New technique exceeds x-ray and electron diffraction in spatial composition profiling

July 5 2006

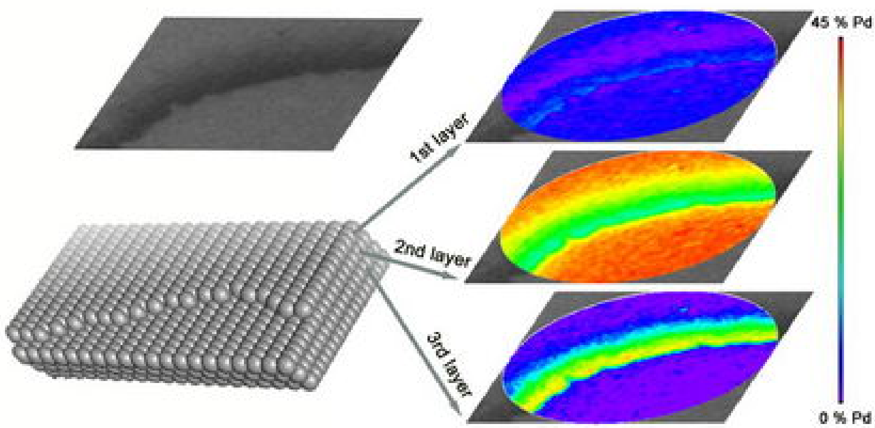

Image credit: James Hannon, IBM

“We were excited to see this,” says James Hannon, a researcher at IBM’s T.J. Watson Research Center in Yorktown Heights, New York. “People knew it would be possible, but no one had ever tried it. This is the first time this has ever been done.” Hannon refers to a new technique developed by him and his colleagues—other researchers at the University of New Hampshire and Sandia National Laboratories in Albuquerque—to profile the spatial composition of ultrathin films in alloys in three dimensions.

In a Letter titled "Origins of Nanoscale Heterogeneity in Ultrathin Flims," and published June 22nd by *Physical Review Letters*, Hannon presents the technique to measure the composition of ultrathin films during growth. This breakthrough is expected to help engineers and others working with thin films in a variety of technological fields as they work to create and manipulate new materials. "There are a lot of problems you could address if you could see how these films develop," Hannon tells *PhysOrg.com*.

As an example, Hannon explains that the technique could be used to investigate in thin films. "You could measure the spacing between the first and second layers. If there were strain, it would buckle. Such strain would impact device performance. Right now, you would not be able to spatially resolve the strain." The implication is that with the proper measurements, and with the knowledge gleaned by using the proposed technique, adjustments could be made to the film layers in order to solve a possible problem. "We could measure the exact configurations of atoms," Hannon says.

Right now, the techniques in use to measure ultrathin films do not provide the kind of advantages offered by the technique proposed by Hannon and his team. With both x-ray and electron diffraction, the lateral resolution is poor, and while scanning probe microscopy offers good lateral resolution, it is generally impossible to tell one atom from another. Hannon's team uses a low-energy electron microscope, which combines electron diffraction and high spatial resolution, to examine copper, and all of the above problems are solved.

But it is not just copper that this technique can be used to study. Hannon thinks that the technique can be applied to study germanium and silicon. "We know they want to mix," he explains. "The surface does dramatic things to make the mixing occur. With this technique we could follow how they alloy in real time."

It is work with alloys that Hannon sees great benefit for from this technique. He is working especially with semi-conductors, trying to figure out more exotic materials could be used. This is where the germanium and the silicon come in. The method has not actually been tested on semiconducting alloys yet, and because germanium and silicon are so similar, they would make a simple system to test. “It should be very simple,” says Hannon, “a nice test system to see how it works in semiconductors.”

Hannon does admit one main problem: the small size of the data set. “It’s a question of proving that this works,” he explains. “People could have tried this years ago, but the data set was thought too small. There is still a question of how much data is needed.” But Hannon feels that this can be overcome if the technique works on semiconductors.

“The industry is moving this way,” Hannon says. “Understanding alloying will be important for materials questions that come up.”

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