they use) asked to buy one of their devices to study exosomes – tiny sac-like structures formed inside cells and released into the blood by many types of cells, including cancer cells.

"We were like, 'What are exosomes?'" Freedman confessed. "Never even heard of them." But the pair did their research, which told them this was an exciting area of nanoparticles important to researchers. "We learned very quickly that the the exosome-field-needed tools and all we had to do was make small changes on our chip to detect them," Freedman said. "And all of a sudden, we had a product in this whole new rapidly growing space."

With the pivot to exosomes, they'd found their product-market fit. "That's when investors paid attention," Freedman said. NanoView raised $4 million in a Series A first round of venture funding in mid-2017. "We were just building, we weren't generating revenue, so the pressure wasn't there," Freedman said. The company moved out of the BIC in 2018, into offices in Brighton. That summer, Jerry Williamson took over as CEO of a company that had grown to more than a dozen employees. Williamson, who had earned his MBA at Questrom, had joined the board of their company the prior year. "We recognized that we needed more than the two of us to run things if we were going to be successful," Freedman said. "And Jerry brought experience having been a successful CEO." A few months later, the company raised another $10 million in venture funding.

Post-BU: Growing the Company:
NanoView launched its first product in 2019 at the international conference of the Society for Laboratory Automation and Screening in Washington, D.C., where it was one of three entrants out of 56 honored with a New Product Award. "That's when we really started learning what customers want," Freedman said.

NanoView didn't take off in the fashion of a rocket ship, as sometimes happens with startups. COVID provided one blow. The company was showing momentum, but a lot of the academic research labs were shut down and those that were operating were open were hardly focused on exosomes. NanoView was up against much larger, entrenched competitors and though they believed their technology was superior, they were still at the point where every sale was a custom job. "You want that flywheel spinning," Freedman said. Instead, it was a grind.

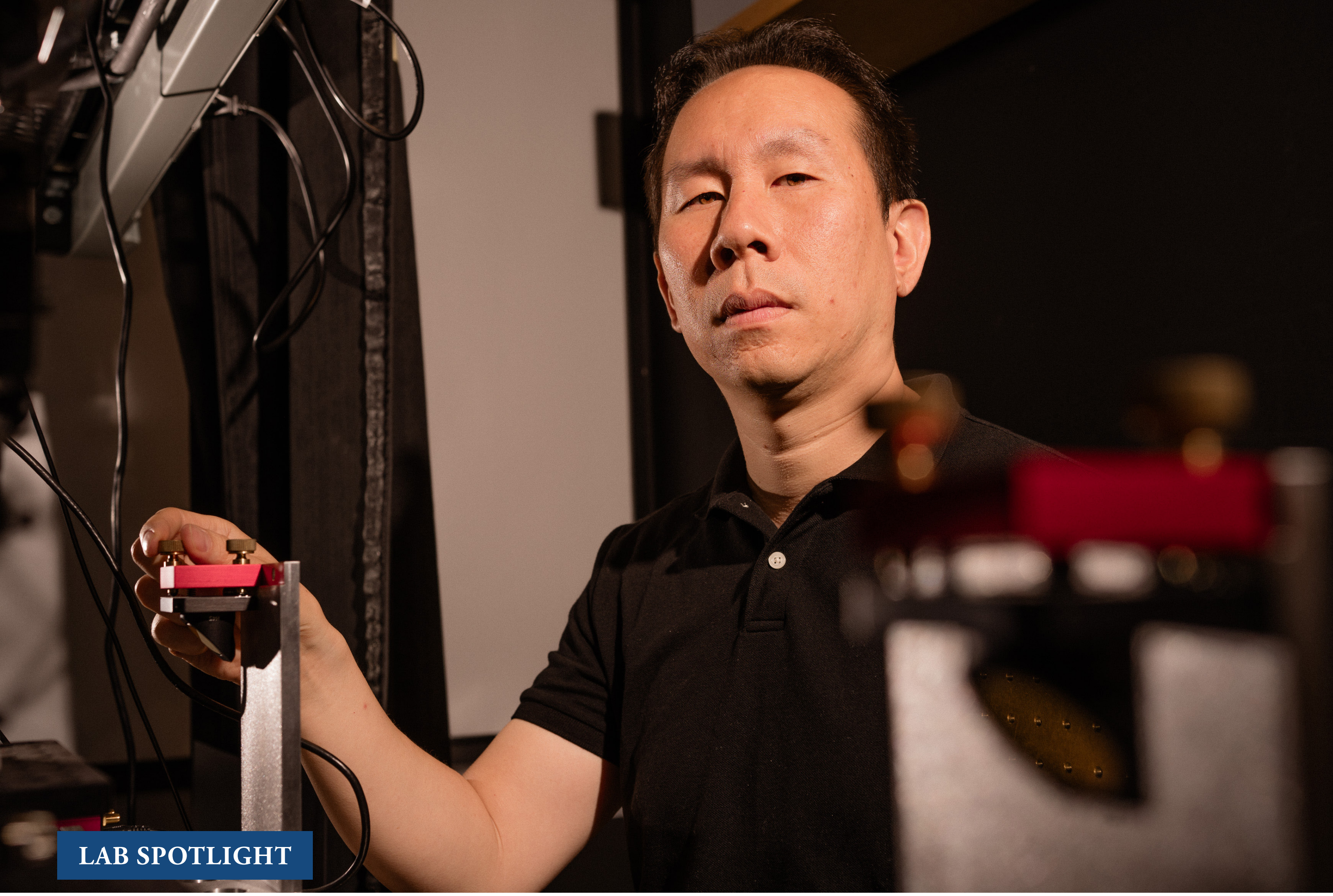
Growth for the company returned in 2021 and resulted in a strong year for NanoView. In early 2022, NanoView began developing a product for the cell and gene therapy market. That, Freedman and Daaboul believe, is what drew the attention of Unchained Labs, which purchased the company in May of that year. The deal terms are undisclosed, but Daaboul and Freedman feel that the technology has found a great home and that the founders and investors had a successful journey.

The pair worked long enough at Unchained Labs to see its product relaunched under the brand name

Leprechaun. "They're great at commercializing. That's what they do," Daaboul said of Unchained. "Basically, we got the product to the point where they can start selling it." The two left around nine months after the sale, in early 2023 and, after a few weeks of much-needed rest and rejuvenation with family, have slowly started to work their networks in search of what might be next. "Ultimately, I would love to start another company," Freedman said. Both are hoping to work as advisors and mentors to others just starting the path that they travelled.

"The thing I love about our experience is that at BU, I always felt like we were all on the same team," Daaboul said. "Everyone was so supportive in helping us get things off the ground." Both Daaboul and Freedman are keen to do what they can do to help younger versions of themselves on their entrepreneurial journey, especially if they have an affiliation with BU, because they want to give back for all the help they received along their journey.

Daaboul and Freedman's newly-rebranded product "Leprechaun" from Unchained Labs



HOW DO DECISIONS MADE IN THE BRAIN INFLUENCE BEHAVIOR? – JERRY CHEN'S LAB IS ENGINEERING NEW TOOLS TO VISUALIZE THE BRAIN'S PROCESSES

by Tess Joosse, Photos by Christopher McIntosh

At the crux of Jerry Chen's research are some of the most elemental questions about the cognitive experience. "How do we perceive the world? How do we use that information to make decisions? We're interested in understanding the basic functions of how we behave," he says.

For each event perceived and decision made, there is a complex web of neural circuitry involved. Understanding how the central nervous system's many layered parts work to create knowledge from past experiences is an overarching goal in Chen's lab, which has published papers in Science, Nature Communications, Nature Methods, and Neuron, just to name a few.

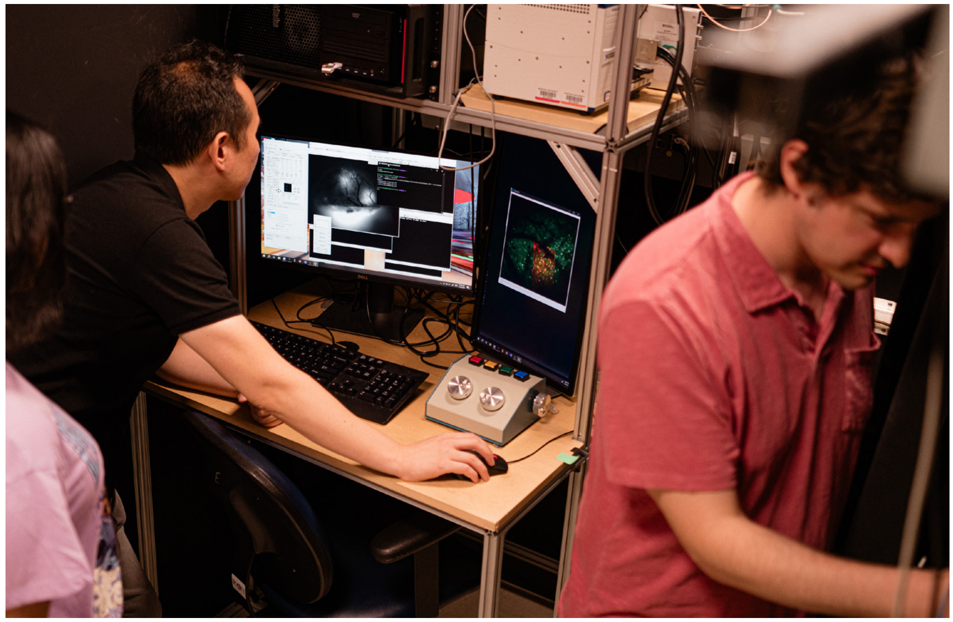
"We're interested in studying this question at different scales. In the brain, we're interested in how genes give rise to molecules that define how neurons function, how the neurons themselves come together to form circuits, and how those circuits then carry out computations," says Chen, a faculty member in both the Photonics Center and the Neurophotonics Center, College of Arts and Sciences assistant professor of biology, and affiliated College of Engineering assistant professor of biomedical engineering.

Across these many scales, Chen and members of his lab use an array of imaging techniques to get a front row seat to what's happening within the brain. "As researchers, we like to actually be able to look at things we're measuring and observe these processes," he says. They use these tools to zoom in on individual molecules within a neuron, and "zoom out to look at how all these neurons are talking to each other."

The team's approaches aren't just focused on spatial scales but also on temporal ones, investigating what's happening in sections of the brain across time. Neurons communicate with one another within milliseconds, Chen explains, while processes like learning and memory occur over longer ranges of time.

And even two brain cells sitting next to each other can have vast differences. "All the neurons in our brain are not all the same. They're very diverse, and they're potentially carrying out a lot of distinct roles. And their roles are largely defined by the genes that are being expressed," Chen says.

To study the relationships between gene expression, neuronal activity, and behavior, Chen's lab created a workflow called "comprehensive readout of activity and cell type markers", or "CRACK" for short. The experiments involve first



training mice to lick a sensor when they detect a matching pair of stimuli, a task similar to the card game known as "memory", Chen explains, in which a player flips over cards (arrayed face down on a table) one by one with the goal of matching pairs.

In the lab's mouse version, the researchers use a rotor to brush the whiskers of a mouse either towards or away from its face. Whiskers are highly sensitive and convey important information to the animal, Chen says. "They have very fine tactile acuity with their whiskers, similar to what we have with our fingertips," he says. The mouse is rewarded with a sip of water for not licking in response to two brushes that don't match. "The animal has to generalize and make a rule to say, 'These two bits of whisker stimuli were the same, or they were different,'" Chen says.

As mice perform this memory task, Chen and the members of his lab—including David Lee, a sixth-year PhD student—capture their behavior on high-speed video and use 2-photon calcium imaging to peer deep into their brains. Calcium rushes into a neuron as it fires, and 2-photon imaging allows the team to track these changes at single-cell resolution to determine where and when neurons are active.

"Then at the end of our experiments, we take the tissue out, and we find the neurons that we imaged previously in the living brain," Chen explains, using a technique called fluorescent in situ hybridization to stain these samples for mRNA of multiple genes. Combined, the techniques paint a picture of what genes and circuits are involved in different scenarios of learning and decision making.

These detailed visualizations first piqued Lee's interest as a new graduate student, when Chen showed them in a first-year seminar research presentation. "When I first saw videos of neurons actually lighting up while an animal was awake and behaving and thinking, I was like, 'That's exactly what I want to do,'" Lee says. "We're able to see what happens as animals learn and

think."

Since then, in Chen's lab Lee has used these techniques to study the perirhinal cortex, an area of the brain that receives information from the whisker system in mice and is linked to regions implicated in learning and memory. As the animals figure out the whisker-brush memory "game", Lee images the same set of cells twice a day, in the end looking at how those cells changed in the process.

He's found that as a mouse learns how to accomplish the task over time, a "reward" signal in the mouse's brain starts to show up earlier and earlier during the whisker-brush trials. Initially, the reward signal can only be detected at the end of the memory task. But then, "as the animals begin to have enough information to know they're going to be rewarded," Lee says, "it begins to occur not just at the end of the trial but during the stimuli, when the animal is actually thinking about it and saying, 'Oh, I have enough information. I can get water here.'"

Members of the Chen lab are also developing new microscopic tools to assist in their investigations of neural circuits. Xin Ye, a seventh-year PhD student in the lab, has created a microscope for viewing changes in voltage between cells. While 2-photon calcium imaging is a powerful tool for visualizing neuronal activity, calcium is still just a proxy for the change in voltage that actually indicates a neuron is firing. A tool that can image voltage directly is highly desirable, Ye says.

"BEING ABLE TO LOOK AT INDIVIDUAL BRAINS ACROSS SCALES ALLOWS US TO ANSWER QUESTIONS ABOUT HOW WE ARE DIFFERENT, AND HOW WE THINK DIFFERENTLY."

– Jerry Chen

"It's something that scientists want."

To design the microscope, Ye and her colleagues employed a phenomenon called temporal multiplexing, in which multiple paralleled laser beams are pulsed at delayed time intervals. "We have this [concept], but nobody has actually applied it to ultrafast imaging," she says. To build it, they combined, modeled, and tested many different components in a long process of troubleshooting and trial-and-error. They created a bespoke setup that placed multiple laser beams in the same field of view, enabling them to scan a small area of the brain for changes in voltage.

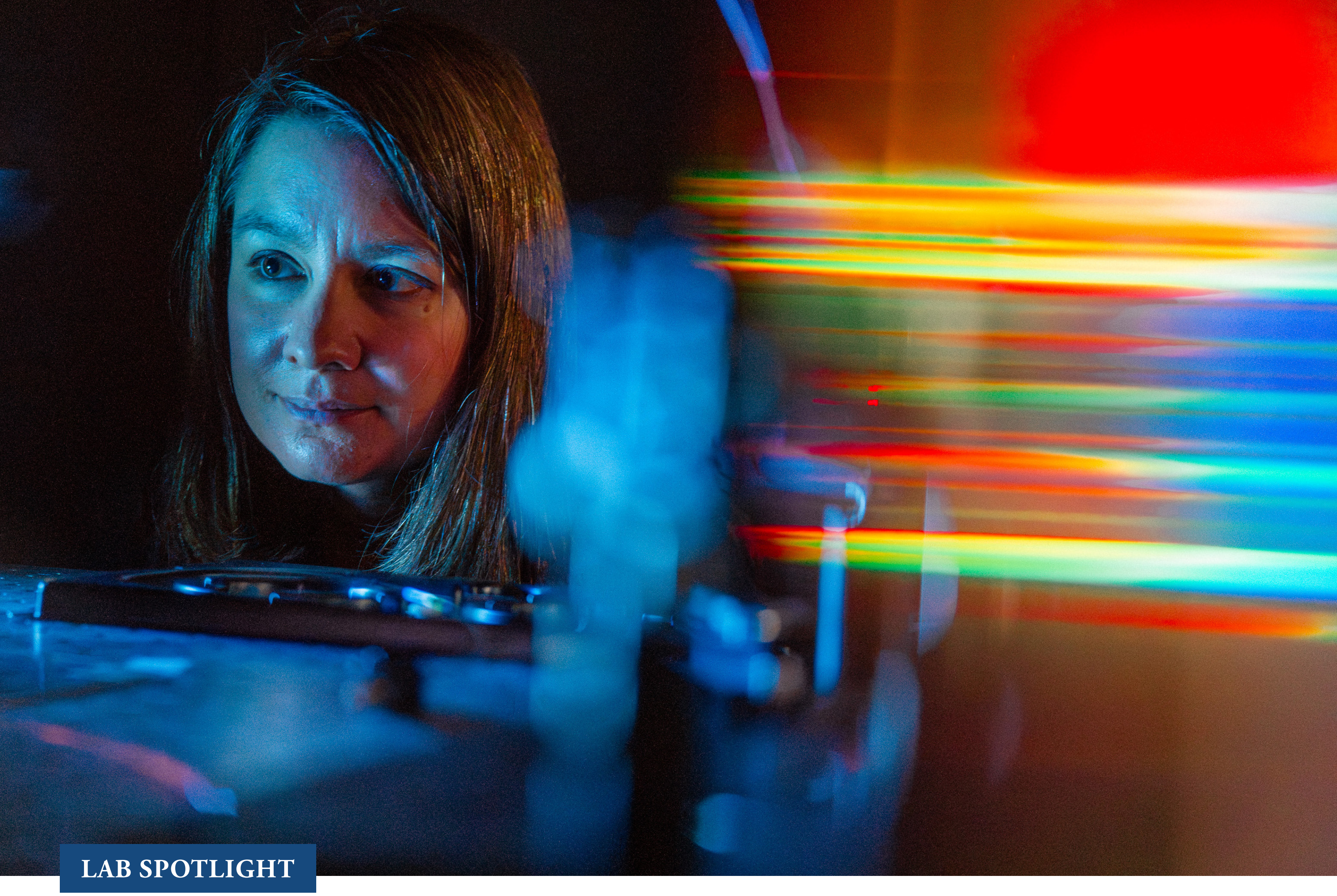
"The concept is set at the very beginning, but the middle is more like an engineering project to put this concept into an actual microscope," Ye explains. "It's extremely exciting … to start building something totally new, from scratch," she says of the project.

Chen notes that this type of voltage imaging is now more practical and feasible to do and will likely be more widely adopted across neuroscience research in the coming years. "What everybody wants to measure is voltage," he says.

Meanwhile, Lee is developing automated methods of whisker training the mice, hoping not just to teach them the memory task but also employing new techniques to measure if and how the mice learn it. While manually training the mice, the team has observed a remarkable range of idiosyncrasies in how different mice try to chip away at the task. "Some are running around in circles, some mice are just impulsively engaging with the system, some animals appear to be more deliberately trying to pay attention to the stimulus and respond accordingly," Chen says. "Behaviorally, you see a lot of differences that we're trying to characterize."

Automating the training frees up the group to study this behavioral diversity in depth, he says. "It allows us to look more broadly at the variations in individuals, and then start to hone in on what are the neuronal differences that could be causing these behavioral differences."

These questions about variations in gene expression and circuitry are linked to why Chen chose to study the brain in the first place: "Introspection — just understanding who I am as a person," he says. "We're all individuals, right? Being able to look at [and compare] individual brains across scales allows us to answer questions about how we are different, and how we think differently."



LAB SPOTLIGHT

HOW ULTRAFAST LASERS DEVELOPED IN MICHELLE SANDER'S LAB ARE SPEEDING UP BIOLOGICAL RESEARCH

by Kat J. McAlpine, Photos by Christopher McIntosh

Michelle Sander and her lab group at Boston University are seeking out new ways to build ultrafast lasers – lasers that emit such short-lasting pulses of light that their duration is difficult to fathom.

"I'm particularly interested in developing lasers on the femtosecond scale – a fraction of a second so small that its ratio is the same as one second to 32 million years," Sander says.

At these incredibly ultra-short timescales, Sander and her team are interested in the way light and matter interact. "When you shine light onto a material, you can characterize that material or change its properties," she says. "Light pulses can travel up to 300 nanometers within one femtosecond – a distance that's just a fraction of the width of a human hair – and create new phenomena that we don't see with longer-lasting or continuous laser light. We're working to design novel lasers that can emit these femtosecond pulses and to better understand the formation of these pulses and their effect on materials."

Sander, who at BU is a faculty member at the Photonics and Neurophotonics Centers and a College of Engineering associate professor of electrical and computer engineering, launched her lab more than 10 years ago after earning a PhD from Massachusetts Institute of Technology. But her career in engineering began at an early age. When she was a young student growing up in Germany, she remembers being fascinated by physics and technology during high school.

“There was a program aimed at recruiting more women in STEM fields, offering hands-on experiences in different types of labs,” she says. “At that time, less than 5 percent of electrical engineering students were women.” Sander jumped at the opportunity to intern in an electrical engineering lab at a local university, which helped cement her interest in the field. After high school, she started taking university-level engineering courses in Germany, and then earned a Fulbright fellowship that brought her to the Georgia Institute of Technology in Atlanta for graduate studies.

Today, at BU, Sander’s team is looking beyond fundamental research to develop practical, real-world applications based on various lasers and further elucidate what these lasers can reveal about different materials. She considers her team to be a “research family,” made up of many deep connections within the group that have developed through intense discussions about science and common goals.

“I think it’s really important to have an atmosphere where people can get direct feedback and also communicate directly with others,” says Sander, who is also affiliated with BU’s biomedical engineering and materials science and engineering departments. “Every paper a lab member publishes, every presentation a student gives at a conference, these are really exciting and meaningful moments for our team.”

She invites innovation and creativity into the lab and says it’s hard to predict which direction the team’s research will go in – she and her team are always open to new ideas and external partnerships.

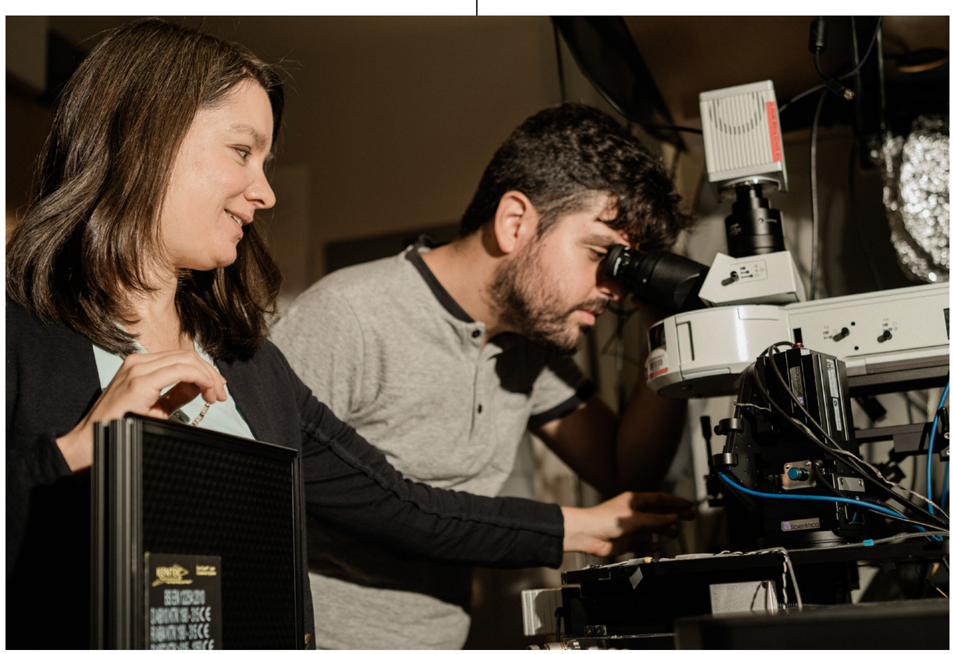
When optics, physics, and biology collide

Right now, the team is excited about several multi-institutional collaborations that apply their expertise towards biological applications.

For example, the Sander group has been designing photothermal microscopes that use mid-infrared light to detect chemical signatures. As mid-infrared light is absorbed by a sample, the material is excited and heated up. Different materials feature unique characteristic responses, absorbing or losing heat more quickly or slowly depending on their chemical makeup and properties, which allows for complex structures to be analyzed and visualized. One such use for photothermal microscopy is the imaging of cells and biological structures.

But many conventional microscopes struggle to image cells and tissues inside water or other media without labeling cells with stains or fluorescent dyes. “If you have a lot of similar materials under the microscope, how do you differentiate between biological structures and the medium they’re in?” Sander says. “Water has strong background absorption at mid-infrared wavelengths, which can easily mask the signal from interesting biological features.”

By adding a shorter-wavelength laser pulse to this imaging system, Sander and her team have enhanced the spatial resolution of mid-



infrared microscopy in a label-free manner.

"This technology has allowed us to investigate chemical content in a variety of samples for biological and material science applications, as well as visualize heat transfer dynamics across a variety of interfaces," says Panagis Samolis, a postdoctoral associate who first came to Sander's lab as an undergraduate researcher in 2016 before staying on with the team to earn his PhD. "It's been a very dynamic imaging technique with a lot of room to explore both optics as well as the fundamental physics of heat transfer."

They recently used their approach to provide a closer look at axons – long, tendril-shaped parts of neurons that transmit signals to neighboring cells – in their natural watery environment. Their findings are forthcoming in Analytical Chemistry and will be highlighted on the front cover. Given that cells throughout the human body are about 70 percent water, these new capabilities could have exciting implications for biological research.

For another project, her team is working with collaborators at the Swinburne University of Technology in Australia. "We're looking at fibroblast cells, which are these cells that form connective tissues," Sander says.

In humans and animals, fibroblast cells make up the matrix of collagen that connects various tissues. "Using our photothermal system, we were able to image fibroblasts in their natural medium of collagen, revealing the cell and nucleus membranes on the scale of nanometers," she says. "In our imaging technique, the fibroblasts' cell membranes act like a thermal barrier, allowing us to better differentiate the structure of the cells and achieve heightened detail based on their heat diffusion dynamics."

> "EVERY PAPER A LAB MEMBER PUBLISHES, EVERY PRESENTATION A STUDENT GIVES AT A CONFERENCE, THESE ARE REALLY EXCITING AND MEANINGFUL MOMENTS FOR OUR TEAM."
>
> *– Michelle Sander*

New frontiers for fiber-based laser imaging

Another major focus of the lab, originally supported by an Air Force Young Investigator Award from the Air Force Biophysics program, has been developing new fiber laser techniques to probe and control the activity of neurons. Fiber lasers are extremely fine strands of silica that can transmit light from one end to the other without losing much energy and power. They are the backbone of modern-day fiber-optic telecommunications and are also an important tool used by biologists to image precise areas of biological tissues and cells.

"We are collaborating with groups in Italy from their National Research Council in Bologna (Consiglio Nazionale delle Ricerche) and the University of Bari. They are the experts in neuronal biology, and we are the experts in imaging and probing. Together, we are working to understand how brain cells develop and communicate with each other," Sander says.

To enable a detailed view into electrical activity between neuronal cells, and to ensure robust control while modulating brain cell activity, Sander's team has developed fiber lasers that produce longer wavelengths (two microns) than more conventional fiber lasers.

In crayfish and other animal models, "we are using our two-micron fiber lasers to trigger neuronal activity through tiny changes in temperature caused by light," Sander says. "Most researchers to date have focused their attention on stimulating axons, but we have instead focused on synapses," or the junctions between neurons that send and receive electrical and chemical signals between cells. "We found that by modulating the synapse using our laser, rather than the axons, we can use less energy to induce neuronal activity."

Ultrafast, high-energy lasers at the two-micron wavelength can also be converted to shorter wavelengths, enabling a fiber-based light source for two-photon microscopy, an imaging technique with enhanced excitation localization, improved depth, and spatial resolution than more traditional microscopy. Sander's lab is currently working with a broader BU team to apply their amplified two-micron fiber laser system to enable two-photon voltage imaging of neuronal activity in mice.

"Ultrafast fiber lasers can be described by a single, universal math equation, but in experiments, rich, complex, and sometimes extreme or even mysterious light dynamics can be generated from these lasers," says Shutao Xu, a fifth-year PhD student in Sander's group. "I enjoy designing and optimizing these fiber laser systems, trying to understand each unique system's operation in detail, and the overall process of organizing random and chaotic light into stable, coherent, ultrashort pulses. I'm very excited about seeing our lasers applied to two-photon imaging setups so that scientists can look deeper into biological tissues at a faster speed."

Ideas, ambitions, and genuine care

In the lab and in the classroom, Sander says she is fueled by everyday moments of learning and inspiration, and by mentoring up-and-coming engineers. To date, her lab has brought more than 30 undergraduate researchers onto their team. "When you see a lab member or student struggling to make a breakthrough, and then all of a sudden they get it, and you see the light in their eyes, it's extremely rewarding."

She's also recruited students from other countries, including Australia, Germany, and France, to visit and join her lab. "Creating a working environment where there is perspective from other cultures and from external institutions is very enriching for our team" she says. "I think BU has been a great place for my team to be – with all BU's interdisciplinary centers, there are so many opportunities locally and abroad to network with colleagues from other fields. It feels unique to be in an institution that creates so many different points of contact for researchers to explore."

Members of her team say they have developed genuine care and appreciation for their teammates in the lab and beyond work on a personal level. "In this environment, I've found myself able to openly share ideas and ambitions, as well as find and keep the self-motivation needed throughout my [eight-plus] years in Dr. Sander's lab," Samolis says. "She always leaves room for her students to find their pathways as future scientists while providing support and accommodating our individual characters, strengths, and weaknesses."

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.

PHOTONICS EVENTS AND SPEAKERS

Date	Event
July 28, 2022	**Photonics Center Community Cookout**
August 9, 2022	**Photonics Center Community Ice Cream Truck**
August 25, 2022	**Photonics Center Forum with Dr. Balazs Rozsa**
November 9, 2022	**Photonics Center Community Café Social**
November 2-3, 2022	**Photonics Center Review by BU Office of Research**
November 10, 2022	**Photonics Center New Staff Welcome Lunch**
December 1, 2022	**Photonics Center Symposium**
December 7, 2022	**Photonics Center Holiday Party**
December 8, 2022	**Photonics Center Student Town Hall**
January 24, 2023	**Student OSA/SPIE Chapter Officers Elections Lunch & Learn**
February 9, 2023	**Photonics Center Community Café Social**
February 22, 2023	**Photonics Center Community Lunch & Learn with Assistant Professor Loza Tadesse**
February 28, 2023	**Photonics Center Community Lunch in Recognition of the Award of Tenure for Associate Professor Keith Brown, Alex Sushkov, and Brian Walsh**
March 29, 2023	**Photonics Center Community Lunch & Learn with Research Assistant Professor Xiaojun Cheng**
March 30, 2023	**Photonics Center Staff Appreciation Dinner**
April 25, 2023	**Photonics Center Community Lunch & Learn with Research Associate Noah Rubin**
May 2, 2023	**Research on Tap, co-hosted by Jerry Chen**
May 31, 2023	**Photonics Center Community Lunch & Learn with Associate Professor Alex Sushkov**
June 12, 2023	**Photonics Center Community Lunch & Learn with Sidney R. Cohen**

June 22-23, 2023	**Photonics Center Summer Chemical Imaging Workshop, hosted by Ji-Xin Cheng**

CELL-MET ERC EVENTS

Date	Event
November 15-17, 2022	**CELL-MET ERC Industry Days**
June 13-16, 2022	**CELL-MET Tissue Engineering: Dr. Rodegher, "Group Innovation and Problem-Solving: From Participation to Co-Creation**
February 3, 2023	**CELL-MET Tissue Engineering: Dr. Baker, "Microenvironmental Mechanics Govern Engineered Cardiac Tissue Assembly and Maturation"**
February 10, 2023	**CELL-MET Tissue Engineering: Dr. Chen, "Cardiac Tissue Engineering"**
February 15-16, 2023	**CELL-MET Retreat at Florida International University (FIU)**
February 17, 2023	**CELL-MET Heart Symposium at FIU**
March 17, 2023	**CELL-MET Tissue Engineering Dr. Lejeune, "Curating Mechanically Relevant Image-Based Data"**
March 24, 2023	**CELL-MET Tissue Engineering Dr. White, "Nanoscale 3D Printing Enables Cardiac Organ-on-Chip Models"**
March 31, 2023	**CELL-MET Tissue Engineering: Dr. Bifano, "Measuring Engineered Heart Tissue Contractile Force"**
April 7, 2023	**CELL-MET Tissue Engineering: Town Hall**
April 14, 2023	**CELL-MET Tissue Engineering: Town Hall**
May 22-25, 2023	**CELL-MET ERC Annual NSF Site Visit (Hybrid: In-Person & Virtual)**

Shared Facilities for Research

THE PHOTONICS CENTER remains steadfast in its commitment to fortify and advance research infrastructure, continually providing our researchers with an advantageous environment. Over the past year, we have exemplified this pledge through our financial and technical contributions in several key areas:

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

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

3. **Equipment Acquisition** – In a continued pursuit to elevate the standards of our shared labs and enhance their inventory, we have successfully acquired a diverse array of research equipment. Included in our acquisitions are three pivotal pieces of capital equipment that significantly augment our shared labs' capabilities in micro/nano fabrication. Other notable additions include a desktop Scanning Electron Microscope (SEM) and a thin-film measurement tool with nanometric sensitivity. These recent acquisitions underscore our commitment to providing state-of-the-art resources to our researchers.

4. **Nikon Super-resolution SoRa Microscope** – The procurement and operationalization of this cutting-edge tool was made possible through the combination of an NSF Major Instrumentation Grant awarded to Professor Thomas Bifano and cost-share from the Photonics Center. This instrument has broadened horizons for our researchers, offering newfound potential in the realms of transcriptomics and live tissue imaging.

5. **Ongoing Operational Evaluation** – We are consistently appraising the functionality of our shared labs, focusing on eliminating operational bottlenecks and refining efficiency. This ongoing initiative aims to support our researchers' needs more effectively, continuously improving our service delivery. In line with these objectives, Hossein Alizadeh was promoted to the role of Technical Director. One of his primary responsibilities is the strategic planning and enhancement of shared labs' operations. As part of his new role, he supervises the lab managers for our core facilities and provides strategic guidance to bolster the operations across the shared labs. Key actions taken towards achieving these goals include strategic reassignment of lab managers, the acquisition of crucial new equipment, the implementation of new operational tools to streamline equipment scheduling and usage, and a more vigorous pursuit of instrumentation grants.

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 2500 square feet 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 and Rajendra Dulal.

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 Rajendra Dulal and Alexey Nikiforov.

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:

- Imaging/Biosensing
- 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 impact on society in applications including 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 were the CELL-MET ERC in FY18 and 5-year renewal in FY23, and the award of an NSF MRI in FY23 for the acquisition of a Spinning Disk Confocal Super-Resolution Microscope for Transcriptomics

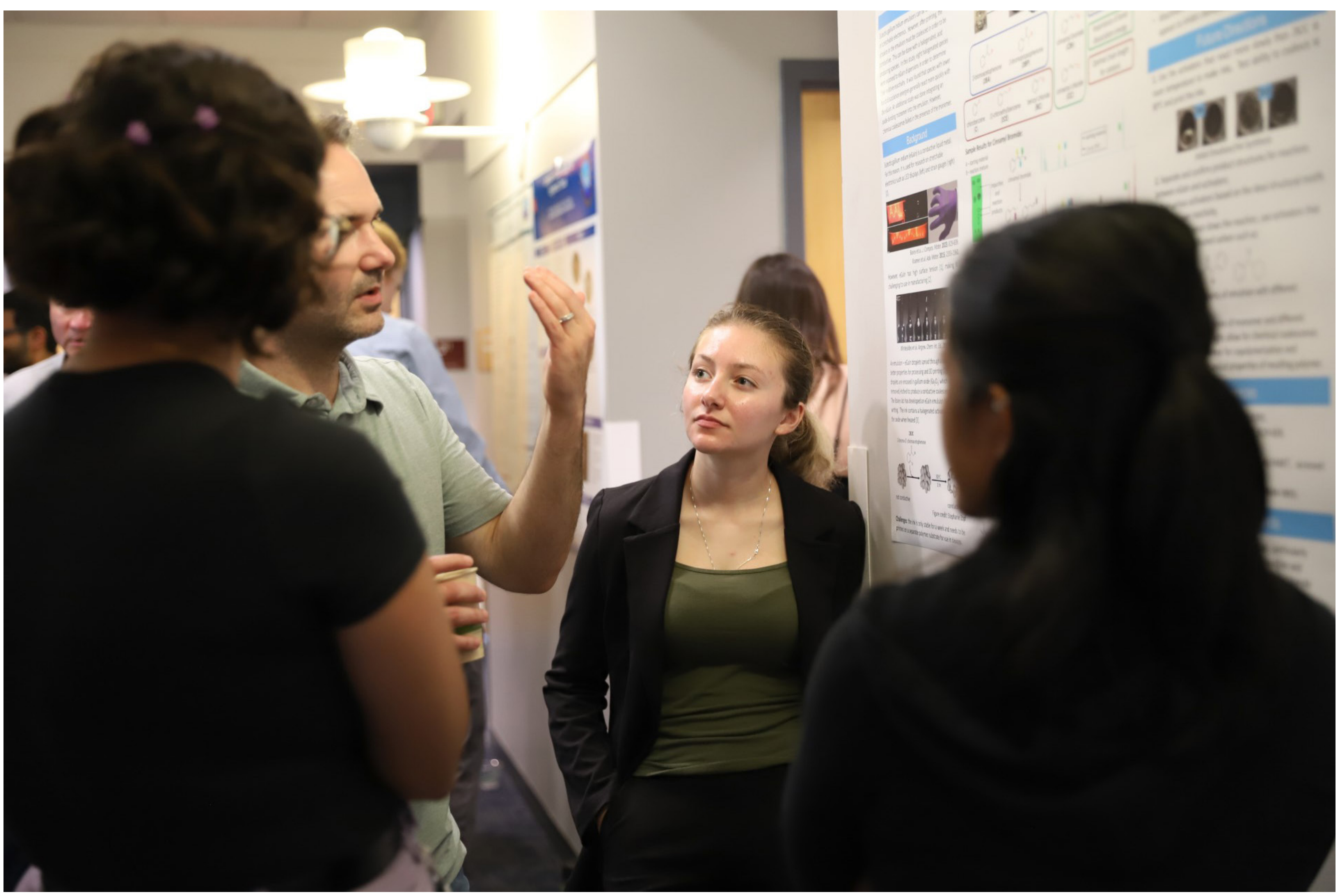
Photos taken from the RET/REU Poster Session. Credit: Kelly Peña

Research now installed in the Life Science and Engineering building (LSEB). The support continues post-award with project administration and assistance on compliance matters from sponsor and University perspectives. The Photonics Center continues to provide 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 third year of five years, with Professor Anna Devor as PI through the NIH BRAIN Initiative; and now administering Professor Enrico Bellotti's DOD/ARL funded Center for Semiconductor Materials and Device Modeling (CSM), which renews this fall for $6.25M for 5 years and includes a consortium of industry and academic partners.

The resources and expertise of the Photonics Center staff are employed to manage several training grants that include RET, REU, and REM grants, and other summer research experience programs.

Additionally, our team continued to work closely with faculty to prepare approximately 12 grant proposals in FY23 for about $26M.

At the BIC, Photonics Center staff are implementing strategic priorities that align the Center more closely with ongoing faculty member research and educational activities. Placing an emphasis on translational research, the BIC has added three companies in the past year. Additionally, the BIC now has three strategic partners that have the resources to exploit photonics technologies anchor our educational, innovation, and technology transfer efforts.



Photos taken from the RET/REU Poster Session. Credit: Kelly Peña

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McNaughton, R., Pieper, C., Sakai, O., Rollins, J. V., **Zhang, X.**, Kennedy, D. N., . . . ELGAN-ECHO Study Investigators. (2022). Quantitative MRI Characterization of the Extremely Preterm Brain at Adolescence: Atypical versus Neurotypical Developmental Pathways.. *Radiology, 304*(2), 419-428. doi:10.1148/radiol.210385

FACULTY AWARDS

- Professor **Soumendra Basu** won the TMS LMD and EPD Best Energy Paper Award - Professional, The Materials Society (TMS), LMD and EPD Divisions, 2022
- Professor **David Boas** delivered the 2023 DeLisi Lecture at the College of Engineering
- Professor **David Boas** was named Arthur G.B. Metcalf Chair
- **Jerry Chen** was promoted to Associate Professor and awarded tenure in 2023, and was a Molecular Basis of Cognition Scialog Fellow at the Research Corporation for Science Advancement in 2022
- Professor **Ji-Xin Cheng** was awarded BU's 2022 Innovator of the Year
- Professor **Anna Devor** was promoted to full professor in 2023
- Associate Professor **Mary Dunlop** was awarded the NSF Transitions Award, 2022
- Assistant Professor **Maria "Masha" Kamenetska** won the NSF CAREER Award, CAREER, NSF, Division of Chemistry, CSDM-A, Alexandria, United States, 2022
- Associate Professor **Michael Economo** won the NSF CAREER Award, CAREER, NSF, Division of Integrative Organismal Systems, United States, 2022
- Assistant Professor **Hadi T. Nia** won the NSF CAREER Award, as well as the NIH Director's New Innovator Award (DP2), and the Beckman Young Investigator award, Beckman Foundation, in 2022
- Associate Professor **Miloš Popović** was awarded the 2022 Boston University Supervisor of the Year.
- Professor **Xin Zhang** won the 2023 IEEE EMBS Society Award
- Professor **Xin Zhang** won the 2023 STAT Madness All-Star Award
- Professor **Xin Zhang** won the 2023 ASME Per Bruel Gold Medal.

PATENTS [3]

- **Bishop, D.**, Barrett, L., and Forrest, S., (2022, April 5), *Microelectromechanical shutters for organic vapor jet printing*
- **Cheng, J.**, & Lin, H., (2022, February 1), 11,237,111 B2, *High-speed delay scanning and deep learning techniques for spectroscopic SRS*
- **Dal Negro, L.**, Lanef, A., Raukas, M., Gorsky, S., & Zhang, R. (2022, April 5). US Patent 11,294,195, *Aperiodic nano-optical array for angular shaping of incoherent emissions*. Retrieved from https://patents.google.com/patent/US11294195B2/en
- **Mertz, J.**, Beaulieu, D., & **Bifano, T.**, (2022, January 18), 11,226,474 B2, *Reverberation microscopy systems and methods*
- **Paiella, R.**, & Kogos, L., (2022, February 22), 11,257,856 B2, *Lens-free compound eye cameras*
- **Unlu, M. S.**, Daaboul, G., & Yurt, A. (2022, August 30). 11,428,626, *Polarization enhanced interferometric imaging.* Retrieved from https://patents.google.com/patent/US11428626B2/en
- **Unlu, M. S.**, Bergstein, D., Ruane, M., & **Goldberg, B.** (2022, March 15). 11,275,030, *Structured substrates for optical surface profiling*. Retrieved from https://patents.google.com/patent/US11275030B2/en
- **Zhang, X., Anderson, S.**, Zhao, X., & Duan, G., (2022, January 11), 11,219,384 B2, *Nonlinear and smart metamaterials useful to change resonance frequencies*

[3]Patents are reported for the University Fiscal Year, July 1, 2022 – June 30, 2023.

Faculty List

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Research interests:
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- Adaptive optics

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Research interests:
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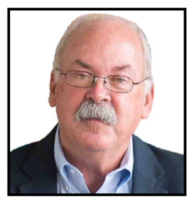

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Research interests:
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- Mesoscale soft materials
- Scanning probe techniques

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- Experimental nanomechanics of 2D materials
- Molecular transport through porous graphene
- Graphene adhesion

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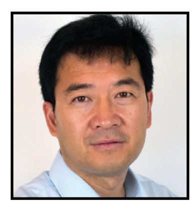
Research interests:
- Long-range cortical communications



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Research interests:
- Label-free microscopy
- Medical Photonics

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Research interests:
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- Identification of biomarkers of infection
- Virus/host interactions

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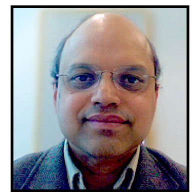

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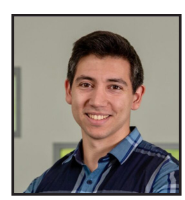

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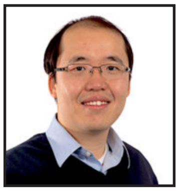
- Interactions of biomaterials with nanostructures
- Carbon nanotubes



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- Gigapixel 3D microscopy
- Compressive imaging

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- Solar wind-planetary coupling
- Small spacecraft

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- Mechanical metamaterials

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- Pathophysiology of epilepsy
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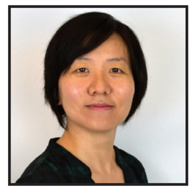

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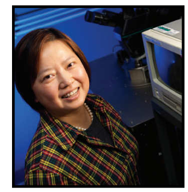
Research interests:
- Nano materials for their potential applications in nanoscale devices and biological applications



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- Micro nanomaterials
- Micro nanomechanics

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- Spontaneous resonance Raman studies of photodissociative and biological chromophores

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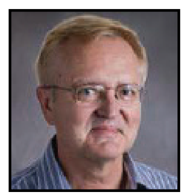
Research interests:
- Biological sensors
- Semiconductor IC optic failure analysis
- Nanotubes and nano-optics



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Research interests:
- Auditory physiology
- Neurocomputing and biosensors

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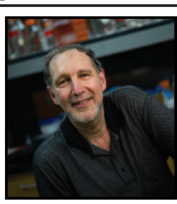
Research interests:
- Amorphous semiconductors



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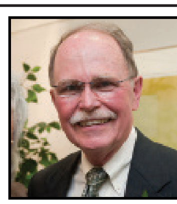
Research interests:
- Biomembrane technology and biomolecular photonics
- Ion transport



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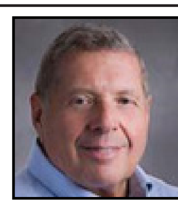
Research interests:
- Resonant cavity biosensors



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Research interests:
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- Neural coding

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Research interests:
- High technology
- Venture capital businesses

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: 2022-2023 Chair – Xiaowei Ge
The Distinguished Speaker Seminar Series is managed by student leaders of the BU student chapters of the OSA and SPIE. 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: 2022-2023 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: 2022-2023 Chair – Professor Thomas Bifano
This committee chair generates policy guidelines for space management.

Symposium: 2022-2023 Chair – Professor Luca Dal Negro
The Photonics Center annual symposium entitled "Photonics & Artificial Intelligence" was held on December 1, 2022, chaired by Professor Luca Dal Negro.

Education Committee: 2023-2023 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 Bjoern Reinhard and staff members are Cara Ellis McCarthy, Beth Mathisen, and Hossein Alizadeh.

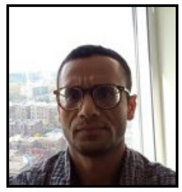
Photonics Center PhD Students and their Dissertation Titles

Photonics Center Faculty Member	Academic Year 2022-2023 PhD Graduates and Dissertation Titles
Thomas Bifano	**Marshall Ma** "*High Throughput Screening System for 3D Engineered Cardiac Tissue*"
David Bishop	**Nicholas Fuhr** "*Wide- and Zero-Bandgap Nanodevices for Extreme Biosensing Applications*"
David Boas	**John Thomas Giblin** "*Quantifying the Effects of Cerebral Capillary Flow Disruptions with Two Photon Microscopy*"
David Boas	**Antonio Ortega Martinez** "*Wearble Brain Computer Interfaces with Near Infrared Spectroscopy*"
David Boas	**Kuan Cheng Wu** "*Critical Closing Pressure with Pulsate Diffuse Optical Signals*"
David Boas	**Jiarui Yang** "*Serial Sectioning Block-Face Imaging of Post-Mortem Human Brain*"
Keith Brown	**Verda Saygin** "*Closed-Loop Nanopatterning and Characterization of Polymers with Scanning Probes*"
Scott Bunch	**Metehan Calis** "*Mechanical Characterization of Two-Dimensional Heterostructures by a Blister Test*"
Jerry Chen	**Xin Ye** "*Ultra-Fast Two-Photon Microscope for Population Neuronal Voltage Imaging*"
Ji-Xin Cheng	**Sebastian Eureko Jusuf** "*Antimicrobial Phototherapy: Mechanisms and Translation*"
Ji-Xin Cheng	**Peng Lin** "*Volumetric Stimulated Raman Scattering Microscopy*"
Ji-Xin Cheng	**Yuying Tan** "*Uncovering Cancer Metabolic Signatures by High-Content stimulated Raman Scattering (SRS) Imaging*"
John Connor	**Jamie Strampe** "*Utilizing Blood-Based Biomarkers to Characterize Pathogenesis and Predict Mortality in Viral Hemorrhagic Fevers*"
Luca Dal Negro	**Yuyao Chen** "*An Integrated Neural Network and Optimization Framework for the Inverse Design of Optical Devices*"
Mary Dunlop	**Nathan Tague** "*Utilizing Light as an Input and Output for Synthetic Biology and Metabolic Engineering*"
Shyamsunder Erramilli	**Alp Akpinar** "*Search for Invisible Decays of the Higgs Boson Produced by Vector Boston Fusion with the CMS Detector*"

Photonics Center Faculty Member	Academic Year 2022-2023 PhD Graduates and Dissertation Titles
Shyamsunder Erramilli & Alexander Sushkov	**David Long** *"Topology in Quasiperiodically Driven Systems"*
Shyamsunder Erramilli	**Sakib Matin** *"Noise Driven Phas Transition in the Olami-Feder-Christensen model"*
Xue Han	**Andrew Martin** *"Tools for Modulating and Measuring Authophagy"*
Xue Han	**Rebecca Ann Mount** *"Characterization of Hippocampal CA1 Network Dynamics in Health and Autism Spectrum Disorder"*
Ajay Joshi	**Rashmi Agralwal** *"Hardware Accelerators for Post-Quantum Cryptography and Fully Homomorphic Encryption"*
Ajay Joshi	**Marcia Sahaya Louis** *"Machine Learning for Magnetic Resonance Spectroscopy: Modeling in the Pre-clinical Development Process"*
Xi Ling	**Weijun Luo** *"Deterministic Localization and Modulation of Single Photon Emitters in Two-Dimensional Semiconductor"*
Roberto Paiella	**Abdullah Gok** *"Novel Optoelectronic Devices for Visible and Near-Infrared Applications: From Strain-Induced Ge Heterostructures to Lossless Millimeter-Long Dielectric Light Combiners"*
Roberto Paiella	**Yuyu Li** *"Graphene-Based Terahertz Emitters and Terahertz Metasurfaces"*
Miloš Popović	**Imbert Wang** *"Electronic-Photonic Quantum Systems-On-Chip and a Sub-Wavelength All-Evanescent Cavity"*
Miloš Popović	**Bohan Zhang** *"Design of High Performance Radiative and Resonant Silicon Photonics Devices by Efficient Control of Light Propogation and Radiation"*
Siddharth Ramachandran	**Havva Kabagoz** *"Energetic Ultrafast Frequency Generation in Multimode Fibers"*
Siddharth Ramachandran	**Xiao Liu** *"Orbital Angular Momentum Source Generation via Parametric Nonlinear Interactions"*
Darren Roblyer	**Anup Tank** *"Optical Imaging Markers of Breast Cancer Treatment Response and Resistance"*

Photonics Center Faculty Member	Academic Year 2022-2023 PhD Graduates and Dissertation Titles
Alexander Sushkov	**Bowen Zhao** *"New Aspect of Deconfined Quantum Criticality"*
Alexander Sushkov	**Janos Adams** *"Search for axion dark matter using solid state nuclear magnetic resonance and superconducting magnetometers"*
Lei Tian	**Yunzhe Li** *"Robust Deep Learning for Computational Imaging Through Random Optics"*
Selim Ünlü	**Iris Celebi** *"Pixel-Diversity Interferometric Imaging: A New Paradigm for Practical Detection of Nanoparticles"*
Chen Yang	**Lenli Shi** *"Optoacoustic Cell Modulation at Micron-Scale Precision"*
Xin Zhang	**Samuel Kann** *"Sensor-Enabled and Multi-Parametric Evaluation of Drug Induced Nephrotoxicity in a Kidney-on-Chip"*
Xin Zhang	**Ke Wu** *"Magnetic Field Enhancement in Metamaterials"*

Leadership & Staff

 **Hossein Alizadeh** *Technical Director* 8 St. Mary's St., 617-353-0632 halizade@bu.edu	 **Thomas Bifano** *Center Director* 8 St. Mary's St., 927 617-353-8908 tgb@bu.edu	 **Rajendra Dulal** *Laboratory Manager* 8 Saint Mary's St., 909A 617-353-9044 rdulal@bu.edu	 **Meghan Foley** *Senior Manager of Finance & Administration* 8 St. Mary's St., 931 617-358-4438 megfoley@bu.edu	 **Danny Giancioppo** *Communications Manager* 8 St. Mary's St., 938 617-353-8656 dannyvg@bu.edu
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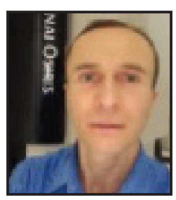
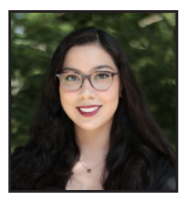
 **Beth Mathisen** *Program Manager* 8 St. Mary's St., 937 617-353-8907 bethmath@bu.edu	 **Cara Ellis McCarthy** *Executive Director* 8 St. Mary's St., 928 617-358-4257 cellis@bu.edu	 **Alexey Nikiforov** *Laboratory Manager* 8 St. Mary's St., 909 617-353-9045 alnik@bu.edu	 **Kelly Peña** *Communications Specialist* 8 St. Mary's St., 929 617-358-4924 kmpena@bu.edu	 **Sandra Rodegher** *Program Manager, ERC* 860-608-4250 srodegh@bu.edu
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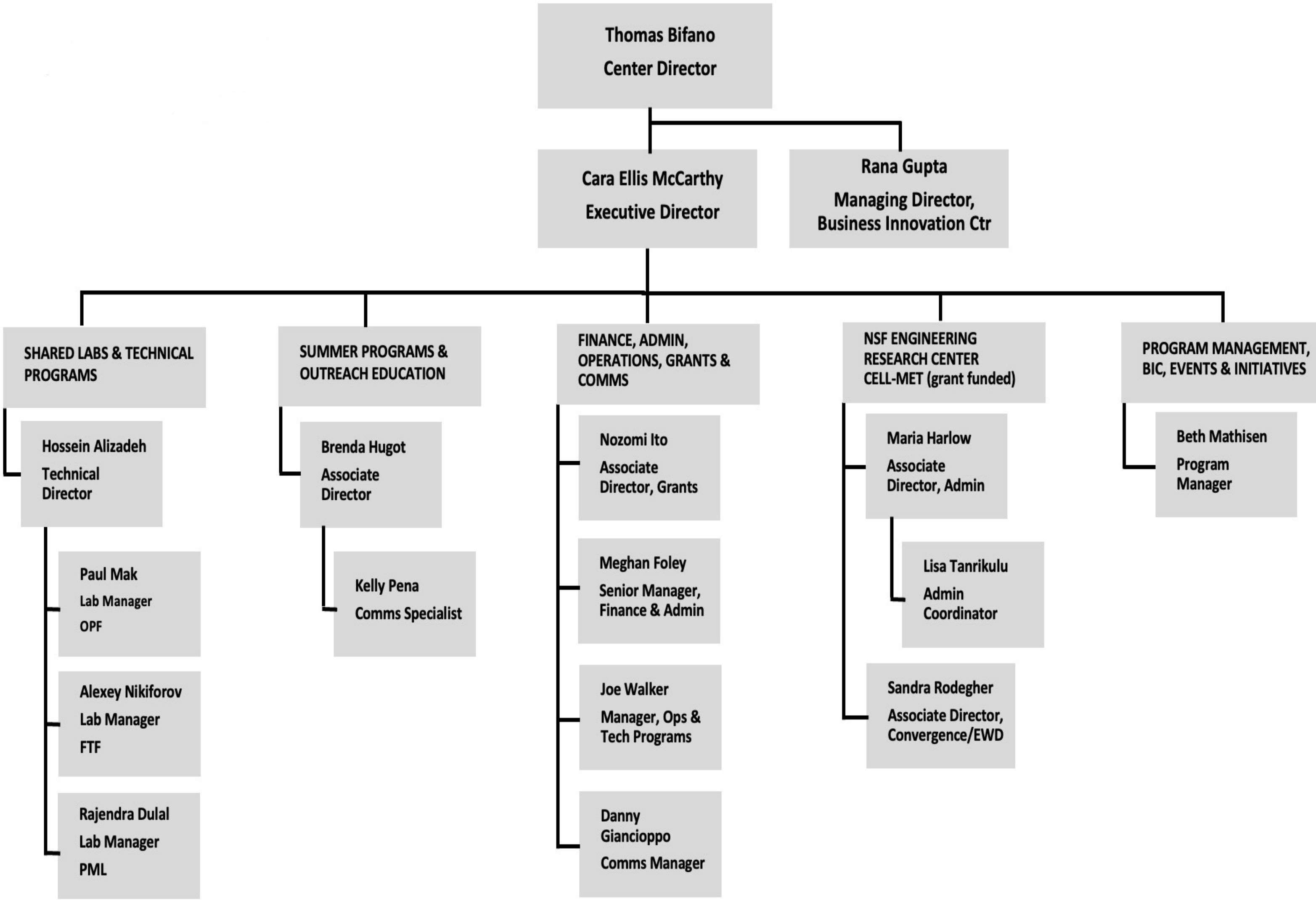
Organizational Chart



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

LIST OF CURRENT GRANTS AWARDED IN FY23 (total: $52.9M)
Photonics faculty members received $52.9M in external funding. The following table lists funds in the fiscal year (July 1, 2022 – June 30, 2023), 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)*
ARTHROSCOPIC RAMAN MONITORING OF CARTILAGE CONTENT FOR PTOA DIAGNOSIS AND CHONDROREGENERATIVE TREATMENT RESPONSE	ALBRO MICHAEL	NIH/National Institute of Arthritis & Mu	08/02/2022	05/31/2027	$502,703
A BIO-INSPIRED LATENT TGF-BETA CONJUGATED SCAFFOLD FOR PATIENT-SPECIFIC CARTILAGE REGENERATION	ALBRO MICHAEL	NIH/National Institute of Arthritis & Mu	06/01/2022	05/31/2027	$437,650
ARTHROSCOPIC RAMAN MONITORING OF CARTILAGE CONTENT FOR PTOA DIAGNOSIS AND CHONDROREGENERATIVE TREATMENT RESPONSE	ALBRO MICHAEL	NIH/National Institute of Arthritis & Mu	08/02/2022	05/31/2027	$583,998
ADVANCE COATINGS FOR ENERGY DEVICES	BASU N SOUMENDRA	Nissan North America Inc.	03/23/2020	04/30/2025	$80,000
FIELD EMITTER ROBUST VACUUM INTEGRATED NANOELECTRONICS (FERVIN)	BELLOTTI ENRICO	Florida International University	07/15/2019	02/14/2024	$92,814
AI/ML-MADE: AI/ML AUGMENTED MATERIALS AND DEVICE EXPLORATION	BELLOTTI ENRICO	Department of Defense/ Army Contracting C	09/30/2022	07/31/2023	$500,000
BROADBAND OPTICAL ATTENUATOR VIA AMPLIFIED FREE CARRIER ABSORPTION	BELLOTTI ENRICO	Physical Sciences, Inc.	09/01/2022	01/17/2023	$61,900
OPTICAL AND THERMOMECHANICAL DESIGN OF HIGH REFLECTIVITY DEFORMABLE MEMBRANES	BIFANO G THOMAS	Regents of the University of Minnesota	09/01/2017	08/31/2022	$158,804
MRI: ACQUISITION OF A SPINNING DISK CONFOCAL SUPER-RESOLUTION MICROSCOPE FOR TRANSCRIPTOMICS RESEARCH AT BOSTON UNIVERSITY	BIFANO G THOMAS	National Science Foundation	09/01/2022	08/31/2025	$615,508
ELECTROMAGNETIC DEFORMABLE MIRROR RESEARCH AND DEVELOPMENT	BIFANO G THOMAS	Boston Micromachines Corporation	05/01/2023	12/31/2023	$109,913
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	01/01/2022	11/30/2026	$559,055

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
VALIDATION OF LIGHT SCATTERING SPECTROSCOPY FOR INTRA-OPERATIVE MARGIN GUIDANCE DURING ORAL CANCER RESECTION	BIGIO J IRVING	Boston Medical Center Corporation	07/07/2020	06/30/2025	$179,235
PERSONNEL AGREEMENT FOR RESEARCH SERVICES OF IRVING BIGIO	BIGIO J IRVING	VA Boston Healthcare System	07/01/2022	12/31/2022	$53,121
PERSONNEL AGREEMENT FOR RESEARCH SERVICES OF OUSAMA A'AMAR	BIGIO J IRVING	VA Boston Healthcare System	08/01/2022	08/31/2022	$12,665
NANOSYSTEMS ENGINEERING RESEARCH CENTER FOR DIRECTED MULTISCALE ASSEMBLY OF CELLULAR METAMATERIALS WITH NANOSCALE PRECISION: CELL-MET	BISHOP DAVID	National Science Foundation	10/01/2017	09/30/2023	$4,250,000
NANOSYSTEMS ENGINEERING RESEARCH CENTER FOR DIRECTED MULTISCALE ASSEMBLY OF CELLULAR METAMATERIALS WITH NANOSCALE PRECISION: CELL-MET	BISHOP DAVID	National Science Foundation	10/01/2017	09/30/2023	$3,280,481
DETECTION OF BIOMAGNETIC FIELDS VIA MEMS GRADIOMETER	BISHOP DAVID	Sony Corporation of America	11/15/2022	11/14/2023	$100,000
TIME-GATED DIFFUSE CORRELATION SPECTROSCOPY FOR FUNCTIONAL IMAGING OF THE HUMAN BRAIN	BOAS DAVID	Massachusetts General Hospital	09/21/2019	06/30/2024	$127,784
NEUROPHOTONIC ADVANCES FOR MECHANISTIC INVESTIGATION OF THE ROLE OF CAPILLARY DYSFUNCTION IN STROKE RECOVERY	BOAS DAVID	NIH/National Institute of Neurological D	09/27/2022	08/31/2027	$693,711
COMPARING LASER SPECKLE CONTRACT AND DIFFUSE CORRELATION SPECTROSCOPY MEASUREMENTS IN HUMAN BRAIN FUNCTION	BOAS DAVID	Facebook Technologies, LLC	04/20/2021	12/13/2022	$584
AN ACCELERATED WORKFLOW FOR THE DISCOVERY OF BLOCK COPOLYMER CONFORMAL THIN ELECTROLYTE FILMS	BROWN KEITH	Toyota Research Institute	04/01/2023	03/31/2024	$125,001
EXPLORATION OF FLEXOELECTRIC MATERIALS PRODUCED USING ADDITIVE MANUFACTURING	BROWN KEITH	Honeywell Federal Manufacturing & Techno	04/24/2023	08/31/2023	$101,490
ACCELERATED EXPLORATION OF METAL-ORGANIC FRAMEWORK (MOF)-POLYMER INTERFACES	BROWN KEITH	Department of Defense/ DTRA	08/15/2022	08/14/2023	$100,000
CORTICAL INTERACTIONS UNDERLYING SENSORY REPRESENTATIONS	CHEN JERRY	NIH/National Institute of Neurological D	09/30/2018	06/30/2023	$379,500
EFFICIENT TWO-PHOTON VOLTAGE IMAGING OF NEURONAL POPULATIONS AT BEHAVIORAL TIMESCALES	CHEN JERRY	NIH/National Institute of Neurological D	08/15/2022	07/31/2023	$1,336,736

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
BRIDGING FUNCTION, CONNECTIVITY, AND TRANSCRIPTOMICS OF MOUSE CORTICAL NEURONS	CHEN JERRY	Allen Institute, d/b/a Allen Institute f	09/01/2022	06/30/2027	$402,297
UNVEILING THE MECHANISMS OF ULTRASOUND NEUROMODULATION VIA SPATIALLY CONFINED STIMULATION AND TEMPORALLY RESOLVED RECORDING	CHENG JI-XIN	NIH/National Institute of Neurological D	09/30/2018	06/30/2023	$654,740
VIBRATIONAL SPECTROSCOPIC IMAGING TO UNVEIL HIDDEN SIGNATURES IN LIVING SYSTEMS	CHENG JI-XIN	NIH/National Institute of General Medica	07/01/2020	06/30/2025	$577,500
VIBRATIONAL SPECTROSCOPIC IMAGING TO UNVEIL HIDDEN SIGNATURES IN LIVING SYSTEMS	CHENG JI-XIN	NIH/National Institute of General Medica	07/01/2020	06/30/2025	$577,500
SENSING VULNERABLE PLAQUE IN VIVO BY AN ALL-OPTICAL INTRAVASCULAR ULTRASOUND AND PHOTOACOUSTIC CATHETER	CHENG JI-XIN	NIH/National Heart, Lung, and Blood Inst	09/01/2020	08/31/2024	$580,378
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 Ima	04/01/2022	12/31/2025	$410,540
MAPPING CANCER METABOLISM BY MID-INFRARED PHOTOTHERMAL MICROSCOPY	CHENG JI-XIN	NIH/National Cancer Institute	09/20/2021	08/31/2024	$385,566
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 Ima	04/01/2022	12/31/2025	$45,617
TARGETING LIPID UNSATURATION IN OVARIAN CANCER STEM CELLS	CHENG JI-XIN	Northwestern University	08/01/2018	07/31/2023	$170,128
BOND-SELECTIVE INTENSITY DIFFRACTION TOMOGRAPHY	CHENG JI-XIN	Silicon Valley Community Foundation	03/01/2023	08/31/2025	$1,360,955
SUB-MILLIMETER PRECISION WIRELESS NEUROMODULATION USING A MICROWAVE SPLIT RING RESONATOR	CHENG JI-XIN	NIH/National Eye Institute	08/01/2022	07/31/2025	$247,500
FLUORESCENCE ENHANCED PHOTOTHERMAL INFRARED SPECTROSCOPY (FE-PTIR) BREAKTHROUGH FOR SIMULTANEOUS FLUORESCENCE MICROSCOPY AND SUB-MICRON IR SPECTROSCOPY	CHENG JI-XIN	Photothermal Spectroscopy Corp.	11/01/2022	08/31/2024	$150,000
INCORPORATION OF QUANTITATIVE SRS IMAGING IN SEISA FOR DEVELOPING ANTICANCER NANOMEDICINES	CHENG JI-XIN	Brandeis University	03/01/2022	02/28/2028	$123,750
INFRARED THERMAL SENSING OF SINGLE BIO-NANOPARTICLES	CHENG JI-XIN	Leonardo DRS Daylight Solutions	10/01/2022	09/30/2023	$100,000

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
PERSONNEL AGREEMENT FOR RESEARCH SERVICES OF HONGJIAN HE	CHENG JI-XIN	Jesse Brown VA Medical Center	01/01/2023	12/31/2023	$75,120
IPA FOR CHENG JI-XIN	CHENG JI-XIN	Jesse Brown VA Medical Center	01/01/2023	12/31/2023	$22,119
UNVEILING THE MECHANISMS OF ULTRASOUND NEUROMODULATION VIA SPATIALLY CONFINED STIMULATION AND TEMPORALLY RESOLVED RECORDING	CHENG JI-XIN	NIH/National Institute of Neurological D	09/30/2018	06/30/2023	$149,320
ADVANCEMENT OF A POXVIRUS INHIBITOR	CONNOR H JOHN	NIH/National Institute of Allergy & Infe	03/12/2020	02/28/2025	$656,410
DETERMINANTS OF COVID19-INDUCED VENOUS THROMBOSIS AND TARGETED THERAPY ASSESSED WITH BIOENGINEERED VEIN-CHIP	CONNOR H JOHN	NIH/National Heart, Lung, and Blood Inst	05/01/2021	04/30/2025	$732,287
DEVELOPMENT OF A RVSV VECTORED VACCINE FOR LASSA VIRUS: NONHUMAN PRIMATE EFFICACY AND IMMUNOGENICITY STUDIES	CONNOR H JOHN	University of Texas Medical Branch at Ga	09/01/2021	08/31/2023	$766,816
NOVEL ULTRAFAST NONLINEAR MATERIALS AND HYBRID PHOTONICPLASMONIC NANOSTRUCTURES FOR IR MULTIBAND IMAGING AND DETECTION	DAL NEGRO LUCA	Department of Defense/ Army Contracting C	08/01/2022	07/31/2024	$73,200
NOVEL ULTRAFAST NONLINEAR MATERIALS AND HYBRID PHOTONICPLASMONIC NANOSTRUCTURES FOR IR MULTIBAND IMAGING AND DETECTION	DAL NEGRO LUCA	Department of Defense/ Army Contracting C	08/01/2022	07/31/2023	$40,000
NOVEL ULTRAFAST NONLINEAR MATERIALS AND HYBRID PHOTONICPLASMONIC NANOSTRUCTURES FOR IR MULTIBAND IMAGING AND DETECTION	DAL NEGRO LUCA	Department of Defense/ Army Contracting C	08/01/2022	07/31/2023	$100,995
ABERRATION-CORRECTING TOPOLOGICALLY OPTIMIZED METASURFACE (ATOM)	DAL NEGRO LUCA	Physical Sciences, Inc.	10/01/2022	07/31/2023	$157,000
NEURAL CIRCUITS FOR REGULATING SOCIAL BEHAVIOR IN RODENTS	DAVISON IAN	NIH/National Institute on Deafness & Com	03/01/2019	02/28/2024	$324,837
SENSORY-MOTOR STRATEGIES FOR ODOR-GUIDED NAVIGATION	DAVISON IAN	NIH/National Institute of Neurological D	09/02/2022	07/31/2025	$1,163,250
TOFFLER SCHOLAR PROGRAM	DAVISON IAN	Massachusetts General Hospital	12/27/2021	08/31/2022	$12,261
LOCAL NEURONAL DRIVE AND NEUROMODULATORY CONTROL OF ACTIVITY IN THE PIAL NEUROVASCULAR CIRCUIT	DEVOR ANNA	NIH/National Institute of Neurological D	08/16/2021	05/31/2026	$2,784,416

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
EFFECTS OF INTRINSIC AND DRUG-INDUCED NEUROMODULATION ON FUNCTIONAL BRAIN IMAGING	DEVOR ANNA	NIH/National Institute on Drug Abuse	08/01/2020	05/31/2025	$377,297
UNDERSTANDING THE RELATIONSHIPS BETWEEN FUS-BBB OPENING, NEUROINFLAMMATION, AND THE NEUROVASCULAR RESPONSE	DEVOR ANNA	The Brigham and Women's Hospital, Inc.	09/02/2020	06/30/2023	$58,316
CELL-TO-CELL HETEROGENEITY AND THE EMERGENCE OF ANTIBIOTIC RESISTANCE	DUNLOP MARY	NIH/National Institute of Allergy & Infe	06/05/2019	05/31/2024	$412,186
CLARE BOOTHE LUCE FELLOWSHIP FOR MADISON FLETCHER	DUNLOP MARY	The Henry Luce Foundation, Inc.	09/01/2023	08/31/2025	$112,157
CELL-TO-CELL HETEROGENEITY AND THE EMERGENCE OF ANTIBIOTIC RESISTANCE	DUNLOP MARY	NIH/National Institute of Allergy & Infe	06/05/2019	05/31/2024	$41,468
CELL-TO-CELL HETEROGENEITY AND THE EMERGENCE OF ANTIBIOTIC RESISTANCE	DUNLOP MARY	NIH/National Institute of Allergy & Infe	06/05/2019	05/31/2024	$50,167
LINKING MOTOR CORTEX ACTIVITY AND MOVEMENT IN THE MOUSE OROFACIAL SYSTEM.	ECONOMO NICHOLAS MICHAEL	NIH/National Institute of Neurological D	02/01/2022	01/31/2027	$412,498
INVESTIGATING THE CONTROL OF MOVEMENTS BY SUBSPACES AND CELL TYPES IN THE MOUSE OROFACIAL SYSTEM	ECONOMO NICHOLAS MICHAEL	Whitehall Foundation, Inc.	03/01/2021	02/25/2025	$75,000
REVERSE ENGINEERING THE BRAIN STEM CIRCUITS THAT GOVERN EXPLORATORY BEHAVIOR	ECONOMO NICHOLAS MICHAEL	University of California, San Diego	06/01/2020	05/31/2023	$100,000
CAREER: HIGH-LEVEL CONTROL OF LOW-LEVEL CIRCUITS IN THE MAMMALIAN MOTOR SYSTEM	ECONOMO NICHOLAS MICHAEL	National Science Foundation	04/01/2023	03/31/2028	$700,000
LINKING MOTOR CORTEX ACTIVITY AND MOVEMENT IN THE MOUSE OROFACIAL SYSTEM.	ECONOMO NICHOLAS MICHAEL	NIH/National Institute of Neurological D	02/01/2022	01/31/2027	$36,152
LINKING MOTOR CORTEX ACTIVITY AND MOVEMENT IN THE MOUSE OROFACIAL SYSTEM.	ECONOMO NICHOLAS MICHAEL	NIH/National Institute of Neurological D	02/01/2022	01/31/2027	$41,102
ROADMAP FOR COLLABORATION: NEMS SENSORS FOR CHARACTERIZATION OF POLYMER SOLUTIONS	EKINCI KAMIL	Aramco Services Company	05/22/2019	12/05/2024	$116,172
COMPREHENSIVE MULTI-NEURON IMAGING OF NEURODEGENERATION IN C. ELEGANS	GABEL V CHRISTOPHER	Alzheimer's Association	06/01/2023	05/31/2026	$200,000
TBI IDENTIFICATION AND MONITORING THROUGH RETINAL SCANNING	GOLDSTEIN E LEE	Rebion	04/01/2022	03/31/2024	$250,000
LASTING IMPACTS: DYNAMIC 3D HUMAN BIOPRINTED NEUROVASCULAR MODEL TO STUDY TRAUMATIC BRAIN INJURY PATHOPHYSIOLOGY	GOLDSTEIN E LEE	Lawrence Livermore National Laboratory	09/22/2022	08/31/2023	$287,500

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
TBI IDENTIFICATION AND MONITORING THROUGH RETINAL SCANNING	GOLDSTEIN E LEE	Rebion	04/01/2022	03/31/2023	$250,000
MULTIDIMENSIONAL OPTIMIZATION OF VOLTAGE INDICATORS FOR IN VIVO NEURAL ACTIVITY IMAGING	HAN XUE	NIH/National Institute of Mental Health	03/01/2020	01/31/2025	$677,707
VOLTAGE IMAGING ANALYSIS OF STRIATAL NETWORK DYNAMICS RELATED TO VOLUNTARY MOVEMENT AND PARKINSONS DISEASE	HAN XUE	NIH/National Institute of Neurological D	04/01/2020	03/31/2025	$395,985
COLLABORATIVE RESEARCH: DYNAMIC INTERACTIONS OF INDIVIDUAL NEURONS IN SUPPORTING HIPPOCAMPAL NETWORK OSCILLATIONS DURING BEHAVIOR	HAN XUE	National Science Foundation	10/01/2020	09/30/2025	$73,641
OPTICAL VOLTAGE IMAGING ANALYSIS OF THE CELLULAR AND NETWORK MECHANISMS OF DEEP BRAIN STIMULATION	HAN XUE	NIH/National Institute of Neurological D	09/21/2022	08/31/2025	$2,023,746
VOLTAGE IMAGING ANALYSIS OF STRIATAL NETWORK DYNAMICS RELATED TO VOLUNTARY MOVEMENT AND PARKINSONS DISEASE	HAN XUE	NIH/National Institute of Neurological D	04/01/2020	03/31/2025	$88,932
ELECTRO-PHOTONIC COMPUTING (EPIC) FOR ON-PREMISE APPLICATIONS	JOSHI JAYANT AJAY	Lightmatter, Inc.	11/12/2021	11/11/2023	$384,724
CAREER: PROBING AND MANIPULATING ELECTRONIC AND SPIN DEGREES OF FREEDOM IN PARAMAGNETIC SINGLE MOLECULE CIRCUITS	KAMENETSKA MARIA	National Science Foundation	01/01/2022	01/31/2027	$260,000
DETERMINING THERMODYNAMIC PROPERTIES OF RNA APTAMERS USING OPTICAL TWEEZER SINGLE MOLECULE FORCE SPECTROSCOPY	KAMENETSKA MARIA	Arrakis Therapeutics	02/01/2023	08/01/2023	$39,999
CAREER: PROBING AND MANIPULATING ELECTRONIC AND SPIN DEGREES OF FREEDOM IN PARAMAGNETIC SINGLE MOLECULE CIRCUITS	KAMENETSKA MARIA	National Science Foundation	01/01/2022	01/31/2027	$51,995
SARS-COV-2 VARIANT DYNAMICS	KLAPPERICH M CATHERINE	Boston Medical Center Corporation	10/01/2021	09/30/2022	$29,481
SYNTHESIS OF NEW 2D CRYSTALS VIA SELECTIVE ATOMIC SUBSTITUTION	LING XI	Department of Energy	08/01/2020	07/31/2023	$142,232
MRI: ACQUISITION OF AN X-RAY PHOTOELECTRON SPECTROMETER FOR RESEARCH AND EDUCATION AT BOSTON UNIVERSITY	LING XI	National Science Foundation	08/15/2022	07/31/2025	$599,900
NEW COOPERATIVE ADSORBENTS AND REGENERATION METHODS FOR THE EFFICIENT REMOVAL OF CARBON DIOXIDE FROM AIR	LUBNER SEAN	Lawrence Berkeley National Laboratory	04/20/2023	08/31/2024	$80,000

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
MULTI-LAYER NEURONAL IMAGING WITH REVERBERATION MULTIPHOTON MICROSCOPY	MERTZ JEROME	NIH/National Institute of Neurological D	03/15/2020	12/31/2024	$360,465
FAST, LARGE-SCALE NEURONAL IMAGING WITH MULTI-Z CONFOCAL MICROSCOPY	MERTZ JEROME	NIH/National Institute of Biomedical Ima	02/01/2020	11/30/2023	$397,254
MULTI-LAYER NEURONAL IMAGING WITH REVERBERATION MULTIPHOTON MICROSCOPY	MERTZ JEROME	NIH/National Institute of Neurological D	03/15/2020	12/31/2024	$40,051
FAST, LARGE-SCALE NEURONAL IMAGING WITH MULTI-Z CONFOCAL MICROSCOPY	MERTZ JEROME	NIH/National Institute of Biomedical Ima	02/01/2020	11/30/2023	$44,139
METASCULPTING LIGHT IN THE BRAIN	NDAO ABDOULAYE	The Kavli Foundation	11/01/2022	10/31/2023	$57,500
MAKING LENSES SMART FOR OPTICAL IMAGING AND BEYOND	NDAO ABDOULAYE	Research Corporation for Science Advance	08/01/2022	07/31/2023	$55,000
SHEDDING STRUCTURED LIGHT ON FAIRNESS IN HEALTHCARE	NDAO ABDOULAYE	The Arnold and Mabel Beckman Foundation	09/01/2023	08/31/2027	$150,000
CLARE BOOTHE LUCE GRADUATE FELLOWSHIP FOR GABRIELLE GRIFNO	NIA HADI	The Henry Luce Foundation, Inc.	09/01/2021	08/31/2023	$76,947
PROBING FUNCTIONING LUNG AT THE CELLULAR RESOLUTION IN HEALTH AND DISEASE	NIA HADI	NIH/National Heart, Lung, and Blood Inst	09/01/2022	08/31/2025	$1,485,000
CAREER: LUNGEX FOR PROBING MULTISCALE MECHANOBIOLOGY OF PULMONARY RESPIRATION-CIRCULATION COUPLING IN REAL-TIME	NIA HADI	National Science Foundation	08/15/2023	07/31/2028	$566,473
PROBING THE PHYSICAL AND IMMUNE MICROENVIRONMENT IN LUNG TUMORS AT HIGH SPATIOTEMPORAL RESOLUTION	NIA HADI	Johnson & Johnson Enterprise Innovation,	01/01/2023	12/31/2023	$250,000
METASURFACE PHOTODETECTORS FOR COMPUTATIONAL IMAGING	PAIELLA ROBERTO	National Science Foundation	10/01/2022	09/30/2025	$457,500
PROPERTIES OF FERROMAGNETIC NEMATIC LIQUID CRYSTAL MATERIALS FOR INTEGRATED PHOTONICS	POPOVIC MILOS	Polaris Electro-Optics, Inc.	01/01/2023	12/31/2023	$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 Colorad	01/17/2023	10/16/2023	$225,000
FUSE-TG: ELECTRONIC-PHOTONIC SYSTEMS-ON-CHIP FOR COMPUTATION, COMMUNICATION AND SENSING	POPOVIC MILOS	University of California, Berkeley	06/01/2023	05/31/2024	$80,000
ASCENT: COLLABORATIVE RESEARCH: SCALING DISTRIBUTED AI SYSTEMS BASED ON UNIVERSAL OPTICAL I/O	POPOVIC MILOS	National Science Foundation	08/15/2020	07/31/2023	$8,000
LIGHT-MATTER INTERACTIONS WITH A TWIST	RAMACHANDRAN SIDDHARTH	Department of Defense/ ONR	09/01/2019	08/31/2024	$599,309

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
LOW SWAP SOURCES FOR HIGH-POWER BLUE COMMUNICATIONS	RAMACHANDRAN SIDDHARTH	Department of Defense/ ONR	05/01/2020	07/31/2024	$100,000
LOW SWAP SOURCES FOR HIGH-POWER BLUE COMMUNICATIONS	RAMACHANDRAN SIDDHARTH	Department of Defense/ ONR	05/01/2020	04/30/2023	$20,000
LOW SWAP SOURCES FOR HIGH-POWER BLUE COMMUNICATIONS	RAMACHANDRAN SIDDHARTH	Department of Defense/ ONR	05/01/2020	04/30/2023	$80,000
SINGLE-CELL AND TARGET SPECIFIC RESOLUTION OF MULTIPLE MEMORIES ACROSS THE BRAIN	RAMIREZ STEVE	Research Foundation for Mental Hygiene	09/13/2019	08/31/2023	$385,494
THE EFFECT OF ADOLESCENT DRUG-INDUCED NEUROIMMUNE SIGNALING IN SEX-SPECIFIC SOCIAL DEVELOPMENT AND REWARD LEARNING	RAMIREZ STEVE	Albany Medical College	07/01/2022	03/31/2027	$14,208
RESTORING ACCESS TO MEMORIES 'LOST' AS A RESULT OF SLEEP DEPRIVATION	RAMIREZ STEVE	Department of Defense/ AFOSR	09/01/2021	08/31/2024	$242,254
MAPPING AND MANIPULATING NEURAL MEMORY CIRCUITS IN MICE (SDL) TO TACKLE BRAIN DISORDERS THAT DISPROPORTIONALLY AFFECT UNDERREPRESENTED GROUPS BY MODIFYING NEURONS TIED TO MEMORY	RAMIREZ STEVE	Silicon Valley Community Foundation	12/01/2022	11/30/2027	$1,150,000
NEURON-ASTROCYTE DYNAMICS IN LEARNING AND MEMORY WITH POPULATION- AND SINGLE-CELL RESOLUTION	RAMIREZ STEVE	Ludwig Family Foundation	05/23/2023	05/22/2025	$350,025
RESTORING THE BRAIN WITH ACTIVATED MEMORIES	RAMIREZ STEVE	The Pew Charitable Trusts	07/12/2022	07/12/2027	$300,000
THE EFFECT OF ADOLESCENT DRUG-INDUCED NEUROIMMUNE SIGNALING IN SEX-SPECIFIC SOCIAL DEVELOPMENT AND REWARD LEARNING	RAMIREZ STEVE	Albany Medical College	07/01/2022	03/31/2027	$14,208
RESTORING ACCESS TO MEMORIES 'LOST' AS A RESULT OF SLEEP DEPRIVATION	RAMIREZ STEVE	Department of Defense/ AFOSR	09/01/2021	08/31/2024	$15,000
ILLUMINATING DYNAMIC RECEPTOR CLUSTERING IN THE EPIDERMAL GROWTH FACTOR RECEPTOR SIGNAL TRANSDUCTION PATHWAY USING PLASMON COUPLING	REINHARD M BJOERN	NIH/National Cancer Institute	04/01/2020	03/31/2025	$391,875
PLASMONIC INACTIVATION OF VIRUS AND MYCOPLASMA CONTAMINANTS	REINHARD M BJOERN	NIH/National Institute of General Medica	08/01/2021	05/31/2025	$330,000
PLASMONIC INACTIVATION OF VIRUS AND MYCOPLASMA CONTAMINANTS	REINHARD M BJOERN	NIH/National Institute of General Medica	08/01/2021	05/31/2025	$-
IMPROVED NANOPARTICLE TARGETING OF TISSUE MYELOID CELLS FOR HIV-1 LONG-ACTING PRE-EXPOSURE PROPHYLAXIS	REINHARD M BJOERN	NIH/National Institute of Allergy & Infe	03/17/2023	02/28/2027	$787,467

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
INTERFEROMETRIC PLASMON RULER FOR ELUCIDATING STRUCTURAL DYNAMICS ON THE SINGLEMOLECULE LEVEL	REINHARD M BJOERN	NIH/National Institute of General Medica	09/20/2022	08/31/2024	$229,758
ILLUMINATING DYNAMIC RECEPTOR CLUSTERING IN THE EPIDERMAL GROWTH FACTOR RECEPTOR SIGNAL TRANSDUCTION PATHWAY USING PLASMON COUPLING	REINHARD M BJOERN	NIH/National Cancer Institute	04/01/2020	03/31/2025	$73,626
ESTIMATING BLOOD PRESSURE CHANGES USING LASER SPECKLE CONTRAST MEASUREMENTS ON THE WRIST AND HAND	ROBLYER DARREN	Facebook Technologies, LLC	12/07/2021	03/31/2023	$269,561
FREQUENCY DOMAIN SHORTWAVE INFRARED SPECTROSCOPY (FD-SWIRS) FOR VOLUME STATUS MONITORING DURING HEMODIALYSIS IN END STAGE KIDNEY DISEASE	ROBLYER DARREN	NIH/National Diabetes & Digestive & Kidn	03/01/2022	01/31/2024	$254,104
FREQUENCY DOMAIN DIFFUSE OPTICAL SPECTROSCOPY AND DIFFUSE CORRELATION SPECTROSCOPY FOR ASSESSING INSPIRATORY MUSCLE METABOLISM IN MECHANICALLY VENTILATED PATIENTS	ROBLYER DARREN	NIH/National Institute of Biomedical Ima	09/15/2021	06/30/2023	$200,840
LABEL-FREE MEASUREMENT OF BLOOD LIPIDS WITH HYPERSPECTRAL SHORT-WAVE INFRARED SPATIAL FREQUENCY DOMAIN IMAGING TO IMPROVE CARDIOVASCULAR DISEASE RISK PREDICTION AND TREATMENT MONITORING	ROBLYER DARREN	NIH/National Institute of Biomedical Ima	07/01/2020	03/31/2023	$20,923
MULTIPLEXED IMAGING IN THE NEAR INFRARED WITH INDIUM PHOSPHIDE QUANTUM SHELLS	ROBLYER DARREN	Northeastern University	08/01/2022	07/31/2023	$110,478
PHOTOTHERMAL LABEL-FREE DYNAMIC PROBING AND MODULATION OF ASTROCYTES AND FIBROBLAST CELL MODELS	SANDER MICHELLE	Department of Defense/ AFOSR	12/01/2022	11/30/2025	$209,288
CAREER: TOWARDS SUPER-RESOLUTION LABEL-FREE MID-INFRARED PHOTOTHERMAL IMAGING	SANDER MICHELLE	National Science Foundation	03/01/2019	08/31/2024	$37,700
INVESTIGATING MECHANISMS UNDERLYING PERCEPTUAL INTEGRATION IN AUTISM	SCOTT BENJAMIN	Simons Foundation	12/01/2021	11/30/2024	$-
INVESTIGATING MECHANISMS UNDERLYING PERCEPTUAL INTEGRATION IN AUTISM	SCOTT BENJAMIN	Simons Foundation	12/01/2021	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	04/13/2023	03/31/2025	$412,500

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
UNDERSTANDING CORTICAL CONTROL OVER SUBCORTICAL STRUCTURES USING AN EVOLUTIONARY INSPIRED ENGINEERING APPROACH	SCOTT BENJAMIN	Research Corporation for Science Advance	02/01/2023	01/31/2024	$55,000
ADAPTIVE IONOSPHERIC OBSERVATORY USING DUAL-FREQUENCY SMARTPHONES	SEMETER L JOSHUA	NASA	10/21/2022	10/20/2023	$80,000
COLLABORATIVE RESEARCH: ANOMALOUS PLASMA COOLING IN THE TOPSIDE IONOSPHERE: OBSERVATIONS AND MODELING OF SOLAR MODULATIONS MEASURED BY DMSP DURING SOLAR ECLIPSES	SEMETER L JOSHUA	National Science Foundation	09/01/2019	08/31/2023	$55,395
COMPREHENSIVE MINIMALLY/ NON-INVASIVE MULTIFACETED ASSESSMENT OF NANO-/ MICROELECTRONIC DEVICES (COMMAND)	SERGIENKO V ALEXANDER	State University of New York at Buffalo	06/15/2022	06/14/2027	$200,000
QUANTUM SENSING AND SIMULATION FOR FUNDAMENTAL DISCOVERY	SUSHKOV ALEXANDER	Stanford National Accelerator Laboratory	03/10/2022	08/31/2024	$366,336
LOCAL DYNAMICS AND CONTROL OF NOISY TWO-LEVEL SYSTEMS COUPLED TO A CENTRAL QUBIT	SUSHKOV ALEXANDER	National Science Foundation	08/01/2020	07/31/2023	$140,928
COMPUTATIONAL MINIATURE MESOSCOPE FOR CORTEX-WIDE, CELLULAR RESOLUTION CA2+ IMAGING IN FREELY BEHAVING MICE	TIAN LEI	NIH/National Institute of Neurological D	04/01/2022	03/31/2027	$412,500
A NOVEL METHOD FOR VOLUMETRIC OXYGEN MAPPING IN LIVING RETINA	TIAN LEI	Johns Hopkins University	03/01/2021	02/28/2025	$100,443
REFLECTION-MODE COMPUTATIONAL 3D PHASE AND POLARIZATION IMAGING FOR SEMICONDUCTOR WAFER METROLOGY AND INSPECTION	TIAN LEI	Samsung USA	12/15/2021	12/15/2023	$165,000
COMPUTATIONAL MESOSCOPE FOR ULTRAFAST MULTISCALE 3D IMAGING	TIAN LEI	Silicon Valley Community Foundation	03/01/2023	08/31/2025	$1,310,540
MESOSCOPIC MICROSCOPY FOR ULTRA-HIGH SPEED AND LARGE-SCALE VOLUMETRIC BRAIN IMAGING	TIAN LEI	Johns Hopkins University	04/01/2023	03/31/2027	$93,179
LARGE-SCALE AVERAGE TRENDS IN PLASMA PARAMETERS ACROSS THE HELIOSPHERE	WALSH MICHAEL BRIAN	University of Delaware	03/01/2022	02/29/2024	$19,086
LUNAR ENVIRONMENT HELIOPHYSICS X-RAY IMAGER (LEXI)	WALSH MICHAEL BRIAN	NASA	03/19/2020	10/15/2024	$1,459,151
ACSEPT: A COMPACT SOLAR ENERGETIC PARTICLE TELESCOPE	WALSH MICHAEL BRIAN	NASA	08/19/2020	08/18/2023	$180,687

AWARD TITLE (FULL)	PI	SPONSOR	PROJECT START DATE	PROJECT END DATE	ADDITIONAL FUNDS THIS BUDGET PERIOD (TOTAL OBLIGATED)*
ACSEPT: A COMPACT SOLAR ENERGETIC PARTICLE TELESCOPE	WALSH MICHAEL BRIAN	NASA	08/19/2020	08/18/2023	$180,687
ACSEPT: A COMPACT SOLAR ENERGETIC PARTICLE TELESCOPE	WALSH MICHAEL BRIAN	NASA	08/19/2020	08/18/2023	$219,534
LARGE-SCALE AVERAGE TRENDS IN PLASMA PARAMETERS ACROSS THE HELIOSPHERE	WALSH MICHAEL BRIAN	University of Delaware	03/01/2022	02/29/2024	$41,126
MA SPACE GRANT CONSORTIUM FALL 2022 FELLOWSHIP (ADAM BOLDI)	WALSH MICHAEL BRIAN	Massachusetts Institute of Technology	09/01/2022	12/31/2022	$2,500
MA SPACE GRANT CONSORTIUM SPRING 2023 FELLOWSHIP FOR BAHLOUS BOLDI	WALSH MICHAEL BRIAN	Massachusetts Institute of Technology	03/01/2023	05/31/2023	$2,500
TRAINING PROGRAM IN QUANTITATIVE BIOLOGY & PHYSIOLOGY (QBP)	WHITE A JOHN	NIH/National Institute of General Medica	07/01/2022	06/30/2027	$530,535
SYNCHRONIZATION IN NOISY, HETEROGENEOUS EXCITATORY/ INHIBITORY NETWORKS	WHITE A JOHN	Louisiana State University	08/01/2018	04/30/2023	$200,091
INVESTIGATING HOW BIOCHEMICAL AND MECHANICAL CUES SHAPE CALCIUM DYNAMICS IN FIBROBLAST CELLS	WHITE A JOHN	Howard Hughes Medical Institute	07/05/2022	12/31/2022	$3,000
UNDERSTANDING THE MECHANISM OF MICROWAVE NEURON INHIBITION	YANG CHEN	Department of Defense/ ARO	05/09/2022	05/08/2024	$100,000
UNDERSTANDING THE MECHANISM OF MICROWAVE NEURON INHIBITION	YANG CHEN	Department of Defense/ ARO	05/09/2022	05/08/2023	$90,000
MRI COMPATIBLE AND WEARABLE OPTICAL-DRIVEN FOCUS ULTRASOUND FOR NEURO-MODULATION	YANG CHEN	Focused Ultrasound Surgery Foundation	12/07/2022	12/06/2023	$-
MRI COMPATIBLE AND WEARABLE OPTICAL-DRIVEN FOCUS ULTRASOUND FOR NEURO-MODULATION	YANG CHEN	Focused Ultrasound Surgery Foundation	12/07/2022	12/06/2023	$80,000
DEVELOPING INJECTABLE HYDROGEL WITH A POTENTIAL IN PHOTOACOUSTIC RETINA STIMULATION	YANG CHEN	Axorus	04/01/2023	08/31/2023	$29,999
FABRICATION OF FLAT PHOTOACOUSTIC FILM FOR RETINAL STIMULATION	YANG CHEN	Axorus	11/01/2022	12/31/2022	$9,999
DRAPER LABORATORIES STUDENT AGREEMENT (SAMUEL KANN)	ZHANG XIN	Draper Laboratory, Inc.	04/29/2019	12/31/2022	$41,021
STTR PHASE 1: ENHANCING MRI PERFORMANCE BY USING NONLINEAR METAMATERIALS	ZHANG XIN	Primetaz, LLC	07/28/2022	03/31/2023	$110,458

TOTAL: $52,931,466

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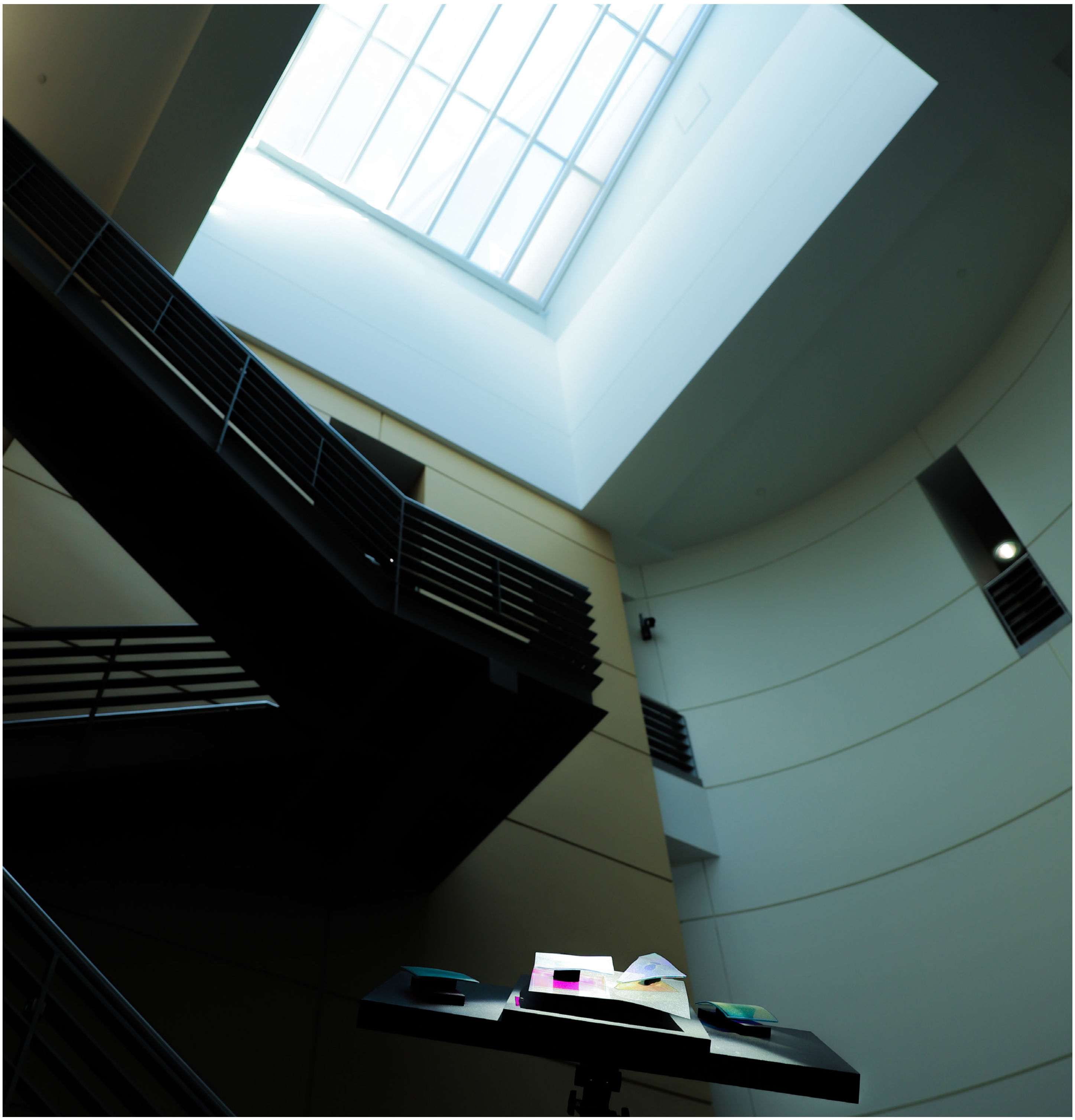

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