A single hole spin with enhanced coherence in natural silicon

Presenting Author : B.Brun

Co-Authors : N. Piot[1*], B. Brun[1*], V. Schmitt[1], S. Zihlmann[1], V. P. Michal[2], A. Apra[1], J. C. Abadillo-Uriel[2], X. Jehl[1], B. Bertrand[3], H. Niebojewski[3], L. Hutin[3], M. Vinet[3], M. Urdampilleta[4], T. Meunier[4], Y.-M. Niquet[2], R. Maurand[1], S. De Franceschi[1]

1-Univ. Grenoble Alpes, CEA, Grenoble INP, IRIG-Pheliqs, Grenoble, France. 2-Univ. Grenoble Alpes, CEA, IRIG-MEM-L Sim, Grenoble, France. 3-Univ. Grenoble Alpes, CEA, LETI, Minatec Campus, Grenoble, France. 4-Univ. Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, Grenoble, France.

CEA Grenoble, 17 Av des martyrs, 38000 Grenoble

boris.brun-barriere@cea.fr

Spin quantum bits in semiconductor appear to be one of the most promising technologies for the development of the quantum processor. Although electrons are the focus of modern research, holes exhibit many interesting physical properties. In particular, spin-orbit interaction allows a fully electrical control of the hole spin qubit state [1]. As a drawback, any external electric perturbation is likely to induce decoherence. Here we demonstrate for a single hole qubit in silicon the existence of sweet spots at which the qubit is decoupled from charge noise while keeping an efficient electrical driving. We first realize spin single-shot readout of the first hole accumulated in a natural silicon quantum dot made from a semi-industrial 300mm CMOS foundry. Subsequently, we characterize the hole spin g-tensor and its susceptibility to electric fields by coherent manipulation depending on the external magnetic field orientation. It reveals optimal operation points at which the longitudinal spin-electric susceptibility is minimal. At these sweet spots, we measure a Hahn-Echo decay time in the order of 100us while maintaining Rabi frequencies in the MHz range. This work opens new perspectives for quantum processing based on spin-orbit qubits.

(arXiv:2201.08637v1)

References

[1] Bosco et al, *PRX Quantum*, 2021
[2] Elzermann et al, *Nature*, 2004

Figures

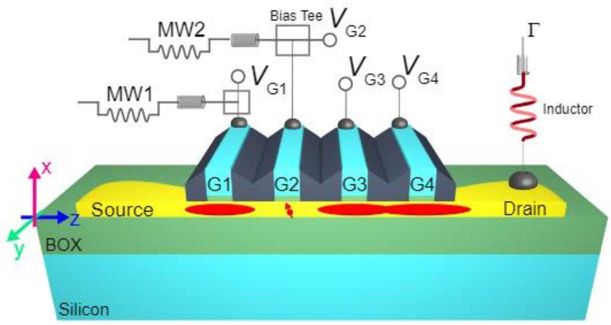

Figure 1: Simplified 3-dimensional representation of a silicon (yellow)-on-insulator (green) nanowire device with four gates. Gate 2 (G2) defines a quantum dot hosting a single hole. The drain contact is connected to an off-chip, surface-mount inductor to enable rf-reflectometry readout.

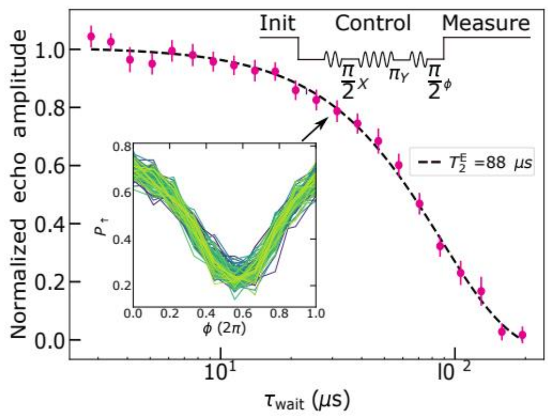

Figure 2: Normalized echo amplitude versus the free evolution time using a Hahn echo sequence (See top left inset). Black dashed line represents the Gaussian fit to extract the extended coherence time at the optimised working point.