

Figure 1. Schematic of a laser focused through a transparent electrode onto a photovoltaic blend film. Current is collected with a metal-coated atomic force microscope tip.

active devices with an area of 1.5 mm^2 (see Figure 1).

In between the Al electrodes of a device, the researchers aligned a conductive AFM probe at the center of a diffraction-limited laser (532 nm) spot, which generated a photocurrent signal sufficient for imaging at current levels in the range of $\sim 1\text{--}10 \text{ pA}$ at low intensity or at $\sim 1 \text{ nA}$ at high intensity, corresponding to observation of the photocurrent intensity dependence over nearly six orders of magnitude in illumination intensity.

The research team collected photocurrent images under short circuit conditions (zero applied bias) as well as with various voltages applied between the ITO layer and the conductive, Pt-coated AFM probe tip. Contact mode was used to simultaneously measure the current and film height. The researchers observed variations in photocurrent by as much as a factor of three between individual PCBM domains with similar topography. They attributed these variations to differences in vertical film structure. The researchers speculate that "MDMO-PPV-rich regions generate low photocurrents because of poor charge mobility and/or energy level alignment" whereas "PCBM-rich regions generate more photocurrent, but the vertical position of a PCBM-rich domain and domain-stacking can limit electron extraction or enhance electron extraction depending on the thickness of the MDMO-PPV:PCBM overlayer."

In addition, the researchers observed smaller photocurrent fluctuations on a

length scale in the range of $\sim 200\text{--}600 \text{ nm}$. Photocurrents averaged from hundreds of measurements made with the Pt tip agree well with the photocurrents measured for bulk devices with Al contacts, demonstrating that the pcAFM measurements provide information relevant to device operation, despite the differences in geometry and intensity.

The researchers concluded that local heterogeneity diminishes solar cell performance; gaining greater control and regularity of film morphology in both lateral and vertical directions will improve performance. In addition, the researchers said that their technique's "simplicity should allow for the characterization of many other organic blends over a wide range of illumination intensity. Further, [because] this technique is based on standard current-voltage measurements, albeit on solar cells the size of the AFM tip, it is interesting to speculate that other current-voltage based characterizations, including space-charge limited photocurrent and time-of-flight mobility measurements, might be accessible with high resolution."

STEVEN TROHALAKI

Temperature Limit Set for Future Superconducting Magnet

The material currently used in magnetic resonance (MR) imaging machines in both hospitals and research laboratories—a low-temperature superconducting alloy of the metallic element niobium—has been pushed almost as far as it can go in achieving a magnetic field, of $\sim 21 \text{ Tesla}$. "A holy grail of the scientific community, as set out recently by the National Research Council, is to build a superconducting magnet of 30 Tesla," said William Halperin of Northwestern University. Now, a high-temperature superconductor—Bi-2212, a compound containing bismuth—has been identified as a material that might be suitable for the new wires needed to one day build a 30-Tesla magnet. A report on this finding has been published in the April issue of *Nature Physics* (p. 239; DOI: 10.1038/nphys540) by Halperin and B. Chen of Northwestern, P. Guptasarma of the University of Wisconsin–Milwaukee, D.G. Hinks of Argonne National Laboratory, V.F. Mitrović of Brown University, and A.P. Reyes and P.L. Kuhns of the National High Magnetic Field Laboratory in Tallahassee, Fla.

Halperin said, "In MR imaging, the higher the magnetic field, the higher the resolution, which provides scientists with more detail for analysis. A 30-Tesla magnet could drive significant advances in chemistry, biology, and medicine."

A superconductor, when cooled to its

appropriate temperature, conducts electricity without any resistance. Superconductivity first appears in Bi-2212 at a high temperature of 90 K, but Halperin and his colleagues found that the stable state required in high-magnetic fields can be established only when the temperature falls below 12 K. The team established this limit for Bi-2212.

Using MR techniques at the National High Magnetic Field Laboratory, Halperin and his team studied Bi-2212. To measure its properties, they put the rare isotope oxygen-17 into a crystal of Bi-2212, with the isotope acting as a probe, much like a fluorescent dye. They then determined the phase diagram of the material where superconductivity is stable, which showed high temperature and high magnetic field could not be achieved together.

"To create a 30-Tesla magnet, we need a superconducting material that can carry the required amount of electricity without blowing up," said Halperin; "We have found that the operating temperature for Bi-2212 must be below 12 K. The good news is that this temperature can be reached by cooling the magnet with liquid helium. If we had found the upper limit to be 2 K then the cryogenic requirements would be intractable."

"Sometimes what seems to be bad can be good," said Chen, lead author of the article and a graduate student of Halperin's. "Our findings set a speed limit. If you go beyond this speed you may have trouble. Knowing the upper temperature limit is a kind of security."

Halperin said, "Now that we have this information about Bi-2212, the next question is, 'Can such a magnet actually be made?'"

Flow of Tiny Bubbles Mimics Computer Circuitry

In work that could dramatically boost the capabilities of "lab-on-a-chip" devices, researchers at the Massachusetts Institute of Technology have created a way to use tiny bubbles to mimic the capabilities of a computer. The team, based at MIT's Center for Bits and Atoms, reports in the February 9 issue of *Science* (p. 832; DOI: 10.1126/science.1136907) that the bubbles in their microfluidic device can carry on-chip process control information, just like the electronic circuits of a traditional microprocessor, while also performing chemical reactions.

Researcher N. Gershenfeld, director of the Center for Bits and Atoms, said, "Bubble logic merges chemistry with computation, allowing a digital bit to carry a chemical payload. Until now, there was a clear distinction between the

materials in a reaction and the mechanisms to control them."

Microfluidics allow scientists to create tiny chips where nanoliters of fluids flow from one part of the chip to another, undergoing controlled chemical reactions in different parts of the chip and replacing the conventional test tubes and glassware used for chemistry for centuries.

The technology has the potential to revolutionize large-scale chemical analysis and synthesis, environmental and medical testing, and industrial production processes, but applications outside of the laboratory have been limited so far by the external control systems—valves and plumbing—required for its operation.

But now, the research team is able to control microfluidic chips by the interactions of bubbles flowing through microchannels, eliminating the need for external controls (see Figure 1).

"Now you can program what's happening inside the lab on a chip, by designing bubble logic circuits that function just like their electronic counterparts," said M. Prakash, Gershenfeld's co-author and graduate student.

Controlling chemical reactions will likely be a primary application for the chips, according to the researchers. It will be possible to create large-scale microfluidic sys-

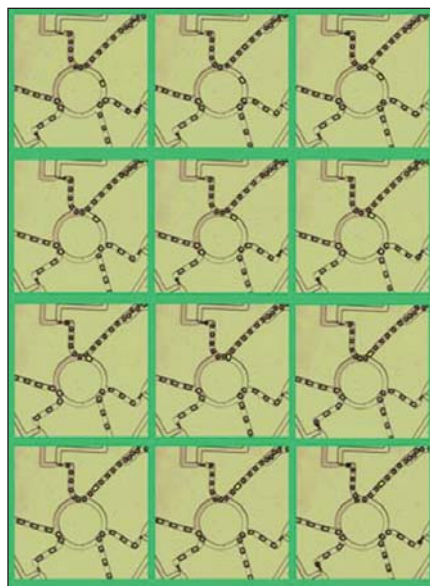


Figure 1. A colored montage of a ring oscillator used in a microfluidic computer. Starting with top left image, and reading left to right, the bubble flows around the ring toward the left until it reaches and joins a stream of bubbles. Image/Felice Frankel and Manu Prakash.

tems such as chemical memories, which store thousands of reagents on a chip (similar to data storage), using counters to dispense exact amounts and logic circuits to deliver them to specific destinations.

Other applications include combinatorial synthesis of many compositions at the same time, programmable print heads that can deposit a range of functional materials, and sorting biological cells.

The researchers modeled their new microfluidic chips on the architecture of existing digital circuits. But instead of using high and low voltages to represent a bit of information, they use the presence or absence of a bubble. They report on nitrogen bubbles in water, but any other combinations of materials that do not mix would work, such as oil and water.

In the *Science* article, the researchers report the elements needed for any new logic family, including gates, memories, amplifiers, and oscillators. The speed of operation is about 1000 times slower than a typical electronic microprocessor, but 100 times faster than the external valves and control systems used in existing microfluidic chips. Gershenfeld and Prakash anticipate that its invention will allow existing circuit designs (and designers) to work in the domain of microfluidics.

News of MRS Corporate Affiliates/Materials institutions

FUJIFILM Dimatix, Inc. (Santa Clara, Calif.), a wholly owned subsidiary of FUJIFILM Corp. and a developer and manufacturer of high-performance ink jet printheads and components used in a broad range of industrial, non-impact imaging applications, has been presented with the inaugural *Silicon Valley/San Jose Business Journal Emerging Technology Award* in the Biotechnology category for its innovative Dimatix Materials Printer (DMP).

The **Harvard Center for Microfluidic and Plasmonic Systems (MIPS)** is a multi-institution research initiative in

affiliation with Harvard University's programs in engineering and applied sciences. The three-year program, as announced in December 2006, has over \$2 million in total funding from the Defense Advanced Research Projects Agency (DARPA) and industry partners. Led by **Ken Crozier**, Assistant Professor of Electrical Engineering, the Center will carry out fundamental research into surface plasmon nanostructure design, fabrication, imaging, and integration with microfluidic systems. Other participating academic/research institutions include the Harvard Medical School, the Univer-

sity of Massachusetts at Amherst, and the Charles Stark Draper Laboratory. Industrial partners include U.S. Genomics, RSoft Design Group, LumArray, and Luminus Devices.

Plextronics, Inc. (Pittsburgh, Pa.) a developer of active layer technology for printed electronic devices, has been honored in 2006 with the **Organic Semiconductor Industry Award (OSIA) for Start-up of the Year** and the **National Renewable Energy Laboratory's Clean Energy Entrepreneur of the Year Award**. □

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