



(43) International Publication Date
2 August 2012 (02.08.2012)

- (51) International Patent Classification:
B32B 17/10 (2006.01) *H01L 31/048* (2006.01)
- (21) International Application Number:
PCT/US2012/022514
- (22) International Filing Date:
25 January 2012 (25.01.2012)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
61/436,719 27 January 2011 (27.01.2011) US
13/355,837 23 January 2012 (23.01.2012) US
- (71) Applicant (for all designated States except US): **CORNING INCORPORATED** [US/US]; 1 Riverfront Plaza, Corning, New York 14831 (US).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **KROL, Mark Francis** [US/US]; 11 Linden Lane, Painted Post, New York 14870 (US). **WEBB, James Ernest** [US/US]; 102 High Road, Corning, New York 14830 (US).
- (74) Agent: **THOMPSON, Tina N**; Corning Incorporated, Intellectual Property Department, SP-Ti-03-01, Corning, New York 14831 (US).

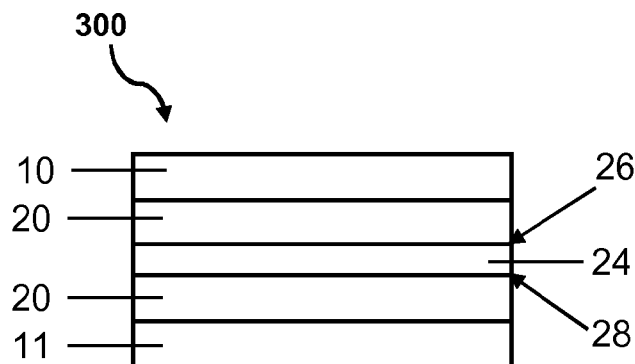
(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, 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, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, 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, ML, MR, NE, SN, TD, TG).

Published:

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

(54) Title: LAMINATED PV MODULE PACKAGE



20(c)

Figure 3

(57) Abstract: Laminated packages and photovoltaic modules having a glass substrate layer or a plurality of glass substrate layers encapsulated between top and bottom glass protective layers. The glass substrate layers can have similar CTE. Likewise, the top and bottom glass protective layers can have similar CTEs, CTEs that may be different from the CTE of the glass substrate layer or layers.

LAMINATED PV MODULE PACKAGE

[0001] This application claims the benefit of priority under 35 U.S.C. §119 of U.S. Provisional Application Serial No. 61/436719 filed on January 27, 2011 and claims the benefit of priority under 35 U.S.C. §120 of U.S. Application Serial No. 13/355837 filed on January 23, 2012 the content of which is relied upon and incorporated herein by reference in its entirety.

BACKGROUND

FIELD

[0002] Embodiments relate generally to laminated glass packages, and more particularly to laminated glass packages useful, for example, for thin film or wafered photovoltaic modules.

TECHNICAL BACKGROUND

[0003] Photovoltaic modules are used to convert sunlight into electricity. Two major types used or in development today are wafered modules using multiple silicon wafers connected together and thin film modules using cadmium telluride (CdTe), copper indium gallium diselenide (CIGS) or thin film (amorphous and microcrystalline) silicon. Typical packages **100** for the wafered modules have one protective glass layer **10** such as soda lime, a polymer backsheet **12**, silicon wafers **16** and encapsulant layers **20** between the protective glass layer and the backsheet, and an edge seal **18**, a metal frame **14**, and electrical contacts **22** as shown by the cross section in **Figure 1A**. Typical packages **101** for thin film modules have two protective glass layers **10** such as soda lime, a thin film(s) **17**, an encapsulant layer **20** between the two glass sheets, an edge seal **18**, and electrical contacts **22** as shown by the cross section in **Figure 1B**. Ethylene vinyl acetate (EVA), polyvinyl butyral (PVB) or other encapsulants are commonly used to bond the two sheets together. Sealing materials such as a butyl sealant at the module perimeters are used to increase moisture resistance.

[0004] PV modules need to endure various environmental conditions that can cause stresses in the glass sheets. Modules are subjected to forces from wind, snow and hail. International Electrotechnical Commission (IEC) document 61646, "Thin-Film Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval," states that a thin film photovoltaic module must withstand wind loads of 2400 Pa, snow loads of 5400 Pa, and impacts by 25 mm

diameter ice balls projected in a direction perpendicular to the module face at a speed of 23 m/s (51 mph).

[0005] Embodiments described herein may provide solutions to minimize and potentially eliminate the described bowing resulting from lamination when using specialty glasses while also improving the module mechanical robustness.

SUMMARY

[0006] This application describes a laminated glass package that is symmetric with respect to glass coefficient of thermal expansion (CTE) variations through the module package thickness. This package includes 3 or more layers of glass. Starting with the glass on the outside surface, it is ideally paired with a glass of the similar CTE on the other outside surface. The next layer of paired glasses is also ideally of similar CTE, but the CTE can be different than other pairs in the package. In instances where a center sheet of glass is used, this glass may have a CTE different from the CTE of the matched pairs of glass surrounding it. The laminated glass package may be a thin film photovoltaic module package with two sheets of soda lime silicate glasses on the module exterior acting as protective glass layers, wherein there is placed one or more glass substrate layers between the glass protective layers.

[0007] One embodiment is a laminated glass package comprising a glass substrate layer having a top surface and a bottom surface, a bottom glass protective layer, the bottom glass protective layer being laminated to the bottom surface of the glass substrate layer, and a top glass protective layer, the top glass protective layer being laminated to the top surface of the glass substrate layer, wherein the top glass protective layer and the bottom glass protective layer have similar coefficients of thermal expansion.

[0008] Another embodiment is a laminated glass package comprising a first glass substrate layer having a top surface and a bottom surface, a second glass substrate layer having a top surface and a bottom surface, a bottom glass protective layer, the bottom glass protective layer being laminated to the bottom surface of the second glass substrate layer, and a top glass protective layer, the top glass protective layer being laminated to the top surface of the first glass substrate layer, wherein the top glass protective layer and the bottom glass protective layer have similar coefficients of thermal expansion.

[0009] Another embodiment is a photovoltaic module comprising a glass substrate layer having a top surface and a bottom surface, a bottom glass protective layer, the bottom glass protective layer being laminated to the bottom surface of the glass substrate layer, a top glass protective layer, the top glass protective layer being laminated to the top surface of the glass substrate layer, and a photovoltaic functional material disposed between either the bottom surface or the top surface of the glass substrate layer and either the bottom or the top glass protective layer, wherein the top glass protective layer and the bottom glass protective layer have similar coefficients of thermal expansion.

[0010] A further embodiment is a photovoltaic module comprising a first glass substrate layer having a top surface and a bottom surface, a second glass substrate layer having a top surface and a bottom surface, a bottom glass protective layer, the bottom glass protective layer being laminated to the bottom surface of the second glass substrate layer, a top glass protective layer, the top glass protective layer being laminated to the top surface of the first glass substrate layer, and a photovoltaic functional material disposed between either the bottom surface of the first glass substrate layer or the top surface of the second glass substrate layer and either the bottom or the top glass protective layer, wherein the top glass protective layer and the bottom glass protective layer have similar coefficients of thermal expansion.

[0011] Additional features and advantages of the invention will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from the description or recognized by practicing the invention as described in the written description and claims hereof, as well as the appended drawings.

[0012] It is to be understood that both the foregoing general description and the following detailed description are merely exemplary of the invention, and are intended to provide an overview or framework for understanding the nature and character of the invention as it is claimed.

[0013] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate one or more embodiment(s) of the invention and together with the description serve to explain the principles and operation of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The invention can be understood from the following detailed description either alone or together with the accompanying drawing figures.

[0015] **Figure 1A** and **Figure 1B** show conventional cross sectional schematics of wafered and thin film modules, respectively.

[0016] **Figure 2A** and **Figure 2B** show cross sectional schematics of the effect of CTE on bowing of a dual glass PV module.

[0017] **Figure 3** shows a cross sectional schematic of a laminated glass package, according to one embodiment.

[0018] **Figure 4** shows a cross sectional schematic of a PV module, according to one embodiment.

[0019] **Figure 5** shows a cross sectional schematic of a PV module, according to one embodiment.

[0020] **Figure 6** shows a cross sectional schematic of a laminated glass package, according to one embodiment.

[0021] **Figure 7** shows a cross sectional schematic of a PV module, according to one embodiment.

DETAILED DESCRIPTION

[0022] Reference will now be made in detail to various embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[0023] As used herein, the term “specialty glass” is used to describe any glass layer having a chemical composition that is different than the chemical composition of common soda lime glass. Specialty glasses typically have CTE values over the range, but not limited to, 2 to 9 ppm/°C, for example, 3 to 9 ppm/°C, for example, 3 to 5 ppm/°C and common soda lime glass has CTE values in the range of 8 to 9 ppm/°C.

[0024] Specialty glasses have been identified as an enabler to improving conversion efficiency. As a result of modifying the glass composition, the coefficient of thermal expansion (CTE) may not be equivalent to that of commonly used soda lime silicate glass. **Figure 2A** and **Figure 2B** show the effect of CTE on the flatness of a laminated module. Features **200** of a PV module are shown in **Figure 2A**. If the CTE's of the glass sheet, such as a specialty glass

sheet **24** and the other glass sheet, such as a soda lime glass sheet **10** are the same when laminated, for example, with an encapsulant layer **20**, the module remains flat with minimum bow. If the CTE's of the specialty glass **24** and the other glass sheet, such as a soda lime glass sheet **10** are different when laminated, for example, with an encapsulant layer **20**, the module is bowed to some degree dependent upon the magnitude of the CTE mismatch. The bowing results from the lamination process occurring at a higher temperature than the module use range. As a result the module is bowed toward the higher CTE glass, as shown in **Figure 2B**. The maximum bow occurs at the coldest temperature the module experiences.

[0025] One embodiment is a laminated glass package comprising a glass substrate layer having a top surface and a bottom surface, a bottom glass protective layer, the bottom glass protective layer being laminated to the bottom surface of the glass substrate layer, and a top glass protective layer, the top glass protective layer being laminated to the top surface of the glass substrate layer, wherein the top glass protective layer and the bottom glass protective layer have similar coefficients of thermal expansion.

[0026] Herein is described a laminated glass package that is symmetric with respect to glass CTE variations through the module package thickness. **Figure 3** shows a cross sectional schematic of features of a laminated glass package **300**, according to one embodiment. In this embodiment, the laminated glass package comprises a glass substrate layer **24** that has both a top surface **26** and a bottom surface **28**.

[0027] The glass substrate layer may be a thin soda lime glass, or a specialty glass that has been engineered to have (a) a particular CTE different from soda lime glass; (b) a desirable chemical compositions; (c) engineered to have a high strain point; and/or (d) engineered to have some other desirable property that may enhance the performance of the glass. The glass substrate layer, for example, specialty glass layer can have a thickness of 1.5mm or less, for example, 1.4mm or less, for example, 1.3mm or less, for example, 1.2mm or less, for example, 1.1mm or less, for example, 1.0mm or less, for example, 0.9mm or less, for example, 0.8mm or less than, for example, 0.7mm or less, for example, 0.6mm or less, for example, 0.5mm or less, or, for example, in the range of from 0.5mm to 1.5mm, for example, from 0.5mm to 1.4mm, for example, from 0.5mm to 1.3mm, for example, from 0.5mm to 1.2mm, for example, from 0.5mm to 1.1mm, for example, from 0.5mm to 1.0mm, or for example, from 0.05mm to 0.5mm.

[0028] As shown in **Figure 3**, the laminated glass package comprises a top protective glass layer **10** and a bottom protective glass layer **11**, the bottom glass protective layer being laminated to the bottom surface of the glass substrate layer, and the top glass protective layer being laminated to the top surface of the glass substrate layer. In one embodiment, the top glass protective layer and the bottom glass protective layer have similar coefficients of thermal expansion.

[0029] In one embodiment, the protective glass layers are standard soda lime glass of a thickness sufficient to provide the mechanical damage resistance and other reliability requirements. **Figure 3** further describes encapsulant layers **20** interposed between the glass substrate layer **24** and the top and bottom glass protective layers **10** and **11**.

[0030] The encapsulant layers may be an Ethylene-vinyl acetate (EVA) silicone-based material (e.g. STR PhotoCap[®] 0507P), or a polyvinyl butyral (PVB) silicone-based material (e.g. Kuraray Trisifol[®] Solar R40). These materials are used as a bonding material to bond adjacent glass sheets together. The encapsulant layers may also be of some other material known in the art that may have suitable characteristics such as adhesion or transmission. In one embodiment, the CTE of the top protective glass layer and the bottom protective glass layer are similar if not identical. The CTE of the glass substrate layer may be different from the CTE of the protective glass layers.

[0031] Another embodiment, features of which are shown in **Figure 6**, is a laminated glass package **600** comprising a first glass substrate layer **24(a)** having a top surface **26** and a bottom surface **28**, a second glass substrate layer **24(b)** having a top surface **27** and a bottom surface **29**, a bottom glass protective layer **11**, the bottom glass protective layer being laminated to the bottom surface of the second glass substrate layer, and a top glass protective layer **10**, the top glass protective layer being laminated to the top surface of the first glass substrate layer, wherein the top glass protective layer and the bottom glass protective layer have similar coefficients of thermal expansion. The laminated glass package can further comprise a first encapsulation layer **20(a)** interposed between the top surface of the first glass substrate layer and the top glass protective layer, and a second encapsulation layer **20(b)** interposed between the bottom surface of the second glass substrate layer and the bottom glass protective layer. The laminated glass package may further comprise a third encapsulation layer **20(c)** disposed between the first and second glass substrate layers.

[0032] Another embodiment is a photovoltaic module comprising a glass substrate layer having a top surface and a bottom surface, a bottom glass protective layer, the bottom glass protective layer being laminated to the bottom surface of the glass substrate layer, a top glass protective layer, the top glass protective layer being laminated to the top surface of the glass substrate layer, and a photovoltaic functional material disposed between either the bottom surface or the top surface of the glass substrate layer and either the bottom or the top glass protective layer, wherein the top glass protective layer and the bottom glass protective layer have similar coefficients of thermal expansion.

[0033] Features of a photovoltaic module **400** are shown by the cross sectional illustration shown in **Figure 4**. Referring to **Figure 4**, a photovoltaic module may comprise a laminated glass package such as the embodiment shown in **Figure 3**. In one embodiment, the glass substrate layer **24** is a specialty glass. The material and thicknesses of the substrate layers may be as previously described above. It is conceivable that, depending upon the material and/or the thicknesses of the top protective glass layer **10** and the bottom protective glass layer **11**, the glass substrate layer may be 0.5mm or less. In one embodiment, encapsulant layers **20(a)** and **20(b)** are interposed between the glass substrate layer **24** and the top glass protective layer **10** and between the functional layer **30** and the bottom glass protective layers **11**, respectively. Depending upon the material used for the encapsulant layers **20(a)** and **20(b)**, an edge seal **18** may be advantageous. The edge seal is typically of a non-conductive butyl sealant material, and provides additional hermetic sealing to the module. A photovoltaic functional material **30** may be a cadmium telluride (CdTe) functional layer, a CIGS functional layer, a silicon-tandem (Si-Tandem) functional layer or even an amorphous silicon (a-Si) functional layer. Where the photovoltaic functional material **30** is CdTe, Si-Tandem or a-Si, the functional layer is disposed on and/or adhered to the bottom surface **28** of the glass substrate layer **24** (embodiment shown in **Figure 4**). Where the photovoltaic functional material **30** is CIGS, then the functional layer is disposed on and/or adhered to the top surface **26** of the glass substrate layer **24**. Attached to the functional layer are bus bars **32** and attached thereto are conducting ribbons **34**.

[0034] In the case of silicon wafer based photovoltaic modules, where the photovoltaic functional material is silicon wafers, the silicon wafers and interconnecting electrodes and bus bases can be disposed in the encapsulant layer between the glass substrate layer **24** and bottom

glass protective layer **12**. In some embodiments, the silicon wafers are surrounded by the encapsulant layer.

[0035] The bottom protective glass layer **11**, in one embodiment, is provided with a through via or feed through hole **36** to allow the ribbon connectors to pass through the bottom protective glass layer. Also as shown in **Figure 4**, a junction box **38** is connected to the conducting ribbons and attached to the bottom surface of the bottom protective glass layer, also at the point of the feed through hole.

[0036] Further referring to **Figure 4**, the top protective glass layer **10** and the bottom protective glass layer **11** may be made out of tempered soda lime glass of a thickness, for example, 1.5mm or more, for example 2.0mm or more. The protective glass layers provide the PV module with the required mechanical robustness against wind, snow, and hail. The encapsulant layers **20(a)** and **20(b)** are interposed between the glass substrate layer **24** and the top glass protective layer and between the functional layer **30** and the bottom glass protective layer, respectively. Depending upon the encapsulant layers **20(a)** and **20(b)** materials used, an edge seal **18** may be advantageous. The edge seal, for example, a perimeter seal is typically of a non-conductive butyl sealant material, and provides additional hermetic sealing to the module. As with the glass package, it is preferable for the CTE of the top protective glass layer and the bottom protective glass layer to be similar if not identical. The CTE of the glass substrate layer may be different from the CTE of the protective glass layers. This symmetric stacking of the top and bottom protective glass layers having similar CTEs, significantly reduces if not eliminates the lamination bow.

[0037] A further embodiment is a photovoltaic module comprising a first glass substrate layer having a top surface and a bottom surface, a second glass substrate layer having a top surface and a bottom surface, a bottom glass protective layer, the bottom glass protective layer being laminated to the bottom surface of the second glass substrate layer, a top glass protective layer, the top glass protective layer being laminated to the top surface of the first glass substrate layer, and a photovoltaic functional material disposed between either the bottom surface of the first glass substrate layer or the top surface of the second glass substrate layer and either the bottom or the top glass protective layer, wherein the top glass protective layer and the bottom glass protective layer have similar coefficients of thermal expansion.

[0038] Features of a photovoltaic module **500** and **700** are shown by the cross sectional illustrations shown in **Figure 5** and **Figure 7**, respectively. In these embodiments, a plurality of glass substrate layers may be used. A first glass substrate layer **24(a)** can be a thin specialty glass. The glass, for example, the specialty glass can have a thickness of 1.5mm or less, for example, 1.4mm or less, for example, 1.3mm or less, for example, 1.2mm or less, for example, 1.1mm or less, for example, 1.0mm or less, for example, 0.9mm or less, for example, 0.8mm or less than, for example, 0.7mm or less, for example, 0.6mm or less, for example, 0.5mm or less, or, for example, in the range of from 0.5mm to 1.5mm, for example, from 0.5mm to 1.4mm, for example, from 0.5mm to 1.3mm, for example, from 0.5mm to 1.2mm, for example, from 0.5mm to 1.1mm, for example, from 0.5mm to 1.0mm, or for example, from 0.05mm to 0.5mm. A photovoltaic functional material **30** is disposed between either the bottom surface of the first glass substrate layer or the top surface of the second glass substrate layer and either the bottom or the top glass protective layer or, in some embodiments, attached to the bottom surface of the first glass substrate layer **24(a)** as described above for CdTe, a-Si, and Si-Tandem as shown in **Figure 5**. Attached to the photovoltaic functional material are the bus bars **32** and attached thereto are the conducting ribbons **34**. A second glass substrate layer **24(b)**, which in one embodiment is a matched glass to the first glass substrate layer **24(a)**, namely a similar specialty glass having a similar CTE, is attached to the first glass substrate layer via the use of an encapsulant layer **20(c)**. In the case of CIGS, the functional layer, bus bars, and conducting ribbons are disposed on the top surface of the second glass substrate layer **24(b)**. In the case of silicon wafer based modules as shown in **Figure 7**, the silicon wafers **16** and interconnecting electrodes **35** and bus bars **32** can be disposed in the encapsulant layer **20(c)** between the first glass substrate layer and second glass substrate layer. Top and bottom protective glass layers, **10** and **11** respectively, are provided to enclose the matched specialty glass layers. The photovoltaic module can further comprise a first encapsulation layer **20(a)** interposed between the top surface of the first glass substrate layer and the top glass protective layer, and a second encapsulation layer **20(b)** interposed between the bottom surface of the second glass substrate layer and the bottom glass protective layer. The laminated glass package may further comprise a third encapsulation layer **20(c)** disposed between the first and second glass substrate layers.

[0039] Further encapsulant layers **20** are employed to adhere the first glass substrate layer **24(a)** to the top protective layer **10**, and the second glass substrate layer **24(b)** to the bottom protective layer **11**. As previously described, the bottom protective glass layer has a feed through hole **36** to allow the ribbon connectors **34** to pass through the bottom protective glass layer **11**. In one embodiment, the top protective glass layer and the bottom protective glass layer can be tempered soda lime glass, for example, of a thickness 3.2mm or less, for example, 2mm or less, or, for example, 1.5mm or more, or for example, 1.5mm to 3.2mm. In some embodiments, the protective glass layers can have a thickness of 1.5mm or less, for example, 1.4mm or less, for example, 1.3mm or less, for example, 1.2mm or less, for example, 1.1mm or less, for example, 1.0mm or less, for example, 0.9mm or less, for example, 0.8mm or less than, for example, 0.7mm or less, for example, 0.6mm or less, for example, 0.5mm or less, or, for example, in the range of from 0.5mm to 1.5mm, for example, from 0.5mm to 1.4mm, for example, from 0.5mm to 1.3mm, for example, from 0.5mm to 1.2mm, for example, from 0.5mm to 1.1mm, for example, from 0.5mm to 1.0mm, or for example, from 0.05mm to 0.5mm. Further, the top protective glass layer and the bottom protective glass layer, in one embodiment, are the same material and have similar if not identical CTEs. As shown in **Figure 5** and **Figure 7**, an edge seal **18** is used to further encapsulate the module. The edge seal **18** is placed between the top protective layer **10** and the bottom protective layer **11**, thereby fully enclosing the glass substrate layers. The CTE of the glass substrate layers may be different from the CTE of the protective glass layers. This symmetric stacking of the top and bottom protective glass layers both having similar CTEs, surrounding a matched CTE pair of glass substrate layers, significantly reduces if not eliminates the lamination bow. To complete the photovoltaic module, also as shown in **Figure 5** and **Figure 7**, the junction box **38** is connected to the conducting ribbons and attached to the bottom surface of the bottom protective glass layer, also at the point of the feed through hole **36**.

[0040] In the embodiments described herein, the glass substrate layers can be specialty glasses having CTE values over the range, but not limited to, 2 to 9 ppm/°C, for example, 3 to 9 ppm/°C, for example, 3 to 5 ppm/°C and the glass protective layers can be common soda lime glass having CTE values in the range of 8 to 9 ppm/°C. The glass protective layers can be either strengthened or tempered glass, for example, strengthened or tempered soda lime. In some embodiments, the glass substrate layers and the protective glass layers can have the same

CTE. In one embodiment, soda lime glass is the top and bottom protective layers with a CTE of from 8 to 9 ppm/°C and the glass substrate layer(s) is a specialty glass with a CTE of from 3.1 to 4.5 ppm/°C.

[0041] It will be apparent to those skilled in the art that various modifications and variations can be made to the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

CLAIMS

What is claimed is:

1. A laminated glass package comprising:
a glass substrate layer having a top surface and a bottom surface;
a bottom glass protective layer, the bottom glass protective layer being laminated to the bottom surface of the glass substrate layer; and
a top glass protective layer, the top glass protective layer being laminated to the top surface of the glass substrate layer,
wherein the top glass protective layer and the bottom glass protective layer have similar coefficients of thermal expansion.
2. The package according to claim 1, wherein the glass substrate layer has a thickness of 1.5 mm or less.
3. The package according to claim 1, wherein the top and bottom glass protective layers each have a thickness of 1.5 mm or more.
4. The package according to claim 1, wherein the glass substrate layer has a coefficient of thermal expansion which is different than the coefficients of thermal expansion of the top and bottom glass protective layers.
5. The package according to claim 4, wherein the glass substrate layer is a specialty glass.
6. The package according to claim 1, wherein the top and bottom glass protective layers are both a soda lime glass.
7. The package according to claim 1, further comprising:
a first encapsulation layer adhered to the top surface of the glass substrate layer; and
a second encapsulation layer adhered to the bottom surface of the glass substrate layer.
8. A laminated glass package comprising:
a first glass substrate layer having a top surface and a bottom surface;

a second glass substrate layer having a top surface and a bottom surface;
a bottom glass protective layer, the bottom glass protective layer being laminated to the bottom surface of the second glass substrate layer; and
a top glass protective layer, the top glass protective layer being laminated to the top surface of the first glass substrate layer,
wherein the top glass protective layer and the bottom glass protective layer have similar coefficients of thermal expansion.

9. The package according to claim 8, wherein the first glass substrate layer and the second glass substrate layer have similar coefficients of thermal expansion.
10. The package according to claim 8, further comprising:
a first encapsulation layer interposed between the top surface of the first glass substrate layer and the top glass protective layer; and
a second encapsulation layer interposed between the bottom surface of the second glass substrate layer and the bottom glass protective layer.
11. A photovoltaic module comprising:
a glass substrate layer having a top surface and a bottom surface;
a bottom glass protective layer, the bottom glass protective layer being laminated to the bottom surface of the glass substrate layer;
a top glass protective layer, the top glass protective layer being laminated to the top surface of the glass substrate layer; and
a photovoltaic functional material disposed between either the bottom surface or the top surface of the glass substrate layer and either the bottom or the top glass protective layer,
wherein the top glass protective layer and the bottom glass protective layer have similar coefficients of thermal expansion.
12. The module according to claim 11, wherein the photovoltaic functional material comprises a thin film photovoltaic layer or a silicon wafer.

13. The module according to claim 11, further comprising:
 - a first encapsulation layer interposed between the top surface of the glass substrate layer and the top glass protective layer; and
 - a second encapsulation layer interposed between the bottom surface of the glass substrate layer and the bottom glass protective layer.
14. The module according to claim 13, further comprising:
 - an edge seal, sealingly attached to the top glass protective layer and to the bottom glass protective layer, enclosing therein the glass substrate layer having the functional layer thereon and the first and second encapsulation layers.
15. The module according to claim 11, wherein the glass substrate layer has a thickness of 1.5 mm or less.
16. The module according to claim 11, wherein the top and bottom glass protective layers each have a thickness of 1.5 mm or more.
17. The module according to claim 11, wherein the glass substrate layer has a coefficient of thermal expansion which is different than the coefficients of thermal expansion of the top and bottom glass protective layers.
18. A photovoltaic module comprising:
 - a first glass substrate layer having a top surface and a bottom surface;
 - a second glass substrate layer having a top surface and a bottom surface;
 - a bottom glass protective layer, the bottom glass protective layer being laminated to the bottom surface of the second glass substrate layer;
 - a top glass protective layer, the top glass protective layer being laminated to the top surface of the first glass substrate layer; and
 - a photovoltaic functional material disposed between either the bottom surface of the first glass substrate layer or the top surface of the second glass substrate layer and either the bottom or the top glass protective layer,

wherein the top glass protective layer and the bottom glass protective layer have similar coefficients of thermal expansion.

19. The module according to claim 18, wherein the photovoltaic functional material comprises a thin film photovoltaic layer or a silicon wafer.
20. The module according to claim 18, further comprising:
a plurality of encapsulation layers interposed between the top and bottom glass protective layers and the first and second glass substrate layers.
21. The module according to claim 18, further comprising:
an edge seal, sealingly attached to the top glass protective layer and to the bottom glass protective layer, enclosing therein the first and second glass substrate layers and the plurality of encapsulation layers.
22. The module according to claim 18, wherein the first and second glass substrate layers have similar coefficients of thermal expansion.
23. The module according to claim 18, wherein the first glass substrate layer and the second glass substrate layers both have thicknesses of less than 1.5 mm.
24. The module according to claim 18, wherein the top and bottom glass protective layers each have a thickness of 1.5 mm or more.
25. The module according to claim 18, wherein the first and second glass substrate layers are a specialty glass having a coefficient of thermal expansion that is not equal to the coefficient of thermal expansion of the top and bottom glass protective layers.

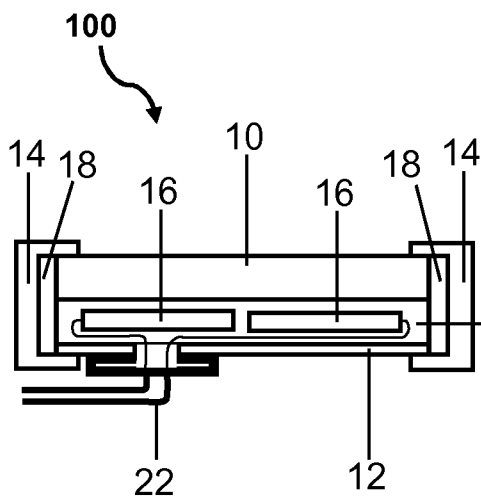


Figure 1A
Prior Art

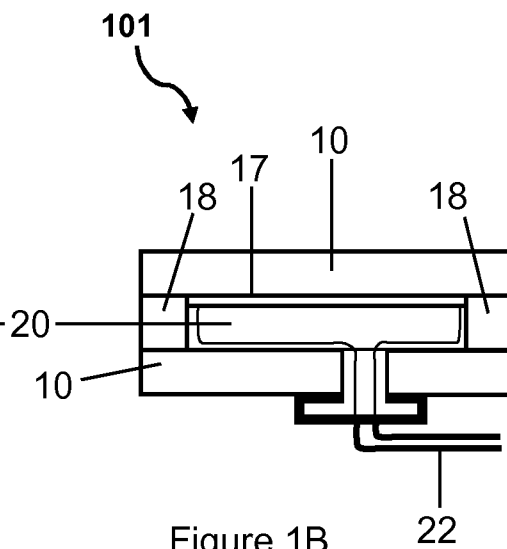


Figure 1B
Prior Art

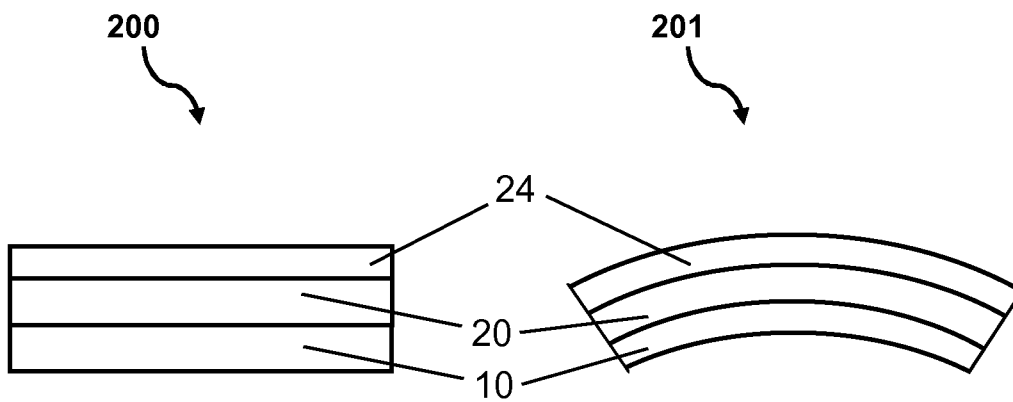
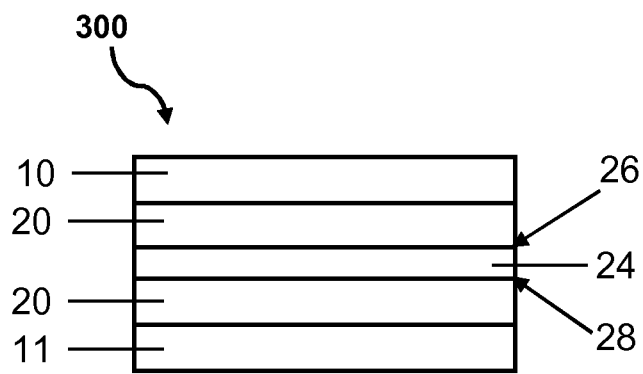


Figure 2A

Figure 2B



20(c) Figure 3

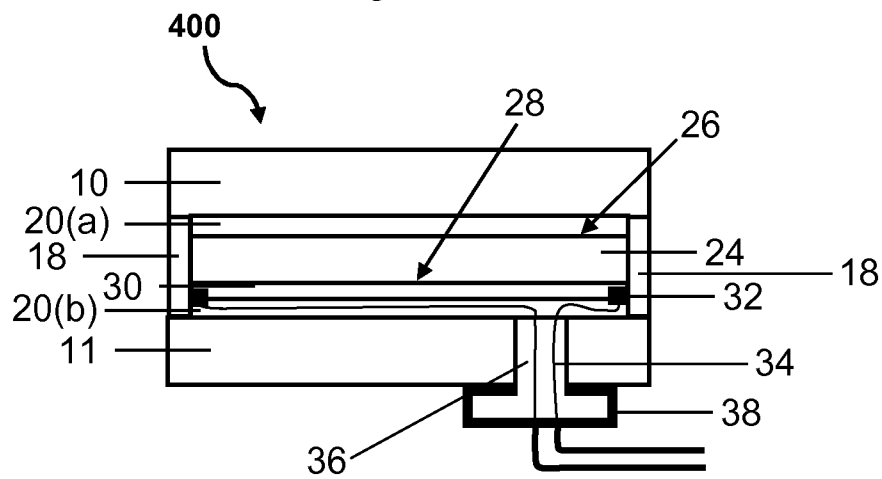


Figure 4

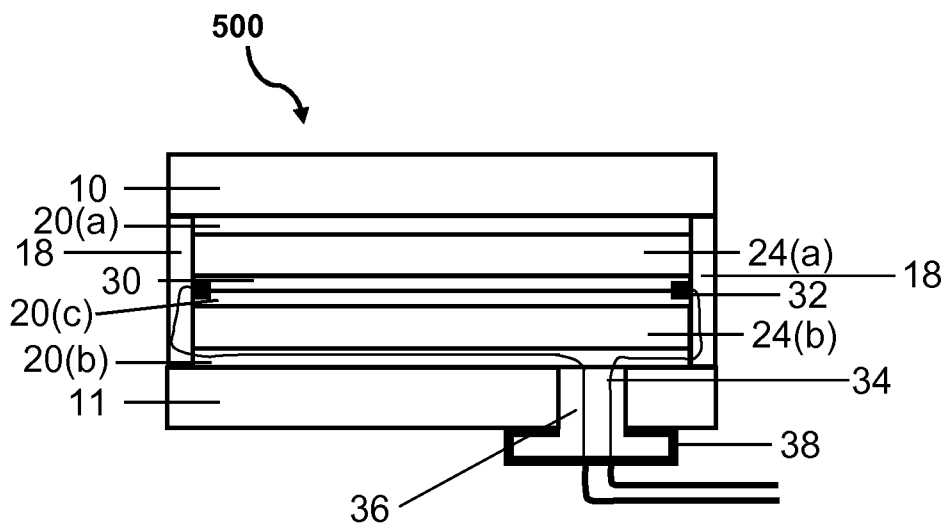


Figure 5

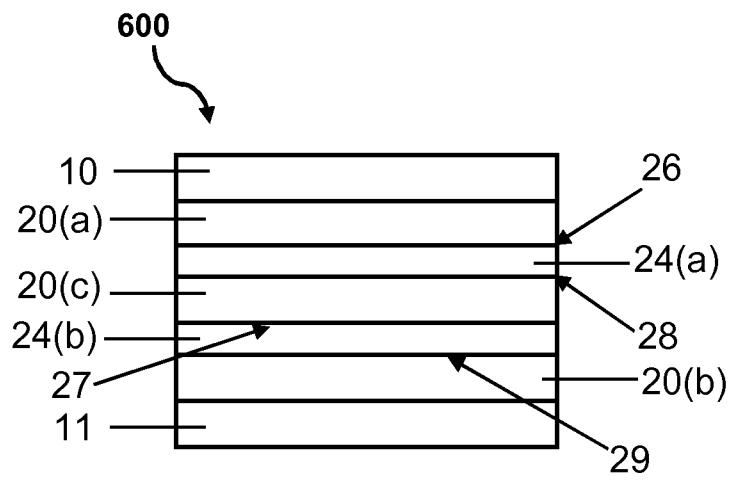


Figure 6

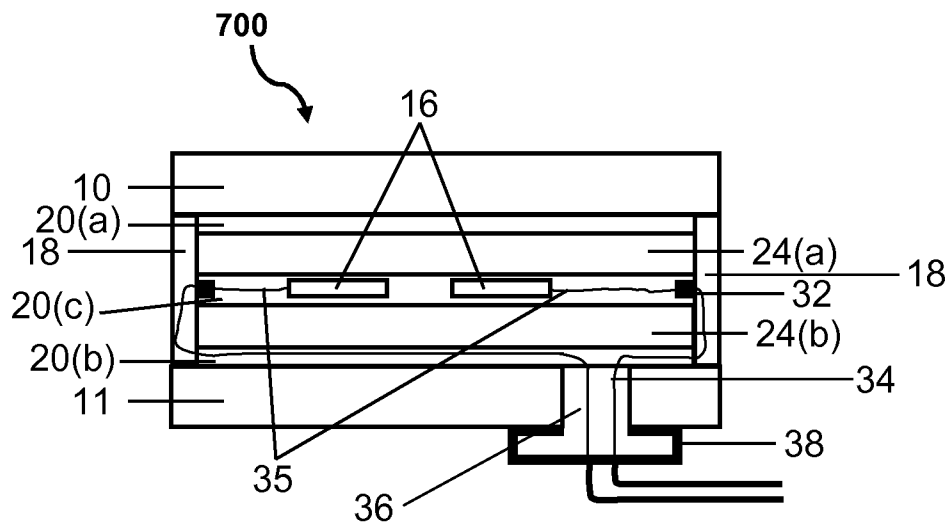


Figure 7

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2012/022514

A. CLASSIFICATION OF SUBJECT MATTER

INV. B32B17/10 H01L31/048
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)

B32B H01L

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 practical, search terms used)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2006 042538 A1 (FUTECH GMBH [DE]) 27 March 2008 (2008-03-27) paragraph [0018] - paragraph [0020] paragraph [0027] - paragraph [0028] paragraph [0034] paragraph [0079] - paragraph [0084]; figure 5 paragraph [0106] - paragraph [0122]; claims; figure 6 -----	1-10
X	GB 1 319 846 A (KALLE AG) 13 June 1973 (1973-06-13) page 1, line 51 - page 2, line 98; examples ----- -/--	1,2,4,7



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

"E" earlier document 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

13 April 2012

Date of mailing of the international search report

07/05/2012

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Lindner, Thomas

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2012/022514

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/127679 A1 (GULATI SURESH T [US] ET AL GULATI SURESH THAKORDAS [US] ET AL) 15 June 2006 (2006-06-15) paragraph [0058] - paragraph [0059]; figures 3,4 -----	1,4
X	US 2010/224235 A1 (TAKAGI NAOTO [JP] ET AL) 9 September 2010 (2010-09-09) paragraph [0093]; claims 1,2,13; figure 3A -----	1,2,5,7, 11-15
X	US 2010/200063 A1 (DJEU DEREK [US]) 12 August 2010 (2010-08-12) paragraph [0035] - paragraph [0046]; figure 7 -----	11-17
X	US 2003/124341 A1 (BURROUGHES JEREMY HENLEY [GB] ET AL) 3 July 2003 (2003-07-03) paragraph [0009] - paragraph [0010] paragraph [0042] - paragraph [0043] -----	1,11
X	JP 11 340494 A (MATSUSHITA ELECTRIC IND CO LTD; NAT HOUSE IND) 10 December 1999 (1999-12-10) abstract -----	1,8,11
Y	US 4 461 922 A (GAY CHARLES F [US] ET AL) 24 July 1984 (1984-07-24) column 5, line 18 - line 64 column 10, line 48 - column 11, line 6; claims; figures 9A,9B -----	18-25
Y	WO 2009/145909 A1 (CORNING INC [US]; DAWSON-ELLI DAVID FRANCIS [US]; DEMARTINO STEVEN EDW) 3 December 2009 (2009-12-03) paragraph [0019]; claims; figures 1,2 -----	18-25
A	US 4 625 070 A (BERMAN ELLIOT [US] ET AL) 25 November 1986 (1986-11-25) claims; figure -----	18-25
A	US 2003/087746 A1 (RITTER SIMONE [DE] ET AL) 8 May 2003 (2003-05-08) paragraph [0007] - paragraph [0008]; claims 9,10 -----	2,4,5, 12,15, 17,19, 22,23,25
A	EP 1 038 663 A2 (AGFA GEVAERT NV [BE] AGFA GEVAERT [BE]) 27 September 2000 (2000-09-27) paragraph [0007] -----	1,8,11, 18

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2012/022514

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102006042538 A1	27-03-2008	NONE	
GB 1319846 A	13-06-1973	AT 311685 B BE 758410 A1 CH 522499 A DE 1955853 A1 ES 385185 A1 FR 2067009 A7 GB 1319846 A LU 61992 A1 NL 7015720 A SU 388401 A3	26-11-1973 03-05-1971 30-06-1972 13-05-1971 01-09-1973 13-08-1971 13-06-1973 26-07-1972 10-05-1971 22-06-1973
US 2006127679 A1	15-06-2006	CN 101076447 A EP 1836274 A2 EP 2444246 A1 JP 2008522950 A KR 20070087650 A TW 1284091 B US 2006127679 A1 WO 2006065657 A2	21-11-2007 26-09-2007 25-04-2012 03-07-2008 28-08-2007 21-07-2007 15-06-2006 22-06-2006
US 2010224235 A1	09-09-2010	CN 102341914 A EP 2404321 A1 US 2010224235 A1 WO 2010102303 A1	01-02-2012 11-01-2012 09-09-2010 10-09-2010
US 2010200063 A1	12-08-2010	NONE	
US 2003124341 A1	03-07-2003	NONE	
JP 11340494 A	10-12-1999	NONE	
US 4461922 A	24-07-1984	NONE	
WO 2009145909 A1	03-12-2009	AU 2009251825 A1 CN 102113133 A EP 2311099 A1 JP 2011524270 A KR 20110021934 A TW 201029194 A US 2012037229 A1 WO 2009145909 A1	03-12-2009 29-06-2011 20-04-2011 01-09-2011 04-03-2011 01-08-2010 16-02-2012 03-12-2009
US 4625070 A	25-11-1986	NONE	
US 2003087746 A1	08-05-2003	AU 2852401 A DE 10005088 C1 JP 4757424 B2 JP 2003525830 A US 2003087746 A1 WO 0156941 A1	14-08-2001 15-03-2001 24-08-2011 02-09-2003 08-05-2003 09-08-2001
EP 1038663 A2	27-09-2000	NONE	