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Fabrication of YBCO coated conductors using magnetron sputtering

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Epitaxial $YBa_2Cu_3O_{7-x}$ (YBCO) superconducting films have been obtained on the rolling assisted biaxially textured Ni substrates (RABiTS). To prevent the interaction between YBCO and metallic substrate CeO_2 and YSZ films were employed as the diffusion buffers. The full width at half maximum (FWHM) of the ϕ-scan of CeO_2 (220) is 11° whereas that of YSZ (220) is 15°, showing a good in-plane orientation. On such YSZ/CeO_2 buffered Ni substrates YBCO films were epitaxially grown by using cylinder target in a dc magnetron sputtering system. At 77 K a transport critical current density J_{ct} as high as 6×10^5 A/cm^2 was obtained. The microstructure and crystallinity of these films were characterized by scanning electron microscopy (SEM), Auger electron spectrum (AES), and x-ray diffraction (XRD).

1. INTRODUCTION

High temperature superconducting (HTS) tapes have attracted lots of research interests due to their importance in many industrial applications. Recent research interests are mainly concentrated at biaxially textured YBCO thick films on metallic tapes [1-2]. These YBCO-based tapes offer prospects for operation both at high temperature and in substantial magnetic fields. Various metallic materials, like Ni and Ag, have been used as the substrates. In this paper we presented our results on fabricating epitaxial YBCO films on the cube-textured Ni substrates by magnetron sputtering. To block the interaction between YBCO and Ni substrate, epitaxial buffer layers of YSZ/CeO_2 were made between the grown YBCO and Ni. Good superconductivity and high current carrying capacity was obtained in these films.

2. EXPERIMENTAL

The (100)[001] cube-textured Ni substrates were prepared by a standard cold-rolling process followed by recrystallization thermal treatment. After polishing and annealing the Ni tapes, the YSZ/CeO_2 buffer layers and the YBCO film were deposited by radiofrequency (rf) and dc magnetron sputtering, respectively. The deposition details can be found in Ref. [3]. All the films were analyzed by XRD, AES, and SEM. Electrical properties of the YBCO film were measured by standard four-probe method with the criterion of 1 μV/cm.

3. RESULTS AND DISCUSSION

The interaction between YBCO and metallic substrate presents a difficulty in fabrication of high quality superconducting tapes. In our work a bi-layer buffer YSZ/CeO_2 was utilized to efficiently block the diffusion of Ni. The main reason to employ a CeO_2 layer directly on Ni is that the formation of NiO could be suppressed during the growth of CeO_2 film. A mixture of Ar and H_2 were used as the sputtering gas to prepare CeO_2 layer. However, the CeO_2 layer often presents poor surface (see Fig. 1a). To improve the surface morphology and to enhance the epitaxy of YBCO film, a thin YSZ layer was grown on CeO_2/Ni. Fig. 1b is the SEM photo of the surface morphology of the YSZ film. We could not observe any pinhole or microcrack in the YSZ film. The film became much flat and smooth. The interdiffusion through all layers in our samples was studied by using AES analysis. Fig. 2 shows a typical Auger electron depth profile of the YBCO/YSZ/CeO_2/Ni films. The platform of every element in the YBCO layer displays that the composition is uniform along the depth. It can be seen that at the CeO_2/Ni interface a considerable interdiffusion of Ni and Ce took place. In contrast,

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Figure 1. SEM micrographs of the typical surface morphology of (a) the CeO_2 and (b) the YSZ buffer layers.

the YBCO/YSZ and YSZ/CeO_2 interfaces were clear, suggesting that extensive diffusion of Ni through the buffer layer microstructure did not occur. In particular, the interface between YBCO and YSZ was well defined. It ensures highly epitaxial growth and good quality of the superconducting films.

The epitaxy and in-plane orientation of the buffer layers and YBCO film were examined by XRD. The FWHM of ϕ–scan for CeO_2 (220) and YSZ (220) are 11° and 15°, respectively, indicating good in-plane orientation. The rocking curve FWHM of the YBCO (005) peak was found being less than 4.7°, demonstrating the improved epitaxy by using the YSZ layer.

By using the YSZ/CeO_2 bi-layer buffer, high quality epitaxial YBCO films have been fabricated. These films showed very good superconductivity as reflected by the high transition temperature and current carrying capacity. Most of our samples showed a full superconducting transition above 85 K. At 77 K the J_{ct} value can reach 6×10^5 A/cm^2, which is comparable to the best results reported by other groups so far. These superior properties make such tapes being very promising for various applications.

4. CONCLUSION

By using YSZ/CeO_2 bi-layer buffer epitaxial YBCO films with good superconductivity have been made on the cube-textured Ni substrate by magnetron sputtering method. The buffer layers as well as YBCO films were well c-axis oriented and in-plane aligned. The FWHM of the rocking curve for YBCO (005) is 4.7°. AES analysis indicated that the buffer layers effectively prevented the oxidation

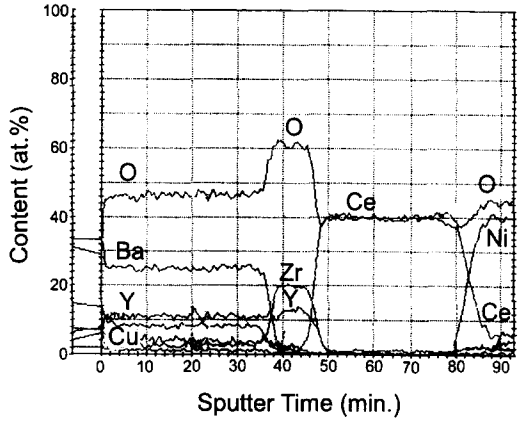

Figure 2. Auger electron depth profile of the YBCO/YSZ/CeO_2/Ni.

of Ni substrate surface and interdiffusion between substrate and YBCO film. High values of the transition temperatures > 85 K and the transport J_c (77 K, 0 T) excess 6×10^5 A/cm^2 underline the good quality of our YBCO tapes made on Ni substrates.

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