UNIVERSITY OF EXETER

EPSRC Centre for Doctoral Training in Metamaterials XM²

Acoustic Interface States via Material Variation

B.P. Pearce, J.D Smith[2], P.G. Petrov[1], J.R. Sambles[1], A.P. Hibbins[1]
[1] Department of Physics and Astronomy, University of Exeter, EX4 4QL
[2] DSTL Porton Down, Salisbury, SP4 0JQ

Abstract This work concerns acoustic interface states, vibrations which are localised at an interface as a consequence of layering of different materials. Numerical modelling of novel structures has been performed and preliminary experimental confirmation is underway.

Introduction

A periodic layered structure (a 1D crystal) formed of two different materials may inhibit sound propagation over a band gap (stop band) dictated by the materials and their periodicity. If two different layered structures are attached then at the boundary between them, provided suitable conditions are met, an interface vibrational state may form [1]. Such a localised state may provide strongly resonant transmission for a frequency within the overlapping bandgaps of the two layered structures. Previous works found these states between multilayers with differing geometry [1,2,3]. Here we show that varying the material composition offers an alternative route.

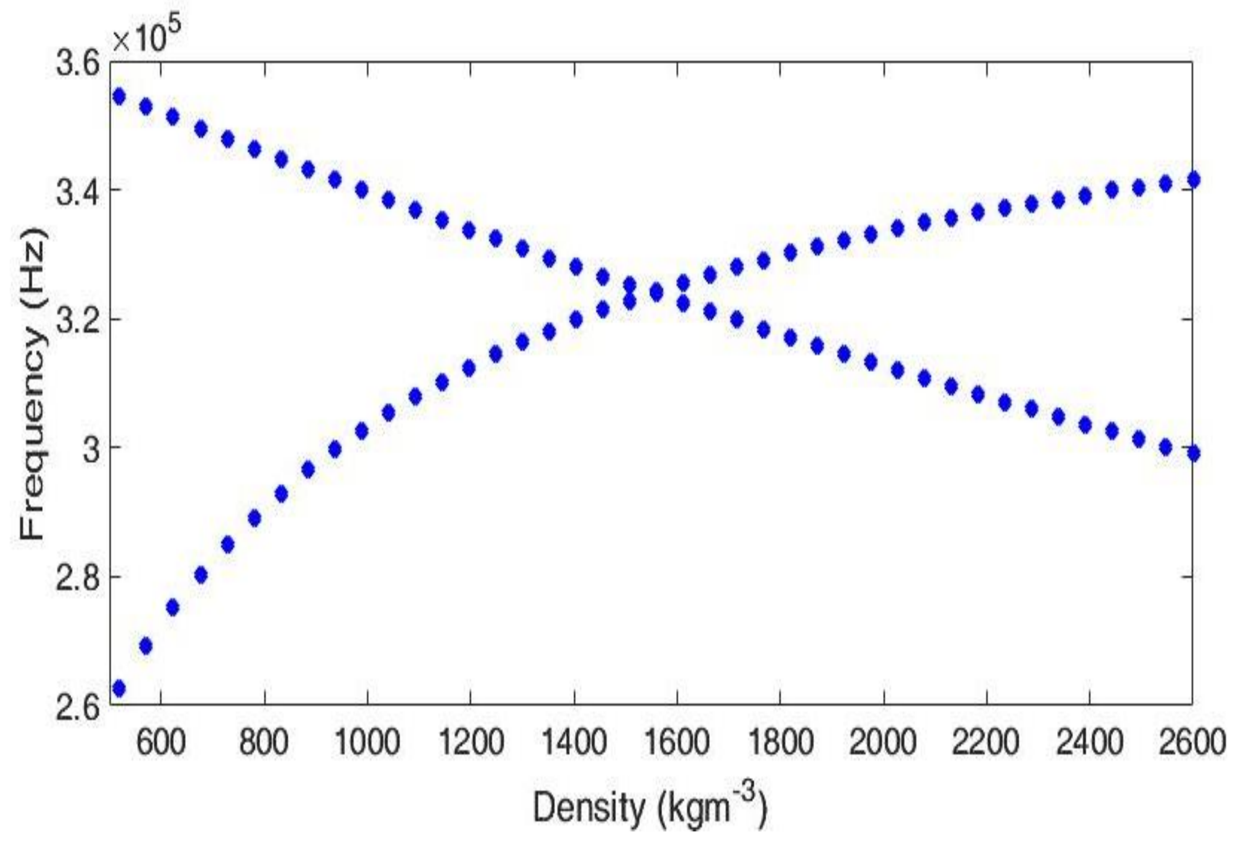

Figure 1. Figure showing the start and end frequency of the lowest bandgap of a 1D layered crystal as the density of one of the two materials is varied. The other is fixed at 1500 kgm^{-3}. All other material parameters were kept constant.

Numerical Modelling

All modelling was performed with COMSOL. Five unit cell, two component layered 1D crystals were explored (Fig. 2). The materials were 'A', a 3 mm thick layer of ABS plastic and 'B', which was either aluminium or water of thickness 0.3 mm. The proposed structures, chosen to support an interface state, were modelled to obtain their transmission spectra, both separately (Fig. 3) and as a combined interface system (Fig. 4).

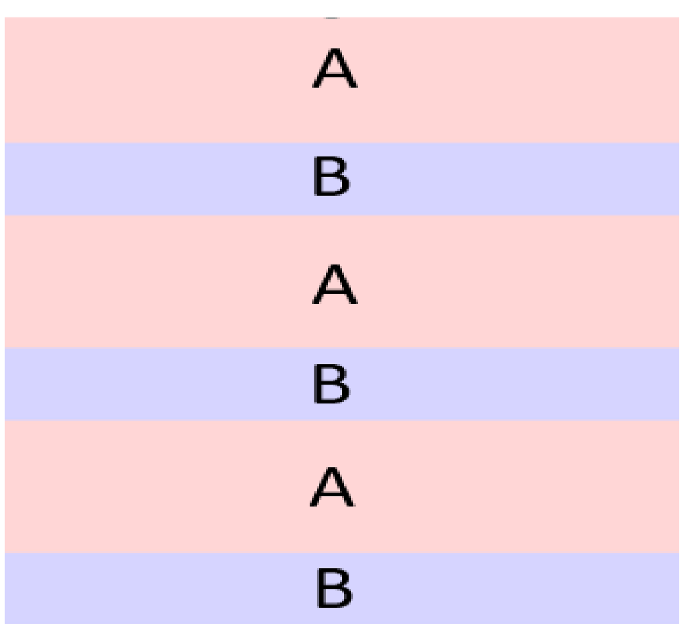

Figure 2. Diagram of a simple 1D layered crystal, comprised of alternating layers of materials 'A' and 'B'.

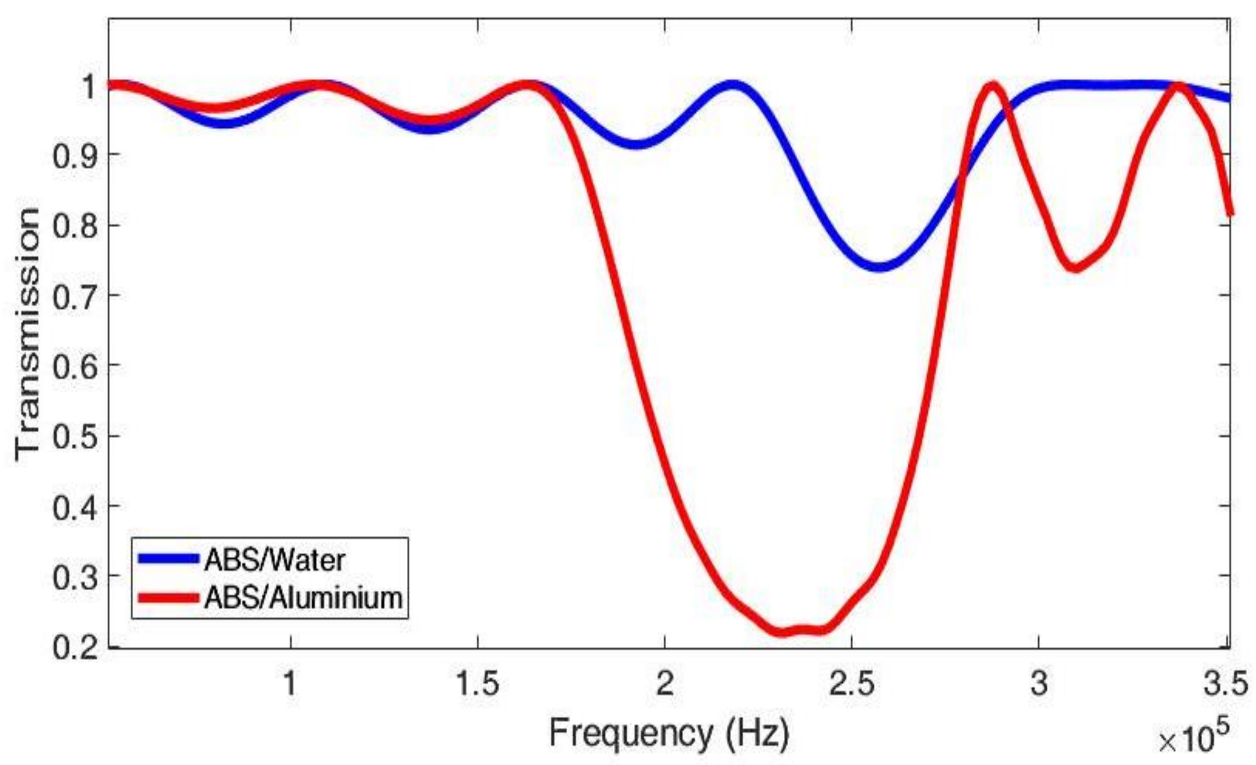

Figure 3. Model of the transmission for the individual ABS/Water and ABS/Aluminium 1D crystals. These exhibit stop bands that overlap.

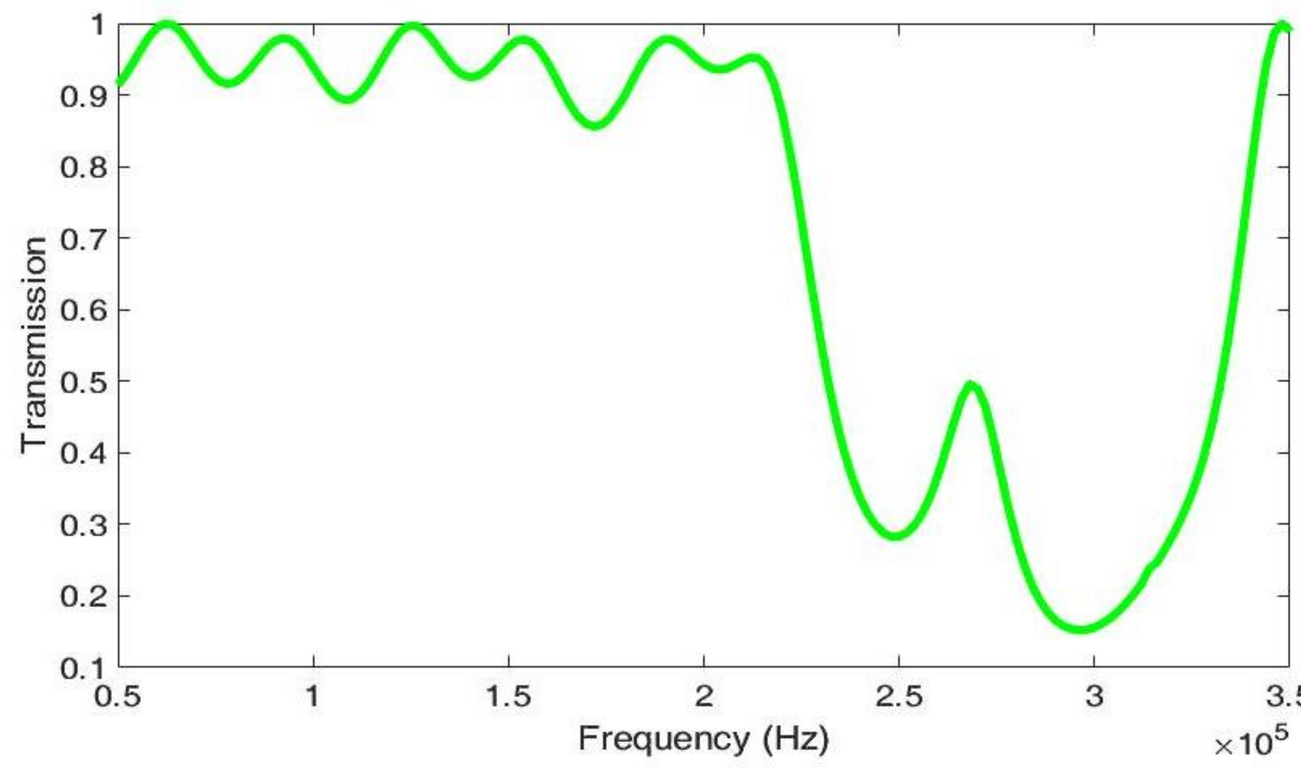

Figure 4. Model of the transmission for the combined interface system, present in the stop band is a transmission peak at about 270 kHz. This is due to an interface state.

Preliminary Experiment

A preliminary transmission spectra for an experimental ABS/water crystal is shown in Fig. 5.

The experimental results show rather poor agreement with the numerical modelling. Possible reasons for this include inhomogeneity within the sample, discrepancies in the elastic properties of the ABS or the influence of mass loading upon the sample.

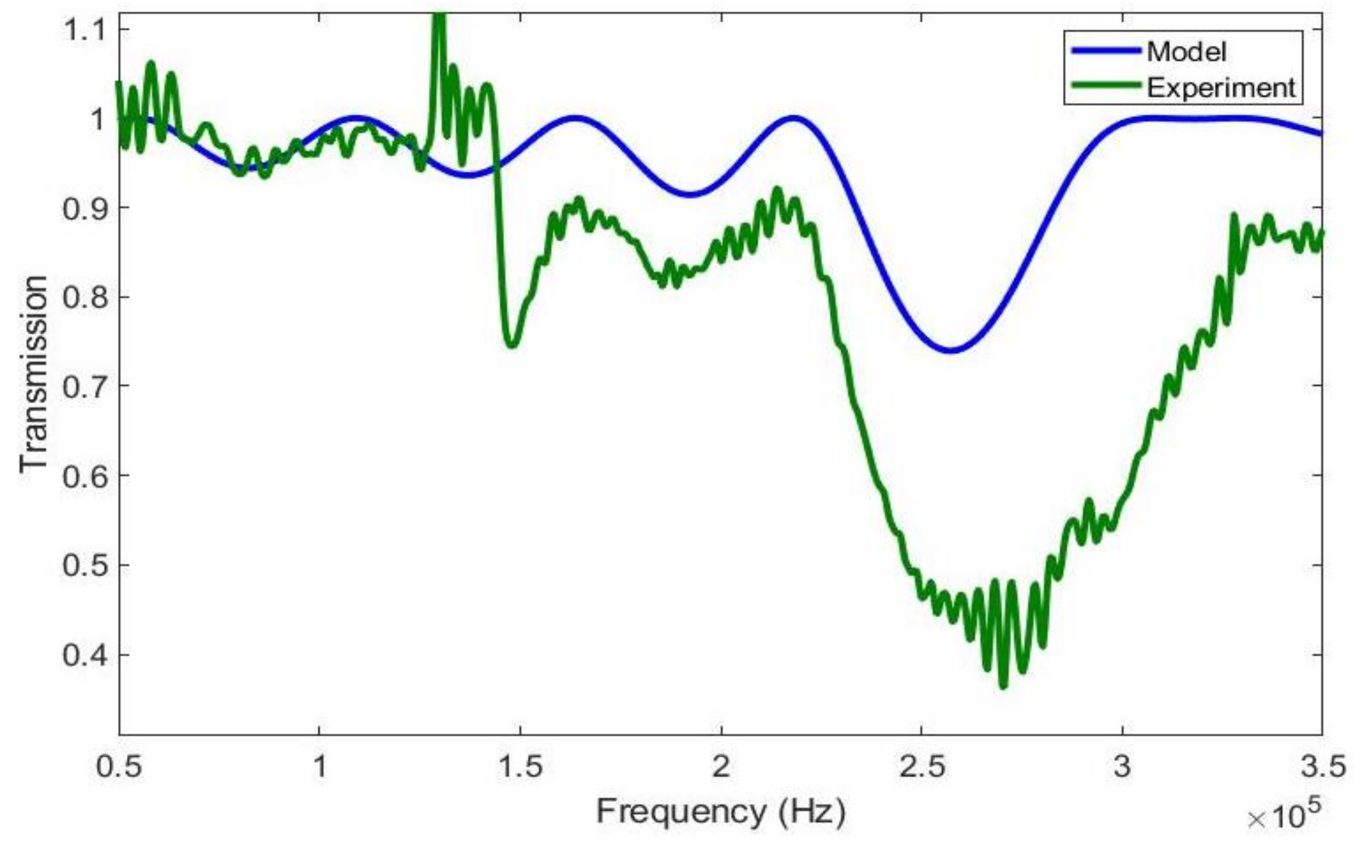

Figure 5. Experimental and model transmission spectra for a water 5 layer ABS structure. The experimental spectra exhibits a bandgap that is larger and deeper than that predicted by numerical modelling.

bp274@exeter.ac.uk
ex.ac.uk/BenjaminPearce
www.exeter.ac.uk/metamaterials

References

[1] Xiao, M., et al (2017) *Physical Review X*, *4*(2), 1–12.
[2] Yue, L., et al (2018). *Scientific Reports*, *8*(1), 1–10
[3] Li, X., et al (2018). *New Journal of Physics*, *20*(7), 073032.

[dstl] EPSRC Pioneering research and skills