Enhanced Photoluminescence in Layered 2D Heterostructure

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Two-dimensional materials (2D) have attracted substantial attention in the nano-optoelectronic industry owing to their unique properties. A great deal of research has been concentrated exploring the optoelectronic properties of different 2D materials. But, significant development is still required to achieve practical applications. Monolayer (1L) TMDs are direct bandgap semiconductors showing strong light-matter interaction, but as bulk, they show indirect bandgap that limits their optoelectronic performances. However, owing to the lack of materials in 1L, the carrier density of states for absorption is limited. To address such shortcomings, here, we have designed vertical stakes of 1L TMDs separated by few-layer hBN, which separates the 1L TMDs keeping the intrinsic properties of 1L TMDs intact in the heterostructure. Interestingly, the emission spectra of such heterostructures show much stronger radiation density at the heterojunction compared to its monolayer counterpart. Also, we observed that the enhancement can be tuned by varying the hBN thickness. We relate such enhancement to the weak van der Waals coupling of exciton at the heterojunction. We further map the excited state carrier lifetime, which shows a much shorter lifetime at the heterojunction confirming the coupling induced emission at the junction, which makes the emission intensity stronger. Our work, therefore, should be beneficial and timely for the development of high-performance nano-optoelectronic devices.