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Advanced Photon Source

A New X-ray Imaging Facility at the APS

The Advanced Photon Source (APS) at Argonne National Laboratory has completed construction and commissioning of a new, dedicated, full-field x-ray imaging facility at X-ray Operations and Research beamline 32-ID. The facility began full operation and accepted general users in October 2007. The main objective of the new facility, the first dedicated beamline for full-field imaging at the APS, is to satisfy rapidly growing needs for advanced x-ray imaging investigations in materials science and biology, and to promote research and development to advance the cutting-edge in x-ray imaging.

Planning for the facility dates back to 2004, when workshops were organized to evaluate emerging future scientific directions at the APS. At those workshops, one of the recommendations from the community to the APS was to establish a dedicated beamline for full-field x-ray imaging. This recommendation was fully endorsed by the APS Scientific Advisory Committee in early 2005. Following discussion among APS users and staff, a decision was made to reprogram the existing beamline 32-ID as the new full-field imaging facility by updating existing beamline components and optics, and by extending the beamline and constructing a new experiment hutch, 32-ID-C, at 70 m from the source, to complement the existing 32-ID-B at 38 m from the source. Both are compatible with either a white undulator beam or a monochromatic undulator beam in the range of 8-35 keV provided by a pair of polished Si (111) flat crystals. A double-mirror system is used for harmonic rejection up to 18 keV.

The facility currently supports research programs in static and dynamic phase-contrast imaging, ultra-small-angle-scattering imaging, and transmission x-ray microscopy (TXM). For phase-contrast imaging, a special, local, low-β machine lattice may be employed to reduce the horizontal source size by >2, down to $\sigma = 210$ μm, leading to enhanced phase contrasts, especially for low-Z materials. This, coupled with the high x-ray flux offered by the APS undulator, allows high-definition phase-enhanced imaging with exposure times as short as 200 μs in the monochromatic mode, and down to ultra-fast single-pulse temporal resolution of ~150 ps in the white-beam mode, with simultaneous spatial resolution in the 1-5-μm range. These unique capabilities open new research areas in synchrotron x-ray imaging applications ranging from ultrafast imaging of materials processing and transient fluid dynamics to real-time and sub-video-rate imaging of biological functions in live insects and small animals.

In order to satisfy the need for nanometer-scale imaging at the APS, an international partner-user collaboration on a hard x-ray transmission microscope has been formed between Academia Sinica in Taiwan; Xradia, Inc., in the U.S.; and the APS. As a result, a new TXM has been designed and fabricated by Xradia and installed in 32-ID-C. This instrument exploits both absorption contrast and phase contrast via the Zernike method. It is equipped with several sets of Fresnel zone-plate objectives with 45-nm outermost zone width, and is designed for operating in the 7 to 18-keV energy range. This instrument and all other instruments at 32-ID are available to general users through the APS General User Proposal System:
(http://www.aps.anl.gov/Users/Scientific_Access/General_User/index.html

The new x-ray imaging facility at 32-ID is funded by the U.S. Department of Energy's Office of Basic Energy Sciences. For more information about the experimental programs at 32-ID, please contact Qun Shen (qshen@aps.anl.gov) or Wah-Keat Lee (wklee@aps.anl.gov).

After successful installation and early commissioning of the new Zernike phase-contrast-transmission x-ray microscope in experiment station 32-ID-C. Standing left to right: Yong Chu (Argonne X-ray Science Division [XSD]), Wah-Keat Lee (XSD), Qun Shen (XSD), Yeukuang Hwu (Academia Sinica, Taiwan, principal investigator for the TXM partner-user project), Jaemock Yi (Academia Sinica), and Andrei Tkachuk (Xradia, Inc.). Kneeling left to right: Hung-Jen Wu and Hsue-Ren Wu (Academia Sinica).

Inset: X-ray imaging of beetles, which helped to confirm that tracheal system design may limit size in insects, is representative of the scientific programs at sector 32. See: A. Kaiser et al., "Increase in tracheal investment with beetle size supports hypothesis of oxygen limitation on insect gigantism," Proc. Nat. Acad. Sci. USA 104(32), 13198 (August 7, 2007).

Call for General-User Proposals

The Advanced Photon Source is open to experimenters from all scientific disciplines.
General-user proposals for beam time during Run 2008-2 are due by March 7, 2008.
Information on access to beam time at the APS is at http://www.aps.anl.gov/user/beamtime/get_beam.html or contact Dr. Dennis Mills, DMM@aps.anl.gov, 630/252-5680.

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