

read-back amplitudes depend strongly on the write phase, vanishing for writing out-of-phase on the single-domain islands as a result of the fact that bit transitions (domain walls) cannot be placed in the islands, and thus each island would have a 0.5 probability of being magnetized either up or down. The researchers also found evidence that for in-phase writing, there is a reduction of the read-back signal compared with the unpatterned media of identical linear density, which was linked to the reduction of magnetic material associated with patterning, although even the very smallest islands clearly exhibit a periodic signal. The work is still in its beginning stages, and it will continue focusing on improving the stability of the patterned island arrays.

CLAUDIU MUNTELE

Electrical Microdischarge Channel Integrated with Si p-n Diode Allows Efficient Generation of Visible/Near-IR Light

Efforts to generate visible or near-infrared radiation from silicon have a long history, but have been only moderately successful. External quantum efficiencies as high as ~1% are the most that could be obtained after extensive research. A research team from the Department of Electrical and Computer Engineering at the University of Illinois has taken a different approach to overcome the problem, integrating a reverse-biased silicon *p-n* junction with an electrical gas-discharge microchannel as reported in the February 5 issue of *Applied Physics Letters*. The gas discharge driven by a *p-n* junction offers the possibility of fabricating large arrays, and can be directly integrated with electronic and opto-electronic devices.

In designing these devices, C.J. Wagner, S.-J. Park, and J.G. Eden used commercially available diodes with the casings removed. After depositing a poly(methyl methacrylate) (PMMA) film around the perimeter of the exposed area for breakdown prevention, they drilled by ultrasonic milling a cylindrical channel through the ohmic contact and the *p-n* junction. The devices were then filled with the desired pressure of research-grade gas. For a Ne gas pressure of 700 Torr, the wavelength-integrated (300-800-nm) output power was ~48 μ W for an operating current of 5.7 mA and a bias voltage of 134 V. Unlike previous hollow and planar cathode microdischarge devices fabricated in Si, no dielectric layer is required with this approach. The simplicity and robust structure of these hybrid semicon-

ductor/gas-discharge devices as well as their suitability for manufacture by conventional photolithographic and laser micromachining techniques make them attractive for arrays and on-chip atomic-frequency standards.

CLAUDIU MUNTELE

Single-Electron Inverter Achieves Voltage Gain of 2.6 at 25 mK

Theoretically, single-electron tunneling devices could be used for computation because they can be made very small and would consume little power. However,

few actual logic elements have been built and tested. C.P. Heij, P. Hadley, and J.E. Mooij from Delft University of Technology, The Netherlands, recently fabricated and experimentally tested a single-electron inverter.

As reported in the February 19 issue of *Applied Physics Letters*, the inverter consists of two identical single-electron transistors (SETs) in series, sharing a common input gate, bearing a strong resemblance to a standard complementary metal-oxide semiconductor (CMOS) inverter. Each SET contains a small aluminum island,

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capacitively coupled with the input voltage V_i through an 8-nm-thick Al_xO_y layer. Small tunnel junctions connect the transistors to power lead, output, and ground. A load capacitor connects the output to the ground to suppress charging effects. Two tuning gates, with voltages V_{g1} and V_{g2} , are used to tune the induced charges on the two islands.

The device was fabricated on a thermally oxidized silicon substrate using a high-resolution electron-beam pattern generator at 100 kV. A bottom layer of Al served as the lower electrodes of the gate capacitors and the load capacitor. An Al_xO_y dielectric layer was created upon these electrodes by oxidizing the sample in an O_2 plasma. A second (upper) layer of Al forms the aluminum islands and the leads; on this layer the four tunnel junctions were defined by shadow evaporation.

The inverter operates such that one SET is conducting while the other is in Coulomb blockade, depending upon the input voltage. Shifting the input voltage alters the induced charge on the SETs by a fraction of an electron and inverts the input.

Measurements were performed in a dilution refrigerator with a base temperature of 25 mK, while suppressing superconductivity using a 1 T magnetic field. The input-output behavior of this device varied greatly depending on the two gate voltages V_{g1} and V_{g2} . A maximum voltage gain of 2.6 was achieved at 25 mK, which remained larger than one up to about 140 mK, confirming that the device operated as designed. This is the highest temperature for which voltage gain in a SET has been achieved.

Inverters are building blocks for other digital logic elements, including NAND or NOR gates, SRAMS, and ring oscillators which should be producible from variations of or combinations of SET inverters. To date, however, there is no automatic method that would allow optimization of performance by adjusting gate voltages on-chip. The researchers state that "this is probably the largest problem inhibiting the further development of this sort of logic."

WIRAWAN PURWANTO

Electrophoretic Approach Results in 3D Assemblies of Gold Nanoparticles

A promising synthetic path for the preparation of three-dimensional (3D) films of gold nanoparticles has been described by a team of researchers at the Notre Dame Radiation Laboratory. In the February issue of *Nano Letters*, they report that highly porous nanostructured

films were assembled using an electrophoretic approach. The film thickness could be controlled by varying the concentration of gold colloids in solution and the applied voltage. The particles did not aggregate, as evidenced by the strong surface plasmon band.

The electrophoretic deposition method subjects colloidal solutions of tetraoctylammonium-bromide-capped gold nanoparticles of 5–10-nm diameter in toluene to a dc electric field (50–400 V). This results in a negative charge on the gold nanoparticles, which are then driven toward the positively charged electrode surface. In this study, the composite electrode consisted of an optically transparent electrode (conducting glass) onto which was cast a nanostructured TiO_2 film. The porous TiO_2 film is required for good deposition of the gold nanoparticles. The nanoparticles form a 3D array on the electrode surface without undergoing aggregation or inducing bulk film effects.

"We believe that the capping material acts as a spacer between the adjacent particles in the film," said senior research scientist Prashant V. Kamat, who conducted this study together with Nirmala Chandrasekharan, a postdoctoral re-

searcher at the Radiation Laboratory. "The films exhibit a strong surface plasmon band, which indicates that they retain their identity as individual nanoparticles." The thickness of the films can be controlled by adjusting the concentration of the colloidal solutions and the applied voltage.

The nanostructured films obtained by electrophoretic deposition are stable in atmosphere and highly porous, thus providing a large surface area for anchoring electroactive or photoactive molecules.

"To the best of our knowledge, this is the first report that highlights the feasibility of achieving relatively thick nanoporous gold films with minimal aggregation effects," said Kamat. "The ability to assemble gold nanoparticles as a 3D array of clusters opens new avenues for designing sensors and optoelectronic nanodevices. Nanostructured gold films of high surface area also have potential applications in catalysis and photoelectrochemistry."

CORA LIND

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