The use of mutual interactions between electronic states and spin and orbital degrees of freedom combined with the fundamental breaking of symmetry is currently one of the most exciting research areas. This effect is the basis for the giant magnetoresistance, manipulation of magnetic domains by means of momentum momentum transfer and the use of the Rashba effect to manipulate the electron spin. These effects have also led to prominent discoveries of new quantum phases, such as topological insulators, Weyl half-metals and Majorana fermions. Materials with large Rashba splitting and with helical ferromagnetic ordering such as $Ge_{1-x}Mn_xTe$ provide extraordinary physical properties due to the coexistence and coupling between ferromagnetism and ferroelectricity in one system. Multiferroic $Ge_{1-x}Mn_xTe$ inherits from the α-GeTe ferroelectricity the gigantic Rashba splitting of three-dimensional volumetric states, which competes with Zeeman's spin-induced fission induced by magnetic exchange interactions. Through the use of strong magnetic fields, manipulation of spin textures can be shown, which is also possible for electric fields based on multiferroic coupling. The control of spin fission and blocking by using ferromagnetism and ferroelectricity opens fascinating new paths for highly multifunctional Rashba multiferroic devices adapted to reprogrammable logic and memory applications.

Semiconductor mixed crystals belonging to the group IV-VI of the Periodic Table of Elements, ie GeTe containing paramagnetic admixtures, have been the subject of intensive research conducted in Poland and in the world for several decades. In the group of Applicants for the first time the occurrence of semi-magnetic ferromagnetism induced by long-range RKKY interactions in $Pb_{1-x-y}Sn_xMn_yTe$ crystals in semiconductors was discovered. Of all the IV-VI semiconductors, GeTe crystals are characterized by the highest value of the coupling constant J_{pd} = 0.8 eV - therefore, for several years many research groups in the world have been dealing with the improvement of growth technologies and the magnetic and electrical properties of $Ge_{1-x}Mn_xTe$ crystals. The latest research devoted to the $Ge_{1-x}Mn_xTe$ thin films report the existence of a ferromagnetic order with Curie temperatures of 200 K, which significantly increases the hopes associated with the potential uses of this material by further increasing the T_C above room temperature. Semimagnetic semiconductors based on the IV-VI matrix have a number of unique properties that imply practical applications. The presented properties make both the $Ge_{1-x}TM_xTe$ crystals (where TM is a transition metal) as well as their derivatives, an extremely important research and technological area, due to the significant strength of long-range magnetic interactions carried by free carriers (RKKY interactions). The growing interest in these materials has led in recent years to a significant increase in Curie temperatures to 140 K and 190 K for $Ge_{1-x}Cr_xTe$ and $Ge_{1-x}Mn_xTe$, respectively. Technological progress made in recent years along with high Curie temperatures creates real opportunities to further increase them and achieve the basic from the point of view of application applications - ferromagnetism at room temperature.

Extremely important in the context of basic research as well as potential applications of $Ge_{1-x}TM_xTe$ crystals and derivatives, is the search for correlations between magnetic and electron properties of ferromagnetic semiconductors sampled at the nano scale. It turns out that in these materials correlations between electrical and magnetic properties are extremely strong, have a complicated nature and are currently poorly understood. For this reason, understanding the physical mechanisms responsible for the various magnetoresistance effects and the Hall's anomalous conduct is very important from the point of view of the development of this field of solid state physics, especially in the context of the practical use of materials in spin electronics.

Semiconductors from group IV-VI, in contrast to materials III-V and II-VI, allow independent control of magnetic and electronic properties, since transition metal ions are in these materials isoelectronic dopant. It should be mentioned that in semi-magnetic semiconductors it is possible to manipulate the force of magnetic interactions by means of electrical polarization. From the point of view of the practical applications of GeTe crystals, this is a very important feature enabling the control of ferromagnetism with more degrees of freedom than in other semiconductors. The issue of controlling the magnetic properties of crystals by independent change of their chemical composition, concentration and motility of carriers.