

## Résonateurs micro-onde sur silicium pour un futur ordinateur quantique

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**Stage pouvant se poursuivre en thèse :** Oui

### Résumé :

Tu ne comprends rien à un ordinateur classique mais tu penses qu'un ordinateur quantique serait franchement super cool, alors ce sujet de stage est fait pour toi!

### Sujet détaillé :

More seriously with the miniaturization of electronic devices, the semiconductor industry has to deal with complex technical barriers and is forced to introduce novel and innovative concepts. In this new paradigm quantum computing is a major new frontier in information technology with the potential for disruptive impact. Many different materials and approaches have been explored so far, with an increasing effort on scalable implementations based on solid-state platforms. Diverting silicon technology is the approach explored in our Lab. Concretely the idea is: Can we create a quantum bit (the quantum analog of a bit) from a 'basic' silicon transistor? The answer is yes, as we demonstrated recently [1]. The working principle of the qubit is to trap a spin inside the channel of a silicon transistor and to manipulate this spin via microwave signal applied on the gate electrode. Of course to be exciting all the experiment is done at very low temperature  $T=10\text{mK}$  in a big dilution refrigerator. To go a step towards computing architecture, one may want to couple distant qubits. To take up this challenge a microwave photon can be used as a quantum mediator between the qubits. Practically silicon transistors will be embedded in a superconducting microwave resonator enabling the coupling between the spin qubits and the microwave photons trapped in the resonator [2-4].

In this Master project you will fabricate superconducting microwave resonators from Niobium Nitride (NbN) or Titanium nitride (TiN) films. More precisely you will structure the films into transmission lines, wires and coils that define microwave resonators. For this fabrication you will work in the Upstream Technological Platform of CEA: <http://pta-grenoble.com>. You will characterize the properties of these circuit elements at very low temperature (quality factors, resonance frequency), and will compare the results to numerical simulations. Eventually, you will couple a silicon transistor to the microwave circuit that performs best. In short you will start to build a small quantum processor [5]. Nice, isn't it? Starting date 1st March 2018

1. Maurand, R. et al. A CMOS silicon spin qubit. Nat. Commun. 7, 13575 (2016).
2. Landig, A. J. et al. Coherent spin-qubit photon coupling. ArXiv1711.01932v1 1-8 (2017).
3. Mi, X. et al. A Coherent Spin-Photon Interface in Silicon. ArXiv1710.03265v1 1-19 (2017).
4. Samkharadze, N. et al. Strong spin-photon coupling in silicon. 1-5 (2017).
5. Nigg, S. E., Fuhrer, A. & Loss, D. Superconducting Grid-Bus Surface Code Architecture for Hole-Spin Qubits. Phys. Rev. Lett. 147701, 1-6 (2017).

### Compétences requises :

- Enthusiasm and high (self-)motivation
- Ability to work in a team
- (Some) experience with programming
- Knowledge in condensed matter physics and/or microwave engineering



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- A strong motivation for experimentation