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中性子照射によるNb_3Sn線材の臨界電流、臨界温度の変化

Change in critical current and critical temperature of Nb_3Sn wires by neutron irradiation

西村　新[1,2)]、菱沼　良光[1)]

Arata NISHIMURA[1,2)], Yoshimitsu HISHINUMA[1)]

[1)]核融合研、[2)]理化技研(中科院)

[1)]NIFS, [2)]TIPC (CAS)

Introduction

Nb_3Sn wires for ITER TF coil were irradiated in BR2, Belgian reactor #2, and the superconductivity change was studied with the 15.5T superconducting magnet and the variable temperature insert (VTI) in Oarai center, IMR in Tohoku University.

Test procedure and results

The Nb_3Sn wire is 0.8 mm$^{\Phi}$ and made by the bronze-route process. The sample holder in the VTI is shown in Fig. 1. A high purity aluminum rod was used to transfer the heat to the second stage of GM refrigerator and the rod was sandwiched by the current bus bars to cooldown the bus bars and the sample holder. There are three CERNOX sensors to measure the temperature. One is AA type sensor to measure the + electrode and other two sensors are CU type to measure the + and – electrodes. At around 5 K, the specific heat of the metals is very small and there is a small temperature difference in two electrodes. So, the average temperature was used as the sample temperature.

Figure 2 shows the superconducting critical surface. Current, temperature and magnetic field are basic factors to the superconducting materials. On the T-B plane, the following relation between the effective upper critical field and the effective critical temperature was found traditionally:

$$B^*_{C2}(T_C) = B^*_{C2}(0) \times (1 - (T_C/T^*_C(0))^{3/2})$$

where $B^*_{C2}(0)$ is B^*_{C2} at zero K, $T^*_C(0)$ is effective critical temperature where $B^*_{C2}(T)$ becomes zero.

The results are shown in Fig. 3. The horizontal axis is T_C^(3/2). There is a good linear relation between those parameters. Obtained $B^*_{C2}(0)$ and $T^*_C(0)$ are presented in the figure together with the neutron fluence of over 0.1 MeV.

Short summary

The neutron irradiation changes the $B^*_{C2}(0)$ and $T^*_C(0)$. Although $T^*_C(0)$ decreases monotonically, as the fluence increases, $B^*_{C2}(0)$ increased once then decreased. The change in the critical current is considered to be strongly related to this behavior, the change in $B^*_{C2}(0)$.

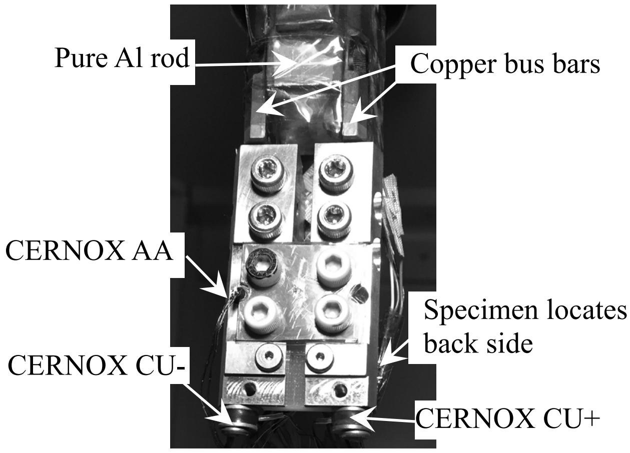

Fig.1 Sample holder and CERNOX sensors.

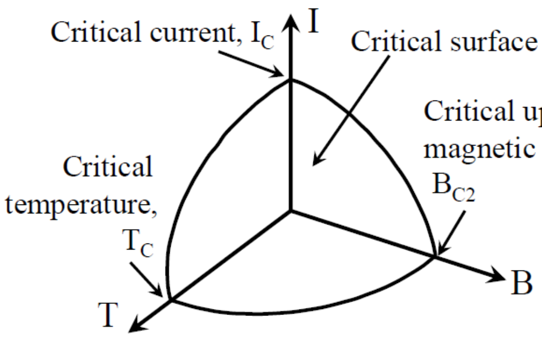

Fig. 2 Superconducting critical surface.

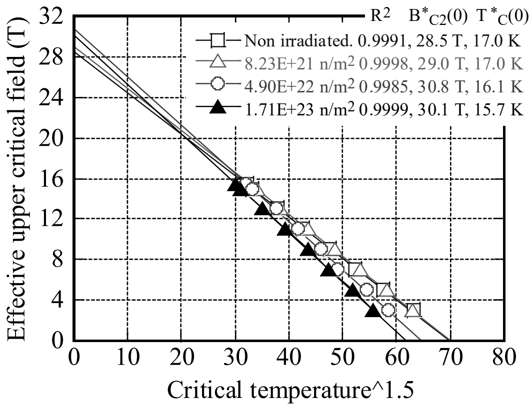

Fig. 3 B^*_{C2} vs Tc^1.5