Fabrication and Properties of integrated crystal-coupled SQUID for proximity detection of Time-Reversal Symmetry-Broken Superconductors

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Abstract

We report on the fabrication and properties of a chip-based superconducting quantum interference device (SQUID) tailored to detect broken time-reversal symmetry (TRS) in unconventional superconductors. TRS breaking can give rise to spontaneous magnetic fields or anomalous flux quantization associated with complex superconducting order parameters such as chiral p-wave symmetry[1]. Our device features a planar SQUID layout with high magnetic sensitivity, onto which superconducting samples are directly placed to maximize coupling between the sample and the SQUID loop[2]. This configuration enables the detection of minute spontaneous magnetic signals originating from TRS-breaking superconductors, such as Sr_2RuO_4 and UPt_3, without the need for a scanning mechanism. This platform also provides a compact and sensitive method for probing the magnetization of crystals several microns in size.

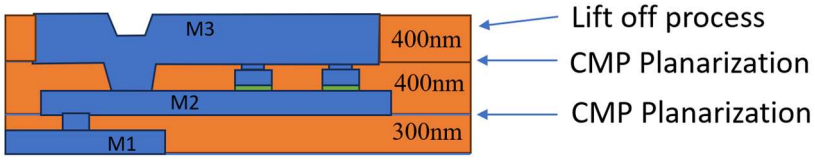

Figure 1 Schematic cross-section of the SQUID device. The top surface is planarized using chemical mechanical polishing (CMP) and lift-off processes, providing a flat platform suitable for placing samples directly on the device

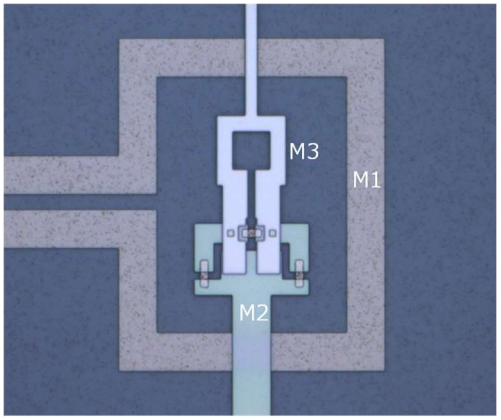

Figure 2 Microscope image of SQUID

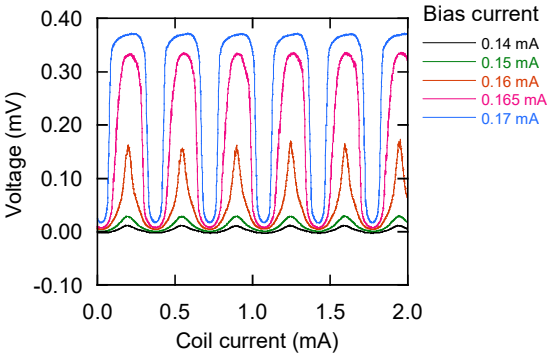

Figure 3 V-Φ characteristics measured at 4 K

Acknowledgement

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References

1) Kallin, C. & Berlinsky, J. Chiral superconductors. Reports on Progress in Physics 79, 054502 (2016).

2) Teshigawara, M., Mawatari, Y., Yamamori, H., Yano, R. and Kashiwaya, S. Evaluation of Magnetic Field Induced by Broken Time-Reversal Symmetry Superconductors. In Proceedings of the 29th International Conference on Low Temperature Physics (LT29) 011069 (2023).

Keywords: SQUID, chiral p-wave symmetry, Time-Reversal Symmetry, Planarization process, proximity detection