The Report of Study in compound thin film solar cells

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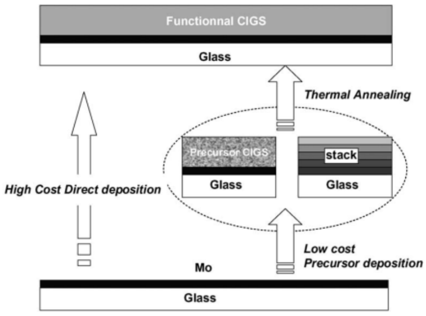
In a recent Copenhagen Convention on Climate Change (COP15), the interest of cosmopolitan represented that we currently have in environmental matter which is serious by emitting CO_2. To solve this problem, one of solutions is to use thin film solar cells which is using unlimited clean source without emitting CO_2. Thin film solar cells have advantageous such as strong light absorbers, a thickness of 1.5 ㎛ and so on. Figure1. showed how to fabricate $CuInS_2$ (CIS) thin film by using different methods.



<Figure1. Thin film fabrication methods>

In order to lower the production cost of solar cells and the rate of electricity generated by solar cells, expensive processes must be replaced with cheap processes as much as possible. For this purpose, electrodeposition is one of the most promising methods because of its low equipment cost, negligible waste emissions, and possible formation of a compact film required for solar cell application. In this method, the heat treatment is required to increase film properties by using thermal annealing process. My work in helmholz zentra berlin, HZB was focused on how to fabricate CIS thin film solar cells using electrodeposition method.

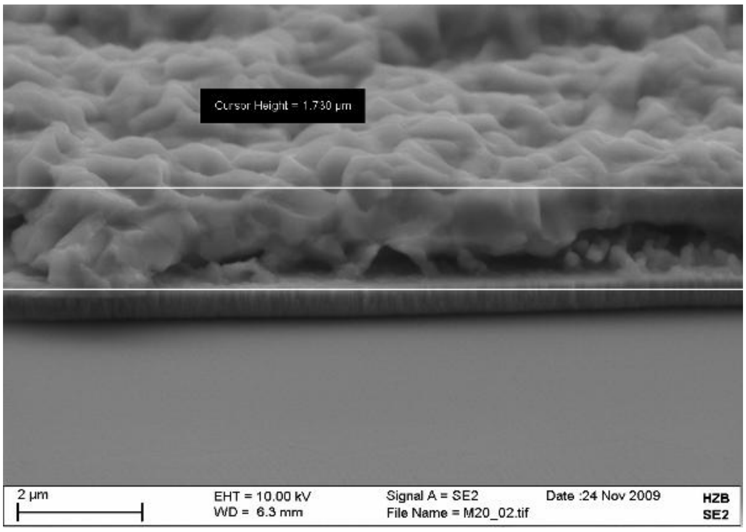
Experimental

Cu and In precursor films were successively deposited on molybdenum-coated soda lime glass (Mo/glass) using a three-electrode-system. Before the deposition, the Mo/glass substrate was treated with 28% ammonia solution for 5 min to remove MoO_x. Cu and In layers were deposited at -0.4 V vs. Ag/AgCl from a solution containing 0.02 M $CuSO_4$ and 0.02 M citric and at -0.75 V from 0.2 M $InCl_3$, respectively. Compositions of these metallic precursors were Cu-rich with a ratio of [Cu]:[In]=1.3:1. The precursor films were heated at 160 °C for 1 h to make homegeuos $Cu_{11}In_9$ alloy, and then sulfurized in 5% hydrogen sulfide in Ar at 450-500 °C. After treatment of the surface with 10% KCN, a CdS layer was deposited on the CIS thin film by the chemical bath deposition (CBD) method. Finally, a ZnO/Al:ZnO layer was then sputtered to form a soalr cell.

An adhesion thin film to substrate was observed by analysis of scanning electron microscope(SEM). Solar cell efficiencies were measured under AM 1.5G, 25℃ and 100 mW/cm^2.

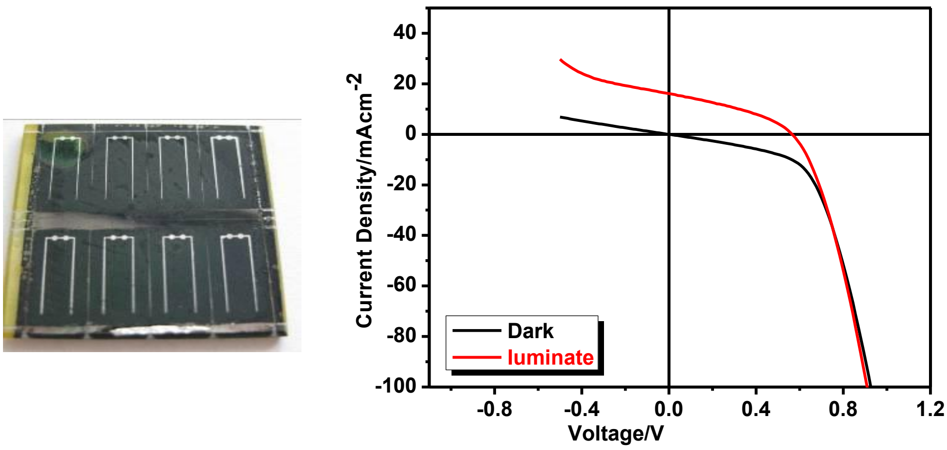
Results

As confirmed by the cross-sectional SEM image of the present device (Fig. 2), thin film has big grain size resulting in less grain boundaries scattering. However, there were many voids at the interface between the CIS film and substrate. This may be the reason for the moderate performance of the solar cell. The thin film thickness was 1.5~1,7 ㎛.



<Figure2. Graphs of efficiencies under AM 1.5G, 25℃ and 100 mW/cm^2 >

Film composition was of 26.1 mol% Cu, 24.7 mol% In and 49.3 mol % S from XRF analysis. The molar ration of Cu/In was changed to 1.05 because a top layer of CuS was removed after 10 % KCN etching. Sun simulation was carried out. The best solar efficiency was 3.3% with a 566 mV V_{oc}, an 16 mA cm^{-2} J_{sc} and a 0.36 F.F under a simulated AM 1.5 irradiation. The limitation of solar cell efficiency was a low F.F which can be explained that the solar cell showed big resistance and leakage because of poor adhesion film to substrate by SEM cross-sectional image.



<Figure 3. Compound thin film solar cells (left) and its best sun simulation (right) >

Conclusions

Solar cells having a structure of Al:ZnO/CdS/CIS_2/Mo showed efficiency of 3.26% during short term internship in Germany. However, it still had a problem of low fill factor due to poor adhesion the thin film to substrate. Further optimization thermal annealing process is needs.