

Abstract for an Invited Paper
for the MAR07 Meeting of
The American Physical Society

Generating Spin Currents in Semiconductors with the Spin Hall Effect¹

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There is a growing interest in exploiting electron spins in semiconductor nanostructures for the manipulation and storage of information in emergent technologies based upon spintronics and quantum logic. Recently we have explored two mechanisms for electrically generating spin polarization in non-magnetic materials: current-induced spin polarization and the spin Hall effect. Current-induced spin polarization results in spins being polarized by the internal magnetic field arising from spin-orbit coupling, and the spin Hall effect refers to the generation of a spin current transverse to a charge current in the absence of an applied magnetic field. Recent measurements in ZnSe reveal that both of these effects are robust to room temperature³. Although spin current is difficult to measure directly, the spin Hall effect creates spin accumulation at the edges of a channel which has been measured in bulk epilayers of n-doped semiconductors and in two-dimensional hole and electron systems. More recently, we investigate spin currents generated by the spin Hall effect in GaAs structures that distinguish edge effects from spin transport⁴. We fabricate mesas with transverse channels to allow spins to drift into regions in which there is minimal electric current. Using optical techniques, we observe the electrical generation of a transverse spin current, which can drive spin polarization nearly 40 microns into a transverse channel. Using a model that incorporates the effects of spin drift, we determine the transverse spin drift velocity from the magnetic field dependence of the spin polarization. These results reveal opportunities for an electrical spin source in non-magnetic materials.

¹Work supported by DARPA, NSF and ONR.

²Work performed in collaboration with V. Sih, W. H. Lau, R. C. Myers, V. R. Horowitz and A. C. Gossard.

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