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High-Performance $DyBa_2Cu_3O_{7-x}$ Superconducting Coated Conductors Grown by Inclined Substrate Deposition with I_c Exceeding 1000 A cm^{-1}

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Coated conductor (CC) technology is based on thin film technology. While a high critical current (~ 1000 A cm^{-1}) has been achieved for short samples, the long length CCs technology is still in the development phase. The key requirement of long length CCs technology is to deposit a biaxially textured (almost single crystalline) superconducting thin film on a polycrystalline substrate over kilometres of length. The biaxial texturing of the superconducting film helps to reduce the number of weak-links, large angle grain boundaries that are known to limit current transport.

DyBCO films of varying thickness (0.3-6 μm) were grown on biaxially-textured MgO buffer layers deposited on Hastelloy substrates, typical critical current densities (j_c) were 1.7-2.1 MA cm^{-2} at 77 K in self-field, yielding critical currents exceeding 1000 Acm^{-1} for 6 μm thick DyBCO films.

Usually, full-area mechanical thinning and polishing followed by Ar ion milling or Focused Ion Beam (FIB) preparation are the techniques employed to prepare TEM specimens of thin films. However, TEM specimen preparation of ISD based CCs is challenging primarily because of two reasons: (1) the Hastelloy substrate is only 100 μm thick, (2) the DyBCO film is under compressive stress due to a large lattice mismatch (8.5 %) between MgO and DyBCO. It was found that the film starts bending towards the substrate side as it got thinned due to the compressive stresses present in the DyBCO film. As a consequence, the incidence angle of Ar ions increased and the DyBCO film was preferentially etched. An improved sample preparation techniques for CC will be explained in detail.

MgO films grown by ISD technology (Fig. 1a) revealed a roof-tile surface (Fig. 1b), which provides a regularly faceted surface for the DyBCO film, as could be seen at the MgO-DyBCO interface (Fig. 1c). The MgO buffer layer itself grew in a columnar structure (Fig. 1c).

Samples were analyzed by Transmission Electron Microscopy (TEM) in cross-section. The MgO facets were about 170 nm in size, smooth, planar and were lying on the MgO {200} planes (Fig. 2a). The c-axis of the DyBCO film tilted away from the substrate normal such that it was perpendicular to the MgO (002) facets (Fig. 2b). Despite the large (8.5 %) lattice mismatch, DyBCO grew epitaxially on the MgO buffer layer with a good biaxial texturing; a spread of ~ 4° in the (001) reflections (Fig. 2c) and ~ 6° in the (110) reflections were observed [2]. No misoriented grains were observed even not at the top part of the 6 μm thick DyBCO film [1]. This is a major advantage of ISD technology as compared to other technologies, e.g. RABiTS or IBAD, for which a-axis grains are observed in thicker films.

The DyBCO grain size was about 250-650 nm. A high dislocation density of about 7.4×10^{11} cm^{-2} and stacking faults along the ab-plane were observed in the DyBCO (Fig. 2b). A detailed analysis of the microstructural parameters will be summarized. Volume and surface energies of the DyBCO films were calculated from microstructural data and help to understand the observed growth behavior. A growth model for the DyBCO film growth is discussed.

References
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[3] We thank Dr. Bauer, Dr. Semerad, and Dr. Prusseit of THEVA Dünnschichttechnik for contributing high-quality coated conductor samples. The authors gratefully acknowledge financial support by the Bundesministerium für Wirtschaft und Technologie, the project HIGHWAY, FK 0327489C.

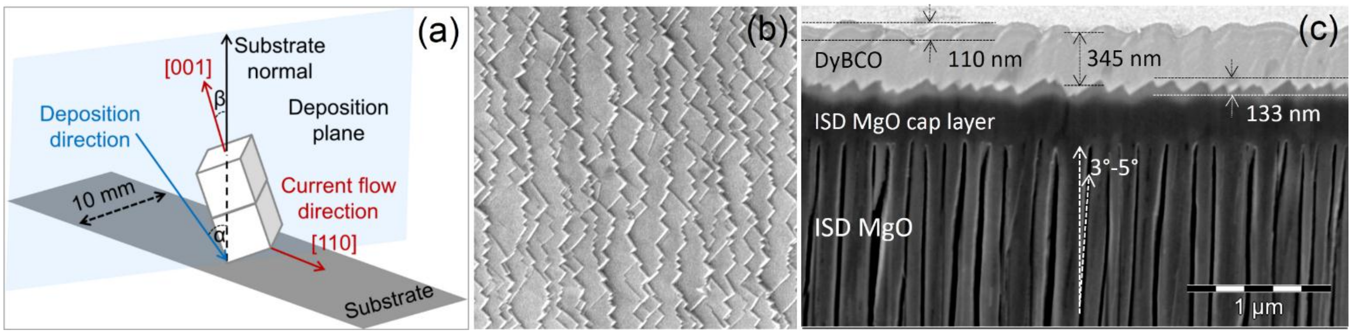

Figure 1. (a) Schematic of the ISD growth and secondary electron image of (b) the MgO buffer layer top surface, (c) the ISD deposited DyBCO coated conductor in cross-section.

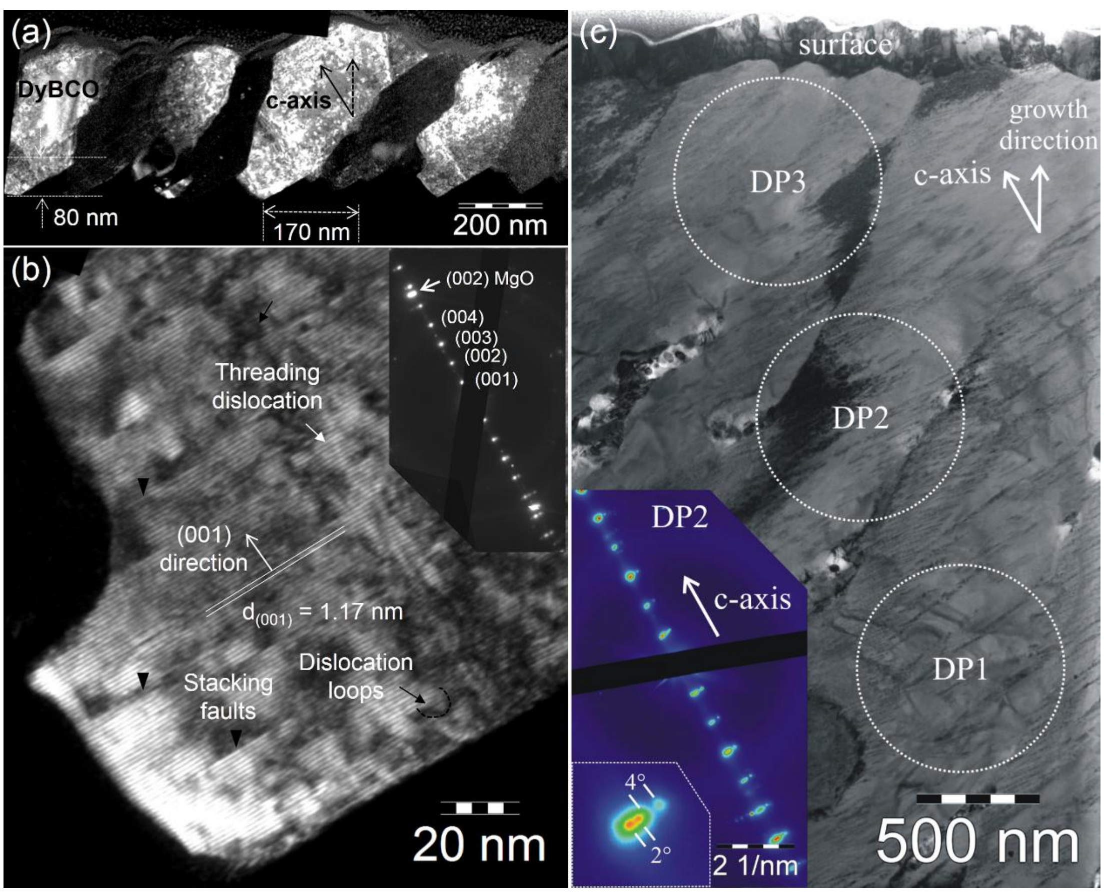

Figure 2. TEM diffraction contrast (001) dark-field images of thin DyBCO film (a) at low-magnification and (b) at high-magnification. (c) A low-magnification bright-field image of thick DyBCO film. All images were obtained in cross-section and insets show selected area diffraction pattern of the respective films.

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