

## Nanostructural Characterization of $Gd_2Zr_2O_7/MgO$ Multilayer Formed by Ion-Beam-Assisted Deposition

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$ReBa_2Cu_3O_{7-x}$  (Re123, Re; Y or rare earth) coated conductors on metallic substrates have been developed that are more than 500m long. Biaxially and highly oriented textured template systems are essential to fabricate such coated conductors on metallic tapes. In addition, these template materials need to suppress chemical reactions and have a small lattice misfit relative to Re123.  $CeO_2/Gd_2Zr_2O_7$  (GZO) system has been used in Japan as such template systems to develop these Re123 coated conductor [1-3]. Even though GZO was directly formed on non-textured metallic alloy substrates by ion-beam-assisted deposition (IBAD), it takes much long time and costs to achieve a GZO layer with a sufficiently oriented texture due to the low deposition rate of IBAD-GZO. MgO layers deposited by IBAD have been developed to reduce production cost of the template system[4,5]. Using IBAD-MgO as an underlying layer for IBAD-GZO, we expect a thinner GZO layer with a sufficiently oriented texture compared with IBAD-GZO directly formed on the metallic alloy. In this study, we characterized the nanostructures of a GZO/MgO multilayer fabricated by IBAD using transmission electron microscopy (TEM) in detail.

A seed  $Y_2O_3$  layer was deposited on Hastelloy tape by pulsed-laser deposition and an MgO layer was fabricated on the seed layer by IBAD. Then, a  $Gd_2Zr_2O_7$  (GZO) layer was formed on the MgO by IBAD. This GZO/MgO/ $Y_2O_3$  layer was thinned using a focused ion beam and a standard ion milling to obtain the specimen for TEM.

The thicknesses of the GZO, MgO and  $Y_2O_3$  layers are about 250nm, 35nm and 10nm, respectively, as shown in Fig. 1. Selected area diffraction pattern in Fig. 2 indicates that the MgO layer is aligned in the [111] and the GZO grains are aligned in the [111] and the [001] perpendicular to the substrate. High resolution image in Fig. 3 indicates that the [111] oriented GZO grain is formed on the MgO layer. Dark-field image of the GZO/MgO multilayer under the (004) of GZO condition is shown in Fig. 4. The GZO layer is well aligned in the [001] beyond about 150nm in thickness from the MgO interface. These results indicate the orientation of the GZO is strongly affected by that of the underlying MgO layer in the initial stage of the formation of the GZO layer, As the GZO layer becomes thicker, it gradually becomes aligned in the [001] direction. The  $\Delta\phi$  value of the GZO, measured by X-ray pole figure, was 13.2 degrees. In the case of direct formation of IBAD-GZO on Hastelloy, a thicker GZO layer (about 800nm) needs be used to achieve the  $\Delta\phi$  values of less than 10-15 degrees as shown in Fig 5. Since the deposition rate of the IBAD-GZO is quite low, we expect both high rates of and low production costs of IBAD-GZO layer having sufficient orientated texture using IBAD-MgO/ $Y_2O_3$  layers.

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References

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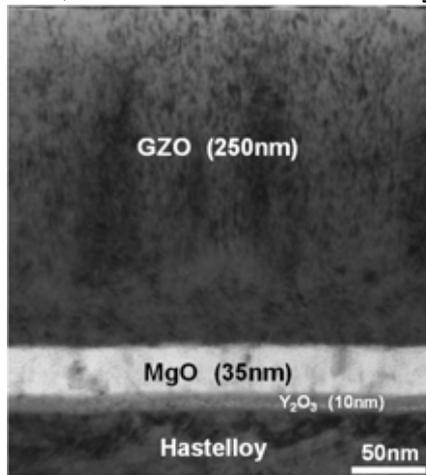


Fig.1 Cross-sectional TEM image of GZO/MgO/Y<sub>2</sub>O<sub>3</sub> on Hastelloy.

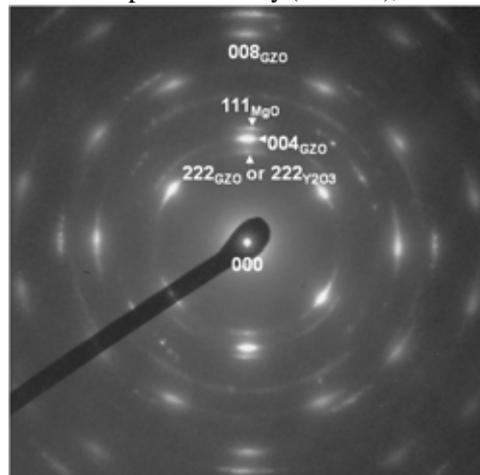


Fig.2 SADP from the GZO/MgO/Y<sub>2</sub>O<sub>3</sub>.

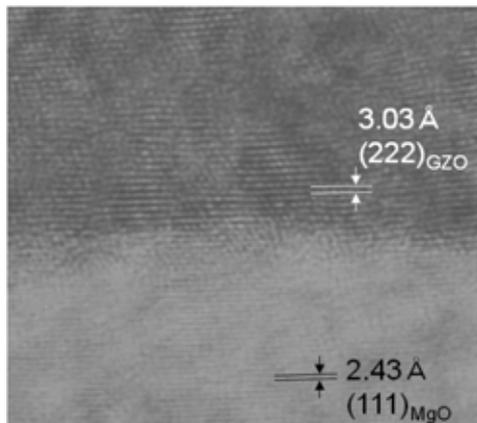


Fig.3 HREM of the GZO/MgO interface.

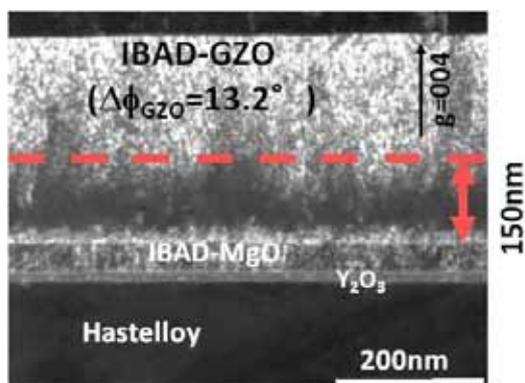


Fig.4 Dark-field image of the GZO/MgO/Y<sub>2</sub>O<sub>3</sub> under the g=004 of GZO condition.

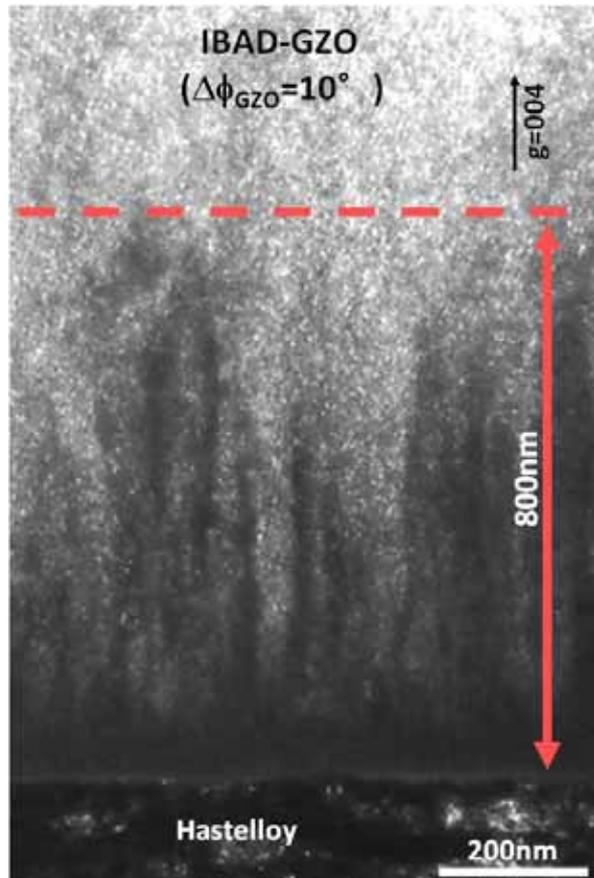


Fig.3 Dark field image of GZO directly formed on Hastelloy under the g=004 of GZO condition..