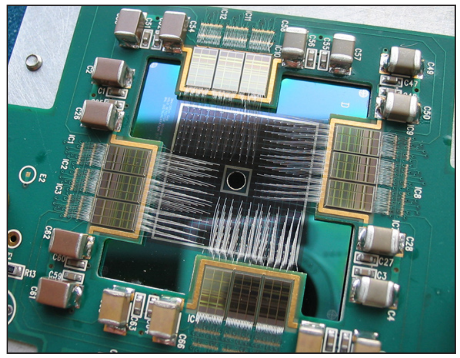
Designing New Electronic Marvels

Instrument development for programs at home and around the world

The Instrumentation Division at Brookhaven National Laboratory works at the cutting edge of instrument development for research programs at the Laboratory and around the world. Specialists design and fabricate unique sensors and equipment that can operate close to the limits of nature, whether it be counting just one or two electrons, creating nanostructures, or producing laser/electron pulses with the shortest-ever time duration. Out of this come sophisticated devices that are used in experiments that extend our understanding of ultrasmall and ultrafast processes. The division also maintains expertise and facilities in specialized high-tech areas essential for this work.



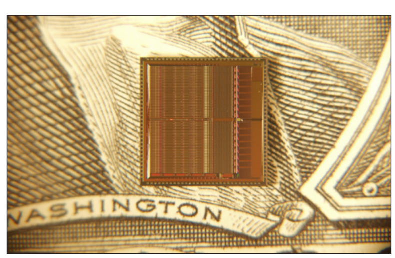
Semiconductor detectors: This silicon detector has 384 discrete pads wire-bonded to an integrated circuit on all four sides. It is used to measure x-ray fluorescence and scattering from biological and material science samples at the NSLS.

Most of the projects are done collaboratively, with scientists bringing their ideas and problems directly to division staff members, who offer unique expertise in tackling challenges. The staff's particular forte is developing new devices and instruments that are not commercially available.

Core Technologies

Semiconductor detectors: The division staff develops and produces prototype radiation and particle detectors for nuclear and high-energy physics experiments, such as ATLAS, located at the Large Hadron Collider at CERN, the European accelerator center in Switzerland; and PHENIX, a detector at Brookhaven's Relativistic Heavy Ion Collider. Already, R&D work has begun for various instruments required for the proposed International Linear Collider, both for machine operations and for the experimental program. Advanced semiconductor technology is also being developed for x-ray experiments at Brookhaven's National Synchrotron Light Source (NSLS) and NSLS-II, for the study of biological and material processes.

Gas and liquid detectors: Fundamental studies are done on the physics of gas-based radiation detectors for use in nuclear and high-energy physics, as well as synchrotron and neutron experiments. There is a continual need to increase the performance of these devices. New detector techniques are studied in the laboratory and, when their characteristics have been fully evaluated, they are scaled up by collaborations for use in major experiments. The division can also produce small numbers of detector systems for user facilities such as the NSLS at Brookhaven, the Spallation Neutron Source at Oak Ridge National Laboratory, and the Neutron Scattering Center at Los Alamos National Laboratory.



Microelectronics: Placed on a dollar bill, this circuit illustrates the tiny size of powerful integrated circuits, which are revolutionizing physics, astronomy, medicine and materials science.

Microelectronics: Many channels of analog and digital electronics can now be miniaturized onto monolithic silicon wafers of just a few square millimeters, greatly improving system performance and reducing power

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The First Video Game?

Early visitors' days at Brookhaven Lab always included static science exhibits. In 1958, the Instrumentation Division's William Higinbotham decided to "liven up the place" by creating an interactive game using an analog computer and oscilloscope screen.

Lines of visitors wrapped around the gymnasium to play Higinbotham's game, which he named "Tennis for Two," as players saw a two-dimensional side view of a tennis court and used controllers with buttons and rotating dials to manipulate a brightly-lit, moving-dot "ball" on screen, just like a modern video game.

Back then, no one could have guessed that Tennis for Two would lead to Pong, Pac-Man, and an entire video game industry.

Gas and liquid detectors: This advanced imaging detector, using a rare isotope of helium, has been designed and fabricated within the division. It is seen here installed on one of the world's most powerful neutron beamlines for biology at Los Alamos National Laboratory. This instrument has opened new vistas on protein crystallography using neutrons as a probe.

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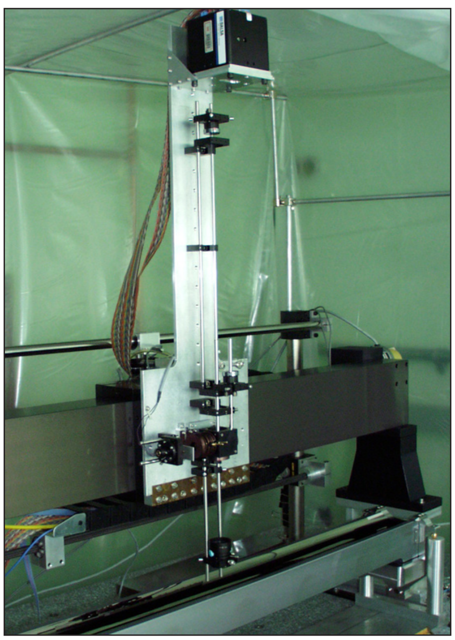
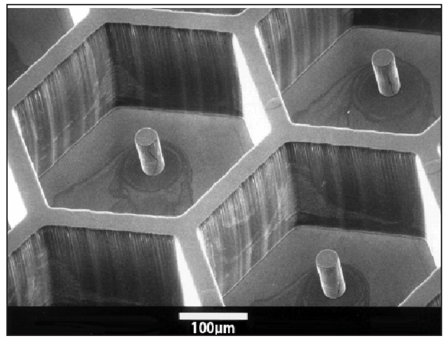
Designing New Electronic Marvels (continued)

consumption. These application-specific integrated circuits are revolutionizing a wide range of instrumentation, and the division's designers provide unique solutions to scientists in nearly all the major Brookhaven facilities, as well as to many outside collaborators.

Lasers and optical metrology: Instrumentation has developed photocathodes that produce the highest-known yield of electrons. These devices have contributed to the success of Brookhaven's Accelerator Test Facility, Source Development Laboratory, and Laser Electron Accelerator Facility. In optical studies, the division has pioneered the development of Long Trace Profilers, which provide a unique, non-contact method for measuring the surface profile of synchrotron mirrors with nanometer precision.



Lasers and optical metrology: The Long Trace Profiler can measure the equivalent of the size of a blade of grass at the far end of a football field. It has become the de-facto instrument for testing mirrors at synchrotron sources around the world.



Micro/nano fabrication: The photograph illustrates the very high aspect ratios (height-to-width ratios) that can be achieved on micro/nanostructures with today's precision optical lithography, together with the unparalleled feature uniformity. The inner pins in this rigid structure have a diameter smaller than a human hair. This example represents an advanced radiation detector for fast, high-precision imaging of x-rays and charged particles.

Micro/nano fabrication: The microfabrication laboratory is fully equipped with the hardware and software necessary for complete design, processing, and characterization of micro or nanoscale structures. Devices with unique geometries are fabricated with either reactive ion etching or advanced optical lithography, and simultaneous imaging and measurement of nanoscale structures with scanning electron microscopy.

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