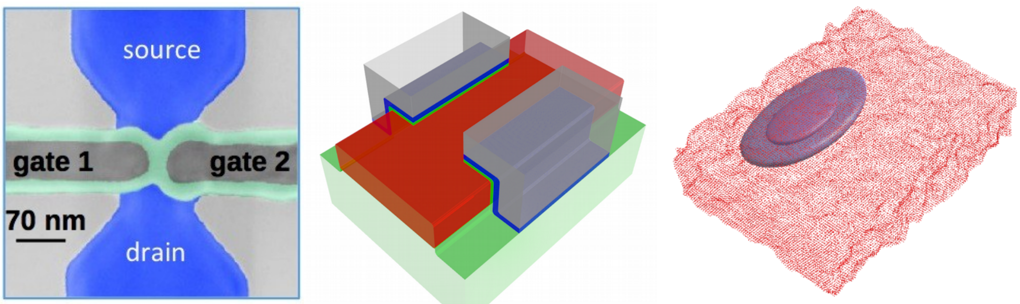
Modeling silicon-on-insulator quantum bits

A post-doctoral position is opened at the Institute for Nanosciences and Cryogenics (INAC) of the CEA Grenoble (France) for up to two years, on the theory and modeling of silicon-on-insulator quantum bits.

Quantum information technologies on silicon have raised an increasing interest over the last five years [1]. Indeed, record coherence times have been achieved in ^{28}Si samples [2]; also, silicon benefits from the exceptional know-how developed for conventional micro-electronics, and is the natural platform for the co-integration of quantum bits (qubits) with the classical circuitry needed to drive them.

France is pushing forward its own original platform based on the “silicon-on-insulator” (SOI) technology developed at CEA Grenoble/LETI. The information is stored in the spin of carrier(s) trapped in quantum dots, which are etched in a thin silicon film and are controlled by metal gates. SOI has many assets: the patterning of the thin film can produce smaller, hence more scalable qubits; also, the use of the silicon substrate beneath as a back gate provides extra control over the qubits. On this SOI platform, CEA has demonstrated the first hole spin qubit [3], and has achieved the electrical manipulation of a single electron spin [4] using the weak, intrinsic spin-orbit coupling in the conduction band of silicon.



(Left) A SOI device with two “face to face” gates, each one controlling a quantum dot beneath. The information is encoded as a superposition of the up and down spin states of the carrier(s) trapped in these dots. (Middle) The same device as modeled in TB_Sim, with silicon in red, SiO_2 in green, HfO_2 in blue and the gates in gray. (Right) Iso-probability surfaces of the ground-state wave function under the leftmost gate; each red dot is a silicon atom at the surface of the channel (surface roughness is included in this simulation).

Many aspects of the physics of silicon spin qubits are still poorly understood. It is, therefore, essential to complement the experimental activity with state-of-the-art modeling. For that purpose, CEA/INAC is actively developing the “TB_Sim” code. TB_Sim relies on atomistic tight-binding and multi-bands **k.p** descriptions of the electronic structure of materials and includes, in particular, a time-dependent configuration interaction solver for the dynamics of interacting qubits. Using TB_Sim, CEA INAC has recently investigated various aspects of the physics of SOI qubits, in tight collaboration with the experimental team in Grenoble and the partners of CEA in Europe [4-8].

<u>The aims of this post-doctoral position are, in particular</u>:

- To model spin manipulation and readout in SOI qubits in order to get a better understanding of the physics of these devices and optimize their design.
- To model decoherence and relaxation at the atomistic scale.

This work will be strongly coupled to the experimental activity in Grenoble. CEA is indeed at the heart of a quantum silicon eco-system in Grenoble, bringing together CEA/LETI (fabrication), CEA/INAC and CNRS/Néel (characterization and modeling) around the development of SOI qubits.[1] The candidate will, therefore, have access to experimental data on state-of-the-art devices.

The candidate should send her/his CV to Yann-Michel Niquet (yniquet@cea.fr), with a list of publications, a motivation letter with a summary of past accomplishments, and contact details of two persons for references (or recommendation letters).

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1 https://www.quantumsilicon-grenoble.eu/

References:

[1] *Embracing the quantum limit in silicon computing*,
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[8] *Strain-induced spin resonance shifts in silicon devices*,
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Additional informations about L_Sim:
http://inac.cea.fr/sp2m/L_Sim/
http://www.researchgate.net/profile/Yann-Michel_Niquet
http://scholar.google.fr/citations?user=h02ymwoAAAAJ

More about Grenoble and its surroundings:
http://www.isere-tourism.com/