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Improvement of critical current asymmetricity in $BaHfO_3$-doped $SmBa_2Cu_3O_y$ superconducting films by ion milling etching

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$REBa_2Cu_3O_y$ (REBCO) high-temperature superconductor has a high T_c and is expected for various applications. Superconducting diodes with asymmetric I_c depending on the current direction have been proposed [1]. The previous studies clarify that the origin of the asymmetricity is the difference of I_c where the vortices penetrate from the film surface to the substrate or the opposite direction[1,2]. For practical application, the rectification rate needs to be improved. We have reported that the small surface roughness (δR) intensifies the asymmetricity [3].

In this study, the asymmetricity was improved by controlling the δR of the REBCO film by a post-treatment using the Ar ion milling.

$BaHfO_3$ (BHO)-doped $SmBa_2Cu_3O_y$ (SmBCO) films were fabricated on $LaAlO_3$ (100) substrates with a thickness of 400 nm by using the pulsed laser deposition method. Several samples were etched by the Ar ion milling. The etching rate and time was 15 nm/min and 4 min, respectively. The films were patterned into bridges with a width of 200 μm and a length of 1 mm. The asymmetricity was measured in an in-plane magnetic field of 0 to 0.4 T at 77.3 K. Fig. 1 shows a typical *I-V* characteristic in the etched sample. The schematic diagram in the figure shows the current and the magnetic field directions for the sample. I_c^{up} corresponds to I_c with the flux motion from the substrate toward the film surface and I_c^{down} is the one with the opposite polarity. Asymmetricity (*Asym.*) was defined by the following equation.

The maximum of *Asym.* for the magnetic field is defined as $Asym.^{max}$. Fig. 2 shows δR dependence of $Asym.^{max}$ at 77.3 K in the BHO-doped films. $Asym.^{max}$ tends to increase with decreasing δR. δR decreased by 20 nm and $Asym.^{max}$ increased by 2% for etching. The results indicate that the Ar ion milling enhances the asymmetry. We will discuss why δR reduction by Ar ion milling improves *Asym.* and will report the results for the inclined Ar ion milling.

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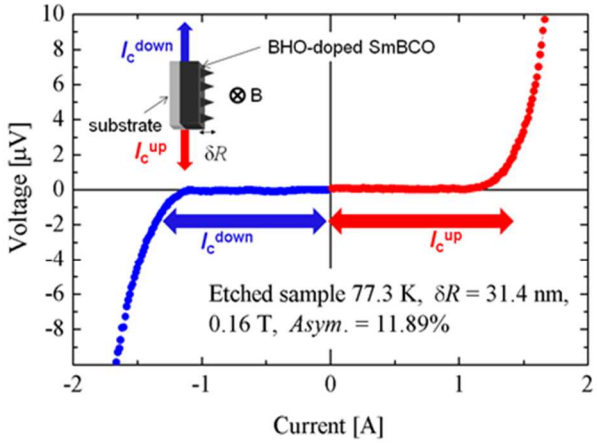

Fig.1 Typical *I-V* characteristics obtained at 77.3 K and 0.16 T in the etched sample.

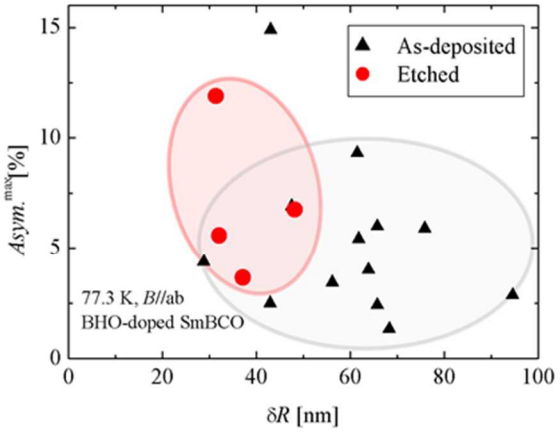

Fig. 2 δR dependence of $Asym.^{max}$ at 77.3 K for BHO-doped SmBCO.

Keywords: REBCO, diode, etching, asymmetricity