Influence of Oxidation Methods on the Volume of PbSnTe Thin Films Consumed during Oxidation

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PbTe-based nanostructures have proved to be a good material to manufacture thermoelectric converters [1]. Many techniques have been developed to prepare PbTe nanomaterials, beginning from a classical thermal evaporation or anodic electrochemical etching and ending with very refined methods of chemical deposition. However, all of them involve surface oxidation that can significantly change dimensions and properties of nanocrystals. For example densified nanocrystalline PbTe composites contain up to several vol. % $PbTeO_3$ or TeO_2. In this case the thickness of oxide layers near grain boundaries may become comparable to that of nanocrystals and thus significantly change their size. The aim of our work is to investigate how the thickness of thin epitaxial films is changed under oxidation and to determine the conditions which ensure the least possible losses of semiconductor material during the oxidation.

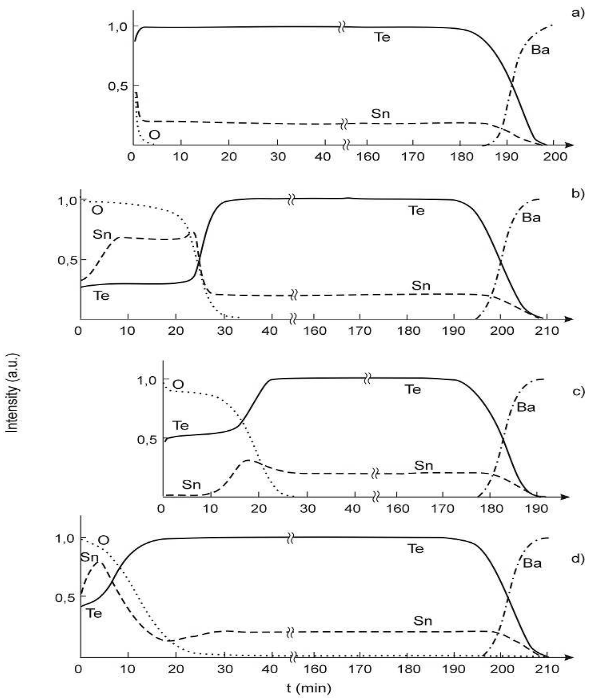

Fig.1. AES depth profiles for 1.25 μm $Pb_{0.8}Sn_{0.2}Te$ epitaxial layer: non-oxidized (a), and after electrochemical (b), chemical (c), and thermal oxidation (d).

We used thin (≤ 1.5 μm) PbTe and $Pb_{0.8}Sn_{0.2}Te$ epitaxial layers grown by flash evaporation on BaF_2 cleaved (111) surface. Three oxidation methods were compared: thermal oxidation in air at 673K, electrochemical (anodic) and wet chemical oxidation. AES and SIMS profiling down to the BaF_2 substrate through PbTe and $Pb_{0.8}Sn_{0.2}Te$ epitaxial layers, makes it possible to determine the correlation between thickness values of an oxide layer and a semiconductor material layer used to grow the oxide (Fig. 1). It is established the thermal oxidation was found to ensure minimum semiconductor material losses because no dissolution occurs while the evaporation of components at these temperatures is negligible. For electrochemical process the thickness of the oxide and residual $Pb_{0.8}Sn_{0.2}Te$ layer are controlled by accumulating SnO_2 at the oxide-semiconductor interface and it is possible to minimize the dissolution of PbTe and $Pb_{0.8}Sn_{0.2}Te$. All of these must be taken into consideration when choosing a method of preparing the nanostructured composites.

[1] J. Martin, L. Wang, L. Chen, G.S. Nolas, Phys. Rev. B 79 (2009) 115311