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


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 $V_g > 0$, $V_b > 0$. 