Postdoctoral position on the modeling of noise in spin qubits

January 12, 2024

A post-doctoral position is open at CEA-LETI in Grenoble (France) on the modeling of charged defects in nanodevices and their impact on the performance of spin qubits. The selected candidate is expected to start early 2024, and the position lasts two years.

Global context:

Spin qubits are among the most promising platforms for quantum computation, with great advances occurring in the last years[1-3]. Semiconductor spin qubits rely on oddly occupied quantum dots to store the information in the spin of the confined carriers, which can be either electrons (n-type Si MOS[4] and Si/SiGe [3] devices) or holes (p-type Si MOS [1] and Ge/SiGe [2] devices).

The spin is often manipulated with electric AC signals thanks to a variety of Spin Orbit Coupling (SOC) mechanisms that couple it to electric fields.[5-7] This makes it also sensible to fluctuations in the electrical environment of the qubit, which can lead to large qubit-to-qubit variability [5] and to charge noise. Charge noise in spin qubit devices potentially comes from charging/decharging events within the amorphous and defective materials (SiO_2, Si_3N_4…) and interfaces of the devices.

Local context:

With the confluence of teams from several research institutes and thanks to the clean room facilities of CEA-LETI, Grenoble has pioneered the industrial manufacturing of spin qubit devices in transistor-like (Si MOS) devices. [1] The CEA-IRIG institute actively develops the 'TB_Sim' code, which is able to describe very realistic qubit structures (see Figure 1) using atomistic tight-binding and multi-bands k.p models. Modelling and simulation have played a key role in the latest achievements: record hole spin lifetimes [9] and spin-photon coupling [10]. Moreover, the CEA-LETI owns a cryogenic wafer prober, which allows to automatically obtain statistics of the spin qubit properties (among which the noise levels) at a wafer level for different device layouts at cryogenic temperatures [9].

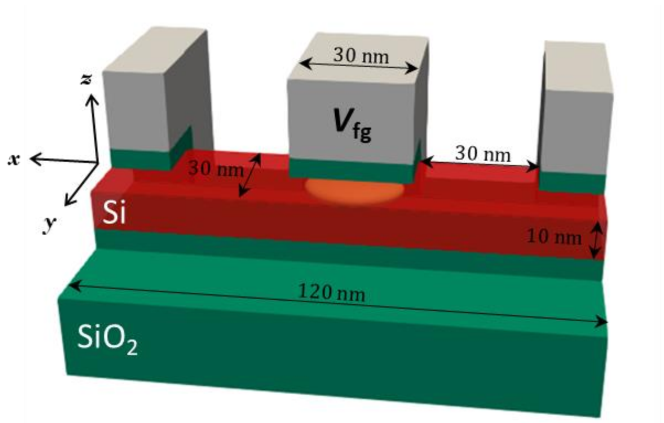

Figure 1: Illustration of a single qubit Si MOS device as simulated with TB_Sim. The ground state hole wavefunction of the singly-occupied quantum dot, computed with a 6KP method, is shown in orange.

Objectives of this position:

The aim of this position is to improve the understanding of noise in spin qubit devices with multiscale simulations. This includes:

- The atomistic characterization of the type of defects and their typical charging/decharging rates with *ab-inito* methods (Density Functional Theory).
- The inclusion of these results to TB_SIM to evaluate the impact of the simulated disorder into the spin qubit properties.
- The comparison between the experimental and simulated data to disentangle the origin of noise in the spin qubit devices fabricated at LETI.
- The exploration of novel device architectures informed by the discoveries made in the preceding phases, leveraging these insights to advance the state-of-the-art in spin qubit technology.

The candidate must have a PhD in Quantum, Condensed Matter or Solid-State Physics (or related topics). Knowledge on the physics of spin qubits and previous experience in *ab-initio* modelling of defects in amorphous materials is a plus. This work includes the simulation of defects at the atomistic level with pre-existing commercial codes, and the eventual upgrade of TB_SIM to include the desired effects. Therefore, the candidate must have programming skills (Python, Fortran) and master Linux environments (Bash, high performance computing (HPC) facilities...).

The selected candidate will join a large multidisciplinary team of researchers from different institutions (CEA, Institut Néel) and a start-up (Quobly) working on Si and Ge spin qubits in Grenoble. She/he will be under the supervision of Dr. Biel Martinez i Diaz at CEA-LETI, and will strongly collaborate with the simulation team of Dr. Yann-Michel Niquet at CEA-IRIG and the integration and characterization teams at CEA-LETI.

How to apply:

The candidate should send her/his CV to Biel Martinez i Diaz (biel.martinezidiaz@cea.fr), with a list of publications, a motivation letter with a summary of accomplishments, and arrange for two recommendation letters. The position is open until filled.

References:

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5. B. Martinez. Phys. Rev. Applied 17, 024022 (2022).
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7. B. Martinez. Phys. Rev. B 106, 235426 (2022).
8. J.C. Abadillo-Uriel. Phys. Rev. Lett. 131, 097002 (2023).
9. L. C. Contamin 2022 International Electron Devices Meeting (IEDM), 2022, pp. 22.1.1-22.1.4.