Master Project

Germanium bolometers for quantum information

In a bolometer, a small absorber heats up under photon absorption. Monitoring the absorber temperature in real time was shown to allow down to single-photon detection for high-energy radiation (X-ray). Quantum information processing in solid-state devices however is based on the exchange of microwave (MW) photons, which have several orders of magnitude lower energies. Extending the powerful bolometry method to the microwave range could be a formidable asset for future quantum technologies. Although the bolometric detection of a single microwave photon remains a challenge, promising steps have been achieved recently in this direction and new micro-bolometers have demonstrated impressive sensitivity [1], and even been used successfully to read a superconducting qubit state [2].

In this internship, we propose to develop novel micro-bolometers based on a two-dimensional hole gas in Germanium [3]. This novel 2D material holds promising perspectives for future quantum technologies, and its high-quality electrical interface to superconductors makes it suitable for novel bolometers development and integration with superconducting qubits.

The candidate will fabricate Ge-based superconducting Josephson junctions, basing on recipes already mastered in the team (fig.1), and characterize their potential as micro-bolometers in a dilution refrigerator. This internship can be pursued by a PhD thesis, during which the candidate will combine these novel detectors to Ge spin qubits and/or gate-based superconducting qubits already developed in the team, in order to reach unprecedented levels of qubit readout fidelities.

References :

[1] Kokkoniemi et al., *Nature* (2020)
[2] Gunyho et al., *arXiv* (2023)
[3] Scappucci, *Nature Rev. Mat.* (2021)

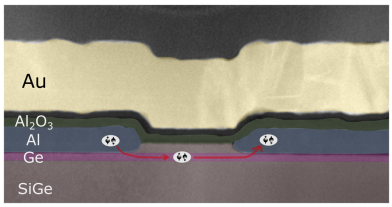

Fig.: Transmission Electron Micrograph of a Ge Josephson junction fabricated at the CEA clean room. (Courtesy of J. Labar, EK Budapest)

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boris.brun-barriere@cea.fr or clemens.winkelmann@grenoble-inp.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