New evaluation method on various gas barrier performances using functional oxide films (1); O_2 or H_2O barrier properties

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Recently, the development of electronic devices on flexible substrates such as polyethylene terephthalate (PET) has been challenged by their poor intrinsic gas barrier properties compared to glass or silicon substrates. As device components are susceptible to degradation caused by atmospheric oxygen or water vapor gas, achieving low water vapor transmission rate (WVTR) and oxygen transmission rate (OTR) are important to ensure device stability and reliability. Among various candidates, amorphous zinc tin oxide (a-ZTO) and amorphous silicon nitride (a-SiNx) films have emerged as promising materials due to their excellent gas barrier performance.[1-3] In this study, a-ZTO[1)] or a-SiNx[2), 3)] thin films with thicknesses ranging from 20 to 200 nm were deposited on glass substrates by RF sputtering using a ZTO (Zn:Sn=2:1) or Si targets, respectively. For the gas barrier evaluation, these a-ZTO and a-SiNx films were deposited onto glass substrates pre-deposited with various transparent conductive oxide (TCO) layers, such as amorphous indium zinc oxide (a-IZO)[4),5)] or ITO films. The as-deposited films and post-annealed films in air were evaluated in carrier density (*n*) of the TCO layers by Hall effect measurements in order for the quantitative estimation on how many oxigen vacacies were disappeared by the annealing oxidation, reflecting the amount of oxygen transmitted [3)]. Figures 1 (a)-(c) and (d)-(f) show the electrical properties of ITO and IZO thin films coated with the gas barrier layers, respectively, where the as-deposited films and the post-annealed films are indicated by ● and ▼, respectively. For ITO films [1], coating with a-SiNx (≥20 nm) prevented a decrease in carrier density after annealing at 400 °C in air, indicating excellent barrier performance. In contrast, a-ZTO films (even at 150 nm) or additional 100 nm SiNx layers on ZTO/ITO showed the decrease in carrier density, suggesting oxygen diffusion from ZTO into the ITO layer in Fig. 1-(b) and (c) because ofn the high annealing temperature of 400 °C. In the case of IZO films, the use of a-SiNx (≥20 nm) and a-ZTO (≥20 nm) films as the over layers effectively suppressed carrier reduction after annealing temperature at 250°C. With thicker ZTO films (≥150 nm) or additional 100 nm SiNx film depositions, the decrease in carrier density was negligible, confirming their oxygen barrier effects. On the evaluation on H_2O vapor barrier properies Al doped ZnO (AZO) films were adopted as the TCO, that will be reported in detail in the conference.

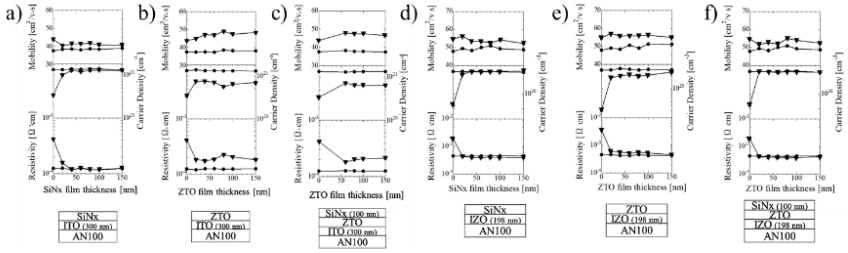

Fig. 1. Electric properties of SiN_x ZTO and SiN_x/ZTO films were deposited on ITO film (a) – (c) and IZO film (d) – (f)

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