(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 February 2019 (28.02.2019)

WIPO | PCT

(10) International Publication Number
WO 2019/037837 A1

(51) International Patent Classification:
H01L 31/048 (2014.01) *B32B 37/10* (2006.01)

(21) International Application Number:
PCT/EP2017/071094

(22) International Filing Date:
22 August 2017 (22.08.2017)

(25) Filing Language: English

(26) Publication Language: English

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(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, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, 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, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,

WO 2019/037837 A1

(54) Title: LIGHTWEIGHT SOLAR PHOTOVOLTAIC MODULE

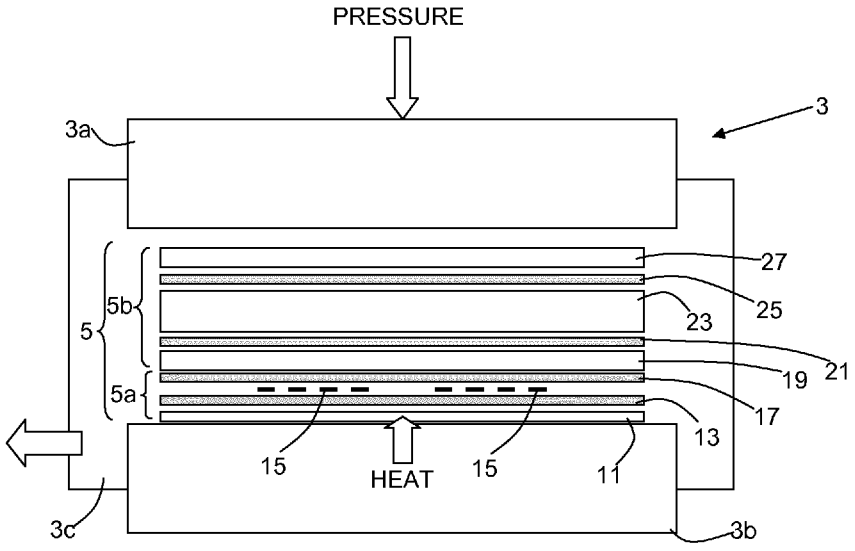


Figure 1

(57) Abstract: Method of manufacture of a photovoltaic module (1), comprising the steps of: - providing a heated vacuum press apparatus (3); - placing in said press apparatus (3) a stack (5) comprising at least the following sequence of separate elements: a) a front-side sheet (11); b) a first sheet of hot melt adhesive (13); c) an array of interconnected photovoltaic cells (15); d) a second sheet of holt melt adhesive (17); e) a first reinforcing sheet (19); f) a third sheet of hot melt adhesive (21); g) a structural core layer (23); h) a fourth sheet of hot melt adhesive (25); i) a second reinforcing sheet (27), - applying heat, vacuum and pressure to said stack (5) by means of said press apparatus (3) so as to cause each of said sheets of hot melt adhesives (13, 17, 21, 25) to bond said stack (5) together in a single process step.

[Continued on next page]

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, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

Description

LIGHTWEIGHT SOLAR PHOTOVOLTAIC MODULE

Technical Field

[0001] The present invention relates to the technical field of solar photovoltaic modules, particularly those which are suitable for integrating into the structure or cladding of a building, notably walls or roofs.

State of the art

[0002] Solar photovoltaic modules are commonly integrated into or onto the structures of buildings so as to generate electricity from the incident sunlight. Typically, these modules comprise a structure based on a (or several) relatively thick sheet(s) of glass, which is relatively heavy and subject to damage from impacts (e.g. from hail, thrown objects or similar), mishandling during installation or maintenance, and similar. Furthermore, the weight of such modules implies high transport costs, and high labour costs during installation.

[0003] There is thus significant interest in developing lighter weight photovoltaic modules for such roles, which comply with the relevant standards IEC61625 and IEC61730 governing such modules. However, until now, no commercially-available lightweight rigid module has been able to satisfy the above-mentioned standards.

[0004] The document US 6051774 describes a photovoltaic module in which a composite backsheet is bonded to a pre-fabricated separately-fabricated solar battery unit comprising photovoltaic elements encapsulated by a protective layer bonded to a support sheet. In an alternative embodiment, this unit comprises photovoltaic elements encapsulated in a transparent adhesive agent and sandwiched between a transparent panel member and a backing sheet member.

[0005] This arrangement comprises a significant number of layers, and requires that the solar battery unit be fabricated in a separate process step prior to assembly of the complete module. Furthermore, this module comprises

openings or porosities intended to allow degassing during fabrication and to air to flow through the structure in operation, and as a result, several of the layers comprise perforations. This is clearly undesirable, since these openings provide a pathway for moisture deep into the structure of the module, with consequent problems for longevity.

[0006] WO2009/149850 describes another lightweight photovoltaic module, comprising EVA-embedded solar cells bonded to a prefabricated rear sandwich structure comprising fibre-resin composites directly bonded to a suitable core without intermediate layers by means of fibres soaked in a curing resin ("prepregs") directly in contact with the core in a suitable press. This prefabricated rear sandwich structure is then placed in another press, and the remainder of the module is placed thereupon and assembled. The document also states that it is possible to lay the rear sandwich structure in unbonded form in the press at the same time as the remainder of the module. However, given that the document only discloses using fibres in the form of prepregs for constructing the rear sandwich structure, such a manufacturing technique seems highly unlikely to be satisfactory, since the liquid resin of the prepregs is likely to be difficult to contain sufficiently. It will thus spread to other parts of the module or the press apparatus as undesired contamination during assembly or during pressing. Although this variant can allegedly be formed in a single step, this implied requirement to handle wet prepregs for the rear sandwich structure is clearly inconvenient. This view is supported by their concrete example, in which the rear sandwich is assembled in a separate press step prior to assembly of the complete module so as not to attempt to handle wet prepregs during final assembly of the module.

[0007] An object of the invention is hence to overcome the above-mentioned drawbacks of the prior art, and thereby to provide a solar photovoltaic module which is stiff, lightweight, and can be manufactured in a single processing step.

Disclosure of the invention

[0008] More specifically, the invention relates to a method of manufacture of a photovoltaic module, comprising the steps of:

[0009] - providing a heated vacuum press apparatus such as a heated vacuum bag press or any other convenient type;

[0010] - placing in said press apparatus a stack comprising at least the following sequence of separate elements:

[0011] a) a front-side sheet;

[0012] b) a first sheet of hot melt adhesive;

[0013] c) an array of interconnected photovoltaic cells;

[0014] d) a second sheet of holt melt adhesive;

[0015] e) a first reinforcing sheet;

[0016] f) a third sheet of hot melt adhesive;

[0017] g) a structural core layer;

[0018] h) a fourth sheet of hot melt adhesive;

[0019] i) a second reinforcing sheet.

[0020] This sequence can be exactly as stated without any intermediate elements (i.e. with each enumerated element being placed directly upon the previously-mentioned element), or may comprise intermediate elements interposed therein between two consecutively-mentioned elements. It must also be noted that the listed elements are explicitly described as separate elements, and are thus not sub-assemblies. For instance, this method does not include laying an already-assembled front layup comprising elements a) to d), or a composite backsheet comprising elements e) to i) already assembled into a sub-assembly; the elements comprised by such a sub-assembly are by definition no longer “separate elements”, since they have been already unified. This sequence can be placed in the order a) to i), or in the inverse order, i.e. i) to a), which results in exactly the same sequence when considered in the opposite direction (i.e. top-to-bottom rather than bottom-to-top).

[0021] Once the stack has been laid into the press, heat, vacuum and pressure (atmospheric as a result of the vacuum, mechanical or a combination thereof)

are applied to said stack by means of said press apparatus so as to cause each of said sheets of hot melt adhesives to bond said stack together.

[0022] As a result, it is possible to assemble the entire stack from separate elements into a stiff lightweight solar photovoltaic module in a single process step in equipment commonly present in photovoltaic manufacturing facilities, with no liquid adhesives that may spread, cause contamination or lead to the need for a post-curing process. This is not possible with existing technology (which typically requires at least one sub-assembly to be pre-assembled before being placed in the stack), and represents a significant improvement in process efficiency and yet can create modules compliant with IEC 61215 and IEC 61730.

[0023] Advantageously, the stack further comprises between elements a) and b), the following sequence of further elements:

[0024] a1) a fifth sheet of hot melt adhesive; and

[0025] a2) an additional functional layer.

[0026] These intermediate layers permit incorporating a functional layer (e.g. one which comprises at least one of a polymeric film, glass fibres, a coloured layer, an interferential filter, a diffraction grating), so as to add desired mechanical and/or optical properties to the module.

[0027] Advantageously, said heat is applied from at least the front side of said stack, i.e. is applied to the front-side sheet. This results in improved encapsulation of the photovoltaic cells, and thus excellent structural integrity of the resulting module. However, applying heat from both sides or from the back side is also possible.

[0028] The step of applying heat and pressure may be carried out under the following conditions:

[0029] - temperature between 120 and 180°C, preferably between 150 and 170°C, further preferably substantially 165°C;

[0030] - pressure between 400 and 1000 mbar, preferably between 800 and 1000 mbar.

[0031] Advantageously, each sheet of hot melt adhesive has the following properties:

[0032] - thickness in the range of 0.2 to 0.6mm, preferably 0.3 to 0.5mm;

[0033] - a melting point in the range 80 to 120°C, preferably 90-110°C, more preferably 95-105°C.

[0034] - a glass transition temperature above 85°C, preferably above 100°C, and

[0035] - a complex modulus above 3000kPa at 20°C, preferably above 6000kPa at 20°C.

[0036] Advantageously, each sheet of hot melt adhesive comprises at least one of: Ethylene-vinyl acetate, Polyvinyl butyral, Polyolefin, Thermoplastic Polyolefin, Thermoplastic Polyurethane, silicone, ionomer. Each sheet may be the same as, or different to, at least one other.

[0037] Advantageously, the photovoltaic module obtained by the single-step process described above is inverted in the press and is subjected to a supplemental step of application of heat, pressure and vacuum. The parameters of this supplemental application of heat, pressure and vacuum may be the same as, or different to, the first. This optional extra step does not contribute to the assembly of the stack into a module per se, since that has already been achieved in the single processing step as detailed above. However, it may contribute to the longevity of the module by improving the bonding, depending mostly on the heat conductivity properties of layers e) to i)

[0038] The invention further relates to a photovoltaic module comprising a stack comprising the following sequence of elements:

[0039] a) a front-side sheet;

[0040] b) a first sheet of hot melt adhesive;

[0041] c) an array of interconnected photovoltaic cells;

[0042] d) a second sheet of holt melt adhesive;

[0043] e) a first reinforcing sheet;

[0044] f) a third sheet of hot melt adhesive;

[0045] g) a structural core layer;

[0046] h) a fourth sheet of hot melt adhesive;

[0047] i) a second reinforcing sheet.

[0048] This structure permits assembly of a lightweight module in a single manufacturing step, without requiring to pre-prepare sub-assemblies, and

hence contributes to being able to achieve a significant improvement in process efficiency and yet can create modules compliant with IEC 61215 and IEC 61730. Such a module is obtainable by the method mentioned above.

[0049] Advantageously, the photovoltaic module further comprises, situated directly or indirectly between elements a) and b), the following sequence of further elements:

[0050] a1) a fifth sheet of hot melt adhesive; and

[0051] a2) an additional functional layer.

[0052] These intermediate layers permit incorporating a functional layer (e.g. one which comprises at least one of a polymeric film, glass fibres, a coloured layer, an interferential filter, a diffraction grating), so as to add desired mechanical and/or optical properties to the module.

[0053] Advantageously, each of the enumerated elements of the module is situated directly in contact with the subsequent layer indicated. In other words, each listed element is situated directly upon the next. A simple, strong module is thus obtained.

[0054] Finally, the invention relates to a building comprising a photovoltaic module as mentioned above, e.g. situated on the roof or as wall cladding.

Brief description of the drawings

[0055] Further details of the invention will appear more clearly upon reading the description below, in connection with the following figures which illustrate:

- Figure 1: a schematic diagram of a method of the invention;
- Figure 2: a schematic diagram of a solar photovoltaic module according to the invention;
- Figure 3: a schematic diagram of a further solar photovoltaic module according to the invention; and
- Figure 4: a schematic representation of a building provided with a solar photovoltaic module according to the invention.

Embodiments of the invention

[0056] Figure 1 illustrates schematically a method of manufacture of a solar photovoltaic module 1 according to the invention, and figure 2 illustrates the completed module 1 thus obtained.

[0057] In figure 1, a heated vacuum press apparatus 3 has been provided. This press apparatus 3 has been schematically represented by upper 3a and lower 3b press halves and a flexible vacuum chamber 3c situated therebetween, the evacuation of air being represented schematically by the horizontal arrow. The press 3 can also be a bag-type press without upper press half 3a, as is generally known in the art, or any other convenient type of press.

[0058] In the illustrated variant, lower press half 3b can be heated so as to apply heat to the stack 5 of elements placed in sequence therein during pressing, for reasons which will become clear below.

[0059] This stack 5 of elements is placed on the lower press half in the following sequence (from bottom to top, i.e. in the order in which they are placed) of separate elements that are not at this stage bonded one to the other e.g. in the form of sub-assemblies:

[0060] a) a front-side sheet 11;

[0061] b) a first sheet of hot melt adhesive 13;

[0062] c) an array of interconnected photovoltaic cells 15;

[0063] d) a second sheet of holt melt adhesive 17;

[0064] e) a first reinforcing sheet 19;

[0065] f) a third sheet of hot melt adhesive 21;

[0066] g) a structural core layer 23;

[0067] h) a fourth sheet of hot melt adhesive 25;

[0068] i) a second reinforcing sheet 27.

[0069] In the illustrated embodiment, each layer of the stack 5 is a substantially planar element which is laid directly upon the layer mentioned previously, however the presence of intermediate layers is not excluded. Indeed, figure 3 illustrates another embodiment which comprises several intermediate layers (see below). It should, however, be noted that the planar nature of the stack layers is not to be construed as limiting. The same principle can be applied to

non-planar modules exhibiting a curvature in one or more directions, corrugations or similar. In such cases, the shape of the press 3 is adapted accordingly

[0070] The front-side sheet 11 is destined to face the incident light, and serves to protect the module 1 from the elements (rain, dirt etc.) while allowing incident light to pass. Suitable materials include ETFE (Ethylene tetrafluoroethylene), ECTFE (Ethylene ChloroTriFluoroEthylene), PET (Polyethylene terephthalate), PMMA (Poly(methyl methacrylate)), PC (Polycarbonate), or ultra-thin glass, e.g. with a thickness of between 25 and 100 μm. Ideally, however, the module 1 is glass-free.

[0071] The sheets of hot melt adhesive 13, 17, 21, 25 are non-liquid adhesives used instead of conventional liquid adhesives that harden. Such hot melt adhesives typically have a melting point in the range 80-120°C, preferably 90-110°C, more preferably 95-105°C. They also typically have a glass transition temperature above 85°C, preferably above 100°C, and a complex modulus above 3000kPa at room temperature (20°C), preferably above 6000kPa. These sheets are unperforated to ensure the integrity of the resulting module 1 and to prevent ingress and migration of air, moisture etc. in use.

[0072] Examples of suitable materials include: EVA (Ethylene-vinyl acetate), PVB (Polyvinyl butyral), PO (Polyolefin), TPO (Thermoplastic Polyolefin), TPU (Thermoplastic Polyurethane), sheets of silicone, ionomers, and so on. These materials may be thermoplastics or thermosets as appropriate.

[0073] The various sheets of hot melt adhesive 13, 17, 21, 25 typically have a thickness in the range of 0.2 to 0.6mm, preferably 0.3 to 0.5mm, and may be made of the same or different materials depending on the properties of the adjacent layers. For instance, it may be desirable that the first and second sheets of hot melt adhesive 13, 17 are made of EVA, and that the third and fourth 21, 25 are made of TPO. Use of such sheets has several advantages. Firstly, they are easily-handled, and the risk of contamination by adhesive accidentally being distributed in undesired places due to the mishandling that can occur with liquid adhesives is eliminated. Furthermore, they permit the

entire stack 5 to be solidified into the finished module 1 in a single processing step, including the encapsulation of the photovoltaic cells 15. Since no liquid adhesives are used, there is no requirement for extra process steps, nor is there potential degassing as often occurs due to the chemical reactions taking place during solidification of a liquid adhesive, and hence reduced risk of formation of bubbles.

[0074] The interconnected photovoltaic cells 15 are laid on the first sheet of hot melt adhesive 13, with all interconnects etc. already in place. These interconnects, junction boxes and so on are well-known and need not be illustrated or described further. The photovoltaic cells 15 may be crystalline or thin-film solar cells of any known type e.g. based on silicon or germanium.

[0075] Upon the photovoltaic cells 15 is laid a second sheet of hot melt adhesive 17. During pressing, the first and second sheets of hot melt adhesive 13, 17 will encapsulate the photovoltaic cells 15 and bond them to the front sheet 11, thereby constituting the front layup 5a of the photovoltaic module 1.

[0076] The next element, placed upon the second sheet of holt melt adhesive 17, is a first reinforcing sheet 21, which lends structural integrity to the module 1 in combination with the other elements of a composite backsheet 5b. This first reinforcing sheet 21 may be, for instance, glass fibre reinforced polymer (GFRP), carbon fibre reinforced polymer (CFRP), aramid reinforced polymer, bio-fibre reinforced polymer (with e.g. cotton, linen, hemp or similar as the fibres), aluminium, or other relatively low-density metal. It should be noted that in the case of fibre reinforced polymers, these are standard products that are acquired in usable form and do not need further processing. Ideally, they should be degassed, e.g. by having been thermally cured during their manufacture, e.g. by being held at 100-140°C, preferably 110-130°C, further preferably 115-125°C for a period of time between 2-8 hours, further preferably 3-7 hours, even further preferably 4-6 hours. Moreover, their glass transition temperature Tg should ideally be above the processing temperature, and for sure above the maximum operating temperature. Such degassed substances do not release gases during the pressing step for forming the module 1, and thus help to prevent formation of bubbles in the

finished module 1. Even if a reinforcing sheet 21, 27 has had some pre-processing or pre-assembly performed upon it, or itself has a composite layered structure, it is still considered as a "separate element" in the context of the present invention since it is a single unitary element performing a single function amongst the elements listed as forming part of the stack. In other words, it does not comprise several of the listed stack elements, unlike would be the case of a pre-assembled front layup which comprises three different functional layers, each of which is explicitly named as forming part of the stack. In essence, the reinforcing sheets 21, 27 are always considered as single elements within the context of the present invention, irrespective of their construction.

[0077] Third sheet of hot melt adhesive 21 is then laid upon the first reinforcing sheet 21, and then structural core layer 23 is laid thereupon.

[0078] Structural core layer 23 is for instance a honeycomb, solid or corrugated structure in aluminium or (fibre-reinforced) polymer such as aramid, aramid paper, matting or woven material, a polymer foam such as a PET or PVF (Polyvinyl fluoride), balsa wood, other types of wood, or any other suitable material which can bond to the adjacent hot melt adhesive layers 21, 25 and can withstand the temperatures and pressures exerted during the pressing step. In the case in which the structural core layer 23 is porous (e.g. PET foam), the edges of the module can be sealed after assembly by any desired means (e.g. a frame, application of a sealant, or other convenient arrangement). However, in the case in which structural core layer 23 is non-porous (e.g. an aluminium or polymer honeycomb structure or other), the completed module 1 requires no further finishing and can be used directly from the press after making the appropriate electrical connections.

[0079] Upon the fourth hot melt adhesive layer 25 is placed a second reinforcing sheet 27, which may be the same or different to the first reinforcing sheet 19 described above.

[0080] Once the stack 5 has been completed, it is pressed under the application of pressure and heat applied from at least the lower press half 3b. In the illustrated embodiment, since the stack 5 has been arranged on the heated

lower press half 3b starting from the front side of the module 1, maximum heat is applied to the first and second hot melt adhesive layers 13, 17, which ensures that these layers bond well together and encapsulate the photovoltaic cells 15 in a high-quality fashion. However, it is also possible to apply heat from both sides of the stack 5, by means of a heated upper press half 3a, if present, or by means of an auxiliary heating element placed on top of a vacuum bag press in the case this type of press is used. It should also be noted that the stack 5 can be placed in the press 3 in the opposite order, i.e. starting from element i) and working towards element a), this resulting in the same sequence just considered in the opposite order (i.e. top-to-bottom rather than bottom-to-top). In such a case, heat would be applied from either or both sides.

[0081] This press step is carried out under vacuum, e.g. using a vacuum bag press, using air pressure to exert a pressure of 400 to 1000 mbar to the stack 5 in consequence of the same amount of vacuum being drawn from the inside of the bag. However, other types of vacuum press are possible, and may be provided with a mechanical press arrangement to augment the pressure applied above that possible relying exclusively on atmospheric pressure. The application of substantially 400-1000 mbar of vacuum, irrespective of whether air pressure is used to press the stack 5 or if mechanical pressure is used, prevents the formation of bubbles of trapped air in the stack 5 as it cures, since all air between the elements is thereby evacuated before the hot melt adhesive layers 13, 17, 21, 25 melt and bond to their adjacent elements.

[0082] Heat is applied such that the temperature of the process reaches between 120 and 180°C, preferably 150-170°C, further preferably substantially 165°C. The press 3 may be pre-heated for a period of time, e.g. from 200-600 seconds

[0083] Once pressure is applied, temperature is maintained to cure the hot melt adhesive layers 13, 17, 21, 25, e.g. for 800-1200 seconds, preferably for 900-1100 seconds.

[0084] Then, if desired, the resulting module 1 can be cooled for a period of up to about 600 seconds to facilitate removal from the press 3 and prevent module

1 bending upon cooling due to thermal stresses set up due to different cooling rates of the edges and the centre of the module 1 and due to the different coefficient of thermal expansion associated with the materials of the module stack.

[0085] The resulting module 1 is illustrated in figure 2, with its front-side upwards (i.e. the opposite orientation compared to figure 1).

[0086] As can be seen, the entire structure of the module 1 is successfully produced in a single pressing step, including embedding the photovoltaic cells 15 into the combined layer resulting from the fusion of first and second hot melt adhesive layers 13, 17.

[0087] However, it is also possible to perform a so-called double lamination process, in which the module 1 is inverted in the press after the above-mentioned pressing step and is subjected to a second application of heat and pressure. This subsequent step can further improve the bonding obtained (especially if low thermal conductivity materials are used for layers e) to i)), but is not an essential step since the first pressing is sufficient to bond the stack 5 into the module 1.

[0088] Figure 3 illustrates a further embodiment of a solar photovoltaic module 1 according to the invention. This embodiment differs from that of figures 1 and 2 in that the front-side sheet is not placed directly upon the first hot melt adhesive layer 17, but is separated therefrom by a fifth hot melt adhesive layer 31 and an additional functional layer 29, which separates the fifth hot melt adhesive layer 31 from the first hot melt adhesive layer 13. Again, the fifth hot melt adhesive layer 31 may be the same or different to the others, as described above.

[0089] This additional functional layer may for instance comprise a polymeric film provided for its optical or structural properties, a coloured layer, glass fibres, an interferential filter such as a diffraction grating, or other functional layer to e.g. improve the impact resistance and/or change the appearance of the module 1.

[0090] Furthermore, other additional layers (and corresponding extra hot melt adhesive layers as required) can be incorporated into the structure as

desired. Also, further layers can be added to the front and/or back sides of the module 1 either during the above-mentioned processing, or in later steps. Also, frames, mounting points and so on can be added, as is generally known. Such extra features and extra steps are in no way excluded by the present invention, which is limited only insofar as defined in the appended claims.

[0091] The finished module 1 typically has a total thickness from 6-25mm, preferably 6-12mm, further preferably 6-10mm, and has a bending stiffness in the range of 9-19 Nm^2, preferably 10-16 Nm^2, further preferably 13-15 Nm^2.

[0092] Figure 4 illustrates schematically a building 33 comprising a pair of modules 1 according to the invention, one mounted on the roof, the other cladding a wall.

[0093] Implementation example

[0094] A module 1 according to figure 2 was constructed by the method of figure 1, using the following materials:

- front-side sheet 11: ETFE (Saint Gobain), thickness 0.1mm;
- each sheet of hot melt adhesive 13, 17, 21, 25: 1 layer of EVA (Bridgestone S88), thickness 0.45mm;
- photovoltaic cells 15: Bosch Solar Energy M 3BB;
- each reinforcing sheet 19, 27: GFRP (Swiss Composite, 220g/m^2 glass fibres), thickness 0.8mm;
- structural core layer 23: aluminium honeycomb (Eurocomposite ECM 4.8-77 3003 ZrOx), thickness 6mm.

[0095] The GFRP had previously been prepared, e.g. by its manufacturer, by embedding four layers of uni-directional glass fibre tapes with the relative orientations [0/90/90/0] in an epoxy matrix, and was cured at room temperature in a vacuum bag for 24 hours and then annealed at 100°C for 15 hours to degas it. The stack 5 was then assembled as discussed above, and hot-pressed under vacuum at 165°C with 300 seconds of pre-heating, 1000mbar pressure, 1080 seconds of curing and 600 seconds of cooling.

[0096] The resulting module 1 successfully passed the test sequence according to IEC 61215, and had a weight below 10 kg/m^2.

[0097] Although the invention has been described with reference to specific embodiments, variations thereto are possible within the scope of the invention as defined in the appended claims.

Claims

1. Method of manufacture of a photovoltaic module (1), comprising the steps of:
   - providing a heated vacuum press apparatus (3);
   - placing in said press apparatus (3) a stack (5) comprising at least the following sequence of separate elements:
   a) a front-side sheet (11);
   b) a first sheet of hot melt adhesive (13);
   c) an array of interconnected photovoltaic cells (15);
   d) a second sheet of holt melt adhesive (17);
   e) a first reinforcing sheet (19);
   f) a third sheet of hot melt adhesive (21);
   g) a structural core layer (23);
   h) a fourth sheet of hot melt adhesive (25);
   i) a second reinforcing sheet (27),
   - applying heat, vacuum and pressure to said stack (5) by means of said press apparatus (3) so as to cause each of said sheets of hot melt adhesives (13, 17, 21, 25) to bond said stack (5) together in a single process step.

2. Method according to the preceding claim, wherein said stack (5) further comprises between elements a) and b), the following sequence of further elements:
   a1) a fifth sheet of hot melt adhesive (31); and
   a2) an additional functional layer (29).

3. Method according to claim 2, wherein said additional functional layer (29) comprises at least one of:
   - a polymeric film;
   - glass fibres;
   - a coloured layer;
   - an interferential filter;
   - a diffraction grating.

4. Method according to any preceding claim, wherein said heat is applied from at least the front side of said stack (5).

5. Method according to any preceding claim, wherein said step of applying heat and pressure is carried out under the following conditions:
- temperature between 120 and 180°C, preferably between 150 and 170°C, further preferably substantially 165°C;
- pressure between 400 and 1000 mbar, preferably between 800 and 1000 mbar.

6. Method according to any preceding claim, wherein each sheet of hot melt adhesive (13, 17, 21, 25) has the following properties:
- thickness in the range of 0.2 to 0.6mm, preferably 0.3 to 0.5mm;
- a melting point in the range 80 to 120°C, preferably 90-110°C, more preferably 95-105°C.
- a glass transition temperature above 85°C, preferably above 100°C, and
- a complex modulus above 3000kPa at 20°C, preferably above 6000kPa at 20°C.

7. Method according to any preceding claim, wherein each sheet of hot melt adhesive (13, 17, 21, 25) comprises at least one of: Ethylene-vinyl acetate, Polyvinyl butyral, Polyolefin, Thermoplastic Polyolefin, Thermoplastic Polyurethane, silicone, an ionomer.

8. Method according to any preceding claim, wherein the photovoltaic module (1) obtained by said application of heat, pressure and vacuum is inverted in the press and is subjected to a supplemental step of application of heat, pressure and vacuum.

9. Photovoltaic module (1) comprising a stack (5) comprising the following sequence of elements:
a) a front-side sheet (11);
b) a first sheet of hot melt adhesive (13);

c) an array of interconnected photovoltaic cells (15);

d) a second sheet of holt melt adhesive (17);

e) a first reinforcing sheet (19);

f) a third sheet of hot melt adhesive (21);

g) a structural core layer (23);

h) a fourth sheet of hot melt adhesive (25;

i) a second reinforcing sheet (27).

10. Photovoltaic module (1) according to the preceding claim, further comprising between elements a) and b) the following sequence of further elements:

a1) a fifth sheet of hot melt adhesive (31); and

a2) an additional functional layer (29).

11. Photovoltaic module (1) according to any of claims 9-10, wherein each of said elements (13, 15, 17, 19, 21, 27, 27, 29, 31) is situated directly in contact with the subsequent layer mentioned.

12. Photovoltaic module (1) according to any of claims 9-11 obtained by the method of one of claims 1-7.

13. Building (33) comprising a photovoltaic module (1) according to any of claims 9-12.

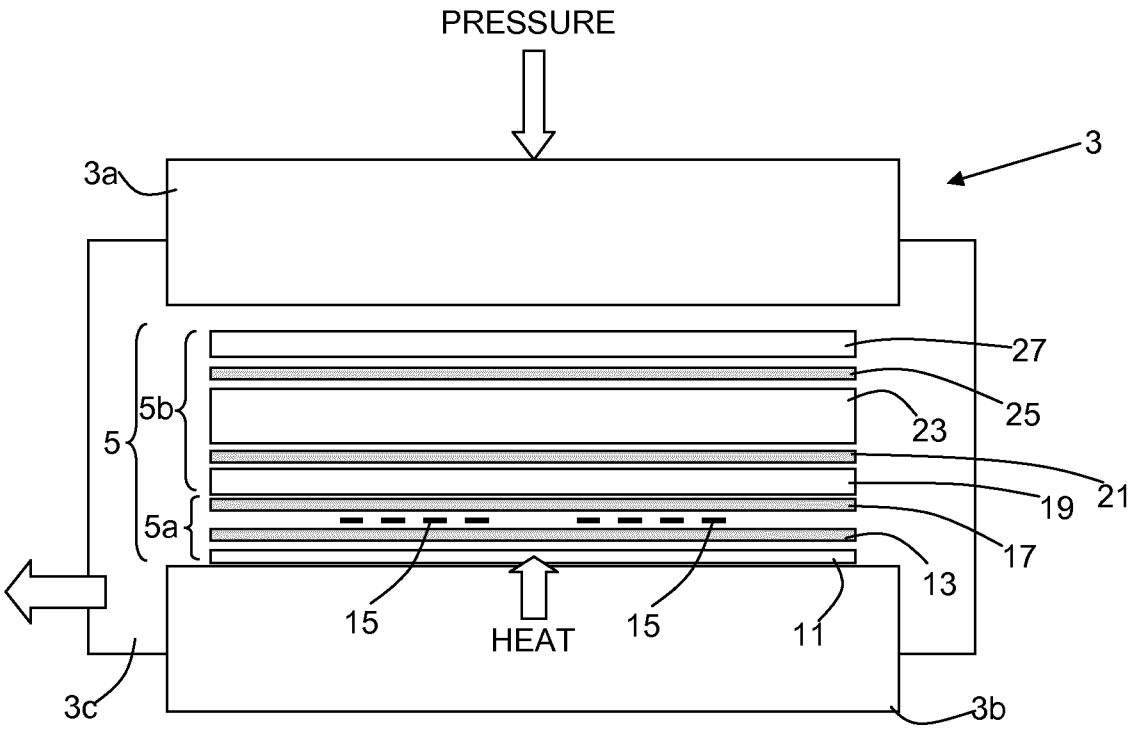


Figure 1

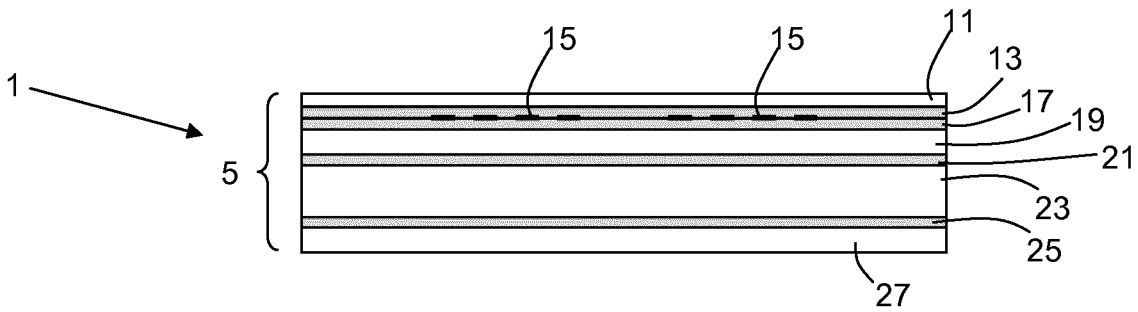


Figure 2

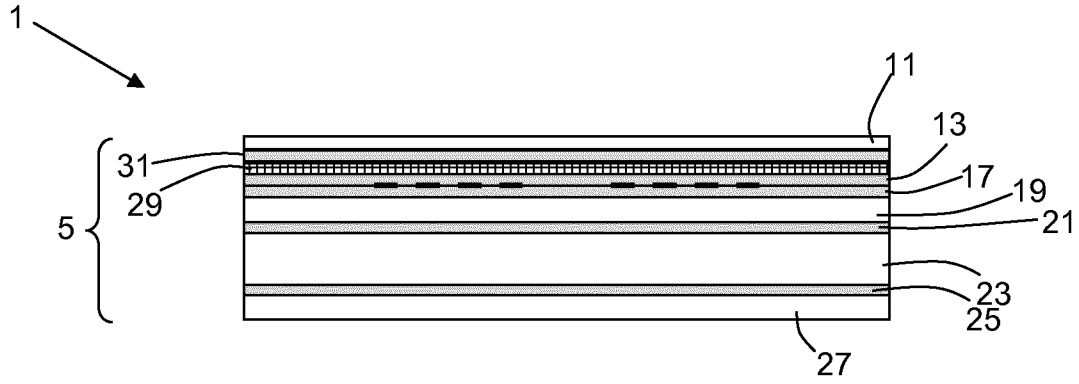


Figure 3

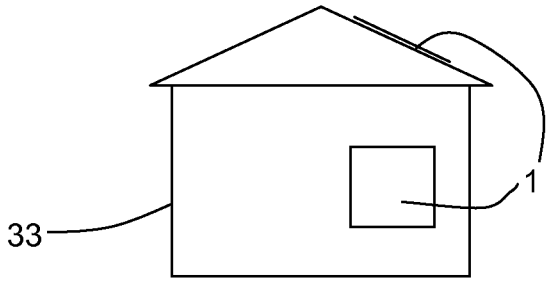


Figure 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/071094

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L31/048 B32B37/10
ADD.

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)
H01L B32B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

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Y	WO 2013/005746 A1 (ASAHI GLASS CO LTD [JP]; IKEDA YASUHIRO [JP]; SAKAMOTO HIROSHI [JP]; K) 10 January 2013 (2013-01-10) abstract; figure 11 -----	2,3,10
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 April 2018	24/04/2018

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/071094

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 2017/165952 A1 (HOFFMAN TED M [US] ET AL) 15 June 2017 (2017-06-15) paragraphs [0048] - [0054]; figures 5-6 -----	8

1

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Information on patent family members

International application No
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