# Observation of grain-boundary on bicrystal

**Tetsuro Maki, Yoshihiro Nakatani, Xiangyan Kong**
**Akinori Yutani and Hideo Itozaki**
*Graduate School of Engineering Science, Osaka University*

**Masayuki Abe and Toshimasa Matsuoka**
*Graduate School of Engineering, Osaka University*

大阪大学
Osaka University

GCOE CEDI
Osaka Univ.
EDIS2008

# Contents



1. The aim of our IDER unit

2. The members of the unit and each role

3. Recent activity of our unit

   *FE-SEM and AFM observations of the grain-boundaries on bicrystal*

4. Conclusions

# 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

*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*

# Recent activities of our unit



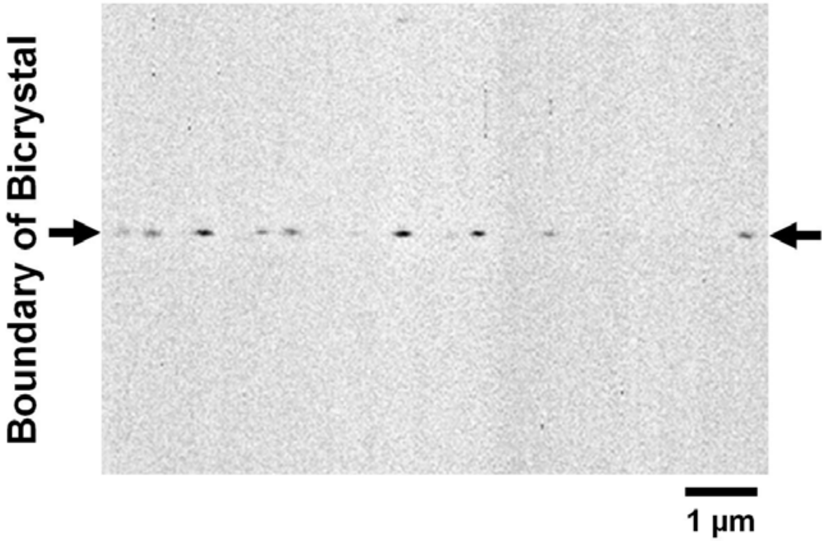
*$SrTiO_3$ (STO) bicrystal substrates are useful for*
**fabrication of grain-boundary Josephson junctions**
*by growing $YBa_2Cu_3O_{7-x}$ (YBCO) thin films on the substrates.*

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

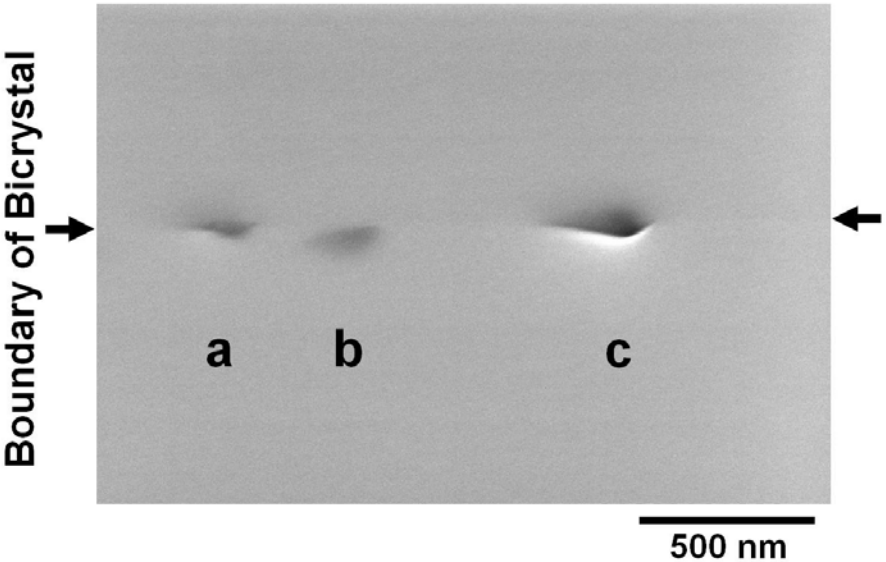
*It is important to evaluate*
**the surface of the bicrystal boundary of the substrates.**

**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.**

## Secondary electron images of the bicrystal boundary of a STO substrate with wide-range and high magnification




**Wide-range**



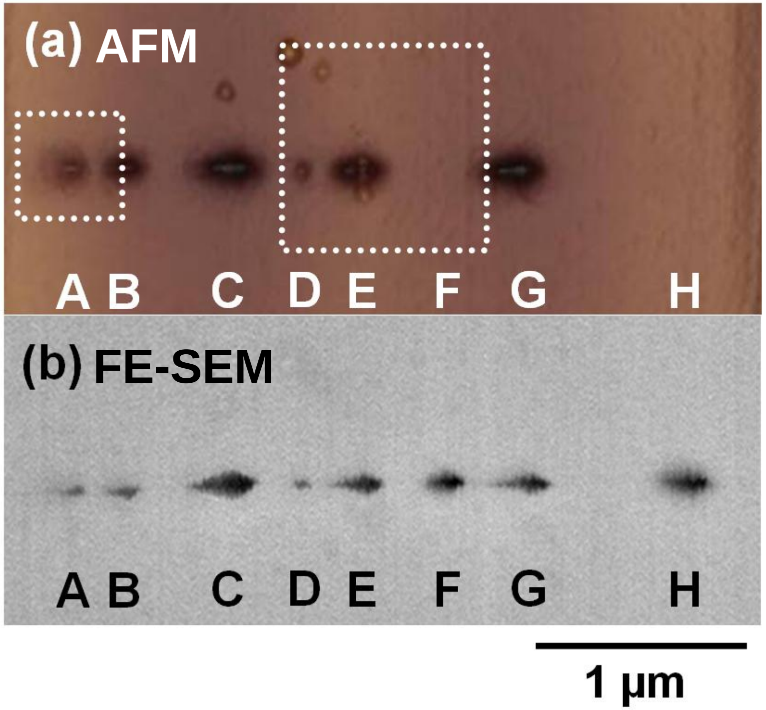

**High magnification**

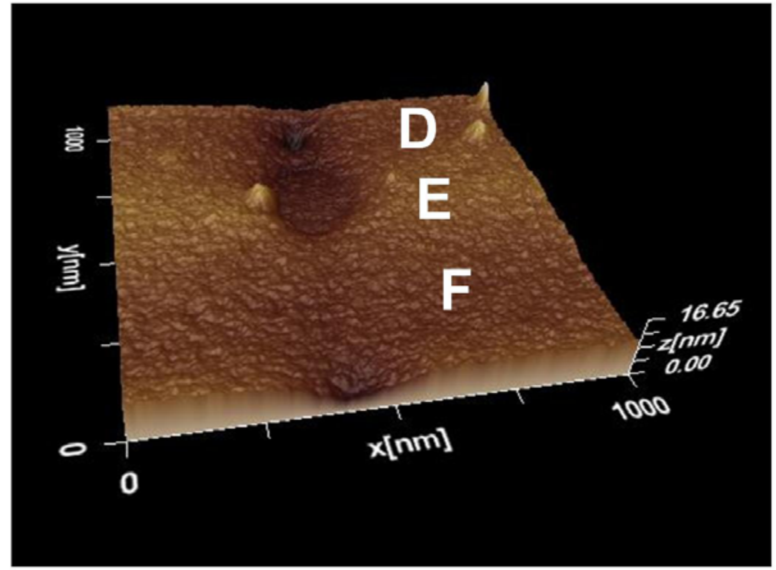
*The high magnification image reveals*
**the morphological difference between the defects b and c***.*

*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

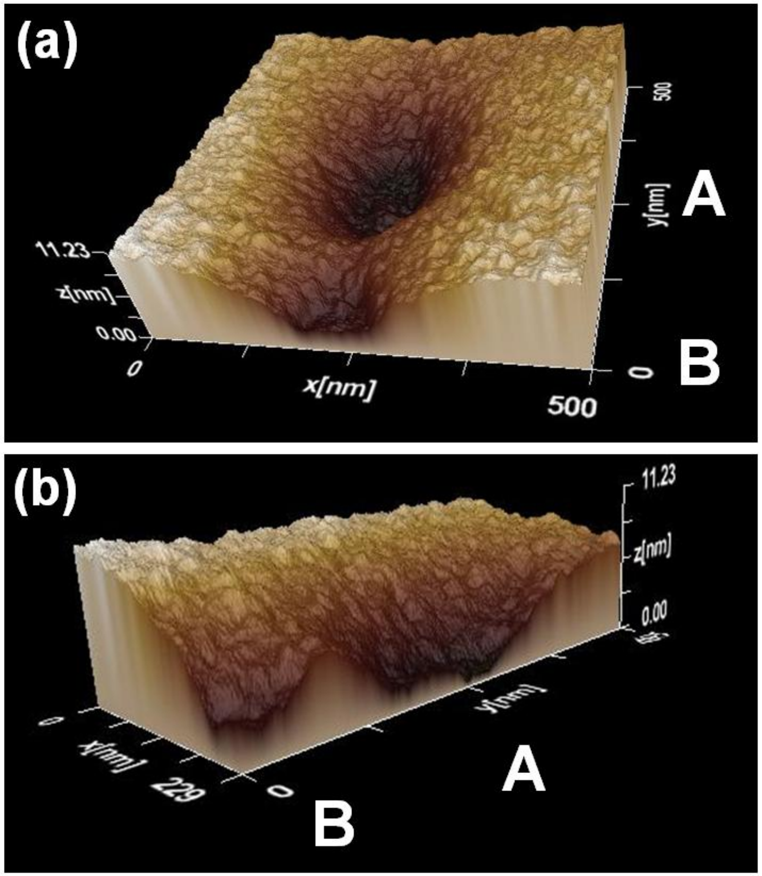


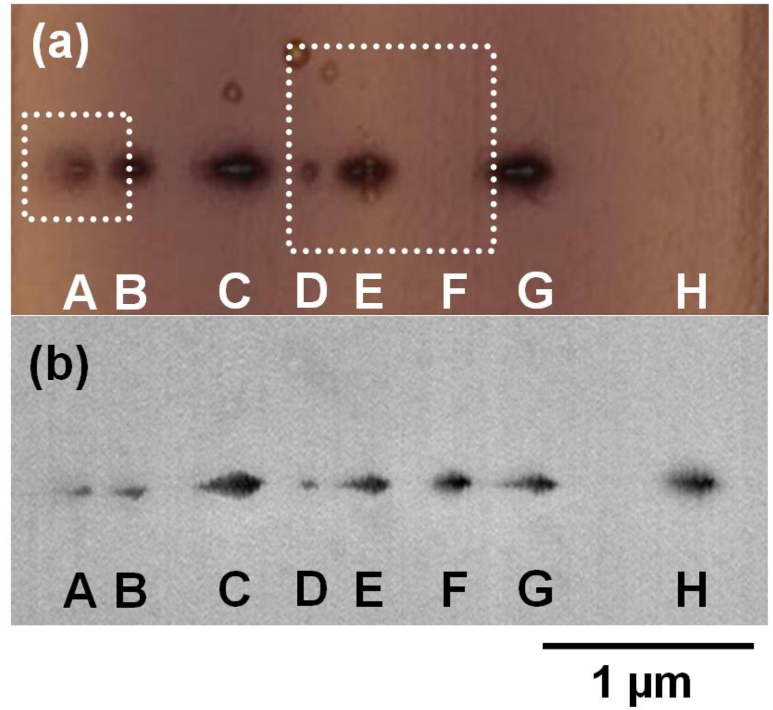



*By comparing (a) AFM and (b) FE-SEM image,*
*the defects observed in the secondary electron image mostly have* **a grooved shape**. *However, the defects of* **F** *and* **H** *have obviously* **no grooved shape**, **but the flat surface**,
*where the secondary electron emission was suppressed.*

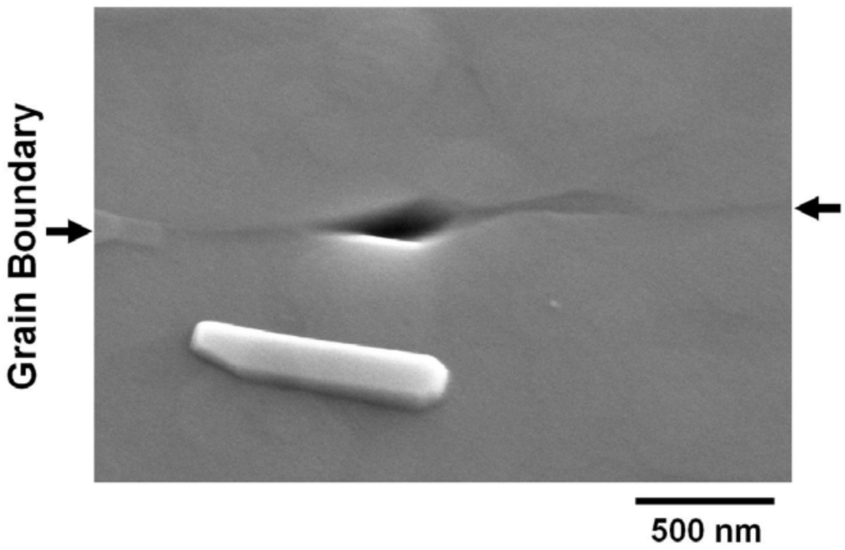
# AFM image of the enclosed area of the 500 nm square and the cross-sectional view

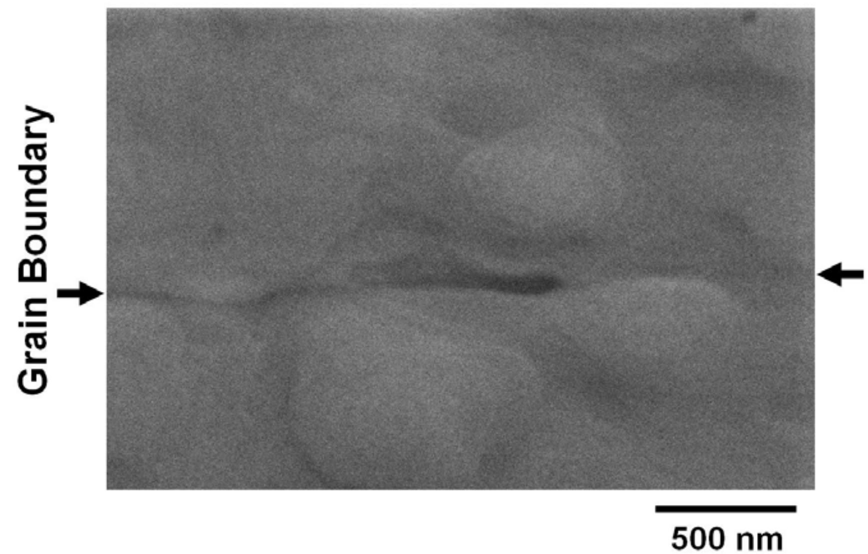



*The depth of the defect **A** is estimated to* **around 10 nm**.

## Secondary electron images of the grain-boundary of an YBCO thin film grown on the STO bicrystal substrate




*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**.