Supporting Information:
Experimental realization of phonon demultiplexing in three-dimensions

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Multiplexing elastic waves based on metasurfaces “i.e., 2D plates”, considers periodicity in the x-y directions only and is not periodic along the z direction. In other words, it has a band gap only in the x-y plane, therefore, you can only bend the wave in plane. In contrast, our unit cell is periodic in x, y and z. The inherently 3D band gap is a full gap in all planes and all propagation directions. While, we ultimately realize the final device as 4 coupled (i.e., all connected at the source) columns as the 1D periodic dispersion curves serve as the limiting case for the performance of our 3D proposed design. The figure below (Figure S1) shows how does the dispersion curve evolve if we remove one or two periodic boundaries from the unit cell. For a fully periodic unit cell in all directions, we see the biggest band gap (Fig S1-left). As we remove the periodicity in the z direction (i.e., 2D periodicity), we start seeing more standing modes, and widening of the transmission bands (Fig S1-middle). In the case of 1D periodicity, we observe more flat modes and a reduction in the band gap width. Therefore, a 3D design that works with 1D periodicity (the limiting case), must work with full-fledged periodicity without any loss of generality.

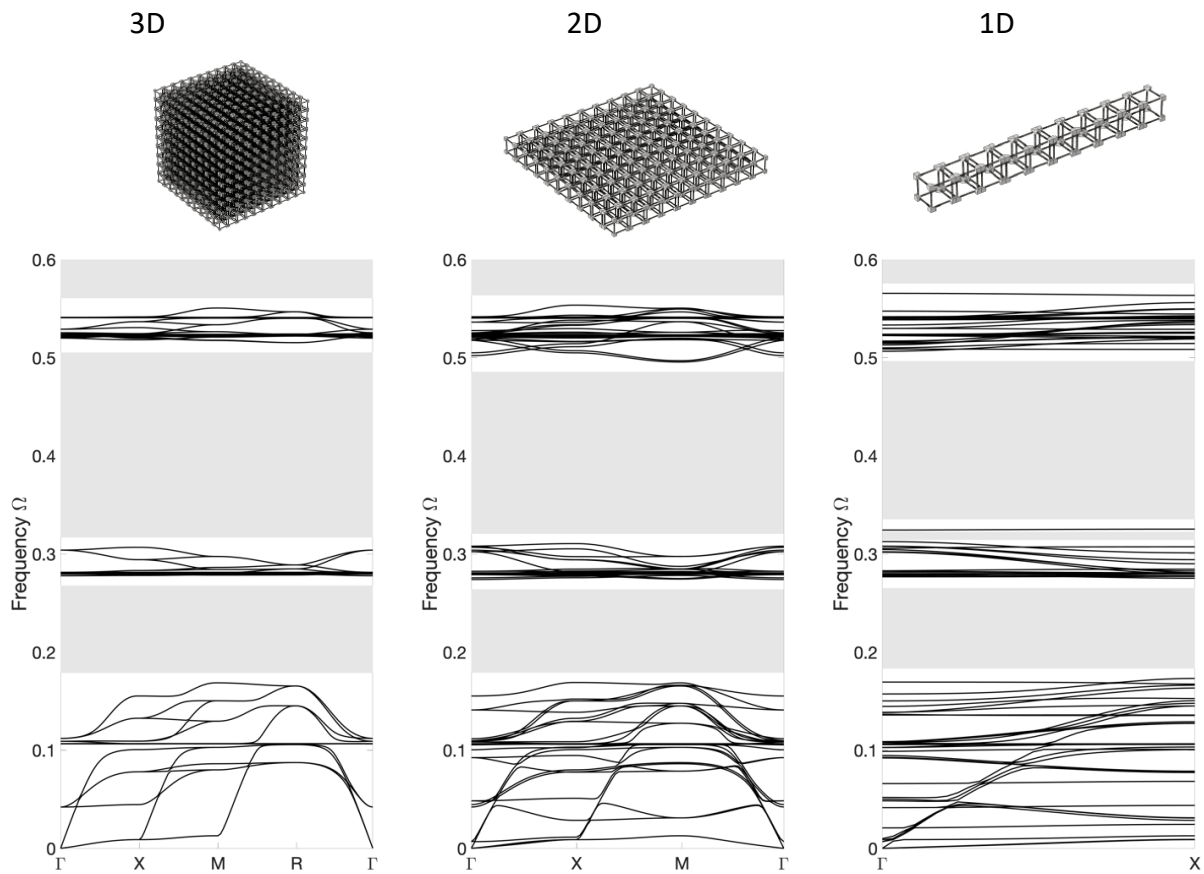

Figure S1: Dispersion curves of the proposed 3D unit cell with periodicity in all directions (left), periodicity along x and y(middle) and periodicity along x(right).

The connectivity of the four channels in our experimental demonstration or the directionality of the input can be easily modified. A variation of our de-multiplexer based on the same design is presented in Figure S2 shows a meta-device/ meta-structure that can take input from any direction with all connected parts throughout. As the periodicity is in all directions for all channels, an excitation from any direction will pass through at least 5 unit cells in any given directions and that will result in separating the signals.

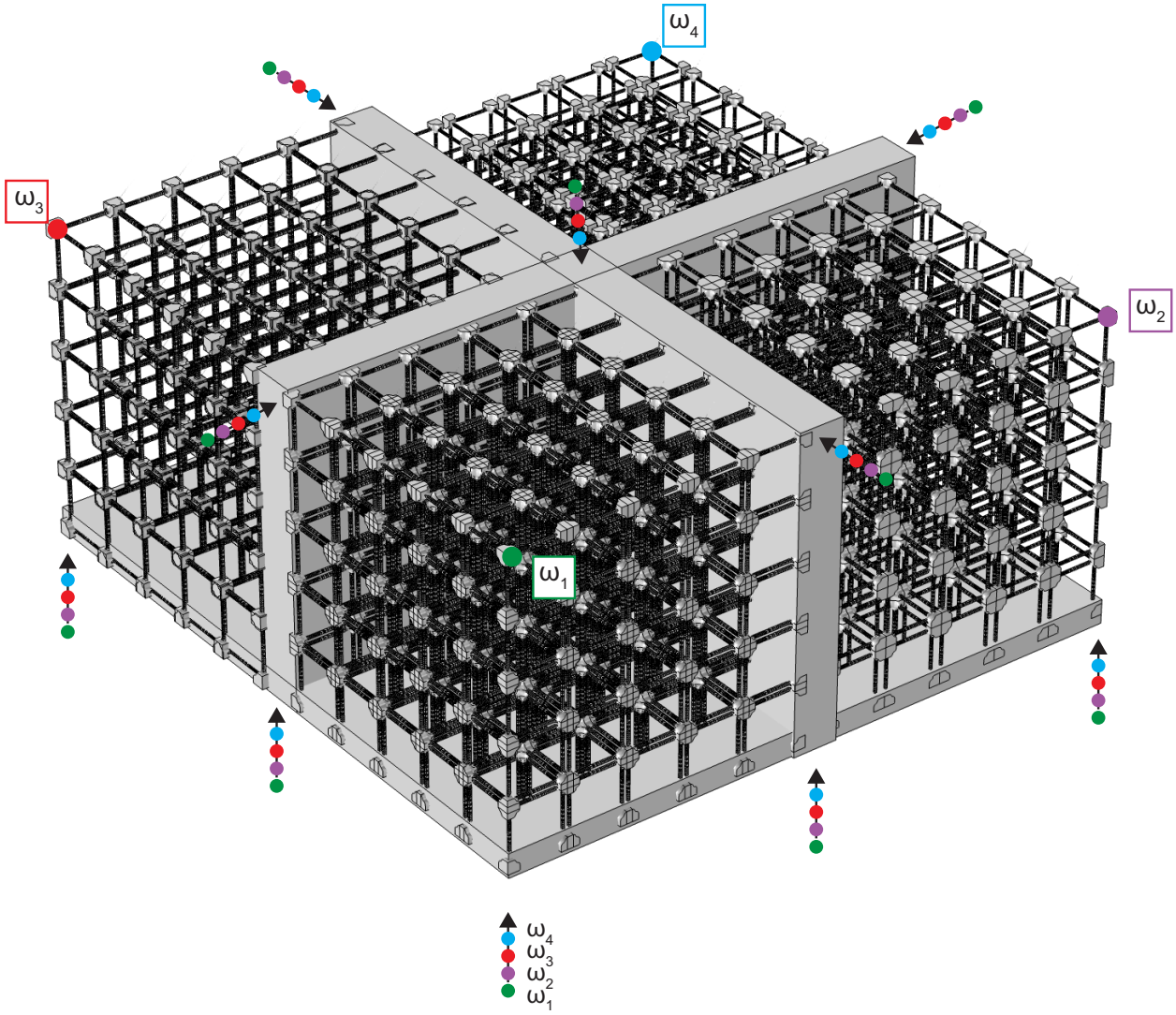

Figure S2: A schematic representation of a 3D multiplexer that have all channels connected and can function in all directions and polarizations.