Electroluminescent Emission of Excited Rydberg Excitons in a WSe_2 Tunneling Diode

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Excitonic complexes play a central role in the optical response of monolayer (ML) semiconducting transition-metal dichalcogenides (STMDs). Their rich behavior and mutual interplay are crucial for engineering novel valleytronic and flexible optoelectronic devices, enabled by their large binding energies and strong spin–orbit coupling [1]. Among STMDs, WSe_2 is particularly attractive due to the presence of excited neutral exciton states that closely resemble the Rydberg states of a three-dimensional hydrogen atom [2].

Here, we report electroluminescent (EL) emission from Rydberg excitons in high-quality, hexagonal boron nitride (hBN)-encapsulated ML WSe_2 tunneling diode devices with graphite contacts, as shown in Fig. 1(a). By applying a gate voltage, we obtain high-resolution EL spectra revealing emission from various excitonic complexes and their excited states (Fig. 1(b)). The EL response of the device was further investigated in high magnetic fields up to 16 T, allowing us to resolve higher excited states of the Rydberg series. Our results provide important insight into electroluminescent excitonic recombination mechanisms and establish electrically driven Rydberg excitons as a promising platform for WSe_2-based quantum optoelectronic devices.

References

[1] G. Wang, Rev. Mod. Phys., 90 (2018)
[2] M. R. Molas, Physical Review Letters 123, 136801 (2019)

Figures

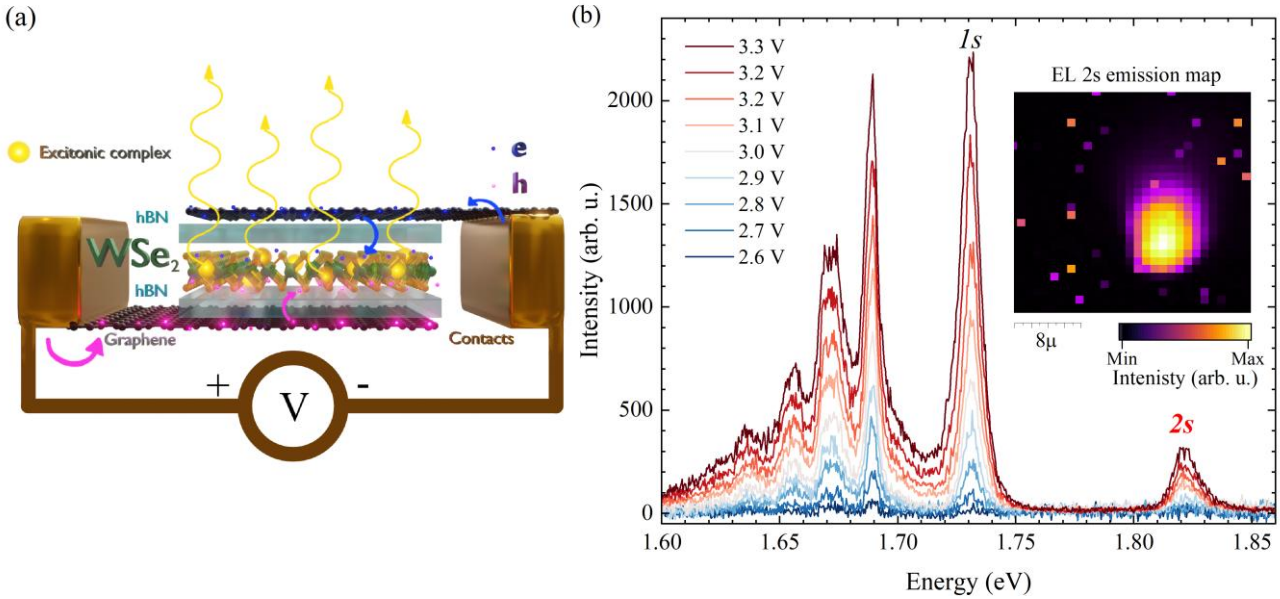

Figure 1: (a) Schematic drawing of the tunneling diode device and its EL emission. (b) Evolution of the EL spectra with varying gate voltage. The inset shows an optical image of the sample with the corresponding EL map of the 2*s* state.