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Band Gaps of the Nanoscaled Periodic Layered Structures

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With the rapid development of the technology in the fields of communication information, medical engineering, etc., the size of acoustic devices is required to be smaller and smaller. For instance, the gigahertz communication generally requires the nanosized devices. The hypersonic phononic band gaps could be used to design new thermo-electric devices, acoustic-optic devices, nano electric-mechanical systems (NEMS), etc. Recently, the manufacture, measurement and computation of the hypersonic PNC together with its applications in manipulation of hypersonic acoustic waves have received more and more considerable attention. It is known that the size-effect will become more important and should be taken into account when a system is in the dimension of several nanometers. In this paper the elastic waves propagating normally and obliquely in the 1D nanoscaled periodic layered structures are studied by using the nonlocal elastic (NLE) continuum theory. The NLE theory includes the effects of the long range interatomic forces by supposing that the stress-state at a point is related to the strain-state at all points of the entire body. the conception of the localization factors are introduced to describe the band structures for waves propagating either normally or obliquely in the nanoscaled system. Both the anti-plane and mixed in-plane wave modes are considered. The localization factors as well as the dispersion curves are calculated to analyze the behaviors of the wave propagation. A cut-off frequency is found, beyond which waves cannot propagate through the system. The influences of the ratio of the internal to external characteristic lengths on the cut-off frequency and band structures are discussed. The generation and behavior of the band gaps with or without the mode conversion are also analyzed for the mixed in-plane wave modes.

Keywords: elastic waves, phononic crystals, nonlocal elastic continuum theory, bandgaps, localization factor