Excitonic transistor based on 2D materials

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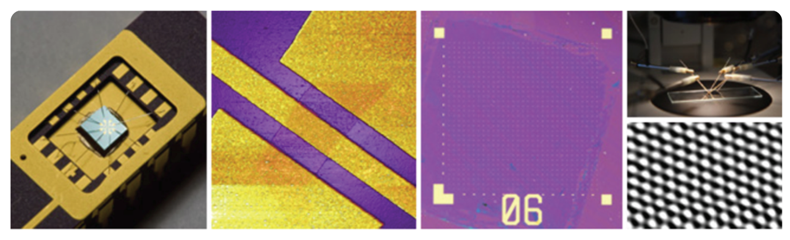
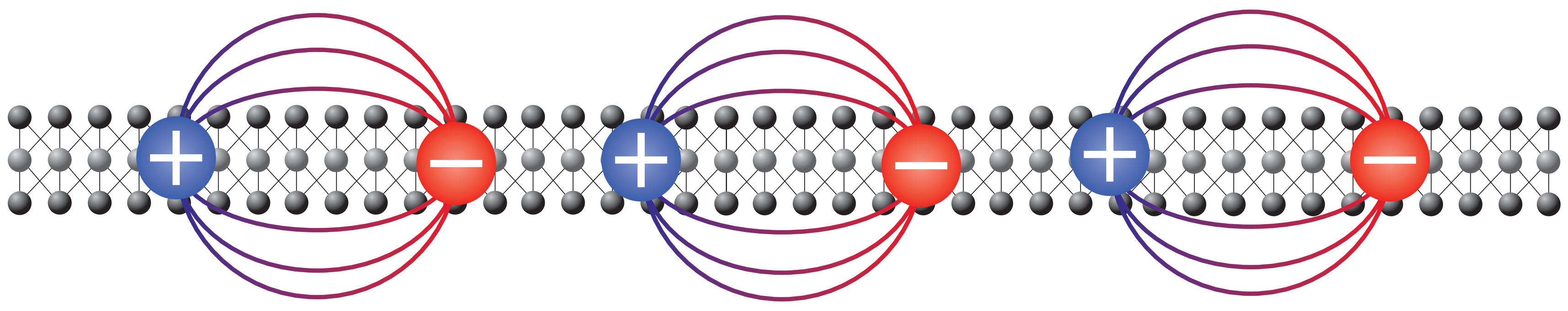


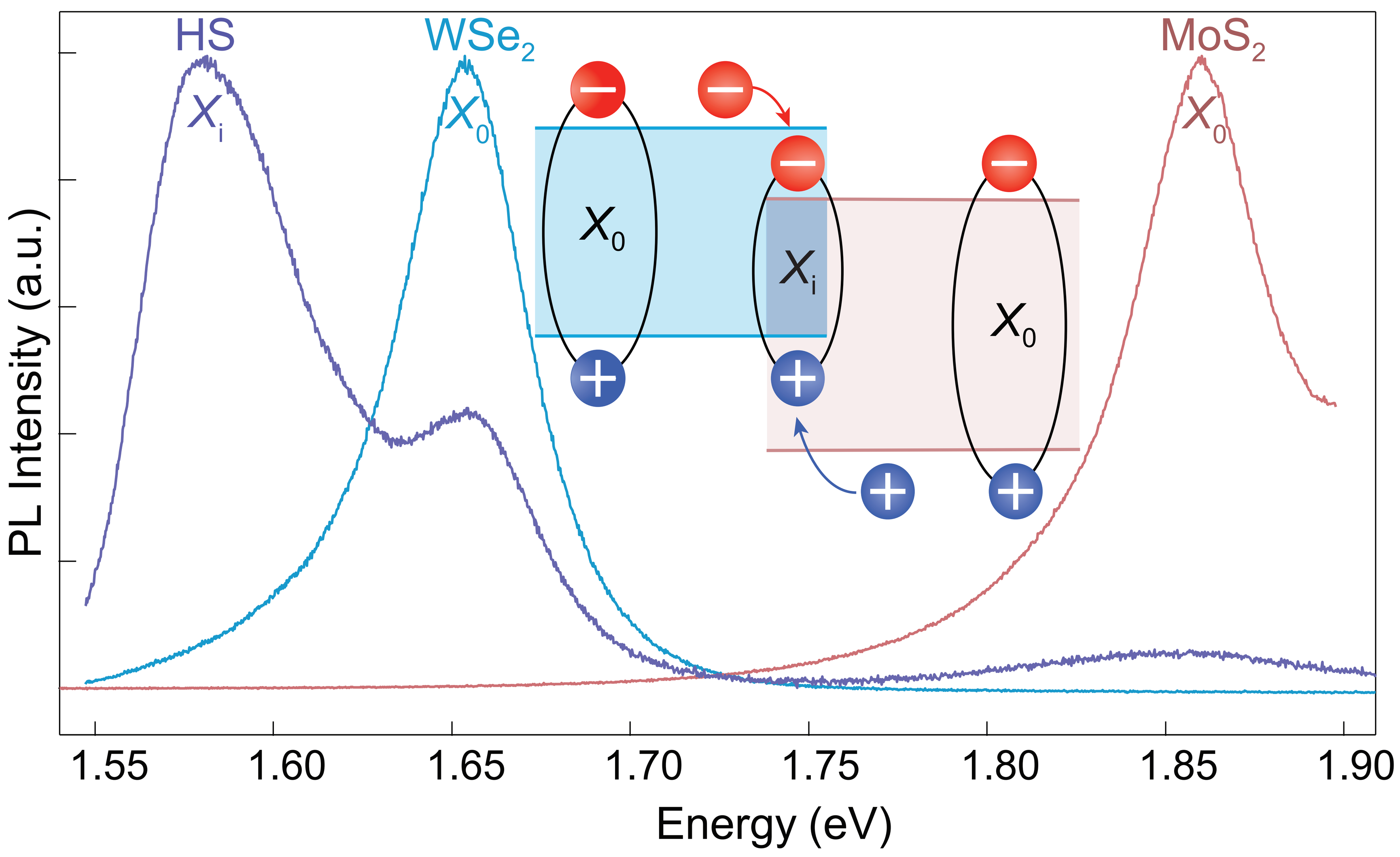
1. Introduction

We demonstrate here excitonic device operating at room temperature exploiting van der Waals heterostructures based on 2D materials.

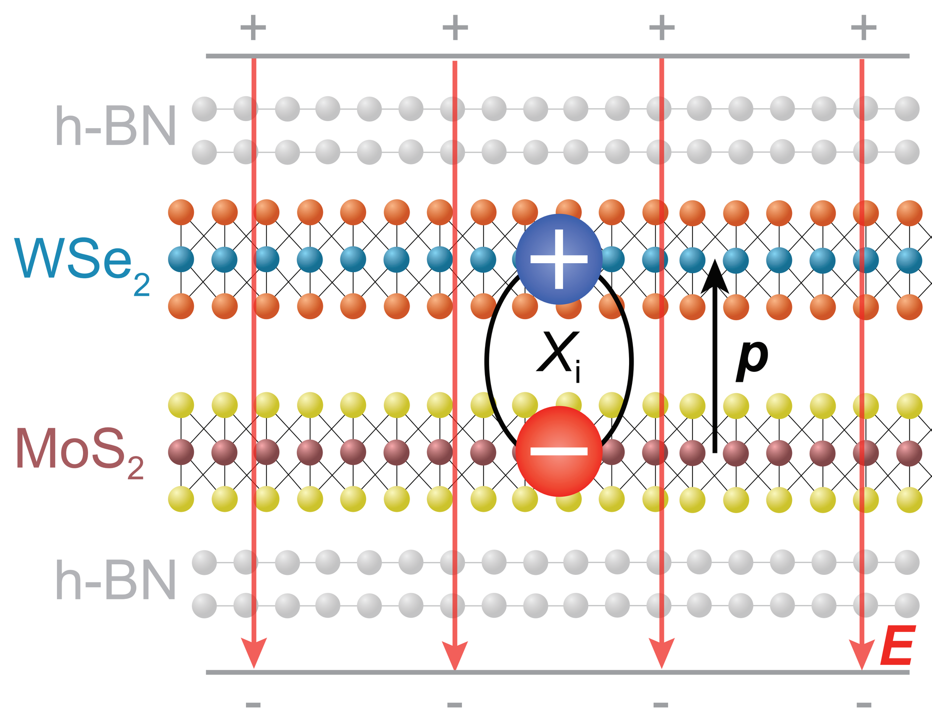
- Reduced screening in the 2D materials elevates the binding energy of excitons. This makes them stable even at room temperature:

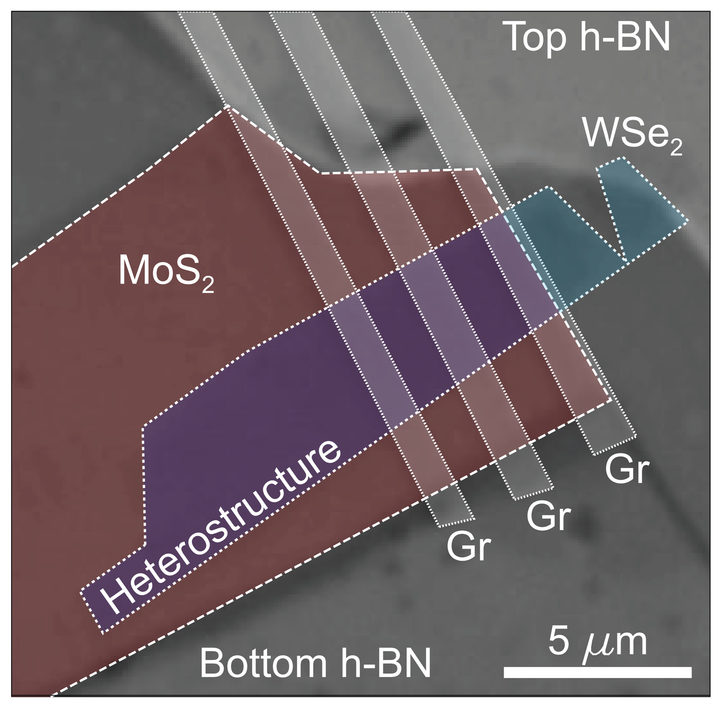


- Type-II band alignment of MoS_2-WSe_2 heterostructure (HS) leads to the formation of a low-energy long-living interlayer exciton X_i:

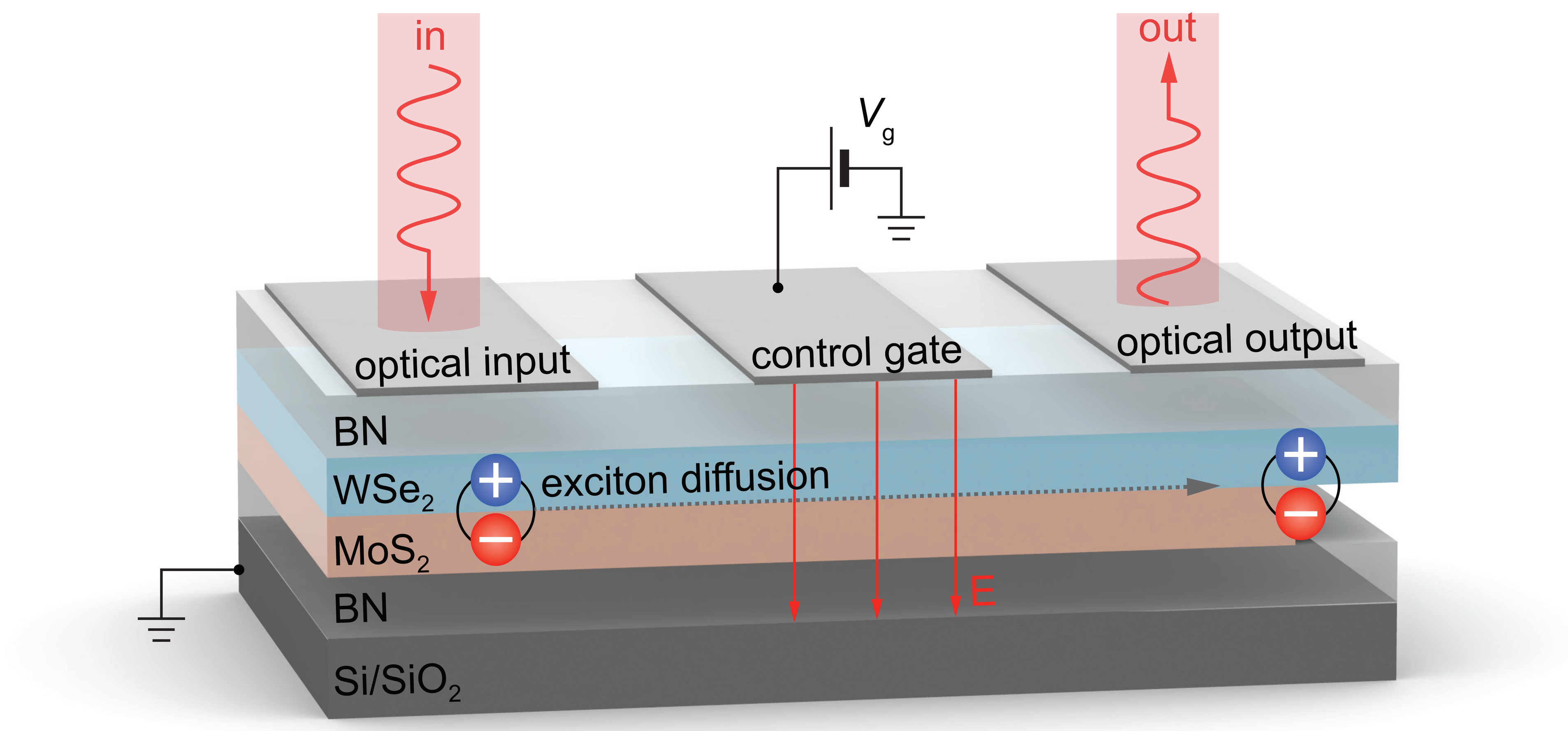


2. Device structure

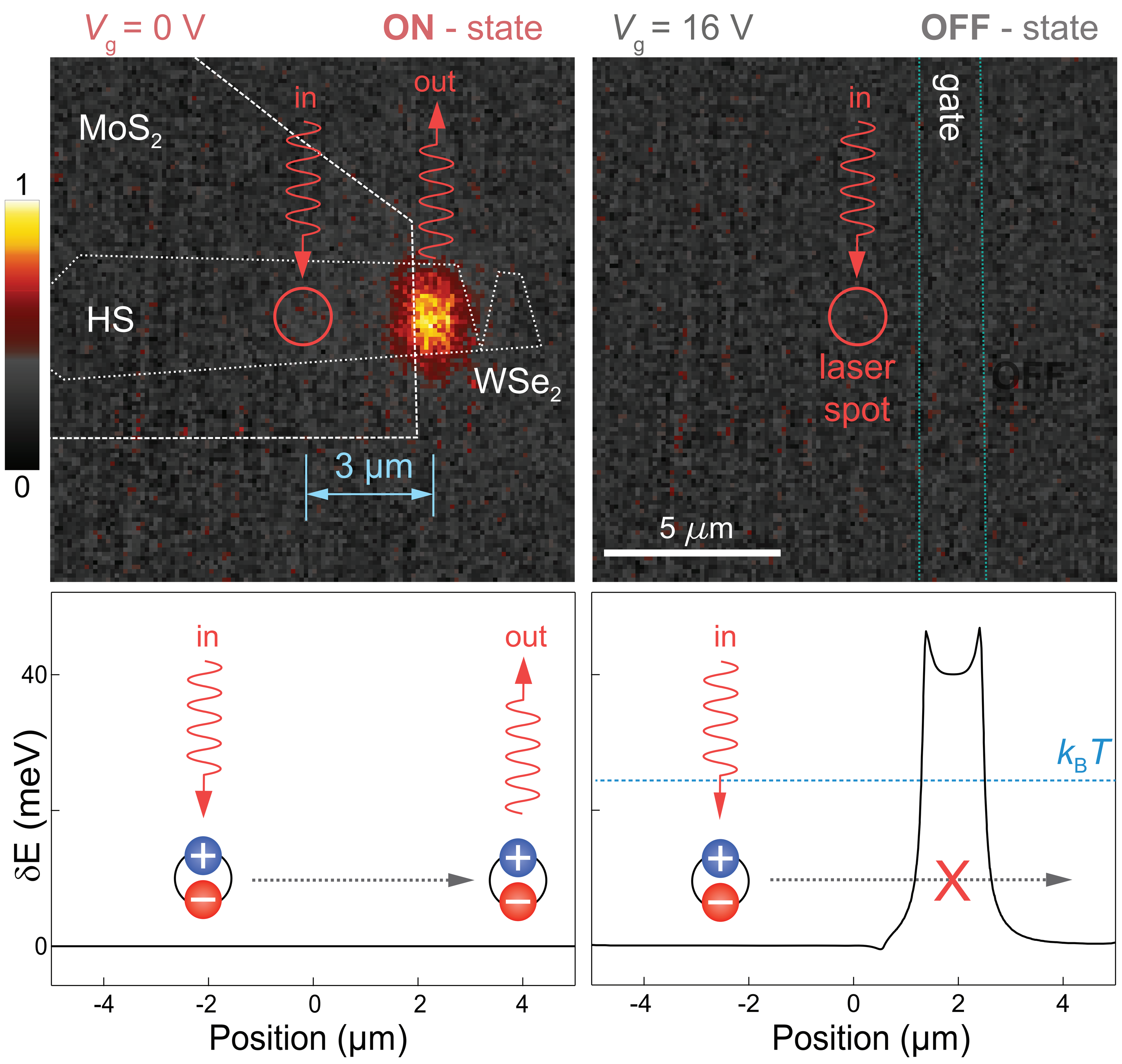




Confinement of holes and electrons in MoS_2 and WSe_2 respectively results in permanent out-of-plane dipole moment $\boldsymbol{p}$ of interlayer exciton X_i. This allows the manipulation of exciton dynamics via external electric field $\boldsymbol{E}$:

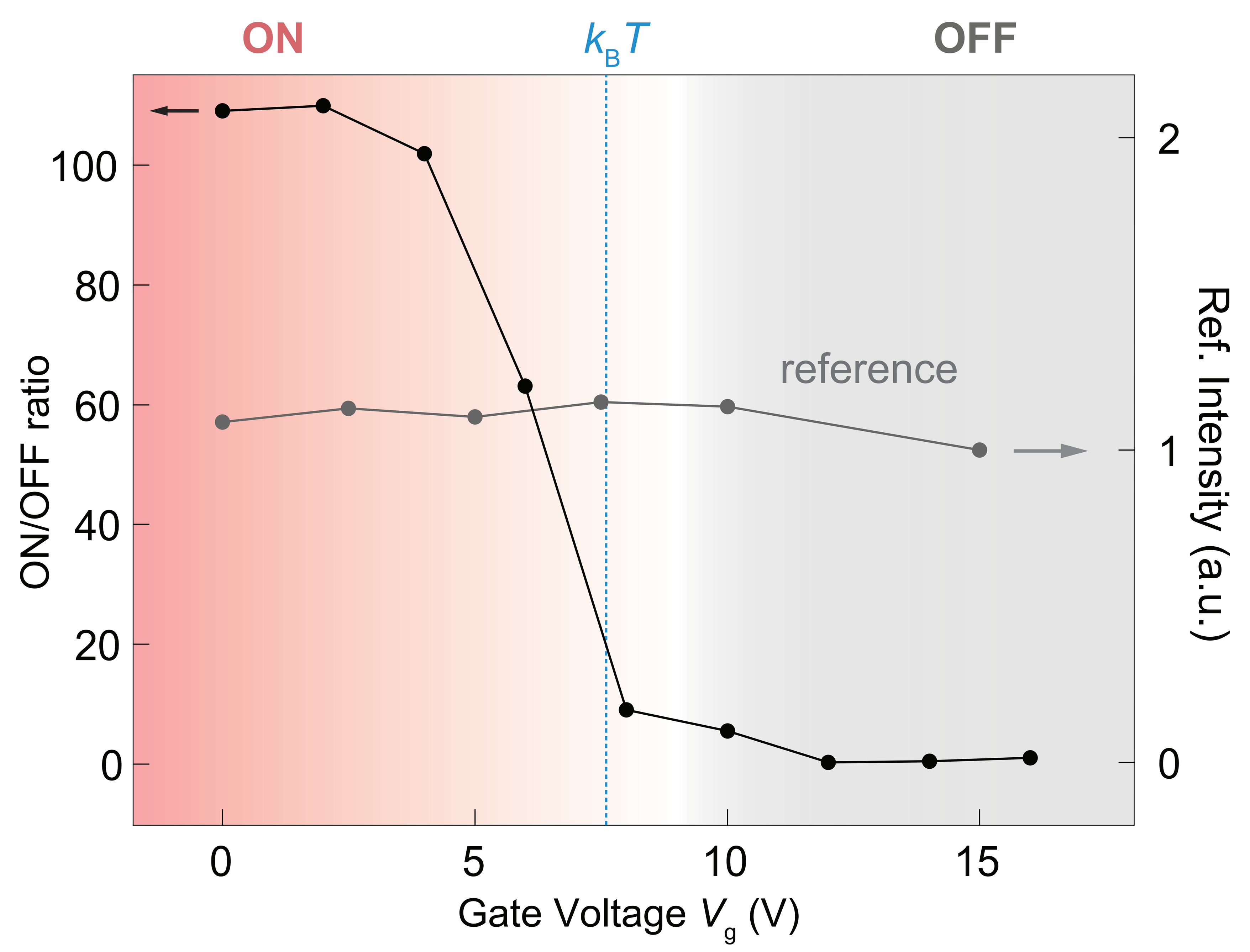


3. Excitonic device operation



Exciton flux blockage is achieved if the barrier is higher than $k_B T$

4. Excitonic flux switch

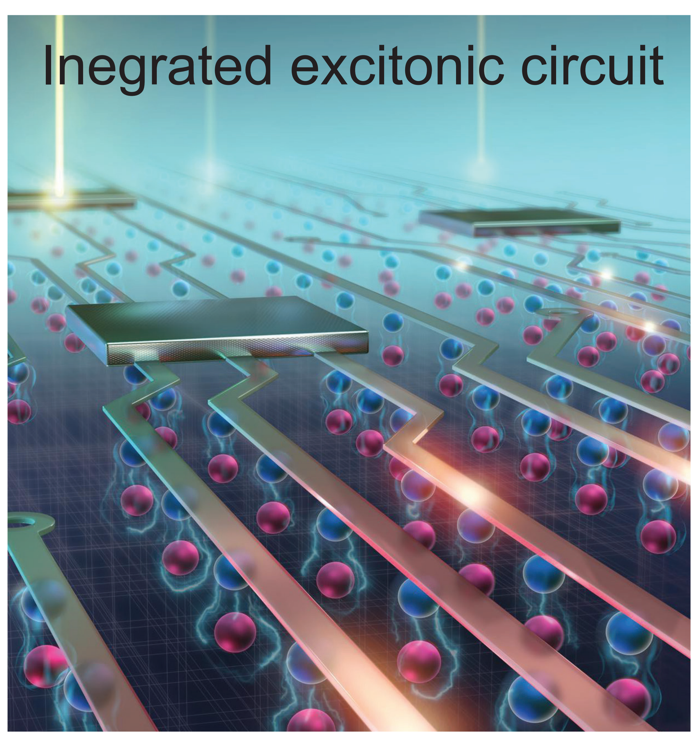


Fabricated device demonstrates an electrically controlled excitonic switch:

- Extracted ON/OFF ratio exceeds 100, limited by the noise-level of the measurement set-up in the OFF state
- ON-OFF switch happens at 8 V applied to the top gate that corresponds to the energy barrier of 25 meV equivalent to the thermal energy $k_B T$

5. Conclusion

- We fabricate a device where interlayer excitons are hosted in the MoS_2-WSe_2 heterostructure encapsulated by h-BN crystals and are controlled by the transparent graphene gates.
- Such a heterostructure device allows the observation of excitonic transistor actions at RT.
- Possibility of using 2D materials in future excitonic circuits for room temperature operations:



Reference

Dmitrii Unuchek*, Alberto Ciarrocchi*, et al. Room-temperature electrical control of exciton flux in a van der Waals heterostructure, *Nature*, 506:7718, **2018**. DOI: 10.1038/s41586-018-0357-y

Fundings

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