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.Josephson Junctions for Applications

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Josephson tunneling was discovered in 1962 and since then a great number of application possibilities has been proposed. In many applications, especially in instrumentation Josephson junctions are superior to the conventional methods. The use of Josephson junctions has not increased as fast as one would expect on the basis of these great possibilities. This is due to the difficulties encountered in the fabrication of the components based on Josephson phenomena. Components are as a rule unstable and the repeatibility in fabrication is poor.

In this report a method is described which yields stable and robust junctions with a fairly good repeatibility in fabrication. The good results are achieved by a successfull choice of the superconducting materials and by the use of an oxygen glow discharge when forming the barrier between the superconducting electrodes.

We use niobium as a base electrode and lead as a top electrode. The electrodes are vacuum evaporated through metal masks onto a glass substrate. The surface of the niobium film is oxidized before the evaporation of the lead film. The thickness of the oxide layer is about 20 Å and can be varied by varying the glow discharge time. The magnitude of the Josephson current depends on the thickness of the insulating layer. By varying the oxidation time from 20 sec to 2 minutes we get junctions with Josephson currents varying from 100 mA to 50 μA. All the fabrication steps are completed without opening the vacuum chamber.

The stability of the junctions is excellent. Some junctions have been cooled down to liquid helium temperature more than twenty times during two years without any noticeable changes in normal tunneling resistances. The junctions are stored at room temperature in normal laboratory atmosphere.

We are developing Josephson components for two applications; for a parametric amplifier in microwave frequencies and for a sensitive measuring instrument capable of sensing magnetic field, electrical current and voltage. The microwave project is performed in co-operation with the Radio Laboratory of Helsinki University of Technology. The major problem in microwave applications is the coupling of Josephson junctions to external circuits. By using a vacuum evaporated $\lambda/4$-transformer chain we have succeeded in coupling the junction to a wave-guide with an efficiency of better than 20 dB.

The measuring instrument is based on the quantum interference phenomenon in closed superconducting rings. The sensor consists of a ring closed by a Josephson junction and an evaporated flux transformer which is composed by 18 parallel superconducting loops. The instrument is developed in co-operation with the Department of Technical Physics of Helsinki University of Technology.