

Sn/Pb ペロブスカイト太陽電池の電荷分離機構の解明と高効率化への提案

Clarification of charge separation and recombination dynamics in Sn/Pb halide

perovskite solar cells: uncovering the bottleneck of the efficiency

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Organometal trihalide perovskite-based solid-state hybrid solar cells have attracted unexpected increasing interest because of the high efficiency (the record power conversion efficiency has been reported to be over 17%) and low cost for preparation.¹⁾ The high efficiency was thought to mainly originate from the strong optical absorption over a broader range (up to 800 nm for Pb) and longer lifetimes of photoexcited charge carriers (in the order of 10 ns – 100 ns) of the organometal trihalide perovskite absorbers. Recently, Hayase and coworkers have succeeded in harvesting energy in the NIR region by using Sn/Pb cocktail halide based perovskite materials covering up to 1060 nm and an efficiency of 4.18 % was achieved.²⁾ To improve the photovoltaic performance of Sn/Pb halide based perovskite solar cells, charge separation and recombination dynamics are key factors and should be understood deeply. In this paper, we have studied and clarified charge separation and recombination dynamics of Sn/Pb halide based perovskite solar cell using transient absorption (TA) techniques. $\text{CH}_3\text{NH}_3\text{Sn}_{0.5}\text{Pb}_{0.5}\text{I}_3$ was deposited onto mesoporous TiO_2 substrates using one step method and P3HT was used as a hole transport material.²⁾ We found that ultrafast charge separation in a time scale of 1 ps was observed at both the $\text{TiO}_2/\text{CH}_3\text{NH}_3\text{Sn}_{0.5}\text{Pb}_{0.5}\text{I}_3$ (Fig. 1) and $\text{CH}_3\text{NH}_3\text{Sn}_{0.5}\text{Pb}_{0.5}\text{I}_3/\text{P3HT}$ interfaces. On the other hand, charge recombination at $\text{TiO}_2/\text{CH}_3\text{NH}_3\text{Sn}_{0.5}\text{Pb}_{0.5}\text{I}_3$ and $\text{CH}_3\text{NH}_3\text{Sn}_{0.5}\text{Pb}_{0.5}\text{I}_3/\text{P3HT}$ interfaces occurred in a time scale of 10 μs and 16 ps, respectively. Our results indicate that the bottleneck of photovoltaic efficiency in Sn/Pb cocktail halide based perovskite solar cell is the recombination rather than charge separation and the efficiency can be improved by suppressing the recombination (especially that at $\text{CH}_3\text{NH}_3\text{Sn}_{0.5}\text{Pb}_{0.5}\text{I}_3/\text{P3HT}$ interface) through appropriate surface passivation and interfacial engineering.

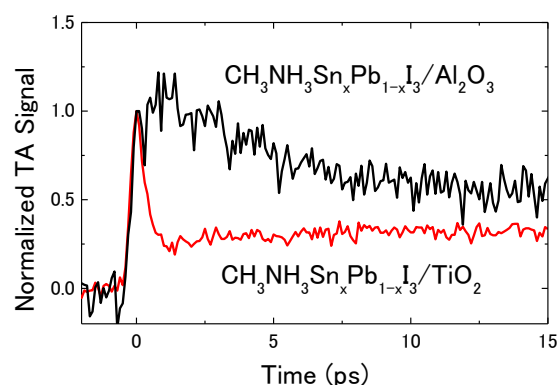


Fig. 1 TA responses of $\text{TiO}_2/\text{CH}_3\text{NH}_3\text{Sn}_{0.5}\text{Pb}_{0.5}\text{I}_3$ and $\text{Al}_2\text{O}_3/\text{CH}_3\text{NH}_3\text{Sn}_{0.5}\text{Pb}_{0.5}\text{I}_3$.

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