Design and fabrication of 3D-printed composite metastructure with subwavelength and ultrawide bandgaps

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Abstract

Architected composite metastructures can exhibit a subwavelength ultrawide bandgap (BG) with prominent emerging applications in the structural vibration and noise control and, elastic wave manipulation. The present study implemented both forward and inverse design methods based on numerical simulations and machine learning (ML) methods, respectively to design and fabricate an architected composite metastructure exhibiting subwavelength and ultrawide BGs. The multilayer perceptron and radial basis function neural networks are developed for the inverse design of the composite metastructure and their accuracy and computation time are compared. The band structure revealed the presence of subwavelength and ultrawide BGs generated through local resonance and structural modes of the periodic composite lattice. Both in-plane and out-of-plane local resonant modes of the periodic lattice structure were responsible for inducing the BGs. The findings are confirmed by calculating numerical wave transmission curves and experiment tests on the fabricated supercell structures, utilizing 3D-printing technology. Both numerical and experimental results validate the ML prediction and the presence of subwavelength and ultrawide BG was observed. The design approach, research methodology and proposed composite metastructure will have a wide range of application in the structural vibration control and shock absorption.

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