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Excitonic devices based on van der Waals heterostructures

Excitons and their complexes with giant oscillator strength play a fundamental role in mediating the strong coupling between light and 2D semiconductors in both linear and non-linear optics regimes. The room temperature stability of these excitons makes 2D semiconductors attractive for a number of novel photonic devices including ultra-fast photo-detectors, optical modulators, chiral light emitters, single photon sources, and exciton-polariton lasers [1]. In order for these devices to be integrated for photonic devices, practical schemes for electrical generation, manipulation, and detection of excitons need to be developed. In our group, we fabricate artificial quantum wells based on van der Waal heterostructures and investigate the dynamics of 2D excitons to achieve the desired photonic functionalities. In this talk, I will start by discussing our findings on the ultrafast dipole-dipole energy transfer processes involving 2D excitons in various heterostructure types [2,3] and move onto our recent efforts in realizing electro-optical (electroluminescence, electro-absorption, and Pockels effect) devices. We demonstrate highly efficient electrical generation of excitons and correspondingly enhanced excitonic electroluminescence in metal-insulator-semiconductor (MIS) van der Waals heterostacks (Figure 1) and discuss unique ways in which hexagonal boron nitride can be used to explore hole transport and hot carrier effects in such devices.

References

[1] F. Xia et al. “Two-dimensional material nanophotonics” Nat. Phot. 8, 899 (2016).
[2] D. Kozawa *et al.* "Efficient interlayer energy transfer via 2D dipole coupling in $MoSe_2/WS_2$ heterostructures" Nano Lett. 16, 4087 (2016).
[3] W. Zhao *et. al.* “Exciton-plasmon coupling and electromagnetically induced transparency in monolayer semiconductors hybridized with Ag nanoparticles” *Adv. Mater.* 28, 2709 (2016).

Figures

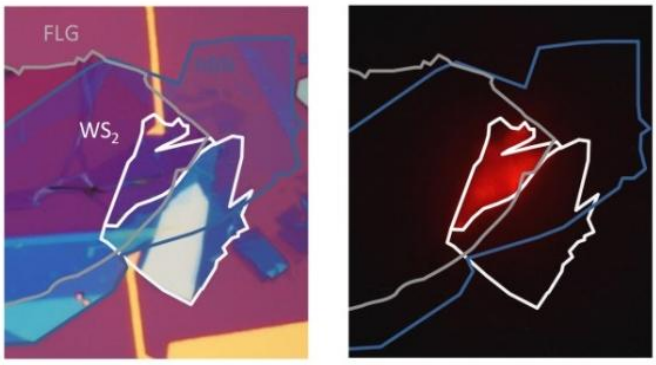

Figure 1: Planar electroluminescence from an MIS-type van der Waals heterostructure