Flip-chip-based microwave spectroscopy of Andreev bound states in a planar Josephson junction

Deividas Sabonis

M. Hinderling[1], S. Paredes[1], D. Z. Haxell[1], M. Coraiola[1], S. C. ten Kate[1], E. Cheah[2], F. Krizek[1, 2], R. Schott[2], W. Wegscheider[2], F. Nichele[1]

[1]IBM Research – Zurich, Säumerstrasse 4, CH-8803 Rüschlikon, Switzerland.
[2]Laboratory for Solid State Physics, ETH Zurich, Otto-Stern-Weg 1, CH-8093 Zürich, Switzerland.

Deividas.Sabonis@ibm.com

We demonstrate a flip-chip-based approach to microwave measurements of Andreev bound states in a gate-tunable planar Josephson junction using inductively-coupled superconducting low-loss resonators [1]. By means of electrostatic gating, we present control of both the density and transmission of Andreev bound states. Phase biasing of the device shifted the resonator frequency, consistent with the modulation of supercurrent in the junction. Two-tone spectroscopy measurements revealed an isolated Andreev bound state consistent with an average induced superconducting gap of 184 μeV and a gate-tunable transmission approaching 0.98. Our results represent the feasibility of using the flip-chip technique to address and study Andreev bound states in planar Josephson junctions, and they give a promising path towards microwave applications with superconductor-semiconductor two-dimensional materials.

References

[1] M. Hinderling, D. Sabonis, S. Paredes, D. Z. Haxell, M. Coraiola, S. C. ten Kate, E. Cheah, F. Krizek, R. Schott, W. Wegscheider, F. Nichele, arXiv:2212.11164 (2022).

Figures

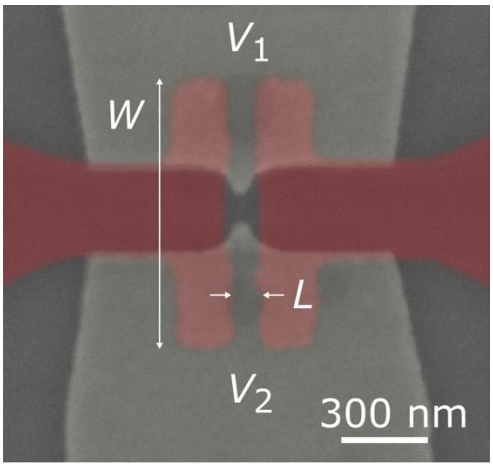

Figure 1: Gate-tunable planar Josephson junction (JJ) defined in a two-dimensional InAs/Al heterostructure was embedded in the rf-SQUID. The Al (red) was selectively removed to form a $L \approx 110$ nm long and $W \approx 940$ nm wide JJ. A split-gate (light gray) was evaporated on top of the JJ for controllable depletion of the weak link in the exposed InAs two-dimensional electron gas (dark gray).