X-Ray Diffraction: The Business of Training Scientists

The scattering of x-ray beams can be used to investigate physical properties of materials, to decipher the structures of solids and thin films, or to examine chemical compositions. Because the wavelength of an x-ray is on the order of an angstrom, the distance separating atoms in solids, the scattering pattern of the x-ray can reveal the arrangement of atoms in a structure. However, this type of work is only part of the activity completed at Northwestern’s Jerome B. Cohen X-Ray Diffraction Facility.

A major function of the X-Ray Diffraction Facility is to train students in x-ray techniques pertinent to their pursuit of careers in industry, academia, and national labs. Another goal of the facility is to train and prepare students and postdocs for using the ultra-high intensity x-ray beams at Argonne National Laboratory’s Advanced Photon Source (APS).

“At the APS, beam time is very limited, so each research team needs to make sure that everything is working beforehand,” says Michael Bedzyk, materials science and engineering, and director of the X-Ray Diffraction Facility. “As much as possible, we try to ensure that the instrumentation in our facility matches that of the instruments and software at the APS, so students can learn to operate equipment under less time pressure.”

When founding director Jerome Cohen ran the facility, it was mainly used for metallurgical studies and the exploration of residual stress in the surface of metals. As time passed, studied materials expanded to include those of interest to electronics, super conductivity, polymers, and nanotechnology. Bedzyk’s group uses x-rays to explore how atoms align at the interfaces that separate two different materials. This involves, for example, the atomic layer growth of thin films or liquid solid interfaces where the transport of groundwater contaminants, such as lead and arsenic ions, are studied in modeled systems.

“In materials science, most metals and ceramics have crystal structures that already have been determined,” Bedzyk says. “So one needs to look for challenges, such as where one material aligns itself with another material. It is the interface that, in many cases, strongly influences the properties of nanoscale structures found in electronic, magnetic, and catalytic systems. X-rays, with their high penetrating power are ideal for looking at these buried interfacial structures.”

Bedzyk says a new frontier for x-ray scattering lies in biological materials. For example, Chad A. Mirkin, chemistry, Samuel I. Stupp, materials science and engineering and chemistry, and their groups use small-angle x-ray scattering at the facility to study self-assembled molecular structures that have pharmaceutical and medical applications.

All undergraduates who major in materials science are required to take the crystallography and diffraction course with weekly lab projects that use the x-ray facility. Other students in physics, electrical engineering, chemistry, and chemical engineering also take the course as an elective if they plan to do x-ray work as a part of their research. Bedzyk teaches the lecture component of the class, and the hands-on laboratory training is taught by facility manager Jerry Carsello, materials science and engineering.

“We’re in the business of training scientists,” says Carsello, who joined the facility 26 years ago when it was directed by Cohen. “We do hands-on training, so they can do the work without help from a technician.”

With the facility celebrating its 50th anniversary this year, Carsello says that it has undergone a remarkable transformation over the years.

“Before Cohen, the facility was just a couple of machines in the basement,” Carsello says. “When he took it over in 1960, he brought the equipment to the front of the Tech Building, wrote proposals, received new funds, and bought new equipment.”

After Bedzyk became director in 1999, he expanded the facility to include 75 percent more equipment, making Northwestern’s x-ray lab one of the largest of its kind in terms of instruments and users.

“One reason our lab is successful is because Northwestern has a long history with x-ray scattering that started with Jerry Cohen many years ago,” Bedzyk says.

To learn more about the Jerome B. Cohen X-Ray Diffraction Facility on the first floor of Cook Hall, stop by the lab or visit it online at www.research.northwestern.edu/xray.