

## Comparison between PbTe and SnTe oxidation processes

J. Cebulski<sup>1</sup>, M. Trzyna<sup>1</sup>, S. Fadeev<sup>2</sup>, N. Berchenko<sup>1</sup>, K. Kurbanov<sup>3</sup>, and T. Story<sup>4</sup>

<sup>1</sup> Faculty of Mathematics and Natural Sciences, University of Rzeszow,  
Pigonia 1, 35-310 Rzeszow, Poland

<sup>2</sup> Lviv Polytechnic National University, Lviv, Ukraine

<sup>3</sup> Flight College of National Aviation University, Kremenchuk, Ukraine

<sup>4</sup> Institute of Physics, PAN, Warsaw, Poland

Over the past decade a significant progress in the synthesis of narrow gap IV-VI (PbTe, SnTe, PbS and PbSe), nanocrystals demonstrated their high potential for various optical, electronic, and optoelectronic applications. However, the parameters of devices depend largely on the properties of interfaces between the nanocrystals. Most often, these interfaces are formed by the oxides, the composition of which, as it will be shown below, is dependent upon the initial semiconductor composition. First of all, for the studies of initial oxidation stages, we investigated the potentiodynamic polarization curves of PbTe and SnTe and their elementary constituents (Pb, Sn and Te). As the PbTe and SnTe surfaces etched with the most frequently used HBr-Br<sub>2</sub> solution yield thin elemental Te layers we used mechanically polished surfaces of PbTe and SnTe monocrystals grown by Czochralski and Bridgeman methods respectively. The PbTe samples were n- and p-type and SnTe only p-type; however, the type and charge carriers were irrelevant, in agreement with the semiconductors low bandgap. Kinetic curves were recorded on a potentiostat in phosphate buffered electrolyte which was subsequently used for the samples anodic oxidation. Comparison of the anodization curves of PbTe and SnTe and their elementary constituents allows the identification of electrode reactions on the corresponding current peaks on the potentiodynamic polarization curves. Thus, the maximum at 0.015 B observed for curves of lead and all lead chalcogenides corresponds to the metallic lead dissolution reaction. Then, the peak at 0.22 V observed only for PbTe corresponds to the electrochemical oxidation of lead, and a broad peak in the potential range 0.47÷0.72 V should correspond to a change in the degree of tellurium oxidation. Comparing the curves for SnTe and Sn it can be concluded that the peak at 0.32 V corresponds to the reaction Sn→SnO, and the peak at 0.42 V to the transition SnO→SnO<sub>2</sub>. It should be noted that in the potentiodynamic polarization curve for SnTe, unlike PbTe, there are no Te oxidation peak, which is consistent with the calculated by us Sn-Te-O phase equilibrium diagram, according to which the oxidation of the tin only is at first oxidation step energetically favorable. And, as it was revealed by Auger Electron Spectroscopy (AES) profiling of the anodic oxide-SnTe interface, tin not only predominantly oxidizes but also diffuses from the semiconductor. For comparison, the anodic oxide - PbTe interface according to AES is sharp with a uniform distribution of the elements on either side of the interface. This once again confirms the prediction Pb-Te-O phase equilibrium diagram that in PbTe the simultaneous oxidation of both components occurs with the formation of ternary PbTeO<sub>3</sub> oxide. Comparison of cathodoluminescence (CL) spectra for anodically oxidized PbTe and SnTe samples demonstrates that their luminescence bands have very different groups of peaks. This can be explained by the fact that the PbTe anodic layer consists of ternary oxide PbTeO<sub>3</sub> with the intracenter luminescence from Pb<sup>2+</sup> ions. The CL spectra for SnTe anodic layer are characteristic for the luminescence from the mixture of binary oxides (SnO<sub>2</sub> and TeO<sub>2</sub>).

Our investigations show that under the same growing conditions, the grain boundaries in SnTe nanostructures will consist of a mixture of tin oxide and elemental tellurium and of ternary oxide PbTeO<sub>3</sub> in PbTe nanostructures.