Electric field induced delamination of 2D layered materials

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Scanning tunneling microscopy measurements on 2D layered materials show a wide variety in reported topography and spectroscopy results. We demonstrate that, depending on the applied tip-sample bias voltage, the surface of 2D layered materials can appear to have different topography. At a positive applied voltage, the top layer of MoS_2 is completely stretched and the surface appears to be flat. In contrast, at a negative bias voltage, the surface is puckered as shown in Figure 1. This puckered surface is reminiscent of the surface of free-standing graphene [1]. This is attributed to surface manipulation via electrostatic forces.

The relation between the applied bias voltage and the stretching of the MoS_2 has shown to cause the layers to be pulled up for hundreds of nanometers. A theory is proposed to describe the relevant attractive electrostatic forces between tip and sample [2] and the opposing restoring forces of the membrane [3] that can describe the lifting behavior as function of the applied electrostatic force as shown in Figure 2.

References

[1] P. Xu, Y. Yang, et al., Phys. Rev. B, 85 (2012) 121406
[2] S. Belaidi, P. Girard, G. Leveque, J. Appl. Phys., 81 (1997) 1023
[3] K-T. Wan, Yiu-W Mai, Int. J. Fract., 74 (1996) 181

Figures

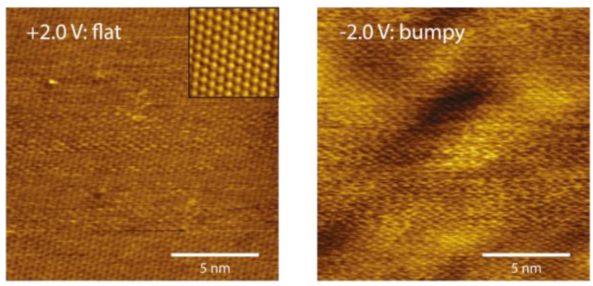

Figure 1: The STM tip can manipulate the surface of 2D layered materials such as MoS_2.

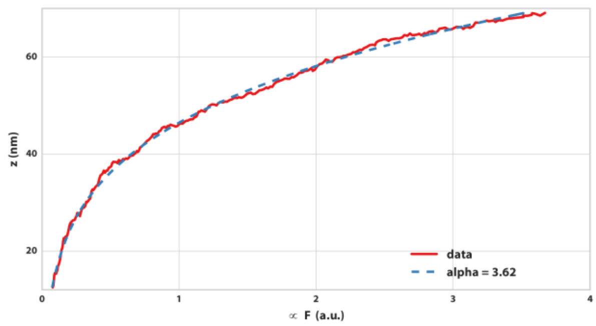

Figure 2: The lifting of the top graphite layer fits stretching behaviour with a power of 3.62.