Atomic Structural Analysis of YBCO Bicrystal Grain Boundary by Aberration Corrected STEM

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Introduction

YBCO high-temperature superconductors have great potential for high-magnetic-field technology, as demonstrated by the recent achievement of the new world record – 26.8 tesla magnet. However, grain boundaries (GB) have been the major obstacles in practical application of the high temperature superconductors, because the superconducting critical current density ($J_c$) drops exponentially across the boundaries with increased grain misorientation. Even the second-generation superconducting coated conductors made from YBCO have 5-7° tilt GBs. It has been shown that Ca doping can improve the $J_c$ across the GB even at low misorientation angle[1]. Reported here is the work in progress in an effort to characterize the atomic structures of the dislocations, and the local chemical composition at the GB in the 6° and 7° tilt YBCO bicrystal with and without Ca doping.

Experimental

The bicrystal thin film was grown on SrTiO$_3$ [001] bicrystal by pulsed laser deposition. The atomic structural characterization was carried out on a Jeol-2200F equipped with a probe Cs corrector having 1Å resolution.

Results and Discussion

Atomic resolution Z-contrast imaging or high angle annular dark field imaging (HAADF) has been used to image the dislocation core structures of a 7° GB doped with 15% Ca. Because of the intuitive nature of the high resolution Z-contrast image, the core structure is revealed immediately and clearly without further simulation, as shown in Fig.1a. Chemical or elemental information from atomic columns could also be obtained by electron energy loss spectroscopy (Fig.1b).

Conclusions

Preliminary results show the Ca segregation into the GB for the 15% Ca doped YBCO bicrystal.

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References