Strain engineering in Ge/GeSi spin qubits heterostructures

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Hole spin qubits in Si and Ge/GeSi heterostructures have made outstanding progress in the past few years. They can be efficiently manipulated with electric fields thanks to the strong spin-orbit interaction in the valence bands of these materials [1]. High fidelity four-qubit processors have been demonstrated, as well as the control of charge in a sixteen-dot array [2], and the coherent shuttling in a ten-qubit array [3].

However, germanium spin qubits in planar heterostructures suffer from the strong anisotropy of the gyromagnetic g-factors of heavy-holes, where the out-of-plane g-factor can be up to 100 times larger than the in-plane g-factors [4].

In this work, we explore the prospects for strain engineering in planar silicon/germanium heterostructures [5]. We show, with analytical models as well as numerical simulations on realistic setups, that uniaxial strains can significantly increase the in-plane g-factors. In particular, we demonstrate that the relaxation of a rectangular mesa with a large length to width ratio, etched in a strained buffer, is essentially uniaxial (see Figure 1). We discuss how such inhomogeneous uniaxial strains can improve the control over the qubits and soften the strong dependence on the magnetic field orientation. We finally predict how the strains influence the rotation angle of the precession axis and the Rabi frequency for shuttling protocols in double quantum dots.

References

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Figures

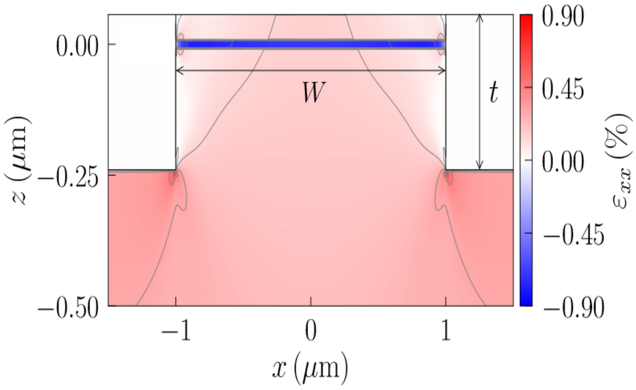

Figure 1: Map of the strain ε_{xx} in the cross section of a mesa with *W*=2 μm and depth *t*=0.3 μm.