Master thesis Project

Topological-superconductor 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. Over the last decade, a plethora of 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 could 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.* topological/superconductor phases) 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]

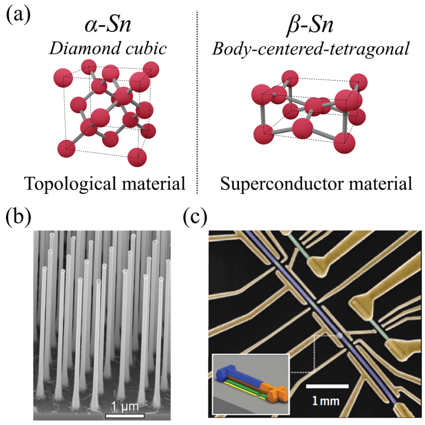

Figure: (a) Allotropes of Sn. (b) Vertical NW array. (c) Single NW quantum device.

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 collaborations and networking. Collaborations with Canada (Polytechnique Montréal), Italy (University of Milano Bicocca), Singapore (Nanyang Technological University), Denmark (University of Copenhagen), 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 quantum optoelectronic measurements), background in solid-state physics.

Starting date: Spring 2024.

Contact. Simone Assali (IRIG/PHELIQS, Grenoble).

APPLY NOW!

To apply for this position, send your application (including CV) by e-mail to: simone.assali@cea.fr.

French Commission for Atomic Energy and Alternative Energies
Interdisciplinary Research Institute of Grenoble
Quantum Photonics, Electronics and Engineering Laboratory
17 av. des Martyrs – 38054 Grenoble cedex 9 – France