

NANOSTRUCTURED NiO GROWN ON ALUMINA NANOPOROUS MEMBRANES BY ION-BEAM ASSISTED REACTIVE THERMAL EVAPORATION OF Ni

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One of the effects of growing porous materials at the nanoscale is that the effective surface is dramatically increased. This is especially important in applications that involve an interaction between gases or liquids and the material surface, including air pollution control, solvent recovery, radioactive waste treatment, and odour control. After the recent development of ordered nanoporous alumina membranes through an easy and low-cost anodic process, many efforts are being devoted to functionalize this nanostructured material with metals and compounds. NiO and NiO_x have interesting catalytic and magnetic properties, as well as a good sensitivity in gas sensing applications. In this work we report on the growth of nanostructured NiO on alumina nanoporous membranes by ion-beam assisted thermal evaporation of Ni.

Alumina nanoporous membranes with a thickness of 0.5 μm have been grown by anodic oxidation of aluminium in oxalic acid. The pore diameter and the distance between pores were approximately 35 nm and 60 nm, respectively. Nickel was then thermally evaporated on these templates at room temperature in an oxygen atmosphere of 1·10⁻⁵ mbar. Under these experimental conditions, the growth rate of NiO is, approximately, 0.3 nm/min. With the aim of optimize the material input into the pores, ion beam assistance was used. A low energy ionic oxygen beam was directed onto the substrate at an angle normal to the surface.

Under these conditions, NiO grows as nanometric whiskers and flakes both at the walls and inside the pores of the alumina membranes, as it was determined by field emission scanning electron microscopy. The typical shape of the observed nanostructures is oblong, approximately 5-10 nm long and 15-30 nm wide (see figure 1). The thickness of the nanostructured NiO coatings laid between ~20 and ~100 nm. Ni-2p x-ray photoelectron spectroscopy has been performed on the NiO samples and compared with non-ion-assisted NiO films, as well as with bulk NiO. As it is reported elsewhere [1], the Ni-2p spectral lineshape of very thin NiO films, of the order of one monolayer, is different to that of bulk NiO. The observed differences can be explained in terms of a poor screening of the Ni-2p hole by the ligands, associated with a lower coordination around the Ni emitter due to the nanometric thickness of the coating. It has also been observed that this behaviour disappears for thicker coatings, from about 10 nm. In the case of nanostructured NiO deposited on alumina membranes, we observed the typical features of monolayered NiO coatings even for much thicker coverages. This is consistent with the nanometric dimensions of the NiO structures observed by SEM, each of them acting as a single nano-deposit with similar properties to a continuous NiO monolayer on a flat substrate.

References:

[1] L. Soriano, A. Gutiérrez, S. Palacín, I. Preda, *to be published*

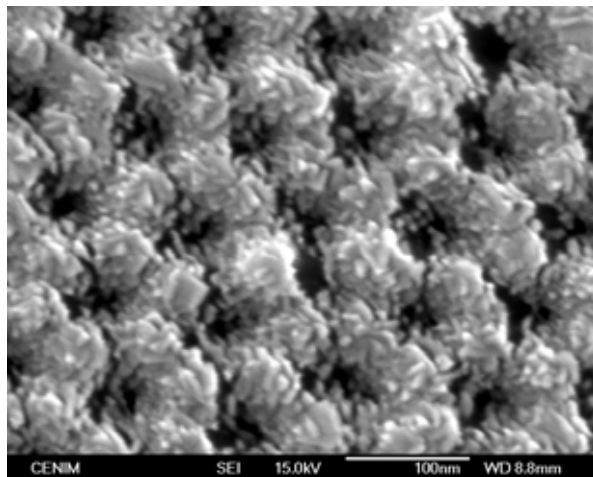
Figures:

Figure 1: SEM micrograph of ~30 nm thick nanostructured NiO grown by ion-beam assisted reactive thermal evaporation of Ni on a nanoporous anodic alumina template.

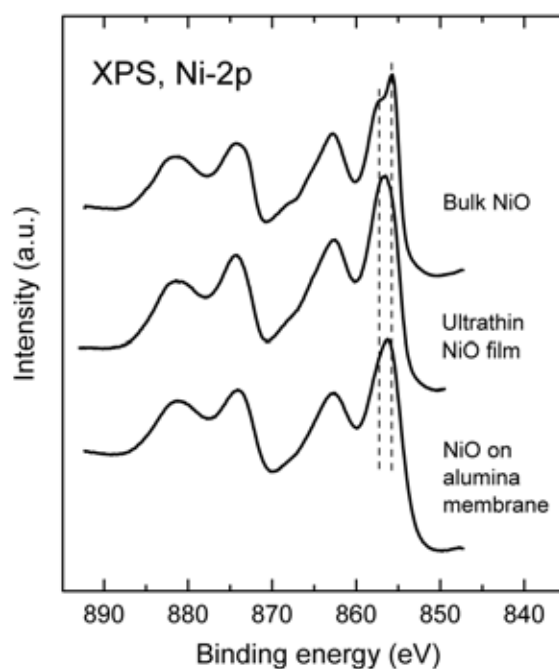


Figure 2: Ni-2p XPS spectra of bulk NiO, an ultrathin NiO film (~5 nm), and a NiO nanostructured coating grown on a nanoporous alumina membrane (>100 nm thick). The vertical dashed lines correspond to the typical features of bulk NiO, at 857.3 eV and 858.8 eV, respectively. Both features are lacking both in the ultrathin film and the nanostructured coating spectra.