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Generation, Modulation and Electrical Detection of Spin Currents in Silicon in a Lateral Transport Geometry[1]

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The electron's spin angular momentum is one of several alternative state variables under consideration on the *International Technology Roadmap for Semiconductors*. Electrical injection / transport of spin-polarized carriers is prerequisite for developing such an approach. While significant progress has been realized in GaAs, little has been made in Si. Electrical injection of spin-polarized electrons is demonstrated in Fe/Al2O3/Si (001) n-i-p structures by measuring the circular polarization of the electroluminescence (EL). The EL polarization tracks the Fe magnetization, confirming spin injection into the Si, and reflects Fe majority spin, consistent with the common delta_1-symmetry of the Fe and Si bands. The Si spin polarization is ~30% at 5K, with significant polarization extending to at least 125K. These results are confirmed in Fe/Al2O3/Si/AlGaAs/GaAs quantum well structures – the GaAs EL shows that spin transport occurs despite poor crystalline quality of Si epilayers on GaAs, the 0.3 eV Si/AlGaAs CB offset, and air exposure of the interfaces. Lateral transport structures and non-local detection techniques are used to create a spin current which flows separately from the spin-polarized charge current. This spin diffusion current is sensitive to the relative magnetizations of the injecting and detecting contacts, and can be modulated by a perpendicular magnetic field (Hanle effect) which causes precession in the transport channel. The generation of spin currents, coherent spin precession and electrical detection using magnetic tunnel barrier contacts and a simple lateral device geometry compatible with "back-end" silicon processing will facilitate development of silicon-based spintronic devices.
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