

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 $3 \times 10^{18} \text{ W/cm}^2$ 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 ^{10}B 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 ^{11}C was detected in the boron sample when the deuterated film was placed on the front of the foil and laser pulsing was performed; no ^{11}C 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 Shanzler 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.