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New type of Nb microbridges

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It has been shown that the self heating effect limits the performance of superconducting microbridges and induces thermal hysteresis.[1)] Variable-thickness bridges (VTB's) have one of the most favorable geometries to reduce this effect. Another promising type of bridge has a structure which connects two Nb planes separated by a thin insulating film through a small pinhole in the insulator. This resembles point contact Josephson junctions. With this second structure, bridges with very short length are easily formed by using a thin insulating layer. Another potential advantage is that the active region is self-passivated by the insulating and the Nb films. Though this type of bridges has these advantages, only a few works have been reported.[2, 3)]

We have been investigating this type of bridges or the vertical type bridges. In this paper, fabrication process and the basic characteristics will be presented.

Fabrication process of Nb vertical type bridges is shown in Fig. 1. About 300 nm thick Nb with T_c = 9 K and 100 nm thick SiO_2 films were evaporated successively on a Si wafer at 300°C by an electron beam evaporation. After the evaporation, patternning of the SiO_2 layer was done to form electrode pads on the bottom Nb film. The patternning was done by CF_4 rf sputter etching using Au films as a mask, which was formed by photolithography and ion etching by 500 eV Ar ion. A pinhole with a diameter ranging from 200 nm to 400 nm was formed in the SiO_2 layer by electron beam lithography and the same etching process as above. This etching process could realize a very exact pattern transfer as shown in Fig. 2.

The Nb top layer was evaporated after sputter cleanning of the surface of the bottom Nb layer by 500 eV Ar ion.

The typical current-voltage characteristics (IVC) of the Nb vertical type bridges are shown in Fig. 3. No hysteresis in IVC was observed over the entire temperature range measured. For planor VTB's, we always observed hysteresis in IVC at low temperature. This hysteresis may be due to a self heating effect and the present results may take as an indication that the vertical type bridge is very efficient to remove heat.

Temperature dependence of the critical current, I_c, is shwon in Fig. 4. I_c exhibits a weak temperature dependence as observed for Nb clean point contacts[4)] and some VTB's.[1)] The weak temperature dependence is advantageous for various applications.

Fig. 5 shows the dependence of I_c on the applied magnetic field for SQUID composed of two vertical type bridges. It is clear that I_c is modulated periodically by the applied magnetic field.

In summary, we found that the vertical type bridges exhibit several advantages both in ease of fabrication and their characteristics and are very promising structures.

References

1) Li-Kong Wang et al: J. Appl. Phys. 49 (1978) 5602
2) D.W. Jillie et al: IEEE Trans. Mag. Mag-15 (1979) 486
3) K. Gamo et al: IEEE Trans. Electron Device (to be published)
4) R.A. Buhrman et al: J. Appl. Phys. 45 (1974) 4045

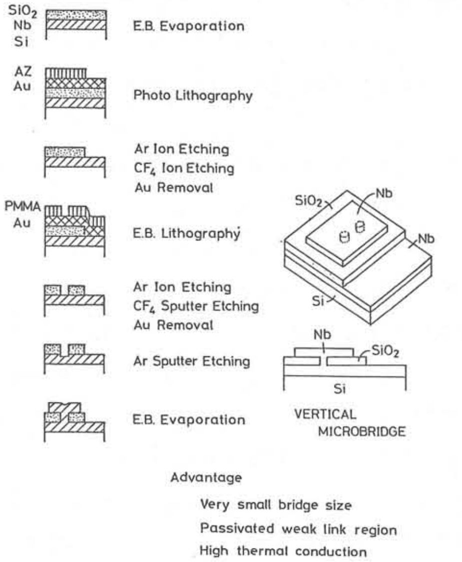

Fig. 1. Fabrication process of a Nb vertical type bridge.

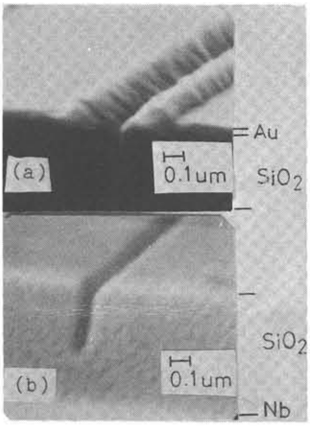

Fig. 2. CF_4 reactive rf etching profile of SiO_2 before (a) and after (b) removal of the Au mask.

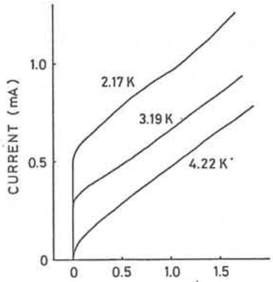

Fig. 3. Current-Voltage characteristics of the vertical type bridge with a pinhole diameter of 0.4 μm.

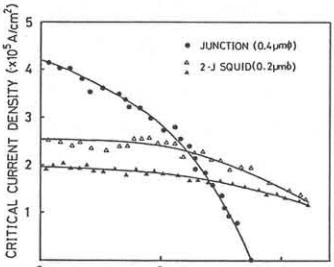

Fig. 4. Temperature dependence of I_c.

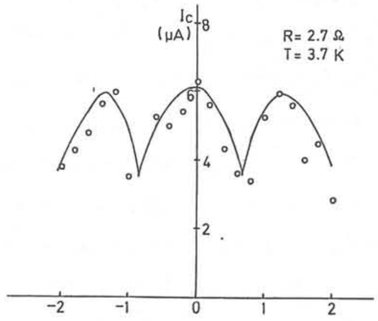

Fig. 5. Dependence of I_c on the applied magnetic field.