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(56) Documents Cited:
WO 2008/093962 A **WO 2000/077336 A**

(58) Field of Search:
INT CL **C03C, H01G, H01L, H01M**
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(54) Title of the Invention: **Glass sealing method**
Abstract Title: **Photovoltaic panel seals**

(57) Photovoltaic cell structures are located in between a front and back side glass substrate aligned in parallel, preheated solder glass is deposited along the perimeter of the glass substrates covering the gap between the front and back glass substrates, and pressure is applied onto the deposited solder glass to form a seal encapsulating the space in between the front and back side glass substrates. Heating the solder glass sealing material prior to deposition onto the glass substrate reduces the exposure of the photovoltaic cells to the high temperatures necessary for forming a solder glass seal between the front and back glass substrates.

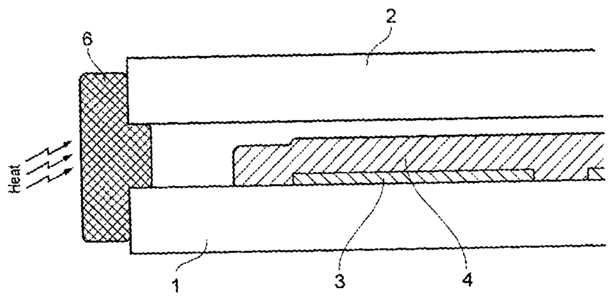

FIG. 4

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

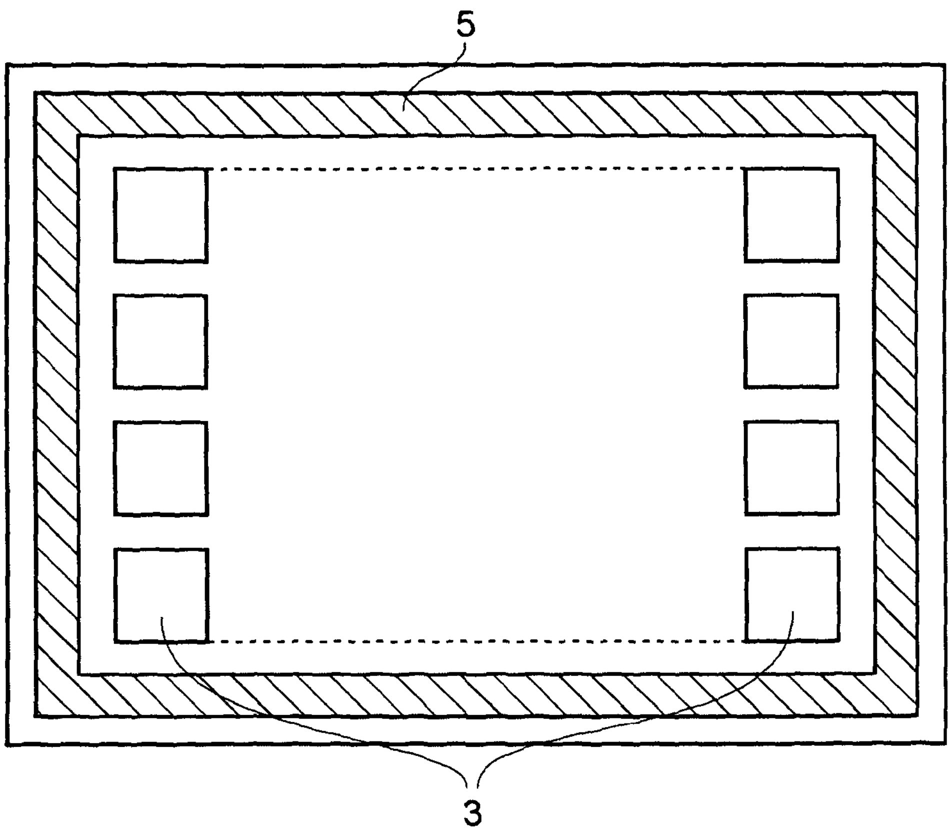

FIG. 1

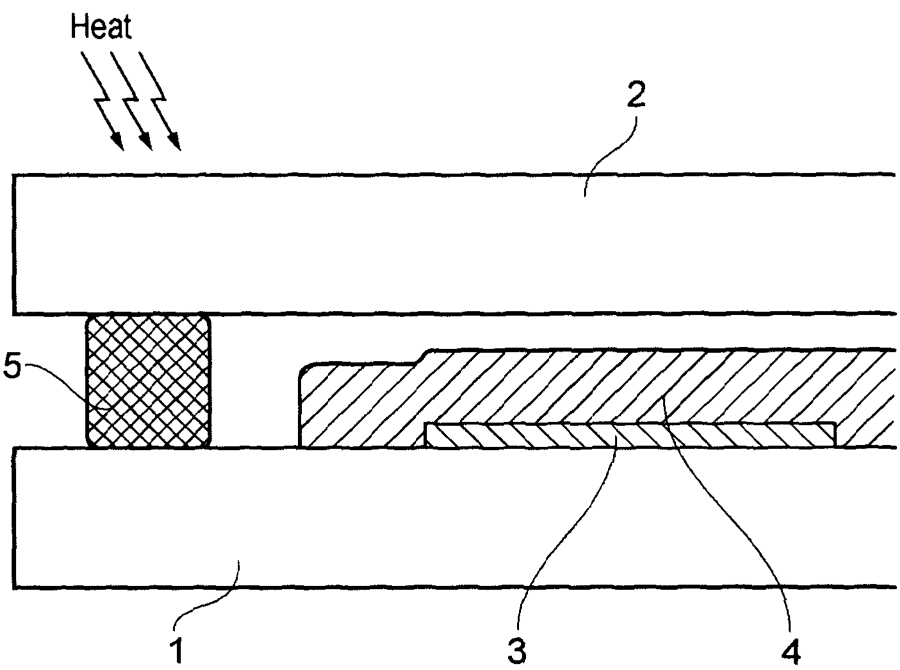

FIG. 2

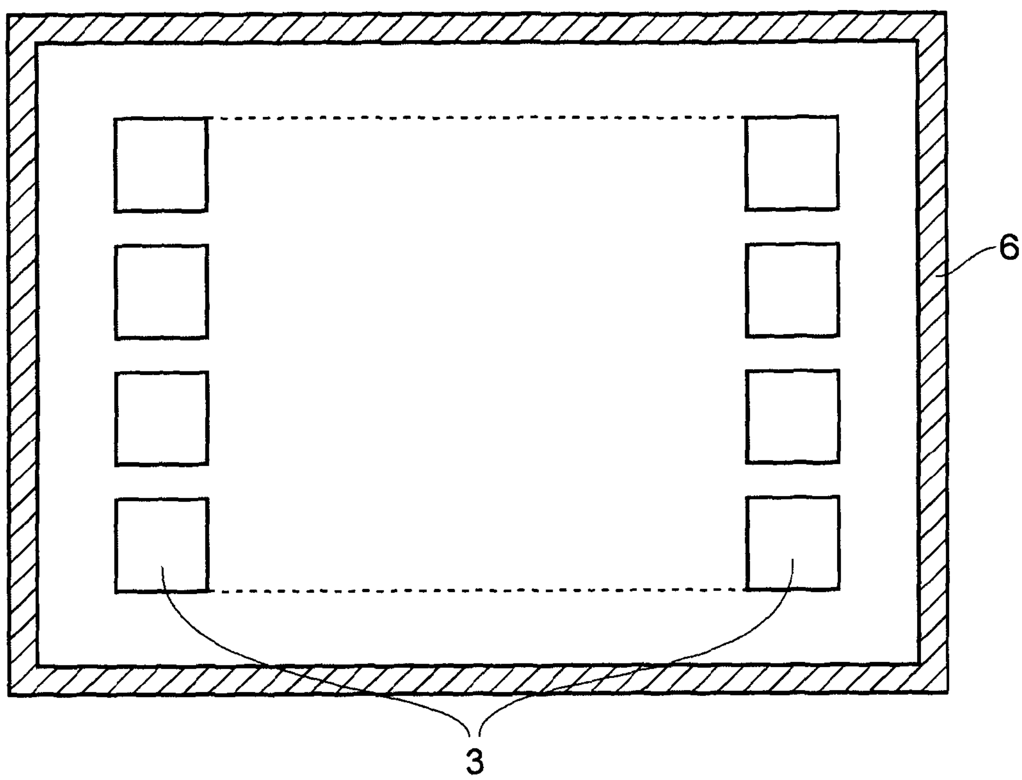

FIG. 3

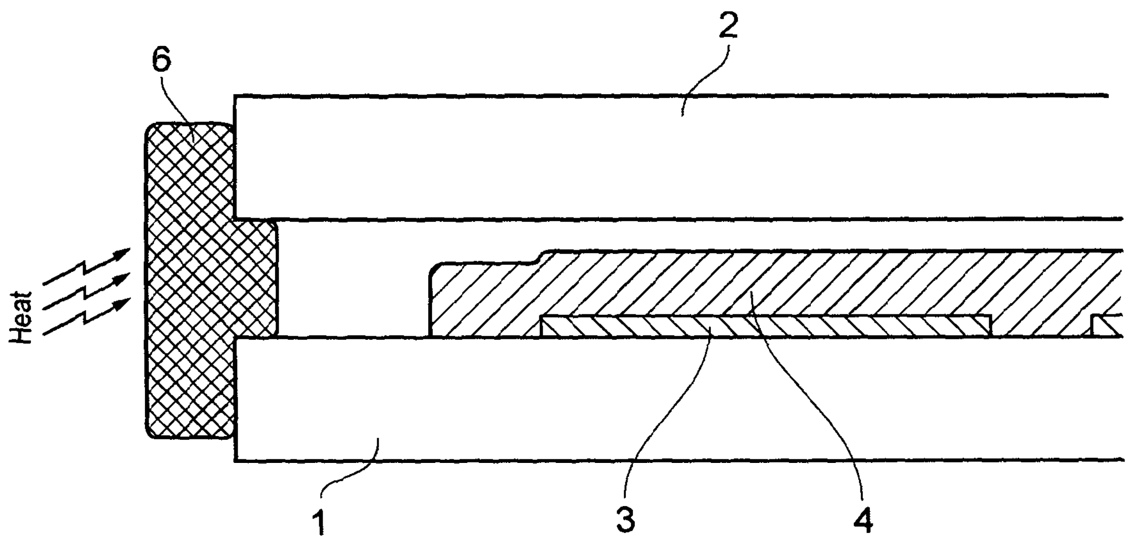

FIG. 4

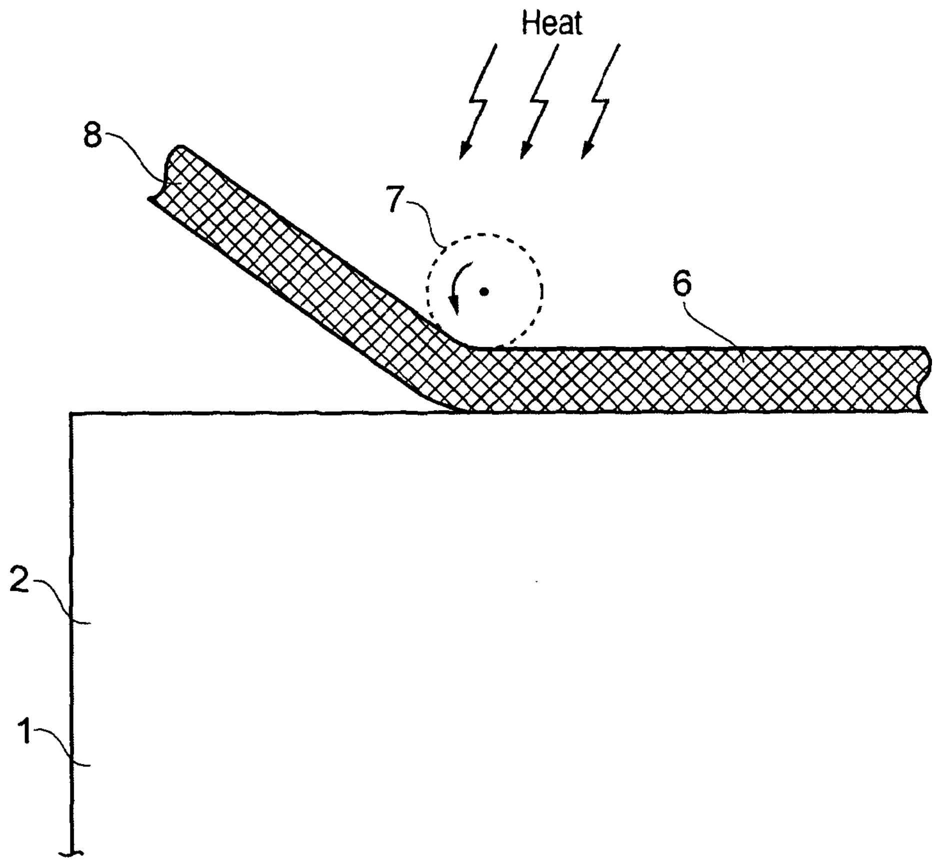

FIG. 5

Glass sealing method

Field of the invention

The invention concerns a method for sealing the photovoltaic cell structures inside photovoltaic modules from the environment. Specifically, the invention relates to protecting thin film photovoltaic cell structures from moisture.

Background

A photovoltaic module is an assembly of photovoltaic cell structures. These structures can be discrete cell components that are electrically connected to each other in a series connection with metal bands, or they can have been formed in a monolithic thin film deposition and structuring process. In a module based on discrete bulk or thin film cells, the cells can be placed on a polymer sheet placed on a glass sheet. Monolithic thin film photovoltaic cell modules are manufactured by deposition and patterning of front contact, absorber, and back contact layers onto a glass substrate plate. A thin film superstrate structure is obtained if the order of front and back contact layers is reversed. For both discrete cell based modules and monolithic modules it is customary to apply a protective polymer layer over the layers, which is subsequently heated to form an adhering polymer seal covering the photovoltaic structures. In the glass-cell-glass configuration illustrated in Figure 1 and Figure 2 the encapsulation of the photovoltaic module is completed by covering the back glass substrate (1), photovoltaic cell structures (3), and passivation layer (4) with a mechanical protection provided by a second front glass plate (2).

Moisture diffusing from the edges of a glass-cell-glass module into the areas with photovoltaic cell structures (3) can cause corrosion of metallic interconnections, and in the case of monolithic thin film photovoltaic cells, degradation of the absorber material. It is therefore beneficial to provide a permanent moisture barrier at the perimeter of the module. The choice of sealing material and the sealing process has to be performed with a set of limitations to achieve the desired result. Due to the requirements of reliable sealing for module lifetimes exceeding 25 years, it is preferable to use an inorganic material for the seal. Another concern in this regard is to avoid excessively high temperatures in the areas with photovoltaic cell structures during the sealing process. Excessively high temperatures will cause the polymer to both float towards the module edges and emit gases, and thereby interfere with the sealing process. Further on there can be deterioration of the protective polymer layer (4) and of the photovoltaic cell structures (3) themselves.

Prior art

US 6 469 243 discloses how to make a sealing between two glass substrates encapsulating dye sensitized photovoltaic cell structures by depositing a pasty glass frit comprising 50% glass powder and 5% acrylic resin binder along the perimeter of the glass substrates, and then cure the frit to form a seal by heating up to 410 °C.

US 6 541 083 discloses a thermally insulating glass panel consisting of two parallel glass substrates placed with a distance from each other using a set of spacers, and which is vacuum sealed using a solder glass deposited in a pattern on one glass substrate, which is consequently used for welding along the perimeter of the glass substrates. The solder glass in this case is an alkali silicate glass.

US 5 489 321 discloses thermally insulating glass panels where the solder glass material, placed in a pattern inside the perimeter, contains light absorbing ions. The increase in temperature required for welding is achieved by laser light illumination.

The prior art, illustrated in Figure 1 and Figure 2, has the disadvantage that the protective polymer material (4) has to be removed on the glass substrate surface in a pattern along the glass substrate perimeter before the glass frit or solder glass pattern (5) is deposited in this region. Methods based on thermal heating will cause the polymer layer to both float and outgas at the elevated temperatures which are required to weld the glass substrate plates (1) and (2) together,. The surface of the solder glass material will become contaminated with polymer, which will degrade the glass seal, and the seal will also trap gases originating from heated areas of the polymer passivation.

Using methods based on predeposited solder glass it will be preferable to keep the deposited glass layer melted at the entire perimeter during the welding process, while using a homogeneous mechanical pressure at the entire perimeter of the glass plates, in order to ensure proper sealing. When the heating for welding, introduced thermally or by lamp or laser light, is confined to small regions, it will be required to use force on the glass plates to reduce glass plate separation in order to ensure contact between solder glass and the front glass plate (2). The still solid solder glass in zones that are not welded will act against a reduction of glass plate separation, unless the substrates have sufficient plasticity to yield locally. This procedure can introduce mechanical stress in the substrates in the welded regions, and there is a possibility for insufficient sealing if the solder glass (5) surface or the front glass plate (2) surface has height variations.

Objective of the invention

The main objective of the invention is to provide a method for sealing photovoltaic cell structures from the ambient atmosphere.

It is a further objective of the invention to provide a method of sealing the solar cells without excessive heating of the photovoltaic cell structures.

The objective of the invention may be achieved by the features as set forth in the description below and in the appended claims.

Short description of the Figures

Figure 1 is a top view of a prior art solar cell module showing a solder glass seal (5) and photovoltaic cells (3).

Figure 2 is a side view of a prior art solar cell module showing a substrate glass (1), a front glass (2), a photovoltaic cell (3), passivation (4) and a solder glass seal (5).

Figure 3 is a top view of a solar cell module of the invention showing a solder glass seal (6) and photovoltaic cells (3).

Figure 4 is a side view of a solar cell module of the invention showing a substrate glass (1), a front glass (2), photovoltaic cells (3), passivation (4) and a solder glass seal (6).

Figure 5 is a top view of a solar cell module of the invention being sealed using pre-heated solder glass (8) to form a seal (6) using a roller structure (7) along the edge of a substrate glass (1) and a front glass (2).

Description of the invention

The invention illustrated in Figure 3 and Figure 4 is based on the realization that sealing photovoltaic modules, without excessive heating of the photovoltaic cell structures (3), including passivation layers (4), may be obtained by applying an object of solder glass (6) preheated to a viscous state along the external perimeter of the glass substrates, where the glass edge is locally preheated to a temperature corresponding to the temperature of the solder glass, and then press the viscous object of solder glass into contact with the back and front glass substrates.

Thus, in a first aspect the invention relates to a method for sealing photovoltaic cell structures (3) from the ambient atmosphere, wherein the photovoltaic cell structures are located in between a front (2) and back (1) side glass substrate, wherein the substrates are aligned in parallel and at a distance from each other, the method comprising depositing an object of solder glass (6) preheated to a viscous state along the perimeter of the glass substrates covering the gap between the front and back glass substrates to form a welded closure encapsulating the space in between the front and back side glass substrates.

In a second aspect of the invention, pressure on the object of solder glass (6) can be applied by a mechanical tool, or gravity, to ensure contact between the solder glass and the perimeters of the front (2) and back (1) side glass substrates.

By forming the sealing by making a welded closure by placing the preheated solder glass externally around the perimeter of the front and back glass substrates the influence on the heat sensitive layers of the sealing process can be reduced significantly. For example, polymer residues on the glass edges may advantageously be removed mechanically, chemically, with plasma etching, or by oxidation prior to the glass welding. Techniques which remove polymer not only at the edge, but also in a narrow area in from the perimeter would also be beneficial, because the weld seam would then become stronger. Heat and/or pressure may be applied to the edge of the glass plates, making it possible to reduce the exposure of the polymer passivation area even further.

One sealing method would then be to use a preheated object of solder glass which is placed in contact with the locally preheated glass plate edges, as shown in Figure 5. Gravity and/or applied pressure, for instance by using a roller (7), would be used to ensure contact between the preheated object of solder glass and the front and back glass substrate plates. The combination of viscosity/temperature of the preheated object of solder glass and the force applied to it will push it partly in between the glass plates. A local heat/cool profile is then designed to complete the welding process without introducing potentially harmful stress fields in the glass plate. If the solder glass contains light absorbing ions, the subsequent heating process can be achieved with lamp or laser light illumination.

The invention may apply to any dimension or shape of the solder glass as long as it is able to obtain a tight contact with both the front and back glass substrate. A suited form is e.g. a glass ribbon.

The applied pressure of 10 N/mm^2 or less for obtaining a tight contact between the preheated viscous object of solder glass and the back and front substrates should be adapted to the viscosity of the solder glass at the soldering temperature.

When the object of solder glass is a solder glass ribbon, the method of the invention entails preheating the solder glass ribbon to, and keeping it at, a temperature above the softening point of the solder glass, in the range from 350 °C to 700 °C, before being applied to the edges of the front and back glass substrate plates to make a seal.

By the term “viscous” it is meant a state where the solder glass is heated to a temperature above its softening point such that it may be formed by applying a pressure as defined above.

The temperature of the preheated object of solder glass should be as low as possible, but sufficiently high to obtain a viscous state such that a tight seal between the front and back glass substrate plates will be formed. The temperature shall be above the softening point of the solder glass, usually in the range from 350 °C to 700 °C, when being applied to the edges of the front and back glass substrates.

In the method of the invention, to ensure a desired completion of the welding process, the welded seal has to be held at a temperature in the range from 350 °C to 700 °C and then annealed and cooled in a controlled process. The heating at this stage can be thermal, or provided by absorption of infrared or visible light.

Optionally, the welded edge may be mechanically protected with a mechanical frame produced from metal, plastic, or other suited material after the sealing process is completed.

The method of the invention may also advantageously be used in the production of wafer based photovoltaic modules.

Preferred embodiments of the invention

In a first embodiment of the invention a method of sealing photovoltaic cell structures from the ambient atmosphere is provided, wherein the photovoltaic cell structures are located in between a front and back side glass substrate aligned in parallel and at a distance from each other, the method comprising depositing a preheated object of solder glass along the perimeter of the glass substrates covering the gap between the front and back glass substrates, and applying a pressure onto the deposited solder glass object to form a welded closure encapsulating the space in between the front and back side glass substrates.

In a second embodiment of the invention, the method is further comprising the step of removing the protective polymer residues from the edge perimeter of the back and front side glass substrates prior to the step of depositing the preheated object of solder glass along the perimeter of the glass substrates. The polymer layers may be removed mechanically, chemically, with plasma, and/or by oxidation.

In a further embodiment of the invention, the protective polymer layers are removed from the edge of and to a distance from 0 to 5 mm in from the edge of the front and back side glass substrates.

In a still further embodiment of the invention, the preheated object of solder glass is a preheated solder glass ribbon.

In a still further embodiment of the invention, the object of solder glass is preheated to a temperature equivalent to the working point of the solder glass before being deposited along the edges of the front and back glass substrates.

In a further embodiment of the inventive method of the invention, the pressure is applied to the preheated solder glass object using a roller structure and/or gravity.

In a still further embodiment of the method of the invention, the pressure applied to the preheated solder glass object of 10 N/mm^2 or less, is sufficient to cause a viscous deformation of the solder glass ribbon.

In a further embodiment of the inventive method, the pressure applied to the preheated solder glass object causes the solder glass object to be partially introduced in the volume at the edge between the front and back side glass substrates.

In a still further embodiment of the invention, the object of solder glass is preheated to a temperature above the softening point of the solder glass, in the range from 350 °C to 700 °C, before being deposited along the edges of the front and back glass substrates, where the glass edges have been preheated to a temperature corresponding to the temperature of the solder glass.

In a further embodiment of the inventive method the solder glass after being brought into contact with the substrate glass edges, is held at the welding temperature, in the range from 350 °C to 700 °C, in order to complete the soldering process before being annealed and cooled in a controlled process.

In a further embodiment of the invention, the method additionally comprises the step of protecting the welded seal by fitting a mechanical frame produced from metal, plastic, or the like to the front and back glass substrates.

CLAIMS

1. Method for sealing photovoltaic cell structures from the ambient atmosphere, wherein the photovoltaic cell structures are located in between a front and back side glass substrate aligned in parallel and at a distance from each other, the method comprising depositing an object of solder glass preheated to a viscous state along the edge perimeter of the glass substrates covering the gap between the front and back glass substrates, and thereby forming a welded closure encapsulating the space in between the front and back side glass substrates.

2. The method according to claim 1, further comprising applying external pressure by a mechanical tool and/or gravity acting on the object of solder glass.

3. The method according to claim 1, further comprising the step of removing the protective polymer layer residues from the perimeter of the back and front side glass substrates prior to solder glass deposition.

4. The method according to claim 3, wherein the protective polymer layers are removed mechanically, chemically, with plasma, and/or by oxidation.

5. The method according to any of claims 3-4, wherein the protective polymer layers are removed from the edge of and to a distance from 0 to 5 mm in from the perimeter of the front and back side glass substrates.

6. The method according to claim 1, wherein the preheated object of solder glass is a preheated solder glass ribbon.

7. The method according to claim 2, wherein the mechanical tool is a roller.

8. The method according to claim 2, wherein the pressure applied to the preheated solder glass object is 10 N/mm^2 or less, to cause a viscous deformation of the solder glass.

9. The method of claim 2, wherein the pressure applied to the preheated solder glass object causes the solder glass object to be partially introduced in the volume between the front and back side glass substrates.

10. The method according to claim 1, wherein the object of solder glass is preheated to a temperature above the softening point of the solder glass, in the range from 350 °C to 700 °C, before being deposited along the glass substrates, and wherein the glass edges are locally heated to a corresponding temperature.

11. The method according to the claim 1, wherein the solder glass after being brought into contact with the substrate glass edges, is held at the welding temperature, in the range from 350 °C to 700 °C with thermal heating or heating

with visible or infrared light, in order to complete the soldering process before being annealed and cooled in a controlled process.

12. The method of claim 1, further comprising the step of c) protecting the welded seal by fitting a mechanical frame produced from metal, plastic, or the like to the front and back glass substrates.

Application No: GB0817505.1 **Examiner:** Mr Steven Morgan

Claims searched: all **Date of search:** 9 February 2009

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A		WO00/77336 A (SYDNEY UNI)
A		WO2008/093962 A (DONGJIN)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :

Worldwide search of patent documents classified in the following areas of the IPC

C03C; H01G; H01L; H01M

The following online and other databases have been used in the preparation of this search report

Online: WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
None		