Photo-induced carrier dynamics and exciton broadening mechanism in all-inorganic metal halide perovskite nanocrystals: Role of halide composition.

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All-inorganic cesium lead halide perovskite nanocrystals ($CsPbX_3$, X = Cl, Br and I) have sparked intense research interest due to their superior optical properties and cost-effective synthesis. Mechanism and dynamics of relaxation of hot and thermalized charge carriers due to recombination and trapping followed by photo excitation of these NCs are the key factor to realization of their full potential in device performance. In previous reports, utilizing transient absorption spectroscopy (TAS) hot carrier relaxation dynamics and the impact of halide composition on relaxation timescales has been studied. However hot carrier relaxation followed by carrier trapping at longer time scales of several nanosecond has still avenues to explore. In this work we have studied ultrafast carrier relaxation dynamics followed by carrier trapping in $CsPbB_3$, $CsPbBr_2I$, $CsPbBr_{1.5}I_{1.5}$ and $CsPbBrI_2$ nanocrystals to elucidate the impact of halide composition on the fundamental photophysical properties at early as well as longer time scales followed by photo excitation, using temperature dependent photoluminescence (PL) and pump fluence dependent transient absorption measurements. For the sample $CsPbBr_{1.5}I_{1.5}$, from the temperature dependent PL in the temperature range of 80 K to 300 K; the extracted PL full width half maxima (FWHM) and integrated PL intensity was plotted as a function of temperature and the theoretical fitting of PL FWHM yields inhomogeneous broadening at T=0 K to be 36.35 meV, coupling strength to the longitudinal optical phonon to be 144 meV and optical phonon energy to be 31 meV. Transient absorption spectra were measured at 400 nm pump excitation. A strong band-edge bleach signal (PB) was observed around 550 nm along with two photo induced absorption (PA) bands. We shall discuss more

in detail the various aspects of the obtained TAS data. Importantly, comparing the fluence dependent pump-probe signal for different mixed halide composition a comprehensive understanding of the dependence of the hot-carrier cooling rate on the halide identity and succeeded trap state dynamics is possible.

Biography of the presenting author:

Chinmoy Biswas received his M.Sc. degree in physics from the University of Kalyani, India in 2014. He joined the M. Tech program at the Indian Institute of Technology Kharagpur and completed the degree in 2016. He joined as Junior Research Fellow at IIT Kharagpur, India, where he performed research on femtosecond filamentation and supercontinuum generation in non-linear crystalline medium from 2016 to 2017. He joined as a Ph.D. student at the Department of Physics, Indian Institute of Technology Hyderabad, in August 2017, under Dr. Sai Santosh Kumar Raavi. He received joint Ph. D. fellowship from the Indian Institute of Technology Hyderabad, India, and Swinburne University of Technology, Australia, under joint Ph. D. program. He received his Ph.D. in April 2023 with a thesis on ultrafast dynamics and coherent multidimensional spectroscopy of optoelectronic materials. At present he is postdoctoral researches fellow in ELI-ALPS laser research institute in Hungary.