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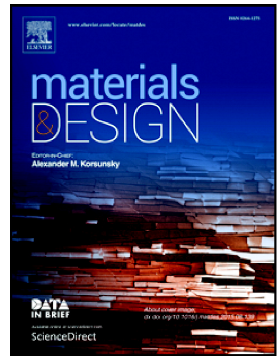

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Role and significance of thermal loading on the performance of carbon nanotube-based mass sensors

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Abstract

Insights on the sensitivity of carbon nanotube-based mass sensors subject to a uniform thermal environment are provided. The thermal loads are introduced as a means of buckling nonlocal carbon nanotube-based mass sensors in an effort to obtain high frequency shifts before and after the deposition of a nanoparticle on a carbon nanotube (CNT), leading to improved mass detection. In introducing thermal loads, the critical buckling temperature, pre-buckling, and post-buckling behaviors of CNTs with an arbitrary deposited mass are investigated. The CNT is modeled as an Euler-Bernoulli beam and the nonlinear governing equations of motion are derived by virtue of the Hamilton's principle. Eringen's nonlocal theory is employed to account for the interatomic long-range interactions, *i.e.*, the size dependent phenomena occurring at the nano-scale. The proposed model allows for an arbitrarily positioned atomic-mass particle and accounts for the effects of the thermal field and the nonlocal parameter on the pre-buckling and post-buckling dynamics of clamped-clamped nanobeams. It is demonstrated that the temperature change has a remarkable influence on the frequency shift and hence on the sensitivity of the CNT-based mass sensor. The results show that augmenting the temperature in the pre-buckling regime leads to a decrease in the frequency shift, while the temperature rise in the post-buckling configuration has an increasing effect on the sensitivity of the CNT-based mass sensor. Also, it is found that when the temperature exceeds a certain point in the post-buckling region, higher frequency shifts can be obtained compared to the pre-buckling regime. In varying parameters, such as the length, diameter, number of walls (single-walled CNTs or multi-walled CNTs), location of the deposited mass, and nonlocal parameter, greater frequency shifts can be obtained in the post-buckling configurations of the CNT, leading to enhanced sensitivity in the system.

Keywords: mass sensor, uniform thermal loading, nonlocal elasticity, carbon nanotubes, buckling

1. Introduction

In recent years, nanostructures have been introduced as promising candidates in a variety of applications, such as micro/nanoelectromechanical systems (MEMS/NEMS), biomedical sensors, sensitive small resonators, nanoelectronics, nanodevices, and nanocomposites [1-3]. For example, nano-resonators are used to detect the value of a physical quantity through an induced property change in the device. To achieve high sensitivity and enhanced detection of different physical quantities, such as the