Abstract

The purpose of the thesis was investigation of magnetic and electrical transport properties of selected compounds that crystallize in MgAgAs-type crystal structure and contain rare earth metal, transition metal and bismuth. The main aim was the experimental confirmation of topologically non-trivial properties of electronic structure of these compounds. The motivation for these investigations was a great interest in these compounds due to their fascinating physical properties with possible various applications and particular electronic properties, namely inverted bands, predicted by *ab initio* electronic structure calculations making them potential topological materials. Moreover, superconductivity in this type of compounds is also fascinating, it can be unconventional and it may have topological nature, which can be useful for building fault-tolerant quantum computers.

All the investigations were carried out on single crystals grown from the bismuth flux. The subject of the thesis was the investigation of eight compounds: YPtBi, LuPtBi, GdPdBi, TbPdBi, DyPdBi, HoPdBi, ErPdBi and LuPdBi. The main accent in our investigations was put on measurements of electronic transport properties. With their help it is possible to confirm experimentally the topologically non-trivial nature of compound. Furthermore, thermodynamic properties of all compounds were studied as well.

The main result of the thesis is indication of the topologically non-trivial properties of investigated compounds. It was found that temperature dependences of electrical conductivity of YPtBi, LuPtBi, HoPdBi, LuPdBi can be described in the whole temperature range by the sum of two functions, corresponding to two independent channels of charge transport: metallic- and semiconducting-like. At low temperatures, the conductivity of semiconducting-like channel becomes to be negligible, which means that, if one ascribes metallic-like channel to the surface electronic states, the bulk of the sample becomes insulating.

The results of magnetoresistance measurements supported the possibility of non-trivial topology. Magnetoresistance of HoPdBi and ErPdBi is negative at low temperatures, but with temperature increasing gradually changes into the positive. On the other hand, magnetoresistance of YPtBi, LuPtBi and LuPdBi is positive, linear and does not demonstrate the saturation, even in the high magnetic field. Such behavior is typical of materials with non-trivial topology – topological insulators, or Dirac and Weyl semimetals. Sharp increase of magnetoresistance of HoPdBi, LuPdBi and YPtBi in weak magnetic fields is the reminiscent of weak-antilocalization

effect, which is also one of the signatures of topological materials. It was noticed that YPtBi, HoPdBi, ErPdBi and LuPdBi demonstrate Shubnikov-de Haas oscillations. The Berry phase of all these compounds was found to be very close to the theoretical value of π, characteristic of Dirac fermions.

Single crystals of YPtBi, LuPtBi, HoPdBi and LuPdBi were found to be superconductors below relatively low critical temperatures: 0.96 K, 0.9K, 0.65 K and 1.8 K, respectively. These T_c were confirmed by electrical resistivity and magnetic susceptibility measurements. In turn, temperature dependence of specific heat showed lack of anomaly corresponding to superconducting phase transition. This aspect is of great importance because it rather rules out bulk nature of superconductivity and enhances assumption about superconductivity of surface states only.

Obtained temperature dependences of magnetic susceptibility, heat capacity and electrical resistivity clearly demonstrate antiferromagnetic phase transitions in GdPdBi, TbPdBi, DyPdBi, HoPdBi and ErPdBi at Néel temperatures 12.6 K, 5.3 K, 3.5 K, 1.9 K and 1.1 K, respectively. Results of neutron diffraction experiments on single crystals of ErPdBi, HoPdBi and TbPdBi showed that propagation vector for all compounds is the same, (1/2,1/2, 1/2), which indicates that these compounds can be antiferromagnetic topological insulators.

The main result of this thesis is that several compound were confirmed as strong candidates to topologically non-trivial materials. The obtained results showed that the investigated compounds are fascinating due to the possible co-existence of non-trivial topology of the electronic structure, superconductivity and antiferromagnetism.