# Semiconductors

## paving the information superhighway

Until the middle of this century, silicon was best known as an ingredient of the sand found on every beach and used in glass-making. Now, purified, refined, elemental silicon is the basis of the famed semiconductor that launched the microelectronics revolution. BES researchers are deeply immersed in making sure that silicon and other semiconductors are up to the task of paving the information superhighway.

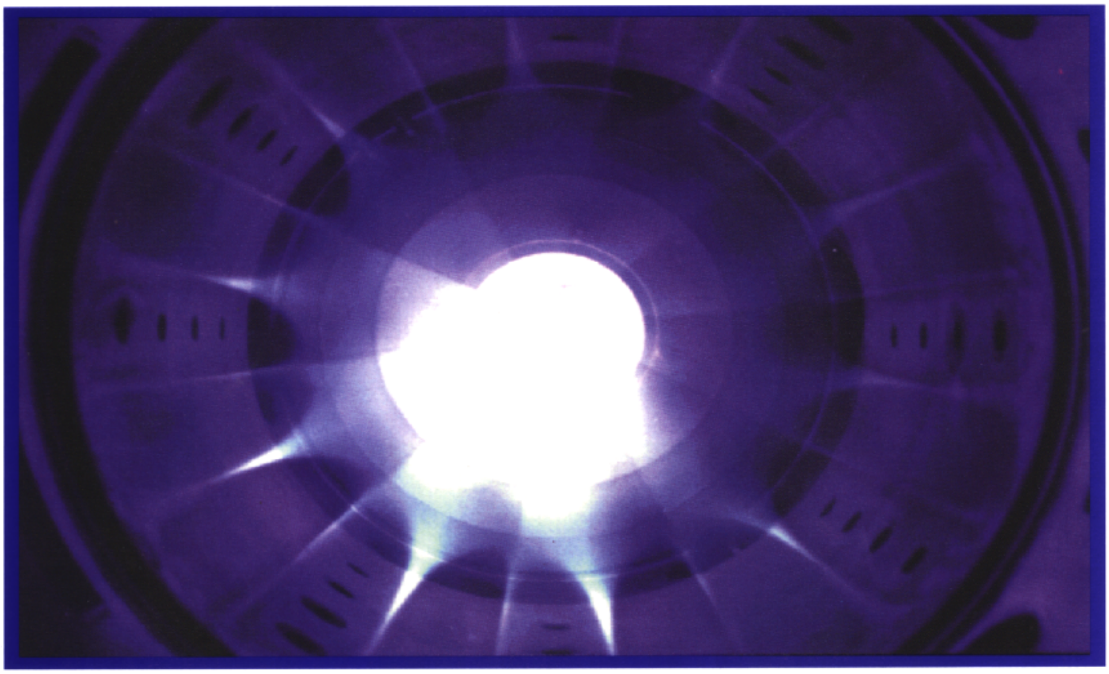
From the first microelectronic chips three decades ago, ever-increasing miniaturization has fueled a relentless march to higher computing power and lower cost. BES-supported researchers are providing industry with the facilities needed to develop patterning tools that further shrink circuit dimensions to the submicroscopic scale.

To sustain the pace of miniaturization, it is equally vital that the purity of the silicon be increasingly refined, especially to eliminate impurities near the surface where the circuit patterns are laid down. As conventional analytical techniques reach their limits, new X-ray methods, developed with the aid of BES facilities, promise to identify and quantitatively measure the unwanted impurities at the required sensitivity.

BES researchers likewise work in partnership with industry to identify the causes of and find solutions for other obstacles that snarl the way to successful miniaturization. Surfaces, for example, must be smooth to nearly atomic dimensions in order to ensure continuity between circuit elements. In addition, once imprinted, patterns are susceptible to disruption when the constituent atoms move away from their intended positions.

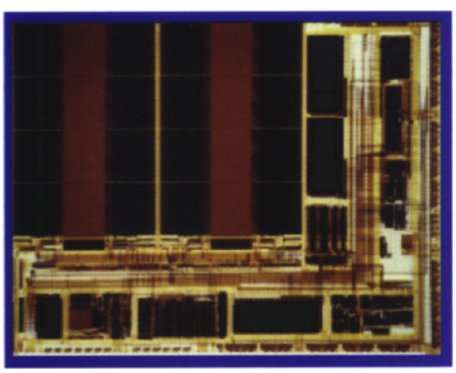
Though silicon has a combination of properties that make it a nearly ideal match for its microcircuit role, it nonetheless cannot do everything. Consequently, BES researchers are leaders in the search for new semiconductors with enhanced capabilities. Materials that show promise are gallium arsenide, gallium nitride, silicon carbide, and diamond, as well as silicon in modified forms such as thin films on substrates made from a different material and alloys containing silicon.

**Based on 10 years of successful experiments at Brookhaven National Laboratory's National Synchrotron Light Source, IBM has built its own X-ray lithography facility and begun producing fully functional devices. In X-ray lithography, advanced computer chips are imprinted on silicon wafers with circuit patterns using synchrotron radiation as the X-ray source.**



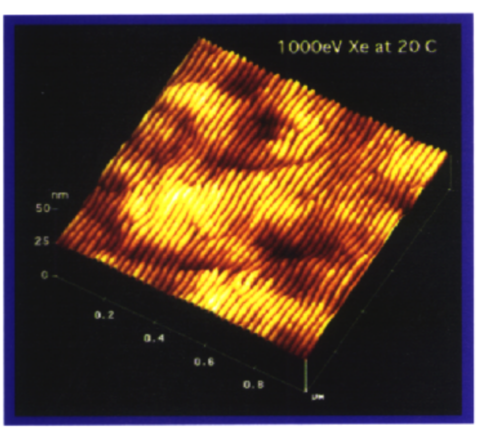
## Plasma Processing

During the processing of computer chips, plasmas (the bluish glow in the photo) created by microwave heating can both etch away unwanted material and lay down new material. Oak Ridge National Laboratory teamed with ASTeX, PlasmaQuest, and the University of Cincinnati to develop a new plasma source for a SEMATECH advanced plasma processing program.



## Analyzing Impurities

(left) Fabricating future computer chips with features that are less than 0.1 microns will require that metal contamination on the surface of silicon wafers be less than one part in 100 million. Hewlett-Packard, Intel, Fisons Instruments, and the Stanford Synchrotron Radiation Laboratory are working together on a new X-ray technique to measure such tiny quantities.




## Measuring Surface Roughness

A collaboration between SEMATECH and Sandia National Laboratories led to developing tools for characterizing near-atomic-scale surface roughness of silicon wafers during fabrication of computer chips, such as the silicon dioxide-covered surface shown in this atomic force microscopy image.