Supplementary Section

Fabrication of Nb and MoGe SQUID-on-tip probes by magnetron sputtering

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1. Drawings

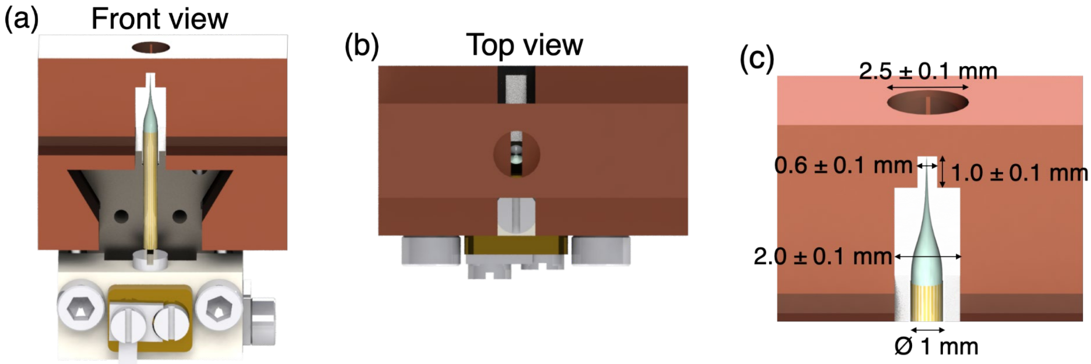

Fig. S1: Illustration of the deposition holder and sensor holder with dimensions indicated in (a) front view, (b) top view, and (c) a closer view of the tip inside holder slit.

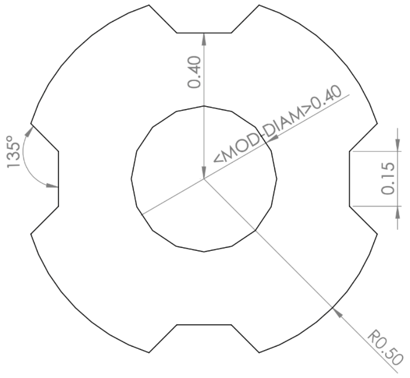

Fig. S2: Nominal dimensions of the quartz capillary used for fabrication.

2. Effective and Geometrical SQUID-on-tip Diameters

SQUID-on-tip material	Effective diameter (nm)	Geometrical diameter (nm)	Figure caption
Nb	48	54	(a)
Nb	54	60	(b)
Nb	58	65	(c)
MoGe	81	88	(d)
MoGe	77	83	(e)
MoGe	71	82	(f)

Table S1: List of measured effective and geometrical diameters for Nb and MoGe SQUID-on-tip sensors. The systematic difference of just a few nanometers between the effective and geometrical diameters is likely not significant, because our systematic error in determining the geometrical diameter from SEM images is of this order or larger. So, within our error, the effective and geometrical diameters are the same.

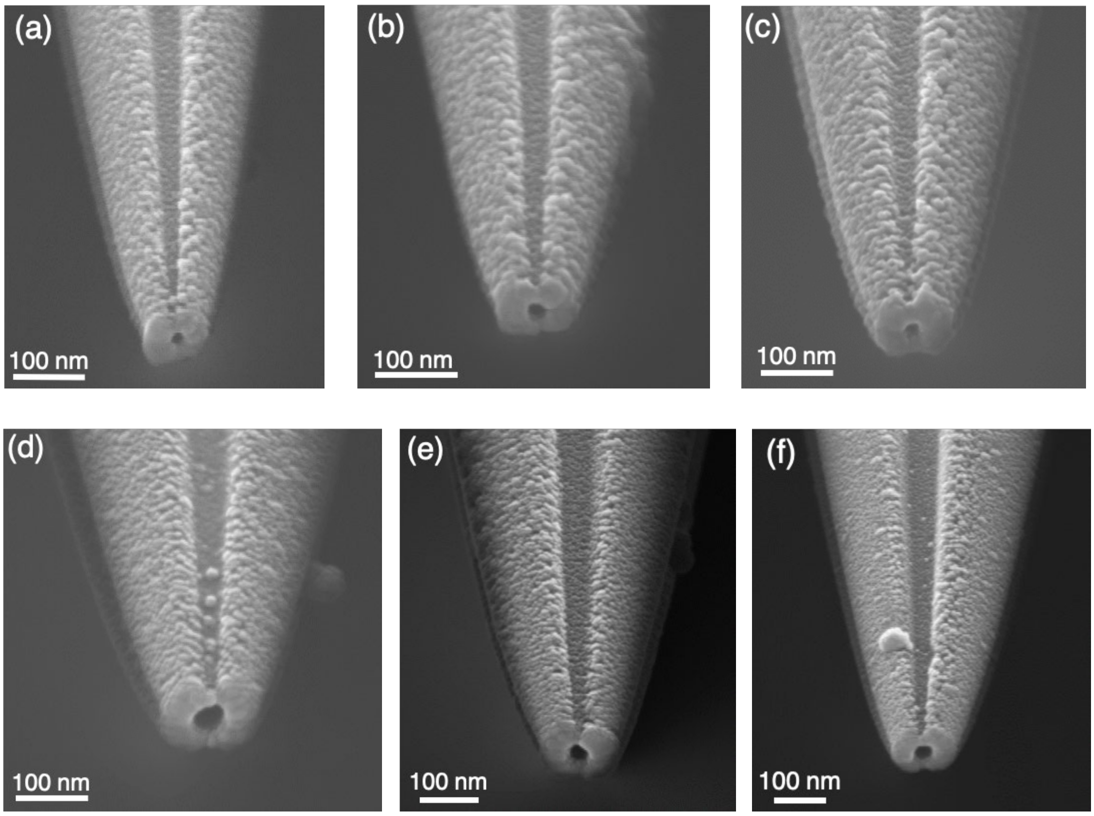

Fig. S3: SEM micrographs for (a-c) Nb and (d-f) MoGe SQUID-on-tip sensors of different geometrical and effective diameters.

3. Temperature Dependence of SQUID-on-tip Resistance

We measure the resistance of a Nb SQUID-on-tip as a function of temperature for a Nb SQUID-on-tip with an effective diameter of 48 nm and a geometrical diameter of 55 nm. The thickness of the Nb film deposited on the sides of the device was 25 nm, while on the apex it was 20 nm. The measurement, shown below, shows several transitions. The lowest temperature transition corresponds to the SQUID-on-tip device itself and occurs around 5.4 K. The highest temperature transition corresponds to the T_c of the film deposited on the pulled capillary and occurs at around 7.9 K. A device reported by Vasyukov et al. (ref. 17) showed a higher T_c for the film of 8.7 K, but with a thicker film on the sides of 35 nm, while on the apex it was 23 nm.

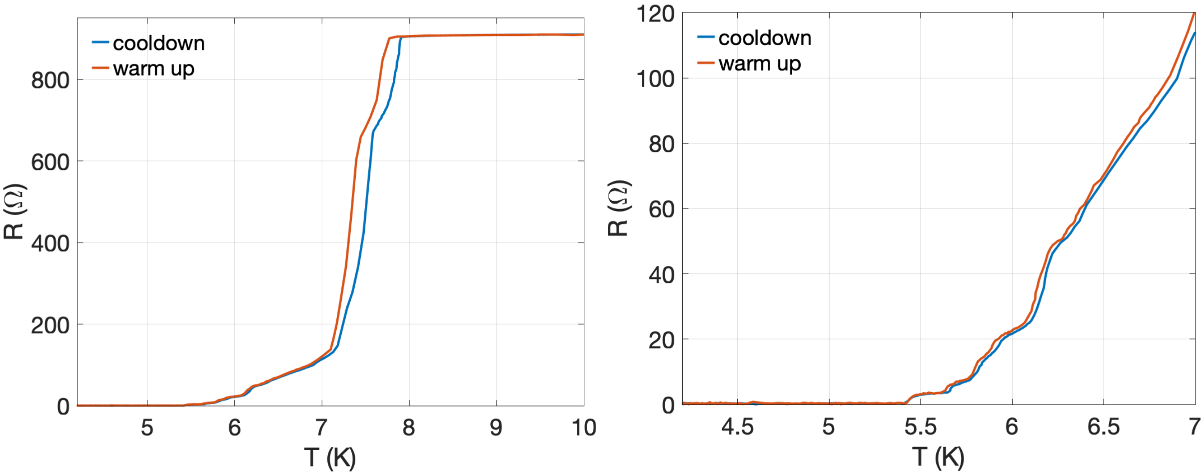

Fig. S4: Resistance as a function of the temperature for a Nb SQUID-on-tip. The left panel shows the full measurement, and the right panel, a zoomed view around the SQUID-on-Tip T_c.

4. Yield and Reproducibility

MoGe SQUID-on-tip devices have a yield of ~90% (12/13). Failed sensors are mostly the consequence of dust/dirt near the apex. Overall, the MoGe SQUID-on-tip fabrication is reliable with little sensor-to-sensor variation.

In order to minimize the chances of dust-related failed fabrication, we currently store pulled tips inside a vacuum desiccator, and retrieve them by venting with N2 gas prior to deposition. We observe that PM0.2 (particulate matter of max 0.2 µm) tend to attach close to the tip. Further precautions could be taken, such as handling the tips only in a clean-room environment, but have not yet been implemented.

The fabrication of Nb SQUID-on-tip sensors is more recent than MoGe sensors, and so the process has only recently been optimized. So far, they show a yield of roughly ~50% (19/37). We have been consistently producing Nb SQUID-on-tip sensors with similar effective diameters, however, they tend to have slightly high critical currents (with sharp transitions). We attribute these high critical currents to an imprecision in the deposition thickness control, which is more relevant for the thinner Nb devices than the thicker MoGe devices.