MOFETs II—MHz-operating Organic Field Effect Transistors II

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CSEM's sub-micrometer-channel organic field-effect transistors (MOFETs) technology – a combination of Hot Embossing Nanoimprint lithography (HE-NIL, standard industrial process) and self-aligned patterning of source and drain contacts – is under continuous optimization. After successfully downscaling the dielectric thickness (<50 nm), the current focus is set on proper selection of the semiconductor and the system integration. A ZnO suspension was casted onto CSEM's semiconductor screening platform. Preliminary results show operational transistors and environmental stability. The system integration was performed by using so-called inkjet gate array approach enabling higher system yield. This integration approach applied to MOFET technology can potentially deliver faster and low operating voltages organic circuits thus opening new opportunities for CSEM (e.g. RFID tags and smart printed circuits boards).

Organic Field Effect Transistors (OFETs), which can be fabricated with high throughput technologies on flexible and disposable substrates, can provide an alternative to inorganic amorphous silicon TFTs (a:Si TFTs). High performing OFETs with switching frequencies in MHz-range and low operating voltages are sufficiently good for display backplanes, RFID tags or disposable sensors.

The aim of MIP MOFETs II project was to further enhance CSEM's state-of-the-art organic field effect transistors (OFETs) technology (see Figure 1) by selecting proper semiconductor, with higher mobility and environmental stability and to demonstrate improved system integration yield by using so-called inkjet gate array approach.

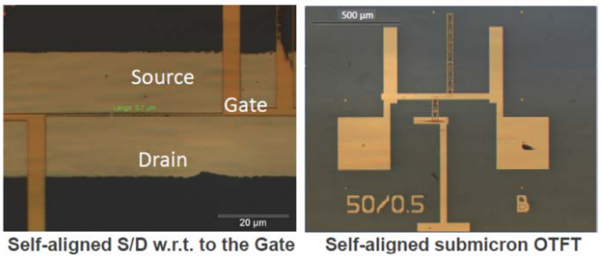

Figure 1: CSEM's sub-micrometer channel OTFTs technology.

Recently amorphous oxide semiconductors, which can also be printed, started drawing more and more attention as an alternative transistor active layer with respect to the traditionally used polymer-based semiconductors. We have tested a ZnO suspension casted by blade-coating on top of Si/SiO$_2$ dies with pre-patterned Au source /drain electrodes.

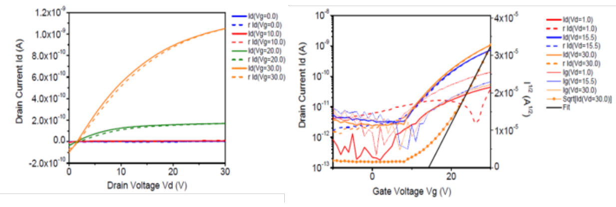

Figure 2: Typical output and transfer characteristics of the first batch of ZnO based OTFTs on the dedicated test substrates.

The resulting ZnO printed film shows a typical OTFTs behavior, illustrated in Figure 2. However, the preliminar resulting field-effect mobility is still low e.g. in the range of 10^{-6} cm^2/Vs. Therefore, further material/solvent testing need to be continued in order to achieve vacuum-deposited a:Si performances. Afterwards this material should be tested on the MOFETs' transistor stack. This work is in progress.

The second objective of this project was the demonstration of the MOFETs integration capabilities, through a digital circuit. A recent integration approach, the so-called inkjet gate array [11], was applied in a fault-tolerant design. This approach is illustrated in Figure 3.

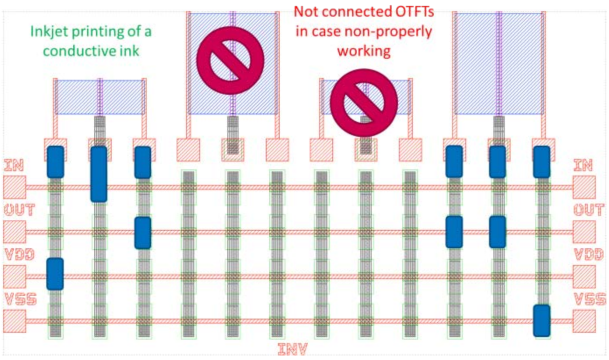

Figure 3: Inkjet Gate Array approach illustrated on Zero-Vgs Inverter.

As shown, only the properly working OFETs will be connected to the interconnections/bus lines, while non-working ones will remain disconnected. This interconnection process will be done by inkjet printing (blue areas in Figure 3). As the result, the system integration yield can be maximized.

Finally, the demonstrator, a capacitive sensor digital interface (illustrated in Figure 4), was designed with the above-mentioned integration approach and is under fabrication.

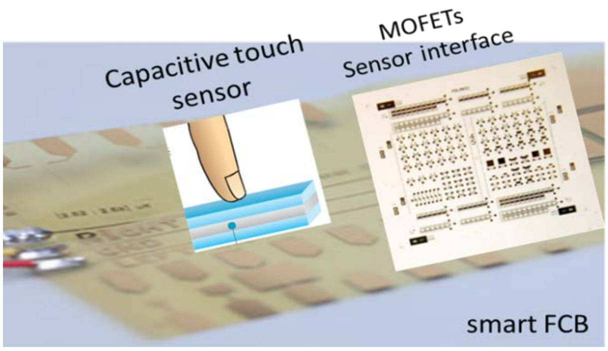

Figure 4: MOFETs II demonstrator concept.

This demonstrator provides an interface on foil to printed capacitive sensors. The modulation of the sensor capacitance, for example due to externally applied pressure, is detected in the frequency domain and indicated in a digital manner through an LED indicator. The demonstrator highlights the yield-increasing integration approach on MOFETs' technology.

[1] J. Carrabina, *et al.*, "Inkjet gate array: Novel concept to implement electronic systems", LOPE-C, Munich, May 26, 2014