§75. Establishment of Critical Current Measurement Techniques Using a 15.5 T Conduction-cooled Superconducting Magnet

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A systematic neutron irradiation study on superconducting materials has been stopped since 1990s. As a result reliable experimental data of post-irradiation superconducting properties are not available for thereafter developed advanced-superconducting-strands such as a high-performance bronze-route Nb_3Sn wire for ITER uses and a Nb_3Al wire for DEMO with much better strain tolerance. Meanwhile, until this year-end, a 15.5 T conduction-cooled superconducting magnet system will be installed at the International Research Center for Nuclear Materials Science, Institute for Materials Research, Tohoku University. This study has been performed to establish a critical current measurement technique using such a 15.5 T conduction-cooled superconducting magnet.

From a safety view point it is a critical issue to shut down a sample current without a delay when a certain normal conductive resistance would appear during critical current measurements, otherwise consumed electric power, the product of generated sample voltage by sample current, would increase the sample temperature beyond its melting points and thus break the activated superconducting wire. Therefore, the above mentioned 15.5T conduction-cooled superconducting magnet system utilizes the so-called switching current source which can shut down a sample current within a microsecond delay after detecting a certain level of sample voltage. For a double safety, the sample current should be also automatically reduced when sample voltage arises, by bypassing itself into a shunt resistor which is connected in parallel (figure 1). However, such a shunt resistor circuit would make it difficult to monitor the actual sample current. Thus, we have planned to monitor both a shunt voltage and a shunt temperature for the sample current correction.

Two temperature sensors are directly attached on the shunt resistor. Using a shunt resistance vs temperature curve for a given magnetic field (figure 2), the actual sample current could be obtained by subtracting, from the source current, the shunt current which would be calculated by dividing the shunt voltage with the shunt resistance as a function of the shunt temperature and magnetic field. For this purpose, we purchased this year two Cernox temperature sensors and a Lakeshore 340 temperature controller which could display two temperatures monitored simultaneously. The designed measurement system of critical current for neutron irradiated samples is shown in figure 3.

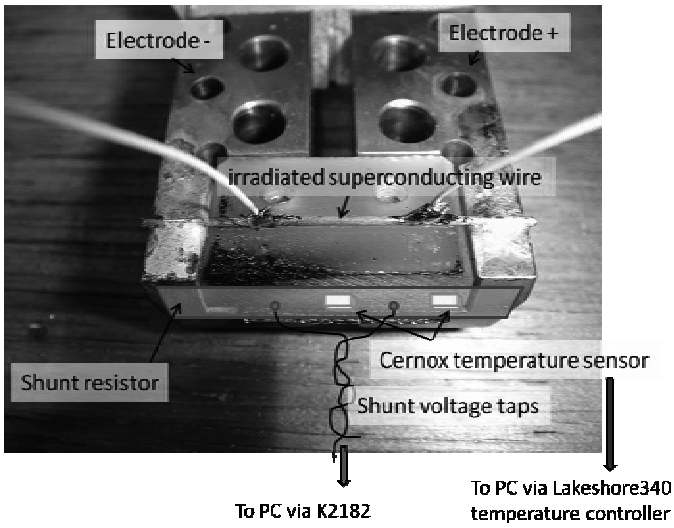

Fig. 1. A shunt resistor current-sharing circuit to suppress the melting of an activated-superconducting-wire during critical current measurements.

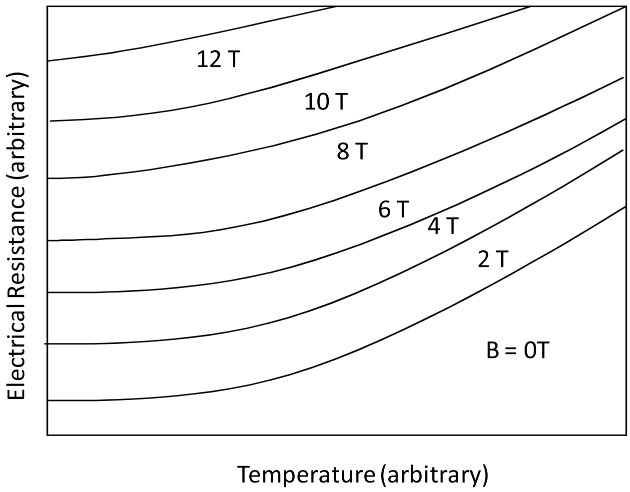

Fig. 2. Schematically illustrated correction curves of shunt resistance as a function of temperature with respect to variable magnetic field from 0 to 12 T.

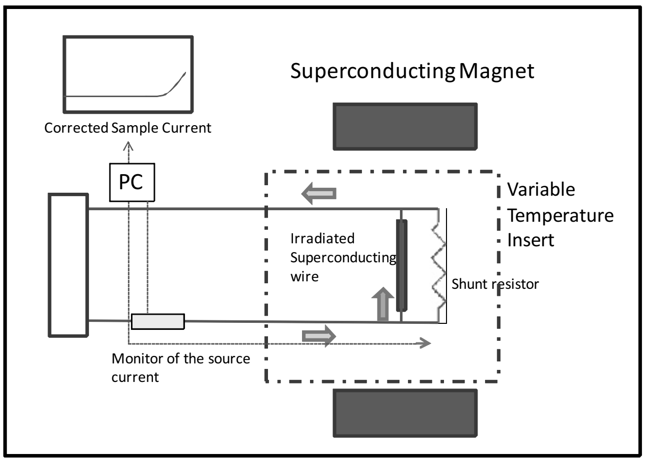

Fig. 3 Designed measurement system of critical current.