POLITECHNIKA ŚLĄSKA W GLIWICACH

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PRACA DOKTORSKA

Analiza struktury i własności optycznych jednowymiarowych nanomateriałów ceramicznych SnO_2 oraz In_2O_3 wytwarzanych hybrydową techniką zol-żel i elektroprzędzenia z roztworu

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Abstract

The aim of this work was to prepare one-dimensional SnO_2 and In_2O_3 nanostructures by electrospinning from a solution followed by a calcination, and to study their structure, morphology and optical properties. In the first stage, homogeneous spinning solutions were prepared with various molar concentrations of metal oxide precursor (0.15; 0.30; 0.60; 1.00 mol/dm^3), which were then subjected to electrospinning at constant process parameters. IObtained in this way nanofiber polymer/precursor mats were obtained, according to the results of TGA analysis, were calcined at 500 and 600°C in order to remove the polymer and form ceramic one-dimensional SnO_2 and In_2O_3 nanostructures. In the next stage of the experiment, the morphology of the obtained SnO_2 and In_2O_3 nanostructures was analysed, which showed that the obtained ceramic materials were in the form of nanofibers and nanowires free from structural defects, the diameter of which increased with the increase in the molar concentration of the precursor in the spinning solution. It was also found that the use of too high molar concentration of the precursor may result in the formation of artifacts in the form of nanobelts among structures with the desired morphology. A detailed analysis of the morphology of the obtained ceramic nanomaterials showed that they were composed of interconnected nanoparticles, taking a one-dimensional form characterised by a large specific surface and the presence of mesopores. The chemical composition of the obtained nanomaterials and the fact that they were free of impurities and polymer residues were also confirmed by means of spectroscopic techniques, which proves the correct selection of the calcination temperature. Based on the XRD analysis, both groups of materials were found to be polycrystalline. SnO_2 nanostructures were mainly composed of the crystallites of the tetragonal SnO_2 polymorphic form and a trace amount of the rhombohedral form, while the In_2O_3 only of the cubic form. The last stage of the experiment was the analysis of the optical properties of SnO_2 and In_2O_3 nanostructures, which showed that they are characterized by the absorption of radiation in the UV range, and with the increase in the concentration of the precursor in the spinning solution, and thus the diameter of the nanostructures, a shift of the absorption edge towards visible light was observed. The optical energy gap of the SnO_2 and In_2O_3 nanowires was also determined, which was in the range of 3.24-3.73 eV and 2.80-3.43 eV, respectively. The physicochemical properties of the obtained one-dimensional nanostructures allow us to believe that they can be successfully used in the construction of modern optoelectronic devices, innovative photovoltaic cells and in photocatalysis processes.