1640
doi:10.1017/S1431927616009041
Microsc. Microanal. 22 (Suppl 3), 2016

Study on Chemical Vapor Deposition Growth and Transmission electron Microscopy MoS_2/h-BN Heterostructure

Fu Zhang[1 2], Mohammed Abu AlSaud[1 2], Mel Hainey Jr.[1], Ke Wang[1 2], Joan M. Redwing[1 2], Nasim Alem[1 2]

[1] Department of Materials Science and Engineering and Materials Research Institute, The Pennsylvania State University, University Park, PA 16802, USA.
[2] Materials Research Institute, The Pennsylvania State University, University Park, PA 16802, USA.

Van der Waals (vdW) heterostructures of transitional-metal dichalcogenides (TMDs) have attracted significant attention owing to their superior electronic and optoelectronic properties, opening up pathways to generate novel materials via a bottom-up approach [1,2]. The properties of heterostructures can arise from their interfacial structure. Recent research has demonstrated that free-standing TMD/graphene heterostructures have a significant photoluminscence quenching response compared to monolayer crystals [3], strongly suggesting effective transport of the charge carriers at the interface in free-standing heterostructures.

Hexagonal boron nitride (hBN) is an ideal substrate to maintain the intrinsic electronic and optoelectronic properties of TMDs[4,5]. In addition, due to its insulating nature, hBN is considered to be an ideal substrate for the growth of vdW heterostructures and fabrication of electronic devices. In this study, we determine the nucleation and growth of vdW heterostructures and the role of substrate defects in the epitaxial growth of TMDs on hBN. This study uses atomic resolution aberration-corrected Scanning/Transmission Electron Microscopy (AC-S/TEM) imaging and spectroscopy to investigate the atomic, chemical, and electronic structure of the TMDs/hBN heterostructures and their epitaxy as a function of substrate defects.

Monolayer and few layer Molybdenum Disulphide (MoS_2) triangles are grown on Mechanically-exfoliated (ME) hBN using atmosphere pressure chemical vapor deposition (CVD) technique. Figure 1a shows an SEM image of the MoS_2/hBN heterostucture, while figure 1b shows an annular dark field (ADF)-STEM image of the same heterostructure. MoS_2 triangles (100~400 nm) are epitaxially grown and orientated at 180^o with respect to each other on top of ME-hBN. In this study we observe higher density of MoS_2 triangles grown at the step edges due to the presence of dangling bonds [3,6]. The strict crystallographic relationship between MoS_2 and ME-hBN, is confirmed by electron diffraction analysis shown in Figure1c. Figures 1b and 1d show ADF-STEM images of the heterostructure and the presence of energetically preferred zigzag edge in MoS_2 grown on ME-hBN. In this study we will further explore the role of substrate defects on the nucleation of TMDs and the resulting epitaxy, orientation relationship, and the layer thickness of TMDs/hBN heterostructure.

Reference
[1] Q. H.Wang, K. Kalantar-Zadeh, A. Kis, J. N.Coleman, M. S. Strano, Nat. Nanotechnol.2012, 7, 699–712.
[2] M.Chhowalla, H. S.Shin, G. Eda, L. J. Li, K. P. Loh, H. Zhang. Nat. Chem. 2013, 5,263–275.
[3] A. Azizi, S. Eichfeld, G. Geschwind, K. Zhang, B. Jiang, D. Mukherjee, et al. ACS Nano 2015,9,4882-4890
[4] C. R.Dean, A. F.Young, P.Cadden-Zimansky, L.Wang,H.Ren, K. Watanabe, T.Taniguchi, P.Kim,J.Hone,K. L.Shepard. Nat. Phys. 2011, 7, 693–696
[5] H.Qiu, T. Xu,Z. L.Wang, W.Ren, H. Y. Nan, Z. H.Ni, Q.Chen,S. J.Yuan, F. Miao, F. Q. Song, et al. Nat. Commun. 2013, 3642.
[6] M. Okada, T. Swazaki, K. Watanabe, T. Taniguch, H. Hibino, H. Shinohara and R. Kitaura. ACS Nano 2014,8,8237-8277

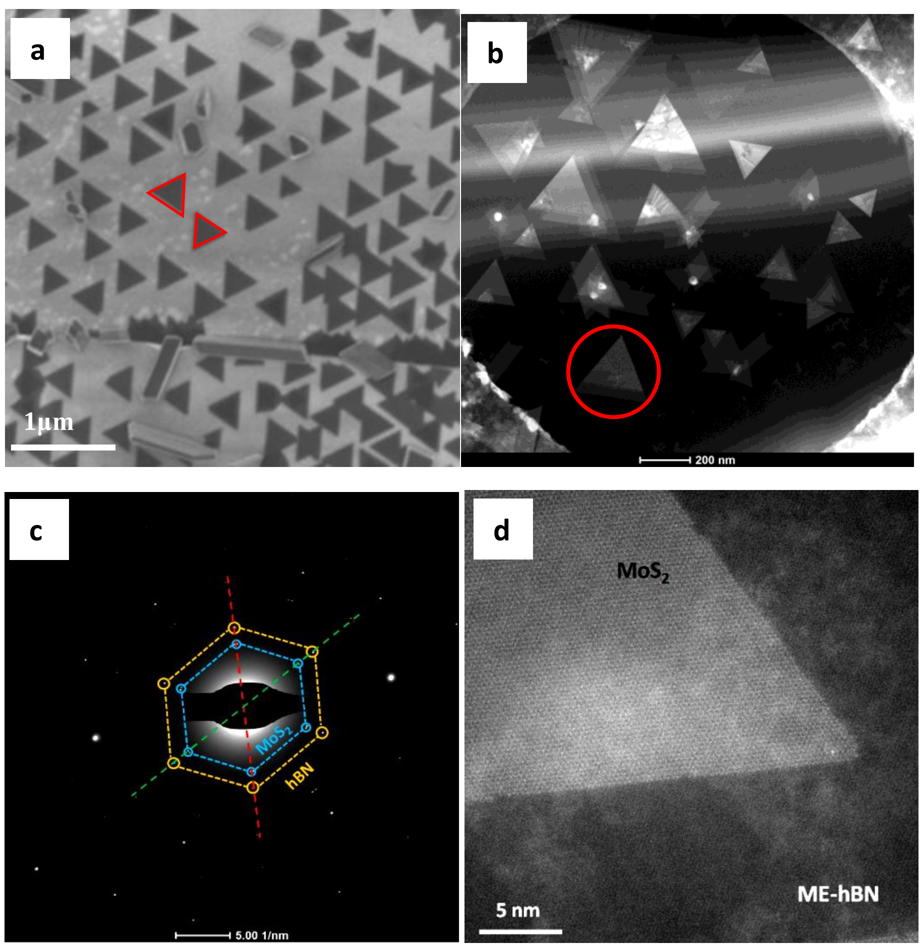

Figure.1 (a) SEM image and (b) Annular dark field (ADF)-STEM image of trianglar-shaped MoS_2 grown on a ME-hBN flake. (c) the diffraction pattern from the red-circled MoS_2/hBN, yellow shows hBN pattern, blue shows MoS_2 pattern, there is an exact 0 degree orientation relationship between the interface of epitaxial MoS_2 and underlying ME-hBN templates), (d) High resolution ADF-STEM image of a trianglar-shaped MoS_2 edge on top of a hBN flake.

https://doi.org/10.1017/S1431927616009041 Published online by Cambridge University Press