Nano Focus

2D self-assembly of a monolayer film of gold nanoparticles achieved in 10-min synthesis

Uniform thin films composed of closely packed nanoparticles are important for applications such as nanoelectronics, light-emitting diodes, solar cells, and magnetic data storage. While electrostatically stabilized gold nanoparticles (Au-NPs) in water irreversibly aggregate, alkanethiolate-coated Au-NPs are very stable, and can be dried into a powder and subsequently re-dispersed in solvents without size change.

Traditional methods for two-dimensional (2D) self-assembly of NPs coated with hydrophobic organic ligands include Langmuir-Blodgett deposition and spin-coating, although monolayer films prove difficult with the latter. Previously reported, however, were monolayer films prepared with a simple method for 2D self-assembly of dodecanethiol (DDT)-coated Au-NPs at the air-toluene interface of an evaporating toluene droplet. Nevertheless, drawbacks are inherent in the modified Brust methods used to synthesize the Au-NPs, which include the slow Au-NP formation in toluene, and the difficulty in removing from the Au-NPs the surfactant tetraoctylammonium bromide (TOAB), required to transfer gold ions from the aqueous phase to toluene.

Recently, however, S.-K. Eah and co-researchers at Rensselaer Polytechnic Institute have developed a new, 10-min., TOAB-free method for synthesizing DDT-coated Au-NPs. The researchers have uploaded a three-minute demonstration video at http://www.youtube.com/watch?v=nqkwM9o1s-w.

Eah and co-researchers reported in the May 18th issue of *Langmuir* (DOI: 10.1021/la100591h; p. 7410) that they synthesized Au-NPs in water by borohydride reduction. Phase transfer and coating with DDT was then performed by adding acetone to the aqueous Au-NP mixture, and then adding hexane containing DDT. After vigorous shaking for 30 s, the DDT-coated Au-NPs were transferred to the hexane with all reaction byproducts remaining in the aqueous-acetone phase, making a product-cleanup step unnecessary. The researchers found that the lack of the normally used stabilizer molecules was critical for the Au-NP phase transfer. By controlling reaction conditions, the researchers were able to precisely tune the Au-NP diameters in the range of 3.2–5.2 nm. The Au-NPs were indispersible in toluene and therefore self-assembled into a monolayer, closely packed film at the toluene-air interface of a toluene droplet. For Au-NPs with diameter above 4 nm, the Au-NP arrays transferred intact to the substrate as the toluene evaporated. However, droplets containing 3.2 nm and 4.0 nm diameter Au-NPs did not maintain monolayer formation on the substrate as the toluene evaporated, Furthermore, the researchers found that the negative charge on the Au-NPs in nonpolar solvents is an important requirement for such self-assembly. Eah and co-researchers said, “We believe that controlling the charge number of nanoparticles in nonpolar solvents together with precise size-tuning is a new research direction with many open questions, especially for exploiting the 2D self-assembly property in a toluene droplet.”

Steven Trohalaki

First operation of a Pr:YAlO$_3$ microchip laser achieved at near-infrared wavelength

Microchip lasers are monolithic solid-state lasers that use a small single crystal as the gain medium. Typically these crystals are composed of a host crystal doped with ions such as neodymium Nd^{3+} or praseodymium (III) Pr^{3+}. In an effort to construct a laser that is both compact in size and operates at infrared laser wavelengths, M. Fibrich, H. Jelínková, and J. Šulcat of Czech Technical University in Prague and K. Nejezchleb and V. Škoda at Crytur Ltd. in Turnov created the first microchip praseodymium (III) yttrium aluminum oxide laser, YAlO$_3$ (YAP), Pr:YAP. These materials are ideal for laser use due to good thermal and mechanical properties and the ability to have high population inversion.

In the August 1st issue of *Optics Letters* (DOI:10.1364/OL.35.002556; p. 2556), the researchers described the fabrication and operation of the Pr:YAP laser microchip system. The system consisted of a GaN laser diode pump operating at 448 nm wavelength (which facilitates the excitation of electrons from lower to higher energy states in the microchip laser crystal), a collimating lens, a focusing lens, the Pr:YAP microchip laser crystal, and a filter all aligned in sequence. The cylindrical Pr:YAP crystal was Czochralski-grown, was 5 mm long and 5 mm in diameter, cut along the *b*-axis, and was free of cracks and twins. The Pr:YAP crystal was coated with dielectric films on both sides. The coating on one side was designed to transmit radiation from the GaN laser diode pump source and to be highly reflective at the microchip laser wavelength. The coating on the opposite side was designed to be 98% reflective for the microchip laser wavelengths generated at 747 nm and partially reflective of the pump laser diode light.

To analyze system performance, up to one watt of power was supplied to the system through the laser diode pump. The light beam generated from the pump laser diode passed through the collimating lens and was focused on the Pr:YAP crystal to a spot size of 60 µm. The pump beam was linearly polarized and oriented with polarization parallel to the *c*-axis of the microchip laser crystal. The spectral line shape of the microchip laser output radiation was measured using a fiber spectrometer to be 0.7 nm full width at half maximum. Laser oscillation threshold was achieved at a pump laser diode

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