Structure and Optical Characterization of Earth Abundant $Cu_2MSn(S,Se)_4$ layer for Thin Film Solar Cell

***LIE Stener*[1]**

[1]NTU Materials Science and Engineering, Nanyang Technological University, Singapore

INTRODUCTION

Cu_2MSnS_4 (where M = Ni, Mn, and Mg) thin films were successfully fabricated on Molybdenum-coated glass by chemical spray pyrolysis (CSP) technique. The precursor used was a mixture of metal ion Chlorides and Thiourea with fixed ratio. The pyrolysis was done in atmospheric condition with hotplate temperature 450^{o}C. This was followed by a selenization process with temperature 520^{o}C for 12 minutes. Investigation on the crystal structure and optical properties were done to act as premises to select the compound to focus for fabricating thin film solar cells. The result showed $Cu_2MnSn(S,Se)_4$ is more promising owing to its crystallinity, purity and low band gap. Following that, a study on selenization temperature dependency was done to study its effect on the crystal structure, band gap and J-V Curve with three different temperatures, 460^{o}C, 500^{o}C and 540^{o}C. The result shows a better crystallinity, lower band gap and higher efficiency for higher temperature. The efficiency achieved was around 0.0001%.

PURPOSE OF WORK

The aim is to develop CMTS as an alternative from CZTS for thin film solar cell by substituting zinc with other bivalent metal, with a simple and green method of spray pyrolysis. Zinc's role in the CZTS structure is overlapping with Copper, thus it limits and complicates the process to obtain a good working CZTS. The chemical spray pyrolysis method involves no toxic or organic materials and suitable for large scale and mass production in ambient conditions. Crystal Structure and Optical Properties characterization were done to select the best and viable alternative. Study in selenization temperature was aimed to find the best temperature to gain better result in terms of properties and efficiency.

METHOD

Copper chloride dihydrate ($CuCl_2 \cdot 2H_2O$), tin chloride dehydrate ($SnCl_2 \cdot 2H_2O$), Thiourea ($SC(NH_2)_2$) and Nickel (II) Chloride ($NiCl_2.6H_2O$) / Manganese (II) Chloride ($MnCl_2.4H_2O$) / Magnesium Chloride ($MgCl_2.6H_2O$) were dissolved into 160 ml water. The solutions were sprayed into Molybdenum-coated glass with N_2 as carrier gas at 450^{o}C, constant pressure of 4 bar and spray rate of 3ml/min. Selenization was conducted under Ar protected for 12 min. The investigation of the crystal structure and optical properties were done by characterization using X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Ultraviolet-visible light Spectroscopy (UV-Vis) and Raman Scattering Spectroscopy. Device Fabrication was done through deposition of CdS by Chemical Bath Deposition and TCO by magnetron sputtering. The measurement of J-V Curve was done using Solar Simulator

RESULTS AND CONCLUSIONS

- $Cu_2MnSn(S,Se)_4$ samples provide better result in terms of crystallinity and purity.
- The higher selenization temperature on $Cu_0MnSn(S,Se)_4$ shows better crystallinity and smaller band gap
- As the temperature increases the device's efficiency increases with the highest efficiency of 0.0001% at 540^{O}C selenization temperature.