Author's Accepted Manuscript

www.elsevier.com/locate/ijmecsci

Nonlocal mass-nanosensor model based on the damped vibration of single-layer graphene sheet influenced by in-plane magnetic field

Danilo Karličić, Predrag Kozić, Sondipon Adhikari, Milan Cajić, Tony Murmu, Mihailo Lazarević

PII: S0020-7403(15)00128-9
DOI: http://dx.doi.org/10.1016/j.ijmecsci.2015.03.014
Reference: MS2955

To appear in: *International Journal of Mechanical Sciences*

Received date: 25 November 2014
Revised date: 3 March 2015
Accepted date: 19 March 2015

Nonlocal mass-nanosensor model based on the damped vibration of single-layer graphene sheet influenced by in-plane magnetic field

Danilo Karličić[1], Predrag Kozić[1], Sondipon Adhikari[2], Milan Cajić[3], Tony Murmu[4,*], Mihailo Lazarević[5]

[1] Faculty of Mechanical Engineering, University of Niš, A. Medvedeva 14, 18000 Niš, Serbia
[2]College of Engineering, Swansea University, Singleton Park, Swansea SA2 8PP, UK
[3]Mathematical Institute, Serbian Academy of Sciences and Arts, Kneza Mihaila 36, 11001 Belgrade, Serbia
[4]School of Engineering, University of the West of Scotland, Paisley, PA12BE, UK
[5]Faculty of Mechanical Engineering, University of Belgrade, Kraljice Marije 16, 11000 Belgrade, Serbia

Abstract. Nano-materials such as graphene sheets have a great opportunity to be applied in development of a new generation of nanomechanical sensors and devices due to their unique physical properties. Based on the nonlocal continuum theory and vibration analysis, the single-layered graphene sheet with attached nanoparticles affected by in-plane magnetic field is proposed as a new type of the mass-nanosensor. The nonlocal Kirchhoff - Love plate theory is adopted to describe mechanical behavior of single-layered graphene sheet as an orthotropic nanoplate. The equation of motion of a simply supported orthotropic nanoplate is derived, where the influence of Lorentz magnetic force is introduced through classical Maxwell equations. Complex natural frequencies, damped frequency shifts and relative shift of damping ratio for nanoplate with attached nanoparticles are obtained in the explicit form. The influences of the nonlocal and magnetic field parameter, different mass weights and positions of attached nanoparticles and damping coefficients on the relative damped frequency shift and relative shift of damping ratio are examined. The presented results can be useful in the analysis and design of nanosensors applied in the presence of strong magnetic field. Our results show that magnetic field could be successfully used to improve sensibility performances of nanomechanical sensors.

Key words: Nonlocal elasticity theory; mass-nanosensor; in-plane magnetic field; damped natural frequency; damped frequency shift.

1. Introduction

Recent developments of nanomechanical sensors cause an increase of a number of theoretical studies constructing the mathematical framework to investigate their dynamic behavior and performances. This can be especially important in predesign procedures of mass-sensor devices. In the literature, one can find many examples of application of nanomechanical sensors for calorimetric gas detection, drug screening, genetics, proteomics, glycemic, microbiology, metabolic measurements and other applications in chemical, environmental and biological detection [1, 2]. In some of the works, graphene sheet nanostructures are suggested for nanosensor application where one of the advantages compared to the CNT based sensors is the larger surface for catching the particles. In the follow, we give a short review of scientific works where molecular dynamics and nonlocal continuum methods are applied to examine mass-nanosensors. In the work by Sakhaee-Pour et al. [3], the authors have investigated the application of single-layer graphene sheet as strain sensor by using the molecular structural mechanics approach. For the first time, a closed-form equation for the frequency shift caused by added mass on carbon nanotube sensor was derived in Chowdhury at el. [4] using the energy principles. The authors also investigated the linear approximation of the nonlinear sensor equation and validated the results for a wide range of cases. Adhikari and Chowdhury [5] derived closed-form transcendental equations for the frequency shift from added point and distributed mass by using the energy principles. In addition, the authors calculated the calibration constants proposed in order to obtain explicit relations between the added mass and frequency shift. Further, in [6] the same authors proposed a single-layer graphene sheet as mass sensor. By developing the appropriate mathematical framework, they considered four types of distributed mass loadings, obtained explicit relations between frequency shift and added mass as well as for non-dimensional calibration constants. The obtained results are validated with molecular dynamics simulation. In the previously described papers, classical continuum or molecular dynamics models are used to describe the dynamic behavior of nanostructures.

----

* T. Murmu: email: murmutony@gmail.com Tel: 44 (0) 141 848 3235