Applications of Synchrotron Radiation in Nanoscience and Technology Workshop, May 23, 2001

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Nearly 100 people attended the one-day workshop on "Applications of Synchrotron Radiation in Nanoscience and Technology" organized by Peter Johnson and Chi-Chang Kao of BNL. The goal of the workshop was to bring together researchers in nanoscience and experts in synchrotron techniques to explore the use of the wide range of experimental tools at the NSLS in this critically important area. It was the second nanoscience workshop held at BNL within the last six months. The day began with Rick Osgood, the BNL Associate Laboratory Director of Basic Energy Science, giving an overview of Brookhaven's plan for a new Nanoscience Center to be established in the next few years. This proposed new facility, physically attached to the NSLS, will serve as a focal point for nanoscience research in the Northeast through extensive university and industrial collaborations.

The scientific component of the workshop started with two talks on polymer films given by Jan Genzer, Department of Chemical Engineering (North Carolina State University), and Tom Russell, Polymer Science and Engineering Department (University of Massachusetts). Genzer described a novel combination of self-assembly of surface grafting molecules with mechanical manipulation of the grafting points in the underlying elastic surface to produce what he called "mechanically assembled monolayers (MAM)". Superior nonwetting and barrier properties were found on a MAM using semifluorinated molecules. Other potential applications of this novel fabrication technique were also discussed. A review on "Templating Polymers" to create well-ordered structures from nanometer to micrometer scale was given by Russell. For example, by exploiting the equilibrium self-assembled morphology of asymmetric diblock copolymers, a very simple, yet robust, chemical method to fabricate ultrahigh-density arrays of nanopores with high aspect ratios was demonstrated. These nanopores can then be used in a variety of device fabrications.

These two talks were followed by a presentation on the physics of mono-dispersed magnetic nanoparticles by Sara Majetich of Carnegie Mellon University, and a talk on the various chemical approaches to synthesize mono-dispersed nanomaterials by Stephen O'Brien of Columbia University. Majetich described the method to prepare mono-dispersed magnetic particles down to few nanometers. More interestingly, these mono-dispersed magnetic particles were found to self-assemble into two and three dimensional crystal structures. She also pointed out the challenges in characterization of the individual as well as collective magnetic properties of these systems, and in the understanding of the interactions between these particles as a function of the size of the particles and the distance between them.

In the afternoon sessions, Simon Mochrie of Yale University gave a review of using x-ray photon correlation spectroscopy in the study of equilibrium dynamics in polymers. It was followed by Wayne Goodman of Texas A&M. Goodman talked about a variety of nanocatalysts with particular emphasis on the unusual size dependence in the catalytic reactivity of oxidation of carbon monoxide for 1 to 6 nanometer size gold clusters supported on titania. He was able to show that the structure sensitivity of this reaction is related to a quantum size effect with respect to the thickness of the gold islands; islands with two layers of gold are most effective for catalyzing the oxidation of carbon monoxide. These results point to the exciting possibility of tailoring catalytic reactivity through the control of size and shape of the metal particles, as well as the need to understand the electronic structure of these particles.

Paul Weiss of the Chemistry Department of Pennsylvania State University gave a very interesting presentation on the use of a scanning tunneling microscope (STM) to study the mechanism of molecular switches. The conductance switching of single and bundled phenylene ethynylene oligomers isolated in matrices of alkanethiolate monolayers was tracked over time. When the surrounding matrix is well ordered, the rate at which the inserted molecules switch is low. Conversely, when the surrounding matrix is poorly ordered, the inserted molecules switch more often. From these observations, he was able to conclude that the switching is a result of conformational changes in the molecules or bundles, rather than electrostatic effects of charge transfer. He also showed the combined use of self-assembly and electron beam lithography to create novel nanostructures. The workshop concluded with a presentation by Beatriz Noheda of the BNL Physics Department on her work on the understanding of the origin of high piezoelectricity in the $PbZr_{1-x}Ti_xO_3$ (PZT) materials and the ultrahigh piezoelectricity in the relaxor ferroelectric $PbZn_{1/3}Nb_{2/3}O_3$-$PbTiO_3$ system using high-resolution x-ray powder diffraction measurements.

In addition to these very interesting presentations, there were many lively discussions among the workshop participants during the coffee breaks and lunch. Indeed, by the end of the day, several new collaborations had been established.