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Design and evaluation of a Double-Gate Organic Thin Film Transistor (OTFT) for biosensing

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Organic Thin Film Transistors (OTFTs) technology opens new opportunities for the biosensor industry, achieving very low detection limits with low-cost and biocompatible materials processed on large-area flexible substrates. However, existing structures of OTFT-biosensors often limit the use of materials with poor-stability in air or water because it exposes the Organic Semiconductor (OSC) to the analyte.

In this study, we designed a double-gate architecture that protect the OSC from direct analyte interactions thanks to a deported sensitive gate structure, and we investigate its potential for biosensing applications. The structure is inspired from a single top-gate OTFT technology we modified to add a second gate below the OSC channel. We defined a very versatile process combining spin-coating of the OSC and organic dielectric layers, photolithography for patterning the channel and gold electrodes, and screen-printing of conductive polymer PEDOT:PSS for top-gate electrodes.

Double-gate operation measurements have shown the electrostatic interdependence of the threshold voltages for the double-channel structure, and identified the best couple of gate-voltages to reach the maximum transconductance for readout voltage optimisation. Optical microscopy, profilometry and Scanning Electron Microscopy validated the geometric parameters extracted from electrical measurements. First trials of silane-epoxy surface chemistry for bioreceptor grafting (oligonucleotides) have been conducted on PEDOT:PSS gate-electrode, showing no critical material deterioration for electrical performances.

This work demonstrates that our double-gate OTFT has the potential to become a biosensor, opening the gate to further studies of biofunctionalisation and detection limit evaluation.