

Terawatt Laser Pulses Generate Collimated Beams of Fast Protons from Thin Foil Targets

Most of the recent research into the interaction of pulsed laser beams with matter (solids, gas jets, and clusters) has focused on the generation of compact neutron sources. Now a team of researchers from the University of Michigan and Osaka University are reporting the production of a collimated beam of fast protons with energies as high as 1.5 MeV when a high-intensity, high-contrast sub-picosecond laser is focused onto a thin foil target. This development could prove significant for the initiation of small-scale nuclear reactions in the laboratory.

As reported in the May 1 issue of *Physical Review Letters*, the experimenters used a 10 TW hybrid Ti:sapphire/Nd:phosphate glass CPA laser capable of delivering up to 4 J in a 400 fs pulse at a wavelength of 1.053 μm . The laser pulses were frequency doubled to generate 1 J pulses of green light and then focused to obtain intensities of 3×10^{18} W/cm² incident on thin foil targets. When this laser was focused on a thin film of aluminum with a thickness of 1.8 μm at angles of incidence ranging from 0° to 45°, a collimated beam of fast protons emerged in a direction normal to the back of the foil in a confined cone angle of $40 \pm 10^\circ$. The number of protons generated was of the order of magnitude 10^9 .

To pinpoint the depth of proton generation in the foil, reaction studies involving deuterons and the boron isotope ¹⁰B were performed. With the isotope placed 1 cm behind the foil target, a thin layer of deuterated plastic was placed alternately on the front or back of the foil. The carbon isotope ¹¹C was detected in the boron sample when the deuterated film was placed on the front of the foil and laser pulsing was performed; no ¹¹C was detected when it was affixed to the back. This confirms that the ions are being accelerated from the front side of the thin foil. The researchers attribute the source of the protons to a thin layer of hydrocarbon and/or water vapor contaminants on the front of the foil. The proposed mechanism is charge separation due to hot-electron generation by the "vacuum heating" effect.

TIM PALUCKA

Improved Electronic Nose Developed for Highly Sensitive Detection and Discrimination of Biogenic Amines

A team of researchers from California Institute of Technology, Division of Chemistry and Chemical Engineering has

developed an "electronic nose" that is highly sensitive to biogenic amines. Biogenic amines have been related to, among other things, freshness of foods, biomarkers for lung cancer, and breath odor in patients with renal failure. The researchers report the development of an electronic nose for biogenic amines that is a million-fold improvement over previous such devices and which significantly outperforms the human nose. Although the researchers have previously reported the construction of such a device consisting of an array of chemically sensitive resistors based on a mixture of carbon black and an

insulating organic polymer (whose sensitivity exhibits trends generally close to the human nose for vapors of alkanes, alcohols, esters, carboxylic acids, and ketones), its thresholds for sensitivity to biogenic amines such as putrescine, cadaverine, and spermine are far away from those of its human competitor. For the new device, as reported in the March issue of *Chemistry of Materials*, the team has exploited the possibility of amines interacting with, and manipulating chemically, the electrical properties of a conducting organic polymer used in a composite material. Using the conductive polyaniline (referred to as

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emeraldine salt) mixed with carbon black, the team obtained experimental thresholds of 10 ppt (parts per trillion) for butylamine and 1 ppt for cadaverine, while the thresholds for the non-amine vapors were comparable to those of the previous device built. For comparison, the human detection threshold for butylamine has been reported to be between 0.1 and 1 ppm.

IULIA C. MUNTELE

Strong Directional Emission Observed in Lasing Characteristics of a Pendant Drop Deformed by an Applied Electric Field

In an article published in the April 1 issue of *Optics Letters*, Xiao-Yun Fu and Wing-Kee Lee from the Chinese University of Hong-Kong, Department of Physics, report the results of their studies of the lasing properties of an oval-shaped resonant cavity (ORC) with a continuously variable aspect ratio. The ORC was formed with a dye-doped pendant drop (rhodamine 6G dye in an ethylene glycol solution) placed inside a variable static electric field. Pumped with a nitrogen laser, the ORC drop was found to have strong directional emission characteristics and an intensity enhancement factor as great as 19.5, results that are in good agreement with the theoretical calculations. The anisotropy was found to increase as the eccentricity was increased. Also, the lasing threshold was found to decrease with the increase in eccentricity; for $e = 0$, the threshold was 6.2 μJ , while for $e = 0.38$, the threshold dropped to 3.8 μJ . Although no previous investigation on the optical properties of a continuously deformable pendant drop has been reported, tiny whispering-gallery-type lasers, such as microdisk, microcylinder, and microdroplet (circulatory symmetric resonators) have been previously studied, and are known to have two intrinsic disadvantages: the lack of high output power and directional emission. The use of asymmetric resonant cavities is believed to overcome these disadvantages.

CLAUDIU MUNTELE

Uniform Monolayer of Organic Molecules Provides Precise Control of Semiconductor Device Properties

The functions of organic molecules are so diverse that their inclusion in electronics would provide an extensive range of possibilities. However, the observation of these molecules' electrical properties has been impeded by incongruities in the

structure of organic molecules themselves. Layers of organic molecules that are used in this kind of research contain "pinholes" which are small defects that are very difficult to detect but radically sway conductance. Determining whether measurements resulted from the passage of the current through the organic molecules or through a pinhole was very difficult.

Researchers at the Weizmann Institute have found that changing the type of organic molecules in a monolayer led to a predictable, systematic change in the electrical characteristics of a semiconductor device. Not only were the researchers able to control the properties of the semiconductor in the device, but they also were able to predict the kind of control that would be exerted by different types of organic molecules over the device.

The researchers chose to analyze the molecules indirectly by focusing on the influence that the molecules were suspected to have on semiconductors. Using a series of molecules synthesized by Abraham Shanzer of the Weizmann Institute's Organic Chemistry Department, Ayelet Vilan, a graduate student working with David Cahen of the Materials and Interfaces Department, constructed a one-molecule-thick layer of very short organic molecules. The organic materials used were the so-called "di-carboxylic acids," which are tartaric acid derivatives; tartaric acid is also known as "fruit acid," and found, for example, in wine. Vilan placed the monolayer on a common semiconductor, GaAs, and directed an electric current through it. The monolayer was so thin that, for the most part, the electric current passed by the molecules without interacting with them. In an article published in the March 9 issue of *Nature*, the researchers report that this fact meant that it was of minimal importance if the electrons went via a molecule or a pinhole. According to the researchers, though, it is important to note that while the organic molecules barely affect the passage of the electrical current through them, they very much influence the electron affinity of the semiconductor, the energy that an electron gains when it comes from infinity into the semiconductor's conduction band.

Along with the decision to work with monolayers of organic molecules, Vilan developed a method for preparing semiconductor devices. The technique is founded on a widely used semiconductor device (diode), which is comprised of a semiconductor connected to a metal. She inserted the di-carboxylic acid organic monolayer between these two components—placed by self-assembly of the

molecules on the GaAs. Since the organic molecules were sandwiched between the semiconductor and the metal sheet, it was critically important to ensure that the delicate monolayer would not be crushed underneath the metal sheet. Vilan used a thin gold leaf as the metal sheet and gently floated it onto the monolayer. Thus, the monolayer remained intact. Vilan said that this study "provides new insights into the emerging field of molecular electronics. So little is known about the effects that occur between molecules and the electric conductors we normally use. This approach may provide a basis for the design of novel types of semiconductor-based devices, from improvements in relatively simple devices such as solar cells, to possible new types of computer chips."

Sn/Li₂O Nanocomposites Synthesized as Negative Electrode Materials for Lithium-Ion Batteries

A team of researchers, D.L. Foster, J. Wolfenstine, J.R. Read, and W.K. Behl, at the U.S. Army Research Laboratory, reported a method for the preparation of lithium oxide/tin nanocomposites in the May issue of *Electrochemical and Solid-State Letters* which show promising properties as electrode materials. The straightforward synthesis yields tin particles on the order of 100 nm or less which are uniformly distributed within a lithium oxide matrix. The composites showed improved performance as electrode materials compared to other SnO electrodes with the elimination of most of the irreversible capacity on the first cycle.

In an effort to enhance safety and rechargeability of lithium batteries, pure lithium anodes have been replaced by other lithium-containing compounds in recent years. Among the promising candidates are lithium/tin oxide nanocomposites that are transformed to tin/lithium oxide composites during the first cycle. This reduction "leads to a large irreversible capacity loss on the first discharge cycle," said Foster. Therefore, the team investigated the possibility of using a chemical reaction to form a tin/lithium oxide nanocomposite.

The successful process utilizes the commercially available precursors lithium nitride and tin oxide. The reactants are jar milled under a dry argon atmosphere for five days at room temperature, leading to the formation of tin, lithium oxide, and nitrogen gas. X-ray diffraction confirmed that the product contained a mixture of crystalline tin and an amorphous component that is most likely lithium oxide.

Scanning electron microscopy (SEM) imaging showed that most of the tin particles fall in the size range below 100 nm with fairly round shapes and a uniform distribution throughout the Li_2O matrix. "But apparently, there are still enough large tin particles to account for the rather narrow x-ray intensity peaks," said Wolfenstine. Electrical measurements resulted in curves for the jar milled composite and a SnO electrode that are very similar, but as expected the milled sample shows only little irreversible capacity loss. This indicates that the milling of Li_3N and SnO is a viable process for the formation of $\text{Sn}/\text{Li}_2\text{O}$ nanocomposites that avoids the difficult milling of soft and ductile tin itself.

The researchers agree that there is still room for optimization "such as controlling the temperature during the milling process, adding an inert material such as Al_2O_3 or Li_2O to the starting materials before milling, or starting with a tin-oxide glass or tin-oxide composite glass" in an effort to achieve even smaller particle sizes.

CORA LIND

Rod-Shaped CdSe Nanocrystals Produced

To date, experimental nanocrystals fashioned from semiconductors have been shaped like dots or spheres. However, researchers at Lawrence Berkeley National Laboratory and the University of California—Berkeley have produced CdSe nanocrystals that are shaped like rods as reported in the March 2 issue of *Nature*.

"We have demonstrated that controlling the kinetics of semiconductor nanocrystal growth can be used to vary the shapes of the resulting particles from a nearly spherical morphology to a rod-like one," said Paul Alivisatos, the leader of the experimental team who holds a joint appointment with Berkeley Lab's Materials Sciences Division, and with the UC Berkeley Chemistry Department. "These rod-like semiconductor nanocrystals may prove advantageous in biological labeling experiments and as chromophores in light-emitting diodes."

By carefully maintaining a relatively fast rate of growth in the right mix of surfactant, the researchers could induce crystals of a selected size to assume an elongated rod-like faceted shape that maximized crystal surface area. Subsequent tests showed that these rod-shaped nanocrystals emit light that is polarized along their long-axis in contrast to the nonpolarized light fluoresced by cadmium-selenide nanocrystal dots.

"Polarized emission along the long axis of these rods should be in biological tag-

ging experiments where the orientation of the tag needs to be determined," said Alivisatos.

Other tests showed that the gap between emission and absorption energies is larger for nanocrystal rods than for nanocrystal dots, which Alivisatos said should be an advantage in applications such as light-emitting diodes (LEDs) where the re-absorption of light can be a problem. It was also shown that the multiple rods could be packed and aligned, another advantage for both LEDs and for the use of these rods in photovoltaic cells.

Interactions of Synthesized Magmas Indicate the Importance of Chemical Reactions in the Formation of Volcanic Edifices

Recent experiments by Craig Lundstrom of the University of Illinois have shed light on how glassy materials are formed in exotic chunks of mantle called xenoliths, and how ascending magmas in the mantle can affect the lava output at Earth's surface through chemical, rather than thermal, reactions.

Lundstrom, a professor of geology,

said, "Sodium in ascending magma can quickly diffuse into the surrounding mantle at lower pressures, fundamentally altering the process by which the mantle melts. Sodium infiltration can account for the creation of silica-rich glasses in xenoliths, and for the anomalous mineralogical composition of mantle found beneath mid-ocean ridges."

Xenoliths are pieces of mantle that get pulled off and are carried to the surface during a volcanic eruption. Within the xenoliths are former melts—now found as glasses—which differ radically from the magma that typically emanates from the mantle, basalt. The glasses reside between the two primary silicate minerals of the uppermost mantle, olivine and orthopyroxene.

"Xenoliths have been found in alkali-rich magmas from ocean island and continental volcanic settings worldwide," Lundstrom said. "But the origin of the glassy regions, and why they have peculiar elemental compositions, have been poorly understood."

As reported in the February 3 issue of *Nature*, to study the potential chemical interaction, Lundstrom first synthesized samples of magma found deep in the

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mantle and of mantle lying much closer to the surface in a high-temperature, high-pressure apparatus. He then placed these samples together in the same apparatus and heated them for 10 min. After cooling the samples, he separated them and analyzed their mineralogical compositions.

"We generally think of magmas as moving very slowly and geological processes as occurring over hundreds of thousands of years, so it's really amazing how much happens in just 10 minutes," Lundstrom said. "In that brief time, considerable migration occurred as sodium diffused through the melt between mineral grains, significantly altering the composition of the material."

In a positive-feedback loop, the infiltrating sodium causes orthopyroxene to break down into olivine plus the peculiar composition melt. This melt, in turn, causes even more sodium to be pulled in. Lundstrom said that the increase in olivine and the decrease in orthopyroxene within the diffusively infiltrated piece of mantle may explain another perplexing observation: the anomalous ratio of these minerals found in the shallow mantle region beneath mid-ocean ridges.

He said, "We tend to think of volcanic edifices—like the Hawaiian Islands—as resulting from hot spots in the mantle. But these results show that sodium-rich, silica-poor magma can cause the surrounding mantle to melt through a chemical reaction without invoking huge quantities of heat." Lundstrom also said that the diffusion process could be important to melting the cold lithospheric "plates" that cover the earth.

Model of Interactions Between Coupled Atomic Bose Condensate and Molecular Gas Predicts Formation of Molecular Bose Condensates

Researchers investigating dilute Bose-Einstein condensation (BEC) have proposed a novel, non-Arrhenius chemical kinetics at ultralow temperatures. D.J. Heinzen and R.H. Wynar at the University of Texas—Austin, and P.D. Drummond and K.V. Kheruntsyan at the University of Queensland in Australia have named this phenomenon "superchemistry." Defined as "the coherent stimulation of chemical reactions via macroscopic occupation of a quantum state by a bosonic chemical species," superchemistry involves giant collective oscillations between a dilute, trapped Bose-condensed atomic gas and a diatomic molecular Bose gas. Coupling takes place between these two species through coherent Raman transitions, and

leads to the formation of a molecular Bose condensate through stimulated emission of molecular bosons.

Of particular interest in their model is the introduction of the particle number nonconserving potential, similar to parameters used to describe nonlinear optics. In the Arrhenius kinetics model the rates of chemical reaction are independent of the number of particles of product species and tend toward zero at ultralow temperatures. However, as published in the May 1 issue of *Physical Review Letters*, the proposed superchemistry kinetics model shows that chemical conversions inside a Bose condensate are caused by coherent stimulated emission, which is enhanced by the number of molecules already occupying the ground state. The current research considers the specific case of stimulated Raman coupling induced by two laser fields of different frequencies; resonant coupling occurs when Raman detuning goes to zero. A trap potential localizes the interaction volume.

The investigators see potential applications in the area of quantum-controlled chemical synthesis.

TIM PALUCKA

Wavelength-Interchanged Optical Sensor Facilitates Biochemical Analysis

M. Wiki and R.E. Kunz from Centre Suisse d'Electronique et de Microtechnique in Zurich, Switzerland reported in the April 1 issue of *Optics Letters* a novel sensor that allows the simultaneous measurement of several different biochemicals. The miniature (18 cm × 6 cm × 4 cm) integrated-optical sensor relies on wavelength-modulation techniques to interrogate multiple waveguide sensing regions in a single integrated-optical chip for accurate measurements of effective refractive index changes at a high data rate. The sensor can exploit the wide tuning range of vertical-cavity surface-emitting lasers to obtain high-resolution spectral measurements of refractive-indices. The integrated optical chip structure is based upon TiO₂ waveguide structures fabricated over a polycarbonate substrate onto which grating structures are fabricated using a hot embossing process. The experiments with this sensor yielded a resolution (in units of the effective refractive index) $\Delta N_{pp} = 10^{-7}$. The researchers' method consists of an input grating-coupler scheme. The structure consists of two different grating pads, one used as a reference pad and one of which is obstructed by the transparent biochemical layer to be analyzed. The position of the output resonance peak is a measure of

the effective refractive index of the sensor chip, and hence contains the desired information about the biochemical layer, information that can be extracted by applying a theoretical model of the IO sensor chip. Integrated optics is one well-known technique for label-free detection of (bio)electrical reactions, and has been used for many years. Previously developed integrated-optical sensors include sensors based on uniform grating couplers, chirped grating couplers, surface-plasmon resonance, resonant mirrors, and difference Mach-Zehnder and Young interferometers. But for practical applications, most label-free sensors either do not achieve the desired resolution for multiple channels, or are very bulky and expensive.

CLAUDIU MUNTELE

Blends of Electron- and Ion-Conducting Polymers Yield Fast Electrodes in Supercapacitors

A team of researchers at Linköping University in Sweden described the synthesis of polymer blends that are both electron- and ion-conducting in the May issue of *Electrochemical and Solid-State Letters*. The blends consist of electronically conductive PEDOT-PSS (poly(3,4-ethylenedioxythiophene)-polystyrenesulfonate) and ionically conductive PEO (polyethylene oxide) and give higher energy densities at high power densities compared to pure PEDOT-PSS polymers. The network morphology of the PEDOT-PSS extends these electrodes into the third dimension, making them promising materials for use in supercapacitors, sensors, and electrocatalysts.

"Electronically conducting polymers are of interest for use as electrode materials because their amorphous nature gives them good permeability to electrolytes," said Olle Inganäs from Linköping's Applied Physics Division. "However, ionic compatibility is often low, which limits the charge transfer in these systems by the slow ionic exchange." In recent years, the researchers obtained a patent on a process that involves doping PEDOT with PSS and ionically cross-linking the resulting polymer into highly swollen hydrogels. This yields 3D networks of electronically conducting polymers with more than 90% in an aqueous phase that provides good ionic mobility. "But application of PEDOT-PSS hydrogel electrodes is restricted to aqueous systems, which have comparatively small windows for electrochemical potentials", said Soumyadeb Ghosh, a postdoc at Linköping University. In order

to force the polymer to swell in organic solvents, he and Inganäs investigated the behavior of PEDOT-PSS blends with PEO, which are known to form conductive PEDOT-PSS networks in a PEO matrix that could provide space for ionic movements.

Films of the polymer blends were cast onto gold-coated silicon wafers from aqueous dispersions and used as active electrodes. Cyclic voltammetry indicated that the PEDOT-PSS/PEO blends show the expected higher ionic mobility. Although the measured current is lower than for swollen hydrogels, the two values become comparable if they are normalized to the mass of PEDOT-PSS that is present in each electrode. This indicates similar efficiencies for both systems. The efficiency of the blend electrode increases with decreasing PEDOT-PSS content (down to about 25%), showing that the high compatibility of the two polymers allows the formation of a network morphology even at low PEDOT-PSS concentrations. Supercapacitor measurements gave high energy densities for the blend electrodes even at power densities five times higher than the drop-off for pure PEDOT-PSS electrodes. "These power densities were calculated using the total weight of the blend", Ghosh said. "This means that we get higher energies with a smaller amount of redox material."

"The increase in ionic mobility in the PEDOT-PSS blend with inclusion of PEO can be ascribed to the intrinsic ionic conductivity of the latter polymer as well as to the swelling of the PEO phase in the acetonitrile solution, creating space for ionic movement," Inganäs said. The researchers reported that the comparative experiments with blended and unblended PEDOT-PSS electrodes in a solid-state cell suggest that "the intrinsic ionic conductivity of PEO does contribute to the enhancement of ionic mobility."

Currently, the group is working "on better crosslinking of the electronically conducting PEDOT-PSS phase and on loading the material with more energy-rich material to increase the energy density, keeping the network morphology and hence the ionic mobility intact," said Ghosh. In the hydrogels, this has been achieved by introduction of polypyrrole, a second conducting polymer.

CORA LIND

Versatile Pattern Transfer Process for Polymers Developed

Researchers from the University of Massachusetts and the University of Groningen, The Netherlands, have

reported a nanoscopic pattern transfer phenomenon. Erik Schaffer, a graduate student at Groningen, and Thomas Thurn-Albrecht, a postdoctoral researcher at Massachusetts, placed a thin film of polystyrene atop an electrode. They placed a second electrode above the film, leaving an air gap between the film and the top electrode. They then heated the polystyrene, liquefying it, and placed a small voltage on the electrodes.

With time, as reported in the February 24 issue of *Nature*, the surface of the film appeared pockmarked. Tom Russell, in polymer science and engineering at Massachusetts, said that the electric field amplified waves on the liquid's surface. The waves were increasingly amplified and eventually were pulled to the top electrode. The phenomenon appears under the microscope as a dark ring on a light background. As time passed, more and more circles appeared. The circles were all the same size, and appeared at a precise distance from one another.

Russell said that the phenomenon occurs because of the interaction of four competing forces. Those forces include the electrical force, which pulls the liquid toward the top electrode; the surface energy of the liquid, which wants the liquid to lie flat; the viscosity of the liquid as crests and valleys form and the liquid moves; and the effects of atmospheric pressure. "It doesn't happen helter-skelter," he said. "It happened at very distinct distances that represents a delicate balance between all of these forces."

Through a process called pattern transfer, the researchers can "imprint" a film with a very specific design. In this process, an electrode is etched with a master pattern. The master electrode has a topography of "hills" and "valleys." When a voltage is applied, the film responds most strongly to the closest portions of the electrode, creating a replica of the master design on the polymer film. The researchers said that their findings have implications in paving the way for still-smaller integrated circuits, magnetic storage in computers, and on-chip sensors—all of this without the use of chemicals.

Additional CeO₂ Buffer Layer Improves Performance of Superconducting Tape

The microstructural development of a superconducting tape (coated conductor) consisting of a layer of YBa₂Cu₃O_y (Y-123) superconducting material (1–3- μ m thick) on an Inconel 625 substrate 100- μ m thick with a layer of yttria-stabilized zirconia (YSZ) 0.8- μ m thick and CeO₂ buffer lay-

ers (~0.03- μ m thick) was studied by researchers at the Los Alamos National Laboratory (LANL). They reported in the May 2000 issue of the *Journal of Materials Research* that an additional buffer layer is useful "for removing the misfit strain from the interface with the superconductor and limiting the extent of interfacial reactions with Y-123."

Since its discovery, Y-123 has been actively investigated for high critical current and high current density applications at liquid nitrogen temperatures. The epitaxially prepared materials studied at LANL exhibit the best critical current and current density in a 1 m Y-123 tape produced to date. These favorable characteristics are believed to result from the use of two buffer layers between the substrate and the superconducting film. The YSZ buffer layer improves performance by preventing the Ni and Cr from the substrate from contaminating the Y-123 layer and providing a biaxially aligned template for its growth. The CeO₂ buffer layer is believed to improve conductor performance by removing the lattice mismatch strain between the YSZ and Y-123 layers. To extend the current technology to the production of conductors longer than 1 m, and possibly improve conductor performance, the microstructural properties of the conductor during processing need to be investigated. This study detected and explained a number of such features.

A Cr₂O₃ layer was detected between the substrate and the YSZ layers by electron diffraction and energy dispersive spectroscopy. The researchers speculate that this layer formed *in situ* during the high temperature deposition of the CeO₂ and Y-123 layers and not during the room temperature deposition of the YSZ. The researchers believe that it is the Cr₂O₃ layer that prevents Ni and Cr from the Inconel from contaminating the Y-123, as neither metal could be detected above the Cr₂O₃. This is an important finding because it proves that the Inconel substrate is compatible with the YSZ layer. This is advantageous because YSZ is the only material known that can be reliably deposited as a biaxially textured film for Y-123 deposition.

No evidence for a reaction between YSZ and CeO₂ was detected; however, there was evidence of misfit dislocation between the layers. According to the researchers, since Y-123 is closely lattice matched to CeO₂, the extra buffer layer apparently moves the misfit strain away from the Y-123 film. The researchers reported, "A volume constraint imposed by the overlying Y-123 film may act as a kinetic barrier and limit the extent of the

reaction." This result confirms the hypothesis that CeO_2 improves performance by removing the misfit strain between YSZ and Y-123.

The formation of several secondary phases was detected between CeO_2 and Y-123 indicating chemical reactions between the two layers. The formation of these phases is believed to have occurred after the deposition of the Y-123 because the biaxially textured structure of the Y-123 was not affected by the presence of a different phase below it. The reactions between these layers liberated material from the CeO_2 layer which diffused into the Y-123 layer as planar defects causing many gaps and cracks in this layer. These defects did not significantly affect the performance of the conductor used in this study but they may pose a problem for thicker layers of Y-123 or those deposited at higher temperatures.

GREGORY A. KHITROV

Development of Poly(ferrocenophane) Yields a Moldable Magnetic Ceramic Material

Researchers from the University of Toronto have reported in the February 25 issue of *Science* a step toward tunable, ceramic magnets. Mark J. MacLachlan and colleagues transformed iron-and-polymer molecules into a magnetic ceramic material, which was molded into various shapes. The key to the process is a technique for opening the rings in polymers. The group begins with monomers of silaferrocenophane (SFP). Subjecting the SFP to gentle heat produces poly(ferrocenylsilane), or PFS. Poured into molds of various shapes and subjected to more low heat, the molecules in this precursor material transform into a cross-linked network, which is loaded with trapped iron.

High doses of heat in a pyrolysis chamber sets the encapsulated iron free to seek other iron and form nanoclusters. Because larger clusters are more strongly magnetic, or ferromagnetic, the researchers can tune the material's magnetism by adjusting the temperature inside the pyrolysis chamber. Around 500°C , the structure transforms, and iron starts coming together. The size of the clusters grows in correlation with higher temperatures.

Molded into different shapes, such a material may be useful for high-density data storage, antistatic coatings for aircraft or spacecraft, among other applications, according to the research team. □

Correction

In *MRS Bulletin*, March 2000 issue, page 45, an incorrect illustration ran in Figure 11c from the article "Science and Applications of Mixed Conductors for Lithium Batteries," by Michael M. Thackeray, John O. Thomas, and M. Stanley Whittingham. See the corrected full figure that follows.

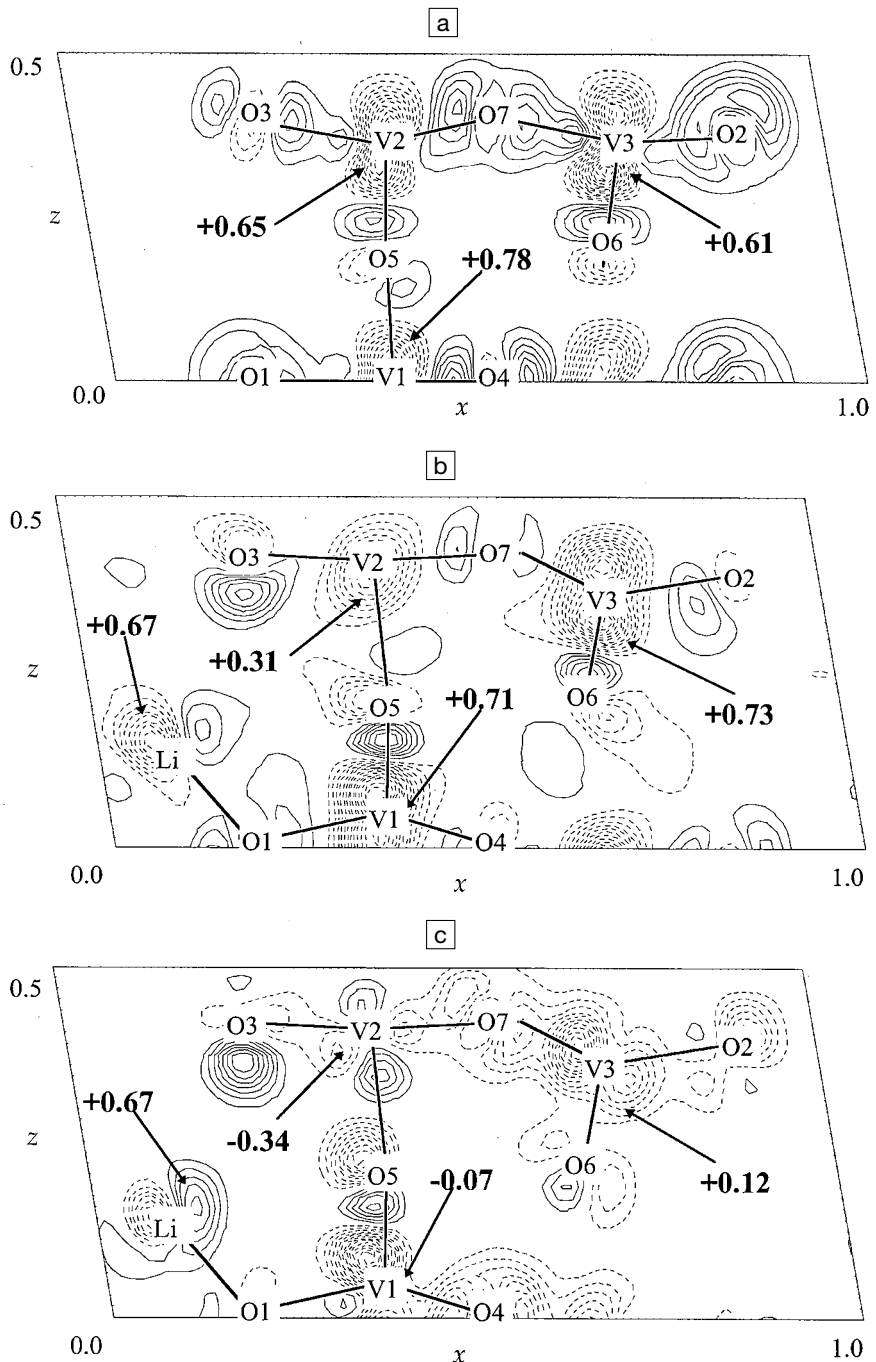


Figure 11. Deformation electron-density maps for (a) V_6O_{13} and (b) $\text{Li}_2\text{V}_6\text{O}_{13}$, and (c) the difference deformation electron-density map ($[\text{Li}_2\text{V}_6\text{O}_{13} - \text{V}_6\text{O}_{13}]$) in the a - c plane of V_6O_{13} . Contour intervals plotted at $0.05 \text{ e}/\text{\AA}^3$; negative regions are represented by solid lines; positive regions are represented by dashed lines; zero level removed.