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Electrically tunable charged exciton electroluminescence in monolayer WSe_2

As excitonic complexes that are both mobile and charged, trions are intrinsically interesting in their properties. [1] Monolayer WSe_2, which is an ambipolar semiconductor, has been found to exhibit both positive and negative trion upon photoexcitation under suitable doping conditions. [2] However, controllable electrical generation of these two different kinds of charged excitons has remained challenging. In this work, both positive and negative trion are created electrically in monolayer WSe_2 by controlled unipolar injection of electrons and holes via carrier tunneling and electrostatic doping process. We observed planar electroluminescence derived from either positive trion X^+ or negative trion X^- in the same device at different gate conditions. Our observation indicates that controlled unipolar electron or hole tunneling can be achieved across a thin layer of hexagonal boron nitride (hBN) under suitable bias conditions. The unipolar tunneling and the realization of controlled electrical generation of pure trion opens up new opportunities for investigating hot carrier injection, trion manipulation and on-chip excitonic devices based on 2D semiconductors.

References

[1] Sanvitto D, et al. Observation of charge transport by negatively charged excitons. Science 294, 837-839 (2001).
[2] Jones AM, et al. Optical generation of excitonic valley coherence in monolayer WSe_2. Nat. Nanotechnol. 8, 634-638 (2013).

Figures

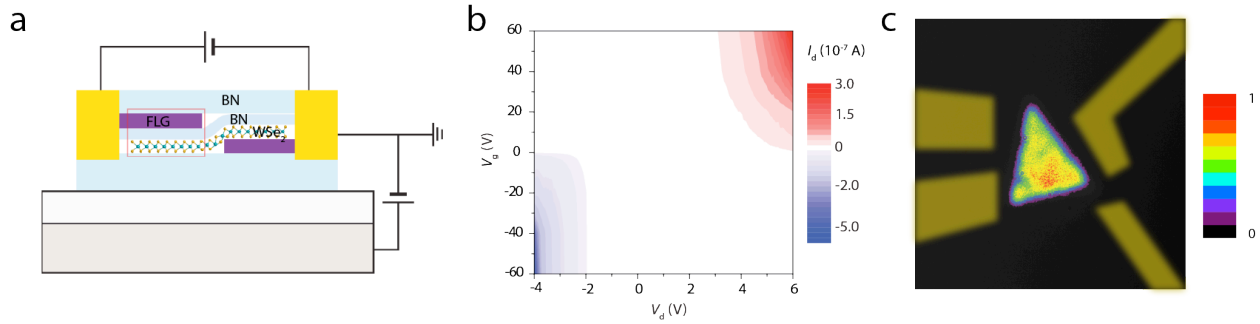

Figure 1: (a) Schematic cartoon of the device. The core MIS heterostacks consisting of ML-WSe_2/h-BN/FLG are highlighted in the red rectangle. (b) 2D plot of the tunneling current with respect to the gate voltage V_g and the bias voltage V_d. The tunneling current only exists at forwarding bias with positive backgate and reverse bias with negative backgate. (c) Planar EL emission of negative trion with V_g >0, V_b >0.