Extended Abstracts of the 20th (1988 International) Conference on Solid State Devices and Materials, Tokyo, 1988, pp. 601-602

The Fabrication of Josephson Junctions on Y-Ba-Cu-O Thin Films

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This paper describes a successful fabrication of Josephson tunnel junctions on YBCO thin films based on a new surface stabilization technology. The authors found that the coating of the YBCO surface with Ag followed by low temperature annealing stabilizes the surface and that the film surface exibits superconductivity[1]. This phenomenon was utilized for the junction fabrication.

YBCO thin films, 0.7 m thick, were prepared for junction fabrication by the multi-target reactive sputtering method[2]. Though the transition temperature of the films after the device fabrication process scattered between 34 K and 72 K, no qualitative difference was observed for the junction characteristics.

Fig.1 shows a microphotograph of the fabricated junction. Wet etching with diluted nitric acid and the conventional lift-off process were used for the fabrication. Before the junction area definition with a negative resist, which simultaneously works as an isolation film, 1000 A-thick Ag was selectively deposited and the film was annealed at 550℃ in O_2 for 6 hours. A very good electrical contact with undetectable contact resistance below Tc of YBCO was attained through this heat treatment, though a ball-up of Ag often resulted. The counter electrode was a Pb-In alloy. An artificial barrier of thermally oxidized Al was introduced for some specimens. However, no substantial improvement in the I-V characteristic was found between those with and without the artificial barrier, suggesting that the natural oxide of the Pb-In alloy was responsible for the observed Josephson characteristics. The junction dimensions were varied from 20x20 μm^2 to 100x100 μm^2.

Fig.2 shows a typical I-V characteristic of the junction at 4.2 K. A dc Josephson current and a large voltage jump amounting to 20 mV were clearly observed. Fig.3 shows the temperature dependences of the critical current Ic and the minimum finite voltage current Im for the 40x40 μm^2 junction. Ic shows a linear dependence on Tc-T and no saturation was observed down to 4.2 K. This is in contrast to the Ambegaokar and Baratoff theory[3], suggesting incompleteness of the tunnel barrier. The capacitance value of the junction estimated from the Im/Ic ratio was also about two orders smaller than that expected for the complete tunnel junction. Improvement in the barrier layer is necessary to improve the junction characteristics.

In conclusion, Josephson junctions with a highly hysteretic behavior were successfully fabricated on YBCO thin films. The large voltage jump amounting to 20 mV is very encouraging for future applications of high-Tc oxides to Josephson devices.

[1] K.Mizushima et al.; to be published in Jpn. J. Appl. Phys.
[2] T.Miura et al. ; to be published in Jpn. J. Appl. Phys.
[3] V.Ambegaokar et al. ; Phys. Rev. Lett. 10, p486, (1963)

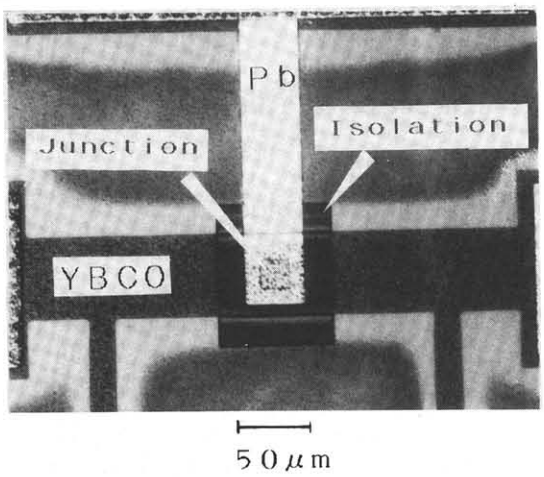

Fig.1
Microphotograph of fabricated Josephson junction on YBCO thin film

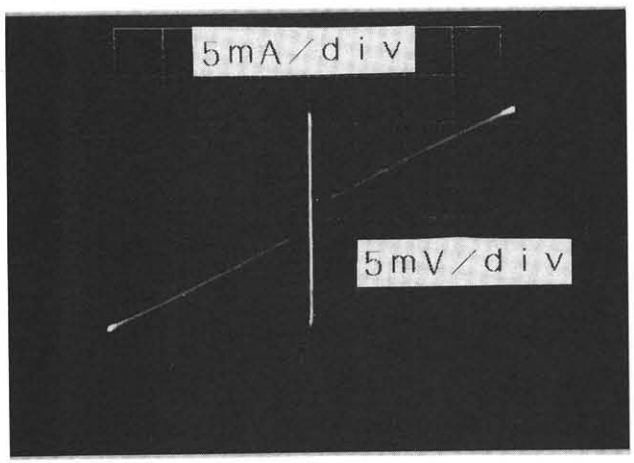

Fig.2
Current-voltage characteristic observed at 4.2 K for 40x40 μm^2 junction

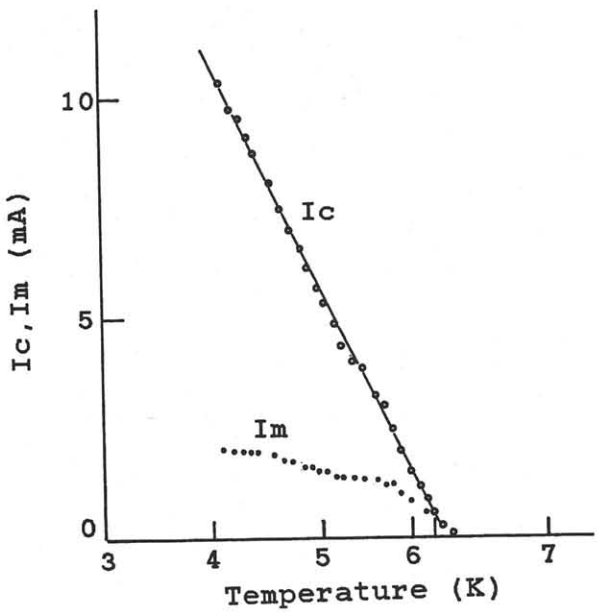

Fig.3
Temperature dependence of critical current Ic and minimum finite current Im for 40x40 μm^2 junction