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3D elastic phononic crystal structure with ultra-wide bandgap

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The study of wave propagation along spatially periodic structures [1] is of great interest for solid state physics while approaching the influence of atomic vibration on crystal properties [2]. The peculiar property of these structures is the formation of bandgaps, i.e. portions of the frequency response for which an incident wave cannot propagate through the crystal. This idea is used in several applications in the electromagnetic domain, namely the so-called photonic crystals (PtCs), to build waveguides, mirrors and filters [3]. More recently [4], large interest has been devoted to phononic crystals (PnCs). Formally, a phonon is a quasi-particle that describes the vibrational state of a lattice. Therefore depending on dimensions and materials of the crystal structure, applications range from earthquake protection (seismic metamaterials [5,6]) to vibrations suppression and noise isolation, from acoustic diodes to thermal metamaterials [7].
It is undeniable that bandgap width is a key factor to boost performances and robustness, i.e. wider bandgap means stronger attenuation around gap central frequency. Width of a bandgap can be expressed using the gap-mid gap ratio, a non-dimensional parameter that avoids frequency dependence [8].
This work reports a comprehensive modeling and experimental characterization of several three-dimensional phononic crystals composed of a single material in a network topology [8,9]. Those structures are endowed with ultra-wide complete bandgaps (among them there's the widest in literature), together with a brand new methodology to lower the opening frequency of the bandgap.
Prototypes of the finite crystal structures have been manufactured in polyamide by means of additive manufacturing technology and tested to assess the transmission spectrum of the crystals in the audible frequency band.

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