Material characterization and electrochemical performance for all-inkjet organic ISFET-based biosensor

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Organic electronics (OE) offers the possibility to produce devices on large-area, low-cost, plastic substrates. Recently, an interesting OE application has emerged into the field in biosensing application. The tireless development of Organic Thin Film Transistors (OTFTs) has offered the opportunity to develop flexible sensitive field-effect transistors. The sensitivity of organic materials has been used intentionality by exposing an active layer of the OTFT to the biological target. The presence of biological material (i.e antibodies, DNA etc) dissolved in the electrolytic solution alters the electrical properties of the exposed layer. From this principle, several examples of biosensors have been developed, based on the possibility of functionalizing the surface of the exposed layer with molecular layers with specific binding properties for the biomolecules solved in medium to monitor. Thanks to this feature, OTFT-based ion-sensitive field - effect transistors (ISFET) have been developed (Bartic and Borghs, 2006). In such structures, the gate contact of OTFT is replaced by an electrolyte and a reference electrode exposing the dielectric layer to the specimens. The detection of the biological material is performed via the field effect since the properties of the dielectric material are strongly affected.

In principle, with respect to the silicon based structures, inkjet based FET is proposed to minimize the fabrication cost and reduce processing complexities. Inkjet printing is a flexible, versatile and low-cost technique which doesn't require tooling, masks or screens. In addition, these devices can be fabricated by stamping or other deposition techniques onto different kinds of materials, which require low temperatures, are environmentally friendly and can easily adapted to mass fabrication processes.

In this work we report on the fabrication of an all- inkjet electrolyte-insulator-semiconductor (EIS) device, as likeness of the metal-insulator-semiconductor (MIS) structure, of which provides electrical detection by the capacitive coupling between ions and the dielectric layer. A simplified diagram of the EIS is shown in Figure. Focusing on the interface electrolyte-dielectric layer, deep electrical characterization is performed to different dielectric inks to employ the suitable dielectric which stands up the solution without seeping through it and finally, affecting the semiconductor layer. Two steps using different techniques are used to deposit the dielectric layer. As first approach, the deposition technique will be based on spin coating to reduce the deposition time-constrains in comparison to inkjet technique. Electrical characterization of EIS guides us to select the best suitable dielectrics. As second approach, inkjet printing technique will be used to deposit those dielectric materials obtaining an all-inkjet EIS device.

Among the dielectrics assessed, MMAcoMAA was selected for its strength among electrolyte solution. Moreover, an assessment both number of dielectric layers and thickness were performed to reduce leakage current through it.

A funcionalization of the MMAcoMAA was carried out to allow the immobilization of bovine serum albumin (BSA) proteins onto the gate surface. It consists in plasma oxidation of the MMA layer followed by an incubation using 3-aminopropyltriethoxysilane (APTES). Different concentrations of amino-groups were compared and characterized by colorimetric method for quantification of amine groups.

To evaluate the detection of the immobilized protein BSA, two kinds of EIS structures were fabricated. The structures are based on buffer electrolyte PBS-MMAcoMAA dielectric functionalized- semiconductor with and without BSA protein onto the dielectric surface. The capacitance-voltage (C-V), Impedance measurements and, confocal and interferometry images were performed. Moreover, the repeatability with different devices was studied.