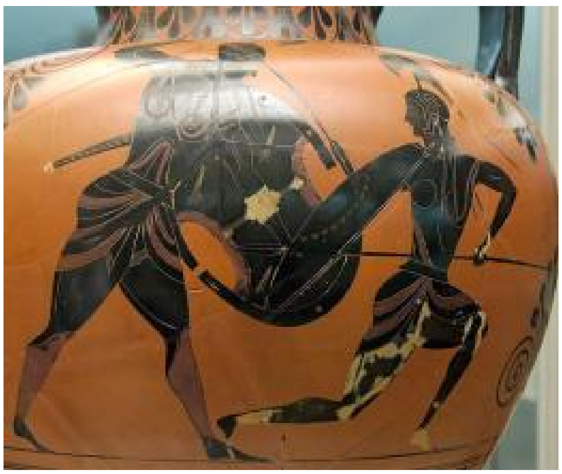
Multi-faceted method can benefit study of materials from batteries to classic art

March 4 2011, by Lori Ann White



An Attic black-figured amphora, currently in the British Museum, of the type that will be studied here at SLAC. (Photo by Marie-Lan Nguyen.)

What do lithium ion batteries and 2500-year-old Greek pottery have in common? One answer is surfaces. And surfaces are where chemistry happens.

SSRL staff scientist Apurva Mehta is careful to emphasize the plural—surfaces. Often, many, differing surfaces exist on one sample, which means a variety of chemical reactions can occur on one material. According to Mehta, such material is "hierarchically heterogeneous." In other words, it displays different behaviors depending on the size scale.

"There's a whole class of materials with structure at all different levels," Mehta explained," and something happening at every level that's important." He offered soil as an example. "Soil has large rocks, small rocks, porosities. Depending on the size of the soil particles, contamination in groundwater trickling through that soil moves at different rates, reacts at different rates, and reacts with different materials." For scientists to understand what happens in total, Mehta said, they have to know what happens at all levels, on all surfaces.

This is easier said than done, even—or perhaps especially—at an advanced synchrotron facility such as the Stanford Synchrotron Radiation Lightsource, where custom instruments are carefully optimized to look at specific sample characteristics. Such instruments have pre-determined fields of view and can focus on details down to a certain size. These capabilities differ from beamline to beamline—like reading glasses that show 12-point text on a paperback page sharp and clear versus binoculars that capture a deer standing in a meadow.

For example, the instruments at SSRL Imaging Beamline 6-2 have a field of view of about 10 micrometers, or 10 millionths of a meter, and can resolve objects as small as 30 nanometers, or billionths of a meter. In contrast, Beamline 10-2 shows a field of view in the tens of millimeters and a resolution of about twenty micrometers, with Beamline 2-3 spanning the gap with a resolution of 2 microns and field of view of hundreds of microns. Beamline detectors also vary in contrast, or the chemicals to which they're sensitive—like one telescope with a filter that shows the red of ionized hydrogen versus a second with a filter that brings out the green of doubly-ionized oxygen.

Each view reveals important information, and according to Mehta, it's best to combine several. "When you think of [imaging samples] in these terms it's obvious," he said. But all too often the obvious seems an unreachable ideal.

"When you're a user, you don't have much time [to perform an experiment]. A couple of days at the most. If you find out your sample works for one beamline but not another, you're in trouble." Each beamline has its own mounting requirements and detector geometries; all can affect the quality of the data. "And you don't know if discrepancies are real or from processing inconsistencies," Mehta said. Attempts to take multiple, complementary views of a sample may come to naught.

Which brings us back to 2500-year-old Greek pottery.

SLAC, the Aerospace Corporation and the Getty Conservation Institute, the art and archeology conservation arm of the J. Paul Getty Foundation that also administers the famous Getty Museum, have received almost half a million dollars to conduct research into Attic pottery. This iconic black and red pottery owes its striking contrast to the behavior of two iron compounds in the clay together with the heat and concentration of oxygen in the kiln as they were fired—in other words, surface chemistry.

SLAC co-principal investigators Mehta and Piero Pianetta are involved in the search for a postdoctoral researcher for the three-year project. The researcher, based at the Getty for the first two years and at SLAC for the third, will use beam time on SSRL's Imaging Beamlines 2-3, 6-2 and 10-2 to characterize the surfaces of Attic pottery samples. As an integral part of the proposal, Mehta explained, the researcher will also focus on developing an efficient methodology for collecting valid data from beamlines with different capabilities, and then teach her methodology to other researchers. In this way, other research topics of interest to materials scientists—from ancient artifacts to lithium ion batteries—can benefit from the new methodology.

The goal is to develop a comprehensive approach to investigating material surfaces, Mehta said, which could include adding the Aerospace Corporation's electron microscopes to the suite of imaging tools used in the study. "They have very nice electron microscopes that we will use to go beyond the 30 nanometer resolution of Beamline 6-2 if necessary," he continued.

"You must have tools that can do all this—study the different chemistries at different hierarchies," Mehta said. Such tools are becoming more common, and the comprehensive images they can reveal of surface chemistries are as beautiful to a materials scientist as the warriors and gods incised on Attic vases are to art lovers.

Provided by SLAC National Accelerator Laboratory

Citation: Multi-faceted method can benefit study of materials from batteries to classic art (2011, March 4) retrieved 23 April 2024 from https://phys.org/news/2011-03-multi-faceted-method-benefit-materials-batteries.html