

Coherent interaction of a hole spin and a microwave photon

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Recently, hole spins in silicon and germanium have shown increasing interest for quantum information processing owing to the advantage of manipulating their state with electric instead of magnetic microwave fields [1,2]. This is possible due to the strong spin-orbit interaction intrinsically present in the valence band of these materials. Spin-orbit coupling offers as well the possibility to couple a hole spin to the electric field component of a microwave photon.

Here we show a strong hole spin-photon interaction on a CMOS compatible platform. We find a coupling strength of 300 MHz, exceeding the spin decoherence rate and the photon decay rate by a factor 30. Our coupling largely exceeds the best figures reported so far in the case of electrons in silicon [3,4], opening the door to the achievement of high-fidelity two qubits gate with distant spins. Moreover, the dominating Rashba spin-orbit coupling allows us to tune the spin-photon coupling strength by more than one order of magnitude by simply varying the magnetic field orientation with respect to the spin-orbit field.

References

- [1] F. Giustino *et al.*, *J. Phys. Mater.* **3** 042006 (2020)
- [2] G. Scappucci *et al.*, *Nat Rev Mater* **6**, 926–943 (2021).
- [3] Borjans, F., *et al.*, *Nature* 577, 195 (2020)
- [4] P. Harvey-Collard, arXiv:2108.01206.

Figures

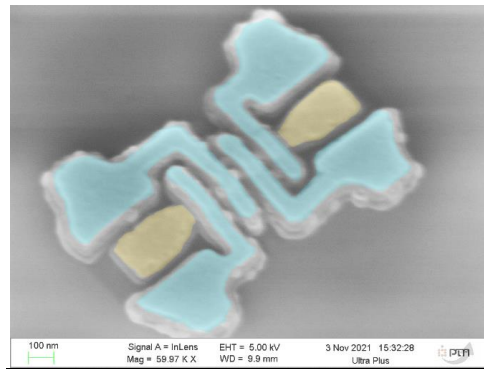


Figure 1: Colorized scanning electron micrograph of a silicon-on-insulator nanowire (yellow) with four gates (blue).

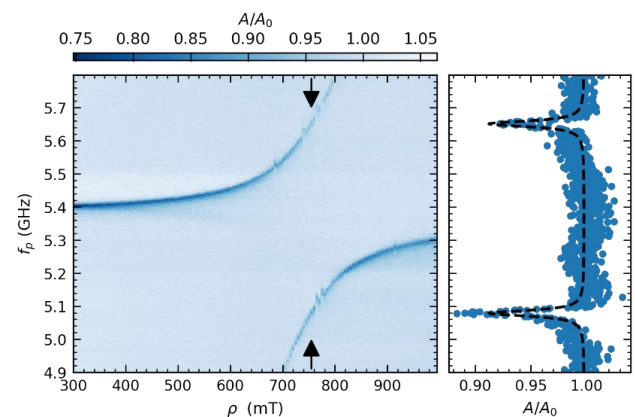


Figure 2: Transmission of the cavity as a function of in-plane magnetic field with a clear avoided crossing attributed to the strong spin-photon coupling. A line cut through the position indicated by the arrows shows a Rabi vacuum splitting of 600 MHz.