



BERKELEY SENSOR & ACTUATOR CENTER

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Directors

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This Industry/University Cooperative Research Center, founded in 1986 as the National Science Foundation Center for Microsensors and Microactuators, is devoted to interdisciplinary engineering research on micro- and nano-scale sensors, moving mechanical elements, microfluidics, materials, and processes that take advantage of progress made in integrated-circuit technology.

Goals of BSAC:

- (1) Create a leadership microsystems research environment by combining the best researchers, faculty, and industrial partners bound through the collective appeal of *top rank University resources, an environment of collaboration, and access to a diverse group of Industrial members* who are usually current or future market leaders in their segments.
- (2) Enhance the educational experience of our graduate students.
- (3) Reduce the time to commercialization of BSAC research by Industrial Members and entrepreneurial researchers by establishing systematic progress in *multiple phases* of new technology formation: *a)materials/process/packaging; b)devices and structures; and c)system integration*. This strategy requires a broader range of projects and a larger research organization than most research consortia would be able to maintain.
- (4) Maintain collaboration with Industrial Members to insure commercial relevancy of the research.

Research Scope: Topics, which will vary as the field develops, include: (1) phenomena useful for sensing various measurands (mechanical, electromagnetic, optical, fluidic, thermal, chemical and biological variables); (2) physical and electrical methods for interfacing arrays of sensors, actuators, and other MEMS and NEMS structures to electronic devices for detection, control, analysis, communications, and display purposes; (3) fabrication techniques for making economical integrated MEMS/NEMS in large quantities; and (4) materials, processes, and packaging to enable new applications and new levels of performance. Individual research projects are expected to last from two to four years.

Personnel: The research involves more than 120 graduate students and post-doctoral researchers, and more than 30 faculty from Electrical Engineering; Computer Science; Chemical Engineering; Mechanical Engineering; Materials Science; Bio-Engineering; and the University of California at Davis, and more than 100 research projects. Collaboration with other on-campus research groups expands the research impact of BSAC. Several Industrial Members have researchers in residence; others visit campus frequently to use laboratory facilities.

Benefits to Industrial Partners: Participation in the Center provides Industrial Members (partners) with access to wide-ranging research from the best and brightest researchers in a University with worldwide recognition. Members see Center research at an early stage for a timely view of new developments before publication. Extensive formal research reviews are conducted on-campus twice per year, in March and September, specifically for Industrial Members. Members, through the Industrial Advisory Board, influence the directions taken in the research and policies of the consortium. Members can obtain exclusive or non-exclusive, royalty-bearing rights to inventions made in the Center at favorable terms. Member organizations can nominate researchers to be seminar speakers and medium-term Center visitors. Industrial funding for the Center has been granted full DoD IR&D status. Industrial Members are invited to special presentations of research at the Center. Relationships formed among Industrial Members, faculty, and researchers tend to persist throughout developers' and researchers' careers, creating subtle but lasting organizational value to members and graduates. Contact with graduate students in training can lead to hiring for summer and long-term positions. Nearly 50% of BSAC PhD graduates have taken positions with BSAC Industrial Member companies or Laboratories. No single Industrial Member is likely to establish the high risk, high reward multi-project environment available through the research consortium. BSAC research has spawned new businesses or divisions for its members and new start-ups from among its researchers.

Administrative Structure: The Center is directed administratively by Executive Director John Huggins and by the Electronics Research Laboratory, headed by Professor Albert P. Pisano, who is also a BSAC Director. The Industrial Advisory Board mentioned above includes up to two voting representatives from each member organization.

Facilities: Researchers use the extensive Berkeley Microfabrication (integrated circuits) Laboratory, the new Polymer Lab in Hearst Mining; Automated Device Characterization Lab, new CAD/CAM facilities in Cory Hall (EECS Dept. and ERL), and other specialized facilities, such as those for polymer and plasma-deposition research in Lewis Hall (Chemical Engineering), CAD tools in Etcheverry Hall (Mechanical Engineering), photonics laboratory at UC Davis, and surface characterization tools at the Lawrence Berkeley Laboratory. A major Bionanotechnology Laboratory in Evans Hall is under construction, and a new CITRIS Microfabrication Laboratory is scheduled for 2007 occupancy.

Funding: Federal and State research funds, together with **annual \$50,000 per-Member** contributions, support the Center. The funds from BSAC Industry Memberships comprise only about 10%-15% of BSAC research funds, the bulk of which are from competitive federal grants. But 100% of the research results are made available to Industrial Members, as they happen, before external disclosure or publication, and with favored IP access by members. This funding gain represents a large advantage in the research investment for Industrial Members. University indirect costs (overhead) are not charged against membership fees, which are used for direct support of Center programs.

Some Current Major BSAC Multi-Project Programs

- Integrated wireless microwatt transceiver
- Wireless networks of energy-scavenging communicating microsensors
- Resonator arrays, RF microrelays, and Tunable RF micro capacitors and inductors for programmable radios
- Biosensors and biomanipulators
- Fluidic microvalves, mixers and micropumps
- Adaptive optical micromirror arrays
- Rotary internal combustion engine and microbial energy systems,
- MEMS-based steered free-air laser communication system
- Miniaturized Nano Mechanically Regulated Rubidium atomic clock
- Monolithic self-propelled microbotics
- Advancing the “E” in MEMS (benchmark electronic mixed-signal IC interface electronics)
- CAD for MEMS
- Silicon Germanium MEMS on CMOS process
- Silicon Carbide harsh environment and rigid structure MEMS processing
- Polymer micromachining process

Achievements :Among the pioneering milestones, firsts, or significant benchmarks of BSAC are

- First Surface Micromachining of Polysilicon
- Gyro Inertial Sensors and Accelerometers
- Thin-Film MEMS Poly-Si, Silicon Nitride, Silicon Carbide
- Lamb Wave Acoustic Sensors
- Acoustic Wave and Fluidic Micropumps and Mixers
- Comb-Driven MEMS Actuators
- MEMS Micropositioning Components & System for Hard Disk Drive
- Pin-Jointed Self-Assembled Micromechanical Structures
- Surface-Micromachined Gears, Cranks and Springs
- Anti-Stiction Elements, Dimpled Structures, and Surface Treatments
- MEMS Micro-Vibromotors
- Hinged, Fold-Out Micromachined Out-of-plane Robotic Structures
- X-and Y-Rastered Real-Time Projected Display System
- MEMS Based Free-Space Collimated Beam Communications/ Optics
- Piezoelectric MEMS Silicon-Diaphragm Microphone
- MEMS-Scanned Barcode Reader
- Microfluidic Host-Fueled Glucose Microbial Power Cell
- Room temperature, directed growth of Multiwalled carbon nanotubes and Silicon nanowires
- Localized thermal bonding for micropackaging and fluidic / biosample encapsulation
- Precision controllable arrays of polymer lenses and mirrors for adaptive optics and imaging applications

BSAC welcomes inquiries from technology-based companies interested in participating in our research consortium as industrial members, and from top students seeking advanced degrees in our specialties.
