



(51) International Patent Classification:

E04B 9/04 (2006.01) *E04B 9/00* (2006.01)
E04B 1/86 (2006.01) *E04B 1/74* (2006.01)
E04B 1/84 (2006.01)

(21) International Application Number:

PCT/US2024/061100

(22) International Filing Date:

19 December 2024 (19.12.2024)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

63/612,250 19 December 2023 (19.12.2023) US

(71) Applicant: **ARMSTRONG WORLD INDUSTRIES, INC.** [US/US]; 2500 Columbia Avenue, P.O. Box 3001, Lancaster, PA 17604-3001 (US).

(72) Inventors: **KRICK, Charles, G.**; 729 Rosemont Drive, Lititz, PA 17543 (US). **FITZHUGH, Gilbert, W.**; 125 Hammersmith Lane, Lititz, PA 17543 (US).

(74) Agent: **RADEFELD, Julia, G.**; The Belles Group, Pc, 1800 John F. Kennedy Boulevard, Suite 1010, Philadelphia, PA 19103 (US).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE,

(54) Title: ACOUSTIC STRUCTURES AND SURFACE COVERING SYSTEMS COMPRISING PHASE CHANGE MATERIAL AND METHODS OF MAKING THE SAME

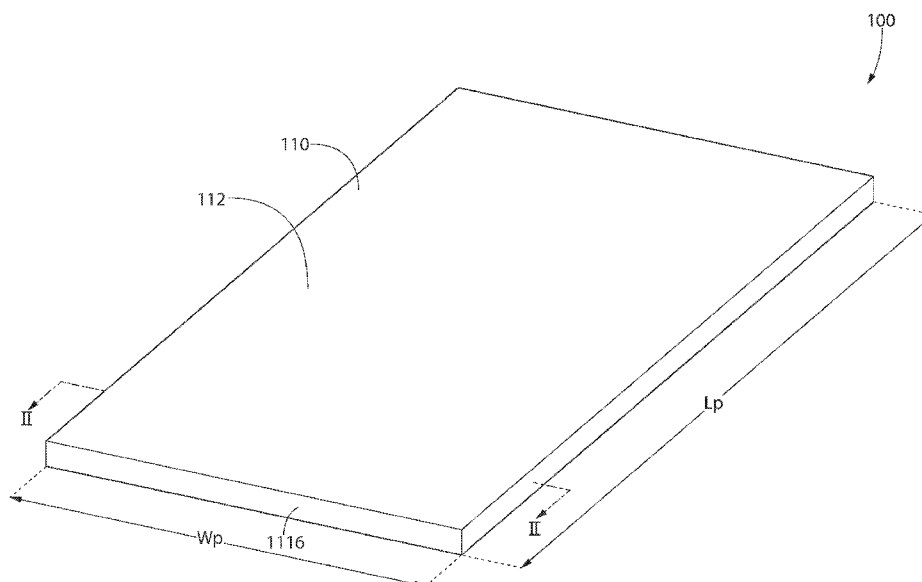


FIG. 1

(57) Abstract: Disclosed herein is an acoustic building panel including a porous substrate having a first major surface opposite a second major surface. The substrate includes one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material. The substrate is impregnated with a microencapsulated phase change material.



SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

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/ 612250 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 porous substrate having a first major surface opposite a second major surface. The substrate includes one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material. The substrate is impregnated with a microencapsulated phase change material.

[0008] In one example, the phase change material is microencapsulated in a polymeric material. In one example, the phase change material is an aqueous dispersion microencapsulated in a polymeric material. In one example, the phase change material is an organic material. In one

example, the phase change material is a powdered material. In one example, the phase change material has an average particle size ranging from about 10 microns to about 50 microns, from about 10 microns to about 30 microns, or from about 10 microns to about 20 microns. In one example, the phase change material is concentrated adjacent to the first major surface of the substrate. In one example, the phase change material is concentrated adjacent to the second major surface of the substrate. In one example, the phase change material is evenly distributed throughout the substrate. In one example, the phase change material is dry infused into the substrate.

[0009] In one example, the substrate has an average pore size that is greater than the average pore size of the phase change material. In one example, the substrate has an average pore size ranging from about 40 μm to about 100 μm . In one example, the substrate has a porosity ranging from about 80% to about 95%.

[0010] In one example, the acoustic building panel includes a scrim positioned over one of the first major surface or the second major surface of the substrate. In one example, the acoustic building panel includes an adhesive adhering the scrim to the substrate.

[0011] In one example, the acoustic building panel exhibits a thermal resistance of about 21.2 m-K/Watt nominal. In one example, the acoustic building panel is configured to store about 25 BTU/SF to about 75 BTU/SF of thermal energy. In one example, the acoustic building panel has an NRC value of at least about 0.5.

[0012] Also disclosed are surface covering systems for storing thermal energy.

[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 acoustic building panels. Each acoustic building panel includes a porous substrate having a first major surface opposite a second major surface, the substrate including one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material. The substrate is impregnated with a microencapsulated phase change material.

[0014] In one example, the phase change material is microencapsulated. In one example, the phase change material is an aqueous dispersion microencapsulated in a polymeric material. In one example, the phase change material is an organic material. In one example, the phase change material is a powdered material. In one example, the phase change material has an average particle size ranging from about 10 microns to about 50 microns, from about 10 microns to about 30 microns, or from about 10 microns to about 20 microns. In one example, the phase change material

is concentrated adjacent to the first major surface of the substrate. In one example, the phase change material is concentrated adjacent to the second major surface of the substrate. In one example, the phase change material is evenly distributed throughout the substrate. In one example, the phase change material is dry infused into the substrate.

[0015] In one example, each substrate has an average pore size that is greater than the average pore size of the phase change material. In one example, each substrate has an average pore size ranging from about 40 μm to about 100 μm . In one example, each substrate has a porosity ranging from about 80% to about 95%.

[0016] In one example, each acoustic building panel includes a scrim positioned over one of the first major surface or the second major surface of each substrate. In one example, each acoustic building panel includes an adhesive adhering the scrim to the substrate.

[0017] In one example, each acoustic building panel of the system exhibits a thermal resistance of about 21.2 m-K/Watt nominal. In one example, each acoustic building panel of the system is configured to store about 25 BTU/SF to about 75 BTU/SF of thermal energy. In one example, each acoustic building panel of the system has an NRC value of at least about 0.5.

[0018] Also disclosed are methods for manufacturing acoustic building panels for storing thermal energy.

[0019] In one example, the method includes providing a porous substrate having a first major surface opposite a second major surface and infusing a microencapsulated phase change material into the pores of the substrate.

[0020] In one example, the infusing includes dry infusion. In one example, the infusing includes applying a microencapsulated phase change material to the first major surface of the substrate, applying an alternating electric field to the second major surface on the substrate, and drawing the phase change material from the first major surface into the pores of the substrate to yield a substrate impregnated with the phase change material.

[0021] In one example, the phase change material is microencapsulated in a polymeric material. In one example, the phase change material is an aqueous dispersion microencapsulated in a polymeric material. In one example, the phase change material is an organic material. In one example, the phase change material is a powdered material. In one example, the phase change material has an average particle size ranging from about 10 microns to about 50 microns, from about 10 microns to about 30 microns, or from about 10 microns to about 20 microns. In one

example, the phase change material is concentrated adjacent to the first major surface of the substrate. In one example, the phase change material is concentrated adjacent to the second major surface of the substrate. In one example, the phase change material is evenly distributed throughout the substrate.

[0022] In one example, the substrate has an average pore size that is greater than the average pore size of the phase change material. In one example, the substrate has an average pore size ranging from about 40 μm to about 100 μm . In one example, the substrate has a porosity ranging from about 80% to about 95%.

[0023] In one example, the method includes positioning a scrim over one of the first major surface or the second major surface of the substrate. In one example, the method includes applying an adhesive to the substrate to adhere the scrim to the substrate.

[0024] In one example, the acoustic building panel is configured to store about 25 BTU/SF to about 75 BTU/SF of thermal energy. In one example, the acoustic building panel exhibits an NRC value of at least about 0.5.

[0025] 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

[0026] 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.

[0027] Figure 1 is a top perspective view of an acoustic building panel according to an example of the present disclosure;

[0028] Figure 2 is a cross-sectional view of an acoustic building panel of the present disclosure;

[0029] Figure 3 is a cross-sectional view of an acoustic building panel of the present disclosure;

[0030] Figure 4 is a top perspective view of a surface covering system according to an example of the present disclosure; and

[0031] Figure 5 is a cross-sectional view of a surface covering system of the present disclosure.

DETAILED DESCRIPTION

[0032] 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.

[0033] 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”.

[0034] 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.

[0035] 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.

[0036] According to the present application, use of the term “about” in conjunction with a numeral value refers to a value that may be $\pm 5\%$ 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.

[0037] 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.

[0038] 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.

[0039] 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.

[0040] 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.

[0041] 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.

[0042] 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.

[0043] 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 rating of ASTM E84 Class A with smoke developed (SDI) <25 and flame spread (FSI)<50.

[0044] Still referring to Fig. 1, the acoustic building panel 100 includes a phase change material. The phase change material is dispersed within the pores of the porous matrix defining the substrate 110. In one example, the phase change material is dispersed within the pores of the substrate 110 such that the substrate 110 is impregnated with the phase change material. In another example, the phase change material is dry infused into the substrate 110 such that the substrate is wet formed and dried prior to being impregnated with the powdered microencapsulated phase change material.

[0045] In one or more examples, the phase change material is an organic material. In another example, the phase change material is microencapsulated in a polymeric material. In yet another example, the phase change material is an aqueous dispersion microencapsulated in a polymeric material. In another example, the phase change material is a powdered material.

[0046] The phase change material may be characterized by its physical properties. In one example, the phase change material has an average particle size ranging from about 10 microns to about 50 microns. In another example, the phase change material has an average particle size ranging from about 10 microns to about 30 microns. In another example, the phase change material has an average particle size ranging from about 10 microns to about 20 microns.

[0047] The phase change material may be positioned within the substrate 110 so as to optimize thermal storage properties. In one example, the phase change material is concentrated adjacent to the first major surface 112 of the substrate 110. In another example, the phase change material is concentrated adjacent to the second major surface 114 of the substrate 110. In yet another example, the phase change material is evenly distributed throughout the thickness the substrate 110.

[0048] In one or more examples, the substrate 110 has an average pore size that is greater than the average pore size of the phase change material. In another example, the substrate 110 has an average pore size ranging from about 40 μm to about 100 μm . In yet another example, the substrate 110 has a porosity ranging from about 80% to about 95%.

[0049] In one or more examples, the acoustic building panel 100 is characterized by its thermal properties. In one example, the acoustic building panel 100 exhibits a thermal resistance of about 21.2 m-K/Watt nominal. In another example, the acoustic building panel 100 is configured to store from about 25 BTU/SF to about 75 BTU/SF of thermal energy.

[0050] In one or more examples, the acoustic building panel 100 is characterized by its acoustic properties, such as noise reduction coefficient (NRC) and ceiling attenuation class (CAC) rating. An NRC rating of 0 is a perfect sound reflection material. An NRC rating of 1 is a perfect sound absorption material. CAC is a measure for rating the performance of a ceiling material as a barrier to block airborne sound transmission through the material to/from the plenum above the ceiling. In one example, the acoustic building panel 100 has an NRC value of at least about 0.5. In another example, the acoustic building panel 100 has a CAC value of at least about 46.

[0051] Referring to Fig. 2, in one or more examples, the acoustic building panel 100 further includes a scrim 120 having a first major scrim surface 122 opposing a second major scrim surface

124 and a thickness t_2 . The scrim 120 is positioned over one of the first major surface 112 or the second major surface 114 of the substrate 110. In one example, the second major scrim surface 124 of the scrim 120 is coupled to the first major surface 112 of the substrate 110 with an adhesive. In one example, the scrim 120 is comprised of fiberglass.

[0052] Referring to Fig. 3, in one or more examples, the acoustic building panel 100 may further include a coating 130 having a thickness t_3 over one of the first major surface 112, the second major surface 114, or the scrim 120. In one example, the coating 130 includes a pigment such a titanium dioxide, diatomaceous earth, calcium carbonate, aluminum hydroxide, or barium sulfate, and a binder such as vinyl acrylic polymer. The coating 130 may be selected to balance desired acoustic and aesthetic properties.

[0053] Referring to Fig. 4 and Fig. 5, also disclosed is a surface covering system 200, such as a ceiling system or a wall system. In one example, 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.

[0054] In one or more examples, each building panel 250 of the plurality of building panels 205 includes a porous substrate 210 having a first major surface 212 opposite a second major surface 214. The substrate 210 is a porous matrix comprised of one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material.

[0055] In one or more examples, the substrate 210 is impregnated with a microencapsulated phase change material such that the microencapsulated phase change material is located within the pores of the substrate 210. In one example, the phase change material is microencapsulated in a polymeric material. In another example, the phase change material is an aqueous dispersion microencapsulated in a polymeric material. In yet another example, the phase change material is an organic material. In another example, the phase change material is a powdered material.

[0056] In one or more examples, the phase change material has an average particle size ranging from about 10 microns to about 50 microns. In another example, the phase change material has an average particle size ranging from about 10 microns to about 30 microns. In another example, the phase change material has an average particle size ranging from about 10 microns to about 20 microns.

[0057] The phase change material may be concentrated adjacent to the first major surface 212 of each substrate 210 of the system 200. In another example, the phase change material is

concentrated adjacent to each second major surface 214 of each substrate 210 of the system 200. In yet another example, the phase change material is evenly distributed throughout each substrate 210 of the system 200. In a further example, at least one building panel 205` of the plurality of building panels 205 includes a substrate having phase change material concentrated adjacent to the first major surface 212 and at least one building panel 205' of the plurality of building panels 205 having substrate having phase change material concentrated adjacent to the second major surface 214.

[0058] In one or more examples, the phase change material of the system 200 is dry infused into each substrate 210 such that it is located within the pores of the substrate 210 matrix. In one example, the substrate 210 has an average pore size that is greater than the average pore size of the phase change material such that the powdered microencapsulated phase change material fits within the pores of the matrix of the substrate 210. In one example, the substrate 210 has an average pore size ranging from about 40 μm to about 100 μm . In another example, the substrate 210 has a porosity ranging from about 80% to about 95%.

[0059] Referring to Fig. 5, in one or more examples, each building panel 205` of the plurality of building panels 205 includes a scrim 220 positioned over one of the first major surface 212 or the second major surface 214 of each substrate 210. The scrim 220 has a first major scrim surface 222 opposing a second major scrim surface 224. In one example, the second major scrim surface 224 is adhered to the first major surface 212 of the substrate 210 with an adhesive.

[0060] Still referring to Fig. 5, in one or more examples, each building panel 205` of the plurality of building panels 205 includes a coating 230 having a thickness t_3 over one or more of the first major surface 212, the second major surface 214, the scrim 220, or the plurality of seams 215. In one example, the coating 230 includes a pigment such a titanium dioxide, diatomaceous earth, calcium carbonate, aluminum hydroxide, or barium sulfate, and a binder such as vinyl acrylic polymer. The coating 230 may be selected to balance desired acoustic and aesthetic properties.

[0061] Each building panel 205` of the plurality of building panels 205 may be characterized by its thermal control properties. In one example, each building panel 205` of the plurality of building panels 205 exhibits a thermal resistance of about 21.2 m-K/Watt nominal. In another example, each building panel 205` of the plurality of building panels 205 is configured to store about 25 BTU/SF to about 75 BTU/SF of thermal energy.

[0062] The surface covering system 200 may be further characterized by its acoustic properties, such as noise reduction coefficient (NRC) and ceiling attenuation class (CAC) rating. An NRC rating of 0 is a perfect sound reflection material. An NRC rating of 1 is a perfect sound absorption material. CAC is a measure for rating the performance of a ceiling material as a barrier to block airborne sound transmission through the material to/from the plenum above the ceiling. In one example, each building panel 205 of the surface covering system 200 has an NRC value of at least about 0.5.

[0063] Also disclosed is a method for manufacturing an acoustic building panel 100 for storing thermal energy. In one or more examples, the method includes providing a porous substrate 110 having a first major surface 112 opposite a second major surface 114 and infusing a phase change material into the pores of the substrate 110.

[0064] In one example, the infusing includes dry infusion. In another example, the infusing includes applying a phase change material to the first major surface 112 of the substrate 110, applying an alternating electric field to the second major surface 114 of the substrate 110, and drawing the phase change material from the first major surface 112 into the pores of the substrate 110 to yield a substrate 110 impregnated with the phase change material.

[0065] In one or more examples, the substrate 110 is a porous structure comprised of one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material.

[0066] In one or more examples, the phase change material is an organic material. In another example, the phase change material is microencapsulated. In yet another example, the phase change material is an aqueous dispersion microencapsulated in a polymeric material. In another example, the phase change material is a powdered material.

[0067] The phase change material may be characterized by its physical properties. In one example, the phase change material has an average particle size ranging from about 10 microns to about 50 microns. In another example, the phase change material has an average particle size ranging from about 10 microns to about 30 microns. In another example, the phase change material has an average particle size ranging from about 10 microns to about 20 microns.

[0068] The phase change material may be positioned within the substrate 110 so as to optimize thermal storage properties. In one example, the phase change material is concentrated adjacent to the first major surface 112 of the substrate 110. In another example, the phase change material is

concentrated adjacent to the second major surface 114 of the substrate 110. In yet another example, the phase change material is evenly distributed throughout the thickness t_1 of the substrate 110.

[0069] In one or more examples, the substrate 110 has an average pore size that is greater than the average pore size of the phase change material. In another example, the substrate 110 has an average pore size ranging from about 40 μm to about 100 μm . In yet another example, the substrate 110 has a porosity ranging from about 80% to about 95%.

[0070] In one or more examples, the acoustic building panel 100 is characterized by its thermal properties. In one example, the acoustic building panel 100 exhibits a thermal resistance of about 21.2 m-K/Watt nominal. In another example, the acoustic building panel 100 is configured to store from about 25 BTU/SF to about 75 BTU/SF of thermal energy.

[0071] In one or more examples, the acoustic building panel 100 is characterized by its acoustic properties, such as noise reduction coefficient (NRC) and ceiling attenuation class (CAC) rating. An NRC rating of 0 is a perfect sound reflection material. An NRC rating of 1 is a perfect sound absorption material. CAC is a measure for rating the performance of a ceiling material as a barrier to block airborne sound transmission through the material to/from the plenum above the ceiling. In one example, the acoustic building panel 100 has an NRC value of at least about 0.5. In another example, the acoustic building panel 100 has a CAC value of at least about 46.

[0072] In one or more examples, the method includes positioning a scrim 120, such as a fiberglass scrim, over one of the first major surface 112 and the second major surface 114 of the substrate 110. In another example, the method includes applying an adhesive to the substrate 110 to adhere the scrim 120 to the substrate 110.

[0073] The disclosure may be characterized by the following clauses.

[0074] Clause 1: An acoustic building panel comprising: a porous substrate having a first major surface opposite a second major surface, the substrate comprising one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material, wherein the substrate is impregnated with a microencapsulated phase change material.

[0075] Clause 2: The acoustic building panel according to clause 1, wherein the phase change material is microencapsulated in a polymeric material.

[0076] Clause 3: The acoustic building panel according to any one of clauses 1 or 2, wherein the phase change material is an aqueous dispersion microencapsulated in a polymeric material.

[0077] Clause 4: The acoustic building panel according to any one of clauses 1 to 3, wherein the phase change material is an organic material.

[0078] Clause 5: The acoustic building panel according to any one of clauses 1 to 4, wherein the phase change material is a powdered material.

[0079] Clause 6: The acoustic building panel according to any one of clauses 1 to 5, wherein the phase change material has an average particle size ranging from about 10 microns to about 50 microns, from about 10 microns to about 30 microns, or from about 10 microns to about 20 microns.

[0080] Clause 7: The acoustic building panel according to any one of clauses 1 to 6, wherein the phase change material is concentrated adjacent to the first major surface of the substrate.

[0081] Clause 8: The acoustic building panel according to any one of clauses 1 to 7, wherein the phase change material is concentrated adjacent to the second major surface of the substrate.

[0082] Clause 9: The acoustic building panel according to any one of clauses 1 to 8, wherein the phase change material is evenly distributed throughout the substrate.

[0083] Clause 10: The acoustic building panel according to any one of clauses 1 to 9, wherein the phase change material is dry infused into the pores of the substrate.

[0084] Clause 11: The acoustic building panel according to any one of clauses 1 to 10, wherein the substrate has an average pore size that is greater than the average pore size of the phase change material.

[0085] Clause 12: The acoustic building panel according to any one of clauses 1 to 11, wherein the substrate has an average pore size ranging from about 40 μm to about 100 μm .

[0086] Clause 13: The acoustic building panel according to any one of clauses 1 to 12, wherein the substrate has a porosity ranging from about 80% to about 95%.

[0087] Clause 14: The acoustic building panel according to any one of clauses 1 to 13, further comprising a scrim positioned over one of the first major surface or the second major surface of the substrate.

[0088] Clause 15: The acoustic building panel according to clause 14, further comprising an adhesive adhering the scrim to the substrate.

[0089] Clause 16: The acoustic building panel according to any one of clauses 1 to 15 exhibiting a thermal resistance of about 21.2 m-K/Watt nominal.

[0090] Clause 17: The acoustic building panel according to any one of clauses 1 to 16 configured to store about 25 BTU/SF to about 75 BTU/SF of thermal energy.

[0091] Clause 18: The acoustic building panel according to any one of clauses 1 to 17 having an NRC value of at least about 0.5.

[0092] Clause 19: A surface covering system comprising: a plurality of 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 building panel comprising: a porous substrate having a first major surface opposite a second major surface, the substrate comprising one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material, wherein the substrate is impregnated with a microencapsulated phase change material.

[0093] Clause 20: The surface covering system according to clause 19, wherein the phase change material is microencapsulated in a polymeric material.

[0094] Clause 21: The surface covering system according to any one of clauses 1 or 20 wherein the phase change material is an aqueous dispersion microencapsulated in a polymeric material.

[0095] Clause 22: The surface covering system according to any one of clauses 19 to 21, wherein the phase change material is an organic material.

[0096] Clause 23: The surface covering system according to any one of clauses 19 to 22, wherein the phase change material is a powdered material.

[0097] Clause 24: The surface covering system according to any one of clauses 19 to 23, wherein the phase change material has an average particle size ranging from about 10 microns to about 50 microns, from about 10 microns to about 30 microns, or from about 10 microns to about 20 microns.

[0098] Clause 25: The surface covering system according to any one of clauses 19 to 24, wherein the phase change material is concentrated adjacent to the first major surface of the substrate.

[0099] Clause 26: The surface covering system according to any one of clauses 19 to 25, wherein the phase change material is concentrated adjacent to the second major surface of the substrate.

[0100] Clause 27: The surface covering system according to any one of clauses 19 to 26, wherein the phase change material is evenly distributed throughout the substrate.

[0101] Clause 28: The surface covering system according to any one of clauses 19 to 27, wherein the phase change material is dry infused into the pores of the substrate.

[0102] Clause 29: The surface covering system according to any one of clauses 19 to 28, wherein the substrate has an average pore size that is greater than the average pore size of the phase change material.

[0103] Clause 30: The surface covering system according to any one of clauses 19 to 29, wherein the substrate has an average pore size ranging from about 40 μm to about 100 μm .

[0104] Clause 31: The surface covering system according to any one of clauses 19 to 30, wherein the substrate has a porosity ranging from about 80% to about 95%.

[0105] Clause 32: The surface covering system according to any one of clauses 19 to 31, further comprising a scrim positioned over one of the first major surface or the second major surface of the substrate.

[0106] Clause 33: The surface covering system according to clause 32, further comprising an adhesive adhering the scrim to the substrate.

[0107] Clause 34: The surface covering system according to any one of clauses 19 to 33, wherein each building panel exhibits a thermal resistance of about 21.2 m-K/Watt nominal.

[0108] Clause 35: The surface covering system according to any one of clauses 19 to 34, wherein each building panel is configured to store about 25 BTU/SF to about 75 BTU/SF of thermal energy.

[0109] Clause 36: The surface covering system according to any one of clauses 19 to 35, wherein each building panel has an NRC value of at least about 0.5.

[0110] Clause 37: A method for manufacturing an acoustic panel comprising: providing a porous substrate having a first major surface opposite a second major surface; and infusing an encapsulated phase change material into the pores of the substrate.

[0111] Clause 38: The method according to clause 37, wherein the infusing comprises dry infusion.

[0112] Clause 39: The method according to any one of clauses 37 or 38, wherein the infusing comprises: applying a microencapsulated phase change material to the first major surface of the substrate; applying an alternating electric field to the second major surface on the substrate; and

[0113] drawing the phase change material from the first major surface into the pores of the substrate to yield a substrate impregnated with the phase change material.

[0114] Clause 40: The method according to any one of clauses 37 to 39, wherein the phase change material is microencapsulated in a polymeric material.

[0115] Clause 41: The method according to any one of clauses 37 to 40, wherein the phase change material is an aqueous dispersion microencapsulated in a polymeric material.

[0116] Clause 42: The method according to any one of clauses 37 to 41, wherein the phase change material is an organic material.

[0117] Clause 43: The method according to any one of clauses 37 to 42, wherein the phase change material is a powdered material.

[0118] Clause 44: The method according to any one of clauses 37 to 43, wherein the phase change material has an average particle size ranging from about 10 microns to about 50 microns, from about 10 microns to about 30 microns, or from about 10 microns to about 20 microns.

[0119] Clause 45: The method according to any one of clauses 37 to 44, wherein the phase change material is concentrated adjacent to the first major surface of the substrate.

[0120] Clause 46: The method according to any one of clauses 37 to 45, wherein the phase change material is concentrated adjacent to the second major surface of the substrate.

[0121] Clause 47: The method according to any one of clauses 37 to 46, wherein the phase change material is evenly distributed throughout the pores of the substrate.

[0122] Clause 48: The method according to any one of clauses 37 to 47, wherein the substrate has an average pore size that is greater than the average pore size of the phase change material.

[0123] Clause 49: The method according to any one of clauses 37 to 48, wherein the substrate has an average pore size ranging from about 40 μm to about 100 μm .

[0124] Clause 50: The method according to any one of clauses 37 to 49, wherein the substrate has a porosity ranging from about 80% to about 95%.

[0125] Clause 51: The method according to any one of clauses 37 to 50, further comprising positioning a scrim positioned over one of the first major surface or the second major surface of the substrate.

[0126] Clause 52: The method according to clause 51, further comprising applying an adhesive to the substrate to adhere the scrim to the substrate.

[0127] Clause 53: The method according to any one of clauses 37 to 52, wherein the acoustic building panel exhibits a thermal resistance of about 21.2 m-K/Watt nominal.

[0128] Clause 54: The method according to any one of clauses 37 to 53, wherein the acoustic building panel is configured to store about 25 BTU/SF to about 75 BTU/SF of thermal energy.

[0129] Clause 55: The method according to any one of clauses 37 to 54, wherein the acoustic building panel exhibits an NRC value of at least about 0.5.

[0130] Clause 56: The method according to any one of clauses 37 to 55, wherein the acoustic building panel is a ceiling panel.

[0131] Clause 57: The method according to any one of clauses 37 to 55, wherein the acoustic building panel is a wall panel.

[0132] 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 porous substrate having a first major surface opposite a second major surface, the substrate comprising one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material, wherein the substrate is impregnated with a microencapsulated phase change material.
2. The acoustic building panel according to claim 1, wherein the phase change material is microencapsulated in a polymeric material.
3. The acoustic building panel according to any one of claims 1 or 2, wherein the phase change material is an aqueous dispersion microencapsulated in a polymeric material.
4. The acoustic building panel according to any one of claims 1 to 4, wherein the phase change material has an average particle size ranging from about 10 microns to about 50 microns, from about 10 microns to about 30 microns, or from about 10 microns to about 20 microns.
5. The acoustic building panel according to any one of claims 1 to 4, wherein the phase change material is concentrated adjacent to the first major surface of the substrate.
6. The acoustic building panel according to any one of claims 1 to 4, wherein the phase change material is concentrated adjacent to the second major surface of the substrate.
7. The acoustic building panel according to any one of claims 1 to 4, wherein the phase change material is evenly distributed throughout the substrate.
8. The acoustic building panel according to any one of claims 1 to 7, wherein the phase change material is dry infused into the pores of the substrate.

9. A surface covering system comprising:

a plurality of 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 building panel comprising:

a porous substrate having a first major surface opposite a second major surface, the substrate comprising one or more of mineral fiber board, fiberglass, jute fiber, wood, or a composite material, wherein the substrate is impregnated with a microencapsulated phase change material.

10. The surface covering system according to claim 9, wherein the phase change material is microencapsulated in a polymeric material.

11. The surface covering system according to any one of claims 9 or 10 wherein the phase change material is an aqueous dispersion microencapsulated in a polymeric material.

12. The surface covering system according to any one of claims 9 to 11, wherein the phase change material has an average particle size ranging from about 10 microns to about 50 microns, from about 10 microns to about 30 microns, or from about 10 microns to about 20 microns.

13. The surface covering system according to any one of claims 9 to 12, wherein the phase change material is concentrated adjacent to the first major surface of the substrate.

14. The surface covering system according to any one of claims 9 to 12, wherein the phase change material is concentrated adjacent to the second major surface of the substrate.

15. The surface covering system according to any one of claims 9 to 12, wherein the phase change material is evenly distributed throughout the substrate.

16. The surface covering system according to any one of claims 9 to 15, wherein the phase change material is dry infused into the pores of the substrate.

17. A method for manufacturing an acoustic panel comprising:
providing a porous substrate having a first major surface opposite a second major surface;
and
infusing an encapsulated phase change material into the pores of the substrate.
18. The method according to claim 17, wherein the infusing comprises dry infusion.
19. The method according to any one of claims 17 or 18, wherein the infusing comprises:
applying a microencapsulated phase change material to the first major surface of the substrate;
applying an alternating electric field to the second major surface on the substrate; and
drawing the phase change material from the first major surface into the pores of the substrate to yield a substrate impregnated with the phase change material.
20. The method according to any one of claims 17 to 19, wherein the phase change material is microencapsulated in a polymeric material.
21. The method according to any one of claims 17 to 20, wherein the phase change material is an aqueous dispersion microencapsulated in a polymeric material.
22. The method according to any one of claims 17 to 21, wherein the phase change material has an average particle size ranging from about 10 microns to about 50 microns, from about 10 microns to about 30 microns, or from about 10 microns to about 20 microns.
23. The method according to any one of claims 17 to 22, wherein the phase change material is concentrated adjacent to the first major surface of the substrate.
24. The method according to any one of claims 17 to 22, wherein the phase change material is concentrated adjacent to the second major surface of the substrate.

25. The method according to any one of claims 17 to 22, wherein the phase change material is evenly distributed throughout the pores of the substrate.

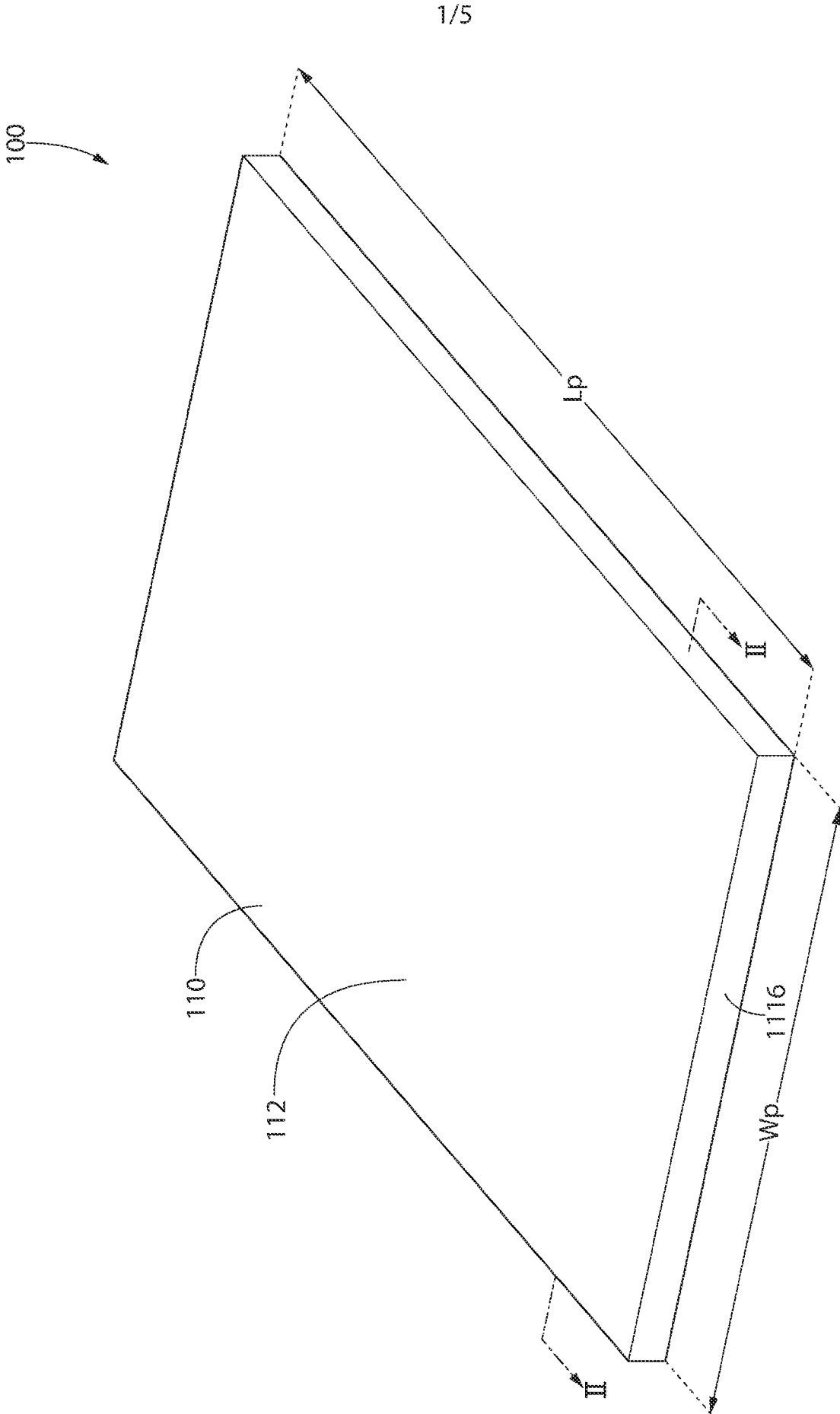


FIG. 1

2/5

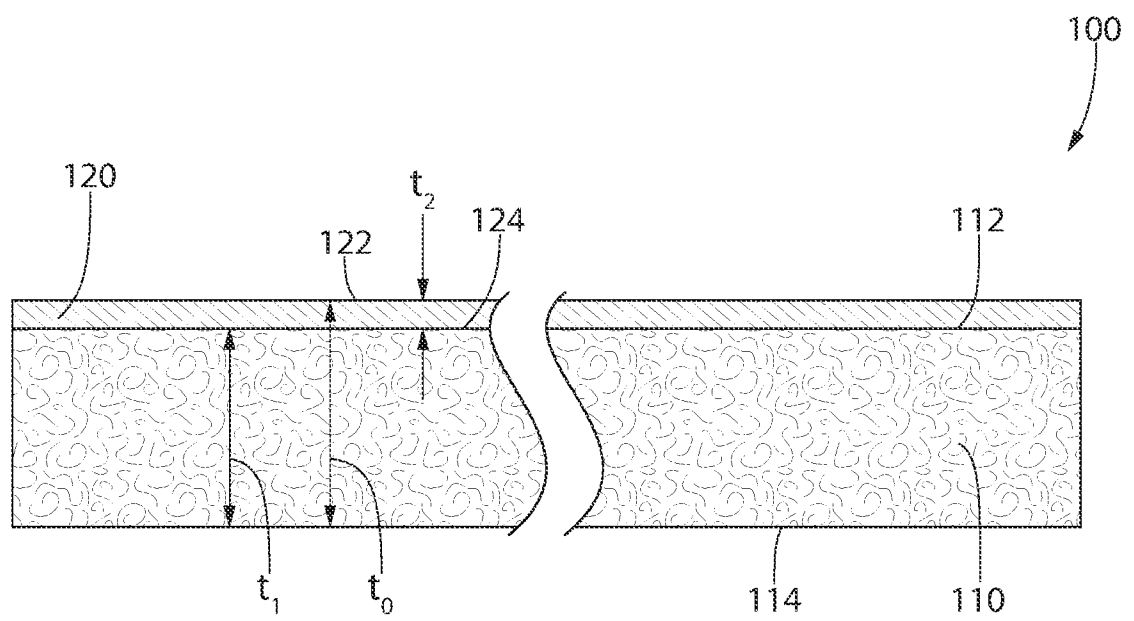


FIG. 2

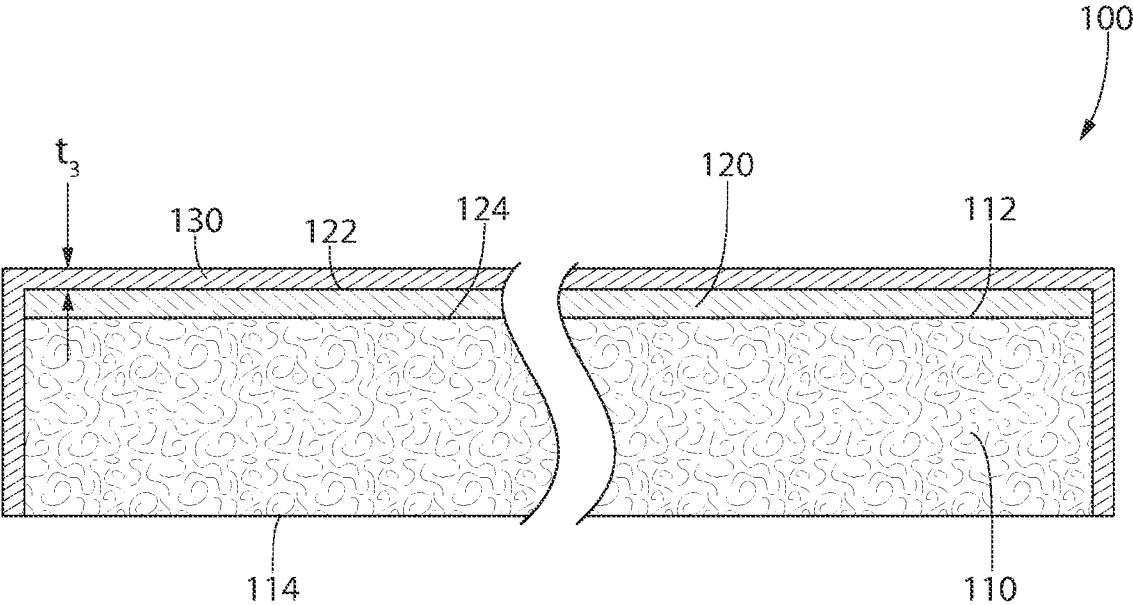


FIG. 3

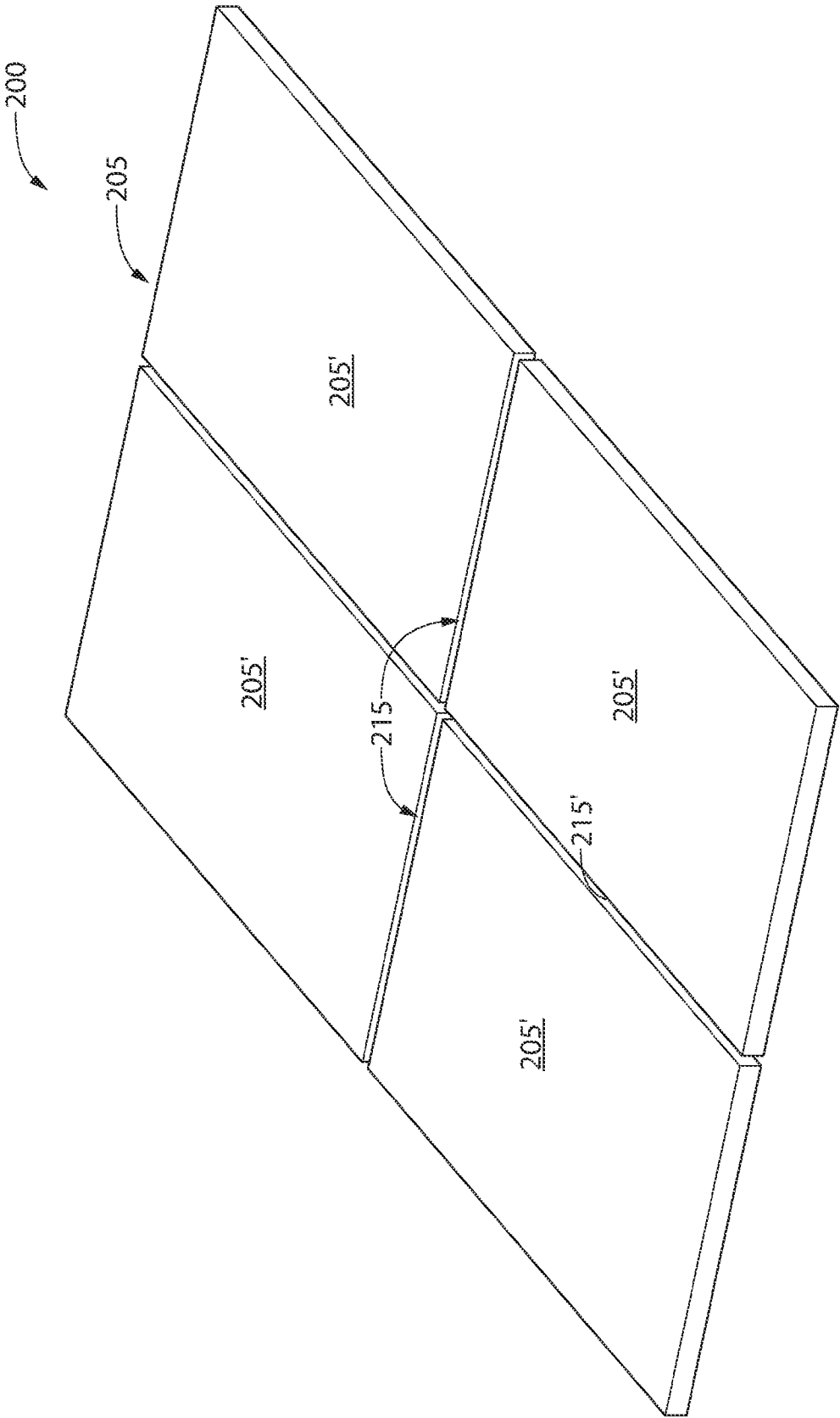


FIG. 4

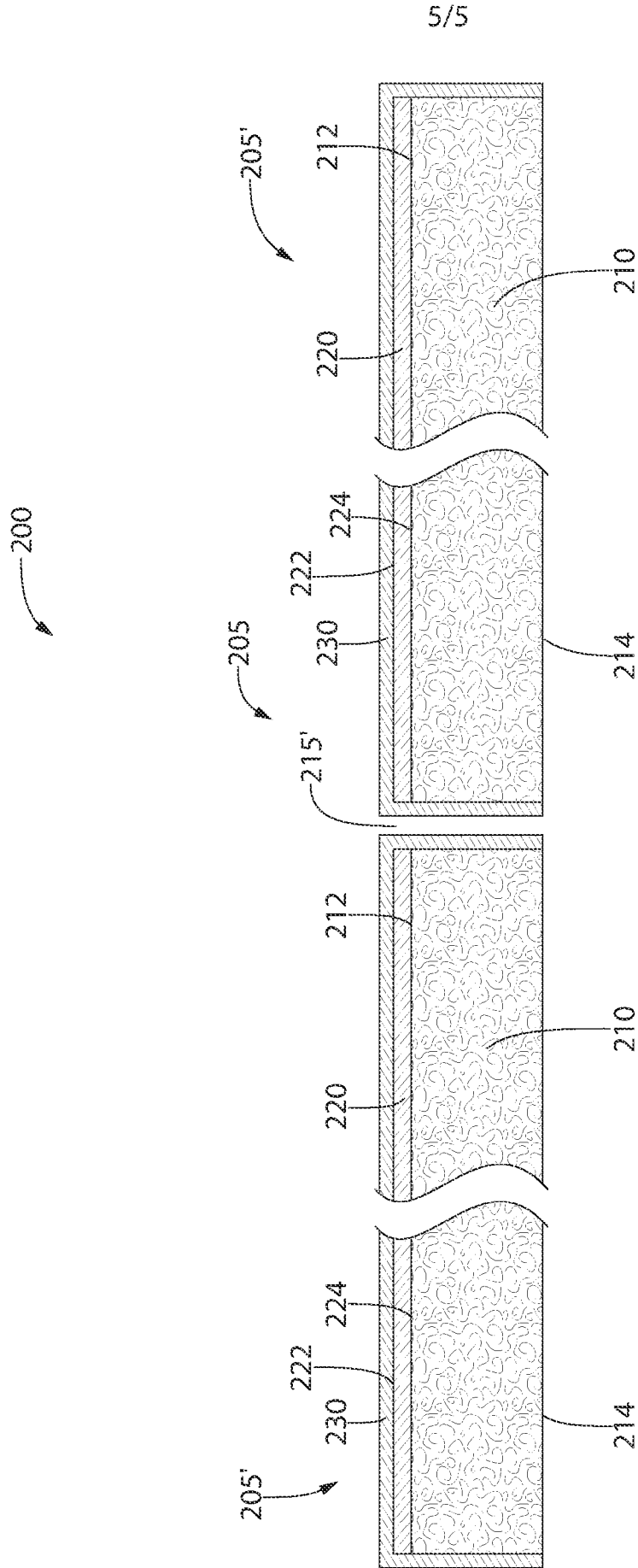


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2024/061100

A. CLASSIFICATION OF SUBJECT MATTER E04B 9/04(2006.01)i; E04B 1/86(2006.01)i; E04B 1/84(2006.01)i; E04B 9/00(2006.01)i; E04B 1/74(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); B01J 19/08(2006.01); B05C 5/00(2006.01); B27N 3/00(2006.01); C09K 5/02(2006.01); E04B 1/76(2006.01); E04C 2/26(2006.01); E04C 2/52(2006.01); F16L 59/00(2006.01); F28D 20/02(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: porous substrate, phase change material, microcapsule, impregnation, dry infusion, alternating electric field		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2017-198002 A (EIDAI CO., LTD.) 02 November 2017 (2017-11-02) paragraphs [0029]-[0036], [0052]-[0053] and figures 1-7	1-25
Y	KR 10-1367420 B1 (TAPS INTERNATIONAL CO., LTD.) 28 February 2014 (2014-02-28) paragraphs [0026]-[0029], [0036]-[0037], [0047] and figure 1	1-25
Y	JP 2018-189296 A (EIDAI CO., LTD.) 29 November 2018 (2018-11-29) paragraphs [0052]-[0053] and figure 2	5-6,13-14,23-24
Y	US 2011-0097505 A1 (MARDUEL, JORIC) 28 April 2011 (2011-04-28) paragraph [0035] and figures 1-2	19
A	KR 10-1492441 B1 (REMTECH CO., LTD. et al.) 12 February 2015 (2015-02-12) paragraphs [0081]-[0082] and figure 1	1-25
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “D” document cited by the applicant in the international application “E” earlier application or patent but published on or after the international filing date “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 22 April 2025		Date of mailing of the international search report 23 April 2025
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon 35208, Republic of Korea Facsimile No. +82-42-481-8578		Authorized officer PARK, Tae Wook Telephone No. +82-42-481-3405

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/US2024/061100

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)		Publication date (day/month/year)
JP	2017-198002	A	02 November 2017	JP	6826374 B2	03 February 2021
KR	10-1367420	B1	28 February 2014	None		
JP	2018-189296	A	29 November 2018	JP	6936618 B2	15 September 2021
US	2011-0097505	A1	28 April 2011	AT	E554904	15 May 2012
				BR	PI0914572 A2	15 December 2015
				BR	PI0914572 B1	26 February 2019
				CA	2728961 A1	07 January 2010
				CA	2728961 C	16 February 2016
				CN	102083599 A	01 June 2011
				CN	102083599 B	06 November 2013
				DK	2331309 T3	04 June 2012
				EP	2331309 A1	15 June 2011
				EP	2331309 B1	25 April 2012
				ES	2382270 T3	06 June 2012
				FR	2933327 A1	08 January 2010
				FR	2933327 B1	20 August 2010
				JP	2011-526659 A	13 October 2011
				JP	5386581 B2	15 January 2014
				KR	10-1614560 B1	21 April 2016
				KR	10-2011-0027813 A	16 March 2011
				PL	2331309 T3	28 September 2012
				PT	2331309 E	25 May 2012
				RU	2011103545 A	10 August 2012
				RU	2486055 C2	27 June 2013
				US	8967079 B2	03 March 2015
				WO	2010-001043 A1	07 January 2010
KR	10-1492441	B1	12 February 2015	None		