Accepted Manuscript

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Science Bulletin
www.scibull.com

PII: S2095-9273(17)30098-1
DOI: http://dx.doi.org/10.1016/j.scib.2017.02.007
Reference: SCIB 70

To appear in: *Science Bulletin*

Please cite this article as: J. Yuan, W. Chen, J. Lou, Two dimensional heterostructure: perfect platform for exploring interface interaction, *Science Bulletin* (2017), doi: http://dx.doi.org/10.1016/j.scib.2017.02.007

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Two dimensional heterostructure: perfect platform for exploring interface interaction

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Two-dimensional (2D) materials have been attracting great amount of attentions from researchers worldwide due to their exotic mechanical, optical, electrical, thermal and catalytic properties, which could enable their potential applications in future multifunctional devices. The interests in 2D materials were initially inspired by the successful exfoliation and characterization of monolayer graphene in 2004.[1] However, the absence of a band gap in graphene limits its use in many logic electronic devices. The demonstration of semiconducting monolayer molybdenum disulfide based field-effect transistors,[2] along with the successful preparation of other monolayer transition metal dichalcogenides by various methods,[3-7] provide new possibilities of creating novel devices with additional functionalities.

One distinctive advantage of 2D materials is that they can form different kinds of vertical heterostructures by stacking monolayers of different chemical compositions together. Such artificial crystals do not exist in nature. With the availability of increasing number of 2D building blocks, it brings the concept of designing materials at the atomic level closer to reality. Due to their atomically thin thickness, there will be no such difference as bulk to surface/interface as in conventional three-dimensional materials. Interface interaction is the main consideration when designing 2D heterostructures, and such interactions directly determine the performance of final devices. A lot of examples have been successfully demonstrated utilizing this idea, for instance, tunneling field-effect transistor with on/off ratio larger than 10^6,[8] ultra sensitive photodetector,[9] room temperature light-emitting diode[10] and strong light-matter interaction with quantum efficiency more than 30%, etc.[11]

Raman and photoluminescence (PL) spectroscopy are very powerful tools in studying 2D semiconducting materials due to their high sensitivity, nondestructive and fast nature. They are the most convenient characterization techniques to understand phonon vibrations and electronic structures. Understanding the Raman and PL behaviors of these two dimensional materials will be of importance in designing new devices. In a paper published recently, Fang and co-workers[12] carried out a new study on the temperature dependence of Raman and PL spectra of vertical stacked MoS_2/WS_2 heterostructure, which illustrates the effect of temperature on 2D materials.

The heterostructure of MoS_2/WS_2 was prepared with tellurium assisted chemical vapor deposition, which provided a cleaner interface to study the interaction between these two materials. By using scanning electron microscope (SEM), atomic force microscope (AFM) and Raman microscopy, they confirmed that the heterostructure