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Sergey I. Fomenko, Mikhail V. Golub, Ali Chen, Yuesheng Wang, Chuanzeng Zhang

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Band-gap and pass-band classification for oblique waves propagating in a three-dimensional layered functionally graded piezoelectric phononic crystal

Sergey I. Fomenko[a,*], Mikhail V. Golub[a], Ali Chen[b], Yuesheng Wang[b], Chuanzeng Zhang[c]

[a]*Institute for Mathematics, Mechanics and Informatics, Kuban State University, Krasnodar, 350040 Russia*
[b]*Institute of Engineering Mechanics, Beijing Jiaotong University, Beijing 100044, PR China*
[c]*Department of Civil Engineering, University of Siegen, D-57068 Siegen, Germany*

Abstract

Three-dimensional time-harmonic wave motion in a layered functionally graded (FG) piezoelectric periodic composite (phononic crystal) composed of a finite or an infinite number of unit-cells is considered. A longitudinal or transverse plane waves incident obliquely to the interfaces of a finite phononic crystal between two half-spaces is studied. The paper proposes a semi-analytical method to simulate and analyse the wave fields in a phononic crystal in the case of arbitrary angles of incidence. It is shown that the method is numerically stable for an arbitrary number of unit-cells in finite phononic crystals. Several kinds of pass-bands and band-gaps can be distinguished by employing the derived semi-analytical expressions: band-gaps, pass-bands, low transmission pass-bands, quasi-longitudinal and quasi-transverse band-gaps. Using the present approach a detailed parametric analysis of the influences of the type and incidence angle of an incident wave, and the material and geometrical parameters of the FG interlayers on wave propagation is conducted.

Keywords: wave motion, periodically layered composites, piezoelectricity, semi-analytical method, phononic crystals, functionally graded materials, band-gaps, pass bands

1. Introduction

Since 1990s considerable efforts have been made in the field of acoustic metamaterials and phononic crystals (PnCs) [1]. PnCs can be used for wave energy manipulation due to their unique

*Corresponding author
Email address: sfom@yandex.ru (Sergey I. Fomenko)