Surface Roughness Induced Spin Scattering and Relaxation in Silicon SOI MOSFETs

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Silicon is a plausible material for spin-based applications. It attracts much attention because of urgent needs of deeper understanding the fundamental spin relaxation mechanisms [1], [2].

We investigate the surface roughness induced spin relaxation in a SOI double-gate spin field-effect transistor. To accurately describe the band structure in the presence of the intrinsic spin-orbit interaction the two-band **k·p** Hamiltonian has been generalized to include the spin degree of freedom. The spin-orbit term $\tau_y \otimes (k_x\sigma_x - k_y\sigma_y)$ couples states with the opposite spin projections from the opposite valleys, σ_x and σ_y are the spin Pauli matrices, and τ_y is the y-Pauli matrix in the valley degree of freedom. In the presence of strain and confinement the four-fold degeneracy of the lowest subband is partly lifted, however, the degeneracy of the eigenstates with opposite spin projections, $\Uparrow\rangle$ and $\Downarrow\rangle$, is preserved. The degenerate states are chosen to satisfy $\langle \Uparrow n \pm |\sigma_x| n \pm \Downarrow\rangle = 0$. The surface roughness scattering matrix elements are taken proportional to the square of the product of the subband function derivatives at the interfaces. The intersubband matrix elements between the states with the opposite wave vectors **k** and -**k** are shown in Fig.1. Fig.2 demonstrates that the intersubband spin relaxation matrix elements increase with the k value increased. At the same time they decrease for larger shear strain rapidly. Thus shear strain used to enhance electron mobility can also be used to boost the spin lifetime.

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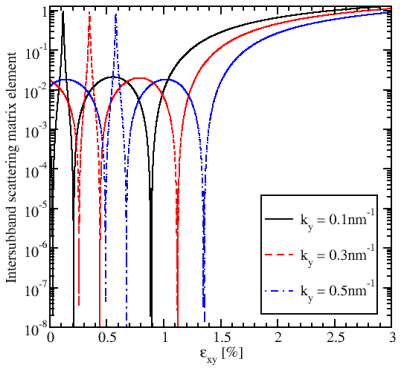

Fig. 1. Intersubband scattering matrix elements normalized to the intrasubband scattering at zero strain as a function of strain for k_x =0.5nm^{-1}. The well width is 4nm.

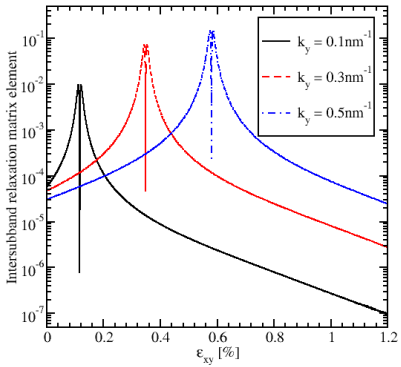

Fig 2. Intersubband relaxation matrix elements' (normalized to intrasubband scattering at zero strain) dependence on shear strain for several values of k_y . Spin is injected along [100] direction.

References

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