Effects of In-Situ Annealing on Sub-micron Thick Cu(In,Ga)Se_2 Thin Films

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The efficiency is generally decreased with the thickness of Cu(In,Ga)Se_4 films due to decreasing short circuit current density (J_{sc}) [1]. Furthermore, the open circuit voltage (V_{oc}) and fill factor (*FF*) also decreased with thickness. The main causes of changed V_{oc} and *FF* are surface morphology, grain size, various defects, etc. Many researchers have attempted to improve these parameters [2]. Recently, we observed that V_{oc}, J_{sc}, and *FF* of sub-micron thick CIGS films were significantly improved after an in-situ annealing process. In addition, this method can simply improve surface morphology and grain size by supplying thermal energy.

Sub-micron thick Cu(In,Ga)Se_2 (CIGS) thin films were deposited on Mo-coated soda-lime glass substrates under various conditions by single-stage co-evaporation. Generally, the short circuit current (J_{sc}) decreased with the decreasing thickness of the absorber layer. However, in this study, J_{sc} was nearly unchanged with decreasing thickness, while the open circuit voltage (V_{oc}) and fill factor (*FF*) decreased by 31.9 and 31.1 %, respectively. We believe that the remarkable change of V_{oc} and *FF* can be attributed to the difference in the total amount of injected thermal energy. Using scanning electron microscopy, we confirmed that the surface morphology becomes smooth and the grain size increased after the annealing process. In the X-ray diffraction patterns, the CIGS thin film also showed an improved crystal quality. We observed that the electric properties were improved by the in-situ annealing of CIGS thin films. The reverse saturation current density of the annealed CIGS solar cell was 100 times smaller than that of reference solar cell. Thus, sub-micron CIGS thin films annealed under a constant Se rate showed a 64.7 % improvement in efficiency.

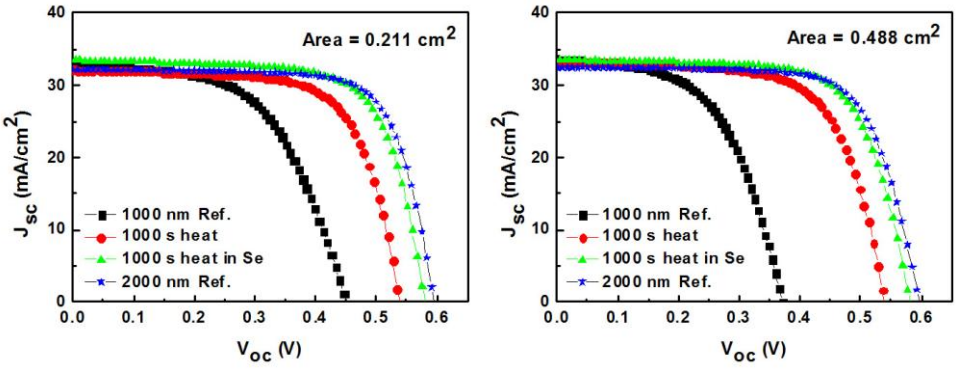

Fig. 1. Current–voltage (*J-V*) curves of sub-micron-thick CIGS films grown under different conditions.

Acknowledgment

This work was supported by the DGIST R&D Programs of the Ministry of Science, ICT & Future Planning of Korea (15-BD-05).

References

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