

1. Publishable Summary (year 4)

The last period the COSMIC project has been dedicated to the implementation of the COSMIC results into concrete demonstrators, which show convincingly the market opportunities for the different application fields in organic electronic. These different product segments are addressed by the different manufacturing platforms for large volume or large area devices.

With their W2W platform IMEC and TNO have taken over the demonstration task for the line driver, where they used their process flow for evaporated n- and p-type semiconductor to fabricate flexible display line drivers. A 32-bit line driver has been verified to be fully functional and being capable of driving a flexible OLED display. Also a correctly functional arithmetic logic unit (ALU) with organic transistors has been achieved. The devices cannot be reliably operated in air without further thin film barrier. Therefore a mixed application could not be implemented.

CEA-Liten's S2S platform based on printing processes achieved another outstanding result within COSMIC. An organic analog-to-digital converter with 4 bits has been already completed in 2012. For the end of the project a silent tag circuit is integrated, which is already in its 4-bit-version a very ambitious and complex circuit with regard to implementation of analog parts, signal detection and number of logic gates. Although the ready processed tag initially does not work as a whole; it could be shown that really large building blocks of the circuit with about 250 transistors are operating properly, including the receiver and the code recognition. Already this result clearly exceeds current state-of-the art in printed organic electronics and gives confidence that residual defects can be overcome in near future. At the end of the project, the printed S2S CMOS Design Tool Kit is now ready, first libraries of analog and digital blocks have been demonstrated and can be combined with printed P-OTFT active matrix backplane to realize Large Area Sensing Surfaces and Smart Interconnected Objects. CEA is open to innovative designers for prototyping circuits on plastics; this has already been tested by academic teams.

Fraunhofer EMFT has re-focused its roll-to-roll technology towards applications with a cost structure that are compliant with a low-cost large-volume application. For this the development targets on an RF system that facilitates sensor readout by modulation of the carrier frequency. To overcome the existing roadblocks in its technology lot of hope is set into the new Flexink materials, which have been tested with promising results by TU Berlin. However the process transfer has not yet succeeded in rising organic electronic performance above the necessary level.

Major enabler of the COSMIC developments are design, layout, characterization and modeling developed in collaboration between TU Eindhoven, University of Catania, CNR Rome and STMicroelectronics. The partners in this work package extensively worked in innovative circuit design of digital and analog building blocks, considering also design solutions adapted to organic material limitations and processing variations. Modeling provided a thorough analysis of the contact effects in staggered and coplanar (W2W technology) OTFTs. From these experimental results new model parameters were extracted and included in the new design kit.

In preparation of the planned demonstrators the industrial partners have worked out the system architecture for the planned circuits. Customized hardware platforms have been built, which allow to test the correct function of every lead application and to simulate an interaction between different lead application devices. Unfortunately verification of this mixed application remains a future task, since the different

limitations of the devices (air stability, availability, functionality) makes it impracticable to bring them together in a meaningful way.

Finally the developments have been accompanied by electrical analysis for modelling and reliability investigations under the lead of CNR. Reliability under bias stress has been extensively studied mainly with oTFT and circuits from CEA and to lesser extend also for W2W and R2R transistors. The results confirm that the observed instabilities are related to the combination of two mechanisms: a.) self-heating and b.) field induced charge trapping in the presence of water/OH-groups.

The industrial partners also undertook research on the business potential of COSMIC applications. With the support of CEA, Friendly Technologies explored the market and applications of pure and custom printed silent tags. ST explored the market and applications of the ALU and ADC. With the support of IMEC, Plastic Logic explored the market of the printed line driver. The industrial partners concluded that the potential market for the COSMIC applications is vast and justifies the present and further R&D investment.

Overall COSMIC has moved organic electronics a large big step forward from an engineering view as well as from a scientific perspective. There still are problems to solve but the project has well approached a point where this technology finds marketable applications, also beyond the classical lead applications.

For more information see the project website www.project-cosmic.eu

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