

ACOUSTIC BARRIER AND ACOUSTIC METABLOCKS**CROSS-REFERENCE TO RELATED APPLICATION**

[0001] This application claims the benefit of priority to the Singapore application no. 10202303567Y filed December 19, 2023, the contents of which are hereby incorporated by reference in their entirety for all purposes.

TECHNICAL FIELD

[0002] This application relates to the field of acoustics, and more particularly to an acoustic barrier, and acoustic metablocks.

BACKGROUND

[0003] In environments where noise sources such as machines are present, machine noise and environmental noise form disturbances to human subjects or machine operators during work or rest. The typical solution is the use of personal protective equipment, such as ear plugs. However, ear plugs block out the majority of noise and sound, inclusive of a co-worker's voice, thus causing ineffective communications between co-workers during work or rest.

SUMMARY

[0004] According to an aspect, disclosed herein is an acoustic barrier. The acoustic barrier comprises: a frame defining a plurality of receiving positions and an acoustic axis; a plurality of first acoustic metablocks detachably coupled to respective first ones of the plurality of receiving positions, each of the plurality of first acoustic metablocks comprising: a first housing defining a first interior chamber and a first aperture, the first aperture fluidly communicable with the first interior chamber, the first aperture allowing fluid communication through the first

housing along the acoustic axis; and a plurality of second acoustic metablocks detachably coupled to respective second ones of the plurality of receiving positions, each of the plurality of second acoustic metablocks comprising: a second housing defining a second interior chamber; and a pair of polymer sheets sealingly coupled to opposing faces of second housing along the acoustic axis to seal the second interior chamber, wherein each of the plurality of first acoustic metablocks defines a first acoustic transmission loss spectrum, and each of the plurality of second acoustic metablocks defines a second acoustic transmission loss spectrum, wherein the first acoustic transmission loss spectrum is distinct from the second acoustic transmission loss spectrum.

[0005] According to another aspect, disclosed herein an acoustic metablock. The acoustic metablock comprises: a first housing defining a first interior chamber; at least one first inner wall formed in the first interior chamber to form a plurality of first sub-chambers interior of the first housing, the at least first inner wall defining a first aperture through the first housing along the acoustic axis, wherein the at least one first inner wall defines at least one first through-hole such that the plurality of first sub-chambers are fluidly communicable with the first aperture, wherein each of the plurality of first sub-chambers comprises a plurality of labyrinth walls.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Various embodiments of the present disclosure are described below with reference to the following drawings:

[0007] FIG. 1 is a perspective view of the acoustic barrier according to various embodiments;

[0008] FIG. 2 is a front view of a frame of the acoustic barrier of FIG. 1;

[0009] FIG. 3A is a front view of the acoustic barrier of FIG. 1;

[0010] FIG. 3B is a sectional front view of the acoustic barrier of FIG. 1;

- [0011] FIG. 4 shows exemplary acoustic transmission loss spectra according to various embodiments;
- [0012] FIG. 5 is a perspective view of a first metablock according to various embodiments;
- [0013] FIG. 6 is a front view of FIG. 5;
- [0014] FIG. 7 is a sectional perspective view of FIG. 5;
- [0015] FIG. 8 is a front view of FIG. 7
- [0016] FIG. 9 is a sectional perspective view of a first metablock according to various embodiments;
- [0017] FIG. 10 is a front view of FIG. 9;
- [0018] FIG. 11 is a sectional perspective view of a first metablock according to various embodiments;
- [0019] FIG. 12 is a front view of FIG. 11;
- [0020] FIGS. 13A to 13D shows the front views of different first metablocks according to various embodiments;
- [0021] FIG. 13E shows exemplary acoustic transmission loss spectra of various exemplary embodiments of the first metablock 200;
- [0022] FIG. 14 is a perspective view of a second metablock according to various embodiments;
- [0023] FIG. 15 is a perspective view of the second metablock of FIG. 14 showing the internal structure;
- [0024] FIG. 16 is an exploded view of the second metablock of FIG. 14;
- [0025] FIG. 17 is a sectional perspective view of a second metablock according to various embodiments;
- [0026] FIG. 18 is a front view of a second metablock according to various embodiments;

[0027] FIG. 19 shows exemplary acoustic transmission loss spectra of various exemplary embodiments of the second metablock with a variety of second through-hole diameters;

[0028] FIG. 20 shows multiple exemplary first acoustic transmission loss spectra and an exemplary second acoustic transmission loss spectra;

[0029] FIG. 21 is a front view of an acoustic barrier according to various embodiments;

[0030] FIG. 22 shows an exemplary acoustic cage according to various embodiments;

[0031] FIG. 23 shows another exemplary acoustic cage according to various embodiments;

[0032] FIG. 24 shows an experimental setup for measuring the acoustic transmission loss spectra of the acoustic cage of FIG. 23;

[0033] FIG. 25 shows an exemplary acoustic transmission loss spectrum of the acoustic cage of FIG. 23;

[0034] FIG. 26 shows a scaled up exemplary acoustic cage (half height) according to various embodiments;

[0035] FIG. 27 shows an experimental setup for measuring the acoustic transmission loss spectra of the acoustic cage of FIG. 26;

[0036] FIGs. 28 and 29 show exemplary acoustic transmission loss spectra of the acoustic cage of FIG. 26;

[0037] FIG. 30 shows a scaled up exemplary acoustic cage (full height) according to various embodiments;

[0038] FIG. 31 shows exemplary acoustic transmission loss spectra of the acoustic cage of FIG. 26 and FIG. 30;

[0039] FIG. 32 is a perspective view of an acoustic cage according to various embodiments;

[0040] FIG. 33 is a perspective view of an acoustic cage with a perforated cover according to various embodiments; and

[0041] FIG. 34 shows exemplary acoustic transmission loss spectra of the acoustic cage of FIG. 33.

DETAILED DESCRIPTION

[0042] The following detailed description is made with reference to the accompanying drawings, showing details and embodiments of the present disclosure for the purposes of illustration. Features that are described in the context of an embodiment may correspondingly be applicable to the same or similar features in the other embodiments, even if not explicitly described in these other embodiments. Additions and/or combinations and/or alternatives as described for a feature in the context of an embodiment may correspondingly be applicable to the same or similar feature in the other embodiments.

[0043] In the context of various embodiments, the articles “a”, “an” and “the” as used with regard to a feature or element include a reference to one or more of the features or elements.

[0044] In the context of various embodiments, the term “about” or “approximately” as applied to a numeric value encompasses the exact value and a reasonable variance as generally understood in the relevant technical field, e.g., within 10% of the specified value.

[0045] As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

[0046] The term “acoustic transmission loss spectrum” may refer to a set of transmission losses across a specific frequency range for an incident acoustic wave passing through an interface or a structure, such as a metablock. The “acoustic transmission loss spectrum” may generally correspond to or be indicative of the noise suppression or noise reduction performance of the metablock over the specific frequency range. For example, the “acoustic transmission loss spectrum” over a frequency range of 20Hz to 1600Hz may correspond to a noise reduction performance of the metablock or acoustic barrier over the frequency range of 20Hz to 1600Hz.

[0047] The term “distinct” used in the context of two acoustic transmission loss spectra may refer to two spectra which have a generally different spectrum magnitude or shape/form across a common frequency range. For example, over a common frequency range (such as 200Hz to 1000Hz), a first acoustic transmission loss spectrum with a peak at 800Hz may be considered “distinct” from a second acoustic transmission loss spectrum with a peak at 600Hz. In another example, over a common frequency range (such as 10Hz to 200Hz), a third acoustic transmission loss spectrum with a peak transmission loss magnitude of 20dB may be considered “distinct” from a fourth acoustic transmission loss spectrum with a peak transmission loss magnitude of 10dB. In another example, when acoustic transmission spectra with similar spectrum peaks with small variations in respective magnitudes are not considered “distinct”.

[0048] The present disclosure proposes a reconfigurable acoustic barrier. The acoustic barrier may be configured and reconfigured according to different noise sources or environments. The noise blocking effect provided by the acoustic barrier may be altered or configured by varying the acoustic transmission losses. The proposed acoustic barrier may be used for different use cases or applications, such as in a machine work-shop, in a library, to enhance a quiet room, etc.

[0049] In various embodiments, the acoustic barrier may be reconfigured based on a location of the user/human subject. For example, portions of the acoustic barrier near the user’s head may be an area of lower noise or higher noise blocking, while portions away from the user’s head, such as the lower limbs, may be an area with higher noise but with ventilation. In other embodiments, the acoustic barrier may be configured based on a sound location of a machine or a robot. For example, ventilation may be provided on the top portions of the acoustic barrier while the higher noise blocking may be provided at lower portions nearer to the moving parts of the machine.

[0050] In various embodiments, the acoustic barrier may be a portable or movable barrier. For example, wheels may be provided at a bottom side of the acoustic barrier. In various embodiments, the acoustic barrier may be a planar barrier similar to a wall structure. In various embodiments, multiple acoustic barriers may be used to form an enclosure such as a box. In various embodiments, multiple acoustic barriers may be attachable and detachable from one another to form an acoustic structure and to be kept when not in use.

[0051] In various embodiments, the acoustic barrier may be used to reduce noise in a lower frequency spectrum, such as between 20Hz to 1600Hz, between 50Hz to 1000Hz, etc. In various embodiments, the acoustic barrier may include a frame which defines multiple receiving positions for metablocks. The acoustic barrier may include multiple first metablocks detachably coupled to selected ones of the multiple receiving positions. The acoustic barrier may also include multiple second metablocks detachably coupled to selected ones of the multiple receiving positions. The first metablock may define a first acoustic transmission loss spectrum and the second metablock may define a second acoustic transmission loss spectrum. The first acoustic transmission loss spectrum is distinct from the second acoustic transmission loss spectrum.

[0052] The first metablock may define a through-aperture which allows fluid communication across the first metablocks. The through-aperture(s) allows natural ventilation across the acoustic barrier without the need for mechanical ventilation, such as a fan, resulting in energy saving. It was also noted that natural ventilation may also cut down the risk of infectious disease transmission. The first metablock may also include one or more interior chambers, such as Helmholtz chambers or labyrinth chambers, for providing noise reduction.

[0053] The second metablock may include an interior chamber sandwiched between two polymer sheets configured to provide noise reduction. Each of the first metablock and the second metablock may be detachably coupled to one receiving position, and reattached or

displaced to another receiving position when there is a change in noise source or when there is a movement in the human subject.

[0054] FIGs. 1 to 4 illustrates an acoustic barrier 50 according to various embodiments of the present disclosure. The acoustic barrier 50 may include a frame 100. As shown in FIG. 2, the frame 100 may define a plurality of receiving positions 110. In addition, the frame 100 may define an acoustic axis 120. The acoustic axis 120 may be the general direction of an approach soundwave or acoustic wave. In some embodiments, the frame 100 may be a planar structure defining a barrier plane 130. In some embodiments, the acoustic axis 120 may be orthogonal to the planar structure or the barrier plane 130. Referring to FIG. 1, during operation, a first direction 83 may define a height direction of the acoustic barrier 50, a second direction 85 may define a lateral direction of the acoustic barrier 50, and a third direction 87 may define a depth direction of the acoustic barrier 50. In various embodiments, a top side or top portion and a bottom side or bottom portion of the acoustic barrier may be defined by the height direction 83. In various embodiments, the frame 100 may define a frame thickness (FT) along the depth direction 87.

[0055] In various embodiments, the acoustic barrier 50 may comprise a plurality of first acoustic metablocks 200 detachably coupled to respective first ones 110a of the plurality of receiving positions 110. In addition, the acoustic barrier 50 may comprise a plurality of second acoustic metablocks 300 detachably coupled to respective second ones 110b of the plurality of receiving positions 110.

[0056] According to the application or context, the acoustic barrier 50 may be configured based on user requirements. Hence, each of the plurality of first acoustic metablocks 200 may be selectively coupled to the respective first ones 110a of the plurality of receiving positions 110. Similarly, each of the plurality of second acoustic metablocks 300 may be selectively coupled to the respective second ones 110b of the plurality of receiving positions 110. In some

embodiments, each of the plurality of receiving positions 110 may be of similar dimension such that respective positions of the plurality of first acoustic metablocks 200 may be interchangeably swapped with the plurality of second acoustic metablocks 300.

[0057] In various embodiments, as shown in FIGs. 3A and 3B, the plurality of first acoustic metablocks 200 and the plurality of second acoustic metablocks 300 may be non-uniformly distributed in the plurality of receiving positions 110. In some instances, the plurality of receiving positions 110 may form an array of receiving positions 110 and hence the first and second acoustic metablocks 200/300 may be arranged or disposed in an array configuration.

[0058] Referring to FIG. 4, according to various embodiments, each of the plurality of first acoustic metablocks 200 may define a first acoustic transmission loss spectrum 202. Each of the first acoustic transmission loss spectrum 202 for the plurality of first acoustic metablocks 200 may be similar and/or near-identical to each other, and hence non-distinct from one another. Similarly, and each of the plurality of second acoustic metablocks 300 may define a second acoustic transmission loss spectrum 302. Each of the second acoustic transmission loss spectrum 302 for the plurality of second acoustic metablocks 300 may be similar and/or near-identical to each other, and hence non-distinct from one another. In various embodiments, as shown in FIG. 4, each of the first acoustic transmission loss spectrum 202 may be distinct from each of the second acoustic transmission loss spectrum 302.

[0059] In various embodiments, the first acoustic transmission loss spectrum 202 may comprises at least one first spectrum peak 204. Similarly, the second acoustic transmission loss spectrum 302 comprises at least one second spectrum peak 304. As shown in FIG. 4, the at least one first spectrum peak 204 may have a different peak frequency and/or peak magnitude from the at least one second spectrum peak 304.

[0060] FIGs. 5 to 8 illustrate a first acoustic metablock 200 according to various embodiments of the disclosure. The first acoustic metablock 200 may comprise a first housing

210. The first housing 210 may be a hollow housing. The first housing 210 may be made from a polymer material. The first housing 210 may define a first interior chamber which may be formed from one or more first sub-chambers 240, for example four first sub-chambers 240. The first acoustic metablock 200 may define a first metablock plane 260 parallel to the barrier plane 130. The first metablock plane 260 may be orthogonal to the acoustic axis 120. The first housing 210 may include at least one first inner wall 220 defining the first aperture 230. The first aperture 230 may allow fluid communication through the first housing 210 along the acoustic axis 120. In various embodiments, the at least one first inner wall 220 may divide the first interior chamber into a plurality of first sub-chambers 240. Each of the at least one first inner wall 220 may comprise at least one first through-hole 222. The at least one first through-hole 222 may enable the plurality of first sub-chambers 240 to be fluidly communicable with the first aperture 230. Hence, the first aperture 230 may be fluidly communicable with the first interior chamber.

[0061] In various embodiments, the first acoustic metablock 200 may define a first metablock axis 250. The first metablock axis 250 may be parallel to the acoustic axis 120 and/or orthogonal to the barrier plane 130. As shown in FIG. 5, the first aperture 230 may extend uniformly through the first housing 210 along the first metablock axis 250. The first aperture 230 may be a quadrilateral aperture. In alternative embodiments, the first aperture 230 may extend non-uniformly through the first housing 210 along the first metablock axis 250. In other words, the first aperture 230 may have a non-uniform cross-section along the first metablock axis 250.

[0062] The first aperture 230 may allow natural ventilations through the respective first acoustic metablocks 200, while the plurality of first sub-chambers 240 such as Helmholtz's resonators or Labyrinth resonators acts to provide additional damping and noise mitigation for particular frequencies.

[0063] In various embodiments, the frequency for noise mitigation or first acoustic transmission loss spectrum may be tuned by varying the size of the first aperture 230, the number and sizes of first sub-chambers 240, the number of first through-holes 222, etc.

[0064] In various embodiments, as shown in FIGs. 9 and 10, the plurality of first sub-chambers 240 may comprise a plurality of labyrinth walls 242. The plurality of labyrinth walls 242 may be integrally formed with the first housing 210, for example, by using additive manufacturing or 3D printing. The plurality of labyrinth walls 242 may form a serpentine path in each of the plurality of first sub-chambers 240. The serpentine path may aid in increasing the acoustic/soundwave travel, attenuating the noise in the process.

[0065] In various embodiments, as shown in FIGs. 9 and 10, the first housing 210 may define a first interior chamber which may be formed from two first sub-chambers 240. The at least one first inner wall 220 may divide the first interior chamber into two equal and symmetrical first sub-chambers 240. This increases the volume of each sub-chamber and hence alters or varies the first acoustic transmission loss spectrum 202 of the first acoustic metablock 200. In addition, two of the first inner wall 220 may each comprise a first through-hole 222. The first through-hole 222 may be configured on the top first inner walls 220 (along the height direction 83) such that water or liquid does not easily enter the first acoustic metablock 200.

[0066] The embodiments as described above are exemplary illustrations and are not limited thereto. Referring further to FIGs. 13A to 13D, various embodiments of the first acoustic metablock 200 is shown. In an example as shown in FIG. 13A, the first aperture 230 may be a circular aperture. In an example as shown in FIG. 13B, the first aperture 230 may be a square aperture. In an example as shown in FIG. 13C, the first aperture 230 may be a hexagonal aperture. In an example as shown in FIG. 13D, the first aperture 230 may be a rectangular aperture. In some examples, the first housing 210 may include a square cross section as shown

in FIGs. 13A and 13B. In other examples, the first housing 210 may include a rectangular cross section as shown in FIGs. 13C and 13D.

[0067] In some embodiments, selected ones of the first through-hole 222 formed on the at least one first inner wall 220 may be sealed or blocked, for example using a stopper or a tape. In some embodiments, selected ones of the first through-hole 222 formed on the at least one first inner wall 220 may be partially sealed or partially blocked, for example using a stopper or a tape. In some embodiments, the first through-holes 222 may be of different dimension or size. In some embodiments, selected ones of the first sub-chambers 240 may not be in fluid communication with the first aperture 230.

[0068] FIG. 13E shows exemplary acoustic transmission loss spectra of various exemplary embodiments of the first acoustic metablock 200.

[0069] FIGs. 14 to 16 illustrate a second acoustic metablock 300 according to various embodiments of the disclosure. The second acoustic metablock 300 may comprise a second housing 310. The second housing 310 may be a solid housing. The second housing 310 may be made from a polymer material. The second housing 310 may define a second interior chamber which may be formed from one or more second sub-chambers 340, for example two second sub-chambers 340. The second acoustic metablock 300 may define a second metablock plane 360 parallel to the barrier plane 130. The second metablock plane 360 may be orthogonal to the acoustic axis 120. The second acoustic metablock 300 may further include a pair of polymer sheets 330 coupled to opposing faces of second housing 310. The pair of polymer sheets 330 may be sealingly coupled to the second housing 310 along the acoustic axis 120 to seal the second interior chamber.

[0070] In various embodiments, the second housing 310 may include at least one second inner wall 320 defining a plurality of second sub-chambers 340. Hence, the pair of polymer sheets 330 may seal the plurality of second sub-chambers 340. Therefore, the second housing

310 and the pair of polymer sheets 330 may sealingly form the plurality of second sub-chambers 340. As such, the plurality of second sub-chambers 340 are not in fluid communication with an exterior of the second housing 310, but are in fluid communication with one another. The at least one second inner wall 320 may provide additional structural support for the pair of polymer sheets 330.

[0071] In various embodiments, the pair of polymer sheets 330 may be PVC sheets and/or Polyethylene sheets. The pair of polymer sheets 330 may be made from PVC membranes and/or other semi-rigid plastic membranes. Different from stretchable polymer sheets which may form wrinkles or folds, the pair of polymer sheets 330 may be substantially non-stretchable along the second metablock plane 360.

[0072] In various embodiments, each of the at least one second inner wall 320 defines at least one second through-hole 322. The at least one second through-hole 322 enables the plurality of second sub-chambers 340 to be fluidly communicable with one another. It was observed that the inclusion of the at least one second through-hole 322 may cause the second acoustic transmission loss spectrum to shift to a lower frequency (for example, from 1060 Hz to 870 Hz) for all orientations of the second acoustic metablock 300. This may improve the noise reduction effect for low frequency noise. In various embodiments, the at least one second through-hole 322 may be configured with different dimensions or hole-sizes. For example, the second through-hole 322 may be in a range of 3mm to 8mm.

[0073] The at least one second through-hole 322 may be suitably sized to provide additional damping for noise mitigation. The position of the at least one second inner wall 320, the hole-size(s) of the at least one second through-hole 322, the number of second through-holes 322 may be varied to alter a resonance frequency for noise mitigation.

[0074] In various embodiments, the second acoustic metablock 300 may define a second metablock axis 350. The second metablock axis 350 may be parallel to the acoustic axis 120

and/or orthogonal to the barrier plane 130. In various embodiments, referring again to FIG. 3B, selected ones of the second acoustic metablocks 300a/300b/300c/300d may be angularly offset about the respective second metablock axis 350 from one another. In other words, the second acoustic metablocks 300a/300b/300c/300d are disposed in different orientation from each other in the frame 100. In some embodiments, the selected ones of the second acoustic metablocks 300a/300b/300c/300d may be orthogonal about the respective second metablock axis 350 relative to one another. In other words, the second acoustic metablocks 300a/300b/300c/300d may be disposed orthogonal to each other in the frame 100.

[0075] In various embodiments, the first acoustic metablocks 200 may each define a first thickness T1 along the acoustic axis 120 or first metablock axis 250. The second acoustic metablocks 300 may each define a second thickness T2 along the acoustic axis 120 or second metablock axis 350. The first thickness T1 may be substantially equal to the second thickness T2 such that the acoustic barrier is formed with opposing flat surfaces.

[0076] Referring to FIG. 17, in some embodiments, the second acoustic metablock 300 may define two second sub-chambers 340 and the second inner wall 320 may be formed with three second through-holes 322. Therefore, the second through-hole 322 may allow the two second sub-chambers 340 to be fluidly communicable with one another. The number of second through-holes 322 in each second metablock acoustic 300 may be varied to vary the respective acoustic transmission loss spectrum.

[0077] Referring to FIG. 18, in various embodiments, the second acoustic metablock 300 may define four second sub-chambers 340a/340b/340c/340d. The second housing 310 may comprise multiple second inner walls 320, each formed with a second through-hole 322. The second through holes 322 may allow the four second sub-chambers 340a/340b/340c/340d to be fluidly communicable with one another.

[0078] The embodiments as described above are exemplary illustrations and are not limited thereto. FIG. 19 shows exemplary acoustic transmission loss spectra of various exemplary embodiments of the second acoustic metablock 300 with a variety of second through-hole diameters.

[0079] FIG. 20 shows multiple exemplary first acoustic transmission loss spectra 202 and an exemplary second acoustic transmission loss spectra 302. It may be seen that the first acoustic transmission loss spectrum 202 comprises at least one first spectrum peak 204. Further, the second acoustic transmission loss spectrum 302 comprises at least one second spectrum peak 304. The at least one first spectrum peak 204 has a different peak magnitude and/or peak frequency relative to the at least one second spectrum peak 304.

[0080] FIG. 21 illustrates an acoustic barrier 50 according to various embodiments of the disclosure. The acoustic barrier 50 may include a quadrilateral frame 100 defining a plurality of receiving positions 110. In various embodiments, each of the plurality of first acoustic metablocks 200 may have a different size from each of the plurality of second acoustic metablocks 300. Hence, it may be appreciated that the plurality of receiving positions 110 may be of different sizes/dimensions. For example, first ones 110a of the plurality of receiving positions 110 for receiving the first acoustic metablocks 200 may be larger than second ones 110b of the plurality of receiving positions 110 for receiving the second acoustic metablocks 300.

[0081] The acoustic barrier 50 may create a quiet zone by mitigating the environmental noise. The acoustic barrier 50 may also be used to shield a noise source such as machines or manufacturing processes. The acoustic barrier 50 may be used as partitions in an open space, partitions for pods or for creating a quiet corner in public areas, gardens, parks or open office. The acoustic barrier 50 may also be used for shielding a noise source such as a portable aircon unit, a printer, machines or manufacturing processes.

[0082] In various embodiments, the acoustic barrier 50 may be modular, reconfigurable and/or

stackable. The acoustic barrier or parts of the acoustic barrier, such as the metablocks, may be fabricated by additive manufacturing such as 3D printing or injection molding for polymers/plastics, and/or other manufacturing process for woods and metals. In various embodiments, the frames receiving the metablocks may be made of woods and/or metal. In an example, the frames may be formed from aluminum T-slots.

[0083] In various embodiments, with the use of PVC membranes or semi-rigid/stiff plastic membranes, wrinkling and loss of tension during use or other problems relating to softer membranes such as Mylar sheets may be mitigated as such soft membrane may need to be stretched during the manufacturing process and also will be difficult to be scaled up for larger area. In various embodiments, the PVC sheets may be sized according to the metablocks for easy scale up and may also be configured in a variety of colours for aesthetics functions.

[0084] Referring to FIGs. 22 and 23, as exemplary embodiments, multiple planar acoustic barriers may be used to form an acoustic cage. The acoustic cage may shield a human subject from the environment by creating a quiet zone within the acoustic barrier/acoustic cage. Alternatively, the acoustic cage may shield a noise source within the acoustic cage, reducing the noise emitted outwards through the acoustic cage. In examples, the acoustic barrier/acoustic cage may form part of the panels for internal partitions, windows, or for a typical soundproof pod or room.

[0085] FIGs. 24 and 25 illustrate an experimental set up and measurement results for the acoustic transmission loss spectra of the acoustic cage in FIG. 22. It may be seen that acoustic transmission losses (or acoustic noise reduction) at low frequency (e.g. below 1000Hz) may reach 30dB.

[0086] It may be appreciated that the acoustic barrier may be scaled up to a larger size in comparison to the acoustic barrier/acoustic cages as shown in FIGs. 22 and 23. In other exemplary embodiments as shown in FIG 26, the size of the acoustic barrier/acoustic cage was scaled up to the size of a table (half height) sufficient to house a machine. In addition, sealings were provided between each of the acoustic barrier to improve noise mitigation.

[0087] FIG. 27 shows the experimental set up for measuring the acoustic transmission loss spectrum of the acoustic cage in FIG. 26. FIG. 28 shows the experimental results (the acoustic transmission loss spectrum) of the acoustic cage in FIG. 26 from 80Hz to 800Hz. FIG. 29 shows the experimental results (the acoustic transmission loss spectrum) of the acoustic cage in FIG. 26 from 80Hz to 300Hz. It may be seen that scaling up the size of the acoustic barrier improves the noise mitigation performance at lower frequency (e.g. below 200Hz).

[0088] In yet other exemplary embodiments as shown in FIG. 30, the size of the acoustic barrier/acoustic cage was further scaled up to the size of a chamber/enclosure (full height) sufficient to house a human subject. FIG. 31 shows the experimental results (the acoustic transmission loss spectrum) and comparison between the acoustic cages in FIGs. 26 and 30 in the frequency range of 50Hz to 500Hz. It may be seen that noise mitigation performance for the full height acoustic cage is superior for frequencies below 150Hz.

[0089] FIGs. 32 and 33 illustrate an acoustic cage 30 according to various embodiments of the present disclosure. The acoustic cage 30 may include multiple acoustic barriers 50 coupled together forming an enclosure. Wheels may be provided to each acoustic barrier 50 such that the acoustic cage 30 is a moveable structure. In various embodiments, one or more acoustic barrier 50 may be configured as a door of the acoustic cage 30. In addition, a top cover 40 may be provided disposed on a top portion of the acoustic cage 30. The top cover 40 may be made from polymer.

[0090] Referring to FIG. 33, in various embodiments, a perforated cover 60 may be provided coupled to a face of the acoustic barrier 50. The perforated cover 60 may provide protection to the acoustic barrier 50 against physical damages such as an impact from a foreign object. The perforated cover 60 may also provide noise attenuation at higher frequency in comparison to the acoustic barrier 50. The perforated cover 60 may be formed from a polymer material such as polycarbonate. In other examples, the perforated cover 60 may be formed from metal. In some examples, the perforated cover 60 may have a thickness of at least 3 mm, a hole diameter of 10 mm and hole separation (arrow in FIG. 33) of 15 mm.

[0091] FIG. 34 shows the experimental results (the acoustic transmission loss spectrum) of the acoustic cage of FIG. 33 from 50Hz to 800Hz. It may be seen that the inclusion of the perforated cover improves the noise mitigation performance at higher frequency (e.g. above 500Hz).

[0092] All examples described herein, whether of methods, materials, or products, are presented for the purpose of illustration and to aid understanding and are not intended to be limiting or exhaustive. Modifications may be made by one of ordinary skill in the art without departing from the scope of the invention as claimed.

CLAIMS**1.** An acoustic barrier, comprising:

a frame defining a plurality of receiving positions and an acoustic axis;

a plurality of first acoustic metablocks detachably coupled to respective first ones of the plurality of receiving positions, each of the plurality of first acoustic metablocks comprising:

a first housing defining a first interior chamber and a first aperture, the first aperture fluidly communicable with the first interior chamber, the first aperture allowing fluid communication through the first housing along the acoustic axis; and

a plurality of second acoustic metablocks detachably coupled to respective second ones of the plurality of receiving positions, each of the plurality of second acoustic metablocks comprising:

a second housing defining a second interior chamber; and

a pair of polymer sheets sealingly coupled to opposing faces of second housing along the acoustic axis to seal the second interior chamber,

wherein each of the plurality of first acoustic metablocks defines a first acoustic transmission loss spectrum, and each of the plurality of second acoustic metablocks defines a second acoustic transmission loss spectrum,

wherein the first acoustic transmission loss spectrum is distinct from the second acoustic transmission loss spectrum.

2. The acoustic barrier as recited in claim 1, wherein each of the plurality of first acoustic metablocks further comprising:

at least one first inner wall defining the first aperture, the at least first inner wall dividing the first interior chamber into a plurality of first sub-chambers, wherein the at least one first inner wall comprises at least one first through-hole such that the plurality of first sub-chambers are fluidly communicable with the first aperture.

3. The acoustic barrier as recited in claim 2, wherein each of the plurality of first sub-chambers comprises a plurality of labyrinth walls.
4. The acoustic barrier as recited in claim 3, wherein the plurality of labyrinth walls form a serpentine path in each of the plurality of first sub-chambers.
5. The acoustic barrier as recited in any one of claims 2 and 4, wherein each of the plurality of first acoustic metablock defines a respective first metablock axis parallel to the acoustic axis, wherein the first aperture extends uniformly through the first housing along the respective first metablock axis.
6. The acoustic barrier as recited in any one of claims 1 and 5, wherein the first aperture is a quadrilateral aperture.
7. The acoustic barrier as recited in any one of the above claims, wherein each of the plurality of second acoustic metablocks further comprising:

at least one second inner wall dividing the second interior chamber into a plurality of second sub-chambers, wherein the pair of polymer sheets seal the plurality of second sub-chambers,

wherein the at least one second inner wall defines at least one second through-hole such that the plurality of second sub-chambers are fluidly communicable with one another.

8. The acoustic barrier as recited in claim 7, wherein each of the plurality of second acoustic metablock defines a respective second metablock axis parallel to the acoustic axis, and wherein selected ones of the plurality of second acoustic metablocks are angularly offset about the respective second metablock axis from one another.
9. The acoustic barrier as recited in claim 8, wherein the selected ones of the plurality of second acoustic metablocks are orthogonal about the respective second metablock axis relative to one another.
10. The acoustic barrier as recited in any one of the above claims, wherein each of the plurality of first acoustic metablocks has a different size from each of the plurality of second acoustic metablocks.
11. The acoustic barrier as recited in any one of the above claims, wherein the pair of polymer sheets comprises one or both of: a PVC sheet and a Polyethylene sheet.
12. The acoustic barrier as recited in any one of the above claims, wherein each of the pair of polymer sheets is substantially non-stretchable along a respective second metablock plane, the respective second metablock plane orthogonal to the acoustic axis.

13. The acoustic barrier as recited in any one of the above claims, wherein each of the plurality of first acoustic metablocks is selectively coupled to the respective first ones of the plurality of receiving positions, and wherein each of the plurality of second acoustic metablocks is selectively coupled to the respective second ones of the plurality of receiving positions.
14. The acoustic barrier as recited in any one of the above claims, wherein the plurality of first acoustic metablocks and the plurality of second acoustic metablocks are non-uniformly distributed in the plurality of receiving positions.
15. The acoustic barrier as recited in any one of the above claims, wherein the first acoustic transmission loss spectrum comprises at least one first spectrum peak and the second acoustic transmission loss spectrum comprises at least one second spectrum peak, wherein the at least one first spectrum peak has a different peak magnitude relative to the at least one second spectrum peak.
16. The acoustic barrier as recited in any one of the above claims, wherein the first housing and the second housing are made from polymers.
17. The acoustic barrier as recited in any one of the above claims, wherein the plurality of receiving positions forms an array of receiving positions.
18. The acoustic barrier as recited in any one of the above claims, wherein a first thickness along the acoustic axis for each of the plurality of first acoustic metablocks is

substantially equal to a second thickness along the acoustic axis for each of the plurality of second acoustic metablocks.

19. The acoustic barrier as recited in any one of the above claims, wherein the frame is a planar structure.

20. An acoustic metablock, comprising:

a first housing defining a first interior chamber;
at least one first inner wall formed in the first interior chamber to form a plurality of first sub-chambers interior of the first housing, the at least first inner wall defining a first aperture through the first housing along the acoustic axis,
wherein the at least one first inner wall defines at least one first through-hole such that the plurality of first sub-chambers are fluidly communicable with the first aperture,
wherein each of the plurality of first sub-chambers comprises a plurality of labyrinth walls.