Time-resolved Optical Characterization of Perovskite Semiconductor $CH_3NH_3PbI_3$

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Perovskite CH3NH3PbX3 (X=Cl, Br, and I) semiconductors recently attract growing interests because of their advanced photovoltaic properties. It is significant to reveal the key mechanism that provides the high conversion efficiency of perovskite solar cells. We have studied the static and dynamical optical properties of CH3NH3PbI3. We observed excitation-intensity dependent photoluminescence (PL) intensity and dynamics. PL intensity shows quadratic dependence on the excitation intensity, meaning that the two-carrier radiative recombination process is the PL origin. This is the direct evidence that the photoexcited electrons and holes do not form excitons but behave as free carriers at room temperature. This is also confirmed by the small exciton binding energy (~6meV) evaluated from the analysis of near-band-edge optical absorption spectrum. Under weak excitation, PL dynamics is determined by Shockley-Read-Hall nonradiative recombination, which is related to the defects and impurities. This means that the PL dynamics can be a good evaluation tool for sample quality. In the presentation, I will talk on the photoexcited states and the dynamical optical behaviors of CH3NH3PbI3 thin films and single crystals.