PLD법을 이용한 Ni과 NiW 기판위에 $CeO_2/YSZ/Y_2O_3$ 완충층 증착

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Deposition of $CeO_2/YSZ/Y_2O_3$ buffer layers on Ni and NiW substrate by PLD

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Abstract - Multiple $CeO_2/YSZ/Y_2O_3$ buffer layers, and subsequent YBCO films were deposited on the biaxially textured pure Ni and Ni + 3at%W substrates using pulsed laser deposition. The deposition conditions of buffer layers on Ni and NiW were studied and compared. Good biaxial textures of buffer layers have been obtained on both substrates. The Jc's of YBCO films on these metal substrates were greater than $1\times10^6 A/cm^2$ at 77K, 0T..

1. Introduction

YBCO deposition on rolling assisted biaxially textured substrates (RABiTS) is a major process to fabricate a coated conductor[1,2]. The use of Ni-W alloy (NiW) as biaxially textured substrate has been a recent improvement in the development of RABiST method[3]. These substrates shows a sharper biaxial texture over earlier pure Ni tapes. A successful architecture for buffer layers is $CeO_2/YSZ/CeO_2$ on biaxially textured Ni tapes. The use of a seed layer of Y_2O_3 instead of CeO_2 as in earlier RABiST is the another upgrade of the RABiST method because CeO_2 layer has cracks due to volume changes, which makes the CeO_2 seed layer can not successfully prevent the oxidation of Ni and obstruct the reaction of Ni and YBCO film during the subsequent processing of the other layers within the coated conductor stack. On the other hand, Y_2O_3 does not have serious crack problem even in relatively thick layers[4]. In this paper, the buffer layers with the architecture of $CeO_2/YSZ/Y_2O_3$ were prepared by pulsed laser deposition (PLD), and the deposition conditions on pure Ni and Ni + 3at%W substrates were studied.

2. Experimental

All buffer layers and YBCO film were prepared by PLD. The stoichiometric Y_2O_3, YSZ, CeO_2 and YBCO ceramic targets of 2 inch diameter was ablated by an exicmer KrF pulsed laser (LPX220i with wavelength 248nm from Lambda Physik). The biaxially textured Ni and NiW substrates with the size of about $3\times10mm^2$ were attached with a silver paste on the target holder (also the heater) which was directly facing the target. The deposition temperature was measured by a thermocouple located in the heater block.

The particulars of the deposition system were: fixed laser beam at an angle of 60° to the normal of target; target-substrate distance 65mm; target rotation 25rpm; background pressure $1x10^{-6}$Torr. The deposition conditions were: laser repetition rate 3~20Hz; the size of the laser spot on target ~ 5×1mm^2 and the pulsed laser energy density on the target ~ 2 J/cm^2.

The X-ray diffraction system of D8 DISCOVER with GADDS (general area detector diffraction solution) from Bruker was used to analyze the orientation of films. XRD θ-2θ scan, ω-scan and ϕ-scan have been done with sample oscillation using a 1/4-circle Eulerian cradle xyz stage.

3. Result and Discussion

The in-plane and out of plane texture of Ni and NiW substrates were determined by the FWHM of ϕ-scan (Δϕ) and ω-scan (Δω). The Ni + 3at%W substrates possesses a sharper biaxial texture with in-plane and out-of-plane textures of = 7~9° and = 7~8° as compared with = 9~10° and = 8~9° of the Ni substrates.

During the heating, oxidation of the substrate was prevented by the presence of flowing 200mTorr Ar + 4% H_2 reducing gas. The CeO_2/YSZ/Y_2O_3 buffer layer was prepared by PLD without breaking the vacuum cycle. The deposition condition of the first Y_2O_3 layer on pure Ni and NiW substrates was different. For pure Ni substrate, a thin Y_2O_3 (~5nm) was deposited as seed layer at 650°C, 200mTorr Ar + 4% H_2 forming gas with 5Hz, 200mJ/pulse laser energy, then continuously deposited at 650°C, 0.1mTorr O_2 with 10Hz, 200mJ/pulse laser energy until 150nm thickness. For NiW substrate, the 5nm Y_2O_3 could not block the oxidation of NiW substrate, and the YBCO film finally deposited was not continuous and had many broken bubbles. The Y_2O_3 layer with good surface on NiW was deposited at 650°C, 200mTorr Ar + 4% H_2 forming gas from the beginning to the end.

The YSZ with the thickness of 250nm was deposited at 760~780°C, 0.1mTorr O_2 with 20Hz, 200mJ/pulse laser energy. Then the CeO_2 layer with the thickness of 5nm, as cap layer, was deposited at the same temperature as YSZ, 0.1mTorr O_2 with 3Hz, 200mJ/pulse laser energy The vacuum was broken for target change to deposit YBCO film. During deposition the heater temperature was 760 - 780°C, and the oxygen pressure in the chamber was 200mTorr. Following deposition, the YBCO film was quickly cooled to 550°C under deposition pressure, and then kept for 20 min. under oxygen pressure of 500 Torr.

Fig 1. shows the XRD θ-2θ scans for YBCO/CeO_2/YSZ/Y_2O_3/Ni and NiW. From the substrates to the YBCO film, all layers have only (00L) peaks in θ-2θ pattern. After the Y_2O_3 seed layer deposited epitaxially in reducing das, the small NiO(111) peak og the plot b in Fig. 1. was formed and increased during the YBCO deposition. XRD ω-scan and ϕ-scan were used to examine the orientation of YBCO films.

Table 1. gives the FWHM values of the ϕ-scan (Δϕ) and ω-scan (Δω), which shows the texture quality of the substrate and each layer for NiW substrate is better than the counterpart of Ni substrate.

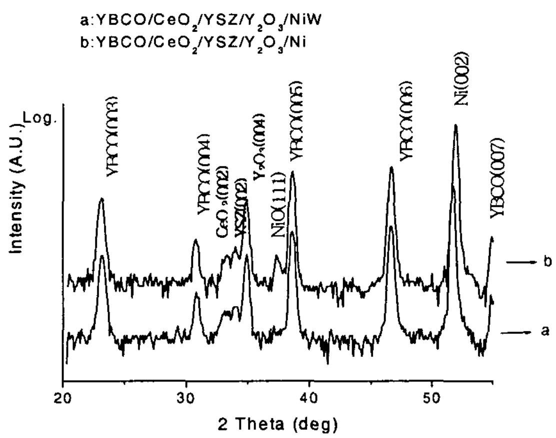

Fig. 1. XRD θ-2θ scans of YBCO/CeO_2/YSZ/Y_2O_3 on Ni and NiW substrate

Table 1. The summary of the biaxial texture

Materials	Δϕ(°)		Δω(°)	
	Ni	NiW	Ni	NiW
YBCO	9.9	9.1	8.2	8.1
CeO_2	8.1	7.2	7.8	7.8
YSZ	10	8.6	10.3	8.6
Y_2O_3	11.4	6.9	10.5	7.4
Substrate	9.2	7.7	8.9	7.4

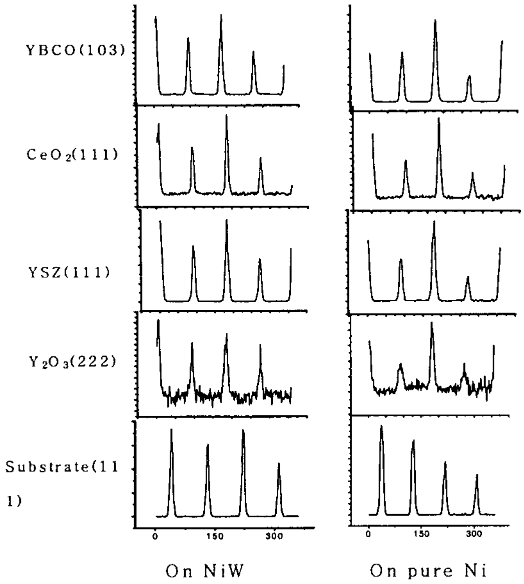

Fig. 2. XRD Φ-scans of $YBCO/CeO_2/YSZ/Y_2O_3$ on Ni and NiW substrates

Fig 2. shows the XRD -scans of the substrates, buffer layers and YBCO films.

The Tc of YBCO films on Ni and NiW was about 86~89K and the Jc was greater than $1\times10^6 A/cm^2$ (77K, 0T) which was obtained from the four-point probe measurements of Ic conducted at 77K in self-field without patterning. In most cases, the Jc of the sample on NiW is larger than that on Ni, which was correlated with the texture quality of substrate and buffer layers.

3. Summary

The biaxially textured buffer layers of $CeO_2/YSZ/Y_2O_3$ have been deposited on both Ni and NiW substrates by PLD. The difference of deposition conditions between Ni and NiW mainly existed at the Y_2O_3 deposition. For the pure Ni substrate, the Y_2O_3 layer was deposited in two steps with different ambience. In the contrast, the whole Y_2O_3 layer on NiW substrate was deposited at Ar + 4%H_2 forming gas, which probably means the oxidation of NiW is easier than pure Ni. The biaxial texture of NiW was better than pure Ni, which led to the better biaxial texture and superconducting properties of YBCO film on NiW than that on pure Ni.

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