trodes. They synthesized the carbon nanocoils by heat-treating solid composites of a carbon precursor (resorcinol formaldehyde gel), silica sol, and a transition-metal salt. The research team said that because the synthetic procedure is simple and inexpensive, it can be readily applied to cost-effective, large-scale production of the material. High surface area and good crystallinity are the characteristics needed for the catalyst support for DMFCs. As the researchers reported in the September 22 issue of *Angewandte Chemie*, their synthesized carbon material exhibited a high surface area of 318 m^2/g and was composed of 5–10-nm-thick graphitic coils. The crystallinity of the material was comparable to that of carbon nanotubes. The researchers said that this was especially important because it is difficult to obtain crystalline carbon materials with a large surface area. For example, they said, many activated carbons have surface areas exceeding 1000 m^2/g, but they are noncrystalline and amorphous. Alternatively, graphite is highly crystalline, but has a very small surface area of <10 m^2/g.

Carbon is a critical material for DMFCs because a good support exhibiting a homogeneous high dispersion of catalytic species is a key factor dominating the overall performance and stability of fuel cells. Hyeon and colleagues identified highly dispersed PtRu alloy catalysts of up to 60 wt% on their carbon support, resulting in higher catalytic activity for methanol oxidation. In a half-cell test for methanol oxidation at 0.6 V, the electrode using the carbon nanocoil had six times higher current than that of a commercialized fuel-cell carbon substrate.

The carbon nanocoil performed better as a support material for fuel cells than other nanostructured carbon materials. In particular, the nanocoils exhibited a current density that was three times higher at a given voltage than that of the graphitic carbon nanofiber, which was known to be one of the best catalyst supports for DMFC electrodes. In nanocoil experiments using a full fuel cell—composed of a cathode, anode, and polymer membrane electrolyte—the maximum power density increased by >85% over the standard commercial sample at 30°C.

Oxide Superlattices Containing Si Nanocrystals and Er Ions Luminesce Efficiently at 1.54 μm

M. Zacharias and colleagues from the Max Planck Institute of Microstructure Physics (Halle, Germany) have developed a means of controlling the size of silicon nanocrystals and custom-manufacturing these crystals on 4 in. wafers. The technique is based on a combination of superlattices—multilayer structures with layer thicknesses of a few nanometers and varying bandgaps—and phase separation in the ultrathin layers.

The superlattice structure of amorphous silicon oxide layers (SiO_x/SiO_2) was manufactured using a standard deposition technique. The researchers employed a variation of this technique by evaporating the silicon oxide either in a vacuum or in an oxygen-containing atmosphere. The resulting amorphous SiO/SiO_2 superlattice structure was then tempered in a nitrogen-containing atmosphere at 1100°C. Through the thermally activated phase separation, the SiO in the ultrathin sublayers transformed into pure silicon nanocrystals and amorphous SiO_2,

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whereby the nanocrystals were automatically surrounded with an appropriate barrier material.

The size of the crystals within the range, for example, of 2–5 nm can be determined by the thickness of the layer. The distance between the crystals can be adjusted by varying the thickness of the SiO_2 barrier layers and the oxygen content of the SiO_x layers. A higher oxygen content would automatically lead to a higher proportion of the amorphous SiO_2 after the phase separation and thereby to a larger distance between the silicon nanocrystals within the sublayer. The luminescence of the silicon increases with the number of crystals, and the quantum efficiency of smaller crystals is higher than that of larger crystals; therefore, primarily very small crystals at high density are required for the highest possible luminescence intensity.

The researchers said that when the nanocrystal structures are implanted with erbium ions, an effective energy transfer occurs from the nanocrystals to the Er^{3+} ions, and the luminescence shifts to ~1.54 μm. This particular wavelength is of technological importance, since the fiber-optic cable employed in optical data transmission exhibits a transmission maximum at 1.54 μm. Additionally, erbium-doped glass fiber is used as an amplifier for optical data transmission. Memory circuitry is another area of application of silicon nanocrystals in oxide matrices. The researchers submitted a patent for their technique for tailor-made silicon nanocrystals on 4 in. wafers.

A Spin-Transfer Switch for Magnetic Memory Spintronics?

Recent studies have demonstrated that when a spin-polarized electric current is passed through a ferromagnet a few nanometers thick, the nanomagnet experiences a large torque due to direct transfer of spin angular momentum. This allows the magnetic moment of the nanomagnet to oscillate at microwave frequencies around its symmetry axis until it reverses its orientation, thereby accomplishing a magnetic switch. D.C. Ralph of Yale University, S.I. Kiselev of Cornell University, and their co-researchers have demonstrated the nature of the physics behind this phenomenon. They reported their work in the September 25 issue of *Nature*.

The research team formed a 130 nm × 70 nm magnetic multilayered nanopillar with layers of magnetic Co and nonmagnetic Cu and Pt deposited on a silicon substrate. The multilayered composition was 80 nm Cu/40 nm Co/10 nm Cu/3 nm Co/2 nm Cu/30 nm Pt. A dc current bias was applied through a top Cu contact, and a static magnetic field was applied in the sample plane. The 40-nm-thick Co layer is referred to as the "fixed" layer because it is relatively insensitive to the applied magnetic field, whereas the 3 nm Co layer is referred to as the "free" layer because it is sensitive to the applied field. The electrons in the dc current were spin-polarized as they passed through the fixed layer. This spin-polarized current was then passed through the free layer. This subjected the magnetic moment of this layer to the spin-transfer torque, resulting in the emission of microwaves. When the researchers measured the microwaves and mapped the strength of the oscillations as a function of electric current and magnetic field, they revealed several types of magnetic excitation. The researchers said the only input was the dc electric current and the applied static magnetic field, while the output contained microwave emissions in a frequency range predicted by theory and prior calculations, clearly demonstrating the spin-transfer mechanism.

This study shows that the magnetic multilayered structure acts as a nanoscale motor, although there is no mechanical motion. Energy from the dc current was converted into high-frequency magnetic rotations. This work has implications for spintronic devices, such as magnetic memory devices. The researchers suggest that nanomagnets driven by spin-polarized currents could be used as tunable nanoscale microwave sources or oscillators.

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