IC SQUID

THIRD INTERNATIONAL CONFERENCE ON SUPERCONDUCTING QUANTUM DEVICES

BERLIN (WEST), JUNE 25 - 28, 1985

CONFERENCE DIGEST

IC SQUID 1985 ist sponsored by
European Physical Society and
Physikalisch-Technische Bundesanstalt
and has received generous support from
Biomagnetic Technologies, Inc. (S.H.E. GmbH)
FA Tiefe Temperaturen der Deutschen Phys. Gesellschaft
Senator für Wirtschaft, Berlin
Siemens AG
Vakuumschmelze GmbH

STATIONARY PROPERTIES OF JOSEPHSON SN-N-NS MICROBRIDGES

V.F.Lukichev, M.Yu.Kupriyanov and A.A.Orlikovsky
General Physics Institute, Academy of Science of the USSR,
117942 Moscow, Vavilov street, 38.

Josephson weak links such as SN-N-NS microbridges have a good outlook for applications in cryoelectronic devices because of their potential high characteristics. However, in spite of relatively good theoretical understanding of main processes[1] in such structures an experimental situation is far from optimum. For example, the $I_C R_N$ product (I_C critical current, R_N normal state resistance) of experimental bridges[2,3] is much more lower than theoretical predictions for this value which should be comparable with one in tunnel junctions. One possible reason of such depressed $I_C R_N$ value is the proximity effect between superconducting film and normal (N) layer. It is obvious that $I_C R_N$ can be reduced also by geometrical factors, for example, because of too low normal resistance. This fact requiers a relatively small thickness of N layer d_N. Furthemore it seems possible to create large gradients ($I_C \backsim d_N^{-1}$) in vertical type microbridges by special current injection in order to raise up I_C (as in SNS sandwich) and keep high R_N ($R_N \backsim d_N^{-1}$ as in microbridge). On the other hand N channel confinement due to too small d_N reduces I_C to zero ($I_C \backsim d_N$). Therefore function $I_C(d_N)$ has to have a maximum. Thus the subject of the report is to investigate the influence of the proximity effect on properties of structures under consideration and to calculate function $I_C(d_N)$ with the aim of optimization.

Earlier, the influence of the proximity effect on properties of SN-N-NS microbridges has been analysed only phenomenologically[3]. In order to evaluate microscopic theory of Josephson effect in SN-N-NS microbridges we start from the following assumptions: 1) the condition of dirty limit is fulfilled for both S and N metals; 2) there is no potential barrier on SN interface; 3) the thickness of S layer is greater than its coherence length ξ_S^*, so that the critical temperature of the SN elecrode is close to that of the bulk superconductor; 4) the thickness of the N metal d_N is much less than its coherence length ξ_N^* and its T_C equals zero.

Under this conditions with the help of Usadel equations we have calculated the temperature dependencies of $I_C R_N$ for various values of the parameter $\gamma_M = (\sigma_N \xi_S^* d_N)/(\sigma_S \xi_N^{*2})$ characterizing the proximety effect in SN electrodes for series of effective weak link lengths. It is shown that for $\gamma_M \lesssim 0.3$ $I_C R_N$ product is reduced not more than factor of two in comparison with the case $\gamma_M = 0$. In fact, this confinement on γ_M is the condition of choice of the suitable pairs of S and N materials giving the small γ_M.

In order to consider quasi-two dimensional processes (which are essential for $d_N \gtrsim \xi_N^*$) we have supposed for simplicity the weak proximity effect ($\gamma_M \ll 1$). We have solved Eilenberger equations for the clean limit with rigid boundary conditions on SN interfaces and with zero normal derivatives at the free surfaces. We have obtained thickness $d_N \approx 0.1\, \xi_N$ for which critical current reaches maximum value. Maximum of I_C in dirty limit lays at $d_N \simeq \xi_N^*$. However, $I_C R_N$ product gradually falls with increasing d_N being approximately constant for $d_N \lesssim \xi_N^*$ and lowering as d_N^{-1} for $d_N \gtrsim \xi_N^*$.

1. M.Yu.Kupriyanov, K.K.Likharev, V.F.Lukichev, Physica, 1981, v.108B, pp.1001-2.
2. J.M.Warlaumont, J.C.Brown, R.A.Buhrman, Appl.Phys.Lett., 1979, v.34, p.415.
3. A.De Lozanne, M.Dilorio, M.R.Beasley, Physica, 1981, v.108B, p.1027.