Nano-Scale Mechanical Systems:
Recent Trends in Nano-Structural Mechanics

Raimondo Luciano

Department of Engineering, University of Naples Parthenope, Napoli, Italy

Abstract

Nanotechnology is the understanding of matter at dimensions between approximately 1 and 100 nanometers. At nanoscale level, unusual physical, chemical and biological properties may be observed and for these particular properties, nanomaterials are spreading all over: in electronic, biotechnology and nanostructure applications. When the sizes are small and comparable to crystal or molecular distances, size effect in mechanical behaviour is detected, and it cannot be neglected when the behaviour analysis is performed. Therefore, classical continuum mechanics cannot be used, due to its scale-free character: rather, atomistic models and Generalised Continuum Theories (GCTs) have to be used. It is worth noticing that, since atomistic modelling is quite time consuming, size-dependent continuum mechanics approaches are widely employed to explain the size-dependent mechanical behaviour. Lattice-based nonlocal models, Eringen's nonlocal models, gradient theory of elasticity, strain- and stress-driven nonlocal models, and peridynamic theory are some of the most widely known and accepted GCTs. In the context of the stress-driven nonlocal model, it has been successfully applied to solve numerous engineering problems, such as: static bending behaviour, buckling and free transverse vibrations of nanobeams.

The present research work is dedicated to the theoretical modelling of nanomaterials with particular attentions to Carbon NanoTubes. More precisely, the two-phase local/nonlocal Stress-Driven integral model is presented. Firstly, such a model is applied to nanobeams free vibrations problems, with particular attention to the determination of the nanobeam natural frequency. Then, it is used to analyse the small-scale effect on the Mode I fracture behaviour of both edge- and centrally-cracked nanobeams, showing a decreasing of the energy release rate by increasing the nonlocality, with a consequent superior advantage in terms of fracture performance of nanobeams with respect to large-scale beams.