§ 7. Kapitza Conductance of an Oxidized Copper Surface in Subcooled and Saturated He II

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Kapitza conductance is an essential characteristic for heat transfer from a metal to He II. Temperature discontinuity occurs at the metal-He II interface. Many studies have been performed to investigate the dependence on various metals because of engineering requirements. On the other hand, superconducting magnets make use of subcooled or saturated He II, around 1.8 K, as the coolant. It has been already reported that the Kapitza conductance of a copper surface around 1.8 K, which corresponds the operation temperature of superconducting magnet, is independent of the He II pressure.

The helical coil system of the Large Helical Device (LHD) might be cooled by subcooled He II in the future to increase the magnetic field. The helical coil conductor is the aluminum-stabilized, pool-boiling, superconductor with a copper sheath. Its surface is treated by chemical oxidation to improve the heat transfer characteristics in He I. The knowledge of the Kapitza conductance of the chemically oxidized copper surface is required for the stability analysis and it had been measured in saturated He II.1) However, the oxidized surface has quite different appearance from a copper surface; it must be considered that the difference of surface condition possibly affects the Kapitza conductance in subcooled He II.

In the present study, the heat transfer of the chemically oxidized copper surfaces has been measured. The dependence of the Kapitza conductance of the oxidized surface on subcooled and saturated He II is discussed.

The configuration was designed for steady state heat transfer measurement as shown in Fig. 1. The sample is a cylindrical shape, 20 mm in diameter and 70 mm in length, with three holes for thermometers and was machined from an oxygen-free copper (OFC) block, RRR=80±20. The surface was treated by chemicals. Three thermometers, germanium sensors, were placed into the holes with Cry-Con thermal conductive grease for good thermal contact at the interval of 20 mm to measure the temperature distribution. A thermofoil heater, 74.5 ohms at room temperature, was glued on the opposite side of the heat transfer surface by Stycast 1266. In order to minimize the heat leak via a flange, the sample with a glass fiber reinforced plastic(GFRP) flange was assembled to a stainless steel flange which is a part of a vacuum can. Indium seal was used at the interface between the flanges.

The cryostat was evacuated and filled with gaseous helium. After the vacuum for thermal insulation of the sample was achieved less than 1.33×10^{-2} Pa, the cryostat was charged with He I. Then, the sample was cooled down to 1.97 K of subcooled or saturated He II.

The Kapitza conductance of the oxidized surface in subcooled and saturated He II was measured. Fig. 2 shows the surface temperature variation. The heat flux was provided up to 17.3 kW/m^2 and 36.6 kW/m^2 in subcooled and saturated He II, respectively. The variations in the maximum heat fluxes resulted from the limited refrigeration capacity in each measurement. There is no apparent difference in Kapitza conductance for either subcooled or saturated He II. The variation is the maximum of 1.2 % in the range of the heat flux from 0 to 17.3 kW/m^2. Even though the surface morphology is quite different for the chemically oxidized surface, the Kapitza conductance is not affected by the pressure difference in He II; like other metals considered in the same temperature region.

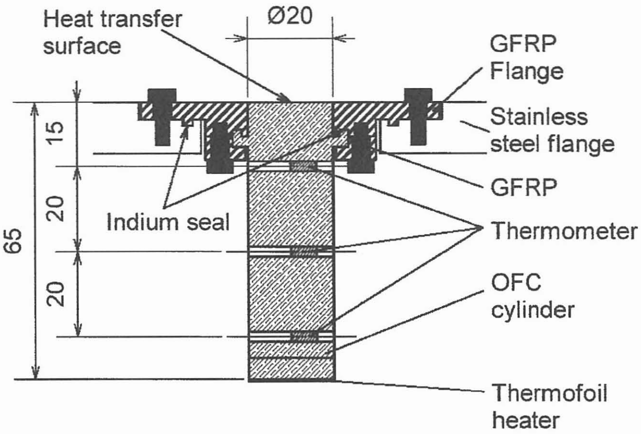

Fig.1. Schematic illustration of the sample

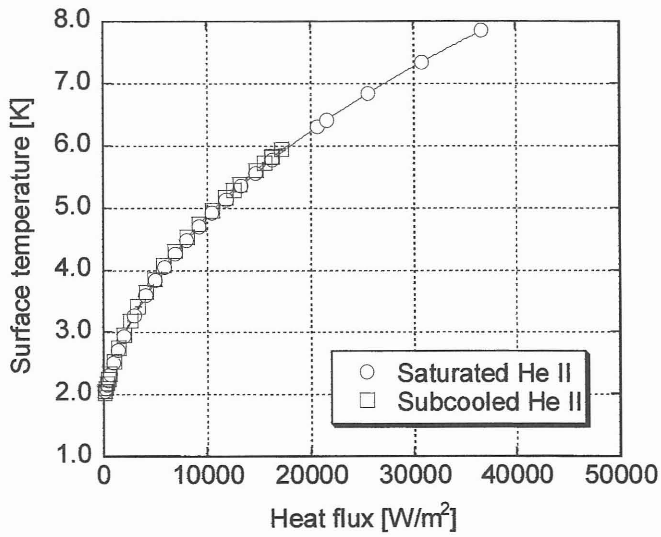

Fig.2. Kapitza conductance of the oxidized copper surface at 1.97 K in subcooled and saturated He II

Reference

1) Iwamoto, A., Maekawa, R. and Mito, T., Cryogenics **41**, (2001) 367.