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Exact postbuckling analysis of highly stretchable-surface energetic-elastic nanowires with various ends' conditions

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Abstract

Exact postbuckling analysis of highly stretchable nanowires under axially compressive loads is of extreme interest due to their potential application in nano-scaled electronic devices. To this end, in the context of the surface elasticity theory of Gurtin-Murdoch, the nonlinear equilibrium equations of such nanowires are established using Euler-Bernoulli beam model. An analytical methodology is suggested to scrutinize postbuckling behavior of the nanostructure. The explicit expressions of the longitudinal and transverse displacements as well as postbuckling load are presented for simply supported, fully clamped, clamped-shear free, and cantilevered nanowires. The obtained postbuckling curves are successfully checked with those of a newly developed Galerkin-based approach. The highly postbuckled shapes of these nanowires are presented, and the importance of the surface energy on their large deformation regime is revealed. Further, the roles of the nanowire's length and diameter as well as surface energy on the obtained results are displayed. The present work can be considered as a benchmark for further analytical investigations on postbuckling analysis of more complex nanosystems like as vertically aligned nanowires undergoing high deflection and rotation.

Keywords: Postbuckling; Highly deformable nanowires; Surface elasticity theory; Euler-Bernoulli beams; Exact solution.

1. Introduction

Nanowire force-based sensors could have potential applications in sensing atomic, biological, and surgical forces involved range from zeptonewtons to several nanonewtons [1–3]. For medicinal purposes, by measuring some physical changes of cells in a body (like as change

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