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Development of a CZTS Solar Cell with CdS Buffer Layer Deposited by RF Magnetron Sputtering

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A thin film solar cell device having the arthitecture Ni/Al/Al:ZnO/i-ZnO/CdS/CZTS/Mo/SLG with a RF-sputtered CdS buffer layer was reported in this study. CZTS absorber layers were prepared on SLG and Mo-coated SLG substrates by sulphurization of sputtered stack precursor films. Structural, morphological, optical and electrical characteristics of absorber layer and interfaces of the layers in the cell structure were investigated in detail. It was determined that CZTS films were crystallized in kesterite structure and had a direct band gap of 1.4 eV and an absorbtion coefficient over 10^4 cm^{-1}. A depth profile of the structure showed that the Na ions diffused quite deeply from SLG substrate through the Mo back contact layer into the CZTS absorber layer. The fabricated solar cell was characterized by current-voltage (I-V) measurements under simulated AM1.5 G spectrum at 0.1 W/cm^2 illumination. An efficiency of 1.64% was obtained from the solar cell with an active area of 0.41 cm^2. The open-circuit voltage (V_{OC}), the short circuit current (I_{SC}) and the fill factor (FF) values of the solar cell were 0.55 V, 9.95 mA and 0.37, respectively. The low FF value was attributed to high series resistance of the cell, the formation of MoS_2 interfacial layer at Mo/CZTS interface and secondary phases in the absorber layer.

Keywords: Cu_2ZnSnS_4, CZTS, solar cells, sputtering, RF-sputtered CdS, buffer layer

1. Introduction

$Cu(In,Ga)S_2$ (CIGS) and cadmium telluride (CdTe) based thin film solar cells are currently the most leading thin film solar cell technologies. They have already reached the commercialization stage and the conversion efficiency values of 22.6 % and 22.1 %, respectively [1]. As known, there are some limitations of both CIGS and CdTe thin film solar cells such as the scarcity of indium (In) and gallium (Ga) in the earth's crust, the rarity of tellurium (Te) and the toxicity of cadmium (Cd). These issues limit a cost effective, large-scale device production of them [2]. However, Cu_2ZnSnS_4 (CZTS) is a quaternary