Abstract of Doctoral Thesis

Title：High Quality Hetero Junction Formation of $Cu_2ZnSn(S,Se)_4$ Solar Cells

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The target of photovoltaic power system in Japan by 2020 is to install the electric power system with 20 GW, consisting of the solar cells with the efficiency of 20%, thus leading to the unit price of 45 yen/W. $Cu_2ZnSn(S,Se)_4$ (CZTSSe) as an alternative absorber has therefore attracted much attention to the high potential, where the physical limit is high efficiency, the material cost is cheap. In this study, the technique for the fabrication of solar cells was considerably developed.

First, the CZTSSe solar cells were evaluated. The results have shown that the CZTSSe absorbers possess the various types of acceptor defects and donor defects, and the interface between buffer layer and absorber has the strong influence on the performance of CZTSSe solar cells. These results have indicated that the efficiency of CZTSSe solar cells is significantly lower than that of other solar cells. Therefore, the improvement of the material quality of CZTSSe absorber and the development of new buffer layer are needed.

The performances of the CZTS solar cell are increased by cleaning and anneal treatment before the deposition of the buffer layer. The efficiency of the solar cell increased from 5.5% to 8.8% with the annealing treatment. This is because the treatment decreases the defect density and increases the carrier density and hole mobility. On the other hand, a (Zn,Mg)O layer as buffer layer was formed to decrease the impact of the defect on interface between buffer layer and CZTS absorber; however, the efficiency of CZTSSe solar cells with (Zn,Mg)O buffer layer is significantly decreased owing to the sputtering damage and high reflectance. For achieving high efficiency, a hybrid buffer layer of (Zn,Mg)O/very thin CdS and anti-reflection coating (ARC) were therefore proposed. As a result, the efficiency with hybrid buffer layers and ARC was 0.3% higher than with CdS buffer layer. Additionally, the hybrid buffer layer can be an appropriate buffer layer of the large-Eg CZTSSe layer.