2D Semiconductor, Transition Metal Dichalcogenides Growth and Its Applications

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Graphene, a single atomic layer of carbon atoms, has attracted grated attention because of its novel physical properties and potential for electro-optical technology. Recently this interest has expanded to the wide class of two-dimensional materials that occur naturally as 2D layers of van-der-Waals crystals. While preserving graphene's flexibility and tenability by external perturbations, atomically thin layers of this broader set of materials provide access to more varied electronic and optical properties, including semiconductor and insulating behavior.

In first part of this presentation, we will discuss some distinctive properties and large area continuous growth of atomically thin 2D semiconductor, especially transition metal dichalcogenide (MX_2 where M=Mo,W and X=Se, S)[1-3]. We also demonstrates monolayer $Mo(S,Se)_2$ is next generation nonlinear optical material for its strong optical nonlinear properties with second harmonic generation characteristics[4-7].

In second part of this talk, we will demonstrate the in-plane heterostructure (HS) of monolayer MX2, especially MoSe2 and WSe2. From synthetic prospective, unlike vertical HS, the lateral HS can only be created by direct growth method. Here, we present the growth of three-atom-thick lateral HS consisting of $MoSe_2$ and WSe_2 monolayers by a pulsed-laser-deposition-assisted (PLD-assisted) selenization method.[2] The monolayer lateral HS flakes (size: ~15 mm to ~40 mm) were obtained by controlling the growth temperature profile. The sharp interface of the grown monolayer lateral HS was verified by morphological and optical characterizations. Interestingly, the photoluminescence spectra acquired from the interface showed clear signatures of pristine $MoSe_2$ and WSe_2 with no intermediate energy peak related to the formation of the $Mo_xW_{1-x}Se_2$ alloy or excitonic matter across the HS, thereby confirming the sharp interface.

References

[1] V. Senthilkumar, et al., Nano Res. **7**, 1759 (2014)
[2] F. Ullah, et al., CrystEngComm **18,** 6992 **(**2016)
[3] H. G. Park, et al., Appl. Spectrosc. Rev. **51**, 621 (2016)
[4] D. J. Clark, et al., Phys. Rev. B **90**, 121409(R) (2014); Phys. Rev. B **92**, 159901(E) (2015)
[5] D. J. Clark, et al., Appl. Phys. Lett. **107**, 131113 (2015)
[6] C. T. Le, et al., Ann. Phy. **528,** 551 (2016)
[7] C. T. Le, et al., ACS Photonics 4, 38-44 (2017)