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Enhanced out-of-plane charge-transfer on a monolayer TMDCs by controlled defect creation: Optical Evidences in Heterostructure and Application for SERS

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Two-dimensional transition metal dichalcogenides (TMDCs) has attracted an increasing attention due to its novel and intriguing material properties. The charge transfer in/out the plane of TMDCs has a crucial role for functions of the TMDCs. Compared with graphene, the TMDCs has a relative low formation energy, therefore point defects are more easily generated in the monolayer of TMDCs. It has been reported that point defects block the charge transfer in the plane of TMDCs. On the contrary, we demonstrate, in this work, the charge transfer out of the plane of TMDCs is enhanced by the controllable formation of point defects, benefiting its application as a Raman enhancement platform. Point defects were generated on the monolayer of TMDCs with the controllable density of point defects via the ion irradiation. The fs optical probe-pump measurements prove that point defects do not hamper the charge-transfer out of the plane of TMDCs monolayers, and the electron transition probability rate between TMDCs and neighbored materials is increased. Besides, point defects with a specific density can significantly enhance the surface enhanced Raman scattering (SERS) effect of TMDCs for 20 times at 680 cm^{-1}. Our work shows a methodology to tailor the charge-transfer out of TMDCs for the desired functions, and promotes the application of TMDCs in SERS for the molecular detection.

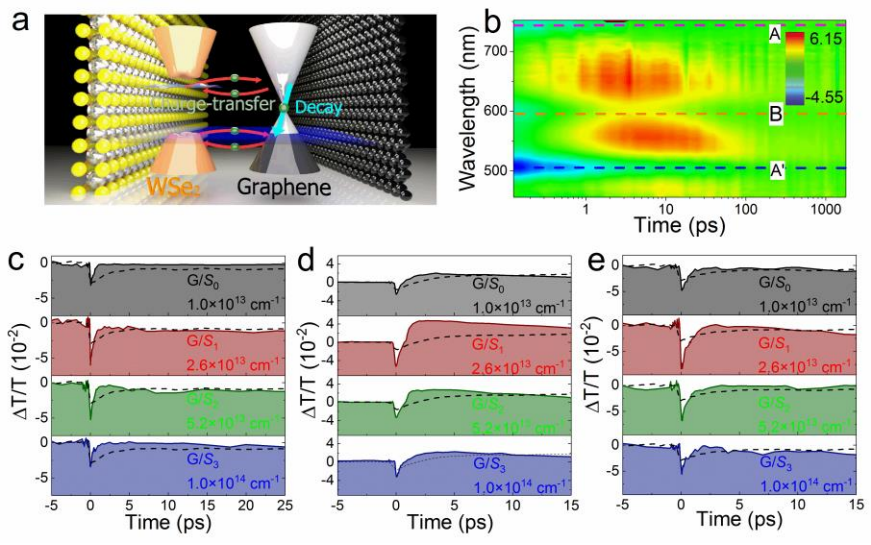

Figure 1. (a) Schematic diagram showing electronic transitions between graphene and the WSe2 monolayer. (b) The fs optical pump-probe spectroscopy of the as-prepared WSe2 monolayer. The intensity of ΔT/T0 at exciton resonances of A' (c), B (d) and A (e). The dashed lines are the spectroscopy of S0 for comparisons