

that lead to the formation of chiroptical rosette nanotubes. At millimolar concentrations and in the absence of a promoter, **1** self-assembles into a racemic mixture of helical rosette nanotubes. An instantaneous transition from racemic to homochiral helical nanotubes accompanies the addition of a promoter. At micromolar concentrations, **1** is unassembled but addition of a promoter triggers self-assembly into rosette nanotubes with a helicity predefined by the promoter. The supramolecular reactions involved must first involve molecular recognition between **1** and the promoter.

Fenniri and co-workers believe that when viewed as a model process by which predefined molecular properties are expressed at the macromolecular level through programmable stereospecific self-assembly.

STEVEN TROHALAKI

Acoustical Memory Observed in LiNbO₃

Michael McPherson and colleagues from the National Center for Physical Acoustics at the University of Mississippi have observed acoustical memory in LiNbO₃ crystals. An acoustical tone burst was stored inside the crystal and reemitted at a later time. They report in the September issue of *Physical Review Letters* that the strength of the memory signal is directly related to the dielectrical properties of the ferroelectric material, and is sensitive to both temperature and frequency. Acoustical memory may be useful for investigating energy exchange processes in ferroelectrics, they said.

Cylinders of bulk LiNbO₃ ranging from 2.4 cm to 3.9 cm in length and from 2.5 cm to 4.5 cm in diameter were used to demonstrate the effect, where the acoustical longitudinal mode propagation along the [001] axis corresponds with the piezoelectrically active direction. A 39° rotated Y-cut 30-MHz transducer was mounted to the top of the sample and a capacitive receiver was mounted to the bottom to capture the resulting signal. A synthesizer function generator produced sinusoidal tone bursts approximately 5 μs in duration. To verify the results, the experiment was repeated in which the configuration involved the removal of the capacitive receiver, causing the transducer to act as both emitter and receiver. In another configuration, a secondary transducer was mounted to the opposite face of the sample, as a standard two-transducer setup. The samples were tested at various temperatures ranging from 24°C to 46°C and within a signal frequency range of 16–26 MHz. The researchers found that the

acoustical memory effect was sensitive to both temperature and frequency, and closely related to the dielectrical properties of the sample, possibly due to the pinning and relaxation of domain walls within the crystal. Within the frequency range, extrema appear in the acoustical memory amplitude, implying a memory center size. The researchers estimate these memory centers to be 140–230 μm for the observed peaks, which corresponds to the size of ferroelectric domains in lithium niobate.

CHRISTINE RUSSELL

Removal Rates in Chemical-Mechanical Planarization of Copper and Silica Surfaces Increase with Particle Concentration When Using Dilute Solutions

Chemical-mechanical planarization (CMP), a polishing process commonly used in the fabrication of wafers and other components in the electronics industry, has removal rates usually proportional to the applied pressure and velocity of the surfaces in contact. This proportionality is defined by the Preston coefficient, and may be linear or follow a power law. The Preston coefficient varies depending on reaction kinetics, solution concentration, or surface properties. A group of scientists from the Motorola Digital DNA Laboratories and the AMD-Motorola Technology Alliance in Austin, Texas, studied the effect of particle concentration on the removal rates, and reported their results in the October issue of *Electrochemical and Solid-State Letters*. K. Cooper and colleagues studied dilute solutions where particle size is negligible compared to the mean particle separation distance, expecting the Preston coefficient to be proportional to the frequency of collisions. In this regime taking into account volumetric considerations, the Preston coefficient has a term proportional to the cubic root of the weight of solids (wt%^{1/3}) present in the solution. In order to prove this dependence, the scientists conducted experiments on silica and copper films. Silicon dioxide films 450 nm thick were deposited by chemical vapor deposition (CVD) on 200-mm silicon substrates. Subsequently, the wafers were polished on a rotational tool for 60 s at constant pressure and velocity using a solution of silica particles with a mean size of 120 nm. Measurements of the film thickness before and after polishing were obtained with a spectrophotometer. Copper films 1.2 μm thick were deposited by physical vapor deposition (PVD) on a 100 nm Cu seed, then annealed for complete recrystallization and polished using a solution of sili-

ca particles with a mean size of 40 nm. Thicknesses were measured with a calibrated four-point probe.

Data showed that in both cases the removal rates follow linear behavior with respect to pressure and velocity. To determine the effect of abrasive solutions on the oxidation and removal rates on copper, measurements were taken with a voltammeter in a Pt disk electroplated with 10 μm of Cu. The disk was rotated at 300 rpm and polished with a pressure of 50 kPa using solutions with <1 wt% and without abrasive particles. During polishing without abrasive particles, a passive oxide layer appeared. On the other hand, particles provided an increase in current density and anodic slope, suggesting that the mechanism of oxidation followed by mechanical removal was apparent. The removal rates for both silica and copper wafers proved to be proportional to wt%^{1/3} with both materials having different critical onset concentrations, and with silica having an onset concentration about six times greater than that for copper. The researchers attribute this to differences in kinetics and removal mechanisms. Copper oxides have poorer adhesion to copper substrates than silica has to silicon, making them easier to remove. Planarity of wafers is improved by increasing slurry concentration, with surface roughness decreasing down to 3.5 times that of the unpolished surface.

SIARI S. SOSA

Method Developed for Asymmetric Patterning of Nanospheres

One approach to fabricating functional nanoscale architectures is the self-assembly of "high-information-content" molecules and nanoparticles modified with a homogeneously distributed layer of molecules. However, the spatial homogeneity at the nanoparticle surface limits both the structural diversity and functional complexity of nanoscale architectures that can be contemplated. It is in this context that researchers at University College Dublin, Ireland have developed a strategy for patterning nanoparticles in order to realize the full potential of this approach. L. Nagle and colleagues have demonstrated the patterning of nanospheres by assembling gold nanoparticles, 16 nm in diameter, on only one side of a larger silica or latex nanosphere, 200 nm and 500 nm in diameter, respectively. Their strategy for patterning nanospheres uses ultrafiltration technology.

As reported in *Nano Letters* (Web release October 10, 2002), the key to modifying one half of a nanosphere lies

in the symmetry-breaking property of a membrane filter upon which the nanospheres reside and represents a significant step forward in the fabrication of complex nanocrystal architecture. The membrane serves as a filter for the larger nanospheres capturing them at the surface while allowing the smaller nanoparticles to pass through. As the nanoparticles flow past the nanospheres, they stick to amine groups that coat the nanospheres. The nanoparticles do not adhere to the underneath of the nanospheres during filtration. The researchers stress the importance of controlling the number of nanospheres retained at the surface of the membrane filter to ensure a sufficient number of unblocked pores so that filtration occurs efficiently.

The material allows for the construction of new types of nanoscale architecture; for example, gold nanoparticles on one face of a nanosphere serve as selective binding sites for more gold nanoparticles. The repeated chemisorption of gold nanoparticles results in the templated assembly of multilayers of gold nanoparticles on one half of individual nanospheres.

This research represents an attempt directed toward building complex nanoparticle architecture and the researchers are quick to point out that, for this to be useful, functionality will be necessary. In this regard, their future efforts will demonstrate the utility of similar materials as biochemical tags, templates for the synthesis of new nanostructures, and potential display elements.

YUE HU

Compressive Stress Drives Formation of Bismuth Nanowires

The properties of bismuth have attracted significant interest because of its highly anisotropic Fermi surface, low carrier densities, small carrier effective mass, and long carrier mean free path. Bi nanowires have previously been produced with radii ranging from 7 nm to 200 nm and lengths of up to tens of microns. As reported in the October 21 issue of *Applied Physics Letters*, a group of researchers from General Motors Research and Development Center in Michigan have synthesized Bi nanowires with radii of 30–200 nm and extremely high lengths of several millimeters. Yang-Tse Cheng and co-workers used magnetron sputtering to synthesize a layered structure consisting of chromium nitride and bismuth, which decomposed onto a CrN matrix and Bi nanowires.

The researchers performed the synthe-

sis on a single-crystal Si(111) substrate. The substrates were cleaned and then Ar-ion etched. A 100–200-nm-thick adhesion layer of Cr was then deposited, followed by a thin layer consisting of a mixture of Cr and Bi deposited in an atmosphere of Ar and N₂. The total thickness of the latter films ranged from 1.5 μm to 2.5 μm. The researchers varied the Bi concentration from 1.5 at.% to 4.3 at.% by changing the power on the Bi target while maintaining constant power on the Cr target. Analysis by scanning electron microscopy (SEM) confirmed that the Bi nanowires were formed by compressive stress. Furthermore, SEM revealed a very high growth

rate of ~5 μm/s. By using wafer curvature measurements and Stoney's equation, the researchers measured the compressive stress of ~470 MPa in a Bi-CrN thin film deposited on a silicon substrate.

The research team concluded that the high compressive stress that accompanies the formation of thin films can be used for the formation of metallic nanowires. They reported, "When the high compressive stress is present in a composite thin film consisting of a low melting point material [like Bi, with a melting point of 271°C] and a high melting point matrix material [such as CrN], the low melting point material may be extruded from the

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