

ISGD-5

5th INTERNATIONAL SYMPOSIUM ON GRAPHENE DEVICES

Landscape of Two-dimensional Materials: Synthesis, Characterization and Applications

LIU Zheng

Nanyang Assistant Professor

School of Materials Science and Engineering, Nanyang Technological University, 639798, Singapore
Technological University, 639798, Singapore

z.liu@ntu.edu.sg

Abstract: Recent times have seen a surge of activity in the exploration of two dimensional atomic layered structures with a range of properties. Here we will discuss our recent efforts in exploring various two-dimensional materials including graphene, hexagonal boron nitride (h-BN), various dichalcogenide systems and hybrid atomic layers consisting of multiple compositions. Scalable synthesis through vapour deposition of several of these structures will be discussed. Understanding of defects such as grain boundaries, edges and point defects in these structures is important for manipulating physical properties in these materials. Our efforts in manipulating these layers into creating vertically stacked hybrids as well as laterally engineered layers will be described. Overall, the talk will summarize our recent progress in synthesizing and characterizing atomically engineered layers of materials with a wide range of properties and their applications on active nano-systems and high performance energy components, e.g. resonators, photodetectors, high-density capacitors, ultrafast lithium storage etc.

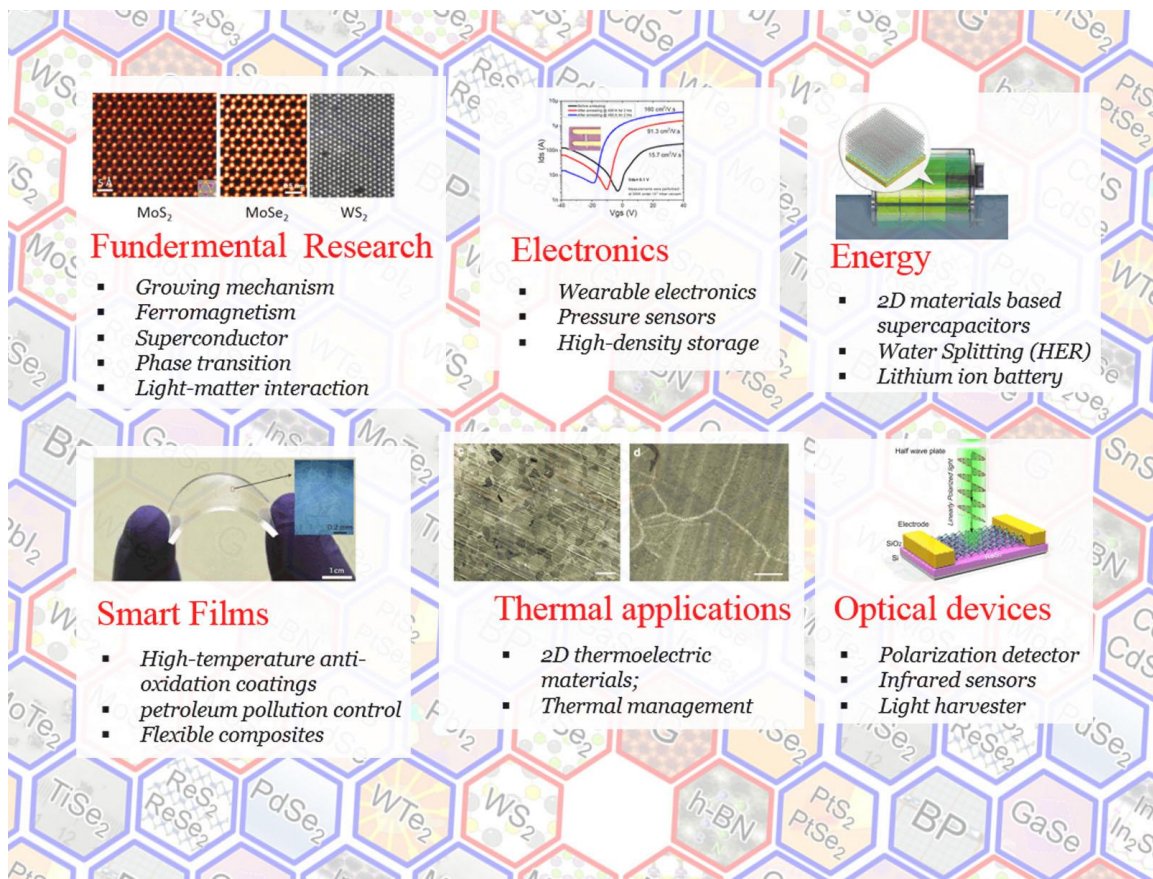


Figure 1 Families of two-dimensional materials and their potential applications

References:

- [1]. Y. Gong, G. Shi, Z. Zhang, W. Zhou, J. Jung, W. Gao, L. Ma, Y. Yang, S. Yang, G. You, R. Vajtai, Q. Xu, A. MacDonald, B. I. Yakobson, J. Lou, **Z. Liu***, and P.M. Ajayan Direct Chemical Conversion of Graphene to Boron, Nitrogen and Carbon Containing Atomic Layers. **Nature Communications**, 2014, 5, 319
- [2]. **Zheng Liu**, Matin Amani, Sina Najmaei, Quan Xu, Xiaolong Zou, Wu Zhou, Ting Yu, Caiyu Qiu, A. Glen Birdwell, Frank J. Crowne, Robert Vajtai, Boris I. Yakobson, Zhenhai Xia, Madan Dubey, Pulickel M. Ajayan and Jun Lou Strain and Structure Heterogeneity in MoS₂ Atomic Layers Grown by Chemical Vapor Deposition. **Nature Communications** 2014
- [3]. Yongji Gong, Junhao Lin, Xingli Wang, Gang Shi, Sidong Lei, Zhong Lin, Xiaolong Zou, Gonglan Ye, Robert Vajtai, Boris I. Yakobson, Humberto Terrones, Mauricio Terrones, Beng Kang Tay, Jun Lou, Sokrates T. Pantelides, **Zheng Liu**, Wu Zhou, Pulickel M. Ajayan Vertical and In-Plane Heterostructures from WS₂/MoS₂ Monolayers **Nature Materials** 2014
- [4]. Y.J. Gong, **Z. Liu**,# A.R. Lupini,# G. Shi, J.H. Lin, S. Najmaei, Z. Lin, A.L. Elías, A. Berkdemir, G. You, H. Terrones, M. Terrones, R. Vajtai, S.T. Pantelides, S.J. Pennycook, J. Lou, W. Zhou, P.M. Ajayan. Band Gap Engineering and Layer-by-Layer Mapping of Selenium-Doped Molybdenum Disulfide. **Nano Letters** 2014, 14, 442.
- [5]. **Z. Liu**, Y.J. Gong et al., “Ultrathin high-temperature oxidation-resistant coatings of hexagonal boron nitride”, **Nature Communications**, 2013, 4, Article number: 2541.
- [6]. S. Najmaei,* **Z. Liu**,* W. Zhou, X. Zou, G. Shi, S. Lei, B. I. Yakobson, J.-C. Idrobo, P. M. Ajayan, J. Lou. Vapour phase growth and grain boundary structure of molybdenum disulphide atomic layers. **Nature Materials** 2013, 12, 754-759. (*Equally first author)
- [7]. **Z. Liu**, L. Ma, G. Shi, W. Zhou, Y. Gong, S. Lei, X. Yang, J. Zhang, J. Yu, K. P. Hackenberg, A. Babakhani, J.-C. Idrobo, R. Vajtai, J. Lou, P. M. Ajayan. In-plane heterostructures of graphene and hexagonal boron nitride with controlled domain sizes. **Nature Nanotechnology** 2013, 8, 119-24.Z.
- [8]. **Z. Liu**, Y. Zhan, G. Shi, S. Moldovan, M. Gharbi, L. Song, L. Ma, W. Gao, J. Huang, R. Vajtai, F. Banhart, P. Sharma, J. Lou, P. M. Ajayan. Anomalous high capacitance in a coaxial single nanowire capacitor. **Nature communications** 2012, 3, 879-879.

Biography



Dr. Zheng Liu received his B.S. degrees (2005) at Nankai University (China), and completed his Ph.D at National Center for Nanoscience and Technology (NCNST, China), working on the synthesis and energy harvest of carbon nanotubes. He then worked in Prof. Pulickel M. Ajayan and Prof. Jun Lou's groups as a joint postdoc research fellow (2010~2012) and research scientist (2012~2013) at Rice University (USA), focusing on the synthesis and applications of two-dimensional (2D) crystals, including graphene, hexagonal boron nitride, oxides and transition metal dichalcogenides (TMD: MoS₂, MoSe₂ etc). He has made contributions not only to the synthesis of 2D heterostructures such as vertical and lateral graphene/h-BN, but also the 2D materials based nanoelectronics, active nano-systems and high performance energy components, e.g. resonators, graphene photodetectors.

He has published more than 60 peer-reviewed papers in top journals including 9 papers in Nature serial journal (Nat Mater, Nat Nanotech and Nat Comm); 17 in Nano Lett; 7 in Adv Mater; 7 in ACS Nano, with total citations more than 4000 and h-index of 32 These works have also been reported by Science daily, IEEE spectrum, etc., and highlighted by the top journals such as Nature Physics, Nature Nanotechnology, Chem Int Ed, etc. He was also a recipient of the World Technology Award in Energy category in 2012. This award has been presented as a way to honor those in doing “the innovative work of the greatest likely long-term significance.” He was awarded the prestigious Singapore NRF Fellowship and Nanyang Assistant Professorship in 2013.