Mesoporous pure and doped WO_3 and In_2O_3 materials for gas sensing applications

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Nanostructured mesoporous materials have been widely studied in the development of catalytic systems due to their large, controllable pore size and high surface area. The pore structure, such as pore size and channel conductivity can be designed for practical application, and a variety of synthetic pathways have been proposed for the development of these nanostructures. The control of the active surface area is one of the most important issues for tailoring the properties of materials used as gas sensors [1]. In order to improve the surface to bulk ratio, mesostructured indium oxide and tungsten oxide have been synthesized in a hard template route [2] with two different structures: i) three-dimensional cubic (Ia-3d) named KIT6, ii) two-dimensional hexagonal structure (p6mm) named SBA15 [3-4]. These materials show a small particle size, about 5–10nm and high active surface area. With the aim of increasing the sensitivity of tungsten oxide to NO_2, we have introduced different concentrations of catalytic additives (Cu and Cr) to these samples. Similarly, calcium oxide in different concentrations has been introduced to mesostructured indium oxide to increase its sensitivity to CO_2.

WO_3 Structural characterization shows that both structures are highly crystalline ordered and thermally stable. For the KIT-6 replica, XRD modeling with ~ 70 % of uncoupled framework model shows good agreement with the observed peak intensities. This model has been confirmed by TEM. Single crystal hexagonal rings with triclinic structure set up the atomic morphology of KIT-6 replica that forms the uncoupled subframework. On the contrary, the particles observed in SBA-15 replica, are randomly oriented in the mesostructured framework (Fig 1). We will discuss the influence of mesoporous structure on the gas sensing performance, since the response of WO_3 as a replica of the KIT-6 is higher and faster than SBA-15 based sensors, although it also presents a higher resistance.

First results in SBA-15 WO_3 catalytically modified with chromium show a better response to low concentrations of NO_2 (below 1ppm) (Fig 2). The influence of the additives on the sensing properties will be discussed, as well, mainly in the range of very low gas concentrations.

Finally, first results in In_2O_3 structural and electrical characterization in both mesoporous structures will be also described. Due to their high surface area and highly crystalline framework, these materials are expected to be very important for catalytic applications, mainly in the field of semiconductor gas sensors.

References:

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Figures:

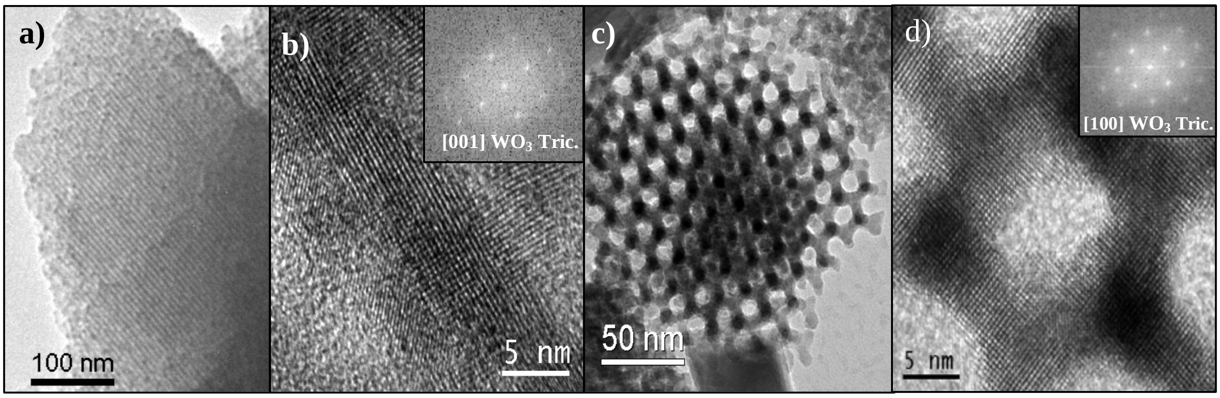

Figure 1. a) TEM image of WO_3 nanoparticle array, replica of SBA-15 silica template. b) HRTEM micrograph of the crystalline framework of SBA-15 WO_3 replica. c) KIT-6 WO_3 replica along the [111] and, d) HRTEM image of the KIT-6 replica with monocristalline hexagonal ring structure.

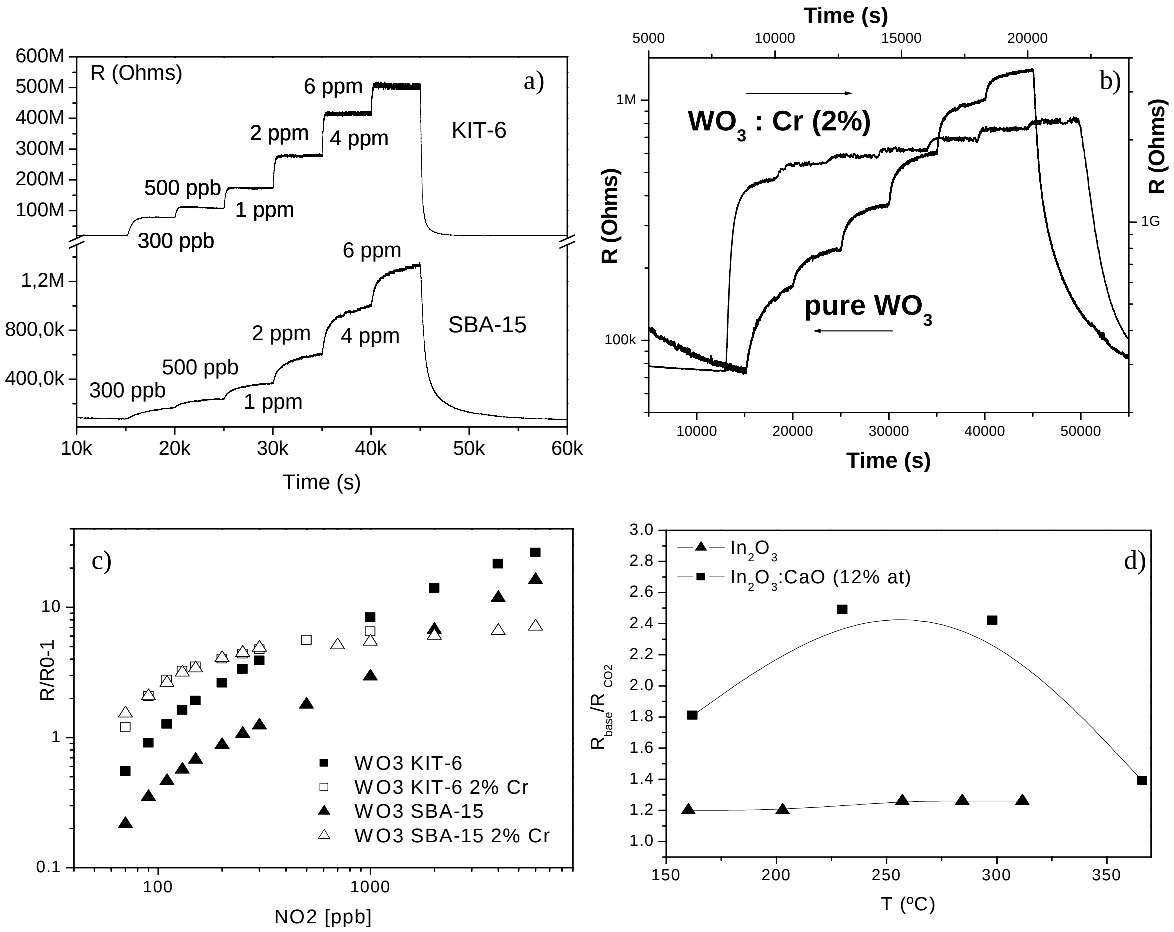

Figure 2. Dynamic behaviour of sensor response of pure a) and doped b) WO3 to different concentrations of NO_2 in synthetic air c)Pure and doped sensor response to different concentrations of NO_2 d) response of In_2O_3 pure and doped to 2000 ppm CO_2 at different temperatures