A continuum model for graphene in nonlinear elasticity and its green applications

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The remarkable mechanical, thermal and electrical properties of graphene attracted the interest of researchers from many engineering fields. Its applications in new green technologies were extensively investigated in the last decade. A deep understanding of the mechanical behaviour of graphene is necessary in order to fully exploit its potentialities. However, only a few experimental tests were carried out due to the small scale of this material [1]. For this reason, accurate mechanical models of the graphene mechanics are required. In this work, we present a continuum membrane model for graphene membranes subjected to large in-plane deformations [2]. We consider a stored energy function that takes into account both nonlinearity and anisotropy of graphene [3]. Under the hypothesis of homogeneous deformations, we derive a solution to the equilibrium problem and the stability is assessed using an energy criterion. Explicit relations between stretches and stresses of the membrane are derived for the cases of uniaxial and equibiaxial loads. A linearization of the finite theory is presented and the expressions of Young's modulus and Poisson's ratio are obtained. Differently from the other continuum models in the literature, the approach proposed in this work is entirely developed in finite elasticity and it may be the basis for accurate investigations on graphene subjected to large deformations.

References

[1] Lee, C., Wei, X., Kysar, J. W., and Hone, J. (2008). Measurement of the elastic properties and intrinsic strength of monolayer graphene. Science, 321(5887), 385-388.
[2] Pelliciari, M., and Tarantino, A. M. (2021). Equilibrium and stability of anisotropic hyperelastic graphene membranes. Journal of Elasticity, 144(2), 169-195.
[3] Höller, R., Smejkal, V., Libisch, F., and Hellmich, C. (2020). Energy landscapes of graphene under general deformations: DFT-to-hyperelasticity upscaling. International Journal of Engineering Science, 154, 103342.