SUMMARY OF Ph.D. DISSERTATION

School	Student Identification Number	SURNAME, First name
Keio University		Kubo Toshiharu

Title

Study on the Superconducting Proximity Effect in Niobium/Graphite Complex Systems

Abstract

In the junction of a superconductor (S) and a normal conductor (N), the superconducting electrons in S penetrate into N. This effect is known as the superconducting proximity effect. Because the superconductivity in S decreases toward the interface between S and N by the proximity effect, the superconducting transition temperature (T^*_C) and the critical field (H^*_C) of S/N bilayer lower from those in the bulk superconductor (T^S_C, H^S_C), and the relation between the amount of the reduction ratio and the film thickness of S and N reflects electronic properties in S and N.

In this study, graphite was used as N. Graphite is a semimetal which has a typical layer structure, and the electrical resistivity along the lamination direction called c-axis is about 100 times larger than that in the basal plane. Though physical properties in the junction of a superconductor and graphite having such large anisotropy have not been clarified, there will be a possibility that the junction has some useful property for superconducting devices. Therefore, the author studied experimentally the dependence of T^*_C and H^*_C of niobium/graphite bilayers on the graphite film thickness in order to obtain the information on the proximity effect for the junction of a superconductor and graphite.

Thin graphite films of various thickness ranging from 20 to 160 nm were prepared by cleaving a kish graphite (KG) which is an original crystal with good crystal perfection. For making a specimen, niobium (Nb) of 40nm in thickness was deposited on a KG film and a quartz glass substrate simultaneously using electron-beam evaporation method. Each resistance of Nb and Nb/KG films was simultaneously measured, from which T_C^* and H^*_C of each film were obtained.

As the experimental results, the ratio of T_C^* to T_C^S (T_C^*/T_C^S) shows a periodic characteristic with the KG film thickness, and its period is about 30nm. Furthermore, the peak values of T_C^*/T_C^S exceed 1.00, while H^*_C lowers from H^S_C at all temperatures ($t = T/T^S_C = 0.85$～0.95) within this experiment. As for the value of $H^S_c - H^*_C$ ($\triangle H_C$), it decreases or increases as the temperature lowers, depending on whether $T^*_C/T^S_C < 1.00$ or $\geqq 1.00$, respectively. The experimental result of T_C^*/T_C^S suggests that the electron correlation at the Nb/KG interface depends on the KG film thickness because of the interference of electron waves in the KG film. Such an interference among waves is caused by the Andreev reflection at the Nb/KG interface and by the normal reflection at the opposite KG surface. Furthermore, the temperature dependence of $\triangle H_C$ implies that the interference effect is changed with the temperature and finally causes the change of T^*_C. In this study, it was clarified that the electron correlation in KG enhances the superconductivity under some values of the quasiparticle's local density of states at Nb/KG interface.