Nanohardness and Young's Modulus of Pb(Te,S) Solid Solution

Stanisław Adamiak[1], Roman Minikayev[2], Elżbieta Łusakowska[2], Jędrzej Korczak[2,3], Andrzej Szczerbakow[2], and Wojciech Szuszkiewicz[1,2]*

[1] *Faculty of Mathematics and Natural Sciences, University of Rzeszów, S. Pigonia 1, PL-35310 Rzeszów, Poland*
[2] *Institute of Physics, Polish Academy of Sciences, al. Lotników 32/46, PL-02668 Warsaw, Poland*
[3] *International Research Center MagTop, Institute of Physics, Polish Academy of Sciences, al. Lotników 32/46, PL-02668 Warsaw, Poland*

Both PbTe and PbS belong to the group of a narrow-gap IV-VI semiconductors crystallizing in the rock-salt structure. For a long time these materials have served for a variety of applications. The PbTe or PbTe-based solid solutions were applied mostly in thermoelectric devices, whereas PbS found the principal applications in the infrared radiation detection. The PbTe is a relatively soft material which can be easily scratched or damaged during processing, fabrication or use of PbTe-based devices. The PbS is much more resistant to wear so the mechanical properties of PbTe and PbS differ substantially. Moreover, the sulphur is much more abundant in nature than the tellurium. These are two of the reasons that PbTe-PbS solid solution system attracts a lot of attention. However, the available literature data on the nanohardness and Young's modulus for Pb(Te,S) solid solution are very limited [1, 2]. The aim of present study is to determine the composition-dependent evolution of selected mechanical properties of this solution. The determination of the nanohardness and Young's modulus by the nanoindentation was selected for this purpose.

The bulk, single crystals of Pb(Te,S) solid solution containing 0, 5%, 10%, 20%, and 100% of PbS were prepared. All crystals were grown by the self-selected vapor growth (SSVG) method [3, 4]. Prior to the nanoindentation measurements the chemical composition of all crystals containing both PbTe and PbS was determined by powder XRD technique. The single crystal orientation was checked by the Laue method. The nanoindentation measurements were performed on the (001)-oriented, natural crystal surfaces with a typical size exceeding 6x6 mm^2. For these measurements the Ultra Nanohardness Tester CSM UNHT/AFM with a several values of maximum load from 1 to 50 mN was used. The average values and standard deviations of the hardness and Young's modulus were extracted from the determined load-displacement results. The data on nanohardness and Young's modulus were collected at room temperature. The currently obtained values of these parameters were compared with existing literature data and the observed differences in mechanical properties of crystals are discussed.

This work was supported in part by National Science Centre (Poland) through grant UMO-2014/13/B/ST3/04393 and by the Foundation for Polish Science through the IRA Programme co-financed by EU within SG OP.

---

* Corresponding author. E-mail address: szusz@ifpan.edu.pl.

[1] M. S. Darrow, W. B. White, R. Roy, J. Mater. Sci. **4**, 313 (1969).
[2] J. E. Ni, E. D. Case, K. N. Khabir et al., Mater. Sci. Eng. B **170**, 58 (2010).
[3] A. Szczerbakow, K. Durose, Prog. Cryst. Growth Charact. Mater. **51**, 81 (2005).
[4] S. Adamiak, E. Łusakowska, E. Dynowska et al., Phys. Status Solidi B 1800549 (2019).