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Electrical spin injection from ferromagnetic metals and semiconductors[1]

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Electrical injection, transport, manipulation and detection of spin polarized carriers in a semiconductor are essential requirements for utilizing the spin degree of freedom in a future semiconductor spintronics technology. Electrical injection has been a particularly vexing issue. We describe results using both ferromagnetic semiconductor (FMS) and FM metal contacts, and review the on-going effort to understand the fundamental issues. Spin-LED structures serve as test platforms, and the quantum selection rules provide a quantitative measure of the electron spin polarization, Pspin, produced in an AlGaAs/GaAs QW. The large values of Pspin=85% obtained using semimagnetic ZnMnSe contacts enable detailed analysis of spin scattering by interface defects. True FM materials are preferable as contacts, and FMSs are promising candidates – their exchange split band edges offer both spin injection and spin-selective transport. An n-type FMS is especially attractive. We describe measurements of electrical spin injection from such an n-type FMS, $CdCr_2Se_4$, into AlGaAs/GaAs LEDs, and discuss interface structure and band offsets. FM metals offer many desirable attributes as spin injecting contacts – high Curie temperatures, low coercive fields and fast switching times – and the fundamental issue of interface conductivity mismatch can be circumvented by utilizing a tunnel barrier. We have successfully injected polarized electrons from a reverse-biased Fe Schottky contact into AlGaAs/GaAs, with Pspin $> 32\%$. We demonstrate via the Rowell criteria that tunneling is indeed the dominant transport process, and confirm that majority spin electrons are responsible. We compare these data with spin injection using Fe/Al_2O_3 contacts into identical structures.

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