Theory of Spin Transport phenomena in Magnetic Tunnel Junctions

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PhD may follow: Yes

Summary :

Magnetic tunnel junctions (MTJ) comprising two ferromagnetic (FM) layers separated by an insulator (I) play a crucial role in current and future developments of spin electronics (spintronics), such as such as magnetic random access memories (MRAM), hard disk drives, logic devices etc. This is due to observation in MTJs of high tunnel magnetoresistance (TMR) ratios, i.e. relative change of resistance when magnetic configuration is switched from parallel to antiparallel. The discovery of a new spintronic phenomenon called spin transfer torque (STT) makes possible controlling magnetic configuration of the tunnel junction by passing spin polarized current through it instead of applying magnetic field. It makes possible thereby creation of new generations of MRAM (STT-MRAM) where both read and write operations can be performed with spin polarised current.

Full description :

The purpose of this internship is to use a tight-binding method and non-equilibrium Green function technique in order to understand deeply the quantum nature of a wide range of spin polarized transport phenomena in magnetic tunnel junctions. Among phenomena to address the priority will be given not only to quantum description of tunnel magnetoresistance (TMR), but mostly to spin transfer torque (STT) since this phenomenonâ€™s behavior defines behavior of STT-MRAM and also is crucial for signal-to-noise ratio (SNR) of magnetic sensors since its contributes to noise. Namely, a physical nature of applied voltage dependences of TMR and STT will be investigated and understood what is extremely important in a view of aforementioned spintronic devices. We expect that these dependences will be very sensitive to electronic band structure of materials involved as well as to thicknesses of the metallic and insulating layers constituting the magnetic tunnel junctions. We will also address Spin Hall Effect and interfacial magnetic anisotropy behaviour in MgO-based tunnel junctions.

Requested skills :

solid background in condensed matter theory and computational methods