IBM Research at the NSLS
Making Denser, Faster Computer Chips

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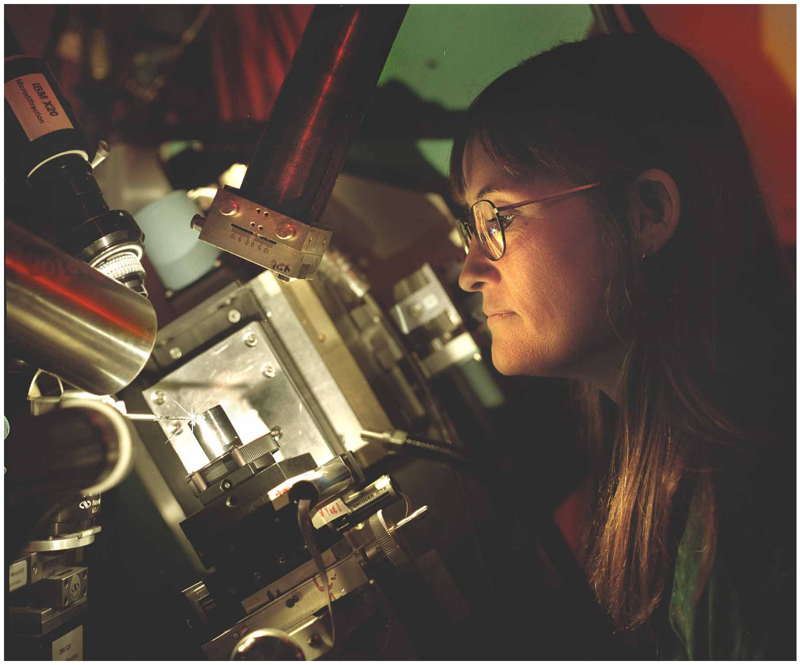
The IBM Research Division has been studying microelectronic computer chips and their component materials at the National Synchrotron Light Source (NSLS) since its commissioning in 1982. Chips are the smooth rectangular or square electronics packages that comprise the microprocessor and memory in a computer, mobile phone, or any number of “smart” appliances. Each microprocessor chip contains many hundreds of thousands of electronic devices - mainly transistors - embedded in many layers of various materials, including silicon, insulators and metals.

Currently, IBM makes devices with some features that are only a few atoms thick. Today, IBM researchers at the NSLS are looking at ways to make these devices even smaller and faster. Electrical signals are transported through smaller devices more quickly and with less effort, which translates to faster, cheaper, and more efficient computers.

“When devices are so small, individual components can behave in unusual ways. For example, what is normally a conductor may act as an insulator when it is small enough,” says Jean Jordan-Sweet, an IBM researcher stationed at beam line X20 at the NSLS. “We study the behavior of these component materials at the atomic level. Using x-rays, we examine all the materials in chips, from silicon to insulators, copper, and tung-



IBM Scientist Jean Jordan-Sweet inspects silicon germanium samples using the micro-diffractometer at beamline X20 at the National Synchrotron Light Source.

sten, and we look at how the materials interact and how the small features behave. These data are needed for designing better devices."

Jordan-Sweet and her collaborators employ several diffraction techniques at X20 that are especially suited for investigating the structural behavior of a wide range of materials in microelectronics. In all types of x-ray diffraction, x-rays bounce off a crystalline sample at specific angles and strike a detector. The diffraction patterns are then mathematically analyzed to determine the structural arrangement of atoms in the sample. One technique that Jordan-Sweet uses is microdiffraction, to study defects and strain -the squeezing or stretching of atomic spacings - in films and devices made of silicon-germanium. This material is being developed for use in strained silicon transistors. Electrical charges can pass through thin layers of strained silicon much faster than they pass through relaxed silicon. Therefore, strained silicon grown on silicon germanium is ideal for making high-speed devices, and, thus, more efficient computers.

The IBM researchers use a micro diffractometer with high-intensity x-rays that are the size of several microns to probe extremely small features in materials. When the samples are scanned, defects can be seen by a change in intensity of diffracted x-rays.

Jordan-Sweet notes the progress in making denser chips over the last decade: "In 1988, IBM researchers using x-ray lithography techniques at the NSLS demonstrated that they could make devices with features that were 0.5 microns long, while manufacturers, including IBM, were actually producing devices having minimum feature sizes of one micron. Today, we're making devices through fairly conventional methods that have features of under 0.2 microns."

Chips are further improved, Jordan-Sweet explained, by advances in materials and processes, such as converting from aluminum to copper conductor lines, or adding an insulating layer between the silicon wafer and the devices grown on it.

"It's getting harder to make that kind of progress," Jordan-Sweet added, "but the NSLS gives us the measurement capabilities we need to develop materials to meet the challenge of improving computer chips in the future."

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