The Origin of Linear and Nonlinear Damping in Graphene Nanomechanical Resonators

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The origin of dissipation in nanoelectromechanical systems (NEMS) remains unresolved. Graphene and carbon nanotubes have emerged as excellent materials to investigate linear and nonlinear damping[1-2] in NEMS. Here we demonstrate that the quality factor of electrically-driven few-layer graphene drumhead resonators is inversely proportional to temperature for drives sufficiently small to probe the linear damping regime. At larger drives, the nanomechanical resonance broadens due to nonlinear damping.[2] The linear and nonlinear damping in graphene resonators can be understood by a model of thermally fluctuating high frequency modes that broaden the spectral response of the measured fundamental mode through nonlinear coupling, similar to a model recently proposed for carbon nanotubes.[3] A model for thin membranes explicitly accounting for the nonlinearities is given, yielding good agreement to experiment. Our results provide a general framework for understanding the origin of linear and nonlinear damping in nanoscale resonators based on ultrathin membranes.

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