§21. Experimental Investigation of Large-Current Capacity HTS Conductors for Fusion Magnets

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Due to the promising properties, such as high critical current density in high magnetic fields at elevated temperatures, high temperature superconductors (HTS) are being considered for fusion reactor magnets [1]. Using HTS conductors in fusion reactors can be economic as they can be used at elevated temperatures of ~20 K or higher. Due to increased specific heats of materials at elevated temperatures, HTS conductors are invulnerable to quench and therefore can provide almost quench free magnets.

HTS conductors are being considered as an option for the LHD-type fusion energy reactor FFHR, which is being designed at NIFS. A cross-sectional view of the proposed 100 kA-class YBCO HTS conductor for FFHR is shown in Fig. 1 (a) [2]. The simple stacking configuration, where all the HTS tapes are stacked together without transposition has been proposed for the HTS conductors. Copper tapes are also used for stabilization and protection.

As a first step towards the development of 100 kA-class HTS conductors, we developed stacked-type 10 kA-class HTS conductors using 34 Bi-2223/Ag HTS tapes (each tape having a critical current of 140 A at self-field and 77 K) in two stacks and then tested them up to the elevated temperature of 30 K under a bias field of 8 T. The cross-sectional view of the 10 kA-class HTS conductor is shown in Fig 1 (b). The conductor fabrication, sample fabrication, experimental procedures, and diagnostics details are described in [2,3].

Figure 2 shows the measured and calculated critical currents of the conductor at different temperatures under a bias field of 8 T (parallel to ab-plane of the tapes). The calculated critical currents (after considering the self-field effects) agree well with the measured critical currents. This indicates no degradation during the fabrication procedures.

Figure 3 shows the calculated and measured stability margins of the conductor. Thermal runaways were not observed even though the conductor temperature could be raised above the current sharing temperatures of the conductor. A large difference between the calculated (in adiabatic conditions) and measured stability margins is considered to be due to the thermal conduction along the conductor. However, the experimental results clearly indicate that HTS conductors are highly stable. The typical stability margin of a low temperature superconducting cable-in-conduit conductor is also shown for comparison.

The ramp rate limitation (RRL) tests were also carried out on the HTS conductors. No RRL effects were observed up to the ramp rate of 1.5 kA/s. The details of the tests and results can be found in [2,3].

The experimental results of 10 kA-class HTS conductors show that HTS conductors are promising for fusion reactors.

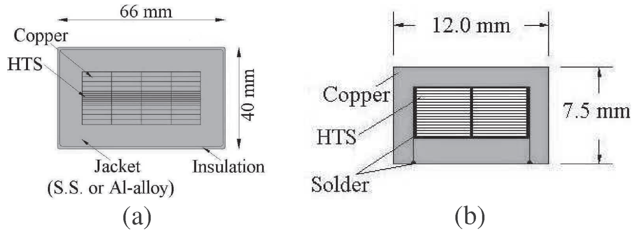

Fig 1: Cross-sectional views of the HTS conductors: (a) proposed 100 kA-class conductor for FFHR coils; (b) tested 10 kA-class conductor using Bi-2223/Ag HTS tapes.

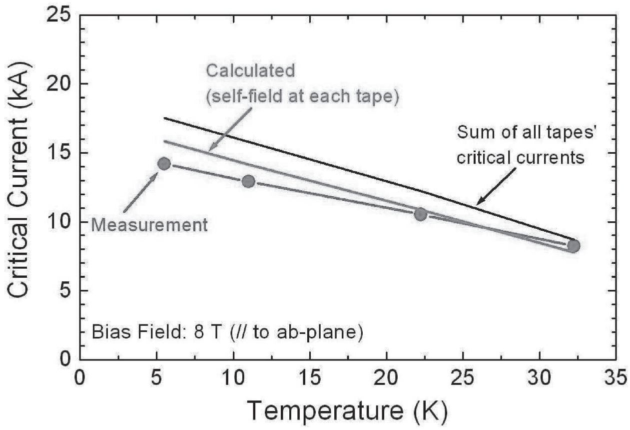

Fig 2: Measured and calculated critical currents of the HTS conductor.

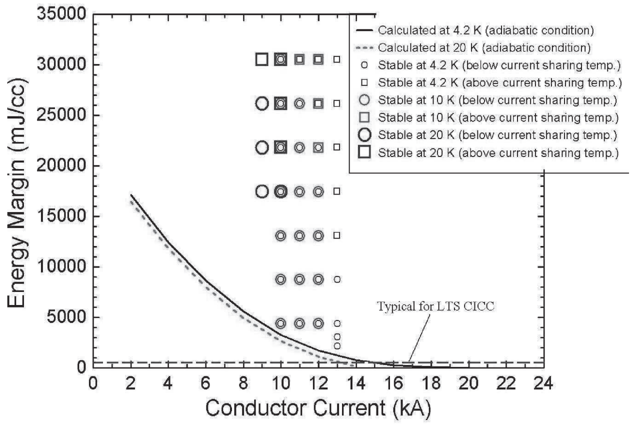

Fig 3: Measured and calculated (in adiabatic conditions) stability margins of the HTS conductor.

[1] Ando, T. et al., IEEE Trans. on Applied Superconductivity **14**, (2004) 1481.
[2] Bansal, G. Ph.D. thesis (Sokendai), 2008.
[3] Bansal, G. et al., to be published in IEEE Trans. on Applied Superconductivity, (2008).