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Spin Transport Studies of Nanoscaled Ferromagnetic Tunneling Devices

Abstract
This thesis presents spin transport studies of ferromagnetic nano-scaled tunneling devices fabricated by atomic force microscopy (AFM) and electron beam lithography (EBL). The thesis covers three main topics:
The first topic is a study of spin accumulation (relaxation) in Au nano-structures using Ni/Au/Ni ferromagnetic single electron transistors (F-SETs). A Ni/Au/Ni F-SET with a single central Au nanodisk is fabricated using AFM manipulation. From the magnetotransport measurements on the devices, we conclude that spin accumulation in the Au nanostructure is below the detection limit due to fast spin relaxation. From comparison with results of theoretical modeling, we deduce an upper bound of 4 ns for the spin-relaxation time in a Au island with dimensions of a few tens of nanometers.
The second topic deals with a magnetoresistance (MR) study of Co/Ni/Co F-SETs defined by EBL. We observe two main interesting results from the measurements: a large negative onset of the MR signal and a rapid decrease of the TMR with increasing bias. The former one can be related to the special geometry design of our devices, while the latter one can tentatively be ascribed to magnon excitations in the central Ni island.
The third topic concerns a tunneling anisotropic magnetoresistance (TAMR) effect observed in Co/AlOx/Au tunnel junctions. We find an increase (decrease) in the MR signal when the magnetization direction of the Co electrode is parallel (perpendicular) to the current direction. We attribute this novel phenomenon to a spin-orbit interaction (SOI) induced asymmetrical mixing of spin-up and spin-down states in the 3*d* bands. The TAMR decreases very sharply with increasing temperature, indicating a very fast drop-off of the SOI induced tunneling DOS anisotropy.

Key words
Spin transport, ferromagnetic single electron transistor, spin relaxation, tunneling magnetoresistance, tunneling anisotropic magnetoresistance.

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