§24. Electrical Insulation of Superconducting and Cryogenic Devices

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1. Introduction

The Large Helical Device(LHD) has both helical and poloidal coils with the storing energy of several GJ which are the largest superconducting coils ever designed. It is apparent that large mechanical stresses due to both electromagnetic force and cryogenic contraction act on the superconductors and insulators. Furthermore the superfluid helium would be a coolant as well as insulating fluid in the second phase of LHD project. The purpose of this research is to give the reliable design criteria of the electrical insulation of LHD.

2. Progress in 1993

2.1 Surface discharge in cryogenic and high density helium

The breakdown strength of pressurized superfluid helium was discovered to have similar level with that of liquid or supercritical helium. However, breakdown is likely to take place along the spacer so that the surface discharge characteristics have to be examined which are usually inferior to those of the fluid itself. The surface discharge voltage along 3mm FRP spacer in the vapor above boiling helium at atmospheric pressure was found to have a half of the breakdown voltage of the corresponding sphere gap. This is approximately equal to the other results in liquid helium.[1] Further verification is needed for the surface discharge in superfluid helium.

2.2 Source of initial electron in liquid helium

In order to elucidate the breakdown mechanism of liquid helium, statistical time lags of breakdown were obtained by the Laue plotting of breakdown data. They have strong dependence on the applied electric field, which is discussed in terms of a mechanism of supplying an initial electron from micro protrusions on the cathode.

2.3 Electrical breakdown of polyimid thin film in cryogenic region

Little is known on the breakdown characteristics of polyimide thin film in the cryogenic region, a typical candidate of coating material. Thin polyimid films in thickness raging from 0.4 to 1.0 μ m formed by the spin-coating method were subjected to self-healing breakdown tests to obtain the breakdown strength (Fb) under a ramp DC voltage in the temperature range from 77 to 500K. The results are shown in Fig. 1.

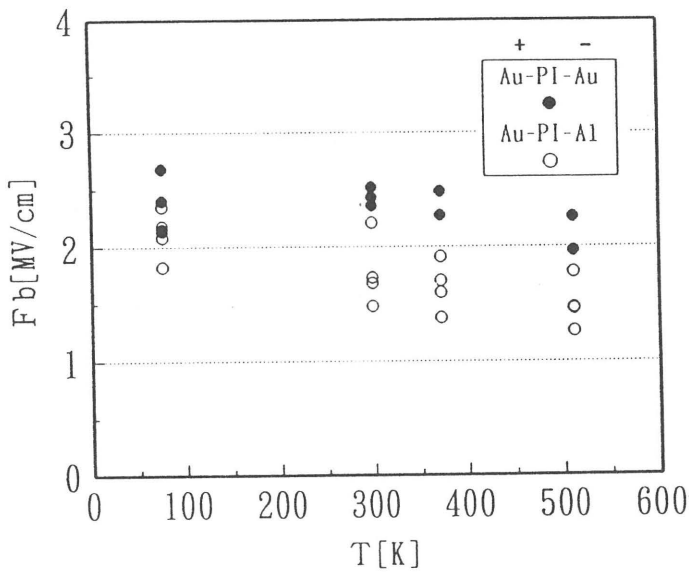

Fig. 1 Temperature dependence of breakdown strength of polyimid thin film

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1)Meats,R.J.,Cryogenics 17,(1977)77.