Composition-dependent photocarrier dynamics in $CH_3NH_3Pb(I_{1-x}Br_x)_3$ thin films

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Over the past few years, organo-metal halide perovskites have emerged as high-potential materials for cost-effective solar cell applications due to their excellent optoelectronic characteristics [1]. The power conversion efficiency (PCE) of single-junction perovskite solar cells increased incredibly, reaching over 20% at present [2]. Besides current extensive efforts to improve further the PCE of single-junction solar cells, using a perovskite subcell in a tandem structure as a top cell is a promising approach to realize devices with a much higher PCE [3]. For such tandem solar cell applications, the band-gap energy of and the recombination of photogenerated carriers in the perovskite layer take critical roles in determining the entire photovoltaic operation of a tandem device. The band-gap energy of perovskite materials could be tuned flexibly and controllably through adjusting the contents of the halide elements [4]. On the other hand, although tremendous studies examining the dynamical optical behaviors of photocarriers in pure-halide perovskites have been done [5], understanding of the composition-dependent photocarrier recombination dynamics in mixed-halide perovskites has remained limited.

In this work, we investigate the composition dependence of photocarrier recombination dynamics in $CH_3NH_3Pb(I_{1-x}Br_x)_3$ ($MAPb(I,Br)_3$) perovskite thin films by means of time-resolved photoluminescence (PL) and transient absorption (TA) spectroscopy. The PL decay dynamics measured under weak excitation condition reveal an increase in the single-carrier trapping rate with increasing the Br content in $MAPb(I,Br)_3$ thin films. Using the obtained single-carrier trapping rate, we are then able to evaluate the composition dependences of the two-carrier recombination and Auger recombination rates from the excitation-dependent TA kinetic traces. We discuss the physical issues behind the composition-dependent photocarrier recombination dynamics in $MAPb(I,Br)_3$ and its possible influences on the performance of perovskite solar cells.

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