

Thermoelectric properties of Indium and Gallium - codoped ZnO thin films

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It is well known that thin film properties such as electrical, optical, thermal properties,... depend on crystal quality of thin films. Recently, researchs on thermoelectric materials have gain interest due to requirement for alternative and sustainable energy sources. We found that among three parameters which control figure of merit ZT of thermoelectric materials are (1) low thermal conductivity κ for obtaining a large temperature gradient between two ends of the material; (2) high electrical conductivity σ ; (3) large Seebeck coefficient S is needed to generate a high voltage per unit temperature gradient. However, electrical conductivity and thermal conductivity vary in a similar way. For example, improvement in σ also increases in κ . Therefore, improvement in ZT is not an easy task. Lattice thermal conductivity can be reduced by degrading crystal quality of materials through introduction of structural defects such as point defects, dislocations, interfaces, precipitates, nanostructure engineering. However, low crystal quality also reduces electrical conductivity. Due to dopant radius, solubility of single dopant (Al, Ga, In...) in the host ZnO materials limit a control of electrical conductivity and crystal quality. In our point of view, because of the difference in ionic radii between Ga (0.062 nm), In (0.081 nm) and Zn (0.074 nm), combination of the larger (In) and smaller (Ga) dopants in size compared to the host atom (Zn) can control the ZnO crystal structure efficiently compared to single dopants, which in turn control electrical conductivity and also thermal conductivity of the host ZnO thin films. In this report, we discuss effects of In and Ga dopants on crystallinity, electrical and thermoelectric properties of ZnO thin films.

Keywords : crystalline IGZO thin film, multi-dopants, electrical properties, thermal conductivity, localized states, film crystallinity, thermoelectric properties