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Crystallinity and optical properties of β-Ga_2O_3/Ga_2S_3 layered structure obtained by thermal annealing of Ga_2S_3 semiconductor

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Abstract

In this work, the β-Ga_2O_3 nanostructures were obtained by thermal annealing in air of β-Ga_2S_3 single crystals at relatively high temperatures of 970 K, 1070 K and 1170 K for 6 h. The structural, morphological, chemical and optical properties of β-Ga_2O_3–β-Ga_2S_3 layered composites grown at different temperatures were investigated by means of X-ray diffraction (XRD), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX) as well as photoluminescence spectroscopy (PL) and Raman spectroscopy. The results show that the properties of obtained β-Ga_2O_3–β-Ga_2S_3 composites were strongly influenced by the thermal annealing temperature. The XRD and Raman analyses confirmed the high crystalline quality of the formed β-Ga_2O_3 nanostructures. The absorption edge of the oxide is due to direct optical transitions. The optical bandwidth was estimated to be approximately 4.34-4.41 eV, depending on the annealing temperature. Annealing of the β-Ga_2S_3 monocrystals at a higher temperature of 1170 K showed the complete conversion of the surface to β-Ga_2O_3. These results demonstrate the possibility to grow high quality β-Ga_2O_3–β-Ga_2S_3 layered composites and β-Ga_2O_3 nanostructures in large quantities for

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various applications such as gas sensing, non-toxic biomedical imaging, nonlinear optical, as well as power device applications. Micro and nanocrystallites present on the surface of the Ga_2O_3 layer contribute to a diffusion of the incident light which leads to an increase of the absorption rate allowing thus to reduce the thickness of the Ga_2O_3 layer, in which the generation of unbalanced charge carriers takes place. By decreasing the Ga_2O_3 layer thickness in such layered composites, the efficiency of photovoltaic cells based on such junctions can be increased.