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Electronic Transport and Device Applications of 2D Materials

Two-dimensional (2D) materials have emerged as promising candidates for post-Moore electronics due to their unique electronic properties and atomically thin geometry. I will start with our studies on atomically thin semiconducting material rhenium disulfide (ReS_2) and type-II Weyl semimetal (WSM) tungsten ditelluride (WTe_2). We observed interesting in-plane anisotropic transport and mechanical properties of ReS_2, together with its potential electronic and optoelectronic applications.[1] In thin tungsten ditelluride (WTe_2) flakes, we observed notable angle-sensitive negative longitudinal magnetoresistance (MR) and strong planar orientation dependence which reveal important transport signatures of chiral anomaly and type-II Weyl fermions. By applying a gate voltage, we further demonstrated that the Fermi energy can be tuned through the Weyl points via the electric field effect; this is the first report of controlling the unique transport properties *in situ* in a WSM system.[2]

By stacking layers of different 2D materials together, van der Waals (vdW) heterostructures offer unprecedented opportunities to create materials with atomic-level precision by design, and combine superior properties of each component. In the second part of my talk, I will show that robust memristors with good thermal stability, which is lacking in traditional memristors, can be created from a vdW heterostructure composed of graphene/$MoS_{2-x}O_x$/graphene.[3] Our latest results on high-performance mid-infrared photodetectors based on atomically thin vdW heterostructures made of black arsenic phosphorus and transition metal dichalcogenides will also be presented.[4]

References

[1] Liu, et al., Nat. Comm. 6, 6991 (2015); Adv. Func. Mater. 26, 1938 (2016); Wang, et al., ACS Nano (2018).
[2] Wang, et al., Nat. Comm. 7, 13142 (2016); Hao, et al., Adv. Func. Mater. (2018).
[3] Wang, et al., Nat. Electronics 1, 130 (2018).
[4] Long, et al., Science Adv. 3, e1700589 (2017); Nano Lett. 16, 2254 (2016).