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Probing Mechanics of Crumpled Two-Dimensional Membranes and Cantilevers RYAN NICHOLL, HIRAM CONLEY, Vanderbilt University, NICKOLAY LAVRIK, IVAN VLASSIOUK, Oak Ridge National Laboratory, YEVGENIY PUZYREV, VIJAYASHREE PARSI SREENIVAS, SOKRATES PANTELIDES, Vanderbilt University, KIRILL BOLOTIN, Vanderbilt University, Freie Universitat — Two-dimensional materials (2DMs) are inevitably crumpled in the out-of-plane direction due to both static wrinkling associated with uneven stresses and dynamic wrinkling resulting from flexural phonons. Here, we investigate the effect of this crumpling on mechanical properties of 2DMs – in-plane stiffness and bending rigidity. To carry out these measurements, we developed techniques to fabricate graphene membranes and singly clamped graphene cantilevers that are stable in vacuum and air. The measurements are performed by actuating these devices electrostatically and monitoring their displacement via sensitive interferometric profilometry both at room and low temperatures. We find that crumpling lowers the in-plane stiffness and strongly increases the bending rigidity of 2DMs. Furthermore, we unravel the relative contribution of static and dynamic wrinkling to observed renormalization of the effective mechanical constants.

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