Analysis of Recombination in RbF Treated CIGS Solar Cells with Different Ga Content.

Univ. Tsukuba[1], Univ. Grenoble Alpes[2], Martin-Luther Univ. Halle-Wittenberg[3],

○(M2) H. Tangara[1], J. Not[2], S. Zahedi-Azad[3], J. Schick[3], A. Lafuente Sampietro[1], R. Scheer[3], T. Sakurai[1]

E-mail: tangkoina@gmail.com

Alkali post-deposition treatment (PDT) has emerged as a preferential method for improving the efficiency of Cu(In,Ga)Se_2 based solar cells with low Ga content. The current record efficiency of 23.35% [1] was achieved using this technique. However, a quantitative analysis of the recombination mechanism rates in the bulk $\mathbf{R^b = R_0^b e^{\frac{qV}{kT}}}$, space charge region (SCR) $\mathbf{R^d = R_0^d e^{\frac{qV}{2kT}}}$ and at the interface $\mathbf{R^i = R_0^i e^{\frac{qV}{kT}}}$, especially for wide-gap CIGS, following PDT has been less investigated. $\mathbf{R_0^b}$, $\mathbf{R_0^d}$ and $\mathbf{R_0^i}$ represent the respective rates at thermal equilibrium. In this work, we report a comparative study of the impact of rubidium (RbF) PDT on the electronic properties and the recombination mechanisms of CIGS materials in low and high Ga cases. CIGSe samples with different [Ga]/([Ga]+[In]), GGI of 0.3, 0.6 and 0.73 were deposited on Mo-coated soda-lime glass by co-evaporation in a multi-stage process [2]. The I-V measurements show an enhancement of the device performances after RbF treatment. An increase of the open-circuit voltage (V_{oc}) along with improvement of the overall efficiency has been observed for all the samples (i.e. GGI= 0.3, 0.6 and 0.73). Temperature and light intensity-dependent I-V measurements were performed to get an insight on the different recombination rates. The recombination rates for CIGSe with GGI= 0.3 and 0.6 with and without RbF-PDT, at thermal equilibrium, are shown in Fig. 1. The results indicate that RbF-PDT is most effective in reducing the recombination in CIGSe for all GGI cases. As shown in the figure, bulk recombination is dominant in CIGSe with low GGI (i.e. 0.3) while recombination in CIGSe with high GGIs occurs mainly at the interface. The analysis indicates that RbF-PDT does not change this trend.

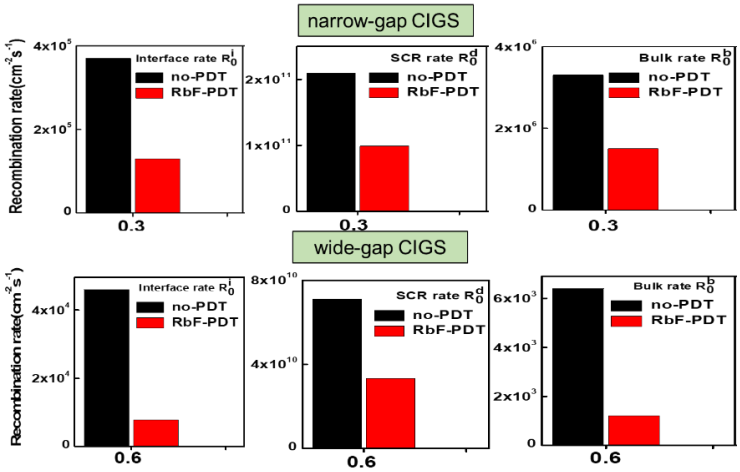

Fig. 1 : Recombination rates at the interface, SCR and in the bulk for CIGSe with different GGI at thermal equilibrium

[1] Available: http://www.solar-frontier.com/eng/news/2019/0117_press.html, 2019-01-17.
[2] S. Zahedi-Azad, M. Maiberg, R. Clausing, R. Scheer, Thin Solid Films, 669 (2019) 629-632.