Thermal analysis of the composition of gallium and sulfur oxides obtained by thermal oxidation of gallium (III) sulfide

Veaceslav SPRINCEAN[1], Iuliana CARAMAN[2], Dumitru UNTILA[1,3], Elmira VATAVU[1], Igor EVTODIEV[1,3], Ion TIGINYANU[3,4]

[1]Faculty of Physics and Engineering, Moldova State University, Alexei Mateevici, 60, MD-2009, Chisinau, Republic of Moldova

[2]Engineering Department, "Vasile Alecsandri" University of Bacau, Calea Marasesti, 157, RO-600115, Bacau, Romania

[3]Ghitu Institute of Electronic Engineering and Nanotechnologies, Academy of Sciences of Moldova, Academiei, 3/3, MD-2028, Chisinau, Republic of Moldova

[4]Department of Microelectronics and Biomedical Engineering, Technical University of Moldova, Stefan cel Mare Avenue, 168, MD-2004, Chisinau, Republic of Moldova

Oxides of both Ga and In elements (Ga_2O_3, In_2O_3) are wide bandgap materials and have molecular gas adsorption properties, such as CO and CO_2. They are materials with semiconductor properties, which doping with chemical elements changes the type of major charge carriers and also the characteristic properties. By thermal annealing of both Ga and In chalcogenides (Ga_2S_3, GaSe, Ga_2Se_3, In_2S_3, In_2Se_3, InSe) in a wide temperature range under normal atmospheres, their dissociation occurs with formation of Ga, In, Se, and S oxides. Both semiconductor and adsorbing properties of the synthesized oxides depends on their structure and composition.

In this work, we study the influence of technological oxidation regime, in normal atmosphere, of Ga_2S_3 singlecrystals with own structural defects on the oxides composition, optical and photoelectric properties, as well as the adsorption of the gases formed as a result of liquid fuel (gasoline) combustion. Ga_2S_3 singlecrystals have been grown by chemical vapour transport (I_2) of the material synthetized from Ga (5N) and S (5N) elements. Thermal annealing was carried out in normal atmosphere for 1-24 hours, at temperatures from 770K up to 1230K.

Chemical composition of the materials obtained as a result of thermal annealing was analyzed by the XRD method and IR spectroscopy. Impurity state of the synthesized oxides was analyzed by absorption spectra in the fundamental edge region and photoluminescence (PL) at low temperatures. At low annealing temperatures (770K) the surface of Ga_2S_3 singlecrystals is covered with a micro-granular layer of $Ga_x(SeO_4)_y$, Ga_2O_3 and sulfur oxides. The composite enrichment with Ga_2O_3 oxide occurs at annealing temperature increase. So at high temperatures (1170-1230K) the XRD patterns contain only reflections from the Ga_2O_3 atomic planes. The composition of the oxides obtained at different temperatures was also determined from the analysis of the IR reflection bands. The bandgap of the Ga_2O_3 oxide layer, obtained by thermal annealing of Ga_2S_3 crystals at 770K, was determined from the absorption spectrum and represents 4.8 eV. It increases slowly at thermal annealing temperature increase. The semiconductor properties of the Ga_2O_3 layer depend on the energy diagram of the levels in the bandgap. Both impurity-induced levels type and energy were determined from the absorption and PL spectra. Kinetics of CO_2 molecules adsorption in the Ga_2O_3 layer, from the Ga_2S_3 singlecrystals surface, is also studied in this paper.