A Step Closer to Printing-Press Electronics

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One goal for the future of electronics is the ability to print large, flexible circuits using machines similar to printing presses. While great strides have been made in developing bendable and lightweight organic materials to use in this type of circuitry, methods to deposit those materials over large areas have not been as successful. Recently, a research group developed a circuit-printing technique that addresses some of the problems that have plagued other attempts.

One such problem, perhaps the biggest, is the inability of the other methods to produce high-resolution features – those down to the micron, or millionth-of-a-meter, scale.

Another issue is the rather low conductivity of the polymer materials used as electrodes in the circuits, which suggests a need for inorganic (metallic) electric contacts. An additional problem is the slight mixing of ink that occurs when ink is layered, which occurs during most types of printing. In conventional graphic-arts printing the end product isn't affected, but, in the case of "electronic inks," mixing would compromise the electrical characteristics of the circuit.

The research group, which includes scientists from the DuPont's Material Science and Engineering division and Organic ID, a subsidiary of Weyerhaeuser that manufactures printable RFID (radiofrequency identification) tags on plastic, fabricated a printing plate used to print the source-drain level of an array of thin-film transistors. Each transistor has a two-micron channel length (the separation between the source and drain lines, which determines transistor performance). This is the smallest channel length so far achieved by circuit-printing processes that have the potential to scale to printing presses. The plate is made of a specific polymer material – one resistant to chemical solvents used with electronic materials – on a flexible backing of Mylar, a type of plastic sheeting.

“We envision that a new generation of high-resolution printing plates in combination with nano-based inks will provide the platform for manufacturing electronic devices very similarly to what you see in commercial printing houses today,” corresponding author Graciela Blanchet of DuPont told PhysOrg.com.

The researchers inked the plate with a solution of silver nanoparticles, which, after the solvent evaporated, left it coated with a dry film of silver (thereby avoiding any mixing issues). The group next pressed the plate onto a Mylar substrate, transferring the nanoparticles from the raised portions of the plate onto the Mylar without degrading the pattern's high-resolution features. At this point, the printed silver pattern can be sintered (a process in which heat is used to increase the conductivity of the film).

The pattern consists of an array of “interdigitated” source and drain lines – that is, two interlaced stacks of lines, source lines on the left and drain lines on the right – that are all about five microns in width and separated by two microns (the transistor channel's length). Each interdigitated array (with the number of line pairs varying from 17 to 120) acts as a transistor: The lines the left are connected, defining the source of the transistor, and the lines on the right are also connected, defining the drain.

The researchers compared their array of dry-printed thin-film silver transistors to an array of gold transistors they produced using “photolithography,” a traditional fabrication method. Their electrical characteristics were nearly identical.

This research is described in the June 7 online edition of *Applied Physics Letters*.

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