Electrical control of electron and hole spins in InSb nanowire quantum dots

V. S. Pribiag[1], S. Nadj-Perge[1], J. W. G. van den Berg[1], S. M. Frolov[1], I. van Weperen[1], S. R. Plissard[2], E. P. A. M. Bakkers[1,2] and L. P. Kouwenhoven[1]

[1] *Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands*
[2] *Department of Applied Physics, Eindhoven University of Technology, The Netherlands*

The spin-orbit interaction enables fast all-electrical control of individual spins in quantum dots. The presence of very large spin-orbit coupling thus makes InSb nanowires a highly promising platform for spin-based qubits. We rely on electric dipole spin resonance (EDSR) to demonstrate single electron spin rotations, measure the strength of the spin-orbit coupling and extract the anisotropic g-factor. Fast Rabi oscillations in excess of 100 MHz are demonstrated [1]. This is considerably faster than typical Rabi frequencies for GaAs qubits, however the coherence times are relatively short (T_{echo} ~35 ns).

A promising approach to enhancing qubit coherence is to use hole spins as qubits instead of electron spins, since hole spins have weaker hyperfine coupling. Here we take advantage of the small bandgap of InSb to readily gate-tune our nanowire devices between few-electron and few-hole quantum dots [2]. In the few-hole regime we demonstrate rotation of single hole spin states via EDSR and use this to extract the hole g-factors. Thanks to the high tunability of these devices we are able to compare important properties of electrons and holes, such as effective masses, g-factors and spin-blockade anisotropies. The ability to control and read out hole spin states paves the way for more coherent, all-electrical hole-spin qubits.

[1] J. W. G. van den Berg et al., Phys. Rev. Lett. **110**, 066806 (2013).
[2] V. S. Pribiag et al., Nature Nanotechnology DOI:10.1038/NNANO.2013.5 (2013).

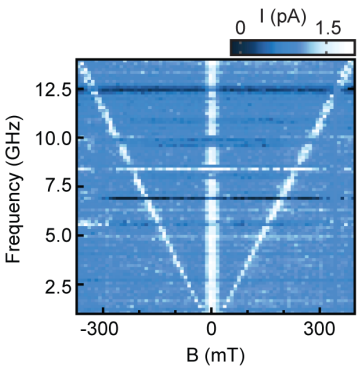

Figure 1. Electric Dipole Spin Resonance of a hole spin state in an InSb nanowire quantum dot.