Investigation of the mechanical properties of a monoatomic layer by combined STM and AFM measurements

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The advent of nanoscale engineered materials has started to revolutionize material science and technology. Further improvement is expected when tailoring the materials down to the atomic scale.
For this and for developing functional systems a detailed understanding not only of the electronic but also of the mechanical properties at nanometer scale is of crucial importance.
Here we study an insulating single atomic layer of hexagonal boron-nitride (h-BN) on Rh(111). The lattice mismatch between the substrate and the h-BN produces a strongly corrugated hexagonal superstructure with 3.2 nm periodicity [1,2]. This superstructure has been shown to be an excellent nanotemplate [3] which allows to decouple electronically molecules and clusters from the underlying substrate [4,5].
To measure its mechanical properties we use a home-built combined scanning tunneling and atomic force microscope operating at low temperatures and with sub-nm oscillation amplitudes. From 3-dimensional frequency shift data we calculate the total energy landscape and lateral and vertical forces acting between the probing tip and the h-BN layer. Slight variations in the forces between the different alignments of the rim sites of the hexagonal corrugation in respect to the Rh surface enable us to derive the elastic properties of the corrugated layer. Our findings are further supported by a statistical evaluation of the lateral displacement of the BN hexagons in atom resolved measurements.

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