Area: 6 Advanced Concepts and New Emerging Materials for Future PV

HOT CARRIER COOLING IN BULK CESIUM LEAD HALIDE PEROVSKITE AND THE QUANTUM DOTS

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Lead halide perovskites are attracting a great deal of interest for optoelectronic applications such as solar cells, LEDs and lasers because of their unique properties. In solar cells, heat dissipation by hot carriers results in a major energy loss channel responsible for the Shockley–Queisser efficiency limit. Hot carrier solar cells offer the possibility to overcome this limit and achieve energy conversion efficiency as high as 60% by extracting hot carriers [1]. Therefore, fundamental studies on hot carrier relaxation dynamics in lead halide perovskites are important. On the other hand, very recently, all-inorganic cesium lead halide (CsPbX3) perovskite solar cells show the potential for making stable photovoltaic devices, even more stable than the standard MAPbI3 solar cells [2-6], and phase stabilization can be reached in CsPbI3 quantum dot (QD) based solar cells [7]. In this study, we have investigated ultrafast photoexcited carrier relaxation dynamics, especially hot carrier cooling, in bulk perovskite CsPbI3 and CsPbI3 QDs using a transient absorption (TA) technique. We have clarified the hot carrier cooling dynamics in bulk CsPbI3 perovskite and CsPbI3 QDs. We find that a non-thermalized carrier population is created within a few 100 fs after excitation. Hot carriers cool slowly to reach the room temperature in a few 10 ps for higher photoexcited carrier density, which originates from a bottleneck of the carrier-phonon interactions. Most importantly, we find that hot carrier cooling can be slowed down a few times in CsPbI3 QDs compared to bulk CsPbI3. This result suggests that energy loss from hot carrier to phonons can be suppressed in the QDs, which may originate from quantum confinement effects in the QDs.

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