SOLUTION DEPOSITION APPROACHES TO COATED CONDUCTOR FABRICATION ON BIAXIALLY TEXTURED Ni-W ALLOY SUBSTRATES.

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ABSTRACT

Sol-gel processing of $La_2Zr_2O_7$ (LZO) was used to process buffer layers on biaxially textured Ni-3 at.%W substrates. A reel-to-reel continuous dip-coating unit was used to deposit the solution buffers. Epitaxial LZO films have been obtained through continuous processing on Ni-3 at.%W substrates with strong texture and uniform microstructure. The carbon content in these films were analyzed using proton resonance Rutherford Backscattering (RBS). The process parameters have been modified so as to study the effect of the carbon content in these films towards further growth of YBCO films with better properties. The LZO buffers were used as seed layers for RABiTS with the architecture of CeO2/YSZ/LZO/Ni-3 at.%W, and YBCO films with critical current density (J_c) of 1.9 MA/cm^2 at 77K in self-field, and a J_c of 0.34 MA/cm^2 at 0.5 T, have been obtained.

INTRODUCTION

Chemical solution deposition techniques have evolved as a viable, low-cost, non-vacuum process for fabrication of long lengths of coated conductors [1-3]. Flexible metal substrates with biaxial texture offer an ideal template for these solution processes. Typically, this process involves deposition of the substrates with a metallorganic precursor solution at room temperature followed by a high temperature annealing to obtain highly crystalline phases. This process offers precise control on composition and stoichiometry and can yield uniform homogeneous films [4]. In this work, we report successful growth of epitaxial $La_2Zr_2O_7$ (LZO) buffer layers on textured Ni-3 at.%W (100) substrates using continuous reel-to-reel dip coating process, and the application of these solution seed layers to process coated conductors with high critical current density (J_c). The effect of some of the process parameters on microstructure and properties will be discussed.

EXPERIMENTAL PROCEDURE

Stoichiometric quantities of lanthanum isopropoxide and zirconium-n-propoxide were dissolved in 2-methoxyethanol and refluxed in a Schlenk-type apparatus to obtain a starting solution with 0.25 M cation concentration. The Ni-W alloy substrates were prepared by cleaning the as-rolled alloy in isopropanol by sonication for 1 h, followed by a recrystallization anneal at 1300°C for 1h in Ar/H_2 (4%) atmosphere to obtain cube-textured (100) Ni-W substrates. The substrates were coated with LZO film using a reel-to-reel continuous dip coating unit. The details of the reel-to-reel dip-coating unit were discussed earlier [4]. The processing temperature was maintained at 1100°C while the coating speed, annealing speed and the process atmosphere were varied, and their influence on the microstructure and properties of the film were studied. The LZO layers were characterized using X-ray diffraction (XRD) for phase purity and texture, scanning electron microscopy

(SEM) for homogeneity and microstructure, and Rutherford Backscattering (RBS) for composition and carbon analysis.

Using r.f. magnetron sputtering, a 200 nm thick YSZ layer and 10 nm thick CeO_2 layer were deposited on the LZO seeded Ni-W substrates at 780°C in 10mTorr of Ar/H_2 (4%) gas. The plasma power was 75W at 13.56 MHz. The YBCO deposited using pulsed laser deposition (PLD) at 790°C in 120mTorr oxygen with average laser energy of 400-410mJ. Resistivity and transport critical current density, J_c, were measured using a standard four-point probe technique.

RESULTS AND DISCUSSION

Four coating speeds, namely, 20cm/h, 80cm/h, 300cm/h, and 1000cm/h were used to deposit films of various thickness, and four annealing speeds, namely 10cm/h, 30cm/h, 40cm/h and 60cm/h were used to process samples at various rates. It was found that coating and annealing conditions made little difference in the phase purity and texture of these films. Typical XRD pattern and ω- and ϕ scans (of a sample processed with a coating speed of 80cm/h and an annealing speed of 10cm/h) are shown in fig.1. The full width at half maximum (FWHM) values of the Ni-W (002) and LZO (004) were 5.9 and 6.5, and those of Ni-W (111) and LZO (222) were 7.6 and 7.8 respectively.

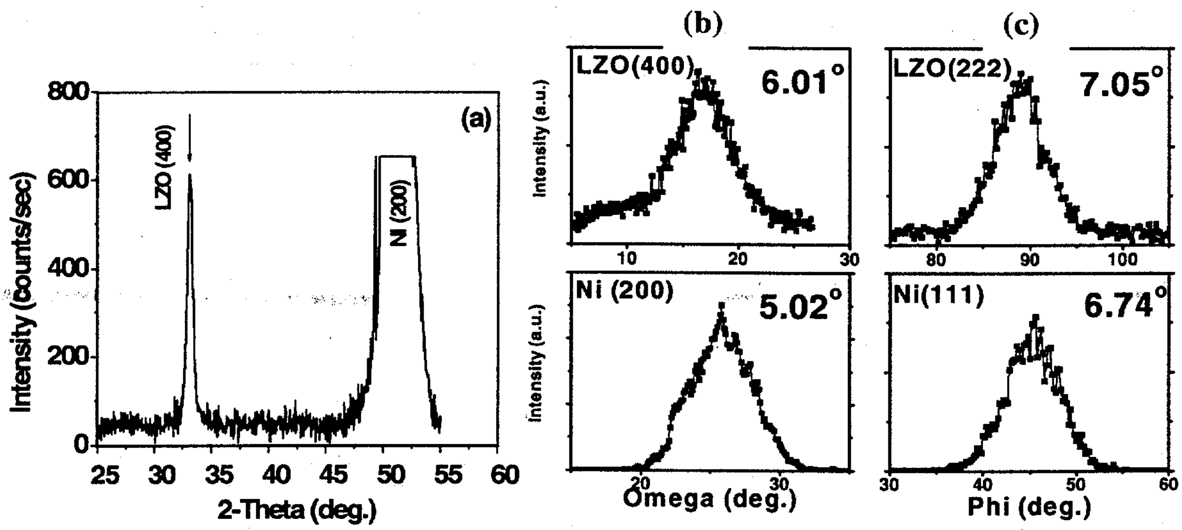

Fig.1. Typical (a) θ-2θ, (b) ω–, and (c) ϕ- scans for a 20 nm thick dip-coated LZO seed layer on textured Ni-W (100) substrate.

The thickness of the seed layers and the carbon content were analyzed using RBS. It was found that the thickness of the LZO film varied as a function of coating speed from 10 nm at 20cm/h coating speed to 80 nm at 1000cm/h coating speed. The carbon content varied with both the coating and annealing speeds. Thicker films processed at 300cm/h and 1000cm/h had significant amounts of carbon. Also, a systematic increase in carbon content with increase in annealing speed was observed. However, within these experimental parameters, the retained carbon did not have any deleterious effect on the deposition of subsequent layers.

Microstructure of the LZO seed layers observed under high resolution SEM is shown in fig.2. The dip coated seed layers are smooth, continuous, crack-free, and fine-grained. On the LZO seed layers, YSZ, CeO_2, and YBCO films were grown. Detailed XRD studies indicate good in-plane and out-of-plane texture for the various layers. The field dependence of

J_c of one of these films is shown in fig.3. The zero field I_c measured was 37.6A/cm-width which translates to a J_c of 1.9 MA /cm^2 at 77K. The J_c at 0.5 T was 0.34 MA/cm^2 at 77K. This shows the presence of good flux pinning in the YBCO film. The current transport properties of the YBCO films did not show a systematic trend with the seed layer process parameters.

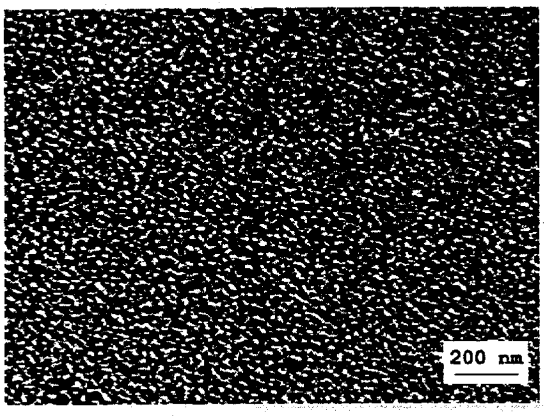

Fig.2 SEM micrograph of 25 nm thick LZO seed layer on biaxially textured Ni-W (100) substrate.

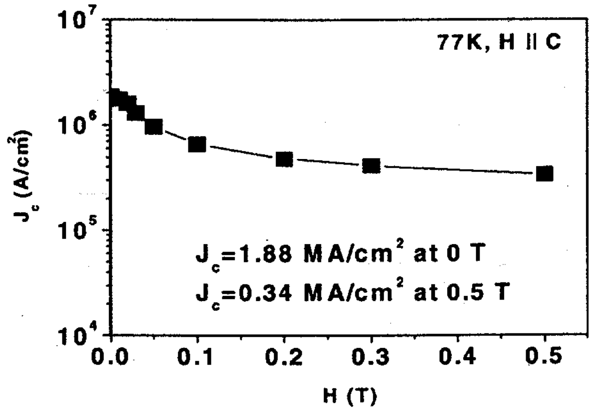

Fig.3 Field dependence of J_c for a 0.2μm thick YBCO film on CeO_2 (sputtered)/YSZ (sputtered)/ LZO (dip-coated)/ Ni-W substrates.

SUMMARY

We have demonstrated that epitaxial LZO buffer layers can be grown on biaxially textured Ni-W (100) substrates using a continuous reel-to-reel dip-coating unit. These buffer layers have a dense, crack-free microstructure. Using these LZO dip-coated layers as seed layers we have produced high-quality YBCO films with a zero field Jc of 1.88 MA/cm2 at 77K with a layer sequence of YBCO (PLD)/ CeO2 (sputtered)/ YSZ (sputtered)/ LZO (dip-coated)/ Ni-W.

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