Design of a Nanostructured Metal-Oxide Solid Solution Based on Sn, Ti and Nb for Gas Sensing Applications

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ABSTRACT

Emerging nanotechnologies improved solid-state sensors design and capabilities and enabled the use of semiconducting metal oxides (SMOXs)-based gas sensors for new and increasingly demanding applications. These new applications require affordable, easy, and precise sensors under conditions where interfering agents and complex environments (e.g. high temperature and pressure) can affect the detection of the target gas. For these reasons, new strategies have been sought to improve the gas sensing performances of common SMOXs.

Recently, great attention has been paid to nanostructures solid solutions based on SMOXs to enhance sensing performance with respect to those of single-oxide counterparts. Tin and titanium dioxides (SnO_2 and TiO_2) are wide-gap n-type semiconductors extensively investigated for the fabrication of solid-state devices for gas sensing applications. They would easily form solid solutions since they can exhibit a rutile type structure where octahedrally coordinated Ti^{4+} and Sn^{4+} have similar ionic radii. Such solid solution combines the positive qualities of the singles oxides, e.g. high sensitivity towards reducing gases and low influence by humidity [1].

Despite the good sensing performances of $Sn_{1-x}Ti_xO_2$, a further improvement has been attempted by means of an Nb doping. The incorporation of Nb^{5+} would increase the conductivity of the material, as niobium acts as donor dopant in n-type semiconductors, and inhibit grain growth [2]. $(Sn,Ti,Nb)_xO_2$ powders were synthetized through co-precipitation by keeping the Sn/Ti proportion constant at the optimal value for sensing performance, while changing Nb concentrations and calcination temperature. Powder compositions, structures and morphologies were investigated by different techniques. Observations at SEM microscopy revealed that the morphology consists of rounded nanoparticles and X-ray powder diffraction analyses confirm that $(Sn,Ti,Nb)_xO_2$ samples were a rutile-type solid solution of tin, titanium and niobium. Electrical characterization of the films showed that the niobium concentration and the heating treatment of powders are fundamental parameters to optimise the sensing characteristics of the film [3].

[1]Carotta, et al., *Sensors and Actuators B* **139** (2009) 329–339

[2]Ferroni, et al. *Sensors and Actuators B: Chemical* **68.1-3** (2000) 140-145

[3]Spagnoli et al. *ACS Sens.* **7, 2,** (2022) 573–583

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Biography: Elena Spagnoli obtained her M.Sc. degree in Chemistry (Magna cum Laude) at the University of Ferrara, in 2019. She is currently a Ph.D. student in Physics at the University of Ferrara, working on the synthesis of nanostructured semiconductors for the development of chemiresistive gas sensors.