640
doi:10.1017/S1431927621002683
Microsc. Microanal. 27 (Suppl 1), 2021
© Microscopy Society of America 2021

Atomic Scale Investigation of Interfaces in MoS_2-ReS_2 In-plane Heterostructures Using High Resolution S/TEM

Saiphaneendra Bachu[1], Lauren Stanton[1], Chenhao Qian[1], Danielle Reifsnyder Hickey[2] and Nasim Alem[1]

[1]Pennsylvania State University, United States, [2]Pennsylvania State University, Pennsylvania, United States

Two-dimensional (2D) heterostructures are formed when two or more individual 2D materials are stacked or stitched next to each other. These heterostructures enable the ability to make multicomponent optoelectronic devices where each 2D material acts as a component. This makes them more conducive towards realizing practical applications such as transistors and photodetectors [1]. With the advent of semiconducting transition metal dichalcogenides (TMD), the interest in forming heterostructures with different members of the TMD family has gained momentum. This is because TMD materials present an opportunity to engineer the band alignment at the heterostructure interface [2]. Band alignment depends on the chemistry of constituent TMD and the interfacial features such as defects, strain and epitaxy. As an example, VS_2-MoS_2 heterostructures were shown to form metal-semiconductor contacts with very low contact resistance because of the metallic nature of VS_2 and semiconducting nature of MoS_2 [3]. In another example highlighting the importance of the interface structure, C. Zhang et al. have reported the band alignment changes from type-II to type-I in WSe_2-MoS_2 lateral heterostructures grown on monolayer WSe_2 because of the 3.8% lattice mismatch strain between WSe_2 and MoS_2 [4].

In this work, we study MoS_2-ReS_2 heterostructures that are synthesized through a two-step chemical vapor deposition (CVD) technique using powder precursors. MoS_2-ReS_2 vertical heterostructures were shown to demonstrate great photoresponse properties and strong interlayer interaction stemming from type-I band alignment [5]. Furthermore, ReS_2 is structurally very different from MoS_2 because it exhibits distinct crystal symmetry resulting in anisotropic properties [6]. This provides an opportunity to create heterostructures with different interface structure and novel properties. Thus, it is important to synthesize and study the atomic structure of interfaces in MoS_2-ReS_2 heterostructures. We have used scanning/transmission electron microscopy (S/TEM) imaging to investigate the atomic and chemical structure of MoS_2-ReS_2 heterostructures after growth. Figure 1a is a low magnification TEM image which shows a large field-of-view image of MoS_2-ReS_2 in-plane heterostructures at the end of two-step CVD process. It is evident that ReS2 growing during the second step fills the gaps between MoS_2 triangles grown in the first step thus forming the in-plane heterostructures. Figure 1b shows a high angle annular dark field (HAADF)-STEM image of a MoS2 triangle (red dashed outline) with ReS_2 nanoflakes grown around it. The presentation will further present the atomic structure, defects, epitaxy and strain between the MoS_2 and ReS_2 at the interface [7].

https://doi.org/10.1017/S1431927621002683 Published online by Cambridge University Press

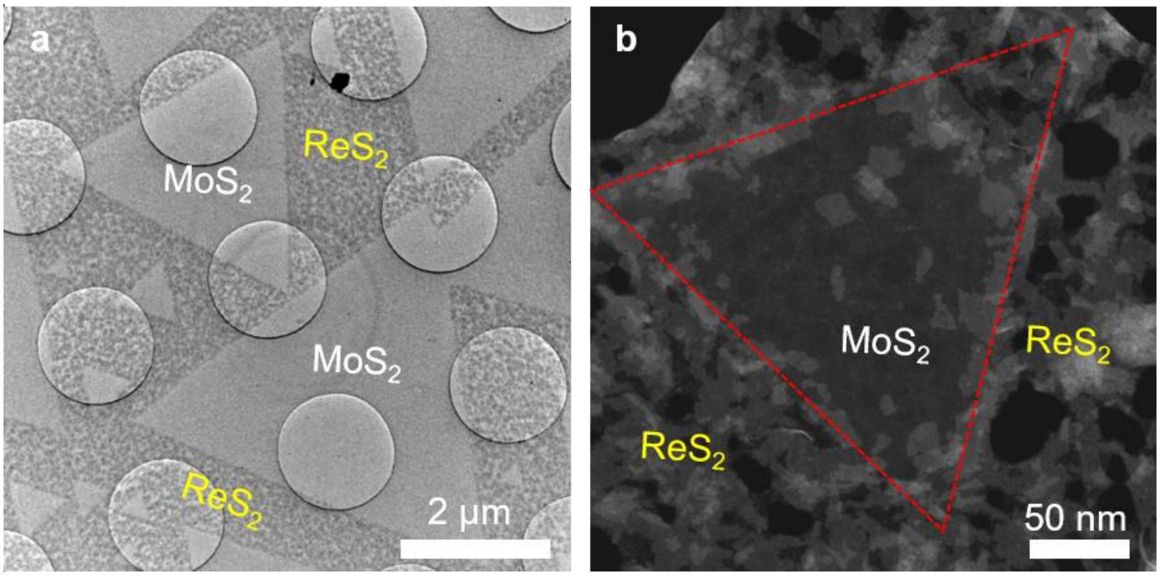

Figure 1. MoS_2-ReS_2 in-plane heterostructures: (a) Low-magnification TEM image showing MoS2 triangles with ReS_2 grown between the triangles thus forming the in-plane heterostructures and (b) HAADF-STEM image of a MoS_2 triangle (red dashed triangle) and ReS_2 nanoflakes grown around the triangle.

References

[1] Gong, Yongji, et al., Nature materials 13.12 (2014): 1135-1142.
[2] Özçelik, V. O., et al., Phys. Rev. B 94 (2006): 035125.
[3] Leong, Wei Sun, et al., Journal of the American Chemical Society 140.39 (2018): 12354-12358.
[4] Zhang, Chendong, et al., Nature nanotechnology 13.2 (2018): 152-158.
[5] Bellus, M. Z. et al., Nanoscale Horiz. 2 (2017): 31–36.
[6] Lin, Yung-Chang, et al., ACS Nano 9.11 (2015): 11249-11257.
[7] This work was supported by the National Science Foundation (NSF), in part under the CAREER program (DMR-1654107), in part by the program EFRI 2-DARE: 2D Crystals by Activated Atomic Layer Deposition (EFRI-1433378), and in part by the Penn State 2D Crystal Consortium-Materials Innovation Platform (2DCC-MIP) under NSF cooperative agreement DMR-1539916.

https://doi.org/10.1017/S1431927621002683 Published online by Cambridge University Press