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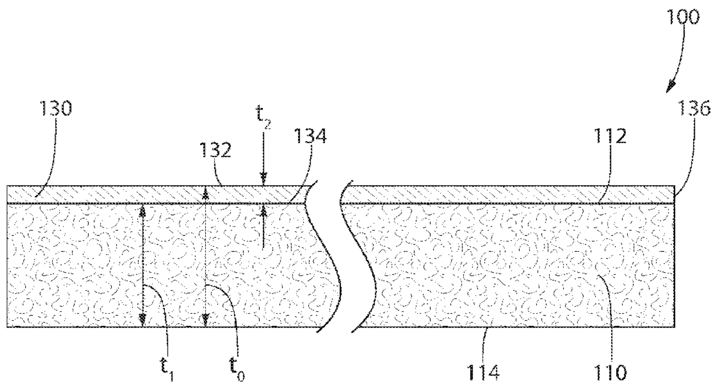

FIG. 2

(57) Abstract: An acoustic building panel for storing thermal energy includes a substrate having a first major surface opposite a second major surface. The acoustic building panel further includes a composite layer over the second major surface of the substrate, the composite layer having a first major composite layer surface opposite a second major composite layer surface and an edge composite layer surface extending from the first major composite layer surface to the second major composite layer surface. The composite layer includes a composite carrier and a phase change material infused into the composite carrier.

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ACOUSTIC STRUCTURES AND SURFACE COVERING SYSTEMS COMPRISING PHASE CHANGE MATERIAL AND METHODS OF MAKING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a PCT International Application that claims the benefit of U.S. Provisional Application No. 63/ 612261 filed on December 19, 2023. The disclosure of the above application is incorporated herein by reference.

FIELD OF THE DISCLOSURE

[0002] The present disclosure relates to acoustic building structures, such as ceiling and wall panels, and more particularly to acoustic building structures comprising phase change material.

BACKGROUND

[0003] Building materials, such as acoustics structures, planks, and panels for ceiling and wall systems, are designed to balance interests with respect to aesthetics, material cost, structural integrity, acoustics, temperature control, and environmental impact.

[0004] Accordingly, those skilled in the art continue research and development in the field of acoustic building structures.

SUMMARY

[0005] This summary is intended merely to introduce a simplified summary of some aspects of one or more implementations of the present disclosure. Further areas of applicability of the present disclosure will become apparent from the detailed description provided hereinafter. This summary is not an extensive overview, nor is it intended to identify key or critical elements of the present teachings, nor to delineate the scope of the disclosure. Rather, its purpose is merely to present one or more concepts in simplified form as a prelude to the detailed description below.

[0006] Applicants have discovered an acoustic building panel for storing thermal energy.

[0007] In one example, the acoustic building panel includes a substrate having a first major surface opposite a second major surface. The acoustic building panel further includes a composite layer over the second major surface of the substrate, the composite layer having a first major composite layer surface opposite a second major composite layer surface and an edge composite layer surface extending from the first major composite layer surface to the second major composite layer surface. The composite layer includes a composite carrier and a phase change material infused into the composite carrier.

[0008] In one or more examples, the composite layer comprises shape stabilized phase change material composite granules. In one or more examples, the composite layer further comprises cement. In one or more examples, the composite layer further comprises siloxane, or other polymer resin binders including acrylic, polyester, polyvinyl acetate, urethane, alkyd, etc. In one or more examples, the composite layer has a thickness ranging from about 1mm to about 25 mm, from about 2mm to about 20mm, or from about 4mm to about 15 mm. In one or more examples, the composite layer stores at least 20 kJ/SF of thermal energy. In one or more examples, the composite layer is activated at a temperature ranging from about 60 °F to about 80 °F. In one or more examples, the composite carrier comprises one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

[0009] In one or more examples, the phase change material comprises an inorganic salt hydrate. In one or more examples, the phase change material comprises calcium chloride hexahydrate. In one or more examples, the phase change material is dry infused into the composite carrier. In one or more examples, the phase change material is vacuum infused into the composite carrier.

[0010] In one or more examples, the substrate comprises one or more of mineral fiber board, fiberglass, jute fiber, wood, polyester felt, or a composite material. In one or more examples, the substrate has a porosity ranging from about 70% to about 96%. In one or more examples, the substrate has a density ranging from about 5.0 lbs/ft^3 to about 30.0 lbs/ft^3.

[0011] In one or more examples, the acoustic building panel further includes a film positioned between the substrate and the composite layer. In one or more examples, the film comprises a polymeric material. In one or more examples, the film comprises PET. In one or more examples, the film comprises a low permeability paint. In one or more examples, the acoustic building panel further includes an adhesive positioned between the film and the substrate. In one or more examples, the acoustic building panel further includes a sealing layer positioned over the composite layer. In one or more examples, the sealing layer comprises PET. In one or more examples, the sealing layer comprises a low permeability paint. In one or more examples, the sealing layer comprises foil. In one or more examples, the acoustic building panel further includes a coating over the edge composite layer surface. In one or more examples, the coating comprises a low permeability paint.

[0012] Also disclosed is a surface covering system.

[0013] In one example, the surface covering system includes a plurality of acoustic building panels configured to be positioned adjacent to each other to form a plurality of seams between each of the plurality of building panels, each acoustic building panel including a substrate having a first major surface opposite a second major surface and a composite layer over the second major surface of the substrate, the composite layer having a first major composite layer surface opposite a second major composite layer surface and an edge composite layer surface extending from the first major composite layer surface to the second major composite layer surface. The composite layer includes a composite carrier and a phase change material infused into the composite carrier.

[0014] In one or more examples, the composite layer comprises shape stabilized phase change material composite granules. In one or more examples, the composite layer further comprises cement. In one or more examples, the composite layer further comprises siloxane, or other polymer resin binders including acrylic, polyester, polyvinyl acetate, urethane, etc.. In one or more examples, the composite layer has a thickness ranging from about 1mm to about 25 mm, from about 2mm to about 20mm, or from about 4mm to about 15 mm. In one or more examples, the composite layer stores at least 20 kJ/SF of thermal energy. In one or more examples, the composite layer is activated at a temperature ranging from about 60 °F to about 80 °F. In one or more examples, the composite carrier comprises one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

[0015] In one or more examples, the phase change material comprises an inorganic salt hydrate. In one or more examples, the phase change material comprises calcium chloride hexahydrate. In one or more examples, the phase change material is dry infused into the composite carrier. In one or more examples, the phase change material is vacuum infused into the composite carrier.

[0016] In one or more examples, the substrate comprises one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material. In one or more examples, the substrate has a porosity ranging from about 70% to about 96%. In one or more examples, the substrate has a density ranging from about 5 lbs/ft^3 to about 30 lbs/ft^3.

[0017] In one or more examples, the surface covering system further includes a film positioned between the substrate and the composite layer. In one or more examples, the film comprises a polymeric material. In one or more examples, the film comprises PET. In one or more examples, the film comprises a low permeability paint. In one or more examples, the surface covering system further includes an adhesive positioned between the film and the substrate. In one or more examples, the surface covering system further includes a sealing layer positioned over the composite layer. In one or more examples, the sealing layer comprises PET. In one or more examples, the sealing layer comprises a low permeability paint. In one or more examples, the sealing layer comprises foil. In one or more examples, the surface covering system further includes a coating over the edge composite layer surface. In one or more examples, the coating comprises a low permeability paint.

[0018] Also disclosed is a method for forming an acoustic building panel.

[0019] In one example, the method includes providing a substrate having a first major surface opposite a second major surface, applying a shape stabilized phase change composite material to the second major surface of the substrate, and consolidating the shape stabilized phase change composite material to form a composite layer having a first major composite layer surface opposite a second major composite layer surface and an edge composite layer surface extending from the first major composite layer surface to the second major composite layer surface.

[0020] In one or more examples, the composite layer comprises shape stabilized phase change material composite granules, particles or a compressed layer. In one or more examples, the composite layer further comprises cement. In one or more examples, the composite layer further comprises siloxane, or other polymer resin binders including acrylic, polyester, polyvinyl acetate, urethane, etc.. In one or more examples, the composite layer has a thickness ranging from about 1mm to about 25mm, from about 2mm to about 4mm, or from about 2.5mm to about 3.5mm. In one or more examples, the composite layer stores at least 20 kJ/SF of thermal energy. In one or more examples, the composite layer is activated at a temperature ranging from about 60 °F to about 85 °F. In one or more examples, the composite layer comprises one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

[0021] In one or more examples, the composite layer comprises an inorganic salt hydrate. In one or more examples, the composite layer comprises calcium chloride hexahydrate.

[0022] In one or more examples, the substrate comprises one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material. In one or more examples, the substrate has a porosity ranging from about 70% to about 96%. In one or more examples, the substrate has a density ranging from about 5.0 lbs/ft^3 to about 30 lbs/ft^3.

[0023] In one or more examples, the method further includes mixing a phase change material with a liquid carrier in a heated environment to yield a liquid phase change material composition, mixing the liquid phase change material composition with a composite carrier to yield a shape stabilized phase change composite material, and cooling the shape stabilized phase change composite material to yield shape stabilized phase change composite material granules prior to applying to the substrate.

[0024] In one or more examples, the mixing comprises dry infusing the phase change material into the composite carrier. In one or more examples, the mixing comprises vacuum infusing the phase change material into the composite carrier.

[0025] In one or more examples, the method further includes mixing a wetting agent, a thickener, and/ or a defoamer with the phase change material and liquid carrier.

[0026] In one or more examples, the method further includes applying a film to the second major surface prior to applying the shape stabilized phase change composite material to the second major surface. In one or more examples, the film comprises a polymeric material. In one or more examples, the film comprises PET. In one or more examples, the film comprises a low permeability paint. In one or more examples, the method further includes applying a sealing layer over the second major composite layer surface. In one or more examples, the sealing layer comprises PET. In one or more examples, the sealing layer comprises a low permeability paint. In one or more examples, the sealing layer comprises foil. In one or more examples, the method further includes applying a coating over the edge composite layer surface. In one or more examples, the coating comprises a low permeability paint. In one or more examples, the acoustic building panel is a ceiling tile. In one or more examples, the acoustic building panel is a wall panel.

[0027] Also disclosed is a method for forming a shape stabilized phase change composite material.

[0028] In one example, the method includes mixing a phase change material with a liquid carrier in a heated environment to yield a liquid phase change material composition, mixing the liquid phase change material composition with a composite carrier to yield a shape stabilized phase change composite material, and cooling the shape stabilized phase change composite material to yield shape stabilized phase change composite material granules or any other shaped particles.

[0029] In one or more examples, the composite carrier is a powdered carrier comprising one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite. In one or more examples, the method further includes mixing a strength additive with the liquid phase change material composition and the composite carrier. In one or more examples, the strength additive comprises cement, siloxane or other polymeric resins. In one or more examples, the method further includes mixing a nucleating agent with the phase change material and liquid carrier. In one or more examples, the cooling comprises freezing the shape stabilized phase change material.

[0030] Further areas of applicability of the present disclosure will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred examples of the disclosure, are intended for purposes of illustration only and are not intended to limit the scope of the disclosure.

DESCRIPTION OF THE DRAWINGS

[0031] The detailed description of the disclosure will be better understood when read in conjunction with the appended drawings. It should be understood, however, that the disclosure is not limited to the precise arrangements and instrumentalities of the examples shown in the drawings.

[0032] Figure 1 is a top perspective view of an acoustic building panel according to an example of the present disclosure;

[0033] Figure 2 is a cross-sectional view of an acoustic building panel of the present disclosure;

[0034] Figure 3 is a cross-sectional view of an acoustic building panel of the present disclosure;

[0035] Figure 4 is a cross-sectional view of an acoustic building panel of the present disclosure;

[0036] Figure 5 is a top perspective view of a surface covering system according to an example of the present disclosure;

[0037] Figure 6 is a cross-sectional view of a surface covering system of the present disclosure;

[0038] Figure 7 is a cross-sectional view of a surface covering system of the present disclosure; and

[0039] Figure 8 is a ceiling system comprising the acoustic building panel of the present disclosure.

DETAILED DESCRIPTION

[0040] For illustrative purposes, the principles of the present disclosure are described by referencing various examples thereof. Although certain examples of the disclosure are specifically described herein, one of ordinary skill in the art will readily recognize that the same principles are equally applicable to, and can be employed in other applications and methods. It is to be understood that the disclosure is not limited in its application to the details of any particular example shown.

The terminology used herein is for the purpose of description and not to limit the disclosure, its application, or uses.

[0041] As used herein and in the appended claims, the singular forms "a", "an", and "the" include plural references unless the context dictates otherwise. The singular form of any class of the ingredients refers not only to one chemical species within that class, but also to a mixture of those chemical species. The terms "a" (or "an"), "one or more" and "at least one" may be used interchangeably herein. The terms "comprising", "including", "containing", and "having" may be used interchangeably. The term "include" should be interpreted as "include, but are not limited to". The term "including" should be interpreted as "including, but are not limited to".

[0042] As used throughout, ranges are used as shorthand for describing each and every value that is within the range. Any value within the range can be selected as the terminus of the range.

[0043] Unless otherwise specified, all percentages and amounts expressed herein and elsewhere in the specification should be understood to refer to percentages by weight of the total composition. Unless otherwise specified, reference to a molecule, or to molecules, being present at a "wt. %" refers to the amount of that molecule, or molecules, present in the composition based on the total weight of the composition. Unless otherwise specified, reference to a molecule, or to molecules, being present "based on the dry weight of the composition" refers to that molecule, or molecules, being present in the composition based on the total weight of the composition in a dry state. The "dry state" refers to solvent being present in the composition at an amount less than 5.0 wt. %, less than about 3.0 wt. %, less than about 1.0 wt. %; preferably less than about 0.5 wt. %, and more preferably less than about 0.25 wt. % of the composition. For example, a composition in the dry state may refer to a composition having about 95% solids, about 98% solids, preferably about 99% solids, or more preferably about 100% solids. By contrast, unless otherwise specified, reference to a molecule, or to molecules, being present "based on the wet weight of the composition" refers to that molecule, or molecules, being present in the composition based on the total weight of the composition which includes at least 5 wt. % of solvent.

[0044] According to the present application, use of the term "about" in conjunction with a numeral value refers to a value that may be +/- 5% of that numeral. As used herein, the term "substantially free" is intended to mean an amount less than about 5.0 wt. %, less than 3.0 wt. %, less than 1.0 wt. %; preferably less than about 0.5 wt. %, and more preferably less than about 0.25 wt. % of the composition.

[0045] Unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art to which this disclosure belongs. All patents, patent applications, publications, and other references cited or referred to herein are incorporated by reference in their entireties for all purposes. In the event of a conflict in a definition in the present disclosure and that of a cited reference, the present disclosure controls.

[0046] In the description of examples disclosed herein, any reference to direction or orientation is merely intended for convenience of description and is not intended in any way to limit the scope of the present disclosure. Relative terms such as "lower," "upper," "horizontal," "vertical,", "above," "below," "up," "down," "top" and "bottom" as well as derivatives thereof (e.g., "horizontally," "downwardly," "upwardly," etc.) should be construed to refer to the orientation as then described or as shown in the drawing (if applicable) under discussion. These relative terms are for convenience of description only and, unless specified otherwise, do not require that the apparatus be constructed or operated in a particular orientation.

[0047] As used herein, terms such as "attached," "affixed," "connected," "coupled," "interconnected," and the like refer to a relationship wherein structures are secured or attached to one another either directly or indirectly through intervening structures, as well as both movable or rigid attachments or relationships, unless expressly described otherwise. Accordingly, the disclosure is not limited to such examples illustrating certain combinations of features that may exist alone or in combination with other features.

[0048] The present disclosure relates to acoustic panels comprising phase change materials. A phase change material is a substance which releases/absorbs energy at phase transition to provide useful heating and/or cooling. Thus, incorporating a phase change material into a building panel (which may be used in a ceiling system, a wall system, a floor system, or the like) may render the building panel capable of assisting in heating or cooling an interior space. In some examples a phase change material may change from a solid to a liquid as it absorbs heat. In some examples, the phase change material may change from a liquid to a gas as it absorbs heat. In other examples, the phase transition may be between two non-classical states of matter, such as conformity of crystals, where the material goes from conforming to one crystalline structure to conforming to another crystalline structure, which may be a higher or lower energy state.

[0049] Phase change materials may be organic phase change materials such as hydrocarbons like paraffins and lipids and sugar alcohols. Phase change materials may be inorganic phase change materials such as salt hydrates. In some embodiments, the phase change material may comprise a salt hydrate material. An example of a phase change material is a salt hydrate phase change material comprising water mixed with calcium chloride and a nucleating agent. Non-limiting examples of appropriate nucleating agents include silica dust, quartz, or combinations thereof. Examples of other phase change materials are paraffin and other salt hydrates. However, other types of phase change material can also be used. Phase change materials may be solid-liquid phase change materials or solid to solid phase change materials. Other phase change materials now known or later discovered may be used.

[0050] Referring to Fig. 1, disclosed is an acoustic building panel 100 for storing thermal energy. The acoustic building panel 100 may be a ceiling panel or a wall panel. The acoustic building panel 100 includes a porous substrate 110 having a first major surface 112 and a second major surface 114 opposite the first major surface 112.

[0051] Referring to FIG. 8, the present disclosure may further include a ceiling system 1 comprising one or more of the acoustic building panels 100 installed in an interior space, whereby the interior space comprises a plenum space 3 and an active room environment 2. The plenum space 3 provides space for mechanical lines within a building (e.g., HVAC, plumbing, etc.). The active space 2 provides room for the building occupants during normal intended use of the building (e.g., in an office building, the active space would be occupied by offices containing computers, lamps, etc.).

[0052] In the installed state, the acoustic building panels 100 may be supported in the interior space by one or more parallel support struts 5. Each of the support struts 5 may comprise an inverted T-bar having a horizontal flange 31 and a vertical web 32. The ceiling system 1 may further comprise a plurality of first struts that are substantially parallel to each other and a plurality of second struts that are substantially perpendicular to the first struts (not pictured). In some embodiments, the plurality of second struts intersects the plurality of first struts to create an intersecting ceiling support grid 6. The plenum space 3 exists above the ceiling support grid 6 and the active room environment 2 exists below the ceiling support grid 6.

[0053] In the installed state, the first major surface 112 of the substrate 110 of the acoustic building panel 100 may face the active room environment 2 and the second major surface 114 of the substrate 110 of the acoustic building panel 100 may face the plenum space 3. The acoustic building panel 100 may be installed such that the horizontal flange 31 contacts the first major surface 112 of the substrate 110 of the building panel 100, thereby vertically supporting the acoustic building panel 100 in the ceiling system 1.

[0054] The substrate 110 of the acoustic building panel 100 may be comprised of any material having requisite material properties. In one example, the substrate 110 of the acoustic panel 100 is a porous matrix includes one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material. In another example, the acoustic building panel 100 is fire resistant such that it has a FSR rating of ASTM E84 Class A (FSI less than 25, SDI less than 50).

[0055] Referring to Fig. 2, the acoustic building panel 100 further includes a composite layer 130 over the second major surface of the substrate 114, the composite layer 130 having a first major composite layer surface 132 opposite a second major composite layer surface 134 and an edge composite layer surface 136 extending from the first major composite layer surface 132 to the second major composite layer surface 134. The composite layer 130 includes a composite carrier material and a phase change material infused into the composite carrier material.

[0056] Still referring to Fig. 2 and to Fig. 3, in one or more examples, the composite layer 130 comprises shape stabilized phase change material composite granules. In one or more examples, the composite layer 130 further comprises one or more of cement and siloxane. In another example, the composite carrier comprises one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

[0057] The composite layer 130 may be further characterized by its physical properties and dimensions. In one or more examples, the composite layer 130 has a thickness ranging from about 1mm to about 25 mm, from about 2mm to about 20mm, or from about 4mm to about 15 mm. In another example, the composite layer 130 stores at least 20 kJ/SF of thermal energy. In another example, the composite layer is activated at a temperature ranging from about 60 °F to about 80 °F.

[0058] The phase change material may be selected based upon its thermal properties and compatibility with the composite carrier material. In one or more examples, the phase change material comprises an inorganic salt hydrate. In another example, the phase change material comprises calcium chloride hexahydrate.

[0059] The phase change material composition may further include a surfactant, such as a wetting agent. In one example, the surfactant includes nonionic branched secondary alcohol ethoxylate surfactant.

[0060] The phase change material composition may further include a thickener. In one example, the thickener comprises nonionic water-soluble polymer. In another example, the thickener comprises hydroxyethylcellulose, PC Grade, for example cellulose, 2-hydroxyethyl ether. In one example, the thickener is added in an amount ranging from about 1 wt.% to about 3 wt. %, from about 1.5 wt.% to about 2.5 wt. %, or about 2 wt.%, based on the total weight of the composition.

[0061] The phase change material composition may further include a defoamer. In one example, the defoamer comprises emulsion of a polyether siloxane copolymer, contains fumed silica, and is solvent-free.

[0062] The phase change material may be present within the composite carrier such that it is stabilized from leaking out of the composite carrier. In one or more examples, the phase change material is dry infused into the composite carrier. In another example, the phase change material is vacuum infused into the composite carrier. In yet another example, the phase change material is impregnated within the composite carrier material.

[0063] The substrate may be characterized by its material and physical properties. In one or more examples, the substrate has a porosity ranging from about 70% to about 96%. In one or more examples, the substrate has a density ranging from about 5.0 lbs/ft^3 to about 30 lbs/ft^3.

[0064] Referring to Fig. 2, the acoustic building panel 100 further includes a film 120 positioned between the substrate 110 and the composite layer 130. In one or more examples, the film comprises a polymeric material. The film 120 is a barrier layer between the composite layer 130 and the substrate 110 such that it does not impact the acoustic properties of the substrate 110. In one or more examples, the film 120 comprises PET. In another example, the film 120 comprises a low permeability paint. The acoustic building panel 100 may further include an adhesive positioned between the film 120 and the substrate 110 to adhere the film 120 to the substrate 110.

[0065] Referring to Fig. 4, the acoustic building panel 100 further includes a sealing layer 150 positioned over the composite layer 130. The sealing layer 150 acts as a barrier to protect the composite layer 130 from separation from the substrate 110. In one or more examples, the sealing layer 150 comprises PET. In in another example, the sealing layer comprises a low permeability paint. In yet another example, the sealing layer comprises foil. The sealing layer 150 may have a thickness ranging from about 1 mil to about 25 mils.

[0066] Still referring to Fig. 4, in one or more examples, the acoustic building panel 100 further includes a coating 140 over the edge composite layer surface 136 of the composite layer 130. In one or more examples, the coating 140 comprises a low permeability paint. The coating 140 is selected to keep the composite layer 130 as applied to the substrate 110. The coating 140 may have a thickness ranging from about 1 mil to about 25 mils.

[0067] Referring to Figures 5, 6, and 7, also disclosed is a surface covering system 200 for storing thermal energy. The surface covering system 200 includes a plurality of acoustic building panels 205 configured to be positioned adjacent to each other to form a plurality of seams 215 between each of the plurality of building panels 205.

[0068] Referring to Fig. 6, in one or more examples, each acoustic building panel 205\` includes a substrate 210 having a first major surface 212 opposite a second major surface 214. Each acoustic building panel 205\` includes a composite layer 230 over the second major surface 214 of the substrate 210. The composite layer 230 has a first major composite layer surface 232 opposite a second major composite layer surface 234 and an edge composite layer surface 236 extending from the first major composite layer surface 232 to the second major composite layer surface 234. The composite layer 230 includes a composite carrier including a phase change material, such that the phase change material is infused into or impregnated within the composite carrier.

[0069] In one or more examples, the composite layer 230 comprises shape stabilized phase change material composite granules. The shape stabilized phase change material composite granules may be formed by dry infusion or vacuum infusion of the phase change material into the composite carrier so as to stabilize the phase change material within the composite carrier. The composite carrier includes one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

[0070] In one or more examples, the composite layer 230 further comprises cement for binding the materials of the composite layer together. In another example, the composite layer 230 further comprises siloxane.

[0071] The composite layer 230 may be present at any thickness needed for achieving desired thermal storage capacity for the given application. In one or more examples, the composite layer 230 has a thickness ranging from about 1mm to about 25 mm, from about 2mm to about 20mm, or from about 4mm to about 15 mm. the composite layer 230 may be further characterized by its material properties. In one or more examples, the composite layer 230 stores at least 20 kJ/SF of thermal energy. In another example, the composite layer 230 is activated at a temperature ranging from about 60 °F to about 80 °F.

[0072] The phase change material may be selected based upon its thermal properties and compatibility with the composite carrier material. In another example, the phase change material comprises an inorganic salt hydrate. In yet another example, the phase change material comprises calcium chloride hexahydrate.

[0073] The phase change material composition may further include a surfactant, such as a wetting agent. In one example, the surfactant includes nonionic branched secondary alcohol ethoxylate surfactant.

[0074] The phase change material composition may further include a thickener. In one example, the thickener comprises nonionic water-soluble polymer. In another example, the thickener comprises hydroxyethylcellulose, PC Grade, for example cellulose, 2-hydroxyethyl ether. In one example, the thickener is added in an amount ranging from about 1 wt.% to about 3 wt. %, from about 1.5 wt.% to about 2.5 wt. %, or about 2 wt.%, based on the total weight of the composition.

[0075] The phase change material composition may further include a defoamer. In one example, the defoamer comprises emulsion of a polyether siloxane copolymer, contains fumed silica, and is solvent-free.

[0076] The phase change material may be present within the composite carrier such that it is stabilized from leaking out of the composite carrier. In one example, the phase change material is dry infused into the composite carrier. In another example, the phase change material is vacuum infused into the composite carrier. In yet another example, the phase change material is impregnated within the composite carrier.

[0077] Each substrate 210 may be comprised of any standard acoustic building material. In one or more examples, the substrate 210 comprises one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material. The substrate 210 may be further characterized by its physical and material properties. In one or more examples, the substrate 210 has a porosity ranging from about 70% to about 96%. In another example, the substrate 210 has a density ranging from about 5.0 lbs/ft^3 to about 30 lbs/ft^3.

[0078] Referring to Fig. 6 and 7, in one or more examples, the surface covering system 200 further includes a film 220 positioned between the substrate 210 and the composite layer 230. In one or more examples, the film comprises a polymeric material. In another example, the film 220 comprises PET. In yet another example, the film 230 comprises a low permeability paint. The surface covering system 200 further includes an adhesive positioned between each film 220 and substrate 210 of the plurality of building panel 205.

[0079] Referring to Fig. 7, in one or more examples, the surface covering system 200 further includes a sealing layer 250 positioned over the composite layer 230. In one or more examples, the sealing layer comprises PET. In another example, the sealing layer comprises a low permeability paint. In yet another example, the sealing layer comprises foil.

[0080] Still referring to Fig. 7, in one or more examples, the surface covering system 200 further includes a coating 240 over the edge composite layer surface. In one or more examples, the coating 240 comprises a low permeability paint.

[0081] Also disclosed is a method for forming an acoustic building panel 100 for storing thermal energy, such as a ceiling tile or a wall panel. In one example, the method includes providing a substrate 110 having a first major surface 112 opposite a second major surface 114.

[0082] The method further includes applying a shape stabilized phase change composite material to the second major surface 114 of the substrate 110. In one example, the phase change composite material includes shape stabilized phase change material composite granules.

[0083] The method further includes consolidating the shape stabilized phase change composite material to form a composite layer 130 having a first major composite layer surface 132 opposite a second major composite layer surface 134 and an edge composite layer surface 136 extending from the first major composite layer surface 132 to the second major composite layer surface 132.

[0084] In one or more examples, the composite layer 130 further comprises cement for binding the shape stabilized phase change material composite granules to form the composite layer 130. In another example, the composite layer 130 further comprises siloxane, or other polymer resin binders including acrylic, polyester, polyvinyl acetate, urethane, alkyd, etc. In yet another example, the composite layer 130 comprises one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

[0085] In one or more examples, the composite layer has a thickness ranging from about 1mm to about 25 mm, from about 2mm to about 20mm, or from about 4mm to about 15 mm. In another example, the composite layer stores at least 20 kJ/SF of thermal energy. In yet another example, the composite layer is activated at a temperature ranging from about 60 °F to about 80 °F.

[0086] In one or more examples, the composite layer 130 formed by the method comprises an inorganic salt hydrate. In another example, the composite layer comprises calcium chloride hexahydrate.

[0087] The substrate 130 of the method may be comprised of any standard acoustic building materials. In one or more examples, the substrate comprises one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material. The substrate may be further characterized by its physical properties. In one example, the substrate has a porosity ranging from about 70% to about 96%. In another example, the substrate has a density ranging from about 5.0 lbs/ft^3 to about 30.0 lbs/ft^3.

[0088] In one or more examples, the method further includes mixing a phase change material with a liquid carrier in a heated environment to yield a liquid phase change material composition. In one or more examples, the mixing comprises dry infusing the phase change material into the composite carrier. In another example, the mixing comprises vacuum infusing the phase change material into the composite carrier.

[0089] The method further includes mixing the liquid phase change material composition with a composite carrier to yield a shape stabilized phase change composite material. In one example, the mixing is performed in a pin mixer.

[0090] The method further includes cooling the shape stabilized phase change composite material to yield shape stabilized phase change composite material granules prior to applying to the substrate. In one example, the cooling includes freezing such that the shape stabilized phase change composite material granules are frozen.

[0091] In one or more examples, the method further includes applying a film 120 to the second major surface 114 prior to applying the shape stabilized phase change composite material to the second major surface 114. In one or more examples, the film 120 comprises a polymeric material. In another example, the film 120 comprises PET. In yet another example, the film 120 comprises a low permeability paint.

[0092] In one or more examples, the method further includes applying a sealing layer 150 over the second major composite layer surface 134 of the composite later 130. In one or more examples, the sealing layer 150 comprises PET. In another example, the sealing layer 150 comprises a low permeability paint. In yet another example, the sealing layer 150 comprises foil.

[0093] In one or more examples, the method further includes applying a coating 140 over the edge composite layer surface 136. In one example, the coating 140 comprises a low permeability paint.

[0094] Also disclosed is a method for forming a shape stabilized phase change composite material. The shape stabilized phase change material is designed for incorporation into building panels 205, such as acoustic ceiling and wall panels to prevent the phase change material from leaking out of the building panels 205.

[0095] In one example, the method includes mixing a phase change material with a liquid carrier in a heated environment to yield a liquid phase change material composition. The heated environment may be at a temperature ranging from about 60 °F to about 80 °F.

[0096] In one or more examples, the method includes mixing the liquid phase change material composition with a composite carrier to yield a shape stabilized phase change composite material. In one example, the mixing is performed in a pin mixer.

[0097] In one or more examples, the method includes cooling the shape stabilized phase change composite material to yield shape stabilized phase change composite material granules. In one example, the cooling is performed at a temperature ranging from about 60 °F to about 80 °F. In another example, the cooling comprises freezing the shape stabilized phase change composite material to yield shape stabilized phase change composite material granules that are frozen.

[0098] In one or more examples, the composite carrier is a powdered carrier comprising one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite. In another example, the phase change material is a liquid selected from inorganic salt hydrate and calcium chloride hexahydrate.

[0099] The method may further include mixing a strength additive with the liquid phase change material composition and the composite carrier. In one or more examples, the strength additive comprises cement or siloxane, or other polymer resin binders including acrylic, polyester, polyvinyl acetate, urethane, alkyd, etc. In another example, the method further includes mixing a nucleating agent with the phase change material and liquid carrier.

[0100] The method may further include mixing a surfactant, such as a wetting agent, with the liquid phase change material composition and the composite carrier. In one example, the surfactant includes nonionic branched secondary alcohol ethoxylate surfactant.

[0101] The method may further include mixing a thickener with the liquid phase change material composition and the composite carrier. In one example, the thickener comprises nonionic water-soluble polymer. In another example, the thickener comprises hydroxyethylcellulose, PC Grade, for example cellulose, 2-hydroxyethyl ether. In one example, the thickener is added in an amount ranging from about 1 wt.% to about 3 wt. %, from about 1.5 wt.% to about 2.5 wt. %, or about 2 wt.%, based on the total weight of the composition.

[0102] The method may further include mixing a defoamer with the liquid phase change material composition and the composite carrier. In one example, the defoamer comprises emulsion of a polyether siloxane copolymer, contains fumed silica, and is solvent-free.

[0103] The disclosure may be characterized by the following clauses.

[0104] Clause 1. An acoustic building panel comprising: a substrate having a first major surface opposite a second major surface; and a composite layer over the second major surface of the substrate, the composite layer having a first major composite layer surface opposite a second major composite layer surface and an edge composite layer surface extending from the first major composite layer surface to the second major composite layer surface, the composite layer comprising: a composite carrier; and a phase change material infused into the composite carrier.

[0105] Clause 2. The acoustic building panel according to clause 1, wherein the composite layer comprises shape stabilized phase change material composite granules.

[0106] Clause 3. The acoustic building panel according to any one of clauses 1 or 2, wherein the composite layer further comprises cement.

[0107] Clause 4. The acoustic building panel according to any one of clauses 1 to 3, wherein the composite layer further comprises siloxane.

[0108] Clause 5. The acoustic building panel according to any one of clauses 1 to 4, wherein the composite layer has a thickness ranging from about 1mm to about 25 mm, from about 2mm to about 20mm, or from about 4mm to about 15 mm.

[0109] Clause 6. The acoustic building panel according to any one of clauses 1 to 5, wherein the composite layer stores at least 20 kJ/SF of thermal energy.

[0110] Clause 7. The acoustic building panel according to any one of clauses 1 to 6, wherein the composite layer is activated at a temperature ranging from about 60 °F to about 80 °F.

[0111] Clause 8. The acoustic building panel according to any one of clauses 1 to 7, wherein the composite carrier comprises one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

[0112] Clause 9. The acoustic building panel according to any one of clauses 1 to 8, wherein the phase change material comprises an inorganic salt hydrate.

[0113] Clause 10. The acoustic building panel according to any one of clauses 1 to 9, wherein the phase change material comprises calcium chloride hexahydrate.

[0114] Clause 11. The acoustic building panel according to any one of clauses 1 to 10, wherein the phase change material is dry infused into the composite carrier.

[0115] Clause 12. The acoustic building panel according to any one of clauses 1 to 11, wherein the phase change material is vacuum infused into the composite carrier.

[0116] Clause 13. The acoustic building panel according to any one of clauses 1 to 12, wherein the substrate comprises one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material.

[0117] Clause 14. The acoustic building panel according to any one of clauses 1 to 13, wherein the substrate has a porosity ranging from about 70% to about 96%.

[0118] Clause 15. The acoustic building panel according to any one of clauses 1 to 14, wherein the substrate has a density ranging from about 5.0 lbs/ft3 to about 30.0 lbs/ft3.

[0119] Clause 16. The acoustic building panel according to any one of clauses 1 to 15, further comprising a film positioned between the substrate and the composite layer.

[0120] Clause 17. The acoustic building panel according to clause 16, wherein the film comprises a polymeric material.

[0121] Clause 18. The acoustic building panel according to clause 16, wherein the film comprises PET.

[0122] Clause 19. The acoustic building panel according to clause 16, wherein the film comprises a low permeability paint.

[0123] Clause 20. The acoustic building panel according to any one of clauses 1 to 19, further comprising an adhesive positioned between the film and the substrate.

[0124] Clause 21. The acoustic building panel according to any one of clauses 1 to 20, further comprising a sealing layer positioned over the composite layer.

[0125] Clause 22. The acoustic building panel according to clause 21, wherein the sealing layer comprises PET.

[0126] Clause 23. The acoustic building panel according to clause 21, wherein the sealing layer comprises a low permeability paint.

[0127] Clause 24. The acoustic building panel according to clause 21, wherein the sealing layer comprises foil.

[0128] Clause 25. The acoustic building panel according to any one of clauses 1 to 24, further comprising a coating over the edge composite layer surface.

[0129] Clause 26. The acoustic building panel according to clause 25, wherein the coating comprises a low permeability paint.

[0130] Clause 27. A ceiling tile comprising the acoustic building panel according to any one of clauses 1 to 26.

[0131] 28. A wall panel comprising the acoustic building panel according to any one of clauses 1 to 26.

[0132] Clause 29. A surface covering system for storing thermal energy comprising: a plurality of acoustic building panels configured to be positioned adjacent to each other to form a plurality of seams between each of the plurality of building panels, each acoustic building panel comprising: a substrate having a first major surface opposite a second major surface; and a composite layer over the second major surface of the substrate, the composite layer having a first major composite layer surface opposite a second major composite layer surface and an edge composite layer surface extending from the first major composite layer surface to the second major composite layer surface, the composite layer comprising: a composite carrier; and a phase change material infused into the composite carrier.

[0133] Clause 30. The surface covering system according to clause 29, wherein the composite layer comprises shape stabilized phase change material composite granules.

[0134] Clause 31. The surface covering system according to any one of clauses 29 or 30, wherein the composite layer further comprises cement.

[0135] Clause 32. The surface covering system according to any one of clauses 29 to 31, wherein the composite layer further comprises siloxane.

[0136] Clause 33. The surface covering system according to any one of clauses 29 to 32, wherein the composite layer has a thickness ranging from about 1mm to about 25mm, from about 2mm to about 4mm, or from about 2.5mm to about 3.5mm.

[0137] Clause 34. The surface covering system according to any one of clauses 29 to 33, wherein the composite layer stores at least 20 kJ/SF of thermal energy.

[0138] Clause 35. The surface covering system according to any one of clauses 29 to 34, wherein the composite layer is activated at a temperature ranging from about 60 °F to about 80 °F.

[0139] Clause 36. The surface covering system according to any one of clauses 29 to 35, wherein the composite carrier comprises one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

[0140] Clause 37. The surface covering system according to any one of clauses 29 to 36, wherein the phase change material comprises an inorganic salt hydrate.

[0141] Clause 38. The surface covering system according to any one of clauses 29 to 37, wherein the phase change material comprises calcium chloride hexahydrate.

[0142] Clause 39. The surface covering system according to any one of clauses 29 to 38, wherein the phase change material is dry infused into the composite carrier.

[0143] Clause 40. The surface covering system according to any one of clauses 29 to 39, wherein the phase change material is vacuum infused into the composite carrier.

[0144] Clause 41. The surface covering system according to any one of clauses 29 to 40, wherein the substrate comprises one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material.

[0145] Clause 42. The surface covering system according to any one of clauses 29 to 41, wherein the substrate has a porosity ranging from about 70% to about 96%.

[0146] Clause 43. The surface covering system according to any one of clauses 29 to 42, wherein the substrate has a density ranging from about 5.0 lbs/ft3 to about 30.0 lbs/ft3.

[0147] Clause 44. The surface covering system according to any one of clauses 29 to 43, further comprising a film positioned between the substrate and the composite layer.

[0148] Clause 45. The surface covering system according to clause 44, wherein the film comprises a polymeric material.

[0149] Clause 46. The surface covering system according to clause 44, wherein the film comprises PET.

[0150] Clause 47. The surface covering system according to clause 44, wherein the film comprises a low permeability paint.

[0151] Clause 48. The surface covering system according to any one of clauses 29 to 47, further comprising an adhesive positioned between the film and the substrate.

[0152] Clause 49. The surface covering system according to any one of clauses 28 to 48, further comprising a sealing layer positioned over the composite layer.

[0153] Clause 50. The surface covering system according to clause 49, wherein the sealing layer comprises PET.

[0154] Clause 51. The surface covering system according to clause 49, wherein the sealing layer comprises a low permeability paint.

[0155] Clause 52. The surface covering system according to clause 49, wherein the sealing layer comprises foil.

[0156] Clause 53. The surface covering system according to any one of clauses 29 to 52, comprising a coating over the edge composite layer surface.

[0157] Clause 54. The surface covering system according to clause 53, wherein the coating comprises a low permeability paint.

[0158] Clause 55. A method for forming an acoustic building panel comprising: providing a substrate having a first major surface opposite a second major surface; applying a shape stabilized phase change composite material to the second major surface of the substrate; and consolidating the shape stabilized phase change composite material to form a composite layer having a first major composite layer surface opposite a second major composite layer surface and an edge composite layer surface extending from the first major composite layer surface to the second major composite layer surface.

[0159] Clause 56. The method according to clause 55, wherein the composite layer comprises shape stabilized phase change material composite granules.

[0160] Clause 57. The method according to any one of clauses 55 or 56, wherein the composite layer further comprises cement.

[0161] Clause 58. The method according to any one of clauses 55 to 57, wherein the composite layer further comprises siloxane.

[0162] Clause 59. The method according to any one of clauses 55 to 58, wherein the composite layer has a thickness ranging from about 1mm to about 25 mm, from about 2mm to about 20mm, or from about 4mm to about 15 mm.

[0163] Clause 60. The method according to any one of clauses 55 to 59, wherein the composite layer stores at least 20 kJ/SF of thermal energy.

[0164] Clause 61. The method according to any one of clauses 55 to 60, wherein the composite layer is activated at a temperature ranging from about 60 °F to about 80 °F.

[0165] Clause 62. The method according to any one of clauses 55 to 61, wherein the composite layer comprises one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

[0166] Clause 63. The method according to any one of clauses 55 to 62, wherein the composite layer comprises an inorganic salt hydrate.

[0167] Clause 64. The method according to any one of clauses 55 to 63, wherein the composite layer comprises calcium chloride hexahydrate.

[0168] Clause 65. The method according to any one of clauses 55 to 64, wherein the substrate comprises one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material.

[0169] Clause 66. The method according to any one of clauses 55 to 65, wherein the substrate has a porosity ranging from about 70% to about 96%.

[0170] Clause 67. The method according to any one of clauses 55 to 66, wherein the substrate has a density ranging from about 5.0 lbs/ft3 to about 30.0 lbs/ft3.

[0171] Clause 68. The method according to any one of clauses 55 to 67, further comprising:

[0172] mixing a phase change material with a liquid carrier in a heated environment to yield a liquid phase change material composition; mixing the liquid phase change material composition with a composite carrier to yield a shape stabilized phase change composite material; and cooling the shape stabilized phase change composite material to yield shape stabilized phase change composite material granules prior to applying to the substrate.

[0173] Clause 69. The method according to clause 68, wherein the mixing comprises dry infusing the phase change material into the composite carrier.

[0174] Clause 70. The method according to any one of clauses 68 or 69, wherein the mixing comprises vacuum infusing the phase change material into the composite carrier.

[0175] Clause 71. The method according to any one of clauses 55 to 70, further comprising applying a film to the second major surface prior to applying the shape stabilized phase change composite material to the second major surface.

[0176] Clause 72. The method according to clause 71, wherein the film comprises a polymeric material.

[0177] Clause 73. The method according to clause 71, wherein the film comprises PET.

[0178] Clause 74. The method according to clause 71, wherein the film comprises a low permeability paint.

[0179] Clause 75. The method according to any one of clauses 55 to 74, further comprising applying a sealing layer over the second major composite layer surface.

[0180] Clause 76. The method according to clause 75, wherein the sealing layer comprises PET.

[0181] Clause 77. The method according to clause 75, wherein the sealing layer comprises a low permeability paint.

[0182] Clause 78. The method according to clause 75, wherein the sealing layer comprises foil.

[0183] Clause 79. The method according to any one of clauses 55 to 78, further comprising applying a coating over the edge composite layer surface.

[0184] Clause 80. The method according to clause 79, wherein the coating comprises a low permeability paint.

[0185] Clause 81. The method according to any one of clauses 55 to 80, wherein the acoustic building panel is a ceiling tile.

[0186] Clause 82. The method according to any one of clauses 55 to 81, wherein the acoustic building panel is a wall panel.

[0187] Clause 83. A method for forming a shape stabilized phase change composite material comprising:

[0188] mixing a phase change material with a liquid carrier in a heated environment to yield a liquid phase change material composition;

[0189] mixing the liquid phase change material composition with a composite carrier to yield a shape stabilized phase change composite material; and

[0190] cooling the shape stabilized phase change composite material to yield shape stabilized phase change composite material granules.

[0191] Clause 84. The method according to clause 83, wherein the composite carrier is a powdered carrier comprising one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

[0192] Clause 85. The method according to any one of clauses 83 or 84, further comprising mixing a strength additive with the liquid phase change material composition and the composite carrier.

[0193] Clause 86. The method according to clause 85, wherein the strength additive comprises cement or siloxane, or other polymer resin binders including acrylic, polyester, polyvinyl acetate, urethane, alkyd, etc.

[0194] Clause 87. The method according to any one of clauses 83 to 86, further comprising mixing a nucleating agent with the phase change material and liquid carrier.

[0195] Clause 88. The method according to any one of clauses 83 to 87, wherein the cooling comprises freezing the shape stabilized phase change composite material to yield shape stabilized phase change composite material granules.

[0196] Examples

[0197] The examples and other implementations described herein are exemplary and not intended to be limiting in describing the full scope of compositions and methods of this disclosure. Equivalent changes, modifications and variations of specific implementations, materials, compositions, and methods may be made within the scope of the present disclosure, with substantially similar results.

TABLE 1

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
PCM (g)	500	500	500	500	500
Defoamer (g)	0	5	5	5	5
Surfactant (g)	0	5	5	5	5
Thickener (g)	0	5	10	15	25
pH	5.38	5.64	6.02	6.02	6.1
Thickener %	0.00%	1.00%	1.90%	2.90%	4.70%

[0198] The samples in Table 1 were tested for moisture stability over a period of time as well as gel viscosity over time with thermal cycling. The thickener used in these Samples included hydroxyethylcellulose, PC Grade, or cellulose, 2-hydroxyethyl ether. The surfactant used included nonionic branched secondary alcohol ethoxylate surfactant.

TABLE 2

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
1 Day	1.1%	1.1%	1.1%	-0.1%	1.0%
9 Days	11.3%	10.6%	9.8%	8.5%	9.8%

15 Days	17.3%	16.1%	14.8%	13.8%	14.9%
27 Days	25.2%	23.4%	22.9%	21.3%	22.4%

[0199] Table 2 provides moisture stability of the various samples over 1 day, 9 days, 15 days, and 27 days. As shown, adding a thickener to the PCM composition yielded a reduction in amount of moisture over time as compared to Sample 1 with no thickener. Specifically, it was surprisingly found that adding a thickener between about 1 wt. % to about 3 wt.% advantageously reduced the amount of moisture absorbed over time.

[0200] While the present disclosure has been described with reference to several examples, which examples have been set forth in considerable detail for the purposes of making a complete disclosure of the disclosure, such examples are merely representative and are not intended to be limiting or represent an exhaustive enumeration of all aspects of the disclosure. The scope of the disclosure is to be determined from the claims appended hereto. Further, it will be apparent to those of skill in the art that numerous changes may be made in such details without departing from the spirit and the principles of the disclosure.

CLAIMS

What is Claimed Is:

1. An acoustic building panel comprising:

a substrate having a first major surface opposite a second major surface; and

a composite layer over the second major surface of the substrate, the composite layer having a first major composite layer surface opposite a second major composite layer surface and an edge composite layer surface extending from the first major composite layer surface to the second major composite layer surface, the composite layer comprising:

a composite carrier; and

a phase change material infused into the composite carrier.

2. The acoustic building panel according to claim 1, wherein the composite layer comprises shape stabilized phase change material composite granules.

3. The acoustic building panel according to any one of claims 1 or 2, wherein the composite layer further comprises cement.

4. The acoustic building panel according to any one of claims 1 to 3, wherein the composite layer further comprises siloxane.

5. The acoustic building panel according to any one of claims 1 to 4, wherein the composite layer has a thickness ranging from about 1mm to about 25 mm, from about 2mm to about 20mm, or from about 4mm to about 15 mm.

6. The acoustic building panel according to any one of claims 1 to 5, wherein the composite carrier comprises one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

7. The acoustic building panel according to any one of claims 1 to 6, wherein the phase change material comprises an inorganic salt hydrate, or wherein the phase change material comprises calcium chloride hexahydrate.

8. The acoustic building panel according to any one of claims 1 to 7, wherein the phase change material is dry infused into the composite carrier, or wherein the phase change material is vacuum infused into the composite carrier.

9. The acoustic building panel according to any one of claims 1 to 8, further comprising a film positioned between the substrate and the composite layer, wherein the film comprises a polymeric material, or wherein the film comprises PET or a low permeability paint.

10. The acoustic building panel according to any one of claims 1 to 9, further comprising a sealing layer positioned over the composite layer, and wherein the sealing layer comprises PET, a low permeability paint, or foil.

11. The acoustic building panel according to any one of claims 1 to 10, further comprising a coating over the edge composite layer surface, wherein the coating comprises a low permeability paint.

12. A ceiling tile comprising the acoustic building panel according to any one of claims 1 to 11.

13. A wall panel comprising the acoustic building panel according to any one of claims 1 to 11.

14. A surface covering system for storing thermal energy comprising:

a plurality of acoustic building panels configured to be positioned adjacent to each other to form a plurality of seams between each of the plurality of building panels, each acoustic building panel comprising:

a substrate having a first major surface opposite a second major surface; and a composite layer over the second major surface of the substrate, the composite layer having a first major composite layer surface opposite a second major composite layer surface and an edge composite layer surface extending from the first major composite layer surface to the second major composite layer surface, the composite layer comprising:

a composite carrier; and

a phase change material infused into the composite carrier.

15. The surface covering system according to claim 14, wherein the composite layer comprises shape stabilized phase change material composite granules.

16. The surface covering system according to any one of claims 15 or 15, wherein the composite layer further comprises cement.

17. The surface covering system according to any one of claims 14 to 16, wherein the composite layer further comprises siloxane.

18. The surface covering system according to any one of claims 14 to 17, wherein the composite layer has a thickness ranging from about 1mm to about 25mm, from about 2mm to about 4mm, or from about 2.5mm to about 3.5mm.

19. The surface covering system according to any one of claims 14 to 18, wherein the composite carrier comprises one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

20. The surface covering system according to any one of claims 14 to 19, wherein the phase change material comprises an inorganic salt hydrate, or wherein the phase change material comprises calcium chloride hexahydrate.

21. The surface covering system according to any one of claims 14 to 20, wherein the phase change material is dry infused into the composite carrier, or wherein the phase change material is vacuum infused into the composite carrier.

22. The surface covering system according to any one of claims 14 to 21, further comprising a film positioned between the substrate and the composite layer.

23. The surface covering system according to claim 22, wherein the film comprises a polymeric material, PET, or a low permeability paint.

24. The surface covering system according to any one of claims 14 to 23, further comprising a sealing layer positioned over the composite layer, and wherein the sealing layer comprises PET, a low permeability paint, or foil.

25. The surface covering system according to any one of claims 14 to 24, comprising a coating over the edge composite layer surface, wherein the coating comprises a low permeability paint.

26. A method for forming an acoustic building panel comprising:

providing a substrate having a first major surface opposite a second major surface;

applying a shape stabilized phase change composite material to the second major surface of the substrate; and

consolidating the shape stabilized phase change composite material to form a composite layer having a first major composite layer surface opposite a second major composite layer surface and an edge composite layer surface extending from the first major composite layer surface to the second major composite layer surface.

27. The method according to claim 26, wherein the composite layer comprises shape stabilized phase change material composite granules.

28. The method according to any one of claims 26 or 27, wherein the composite layer further comprises cement.

29. The method according to any one of claims 26 to 28, wherein the composite layer further comprises siloxane.

30. The method according to any one of claims 26 to 29, wherein the composite layer has a thickness ranging from about 1mm to about 25 mm, from about 2mm to about 20mm, or from about 4mm to about 15 mm.

31. The method according to any one of claims 26 to 30, wherein the composite layer comprises one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

32. The method according to any one of claims 26 to 31, wherein the composite layer comprises an inorganic salt hydrate.

33. The method according to any one of claims 26 to 32, wherein the composite layer comprises calcium chloride hexahydrate.

34. The method according to any one of claims 26 to 33, further comprising:

mixing a phase change material with a liquid carrier and a thickener in a heated environment to yield a liquid phase change material composition;

mixing the liquid phase change material composition with a composite carrier to yield a shape stabilized phase change composite material; and

cooling the shape stabilized phase change composite material to yield shape stabilized phase change composite material granules prior to applying to the substrate.

35. The method according to claim 34, wherein the mixing comprises dry infusing the phase change material into the composite carrier, or wherein the mixing comprises vacuum infusing the phase change material into the composite carrier.

36. The method according to any one of claims 34 to 35, further comprising applying a film to the second major surface prior to applying the shape stabilized phase change composite material to the second major surface, wherein the film comprises a polymeric material, PET, or a low permeability paint.

37. The method according to any one of claims 34 to 36, further comprising applying a sealing layer over the second major composite layer surface, wherein the sealing layer comprises PET, a low permeability paint, or foil.

38. The method according to any one of claims 34 to 37, further comprising applying a coating over the edge composite layer surface, wherein the coating comprises a low permeability paint.

39. The method according to any one of claims 34 to 38, wherein the acoustic building panel is a ceiling tile or a wall panel.

40. A method for forming a shape stabilized phase change composite material comprising:

mixing a phase change material with a liquid carrier in a heated environment to yield a liquid phase change material composition;

mixing the liquid phase change material composition with a composite carrier to yield a shape stabilized phase change composite material; and

cooling the shape stabilized phase change composite material to yield shape stabilized phase change composite material granules.

41. The method according to claim 40, wherein the composite carrier is a powdered carrier comprising one or more of perlite, diatomaceous earth, clay, biochar, and expanded graphite.

42. The method according to any one of claims 40 or 41, further comprising mixing a strength additive with the liquid phase change material composition and the composite carrier.

43. The method according to claim 42, wherein the strength additive comprises cement or siloxane, or other polymer resin binders including acrylic, polyester, polyvinyl acetate, urethane, alkyd, etc.

44. The method according to any one of claims 40 to 43, further comprising mixing a nucleating agent with the phase change material and liquid carrier.

45. The method according to any one of claims 40 to 44, further comprising mixing a thickener with the phase change material and liquid carrier.

46. The method according to any one of claims 40 to 45, further comprising mixing a surfactant with the phase change material and liquid carrier.

47. The method according to any one of claims 40 to 46, wherein the cooling comprises freezing the shape stabilized phase change composite material to yield shape stabilized phase change composite material granules.

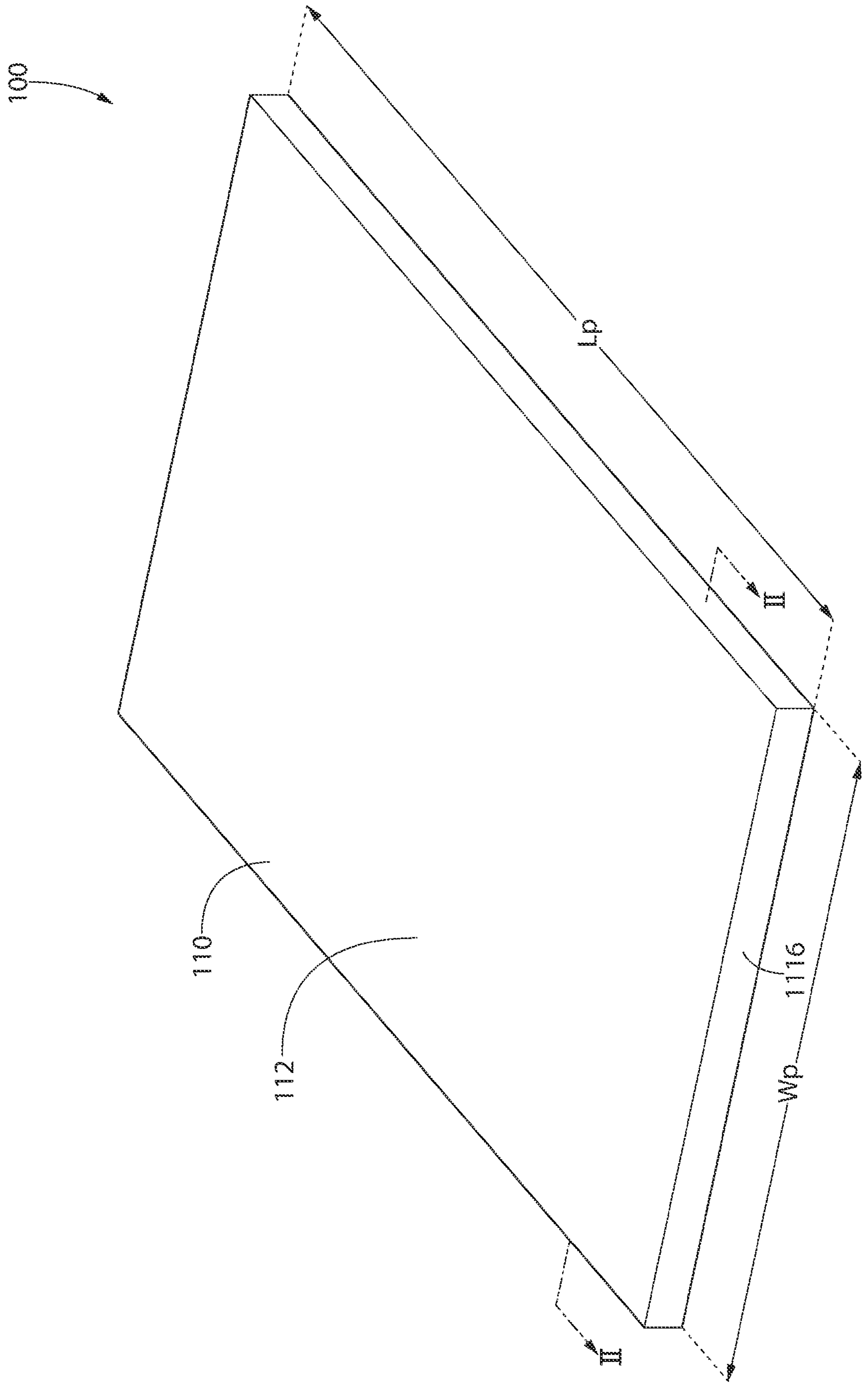


FIG. 1

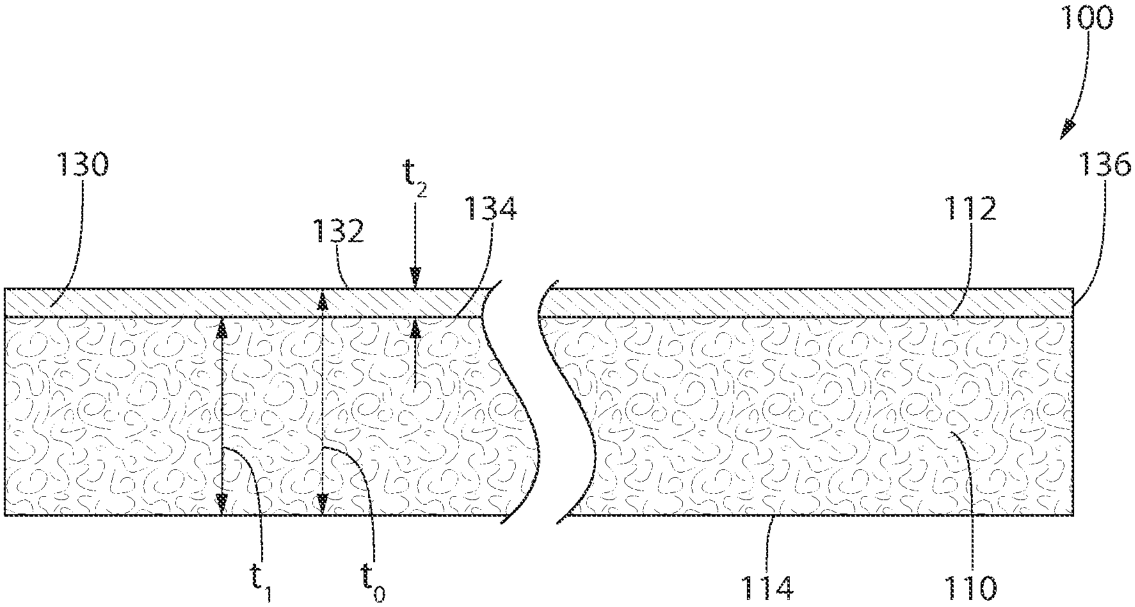
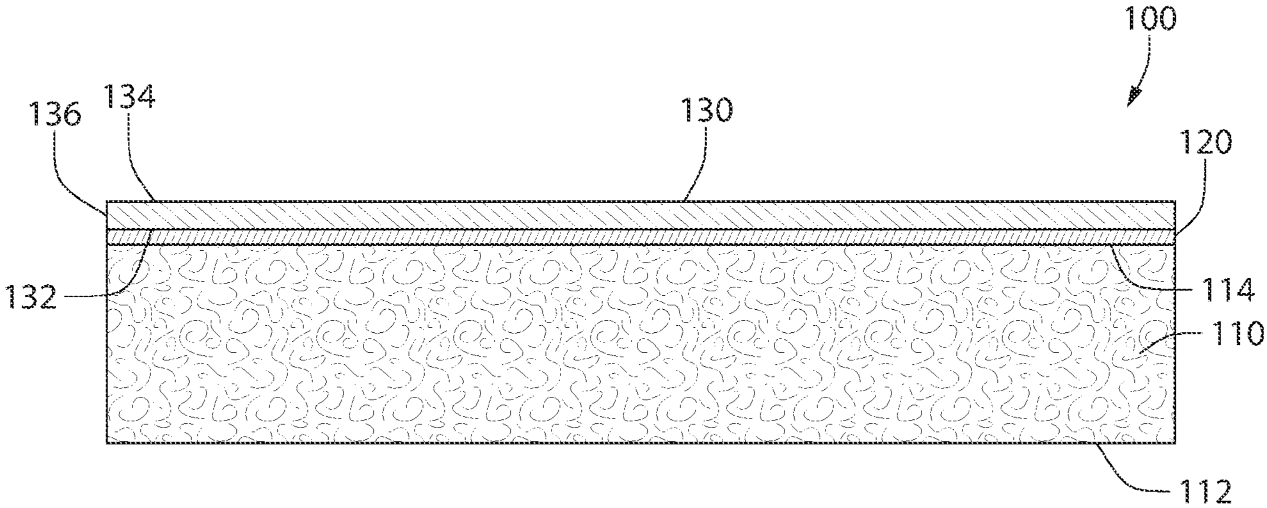


FIG. 2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110
112

FIG. 3

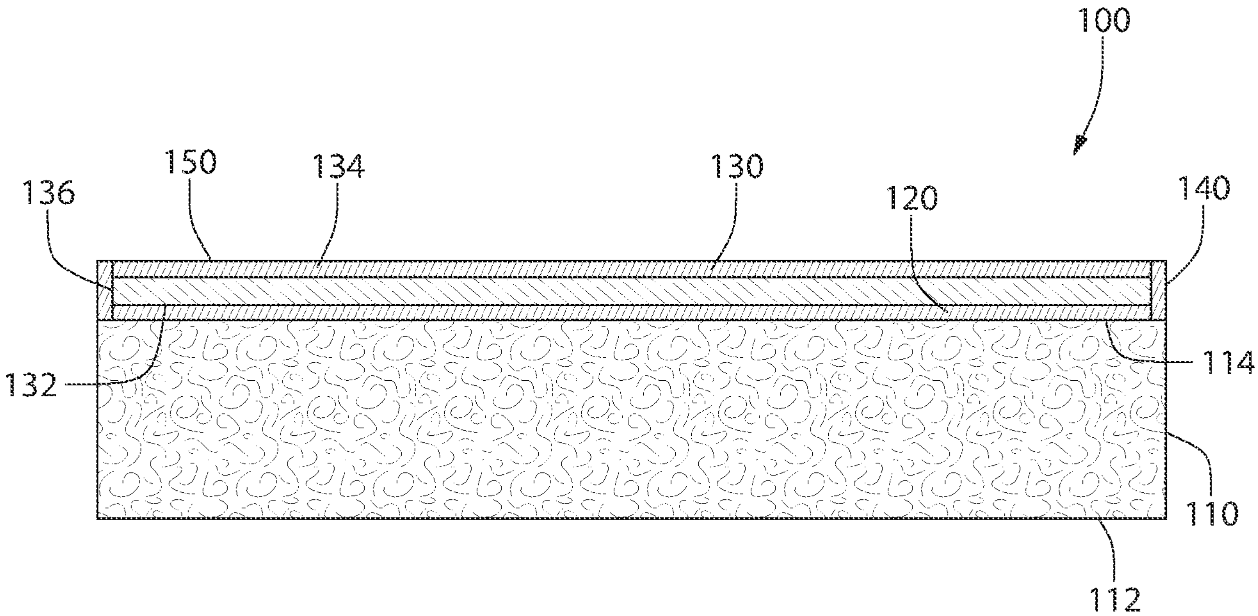
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FIG. 4

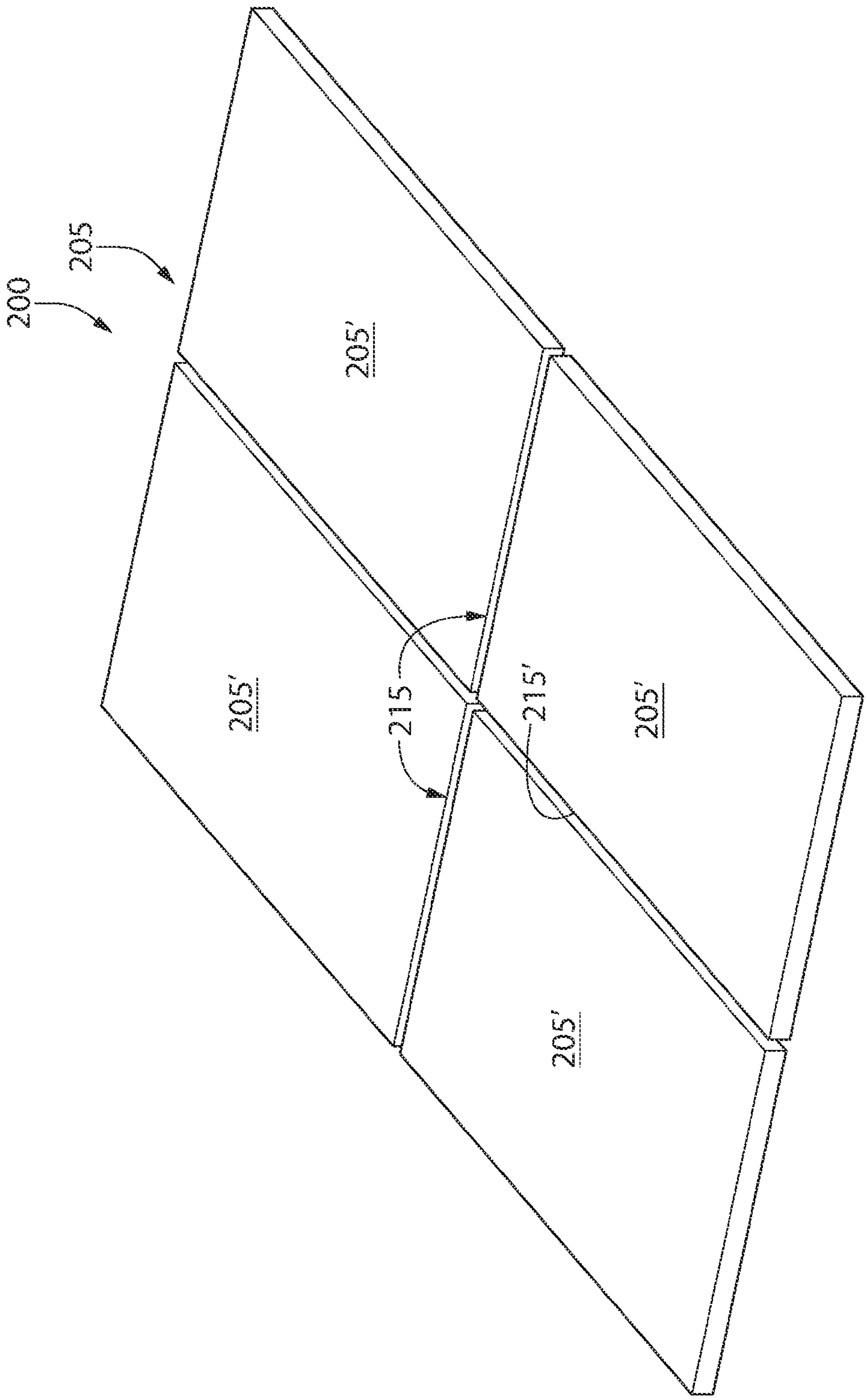

FIG. 5

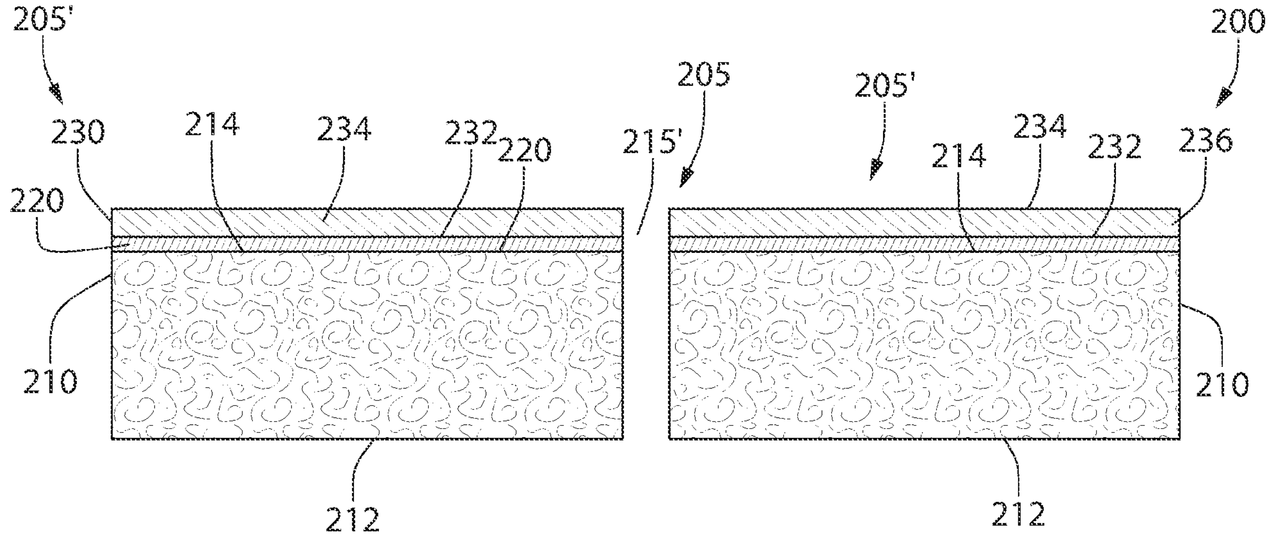
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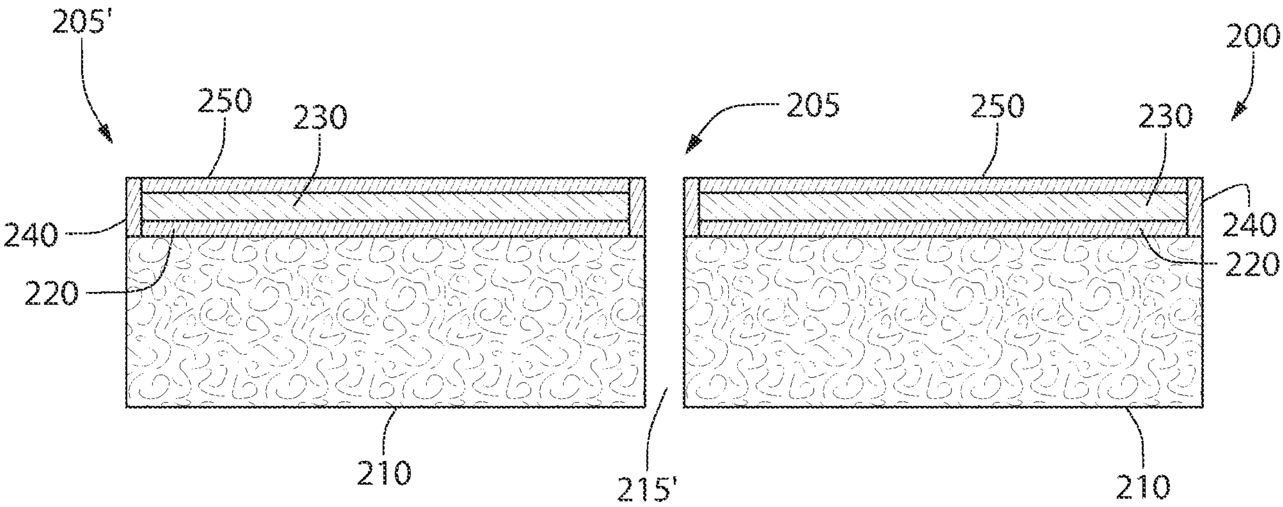
FIG. 6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220
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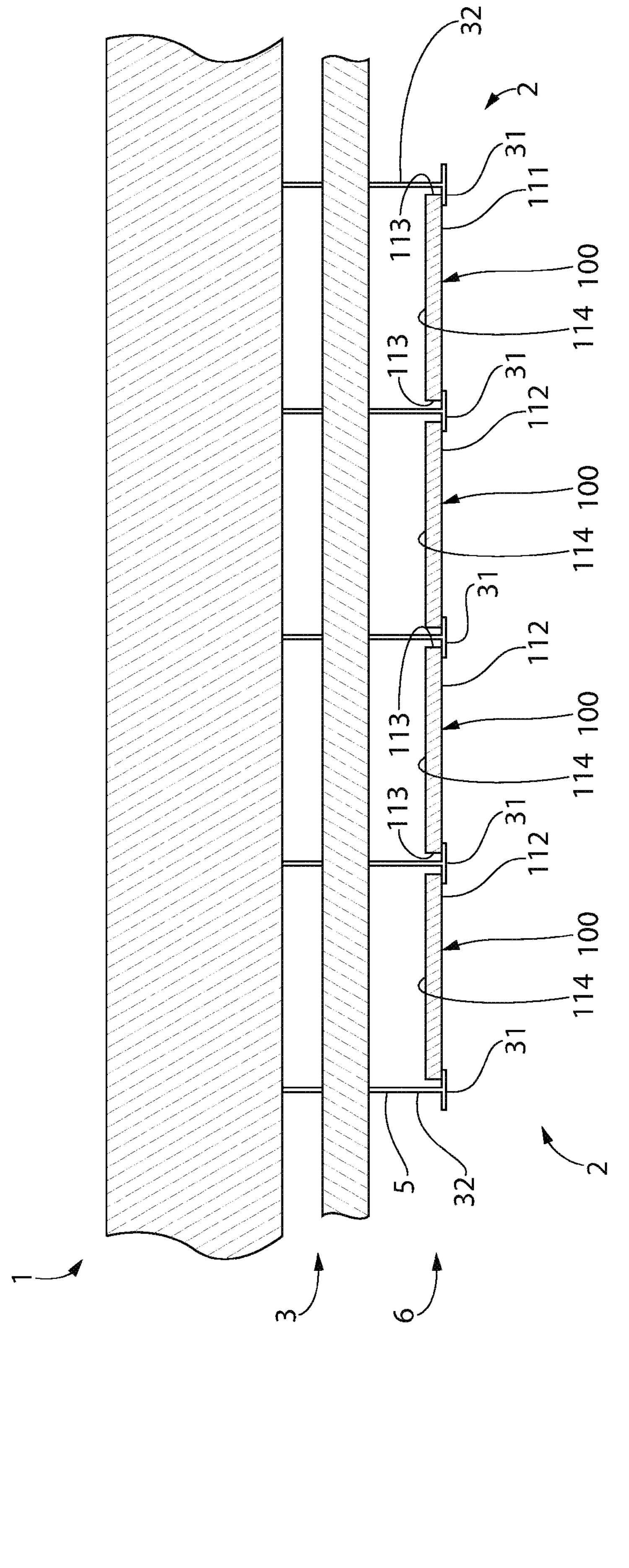
215'
210

FIG. 7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114
31
5
32
2
1
3
6

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2024/061107

A. CLASSIFICATION OF SUBJECT MATTER

E04B 9/04(2006.01)i; **E04B 1/86**(2006.01)i; **E04B 1/80**(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E04B 9/04(2006.01); B32B 13/04(2006.01); C04B 41/85(2006.01); E04B 1/76(2006.01); E04B 1/94(2006.01); E04C 2/26(2006.01); E04F 13/08(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: phase change material, composite carrier, infusion, film, coating, sealing layer, paint, seam

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2022-259785 A1 (YOSHINO GYPSUM CO., LTD.) 15 December 2022 (2022-12-15) paragraphs [0011]-[0018], [0027]-[0041], [0071]-[0075], [0092]-[0095] and figures 1-2C	1-8,12-21,26-35,39-47 9-11,22-25,36-38
Y	JP 2017-198002 A (EIDAI CO., LTD.) 02 November 2017 (2017-11-02) paragraphs [0030], [0038]-[0041] and figure 2	9-11,22-25,36-38
A	KR 10-1395192 B1 (KOREA INSTITUTE OF CONSTRUCTION TECHNOLOGY et al.) 16 May 2014 (2014-05-16) paragraph [0024] and figures 1-2	1-47
A	US 2013-0251986 A1 (CHARLTON et al.) 26 September 2013 (2013-09-26) paragraphs [0026]-[0027] and figure 1	1-47

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 April 2025	**17 April 2025**

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2024/061107

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2019-112929 A (HOKUSHU CO., LTD. et al.) 11 July 2019 (2019-07-11) paragraphs [0024]-[0077] and figure 1	1-47

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2022-259785	A1	15 December 2022	AU	2023-289781	A1	30 November 2023
				CA	3219132	A1	15 December 2022
				CN	117412939	A	16 January 2024
				EP	4328017	A1	28 February 2024
				KR	10-2024-0018450	A	13 February 2024
				TW	202248506	A	16 December 2022
				US	2024-0247176	A1	25 July 2024
JP	2017-198002	A	02 November 2017	JP	6826374	B2	03 February 2021
KR	10-1395192	B1	16 May 2014		None		
US	2013-0251986	A1	26 September 2013	CA	2801752	A1	22 December 2011
				EP	2582517	A1	24 April 2013
				WO	2011-159379	A1	22 December 2011
JP	2019-112929	A	11 July 2019	JP	7217452	B2	03 February 2023