Many-body Van Der Waals Interactions in Multilayer Structures Studied by Atomic Force Microscopy

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Abstract

Van der Waals interaction in multilayer structures was predicted to be of many-body character, almost in parallel with the establishment of Lifshitz theory. However, the diminishing interaction between layers separated by a finite-thickness intermediate layer prevents experimental verification of the many-body nature. Here we verify the substrate contribution at the adhesion between the atomic force microscopy tip and the supported graphene, by taking advantage of the atomic-scale proximity of two objects separated by graphene. While the pairwise dispersion theory overestimates the substrate contribution at critical adhesive pressures, the many-body dispersion theory remedies this deficiency, highlighting the non-additivity nature of substrate contribution. The many-body effect is further understood through the energy spectrum of charge density fluctuations. These findings open the door to modulating the van der Waals interaction on two-dimensional material surfaces, which would be relevant to various technologies, including microelectromechanical systems and surface molecular assembly.

References

[1] Xiao Wang, et al. Nature Communications, 16 (2025) 324

Figures

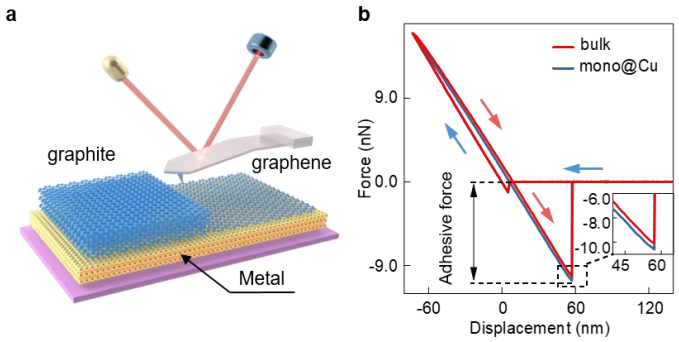

Figure 1: Critical adhesion of monolayer graphene supported on substrates.

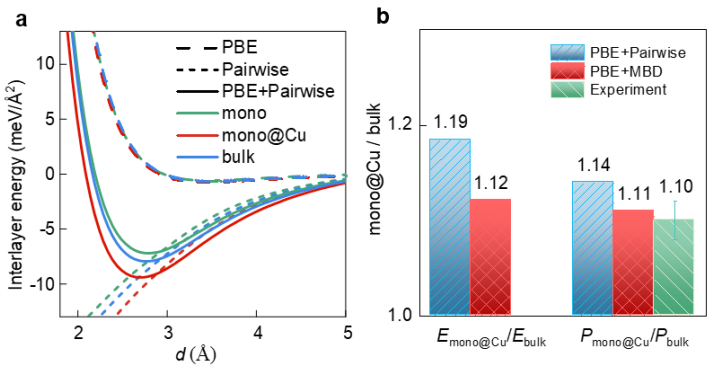

Figure 2: DFT results for the interlayer interaction between a hydrogen passivated silicon layer and (supported) graphene.