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Elastic and Vibrational Characteristics of functionally graded graphene-silicon nanocomposites reinforced with prestressed single layer graphene sheet

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Graphene based nanocomposite materials have drawn the huge attention of the scientists and researchers due to the superior properties of graphene such as better dispersion and relatively lower synthesis cost found in recent investigations [1]. The silicon nanofilm is the most commonly preferred material in the area of NEMS/MEMS and it used as a support/substrate for single layer graphene sheet. This paper deals with the static and dynamic behavior of a graphene-silicon nanosheet composites (GSNC) [2], where silicon nanofilm is covered with an uniaxial prestressed and without a prestressed single layer graphene sheet (SLGS), uniformly distributed along the thickness direction. The effective elastic modulus and fundamental natural frequency of GSNC are evaluated by the non-linear finite-element model (FEM) generated using the interconnection of continuum micro-mechanics approaches [3]. The influence of GSNC geometry, size and position of the normal and prestressed SLGS on one side or both side of the silcon nanofilm are considered for nonlinear stress-strain relationship. The results demonstrate superior load bearing capacity of GSNC beams for both side SLG as compared to the one side SLG. The effect of geometry, dimension, distribution pattern, with the cantilevered boundary condition on the vibration behavior are elucidated. For vibrational characteristics theoretical formulations based on the Euler-Bernoulli beam theory are used for validation. The findings demonstrate that the adjoining only a SLG over a silicon nanofilm remarkably enhances the fundamental frequency of the cantilever nanocomposite beam by 72.5%. The results also show that by placing the SLGS on both side of the silicon nanofilm further strengthen the nanocomposite beam stiffness and consequently improves the natural frequency of the structure by 248.68%. In addition, numerical results are obtained to investigate the effect of uniaxial prestressed SLG but silicon nanofilm is not prestressed in GSNC. The findings show that the prestrain in such a beam will enhance its stiffness and consequently its fundamental natural frequencies in case of SLG and isolated silicon nanofilm but reverse in the case of nanocomposites. The frequency of prestrained SLG increases by almost 21 times and those of Gr-Si and Gr-Si-Gr nanosheet composites decreases by 1.35 times for the length same as the extended length of SLG corresponding to prestrain level of 16.66%.

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