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NANOCASTING SYNTHESIS OF MESOPOROUS SnO_2 FOR HUMIDITY SENSOR APPLICATION

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This work presents the fabrication of humidity sensor based on SnO2 sensing material derived by the nanocasting process using hydrothermally obtained KIT-5 as a hard template.
In a typical wet impregnation process, the infiltration of Sn precursor into mesoporous silica KIT-5, and later evaporation of the solvent were conducted to fill pores to 15 % of the template pore volume. The calcination and removal of the template were performed to obtain the desired mesoporous SnO2. The obtained powder (P) was mixed with a 10 % ethyl-cellulose in α- terpineol solution (S) and acetic acid (A) in the weight ratio P:S:A=7:69.7:23.3 to form a homogeneous paste which was further deposited by doctor blade technique onto alumina substrate with screen printed Pt/Ag electrodes. The film was subjected to a specific drying regime and finally calcined at 550 °C for 5 h.
The obtained SnO2 nanoparticles as well KIT-5 template were characterized using X-ray diffraction (XRD) spectroscopy, Brunauer–Emmett–Teller (BET) analysis and Transmission Electron Microscopy (TEM). Cross section and surface morphology of SnO2 film were characterized by Field Emission Scanning Electron Microscopy (FESEM). The humidity sensing properties of the mesoporous SnO2 sensor were investigated in a JEIO TECH TH-KE-025 temperature and humidity climatic chamber in the range 30–90 % RH. Complex impedance spectra of the as-fabricated sensor were analyzed at room temperature and 50 °C with a HIOKI 3532-50 LCR HiTESTER in a frequency range 42 Hz - 1 MHz.
Nitrogen adsorption isotherms of KIT-5 showed high specific surface area of 610 m2g-1 and average pore diameter of 5.2 nm while those values for SnO2 sample were 33 m2g-1 and 19.9 nm respectively. Even though that mesoporous ordering of nanocasted negative replica was observed by TEM, the presence of agglomerates in SnO2, as well as the relatively low specific surface area of 33 m2g-1, confirm its partial degradation. Diffraction patterns from TEM display well-defined rings typical for cassiterite SnO2. The impedance measured at 42 Hz, at room temperature, and in the range 40-90% RH reduced 509 times, while at 50 °C it reduced 48 times. The sensor exhibited quick response (5 s) and recovery time (16 s) when it exposed to humidity change from 37% RH to 90% RH, and relatively low hysteresis of 3.2% observed at 40% RH and at room temperature showing its promising capacity as a humidity sensor.

Keywords: nanocasting, tin oxide, humidity sensors