Speedier flexible electronics possible with new fabrication process

March 16 2009

A view through the microscope shows microwires aligned in the same direction laying across electrodes below. Courtesy of Zhenan Bao

(PhysOrg.com) -- A clever but simple new way of making transistors out of high-performance organic microwires presents a potential path for products such as smart merchandise tags, light and cheap solar panels, and flexible "digital paper." Engineers at Stanford and Samsung report the new method in a paper to be published online this week in the *Proceedings of the National Academy of Sciences*.

Academic and industrial researchers have been toiling all decade to create flexible electronics based on inexpensive organic materials. These materials can be cheaper than silicon and metal materials (albeit slower in performance), and amenable to cheaper manufacturing processes such as roll-to-roll printing of photovoltaic cells. They are also more compatible with flexible substrates, such as plastics.

"This paper brings together progress on key aspects of building flexible organic electronics," said Zhenan Bao, a Stanford associate professor of chemical engineering and a senior author of the paper. "In our process we can create organic semiconducting microwires with the most desirable electronic properties, flow a dispersed solution of them into a stencil, or mask, and then stamp them onto a pattern of electrodes. Because these wires can be precisely aligned with high density, the result is high-performance transistors."

Although the research alone is not enough to enable economical mass production of low-cost, high-performance flexible electronics, it could make their eventual manufacturing more feasible, said Jong Min Kim, a Samsung Fellow and senior vice president and a co-author of the paper.

"This technology can be applied to printable electronics such as low-cost and large-area display device components, radio frequency ID tags, sensors, memory devices and many different types of energy devices," Kim said.

In electronics, transistors act as switches. The team reported measurements showing that in their "on" state—when they transmit current—the group's dense microwire transistors operated about two-and-a-half times more quickly than the organic transistors most other research groups have announced to date. The transistors also transmit more current. In a flexible electronic display, faster operation results in blur-free motion, and higher current yields a brighter picture.

The performance improvements come from three factors, Bao said: the inherently fast conductivity of the single crystalline microwires, the new alignment method they developed and the ability to pack a high density of wires onto the electrodes. Because almost all of the wires span the electrodes, a large number of them make the connection, ensuring that more current gets across.

The Stanford-Samsung team's transistors are also among the best of a rare breed of organic "n-type" transistors, which transmit negative charges. They are just as necessary as more common "p-type" transistors for making integrated circuits, but have been harder to build.

In addition, the microwires, made from a chemical called BPE-PTCDI, are formulated to be "air stable," meaning that their electrical properties aren't spoiled by exposure to oxygen, as are many n-type organic transistors.

Prototype process

Because the process depends only on a stencil to align and concentrate the wires, the team was able to create patterns in which wires could be aligned in different directions in different places, a necessary capability for producing complex circuit designs. Also, Bao said, the team fabricated transistors over an area of several square centimeters, which suggests that patterning a large area could be feasible.

Demonstrating patterning over larger areas is a key goal for future work, Bao said. The team also hopes to study whether the technique could allow for more cost-effective fabrication of devices such as solar cell panels that use inorganic and organic micro- or nanowires.

Provided by Stanford University (news : web)

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