Journal Name

ARTICLE

## Supplementary Information

Received 00th January 20xx,
Accepted 00th January 20xx

DOI: 10.1039/x0xx00000x

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# Buffer layer-less fabrication of high-mobility transparent oxide semiconductor, La-doped $BaSnO_3$

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Electronic Supplementary Information (ESI) available: [Crystallographic characterizations and Topographic AFM images of the $O_3$ and $O_2$-LBSO films grown on (001) $SrTiO_3$ substrates]. See DOI: 10.1039/x0xx00000x



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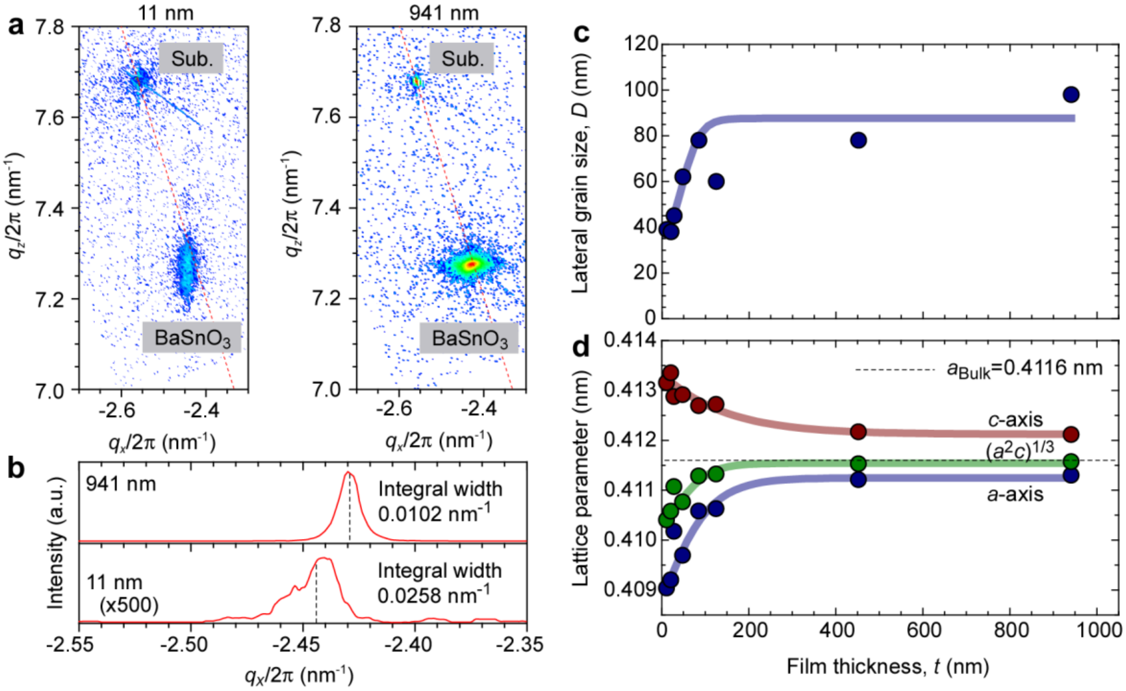


**Figure S1. Crystallographic characterizations of the $O_3$-$La_{0.02}$-$Ba_{0.98}SnO_3$ films grown on (001) $SrTiO_3$ substrates.** (a) reciprocal space mappings of asymmetric (103) diffraction of $O_3$-LBSO films. The symmetry axis of a cubic lattice is indicated by a red line. (103) $BaSnO_3$ diffraction peak approaches the red line, which suggests that lattice strain due to the film/substrate mismatch is gradually deceasing; (b) the cross-sectional intensity plot along the in-plane axis in reciprocal space ($q_x/2\pi$); (c) thickness dependence of the lateral grain sizes; (d) thickness dependent lattice parameter along the in-plane direction (blue), out-of-plane direction (red), and the average lattice parameter (green). All these values approach the lattice parameter of bulk LBSO (black dashed line) with increasing film thickness.





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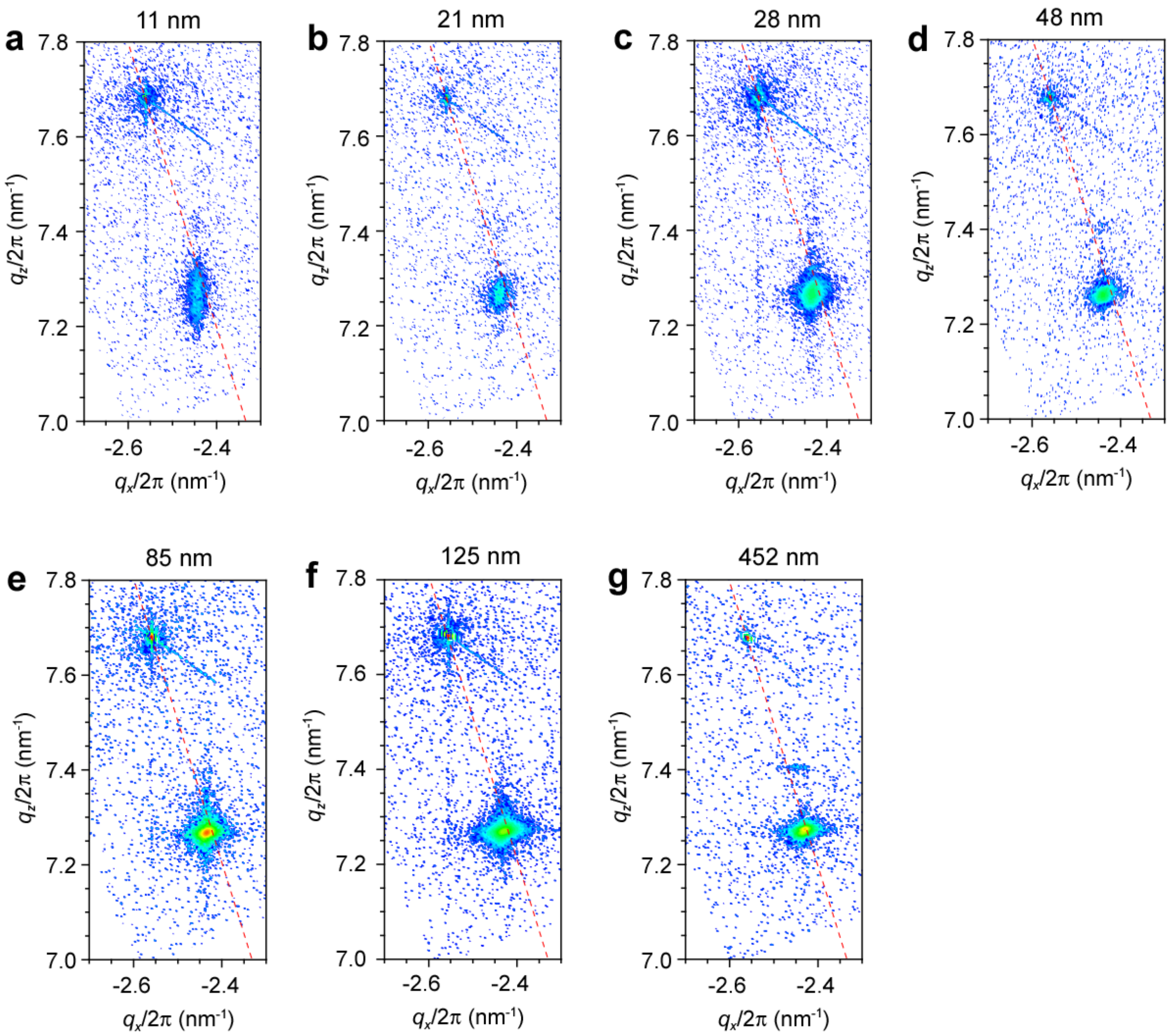


**Figure S2. Reciprocal space mappings of $O_3$-$La_{0.02}$-$Ba_{0.98}SnO_3$ films grown on (001) $SrTiO_3$ substrate around the (103) Bragg diffraction.** The thicknesses of the films were (a) 11 nm, (b) 21 nm, (c) 28 nm, (d) 48 nm, (e) 85 nm, (f) 125 nm and (g) 452 nm. Although very weak diffraction spot is seen at ($q_x$, $q_z$) = (−2.45, 7.4) in g, probably due to the formation of Ruddlesden-Popper type faults, overall crystal phase of the films is $BaSnO_3$.

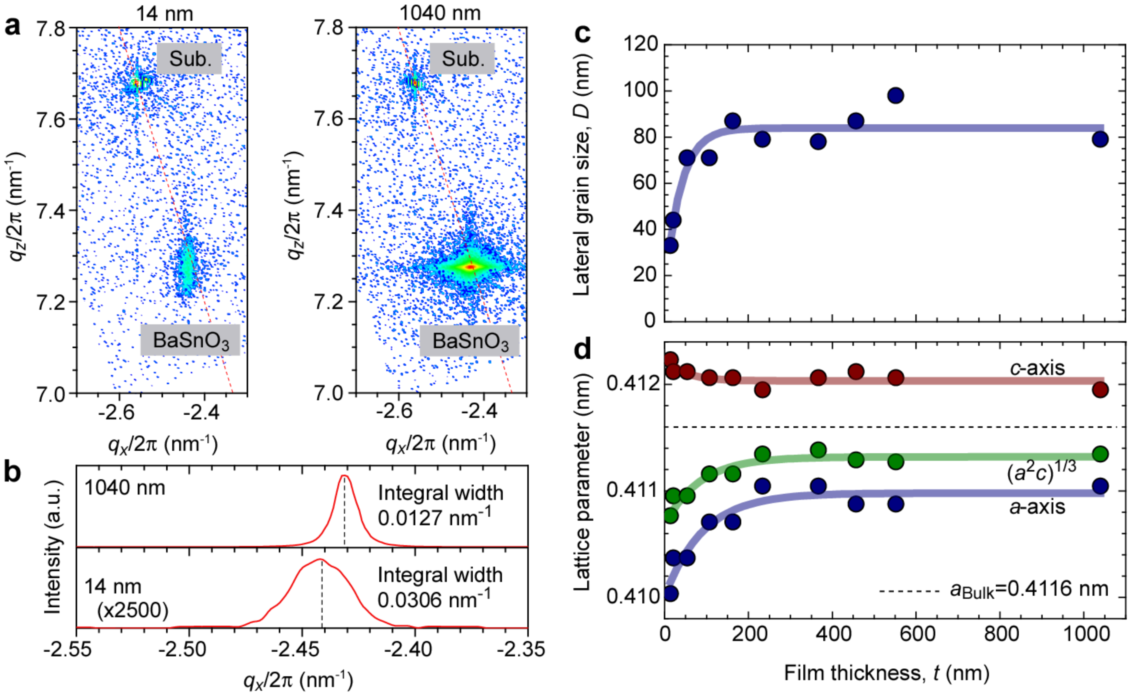


**Figure S3. Crystallographic characterizations of the $O_2$-$La_{0.02}$-$Ba_{0.98}SnO_3$ films grown on (001) $SrTiO_3$ substrates.**[23] (a) reciprocal space mappings of asymmetric (103) reflection of $O_3$-LBSO films. The symmetry axis of a cubic lattice is indicated by a red line. (103) $BaSnO_3$ diffraction peak approaches the red line, which suggests that lattice strain due to the film/substrate mismatch is gradually deceasing; (b) the cross-sectional intensity plot along the in-plane axis in reciprocal space ($q_x/2\pi$); (c) thickness dependence of the lateral grain sizes; (d) thickness dependent lattice parameter along the in-plane direction (blue), out-of-plane direction (red), and the average lattice parameter (green). All these values approach the lattice parameter of bulk LBSO (black dashed line) with increasing film thickness. The crystallographic characteristics of $O_2$-LBSO films were very similar with those of $O_3$-LBSO films.

 

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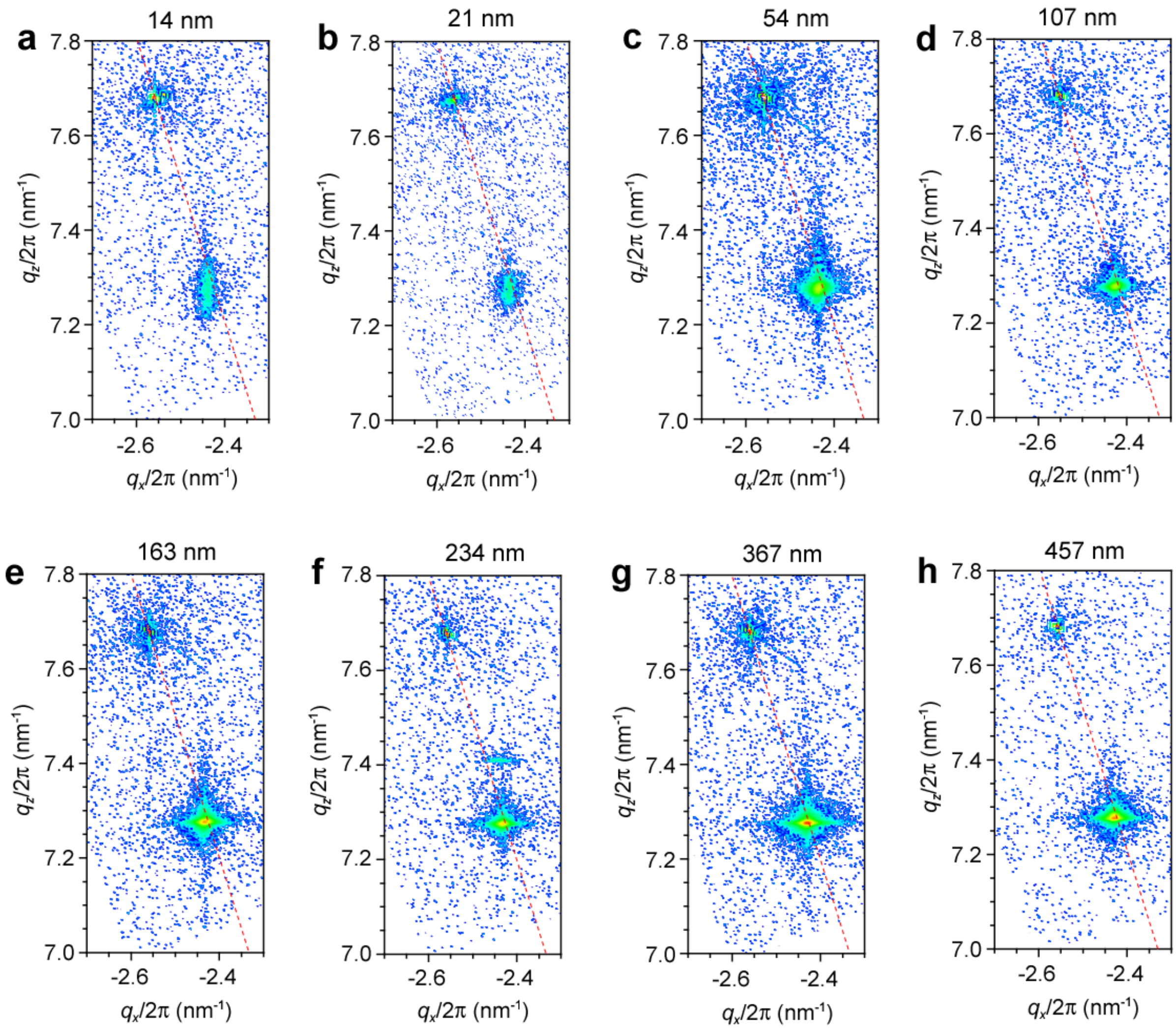


**Figure S4. Reciprocal space mappings of $O_2$-$La_{0.02}$-$Ba_{0.98}SnO_3$ films grown on (001) $SrTiO_3$ substrates around the (103) Bragg diffraction.**[23] The thicknesses of the films were (a) 14 nm, (b) 21 nm, (c) 54 nm, (d) 107 nm, (e) 163 nm, (f) 234 nm, (g) 367 nm, and (h) 457 nm. Although very weak diffraction spot is seen at ($q_x$, $q_z$) = (−2.45, 7.4) in f, probably due to the formation of Ruddlesden-Popper type faults, overall crystal phase of the films is $BaSnO_3$.



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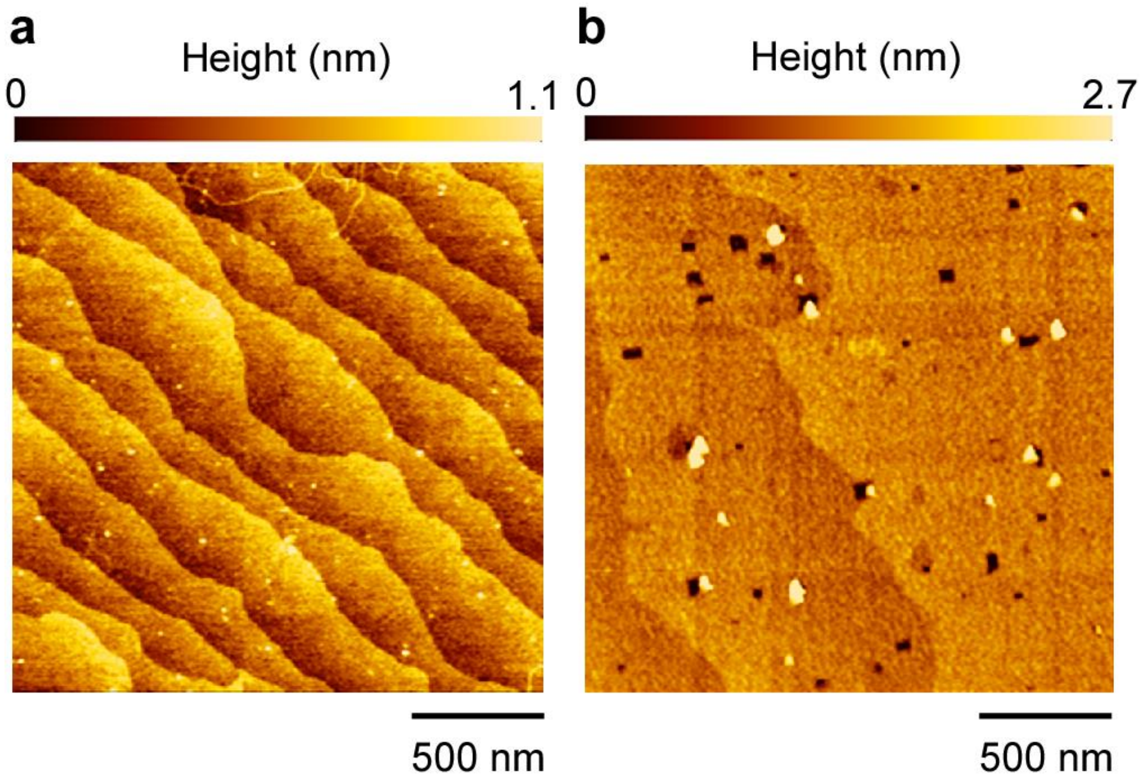


**Figure S5. Topographic AFM images of the $La_{0.02}$-$Ba_{0.98}SnO_3$ films.** (a) $O_2$-LBSO and (b) $O_3$-LBSO. Stepped and terrace structures were observed in both cases, which are commonly observed in high-quality epitaxial films. The oxygen conditions during the film growth do not seem to affect the film surface of the films.




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