

For the XRD measurements, 400-nm-thick Al was deposited onto 500-nm-thick PECVD α -Si:H. The area of the Si $\langle 111 \rangle$ peak was measured at different temperatures. At 140°C, there was no indication of crystallization. After 2–3 min at 150°C, the area of the peak began to increase. More than 40% of the film crystallized within 15 min. The Al was removed by etching and the XRD measurements were repeated, with temperatures up to 250°C. No increase in the $\langle 111 \rangle$ peak area was observed, implying that no crystallization occurred after the Al film was removed, even when annealed at 250°C for 20 min.

Since Al diffusion in α -Si:H at 150°C has been previously reported by several scientists, these researchers believe that the activation energy for crystallization was reduced by Al atoms in the α -Si:H. This agrees with previous work by other researchers showing that implanting P, B, or As in α -Si:H enhances the solid-phase crystallization.

ELIZABETH SHACK

High-Quality, Manganese-Doped ZnSe Nanocrystals Prepared by High-Temperature Organometallic Synthesis

A team of researchers has unveiled a method of preparing manganese-doped ZnSe nanocrystals that are not only superior to previously doped II–IV materials, but are also comparable in quality with the best-known undoped nanocrystals. In their work, published in the January issue of *Nano Letters*, D.J. Norris (NEC Research Institute), N. Yao (Princeton University), and F.T. Charnock and T.A. Kennedy of the U.S. Naval Research Laboratory have used an adapted version of the high-temperature, organometallic synthesis method developed by Hines and Guyot-Sionnest in 1998. Instead of the previously used organometallic source for Mn (diethylmanganese), the researchers used dimethylmanganese, whose lifetime is significantly longer.

To verify that Mn was actually embedded inside the ZnSe nanoparticles, instead of segregating to their surfaces as in the case of CdSe, the researchers applied optical, magnetic circular dichroism (MCD) and electron paramagnetic resonance (EPR) measurements. While photoluminescence and photoluminescence-excitation spectra showed successful doping, they could not guarantee that Mn was actually substituting for Zn in the nanocrystals. The confirmation for that came from the EPR results, which have shown values similar to those for Mn located at cubic lattice sites in bulk ZnSe. In addition to providing evidence for successful

doping, the MCD data also provided clues about the doping level in the samples prepared, with values within the limit of one manganese atom per crystal-lite or less, implying an atomic Mn:Zn ratio of 0.025–0.125%.

This simple method for preparing and testing high-quality ZnSe nanocrystals could provide a model for gaining a detailed understanding of dilute magnetic semiconductor nanocrystals and their potential applications such as trapped single-spin manipulation for the developing field of spintronics.

CLAUDIU MUNTELE

Reversible Thermal Denaturation of Immobilized Met-Hemoglobin Demonstrated

Enzymes, which have been extremely desirable catalysts for chemical reactions, are confined to use at room temperature because of their thermal instability. Immobilized met-hemoglobin (Fe(III) Hb), which showed peroxidase activity in the presence of hydrogen peroxide, is one such example. It starts to denature at 73°C with the loss of peroxidase activity and α -helical content. In the February issue of *Chemistry*

of *Materials*, professor C.V. Kumar and co-worker A. Chaudhari from the University of Connecticut report that Hb, immobilized at the galleries of α -zirconium carboxymethyl phosphonate (α -ZrCMP), did recover after heat denaturation.

The researchers used x-ray diffraction and spectral measurements of circular dichroism and Fourier transform infrared (FTIR) absorbance to verify the reversible thermal denaturation of immobilized Hb/ α -ZrCMP. The increased d spacings of the immobilized Hb on a series of galleries shrank upon heating; however, the d spacings of Hb/ α -ZrCMP recovered after cooling for an hour while the others did not, even after cooling for an extended period. Also, the native protein had characteristic bands in its circular dichroism spectra and IR absorption spectra. The characteristic bands of renatured Hb/ α -ZrCMP remained in position or nearly completely recovered after cooling. However, those characteristic bands either shifted or only partially recovered for other immobilized Hb after denaturation and cooling. The peroxidase activity of immobilized Hb/ α -ZrCMP after denaturation gradually recovered and reached

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100% recovery after an hour. Activities of free protein and immobilized Hb on other galleries recovered by at most 50%. The researchers believe that the combination of the three approaches demonstrate the first stoichiometrically recovered Hb/ α -ZrCMP. The researchers believe that the nature of the surface functions and the chemical reactivities of the support matrix played a very important role during this recovery process. The irreversibility of Hb/ α -ZrRP was due to the space orientation of the carbonyl group. The $\text{CH}_2\text{CH}_2\text{COOH}$ group in Hb/ α -ZrCEP

(α -zirconium carboxymethylphosphonate) reacted with amines to form the amide that prevented the protein from recovering. But the CH_2COOH group in α -ZrCMP was inert to amines, and no amide formed. Thus, Hb/ α -ZrCMP could recover from its denaturation.

According to the researchers, "zirconium phosphonate support matrix with appropriate surface function may function as artificial chaperones for protein folding." In future studies, they plan to conduct molecular studies of these support surfaces for efficient refolding of proteins.

YING LI

Nanowires Fabricated by Step-Edge Decoration Process

Reginald Penner, a professor of chemistry at the University of California—Irvine, and graduate student researchers Michael P. Zach and Kwok Ng, have applied a method called step-edge decoration to build nanowires from molybdenum. The nanowires feature the conductivity, strength, and length necessary for use in microelectronic devices.

As reported in the December 15, 2000, issue of *Science*, the Penner group electrochemically deposited molybdenum dioxide onto a piece of graphite. Rudimentary wires began growing when their molecules linked onto step edges. After the brittle molybdenum dioxide wires were formed, they were heated in hydrogen gas at 350°C to remove the oxygen, leaving only the molybdenum metal.

The resulting pure molybdenum wires were smaller in diameter but also stronger, more conductive, and more flexible than those created in the first step of the process. The metal wires were then embedded in a polystyrene film and peeled off the graphite surface. The nanowires measured between 10 nm and $0.5\ \mu\text{m}$ in diameter and up to $100\ \mu\text{m}$ in length.

In developing a method to build long, uniform nanowires, Penner said that the step-edge decoration method used on graphite is proving to be more practical than using template synthesis, which is another fabrication method. When using templates, he said, a different one is needed for every diameter of wire, and thick templates required for the preparation of long nanowires are not readily available. The step-edge decoration process bypasses these obstacles. □

Correction

The figure in the February 2001 issue of *MRS Bulletin*, page 88, has been reproduced with permission from *Chemistry of Materials*; this is the web site version before publication of its modified version in the December 2000 issue.

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