Charge carrier extraction in a graphene-WSe2-graphene heterostructure

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Abstract

Two-dimensional (2D) crystals, such as graphene, hexagonal boron nitride (hBN) and transition metal dichalcogenides (TMDs), have aroused a lot of interest in both fundamental and applied physics during the past decade. Combining the complementary properties of these crystals in a single heterogeneous material is a promising approach to creating multi-functional, high performance optoelectronics [1]. This can be achieved by stacking them on top of each another, thus forming atomically sharp van der Waals heterostructures with clean interfaces. Recently, photodetectors using TMDs as light absorber and graphene as a gate-tunable electrode have been shown to be highly efficient [2-3]. Optical pump-probe experiments also found the charge transfer between TMDs and graphene to be very fast (~1 ps) [4].

Here we present a spectrally resolved study of the transport properties and photoresponse of graphene-WSe_2-graphene heterostructures, encapsulated in hexagonal boron nitride. First, we find that the device exhibits a gate-tunable Schottky barrier, confirming a nearly defect and trap-free interface. We show that visible light is absorbed in WSe_2, creating excitons that can be efficiently dissociated and extracted via the graphene layers at the top and bottom of WSe_2. The excitonic absorption peaks are directly revealed in the photocurrent spectrum. We study the charge separation efficiency inside WSe_2 and the charge carrier transfer from WSe_2 to graphene. The underlying physics depends strongly on the thickness of WSe_2 and the applied electric field. Our results pave the way to ultra-fast, high-efficiency and gate-tunable photodetectors.

References

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