CVD Growth of Large-Area, Uniform Multilayer h-BN as a Platform for 2D Material Applications

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Multilayer hexagonal boron nitride (h-BN) is widely recognized as an ideal insulator to bring out the intrinsic properties of two-dimensional (2D) materials [1,2]. Catalytic chemical vapor deposition (CVD) method is expected to produce large-area h-BN films suitable for practical applications [3-5]. Although Cu foils/films are widely used as catalyst, monolayer h-BN grows on Cu, which is not thick enough to screen out influences from substrate surface [3,4]. Recently, CVD growth of multilayer h-BN film was reported by using Fe foil, in which dissolution and segregation processes occur during the CVD process [5]. However, this multilayer h-BN film lacks uniformity having inhomogenous film thickness [5]. The growth of uniform multilayer h-BN requires well-controlled dissolution and segregation of B and N atoms. Here, we demonstrate the successful synthesis of large-area, uniform multilayer h-BN films using a metal alloy catalyst. Our multilayer h-BN dramatically improved the optical property of WS_2 grains.

Figure 1a shows an optical micrograph of the multilayer h-BN transferred on SiO_2/Si substrate. This micrograph displays uniform optical contrast, indicating the high uniformity of the multilayer h-BN. As shown in the cross-sectional TEM image (Figure 1b), a well-defined layered structure was clearly observed with a film thickness of ~2.5 nm. The interlayer distance of 0.35 nm corresponds to the multilayer h-BN structure. To demonstrate the performance of our multilayer h-BN as a dielectric substrate for 2D materials, we investigated optical properties of WS_2 grown on the multilayer h-BN. Triangular WS_2 grains with monolayer thickness were obtained on h-BN by CVD (Figure 2a). Intriguingly, we observed an intense and narrow PL peak from the WS_2 grown on h-BN as compared with that on SiO_2/Si (Figure 2b), demonstrating that our h-BN is effective as a dielectric substrate for 2D materials. Our achievement of uniform multilayer h-BN synthesis is expected to offer an ideal platform for 2D materials, greatly contributing to their practical applications.

References

[1] C. R. Dean et al., Nat. Nanotechnol., 5, (2010) 722-726
[2] M. Okada et al., ACS Nano, 8, (2014) 8273-8277
[3] K. Kim et al., Nano Lett., 12 (2012) 161-166
[4] Y. Uchida et al., Phys. Chem. Chem. Phys., 19, (2017) 8230-8235
[5] S. M. Kim et al., Nat. Commun., 6, (2015) 8662

Figures

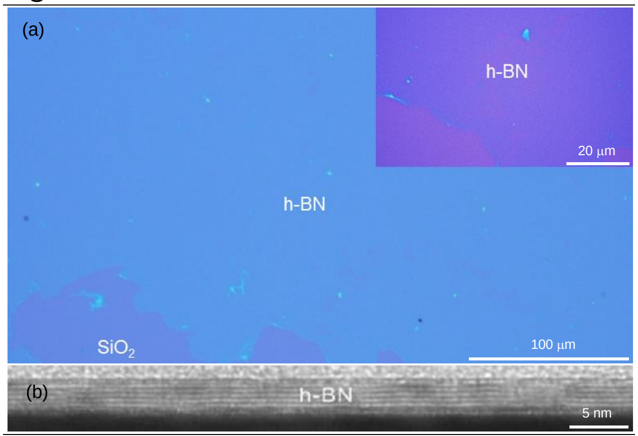

Figure 1: (a) Optical images of multilayer h-BN transferred on SiO_2/Si substrate. (b) TEM image of as-grown h-BN on the metal alloy catalyst.

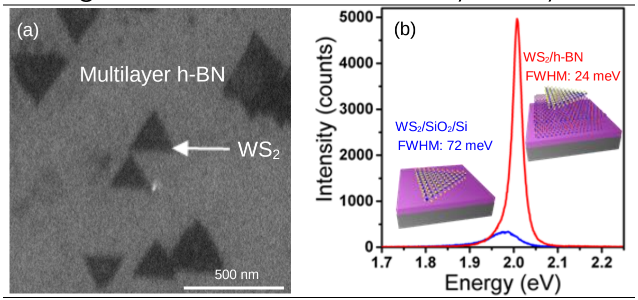

Figure 2: (a) SEM image of WS_2 grains grown on multilayer h-BN. (b) Typical PL spectra of WS_2 grown on the h-BN (red) and SiO_2/Si (blue).