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A6-1 Preparation of Josephson Junction by DC anodization

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The fabrication of uniform oxide barriers is required for making high quality Josephson junctions such as used in 2e/h determination. The thermal oxidation method are mostly used. In the present study oxide barriers are made by the DC anodization method[1], and some properties of the obtained junction are investigated.

Substrate is 2.5x2.5x0.1-cm ordinary slide glass. Edges of the glass are polished off. Substrates are cleaned in a following order; (1) brushing in neutral cleanser for a minute, (2) brushing in the streaming water for a minute,(3) putting into a test tube if the surface of the glass got wet uniformly (if not, processes (1) and (2) are repeated again), (4) rinsing in the distilled water for a few times, (5) dipping in the boiling acetone, and (6) drying up in a desiccator at 60°C for about ten minutes. After substrates have been dried up, an electrode of indium (about 1mm ϕ) and a insulated copper wire (0.09mm ϕ) are attached on the glass for proper anodization. Then, cleaning processes (3) to (5) are repeated again.

Both linear- and cross-type configurations are used for thin film tunneling junctions. The junction sizes are 0.9x0.2-mm for the linear configuration and 1.0x0.2-mm for the cross type. The underlying- and the counter-electrodes are Pb films approximately in 2500Å thickness. They are deposited by evapolation from 99.999% Pb sources at rates of 200Å/sec and 20Å/sec respectively, in a vacuum of 10^{-6} Torr at room temperature.

The constraction of the vacuum chamber for anodization is shown in Fig.1. The chamber is filled with dry oxygen to a pressure about 2 Torr after ten minutes from the deposition of the underlying electrode. Then liquid nitrogen is poured into a cryopanel, which is installed in the vacuum chamber. The chamber is pumped down to a desired oxygen pressure ($10^{-1}\sim10^{-3}$ Torr). Anodization takes place under constant voltages V_1 and V_2 for twenty minutes at room temperature. The pressure in the chamber decreases gradually because of the absorption by the cold cryopanel. Together with the decrease of the pressure, changes in currents I_1 and I_2 occure. For example, $V_1\sim450V$, $V_2\sim1V$, $I_1\sim7\rightarrow 5mA$, $I_2\sim10nA$ and $P\sim100m$ Torr. Under these conditions the normal junction resistance is about 50~200mΩ for the linear configuration.

Two typical I-V characteristics of the Josephson junction[2] with and without the irradiation of microwave are shown in Fig.2. As the theoretical value of I_cR is dependent only on temperature and independent of the junction size, this value is one of good measures of quality of a junction. Theoretical value of I_cR at T=4.2K is approximately 1.67mV for Pb. Values of I_cR and R for the junctions prepared are shown in Fig.3. The magnitude of the excess currents of most of the junctions are less than 10% of I_c. A typical magnetic field dependence of the critical current is shown in Fig.4.

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References

(1)J.Dell'Oca et al; "physics of Thin Films" vol.6, ed. by Francombe and Mauris, N.Y., Academic press, 1971

(2)B.D.Josephson; "Superconductivity" ed. by R.D.Parks, Marcel Dekker, INC. New York 1969

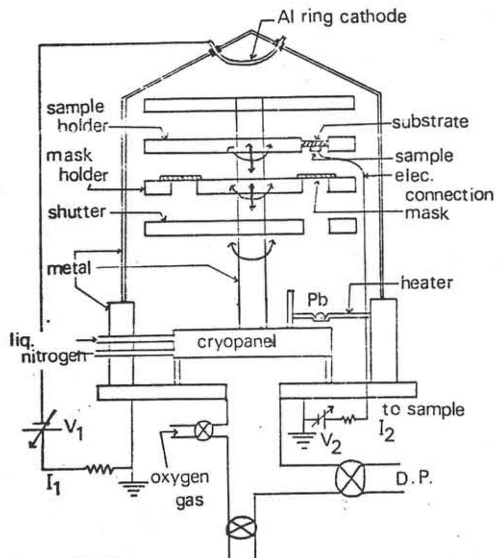

Fig.1

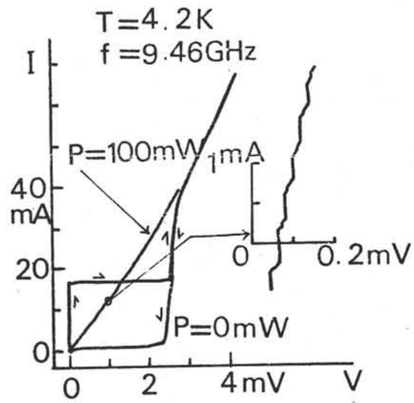

Fig.2

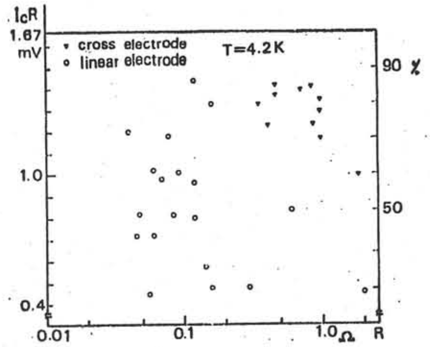

Fig.3

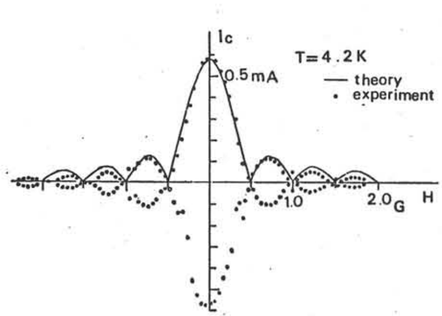

Fig.4