SEMICONDUCTORS

Shaping the Digital Future

Over the past four decades ORNL researchers provided key information and technologies that sparked the growth and improved the economics of the semiconductor industry.

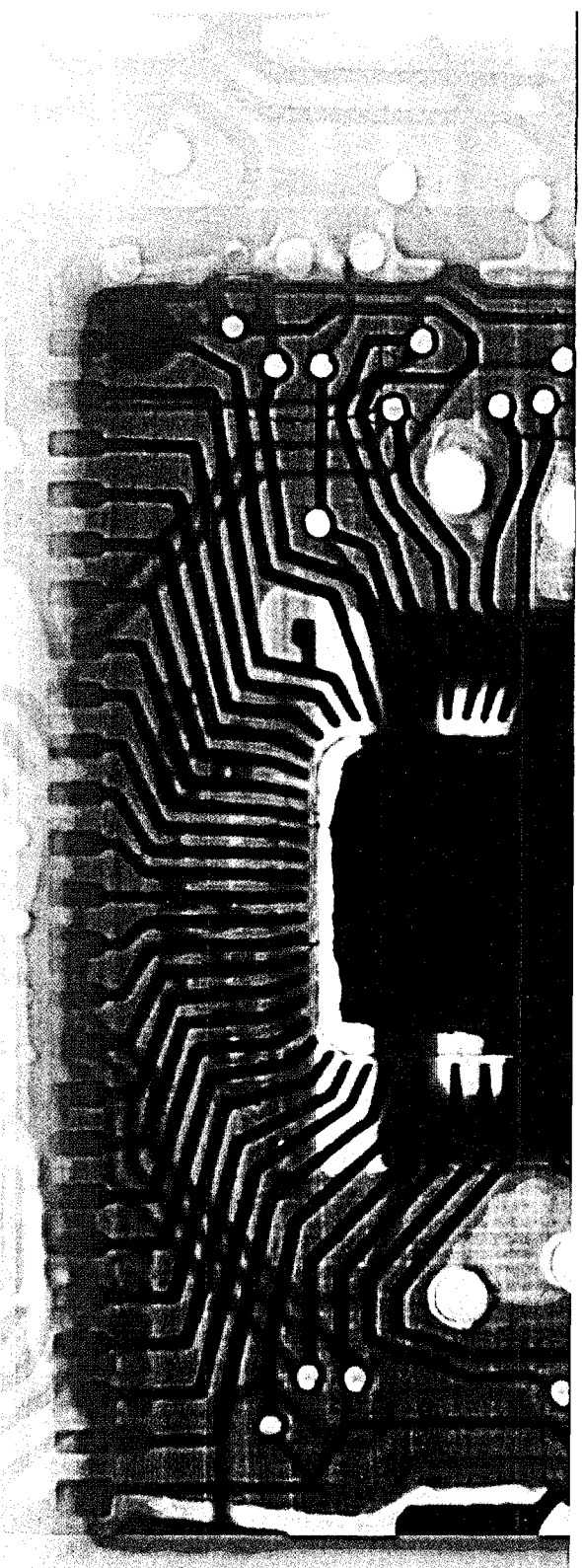
In 1962 Ordean Oen and Mark Robinson, while conducting theoretical research on radiation damage in crystalline materials, ran computer simulations that revealed the ion channeling effect—the long-range motion of atoms parallel to long rows of atoms in the solid. This work and energetic ion-channeling experiments by Thomas Noggle, Bill Appleton, Charles Moak, Sheldon Datz, Herb Krause, and others enabled understanding of channeling phenomena, helping industry produce ion-implanted semiconductor materials with the right properties.

In the 1960s, using the Bulk Shielding Reactor, John Cleland and other ORNL scientists devised a neutron transmutation doping (NTD) method for uniformly distributing phosphorus ions in silicon. More than 100 tons of NTD silicon are produced worldwide each year for use in electronic components.

By combining accelerator-based ion-implantation doping and laser annealing, Rosa Young, C.W. White, and Greg Clarke introduced boron ions into the near surface of a silicon crystal and incorporated them into electrically active sites, while removing all displacement damage in the silicon lattice. This work provided the foundation for the development of rapid thermal annealing, a process widely used in the semiconductor industry.

In 1998 Ken Tobin and associates built two award-winning software tools that help companies rapidly identify manufacturing problems that cause semiconductor wafer defects, thus reducing defect generation, increasing product yield, and cutting costs. These tools have been licensed to Applied Materials, IBM, Motorola, Texas Instruments, and 20 other companies.

ORNL's award-winning direct-to-digital holography process transferred to nLine rapidly finds small defects in deep-lying contacts and trenches in wafers. Tony Moore and associates invented a sensor-based system to control radiofrequency power that produces plasmas for etching wafer circuit patterns. Use of ORNL's system has saved the industry millions of dollars.



ORNL's work helped industry produce semiconductor chips for computers economically.

SUPERCONDUCTORS

Experiencing the Power

The power grid of the future will be more efficient than the present one, thanks to high-temperature superconducting (HTS) wires and cables. HTS wires—being developed by ORNL researchers in collaboration with industrial partners to exploit a phenomenon discovered in 1986—offer much less resistance to the flow of electricity than do copper lines. Devices with such wires will take less space, cost less to operate, and use less energy than equivalent technologies. Superconducting cables in the U.S. power grid will conduct five times as much current as a copper cable of the same size. Because an HTS cable loses little energy as heat, it will cut electrical transmission losses in half, from 8% to 4%.

Using ORNL's rolling assisted, biaxially textured substrates (RABiTS™) technology, developed in 1995, American Superconductor has produced unprecedented 10-meter lengths of nickel-tungsten tapes on which a superconductive oxide and buffer layers have been deposited in alignment with the alloy texture. These tapes carry 100 amperes per centimeter of width, exceeding a Department of Energy goal for 2003. 3M and three other companies seek to commercialize the award-winning ORNL technology. RABiTS™ wires should be available commercially later in this decade for underground transmission cables, motors, transformers, and magnets.

ORNL researchers helped Southwire develop an HTS cable 30 meters long for the company's facility in Carrollton, Georgia. The cable—made of bismuth-strontium-calcium-copper oxide first-generation wires chilled by liquid nitrogen—has operated more than 16,000 hours. RABITS™ wires will be used in second-generation Southwire cables.

ORNL researchers also have developed an innovative cryogenic system to chill HTS wires in a superconducting transformer built by Waukesha Electric Systems and IGC-Superpower. Waukesha's transformer, which uses no flammable oil as do conventional transformers, is to be laboratory tested in 2003.

1960

Pocket screamer devised for use as personnel radiation monitor

Program started to measure genetic effects of chemicals on mice

ORTEC and Tennelec founded by ORNL employees

1961

Development begun on radioisotope heat sources to power space satellites

Neutron transmutation doping method developed at ORNL reactor; later used for making electronic components