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Improved indium oxide transparent conductive thin films by hydrogen annealing

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ABSTRACT

In₂O₃ thin films were prepared by reactive evaporation with post-annealing treatment at forming gas of N₂ and H₂. After post-annealing treatment, the films annealed at forming gas achieved lowest resistivity of $2.70 \times 10^{-4} \Omega \cdot \text{cm}$. The XRD results show that the In₂O₃ films annealed in forming gas and N₂ with good recrystallization. In the forming gas annealing process, hydrogen plays a key role in the generation of oxygen vacancy and enhances the formation of In–OH bond which may influence the electrical and optical properties of the In₂O₃ films.

Keywords : Hydrogen, Indium oxide, Thermal annealing, Oxygen vacancies, Thin films, XPS

1. Introduction

Transparent conductive oxides (TCO) have been used in optoelectronic devices, such as thin films transistor [1] and heterojunction silicon solar cells [2]. Researchers had reported study of In₂O₃ thin films annealed in N₂, air [3], and vacuum [4], respectively. In previous studies, it was found that the chemical states and surface morphology of In₂O₃ films are strongly affected by the gaseous environment during the annealing process [5]. In this study, the In₂O₃ thin films were annealed forming gas and N₂ to investigate the influence of hydrogen on film properties of In₂O₃.

2. Material and methods

In₂O₃ thin films of 100 nm thickness were deposited on glass and polished silicon wafer. Prior to deposition, the chamber was pumped to 8×10^{-4} Pa, and indium particles of 99.999% purity were placed on a tungsten boat. High purity oxygen (99.995%) was used as reactive gas. As-deposited In₂O₃ was deposited by reactive evaporation, followed by furnace annealing in N₂ or forming gas of N₂ and H₂ (N₂ : H₂=90:10). As-deposited In₂O₃ films had a raw resistivity of about $5 \times 10^{-2} \Omega \cdot \text{cm}$ and

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