Preparation of $CuInSe_2$ Thin Film Solar Cell by Electrochemical Deposition

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The $CuInSe_2$ (CIS) thin film solar cell is one of the most popular materials applied in photovoltaic cells because of their highest absorption coefficient and the best thermal stability. Currently, the best $Cu(In,Ga)Se_2$ thin films with efficiency higher than 19% were prepared by an MBE system [1]. However, MBE method is too expensive for a commercial product. To cost it down, electrochemical deposition method to grow all the CIS solar cell layers is developing currently. In this brief report, we characterize the electrochemical deposited $CuInSe_2$ thin film, the Ni backing layer, the ZnO top layers, and ZnO:Al (AZO) conducting layer using XRD and the compositions of the thin films were determined by EDS and XRF. The parameters of electrochemical deposition, which includes the concentration of the precursor solutions, additives, pH values, applied voltages and the annealing temperatures after deposition were studied.

The CuInSe thin films were prepared on Mo sheet, ITO glass or Ni backing ITO glass. The electrolyte is $CuCl_2$ (5 mM), $InCl_3$ (25mM) and SeO_2 (25 mM) together with TEA solution. The ZnO top layer was electrodeposited from Zn nitrate (0.05 M) solution at 65℃. The top transparent conducting layer, AZO layer, was electrodeposited using Zn nitrate (0.05 M) and Al nitrate (0.001M) electrolyte solution.

From the X-ray diffraction spectra (see Fig.1), there is no detectable secondary phases in all the dose of $CuInSe_2$ samples of the $CuInSe_2$ thin film. The compositions of Cu, In and Se are sensitive to the change of electrodeposition potential. In addition, the thin film need an annealing to form crystallines. However, the composition will also be changed during the vacuum annealing (see Table 1). Sample annealing under saturated In and Se partial pressure is needed.

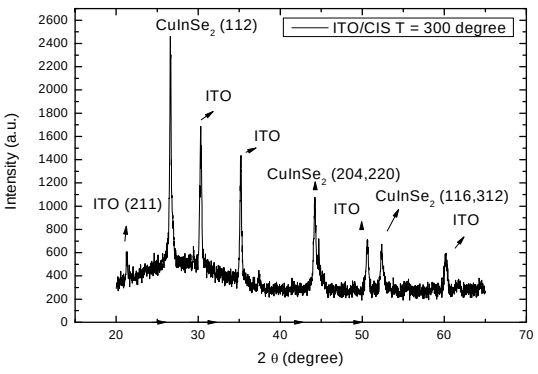

Fig. 1: X-ray diffraction spectra $CuInSe_2$ film deposited on the ITO glass and annealed at 300 ℃, with pH value of 1.75 and the electropotential at -0.62 V (Ag/AgCl). The wavelength is 0.154 nm

For preparation of ZnO layers, the electropotential is important. In Fig. 2, the $Zn(OH)_2$ film was formed at potential of -1.7 V and the ZnO film can be grown on ITO at -0.93 V (Ag/AgCl).

Table 1 The composition change in the CuInSe2 films under vacuum annealing

Elements	200℃	300℃	400℃
Cu	23.45%	25.2%	41.3%
In	28.6%	31.6%	20.5%
Se	48.0%	43.2%	38.2%

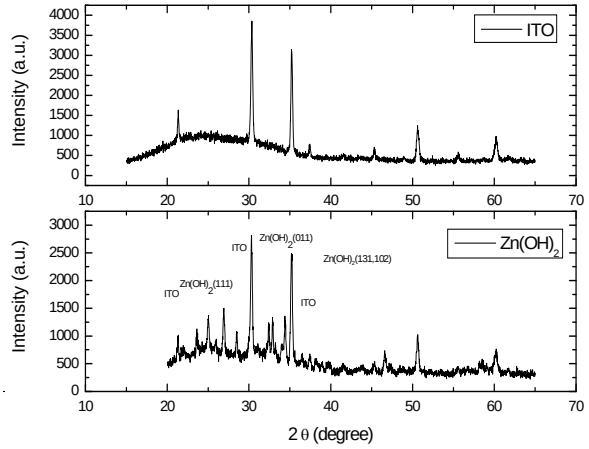

Fig. 2: The electroposition of ZnO layer on ITO at -1.7 V results in $Zn(OH)_2$ layer

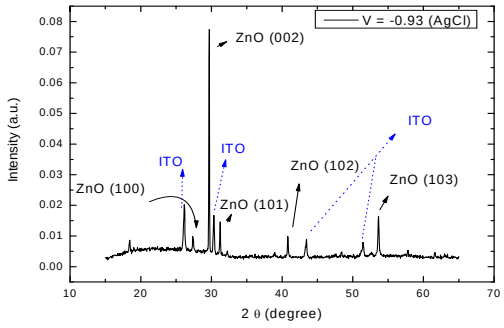

Fig. 3 : The electroposition of ZnO layer on ITO at -0.93 V results in ZnO layer

Reference

[1] K.Ramanathan, Prog. Photovolt : Res. Appl. **11**, 225 (2003).