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Mechanical property measurement - Delamination strength test for copper-plated REBCO coated conductors

力学性能测量 REBCO涂层导体（镀铜）脱层强度测试方法

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Foreword

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REBCO (RE refers to rare earth elements such as Y, Gd, Dy) coated conductors, also known as the second generation of high temperature superconducting tapes, have high irreversible magnetic fields: It has excellent current-carrying capacity under high fields and has important application prospects in superconducting magnets, superconducting cables and superconducting motors: REBCO coated conductor is a multi-layer composite material consisting of a copper stabilization layer, a silver layer, a superconducting layer, a buffer layer and a substrate layer: The conductive layer and buffer layer are ceramic materials, and the other layers are metal or alloy materials: Delamination will occur due to the effect of thermal stress: Once delamination occurs, the current carrying capacity of the material will

decrease, which will bring safety hazards to the operation of the superconducting device: Therefore, it is necessary to establish a standard test method to accurately measure the delamination strength of REBCO coated conductors: The anvil pull method is a method for testing the delamination strength of composite layered materials at room temperature and liquid nitrogen temperature, which is simple in principle and easy to implement: Therefore, this document uses the anvil pull method to test the REBCO coated conductor (copper plating) at room temperature and liquid nitrogen temperature: Delamination strength test was carried out at 3700 °C: In the process of testing the delamination strength of REBCO coated conductor (copper plating) using the anvil pull method, the fracture toughness of ceramic materials is much lower than that of gold: Metals and alloys cause delamination to occur in the superconducting layer and buffer layer; the brittleness of ceramic materials makes the delamination strength test data discrete: The data obtained cannot provide guidance for material preparation and engineering design, so special data analysis methods are needed to process the data: This paper uses the three-parameter Weibull distribution data analysis method to process the test data of delamination strength: On the basis of the fitting parameters, the delamination strength can be directly given based on the reliability criterion: The room temperature delamination strength test characterizes the delamination strength of REBCO coated conductors at the factory and serves as a reference for the delamination strength at liquid nitrogen temperature: The delamination strength test at liquid nitrogen temperature is used to characterize the delamination strength of REBCO coated conductors at low temperatures: The delamination strength can be used to evaluate the preparation process of REBCO coated conductors and serve as a basis for the design of superconducting devices using such conductors: Mechanical Properties Measurement of REBCO Coatings Conductor (copper plating) delamination strength test method

1 Scope

China's national delamination strength test for copper-plated rare earth barium copper oxide coated conductors. A second generation high temperature superconducting tape is a laminate: a metal substrate, several ceramic buffer layers, the superconducting oxide film, a silver cap and a copper stabiliser. Its weakness is exactly what that structure implies - it is strong along its length and weak through its thickness, and a stress that tries to peel the layers apart will separate them at a small fraction of the tape's tensile strength. That matters because a coil wound from the tape and then impregnated with epoxy generates exactly such a stress when it cools: the epoxy shrinks more than the tape and pulls the layers apart, which has destroyed real magnets. Measuring delamination strength is therefore a design input rather than a quality check, and it determines how a coil may be built.

This document describes the testing and data processing methods for the delamination strength of REBCO coated conductors at room temperature and liquid nitrogen temperature: This document applies to REBCO coated conductors (copper plating) with a

copper layer thickness ranging from 5 mm to 20 mm: REBCO coated conductors can be found in this document: This document does not apply to REBCO coatings that are reinforced with stainless steel or other metals or that have an outer surface coated/wrapped with insulating material: Layer conductor:

2 Normative references

The contents of the following documents constitute the essential clauses of this document through normative references in this document: For referenced documents without a date, only the version corresponding to that date applies to this document; for referenced documents without a date, the latest version (including all amendments) applies to This document:

GB/T 2900:100 Electrical terminology Superconductivity

GB/T 13634-2019 Calibration of standard dynamometers for uniaxial testing machines of metallic materials

GB/T 16825:1-2022 Inspection and calibration of static uniaxial testing machines for metallic materials Part 1: Tension and (or) compression testing Inspection and calibration of the force measuring system of the testing machine

GB/T 34987-2017 Weibull analysis

3 Terms and definitions

The terms and definitions defined in GB/T 2900:100 and the following apply to this document: 3:1 anvil In the delamination strength test, the contact area with the sample is a rectangular component connecting the sample surface and the chuck: 3:2 unionbody The anvil and the sample are welded together to form a whole: 3:

3 The tensile force at any time during the delamination strength test is divided by the contact area between the anvil and the sample: 3:

4 Delamination strength sigmad Transverse tensile stress at which the sample fails:

Note: Sample failure refers to the phenomenon of interlayer separation under the action of load, which is manifested as the load reaching the maximum value and then suddenly dropping to 0: