Manifestation of the properties of a topological insulator in semiconducting $Bi_{1-x}Sb_x$ nanowires

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This paper reports a series resistance and magnetoresistance measurements made on single crystal $Bi_{1-x}Sb$ nanowires in semiconductor region with diameters ranging from 100 nm to 1000 nm.

It is known that $Bi_{1-x}Sb_x$ alloys demonstrated the topological nature of surface state. The surface states of pure Bi and Sb have been intensively studied experimentally and theoretically [1-3]. The first 3D topological insulator to be identified experimentally was the semiconducting alloy $Bi_{1-x}Sb_x$, whose unusual surface bands were mapped in an angle-resolved photo emission spectroscopy (ARPES).

Single crystal $Bi_{1-x}Sb_x$ nanowires in glass cover are the most suitable object for studied of the influence dimensional and surface state on electron transport.

Individual monocrystalline Bi-17at%Sb nanowires in glass capillary with diameter 100nm – 3mkm were prepared by liquid phase casting, using the improved Ulitovsky methods [4, 5]. Multiple horizontal zone recrystallizations of the nanowires were used for the homogenization and to improve their structural perfection.

Measurement of the resistance have been carried out over a wide range of temperatures (2-300K) and magnetic field up to 14T. The temperature dependences of the zero-field resistivity and the longitudinal magneto- coefficient of the semiconductor $Bi_{1-x}Sb_x$ nanowires show the sensitive to wire diameter.

Analyses of the resistance dependences R(T) on the wire diameters indicates that at low temperatures in the thin Bi-17at%Sb wires a sharp deviation from exponential temperature behavior resistance R(T) characteristic of bulk semiconductor is observed. In order to explain the experimental results of R(T), we need to take the surface state into account. According to the this deviation correspond to a considerable influence of a metalized well conducting near surface layer formed from the surface states arising through a spin- orbital Rashba interaction in nanowires. We measure the field dependences resistance R(H) at 1.5- 4.2 K and observed quantum oscillations only in thin Bi-17at%Sb wires in longitudinal and transverse directions. This fact indicates a essential contribution of surface states in electron transport a semiconducting $Bi_{1-x}Sb_x$ nanowires.

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