SOLID-PHASE CRYSTALLIZATION OF HYDROGEN-DOPED INDIUM OXIDE FOR LOW-TEMPERATURE PROCESSED TFTS

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An amorphous In–Ga–Zn–O (IGZO) has attracted particular attention for thin-film transistor (TFT) applications owing to its high field effect mobility (μ_{FE}) of more than 10 $cm^2V^{-1}s^{-1}$, steep subthreshold swing, extremely low leakage current, large-area uniformity, and good bias stress stability. Although the μ_{FE} of an IGZO TFT is over one order of magnitude higher than that of an amorphous Si TFT, further improvement of the μ_{FE} of oxide TFTs is required to expand their range of applications for both the displays and LSIs. An indium oxide (InO_x) is known as a potential material for enhancing the μ_{FE} of oxide TFTs. However, undoped InO_x exhibit a high background carrier density of over 10^{20} cm^{-3}, making them unsuitable for a channel material of the TFTs.
In this presentation, nondegenerate ($<10^{18}$ cm^{-3}) hydrogen-doped poly-InO_x (InO_x:H) thin films were successfully prepared by low-temperature (250°C) solid phase crystallization (SPC). An amorphous InO_x:H thin film was first deposited by sputtering in Ar, O_2, and H_2 gases. Then, the SPC was carried out by an annealing at more than 175 °C (Fig. 1(b)). Hall mobility of the InO_x:H films significantly increased to over 70 cm^2 $V^{-1}s^{-1}$ after the SPC at 250–300 °C in N_2; however, these films were degenerate semiconductors with the carrier density of approximately 10^{20} cm^{-3} (blue solid line in Fig. 1(d)). In contrast, the InO_x:H films changed from degenerate to nondegenerate semiconductor when the SPC was carried out in air. Carrier density of the InO_x:H films markedly decreased to as low as 2.4×10^{17} cm^{-3} (red solid line in Fig. 1(d)), which is approximately three orders of magnitude lower as compared with the SPC in N_2 (Fig. 1(f)). The TFTs with a nondegenerate poly-InO_x:H channel were fabricated using an anodized alumina (Al_2O_3) as a gate insulator. An anodized Al_2O_3 has several advantages, such as self-limiting room-temperature process, high dielectric constant, conformal, and pinhole free, to make suitable for a gate insulator (GI) of low-temperature processed TFTs. We demonstrated low-temperature (250 °C) processed poly-InO_x:H TFTs with Al_2O_3 GI using a fully photolithography process. Detail electrical properties of the TFTs will be discussed.

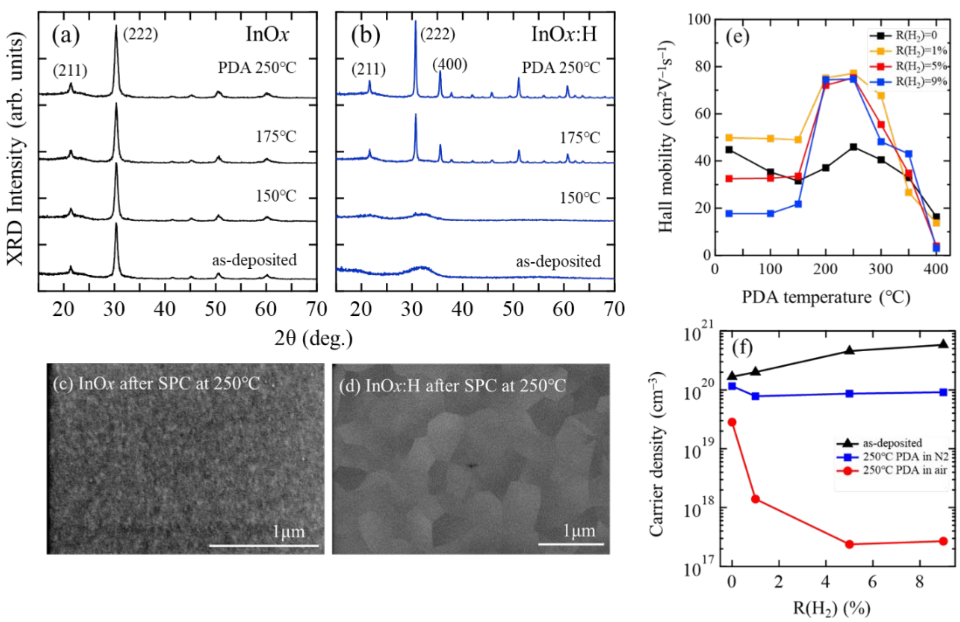

Figure 1 Changes of XRD spectra of (a) InO_x and (b) InO_x:H films after annealing. SEM surface views of (c) InO_x and (d) InO_x:H films after SPC at 250 °C. (e) Hall mobility of InO_x and InO_x:H films as a function of annealing (in N_2) temperature. (f) Carrier density of as-deposited, N_2-SPC, and air-SPC InO_x and InO_x:H films.

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