Interfacial Transport and Collection of Photogenerated Charge Carriers in Bandgap Engineered Lead Halide Perovskite Heterostructures

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Halide perovskites have emerged into a class of promising semiconductor materials for next-generation optoelectronic devices due to their unique excitonic and charge carrier properties. Also, architecting perovskite heterostructures with distinct halide compositions become promising for the generation and transport of charge carriers in solar cells. A facile way to prepare such perovskite heterostructure is halide exchange reactions by partly replacing the halide ions in a parent crystal. Here, we utilize a tightly focused near-infrared (NIR) laser beam to prepare bandgap engineered perovskite heterojunctions as well as control the transport and accumulation of charge carriers across the heterojunctions in methylammonium lead bromide ($MAPbBr_3$) microcrystals.

$MAPbBr_3$ microcrystals (micro-plates and micro-rods) are prepared by the evaporation of the solvent from the precursor solution of $MAPbBr_3$ placed on a glass coverslip in a reaction chamber. To prepare heterojunctions in a $MAPbBr_3$ crystal, a reaction solution of MAI was added into the chamber, and a 1064-nm laser beam was focused onto the surface of the crystals (Figure 1a). Before the NIR laser irradiation, the whole $MAPbBr_3$ crystal shows green emission due to its intrinsic property, which gradually changes into the red at the focal spot. (Figure 1b). The red-shifted photoluminescence (PL) spectrum (Figure 1c) of the laser irradiated area confirms the formation of $MAPb(Br.I)_3$. Furthermore, we investigate the dynamics of photogenerated charge carriers in the heterojunction structures by recording the PL lifetimes of the crystals at different distances starting from the halide exchanged part. We discuss the possible mechanism of charge carrier dynamics in such heterojunction structures from the viewpoint of valence and conduction band continuities.

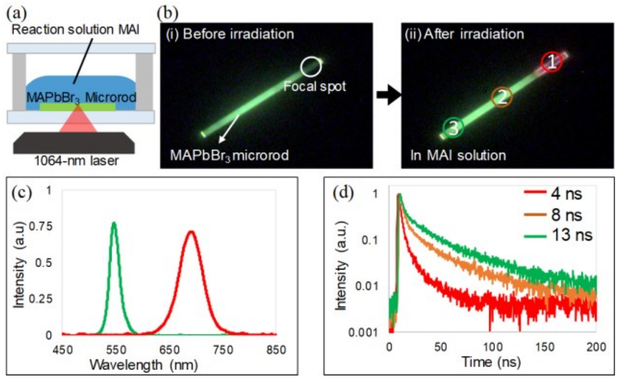

Figure 1. (a) A scheme of the laser irradiation to a $MAPbBr_3$ microrod, (b) the PL images of a $MAPbBr_3$ microrod crystal (i) before and (ii) after the exchange reaction, , (c) the PL spectra collected from a part of the crystal (green) before and (red) after the halide exchange reaction, and (d) the PL decay profiles of the crystal from the irradiated and non-irradiated parts marked in 'b(ii)'.