High-frequency motion of 2D materials

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Suspended graphene and 2D materials open up the possibility to study the dynamics of membranes of only one atom thick. The dynamics of these systems is governed by phenomena that are unique to the nanoscale: for large vibration amplitudes, graphene shows strong nonlinearities that result in spring hardening, nonlinear damping, parametric resonances and mode coupling. An overview of the rich dynamics of high-frequency graphene membrane resonators over different ranges (Fig. 1a) will be given.
At small amplitudes, the dynamics of graphene becomes strongly interlinked with its thermodynamics, and is influenced by wrinkles and entropic effects (Fig. 1b,c). Heat transport in 2D materials is fundamentally different from that in 3D materials, because the out-of-plane stiffness of 2D membranes is much lower than the in-plane stiffness, which significantly alters phonon propagation. Based on the coupling between mechanical and thermodynamics properties in ultrathin membranes, we discuss the use of the high-frequency dynamics of 2D materials to study heat transport, material properties (Fig. 1d) and even magnetic and electronic phase transitions.

Figures

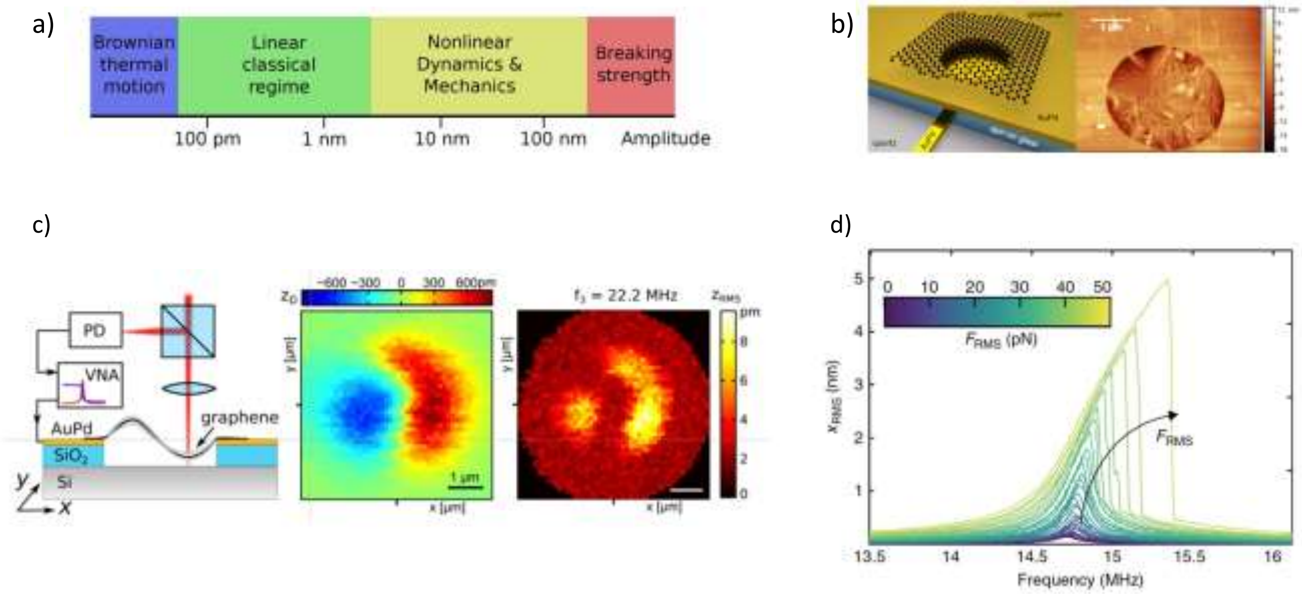

Figure 1. a) Different ranges of dynamical motion of a 5 micron circular graphene membrane. b) Device geometry and effect of wrinkles (studied by AFM) on the graphene dynamics [1]. c) Visualizing the mode shapes of graphene membranes [2]. d) Nonlinear dynamics of graphene membranes for determining its Young's modulus [3].

References

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