PRINTING ELECTRONICS REPORT
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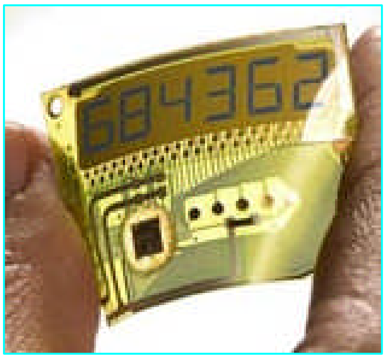
From Ken Gilleo - Ken@ET-Trends.com

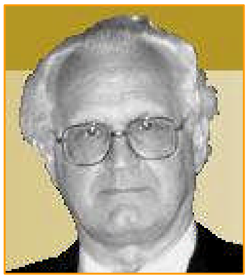
ET TRENDS

MARKETS/OPPORTUNITIES

Printed Electronics ICs - Real vs. Hype - According to IDTechEx, developers of thin-film organic transistors are claiming breakthroughs that they believe will finally push the technology to market. If successful, the efforts could enable a long-promised low-cost class of electronic paper, displays, labels, RFID tags, sensors, smart cards and perhaps even programmable wallpaper. [***In my opinion, PE is being severely over-hyped, especially by IDTechEx. Some of the ploys are to cite "old as new" and praise Polymer Thick Film products that have been around for decades. Membrane switches and RFID antennas have been printed with silver ink for decades. The PE folks, or maybe just IDTechEx, claim super-size markets and probably include stuff that does belong in the PE category. If only conductors and passives are printed, it's not PE; there must be active devices and the transistors is the minimum requirement. Diodes don't count since there is no amplification.***]

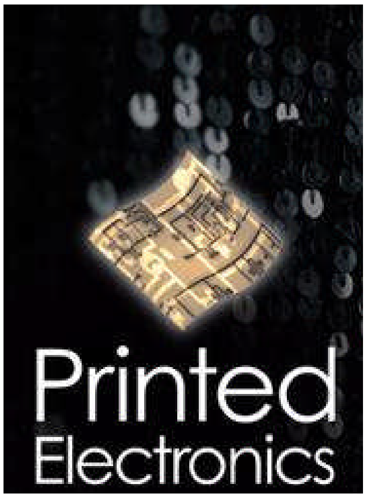


For years, promoters have been billing thin-film transistor circuits, and the broader category of printed or plastic electronics, as the next step beyond wafer-based ICs [***the term thin film is confusing since it applies to very thin, vacuum-deposited electronics. Printed electronics is thicker since it uses Polymer Thick Film (PTF). PTF was specifically called "thick" to differentiate from thin film***]. The technology uses inkjet and screen printers with polymer ***[thick film***] inks to print low-cost, low-density ICs on a system, display or just about anything else. As such, it promises to make the IC ubiquitous [the IC has been ubiquitous for a long time], opening a host of new applications. But despite the millions of dollars that have been invested in R&D over the years, a number of companies have failed to move thin-film transistor circuits into production. The transistors are working in the lab, but not one company has sold any in the commercial market according to Peter Harrop [***the head of hype for IDTechEx of Cambridge, UK***].



CONFERENCES

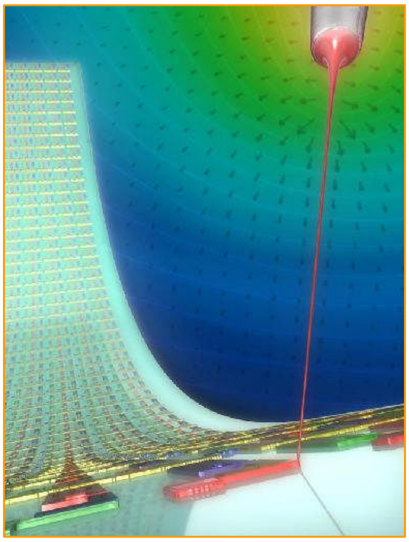
PE Expo - The recent Printed Electronics USA expo saw claims of progress from 3T Technologies, Kovio, Orfid, PolyIC, STMicroelectronics, Thin Film Electronics and others. Many claimed to have solved many of the problems associated with the technology. More than 150 organizations are said to be developing the technology in one form or another. Many seek shares of a [thick] "thin"-film transistor and memory market that IDTechEx predicts will grow from nearly zero today to $40-million by 2009 and $8-billion by 2017. Printed Electronics is a catchall phrase that describes the method of depositing simple electronic circuits on a system via inkjet printer or related means. The broader printed-electronics market, according to IDTechEx, includes conductive inks, electrophoretic displays, organic LEDs [they will probably include non-printed OLEDs to boost numbers], photovoltaics, and transistor circuits [?] and memories. In total, the market for printed electronics, including organics, inorganics and composites, is projected to grow from $1.8 billion in 2007 to $48.18 billion by 2017, according to IDTechEx. The fastest-growing market segments are for thin-film transistors and memory, according to the firm. Unlike traditional silicon chips, thin-film transistor circuits do not use crystalline or amorphous silicon; instead, thin-film products are based on organic or inorganic compounds that enable flexible circuits. [***They are blurring the definition of PE. On one hand, they call it polymer electronics, but here, they state that it can be based on "inorganics". Nanotech, however, has been leading the way with overhype and over-inclusion so that the definition has become meaningless. Perhaps IDTechEx is using the Nano-Marketeer Play Book. While a little bit of hype may be useful, and even unavoidable with enthusiasm, too much generally becomes a heavy burden in the future.***] Source: EE Times.



NEWS ITEMS

Printed Electronics Next Phase - Developers of PE-TFT circuits recently claimed breakthroughs that may finally push the technology to market and enable the long-promised low-cost class of electronic paper, displays, labels, RFID tags, sensors, smart cards and perhaps even programmable wallpaper. For years, promoters have been billing organic TFT circuit and the broader category of Printed Electronics (aka "polymer", "plastic", and "organic" electronics) as the next step beyond wafer-based ICs. [***I disagree; PE is not a replacement technology, but one that can create new products and markets.***] The technology can use inkjet and screen printers with polymer inks to print low-cost, but low-density ICs for display and many other products [***a potential, not yet realized***]. As such, it promises to make the IC ubiquitous, opening a host of new applications. However, despite the millions of dollars that has been invested in R&D over the years, a number of companies, including Intel, have not moved PE into production. Several companies hope to go commercial in 2008 and may include 3T Technologies, Kovio [***more on this company in a later section***], Orfid, PolyIC, STMicroelectronics, and Thin Film Electronics AB. The PE market, per IDTechEx, includes conductive and semiconductor inks, electrophoretic displays, OLEDs, thin-film photovoltaics, and transistor circuits and memories. The most promising segments are for TFT and memory. Successful transistors are the key to huge new markets that are not available to conventional silicon. Source: EE Times.

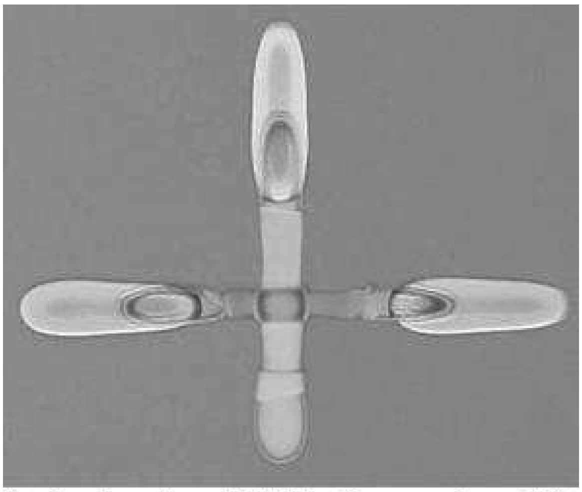
PE Company News - Thin Film Electronics (TFE) now produces low-cost, all-polymer nonvolatile rewritable memories, but is also pursuing RFID tags, smart labels and other applications. It's highly unlikely that PE will replace today's semiconductor memories, but will be a complementary technology to semiconductors. The company is thinking mostly about new applications. Belgium's Cartamundi Group plans to use TFE's technology to deposit memory circuits on a new class of standalone game cards that would let users play games over the Internet. TFE is putting the manufacturing infrastructure in place to bring its technology to market. Agfa and TFE announced that they intend to enhance the materials for volume production of printed memory devices. TFE also signed a deal with InkTec Co. Ltd of South Korea to collaborate on optimizing the latter's silver inks for memory cell electrodes. Meanwhile, ST-Micro claimed to have developed the first entries in a line of standalone thin-film circuits. Using a combination of nanoimprint lithography and inkjet printers, the company has devised a 4-bit arithmetic logic unit, a full adder and a one-time-programmable device. They acknowledged that there are a number of hurdles to clear before the technology enters production. Besides lackluster transistor performance, lack of stability in n-type organic materials is an issue.



Startup Kovio claims to have a silicon-based TFT technology for low-cost RFID tags. While present RFID tags run about 15-cents per unit, Kovio said its technology will lower the cost of RFID tags to 5-cents when it moves into production in 2008. The ultimate goal is to bring the tags down to a 1-cent per unit. PolyIC claims it has beaten rival Kovio. PolyIC is developing PE devices using an industrial roll-to-roll printing process. The company touts two organic-based chips: PolyID, a 13.56-MHz device equipped with a 4-bit memory, and PolyLogo, geared for "smart objects." The first products are expected to sample in a few weeks and the target for the RFID tags is a few-cent range. Startup Orfid claims to have begun shipping its first devices for the display market. Orfid has developed an organic electronic technology called the vertical organic field-effect transistor (VOFET). With its architecture and the use of conductive polymers in its fabrication, the VOFET offers performance characteristics similar to conventional, wafer-based silicon transistors but can be produced at significantly lower cost, the company said. U.K. startup 3T Technologies is working on a generic device platform and process for applying transparent conductive oxide materials to enable what it calls "transparent thin-film technology" or "invisible circuitry." "Based initially on zinc oxide as the active transparent semiconductor, the device construction and manufacturing approach provide the basic building block for transparent logic circuitry and display pixel switching to support a wide range of display media. Source: EE Times

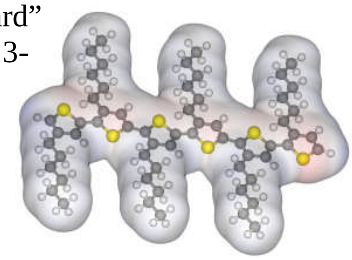
More on Kosio and Inkjet Printing of Transistors - Kovio printed an nFET thin film transistor (TFT) with electron motilities of 80 cm2/Vs. The company used ink jet printing to deposit electronic inks containing doped silicon, insulators, metal and other materials required for the multilayer device, which used 20 µm design rules. The 31-person company is already making integrated CMOS devices in its lab, and the company's roadmap includes creating RFID tags with <1000 transistors by the end of next year at cost targets far below what conventional subtractive silicon processing can achieve. The company's RFID tag chips would start out at the 20-µm design rules, though he said 10 µm design rules have been used in the company labs. Kovio uses stainless steel substrates similar to those used in photovoltaics. Longer term, the company seeks to apply its printing technology to solar and display applications, although the initial target is RFID tags costing just pennies each. Nanocrystals of electronic materials are used to formulate electronic inks.

Kovio claims that with its relatively high motilities, relatively low threshold voltages, and CMOS architectures, it can create CMOS RFID tags with low-power consumption. The transistors are fast enough to support the standard International Standards Organization (ISO) interfaces required to communicate with RFID readers and other parts of the RFID ecosystem. The company has been in stealth mode for six years, and recently achieved $20M in additional venture funding, enough to move to commercialization. The concept of silicon ink been out there for 30 years, but Kosio believes their ability to get to these motilities is a key building block to making things very, very cheaply, which is not easy to do with conventional silicon processing. Through an additive process using printing, we can save substantial amounts of money. While conventional fabs can cost billions and are adept at putting as many as a billion transistors on a single die, the goal with printed electronics is to create manufacturing facilities that are in the $10-million range. These fabs use a fraction of the chemicals required in subtractive processing, and electrical power consumption is also far less. Applications include such items as the billions of bottles and cans made each year that could use embed intelligence and communications capabilities, providing the costs are low enough. Reaching the goal of printing a few thousand transistors per chip very cheaply requires an ability to deposit high-performance silicon inks quickly. Rather than focusing on the number of transistors per square centimeter, a key parameter in printed electronics is “how much material you can lay down in one place per second. Once you get the performance capability that we have now developed, it is all about how to do it faster. If RFID tags can be made for a few pennies each, they will be cheap enough to embed in packaged consumer goods costing a dollar or two at unit volumes that could reach into the trillions. Source: SI



Kovio printed an nFET thin film transistor (TFT) with electron mobilities of 80 cm^2/Vs.

Plextronics to Expand Printed Electronics Technology - Plextronics announced that it has received a strategic investment by Applied Ventures, LLC, the venture capital arm of Applied Materials. The investment will help Plextronics continue to expand its product development and manufacturing capabilities. This investment comes on the heels of Plextronics' recently closed $20.6 million Series B financing, led by Solvay North America Investments LLC, with participation by Birchmere Ventures, Draper Triangle Ventures, Firelake Capital Management and Newlin Investment Company. An additional investment in the Series B round was provided by the Sustainable Energy Fund (SEF) of Central Eastern Pennsylvania. This was the second investment in the company that SEF has made this year. Plextronics has raised a total of $41-million in equity capital over the last 5-years. The printed electronics market comprises next-generation light, power and circuitry products, including flexible displays, plastic solar cells and organic RFID tags. Plextronics' device design, process technology and Plexcore branded inks enable the formation of active electrical layers - the key drivers of printed electronics. Plextronics claims to be a leading innovator of technology for printed electronics. The market for printed electronics was approximately $1-billion in 2006 and is expected to exceed $300-billion within 20 years. [***What are they including?***]. With a company vision of enabling 15-billion printed electronic devices by 2015, Plextronics is creating technology capable of commercial-scale performance and manufacturability. The company's device design, process technology and Plexcore branded inks enable the formation of active electrical layers, the key drivers of printed electronics. Plextronics was founded in 2002 as a spinout from Carnegie Mellon University, based upon conductive polymer technology developed by Dr. Richard McCullough. Over the past five years, Plextronics' team of scientists has refined and further developed this technology to deliver exceptional performance for printed electronics. Per their website, Plextronics sells Plextronics sells the “industry standard” organic semiconductor Plexcore OS P3HT, the highest quality Poly 3-hexyl-thiophene presently available. This p-type semiconductor product encompasses the attributes that drive device performance such as high purity, optimized molecular weight and stability that has enabled high mobility performance in an FET. Source: Nanotech Cafe.



Organic Bull? - ***Scientists rally to stop unrealistic claims made by researchers*** about the performance of a next-generation solar technology. Plextronics says its organic solar cells convert a higher percentage of light into power than its worldwide organic competitors [source: Plextronics Advertisement]. But, researchers working on an early stage technology called organic solar cells are struggling to prove who can convert the most light into electricity. Showing higher energy conversion rates helps open the door to investments. But some scientists are concerned that when it comes to reporting record efficiencies for organic solar cells, a slew of published research papers are coming up with unrealistic and questionable results. Their concern was made public in the October 2007 issue of "Materials Today"; sloppy outcomes can damage the burgeoning field. But just how realistic are such concerns? Organic solar cells are made from carbon-based materials. They can come in the form of high-tech plastics that conduct electricity.

Thin Film Solar & PE - These organic cells are part of the so-called "thin-film" solar category, which is made up of technologies that use little or no silicon, an attractive characteristic in a worldwide shortage of solar-grade silicon. Thin-film advocates say the technologies can be made using a simpler and cheaper manufacturing process, leading to lower costs. The cells also can be printed onto a flexible and lightweight substrate and other surfaces, which could lead to new applications for solar, such as textiles. But investors are lining up. This month, startup Konarka received $45 million in private equity for its "power plastic" technology from Mackenzie Financial Corporation, Good Energies, Pegasus Capital and Draper Fisher Jurvetson. And the Carbon Trust, a private company set up by the British government in response to climate change, is also getting in on the action. In October, it funded a $10.24 million organic solar cell R&D program; the University of Cambridge and The Technology Partnership will spearhead the project. But the technology still has hurdles to overcome before researchers and companies can bring it to the masses. Currently the cells hold relatively low efficiency rates ranging from about 3 to 5% compared to traditional solar electric cells at about a 15 to 20% efficiency. World-record efficiencies are popping up almost every month, leading the (organic solar cell) community into an endless and dangerous tendency to outbid the last report. A group of more than 15 scientists signed an opinion piece. Among them were eight scientists from Konarka, a Lowell, Mass.-based company working on organic solar-cell technology. The article noted opinions expressed are those of the author and the signatories, not the company's. The outbidding phenomenon is said to damage the reputation of organic solar cells, which already face enough difficulties when it comes to convincing people of their benefits over other energy sources. One solution is independent verification of solar-cell efficiencies from the U.S. National Renewable Energy Laboratory, Germany's Fraunhofer Institute for Solar Energy Systems, and other high-level international institutions. Reporting a world record, especially one that may not be repeatable, can penalize the funding agencies or investors for companies with good technology, but lower legitimate numbers. And there's room for differences since the "lab solar light" isn't even standardized. So who does hold the world record for the organic solar cell with the highest energy conversion rate? According to the independent verifiers, that honor belongs to Plextronics with a National Renewable Energy Laboratory certified 5.4% conversion rate. Source: Greentech Media

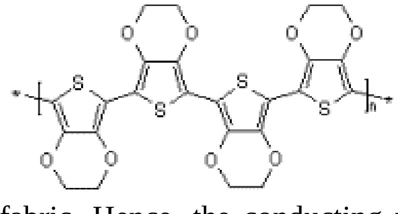
PE SENSORS

PE Sensors on Fabric - Printed strain and stress sensors smart textiles are expected to become an important family of products according to researchers at the US National Textile Center, University of Massachusetts Dartmouth. The properties of conducting polymers deposited onto textiles were studied over 10 years ago by workers at Los Alamos and Milliken who also tested these materials as gas sensors. More recently, workers at Wollongong have demonstrated that elastic textiles impregnated with conducting polymers, by in situ chemical polymerization, can act as strain sensors that can be used to track the motion of human joints. A similar approach can be used to make pressure-sensing foams. Others have studied the strain sensing mechanism in more detail and have shown that two effects are important. The researchers at NTC aimed to print stress and strain sensors on textiles to provide information about the actions of the body for the purposes of controlling and monitoring muscle action. They envisaged printing arrays of conductive piezoresistive sensors onto fabrics and using these to provide semi-quantitative information about the motion of a piece of clothing or other textile. The conducting polymer ink is a nano-particulate suspension which dries to a conducting film. The conductivity is thought to involve quantum tunneling between particles.

They have successfully inkjet printed both silver and non-conducting polymer lines onto textiles using a modified graphics printer that is programmed to repeatedly print over the same area to build up thick ink lines. Conducting leads were formed in two steps:

(1) Inkjet print seed layers on fabric and
(2) Convert these seed layers into metallic lines by electroless plating.

They also printed a suspension of 1.3 % by weight poly- (3,4-ethylenedioxythiophene)-poly-(4-styrenesulfonate) PEDOT-PSS onto mercerized plain, twill and sateen cotton fabrics, each with four different orientations. The printed lines were about 5 cm long by less than 1 mm wide. The resistance of silver is very low, so these lines serve as connectors. The resistances of the conducting polymer lines are in the range of kilo-ohms/cm, and this resistance changes with strain in the fabric. Hence, the conducting polymer can be used as a local strain sensor. The first few strain cycles showed rapid incremental increases in resistance because cracks form on the surface layer of



the printed sensor. On the other hand, the polymer embedded in the fabric flexes without cracking. After the initial period, the resistance value decreased with stretching and increased with relaxation (opposite to the other available strain sensor). All fabrics tested displayed a high gauge factor of 5 or more; whereas, metallic strain sensors have gauge factors in the range of 1.5 to 2. The system could be used to measure human activities; an assembly of sensors and connectors was attached with tape on a human knee and wrist to measure the resistance caused by bending the knee and twisting the wrist at both slow and fast speeds. The cyclic knee bending resistance data was produced. Printed conducting polymer piezoresistive strain sensors on fabrics can give a high negative gauge factor and so high sensitivity to small strains. Good performance derives from the polymer embedded within the yarn, while the surface layer cracks and becomes ineffective after one cycle of strain. The details of the sensing mechanism are unclear but it depends on improved fiber-to-fiber contact during tensile strain of the twisted yarns. These sensors could be used in medical rehabilitation and sports medicine. Source: Printed Electronics World.