Argonne-pioneered X-ray lens to aid nanomaterials research

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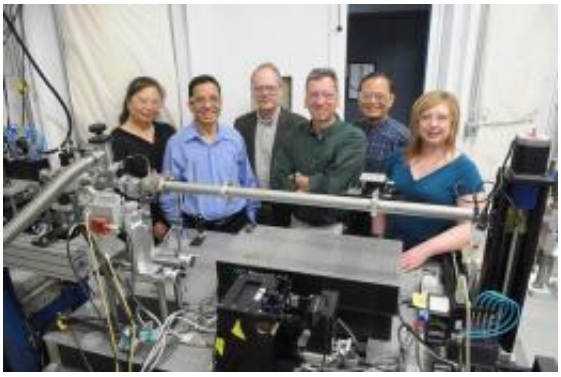

A team of researchers at Argonne has developed the new "multilayer Laue lens," that will let scientists study the nanoscale in greater detail than ever before. From left to right: Bing Shi, Lahsen Assoufid, Brian Stephenson, Jörg Maser, Chian Liu, Lisa Gades.

More affordable and efficient solar cells, batteries and lighting systems could result from a new X-ray lens that will let scientists study the nanoscale in greater detail than ever before.

A team of researchers at the U.S. Department of Energy's (DOE) Argonne National Laboratory has developed the new "multilayer Laue lens". This lens focuses high-energy X-rays so tightly they can detect objects as small as 15 nanometers in size and is in principle capable of focusing to well below 10 nanometers. This approach doubles the resolution over existing lenses, and future advancements could increase

resolution by 10 times.

Understanding, imaging and manipulating the physical world at the nanoscale is critical to designing materials, devices and technologies that impact our daily lives. To aid in this effort, Argonne's Advanced Photon Source (APS) and Center for Nanoscale Materials (CNM) partnered to improve lens capabilities.

"There's a big need to look into the nanoscale world," said Lahsen Assoufid, Optics Group Leader at the APS. “Availability of this new type of X-ray lens will definitely open new windows into to nanoscale science. “

If you want to look at a material closely—really closely—hard X-rays like those produced at Â the APS are the answer. The APS provides some of the nation's brightest beams of X-rays for research; more than 3,500 scientists from industry, academia and national laboratories conducted experiments there last year. These extremely intense and focused X-rays allow scientists to peer into the depths of the nanoworld by focusing the photons on a single small area.

"With this lens, you will be able to see individual nanoparticles," said Argonne physicist Jörg Maser, who conducts research at the APS and CNM." Coupled with the X-rays at the APS, you can detect concentrations of as few as tens of atoms in a complex environment."

The team designed the new lens to improve the focusing of hard X-rays. The lens is crafted by depositing thousands of alternating layers of silicon and tungsten silicide one by one, which are then polished down to just 10 microns thin.

"One of the major 21st century challenges we face is energy," Maser said. "For example, solar energy is not yet cost-effective on a dollar-per-

kilowatt-hour level. In order to drive the price down to $1 per kilowatt, we need solar cells that are more efficient and made from less expensive materials. To get there, we need a better understanding of the defects that occur while solar cells are manufactured."

By watching solar cells as they are manufactured and identifying where the defects occur, scientists hope to improve the quality of manufactured cells.

The Argonne team began work on the lens in 2003, working out the complex calculations to predict how—and whether—it would work. Then they needed to demonstrate the idea, perfect a prototype and test the lens. A set of the lenses is now in use at the APS and the CNM, and more are being fabricated. Brookhaven National Laboratory's X-ray synchrotron has begun a strong research effort in fabricating advanced multilayer Laue lenses, Maser said, and groups in Japan and Europe have begun to develop similar systems.

In the near future, the team is expecting to incorporate the new lenses into microelectromechanical systems, or MEMS: mechanical structures with micrometer-size movable parts. MEMS can be used to precisely position and control these new lenses. Particularly attractive is the possibility of automatically focusing the lenses during experiments, and the ability to scan the X-rays very quickly across samples. This research takes place collaboratively between the APS and Argonne's Center for Nanoscale Materials.

This research was supported by the DOE's Office of Basic Energy Sciences. A recent paper on the lens, "Two dimensional hard x-ray nanofocusing with crossed multilayer Laue lenses", was published in *Optics Express*. The team's deposition approach earned them an R&D100 award in 2005.

Provided by Argonne National Laboratory