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Electrical Spin Injection into InAs/GaAs Quantum Dots at Room Temperature[1]

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Efficient electrical injection of spin-polarized electrons from a magnetic contact into a semiconductor is an essential requirement for utilizing the spin degree of freedom in semiconductor spintronic devices. The spin- polarized light emitting diode (spin-LED) is used as the platform for demonstrating spin injection since it provides a quantitative and model independent measure of the electron spin polarization. Using this method, we have observed an electron spin polarization 32% in GaAs (001) QWs due to electrical spin injection across an Fe/AlGaAs reverse- biased Schottky contact [1]. Recent attention has focused on the unpaired spin of an electron in a charged quantum dot (QD). The lack of available energy states due to the discrete energy level spectrum inhibits both elastic spin flip and inelastic phonon scattering mechanisms, resulting in long spin relaxation times [2]. This is an important requirement for developing spin-based electronics and certain implementations of quantum information technology. We report here room temperature electron spin polarization in InAs/GaAs self assembled QDs by electrical injection of spin-polarized electrons from an Fe Schottky contact. The quantum dots, formed by Stranski-Krastanov strain driven self- assembly during MBE growth, are embedded in the intrinsic region of an AlGaAs/GaAs QW LED structure with an epitaxial Fe film as the surface contact for injection of spin-polarized electrons. The circular polarization of the QD electroluminescence tracks the out-of-plane magnetization of the Fe, and shows that a 5% electron spin polarization is achieved in the InAs QDs. The QD spin polarization persists to room temperature. Nonmagnetic reference samples show a background polarization on the order of 1% which has little dependence on magnetic field. TEM images indicate that the Fe/AlGaAs interface is rougher than expected possibly due to QD incorporation, which is likely to limit spin injection, and may be solved by refining growth procedures. These results demonstrate that practical regimes of spin-based operation are clearly attainable in solid state semiconductor devices.

[1] A.T. Hanbicki et al., APL 80, 1240 (2002), 82, 4092 (2003). [2] M. Paillard et al. PRL 86, 1634(2001).

[1]Work in collaboration with G. Kioseoglou, O. M. J. van t Erve, M. E. Ware, D. Gammon, R. M. Stroud, B. T. Jonker at the Naval Research Lab, and R. Mallory, M. Yasar, A. Petrou at SUNY Buffalo. Supported by DARPA (SPINS Program), ONR, and NSF