Visualizing Exciton Transport in 2D Metal-Halide Perovskites.

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Metal-halide perovskites are a versatile material platform for light-harvesting and light-emitting applications as their variable chemical composition allows the optoelectronic properties to be tailored to specific applications. However, the reduced dimensionality can significantly impact the spatial dynamics of the excitonic excited state within the two-dimensional plane. To study these effects, we employ Transient Microscopy techniques which allow for a direct visualization of the excited state transport.[1] I will start the talk by giving an overview of some of the surprising effects that can be observed, particularly regarding the relationship between lattice softness and the exciton transport properties.[2,3,4]

In the second part of the talk, I will focus on very recent results on exciton transport mixed-halide 2D perovskites.[5] Halide mixing is one of the most powerful techniques to tune the optical bandgap of metal-halide perovskites across wide spectral ranges. However, halide mixing has commonly been observed to result in phase segregation, which reduces excited-state transport and limits device performance. While the current emphasis lies on the development of strategies to prevent phase segregation, it remains unclear how halide mixing may affect excited-state transport even if phase purity is maintained. To try and answer this question, we study the specific case of 2D metal-halide perovskites, in which phase segregation is absent. We show that, despite phase purity, halide mixing inhibits exciton transport in these materials. We find a significant reduction even for relatively low alloying concentrations, with bromide-rich perovskites being particularly sensitive to the introduction of iodide ions. Performing Brownian dynamics simulations, we are able to reproduce our experimental results and attribute the decrease in diffusivity to the energetically disordered potential landscape that arises due to the intrinsic random distribution of alloying sites. Our results show that even in the absence of phase segregation, halide mixing may still impact carrier transport due to the local intrinsic inhomogeneities in the energy landscape.

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