Experimental implementation of elements of superconducting bio-like neurons based on Nb/Au/Nb Josephson junctions

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The development of neural networks based on biosimilar spiking neurons represents a leading frontier in artificial intelligence research. These networks are expected to offer superior capabilities for parallel information processing and enhanced adaptability to dynamic environments. However, a key challenge remains: the fundamental components required for the fastest and most energy-efficient Josephson-based implementations currently possess excessively large planar dimensions, limiting the scalability of such systems.

In this study, we explore the practical feasibility of implementing Josephson junctions with a weak normal (SNS) region—an approach that may overcome the existing barriers to miniaturizing Josephson biosimilar neurons [1, 2]. Josephson SNS contacts Nb/Au/Nb and a two-contact SQUID were manufactured. Experimental measurements were conducted using a dilution refrigerator capable of reaching temperatures as low as 0.2 K. The samples were connected via a four-terminal DC circuit (see Fig. 1a). We investigated the current-voltage characteristics of the samples across a range of temperatures up to the critical temperature $T_c = 9.2K$, and in magnetic fields of up to $3.5T$. The SQUID parameters were also investigated by applying a bias current (see Fig. 1b).

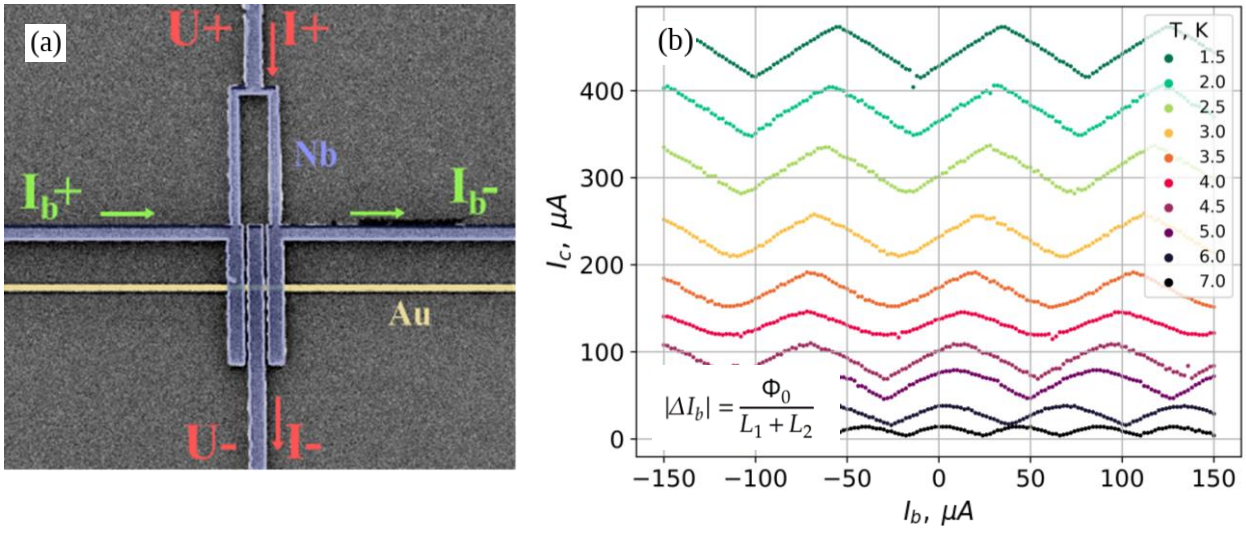

Fig. 1: Two-contact SQUID: (a) – photo taken with SEM; (b) - the dependence of the critical current on the flux induced by the bias current $I_c(I_b)$.

Bibliography

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