Rewritable superlubricity on Nitrogen-doped graphene moiré superlattices

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Achieving superlubric state of graphene under extreme conditions remains rewarding yet challenging, as its outstanding lubricating properties are easily deteriorated by environmental chemical modification, e.g. fluorination, hydrogenation and nitrogen doping have been proved to increase the surface friction of graphene remarkably.

Here, we report that the superlubric sliding could be achieved in the case of nitrogen-doped graphene by tuning graphene-substrate interfacial interaction. Nano-patterned nitrogen-doped graphene is obtained by evaporating C60 to form molecular islands which are used as mask during the nitrogen doping process[1]. After removal of the C60 island, the frictional contrast is shown by the means of atomic force microscopy under ultra-high vacuum with the same tip sliding over the nano-patterned graphene in a single measurement, where the region previously covered by C60 shows lower friction as the interfacial coupling is preserved. Furthermore, the friction of nitrogen-doped graphene can be re-entered into an ultra-low friction state after running-in process due to the recovery of moiré superlattices. Moiré induced by strong interfacial anchoring facilitates the suppression of the out-of-plane deformation of graphene during sliding, which leads to the reduction of friction. The interfacial coupling between graphene and substrate plays a crucial role in controlling the frictional properties of nitrogen-doped graphene.

Our findings are expected to be extended to control nanoscale friction by tuning the interfacial atomic interaction between other two-dimensional materials and substrates.

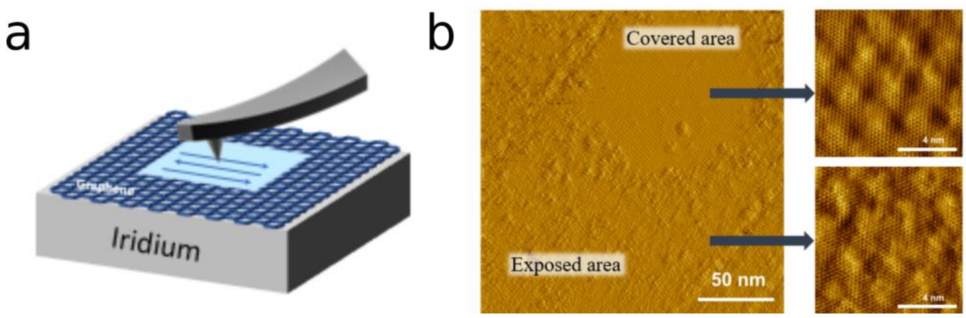

Fig. 1. a) Contact Friction AFM scheme for graphene on Iridium. b) horizontal deflection images in contact AFM on C60 covered and non-covered areas.

[1] Bouatou, M. et al. Advanced Functional Materials **32**, (2022)