

achieved in their respective thin-film structures, opening the door to *in situ* cooling of semiconductors. As reported in the July 14 issue of *Applied Physics Letters*, the researchers used low-pressure metalorganic chemical vapor deposition to grow 100-period Si-doped superlattices with 10-nm AlGaAs barriers and 10-nm AlGaAs wells. The group chose the AlGaAs system for its compatibility with GaAs, and the particular low-Al barrier and well phases, because of their low thermal conductivity compared to GaAs, while exhibiting comparable electrical conductivity. In addition, they can be doped to a very high level.

The scientists fabricated stand-alone microcoolers using standard lithography techniques and Ni/Au/Ge/Au as wire bonding contacts, and they mounted the device on a copper heatsink for analysis. The specific series resistance including contact and superlattice resistance was determined to be  $3.2 \times 10^{-6} \Omega \text{ cm}^2$ . In the measured temperature range of 25–100°C, the cooling effect increased from 0.8°C to 2°C, indicating increasing efficiency with higher temperatures, according to the researchers. Size reduction from  $120 \mu\text{m}^2 \times 120 \mu\text{m}^2$  to  $60 \mu\text{m}^2 \times 60 \mu\text{m}^2$  increased the cooling effect from 0.67°C to 0.8°C, but the trend did not continue with further size reduction. The researchers expect significant improvements in cooling performance through optimization of contact resistance doping level, superstructure, and geometric parameter adjustment.

ALFRED A. ZINN

### Nanocomposites Made from Renewable Resources Exhibit Good Mechanical Properties

Interest in preparing polymeric materials from renewable, plant-based resources has grown in recent years. Plant oils are particularly attractive raw materials because of their worldwide abundance, and “green” polymers are already being used in inks and coatings. However, these materials do not offer the mechanical properties necessary for structural applications. A group of researchers at Kyoto University and Toyota Central R&D Labs has now used plant oils and clay to prepare nanocomposites that show strength, flexibility, and biodegradability. They report their results in the July 1 issue of *Chemistry of Materials*.

The team prepared the nanocomposites by cross-linking either epoxidized soybean oil (ESO) or epoxidized linseed oil (ELO) in the presence of montmorillonite clay modified with organic groups. Wide-angle x-ray diffraction and transmission electron microscopy were used to characterize the insoluble polymeric network. Dynamic viscoelasticity measurements showed that the storage moduli of the nanocomposites increased as a function of clay content. In the absence of clay, only a very soft film was obtained, while nanocomposites with 5–15% clay content displayed flexibility and good mechanical strength. The storage modulus of the ELO clay nanocomposite was greater than that for ESO clay, probably due to a higher cross-linking density in the ELO polymer, according to the researchers.

CATHERINE ORTEL

### Si/TiB<sub>2</sub> Microcomposite as Li-Ion Battery Anode Material Yields High and Stable Discharge Capacity

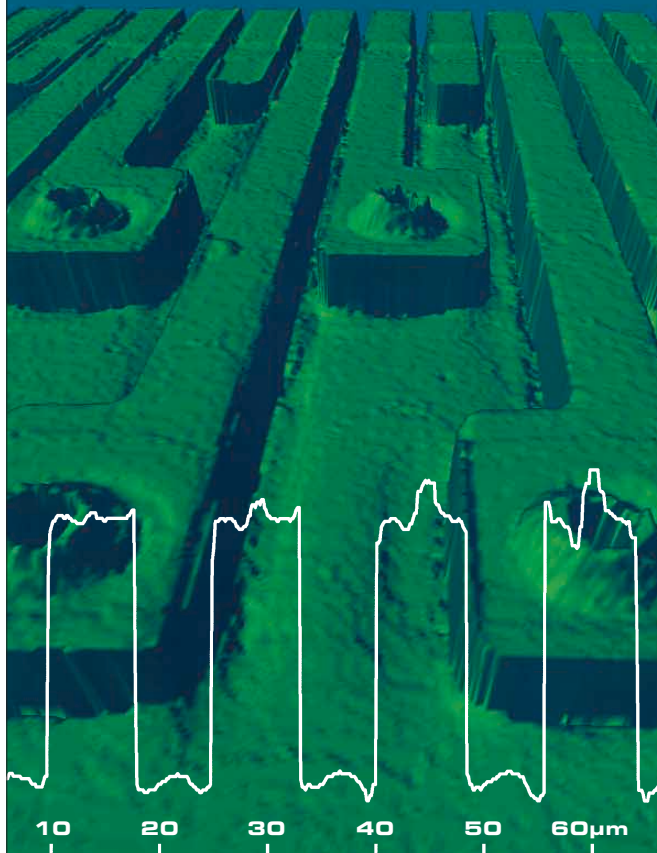
Graphite is currently the main anode material for lithium-ion batteries, the power source of choice for portable electronics such as cellular phones, laptop computers, and video cameras. However, the performance of graphite anodes suffers from a relatively low theoretical maximum capacity of 372 mAh/g and irreversible capacity loss in the first cycle. P.N. Kumta, I.-S. Kim, and G.E. Blomgren of Carnegie Mellon University have found that the use of a microcomposite material consisting of TiB<sub>2</sub> as an inactive host matrix and Si as the finely dispersed active phase minimizes the detrimental stresses during the charge/discharge

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cycles. The Si/TiB<sub>2</sub> microcomposite Li-ion battery anode avoids mechanical failure when compared with silicon and tin-based systems such as SnFeC, Cu<sub>6</sub>Sn<sub>5</sub>, and SnSb systems. The latter have become of recent interest due to their high initial capacities of up to 4000 mAh/g. However, their capacities quickly drop to about 1/20 of their initial values and they suffer from cracking or crumbling caused by the large volume change in the material during repeated charging and discharging.

As described in the June issue of *Electrochemical and Solid State Letters*, the

researchers used high-energy mechanical ball milling to mix and grind the two components, Si and TiB<sub>2</sub>, into a fine micron- to nano-sized powder. Their process yielded a nanostructured material consisting of 300–3000-nm size grains composed of 3–10-nm TiB<sub>2</sub> crystallites and amorphous silicon. An anode fabricated using this material exhibited a stable capacity of ~400 mAh/g after 15 cycles (with a current rate of ~C/25). Phases consisting of larger particles led to materials with higher discharge capacities (726 mAh/g), but with larger losses per cycle, while materi-

als containing smaller particles show a lower initial capacity, but with a much higher overall charge retention (<0.4% loss per cycle). The group examined the anodes using scanning electron microscopy and high-resolution transmission electron microscopy, but could not detect any cracking or other structural damage, indicating that the small TiB<sub>2</sub> particles reduce the stresses caused by the volume change to a tolerable level. The researchers said that these properties make the anode material a viable alternative to the currently used graphite.

ALFRED A. ZINN

### Simulations Indicate That Controlled Vertical Manipulation of Individual Molecules by Scanning Probes Is Possible

The idea of controllable modifications of surface structure on the atomic scale using scanning tunneling microscopy (STM) and atomic force microscopy (AFM) has attracted considerable attention from researchers in the last decade. Manipulation of single molecules is usually classified as lateral or vertical. Lateral manipulation has been extensively studied, while vertical manipulation is now in the beginning stages of research. A group of researchers from Tel Aviv University, Israel and the Donetsk Institute for Physics and Engineering, Ukraine has proposed a method of controlled vertical manipulation of individual molecules with scanning probes. The method is based on the different probabilities of transfer of molecules to the STM tip depending on both tip velocity and the distance of closest approach to the surface. The surface–tip transfer time competes with the tip's velocity; consequently, the adsorbate cannot always follow the motion of the tip.

As reported in the June issue of *Nano Letters*, M. Urbakh of Tel Aviv and co-workers performed detailed modeling of manipulations of molecules by STM or AFM tip by using a “pick-up-and-put-down” (vertical) mode. As a result of their simulations, the researchers presented a map giving the probability of trapping a given number of particles ranging from 0 to 8 for a given driving velocity of the tip. They also calculated histograms for the number of trapped particles for various values of velocity, which indicate that picking up 1, 3, 5, or 8 particles is much more likely than picking up 4, 6, or 7 particles.

The researchers found that the number of molecules picked up by the tip can vary over a wide range, and the number of trapped molecules decreases with an increase in tip velocity. Furthermore,



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