PRESS RELEASE 24 February 2011

Record speed circuits from Stuttgart presented at ISSCC 20011 in San Francisco

Silicon Stencil Mask boosts Organic Thin-Film Transistor Speed

During the IEEE International Solid-State Circuits Conference (ISSCC 2011), held February 10th through 24th in San Francisco, scientists of renowned corporations, such IBM, Intel and Sun, present the latest developments and leading researchers demonstrate their recent findings.

At this meeting, researchers from the Institute for Microelectronics Stuttgart (IMS CHIPS) and the Max Planck Institute (MPI) for Solid State Research in Stuttgart, Germany, present the outcome of their joint effort that led to a record performance organic electronic circuit demonstration by using silicon stencil mask technology. They present a current steering mode 6-bit digital-to-analog convertor (DAC) in organic thin-film transistor (OTFT) technology, which is **1000 times faster** and **30 times smaller** than the currently fastest 6-bit DAC in organics.

OTFT by stencil mask technology: The two institutes have joined in an effort to demonstrate the smallest and fastest OTFT ever built in a manufacturable fabrication process. The group of Dr. Hagen Klauk at MPI is an international leader in research and development of organic thin-film transistor (OTFT) technology with a particular focus on low-voltage (<5 V) operation. This is the voltage range at which microelectronic chips operate. In contrast, most international competitors design OTFTs for high-voltage operation (>50 V), where OTFTs switch comparably faster. Besides supply voltage, the transistor speed is to a large extend determined by the length of the transistor's channel that can be controlled by the gate contact. A shorter channel leads to a faster transistor. Until recently Klauk's group used evaporation of materials through a plastic shadow mask, which is patterned by means of laser cutting. The minimum channel length feasible with this patterning technique is 20 µm. IMS CHIPS, headed by Prof. Joachim Burghartz, is an international renowned expert in nanopatterning. The team of Dr. Florian Letzkus at IMS CHIPS can fabricate silicon membrane stencil masks with feature sizes down to 100 nm, depending on the thickness of the membrane. A set of stencil masks with transistor channel lengths down to less than 1 µm were fabricated, allowing the MPI group to demonstrate transistors with a more than 20-fold shorter channel than before. Those transistors switched more than 100 times faster than the OTFTs built by using the plastic shadow masks. An additional breakthrough resulted from the mechanical quality of the silicon stencil masks, providing excellent stiffness and stability. As a result, the characteristics of transistors across the mask area were very similar, thus allowing for the design of circuits comparably to microelectronic chips. In contrast, the plastic shadow masks tend to some wrinkling and do not attach entirely planar to the substrate. This causes a rather large spread of device characteristics, which severely limit's the choice of circuit topologies that can be realized.

Circuit designers can therefore benefit from both the considerably higher transistor speed and the freedom to apply any circuit topology known from microelectronic circuit design. This led to the successful 6-bit DAC demonstration at ISSCC 2011, which is a 1000 times faster and 30 times smaller circuit than state-of-the-art.

OTFT applications: The OTFT is viewed as the basic device technology considered for future flexible electronic products. This includes flexible displays (so-called electronic paper), diagnostic tapes for medical monitoring and life sciences, radio-frequency identification (RF-ID) tags as a smart replacement for the barcode, smart ticketing and smart signage. The fabrication technology is quite different from microelectronics manufacturing. Flexible electronics will be fabricated by using high-throughput roll-to-roll printing technologies that will be derived from paper printing processes. There is even the vision to fabricate a sheet of electronic paper by using an inkjet printer similar to that on an office desk. While flexible electronics has potential to take a considerable part of the low-cost electronics market it will not be able to compete with microelectronics in terms of performance and integration density. Therefore hybrid solutions combining large-area organic electronics with thin flexible silicon chips may emerge in the future. For that reason there is a strong need for organic electronic transistor technology that operates at the same supply voltage as microelectronic chips.

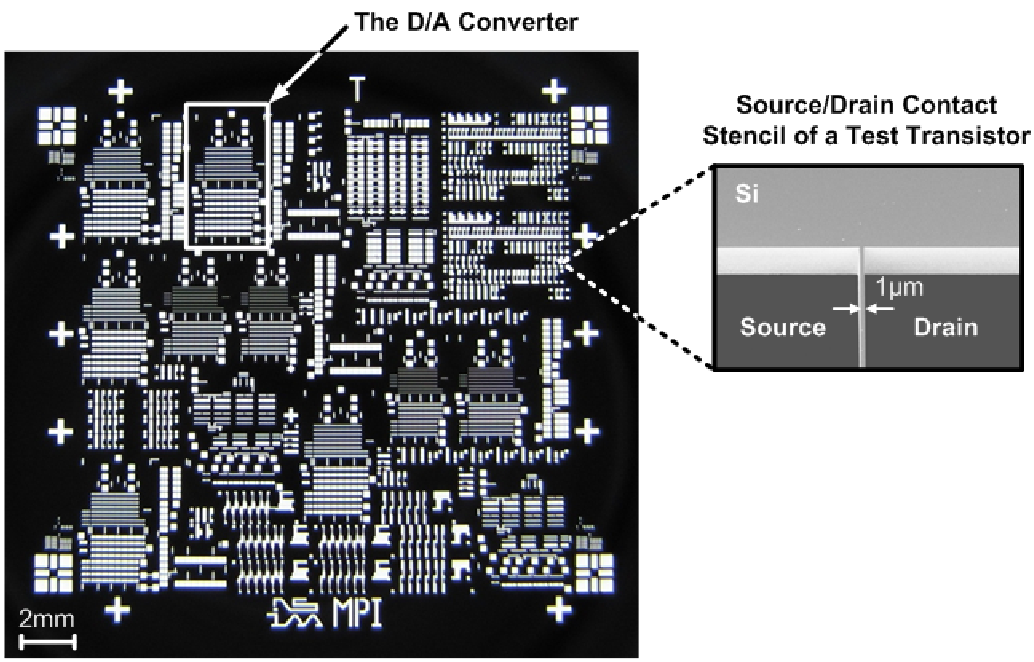

Fig. 1: Overall view of the stencil mask

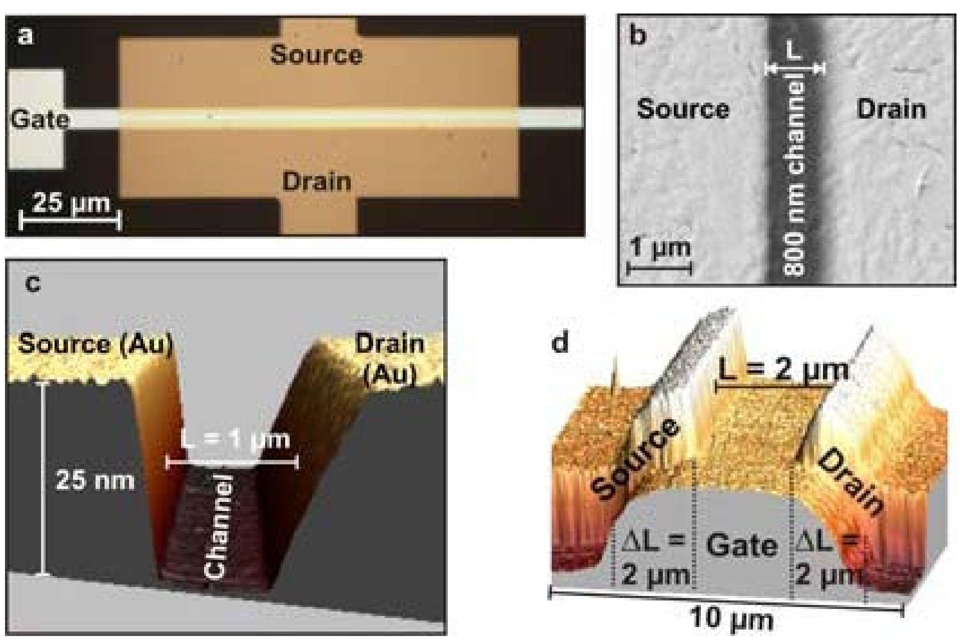

Fig. 2: Top view test transistor (a); REM photograph transistor channel (b); section view of transistor channel (c); section view of test transistor (d)

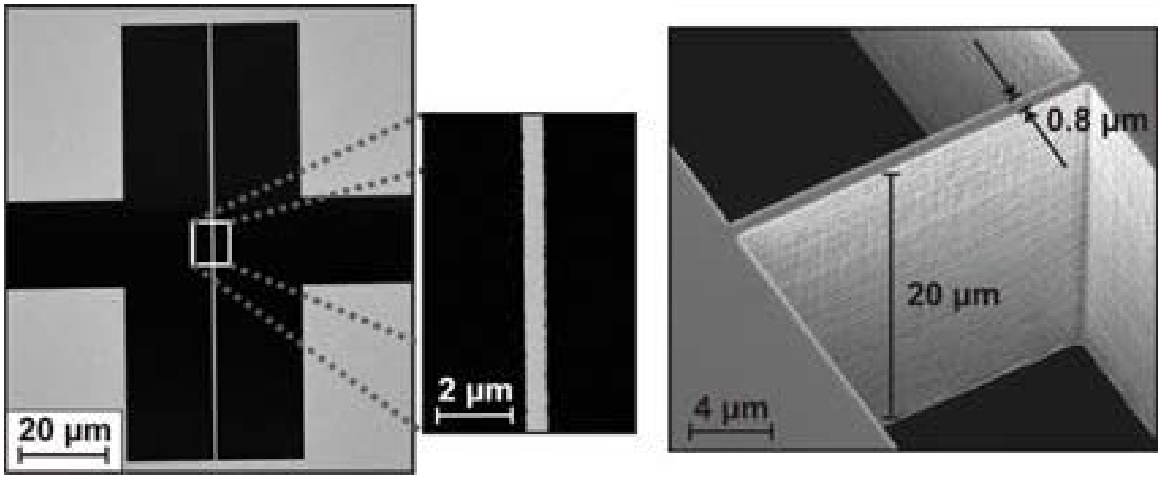

Fig. 3: Microscopic details of the transistor structure on the stencil mask

Summary IMS CHIPS

The Institute for Microelectronics Stuttgart (IMS CHIPS) is a foundation of the state of Baden Wuerttemberg and carries out industrial-oriented microelectronic research and fully qualified-small volume production in silicon technology, customized circuits (ASIC), photo lithography and image sensor technology as well as being involved in professional development. The institute is partner to various small and medium scale companies in Baden Württemberg in particular and cooperates with internationally renowned semiconductor corporations and contractors. Headed by Prof. Joachim Burghartz more than 80 highly qualified employees are contributing their expertise to the important area of microelectronics and its implementation into industry. www.ims-chips.de

Summary MPI (Organic Electronics Group)

The Organic Electronics Group of the Max Planck Institute (MPI) for Solid State Research was established in 2005. Research focuses on novel functional organic materials and on the manufacturing and characterization of organic and nanoscale electronic devices, such as high-performance organic thin-film transistors, carbon nanotube field-effect transistors, inorganic semiconductor nanowire field-effect transistors, and organic/inorganic hybrid radial superlattices. Scientific work in organic electronics is highly interdisciplinary and involves the design, synthesis and processing of functional organic and inorganic materials, the development of advanced micro-and nanofabrication techniques, device and circuit design, and materials and device characterization. www.fkf.mpg.de/oe/

IEEE International Solid State Circuits Conference (ISSCC 2011): http://isscc.org/

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