Synthesis of Single Crystalline Oxide Sheets

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Introduction: Oxides show many fascinating functional properties ensuring their promising future in applications, e.g. flexible electronic devices [1]. However, to generate flexibility, bulk single crystals and thin films on traditional substrates are incapable. Besides, direct film fabrication on flexible substrates, such as organic polymers, is difficult due to extreme growth condition required for oxides, such as high-temperature. Recently, functional electronics were obtained on silicon by etching a sacrificial layer [2]. The same strategy has been applied to obtain oxide sheets. For example, a freestanding perovskites oxide sheet of $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) was prepared by using a water-soluble oxide material, $Sr_3Al_2O_6$ (SAO), as a sacrificed layer [3]. This new way of preparing oxide sheets was also used to fabricate oxide sheets on flexible substrates [1]. However, very limited research on fabricating of perovskites oxide sheets and their transfer on flexible bases has been done to date. In this study, we synthesized $SrRuO_3$ (SRO), $BaTiO_3$ (BTO) and LSMO sheets by using SAO as a sacrificial layer and transferred them on various bases.

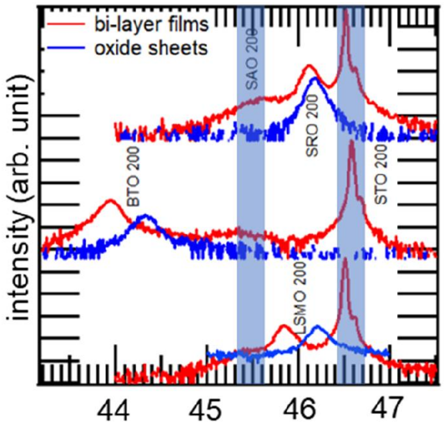

Figure 1. θ–2θ XRD patterns of bi-layer films and oxide sheets.

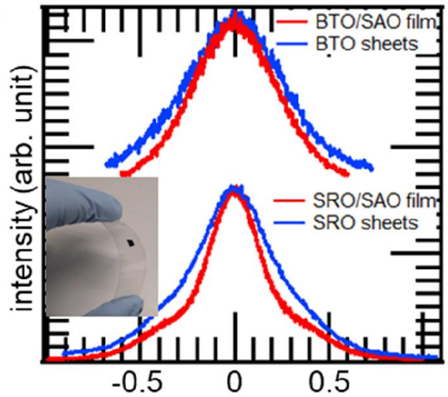

Figure 2. Rocking curves of the 200 diffraction peaks for the bi-layer films and oxide sheets. The inset shows a photograph of the SRO sheet.

Experimental: SRO/SAO, BTO/SAO and LSMO/SAO bi-layer films were fabricated on $SrTiO_3$ (100) (STO) substrates using pulsed laser deposition (PLD). After the fabrication, oxides (SRO, LSMO and BTO) sheets were transferred onto various substrates including glass, sapphire (0001) and PET/Silicone films after dissolving the SAO layers in deionized water. Crystal structure, surface roughness and resistivity of the films and sheets were measured by X-ray diffraction (XRD), atomic force microscopy (AFM) and physical property measurement system (PPMS), respectively.

Results: Figure 1 shows the out-of-plane 2θ-θ XRD patterns of the bi-layer films and oxide sheets transferred on various bases. Unlike the bi-layer films, the SRO, LSMO and BTO sheets show only their n00 diffraction peaks, confirming that single crystalline oxide sheets were successfully synthesized, and SAO was completely dissolved. The rocking curves of SRO and BTO 200 diffraction peak had FMHMs of 0.55° and 0.59°, respectively, which are almost equivalent to those of the bi-layer films, 0.41° and 0.53°, respectively (Fig. 2). This suggests that the crystallinity did not deteriorate so much through the transfer process. The transferred sheets had sizes as large as 12 mm^2, as shown in the inset of Fig. 2, and were flexible. Furthermore, the STO substrates could be reused, as demonstrated in Fig. 3.

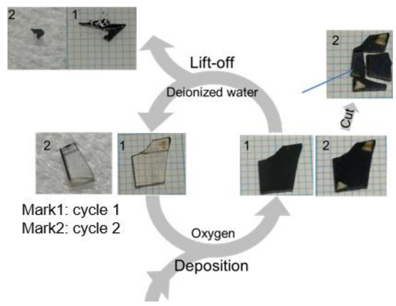

Figure 3. Demonstration of reusability of the STO substrate.

<References> [1] L. Shen, *et al*. Adv. Mater. **29**. 1702411 (2017). [2] S. Bakaul, *et al.* Nat. Commun. **7**. 10547 (2016). [3] D. Lu, *et al*. Nat. Mater. **15**. 1255 (2016).