Formation of Low-Cost CIGSe Absorber by a Novel Selenization Process

Jeong-Yoon Kang, G. Sreedevi, and Chan-Wook Jeon*
School of Chemical Engineering, Yeungnam University, 280 Daehak-ro, Gyeongsan 712-749, Korea.
**Corresponding Author: Tel.: +82-53-810-3860, E-mail: cwjeon@ynu.ac.kr*

$Cu(In,Ga)Se_2$ is the most promising alternative absorber to replace commercialized Cd-containing absorbers for high conversion efficiency solar cells. To date, various vacuum and non-vacuum processes have been reported for the synthesis of CIGSe absorber films. Among them, vacuum methods are known to have higher perfection for mass production technology to produce high quality CIGSe film [1-2]. Especially, the sputtering process followed by selenization is significant for the production of large scale and low cost CIGSe thin film photovoltaic module. However, the commercial selenization is carried out using H_2Se gas which is highly toxic and corrosive. Furthermore, the cost of H_2Se gas is more than 30% of total material cost to make a CIGS photovoltaic module. To avoid this problem, a lot of research had been done utilizing a pure Se for selenization process. But the distribution of Se over a large area is extremely hard. Hence in the present work, we developed a novel selenization technique applying Nozzle-Free-Shower (NFS) as a Se supply source. NFS is the vehicle consisted of porous material to selectively transmit Se vapor. So, large area manufacturing process is possible by simple extending the areal dimension of NFS. This paper explores the reaction mechanism of NFS process for optimizing Cu(In,Ga) selenization to get CIGSe film. Schematic diagram of selenization process(step a to step e) by using NFS RTP was represented in Fig. 1(a). Cu(In,Ga) thin film was pre-heated below 300 ^oC for soaking Se into the precursor film. Subsequently the high temperature annealing processes over 500 ^oC were applied for the grain growth. The whole process was interrupted to observe the phase evolution using X-ray diffraction and the corresponding profiles are shown in Fig. 1(b). During the preheating stage at a low temperature, Se is soaked deep in the precursor and homogenized to give good crystalline film with CuSe phase. At the beginning step of selenization (550 ^oC), CIGS phase formation was initiated throughout the film and then continuously grew to larger CIGS grains which resulted an improvement in the intensity of (204)/(220) peak. During the step d and e, Se reacts with Mo and makes $MoSe_2$, so the XRD pattern showed $MoSe_2$ peak at these steps. The present results suggested that the NFS can be scaled up to any size with excellent Se uniformity, will be beneficial for low-cost CIGSe absorber formation by replacing the high cost H_2Se process.

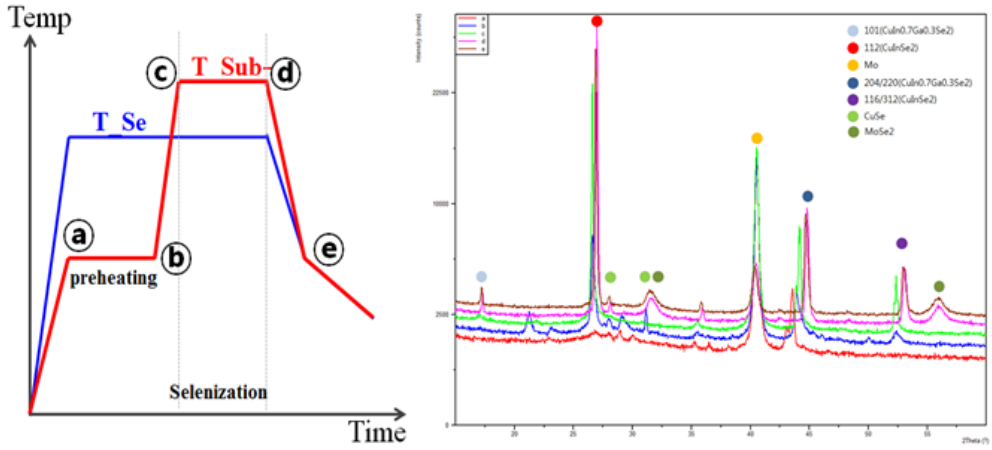

Fig. 1(a) & (b). Schematic diagram of selenization process by using NFS RTP and the XRD patterns of corresponding films

Acknowledgment

This work was supported by the Human Resource Training Program for Regional Innovation and Creativity through the Ministry of Education and National Research Foundation of Korea (NRF-2014H1C1A1066809).

References

1. E.P. Zaretskaya, *Thin Solid Films*, 515(15), 5848 (2007).
2. D.S.Albin, *Proceedings of the 22nd IEEE PVSC*, 562 (1990).