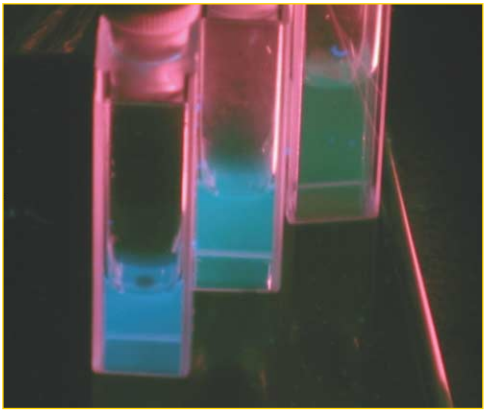
Au nanoclusters are promising biolabels

NANOTECHNOLOGY



Emission from Au_5, Au_8, and Au_{13} nanocluster solutions under ultraviolet irradiation. (© 2004 The American Physical Society.)

Robert M. Dickson and coworkers at Georgia Institute of Technology have fabricated highly fluorescent, water-soluble Au quantum dots (QDs) [Zheng *et al.*, *Phys. Rev. Lett.* (2004) 93 (7), 077402]. The particles are smaller in size, have narrower excitation spectra, but have comparable fluorescence to semiconductor QDs. These properties could make the Au QDs useful as biological labels, energy-transfer pairs, and light-emitting sources for nanoscale optoelectronics.

The researchers synthesized dendrimer-encapsulated Au nanoclusters by the slow reduction of Au salts within an aqueous solution of a poly(amidoamine) or PAMAM dendrimer. The resulting Au QDs are very stable, lasting for months in aqueous solution or in dried powder form.

The QDs show discrete excitation and emission spectra from the ultraviolet to the near infrared depending upon the number of Au atoms in the nanoclusters. This number can be tuned by varying the Au:PAMAM concentration. The team generated Au_5 (ultraviolet), Au_8 (blue), Au_{13} (green), Au_{23} (red), and Au_{31} (near infrared) emitting species with high quantum yields.

The Au nanoclusters behave as 'multielectron artificial atoms' rather than single-electron artificial atoms as semiconductor QDs do, explains Dickson. "These new noble metal QDs link the discrete states characteristic of atoms and the plasmon oscillations occurring in nanoparticles >2 nm in size," he says. "Surprisingly, the physics is accurately described by the simplest model of metallic behavior, the jellium model of free electrons."

While the Au QDs could make useful biolabels, further work is required. "We will need to determine ways to functionalize these QDs so they will get across cell membranes, seek out specific proteins inside a cell, and label those proteins," says Dickson.

Jonathan Wood

Nanoribbons tie up photonic circuits

NANOTECHNOLOGY

Researchers at the University of California, Berkeley and Lawrence Berkeley National Laboratory have fabricated SnO_2 nanoribbons that could be used as optical waveguides in photonic circuits [Law *et al.*, *Science* (2004) **305**, 1269].

Peidong Yang and colleagues synthesized ribbon-shaped SnO_2 nanowires up to 1500 μm long. The single-crystal nanoribbons have rectangular cross-sections that are 100-400 nm in width and thickness. The nanoribbons can act as waveguides much like conventional optical fibers. If laser light is focused onto one end of the ribbon, the generated photoluminescence is strongly guided along the structure to emanate at the opposite end. Visible and ultraviolet light can be channeled into the subwavelength structures with little optical loss.

The SnO_2 nanowires are also sufficiently large and strong to be manipulated under an optical microscope. Twists and bends can be introduced with radii as small as 1 μm without disrupting the waveguiding ability. Individual waveguides can be coupled together by overlapping their ends, or assembled into functional geometries such as Y-junctions, branch networks, or ring oscillators.

The SnO_2 nanoribbons can also be linked to ZnO nanowire light sources and detectors. Assembling nanowire building blocks with different functions, such as light creation, routing, and detection, is one way of achieving photonic circuits that can manipulate light pulses within submicrometer volumes. "We are interested in integrating these waveguide components into a fully functional photonic circuit to carry out on-chip optical computing or in applications such as chip based chemical/biological detection," says Yang.

Jonathan Wood

Carbon particles the easy way

FABRICATION & PROCESSING

Researchers at the University of Bordeaux, France and the University of Warsaw, Poland have developed a simple top-down method for producing carbon micro- and nanoparticles [Garrigue *et al.*, *Chem. Mater.* (2004) **16**, 2984]. These particles could have many applications ranging from catalysis to energy storage and diagnostics, says Alexander Kuhn of the University of Bordeaux.

Their approach is based on the strong chemisorption of a well-known class of inorganic ion, polyoxometalate (POM) anions, on carbon surfaces. Carbon black powder is dispersed in a POM solution under ultrasound. The ultrasound bath and the free energy resulting from the absorption of the POM ions drives the division of carbon black aggregates into much smaller particles. The process is analogous to the preparation of an oil/water emulsion in the presence of an amphiphilic surfactant.

The size of the particles can be tuned from micrometers to nanometers by the duration of the treatment. The size distribution also decreases with increasing treatment time. The particles are stabilized by a negatively charged POM monolayer shell, and the final colloidal suspensions show no sedimentation or degradation over a period of weeks.

"Our top-down approach doesn't need any specific equipment except an ultrasound bath, uses very trivial and cheap chemical ingredients, and leads to highly stable colloidal suspensions of carbon particles," says Kuhn. Bottom-up methods require specific and expensive equipment. "We would like to optimize the technique in the near future and are working on a similar method for the treatment of carbon nanotubes," Kuhn told *Materials Today*.

Jonathan Wood