Observation of grain-boundary on bicrystal

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The aim of our IDER unit

The final aim of our Innovation-oriented Dynamic Education and Research (IDER) unit is to improve the grain-boundary junction properties and to develop the high-quality high-$T_C$ Josephson junction devices such as superconducting quantum interference devices (SQUIDs) or THz detectors.
The members of the unit and each role are

**Dr. T. Maki:** a leader of the unit  
**Mr. Y. Nakatani:** fabrication of high-$T_C$ superconducting thin films and the devices  
**Prof. M. Abe:** observation by an atomic force microscopy (AFM)  
**Prof. T. Matsuoka:** design of the device systems  
**Prof. H. Itozaki:** an adviser of the unit

The research of the unit was carried out together with

**Dr. X. Y. Kong:** design and fabrication of the SQUIDs  
**Mr. A. Yutani:** fabrication of high-$T_C$ superconducting thin films and the devices
SrTiO$_3$ (STO) bicrystal substrates are useful for fabrication of grain-boundary Josephson junctions by growing YBa$_2$Cu$_3$O$_{7-x}$ (YBCO) thin films on the substrates.

Since grain boundary surface of the bicrystal substrates influence the properties of the YBCO thin-film grain-boundary Josephson junctions grown on the substrates,

**It is important to evaluate the surface of the bicrystal boundary of the substrates.**

A field-emission scanning electron microscopy (FE-SEM) and an atomic force microscopy (AFM) observation of STO bicrystal substrates was used to observe the surface defects located along with the bicrystal boundary.
The high magnification image reveals the morphological difference between the defects b and c.

The defect c exhibits a grooved shape, however the defect b exhibits the flat surface and the secondary electron emission was just suppressed.
Comparison between AFM and FE-SEM observation of the defects at the bicrystal boundary of a STO substrate

By comparing (a) AFM and (b) FE-SEM image, the defects observed in the secondary electron image mostly have a grooved shape. However, the defects of F and H have obviously no grooved shape, but the flat surface, where the secondary electron emission was suppressed.
AFM image of the enclosed area of the 500 nm square and the cross-sectional view

The depth of the defect A is estimated to around 10 nm.
The defect of the groove is similar in shape to that of the substrate.

It was also found that an over-growth of the YBCO thin film occurred across the bicrystal boundary, resulting in the meandering shape of the grain boundary.
Conclusions

The characterization of the defects at bicrystal boundaries of the substrates and the defects at grain boundaries of the YBCO thin films grown on the bicrystal boundaries provided us the valuable information to understand the mechanism of the formation of the defects at grain boundaries of the YBCO thin films grown on the bicrystal substrates.

This YBCO defect on the grain boundary might influence to depress superconducting properties of Josephson junction.