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Ar/N_2スパッタリングによる低抵抗アモルファスITO膜の作製：ターゲットー基板間距離の影響

Fabrication of low resistive amorphous ITO films using Ar / N_2 sputtering: Effects of target-substrate distance

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We have recently developed a new fabrication method of amorphous In_2O_3:SnO_2 (a-ITO), nitrogen mediated amorphization (NMA), where a-ITO films are obtained by just introducing N_2 gas into the sputtering atmosphere [1.2]. The NMA method enables us to make a-ITO films with high mobility of 50 cm^2/Vs as well as high thermal stability, where the films maintain the amorphous nature even after annealing at 300°C. Since the flux ratio of N atom to the sputtered atoms changes with the change of target/substrate configuration, the distance between target and substrate ($d_{T\text{-}S}$) should have significant influences on the film properties. Here, aiming to further improvement of the film quality, effects of T-S distance are studied through the analysis of a-ITO films fabricated at various N_2/Ar flow rate ratios.

ITO films were fabricated on quartz glass substrates at 150°C by radio-frequency (RF) magnetron sputtering. $d_{T\text{-}S}$ was varied from 55 to 115 mm. In_2O_3:SnO_2 (10 wt.%) targets were used, and the supplied RF power was 100 W. N_2/Ar flow rate ratio was 0–5%, and the total gas pressure was 0.9 Pa. The film thickness was 50 nm

All the samples fabricated in this study show no x-ray diffraction peaks, indicating that all ITO films are amorphous, due to the low substrate temperature.

Figure 1 shows the electrical properties of a-ITO films as function of $d_{T\text{-}S}$ for various N_2/Ar flow rate ratios. N_2 addition brings significant increase in the mobility from 12–18 to 40–45 cm^2/Vs. We also found that $d_{T\text{-}S}$ affects on the electrical properties. Especially at N_2/Ar =1%, the carrier density decreases with increasing $d_{T\text{-}S}$. Since the flux of sputtered atoms decreases with increasing $d_{T\text{-}S}$ [3] whereas $d_{T\text{-}S}$ have little effect on N atom flux [4], the flux ratio of N atom to sputtered atoms should increase with $d_{T\text{-}S}$. This might contribute to the deactivation of Sn donors, and thus to the carrier density decrease. As a result, a-ITO films with lowest resistivity of 7.5×10^{-4} Ω·cm was obtained at N_2/Ar = 1% and $d_{T\text{-}S}$ = 55–85 mm.

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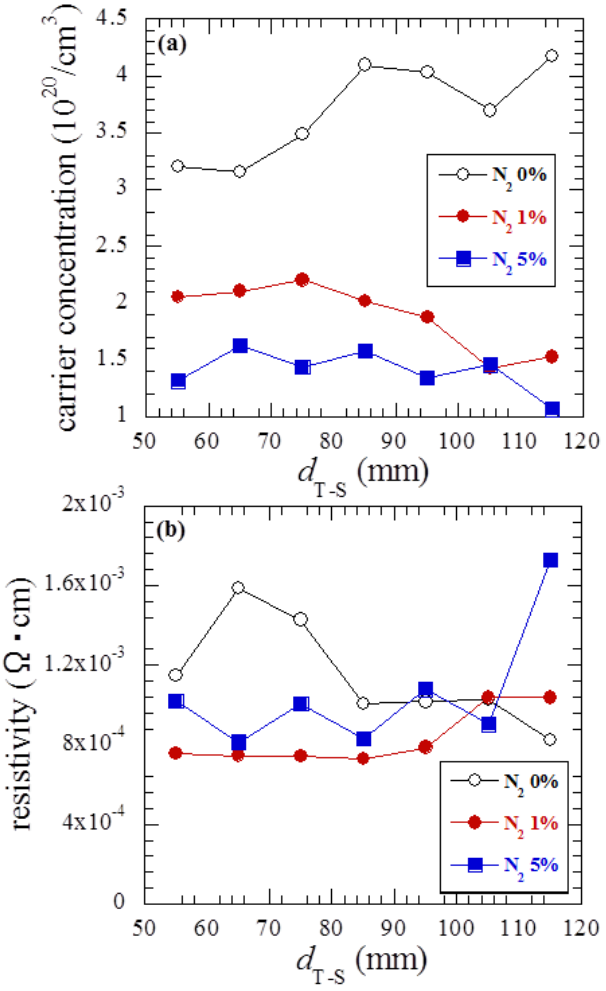

Fig. 1 Electrical properties of a-ITO films as a function of $d_{T\text{-}S}$ for various N_2/Ar flow rate ratios. carrier concentration (a), resistivity (b).