

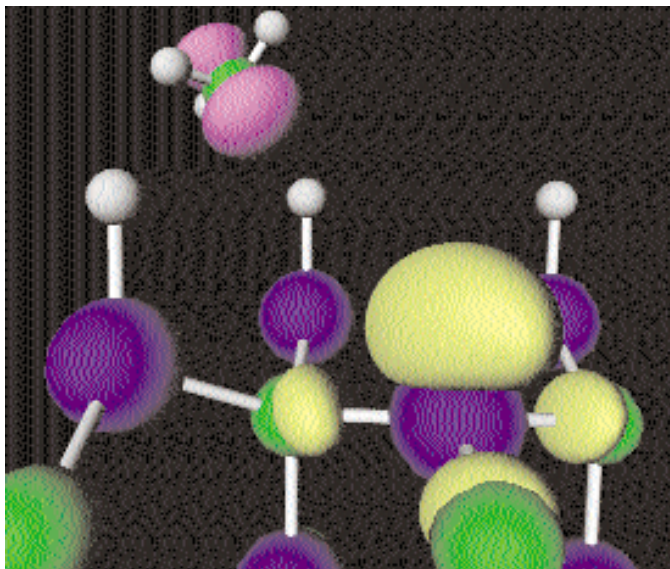
# Exploring Technology in Silicon Hills

The American Physical Society (APS) will hold its 2003 March meeting March 2–7 in Austin, Texas, the hub of an area known in the semiconductor industry as Silicon Hills. Appropriate to the setting, the APS's Forum on Industrial and Applied Physics (FIAP) will focus much of its annual program at the meeting on topics of particular interest to the computer, microelectronics, nanotechnology, equipment, and instrumentation companies that make up the local high-tech community. Most of the 2 tutorials, 18 focus sessions, and 12 invited symposia will assess the state of leading-edge investigations and challenges in heterostructures, semiconductors, nanoscale science, and physics issues in silicon microelectronics.

## Heterostructures

On Sunday, March 2, there will be a pre-meeting tutorial titled "Heterojunctions Everywhere," an event suggested by FIAP and designed to examine in breadth the role and importance of these semiconductor junctions between two dissimilar materials. Nobel laureates Herbert Kroemer of the University of California, Santa Barbara, and Horst Stormer of Columbia University and Lucent Technologies' Bell Laboratories will give an overview of heterojunction physics and its application to semiconductor devices. Heterostructures enable the study of the physics of two-dimensional systems as well as the demonstration of fascinating phenomena, such as the fractional quantum Hall effect. Federico Capasso of Bell Laboratories will review the invention of the quantum cascade laser, an optoelectronic device based on heterostructures, and the process of bringing it to market. Chris van de Walle of Xerox's Palo Alto Research Center will describe how structural changes

and strain affect the electronic band alignment at the interface between two semiconductors and the application of these effects to commercial devices (Figure 1).



**Figure 1. In this simulation from Chris van de Walle's work at Xerox, an ammonia molecule (nitrogen atoms are green, hydrogen gray, and the filled orbital pink) approaches a gallium nitride surface (gallium is blue, and the empty dangling-bond orbital on the surface of the gallium atom is yellow).**

Two invited symposia and one focus session ("IR Applications of Semiconductor Nano- and Microstructures)—held during the regular APS program—will complement the tutorial. The symposium, "Applications of Semiconductor Heterostructures," will describe their commercial uses. In this session, Karl Johnson, director of Motorola's Compound Semiconductor Technology Laboratory, will explain the advantages of an indium gallium phosphide heterojunction bipolar transistor, first proposed by Kroemer in 1983, as a high-frequency power amplifier in a cellular telephone, and what the competing device technologies are. Other invited talks in this session will describe column-IV semiconductor heterostructure devices, applications of the 6.1-Å-lattice-constant family of semiconductors (particularly anti-

monides for infrared detectors), and quantum cascade lasers.

A related symposium will explore the critical role of heterostructures in nanostructured interfaces. Topics in this invited session will range from ab initio theory and modeling of interfaces, to atomic-resolution imaging using transmission electron microscopy, to atomic-layer deposition of high-dielectric-constant (high- $k$ ) gate dielectrics for future silicon complementary-metal-oxide-semiconductor (CMOS) devices. This highly technical program will be augmented by a networking breakfast that FIAP will co-sponsor with APS's Committee on the Status of Women in Physics, which will feature a local leader in high technology as the keynote speaker.

## Semiconductors

Another emphasized theme of the FIAP program will examine the physics problems encountered on the International Technology Roadmap for Semiconductors (ITRS), a periodic assessment of the semiconductor industry's technical needs over the next 15 years and the challenges it confronts in meeting them. "Frontiers in Si CMOS," an invited session organized jointly by FIAP and the Group on Instrumentation and Measurements, will introduce the ITRS roadmap and point out the technical challenges. These problems include the characterization and measurement of high- $k$  gate dielectrics, metal interconnects, and low- $k$  interlayer dielectrics.

Other speakers at this session will address "R&D Strategies for the Semiconductor Industry," "Frontiers of Physics in Low- $k$ /Interconnect Research," "X-ray Measurements for the Semiconductor Industry," and "Beyond Classical CMOS Devices: A Wild West Physics Frontier." A related symposium, "Microelectronics Modeling

and Simulation,” will describe the role of condensed-matter theory and first-principles device modeling in the microelectronics industry.

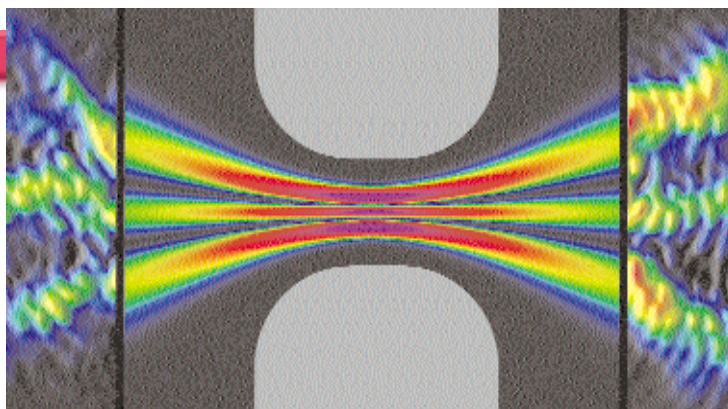
These two symposia and several related focus sessions form a miniconference. The related sessions cover a range of topics: “Measurements and Instrumentation for the Semiconductor Industry,” “Mechanical Properties of Nanostructured Thin Films and Coatings,” “Front-End Materials and Processes for Scaled Si CMOS,” “Novel Complex Oxides,” “Progress in Photovoltaic Technology,” “Optical Telecommunications,” “MEMS/NEMS Science and Technology,” and “Physics of Silicon in Electronic Materials.”

## Nanostructures

The National Nanoscale Initiative (NNI) links 16 U.S. departments and independent agencies in an effort to increase and enhance research in nanoscale science. Since NNI’s inception in early 2000, the National Science Foundation (NSF) and other funding agencies have made large investments in nanoscale science and technology. In September 2001, for example, NSF established Nanoscale Science and Engineering Centers (NSECs) at six universities—Columbia, Cornell, Harvard, Northwestern, Rice, and Rensselaer Polytechnic Institute (RPI).

In a session organized by Ulrich Strom of NSF’s Division of Materials Research, the directors or other senior researchers at the six NSECs—Robert Buhrman, Vicki Colvin, Mark Hersam, Richard Siegel, Horst Stormer, and Robert Westervelt (Figure 2)—will present highlights of early research results from their facilities. They will also describe opportunities to translate scientific discovery into innovative technological products. FIAP and the Division of Condensed Matter Physics will be co-sponsors of this session.

This nanoscience symposium is complemented by a FIAP focus session, “Understanding Molecular and Nanoelectronics,” which continues a successful series of sessions held at last year’s APS March meeting. Contributed papers will describe progress



**Figure 2. Image of the coherent flow of electrons through a quantum point contact formed in a two-dimensional electron gas inside a gallium arsenide/aluminum gallium arsenide heterostructure.**

Robert Westervelt and Eric Heller at Harvard University, Arthur C. Gossard at University of California, Santa Barbara

in theoretical and experimental methods in this area. Topics are expected to include quantum-size effects in the contact interaction between a molecule or atom and a surface, charging of the molecule near a surface, and the scattering of charge carriers at the solid–molecule interface. APS’s Division of Materials Physics (DMP) is organizing a related focus session on transport in nanostructures and ultrathin films.

## Career building


FIAP and the APS Committee on Careers and Professional Development (CCPD) will present a second Sunday tutorial, titled “Things Your Professors Will Never Tell You.” It aims to explain career choices to physics graduate students, postdoctoral fellows, and assistant professors without tenure who need to choose between traditional academic positions and jobs in industry. The instructors will be experienced physicists from industry and universities, who are familiar with these choices and can discuss the opportunities and the consequences of early decisions later in one’s career. In particular, there will be an emphasis on career transitions from university to industry and back, moving from individual contributor to management, and the influence of industrial experience in obtaining funding for university research projects.

A symposium titled “Training Physics Students for the Semiconductor Industry,” also jointly organized by FIAP and CCPD, will continue with this theme. In this invited session, Mark Holtz from Texas Tech University will describe several successful interdisciplinary programs that place physics students studying for a master’s degree in industrial

internships. Two university professors, Mark Law from the University of Florida and Toh Ming Lu from RPI, will discuss the role of funding from the semiconductor industry, through the Semiconductor Research Corp., on physics and engineering education. Larry Larson from International Sematech and Brad Melnick from Motorola,

two senior industrial scientists, will describe their hands-on experiences in the semiconductor industry.

As always, the FIAP program encompasses a broad range of other topics. These sessions include a symposium addressing the “Economic Value of Research,” organized by FIAP and the Forum on Physics and Society. Together with the Division on Biological Physics, FIAP will present a symposium on “Advances in Medical Imaging for Early Cancer Detection,” and another symposium, organized by FIAP and DMP, will discuss “Nitride Semiconductors for Solid-State Nitrides and Other Applications.” A Thursday evening session, “Physics in the Entertainment Industry,” will offer insightful comments on such topics as interstellar travel, alien life forms, and crop circles.

The complete list of FIAP programs is accessible at the APS Web site, <http://www.aps.org>, by either following the link to the FIAP home page or going to the APS March meeting pages. 

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