Crystalline order in the airborne contamination layer on van der Waals materials: universality, composition, structure and manipulation

András Pálinkás[1]
G. Kálvin[1], P. Vancsó[1], M. Szendrő[1], K. Kandrai[1], G. Németh[2], M. Németh[1], Á. Pekker[2], J. S. Pap[1], P. Petrik[1], K. Kamarás[1,2], L. Tapasztó[1] and P. Nemes-Incze[1]
[1]*Centre for Energy Research, 1121 Budapest, Hungary*
[2]*Wigner Research Centre for Physics, 1121 Budapest, Hungary*
andras.palinkas@ek-cer.hu

We identified the molecular building blocks of the contamination layer on the surface of van der Waals (vdW) materials exposed to ambient air. The airborne molecules appear as parallel stripes on distinct vdW material surfaces (graphite, hBN, MoS2). We revealed by STM measurements (9K) that the airborne monolayer self-organizes into a rectangular centered monolayer consisting of alkyl-backboned, linear molecules of 20-26 carbon atoms on graphite. Additional XPS and IR spectroscopy measurements allow us to conclude that the molecular layer consists of normal alkanes. We show a direct causal link between the self-organized stripe structure of the airborne alkane monolayer and the often observed, yet unexplained friction anisotropy domains observed on vdW materials. Furthermore, we show details of the growth dynamics, manipulation of the layer by AFM and the controlled desorption through annealing. Understanding the structure and composition of the universal contaminant layer, is important for both basic science and applications of vdW materials, because the alkane layer may dominate their interaction with the environment.
The paper was published in *Nature Communications* last year.

References

[1] A. Pálinkás et al. Nat. Commun. 13, 6770 (2022).

Figures

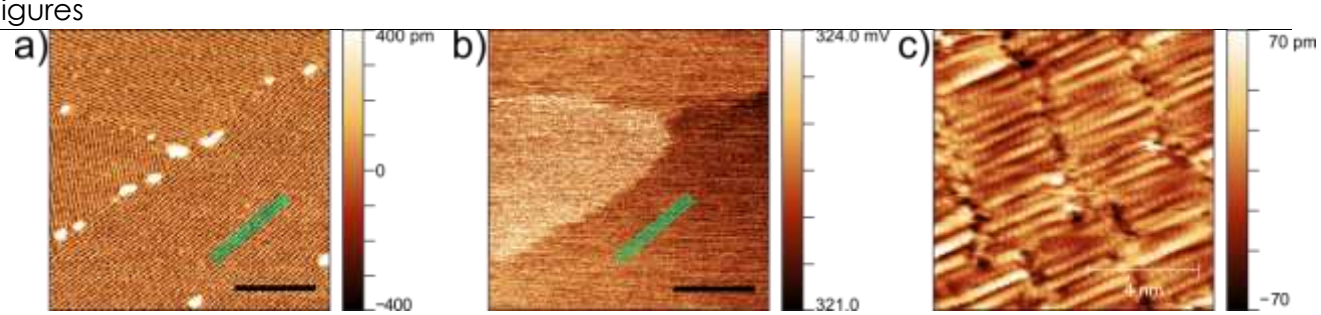

Figure 1: a) Parallel stripes of 4 nm periodicity on the surface of a graphene/hBN heterostructure (PeakForce AFM Topography). **b)** Friction force signal of the same region as in a). **c)** Low temperature STM image of the airborne monolayer on graphite.