use of an alloy-ceramic oxide multilayer. The optical performance of these multilayers in the water-window soft-x-ray region is anticipated to be better than in the hard-x-ray region due to the decrease in diffuse scattering from high-frequency roughness at longer wavelengths.

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Polymer Used for Semiconductor and Dielectric in Photosensitive FET

K.S. Narayan and N. Kumar from Jawaharlal Nehru Centre for Advanced Scientific Research in Bangalore have fabricated a field-effect transistor (FET) which consists of a polymer semiconductor and a polymer dielectric layer along with metal contacts. The researchers reported in the September 17 issue of *Applied Physics Letters* that this FET responds dramatically to light and controls the transistor properties.

The researchers used poly(vinyl alcohol) (PVA) as the transparent, insulating medium and cast it on a glass substrate coated with a partially transparent (10%) gate aluminum electrode to form a micron-thick layer. They dissolved regioregular poly(3-octylthiophene-2,5-diyl) (P3OT), with 98.5% head-to-tail regiospecific conformation, in chloroform and spin-coated on the insulator to form a 100-nm-thick film. The source and drain electrodes were formed with 3-mm-wide gold electrodes with an interelectrode spacing of 70 μm.

The transistor exhibits large photosensitivity represented by sizable changes in the drain-source current at low levels of light, according to the researchers. They reported a current gain of ≈100 for a photon flux rate of ≈1 μW. They reported that the current gain could be increased to as high as 10^3 with higher flux rates and a 150-nm-thick layer of P3OT. They observed that the threshold of the drain source voltage needed to drive the drain current to saturation decreased with increasing light intensity.

The researchers said the light-responsive polymer FET opens a new device-architecture concept for polymer-based electronics as image sensors. "The salient feature in this device is that both the active and dielectric media are polymers. This feature can enable fabricating circuit patterns using processing routes such as ink-jet printing and soft lithographic procedures," said Narayan.

Semiconductor Reservoirs Serve as Sources of Coherent Spin Current

Researchers at the University of California—Santa Barbara (UCSB) and the Pennsylvania State University have discovered a persistent mode of spin current deriving from semiconductor reservoirs that serve as a source of coherent spin currents. In their study reported in the June 14 issue of *Nature*, they have demonstrated high-efficiency spin transfer through interfaces between *n*-GaAs/*n*-ZnSe as well as between *p*-GaAs/*n*-ZnSe under external electrical bias.

David Awschalom, director of the UCSB Center for Spintronics and Quantum Computation and head of this research team, said that previously, theories of electron transport from one material to another suggested that the spin would lose its orientation or scatter from impurities or structural effects. In this study, the spins of

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each electron all pointed in the same direction or were aligned. The question, Awschalom said, was whether a cloud or bundle of electrons all spinning the same way would retain that same spinning when the cloud is moved to an adjacent semiconducting material. When transferring an electron spin across an interface between the semiconductors GaAs and ZnSe in a magnetic field, the researchers found that the spins stayed aligned, even as the temperature of the materials was raised, in some cases, to room temperature.

Furthermore, the researchers observed that the GaAs semiconductor serves as a spin reservoir. Awschalom said that if spin was pulled from one material (e.g., GaAs) to another (e.g., ZnSe), the spins in the adjacent layer acquire the original spin frequency and lifetime of the reservoir. Therefore the total transferred spin current can have the properties of either the reservoir or the adjacent layer, and an external electric field gates the transition between the two very different regimes.

Under electrical bias, the relative increase in spin-coherent injection was up to 500% in the *n*-GaAs/*n*-ZnSe junction. Significantly, this increase was nearly 4000% in the *p*-GaAs/*n*-ZnSe junction. The results in the *n*-*n* junction are due to the GaAs spin reservoirs whereas in the *p*-*n* junction, the data suggest that there is enhancement in spontaneous transfer mechanisms. These results, particularly for the *p*-*n* heterostructures, could point the way toward spin transistors.

Cobalt-Doped Anatase Titanium Dioxide Thin Films Behave as Room-Temperature Magnetic Semiconductors

Scientists at Pacific Northwest National Laboratory (PNNL) have created a thin-film semiconductor material made of titanium, oxygen, and cobalt. Their material demonstrated improvement of magnetic strength by nearly a factor of five over that currently demonstrated.

In order to be practical, spintronics will need to use semiconductors that maintain their magnetic properties at room temperature. This is a challenge because most magnetic semiconductors lose their magnetic properties above critical temperatures that are well below room temperature, and would require expensive and impractical refrigeration in order to work in an actual computer.

Scott Chambers, a chemist and PNNL senior chief scientist, and his team of scientists achieved these properties in a crystalline oxide film known as anatase titanium dioxide that is infused with a small amount of cobalt, a magnetic impurity. As described in a poster presentation at the 2001 Spintronics Workshop in Washington, D.C., in August, Chambers and his team created this magnetic semiconductor material using molecular-beam epitaxy. A team of scientists at IBM, led by research staff scientist Robin Farrow, then characterized the material's magnetic properties.

Ion-Beam Mixing Used to Synthesize Cu-Ag Nanocomposites

Using analytic modeling, atomistic simulations, and experiments, researchers from the University of Illinois at Urbana-Champaign (UIUC) have proposed the use of ion-beam mixing with controlled irradiation conditions to synthesize nanocomposites. Researchers Raúl A. Enrique and Pascal Bellon determined that the nanocomposites are directly stabilized during irradiation because of a dynamical self-organization reaction.

Last year (*Physical Review Letters* **84** [2000] p. 2885), the researchers identified analytically that certain irradiation conditions can lead to a dynamical stabilization of nanocomposites. They later confirmed the analytical predictions by using atomistic kinetic Monte Carlo simulations (*Physical Review B* **63** [2001] p. 134111). In a publication this past summer (*Applied Physics Letters* **78** [2001] p. 4178), Enrique and Bellon demonstrated that this approach works by synthesizing Cu-Ag nanocomposites using 1-MeV Kr irradiations.

"In fact," said Bellon, "the two phases are mixed at such a fine scale that the decomposition cannot be directly seen by electron microscopy imaging techniques."

According to the researchers, the self-organization reaction results because the various dynamical processes operating during irradiation occur at different length scales. The researchers predict that the length scale of these nanocomposites can be continuously tuned by varying the irradiation conditions, such as the irradiation temperature.

"This would be a very important point for the synthesis of optimized nanocomposites, which almost always require a tight control of grain or phase size," said Bellon.

In a separate study, researchers G.C. Rizza and H. Bernas from CNRS in France and M. Strobel and K.-H. Heinig from Forschungzentrum Rossendorf in Germany reported related results on the stabilization of nanoprecipitates in irradiated SiO_2 with gold inclusions (*Nuclear Instruments and Methods in Physics Research B* **178** [2001] p. 78). They are currently applying this method to synthesize active dots in thin films for optical and

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