Reduction of Surface Roughness Induced Spin Relaxation in Thin Silicon Films

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In order to integrate contemporary electronics with spin-based devices three issues must be solved: spin injection, spin transport, and spin detection. We focus on a particular issue in spin transport, namely on spin relaxation due to surface roughness scattering in thin (001) silicon films.

To accurately describe the band structure of silicon in the presence of the intrinsic spin-orbit interaction we generalize the perturbative two-band k•p approach to include the spin degree of freedom. Due to the spin-orbit interaction the spin-up and spin-down functions are not the eigenfunctions of the Hamiltonian resulting in a finite probability of spin-flip during scattering. Surface roughness scattering is taken proportional to the product of the subband function derivatives at the interfaces squared. An accurate inclusion of the spin-orbit interaction results in a large mixing between the spin-up and spin-down states along the [100] and [010] axes resulting in spin “hot spots”. The origin of these “hot spots” lies in the unprimed subband degeneracy in a confined electron system. Shear strain splits the otherwise degenerate unprimed subbands. This energy splitting removes the origin of the spin “hot spots”, which should substantially improve the spin lifetime in thin silicon films.

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