

# Nanocomposites and nanomaterials

## Superconductivity and weak localization of Pd<sub>x</sub>Bi<sub>2</sub>Se<sub>3</sub> whiskers

A. Druzhinin<sup>1,2</sup>, I. Ostrovskii<sup>1,2</sup>, Yu. Khoverko<sup>1,2</sup>, K. Rogacki<sup>2</sup>, N.S. Liakh-Kaguy<sup>1</sup>

<sup>1</sup>*Lviv Polytechnic National University, Lviv, Ukraine.*

*E-mail: [druzh@polynet.lviv.ua](mailto:druzh@polynet.lviv.ua)*

<sup>2</sup>*International Laboratory of High Magnetic Fields and Low Temperatures, Poland, Wroclaw.*

Low temperature superconductivity with  $T_c=4.2$  K have been recently found in GaSb<Te> whiskers [1]. Nowadays the studies of topological insulators Bi<sub>2</sub>Se<sub>3</sub> is promising for observing a set of exotic effects (Kondo effect, presence of Majorana fermions, weak localization, SdH oscillations, etc.).

Temperature dependences of the resistance in n-type Pd<sub>x</sub>Bi<sub>2</sub>Se<sub>3</sub> whiskers with different impurity concentration in the vicinity to the metal-insulator transition (MIT) from metal side of the transition  $(1-2)10^{19}$  cm<sup>-3</sup> were studied in the temperature range 1.5 - 77 K. The peculiarities of whisker resistance such as sharp drop at low temperature 5.3 K were observed for Bi<sub>2</sub>Se<sub>3</sub> whiskers with various Pd concentration, that could be explained by partial superconductivity of the whiskers. Analysis of magnetic field influence on the whisker conductivity allows to determine the main superconductor parameters: upper critical magnetic field  $B_{c2} = 1.5$  T, superconductor coherence length  $\xi(0)=15$  nm, superconductive gap 0.8 meV. The obtained values indicate that a reason of observed superconductivity is likely resulted from a presence of  $\beta$ -PdBi<sub>2</sub> complex originated from Pd intercalation in the crystal during their growth by VLS mechanism.

The rather low values of superconductor coherence length like that as in cuprates indicate in a possibility to observe others exotic phenomena in the whiskers. For Bi<sub>2</sub>Se<sub>3</sub> whiskers with resistivity  $\rho_{300K} = 0.0053$  Ohmcm a resistance minimum was observed at temperature about to 20-25 K, that may indicate in Kondo effect presence in the crystals. The effect is connected with exchange interaction between magnetic moments of singlet electron localized on impurities and free charge carriers and occurs only at certain impurity concentration at the vicinity to MIT.

The whisker magnitoresistance is considered in the framework of weak localization (WL) model and connected with subsurface layers of the whiskers.

[1] Khytruk I., Druzhinin A., Ostrovskii I., Khoverko Yu., Liakh-Kaguy N., Rogacki K. Properties of doped GaSb whiskers at low temperatures // *Nanoscale Research Letters.*– 2017.– Vol. 12:156.