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Crystallinity control of sputtered ZnO films by utilizing buffer layers fabricated via nitrogen mediated crystallization: Effects of nitrogen flow rate

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ZnO is a promising material for transparent conductive oxide (TCO). Since the crystal orientation and the grain size strongly affect both the carrier density and the mobility, crystallinity control is of great significance for further improvement of ZnO films. We have recently demonstrated a novel fabrication method of ZnO films utilizing nitrogen mediated crystallization (NMC), where the crystal nucleus density can be controlled because the nitrogen atoms suppress crystallization of ZnO films [1]. The resultant NMC-ZnO films have well aligned crystal orientation and large grain size compared with the films prepared by a conventional sputtering. Here we utilize the NMC-ZnO films as buffer layers for ZnO:Al (AZO) TCO films and clarify the effects of the N_2 flow rate during sputter deposition of NMC buffer layers on the crystallinity of the AZO films as well as the NMC-ZnO buffer layers. Both the crystal orientation and the grain size of the NMC buffer layers highly depend on the N_2/Ar flow rate ratio. Introduction of small amount of N_2 (N_2/Ar = 4/20.5 sccm) drastically improves the crystallinity of the buffer layers. FWHM of XRD patterns for 2θ-ω and ω scan of (002) plane are 0.25° and 2.6°, being significantly small compared with 0.92° and 3.5° for the buffer layers fabricated without N_2. However, a further increase in N_2/Ar flow rate ratio deteriorates the crystallinity, because excess N atoms in the films disarrange the crystal structure of ZnO. As a result, AZO films with high crystallinity have been successfully fabricated by utilizing the NMC-buffer layers deposited at N_2/Ar = 4/20.5 sccm. The crystal grain size of 100-nm-thick AZO films on the NMC-buffer layers is 60 nm, which is about 5 times larger than that of conventional AZO films. The effects of N_2/Ar flow rate ratio on the electrical properties of AZO films will be discussed at the conference. [1] N. Itagaki et al., Appl. Phys. Express 4 (2011) 011101.

Keywords
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