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Materials Research at the University of California, Santa Barbara

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The antecedents of the University of California, Santa Barbara (UCSB) trace back to 1891, when Anna S. C. Blake arrived from Boston to take up residence in the small mission city by the Pacific Ocean and shortly thereafter founded a manual training school. This private school was supported entirely by Miss Blake until her death in 1899, after which the city school district assumed expenses, with some aid from Miss Blake's estate. The state took over responsibility for the school in 1909 and, after a couple of iterations in the name, became the Santa Barbara State College in 1935. It continued in that form until 1944, when the Regents of the University of California accepted responsibility, in accordance with a legislative bill approved by the state governor. The ultimate result was the creation of a new branch of the University of California for which the Regents originally envisioned a small liberal arts college. The campus moved in 1949 to an ex-Marine Base on a seaside mesa in Goleta with excellent accessibility to the beach and a beautiful ocean vista (**Figure 1**). Increased enrollment pressure, in part as a result of the G.I. Bill, led to the designation of general campus in 1958, along with the name change from "Santa Barbara College" to "University of California, Santa Barbara". Fast-forwarding half a century, the National Research Council provided on September 2010 a comprehensive report evaluating over 5000 doctoral programs in the United States. UCSB's College of Engineering ranks among the top five in the USA, with the UCSB materials program being ranked number one in all metrics applied in the study. To put this achievement in context, no other department in physical science or engineering was similarly ranked. As demonstrated by the contributions in this special *Advanced Materials* issue, materials research at UCSB encompasses efforts distributed amongst several departments, Institutes, and Centers. The composite effort is characterized by a distinctive approach, where traditional boundaries of research are absent and where intellectual input from multiple perspectives merges in order to tackle basic and technological issues across a wide range of materials types. The culture of success and forward-looking work style within the broad Materials effort at UCSB is an interesting success story worthy of some retrospective.

Figure 1. Aerial view of the Marine Corps Air Station Santa Barbara. Photograph courtesy of UCSB Photographic Services.

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The tradition of interdisciplinary research and collaboration at UCSB is partly a product of its youth coupled with the vision of its founders. Robert Mehrabian, who joined UCSB in 1983 as the Dean of the College of Engineering, played a pivotal role in developing the Materials program and in transforming what was regarded, at least externally, as an institution primarily dedicated to teaching. Mehrabian attracted several key players, including the late Anthony G. Evans, who arrived from UC Berkeley in 1985 to lead the effort to establish a new department, and became its founding Chair. The Materials Department was established in 1987, and was built essentially from the ground up, unencumbered by a long history, but with the benefit of a nucleus of outstanding researchers who were already at the university. For example, Robert Odette and Gene Lucas were working on structural materials; Herbert Kroemer (Nobel Prize winner in Physics, 2000) and James Merz focused on electronic materials, but with a distinct emphasis away from silicon mainstay technology; and Alan Heeger (Nobel Prize winner in Chemistry, 2000) and Fred Wudl were working on organic semiconducting polymers. An important strategy was the hire of clusters of faculty with complementary and supporting expertise with many having industrial experience, together with splitting of appointments between departments in engineering and the physical sciences. Evans not only drew other high visibility faculty to Santa Barbara in his areas of interest—including Manfred Rühle, Robert McMeeking, David Clarke and the late Fred Lange—but in partnership with Mehrabian attracted key faculty in the other nascent areas within the Department. For example, Larry Coldren, Evelyn Hu, Arthur Gossard and Pierre Petroff came from Bell Labs to rapidly expand the area of Electronic Materials. Indeed, so many scientists and engineers were recruited from Murray Hill that UCSB was affectionately known for a time as "Bell Labs West." Phillip Pincus, Paul Smith from DuPont, and Dale Pearson from Exxon strengthened the university's efforts in polymer research. Evans and Mehrabian's commitment to excellence, interdisciplinarity and collaboration was an important contributor to the perspective of the people recruited to propel the University towards its current world-class research status. This core philosophy is still evident on campus today (**Figure 2**); the majority of faculty members have joint appointments in more than one department and many of the students and post-doctoral researchers are co-advised.

As shown by the list of publications in this issue, Materials research is deeply embedded in the majority of Engineering and Science Departments throughout the UCSB campus. A new generation of researchers has also emerged that shares the ideals and goals originally envisioned by founders of the program. There are contributions from Materials, Mechanical Engineering, Chemistry & Biochemistry, Physics, Electrical and Computer Engineering, Chemical Engineering, and Molecular, and Cellular and Developmental Biology. There are numerous external collaborators as well. This selection serves as a good example of the interdependence of various traditional areas in defining contemporary Materials research. Such composite efforts are sometimes better facilitated through the formation

Figure 2. Recent aerial panorama of the UCSB Campus. Photograph courtesy of UCSB Photographic Services.

and fostering of organized research units outside the typical confines of traditional academic departmental structures. UCSB has made substantial investment to create such programs as described below.

Since its inception in 1992, the Materials Research Laboratory (MRL) has been synonymous with cutting-edge research in new materials, enabled by experts working at the interface of many scientific and engineering disciplines. The sustained success of the MRL has been a key driver in reinforcing UCSB's international standing as a premier center of excellence spanning the spectrum of materials science research. Among the successes in new materials and new material concepts where the MRL has played a key enabling role are (i) the ubiquitous porous materials that proudly bear the SBA name, (ii) bulk heterojunction photovoltaics that have made plastic solar cells a reality, and (iii) the deep understanding of the natural design principles that are enabling the unique properties and performance of marine organisms to be translated to synthetic materials. By providing for a strong community of researchers through state of the art facilities and outstanding educational opportunities, the MRL continues the tradition of excellence in the original vision of Robert Mehrabian.

The Center for Energy Efficient Materials is an Energy Frontier Research Center funded by the Department of Energy, Office of Basic Energy Sciences. Its mission is to discover and characterize new materials that control the interactions between light, electricity, and heat at the nanoscale, and to apply them to achieve higher efficiencies in photovoltaic solar cells, solid-state lighting, and thermoelectric devices for converting heat into electricity. The Center's research program is highly cross disciplinary and is organized into teams, each having extensive expertise in materials growth, characterization, theoretical modeling; and device design, fabrication, and characterization. These collaborative teams encompass multiple disciplines and multiple institutions: UC Santa Barbara (lead), UC Santa Cruz, Harvard University, the National Renewable Energy Laboratory, and the Los Alamos National Laboratory. Although the center's primary focus is basic research, its longer-term objective is to transfer new materials and devices into the commercial sector to impact the nation's need for sustainable energy resources.

The International Center for Materials Research (ICMR) is a national and global resource for promoting international research collaboration and education in materials science and engineering. The goals of the ICMR are to enable groundbreaking discoveries in materials science and engineering by facilitating international, multidisciplinary research collaborations; to provide opportunities for young researchers to develop the skills needed to excel in a global research environment; and to integrate materials research experiences with an awareness of environmental and developing world issues into undergraduate curricula.

UCSB's long-standing tradition in organic semiconducting molecules and polymers is a primary focus at the Center for Polymers and Organic Solids (CPOS). This Center brings together efforts in physics, chemistry, polymer science, engineering and biology to conduct fundamental research related to technologies including polymer light emitting diodes, plastic solar cells, and optically amplified fluorescent biosensors. The effort spans from the synthesis and design of new molecules, to the collective behavior in the bulk, to, finally, the complete incorporation into optoelectronic devices.

The Institute for Collaborative Biotechnologies (ICB) is an interdisciplinary research and development alliance, led by UCSB, in collaboration with the Massachusetts Institute of Technology and the California Institute of Technology, and with scientific partners from the United States Army and industry. Operating under a charter from the Congress and the Army, the aim of the ICB is to accelerate the transition of discoveries from the university laboratories into commercial development. Special funding mechanisms designed to facilitate this aim help support collaborative developments with industry. Examples include biologically inspired fabrication techniques that create multi-functional nanostructured materials for high power-density batteries, flexible solar panels, advanced infrared detectors and lightweight energy-dispersive materials. Translation of the principles of high-performance biological networks and sensors have led to new technologies for mobile ad hoc networking, unmanned aerial vehicle control and novel devices for high-sensitivity threat detection and identification. Advances in genetic engineering are leading to the development of new tools for systems biology and drug discovery. ICB researches also are using advanced brain imaging technologies to analyze variations in human cognitive strategy, perception and decision making.

The Mitsubishi Chemical Center for Advanced Materials (MC-CAM) is the vehicle for a research alliance between UCSB's materials community and the Mitsubishi Chemical Corporation (MCC)–the largest chemical company in Japan. Since 2001, MC-CAM has supported a broad range of research projects at UCSB in advanced functional materials including projects in organic semiconductors, specialty polyolefins, nanocomposites, solid state lighting and batteries, and fullerenes. This comprehensive program has an enviable record in research efficiency, expending approximately $300,000 on research per invention disclosure, and amassing a portfolio of over 65 disclosures to date. MC-CAM also provides a unique research experience for UCSB students to work alongside experienced MCC scientists both on campus and in facilities in Japan.

The ConvEne (*Conv*ersion of *Ene*rgy through Molecular Platforms) is a National Science Foundation-supported interdisciplinary graduate program (an IGERT program) that helps to train the leaders of tomorrow in the area of materials applied to problems concerning sustainable energy. Graduate students in this program not only carry out cutting-edge interdisciplinary research in advanced materials as relevant in problems in energy conversion,

but also learn about the economic, environmental, and entrepreneurial impact of their research. IGERT students are additionally exposed to research in an international context, and students have travelled on short or long visits to Europe and Asia.

We, and all of our colleagues at UCSB, are pleased that you have taken the opportunity to learn more about our research. We also encourage you to discover other projects, research avenues and educational opportunities on Campus that are not contained in the publications herein. We are also very grateful to the staff of *Advanced Materials* for their kind efforts in the preparation of this issue.

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