

BSAC NEWSLETTER

Berkeley Sensor & Actuator Center | University of California



Message from the Director

As we begin a new year, we at BSAC have taken time to reflect on a highly productive year and are looking towards building on that renewed energy as we move ahead.

I am delighted to share updates from the center. To begin, despite the uncertainties of a very challenging macroeconomic situation, BSAC began the year with four new member companies from very different market segments that joined the center to take advantage of the strategic research opportunities and benefits of BSAC membership.

Our congratulations go to BSAC's eighteen researchers that graduated in 2022 with their Ph.D. or M.S. degrees. May their success continue as they embark upon their careers with BSAC's industry-leading member companies and other top institutions.

For the first time in two years, BSAC hosted our semiannual research review and IAB meeting on the Berkeley campus last fall. Joined by industry members in-person and online, BSAC researchers and faculty shared their latest research through oral presentations, posters, and demonstrations to enable deeper technical discussions.

This year we have planned even more in-person member events that we hope you will join like the Spring and Fall Conferences, and informative weekly seminars from invited external speakers from industry, academia, and BSAC researchers.

I am personally looking forward to meeting again with representatives from each of BSAC's member companies to learn more about your research priorities and to identify new collaboration opportunities as well as strengthen existing ones. As always, your feedback is encouraged, valued, and essential to BSAC's success.

I hope to see you all in Berkeley on April 19 for BSAC's Spring Research Review and IAB meeting. You may [register via the BSAC website](#) starting March 1st.

Wishing you all a healthy, productive, and prosperous 2023!



JONATHAN CANDELARIA
EXECUTIVE DIRECTOR
BERKELEY SENSOR & ACTUATOR CENTER

This Issue:

- Message from the Director
- New Member Welcome
- Upcoming Events
- 2022 Review
- Class of 2022: Center Alumni
- Research Spotlight
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BSAC WELCOMES OUR NEWEST MEMBER COMPANIES



Headquartered in Italy, Brembo is a world leader and innovator in the field of high-performance automotive and motorcycle braking system technology.



U.S. based Qorvo provides high-performance RF solutions to enable advanced wireless communications infrastructure, mobile devices, IoT, industrial and IT networks, and defense and aerospace applications.



Samsung Electronics is a South Korean multinational corporation that develops products addressing a very broad range of vertical markets including consumer electronics, IT and mobile communications, and semiconductor device solutions.



Synergy Marine is a world-leading ship management company headquartered in Singapore that provides end-to-end maritime solutions.

ABOUT BSAC

The Berkeley Sensor & Actuator Center (BSAC) is an interdisciplinary engineering research consortium designed to enable commercially relevant, pre-competitive research through collaboration and sustained partnerships between industry and academia.

Headquartered at the University of California, Berkeley, BSAC launched in 1986 as the National Science Foundation (NSF) Industry/University Cooperative Research Center (I/UCRC) for MEMS and NEMS. For the past 31 years, BSAC has successfully leveraged member financial investment, the resources of top-ranked universities, researchers, labs, and a diverse group of industry leaders, to accelerate the knowledge base in emerging technological and manufacturing sectors and develop the industry's next-generation of innovators.

Today, as a graduated NSF center, BSAC enjoys an international reputation as the premier university-based MEMS research center driving innovative research in micro and nano-scale sensors, moving mechanical elements, microfluidics, materials, processes and systems.

BSAC EVENTS 2023

MARK YOUR CALENDAR

BSAC Spring Research Review & IAB Meeting
19 APRIL 2023 | BERKELEY, CALIFORNIA
Registration opens on 1 March 2023

BSAC Fall Research Review & IAB Meeting
SEPTEMBER 2023 | BERKELEY, CALIFORNIA

BSAC Spring Seminar Series
TUESDAYS AT NOON, FEB - MAY 2023
[View the seminar schedule here.](#)

2022 REVIEW



RESEARCH CONFERENCES & SEMINARS

Last fall, BSAC returned to in-person seminars and conferences. Researchers, industry members, and invited speakers came together on Berkeley's campus to network and share ideas. Members may login to the BSAC website to watch conference [presentations here](#).



CENTER GRADUATES

Eighteen BSAC researchers received their Ph.D. or M.S. degrees in 2022. Check out the "Class of 2022" section on page 6 for a list of their names and dissertation titles. As always, members can view the full list of BSAC alumni on the [BSAC website alumni page](#).



INVENTIONS DISCLOSED

Six invention disclosures were made available to BSAC member organizations for early review. A list is provided on page 10 of this newsletter.



ACADEMIC PUBLICATIONS

In 2022, BSAC researchers uploaded thirty-six publications for members to access via the searchable [publications database](#). A list of these publications is available on page 8 of this newsletter.



HONORS AND AWARDS

Join us in congratulating the following BSAC faculty and researchers who were recognized for their excellence and achievements. Click the titles below to read more.

- Ali Javey - Named 2023 IEEE Fellow
- Liwei Lin - 2022 Bakar Fellows Spark Award Recipient
- Shiekh Zia Uddin - 2022 MRS Graduate Student Gold Award



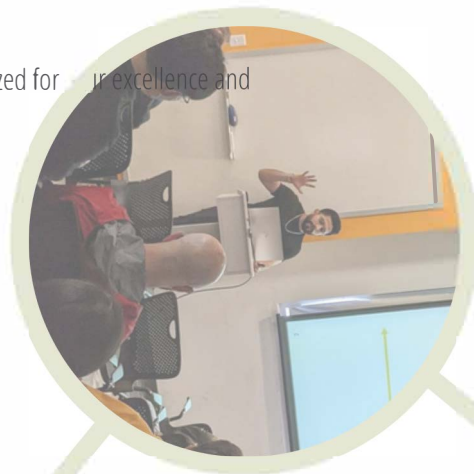
IN THE NEWS

- Slicing the Way to Wearable Sensor Prototypes
- Tiny Switches Give Solid-State LiDAR Record Resolution
- Reasons to be Hopeful, Optimistic and Maybe Even Cheerful in 2022
- ME Ph.D. Student Takes the Road Less Traveled to UC Berkeley



RESEARCH PROJECTS

BSAC researchers added sixteen new projects to the ongoing body of work. Members may view a list a current [BSAC projects here](#) on the website.



INTRODUCING JONATHAN CANDELARIA



Executive Director Jonathan Candelaria joined BSAC in July 2022.

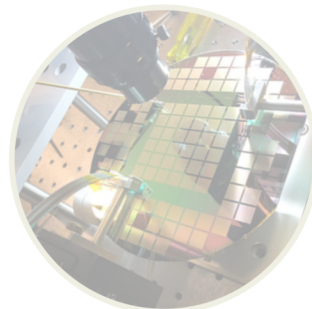
Jonathan brings over 45 years of electronics industry and research program management experience to his role as BSAC's Executive Director.

Prior to joining BSAC, he held Director positions at Stanford University's SystemX Affiliates program and Semiconductor Research Corporation (SRC) as well as various engineering and management positions with Texas Instruments and Motorola, Inc..

Jonathan has over a dozen publications and patents. He received the Motorola Patent of the Year award for an invention that contributed more than \$1B to the company.

As an invited speaker and leader, Jonathan has participated in several industry consortia activities including the the National Optoelectronic Technology Research Task Force and the SIA Semiconductor Technology Roadmap for CMOS.

As a an IEEE member, Jonathan has served in many capacities including General Chair for the Electron Devices Society (EDS) flagship conference, IEDM, and the International Interconnect Technology Conference (IITC), V.P. of Conferences for the EDS, representative in the joint United Nations-IEEE Humanitarian Challenge advisory committee, and as chair of various local IEEE Chapters.



BSAC CLASS OF 2022



Dillon Acker-James, M.S.

Electrical Engineering and Computer Sciences (Pister)
PCB-less Integration of a Robust Wireless MEMS Tactile Package

Joshua Alexander, M.S.

Electrical Engineering and Computer Sciences (Pister)
Single-Chip Micro Mote in EEG, fMRI, and TMS Systems

Oliver Chen, Ph.D.

Electrical Engineering and Computer Sciences (Maharbiz; Pister)
Hydrogel Actuated Carbon Fiber Microelectrode Array

Jordan Edmunds, Ph.D.

Electrical Engineering and Computer Sciences (Maharbiz)
Optical Voltage Sensing: Micro- to Kilo-Scale

Grigorev Georgii, Ph.D.

Mechanical Engineering (Lin)
Topological Optimization of Single Red Blood Cells Hydrodynamic Traps in Bio-Microfluidic Devices

Ruiqi Guo, Ph.D.

Mechanical Engineering (Lin)
Machine Learning for MEMS Structure Design and Pulse Signal Analysis

Niharika Gupta, Ph.D.

Electrical Engineering and Computer Sciences (Javey)
PENDING

Heya Kaakeh, M.S.

Mechanical Engineering (Lin)
A Low-Cost 2D Vibrotactile Array Research Platform for Exploring Haptic Feedback in AR/VR

Nathan Lambert, Ph.D.

Electrical Engineering and Computer Sciences (Pister)
Synergy of Prediction and Control in Model-Based Reinforcement Learning

Zhou (Joe) Li, Ph.D.

Chemical and Biomolecular Engineering (Maboudian)
PENDING

Yu Long, Ph.D.

Mechanical Engineering (Lin)
Renewable Polymeric Energy Harvesters from Moisture and Heat

Hossein Najafi, Ph.D.

Electrical Engineering and Computer Sciences (Boser)
An Optics-Free Ultra-Thin Time-Resolved Intraoperative Imager Using Upconverting Nanoparticles

Jeffrey Ni, M.S.

Electrical Engineering and Computer Sciences (Nguyen)
Suppression of Oscillator Bias Voltage Phase Noise via MEMS Resonator Arraying

Sedat Pala, Ph.D.

Mechanical Engineering (Lin)
Design and Applications of High-Performance Piezoelectric Micromachined Ultrasonic Transducers (pMUTs)

Neil Ramirez, Ph.D.

Mechanical Engineering (Lin)
Electrostatically Charged Polymers for Energy Harvesting and Air Filtration Applications

Fanping Sui, Ph.D.

Mechanical Engineering (Lin)
Ferromagnetism-based Insect-scale Untethered Robots

Shiekh Zia Uddin, Ph.D.

Electrical Engineering and Computer Sciences (Javey)
Understanding Radiative Recombination in Two-Dimensional Semiconductors

QianYi Xie, Ph.D.

Electrical Engineering and Computer Sciences (Nguyen)
PENDING

BSAC Research Collaboration Leads to an NSF Small Business Technology Transfer Project on Blood Pressure Measurement

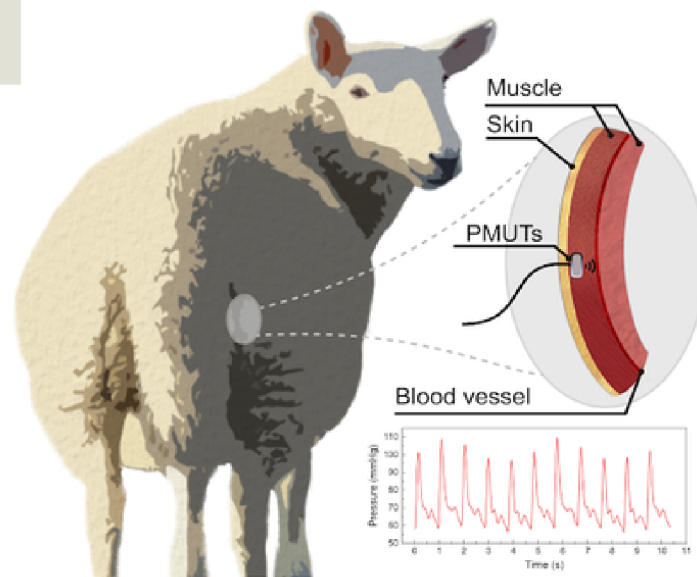
CoraVie Medical, an early-stage startup company, teams up with BSAC to develop a long-term, subcutaneous, and continuous blood pressure (BP) monitoring system.

It is estimated that more than 1.4 billion people worldwide have high blood pressure, defined as a systolic measurement >130 mmHg, which could lead to life-threatening conditions such as stroke, heart failure, and kidney failure. However, the lack of reliability and frequency in BP measurements has delayed optimal treatments. In this project, a subcutaneous monitoring system is proposed to provide accurate, continuous monitoring of BP with better compliance than other systems, such as capturing nighttime BP.

Professor Liwei Lin at BSAC and CoraVie Medical have studied and developed PMUTs (Piezoelectrical Micromachined Ultrasonic Transducers) with specific functions for this project. New research results reveal that these tiny ultrasonic transducers, after placed inside a sheep tissue about 1.5 centimeters above the femoral artery of the blood vessel, can emit and receive ultrasonic waves to differentiate its anterior- and posterior-wall positions [1]. This enables the continuous monitoring of the diameter variations of the blood vessel to reveal the blood pressure.

The findings describe a new class of continuous and silent blood pressure monitoring system without a cuff toward a fully implantable system based on MEMS technologies. Compared to the state-of-the-art works, two distinctive achievements have been demonstrated via a prototype device with a footprint of only $3\text{ mm} \times 3\text{ mm}$ for the PMUTs array: (1) precision and continuous measurements of the blood pressure from the diameter changes of blood vessels as small as $2.3\text{ }\mu\text{m}$ by means of ultrasonic detections of a blood vessel; and (2) experimental validations in both the in vitro artery models and an acute animal study.

The research, which included fundamental studies of the design, fabrication and testing of PMUT sensors, has been reported in a paper published in the 2022 International Conference on Micro Electro Mechanical Systems [1].



The lead author - BSAC graduate student, Yande Peng and other authors have built a phantom to study the blood vessel diameter variations in vitro and conducted the acute in vivo animal study on an adult sheep due to its similar physiology properties to human with the assistance from University of Minnesota Medical School.

The preliminary results from the BSAC collaboration membership have led to the successful application to the National Science Foundation (NSF) Small Business Technology Transfer (STTR) project in 2022. Two key research aims are to be studied, including highly responsive sensing systems by maintaining its ability to derive measure BP when encapsulated in a hermetic and biocompatible material for long-term monitoring; and robust sensing systems to survive and maintain its reliability inside the physiologic environment without interrupting the patients' routine.

[1] Yande Peng, Sedat Pala, Zhichun Shao, Hong Ding, Jin Xie, and Liwei Lin, "Subcutaneous and Continuous Blood Pressure Monitoring by PMUTs in an Ambulatory Sheep," *Proceedings of 35th IEEE Micro Electro Mechanical Systems Conference, Tokyo Japan, Jan. 2022.*

BSAC PUBLICATIONS FOR MEMBER ACCESS: 2022

A High Seebeck Coefficient Thermoelectric Generator Based on a Self-Healing Ionogel, Yu Long; Peisheng He; Yande Peng; Liwei Lin, Conference Paper (Proceedings), 2022

A Large-Scale Microelectromechanical-Systems-Based Silicon Photonics LiDAR, Xiaosheng Zhang; Kyungmok Kwon; Johannes Henriksson; Jianheng Luo; Ming C. Wu, Journal Article, 2022

A Moisture-Resistant Soft Actuator with Low Driving Voltages for Haptic Stimulations in Virtual Games, Wenying Qiu; Zhaoyang Li; Guocheng Wang; Yande Peng; Min Zhang; Xiaohao Wang; Junwen Zhong; Liwei Lin, Journal Article, 2022

A New Chemresistive NO₂ Sensing Material: Hafnium Diboride, Sikai Zhao; Yong Xia; Steven Delacruz; Aifei Pan; Zhou Li; Yanbai Shen; Marcus A. Worsley; Carlo Carraro; Roya Maboudian, Journal Article, 2022

An Improved Lumped Element Model for Circular-Shape pMUTs, Sedat Pala; Liwei Lin, Journal Article, 2022

An Optics-Free Ultra-Thin Time-Resolved Intraoperative Imager Using Upconverting Nanoparticles, Hossein Najafi, Ph.D. Dissertation, 2022

Auto-Posting and Haptic Stimulations via a 35mm Square pMUT Array, Wei Yue; Yande Peng; Hanxiao Liu; Fan Xia; Fanping Sui; Seiji Umezawa; Shinsuke Ikeuchi; Yasuhiro Aida; Liwei Lin, Conference Paper (Proceedings), 2023

Bit Rate-Adapting Resoswitch, Qitong Jin; Kevin H. Zheng; Clark T.-C. Nguyen, Conference Paper (Proceedings), 2022

Bright Mid-Wave Infrared Resonant-Cavity Light-Emitting Diodes Based on Black Phosphorus, Niharika Gupta; Hyungjin Kim; Nima Azar; Shiekh Zia Uddin; Der-Hsien Lien; Kenneth B. Crozier; Ali Javey, Journal Article, 2022

Data-Driven Freeform MEMS Energy Harvester Design Enabled by Machine Learning, Kunying Li; Ruiqi Guo; Fanping Sui; Liwei Lin, Conference Paper (Proceedings), 2022

Deep Learning for Non-Parameterized MEMS Structural Design, Ruiqi Guo; Fanping Sui; Wei Yue; Sedat Pala; Kunying Li; Renxiao Xu; Liwei Lin, Journal Article, 2022

Drone-Mounted Low-Frequency pMUTs for > 6-Meter Rangefinder in Air, Hanxiao Liu; Yande Peng; Wei Yue; Seiji Umezawa; Shinsuke Ikeuchi; Yasuhiro Aida; Chunming Chen; Peggy Tsao; Ying Dong; Xiaohao Wang; Liwei Lin, Conference Paper (Proceedings), 2023

Drug Monitoring with Wearable Sweat Sensors, Li-Chia Tai, Ph.D. Dissertation, 2022

Efficiency Roll-Off Free Electroluminescence from Monolayer WSe₂, Shiekh Zia Uddin; Naoki Higashitarumizu; Hyungjin Kim; I K M Reaz Rahman; Ali Javey, Journal Article, 2022

Enhanced Neutral Exciton Diffusion in Monolayer WS₂ by Exciton-Exciton Annihilation, Shiekh Zia Uddin; Naoki Higashitarumizu; Hyungjin Kim; Jun Yi; Xiang Zhang; Daryl Chrzan; Ali Javey, Journal Article, 2022

Ferrite-Rod Antenna Driven Wireless Resoswitch Receiver, Kevin H. Zheng; Qiutong Jin; Clark T.-C. Nguyen, Conference Paper (Proceedings), 2023

Frequency Compensated Crystal-Free 802.15.4 Wireless Radio, Alex Moreno; Kristofer S.J. Pister, Conference Paper (Proceedings), 2022

Gold NanoParticle Based Plasmonic Sensing for the Detection of SARS-CoV-2 Nucleocapsid Proteins, Kamyar Behrouzi; Liwei Lin, Journal Article, 2022

High-SPL and Low-Driving-Voltage pMUTs by Sputtered Potassium Sodium Niobate, Fan Xia; Yande Xia; Sedat Pala; Ryuichi Arakawa; Wei Yue; Pei-Chi Tsao; Chun-Ming Chen; Hanxiao Liu; Megan Teng; Jongha Park; Liwei Lin, Conference Paper (Proceedings), 2023

In-Situ Synthesized N-Doped ZnO for Enhanced CO₂ Sensing: Experiments and DFT Calculations, Yong Xia; Aifei Pan; Ya-Qiong Su; Sikai Zhao; Zhou Li; Adrian K. Davey; Libo Zhao; Carlo Carraro; Roya Maboudian, Journal Article, 2022

Indistinguishable Photons from an Artificial Atom in Silicon Photonics, Lukasz Komza; Polnop Samutpraphoot; Mutasem Odeh; Yu-Lung Tang; Milena Mathew; Jiu Chang; Hanbin Song; Myung-Ki Kim; Yihuang Xiong; Geoffroy Hautier; Alp Sipahigil, Journal Article, 2022

Influence of Capacitive Transducer Nonlinearities on the Amplitude Limiting of MEMS Based Oscillators, Sherwin A. Afshar; Clark T.-C. Nguyen, Master's Thesis, 2022

Low Voltage AC Electroluminescence in Silicon MOS Capacitors, I K M Reaz Rahman; Shiekh Zia Uddin; Hyungjin Kim; Naoki Higashitarumizu; Ali Javey, Journal Article, 2022

Low-Loss Wafer-Bonded Silicon Photonic MEMS Switches, Amirmahdi Honardoost; Johannes Henriksson; Kyungmok Kwon; Jianheng Luo; Ming C. Wu, Conference Paper (Proceedings), 2022

Mapping and Simultaneous Detection of Arterial and Venous Pulses using Large-Scale High-Density Flexible Piezoelectret Sensor Array, Liuyang Han; Wei Zeng; Ying Dong; Xiaohao Wang; Liwei Lin, Journal Article, 2022

Nonlinear Dynamics of Lateral Electrostatic Gap Closing Actuators for Applications in Inchworm Motors, Ahad M. Rauf; Daniel Contreras; Ryan Shih; Craig Schindler; Kristofer S.J. Pister, Journal Article, 2022

PCB-Less Integration of a Robust Wireless MEMS Tactile Package, Dillon Acker-James; Kristofer S.J. Pister, Master's Thesis, 2023

Resettable Microfluidics for Broad-Range and Prolonged Sweat Rate Sensing, Mallika Bariya; Noelle Davis; Liam Gillan; Elina Jansson; Annukka Kokkonen; Colm McCaffrey; Jussi Hiltunen; Ali Javey, Journal Article, 2022

Single-Chip Micro Mote in EEG, fMRI, and TMS Systems, Joshua Alexander; Kristofer S.J. Pister, Master's Thesis, 2022

Subcutaneous and Continuous Blood Pressure Monitoring by PMUTS in an Ambulatory Sheep, Yande Peng; Sedat Pala; Zhichun Shao; Hong Ding; Jin Xie; Liwei Lin, Conference Paper (Proceedings), 2022

[PUBLICATIONS CONTINUED]

Suppression of Oscillator Bias Voltage Phase Noise via MEMS Resonator Arraying, Jeffrey Ni; Clark T.-C. Nguyen, Master's Thesis, 2022

Synergy of Prediction and Control in Model-based Reinforcement Learning, Nathan Lambert, Ph.D. Dissertation, 2022

Temperature-Insensitive Resonant Strain Sensor, Xintian Liu; Qianyi Xie; Alper Ozgurluk; Clark T.-C. Nguyen, Conference Paper (Proceedings), 2022

Transient Closed-Loop Heating for Localized MEMS Bonding, Daniel Teal; Kristofer S.J. Pister, Conference Paper (Proceedings), 2022

Trial-and-Error Learning for MEMS Structural Design Enabled by Deep Reinforcement Learning, Fanping Sui; Wei Yue; Ziqi Zhang; Ruiqi Guo; Liwei Lin, Conference Paper (Proceedings), 2023

Two-Dimensional Semiconductors for Next-Generation Optoelectronics, Hyungjin Kim, Ph.D. Dissertation, 2022

BSAC INVENTIONS DISCLOSED FOR MEMBER ACCESS: 2022

Case No.	Title	Inventor
B20-101	Wearable Patch for Continuous Analysis of Naturally Secreting Sweat	Ali Javey
B22-002	Reconfigurable Soft Li-Ion Battery	Liwei Lin
B23-028	High-SPL and Low-Driving-Voltage PMUTs	Liwei Lin
B23-031	PMUT for Blood Pressure Monitoring	Liwei Lin
B23-044	Digital Wearable Device for Monitoring Sweat During Exercise	Ali Javey
B23-076	Integrated Microlens Coupler for Photonic Integrated Circuits	Ming C. Wu

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