§79. Neutron Irradiation Effect on Superconducting Magnet Materials for Fusion

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To carry out superconducting tests of neutron irradiated samples, high magnetic field facilities must be prepared in a radiation control area because the samples are activated. Nuclear Basic Infrastructure Strategic Study Initiative supported by MEXT could provide a 15.5 T superconducting magnet system and a variable temperature insert (VTI) at Oarai center, Tohoku University and some tests were carried out using these facilities.

The SC magnet installed is a dry magnet working without liquid helium or liquid nitrogen. Gifford–McMahon (GM) refrigeration with an air cooled compressor is equipped and the magnet generates 15.5 T of the maximum field in a 52 mm RT bore. The magnet system requires only the electric power. This is good not only for management of the radiation control area but also for the magnet users. The VTI has a sample holder and equips 500 A DC power supply. The sample is cooled down by thermal conduction with GM refrigeration and the sample holder temperature is able to be controlled from 4.5 K to around 20 K or more.

The Nb3Sn samples were irradiated at JRR-3 to 1.0 x 10^{21} n/m^2 and 1.0 x 10^{22} n/m^2 with over 0.1 MeV neutron. The sample was set on the sample holder as shown in Fig. 1, and the temperature distribution was measure. Since the Cernox-CU showed stable and repeatable results, the temperature was used for the data analysis.

The electric resistance and temperature were plotted as shown in Fig. 2. As the temperature decreases, the resistance becomes small and zero at a certain temperature. This point is called as on-set temperature and it shows the strand becomes fully superconducting. The temperatures shown in Fig. 2 are the estimated critical temperatures at each magnetic field. As the field becomes higher, the critical temperature becomes lower.

The relation between the critical magnetic field and the critical temperature is shown in Fig. 3. In the figure, the critical magnetic field at 4.2 K under 0.1 A of the sample current is plotted and also the critical temperature under zero field is presented.

Both of the irradiated to 1.0 x 10^{22} n/m^2 and non-irradiated samples show a linear relation between the field and the temperature. However, the inclination of the linear relation is different and the irradiated sample showed steeper relation. If one would extrapolate and calculate the critical temperature at 4.2K, the critical field of the irradiated sample becomes higher than that of non-irradiated. The test will be continued and the data will be analyzed and investigated furthermore.

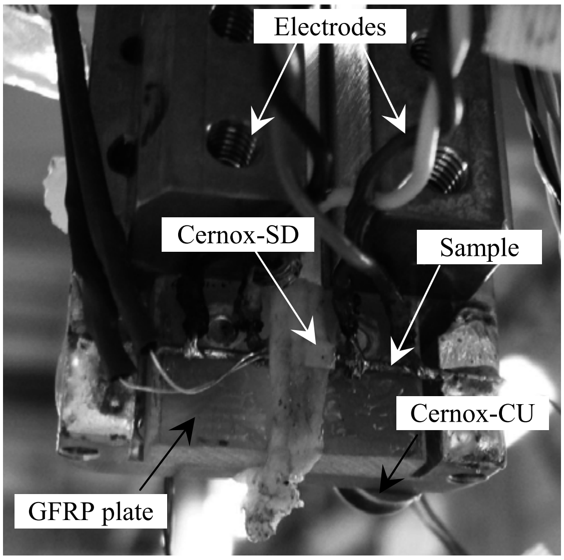

Fig. 1. Set-up status of Nb3Sn strand on sample holder. Cernox-AA (back side), CU and SD were attached to measure temperature distribution.

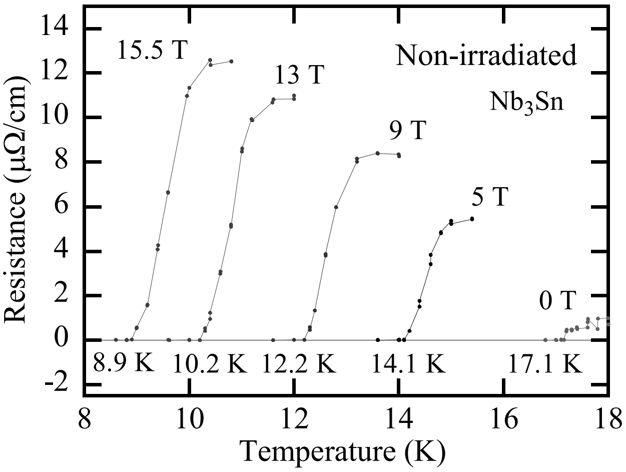

Fig. 2. Relation between electric resistance and temperature. Electric resistane becomes large under higher magnetic field and critical temperature goes down.

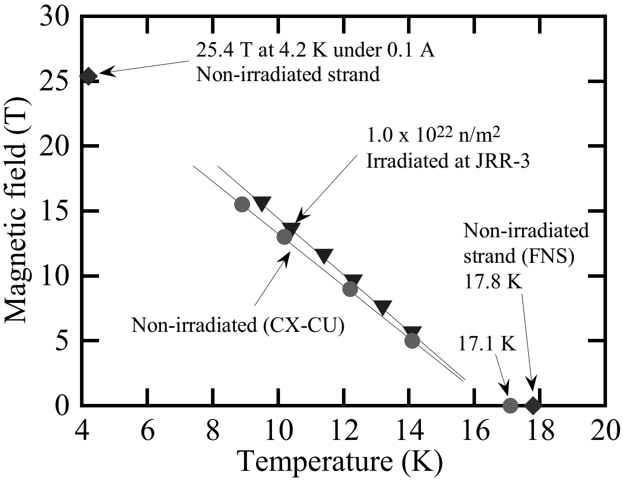

Fig. 3. Relation between critical magnetic field and critical temperature of non-irradiated and 1.0 x 10^{22} n/m^2 neutron irradiated Nb3Sn strands.