WO_3 NANOPARTICLE-FUNCTIONALIZED NANOWIRES FOR NO_x SENSING

A. García Marín, C. García Núñez, E. Ruiz, J. Piqueras, J.L. Pau

Laboratorio de Microelectrónica and grupo ELySE, Dpto. Física Aplicada, Universidad Autónoma de Madrid, 28049 Madrid, Spain.

joseluis.pau@uam.es

Abstract

WO_3 has been proved to be a great material for NO_2 sensing [1,2]. This n-type semiconductor needs high temperatures, around 250 ºC to operate in order to provide a fast response to the gas adsorption [2]. The sensing mechanism lies in the change of film resistance resulting from physisorption, chemisorption and reactions of NO_2 with the intergrain boundaries of the WO_3 aggregates. The NO_2 adsorbed, even at low temperatures, on the semiconductor surface are thought to be ONO^- (nitrito type adsorbates) and dissociate into nitrosyl type adsorbates (NO^+, NO^-) [3]. These adsorbates act on the potential barrier of the grain boundaries improving the conductance of a thin film made of WO_3.

WO_3 nanoparticles (NPs), around 100-nm diameter (see figure 1, left image), have a great surface-to-volume ratio, so its sensitivity is thought to be higher than a thin film. The WO_3-based commercial devices present instabilities that need to be corrected by zeroing the sensor over time. These instabilities are a direct consequence of the charge and discharge of the capacitors associated to the grain boundaries. Therefore, the device design should be refined to minimize this effect. The use of a two adsorption-conduction separated region device may help to prevent these issues.

In our work, the crystal structure of the nanostructures was characterized. The NPs show an amorphous structure since no evidence of diffraction rays were found in the x-ray diffraction (XRD) scans. Energy-dispersive x-ray spectroscopy (EDX) studies show 1:3 stoichiometric compositions (see figure 1, right image). To fabricate the first sensors, the NPs are randomly dispersed on interdigitated electrodes. However, a better approach is also studied. Metal oxide nanowires can be functionalized with WO_3 nanoparticles through electrostatic or covalent bonds. The metal oxide nanowires (NWs) act as conductive channels whereas the WO_3 NP_S perform as the signal transducers. The charge transfer from the WO_3 NP surface to the NW makes that the electrical current flows through the NW avoiding the grain boundaries. For the proof of concept of the device design, dielectrophoresis was used to align the functionalized NWs between electrodes, previously made by photolithography (see figure 2) [4]. Gas sensing tests are planned to evaluate the performance of this architecture as a potential sensor device.

References

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Figures

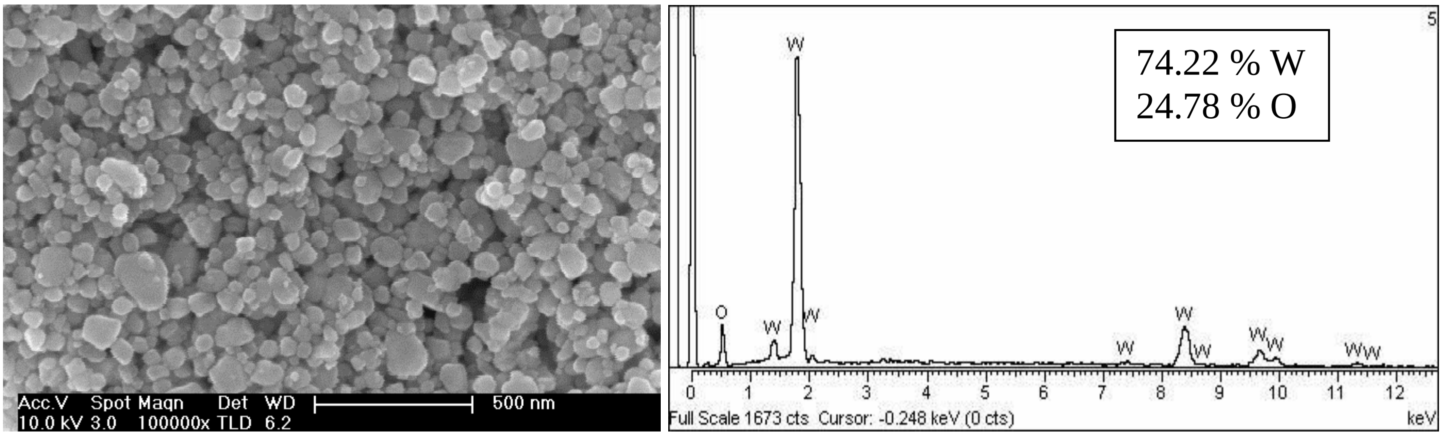

Fig. 1: Scanning electron microscope of WO_3 NPs on a silicon wafer (left); EDX result showing the NP composition.

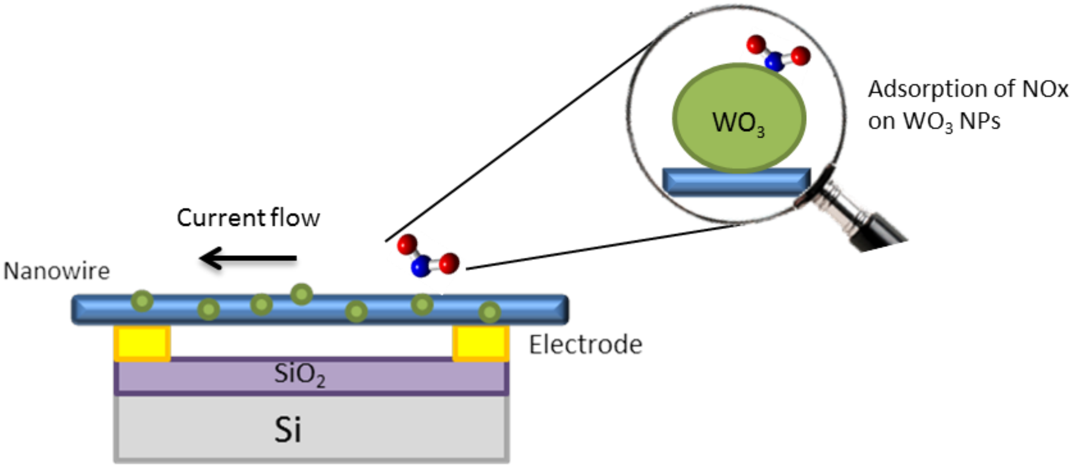

Fig. 2: Schematic view of the proposed sensor. The NW, dielectrophoretically aligned, is covered with WO_3 NPs (green circles), and acting as a conductive channel.