Accepted Manuscript

Thermally tunable band gaps in architected metamaterial structures

Chaitanya Nimmagadda, Kathryn H. Matlack

PII: S0022-460X(18)30656-4
DOI: 10.1016/j.jsv.2018.09.053
Reference: YJSVI 14405

To appear in: *Journal of Sound and Vibration*

Received Date: 8 May 2018
Revised Date: 23 September 2018
Accepted Date: 26 September 2018

Please cite this article as: C. Nimmagadda, K.H. Matlack, Thermally tunable band gaps in architected metamaterial structures, *Journal of Sound and Vibration* (2018), doi: https://doi.org/10.1016/j.jsv.2018.09.053.

Thermally Tunable Band Gaps in Architected Metamaterial Structures

Chaitanya Nimmagadda[a], Kathryn H. Matlack[a]

[a] *Department of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign, Urbana, IL 61801, USA*

Abstract

The combined characteristics of periodic and locally resonant features in metamaterial structures, or meta-structures, give rise to unique wave propagation characteristics such as relatively low and wide band gaps. These meta-structures have a fixed geometry and thus a fixed behavior, however applications that require structural vibration mitigation such as spacecraft and automotive components have variable vibration mitigation requirements over a range of operation and external conditions. In this paper, we propose a method to thermally tune the band gaps of composite meta-structures, which combine a periodic lattice and locally-resonant inclusions, through changes in temperature of the structure. The concept primarily takes advantage of the different moduli of the two materials in the meta-structure that have drastically different temperature dependences, to preferentially tune the modulus of the lattice material compared to the resonant inclusion. We introduce an additional concept, termed thermal partitioning, to partially or fully open and close band gaps by locally controlling the temperature within the meta-structure. We demonstrate these results numerically with finite element simulations.

Keywords: Phononic crystals, metamaterials, tunable band gaps, architected materials, vibration mitigation

1. Introduction

Noise and vibrations create damaging conditions for structural components in spacecraft, aircraft, and vehicles, and can be a source of user discomfort and dissatisfaction. Typical strategies to mitigate noise and vibrations involve adding damping materials/treatments or active noise/vibration control devices a priori, which add mass to and increases the cost of the structure. An alternative is to redesign structural components as mechanical meta-structures, to embed the vibration mitigation properties directly into the component. These mechanical meta-structures are structured material that use meso-scale components to control wave propagation and vibration transmission. They incorporate concepts from phononic crystals and metamaterials to generate acoustic or elastic band gaps, or frequencies that cannot propagate [1–3]. Meta-structures are