NIST Tech Beat Articles
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New Imaging Tool Has X-Ray Eyes

Researchers at the National Institute of Standards and Technology have developed a new way of seeing—with X-ray "eyes" no less. Using its novel instrument, the NIST team can clearly glimpse minute voids, tiny cracks and other sometimes indiscernible microstructural details over a three-dimensional expanse in a wide range of materials, including metals, ceramics and biological specimens.

In its current form, the technology—called ultra-small-angle X-ray scattering or USAXS imaging—functions much like a film camera, albeit a highly specialized one. And where a camera needs a flash to create images, USAXS has the ultimate flash—the Advanced Photon Source at the Argonne National Laboratory. Measuring 1,104 meters (nearly 0.7 mile) around, the APS is a new-generation synchrotron. It produces an abundance of extremely uniform high-energy X-rays that make the new imaging technique work.

USAXS itself is an already established research technique, yielding plots of data points that correspond to angles and intensities of X-rays scattered by a specimen. With the new system, graphed curves become high-resolution pictures. And when taken from different perspectives, pictures can be assembled into three-dimensional images.

Images are actually maps of the small fraction of X-rays that—instead of being absorbed or transmitted through the sample—are scattered by electrons in the material.

March/April 2001

Putting a 'Whisker-Free' Face on Electronic Parts

To improve the solderability of electronic device components, manufacturers often deposit a protective coating made with tin or tin-copper alloy upon the parts. However, these coatings can result in the formation of hair-like crystals known as "whiskers." Whiskers, which may extend for several millimeters, can divert current away from its proper path and cause electrical shorts or failures.

To prevent whisker formation in the past, manufacturers added lead to the tin-based coating. Today's lead-free electronics finishing, however, precludes the use of this harmful substance. Therefore, manufacturers are seeking new ways to coat electronic components with tin or tin-copper alloy without the worry of whiskers. To facilitate the development of these methods, materials researchers at the National Institute of Standards and Technology have been studying the basics of why and how whiskers form. So far, their investigations have revealed seven types (shapes) of whiskers that form with tin and tin-copper alloy coatings. They also have learned that tin whisker growth can be prevented if a thin layer of nickel is deposited on a surface before the tin or tin-copper alloy coating is applied.

Eventually, the NIST researchers hope to devise a test that manufacturers can use to determine the likelihood of whisker formation during the production process.

January 2001

New Standard Test Methods to Keep Auto Industry in Top Form

With the goal of improved fuel economy, U.S. auto manufacturers are looking at using lightweight materials—high-strength steel, aluminum or fiber-reinforced plastic—in auto body parts. The challenge of using these new materials is understanding their behavior during the forming process—how varying states of pushing, stretching and drawing affect final shape and crash-worthiness. Unfortunately, today's computer models cannot make accurate predictions because they lack sufficient data on new material behavior. NIST scientists, partnering with auto industry companies, are working to provide substantial data on the behavior of new materials through developing more effective measurement technologies.

The industry spends some $700 million a year on sheet-metal forming die sets, which shape the material into auto body parts. Arriving at the final die set involves a lot of trial and error on the production floor. New techniques are enabling NIST researchers to collect data throughout the entire forming process rather than just at the point the sample breaks or assumes its final shape. They also are working on minimizing the costly problem of surface roughening through detailed analysis of material microstructures and the strains of the forming process. By designing more accurate computer models, NIST will help manufacturers reduce the number of unsuccessful try-outs, resulting in reduced cycle time for making parts and overall cost savings for industry.

December 2000

Don't Just Fight Tooth Decay ... Reverse It!

While cavities may not become a thing of the past, it may be possible to stop the damage dead in its tracks. When a dentist sees the beginning of tooth decay, there's usually not much that can be done other than repair the damage. Some cavities, surprisingly, can reverse themselves in the early stages. New dental materials under development soon may be able to come to the rescue.

By understanding how tooth enamel forms and dental caries occurs, researchers at the Paffenbarger Research Center in Gaithersburg, Md., a collaboration between the American Dental Association Health Foundation and the National Institute of Standards and Technology are developing remineralization therapies—a form of tissue engineering—to help teeth regenerate. Teeth are constantly in motion, dissolving and rebuilding themselves with the calcium phosphate that is naturally present in saliva. One possibility now undergoing clinical trial is adding calcium phosphate to toothpaste, chewing gums and mouth rinses.

Researchers also are looking into the development of a “smart material” for fillings that could prevent cavities from recurring. When decay-producing acid starts to build up around the tooth or filling, cavity-fighting ingredients would be released to neutralize it. New materials also could reduce the need for root canals. Placing a sticky remineralizing material on the exposed pulp could speed up the natural repair process.

November 2000

The Right ‘Combination' Unlocks the Door to Advanced Materials

New, more complex materials are increasingly in demand for applications in microelectronics, biotechnology and nanotechnology. The use of combinatorial methods—which comprise a special set of tools and techniques—enables scientists to conduct many experiments on many materials at the same time. The National Institute of Standards and Technology is using this methodology to learn more about materials and their structures, properties and processing—data which can help manufacturers accelerate the development of new materials.

Breaking away from the traditional one-at-a-time testing of materials, combinatorial methods allow researchers to rapidly explore a wide range of characteristics about a test material—in parallel and on a miniaturized scale—such as the effects of temperature, thickness and composition. Researchers can easily compare these characteristics, screening for what works and what doesn’t.

Two approaches characterize NIST’s involvement in combinatorial methods. “Combi for NIST” is the use of the method to enhance and accelerate NIST research in areas ranging from polymers and biomaterials to electronic and optical inorganic materials. On the other side, “NIST for Combi” represents a growing effort to use the expertise gained at NIST to develop and validate research tools, establish standards and demonstrate applications of combinatorial methods for industry and academia.

October 2000

Everyday is SUNday Inside the Sphere

A new car’s brilliant finish fades, roofing shingles degrade and weatherstripping cracks. The culprit: the sun’s ultra-violet rays. Strength, safety and color fastness are important to manufacturers who test their products’ ability to withstand UV exposure in two ways—vast open-sky arrays in sun-drenched sites or artificial ultraviolet weathering chambers. Outdoor tests take too long, often stretching for several years. Indoor devices can accelerate the testing process but do not always provide optimal results.

Researchers at the National Institute of Standards and Technology have developed a spherical device that distributes UV radiation uniformly into 32 external specimen chambers, ensuring repeatability and reproducibility of test results. The device is calculated to accelerate UV exposure 30 to 65 times faster than natural solar exposure.

The hollow, two-meter diameter aluminum sphere is lined with highly reflective poly(tetrafluoroethylene). Sealed quartz tube bulbs are arranged uniformly around an opening at the top. Microwave energy heats the gases inside the bulbs to form a high-temperature plasma. The plasma radiates up to 1800 watts of ultraviolet light into the sphere and back out into its specimen chambers.

Materials exposed to the sphere’s UV light for one day potentially receive the equivalent of 65 days of sun. Two months could equal more than 10 years of solar exposure. The sphere’s design allows researchers to test different samples of the same material under precisely the same UV light conditions in separate specimen chambers, each of which can be set for different temperatures, humidities and physical stresses.