Germanium Bolometers for Quantum Information

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In a bolometer, a small absorber heats up under photon absorption. 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].
The aim of this project is to implement microwave bolometers by the use of a two-dimensional hole gas in a semiconducting heterostructure based on Germanium. Such 2D-Ge-based absorbers combine the assets of graphene over metals (very small heat capacity, tuneable carrier density) with the prospects of industry-ready and scalable fabrication techniques [3]. Furthermore, 2D-Ge forms excellent contacts with aluminium leads, allowing for the implementation of superconductor-germanium-superconductor (S-Ge-S) Josephson junctions.
Here we demonstrate that such junctions form sensitive temperature probes as a first step towards microwave bolometers.

References

[1] Kokkoniemi et al., Nature Vol. 586 No. 7827 (2020)
[2] Gunyhó et al., Nature Electronics Vol. 7 No. 4 (2024)
[3] Scappuci et al., Nat Rev Mater Vol. 6 No. 10 (2020)

Figures

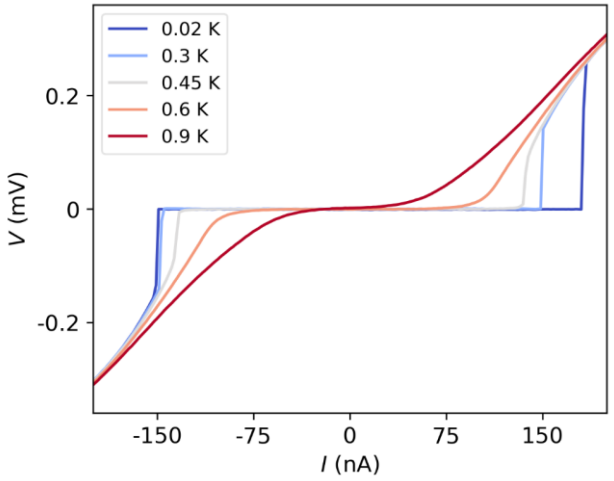

Figure 1: Current-Voltage Characteristics of an Al-Ge-Al Josephson junction at different cryostat temperatures. The critical current decreases with increasing temperature due to quasiparticle excitations.

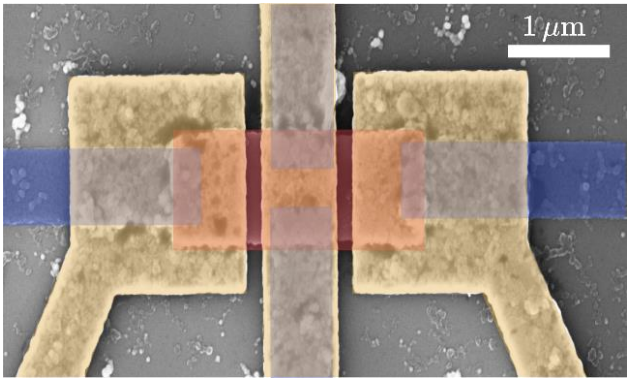

Figure 2: SEM image of a germanium bolometer: visible are the germanium mesa (highlighted in red), superconducting aluminium electrodes (blue) and metal gates (gold).