Study of the oxygen diffusion process in commercial REBCO-based coated conductors

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The performance of $REBa_2Cu_3O_{7-x}$-based coated conductors (REBCO CCs, RE = rare earth element) has improved considerably in the last years, making them strong candidates for multiple applications like compact fusion machines, high-field dipoles for future accelerators, ultra-high-resolution NMR, motors or generators. The oxygen stoichiometry in the REBCO layer is one of the main parameters that define the superconducting properties of the CC. Multiple studies have been carried out on this topic in laboratory scale REBCO films, whilst there is not much knowledge in the case of commercial CCs, for which differences in the microstructure are expected to affect the oxygen diffusion. In this work, we introduce general aspects of the oxygen diffusion processes in REBCO films and present the results of an experimental campaign focused on the oxygenation/deoxygenation of commercial REBCO tapes in the range of temperatures 150°C–750°C. We combined X-ray diffraction, magnetization and current-transport measurements to study the evolution of the superconducting and structural properties of the CCs as a function of the heat treatment parameters. We paid special attention to the low temperature regime ($T < 250$°C), which covers also the temperature range used e.g. for soldering, where we found an early degradation of the critical current due to oxygen out-diffusion from the REBCO grain boundaries. No significant decrease of the critical temperature occurs at such low temperatures, indicating that the out-diffusion of oxygen from the grain cores starts taking place only at temperatures above 250°C. Our observations define a double-channel diffusion process for REBCO CCs, one associated with the grain boundaries, with a lower activation energy, and a second one, with a larger activation energy, related to the grains. The study sheds light on the basic mechanisms that rule the oxygenation/deoxygenation processes in coated conductors, but also provides valuable information for many practical applications.