Digest of Tech. Papers The 8th Conf. (1976 International) on Solid State Devices, Tokyo

B-2-3 Thin film SQUIDs for magnetic field measurements

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Magnetometers based on the use of Superconducting Quantum Interference Device (SQUID) posses an unsurpassed sensitivity. On the other hand SQUID sensors are expensive to prepare and they have had problems with mechanical and thermal stability. We have developed a thin film SQUID sensor which is stable and suitable for mass production.

The sensor consists of one or two Nb-Nb oxide-Pb Josephson tunnel junctions shunted by copper film resistors and a flux collecting circuit with two to eight loops. All the films are deposited on a flat glass substrate by vacuum evaporation. The Josephson junctions are prepared as described previously[1]. The flux collecting loops are made of niobium and lead films and insulated, where needed, by silicon oxide films. Preparation is completed by covering the sensor in a spinner by a thin KTFR layer. To avoid hazardous wire contacts to the films both input and output signals are inductively coupled to the sensor. The protected sensors usually withstand repeated cooldowns and storage at room temperature for several years.

The quality of the sensors depends essentially on the quality of the niobium film. As a measure of the film quality we have used the 300 K/78 K resistance ratio. In our films this ratio varies from 1.5 to 2.5. The films with smaller resistance ratio suffer from considerable flux creeping. This is probably due to the fact that impurities decrease the lower critical field, H_{c1}, of the film. The very small H_{c1} of the heavily polluted films results in a strong fluxoid formation.

The fluxoid formation is found in the magnetometer output as sudden transients when the input signal amplitude exceeds some specific number of flux quanta. This number depends also on the geometry of the sensor. For the 8-hole geometry of Fig. 1 the number is from 100 to 1000, when the resistance ratio of the Nb film varies from 1.8 upwards. For a two hole geometry the number usually exceeds 1000 flux quanta (the maximum we can detect).

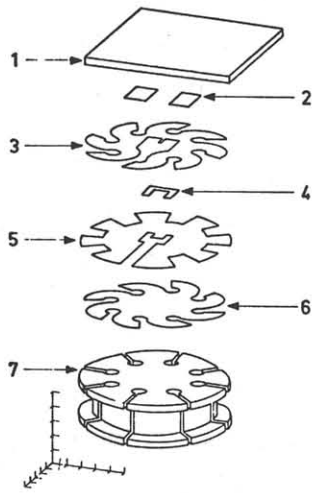

Fig. 1. Eight-hole SQUID. The Josephson junctions are formed between the oxidized Nb film (3) and Pb film (4), and shunted by the Cu film (2). Si-oxide film (5) acts as an insulator, and Pb film (6) closes the flux collecting loops feeding current to the junction. The signal and rf coils are wound around the Nb body (7). The substrate (1) with deposited films is pressed with a spring against the body. One division equals 1 mm.[2]

We have tested the preparation method by preparing a run of 200 sensors of the 4-hole geometry. More than 100 of these were working as a SQUID. Fig. 2 represents the serial production type of our SQUID in the sensor head of a magnetometer. With this system the noise level is below $2 \cdot 10^{-4}$ flux quanta/$\sqrt{\text{Hz}}$.

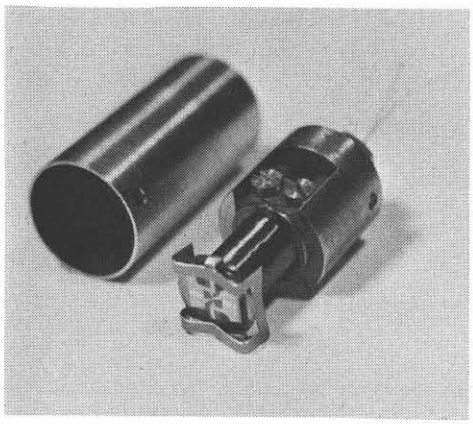

Fig. 2. Four-hole thin film SQUID in the sensor head of a magnetometer.

References:

1. T. Wiik and T. Stubb, J. of the Japan Soc. of Appl. Phys. Vol 43 (1974), 461-463.
2. G.J. Ehnholm, J.K. Soini and T. Wiik, Proc. 14th Int. Conf. Low Temp. Phys., Otaniemi, Finland, Aug. 14-20, 1975, Vol 4, 234-237.