Gate tuneable ultrafast charge transfer in graphene/MoS_2 heterostructures

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We report ultrafast pump-probe measurements on a graphene/MoS_2 heterostructure and demonstrate sub picosecond exciton dissociation and charge transfer from MoS_2 to graphene, one order of magnitude faster than in type II two-dimensional heterostructures [1]. The process can be controlled by applying an external gate and shifting the Fermi level of the graphene layer. For pump-probe measurements we excite the gate controlled graphene/MoS_2 heterostructure at 400 nm, well above the MoS_2 bandgap [2], and probe the normalized differential transmission changes ($\Delta T/T$) of the MoS_2 first exciton (A exciton) at 660 nm with time resolution~200fs. In this configuration, MoS_2 acts as the absorbing material for visible wavelengths while graphene is the electron scavenger [3], as depicted in Fig. 1. We observe strong dependence of recombination dynamics in MoS_2 upon gate voltage biasing and graphene doping. Specifically, higher p-doping in graphene increases the built in potential difference at the graphene/MoS_2 interface (Fig. 1a), enhances the rate of electrons transfer from MoS_2 to graphene (Fig. 2) and as a result reduces the A excitons lifetime in MoS_2. On the other hand, if graphene is n-doped, the built in field is weakened resulting in slower electrons dynamics (Fig. 1b and 2). Charge transfer in layered heterostructures was previously reported [1, 4, 5]. Here we demonstrate that this process can be electrically controlled by external gating. This mechanism is key for applications such as photodetectors [3] and non-volatile memories [6].

References

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Figures

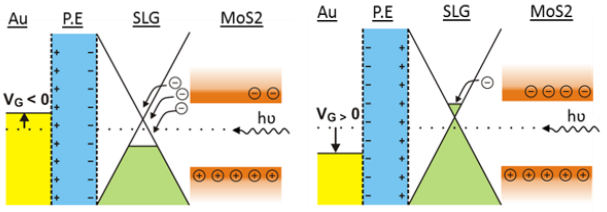

Figure 1: Sketch of the MoS_2 to graphene electron transfer as a function of graphene doping.

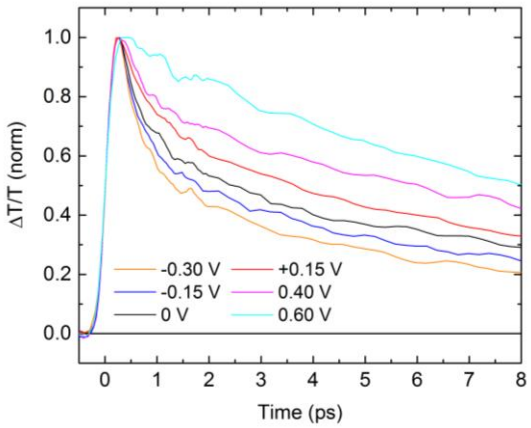

Figure 2: Pump-probe dynamics of graphene/MoS_2 heterostructure probed at 660 nm for different applied gate-voltages.