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Fabrication and characterization of magnetic Josephson Junction towards quantum circuits

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The competition between superconducting and ferromagnetic orders in magnetic Josephson Junctions (JJs) has paved the way for advances in superconducting digital technology, cryogenic memories, and potentially for quantum computing, where the possibility of switching between different critical currents states by means of magnetic pulses is a crucial advantage. We have shown that our approach to use a strong ferromagnet Permalloy (Py) as F-barrier in tunnel SISFS (Superconductor/Insulator/superconductor/Ferromagnet/Superconductor) JJs based on Nb technology allows to scale the junctions' dimensions down to a few μm2 and we have demonstrated their functionality as memory elements compatible in speed and power dissipation with standard single flux quantum (SFQ) circuitry. In principle, these junctions are scalable down to sub-micrometer dimensions: in the framework of the quantum computation, a high-density cryogenic classical memory technology is sought to provide supporting functions for qubit circuits such as read out, control and error-correction. Moreover, we have transferred our knowledge from the Nb-based to Al-based lithography process and demonstrated the hysteretic behavior of the magnetic field pattern in very low quasi-particle dissipation SISFS JJs with Al electrodes. Since superconducting quantum circuits rely almost exclusively on Al based JJs, these results are an important steps in promoting alternative control and readout schemes in superconducting qubits.

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