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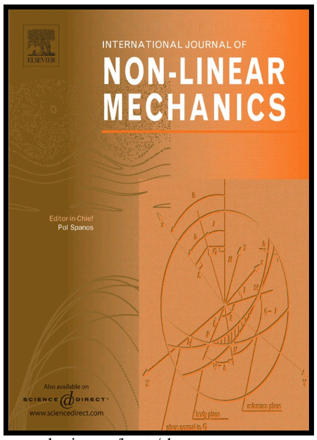

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M. Shaat, A. Abdelkefi

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Material structure and size effects on the nonlinear dynamics of electrostatically-actuated nano-beams

M. Shaat, A. Abdelkefi*

Department of Mechanical and Aerospace Engineering, New Mexico State University, Las Cruces, NM 88003, USA.

shaat@nmsu.edu (M. Shaat)
abdu@nmsu.edu (A. Abdelkefi)

*Corresponding author. Tel.: +15756466546; fax:+15756466111.

Abstract

An accurate nonlinear model for electrostatically actuated beams made of nanocrystalline materials is proposed accounting for the beam material structure and the beam size effects. Two sets of measures are incorporated in the context of the proposed model to account for the inherent properties (the material structure related properties) and the acquired properties (the size dependent properties) of the beam. The inherent properties of the beam are modeled via a micromechanical model while the acquired properties modeled via a non-classical continuum beam theory. The micromechanical model for nanocrystalline materials is proposed where the necessary measures to account for the effects of the grain size, the voids percent and size, and the interface (grain boundary) are incorporated. All the measures presented in the micromechanical model are related to the material structure to correctly model the structure of nanocrystalline materials. According to the classical couple stress and Gurtin-Murdoch surface elasticity theories, a size-dependent Euler-Bernoulli beam model is developed to model the mechanics of electrostatically actuated nano-beams. For the first time, the impacts of the beam material structure along with the beam size on the nonlinear dynamics and pull-in instability behaviors of electrostatically actuated nano-beams are intensively studied. The performed analyses through the present effort reflect the great impacts of the beam material structure and the beam size on the static pull-in, the natural frequencies, the dynamic pull-in, and nonlinear dynamics of electrostatically actuated nano-beams.

Keywords: nanocrystalline materials, nonlinear dynamics, electrostatically actuated beams, surface effects, couple stress.

1. Introduction
