

Strain-programmable Exciton Diffusion in Moiré Heterostructures

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Moiré superlattices in van der Waals heterostructures based on two-dimensional materials have recently gained significant attention as an intriguing platform for exploring strongly correlated electronic states and engineering novel excitonic properties. Such superlattices have been generally created and tuned either by lattice constant mismatch or layer twisting. However, strain is also a powerful tool for tuning the moiré superlattices, which yields fascinating features distinct from the twisted cases due to the C_3 rotational symmetry breaking. Herein, we experimentally and theoretically investigate the optical properties of interlayer excitons (IXs) generated in strain-induced MoSe₂-WSe₂ heterobilayers.

In our experiment, we fabricated vertically stacked MoSe₂-WSe₂ heterobilayers in which uniaxial strain is applied to a single constituent layer (Fig. 1(a)). Due to the type-II band alignment, the heterobilayer exhibits long-lived IXs with electrons and holes spatially separated in opposite layers (Fig. 1(b)). We probe the strain effect on the IX emission polarization and diffusion over the stacked region which shows peculiar coupling of the excitonic behavior with the strain-induced moiré potentials. Firstly, we found the linearly polarized IX emission resulting from the C_3 rotational symmetry breaking of the moiré potential over a wide spatial area (Fig. 1(c)). Secondly, through spatially resolved IX diffusion measurements, we found that IXs diffuse preferentially along the applied strain direction over several micron scales (Fig. 1(d)). Our experimental observations are also consistent with the density functional theory (DFT) calculation results of the strain-induced moiré potential landscapes.

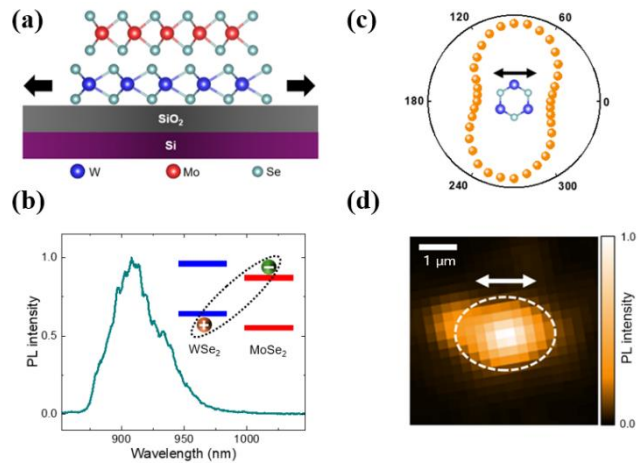


Figure 1. (a) Schematic illustration of the sample. (b) Photoluminescence spectrum of IXs. (c) Linear polarization of IXs perpendicular to the strain direction. (d) Anisotropic IX diffusion of a strained heterobilayer.