EFFECT OF GRAIN BOUNDARIES ON ION MIGRATION IN STABILIZED d-Bi_2O_3 THIN-FILM ELECTROLYTES

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Solid electrolytes with high oxygen-ion conductivity are of significant interest for many applications. Over the past several decades, numerous studies have been conducted on the effect of grain boundaries on the process of increasing the ionic conductivity of solid electrolytes. Given that nanocrystalline thin- or thick-films have been investigated in relation to lowering the operating temperature of solid electrolytes to less than 650 °C, more rigorous and quantitative assessments are necessary to determine how the ion transport characteristics are affected by the numerous interfaces formed in nano-grains devices.

In this context, we selected highly conductive stabilized δ-Bi_2O_3 as a target material and investigated the effect of grain boundary on ionic transport properties. More specifically, we focused on the oxygen ion conductivity and the phase stability that are closely associated with migration of anions and cations, respectively. The nano-polycrystalline thin films of yttria-stabilized Bi_2O_3 (YSB) and erbia-stabilized Bi_2O_3 (ESB) were prepared by the pulsed laser deposition (PLD), and the oxygen ion conductivity was analyzed by AC impedance spectroscopy (ACIS) as a function of temperature and oxygen partial pressure. First, both epitaxial and polycrystalline YSB films show nearly identical levels of oxygen ion conductivity at elevated temperature (350~500 °C) despite the fact that the poly-film possesses an extremely high density of the grain boundaries. Second, the epitaxial ESB thin film maintained cubic δ-phase for a long time (> 100 h) at 600 °C without any conductivity deterioration, whereas the poly film exhibited abrupt phase transition and reduced conductivity similar to bulk ESB. These observations provide precise, quantitative understanding of grain boundary effects through well-defined control experiments and a new direction for utilizing a stabilized δ-Bi_2O_3 as high-performance electrolytes for high-temperature electrochemical applications.

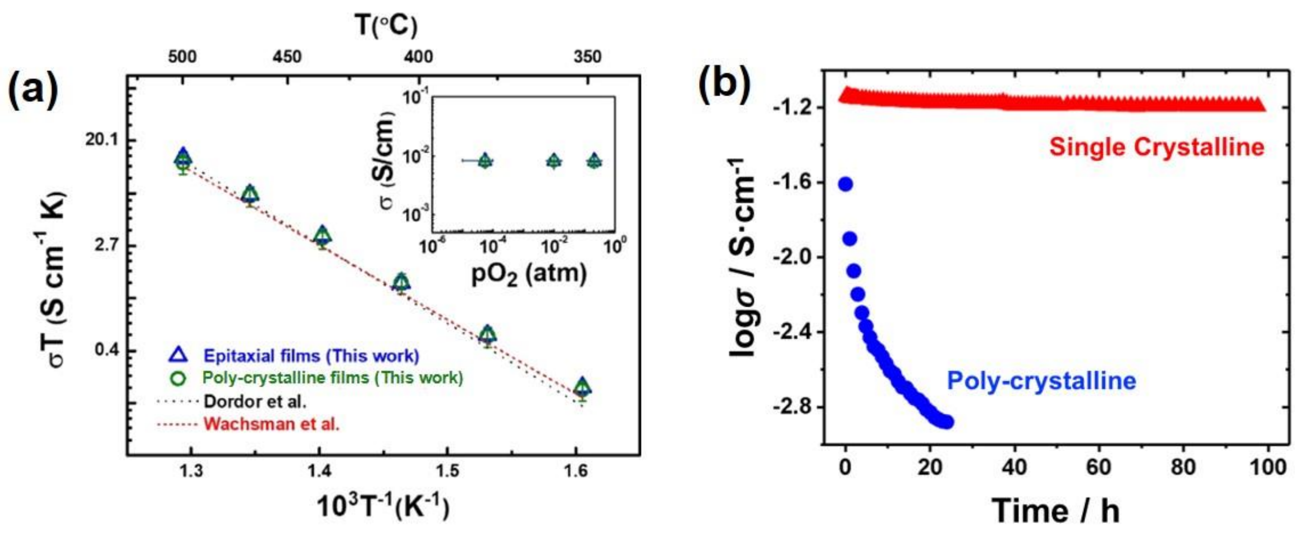

Figure 1 – (a) Arrhenius plot of the electrical conductivity of epitaxial and poly-crystalline YSB films and the (b) time-dependent conductivity behavior in epitaxial and poly-crystalline ESB films, respectively.