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Electrical Performance and Materials Aspects of Bi-2212 Superconducting Fault Current Limiters

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Abstract – Bi-2212 Superconducting fault current limiters (SCFCL's) were subjected to short-circuit testing. The SCFCL's showed optimal electrical performance. However, damages occurred in SCFCL's that were tested under very stressing conditions. Samples of the damaged SCFCL's were investigated by means of XRD, SEM/EDS and T_c measurements. High fractions of textured Bi-2212 with T_c = 85-90 K have been found in the non-damaged regions of the superconducting bulk coils. Cracks and signals of hot spot formation have been observed in the damaged coils. Damaging was attributed to insufficient cooling time between short-circuit tests and to voltage levels exceeding the specified limit.

Fault Current Limiters are devices that lower short circuit currents to acceptable levels, avoiding severe damages in the electrical grid. Superconducting Fault Current Limiters (SCFCL's) are one of the most promising technologies for fault current limitation [1]. The resistive SCFCL devices are based on the fast transition from superconducting to normal state that is provoked by current values well above the critical transition current (I_c) of the superconducting material.

In the present work, four resistive SCFCL components were subjected to short-circuit testing. These components are based on bulk $Bi_2Sr_2CaCu_2O_x$ (Bi-2212) superconducting coils covered by a metallic shunt layer, in order to promote homogeneous superconductor/normal transition, avoiding the formation of hot spots. Before short-circuit testing, the components presented I_c = 278-312 A in liquid nitrogen (77K). The operational AC current (I_{rms}) for each single component is 212 A, in 77 K. Such SCFCL components limited short-circuit currents as high as 10-15 kA (peak value) down to 5-6 kA in the first half cycle (Figure 1). A single component can withstand 210 V (0.5 V/cm) for 80 ms. Highly reproducible results were attained. After short-circuit testing, Voltage vs. Current (DC) curves showed I_c close to 0 A for two SCFCL components that were purposely tested under very stressing conditions. The Bi-2212 coil of the damaged components has been investigated by means of XRD, SEM/EDS and Resistance x Temperature measurements. The non-affected regions showed high fractions of textured Bi-2212 grains with T_c = 85-90 K. Long cracks were found in one of the components (Figure 2). This was attributed to insufficient cooling time between successive short-circuit tests. The other damaged component presented burned regions due to a voltage level exceeding the specified limit during short-circuits with prospective currents within 15-20 kA.

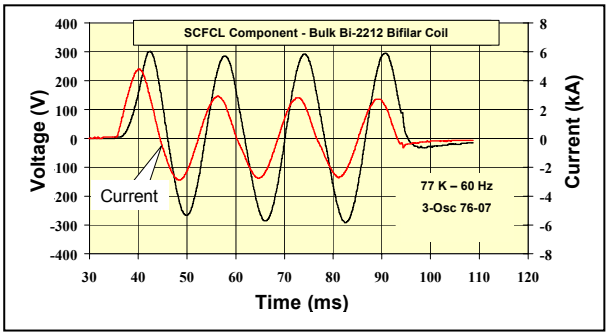

Figure 1: Fault Current Limiting test of Bi-2212 SCFCL component. Prospective current = 11 kA (peak value).

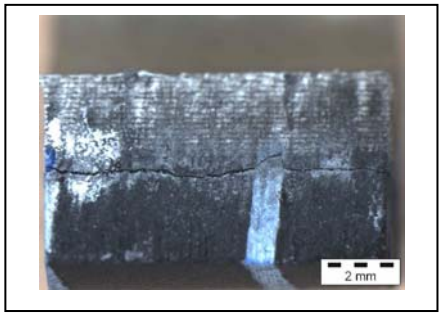

Figure 2: Longitudinal cross-section of Bi-2212 bulk coil showing crack formed by extreme condition testing.

References

[1] M. Noe and M. Steurer, Superconductor Science and Technology, 20 (2007), R15–R29.