HIGH-RATE REEL-TO-REEL CONTINUOUS COATING OF BIAXIALY
TEXTURED MAGNESIUM OXIDE THIN FILMS FOR COATED CONDUCTORS*

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High-Rate Reel-to-Reel Continuous Coating of Biaxially Textured Magnesium Oxide Thin Films for Coated Conductors*

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Biaxially textured thin films of magnesium oxide (MgO) were deposited by electron beam evaporation at deposition rates of 0.6 $\mu\text{m}/\text{min}$ on moving Ni-based alloy tapes as oriented buffer layers for coated conductors. Moving substrates were inclined with respect to the atomic vapor and translated through collimated dual vapor sources. Growth anisotropy in the MgO and self-shadowing effects due to the inclined angle combine to create biaxial texture in the deposited thin films. MgO films grown to a thickness of 2.0 μm with this inclined-substrate deposition technique have yielded in-plane textures of 10-12° full-width half-maximum (FWHM). Results of a parametric study on the in-plane texture in short-length static-mode samples are presented, along with preliminary results of long-length samples deposited under translating conditions.

1. Introduction

The next-generation wire technology based on high-temperature superconductors requires a biaxially textured template layer on to which the superconductor will be coated. These template layers will need to be lattice-matched, chemically compatible, and economically feasible for lengths up to a 1 km. A major hurdle to date in bringing these wires to market has been the slow deposition rate and/or complex deposition geometry needed to deposit biaxially textured template layers.

This study investigates the processing dependence of texture development in magnesium oxide (MgO) films deposited by inclined substrate deposition (ISD) in order to optimize the deposition parameters required for continuous coating. ISD of MgO has been proven effective in creating short-length biaxially textured YBCO coated conductors.[1] Half-meter biaxially textured magnesium oxide has been deposited by using a collimated-flux inclined substrate deposition (CF-ISD) geometry with feed rates of 6.1 cm/min.

The texture in the MgO thin films was evaluated with four-circle x-ray diffraction and selected area electron diffraction (SAED). Growth morphology and structure was investigated by transmission electron microscopy (TEM).

2. Experimental Method

Long-length Hastelloy-C tapes were ultrasonically cleaned in acetone and methanol prior to loading in a reel-to-reel continuous deposition system. The reel-to-reel system was designed to allow simultaneous deposition on two tapes. The feed mechanism and take-up reel were designed to put the as-coated MgO tape in compression with < 5% strain. The tapes were inclined with respect to the atomic vapor at 40° from the substrate normal. The atomic vapor was created with a dual electron beam evaporation system. Evaporation was conducted in two zones; each containing a group of collimators that restricted the angular variance of the atomic flux to < 10°. The feed rate through the two collimated deposition zones was adjusted such that MgO was deposited to a thickness of 1.0 μm in a single pass. The deposition rate for continuous coating was 0.6 $\mu\text{m}/\text{min}$.

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3. Results and Discussion

Cross-sectional TEM coupled with selected area diffraction allowed the investigation of texture development in ISD-MgO as a function of thickness through static samples (see Fig. 1). From intensity-versus-thickness plots of dark-field photomicrographs, the coalescence zone of MgO into textured films occurs at ≈ 900 nm. In-plane texture of the MgO on static samples exhibits little dependence on the deposition rate as shown in fig. 2. Deposition on static samples also shows that in-plane texture improves with an increase in sample inclination with respect to the vapor source; this in turn inclines the (200) face, which grows toward the vapor (see Fig. 3).

Figure 1: TEM photomicrograph of a static sample on Si with SAED patterns at various film thicknesses.

The average in-plane FWHM of a 0.5-m tape deposited under continuous conditions as measured from pole figures was 24.4° . This value is the average FWHM measured from 10 positions along the tapes approximately every 5 cm. The standard deviation of the FWHM was 1.05° with the best value equal to 23.0° ; the highest FWHM was 26.1° . These values are slightly larger than expected from the use of 10° collimators, however the measured FWHM are from films that are considerably thinner than the static samples and the surface texture is expected to be much sharper than the "bulk" value. Work in progress is addressing this issue by evaluating these layers with a thick homoepitaxial layer to confirm the quality of the texture surface of the CF-ISD MgO films.

Figure 2: In-plane texture of ISD-MgO vs. deposition rate for $2.5 \mu\text{m}$ thick films.

Figure 3: In-plane FWHM and (200) face orientation of ISD-MgO vs. substrate inclination angle in static samples ($2.5 \mu\text{m}$ thick).

4. Conclusions

Biaxially textured MgO template layers were deposited on continuously moving Hastelloy-C tapes to a length of 0.5 m by using a collimated-flux inclined substrate deposition (CF-ISD) system. The feed rate of the tapes was 6.1 cm/min over a total deposition zone of 10 cm. The resultant in-plane texture averaged 24.4° FWHM as measured from phi scans of the (220) reflection at 5-cm intervals.

Reference

1. M. Bauer, R. Semerad, and H. Kinder, IEEE Trans. on Appl. Supercond., Vol. 9, No. 2, pp. 1502-1505 (1999)