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Spin Transport in Ferromagnet-Semiconductor Heterostructures[1]

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Over the last two years, there has been significant progress in the integration of metallic ferromagnets with semiconductors, resulting in devices in which spin-polarized carriers are injected and detected electronically. I will discuss experiments on epitaxial Fe/GaAs Schottky tunnel barrier heterostructures patterned into lateral devices in which the ferromagnetic injection and detection contacts are separated by several microns.[1] The Schottky barrier consists of a highly-doped n^+ region ($n^+ \sim 5 \times 10^{18}$ cm^{-3}), and the channel of the device is n-doped GaAs ($n \sim 2 \times 10^{16} - 1 \times 10^{17}$ cm^{-3}). A non-equilibrium spin polarization generated by electrical injection is detected potentiometrically using the non-local transport technique applied originally to metallic systems. An important aspect of this approach is the observation of spin precession and dephasing in the semiconductor channel (the Hanle effect), allowing for electrical measurements of the spin lifetime and diffusion length. We find a strong non-linear dependence of the spin polarization on the injection bias voltage, which we have investigated by preparing samples with different thicknesses of the n^+ region, thus varying the tunnel barrier profile. We find a systematic change in the spin accumulation observed under forward and reverse bias currents as the thickness of the n^+ region increases. Other aspects of these devices have also been explored. For GaAs channels that are doped near the metal-insulator transition, the non-equilibrium electron spin polarization leads to dynamic nuclear polarization, which has a profound impact on the electron spin dynamics at low temperatures. Finally, I will discuss some important considerations for applications in which a bias current flows in the detector. [1] X. Lou *et al.*, Nature Physics **3**, 197 (2007)

[1]In collaboration with X. Lou, C. Adelmann, E.S. Garlid, Q. Hu, T. Kondo, J. Zhang, S.D. Flexner, K.S.M. Reddy, S.A. Crooker, and C.J. Palmstrøm and supported by ONR, the NSF MRSEC, NNIN, and IGERT programs, and the Los Alamos LDRD program.