Cross-plane thermal conductivity of $InGaO_3(ZnO)_m$ (m=integer) single crystalline thin films

Y. Wu[1], H. Cho[1,2], B. Feng[3], M. Mikami[4], W. Shin[4], Y. Ikuhara[3], and H. Ohta[1,2]
[1]IST-Hokkaido Univ., [2]RIES-Hokkaido Univ., [3]Univ. Tokyo, [4]AIST

E-mail: yuzhang_wu@eis.hokudai.ac.jp

The efficiency of thermoelectric power generation depends on the figure of merit ZT ($=S^2 \cdot \sigma \cdot T \cdot \kappa^{-1}$, where S is thermopower, σ is electrical conductivity, T is temperature, and κ is thermal conductivity). In several studies, reducing κ values by utilizing impurities and grain boundaries was proven to be very effective for achieving very high $ZT > 2$ [1, 2]. Thus, understanding the effect of grain boundaries on heat transportation, which is measured by Kapitza resistance, is of significant interest for developing better thermoelectric materials. However, since crystalline defects are often challenging to control, it is difficult to evaluate the effect of boundaries on in the heat transportation in thermoelectric materials.

$InGaO_3(ZnO)_m$ (m=integer) has a natural superlattice structure with adjustable periods (**FIG. a**). Therefore, it is an ideal material to evaluate the effect of boundaries on κ. We fabricated single crystalline $InGaO_3(ZnO)_m$ thin films[3] on (111) YSZ substrates with different m values, which have periodic structures with the periods varying from 1.4 nm to 9.1 nm (**FIG. b**).

The κ of the resultant $InGaO_3(ZnO)_m$ films was measured by the TDTR method at RT (**FIG. c**). As the interface density increased, κ of $InGaO_3(ZnO)_m$ decreased, which is similar to the observation of $In_2O_3(ZnO)_m$ ceramics [4]. In this research, we quantify the Kapitza resistance at interfaces in $InGaO_3(ZnO)_m$ superlattice to determine the role of boundaries in the transportation of heat in layer stacking direction of $InGaO_3(ZnO)_m$.

[1] B. Poudel *et al.*, *Science* **320**, 634 (2008).
[2] K. Biswas *et al.*, *Nature* **489**, 414 (2012).
[3] H. Ohta *et al.*, *Adv. Funct. Mater.* **13**, 139 (2003); K. Nomura *et al.*, *Science* **300**, 1269 (2003).
[4] X. Liang *et al.*, *Appl. Phys. Lett.* **102**, 223903 (2013).

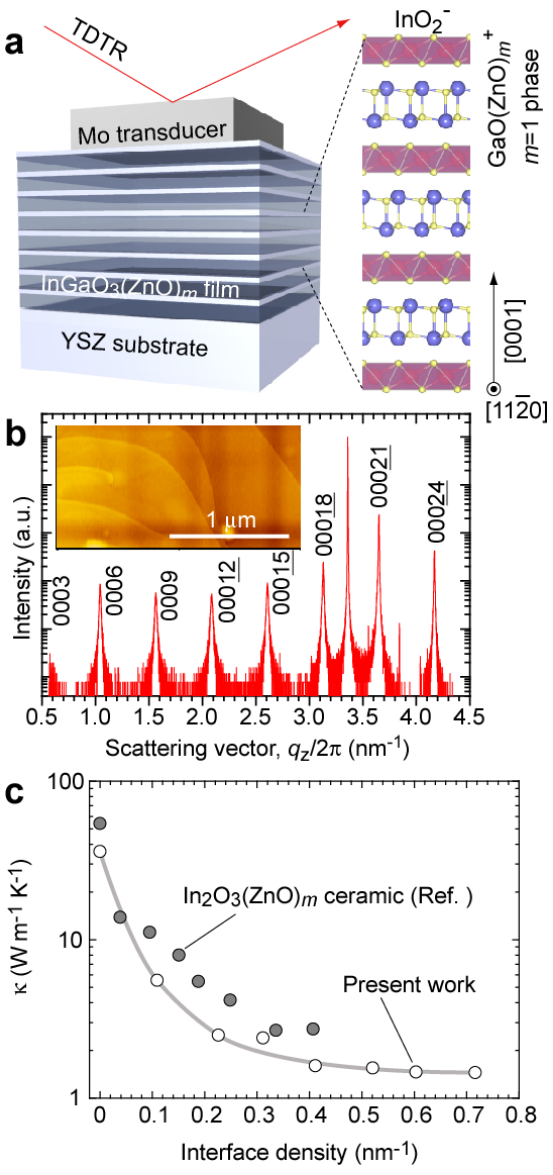

FIG. (a) Schematic illustration of the TDTR measurement, (b) crystallographic data (out-of-plane XRD pattern and topographic AFM image for m=5 film), and (c) thermal conductivity of $InGaO_3(ZnO)_m$ single crystalline films.