PRINTING-DEPOSITION REPORT
(including Printed Electronics)
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BUSINESS & MARKET NEWS

New Printed Electronics Fab - Nanoident Technologies AG (Linz, Austria) has opened a production fab for ***Printed Organic Semiconductors***. The company claims it is the world's first organic fab. Initially, the company is focusing on sensors for life sciences, industrial and security applications. The company will produce about 40,000-m^2 of semiconductor material annually in an 800-m^2 fab with a 400-m^2 clean room. However, since organic electronic geometries are much larger than their silicon counterparts (feature sizes of 20-μ); figures are not really comparable between organic and silicon. The sensors will be available at lower cost; the price will be low enough to offer product for one-time use. Nanoident will produce customer-specific photo sensors in all shapes for a broad range of applications. Presently customers are active in medical and industrial markets. In addition, the parent company will provide technological expertise and basis technology for its application-oriented subsidiaries in Austria, France (Nanoident Biometrics SAS) and USA (Bioident Technologies).

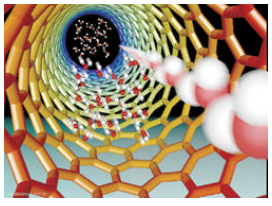
Biodent (Menlo Park, CA) produces a sensor array that it calls ***lab-on-a-chip***, but without electronics. The lab-on-a-chip can be used for a broad range of medical and environmental tests including measuring water quality, and for military sensor applications in the segment of biological and chemical warfare. The company serves customers in the medical and environmental diagnostics market. All sensors presently are designed for one-time use. Another product the company is working on is fingerprint sensors for use in mobile phone applications. With the use of plastic electronics, such sensors can be integrated directly into a mobile handset case. Organic fabs are orders of magnitude cheaper to build then silicon-based fabs; a few million dollars. The devices are designed using standard EDA software. The printing equipment also is off-the shelf with some *modifications* for material deposition. Also, the chemicals used to print the circuits are standard raw materials, but again with some *modifications*. It is very important to find the optimal solvent for each layer. Production started in 4Q-2006 but is still in run-up phase; sensors in low volumes. By the end of 2007, Nanoident plans to have reached full production capacity and have a fab headcount to about 40. Nanoident is privately held and does not provide sales figures. *[Opportunities for equipment and materials? Is this a single company event or a future trend?].*

Printed Electronics or Etched Silicon? - While high-end chips grow more complex at an accelerating pace, process advances do not help cost reduction for simple silicon chips. The cost of a chip factory and of the research to improve chip production is also rising exponentially and there is no mechanism to improve the simplest chips in future. Contrast *Printed Electronics* where production facilities are relatively cheap and easy to expand and the technology is coming down in price. Printed Electronics should therefore eventually replace silicon chips at the low end and other conventional components, including displays. However, it will be many years before very high frequency performance is economically feasible for most forms of Printed Electronics. Even simple

microprocessors and the UHF and microwave part of the RFID market, for example, will be served by silicon chips for many years to come. Given these driving forces, we can assess the appropriateness of the priorities of those developing and exploiting the technology. There is too little emphasis on creating new applications and exploiting existing Printed Electronic technology in the marketplace. Many companies are developing inks intermediate in conductance between carbon and silver based ones. Such inks will have potential if they have the right cost, printing characteristics, environmental credentials etc. In displays, the number of companies attempting to get OLEDs into the market is about 10X the number working on all other types put together. The market potential is more balanced, with a wide variety of price performance compromises needed in particular. In thin film transistors, most developers are concentrating on improving the cheapest technology based on soluble polymer semiconductors. This correctly reflects the market potential. Several companies are launching thin film and printed photovoltaics this year based on different technologies and benefits. There will be room for most of them because the potential markets are so diverse. However, there is little or no effort on creating printed batteries intermediate in performance between cheap and primitive carbon zinc and expensive lithium chemistries with their environmental challenges. The market badly needs something. There are also far too few companies developing the large capacity printed memory that the marketplace will demand. There is also too little effort on co-depositing and co-laminating a wide variety of other components with thin film transistor circuits. Success here may increase market potential by five or ten times. Some of the players are Eastman Kodak, BASF, the University of Tokyo, NanoMas *Technologies USA, the University of California, Paru Corporation Korea, Trinity College Dublin Ireland, Cambridge Display Technology, Plastic Logic* and many other global leaders in Printed Electronics. *[We'll keep tracking this emerging field]*

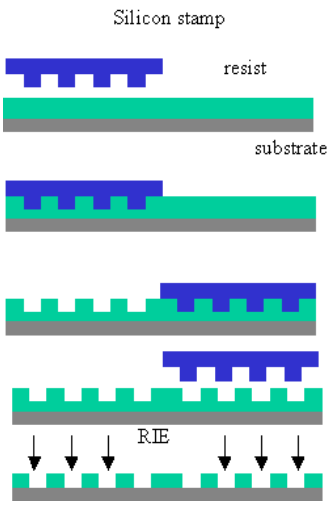
TECHNOLOGY

Nano Spray Technology - EV Group (EVG) announced an achievement in new photoresist coating technology. With its new Nano Spray technology, EVG has been able to demonstrate, for the first time, conformal coatings of vertical via walls 300-µ deep and 100-µ diameter. This new milestone in photoresist application will enable users to carryout further lithography steps in the bottom of the via to create through wafer interconnects and allow a new bandwidth of applications throughout many technologies in Semiconductor processing markets. While the coating of vertical features is common practice in MEMS technology, it has also recently been used in the advanced packaging and interconnect arenas. Vias are used to interconnect the active front side of the wafer to the backside and further onto the pins of the specific wafer level package. This coating technology was first realized by EVG on their EVG100 series coating equipment by development and integration of new spray technology and techniques. Continuous technological improvements of the equipment have enabled the ability to coat even steeper sidewalls than was achievable in the past. Fulfilling these challenging coating requirements was achieved with a unique spray process that is based on a spray mist created by ultrasonic nozzles. To meet the further challenges of the advanced packaging and interconnect markets EVG has developed a completely new Nano Spray nozzle that enables significant improvement in refined dispense and targeted positioning of the spray stream. With this new coating system, homogenous coatings of features 300-µ deep and 100-µ diameter can now be achieved.



Year of the Org-Fab - More polymer-semiconductor-based technology - Nanoident (Linz, Austria) has formally opened the world's first manufacturing facility supporting high-volume commercial production of printed semiconductor products. The facility will use the company's organic Semiconductor 2.0 Platform to produce printed optical sensors. The 2.0 Platform is their core technology which spans EDA tools, expertise in polymer liquid, conductive and semiconducting materials, and printing processes. Nanoident (privately owned) has invested €12-million in its new facility presently using four printing stations built by Fujifilm Dimatix; capacity is 40,000 m2 of substrate per year. Nanoident sees this as a new field opening up new markets in new classes of product and not necessarily competing directly with silicon. The facility is already delivering sample quantities of sensor products and will ramp up to production volumes within months. The printing processes are primarily ink-jet based, although screen printing is also employed for some tasks that do not require the highest resolution. Jet printing deposits materials in layers typically 100-nm thick, and with lateral feature sizes and resolutions of 20-microns. At present, the company can print up to 50x50 cm on rigid or flexible substrates, in its class-100 clean room. Almost any component in conventional electronics can be built in organic printed form, and where appropriate, silicon die can be mounted on the substrate as a hybrid structure. Recent attention in other companies has been focused on light-emitting structures such as OLEDs. The company will build emissive devices for applications such as optical sensors equipped with their own light source but will not go into displays where there are too many companies with deep pockets in that space already. Much of the company's key expertise lies in the detail of dealing with the materials. The conductive polymers and other compounds are obtained off-the-shelf from materials-science companies, but for every application, a specific set of "inks" must be blended: they must give the desired electrical properties, and also must be correct in parameters such as viscosity so that they print correctly. The sequence of solvents must also be compatible so that later layers in the process do not dissolve those first laid down.

Nanoimprint Technology - Nano-imprint lithography has emerged for the development of niche applications like hard-disk media, LEDs and photonics. But, can it be used in mainstream chip production? Though promising, nano-imprint lithography will have a difficult time in mainstream chip production due to throughput and overlay issues, according to analysts. And there may be too many vendors chasing after a relatively small market. MII, EV Group, Obducat, Nanonex and Suss MicroTec are the main providers of nano-imprint tools. Yet, nano-imprint lithography is an emerging technology that has demonstrated the production of chips at line width geometries down to 10-nm and it could be far less expensive than traditional optical lithography. Vast improvements are being made in overlay, throughput and other areas according to Molecular Imprints Inc. (MII), a nano-imprint lithography vendor. The timing is ripe for the technology in advanced IC production. 'There is a role for nano-imprint in sub-32-nm manufacturing. MII has already shipped one tool to Toshiba, which is reportedly using the machine for the development of NAND flash devices, sources said. MII also claims to have devised a 27-nm FinFET device from IBM Corp., based on its nano-imprint tool. The company's Imprio 1100 is a high-throughput, whole-wafer imprinter designed to enable next generation devices in a broad array of applications, including LEDs, high-density substrates for disk drives and optical components. A rival, Obducat AB, recently introduced Sindre, a nano-imprint lithography system for high-volume manufacturing. The Sindre system, named after a legendary



blacksmith dwarf of Nordic mythology, is able to imprint 30 200-mm wafers per hour. The company, which claims to have a 40% market share in nano-imprint lithography, said the Sindre system offers a manufacturing level solution for devices in cameras, mobile phones, flat screens and next-generation hard disk drives.

iNEMI Roadmapping Activity for 2007

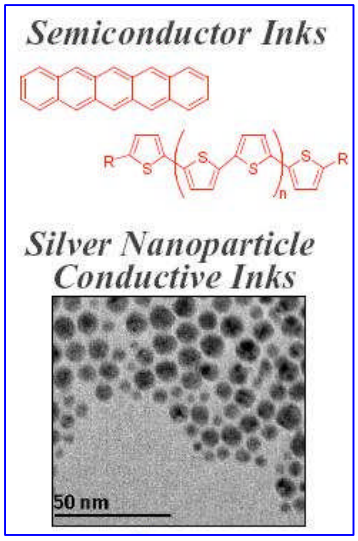
• Organic & Printed Electronics Roadmap debuts in the 2007 iNEMI microelectronics roadmap

• iNEMI members selected organic & printed electronics as future electronics high growth market

What transpired?
• Kickoff of iNEMI Technology Working Group - 02/2006 (Anaheim, CA)

• Engaged companies, academia, and government to provide an outlook for
large-area electronics products (51 participants from 33 organizations/companies)

• WG delivered 1st iNEMI Organic & Printed Electronics Roadmap in September 2006



What is next?
• Revisit and update Organic & Printed Section as necessary

[iNEMI's suggestion of rather old, nano-silver is more of a "knee-jerk" reaction; consider liquid organometallic that can generate continuous metal, for example]