Interfacial Control of K–Q Intervalley Trions in Monolayer WS_2 via Functionalized hBN

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Interfacial engineering effectively tunes the excitonic properties of 2D materials without directly altering the active layer. Monolayer WS_2 supports various charged trions, including conventional K-K´ intervalley trion X_T and lower energy K-Q intervalley trion X_T^Q, whose relative population is susceptible to the carrier density and valley occupation [1]. Here, we study the interfacial effect of on the excitonic properties of monolayer WS_2 by transferring it to methanol-functionalised HBN. To eliminate external effects, we have made both top and bottom-encapsulated devices. Low-temperature photoluminescence measurement performed on the bare WS_2 region and the region supported on the methanol-functionalized hBN. Photoluminescence measurements reveal significant quenching of the overall emission in the heterostructure region compared to bare WS_2, indicating enhanced nonradiative recombination and increased carrier density. While the bare region exhibits a dominant K–K′ intervalley trion (X_T) emission, the heterostructure region shows a pronounced enhancement of the lower-energy K–Q intervalley trion (X_T^Q), indicating redistribution of the trion population. This behavior is attributed to interfacial dipoles and charge transfer induced by methanol adsorption on the hBN substrate, resulting in local n-type doping. The increased electron density shifts the Fermi level toward the Q valley, enabling remote interfacial control of valley-selective excitonic states in WS_2 [1–3].

References

[1] Pei *et al.*, Opto-Electron. Adv. **6**, 220034 (2023)
[2] Gaur *et al.*, Appl. Phys. Lett. **115**, 173103 (2019)
[3] Mak & Shan, Nat. Photonics **10**, 216 (2016)

Figures

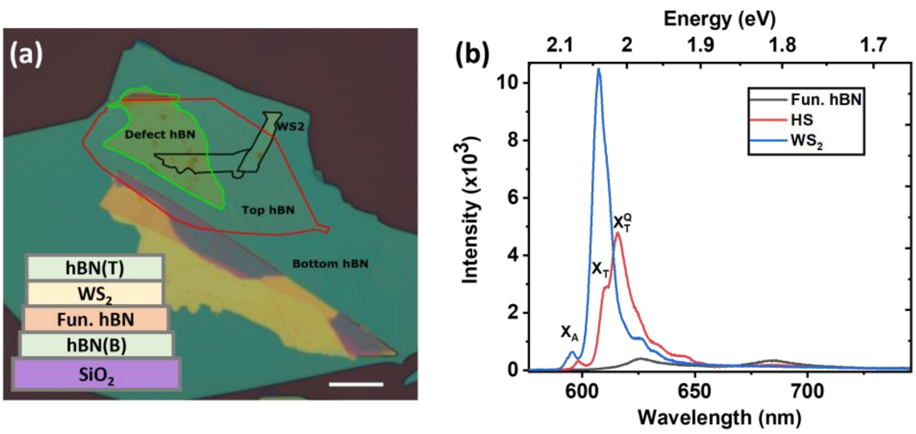

Figure 1: (a) Optical image of the top and bottom encapsulated WS_2/Functionalised hBN heterostructure (Scale bar is 10 μm) (b) PL spectra taken on Functionalised hBN, bare WS_2, and heterostructure regions at 5 K.