ORNL microscope pushes back barrier of 'how small'

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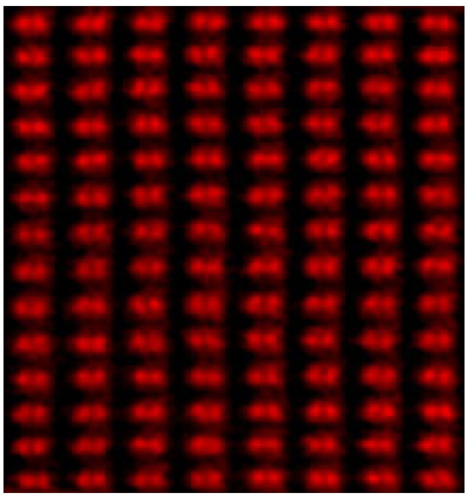

Oak Ridge National Laboratory researchers, using a state- of-the-art microscope and new computerized imaging technology, have pushed back the barrier of how small we can see--to a record, atom-scale 0.6 angstrom. ORNL, a Department of Energy national laboratory, also held the previous record, at 0.7 angstrom.

As reported in the Sept. 17, 2004, issue of the journal Science, researchers obtained the improved resolution with ORNL's 300-kilovolt Z-contrast scanning transmission electron microscope (STEM), aided by an emerging technology called aberration correction. The direct images have been acknowledged as proof of atom-scale resolution below one angstrom and provide researchers with a valuable tool for designing advanced materials.

"Looking down on a silicon crystal, we can see atoms that are only 0.78 angstroms apart, which is the first unequivocal proof that we're getting subangstrom resolution. The same image shows that we're getting resolution in the 0.6 angstrom range," said ORNL Condensed Matter Sciences Division researcher Stephen Pennycook.

An angstrom is an atomic scale unit of measure of one ten- billionth of a meter, approximately equaling the diameter of an atom.

The ORNL researchers teamed with the Nion Company to produce the images of pairs of silicon atom columns in a crystal. The Kirkland, Wash., firm provided the aberration correction technology that corrects errors introduced to the images by imperfections in the electron lenses. Although conceived decades ago, aberration correction technology was only recently made feasible by advances in computational techniques and image-analysis algorithms.

Aberration-corrected microscopy provides a direct image with fewer opportunities for "artifacts," or incorrect image information. Uncorrected microscopy can achieve subangstrom resolution by combining a collection of many images to achieve an image, but it also increases the introduction of artifacts into the images.

By revealing columns of atoms and the position of introduced, "dopant," atoms, the atom-scale images enable a new understanding of materials' properties, Pennycook said. The finer images also enable researchers to more accurately model and predict the behavior of materials on computers before time-consuming and expensive bench tests are conducted.

"With aberration correction you can see everything better, basically," Pennycook said. "It's always better to see what's what. For the materials, chemical and nano sciences, you want to see what is going on at the atomic scale--how atoms bond and how things work."

The latest ORNL images improve on the previous resolution of 0.7 angstrom, also achieved with ORNL's Z-contrast STEM.

In addition to Pennycook, an ORNL corporate fellow, team members are Matt Chisholm, Andy Lupini, Albina Borisevich and Bill Sides Jr. of ORNL's Condensed Matter Sciences Division and Pete Nellist, Niklas Dellby and Ondrej Krivanek of Nion. The work is funded by the Basic Energy Sciences program of DOE's Office of Science.

ORNL has recently constructed an advanced materials characterization laboratory that will further the application of aberration-correction technologies to atom- scale microscopy.

Source: Oak Ridge National Laboratory