*Proceedings IRF2018: 6th International Conference Integrity-Reliability-Failure*
*Lisbon/Portugal 22-26 July 2018. Editors J.F. Silva Gomes and S.A. Meguid*
*Publ. INEGI/FEUP (2018); ISBN: 978-989-20-8313-1*

PAPER REF: 7277

# ISOLATING VIBRATION BY PERIODIC COMPOSITE STRUCTURES

**Hongping Hu[1,2(*)], Yuantai Hu[1,2]**

[1]Department of Mechanics, Huazhong University of Science and Technology, Wuhan 430074, P. R. China;
[2]Hubei Key Laboratory for Engineering Structural Analysis and Safety Assessment, Huazhong University of Science and Technology, Wuhan 430074, P. R. China
[(*)]*Email:* huhp@hust.edu.cn

## ABSTRACT

As periodic composite structures, phononic crystals are employed to isolate vibration owing to its frequency band gap. Aim to overcome some engineering challenges but without loss of the stability, some phononic crystals were proposed with outstanding features, such as low-frequency band gap, broad or ultra-wide band gap, band gap with tunable frequency, small structure size, and strong attenuation.

***Keywords:*** phononic crystal, band gap, ultra-wide, low frequency.

## INTRODUCTION

As artificial periodic structures, phononic crystals (PCs) can modulate efficiently the propagation of acoustic or elastic waves by periodic composite structures. One of the most attractive properties of PCs is its band gaps (BGs), within which acoustic or elastic waves cannot propagate freely without attenuation. To employ the band gap to isolate vibration, some challenges have to be faced as follows: First one is to obtain band gaps with a low center frequency but without loss of stability. Second one is to broaden the band gap. Third one is achieving strong attenuation (Jiang, 2017a). Last but not least, the frequency of the band gap can be adjusted to meet various vibration sources.

PCs with piezoelectric materials usually have another significant advantage that its BGs can be tuned by the circuits and its parameters. The equal frequency shunting circuits were employed to tune the resonance frequency of each circuit into the same, thus an integrating locally resonant BG was obtained (Dai, 2015). Two kinds of equal frequency resonant shunt circuits were designed to achieve an integrated locally resonant BG with a much smaller transmission factor (Dai, 2016). A folding beam-type piezoelectric phononic crystal model was proposed to isolate vibration. The folding structure extends the propagation path of elastic waves, while its structure size remains quite small (Jiang, 2017b). An enhanced plane wave expansion method has been proposed to solve piezoelectric phononic crystal (PPC) connected with resonant shunting circuits (Lian, 2016). Some interesting phenomena were found from the coupling between Bragg scattering and locally resonant of electromagnetic oscillation (Lian, 2017).

## RESULTS AND DISCUSSION

A new phononic crystal with periodic circle cavity sandwich plates was proposed. The periodic circular cavity sandwich plates can generate several low frequency band gaps with wide range and strong attenuation (Jiang, 2017a). A phononic crystal with an ultra-wide band gap was proposed, whose unit cell consists of a cross-like concave hole in the center and four square convex holes at the corners. After optimization, an ultra-wide band gap with gap-to-midgap ratio of 156.0% was achieved, with the filling fraction keeping a relative small value.

Numerical results illustrate that the combination of convex and concave holes is a practicable direction for structural optimization of phononic crystals exhibiting ultra-wide band gaps (Jiang, 2018). A silicon-based cross-like holey phononic crystal strip was proposed for the control of elastic waves. The goal was to obtain a broad bandgap at low frequencies with a lightweight structure. After design, a gap-to-midgap ratio of 47% was obtained with an intermediate filling fraction of the solid material and a small thickness of the strip. The band gap could be moved to an extremely low frequency range while keeping the strip significantly smaller than previously reported phononic crystal strips. The transmission property through a finite number of periods agrees well with the band structure of the infinite system. The proposed phononic crystal strip could for instance be used as an isolating anchor for elastic wave resonators (Jiang, 2017c).

## ACKNOWLEDGMENTS

This work was supported by the National Natural Science Foundation of China (11272126, and 11672113), the Fundamental Research Funds for the Central Universities, HUST: 2016JCTD114 and 2015TS121.

## REFERENCES

[1] Dai, L. X., Jiang, S., Lian, Z. Y., Hu, H. P., Chen, X. D. Locally resonant band gaps achieved by equal frequency shunting circuits of piezoelectric rings in a periodic circular plate. J Sound Vib, 2015, 337, pp. 150-160.

[2] Dai, L. X., Hu, H. P., Jiang, S., Chen, X. D. Two Kinds Equal Frequency Circuits to Achieve Locally Resonant Band Gap of a Circular Plate Attached Alternately by Piezoelectric Unimorphs. Acta Mech Solida Sin, 2016, 29, pp. 502-513.

[3] Jiang, S., Chen, H., Dai, L., Hu, H., Laude, V. Multiple low-frequency broad band gaps generated by a phononic crystal of periodic circular cavity sandwich plates. Compos Struct, 2017a, 176, pp. 294-303.

[4] Jiang, S., Dai, L. X., Chen, H., Hu, H. P., Jiang, W., Chen, X. D. Folding beam-type piezoelectric phononic crystal with a low-frequency and broad band gap. Appl Math Mech-Engl, 2017b, 38, pp. 411-422.

[5] Jiang, S., Hu, H. P., Laude, V. Ultra-Wide Band Gap in Two-Dimensional Phononic Crystal with Combined Convex and Concave Holes. Physica Status Solidi (RRL) - Rapid Research Letters, 2017c, pp. 17003-17.

[6] Jiang, S., Hu, H. P., Laude, V. Low-frequency band gap in cross-like holey phononic crystal strip. Journal of Physics D: Applied Physics, 2018, 51, pp. 045601.

[7] Lian, Z. Y., Jiang, S., Hu, H. P., Dai, L. X., Chen, X. D., Jiang, W. An Enhanced Plane Wave Expansion Method to Solve Piezoelectric Phononic Crystal with Resonant Shunting Circuits. Shock Vib, 2016, pp. 40153-63.

[8] Lian, Z. Y., Hu, H. P., Dai, L. X., Luo, B., Liang, Y. X., Chen, X. D. Coupling between two kinds of band gaps of a shunted tube piezoelectric phononic crystal. J Intell Mater Syst Struct, 2017, 28, pp. 2153-2166.