Spin Transport in 6.1 Å Semiconductors

Ki Wook Kim, Andrey A. Kiselev, and Pil Hun Song
Dept. of Electrical and Computer Engineering
North Carolina State University, Raleigh, NC 27695-7911

Control of spin-dependent transport and preservation of spin polarization is a pivotal prerequisite for the operability of prospective spin devices. In this abstract, we investigate theoretically spin-polarized transport and relaxation in III-V semiconductors including the 6.1-Å materials, and explore the possibility of its manipulation.

Specifically, the relevant spin relaxation rates are estimated as a function of temperature and doping conditions, and regimes of significance are identified for each mechanism in the bulk material. We also investigate spatio-temporal kinetics of electron spin polarization in quasi-1D channels (particularly, InAs) and explore the ability to manipulate spin relaxation. Our approach is based on a Monte Carlo transport model that incorporates information on conduction band electron spins and spin rotation mechanisms. An ensemble of electrons experiencing multiple scattering events is simulated numerically and the decay of spin polarization due to the DP mechanism is analyzed as a function of the channel width and the DP parameter (inverse spin-rotation length). Our results identify different regimes of the spin relaxation and demonstrate that spin polarization can be preserved for a relatively long time and suppression of spin relaxation is possible for quasi-1D channels.

Having established regimes with highly suppressed spin relaxation, we propose a family of ballistic semiconductor microstructures, based on the internal spin-orbit (SO) effect, that can filter/multiplex electron spin. The structures consist of a system of quasi-1D channels and electrodes placed near the channel intersections, so that the gate voltage can effectively manipulate the SO splitting of the 2DEG. Our calculations demonstrate that the proposed devices can redirect electrons with opposite spins from an unpolarized source to separate output leads, and thus, serve as an efficient spin filter without the use of an external magnetic field.