Borophene - hBN lateral heterostructure : mechanical, electronic and frictional properties

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The tribological performance of 2D materials makes them good candidates to reduce friction on a macroscopic scale [1]. Superlubricity, i.e. the ability to slide without friction, has already been observed for various 2D materials such as graphene, MoS2 and MXenes [2], but other materials are being studied as potential candidates for low-friction applications. Borophene [3,4], among its many properties, is predicted to have ultra-low friction and hBN, is already used to reduce or tune the friction properties of materials.

In this work, we use the possibility to form a lateral heterostructure between borophene and hBN to directly compare their mechanical, electronic and tribological properties (Figure 1a,b). In particular, we study the friction between a tip and (i) the weakly corrugated χ_6-borophene layer on the Ir(111) surface or (ii) the hBN/Ir(111) layer with a moiré reconstruction (Figure 1c). Our ultra-high vacuum AFM measurements at room temperature, combined with calculations using the Prandtl-Tomlinson (PT) model confirm the very low friction for borophene, while hBN, which has a higher coefficient of friction, is confirmed as a very low frictional material (Figure 1c). Ab-initio calculations show that the surface of χ_6-borophene has lower friction than hBN due to weaker surface/tip interactions.

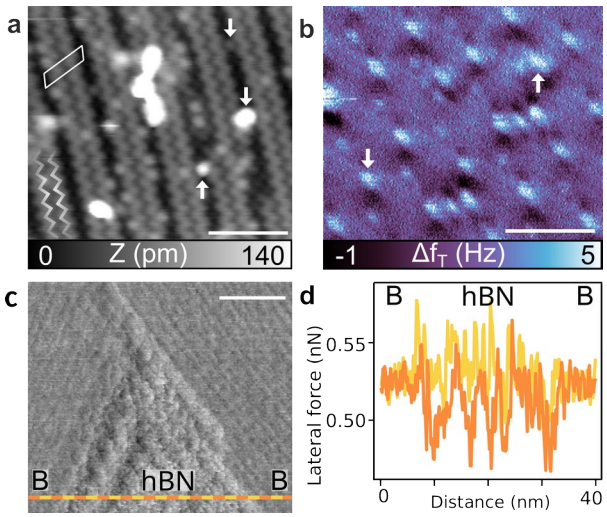

Figure 1. Borophene and hBN on Ir(111). a) STM topography and b) NcAFM torsional frequency shift of the χ_6-borophene polymorph. Defects highlighted with arrows. c) Lateral force of the borophene-hBN lateral heterostructure and d) corresponding profile.

References

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