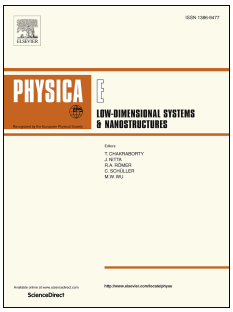
Accepted Manuscript



Lateral vibrations of embedded hetero-junction carbon nanotubes based on the nonlocal strain gradient theory: Analytical and differential quadrature element (DQE) methods

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PII: S1386-9477(18)30782-3

DOI: 10.1016/j.physe.2018.08.022

Reference: PHYSE 13267

To appear in: *Physica E: Low-dimensional Systems and Nanostructures*

Received Date: 26 May 2018

Revised Date: 17 August 2018

Accepted Date: 20 August 2018

Please cite this article as: M. Mohammadian, S.M. Hosseini, M.H. Abolbashari, Lateral vibrations of embedded hetero-junction carbon nanotubes based on the nonlocal strain gradient theory: Analytical and differential quadrature element (DQE) methods, *Physica E: Low-dimensional Systems and Nanostructures* (2018), doi: 10.1016/j.physe.2018.08.022.

Lateral vibrations of embedded hetero-junction carbon nanotubes based on the nonlocal strain gradient theory: Analytical and differential quadrature element (DQE) methods

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Abstract

In the current paper, lateral vibrations of embedded hetero-junction carbon nanotubes (HJCNTs) are investigated. HJCNT and its surrounding medium are idealized as two different connected nonlocal strain gradient Rayleigh beams and a two-parameter (Pasternak) elastic foundation, respectively. The governing differential equation is derived based on the Hamilton's principle, and the classical and higher order boundary conditions are obtained using the weighted residual approach. The sixth-order differential equation is then solved analytically and numerically. The differential quadrature element method based on the Hermit interpolation functions is employed and developed to the stepped nanobeams to establish the reliability of the analytical method. The effects of the nonlocal parameter, the strain gradient parameter, the type of boundary conditions, the type of adopted higher order boundary conditions and the elastic foundation parameters on the frequency and mode shapes are studied and discussed in details. This paper provides an appropriate source not only for the vibrational study of HJCNTs, but also for comparing the vibration results of embedded uniform or stepped nanobeams obtained based on different theories that consider the size-dependent effects.

Key words: Hetero-junction carbon nanotube, Nonlocal strain gradient theory, Differential quadrature element method, two-parameter elastic foundation, frequency

1. Introduction

If two uniform carbon nanotubes (CNTs) with different diameters connect to each other, a hetero-junction carbon nanotube (HJCNT) is formed. Based on the chirality of the connected CNTs, HJCNTs are divided into straight and non-straight (or bent) structures. Also, from the electrical point of view, they are fallen into three groups; metallic-metallic (M-M), semiconducting-semiconducting (S-S) and metallic-semiconducting (M-S) [1]. Bandaru et al. [2]

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