Institut de Recherche
Interdisciplinaire de Grenoble

Pheliqs
Quantum Physics & Engineering

Université Grenoble Alpes

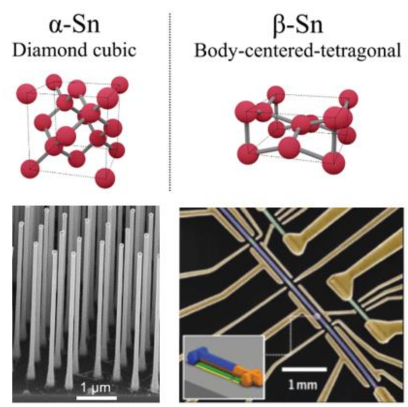
GRENOBLE INP UGA

Master / PhD Thesis Project

Topological-superconducting group IV nanomaterials

Progress in quantum computing stems from major advances in materials science and engineering, and their integration into novel fabrication techniques to develop scalable solid-state qubits architectures. Solid-state quantum devices have been developed by combining multiple materials with inherently different properties within the same device **-** *heterogeneous integration*. This is a significant challenge in materials science, where quantum device operation with high performance requires a very high purity of the interface between two different materials. Any structural defect and roughness at the interface would compromise the ability to detect and manipulate quantum states in solid-state devices.

The goal of this internship is to develop a scalable material platform where quantum properties can be engineered simply by tailoring the crystal structure of a single atomic element – *Tin (Sn)* – and achieve interfaces with the highest quality. Topological insulator/semimetal phases can be tailored in diamond cubic α-Sn by controlling strain,(*1*) while body-centered tetragonal β-Sn behaves as a superconductor at temperatures below 4 K.(*2*) Currently, a controlled switch between α/β-Sn phases is out of reach in a conventional thin film geometry.



The student will establish the growth of one-dimensional (1D) Sn nanowires (NWs) on a Silicon wafer in a molecular beam epitaxy (MBE) system. In NWs a precise control over the growth of α/β-Sn phases (*i.e.* TOP/SC) becomes possible, resulting in defect-free atomically-sharp interfaces with the highest purity. This will provide a truly *homogeneous integration* of multiple states of matter in solid-state quantum devices, paving the way to explore the fundamental processes in topological quantum computation,(*3*) spintronics,(*4*) and quantum photonics.(*5*)

For more information on this topic please read these recent publications (available on demand):

1. A. Barfuss *et al.*, *Phys Rev Lett*. **111**, 157205 (2013).
2. Y. Zhang *et al.*, *Sci Rep*. **6**, 32963 (2016).
3. A. Stern, N. H. Lindner, *Science (1979)*. **339**, 1179–1184 (2013).
4. J. Ding *et al.*, *Advanced Materials*. **33**, 2005909 (2021).
5. E. D. Walsh *et al.*, *Science (1979)*. **372**, 409–412 (2021).

Possible collaboration and networking. Collaborations with Canada (Polytechnique Montréal), The Netherlands (Eindhoven University of Technology), Singapore (Nanyang Technological University), and U.S. (University of Pittsburgh) for atomic-level characterization of materials and devices, strain engineering, and quantum transport measurements.

Possible extension as a PhD: Yes.

Required skills: Interest in performing collaborative experiments in the lab (materials growth, fabrication of devices and measurement), background in solid-state physics.

Starting date: Spring 2023.

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