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Office of Public Affairs
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For release: Sept. 28, 2006

NEW WINDOW ON THE NANO WORLD

Ames Laboratory installs new $1.8 million scanning transmission electron microscope

AMES, Iowa – Researchers at the U.S. Department of Energy's Ames Laboratory can now see the atomic structure of materials with unprecedented clarity thanks to a new $1.8 million scanning transmission electron microscope. The new FEI-Tecnai G2 – F20 STEM was installed in Wilhelm Hall on the Iowa State University campus this summer.

A transmission electron microscope uses high-voltage electron beams to acquire ultrahigh resolution sample images down to Ångström levels for analyzing the atomic structure, crystallographic structure and composition of specimens. The specimens are typically thinned through ion milling or other techniques to a film only a few nanometers thick so that the beam can pass through the sample.

The entire electron path, from gun to screen, must be under vacuum (otherwise the electrons would collide with air molecules and be absorbed), so the final image has to be viewed through a window in the projection chamber. Unlike a light microscope with glass lenses, the electron beam is focused using electromagnetic lenses. By varying the current through the lens coil, the focal length, which determines the magnification, can be varied.

The scanning function employs electron optics to focus the beam into a narrow spot. The beam is scanned back and forth over the sample to form an image. According to Ames Lab scientist Matt Kramer, who is overseeing the operation of the STEM, the new scope will provide much more than just higher resolution than the existing Phillips CM30 STEM.

"One of the big differences is in the scanning probe size," Kramer says. "While the CM30 in theory could do a 1.2 nanometer probe, it had no brightness at that fine probe size. The new STEM has a probe of 0.18 nm with a factor of mor than 100 times more brightness." This will allow for very precise measurements of chemical changes over a few nanometers.

The new machine also has computerized alignment and focusing, which dramatically reduce set-up time. Individual users can even save specific settings and call them up at a later date if they want to look at additional samples.

"The old equipment often required hours to align and focus the beam — it was really an art," Kramer says. "The new equipment is automated so each user can save specific settings, and the computer will realign the

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beam to those settings in a matter of seconds."

Another big difference is the image capture. The older machine uses photographic plates to record images, while the new microscope captures digital images that can be displayed immediately.

While the new machine can perform standard operations, such as bright field, dark field and lattice imaging, it also has features that allow energy-filtered imaging, low-dose imaging, Lorentz imaging, holographic imaging, Z-contrast imaging and 3-D imaging.

"The low-dose imaging is useful when working with sensitive materials, such as polymer films, that could be damaged by the beam," Kramer says. "You can focus the beam on areas outside the main area of interest, then quickly move to the region you want to look at. The older equipment doesn't allow this. By the time you get it focused, the beam has disrupted the structure of the sample."

The Lorentz lenses, coupled with the holographic feature, allows vivid depiction of features such as magnetic fields. And a tomography stage allows the sample to be rotated through various views, which are then assembled into a 3-D image.

With all these capabilities, the equipment is understandably complicated, so not just anyone will have access to it. This means long-term collaborative projects will be given preference along with projects funded by the Office of Basic Energy Sciences. BES provided the funding for the equipment through a special grant in 2005.

Ames Laboratory is operated for the Department of Energy by Iowa State University. The Lab conducts research into various areas of national concern, including energy resources, high-speed computer design, environmental cleanup and restoration, and the synthesis and study of new materials.

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