Synthesis, Characterization and Potential Applications of Novel Two-Dimensional Atomic Layers

Zheng Liu*
School of Materials Science and Engineering, Nanyang Technological University, 639798, Singapore
z.liu@ntu.edu.sg

Abstract

The one-atom-think layer e.g. graphene has fantastic properties and attracted tremendous interests in these years, which opens a window for various two-dimensional (2D) materials. However, making large-size and high-quality 2D is still a great challenge. Using chemical vapour deposition, we have successfully synthesized a wide varieties of 2D materials with high quality and large scale via chemical vapor deposition (CVD) method, including hexagonal boron nitrides (h-BN), transition metal dichalcogenides e.g. molybdenum disulphides (MoS_2), tungsten disulphides (WS_2), cadmium sulphides (CdS), gallium selenides (GaSe) and molybdenum selenides ($MoSe_2$) belonging to binary 2D layers. Ternary 2D layers including BCN, $MoS_{2x}Se_{2(1-x)}$, are also successfully prepared.

In addition, fabrication of 2D heterostructures including vertical and lateral graphene/h-BN, vertical and lateral TMDs are also demonstrated. These work provide a better understanding of the understanding of the atomic layered materials in terms of the synthesis, atomic structure, alloying and mechanical properties. Complementary to the 2D atomic layered grown by CVD method, 2D single-crystal bulk are also prepared via solid reaction including WTe_2, $SnSe_2$, PtS_2, $PtSe_2$, $PdSe_2$, ReS_2, $WSe_{2x}Te_{2(1-x)}$, Ta_2NiS_5 and Ta_2NiSe_5 whose properties are now under exploration. Applications of the 2D layers including optoelectronic devices, energy device and smart coating have also been demonstrated.

References

[1]. Y. Gong, G. Shi, J. Lou, **Z. Liu***, and P.M. Ajayan etc. **Nature Communications**, 2014, 5, 319
[2]. **Z. Liu**, M. Amani, S. Najmaei, PM Ajayan, J. Lou etc **Nature Communications** 2014, 5, 5246
[3]. Y. Gong, J. Lin, B. I. Yakobson, **Z.Liu,** W. Zhou, PM Ajayan etc. **Nature Materials** 2014, 13, 1135
[4]. Y.J. Gong,# **Z. Liu**,# A.R. Lupini,# W. Zhou, P.M. Ajayan. etc. **Nano Letters** 2014, 14, 442
[5]. **Z. Liu**, Y.J. Gong et al., **Nature Communications**, 2013, 4, 2541
[6]. S. Najmaei,* **Z. Liu**,* W. Zhou, P. M. Ajayan, J. Lou. etc. **Nature Materials** 2013**,** 12, 754
[7]. **Z. Liu**, L. Ma, G. Shi, J. Lou, P. M. Ajayan, etc. **Nature Nanotechnology** 2013**,** 8, 119
[8]. **Z. Liu**, Y. Zhan, G. Shi, S. Moldovan, J. Lou, P. M. Ajayan, etc. **Nature communications** 2012**,** 3, 879

Figures

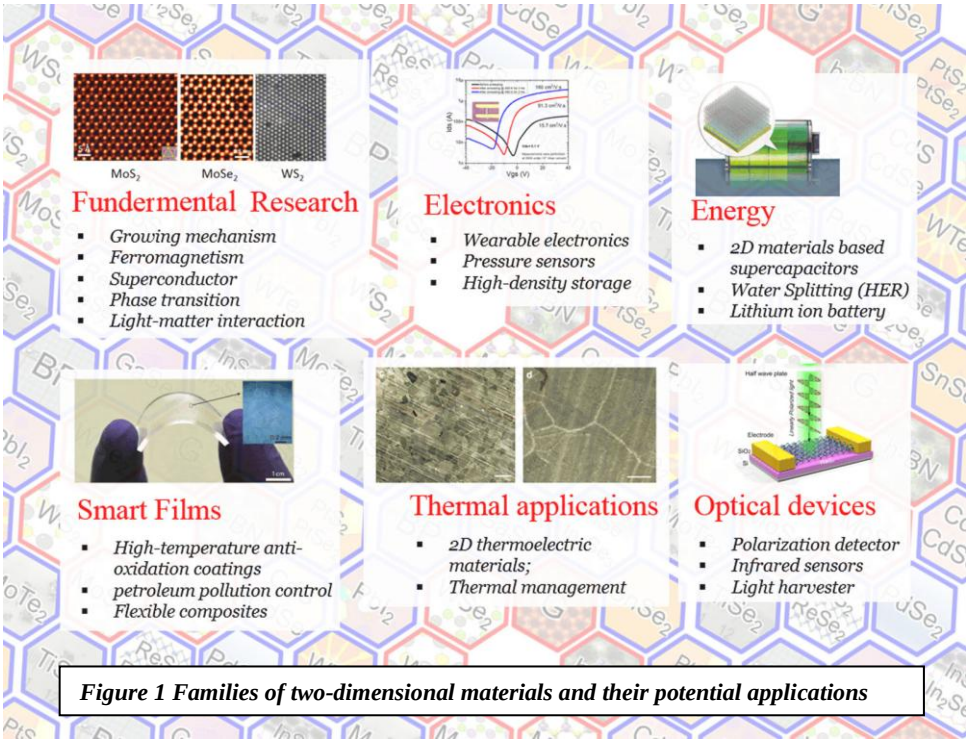

Figure 1 Families of two-dimensional materials and their potential applications