**Surface effects of CIGS thin films between one-step sputtering and co-evaporation process on cell efficiency characterized by scanning probe microscopy**

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Cu(In₁₋ₓGaₓ)Se₂ (CIGS) compound semiconductors have attracted much attention as an absorber material in thin film solar cells because of a high absorption coefficient (1 x 10⁵ cm⁻¹) and controllable band gap energies (1.0 ~ 1.65eV) [1]. Among them, the polycrystalline CIGS solar cells show the higher cell efficiency (~20%) than that of the single crystal solar cells (~13%) [2]. Controversially, grain boundaries (GBs) in polycrystalline CIGS materials have been issued whether or not to act recombination centers for photo-generated carriers. In the literature reported by C. –S Jiang et al., it has been proved that the built-in potential was caused by positive charges trapped at the GB, and the potential plays an important role to attract electrons and repulse holes [3]. In order to investigate the effects of built-in potential at the GBs and inter grains, one-step sputtered CIGS films were used to compare with high performance CIGS films fabricated by co-evaporation process. CIGS thin films were fabricated by using Se-contained quaternary CIGS target and Cu-Se binary target with composition ratio of 0.55:0.7:0.3:2 and 1:1 for Cu:In:Ga:Se and Cu:Se, respectively. Cu-Se interlayer having liquid phase around 580°C was firstly deposited to improve the grain size of the CIGS films and then the one-step sputtered CIGS thin films were grown at 600°C without any additional selenization. Compared to high performance CIGS films grown by co-evaporation, composition ratios of Cu/[In+Ga], Ga/[In+Ga], and Se/[Cu+In+Ga] of one-step sputtered CIGS films are almost consistent. In addition, the only chalcopyrite characteristics without secondary phases such as Cu-Se and OVC were observed in XRD and Raman analysis. Despite the similar physical properties both two films, the CIGS solar cells exhibited considerable differences in device performance, showing the cell efficiency of 10.8 and 18% were observed at one-step sputtering and co-evaporation process, respectively.

In this study, we have investigated GBs potential by using KPFM (Kelvin prove force microscopy) measurement to study the GBs potential effect on the cell performance. Furthermore, detailed results will be discussed to fabricate highly surface-improved CIGS films.

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**Fig. 1.** Cross-section and plane view SEM images of CIGS thin films grown by (a) one-step sputtering method and (b) co-evaporation process.

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