Effects of the homoepitaxial MgO films on the growth of CeO_2 films fabricated by pulsed laser deposition

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Abstract

A series of homoepitaxial MgO (Homo-MgO) layer were deposit by radio-frequency (RF) magnetic sputtering on IBAD-MgO substrates. Then CeO_2 films were deposited on the Homo-MgO films by pulsed laser deposition. The results show that the quality of the CeO_2 film was not linearly dependent on the texture of homo-MgO film as expected and high quality CeO_2 film with the in-plane full width of half maximum of 2.78° was fabricated under the optimized conditions. We adopted the existence of the lattice distortion in the IBAD-MgO films and the growth mode of the homo-MgO to clarify its nature. The appearance of the CeO_2 (111) orientation was explained by the large lattice mismatch and the potential barrier caused by large value of roughness.

Introduction

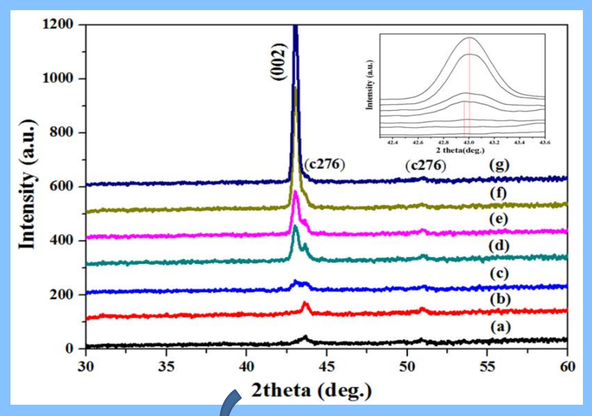
Coated conductors have been approved of great importance to superconducting generator, transmission cable and so on. As the texture layer for coated conductor, IBAD-MgO film is extremely thin (<10 nm), and the lattice mismatch between MgO film and superconducting layer is quite large. Therefore, inserting buffer layers between IBAD-MgO and the REBCO films is prerequisite. In general, buffer layer architecture of $LaMnO_3$ (LMO) /Homo-MgO was used by many scientists. However, the lattice mismatch of Y123[100]/LMO[100] is 1.80%. While the lattice mismatch of Y123[110]/CeO_2[100] is only 0.55%. So here we replace LMO with CeO_2 layer.

Method

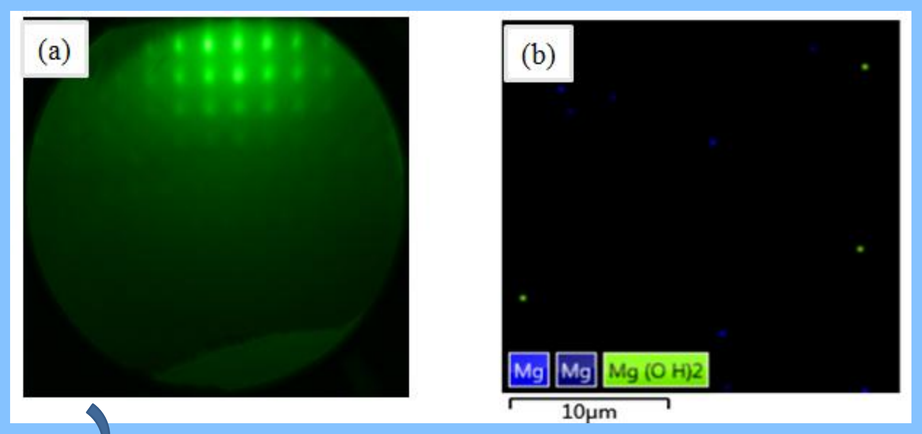
The IBAD-MgO/Y_2O_3/Al_2O_3 buffered hastelloy C276 substrates (10 mm in width and 50 μm in thickness), which were produced by Shanghai Superconductor Technology Co. Ltd. in China, were used to deposit homo-MgO by RF magnetic sputtering. Afterwards, the CeO_2 layer depositions were performed in a reel-to-reel pulsed laser deposition (PLD) system at optimized conditions.

Results I — Homoepitaxial MgO

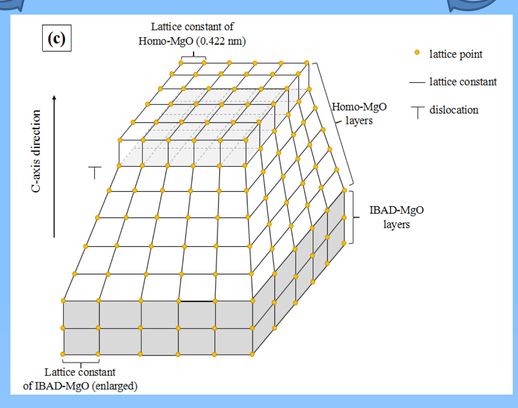
XRD patterns of (a) IBAD-MgO film and homo-MgO films deposited at different sputtering power: (b) 60 W, (c) 70 W, (d) 80 W, (e) 90 W, (f) 100 W and (g) 110 W, respectively. The inset shows the magnified XRD patterns of the MgO (002) peaks.



The reflection high-energy electron diffraction (RHEED) and (b) the electron backscattered diffraction (EBSD) patterns of IBAD-MgO film.

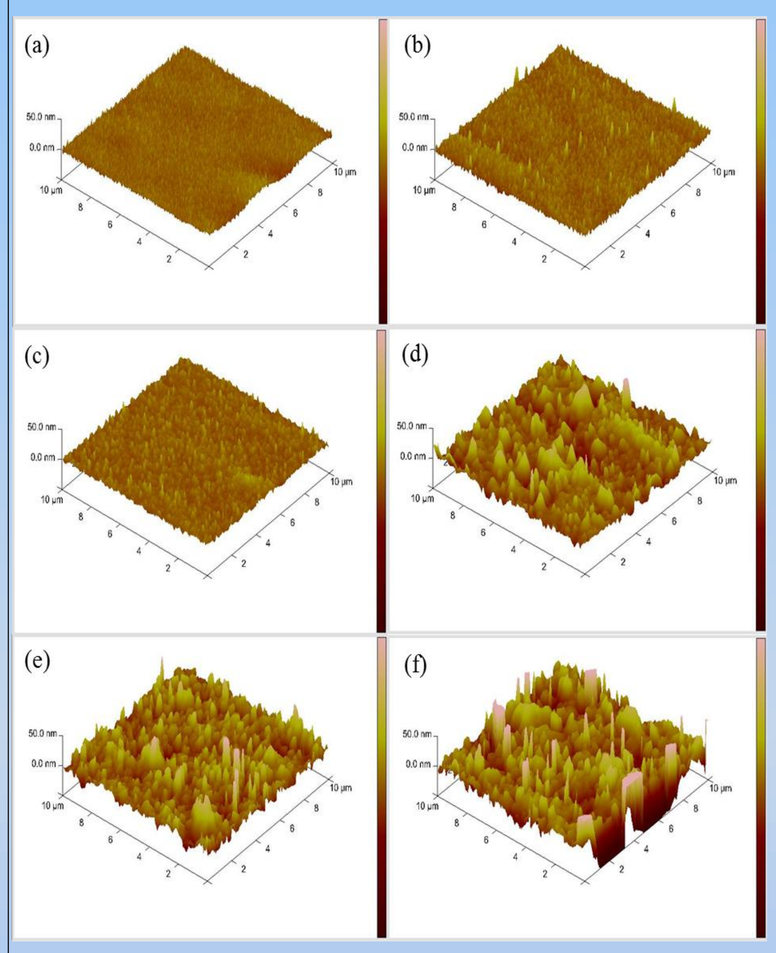


Schematic drawing of the homo-MgO (101) showing the growth mode of homo-MgO on the IBAD-MgO substrate.

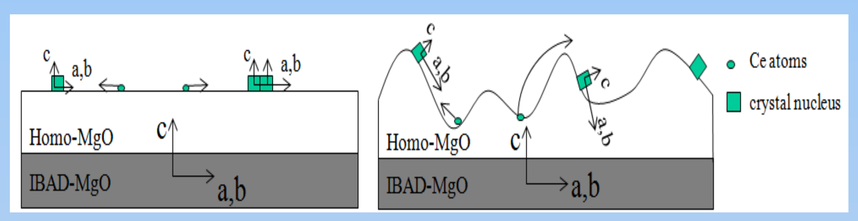


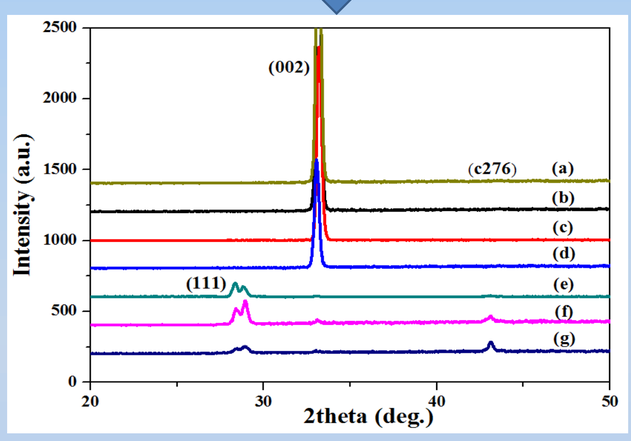
- ✓ The diffraction spots, observed in the RHEED pattern, indicate volmer-weber (VW) growth of the MgO film.
- ✓ The EBSD pattern shows no MgO phase in the IBAD-MgO film.
- ✓ A shift of the MgO (002) to the right was also observed.
- ✓ In the IBAD process, the lattice constant of the cubic MgO film has been enlarged.

Results II — CeO_2 films



Schematic drawings showing the growth process of CeO_2 films on the homo-MgO films fabricated at (a) small and (b) large sputtering power.





XRD patterns of CeO_2 films which deposited on the (a) IBAD-MgO film and homo-MgO films deposited at various sputtering power: (b) 60 W, (c) 70 W, (d) 80 W, (e) 90 W, (f) 100 W and (g) 110 W, respectively.

Conclusion

- ✓ The homo-MgO film and high quality CeO_2 film on the IBAD-MgO substrate was successfully fabricated by the RF magnetron sputtering and PLD techniques in sequence.
- ✓ Increasing the sputtering power (P_s), the in-plane alignment homo-MgO films became better.
- ✓ The highly single c-oriented CeO_2 film with the FWHM of 2.78° was fabricated on the nano-scaled homo-MgO film deposited at 70 W.