Ferromagnetic Josephson junctions with niobium nitride

TARO YAMASHITA, KAZUMASA MAKISE, AKIRA KAWAKAMI, HIROTAKA TERAI, NICT - Kobe — Recently, novel physics and device applications in hybrid structures of superconductor (SC) and ferromagnet (FM), e.g., spin injection into SC, long-range Josephson effect, cryogenic memory, have been studied actively. Among various interesting phenomena in SC/FM structures, a \( \pi \) state (\( \pi \) junction) emerged in ferromagnetic Josephson junctions (SC/FM/SC) is attractive as a superconducting phase shifter for superconducting devices. In the present work, we developed the ferromagnetic Josephson junction in order to realize a quiet superconducting flux qubit with a \( \pi \) junction. Contrary to conventional flux qubits, the qubit with a \( \pi \) junction can be operated without an external magnetic field which is a noise source, and thus good coherence characteristics is expected. As a superconducting material, we adopted niobium nitride (NbN) with high superconducting critical temperature of \( \sim 16 \) K, which can be grown epitaxially on a magnesium oxide substrate. Regarding the ferromagnetic material we used copper nickel (CuNi), and fabricated the NbN/CuNi/NbN junctions and then evaluated the dependences of the Josephson critical current on the temperature, thickness and so on.

\(^1\)This research was supported by JST, PRESTO.

Taro Yamashita
NICT - Kobe

Date submitted: 10 Nov 2016

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