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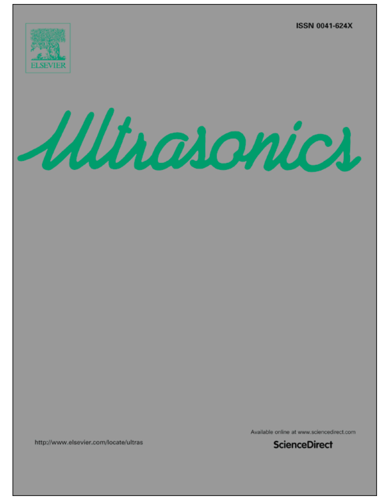

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Achieving directional propagation of elastic waves via topology optimization

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Abstract This paper presents a study on topology optimization of novel material microstructural configurations to achieve directional elastic wave propagation through maximization of partial band gaps. A waveguide incorporating a periodic-microstructure material may exhibit different propagation properties for the plane elastic waves incident from different inlets. A topology optimization problem is formulated to enhance such a property with a gradient-based mathematical programming algorithm. For alleviating the issue of local optimum traps, the random morphology description functions (RMDFs) are introduced to generate random initial designs for the optimization process. The optimized designs finally converge to the orderly material distribution and numerical validation shows improved directional propagation property as expected. The utilization of linear two-dimension phononic crystal with efficient partial band gap is suitable for directional propagation with a broad frequency range.

Keywords: phononic crystal; band gap; waveguide; directional propagation; topology optimization

1. Introduction

As artificial metamaterials, phononic crystals (PCs) have drawn much attention due to their particular characteristics including band gap and negative refraction. Periodic configurations composed of at least two different materials have shown great potential in the design of some special devices such as vibration isolators and mechanical filters. There are many literatures focusing on this innovative field in the past twenty years [1-10]. The existence of band gap seems to be one of the most important properties of PCs. In particular frequency ranges, the PC systems forbid the propagation of elastic or acoustic waves, which has been proved both numerically and experimentally [1, 2]. It thus raises a variety of important and interesting design problems, for example, the design of PCs with maximum band gap [9-14].

As well known, it has attracted much attention to control waves and energy fluxes by taking advantage of engineered materials and structures. For instance, extensive applications of electric diode eventually resulted in the world-wide technical revolution. Similarly, it is

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