Highlights

Novel superconducting and functional materials for energy and environment - 2019

Emerging proton conductivity at the interface between insulating $NdGaO_3$ and $BaZrO_3$

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In a previous article (R. Felici, et al, Phys. Status Solidi B 256, 1800217 (2019)) we reported on the increased conductivity present at the interface between Y-doped $BaZrO_3$ deposited by pulsed laser deposition onto a $NdGaO_3$ wide-band-gap insulator substrate. We made the hypothesis that the enhancement of the conductivity was due to the presence at the interface of a regular network of misfit dislocations. In order to rule out effects induced by the conductivity of the Y doping of the $BaZrO_3$ layer, which is a well known ionic conductor, the present article deals with the interplay between structural properties of the interface region and emerging proton conductivity in thin films of insulating $BaZrO_3$ (BZO) deposited onto $NdGaO_3$ (NGO). High-resolution transmission electron microscopy and surface x-ray diffraction reveal the presence of a large number of misfit dislocations at the interface, allowing the full relaxation of the epitaxial strain. An analysis of the x-ray diffraction patterns reveals the strain relaxation occurs over a thickness of about 3 nm, equally divided between the film and the substrate. Electrical impedance spectroscopy measurements show a sizeable proton conductance, which does not depend on the thickness of the $BaZrO_3$ layer, supporting the idea that transport is only limited to the interface region. The conductance of these systems, about 0.5 S/cm at 650 °C with an activation energy of about 0.86 eV, can mainly be attributed to the defective interface.

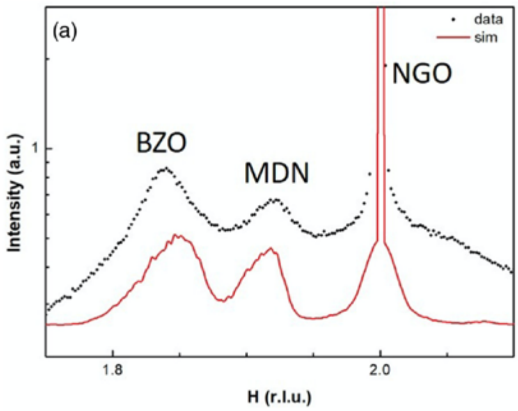

Fig. 1: Surface x-ray diffraction intensity scans along the H direction of a 2.9-nm BZO film on NGO. The full red lines represent theoretical simulations of the diffraction experimental data. BZO, NGO, and MDN tags specify the diffraction peaks associated to the film, to the substrate, and to the misfit dislocation network, respectively.

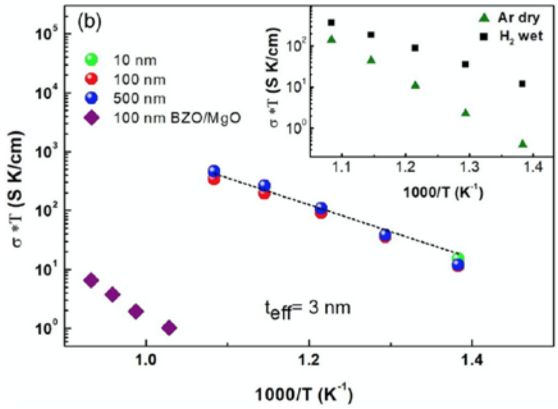

Fig. 1: Arrhenius plot of conductivity values calculated for three films of BZO grown on NGO and for a 100-nm-thick film of BZO grown on MgO, assuming the conducting layer is 3 nm for all the samples. In the inset, conductivity measurement of 100-nm-thick BZO film in dry Ar and wet H2 atmosphere.