Micro- and nano-structured oxides based on Cd- and Sn-doped InSe for volatile organic compound sensors applications

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Abstract. Indium oxide (In_2O_3) is a material widely used in electronic devices as electrodes with high electrical conductivity and optical transparency [1]. The properties of this material extend with the transition from monocrystalline and polycrystalline thin layers to nanostructured films (nanowires, nanobelts, nanoparticles, etc.) [2]. In the nanostructured In_2O_3 material, together with the characteristic properties of the In_2O_3 compound, an intense luminescence in the visible range of the spectrum is emphasized, with maximum intensity in the blue region. In this work, micro and nanostructured In_2O_3 and In_2O_3-InSe (Cd, Sn) layers and micro and nanostructures were fabricated by heat treatment (TT) in atmosphere of undoped InSe single-crystalline wafers doped with Cd and Sn in concentrations ranging from 0.25 at.% and 1.5 at.%. X-ray diffraction (XRD) studies, EDX plots and Raman spectra demonstrated that the layer formed on the surface of InSe (Cd, Sn) plates corresponds to the In_2O_3 compound. Depending on the thermal annealing temperature, nanowires and nanobelts are obtained from In_2O_3 microcrystallites with cubic and hexagonal lattice. The In_2O_3 oxide formation process takes place in two steps. At a certain temperature the phase transformation InSe $\rightarrow In_2Se_3$ and at the second stage In_2Se_3 $\rightarrow In_2O_3$ takes place. The surface and edge defects of InSe lamellae serve as initiation centers for In_2O_3 nanoforms. The forbidden band edge of the In_2O_3 (Cd, Sn) layer is

formed by direct (3.6 eV) and indirect (~2.6 eV) optical transitions [3]. The nanostructured In_2O_3 layers formed on the surface of InSe (Sn) and InSe (Cd) nanocrystals upon radiation excitation near the edge of the optical absorption band (λ=340 nm) emit a photoluminescent radiation band (PL) covering the visible band (400÷700) nm range, with a well pronounced maximum in the 465÷475 nm region. The PL intensity in the maximum band as well as the PL band contour depend on several factors, such as excitation wavelength, excited beam intensity, temperature and time, and dopant concentration. In this paper, the influence of vapors of volatile organic compounds (benzol, acetone) on the peak intensity of the PL band was examined, from which it was determined that acetone vapors lead to the decrease of the PL intensity. The relaxation process of the PL intensity tends to saturation and is reached in ~25÷30 s and depends on the level of Cd and Sn doping of the primary InSe crystals from which the In_2O_3 nanowire arrays were obtained. The ratio of the maximum PL band intensity of the In_2O_3 nanowire layer in the initial not-annealed layer with vapor and its stationary PL intensity in vapor environment can serve as a criterion of the time and concentration of vapors, especially acetone vapors. This research was funded by the Ministry of Education and Research of the Republic of Moldova within the subprogramme no. 011210, "Advanced physical methods and UAV-based technologies for complex monitoring, evaluation and modeling" and the international project within the NATO Science for Peace and Security (SPS) program "Advanced technologies for physical resili-ence of critical infrastructures" (APRIORI), no. SPS MYP G6140.

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