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ENGINEERING THE SURFACE BUCKLING OF MONO-LAYER SUPPORTED GRAPHENE

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In the process of synthesizing graphene by chemical vapor deposition (CVD), the as-grown sample supported on a metallic substrate often exhibits a network of highly localized wrinkles that delaminate from the substrate.[1] Such wrinkles, inducing locally concentrated strains, can strongly influence the electronic and chemical properties of pristine graphene, and thus were generally perceived as defects in experiment.citeZhu In fact, there is an increasing interest in establishing strain engineering of graphene, considering the strong coupling between strain and electronic properties. However, the theoretical understanding of mechanisms behind wrinkling in supported graphene remains incomplete, especially under biaxial compression.

We systematically study the emergence of out-of-plane deformations of supported graphene under uniaxial compression with an atomistic-based continuum model, and with a nonlinear theoretical model. [3] We find that localized wrinkles evolve from distributed ripples due to the nonlinearity in the van der Waals graphene-substrate interactions. We identify friction as a selection mechanism for the separation between wrinkles, as the formation of far apart wrinkles is penalized by the work of friction. Our systematic analysis is a first step towards strain engineering of supported graphene.

Through multiscale simulations of micron-sized samples, we study the physical mechanisms behind the spontaneous emergence of wrinkle networks under biaxial compression, and in particular how the network geometry depends on strain anisotropy and on the frictional properties of the graphene-substrate interface.[4] Furthermore, we propose a strategy to delicately control the location of wrinkles through patterns of weaker adhesion on the substrate. The role of different types of wrinkle junctions is emphasized in the development of a stable wrinkle network. We view wrinkles as an opportunity to locally tune the properties of supported graphene providing functionality, e.g. as a scalable manufacturing method, by selective etching for graphene circuitry, or to create nanofluidic channels. In the application of nanofluidic channels, we examine the stability of wrinkle networks, and show how wrinkle junctions deform into bubbles in the presence of pressure.

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