Mobility of charge carriers in organic-inorganic perovskites

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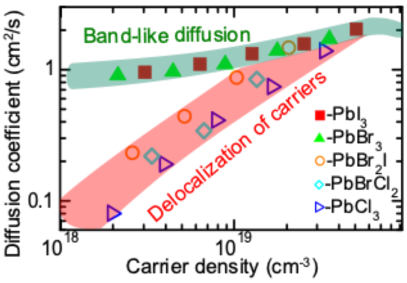

Two regimes of carrier diffusion in $MAPbX_3$ perovskite layers

Metal-halide perovskites became very attractive for cheap and scalable production of not only the solar cells, but also the thin film transistors, light emitting diodes, and lasers. Mobility and lifetime of charge carriers play a crucial role in determining the efficiency of photonic devices; however, some processes governing these parameters remain understudied. In particular, little is still known about the diffusivity and mobility dependencies on carrier density at higher excitations, mostly due to the difficulties in measuring it.

In this presentation, we discuss the results of carrier diffusion, mobility, and lifetime measurements using the time-resolved optical techniques in $CH_3NH_3Pb(Sn)X_3$ perovskite layers. In particular, we show the advantages of light-induced transient gratings method that enables direct determination of carrier diffusivity at high carrier densities. We demonstrate two different regimes of carrier transport in the perovskites, namely band-like or localization-limited carrier diffusion. Band-like diffusion with typical ambipolar coefficient of ~1 cm^2/s takes place in high quality crystals and layers. It is determined by fundamental material properties and is controlled by polar-optical electron-phonon scattering. It increases weakly with carrier density due to degeneracy of carriers and is limited by screened electron-hole scattering at high carrier densities. The trap-limited diffusion, on the other hand, varies in a wide range from 10^{-4} to 1 cm^2/s due to strong dependence on trap and carrier densities.

Finally, we show that diffusivity strongly depends on layer growth technology. It can be enhanced, e.g., by using chemical additives during $MAPbX_3$ layer formation. On the other hand, wet cast $MASnI_3$ layers show intrinsically high diffusivity of carriers comparable to that of vapor deposited layers or crystalline $MAPbX_3$ samples, despite very high background p-type doping.