Universal Dependence of the Spin Lifetime in Silicon Films on the Spin Injection Direction

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Recent spectacular experimental demonstrations of SpinFETs [1] and Spin MOSFETs [2] bring semiconductor spintronics closer to applications. However, in contrast to the electron charge, the total spin of an ensemble of injected spin-polarized carriers is not conserved. The spin relaxation in silicon is due to the Elliott-Yafet mechanism [3,4]. Because of the spin-orbit interaction, the wave function is not a pure spin state, so at every scattering event there is a final probability of a spin flip. In SOI MOSFETs the electron-phonon and surface roughness scattering must be considered. The spin relaxation is determined by the hot spots defined by the degeneracy of the two subbands originating from the two [001] valleys. The spin-orbit field is the strongest at the hot spots [5]. Because this field is in-plane, the spin relaxation should depend on the spin injection orientation. By performing numerical calculations in thin silicon films, we find a universal behaviour of the spin lifetime on the spin injection orientation. This behaviour is preserved for every scattering mechanism and is strain-independent [6] guaranteeing a spin lifetime enhancement by a factor of two [3,7] for in-plane injection as compared to the injection orthogonally to the film.

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