ACOUSTICS2008/3237
Three-dimensional phononic crystals made by brazing aluminum beads to form an opal structure

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Most phononic crystals studied so far are constructed from periodically arranged objects (e.g. spheres or rods) immersed in a continuous solid or fluid medium. In this presentation, we investigate the properties of a different type of phononic crystal made by weakly brazing 4-mm-diameter aluminum beads in a face-centred cubic array, producing a large-scale opal. In this crystal, wave propagation proceeds through the network of coupled beads rather than through the surrounding medium (air in our case), and the main band gaps that we observe result from coupled resonances of the beads rather than from Bragg scattering. Using ultrasonic techniques, we measure the transmission coefficient and the dispersion relation along the ΓL direction, and show that the lowest-frequency gap occurs between about 500 and 600 kHz - a frequency range that is just below the lowest resonance of an isolated aluminum sphere. We have also measured the group velocity, which we find to be negative in the lowest frequency band gap. Further insight into the properties of these phononic crystals is obtained by performing finite difference time domain (FDTD) calculations, in which the coupling between spheres is taken into account by allowing the spheres to overlap.