The SiMBiT bioelectronic smart system

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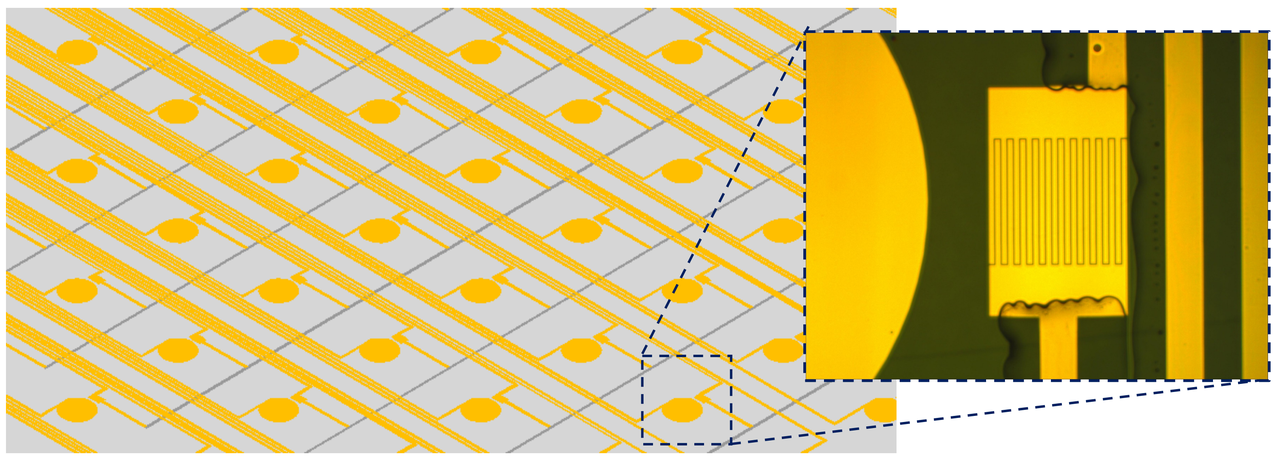
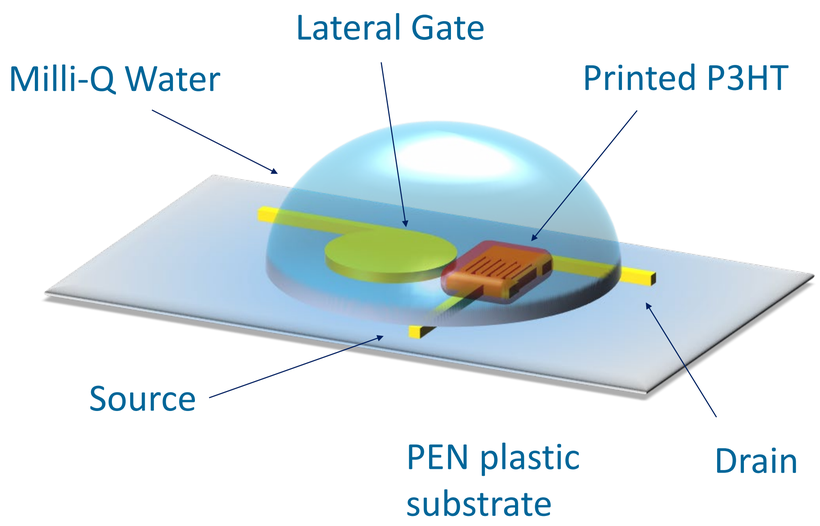
Digitizing biomarkers analysis by quantifying them at the single-molecule level is the new frontier for advancing the science of precision health. Such an occurrence will enormously enhance their ability of curing diseases by supporting better prognosis and permitting the application of precise treatment methods.
The SiMBiT project will develop a bio-electronic smart system leveraging on an existing lab-based proof-of-concept that can perform single-molecule detection of both proteins and DNA bio-markers [1] in a minimal sample volume, with enhanced sensing capabilities. In its final shape, it comprises a 96-well plate with the electrolyte gated organic transistors (EG-TFTs) sensing array and the bio-functionalized gates module along with addressing and front-end electronics and an electronic plate reader.
Here we present the activity of IIT on SiMBiT project which is related to the fabrication, with large-area compatible processes combining printing and laser writing techniques, and optimization of the EG-TFT structure, which will be integrated in a 8x12 matrix.

Water-Gated Transistors Matrix Array

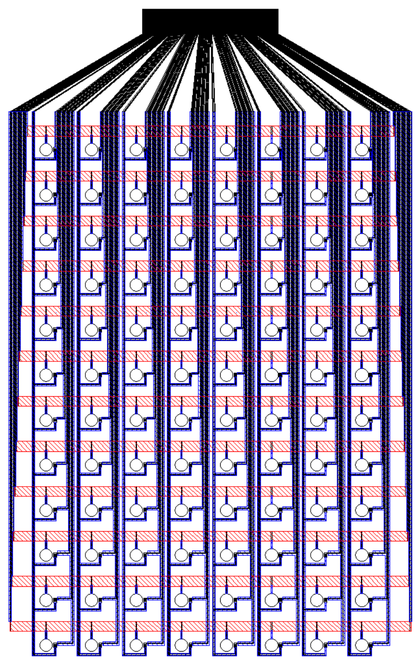


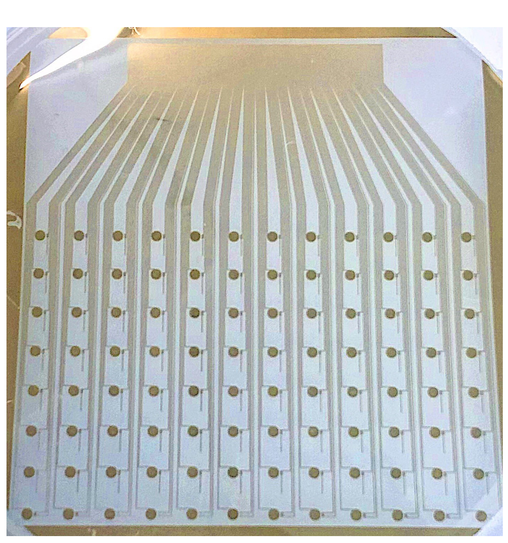


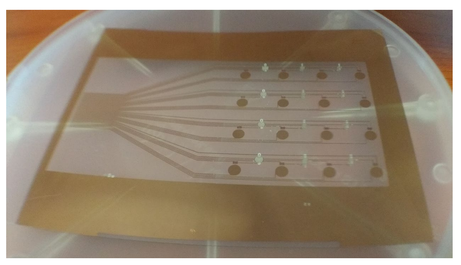
Fabrication Process

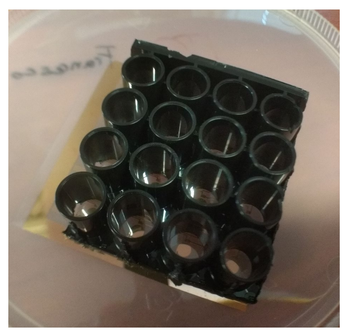
- Lithographic deposition of gold source, drain and lateral gate electrodes
- Inket printing of the organic semiconductor (P3HT) and of SU8 dielectric
- Deposition of the liquid electrolyte over the channel and gate area

Matrix Design and Protoypes



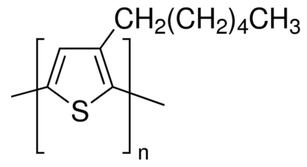


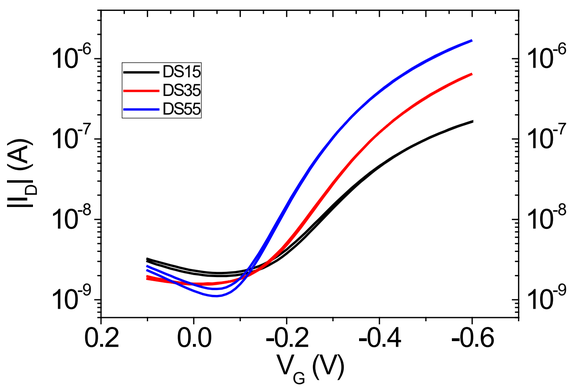




Inkjet Printing the OSCs

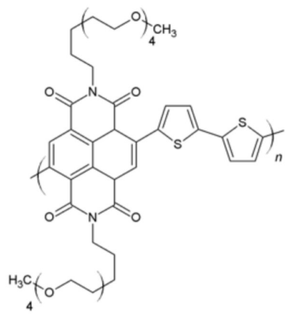
P3HT

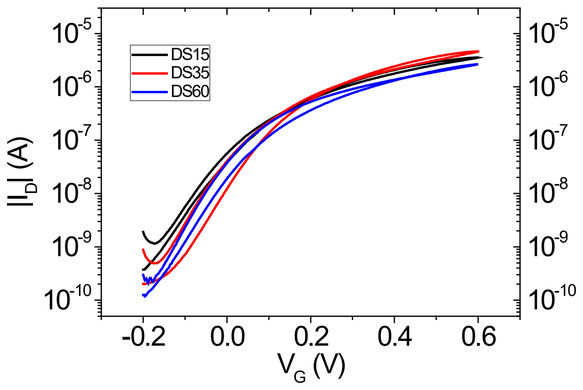




DS	I_{on}	I_{off}	I_{on}/I_{off}
15	160 nA	2 nA	80
35	640 nA	1.6 nA	400
55	1.7 µA	1.1 nA	1540

PNDI2-TEG

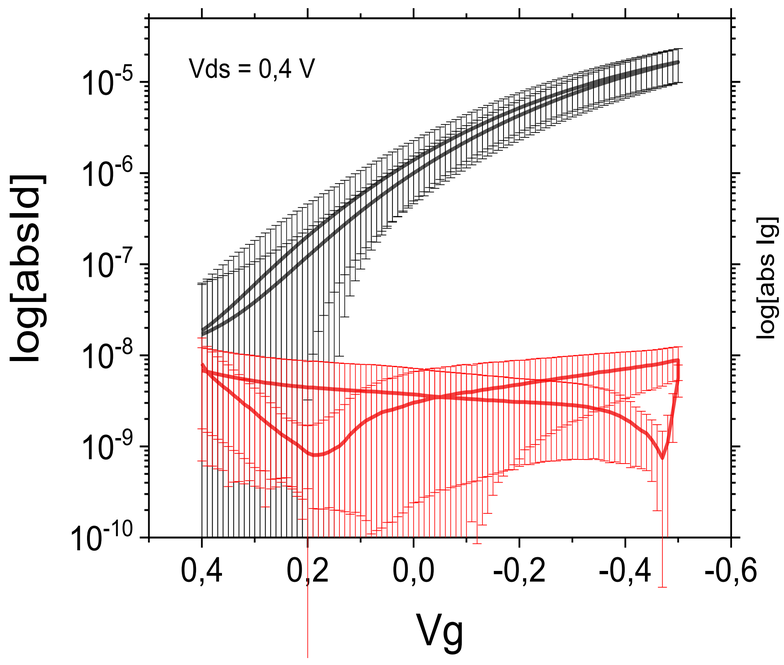




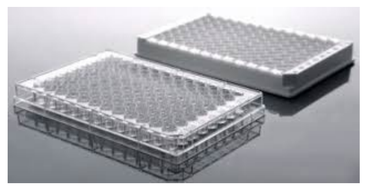
DS	I_{on}	I_{off}	I_{on}/I_{off}
15	3.5 µA	1 nA	3500
35	4.5 µA	500 pA	9000
60	2.6 µA	200 pA	13000

The drop spacing (DS) is the distance between the centers of two contiguous inkjet printed drops. By changing DS, it is possible to finely tune the on/off ratio of the EG-TFT. In fact, varying the DS corresponds to a variation in the thickness of the semiconductor, which leads to an increase/decrease of the bulk conductivity

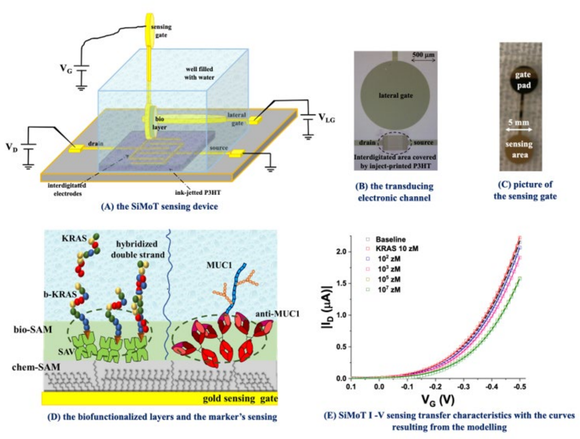
Characterization and Reproducibility of 8x12 Arrays

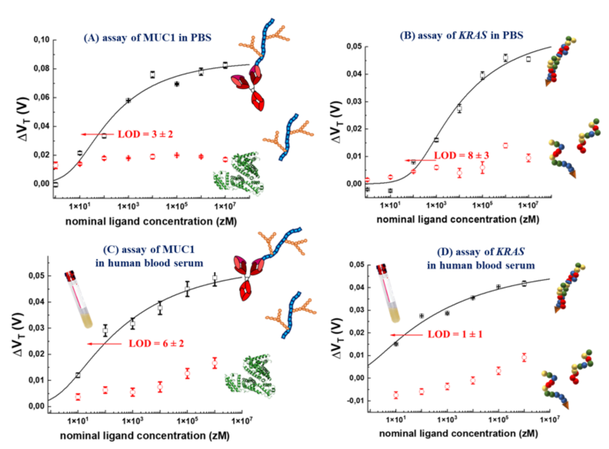


Large Area 6 inches PEN flexible substrate
96 biosensors (layout compatible with standard ELISA plates), 208 tot contacts
Results after stabilization in water
Layout optimized for external reading electronics interface



Biosensing and Single Molecule Detection





Biosensing experiments carried out on the SiMBiT platform (single devices), achieving Limits of Detection (LODs) down to the single molecule level

References

[1] E. Macchia et al., "Single-molecule detection with a millimetre-sized transistor," Nat. Commun., vol. 9, no. 1, 2018.

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