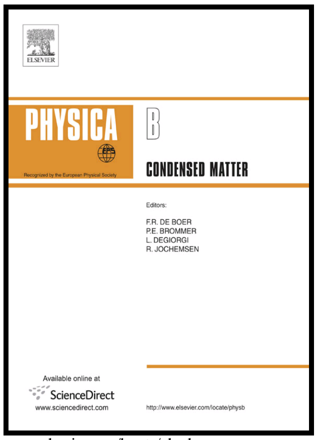

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PII: S0921-4526(17)30198-9
DOI: http://dx.doi.org/10.1016/j.physb.2017.04.022
Reference: PHYSB309913

To appear in: *Physica B: Physics of Condensed Matter*

Received date: 22 September 2016
Revised date: 9 April 2017
Accepted date: 21 April 2017

Cite this article as: Jiankun Huang, Zhifei Shi and Weixin Huang, Multiple banc gaps of phononic crystals with quasi-Sierpinski carpet unit cells, *Physica B Physics of Condensed Matter,* http://dx.doi.org/10.1016/j.physb.2017.04.022

Multiple band gaps of phononic crystals with quasi-Sierpinski carpet unit cells

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Abstract

This work investigated the dispersion curves of phononic crystals with quasi-Sierpinski carpet unit cells via improved plane wave expansion method. The position vector derivative method was applied to generate Sierpinski and quasi-Sierpinski carpet unit cells. Wave dispersion mechanisms of fractal phononic crystals were investigated by calculating the vibration modes of unit cells. The results show that (quasi-)fractal phononic crystals are benefit for obtaining multiple and wider band gaps, especially for the second stage case. For quasi-Sierpinski carpet unit cells, the multiple band gap feature becomes much more obvious due to the increase of the filling fraction. Numerical analysis of a finite quasi-fractal phononic crystal indicated the potential application of phononic crystals with quasi-Sierpinski carpet unit cells.

Keywords: Phononic crystal, quasi-Sierpinski carpet, multiple band gaps, unit cell.

PACS: 63.20.-e, 63.20.D-

1. Introduction

Elastic wave propagations in phononic crystals have attracted an extraordinary amount of attention recently. Phononic crystals are periodic at material arrangements or geometrical configurations. The most distinctive characteristic of phononic crystals is their band gaps, which are also referred to as attenuation zones (AZs). Elastic waves cannot propagate in the phononic crystals if the incident frequencies are in the AZs. Over the past decade, the interest in phononic crystals has been steadily increasing due to their wave tuning performance and potential applications, such as noise control [1, 2], vibration reduction [3, 4], and seismic isolation [5–7].

The theoretical description of phononic crystals is usually studied by means of calculating dispersion curves, which is based on a unit cell from the infinite periodic system with advantage of periodic boundaries [8]. Several classical methods were proposed, including finite-difference time domain method [9, 10], plane wave expansion (PWE) method [4, 11, 12], and finite element method (FEM) [13–15]. The structure should be a finite dimensional system in the practical engineering. The frequency response function (FRF) and transmission spectra were commonly calculated to illustrate the vibration reduction characteristics of the corresponding finite phononic crystals [4, 16, 17]. Meanwhile, experimental observations have demonstrated the existence of the band gaps and their effectiveness on the vibration attenuation [16, 17].

The major work on the phononic crystals was to adjust the band gap feature to dominate the elastic wave propagation. Low-frequency and wide vibration AZs are expected to obtain a better vibration reduction effectiveness in general. More recently, the

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