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Growth of $AgGaTe_2$ Layers by a Closed-Space Sublimation Method

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$AgGaTe_2$ layers were deposited on Si substrates by the closed-space sublimation method. Multiple samples were deposited with various source temperatures and holding times, and constant temperature differential. Variation of the source temperature was used primarily to improve the stoichiometry of the film. Deposited films were evaluated by the θ–2θ method of x-ray diffraction (XRD) and transmission electron microscopy. These results confirmed that the deposited films were stoichiometric (after optimizing the above parameters). From XRD, it was also clear that films deposited on Si (111) have strong preference for (112) orientation.

Key words: Closed-space sublimation method, chalcopyrite compound, $AgGaTe_2$

INTRODUCTION

CdTe is one of the most promising photovoltaic materials available for use in low-cost, high-efficiency solar cells because of its near-optimal bandgap and high absorption coefficient.[1–7] Also, chalcopyrite I–III–VI_2 compounds have recently attracted attention as potential components for semiconductor devices, including applications in solar cells and electrooptic devices.[8–10] In particular, $CuInSe_2$ has already become widely used in making commercial solar cells.[11,12] The bandgap of $AgGaTe_2$ at room temperature is 1.3 eV (close to optimal for absorbing the solar spectrum), and a high optical absorption coefficient is also expected.[13–16] As such, $AgGaTe_2$ is expected to be another ideal candidate novel solar cell material. The lattice constants for the a and c axes of $AgGaTe_2$ are 6.28 Å and 11.94 Å, respectively. Even though the lattice mismatch is fairly large, Si was employed as the substrate in this study owing to its wide use as a substrate material.

This study presents the first deposition of $AgGaTe_2$ thin films by a closed-space sublimation (CSS) method on Si substrates. The CSS method is a vacuum evaporation technique[17,18] and has many advantages for the fabrication of low-cost solar cells; for example, it leads to a rapid growth rate, and the growth system is typically simple. As such, the CSS method is widely used in the fabrication of CdTe thin-film solar cells.

In the CSS method, the stoichiometric powder source and the substrate are placed a very small separation distance apart (a few millimeters) while the source is maintained at a higher temperature than the substrate. Parameters such as the source temperature and temperature differential are crucial for depositing high-quality films. The vapor pressures of Te and Cd are relatively close to each other. As such, control of the stoichiometry during the growth of CdTe by the CSS method is relatively easy. In contrast, the vapor pressures of Te and Ag/Ga are quite different, resulting in some difficulty in controlling the stoichiometry of prepared $AgGaTe_2$ films.

Crystallinity and stoichiometry of the deposited films were studied by x-ray diffraction (XRD) and transmission electron microscopy (TEM). The Cu K_α line was used, and the K_β line was minimized using a nickel K_β filter. In particular, the quality of the film was carefully considered at both macroscopic and microscopic levels. The TEM device (JEM-2100F, JEOL) uses energy-dispersive x-ray (EDX) mapping to resolve images on nanometer scale. This

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