Impedimetric biosensing with interdigitated arrays of nano electrodes fabricated by nanoimprint lithography

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Interdigitated arrays of electrodes (IDEs) have attracted a lot of attention and have been widely studied due to their versatility in sensing [1]. Recently, the development of new lithography techniques has allowed the realization of fast and cheap fabrication of IDEs with nanoscale dimensions. Down-scaling of sensor size leads to higher sensitivity, higher specificity and a reduction of the amount of liquid needed for quantification, so they can be integrated easily for applications in biomedicine.

In this work, we present the fabrication of a (bio)sensor based on interdigitated arrays of nanoscaled electrodes (~250nm pitch), and the first impedimetric measurements. In order to combine micrometer and nanometer size features, the connection pads and lines are first fabricated by UV lithography, metallization (Ti/Au, 7nm/60nm) and lift-off. Aligning marks have been included in the design of the UV mask for the second lithography level: e-beam lithography to define the digits, followed by metal evaporation and lift off. Figure 1 shows results of the fabrication process: the whole chip, fabricated in gold onto a SiO_2/Si substrate (a), one of the arrays (b), and a detail of the digits, which are 180 nm wide and with a pitch of 230 nm (c). These devices can be used already for sensing or as the master to fabricate stamps for nanoimprint lithography (NIL). In the second case, a reactive ion etching (RIE) process is performed. Then, the fabrication of subsequent samples is easier and faster, since the two lithography levels (UV and e-beam lithography) are substituted by one NIL step.

Once the electrodes have been fabricated, they are passivated with PMMA, leaving open only the large pads for external connections and the areas with the digits. Then, they are bounded to a printed circuit board (PCB), and encapsulated with *epotec* ®. At this point, the sensor is ready to be connected to an external electronic system and the electrodes can be immersed in a liquid media (figure 2).

These sensors can be used in different configurations (voltamperometry, red/ox cycling, etc). One of the most interesting is impedance spectroscopy [2], because it allows to get better response when the size of the digits is similar to the element that has to be detected and/or quantified (e.g. nanoparticles). First results, obtained in an aqueous solution of NaCl, are shown in figure 3. From the representation of the imaginary part of the impedance (Z'') as a function of the real one (Z') an electrical equivalent circuit (figue 3.a) is established for a further study of the parameters and a final quantification of the concentration in the solution. We have found that the sensor acts mainly as a capacitor. Figure 3 (b) shows the capacitance measured as a function of the frequency, for different concentrations of NaCl. The capacitance dependence on the concentration, even for very low concentrations, demonstrates the good performance of the sensors.

This work is being developed in the frame of proyects NILSIS and NanoBioMed.

[1] K. Aoki, et al., *J. Electroanal. Chem*, **256** (1988) 269
[2] R. de la Rica et. Al., Appl. Phys. Lett. **90**, 174104 (2007)

<u>Figures:</u>

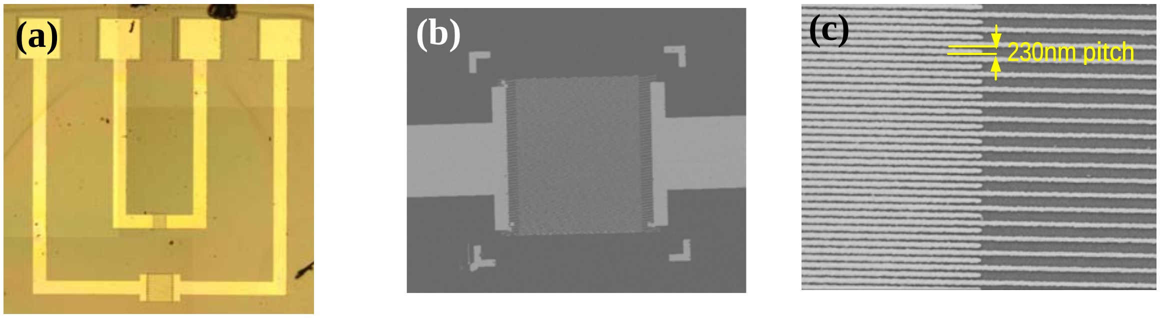

Figure 1. (a), optical image of a sensor, fabricated in gold on a SiO2/Si substrate. The pads are defined by optical lithography, metallization and lift off, and the digits are fabricated in a second step, by e-beam lithography, metallization and lift off. (b), general view of one of the electrodes, and (c), detailed view of the digits.

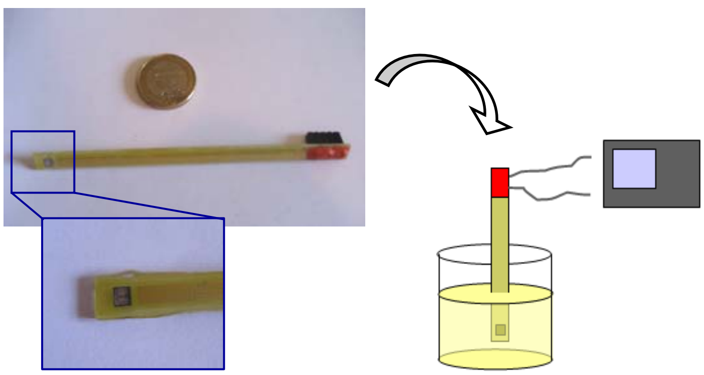

Figure 2. Once the electrode is fabricated, it is bounded to a PCB and encapsulated, so it can be connected to an external electronic system and the electrodes immersed in a solution, for characterization.

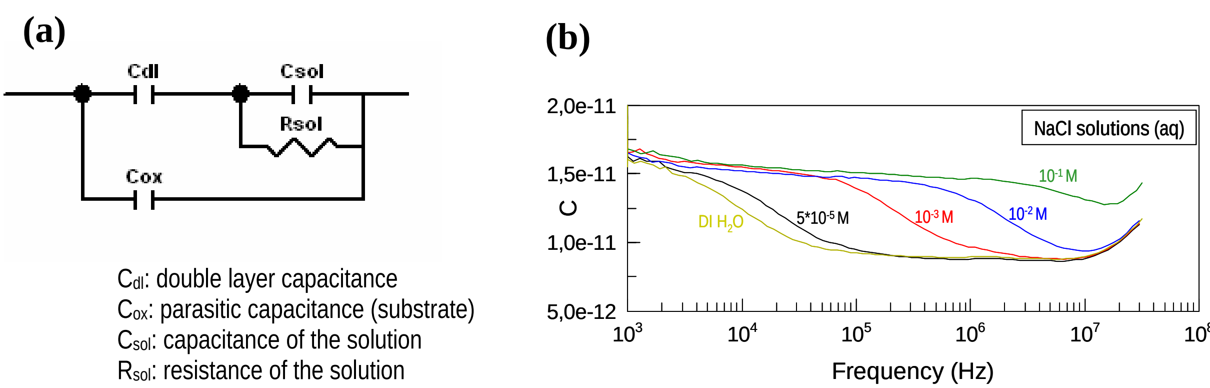

Figure 3. (a) Equivalent circuit of the sensor and (b), results of impedimetric sensing with the nanoIDEs in aqueous solutions of NaCl. The capacitance is measured as a function of the frequency. It changes depending on the concentration of NaCl in the solution. Thus, the sensor can be calibrated and used to quantify the concentration of unknown solutions.