§82. Peltier Current Lead and High Temperature Superconductor

Sakurai, T (Iwakimeisei Univ.)
Tobise, S, Koumoto, K. Kuroda K., (Nagoya Univ.)
Yamaguchi, S.

Current lead has a large temperature difference because this is connected to a power supply and a superconducting magnet. Since the material of the current lead is copper and/or metal, high heat leak is induced. Moreover, Ohmic heating power is added in the current lead. As high heat leak reduces the stability of the magnet and increases operation cost. Therefore, the study to reduce the heat leak, has been performed long time. Recently, high temperature superconductor (HTS) is used for the current lead because no Ohmic loss is added under the temperature of liquid nitrogen temperature, and the thermal conductivity of HTS is almost one-thousands of the copper around 77 K. The heat flux of the HTS current lead is about 40 % of that of the normal current lead in the present experiment[1]. The authors proposed a new current lead which is based on the thermoelectric effect and called Peltier current lead[2]. Since current flows from N-type semiconductor to P-type semiconductor and the these semiconductors are connected to the magnet leads, the heat flux is pumped out from the low temperature side to the high temperature side, and therefore, this is a good thermal insulator in the current lead circuit. The first demonstration experiment has been done successfully in the last year, and the materials of the semiconductors are BiTe(Sb). However, since the present semiconductors have high figure of merit near the room temperature, the lowest temperature of the semiconductor is around 200 K in the experiment. Because of this, we can not connect the semiconductor to the HTS directly. On the other hand, BiSb is known as a good semiconductor which is a N-type semiconductor and has high figure of merit near 77 K[2]. The martial of HTS to use for the current lead is Bi-2223, and this is used under the temperature of 77 K.

Because of these situations, if we can connect Bi-2223 HTS and BiSb directly, we can expect the upper temperature of HTS is lower than 77 K, or the heat flux at the upper temperature of HTS is pumped out by thermoelectric effect. And if we can connect BiSb and BiTe(Sb) directly, we can expect a new current lead which is shown in Fig. 1.

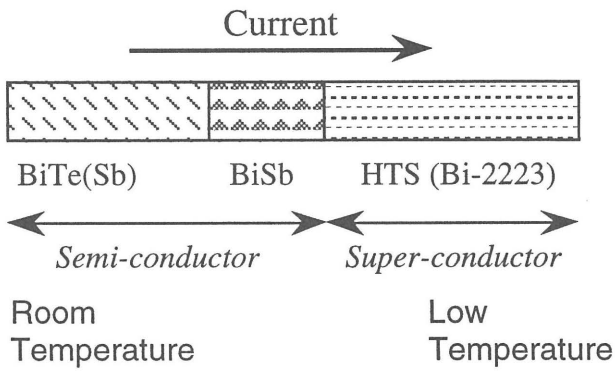

Fig. 1 Conceptual drawing of new current lead

The base material is Bi, and other components of the semiconductor and superconductor are different. Therefore, this principle based on the concept of the functionally gradient material (FGM), which are developed in various fields[3]. But the superconductor and the semiconductor are not same conducting state because the normal conductor and super conductor are used, in this meaning, this proposal expands the concept of FGM.

BiSb is a good N-type semiconductor in low temperature, but w do not know a good P-type semiconductor now. The mobility of P-type semiconductor in low temperature is low, and therefore, the figure of merit is not high like BiSb. The connection method of the superconductor and semiconductor is an important issue to study.

Reference

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