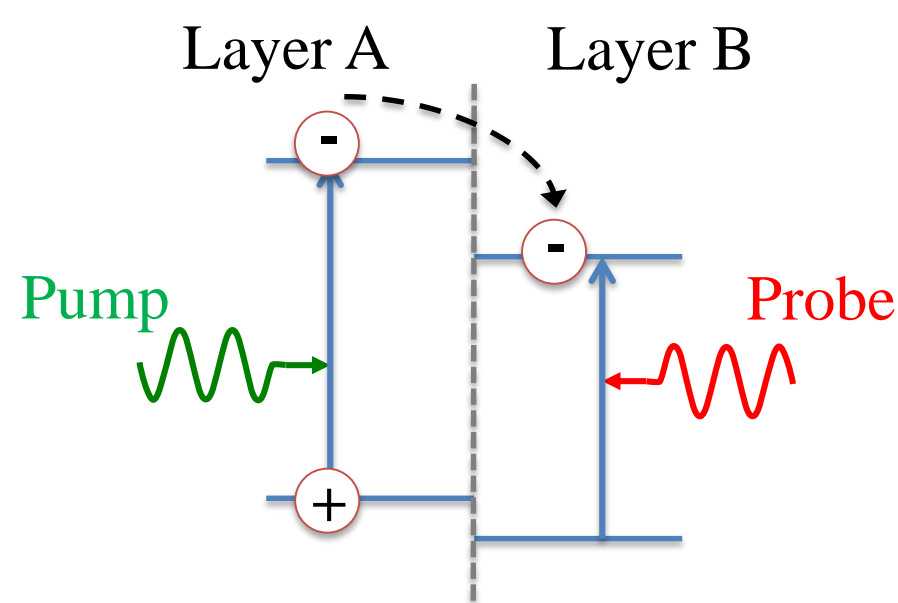
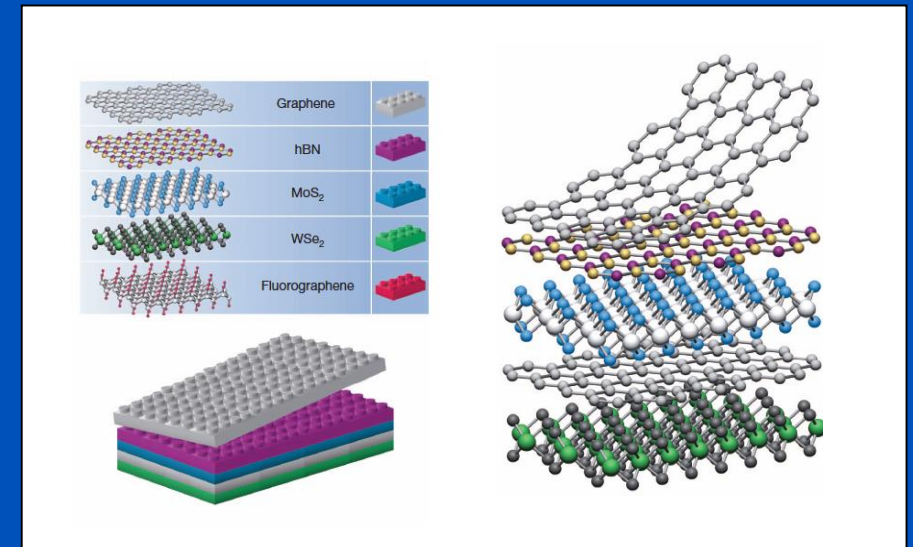


Charge Transfer in van der Waals Heterostructures

Two-dimensional materials can be used to form atomically thin and sharp van der Waals heterostructures, which can potentially open a new world of artificial materials. Emergent properties of these materials rely on two key elements: electron transfer and interlayer coupling. Using graphene-WS₂ and MoS₂-MoSe₂ as examples, we demonstrate ultrafast charge transfer across the van der Waals interface and strong interlayer coupling.

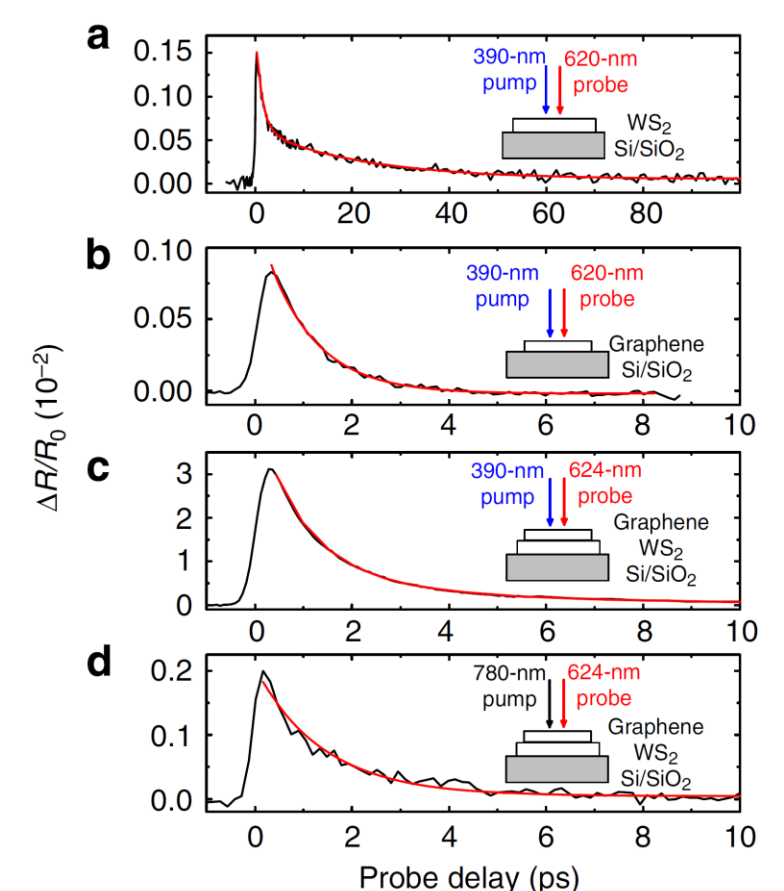
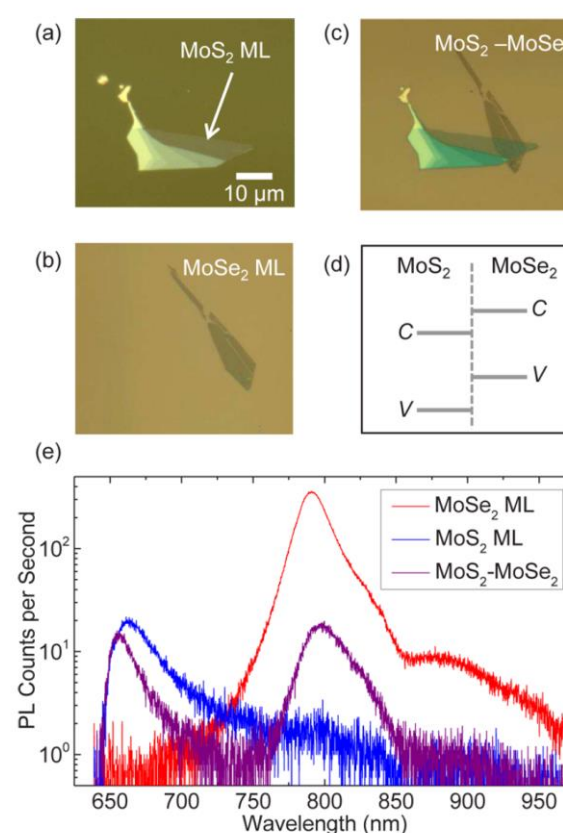


Experimental Approach

The ultrafast pump-probe measurement of charge transfer utilizes the energy difference of optical resonances of the two materials forming the heterostructures. But tuning the pump pulse to the resonance of one layer, electrons in that layer are excited. By observing the appearance of conducting electrons in the other layer with a probe pulse tuned to the resonance of that layer, we can time resolve the charge transfer process.

Main Results

- Carriers injected in WS₂ transfer to graphene in 1 picosecond and with near-unity efficiency.
- Optical properties of WS₂ can be effectively tuned by carriers in graphene.
- Electrons and holes transfer across interface of MoS₂-MoSe₂ in a few picoseconds.
- Indirect excitations with electrons and holes residing in different layers are formed after charge transfer, with longer lifetime.



Related Publications

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Electron transfer and coupling in graphene-tungsten disulfide van der Waals heterostructures

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Ultrafast Charge Separation and Indirect Exciton Formation in a MoS₂-MoSe₂ van der Waals Heterostructure

Frank Ceballos, Matthew Z. Bellus, Hsin-Ying Chiu,* and Hui Zhao*