§12. Electromagnetic and Structural Investigation of Inter-strand Resistance in CIC Conductor for Fusion Magnets

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A cable-In-conduit conductor (CICC) is one of the most promising conductor for larger-scale magnet for fusion devices, such as Force Free Helical Reactor (FFHR). However Nb3Sn is the popular one as a CICC construction material for the conductor in high field region, its mechanical characteristic, of fragile against electromagnetic force during operation is still big issue for applying it to the large scale magnets. That is why we need to investigate the all strand locations and simulate the wire movements expected to take place during operation.

The procedure of the strand trace measurement is described as follows: Firstly, the CICC after heat treatment is impregnated by epoxy resin to harden the strand positions to prevent wire movement during slice process. Secondly, the CICC is cut into pieces with 10 mm in thickness. Finally, resistance measurement in LHe temperature between strand cross sections on both side of the pieces enables us to identify where the strand positions on the two sides of slice sample, i.e. strand trace along the conductor axis in 10 mm long. The strand traces in sample CICC are obtained by connecting the strand positions along conductor axis. The details of the measurement has been already presented.[1)]

The key issue of the measurement at LHe temperature is that the durability of current-feed fine probe whose diameter is less than that of strand against the repetitive measurement sequences. The maintenance cycle could not be so often because the probe and samples are in vacuum and cooled down to LHe temperature by conduction cooling. So we newly developed fine probe as shown in Fig.1. The diameter of the brass tip of the probe is 0.5 mm in diameter and covered with bakelite to prevent the buckling of the fine tip. We tested two materials for the tip to choose the more tolerable one. The materials we selected are indium and silver containing solder.

Fig. 2 shows the experimental results of contact resistance evolutions vs. number of measurement cycles for both indium and silver containing solder. The number of cycles is very small compared to real measurement sequence of about 10,000 cycles per one slice sample. This is due to the poor durability of the indium tip. Its measurable number of the cycle is only one hundred, then the measurement has failed. On the other hand, the durability of silver containing tip is quite excellent, the resistances are almost constant over 1,500 times of measurement cycles.

This results would support the successful measurement of all strand traces of full-size CICC in the next fiscal year. In the future work, the trial probe consists of FRP cover and silver containing tip will be tested in the early 2016.

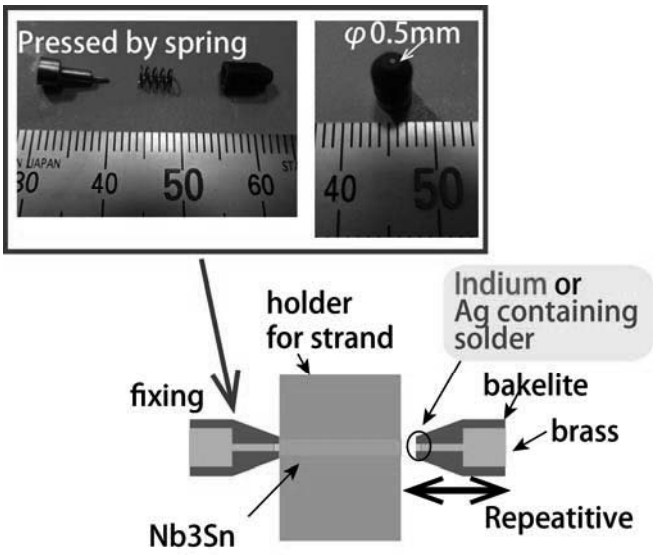

Fig. 1. Schematic of the concept of contact-resistance measurement, in which the pictures of the probe are also shown. The indium and silver containing solder are selected as tips of the probe.

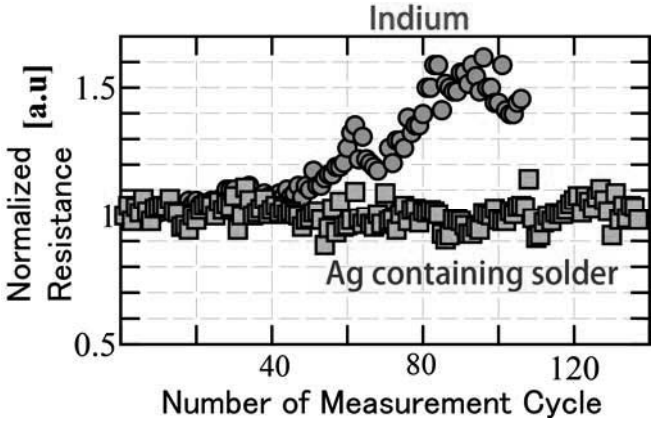

Fig. 2. Experimental results of contact resistance measurement between probe tip and strand cross section as a function of number of measurement cycles. The tip with silver containing solder has excellent durability compared to the soft indium tip.

1) Yagai, T.: IEEE Trans. Appl. Supercond **16** (2006) 835.