N_2 plasma assisted nucleation of h-BN on graphene for strain-free coalescence during van der Waals epitaxy

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Van der Waals (vdW) epitaxy is currently being investigated as a scalable alternative to mechanical exfoliation for the fabrication of heterostructures based on two-dimensional (2D) materials [1]. However, the direct vertical growth of such structures is complicated by the weak out-of-plane interactions in the 2D materials. Therefore, defects in the 2D substrate are the most probable nucleation sites during vdW epitaxy, as we recently demonstrated on the example of hexagonal boron nitride (h-BN) grown on epitaxial graphene (EG) on SiC by molecular beam epitaxy [2]. In this contribution we show how this nucleation can be influenced by an in-situ N_2 plasma pre-treatment. The direct growth of h-BN on EG resulted in 2D hexagonal islands with a random orientation (see Figure 1), while the islands which formed upon the plasma treatment of the EG revealed a triangular shape and a relative orientation of 0° or 180° towards each other (see Figure 2). The plasma treatment resulted not only in a higher nucleation density, but also in an enhanced growth of additional layers of h-BN in the form of polygonal nanoparticles in the centre of most islands. All samples were characterized using atomic force microscopy as well as Raman spectroscopy. The lattice constants in coalesced h-BN layers on EG were further analysed using synchrotron-based grazing incidence x-ray diffraction, which showed a strain relaxation in the h-BN grown after N_2 plasma treatment in comparison to that which was directly grown on EG. The presented results constitute a first step toward a controllable and scalable fabrication of 2D heterostructures.

References

[1] Robinson J.A., ACS Nano 10 (2016) 42.
[2] Heilmann M., Bashouti M., Riechert H., Lopes J.M.J., 2D Materials 5 (2018) 025004

Figures

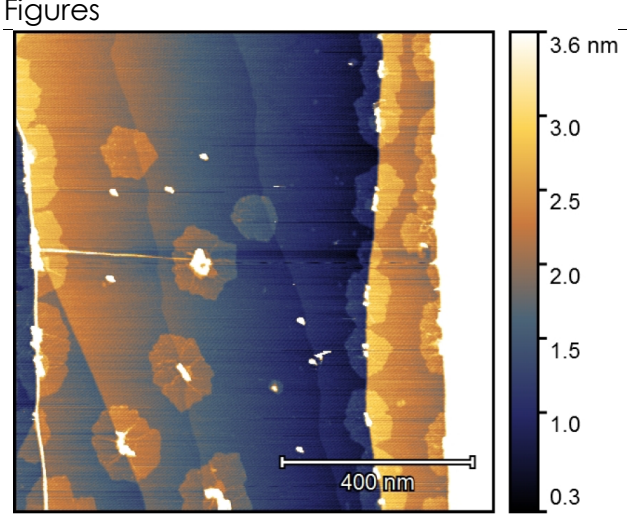

Figure 1: h-BN islands directly grown on EG at 850 °C with hexagonal shape and wrinkles spreading radially from their centre.

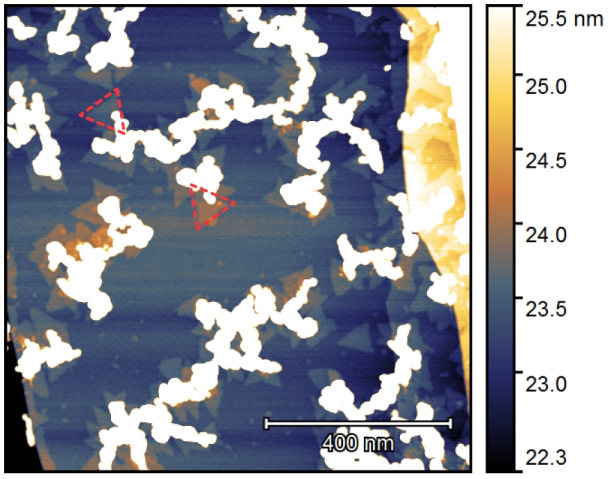

Figure 2: Triangular h-BN islands without wrinkles and a relative rotation of 0° or 180° towards each other apart from step edges in EG. (red triangles mark the orientation of the islands apart from step edges in EG)