§22. First Test Results of Large-Current Capacity YBCO HTS Conductors for Fusion Magnets

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The LHD-type fusion energy reactor FFHR is being designed at NIFS, for which HTS conductors are being considered as an option. A cross-sectional view of the proposed stacked-type 100 kA-class YBCO HTS conductor for FFHR is shown in Fig. 1 (a) [1].

Towards the development of 100 kA-class HTS conductors, we developed a stacked-type 10 kA-class HTS conductor using YBCO and GdBCO HTS tapes (each tape having a critical current of ~200 A at self-field and 77 K) together with copper tapes. The cross-sectional view of the 10 kA-class YBCO conductor is shown in Fig 1 (b). This conductor was tested at elevated temperatures of up to ~25 K under a bias magnetic field of 8 T. The conductor fabrication, sample fabrication, experimental procedures, and diagnostics details can be found in [1].

Figure 2 shows the measured critical currents of the conductor at different temperatures. The critical currents were measured as expected as a function of temperature.

Figure 3 shows the calculated and measured stability margins of the conductor. Like Bi-2223/Ag conductor [2], the YBCO conductor also showed high stability even at high current loading ratio. The high stability margin of the HTS conductor may ensure safe, reliable, and interruption-free (due to no quench) operations of fusion magnets.

The ramp rate limitation (RRL) tests were also carried out on the YBCO conductor. No RRL effects were observed up to the ramp rate of 1.5 kA/s. At higher ramp rates, the conductor even showed higher critical currents. This behavior was due to the decreased joule heating at higher ramp rates from the flux flow resistance in the conductor. Figure 4 shows the experimental results of the RRL tests.

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

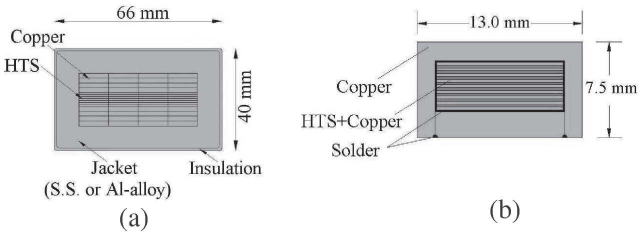

Fig 1: Cross-sectional views of the HTS conductors: (a) proposed 100 kA-class conductor for FFHR coils; (b) tested 10 kA-class conductor using stacks of YBCO and GdBCO HTS tapes.

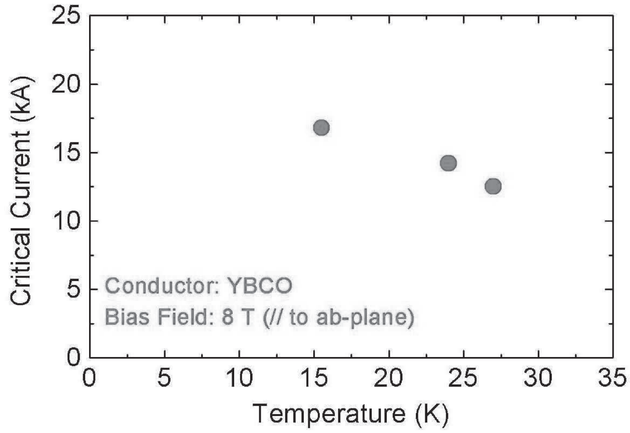

Fig 2: Measured critical currents of the YBCO HTS conductor.

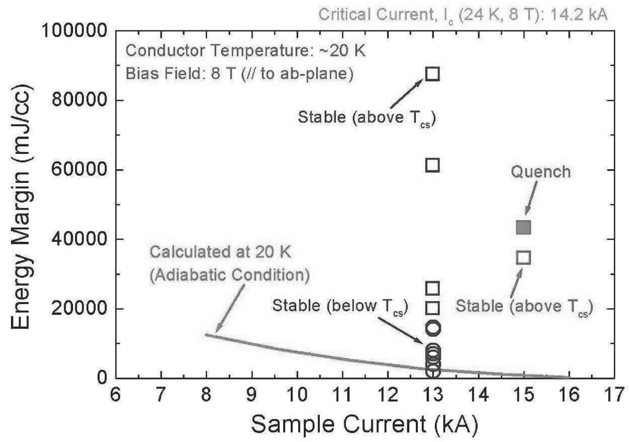

Fig 3: Measured and calculated (in adiabatic conditions) stability margins of the YBCO conductor.

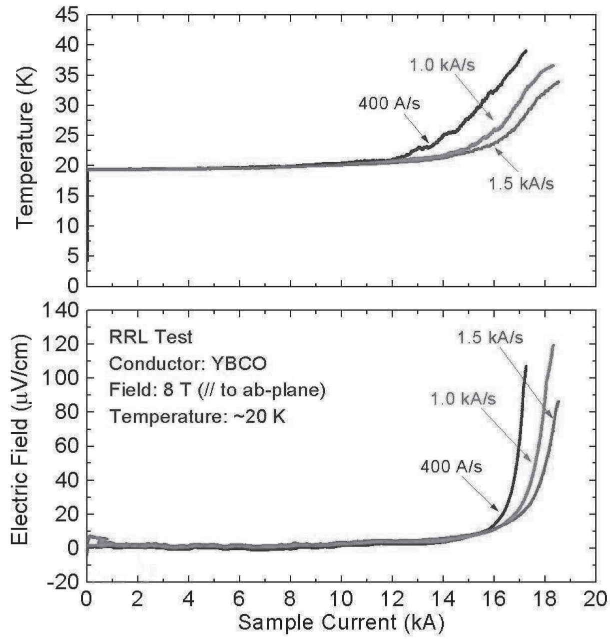

Fig 4: Temperature and electric field evolution in the conductor at different ramp rates.

[1] Bansal, G. Ph.D. thesis (Sokendai), 2008.
[2] Bansal, G. et al., this report.