The influence of seed layer on the structure and superconducting property of BaHfO$_3$ doped Y$_{0.5}$Gd$_{0.5}$Ba$_2$Cu$_3$O$_7$-δ film prepared by pulsed laser

Linfei Liu, Wei Wang, Yanjie Yao, Xiang Wu, Saida Lu, Yijie Li
School of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai 200240, China

Introduction

- Second generation REBa$_2$Cu$_3$O$_y$ (REBCO, RE=rare Earth) high temperature superconductors, also called as coated conductors (CCs), have properties of high critical current capacity make them attractive for use in most applications, such as for cable, motors, generators, and transformers.
- Improvement in the in-filed transport properties of REBCO coated conductors is needed to meet the performance requirements for various practical applications, which can be accomplished by introducing artificial pinning centers (APCs), such as second phase dopant.
- Unfortunately, with increasing dopant level the critical current density $J_c$ at 77 K in zero applied magnetic field decreases.
- In this paper, we propose a self-seeding technique in order to improve the performance of doped REBCO films.

- 5 mol% BaHfO$_3$ (BHO) doped Y$_{0.5}$Gd$_{0.5}$Ba$_2$Cu$_3$O$_7$-δ (YGBCO) layer with self seed layer was grown on CeO$_2$ buffered ion beam assisted deposition MgO (IBAD-MgO) tape by pulsed laser deposition (PLD).
- The effect of the seed layer deposition temperature on the quality of 5 mol% BHO doped YGBCO top layer was investigated by X-ray diffraction (XRD) measurements and scanning electron microscopy (SEM) observations.

Experimental

- CeO$_2$ buffer layer was directly deposited on IBAD-MgO template by reel-to-reel PLD.
- On the CeO$_2$ buffer layers, 2 nm thick 5 mol% BHO doped YGBCO seed layers were deposited at different temperature ranging from 710 °C to 820 °C by PLD.
- Then 200 nm thick 5 mol% BHO doped YGBCO superconducting films were deposited by PLD on the self-seed layers at 820 °C.
- Ag layer was fabricated by reel-to-reel DC magnetron sputtering.

Results - surface morphology of self-seed layer

- A surface roughness increase trend in seed layer was observed with increasing the deposition temperature.
- When deposition temperature was increased to 770 °C, crystal grain was observed. With further increasing deposition temperature, grain became larger and surface became rougher.

Results - surface morphology of 5 mol% BHO doped YGBCO top layer

- With increasing the deposition temperature of seed layer, particles number first decreased and then increased. While the surface of 5mol% BHO doped YGBCO top film had no apparent differences.
- When the seed layer deposition temperature increased to 770 °C, scaly crystal appeared.

Results - superconducting property

- With increasing the growth temperature of self-seed layer from 710 to 820 °C, $J_c$ at 77 K and self-filed of the 5 mol% BHO doped YGBCO top layer first increased from 2.5 to 4 MA/cm$^2$ and then decreased to 3.25 MA/cm$^2$.

Conclusions

- The effect of growth temperature for seed layer on the quality of 5 mol% BHO doped YGBCO top layer was systematically investigated by XRD and SEM observations.
- Pure c-axis oriented 5 mol% BHO doped YGBCO superconducting films were fabricated by self-seeding PLD.
- With increasing the growth temperature of self-seed layer from 710 to 820 °C, $J_c$ at 77 K and self-filed of the 5 mol% BHO doped YGBCO top layer first increased and then decreased.
- The $J_c$ (77 K, self-field) of the 5 mol% BHO doped YGBCO film with self-seed layer deposited at 770 °C was the largest, 4.0 MA/cm$^2$.

Acknowledgment & Contact

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Fig. 1 Schematic diagram of the cross section of coated-conductor architecture based on IBAD-MgO template (a) and a reel-to-reel PLD system (b).

Table 1. The deposition temperature of seed layer in all the samples.

<table>
<thead>
<tr>
<th>Sample</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
<th>S7</th>
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<tbody>
<tr>
<td>Seed layer</td>
<td>2 nm thick 5 mol% BHO doped YGBCO film</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Seed layer deposition temperature (°C)</td>
<td>710</td>
<td>730</td>
<td>750</td>
<td>770</td>
<td>790</td>
<td>810</td>
<td>820</td>
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Fig. 2. (a) XRD 0-2θ patterns of all the samples, (b) FWHM values of YBCO (103) φ scan, CeO$_2$(111) φ scan, YBCO (005) ω scan, YBCO (006) ω scan and CeO$_2$(002) ω scan.

Fig. 3. SEM images of the seed layers deposited at different temperature (a)710°C, (b)730°C, (c)750°C, (d)770°C, (e)790°C, (f)810°C, (g)820°C

Fig. 4. SEM images 5 mol% BHO doped YGBCO films deposited on self-seed layer fabricated at different temperature (a)710°C, (b)730°C, (c)750°C, (d)770°C, (e)790°C, (f)810°C, (g)820°C

Fig. 5. The dependence of $J_c$ at 77 K and self-field on the seed layer deposition temperature.