Description for the general public

„One shouldn't work on semiconductors, that is a filthy mess; who knows whether any semiconductors exist". Wolfgang Pauli, one of the most influential physicists of 20th century, saying this words over 70 years ago, couldn't be more wrong. Only in mid–50s the first semiconductor based computer showed up, and ten years later the internet came to existence. Nobody expected at that time, that in 50 years, these two technologies will dominate telecommunication, transport market and military industries. This rapid technological development would not be possible without a thorough understanding of semiconductor physics – materials which are the basis of most modern electronic devices. Together with their growing popularity, there was a need for smaller, faster and more power–saving devices. It was possible only due to the constant miniaturization of transistors and other semiconductor devices. Today – In the beginning of 21st century, we are approaching the limit of miniaturizing our semiconductor devices which nowadays are few nanometers in size. Similar development is ongoing in the field of magnetic memories in which ferromagnetic (i.e. spontaneously magnetized) materials are exploited.

Taking into account aspects presented above, physicists started to explore additional technological possibilities which may enhance performance of the semiconductor devices. One of which is the spin electronics also called Spintronics. So far we have exploited only one property of electric current carriers - the charge. Spintronics however, aims on taking advantage of the spin degree of freedom. To achieve this goal, researchers from all over the world are trying to create material which could combine properties of semiconductors and ferromagnetic materials. This can be achieved by doping semiconductor (e.g. galium arsenide, GaAs) with magnetic ions (e.g. manganese, Mn). Materials of this kind are called diluted magnetic semiconductors. The goal of this project is to investigate the interplay between electric and magnetic properties occurring close to a so called Curie temperature, at which material is losing it's permanent magnetization, and starts to behave as ordinary, non-magnetic one.

One of the fundamental properties of diluted magnetic semiconductors is occurrence of sharp resistivity maximum at Curie temperature. This phenomenon is known to physicists since five decades, though it did not receive a proper theoretical explanation, so far. Our goal is to check, how this critical behavior depends on material properties (e.g. dopants concentration) and external conditions (e.g. magnetic field). It seems that by employing predictions coming from Quantum Mechanics we will be able to explain the mechanism driving this phenomenon, as well as, give a proper theoretical description.

Further part of the project will be devoted to testing, whether the electric current could change the direction of material magnetization. It turns out to be possible due to additional magnetic field coming from the relativistic interaction of electron spin and material's internal electric field. Our research will be based on two DMS class materials – (Ga,Mn)As and (Pb,Mn,Sn)Te which due to different materials parameters and crystal structure will most likely verify our theoretical predictions.