Contribution ID: **899** Contribution code: **FRI-OR7-303-01** Type: **Oral**

Hybrid Microscopy to Clarify Failure Mechanisms of REBCO Tapes in Meter-Class Pancake-Coils

Friday 19 November 2021 10:00 (15 minutes)

It is required to improve yield of coiling for REBCO-based magnet developments, however, the conventional test method represented by the end-to-end current transport measurement of the coil could not derive detailed information such as the positions of the defects and the mechanisms for the failures. In this study, we have developed a novel method adopting hybrid microscopy integrating magnetic microscopy, scanning electron microscopy, and optical microscopy in order to track down the positions of the defects in the coil winding and followed by microstructural analyses to clarify the mechanisms of the failure in the coiling. We have succeeded in identifying defects in a part of a large-bore shielding coil (over 1 m in the inner-diameter), which is for the 1/2-size whole body REBCO MRI magnet system, and have clarified their mechanisms caused by the pancake-coil winding process. One type of the failure was caused by an insufficient mold release treatment during the impregnation in which a part of the resin was fixed on the tape surface and caused damage in the superconducting layer just under the fixed resin mark with thermal stress in the cooling. As far as the author know, this is the first direct observation that indicates the internal thermal stress due to the anisotropic thermal shrinkage in the coil becomes a cause of coil damage. The other type of the failure was originated from partial interference between the winding frame and the tape edge during winding. These findings allow us to establish appropriate measures for coiling. Namely, this novel approach can be a powerful tool as a fundamental evaluation method for improving the reliability and reproducibility of the coil.

This work was supported by JSPS KAKENHI Grant Numbers JP19H05617 and the New Energy and Industrial Technology Development Organization (NEDO).

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Session Classification: FRI-OR7-303 HTS coil II