

試料搬送型の変調回転磁場印加による REBa₂Cu₃O_y 磁場配向の検討(II)

Study of magnetic alignment in REBa₂Cu₃O_y through sample-transport-based modulated rotating magnetic field application (II)

京都先端科学大・工：〇足立 伸太郎, 木村 史子, 堀井 滋

Kyoto Univ. Adv. Sci (KUAS): 〇Shintaro Adachi, Fumiko Kimura, and Shigeru Horii

E-mail: adachi.shintaro@kuas.ac.jp

To achieve high critical current densities (J_c) in both self-field and in-field conditions for high- T_c cuprate superconductors like REBa₂Cu₃O_y (RE123), it is essential to densify and orient large number of grains. Our research is focused on magnetic alignment methods to achieve biaxial grain orientation of RE123, aiming to enhance the practical application of RE123 as a superconducting wire. Since magnetic alignment does not need highly oriented templates and works at room temperature, it is useful for the enhancement of performance of functional anisotropic materials. These characteristics of magnetic alignment create new opportunities for fabricating thicker films of RE123, a goal that is challenging to achieve using epitaxial technology.

In the magnetic alignment method, the expectation is that the easy and hard axes align perpendicular to the static magnetic field and the modulated rotating magnetic field, respectively. When the grain shape is approximately spherical, the following formula can be used to estimate the required magnetic alignment time τ [1]: $\tau^{-1} = \chi_a B^2 / 6\eta\mu_0$, where χ_a is the dimensionless difference between the magnetic susceptibility along the easy axis and that perpendicular to the easy axis, B is the magnetic flux density, η is the medium viscosity, and μ_0 is the vacuum permeability. In the past, biaxial magnetic alignment of several RE123s required a superconducting magnet [2]. Recently, our group developed an original equipment that can generate a linear drive type of modulated rotating magnetic fields (LDT-MRF) using the permanent magnet arrays [3]. This magnetic alignment equipment is compact and has low (capital investment and operational) costs. Up to now, this LDT-MRF equipment had achieved a static magnetic field of 0.9 T and a rotating magnetic field of 0.8 T. Furthermore, by expanding the width of magnet arrays perpendicular to the LDT direction, we have succeeded in suppressing the tilt of the sample grains in the direction of the hard magnetization axis, thereby achieving the high degrees of orientation of each grain [4-5]. To date, such research has been carried out using batch processes, but the application of this magnetic alignment technology requires a

continuous process.

The concept of our magnetic alignment technique is illustrated in Figure 1. As shown on the left of FIG. 1, the sample (in this case, orthorhombic Dy123 grains) initially shows a random orientation, which is then magnetically aligned in bi- or tri-axial through the central LDT-MRF region. The goal of this study is to continuously extract the sample in the state shown on the right of FIG. 1. At the JSAP Autumn meeting 2024, we demonstrated that the Dy123 ($y \sim 7$) grains of high- T_c cuprate superconductors can be continuously magnetically aligned using an LDT-MRF equipment with sample-transport system [6]. However, as suggested in our report for the JSAP Autumn meeting 2024, one of the current challenges is that the first easy magnetization axis of the Dy123 ($y \sim 7$) grains follow the direction of the leakage magnetic flux lines when sample exits the LDT-MRF equipment. To maximize the J_c of Dy123 ($y \sim 7$), it is necessary to achieve the state of the linear transport direction // a -axis (or b -axis). However, there is a clear lack of understanding regarding the alignment of the magnetic flux lines in the target direction (in the case shown in FIG. 1, X // a -axis, Y // b -axis, Z // c -axis) through the linear sample-transport system (along the X direction in FIG. 1). Therefore, we will collect basic data about the degree of orientation for Dy123 grains with epoxy resin, when the samples are magnetically aligned at various transport speeds using the present magnet array and the sample-transport system of the LDT-MRF equipment. The evaluation of the magnetically aligned Dy123 sample will be performed using the (103) pole figure of the sample's bottom surface. In this presentation, we will provide details of the experimental methods and results.

References

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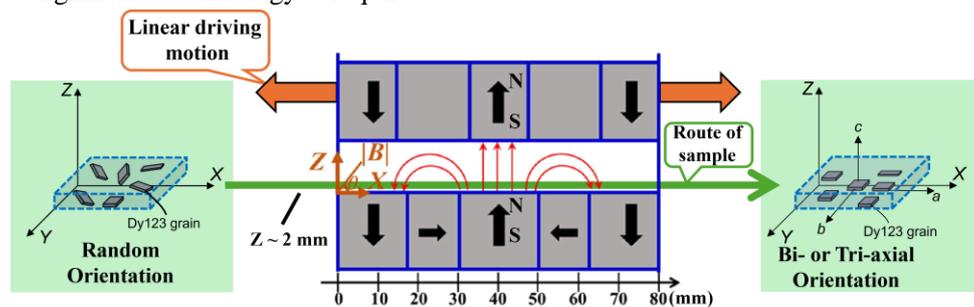


FIG. 1. Concept of the magnetic alignment system through sample-transport-based modulated rotating field.