EFFECT OF INTERFACIAL COMPOUNDS BETWEEN BACK ELECTRODE AND ABSORBER ON PERFORMANCE IN ZnSnP$_2$ SOLAR CELLS

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ZnSnP$_2$ with a chalcopyrite structure shows a p-type conduction [1] and the theoretical conversion efficiency of about 30 % is calculated from Shockley-Queisser limit.[2] Our research group previously reported that the solar cells with the structure of Al/AZO/ZnO/CdS/ZnSnP$_2$/Cu achieved the conversion efficiency of about 2 %. [3] And it was found that some compounds were formed at the interface between Cu back electrode and ZnSnP$_2$ absorber during annealing and they might contribute to decrease the series resistance and improve the conversion efficiency. Although the efficiency was improved, it was not revealed what compounds were formed and how they improve the performance of ZnSnP$_2$ solar cells. In this study, we thus investigated the relation between those compounds and the electric properties at the interface.

ZnSnP$_2$ bulk crystals were prepared by flux method using Sn solution and cut into wafers with the thickness of 1 mm. [4] These wafers were mechanically polished with a series of emery papers and and finally with 1 mm diamond slurry on a buff sheet. Then, two Cu electrodes with the diameter of 1 mm and the thickness of 0.5 μm were DC-sputtered on ZnSnP$_2$ wafers, as shown in Figure 1. The samples were annealed at various temperatures in evacuated quartz ampules with the pressure of 10$^{-3}$ Pa. The I–V characteristics of these samples were measured and the cross-sectional observation was performed using the transmission electron microscopy (STEM).

Figure 2 shows the I–V characteristics of the samples before and after annealing at 400 °C for 15 min. Before annealing, the I–V curve was rectifying and the current was several 10 μA at 1.5 V. It is estimated that Cu/ZnSnP$_2$ junction was a Schottky contact before annealing. On the other hand, the linear relationship between current and voltage was observed after annealing, suggesting that an ohmic contact was formed between Cu and ZnSnP$_2$. In addition, the series resistance decreased by annealing. The STEM-EDS mappings shown in Figure 3 revealed that some compounds were formed at the interface. From the quantities analysis by STEM-EDS, it is suggested that the compound is Cu$_3$P. Considering the I–V characteristics and STEM-EDS before and after annealing, it is estimated that Cu$_3$P or/and some metal compounds affect the electrical properties of Cu/ZnSnP$_2$.

Figure 1: Photograph of Cu/ZnSnP$_2$ sample.

Figure 2: I–V characteristics of Cu/ZnSnP$_2$ before and after annealing at 400 °C for 15 min.

Figure 3: STEM-DF image and corresponding elemental mappings of Cu, Zn, Sn and P in the sample annealed at 400 °C for 15 min.