水素添加 In_2O_3 薄膜の固相結晶化過程における金属-半導体遷移

Metal–semiconductor transition of hydrogen-doped In_2O_3 via solid-phase crystallization.

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Metal oxide semiconductors have attracted a lot of attention for use as an active channel layer of thin film transistors (TFTs) for next-generation flat-panel displays, nonvolatile memories, and so on, due to its outstanding electrical and optical properties.

Our group reported the metal-semiconductor transition (MST) of hydrogen-doped indium oxide (InO_x:H) films via low-temperature (~200 °C) solid phase crystallization (SPC) in ambient air. Field effect mobility of over 100 cm^2/Vs have been obtained from the TFTs with nondegenerate InO_x:H channels [1,2]. However, the MST mechanism of the InO_x:H films has not clarified yet. In this presentation, the effect of oxygen and hydrogen during the deposition on carrier density (Ne) of SPC- InO_x:H films have been investigated.

The 50-nm-thick InO_x:H films were deposited by RF magnetron sputtering in Ar, O_2, and H_2 gases. The O_2 gas flow ratio (R[O_2]) was varied from 2 to 4%, while H_2 gas flow ratio (R[H_2]) was varied from 1 to 9%. The InO_x:H films were then annealed in ambient air at 250 °C for 1 to 60 min.

Figure 1(a) shows the *in-situ* Hall measurement results of the InO_x:H films deposited at R[O_2]-R[H_2] of 3-5 and 4-5%. No significant difference of Ne was observed between the films annealed in vacuum, whereas Ne of both the films decreases significantly at 190 °C owing to the SPC in air. Figure 1(b) shows the annealing time dependence of the Ne of InO_x:H films. We found that the required annealing time for MST strongly depended on both the R[O_2] and R[H_2]. The InO_x:H film deposited at R[O_2]-R[H_2] of 4-5% exhibited a rapid MST within 5 min, while compared with the film deposited at 4-5%, the film deposited at 3-5% showed a slow MST around 30 min. The effect of deposition condition on Ne reduction during annealing in air will be discussed in detail.

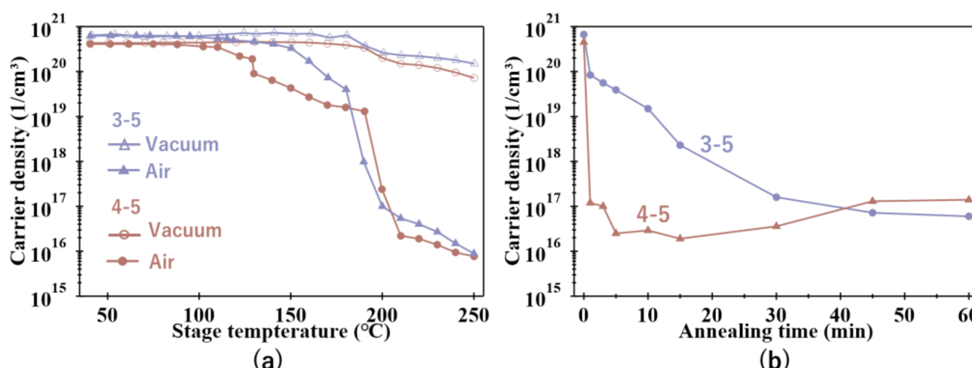

Figure 1. (a) *In-situ* Hall measurement results of the InO_x:H films measured in air and vacuum. (b) Annealing time dependence of the Ne for the InO_x:H films at 250 °C.

Reference [1] Y. Magari, *et al.*, Nature communications, **13**, 1078 (2022).

[2] T. Kataoka, *et al.*, Materials, **15(1)**, 187, (2022).