

EFFICIENCY IMPROVEMENT OF ZNSnP₂ WAFER-BASED SOLAR CELL BY (CD,ZN)S BUFFER LAYER

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ZnSnP₂ wafer-based solar cell with a structure of Al (1 μm)/ZnO:Al (300 nm)/ZnO (50 nm)/CdS buffer (50 nm)/ZnSnP₂ (200 μm)/Cu (500 nm) was first fabricated. It is demonstrated that short-circuit current density (J_{SC}), open-circuit voltage (V_{OC}), fill factor (FF), and efficiency (η) were 8.7 mA/cm², 0.437 V, 0.558 and 2.12 %, respectively (Fig.1 (a)). However, it was reported that the conduction band offset (CBO) at the CdS buffer/ZnSnP₂ absorber interface was estimated to be -1.2 eV, thus making a large cliff at the interface, leading to the decrease in the cell performances especially V_{OC} [1]. In order to improve the CBO at the buffer/ZnSnP₂ absorber interface, the ZnSnP₂ solar cell with (Cd,Zn)S buffer layer was developed, where its structure is Al (1 μm)/ZnO:Al (300 nm)/ZnO (50 nm)/(Cd,Zn)S buffer (50 nm)/ZnSnP₂ (200 μm)/Cu (500 nm) and bandgap (E_g) of (Cd,Zn)S is 2.6 eV, larger than E_g (2.3 eV) of CdS. As a result, J_{SC} , V_{OC} , FF, and η of the ZnSnP₂ solar cell with (Cd,Zn)S buffer layer are enhanced to 10.0 mA/cm², 0.526 V, 0.498, and 2.63 %, respectively (Fig.1 (a)). In Fig. 1(b), external quantum efficiency ratio at -1 and 0 V bias (EQE(-1 V)/EQE(0 V)) for the ZnSnP₂ solar cell with (Cd,Zn)S buffer layer is lower than that of the solar cell with CdS buffer layer. The results suggest that the carrier recombination in the solar cell with (Cd,Zn)S buffer layer is lower than that in the solar cell with CdS buffer layer owing to the improved CBO at the (Cd,Zn)S buffer/ZnSnP₂ absorber interface. In this work, to confirm the decrease in the carrier recombination in the solar cell with (Cd,Zn)S buffer layer, the individual recombination rates at buffer/absorber interface (R^i), in space-charge region (R^d), and in quasi-neutral region (R^b) of the ZnSnP₂ solar cell were investigated by the method reported in Ref. [2], which were extracted from temperature-illumination-dependence open-circuit voltage [2]. Moreover, based on the method [2], the V-independent recombination rates at the buffer/absorber interface (R^i_0), in SCR (R^d_0), and in QNR (R^b_0) were also obtained. The detail for the individual recombination rates will be discussed.

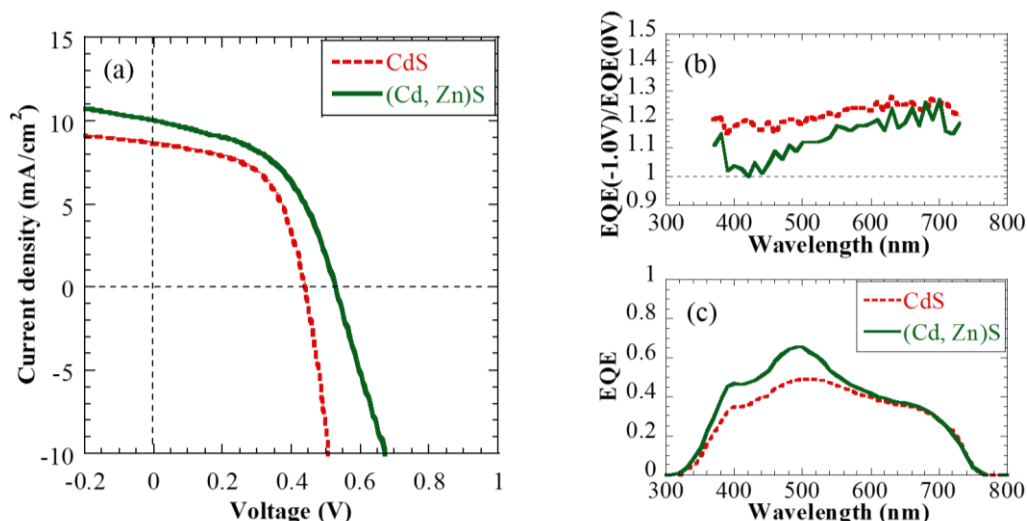


Figure 1:(a) J - V characteristics of ZnSnP₂ solar cells with CdS and (Cd,Zn)S buffer layers, (b) ratios of EQE at -1 and 0 V bias, and (c) EQE spectrum of the solar cells with CdS and (Cd,Zn)S buffer layers.

References

- [1] S. Nakatsuka, et al., J. Appl. Phys.119, (2016) 1.
- [2] J. V. Li, et al., Sol. Energy Mater. Sol. cells 124 (2014) 143-149.