Investigation of spin dynamics in hybrid structures based on ferromagnetic semiconductor (Ga,Mn)As

Abstract:

This dissertation deals with the study of hybrid ferromagnet/semiconductor structures, which are of particular for spintronics. We focused on heterostructures that contain ferromagnetic semiconductor (Ga,Mn)As, which is the most studied model material from the group of diluted magnetic semiconductors. The main goal of this work was a detailed study of the Optical Spin Transfer Torque (OSTT) phenomenon, which is an optical equivalent of the STT effect, which is used in ferromagnetic metal layers for non-thermal switching of the direction of magnetization. In the first part of the work, we describe experiments aimed at achieving non-thermal control of the direction of magnetization in (Ga,Mn)As with the contribution of control of magnetic anisotropy using mechanical strain induced by a piezo-transducer (PZT) in hybrid structure (Ga,Mn)As/GaAs/PZT. For this purpose, the preparation of the structure was first optimized, which was tested in detail by means of X-ray diffraction and magneto-optical methods. However, we were unable to achieve magnetization switching due to the OSTT phenomenon. In addition, we found that the results measured at low temperature are very poorly reproducible, despite very detailed optimization of the preparation, attributed to the influence of mechanical strain between the studied sample and the cryostat cold finger, which differs for each cooling cycle. For efficient use of our optimized preparation process for hybrid structures on PZT, it is therefore necessary to use materials which not only react strongly to the applied mechanical strain but are also magnetically ordered at room temperature (for example, certain non-colinear antiferromagnets). In the second part of this thesis, we dealt with the study of the interaction of electron spin optically injected into the structure (Ga,Mn)As/GaAs, with magnetization in the layer of (Ga,Mn)As. We have found that this interaction results in an ultra-fast reorientation of the electron spin direction. This phenomenon, which forms the basis of the STT phenomenon, has so far been considered only a theoretical concept, because in commonly studied metal ferromagnets, it is not possible to distinguish between electrons that are responsible for magnetization and electrons realizing spin current. However, in the ferromagnetic semiconductor (Ga,Mn)As studied in this thesis, these are different electrons (on *d*- or *s*-orbitals), allowing us to experimentally observe this "presumed" rotation of electron spins due to magnetization.