

## Hybrid nanowires for topological quantum computing

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

### Résumé :

One interesting and promising proposal for quantum computation relies on the so called topological protected quantum bits. Realizing such quantum bits depends on the ability to make materials that can host Majorana bound states. In 2012, signatures of such states were reported in one-dimensional semiconductors with high spin-orbit coupling, coupled to a superconductor [1]. Since then, nanostructured hybrid materials based on superconductor/semiconductor interfaces have received increased attention. Yet, controlled formation of topological protected states can only be realized if the superconductor/semiconductor interface is of high quality. Creating those interfaces in an epitaxial fashion would have many advantages, among them better transparency, controlled interface chemistry, higher current injection and lower disorder.

However, combining crystalline metals and semiconductors is challenging because of the fundamental different properties of both families of materials. Recently, in-situ epitaxial growth of InAs/Al core-shell nanowires exhibited defect free and homogeneous interfaces [2]. The devices revealed a superconducting hard gap demonstrating the high potential of in-situ shell epitaxy. Here, we propose to develop novel interfaces using a higher critical field superconductor such as vanadium to reach the Majorana regime and to perform further topological experiments.

[1] V. Mourik et al 2012 Science 336(6084) 1003

[2] P. Krogstrup et al 2015 Nature materials 14 400

### Sujet détaillé :

In this project, the student will carry out the growth of networks of hybrid nanowires in a III-V molecular beam epitaxy reactor in CEA. In particular, she/he will focus on InAs/V core/shell nanowire fabricated using templates developed in the cleanroom. The student will perform the characterization of the samples by SEM, EDX and/or TEM. Together with partner labs, she/he will participate in low temperature measurement campaigns using a dilution fridge, as well as perform high-end structural studies using advanced equipment and facilities.

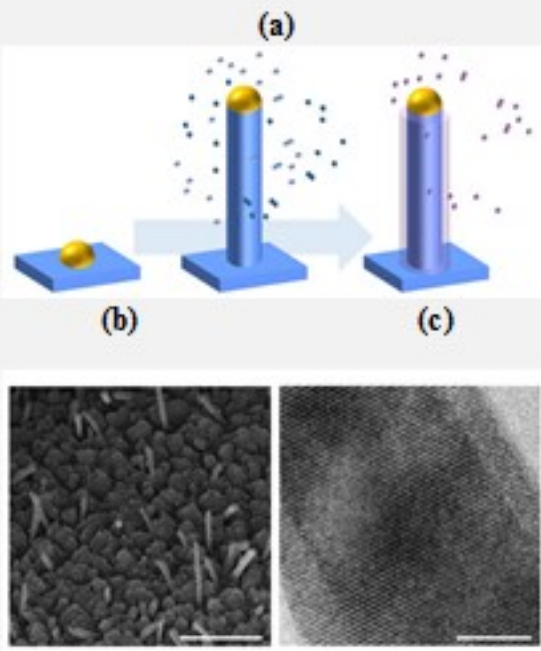
Possible collaboration and networking:

University of Pittsburgh (S. Frolov, M. Hatridge, D. Pekker)

University of California in Santa Barbara (C. Palmstrom)

LAAS Toulouse (S. Plissard)

CEA-INAC (J. Meyer, M. Houzet, S. De Franceschi)



**Description of the VLS methodology. (a) Growth.** InAs nanowires will be grown by the VLS mechanism using gold catalysts. Then a shell of V will be fabricated by switching the growth mode to 2D growth. **(b) Morphology.** SEM image of a sample of InAs/Al nanowires with polycrystalline Al shells. **(c) Structure.** TEM image of a hybrid Si/III-V core-shell nanowire.

**Compétences requises :**

Motivated experimentalist

Programming