Trap assisted ultrafast electron transfer in WS_2/TiO_2 heterostructure

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Transition metal dichalcogenides (TMDCs) are promising materials for flexible optoelectronics, valleytronics and quantum devices [1,2]. As a result of very low thickness (0.7 nm) and low dielectric screening, the optical properties of monolayer (ML) TMDCs are dominated by quasiparticles (exciton, trion etc.)[3]. The quasiparticles are very useful for understanding physics of many body interaction [3]. In general, high trap densities (10^{12}-10^{13} cm^{-2}) are observed in TMDCs grown by chemical Vapour deposition (CVD) technique [4]. Understanding the effect of traps on the performance of optoelectronic devices is essential for increasing the device efficiency. Using transient absorption (TA) spectroscopy, we studied the exciton dynamics in the heterostructure of ML WS_2 and TiO_2. As ML WS_2 was grown by CVD method and TiO_2 film was grown by atomic layer deposition (ALD) technique, high trap density is expected in both the films. In TA measurements, we found that bleach kinetics of WS_2 recovered at a faster rate in WS_2/TiO_2 heterostructure suggesting electron transfer from ML WS_2 to TiO_2. The electron transfer time was estimated to be ~1 ps. Relatively long electron transfer time suggests that in addition to direct electron transfer there is a possibility of trap mediated electron transfer. This study could be useful for designing TMDC-based solar cells and fast photodetectors.

References

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Figures

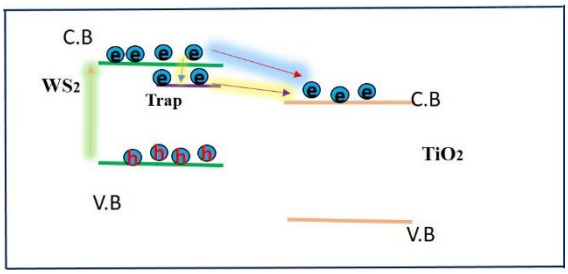

Figure 1: Sketch showing electron transfer paths form ML WS_2 to TiO_2.