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Indentation of Graphene Membranes: Non-Linear Response, Nano-Fracture, and Crack Propagation ROMAIN PERRIOT, YOU LIN, VASILY ZHAKHOVSKY, Department of Physics, University of South Florida, XIANG GU, Department of Applied Physics, Aalto University, IVAN OLEYNIK, Department of Physics, University of South Florida — Recent indentation experiments on graphene have revealed its exceptional strength, making it an excellent candidate for the design of nano- and micro- electromechanical systems. Therefore, it is critical to understand the mechanical properties of graphene, and its response to a wide range of loading pressures beyond the elastic regime. In this work molecular dynamics (MD) simulations of indentation of circular graphene membranes were performed with a newly developed interatomic potential, specifically designed to study graphene under extreme tensile stress. The indentation curves confirmed the experimental observation of a non-linear response at large loads, as well as the brittle failure of the membranes via the generation of nano-cracks. Our MD simulations showed that the fracture process consists of two consecutive stages: an initial bond-breaking event followed by the formation and propagation of cracks. The kinetic theory of bond breaking was applied to determine the breaking strength of graphene and its dependence on the indenter radius, as well as the waiting time for failure. MD simulations were used to provide an atomic-scale description of fracture dynamics.

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