For applications in electrical equipment and mass production, high critical current density ($J_c$) is required. Unfortunately, $J_c$ decreases with increasing YBCO layer thickness in many cases. Some groups tried slowing down the decrease tendency, but when the thickness of the superconducting layer is over 2 μm, the decrease is still obvious. Superconductor/insulator/superconductor tri-layer structure can effectively inhibit thickness effect. In former studies, STO, LaAlO$_3$, CeO$_2$, and NdAlO$_3$ were used as inter-layer materials. Among these materials, STO films represent a promising candidate due to their good chemical stability and small lattice mismatch between YBCO and STO.

Usually, the inter-layer is very thin to match the short coherent length of YBCO along the c-axis direction. And the tri-layer structure is usually prepared symmetrically, which means the thicknesses of the bottom-layer and upper-layer are the same. Former work often focus on the influence of inter-layer on the whole structure.

**Motivation**

- High quality template for subsequent deposition of YGBCO films, lattice mismatch -0.52%
- To inhibit thickness effect
- Bottom-layer may have influence on the whole sample's superconducting property
- Stoichiometric transfer materials from target to substrate

**Introduction**

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**Method**

- Structure of samples
  - YBCO/STO/YBCO Tri-layer (deposited by PLD)
  - Silver
  - Buffer Layers

- Pulsed Laser Deposition (PLD) system

  ![Fig. Basic structure of YGBCO coated conductor.](image)

  - When depositing the tri-layer structure, a multi-step deposition process was used, in which the thickness of the superconducting layer was increased by additional deposition cycles. In each standard cycle, the thickness of the deposited YGBCO layer was approximately 240 nm. Hence, the deposition of the tri-layer structure in S1 consisted of one standard cycle as the bottom-layer, and two standard cycles as the upper-layer, while S2 had an opposite deposition process.
  - The thicknesses of the whole YGBCO superconducting layer of the two samples were both 720 nm. The thickness of the STO inter-layer was 80 nm, based on former experiment results.

- Experimental parameters:
  - KF eximer laser wavelength of 248 nm
  - Laser power density $P_L=1.0$ kJ/cm$^2$
  - Incident angle between the laser beam and the target surface of 45°
  - Distance between the substrate and target of 4 cm.
  - Laser repetition frequency of 160 Hz
  - Oxygen partial pressure $P_0=200$ mTorr

**Results and Discussion**

- Microstructure analysis

  ![Fig. XRD patterns of the bottom-layer of the samples. (a) 0-2θ scans of the samples; (b) magnification of YGBCO (005) peak.](image)

- Surface morphology (SEM)

  ![Fig. Temperature dependence of ac susceptibility for samples with different thickness of bottom-layer.](image)

- Superconducting properties

  ![Fig. XRD patterns of the samples. (a) 0-2θ scans of the samples; (b) magnification of YGBCO (005) peak.](image)

**Conclusion**

- YGBCO/STO/YGBCO tri-layer structures with over $J_c>3.5$ MA/cm$^2$ (self-field, 77 K) have been successfully fabricated asymetrically on a CeO$_2$ buffered C276 tapes by using a multi-step PLD process.
- XRD observation showed that thicker bottom layer had almost no internal stress.
- Better structure and surface morphology contributed to better superconducting properties of the whole samples both under self-field and magnetic field.
- The phenomenon was explained by the growth model, and the results were confirmed with each other.
- Further study on increasing the number of STO inter-layers is in progress.