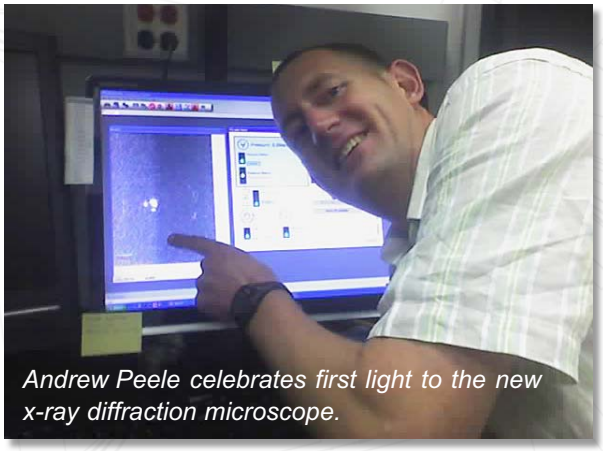
Argonne NATIONAL LABORATORY
www.anl.gov

Advanced Photon Source
Bldg. 401/Rm A4115
Argonne National Laboratory
9700 S. Cass Ave.
Argonne, IL 60439 USA
apsinfo@aps.anl.gov ◦ www.aps.anl.gov

The Advanced Photon Source

Fresnel Coherent Diffraction Imaging at the APS

A new, three-dimensional coherent x-ray diffraction microscope, unique in the world, collected first light from the Argonne Advanced Photon Source (APS) at 4:00 a.m. on Saturday, July 12, 2008. The event capped three months of installation and two days of commissioning at X-ray Operations and Research beamline 2-ID-B by personnel from La Trobe and Melbourne universities, Xradia of Concord, CA (the co-designer—with La Trobe—and manufacturer of the device), and the APS.



Andrew Peele celebrates first light to the new x-ray diffraction microscope.

The new microscope is optimized for Fresnel coherent diffraction imaging (FCDI), with interferometric stabilization of the optics and sample down to 2 nm. FCDI, which was developed by the major partners in this microscope based on an idea originally proposed by David Sayre, is a novel approach to coherent diffraction imaging in which the illuminating wavefront contains a spherical curvature. The basic method was first demonstrated experimentally by Miao and collaborators in 1999 then enhanced by addition of the curved-wave approach by Nugent and collaborators in 2003. Coherent diffraction methods have lately seen an explosion of interest.

FCDI provides reliable and unambiguous image reconstruction; an established spatial resolution better than 20 nm, with expected sub-5-nm resolution; a dose efficiency comparable to that of scanning x-ray microscopy (SXM); quantitative phase measurement; the ability to image any region within a sample with no need for exotic sample preparation; and an experimental configuration that is essentially identical to that of SXM. These are unique capabilities that combine the advantages of SXM for the study of "extended" specimens (samples that are not isolated in an otherwise empty field) and the high-resolution imaging capability of coherent diffraction imaging. The 2-nm precision and stability of the instrument is more than an order of magnitude higher than has ever been achieved in a coherent diffraction x-ray microscope. Given the sensitivity of coherent diffraction methods to structural detail at size scales beyond that accessible with x-ray lenses, it is anticipated that the exceptional stability of the new instrument will enable it to deliver images of nanomaterials and biological specimens with dramatically improved quality.

The ability to study extended samples opens the door to many types of real-world samples such as magnetic films, biological tissues, intracellular structures, buried domains in ordered nanomaterials, and multicomponent organic electronic devices. Experiments planned in the near future for this system include studies of nano-ordering in opal mineral samples; probing ferromagnetic, antiferromagnetic, and orbital ordering in rare-earth/transition-metal films; and imaging the hemozoin—a paracrystalline precipitate—in whole, malaria-infected red blood cells.

Development and fabrication of the microscope was funded by the Australian Research Council Centre of Excellence for Coherent X-ray Science. Use of the Advanced Photon Source at Argonne National Laboratory is supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357. The microscope was brought to the APS under a Partner User Proposal submitted by principal investigator Keith A. Nugent (University of Melbourne), Andrew G. Peele (La Trobe University), and their collaborators, including Leann Tilley (La Trobe), Garth J. Williams (U. Melbourne), Mark A. Pfeifer (La Trobe), Mau-Tsu Tang (National Synchrotron Radiation Research Centre), Ting-Kuo Lee (Academia Sinica), Ian McNulty (Argonne National Laboratory), and Qun Shen (formerly Argonne National Laboratory, now Brookhaven National Laboratory).

Call for APS General-User Proposals

General-user proposals for beam time during Run 2009-1 are due by October 31, 2008
Information on access to beam time at the APS is at http://www.aps.anl.gov/Users/apply_for_beamtime.html
or contact Dr. Dennis Mills, DMM@aps.anl.gov, 630.252.5680

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