Magneto-Photoluminescence Spectroscopy of Interlayer Exciton in van der Waals Heterostructures

Wang, T., Li, Z. (Rensselaer Polytechnic Institute (RPI), Chemical Engineering); Lu, Z. (NHMFL, FSU Physics); Meng, Y., Chen, Y. (RPI Chemical Engineering); Smirnov, D. (NHMFL); Shi, S. (RPI, Chemical Engineering)

Introduction

Transition metal dichalcogenides (TMDCs) represent a new class of atomically thin semiconductors with superior optical and electrical properties. A Van der Waals heterostructure of TMDCs provides a method to construct atomically sharp interface with atomic level control and provides a unique playground for low dimensional physics. In particular, a type II alignment can be formed by a single layer $MoSe_2/WSe_2$ resulting in a large band offset and long-lived interlayer excitons [1]. Magneto-photoluminescence spectroscopy of the interlayer exciton will not only shed light on its origins but also provides guidance for future valleytronics applications.

Experimental

Single layer $MoSe_2$ and WSe_2 were exfoliated and then transferred to the SiO_2/Si substrate. A thin layer of hexagonal boron nitride (h-BN) was transferred on top of the heterostructure to ensure minimum exposure to air. Contacts were fabricated by e-beam lithography followed by gold evaporation. The magneto-PL measurements were performed using a direct-optics micro-spectroscopy setup coupled to the 15/17 T SC magnet (EMR facility).

Results and Discussion

The low temperature photoluminescence (PL) spectra show the interlayer exciton at ~ 1.35 eV, similar to the previous report [1]. The left-circular polarized excitation (K) favorably generates left-circular polarized emission (K) rather than right-circular polarized light (K'). The valley polarization is about 30% and is smaller than that from intralayer exciton, which is about 70%. The external magnetic field up to 14.5 T does not generate obvious Zeeman splitting of the interlayer exciton peak, indicating small g factor. Meanwhile, we also note that the rich spectra feature from the defects close to intralayer exciton peaks is worth investigating.

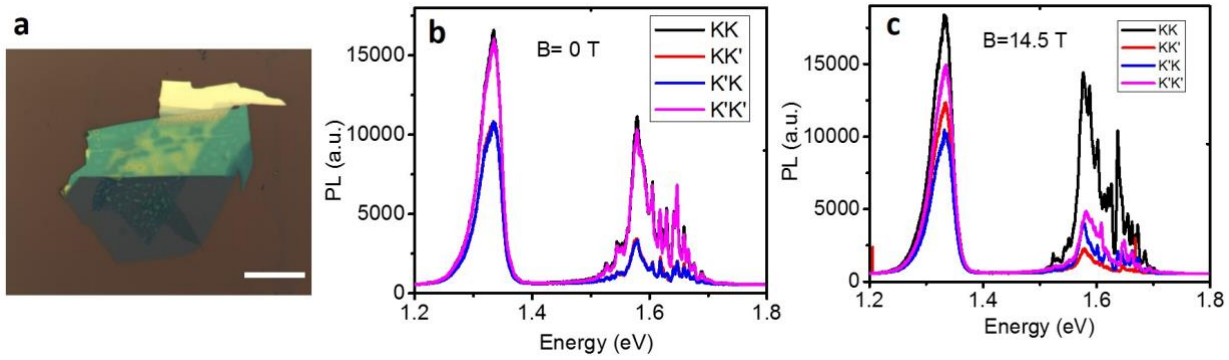

Fig.1 (a) Microscope image of the $MoSe_2/WSe_2$ heterostructure encapsulated by h-BN. Scale bar: 10 μm. (b, c) PL spectra measured with different chiral excitations at 0 T (b) and 14.5 T (c).

Conclusions

We have successfully shown the presence of the valley polarized interlayer exciton and have studied the B field dependence of the PL. Surprisingly, the Zeeman splitting of the interlayer exciton is small. The exact mechanism is still under investigation.

Acknowledgements

A portion of this work was performed at the National High Magnetic Field Laboratory, which is supported by National Science Foundation Cooperative Agreement No. DMR-1157490 and the State of Florida. S. Shi acknowledges the startup fund from RPI.

References

[1] Rivera, P., *et al.*, Science, **351**, 688 (2016).