Structural probing in van der Waals hetero epitaxy

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Two dimensional (2D) layered structures, such as graphene and boron nitride, have been attracting much attention as substrate for the growth of other materials. Direct growth of van der Waals heterostructures combining different types of 2D monolayers is an exciting way to explore exotic 2D building blocks with new functionalities [1]. 2D layers are also used as a van der Waals substrate to grow other bulk materials. For instance, a strain free growth of GaN is expected using graphene substrate. However these 2D materials have no covalent bonding on their surface and the epitaxial correlation between the 2D substrate and the grown materials has not been clearly understood.

In this work, we probe structural correlation at various van der Waals interface using atomic resolution transmission electron microscopy (TEM). First, a directly grown stacking of $MoSe_2$/graphene was studied by a signal separation using FFT (Figure 1). A particular relationship with 2° and 27° mis-orientation was observed, which can be explained by the presence of inversion domain bondaries in $MoSe_2$ [2]. Van der Waals interfaces between MBE grown III-V nitrides and graphene substrate were also investigated to study their epitaxial growth. We demonstrated both oriented and non-oriented GaN/graphene interfaces controlled by the growth procedure. In some cases, we could obtain 2D bi-layer of Gallium and Indium under the graphene (Figure 2).

TEM investigations of various van der Waals interfaces are discussed, correlating to the growth process, intrinsic defect structures and other characterization results.

References

[1] A. Geim et al., Nature, 499 (2013) 419.
[2] C. Alvarez, Nanotechnology, 29 (2018) 425706

Figures

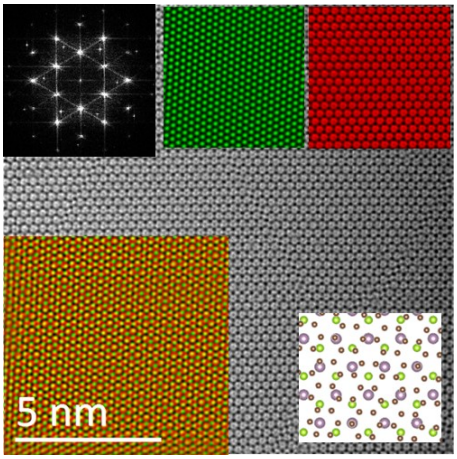

Figure 1: TEM image of $MoSe_2$ on graphene. Signal of each layer was extracted using FFT (green: graphene, red: $MoSe_2$) and superposed to investigate local structural correlation.

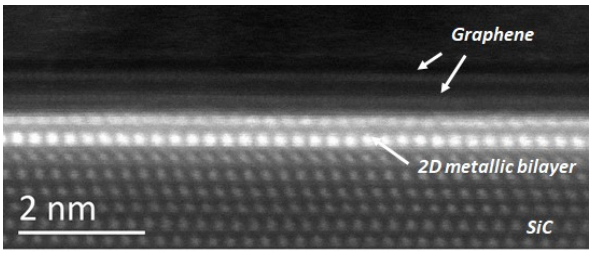

Figure 2: 2D Indium bilayer grown between graphene and SiC by a high temperature intercalation.