

# EDP1-1

## A Study of the HTS Josephson Junction Formed by a Ga Focused Ion Beam

\*Kanji Hayashi<sup>1</sup>, Teppei Ueda<sup>1</sup>, Ryo Ohtani<sup>1</sup>, Seiichiro Ariyoshi<sup>1</sup>, Saburo Tanaka<sup>1</sup>

Toyohashi University of Technology, Toyohashi, Japan<sup>1</sup>

High Temperature Superconductor Josephson Junctions (HTS-JJs) are based on artificial grain boundaries. However, the layout of HTS Superconducting Quantum Interference Devices (SQUIDS) on a bi-crystal substrate is restricted. Therefore, we explored the use of low noise nano-bridge JJs formed by Ga-Focused Ion Beam (FIB) irradiation.

We have studied properties of HTS films by irradiated Ga-FIB in previous paper [1]. In this paper, we report the fabrication method of HTS nano-bridge JJs and its properties. We deposited 100 nm thick YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-d</sub> (YBCO) films on an MgO substrate by pulsed laser deposition, and 20 nm thick gold thin film as a protection layer was deposited in-situ. After that, we fabricated a 4 μm wide micro-channel by photolithography and an Ar ion milling. Then, we patterned a nano-bridge by FIB irradiation (Acceleration voltage: 40 kV, Beam diameter: ~30 nm, Fluence: 2×10<sup>15</sup> ions/cm<sup>2</sup>) on the micro-channel. As a result, the YBCO layer was normalized leaving a width of 500 nm or 1000 nm as a nano-bridge after FIB process. A SEM image of the typical nano-bridge is shown in Fig.1. The critical current of the 500 nm wide nano-bridge was decreased from 1700 μA to 170 μA at 77 K. The nano-bridge was irradiated by a micro-wave to observe Shapiro steps.

Fig.2 shows the V-I characteristics when the nano-bridge was irradiated by a micro-wave with a frequency  $f_{RF}$  of 2 GHz and a power of -13 dBm. A step height of 4.1 μV was observed, consistent with the theoretical value  $\Delta V = (h/2e) \times f_{RF}$ . This result suggested that the nano-bridge behaved as a Josephson junction. In the future, we plan to apply this fabrication method of the JJ to a low noise SQUID.

[1] K. Hayashi *et al.*, Extended Abstracts of 14th International Symposium on HTSHFF2018, p.p.56-57, 2018.

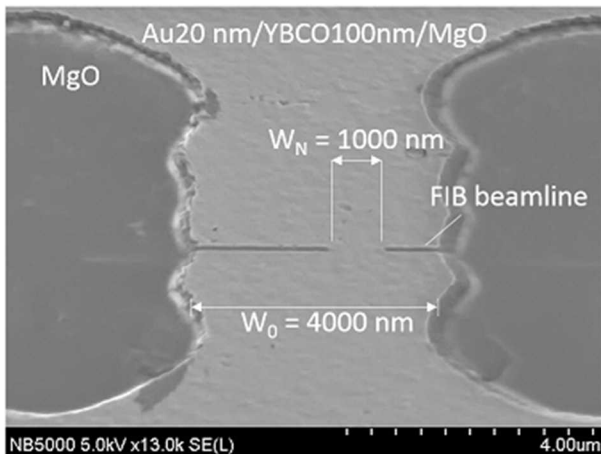


Fig.1 A SEM image of the typical nano-bridge.

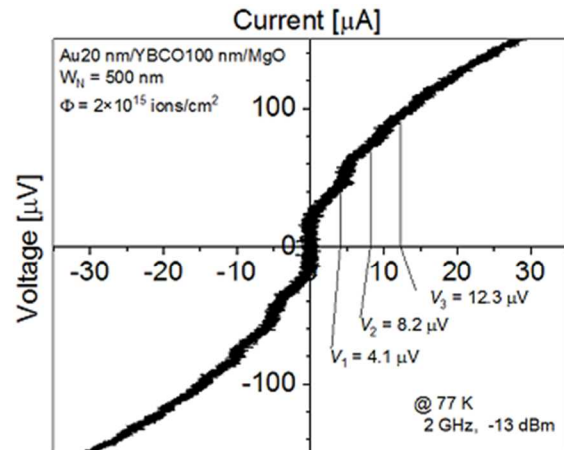


Fig.2 Shapiro-step of the formed nano-bridge.

Keywords: HTS Josephson junction, HTS-SQUID, FIB, Nano-bridge