Characterization of $YBa_2Cu_3O_7$ Thin Films on Miscut LSAT Substrates

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Introduction

$YBa_2Cu_3O_{7-\delta}$ (YBCO) is a high transition temperature superconductor that is used in the fabrication of superconducting electronics. YBCO has an orthorhombic structure with the lattice constants *a=3.82* Å, *b=3.89* Å, and *c=11.68* Å. Experiments have shown that conduction occurs in the copper oxide chanis while the Copper oxide planes act as charge reservoirs, which provide carriers to the CuO planes. The conduction in the copper planes confines conductivity to the *a-b* planes and a large anisotropy in transport properties is observed. Normal conductivity is 10 times smaller along the *c*-axis than in the *a-b* plane.

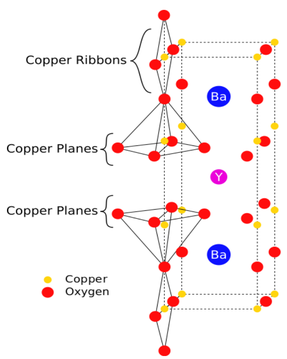

Figure 1. Schematic of the orthorhombic lattice structure of $YBa_2Cu_3O_{7-\delta}$ (YBCO) showing the position of copper planes and copper chains, and lattice parameters

Objectives

A better matched interface is desirable for electronic applications and can potentially be obtained by growth on substrates cut with a small vicinal angle. We have investigated a possible way of getting better lattice match between the substrate and the film using miscut LSAT at different angles with the YBCO layer. We have investigated the effect of miscut angle degree on the homogeneity of the YBCO film and improvement of the desired properties.

Methodology

Four YBCO films with a thickness of 70 nm were grown by Ceraco with Reactive Co-Evaporation (RCE) method on 40 nm CeO_2 buffer layered LSAT substrates prepared with 0º, 2º, 5º, and 7º miscuts. Scanning Electron Microscope (SEM) images of samples were obtained using 2 kV accelerating voltage. Atomic Force Microscopy (AFM) was performed to compare the roughness.

Methodology, Cont.

Four-point, transport measurements of the resistance were carried out from room temperature (~ 300 K) down to 77 K using a liquid nitrogen bath, and warming up from 77 K back to the room temperature. Resistance was measured and resistivity was calculated in μΩ-cm using the Van der Pauw method.

Imaging Results

SEM and AFM images of YBCO on LSAT with 0º, 2º, 5º, and 7º miscuts were taken with a resolution of 5 and 1 μm respectively (Figures 2 and 3). SEM and AFM images show that as we increase the degree of miscut angle, the surface becomes more rough. AFM measurements show that the roughness for YBCO on LSAT changes in the range of 9.5 to 15.7 nm as we increase the miscut angle 0º to 7º .

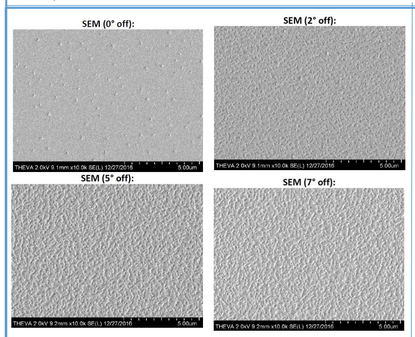

Figure 2, SEM images of YBCO layer on LSAT with 0º, 2º, 5º, and 7º miscut with 5 μm scan

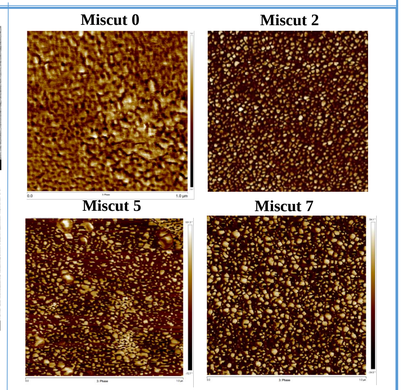

Figure 3, 1 μm AFM scan of YBCO on LSAT with 0º, 2º, 5º, and 7º miscut

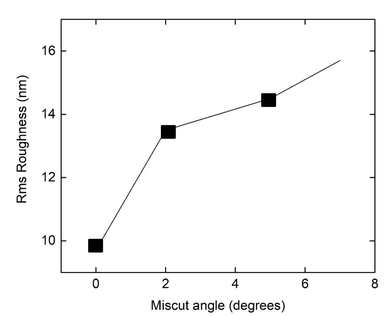

Figure 4, Rms Roughness change with increasing the miscut degree angle for YBCO on LSAT with 0º, 2º, and 5º miscut

Electric results

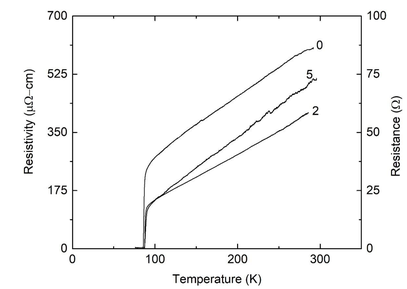

Figure 5, Resistivity VS Temperature of YBCO on LSAT with 0º, 2º, and 5º miscut

Figure 5 shows the resistivity versus temperature results for YBCO on LSAT samples with 0º, 2º, and 5º miscut. The superconducting transition temperature T_c increases as we increase the degree of miscut. The measured values of T_c for 0º, 2º, and 5º miscut samples were 86.2 ± 0.5 K, 87.8 ± 0.5 K, and 88.6 ± 0.5 K.

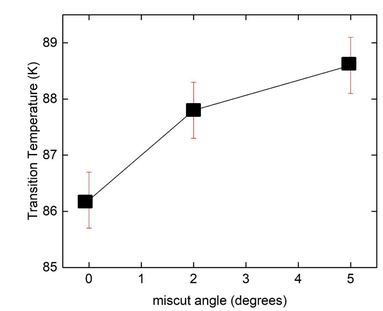

Figure 6, Transition Temperature as a function of miscut degree angle for YBCO on LSAT w

Conclusion

The results show that the surface becomes more rough as the degree of miscut increases (Figure 4). In addition, as we increase the miscut angle from 0 to 5 degrees, Tc increases (Figure 6).

References

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