Oxygen sensor based on the thermoelectric effect

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There are many techniques utilized for the synthesis and fabrication of thick and thin films for chemical sensing. Among others, methods like spin coating, dip coating or screen printing have been already successfully used for the fabrication of oxygen sensors [1]. Most of these techniques are limited for the fabrication of thick films or are not suitable to control the thickness of the coating on the nanometer scale. On the other hand, there are techniques, like the Layer-by-Layer Electrostatic Self Assembly (LbL) method, which are suitable for the deposition of diverse nanostructured materials (ceramics, semiconductors, metals, biomaterials and others) on many types of substrates of even complex surfaces with convex, concave or even conical shapes [2]. Due to this the LbL method can be successfully used for the synthesis and deposition of sensing thin films. More specifically, we propose here the utilization of the LbL method for the fabrication of a new sensor based on the thermoelectric effect for the measurement of oxygen. Basically, nanofilms of Yttria-stabilized zirconia (YSZ) have been deposited by means of the LbL on alumina substrates with interdigitated platinum electrodes. The interdigitated electrodes device consists on a 300 µm thick alumina substrate with platinum interdigitated electrodes (250 µm width and spacing) and a platinum resistance detector (RTD) on one side and a platinum heater (microhot plate) on the other side. The overall dimensions of the alumina are 15mm x 13 mm (see Fig. 1).

In opposition to classic oxygen sensors based on changes of the electrical impedance of YSZ films in presence of oxygen at high temperature [3], this sensor is based on the voltage generated between electrodes due to a temperature gradient [4]. This voltage between the interdigitated electrodes will change depending of the oxygen concentration. See Fig. 2 where the gradient of temperature introduced by the heater can be clearly appreciated.

In Fig. 3, an AFM image of the YSZ films is plotted, it can be seen that these films are homogeneous. The sensing film synthesized for the experiments had a thickness of 150 nm and an average RMS roughness of 49 nm. In Fig. 4 a SEM image of the YSZ deposition onto the interdigitated electrodes device is also shown. In Fig. 5 the response of the sensor at different oxygen concentrations (from 2% to 100%) is plotted. Fig. 6 shows the dynamic response of the sensor when is submitted to repetitive cycles of 100% Nitrogen and 100% Oxygen. To our knowledge, this is the first time that the LbL method has been used for the fabrication of oxygen sensors based on the thermoelectric effect.

References:

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Figures:

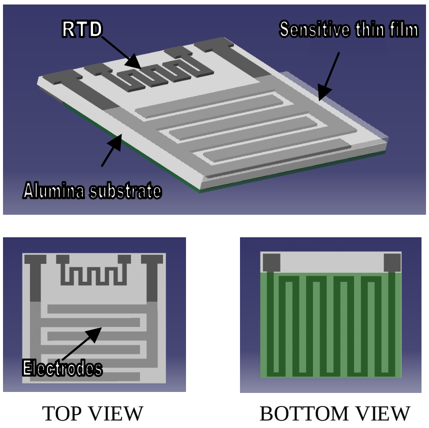

Fig. 1: Setup of the LbL fabricated Oxygen sensor.

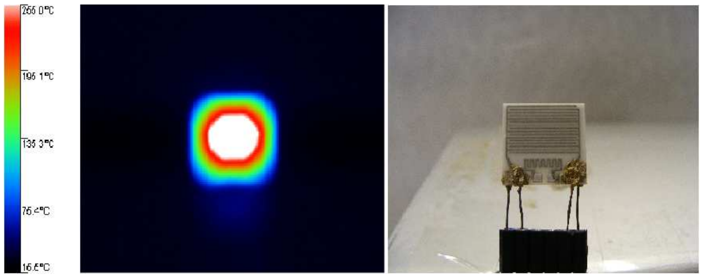

Fig. 2: IR image of the temperature gradient induced in the device.

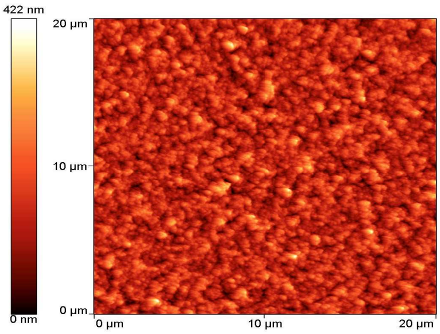

Fig. 3: AFM image of an YSZ layer deposited onto a glass microscope slide.

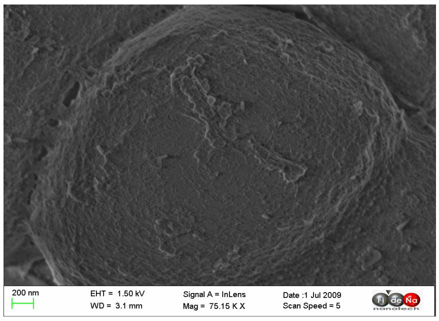

Fig. 4: SEM image of the YSZ layer deposited onto the interdigitated electrodes device.

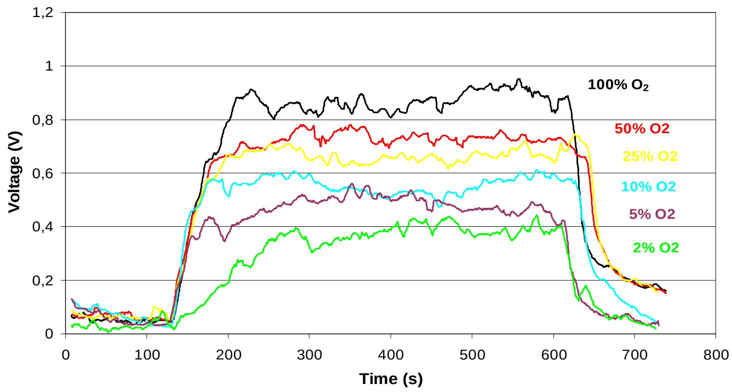

Fig. 6: Typical sensor response to oxygen at different concentrations.

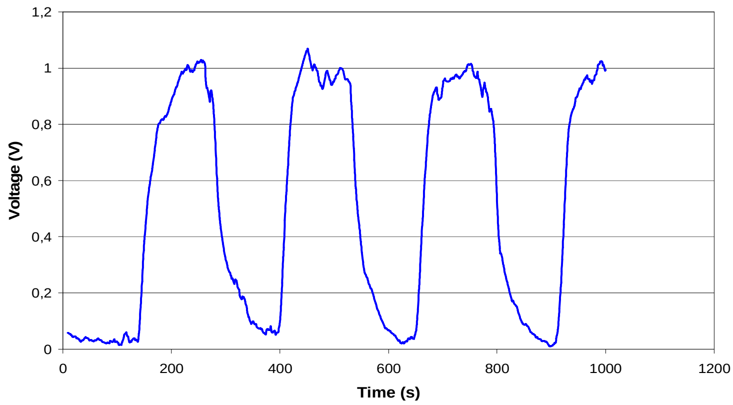

Fig. 5: Sensor response changing Oxygen concentration from 0% to 100%.