From the Editor

Extraordinary Brightness

This issue of *Microscopy Today* focuses on cutting-edge analytical techniques using synchrotron X-ray sources. The first synchrotron was built by Edwin McMillan in 1945. Synchrotron X rays were initially seen as a nuisance at cyclotron accelerators. Today's modern synchrotrons use a particle accelerator as a storage ring that generates photons as the particle path is bent. These facilities provide X-ray beams of extraordinary brightness, allowing unprecedented resolution, in time (pulse widths of 100 ps), energy (100s of eV up to 100+keV), and spatial resolution—about 25 nanometers.

Many useful X-ray techniques are available at synchrotrons including fluorescence, diffraction, tomography, near absorption edge spectroscopy, and several others. These techniques are applied to various materials science challenges, including the study of actinides, aerogels, high explosives, polymer foams, biological materials, cultural heritage artifacts, and fossils—to list a few. Additionally, materials processing and damage processes in materials may be examined *in situ*.

There are over forty synchrotron user facilities spread throughout twenty countries around the world. For open research, access is granted through research proposals. There is no cost for using most facilities, only your time and travel expenses. Each beamline has a team of scientists who provide assistance and guidance in conducting experiments.

In this issue we highlight two techniques commonly found at major synchrotron facilities: X-ray tomography and X-ray fluorescence. Synchrotrons also can be used for nondestructively measuring changes in materials during dynamic experiments (see article by Cordes et al.). X-ray fluorescence uses the X-ray beam to excite atoms of an element in a material, releasing characteristic X rays that provide identification of the element; the number of atoms of the element present; and, with a spatially focused beam, the locations of concentrations of that element. This technique is analogous to energy-dispersive spectrometry in an electron microscope, except that X rays are the excitation source. Synchrotrons can provide such a high flux of X rays that local concentrations of trace elements within a material can be imaged (Gueriau et al.). Recent developments in optics have pushed resolutions ever closer to the diffraction limit for X rays (Chen et al.), and high-energy X rays allow analysis of actinides without expensive sample processing (Havrilla et al.). X-ray sensitive cameras make it possible to collect full-field hyperspectral images of the entire sample at once (Fittschen et al.).

The articles in this issue illustrate some of the state-of-the-art experiments that are performed at synchrotrons around the world. I thank Brian M. Patterson for supplying the information for this editorial.

Charles Lyman
Editor-in-Chief

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Editorial Staff

Charles E. Lyman, *Editor-in-Chief*
charles.lyman@lehigh.edu
(610) 758-4249

Gennifer Levey, *Production Manager*
glevey@meridianartpro.com
(212) 780-0315

Ron Anderson, *Executive Editor*
microscopytoday@tampabay.rr.com

Phil Oshel, *Technical Editor*
oshel1pe@cmich.edu

Stephen Carmichael, *Columnist*
carmichael.stephen@mayo.edu

Michael Davidson, *Pioneers Editor*
davidson@magnet.fsu.edu

Steven Barlow, *Education Editor*
sbarlow@mail.sdsu.edu

Thomas E. Phillips, *Consulting Editor*
phillipst@missouri.edu

E. Ann Ellis, *Microscopy 101 Editor*
eann.ellis@suddenlink.net

Paul Webster, *Calendar Editor*
pwebster@usc.edu

John Shields, *Humor Editor*
jpshield@uga.edu

Thomas Kelly, *Chief Awards Judge*
Thomas.kelly@ametek.com

Advertising Sales

M.J. Mrvica Associates, Inc.
2 West Taunton Avenue, Berlin, NJ 08009
mjmrvica@mrvica.com
(856) 768-9360

Kelly Miller, *Account Manager*
kmiller@mrvica.com

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Cambridge University Press
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