

Dielectric interface disorder in mixed binary/ternary TMDC heterostructures

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Abstract

Disorder phenomena determine the optical properties of semiconductors. Most notably, alloy disorder has been intensively studied in III-V semiconductors [1], but can also be found in transition-metal dichalcogenides (TMDCs) [2]. Semiconductor devices usually contain several layers of different materials and the interface between these layers can also be imperfect, i.e. exhibit interface disorder. This disorder generally leads to an increase in excitonic linewidths. Here, we investigate two transition metal dichalcogenides heterostructures of $\text{Mo}_{0.5}\text{W}_{0.5}\text{Se}_2$ and its binary counterparts, MoSe_2 and WSe_2 , fabricated by exfoliation and dry transfer. We carry out temperature-dependent photoluminescence experiments. The observed spectra are composed of several individual excitonic transitions, including transitions of neutral excitons (X^0) and trions (X^T) from the binary layers, but also the interlayer excitons (ILX).

In a heterostructure of TMDC monolayers, where one monolayer contains a ternary material, one would expect that the inhomogeneous linewidth of the ILX should be in between the inhomogeneous linewidth of the binary material and that of the ternary material. Contrary to this expectation, we find that the PL linewidth of the ILX is significantly larger than that of the neutral excitons present in only the binary or only the ternary material layers. This can be seen from Fig. 1, where we plot the experimentally observed linewidths for the excitonic transitions in the binary material (a) in the ternary material (b) and for the ILX (c). We attribute this additional line broadening to dielectric disorder caused by spatial inhomogeneity at the interface.