SSNN KN2 WO_3/WS_2 COMPOSITE MATERIALS FOR GAS SENSOR AND ENERGY STORAGE APPLICATIONS

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Transition metal binary compounds, especially oxides and chalcogenides, are material of choice for many applications. Particularly, tungsten trioxide (WO_3) has been extensively studied due to its outstanding electrochromic and photochromic properties in the visible and infrared region, high coloration efficiency and relatively low price [1], which makes it suitable for the construction of smart windows, mirrors, optical shutters and display devices [2]. Tungsten trioxide is also a good photocatalyst, gas sensor, chemical sensor and biosensor, material [3]. On the other hand, tungsten disulfide (WS_2) with its unique properties is a promising material for a number of applications such as solid lubricants, catalysts, photosensitive films, electronic and optical devices [2]. Both the materials and their nanocomposites are of great interest for energy storage applications.

A variety of technological methods have been applied so far for the production of WO_3, WS_2 and two-component composite materials. In this paper, we developed technological conditions for obtaining WO_3 nanorod arrays by spin coating on tungsten foils or wires, which are further subjected to surfurization by magnetron sputtering. The commercial W foils and wires are cleaned using ethanol and acetone solution and dried before spin coating. A 0.1 M KOH solution in water was spin cast at a rotation speed of 2500 rotation/min for 30 s in the next technological step. The samples with the spin coated solutions were dried in air and subsequently annealed in a tube furnace for ~2 hours at temperatures in the range of 400-700 °C. The scanning electron microscopy analysis of the produced nanorod arrays morphologies proved that 650 °C is the best annealing temperature. The nanorods have a diameter around 100 nm and a length in the micron range.

The produced nanorod arrays have been characterized by energy dispersive X-ray (EDX), X-ray diffraction (XRD) analysis, high-resolution scanning transmission electron microscopy (HR-STEM), FTIR and Raman scattering spectroscopy. The EDX analysis shows a stoichiometric WO_3 composition, while XRD analysis and Raman spectra suggest the predominance of the monoclinic γ-WO_3 phase, which is also confirmed by the observation of inter-planar 0.351 nm and 0.334 nm spacing in the HR-STEM analysis, corresponding to (012) and (120) reflexes in the XRD pattern.

A sulfur film is deposited for sulfurization on the WO_3 nanorod arrays by radio-frequency magnetron sputtering with a disc of 99.99 % pure sulfur as target in a deposition chamber evacuated to a pressure of $2.5x10^{-5}$ mTorr with a subsequent argon gas pumping at a rate of 50 ml/min to a pressure of $1.9x10^{-2}$ mTorr. The magnetron power was maintained at a level of 75 W during the deposition of the sulfur film. The samples were subjected to annealing during 40 minutes at 600-800 ^{o}C after the magnetron sputtering to generate a mix phase of WS_2/WO_3. The prospects of the produced structures for applications in intrinsic fiber optic sensors and energy storage are also discussed in relation with the analysis of cyclic voltammetry data.

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