The ruthenium cluster dye does not respond well to light at wavelengths below 375 nm, but the titania does respond to those wavelengths. Therefore, when 350-nm light is incident on the cell, a positive photocurrent peak is produced due to the photoelectrochemical property of bare titania, which absorbs ultraviolet light and transfers the generated electrons to the electrode. Above 375 nm, the contribution of the dye depends on the properties of its excited states; when 425-nm light is incident on the cell, a negative photocurrent peak is produced. This is because the dye accepts an electron from the titania layer and is reductively quenched, followed by reduction of electrolyte and transfer of electron to the counter electrode, said the researchers. By using incident light of either 350 nm or 425 nm, current can be produced in opposite directions. Shining both wavelengths simultaneously produces no net current, as they are cancelled out. The truth table matches that of the XOR gate, and other logic gates such as an INH gate can also be obtained by varying the intensity of the excitation wavelength. The researchers said that this demonstration opens new possibilities for molecular optoelectronics.

TUSHAR PRASAD

Method Developed to Measure $\chi^{(3)}$ and Size of Spherical Nanoparticles

Developing characterization methods for nanoparticles will improve the understanding of their roles in biology, chemistry, and materials science. For example, semiconductor nanocrystals display size-dependent optical and electronic properties. Nonlinear optical characterization techniques include Z-scan, hyper-Rayleigh scattering (HRS), and third-harmonic generation (THG), but each has drawbacks. Highly scattering media, such as nanoparticle solutions, present difficulties for Z-scans. HRS requires very precise optical alignment and very sensitive detection equipment and only indirectly measures third-order nonlinear susceptibilities, $\chi^{(3)}$. For a laser beam focused in a homogeneous material, bulk THG cancels because of the Gouy phase shift on both sides of the focus. For a material within an optical cell with glass windows, however, it has been shown previously that THG still occurs in the vicinity of the glass–material interface. Recently, V.I. Shcheslavskiy (University of Southampton, UK) and co-researchers from Sofia University, Bulgaria, and the University of Wisconsin–Milwaukee exploited this fact and developed a simple, novel method that not only measures $\chi^{(3)}$ but also measures the size of spherical nanospheres.

As reported in the May 15 issue of *Optics Letters* (p. 1486), Shcheslavskiy and co-researchers used an experimental setup (Figure 1) that includes a femtosecond Cr:forsterite oscillator with a 26.5-MHz repetition rate (with a 1.25 µm wavelength, and a 40 fs pulse duration, with an average power of 300 mW) as an excitation source. The laser beam was focused on a flow-through, fused-silica cell containing either an index-matching fluid or aqueous solutions of fused-silica nanospheres with diameters of 0.2, 0.3, 0.55, 0.75, or 1.0 µm. The focal volume (~10^{-10} cm^3) contained one or fewer nanoparticles during a measurement.

The researchers derived an expression for the ratio of the TH power generated at the air–glass interface to that generated at the glass–solution interface (see Figure 1) in terms of optical constants of the two media and the refractive index of the solution under study. Another, previously published equation relates the pulse duration power for Rayleigh particles in solution (for such a material with a small inhomogeneity, a non-zero contribution to the THG is observed). These two equations were then used to solve the two unknowns, $\chi^{(3)}$ for the nanosphere solution and the nanosphere diameters, once the TH signals generated at the interfaces and inside the solution were measured. After obtaining $\chi^{(3)}$ for the nanosphere solutions of each size and for an index-matching fluid, a previously published equation relating the three quantities by the volume fraction of the nanospheres is used to obtain $\chi^{(3)}$ for fused silica for each particle size. The researchers obtained an average value of $(2.75 \pm 0.27) \times 10^{-14}$ esu, which agrees with previously reported values for fused silica. The nanosphere diameters agreed with the manufacturer's specifications to within 10%, which is also the typical standard deviation in the diameters, as stated by the manufacturer. The researchers said that their method "is simple, fast, and does not require a high-beam-quality laser source" and "can find application in monitoring structural transformations of macromolecules."

STEVEN TROHALAKI

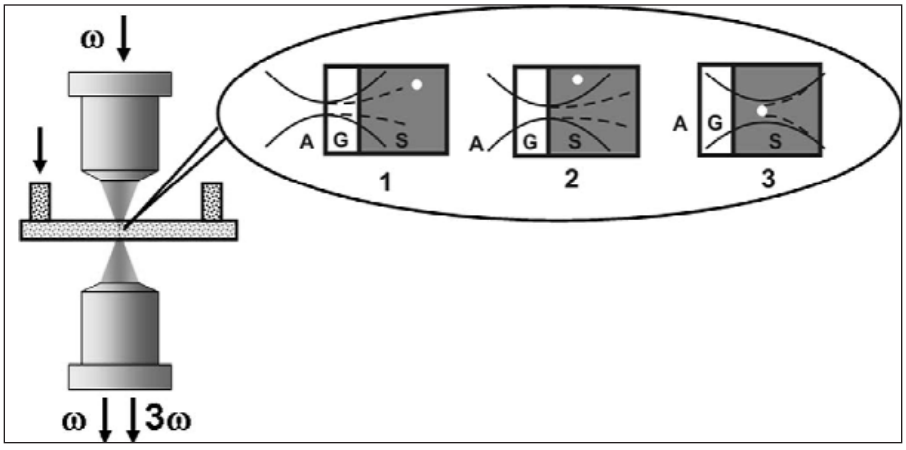

Figure 1. Schematic illustration of an experimental setup to measure third-order nonlinear susceptibilities, $\chi^{(3)}$, and size of nanospheres. A *stands for air,* G *for glass, and* S *for solution. Reproduced with permission from* Optics Letters ***31*** *(10) (May 15, 2006) p. 1486. © 2006 Optical Society of America.*

Bicolored "Janus" Particles with Electrical Anisotropy Synthesized Using a Microfluidic Co-Flow System

So-called "Janus" particles are biphasic microspheres with distinct composition and properties on each half. These particles, having such anisotropic physical properties, can be used, for example, in display devices. Producing Janus particles requires special techniques, and it is difficult to produce them in uniform size in large quantities. Now, T. Nisisako in the Department of Precision Engineering at the University of Tokyo, T. Takahashi of Soken Chemical and Engineering, Sayama Office, and their colleagues have developed a microfluidic system that allows them to efficiently produce 100-µm Janus particles. As reported in the May issue of *Advanced Materials* (p. 1152; DOI: 10.1002/adma.200502431), the device the researchers built is a fluidic module comprising a fluidic channel with two consecutive patterns: a Y-shaped channel, for combining two organic solutions to form a two-phase organic stream; and a planar-sheath-flow geometry, for leading the organic stream into a co-flowing aqueous stream.

The researchers prepared two solutions

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of an acrylic monomer (isobornyl acrylate); one is dispersed with carbon black pigments and another with titanium oxide white pigments. The two solutions are fed into each arm of the Y, respectively, to form a two-color stream at the junction. The two-color stream travels down the leg of the Y and forms droplets when it meets the co-flowing stream of a poly(vinyl alcohol) solution. The droplets are then carried by the co-flowing stream and polymerized into solid microscopic particles outside the fluidic module. The researchers showed that droplets of uniform size could be produced under a limited range of precisely controlled fluidic conditions. Well-defined biphasic particles 117 μm in diameter were formed in these experiments. The researchers also determined that smaller particles (20–30 μm in diameter), which would be needed for high-resolution displays, could be formed, although with a less well-defined two-color boundary.

The prepared microparticles are responsive to electric fields. The researchers built a flat-panel display device with the microparticles dispersed between two electrode panels. In the presence of an external electric field, these microspheres turned to orient their black half to the negatively charged panel. When the researchers reversed the electric field, the particles flipped.

The researchers also showed that it would be possible to scale up the manufacture of Janus particles for commercial applications. They further said that the technique is not limited to polymer components; ceramic or metallic materials are also possible. The researchers speculated that spheres with magnetic anisotropy could be formed by dispersing magnetite in one hemisphere, and that spheres with optical anisotropy could be formed by incorporating a liquid-crystal phase. They also pointed toward the use of "barcoded" particles in potential applications such as "biological multiplexing, multicomponent carriers for targeted drug delivery, and 3D photonic crystals of different domains."

SHIMING WU

Self-Assembled CNT-Based Electronic Devices

Despite significant progress in the scientific understanding of the electronic, optical, and mechanical properties of carbon nanotubes (CNTs), large-scale technological applications of CNTs remain rare. This is partly due to the fact that controlled and efficient assembly of CNTs into electronic devices with high spatial precision remains a major challenge. Now, C. Klinke, J.B. Hannon, A. Afzali, and P. Avouris from the IBM T.J. Watson Research Center in New York have discovered that the use of chemical functionalizing could become an efficient approach to the creation of commercial-scale applications for self-assembled CNT-based electronic devices.

Most CNT devices have been fabricated through electron-beam lithography. Commercial production, however, poses challenges, since this lithography technique cannot be applied at large production scales because of its small yield.

Klinke and co-workers—as reported in the May issue of *Nano Letters* (p. 906; DOI: 10.1021/nl052473f)—used a high-dielectric-constant insulator as the substrate on which to assemble their devices. The unique electrical properties of nanotubes, however, are destroyed when another chemical species is covalently attached to them. To overcome this obstacle, the researchers used a reversible functionalization of nanotubes with a chemical group that makes the CNTs likely to bind specifically to certain materials such as hafnium dioxide or aluminum oxide—all basic high-κ dielectrics—but not to silicon oxide. Once the CNTs have attached themselves at the desired location, the chemical group is removed by a thermal annealing process.

Selective attachment was achieved using the following procedure. Long and narrow aluminum films were first deposited on a SiO_2 substrate. Al_2O_3 was created by oxidizing the Al films using an oxygen plasma. The CNTs were functionalized with a diazonium salt and dispersed in either methanol or ethanol, which was then deposited as a liquid film on the substrate. The liquid film was dried on a hot plate, sonicated in pure methanol, and then dried in N_2. The CNTs aligned along the narrow Al_2O_3 strips. Field-effect transistors were constructed by depositing Pd to produce source and drain structures.

After this processing, the resulting transistors demonstrated excellent electrical properties. This new technique provides the possibility for large-scale integration of CNT-based electronic components into electronic devices, the researchers said.

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