RELATIONSHIPS BETWEEN CONDUCTOR DAMAGE, QUENCHING AND ELECTROMECHANICAL BEHAVIOR IN YBCO COATED CONDUCTORS

A.L. Mbaruku (NHMFL/FSU); U.P. Trociewitz (NHMFL/FSU); X. Wang (CAPS, Electrical Engineering, NHMFL/FSU); J. Schwartz (NHMFL/FSU, Mechanical Engineering, CAPS)

Introduction

Because the failure of high temperature superconductors is fundamentally different than low temperature superconductors, it is possible that a quench can appear to not cause any damage but in fact alter the electro-mechanical properties of the conductor. This work reports results on the effects of quenching on electromechanical behavior for YBCO coated conductors.

Experimental

Stress-strain, strain-I_c and fatigue-I_c tests were performed using low temperature electromechanical testing equipment [1]. The tests were conducted at 77 K on partially quench damaged and non-damaged samples. For strain-I_c measurements, the I_c was first measured in the as-cooled condition and at the onset of load. Then, the strain is increased in steps of approximately 0.015% and I_c remeasured at the end of each of step until $I_c < 7$ A. For fatigue-I_c tests, the samples were subjected to strain controlled fatigue tests with a maximum strain of 0.35% and a strain ratio of 0.5 with a 0.4 Hz loading frequency. I_c was measured after cycles 1, 10, 100 and 1000. The fatigue loading was stopped when the number of cycles reached $2x10^5$. After fatigue testing to $2x10^5$ cycles without failure, the samples were subjected to strain-I_c tests.

Results and Discussion

Partial quench damage causes degradation of mechanical properties of the superconducting tapes (Fig. 1). The cause of degradation on the properties may be the softening of the substrate during the rapid heating and cooling associated with the quench event because the mechanical properties of YBCO coated conductor depend mostly on the properties of the substrate [2]. The *n-values* for partially quench-damaged samples are less than those for non-damaged samples. Partial quench-damage causes degradation of the strain-I_c behavior of the superconducting tape as observed from the strain-I_c results. No performance degradation was observed in fatigue-I_c testing for a strain ratio of 0.5 and a 0.35% maximum strain between the damaged and non-damaged samples when tested to 2×10^5 cycles (Fig. 2). No cracks were observed in the microstructural images for the damaged samples. Transverse cracks have been observed for samples subjected to strain-I_c tests. The formation of cracks is a result of the applied strain and is the cause of I_c degradation for samples subjected to strain- I_c tests.

Conclusions

This study has observed that the mechanical properties of YBCO coated conductors are degraded by partial quench damage. The yield stress is lower compared to samples that did not experience effects of the quench. Furthermore, the strain-I_c behavior is also inferior for quench damaged sample compared to the non-damaged samples.

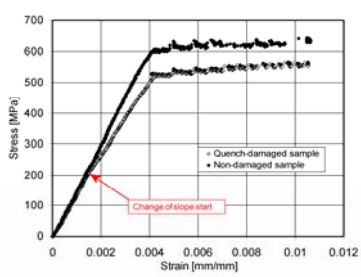

Fig. 1 Stress-strain curves for YBCO coated conductor showing results for quench damaged and non-damaged samples.

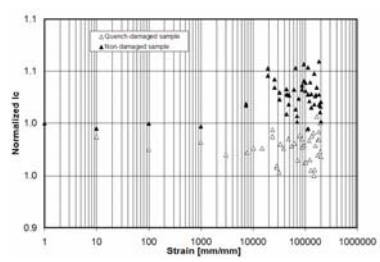

Fig. 2 Normalized I_c versus number of cycles for non-damaged and partially quench damaged samples. Fatigue testing was performed at 77 K with a maximum strain of 0.35%.

The authors thank the Air Force Office of Scientific Research for supporting this work.

[1] Mbaruku, A.L., *et al.*, IEEE Trans. Appl. Supercond., **15**, 3620-3623 (2005).
[2] Cheggour, N., *et al.*, Appl. Phys. Lett, **83**, 4223-4225 (2003).