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# B-3-4 NbN,Nb Double-Layered Base-Electrode Josephson Junctions

Shin KOSAKA, Kazuyoshi KOJIMA*, Fujitoshi SHINOKI, Akira SHOJI and Hisao HAYAKAWA

Electrotechnical Laboratory

1-1-4 Umezono, Sakura-mura, Niihari-gun, Ibaraki 305, Japan

The use of mechanically hard superconducting materials for making Josephson devices has become of increasing interest since that makes it possible to realize excellent stabilities of the devices for the thermal cyclings and storage. Nb junctions[1,2] are widely studied from this point of view. However, the surface of Nb films are so active that surface damage layers developed during plasma processes often cause the increase of the subgap conductance which is not suitable for device applications.

Recently, the integration process for NbN based Josephson devices was developed[3,4] and NbN/Pb junctions were shown to have very small subgap conductances due to the surface stability of NbN films. However, the London penetration depth ( $\lambda_L$ ) of the NbN films are relatively large ( ∿5000A ) compared with those of the Pb-In alloy or the Nb films, resulting in increasing kinetic inductance. This large kinetic inductance decreases the magnetic sensitivity of the interferometer and increases the propagation delay of the wiring.

In this paper, we propose a new base-electrode structure composed of Nb and NbN double layer. This structure makes it possible not only to decrease the kinetic inductance of the base-electrode due to the small $\lambda_L$ of Nb film ( ∿900A ) but also to obtain a good tunneling characteristic of small subgap conductance due to the surface stability of NbN film.

Figure 1 shows an I-V characteristic and a schematic cross-section of a (NbN,Nb)/Pb Josephson junction. The base-electrode was prepared by sequential sputtering of Nb and NbN films at a substrate temperature of 500°C and patterned by a lift-off method using a ZnO film as a resist stencil[3]. The oxide barrier was formed by an rf plasma oxidation method[4].

Junction quality factors, IcRnn and Vm=IcRsg, are plotted in Fig.2 as a function of the thickness of the surface NbN layer, where Ic is the maximum Josephson current, Rnn and Rsg are the normal tunneling resistance and subgap tunneling resistance defined as the static resistance at the voltage of 6mV and 2mV, respectively. As shown in this figure, both IcRnn and Vm increase with the thickness of NbN, which indicates that the tunneling characteristics are much improved by the existence of the NbN surface layer. This clearly shows the surface of NbN is more stable than that of Nb against plasma processes.

The $\lambda_L$ of Nb, ( NbN,Nb ) and NbN films were estimated from independent measurements of stripline inductance, Fraunhofer characteristics and interferometer characteristics, and plotted in Fig.3. As shown in this figure, the $\lambda_L$ of the double-layered film with about 500A thick NbN surface layer is about 2000A, which is much smaller than that of the pure NbN film. From this result, the double-layered electrode is expected to increase the sensitivity of the magnetic field compared with the pure NbN electrode. We have fabricated memory cells by using this double-layered electrode as shown in Fig.4, and observed that the sensitivity is much improved.

In conclusion, we have developed a new fabrication technology with the NbN,Nb double-layered base-electrode, which allows us to make Josephson devices with good tunneling characteristics without losing the magnetic sensitivity.

* Parmanent address : Mitsubishi Electric Co.


References

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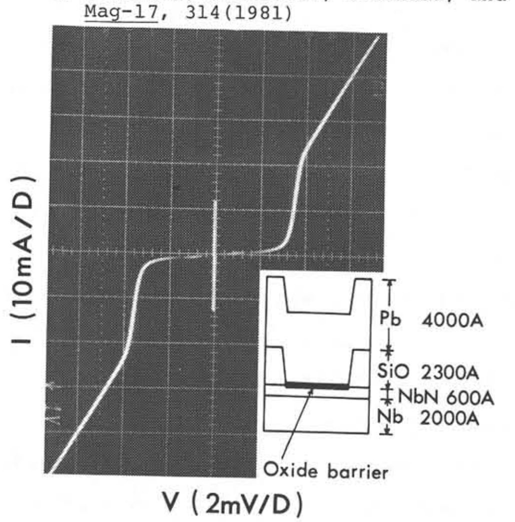


Fig. 1, I-V characteristic and schematic cross-section of (NbN,Nb)/Pb Josephson junction.

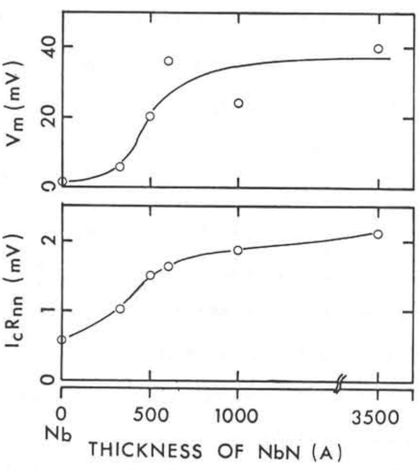


Fig. 2, IcRnn and Vm as a function of thickness of NbN layer. ( Thickness of Nb is 1500A. )

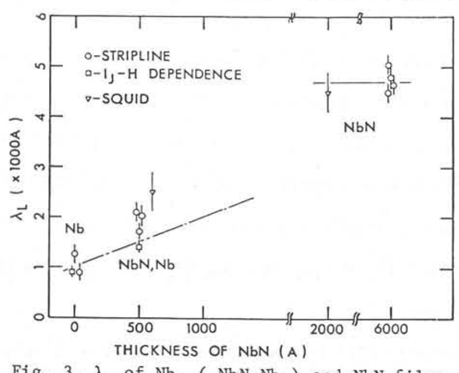


Fig. 3, $\lambda_L$ of Nb, ( NbN,Nb ) and NbN films.

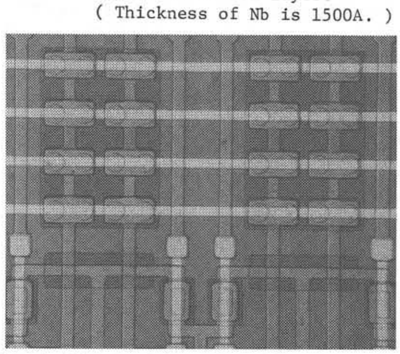

Fig. 4, Memory cells using NbN,Nb double-layered base-electrode Josephson junctions.