Large-Area $CuInGaSe_2$ Solar Cell Efficiency Improvement Using H_2-Plasma-Enhanced Process

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A progressing non-toxic plasma-enhanced solid Se vapor selenization process (PESVS) technique compared to hydrogen assisted Se vapor selenization (HASVS) to achieve a large-area (40x30 cm^2) $Cu(In,Ga)Se_2$ (CIGS) solar panel with enhanced efficiencies from 10.8 % to 13.2 % (14.7 % for active area) was demonstrated. The effects of plasma steps, plasma power and selenization temperature and optimized condition were thoroughly studied in this paper. The remarkable enhancement of the efficiency were ascribed to better crystallinity and enlarged grain size, less Se vacancy formation as well as uniform Ga distribution. These microstructure and compositional change improved fill factor, short circuit current and open circuit voltage, respectively. From reaction kinetics point of view, PESVS provides extra energy to crack Se then help to decrease the reaction activation energy. We believed that this work can provide a facile approach of low temperature selenization for flexible substrate applications or fast selenization for throughput consideration, thus stimulate the mass-production in large scale CIGS PV industry.

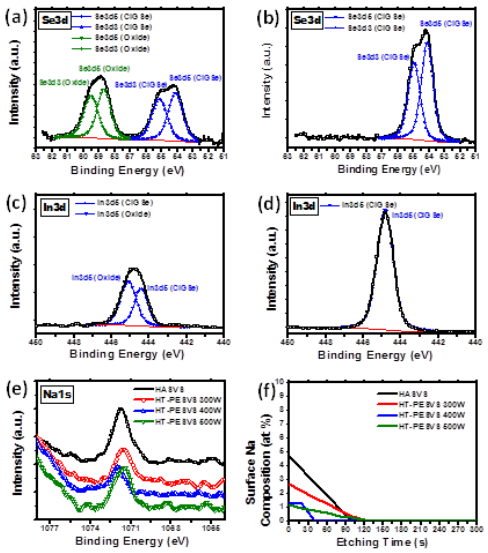

Fig. 1, XPS spectra with and without plasma enhanced reaction for Cu(In,Ga)Se2 films. (a) and (b) were Se 3d spectra, (c) and (d) were In 3d spectra. (e) and (f) were Na 1S spectra and compositional depth profile according to the plasma power.

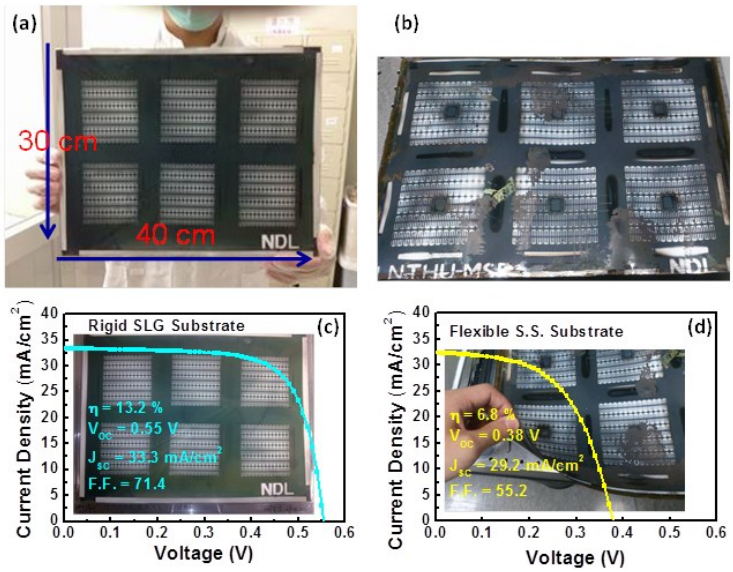

Fig. 2, (a) and (b) were schematic and PESVS cell performance of G1 size (30 cm x 40 cm) CIGS solar panel with rigid soda-lime glass substrate. (c) and (d) were schematic and Low temperature PESVS cell performance of G1 size (30 cm x 40 cm) CIGS solar panel with flexible stainless steel substrate.

References

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