【Grant-in-Aid for Scientific Research (S)】

Broad Section C

Title of Project： Systematization of characterization technologies for high-temperature superconducting wires, conductors and coil windings, and their development to highly reliable magnets

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【Purpose and Background of the Research】

High temperature superconductors allows us to develop ultra-high-field magnets and superconducting applications using simple cooling systems. However, local non-uniformity of the long wire and instability of magnet winding have become obvious, and establishment of designability, stability and reliability are urgent issues.

While the superconducting wire itself has a long length of km class as a practical material, its electromagnetic performance strongly depends on how the quantized flux behavior in the mesoscopic scale can be controlled by controlling nano-sized defects (introduction of artificial pinning centers), and essentially, multi-scale control of the microstructure is required in the wire development.

The purpose of this study is to systematize characterization technologies of superconducting wires, conductors, and coils developed by the authors. Based on that, we will integrate the development of wires, conductors, and coils that have been independently developed so far, in order to dramatically improve the robustness and reduce the cost of the wires, and lead to highly reliable magnets and coiling technologies.

【Research Methods】

(1) Innovation of Characterization Technology for Superconducting Wire, Conductor and Coil: With the integration of AI technology, we will further enhance the advanced characterization method including the reel-to-reel high speed magnetic microscope shown in Fig. 1. This leads to improvement of wire uniformity and establishment of winding technology. In addition, high precision modeling of current transport characteristics will be developed as a base for conductor and magnet design method in consideration of the spatial critical current distribution of the wire.

(2) Improvement of Robustness by Proposing a New Conductor Architecture: A new conductor architecture for realizing robustness and reduction of cost is established. In parallel, a manufacturing process for making a conductor is examined, and the effectiveness of the proposed conductor architecture is verified by prototyping.

(3) Establishment of Elemental Technology for Coiling: Based on the new conductor design, electromagnetic characteristics of the coil windings are analyzed, and are evaluated using the advanced diagnostic technique developed in (1), and the coiling technique is established.

(4) Prototype Evaluation of Small Magnets: On the basis of the results mentioned above, small magnets are prototyped to demonstrate the improvement of reliability, stability and low loss of high temperature superconducting magnets.

Fig. 1 Reel-to-reel scanning Hall probe microscope.

【Expected Research Achievements and Scientific Significance】

The realization of a magnet that maximizes the potential of a high temperature superconducting wire makes it possible to use a high magnetic field and a high speed varying magnetic field, which is difficult in the conventional technology, and contributes to the development of innovative equipment and academic fields related to electrical energy applications such as high field magnets for accelerators, contactless power feeding (application to high-Q coils handling large electric power), and superconducting rotating machines (compact, light-weight, high-power).

【Publications Relevant to the Project】

・Takanobu Kiss, *OYO BUTURI (in Japanese)*, Vol. 85, No. 5, pp. 377-388, 2016.05.
・K. Higashikawa et al., *IEEE Tran. Appl. Supercond.*, Vol. 27, No. 4, 6603004, 2017.06.

【Term of Project】 FY2019-2023

【Budget Allocation】 153,800 Thousand Yen

【Homepage Address and Other Contact Information】

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