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(54) BUSBAR ASSEMBLY

(57) A busbar assembly (1) for installation at a site of use, for example in a windscreen, the busbar assembly (1) comprises a first busbar (3) and a second busbar (2), wherein the second busbar (2) at least partially overlies the first busbar (3), at least one of the first and second busbars (2, 3) is coated with a lead free solder material (32) comprising tin and bismuth, wherein at least one of the first and second busbars (2, 3) comprises securing means (33) configured to secure, in use, the busbar assembly (1) to a site of use.

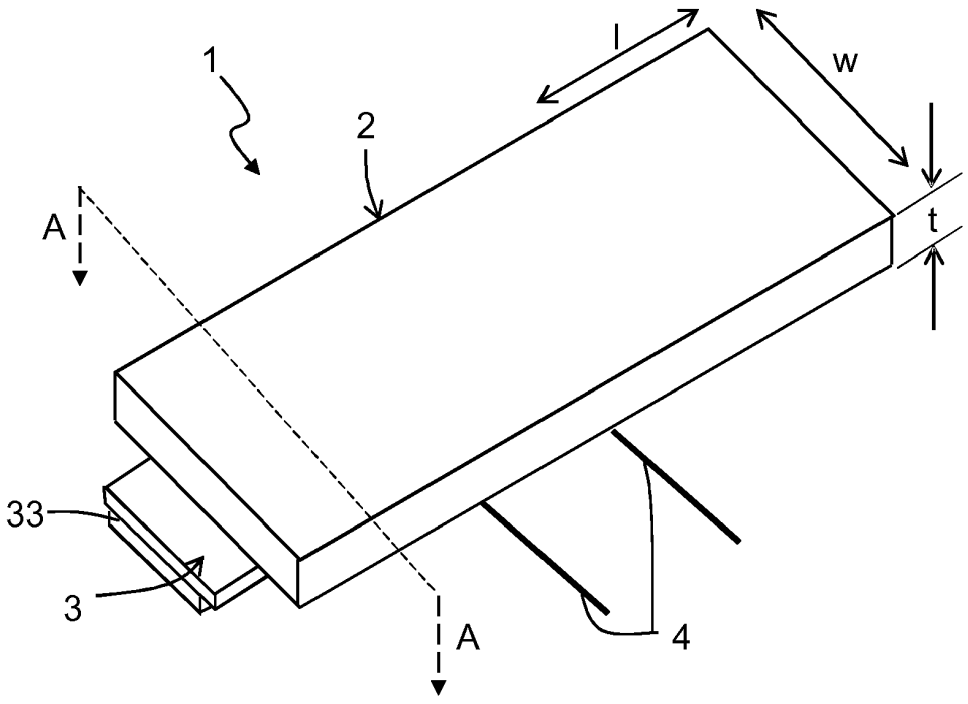

FIGURE 1

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Description

[0001] This invention relates to a busbar assembly. More specifically, although not exclusively, this invention relates to a busbar assembly useable in heated windscreens.

[0002] A busbar assembly is typically used to provide electrical contact between a source of electrical energy and plural circuits in an electrical apparatus or system. Hence, they are formed of electrically conductive material and are typically provided as strips or tubes. It is usual to use a strip or tube shape because of those shape's inherent heat dissipation efficiency. Busbar assemblies may be electrically isolated by use of covering insulators or by use of earthed enclosures. In many cases a busbar assembly is used for electrical conduction and not for performing a structural function.

[0003] It is known to provide as a busbar a copper strip which has been coated with tin. Such busbars are thin so that they can be provided between panes of glass to facilitate electrical connection to one or more resistively heatable wires or filaments (the heating element) in a heated windscreen. Because the busbar is thin it does not cause or generate air gaps between the facing panes of glass, which could lead to failure of the heating element. The tin coating protects the underlying copper from oxidising or otherwise reacting with or in the presence of ingressing water.

[0004] It is also known to solder a busbar assembly to the heating element in order to provide a secure electrical connection betwixt the two, where the solder contains lead and other elements. Recent European legislation requires that solders for soldering in laminated glazing must no longer contain lead from 2020. Therefore, the previously known solders for soldering busbar assemblies to heating elements may no longer be used after that date.

[0005] During manufacture of a heated windscreen it is known to deposit the heating element such that the ends of the resistively heatable wires or filaments extend to or beyond the edge of the panes of glass. These wire ends, disposed at the edge of the panes of glass, are known, subsequent to manufacture, to provide routes for the ingress of air and other undesirable elements such as water.

[0006] It is an object of the current invention to satisfy at least one of the issues aforementioned.

[0007] Accordingly, in a first aspect of the invention there is provided a busbar assembly for installation at or in or on a site of use, e.g. in or on a structure, for example a windscreen, the busbar assembly comprising a first busbar and a second busbar, where at least one of the first and second busbars is coated with a lead free solder material comprising tin and bismuth, wherein at least one of the first and second busbars comprises securing means configured to secure, in use, the busbar to a site of use, e.g. in or on a structure, for example a windscreen.

[0008] The lead-free solder material may comprise silver, which may be present as a minor constituent.

[0009] Accordingly, in a second aspect of the invention there is provided a busbar assembly for installation at or in or on a site of use, e.g. in or on a structure, for example a windscreen, the busbar assembly comprising a first busbar and a second busbar, where at least one of the first and second busbars is coated with a lead free solder material the other of said first and second busbars is coated with a protective material, wherein the coating of lead free solder material is thicker than the coating of protective material, wherein at least one of the first and second busbars comprises securing means configured to secure, in use, the busbar to a site of use, e.g. in or on a structure, for example a windscreen.

[0010] The lead-free solder material may comprise one or more of indium, tin, silver, bismuth. The protective material may comprise tin or a tin alloy. The lead-free solder material and protective material may be chemically distinct.

[0011] The lead-free solder material is coated over and along a substrate material and about its entire periphery and along all of its longitudinal faces/edges to form the busbar. The coating may be applied in a continuous process to a substrate and the busbar cut to length prior to use.

[0012] The first busbar may comprise a lower busbar. The second busbar may comprise an upper busbar. Electrical elements, e.g. heating elements, may be securable or secured, in use, between the first and second busbar.

[0013] The first busbar may comprise a first major surface with longitudinal edges. The first busbar may comprise a first length of electrically conductive material providing said substrate. The second busbar may comprise a second major surface with longitudinal edges. The second busbar may comprise a second length of electrically conductive material providing a second substrate.

[0014] The first and/or second length of electrically conductive material may be elongate. In one embodiment the material is in strip form, *i.e.* it has a length and width dimension significantly larger than its thickness dimension. For example, the material's width dimension can be over 50, say over 60, 70, 80, 90, 100 times its thickness dimension.

[0015] The first and/or second length of electrically conductive material may be dimensionally invariant.

[0016] In this invention, the term dimensionally invariant means a material which has a constant cross section in a longitudinal direction of the bottom and/or top busbar, and constant in this context means that the cross sectional area varies by less than 15%, preferably equal to or less than 10%, preferably equal or less than 9, 8, 7, 6 or 5% along at least a 1mm longitudinal portion, for example along a 2, 3, 4, 5, 6, 7, 8, 9, 10 mm longitudinal portion. In one embodiment, the top and/or bottom busbar is at least 5, 10 or 15cm long and the cross sectional area of solder material varies by 5% or less along a 5, 10 or 15cm length.

[0017] The first and/or second length of electrically conductive material is preferably formed from copper.

[0018] The first length of electrically conductive material may be in strip form and/or may have a width of from 1 to 15

mm, say from 2 to 14 mm, for example from 3 to 10 mm. In one embodiment the first length of electrically conductive material may be about 4 mm wide. The variation of width is preferably tightly controlled, for example less than 10%, say less than 9, 8, 7, 6, 5, 4, 3, 2% in a longitudinal direction.

[0019] The first length of electrically conductive material may have a thickness of from 10 to 120 microns, say from 15 or 30 to 110 microns. In one embodiment the first length of electrically conductive material may be about 100 microns thick. The variation of thickness is preferably tightly controlled, say less than 15%, preferably less than 14, 13, 12, 11, 10, 9, 8, 7, 6%, *e.g.* from 1-5%.

[0020] The second length of electrically conductive material may be in strip form having a width of from 1 to 20 mm, say from 2 to 16 mm, for example from 3 to 15 mm. In one embodiment the second length of electrically conductive material may be about 8 mm wide. The variation of width is preferably tightly controlled, for example less than 10%, say less than 9, 8, 7, 6, 5, 4, 3, 2% in a longitudinal direction.

[0021] The second length of electrically conductive material may have a thickness of from 5 to 100 microns, say from 10 or 20 to 80 microns. In one embodiment the second length of electrically conductive material may be about 50 microns thick. The variation of thickness is preferably tightly controlled, say less than 15%, preferably less than 14, 13, 12, 11, 10, 9, 8, 7, 6%, e.g. from 1-5%.

[0022] In a preferred embodiment, the first busbar is narrower than the second busbar and the first busbar is thicker than the second busbar. In a most preferred embodiment (for example where both the first and second busbars are elongate), the cross sectional area in the width direction A_1 of the first busbar is substantially the same as the cross sectional area A_2 of the second busbar. For example $0.8A_2 \leq A_1 \leq 1.2A_2$, preferably $0.9A_2 \leq A_1 \leq 1.1A_2$ and most preferably $0.95A_2 \leq A_1 \leq 1.05A_2$, for example $A_1 = A_2$.

[0023] In embodiments the first busbar may comprise securing means. Where the first busbar comprises a first major surface with longitudinal edges the securing means may be inboard of one or both of the longitudinal edges. Alternatively, the securing means may protrude or extend beyond one or both of the longitudinal edges. Preferably said securing means lies inboard of one longitudinal edge but extends beyond the other longitudinal edge.

[0024] Additionally or alternatively, the second busbar may comprise securing means. Where the second busbar comprises a second major surface with longitudinal edges the securing means may be at or towards (e.g. adjacent) one or both of the longitudinal edges.

[0025] The securing means may be configured, in use, to secure the first and/or second busbar to a site of use, e.g. a windscreen. The securing means may be configured, in use, to provide a seal (e.g. a fluid tight seal) between the busbar assembly, e.g. the first and/or second busbar, and a site of use. The securing means may extend along a minor or a major portion of the busbar assembly. Most preferably the securing means extends along a major portion, e.g. along the entire length, of the busbar assembly.

[0026] The securing means may comprise an adhesive material, e.g. a pressure and/or heat sensitive adhesive. The securing means may comprise a carrier substrate with a pair of major surfaces, e.g. an inner and an outer surface, each of which may carry adhesive material. Preferably, the adhesive material has two faces, each carrying adhesive or having adhesive properties. The carrier substrate may be formed from a resilient material. Adhesive material on the inner and/or outer surface may be covered by a release liner, e.g. a siliconized release liner such as siliconized paper, which is removably retained on the adhesive material. The adhesive material may or may not be electrically conductive.

[0027] The lead free solder material may comprise silver and/or indium and/or any other suitable lead free material. The coating of lead free solder material may be equal to or less than 30 microns (*i.e.* $\leq 3 \times 10^{-5}$ m) thick, for example 29, 28, 27, 26, 25, 24, 23, 22, 21, 20, 19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 microns thick. Preferably the coating of lead free solder material is from 1 to 20, say 2 to 15 microns thick, for example from 5 to 10 microns thick.

[0028] In embodiments the first busbar is coated with a lead free solder material comprising tin and bismuth and optionally silver. The second busbar may be coated with a protective material.

[0029] Where provided, the protective coating may comprise tin or tin alloy, or a polymeric coating. The protective coating may be equal to or less than 20 microns thick, for example 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 microns thick. Preferably the protective coating (e.g. tin or tin alloy) is from 0.25 to 7, say 0.5 to 5 microns thick, for example from 1 to 4 microns thick. The protective coating is preferably provided on all the longitudinal surfaces of the second length of electrically conductive material. The protective material is coated over and along the longitudinal faces/edges of the second substrate material and about its entire periphery to form the busbar. The protective material may be applied in a continuous process to a substrate and the busbar cut to length prior to use. The protective material may be thinner than the lead free solder material than is the protective coating may be applied as a thinner coating on a busbar than the lead-fee solder material is applied on the other busbar. In an embodiment, the protective material has a nominal or minimum thickness T_p and the lead free solder material has a nominal or maximum thickness T_s and $T_s<T_p$, for example $T_p \geq 1.2\ T_s$. Additionally or alternatively, preferably $T_p < 10t_s$, for example $1.1T_s \leq T_p \leq 10T_s$, for example $T_p<T_s\leq 5T_p$, preferably $T_p<T_s\leq 3.5T_p$. By the term nominal thickness we mean the average thickness across and along the busbar, by the terms maximum or minimum thickness we mean the maximum or minimum thickness at any point along the respective busbars. It is most preferred that the nominal thickness and the maximum or minimum thicknesses vary by

less than 10%, preferably less than 9, 8, 7, 6, 5, 4, 3, 2, 1%.

[0030] The top and bottom busbars may be positioned or positionable, during installation at a site of use, such that the top busbar partially or substantially or entirely overlays the bottom busbar. Most preferably the top busbar is positioned or positionable, during installation at a site of use, such that the top busbar substantially or entirely overlays the bottom busbar. Most preferably the top and/or bottom busbar may be positioned or positionable to contact the one or more electrical elements, e.g. thereby to create electrical connection therewith.

[0031] The one or more electrical elements may comprise wires or filaments. The one or more electrical elements may be elongate and comprise a diameter, e.g. significantly less than their length. In embodiments the electrical elements may be formed from tungsten or any other suitable material and/or may have a diameter of between 5 and 200 microns, say 10 and 150 microns, for example 20 microns.

[0032] A further aspect of the invention provides a windscreen assembly comprising electrical elements, glass blanks and a busbar assembly as described above. The windscreen assembly may further comprise electrical connectors, e.g. for connection between the busbar assembly and a source of electrical energy.

[0033] A yet further aspect of the invention provides a busbar assembly for installation at or in or on a site of use, the busbar assembly comprising a top busbar and a bottom busbar, the bottom busbar comprising a securing means configured, in use, to secure both the top and bottom busbar to a site of use, where, in use, the top busbar is adjacent to the bottom busbar with one or more electrical elements disposed therebetween.

[0034] The securing means may be configured to project or protrude or extend from the bottom busbar, e.g. such that at least a portion of the securing means is outboard of the bottom busbar, for example outboard of a longitudinal edge of the bottom busbar.

[0035] A busbar comprising an elongate strip of conductive material having an outer surface defined by a pair of major surfaces and longitudinal edges, preferably coated over its entire outer surface with a lead-free solder material, and having a securing means secured to one of its major surfaces and lying inboard of one of the longitudinal edges and protruding beyond the other longitudinal edge.

[0036] For the avoidance of doubt, any of the features described herein apply equally to any aspect of the invention.

[0037] Within the scope of this application it is expressly envisaged that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. Features described in connection with one aspect or embodiment of the invention are applicable to all aspects or embodiments, unless such features are incompatible.

[0038] Embodiments of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is an isometric exploded view of a busbar assembly according to a first embodiment of the invention;
Figure 2 is a sectional view taken along the plane indicated by line A-A in Figure 1;
Figure 3 is an end view of the busbar assembly of Figure 1 installed in a windscreen;
Figure 4 is an isometric exploded view of a busbar assembly according to a second embodiment of the invention;
Figure 5 is a section view taken along the plane indicated by line B-B in Figure 4; and
Figure 6 is an end view of the busbar assembly of Figure 4 installed in a windscreen.

[0039] Referring now to Figures 1 and 2, there is shown a busbar assembly 1 according to a first embodiment of the invention, including a first, lower, busbar 3, a second, upper, busbar 2 between which are located heatable wires 4.

[0040] A person skilled in the art will appreciate that the Figures are provided for illustrative purposes only.

[0041] Both the upper and lower busbars 2, 3 are in strip form having a width w, and whereby their respective thickness dimensions t are significantly smaller than are their lengths l. In this case the thickness t may be of the order of tens of microns (e.g. 10 to 200μm), whereas the length l is typically 10s of centimetres (e.g. from 5cm to up to 200 or 300cm).

[0042] The lower busbar 3 is a substrate, preferably comprises a coated substrate CS comprising a first rectangular copper strip 31 coated (preferably evenly and consistently coated) on all of its longitudinal surfaces with a thin protective layer 32 which, in embodiments, is a solder layer 32. A strip of adhesive material 33 is secured to the coated substrate CS on a first major surface 34a and along substantially the entire length thereof, the other major surface 34b being free of adhesive.

[0043] In one embodiment the first strip 31 of substrate is about 4 mm wide and about 100 microns thick. The thin solder layer 32 is preferably between about 1 and 20 microns thick, say between 5 microns and 10 microns thick. The thin solder layer 32 is formed from a low melting point solder which, in embodiments, is a lead-free solder combination of tin and bismuth (for example one or more of Sn42Bi58, Sn36Bi64, Sn36Bi62Ag2). The strip of adhesive material 33 is of rectangular configuration and may be protected by an optional release liner (not shown), which may be formed from siliconized kraft paper. The strip of adhesive material 33, which is applied inboard of both edges of one major face of the coated substrate CS, has a width of about 3 mm. The strip of adhesive material 33 preferably includes a pressure

sensitive adhesive, e.g. acrylic adhesive.

[0044] The upper busbar 2 includes a second coated substrate CS2 comprising a second rectangular copper strip 21 coated on all of its longitudinal faces with a thin protective layer 22 and having a first major surface 24a and a second major surface 24b. The upper busbar 2 has an optional strip of adhesive material 23, which may extend adjacent an edge of the first major surface 24a.

[0045] In one embodiment the second strip 21 of substrate is about 8 mm wide and about 50 microns (10^{-6} m) thick. The thin protective layer 22 is preferably between 1 and 4 microns thick, is most preferably lead-free and may be formed from tin.

[0046] The heatable wires 4 may have any suitable cross-sectional shape and are preferably about 20 microns in diameter. The heatable wires 4 may be formed from tungsten.

[0047] The characteristics of a further embodiment of busbar assembly 1 and typical heatable wires are as follows:

Upper busbar 2	Material Dimensions	Cu(C101) 8.0±0.4mm x 0.05mm±0.5%
Coating	Material	Sn ≥ 99.95%
	Thickness	2.5μm ± 1.5μm
Lower busbar 3	Material	Cu(C101)
	Dimensions	4.0±0.2mm x 0.1mm±0.5%
Coating	Material	Sn Bi
	Thickness	7.5μm ± 2.5μm
Adhesive strip	Material	Acrylic adhesive
	Dimensions	3.0mm x 0.05mm
Release liner	Material	Siliconised kraft paper
	Thickness	80μm
Heatable wires 4	Material	Tungsten
	Diameter	20μm

Table 1. Material Characteristics

[0048] However, whilst it is preferred that one of the busbars (upper 2 or lower 3) will be wider than the other of the busbars (lower 3 or upper 2) it will be appreciated that the upper busbar 2 and lower busbar 3 could be of any width or thickness, for example the upper busbar 2 could be 4, 5, 6, 7, 8, 9, 10, 11, 12 mm wide, and the lower busbar 3 could be 1, 2, 3, 4, 5, 6, 7, 8 mm wide, each preferably with a tolerance of ±0.1mm or higher. Additionally or alternatively, the upper and/or lower busbars 2, 3 may have any suitable thickness, although for reasons of operation and installation we prefer the thickness ranges mentioned above.

[0049] We have found that a wider, thinner upper busbar and a narrower, thicker lower busbar performs exceedingly well. Indeed, we have found that such a busbar assembly, wherein both busbars are coated with lead-free coatings performs very well in terms of its ability to be installed quickly and efficiently and its capacity to handle the stresses and strains of fabrication, installation and operation. In operation, the cross sectional areas of the upper and lower busbars are substantially the same (*i.e.* ±20%) which ensures excellent operation. We have also found that a busbar assembly where the lead-free solder is thicker than the protective coating results in a very robust window assembly.

[0050] Referring now to Figure 3 there is shown a busbar assembly 1 according to a first embodiment of the invention installed in a site of use: a windscreen assembly or laminate WA including an upper glass pane GP1 and a lower glass pane GP2. Typically the interplane volume (indicated at V) is filled with a polymeric layer, which may be formed from polyvinyl butyral (PVB).

[0051] During installation the lower busbar 3 is positioned against the lower glass pane GP2, towards or adjacent an edge thereof. To do so, the first release liner (if provided) is removed from the strip of adhesive material 33 of the lower busbar 3 and the first strip of adhesive material 33 is then pressed against the lower glass pane GP2, thereby securing the lower busbar 3 thereto with the first major surface 34a facing the lower pane GP2

[0052] Heatable wires 4 are positioned on the lower glass pane GP2 such that the heatable wires 4 at least partially lie across the lower busbar 3, and specifically across the second major surface 34b. The upper busbar 2 is then positioned over and along the lower busbar 3, such that the heatable wires are sandwiched between the upper 2 and lower 3 busbars. In this way the first major surface 24a of the upper busbar 2 (see Figure 2) is disposed adjacent the heatable wires 4 and facing the second major surface 34b of the lower busbar 3.

[0053] An interlayer (not shown), which may be formed from polyvinyl butyral (PVB) is positioned against the lower glass pane GP2 (either before or after the wires 4 have been positioned). The upper glass pane GP1 is positioned above

the lower glass pane GP2, and aligned therewith. The entire laminate structure is then clamped together and heated in an autoclave causing the interlayer to liquidify and bond the upper and lower glass panes GP1, GP2 together, hence forming a windscreen.

[0054] In order to produce a reliable electrical connection between the upper and/or lower busbar 2, 3 and the heatable wires 4 it is necessary to securely solder the components together. This may entail soldering of the components, manually or automatically, prior to positioning of the upper glass pane GP1 onto the laminate. Most preferably, however, soldering of the upper and/or lower busbar 2, 3 to the heatable wires 4 (and to any other electrical connections disposed thereagainst) can be accomplished during heating of the laminate within the autoclave. By soldering during autoclaving (instead of prior thereto) manufacturing of heated windscreens may be accomplished more rapidly and, consequently, with reduced expense. In this way the lower busbar 3 is secured to the heatable wires 4 and the top busbar 2 (and to any other electrical connections disposed against it).

[0055] The autoclave may typically be heated to a temperature of between, say, 120 and 160°C. Therefore, in order to effect soldering during autoclaving it is necessary to use a solder material which has a melting point lower than the effective operating temperature than the autoclave. Furthermore it is necessary to use a solder material which forms a robust and reliable electrical connection between the heatable wires 4 and the upper and/or lower busbar 2, 3, such that the electrical connection does not fail during installation and/or use.

[0056] Moreover, solders containing lead will no longer be suitable for use in soldering in laminated glazing from 2020 for automotive windscreens manufactured or sold within the EU.

[0057] The inventors have surprisingly found that a thin layer of solder 31 comprising tin and bismuth (and absent lead), covering all of the longitudinal surfaces of one or both of the busbars 2, 3 (but most preferably the lower busbar 3), may effect soldering of the lower busbar 3 to heatable wires 4 via heating in an autoclave. Furthermore, the thus formed electrical connection between the lower busbar 3 and the heatable wires 4 (and any further electrical components disposed thereagainst) has been found to be robust and reliable and does not fail during installation or use. This has been found to be particularly advantageous when the other of the two busbars (e.g. the upper busbar 2) is provided with a protective layer of tin.

[0058] It is known to deposit the heatable wires 4 onto the lower glass pane GP2 such that their ends abut or extend beyond the edge thereof. Subsequent to formation of the windscreen via autoclaving it is common practice to then remove any heatable wire ends which project beyond the edge of the windscreen laminate, e.g. via cutting. Although the trailing heatable wire ends are removed by this method the wire ends adjacent the edge of the windscreen continue to provide routes for the ingress of air and other undesirable elements such as water, which may consequently lead to corrosion and failure of the windscreen heating apparatus.

[0059] Advantageously, use of a busbar assembly 1 according to the invention mitigates against such ingress of air or other undesirable elements. Without wishing to be bound by any theory, it is believed that the first strip of adhesive material 23, where present, provides a seal adjacent the edge of the windscreen (and, although not shown as such, preferably the facing surface of the lower glass plane GP2), thereby preventing ingress of air or other undesirable elements.

[0060] Referring now to Figures 4 and 5, there is shown a busbar assembly 100 according to a second embodiment of the invention. The second embodiment of the busbar assembly 100 shown in Figures 4 and 5 differs from the embodiment of the busbar assembly 1 shown in Figures 1 and 2 in that the lower busbar 103 includes a relatively wider strip of adhesive material 133 which lies inboard of one of the edges of the lower busbar 103 but protrudes beyond the other edge.

[0061] A first portion 133a of the strip of adhesive material 133 is secured to a first major surface 134a of the lower busbar 103 whilst a second, exposed, portion 133b of the strip of adhesive material 133 extends beyond the longitudinal edge of the lower busbar 103. Preferably, a first release liner RL1 covers a first major surface 135a of the adhesive material 133, across both first and second portions 133a, 133b thereof. Preferably, a second release liner RL2 covers the obverse face 135b of the second portion of the strip of adhesive material 133 as well as (optionally) all or some of the second major surface 134b of the lower busbar 103. Although the second release liner RL2 is shown covering only a portion of the entire second major surface 103b of the lower busbar 103 it will be appreciated that this need not be the case and that the second release liner RL2 may instead cover the entirety of the second major surface 103b of the lower busbar 103, although this is least preferred from an installation point of view.

[0062] As above, both the upper and lower busbars 102, 103 are in strip form, having a width w', and whereby their respective thickness dimensions t' are significantly smaller than are their lengths l'. In this case the thickness t may be of the order of tens of microns (e.g. 10 to 200μm), whereas the length l is typically 10s of centimetres (e.g. from 5cm to up to 200 or 300cm).

[0063] The lower busbar 103 is a substrate, preferably a coated substrate CS' comprising a first rectangular copper strip 131 coated (preferably evenly and consistently coated) on all of its longitudinal surfaces with a thin protective layer 132, which may be a solder layer 132. The strip of adhesive material 133 is secured along substantially the entire length thereof, the other major surface 134b being free of adhesive.

[0064] In one embodiment the first strip 131 of substrate is about 4 mm wide and about 100 microns thick. The thin lead free solder layer 132 is preferably between about 1 and 20 microns thick, say between 5 microns and 10 microns thick. The thin solder layer 132 is formed from a low melting point solder which is most preferably a lead-free solder, e.g. a combination of tin and bismuth (for example one or more of Sn42Bi58, Sn36Bi64, Sn36Bi62Ag2). The strip of adhesive material 133 has a width of about 6 mm but could be wider or narrower. The strip of adhesive material 133 preferably includes a pressure sensitive adhesive, e.g. acrylic adhesive.

[0065] The upper busbar 102 includes a second coated substrate CS2' comprising a second rectangular copper strip 121 coated on all of its longitudinal faces with a thin protective layer 122 and having a first major surface 124a and a second major surface 124b.

[0066] In one embodiment the second strip 121 of substrate is about 8 mm wide and about 50 microns (10^{-6} m) thick. The thin protective layer 122 is preferably between 1 and 4 microns thick and may be formed from tin. It is preferred that the protective layer 122 is thinner than the lead-free solder coating 132.

[0067] The heatable wires 104 may have any suitable cross-sectional shape and are preferably about 20 microns in diameter. The heatable wires 104 may be formed from tungsten.

[0068] Referring now to Figure 6, there is shown a busbar assembly 100 according to the second embodiment of the invention installed in a windscreen and including a upper glass pane GP1' and an lower glass pane GP2' to form a window assembly WA'.

[0069] During installation the first release liner RL1 is removed from the lower busbar 103 which is then positioned against the lower glass pane GP2' at an intended point of use. With the first release liner RL1 removed from the strip of adhesive material 133 it is then pressed against the lower glass pane GP2', thereby securing the lower busbar 103 thereagainst. The second release liner RL2 is removed from the strip of adhesive material 133 and second major surface 103b of the lower busbar 103 to expose the second portion 133b of the adhesive material 133. Heatable wires 104 are deposited onto the lower glass pane GP2' such that one end of the heatable wires 104 lies across the lower busbar 103. The upper busbar 102 is then positioned over and along the lower busbar 103. The upper busbar 102 is then pressed against the exposed portion 133b of the strip of adhesive material 133, and thereby secured thereagainst. In this way the first major surface 124a of the upper busbar 102 is disposed adjacent the heatable wires 104.

[0070] Advantageously, the busbar assembly 101 according to the second embodiment of the invention ensures that installation of the assembly 101 simplified as compared to the first embodiment with a consequential reduction of installation time and expense. Further, the second major surface 134b of the lower busbar 103 is advantageously protected both prior to and during installation by the second release liner RL2. The second release liner RL2 thereby prevents undesirable substances (such as dirt) from accumulating on the second major surface 103b of the lower busbar 103 prior to its installation at a site of use. The second release liner RL2 may also provide a guide for positioning of the upper busbar 102 with respect thereto. In this way the upper busbar 102 may be more accurately and more rapidly located with respect to the lower busbar 103 and/or to the site of use, consequently reducing installation time and improving the repeatability of installation.

[0071] Advantageously, by providing the second release liner RL2 so as to only cover a portion (perhaps a major portion) of the obverse major surface 134b of the lower busbar 103 it makes easier the removal of the release liner RL2 and also ensures or enables the accurate location of the lower busbar 103 at a site of use.

[0072] Advantageously, the strip of adhesive material 133 (and specifically the exposed portion 133b) is completely covered by the upper busbar 102 such that the free edge of the strip of adhesive material 133 is inboard of the adjacent or proximate edge of the upper busbar 102.

[0073] It will be appreciated by those skilled in the art that several variations to the aforementioned embodiments are envisaged without departing from the scope of the invention. For example, although the lead free solder material has been described as comprising or consisting of tin and bismuth the solder material may alternatively comprise or consist of tin and silver, for example tin and bismuth and silver. Alternatively, the lead-free solder material may comprise indium. Additionally or alternatively, although the busbar assembly 1 is described as including a protective layer on the upper busbar and a solder layer on the lower busbar this need not be the case and instead the upper busbar may include a solder layer and the lower busbar may include a protective layer. We have surprisingly found that a lead-free solder formed from tin and bismuth, which may or may not comprise silver, and a protective coating of tin provides, in use, a robust and effective busbar assembly.

[0074] Moreover, the terms upper and lower are used as a convenient moniker in this application, it will be appreciated that the busbars could, in use, be positioned in an inverted sense or at an angle to the horizontal and no inference as to orientation should be inferred from the use of the label 'upper' and/or 'lower' except where the context requires.

Claims

1. A busbar assembly (1; 100) for installation at a site of use, the busbar assembly (1; 100) comprising a first busbar

(3; 103) and a second busbar (2; 102), wherein the second busbar (2; 102) at least partially overlies the first busbar (3; 103), at least one of the first and second busbars (2, 3; 102, 103) is coated with a lead free solder material (32; 132) comprising i) tin and bismuth or ii) indium, wherein at least one of the first and second busbars (2, 3; 102, 103) comprises securing means (33; 133) configured to secure, in use, the busbar assembly (1; 100) at the site of use.

2. A busbar assembly (1; 100) according to Claim 1, wherein the lead free solder material (32; 132) comprises silver.

3. A busbar assembly (1; 100) according to Claim 1 or 2, wherein, in use, electrical elements (4; 104) are located or locatable, between the first busbar (3; 103) and the second busbar (2; 102).

4. A busbar assembly (1; 100) according to and of Claims 1, 2 or 3, wherein the first busbar (3; 103) comprises a first major surface (34a; 134a) with longitudinal edges.

5. A busbar assembly (1; 100) according to Claim 4, wherein the first busbar (3) comprises said securing means (33).

6. A busbar assembly (1; 100) according to Claim 5, wherein said securing means (33) is inboard of one or both of the longitudinal edges.

7. A busbar assembly (100) according to any preceding Claim, wherein said securing means (133) protrudes beyond one of the longitudinal edges of the first busbar (103) for engagement with the second busbar (102).

8. A busbar assembly (1; 100) according to any preceding Claim, wherein the second busbar (2) is coated with a protective coating (22).

9. A busbar assembly (1; 100) according to Claim 8, wherein the protective coating (22) comprises a lead-free material, for example tin or a tin alloy, and/or the protective coating (22) is chemically distinct from the lead-free solder (32).

10. A busbar assembly (1; 100) according to any of Claims 8 or 9, wherein the protective coating (22) is thinner than the lead-free solder (32).

11. A busbar assembly (1; 100) according to any of Claims 8, 9 or 10, wherein the protective coating has a nominal or average thickness T_p and the lead-free solder has a nominal or average thickness T_s and whereby $T_p<T_s\leq 5T_p$, preferably $T_p<T_s\leq 3.5T_p$.

12. A busbar assembly (1; 100) according to any preceding Claim, wherein the first busbar (3) is narrower than the second busbar (2).

13. A busbar assembly (1; 100) according to any preceding Claim, wherein both the first (3) and second busbars (2) are elongate and wherein, in a width direction, the first busbar (3) has a cross sectional area A_1 and the second busbar (2) has a cross sectional area A_2 and wherein $0.8A_2 \leq A_1 \leq 1.2A_2$, preferably $0.9A_2 \leq A_1 \leq 1.1A_2$ and most preferably $0.95A_2 \leq A_1 \leq 1.05A_2$, for example $A_1 = A_2$.

14. A windscreen assembly (WA; WA') comprising electrical elements (4; 104), glass panes (GP1, GP2; GP1', GP2') and a busbar assembly (1; 100) according to any preceding Claim.

15. A windscreen assembly according to Claim 14, wherein the first busbar (3; 103) is secured to a first pane (GP2; GP2') via said securing means (33; 133) and said second busbar (2; 102) is secured to said first pane (GP1; GP1') via further or said securing means (23; 133).

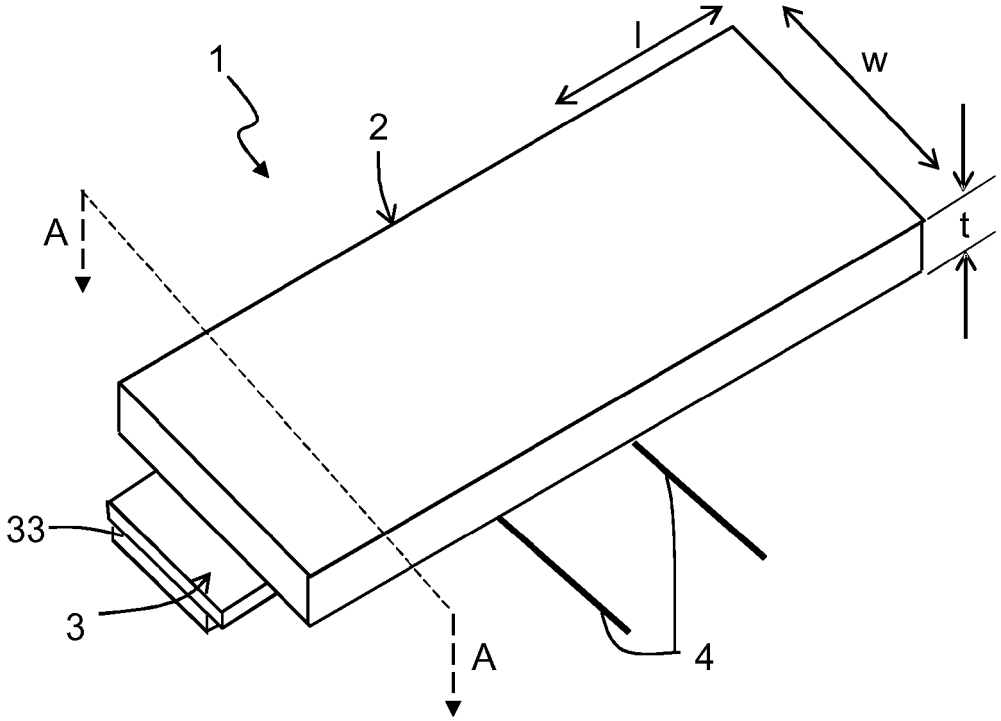

FIGURE 1

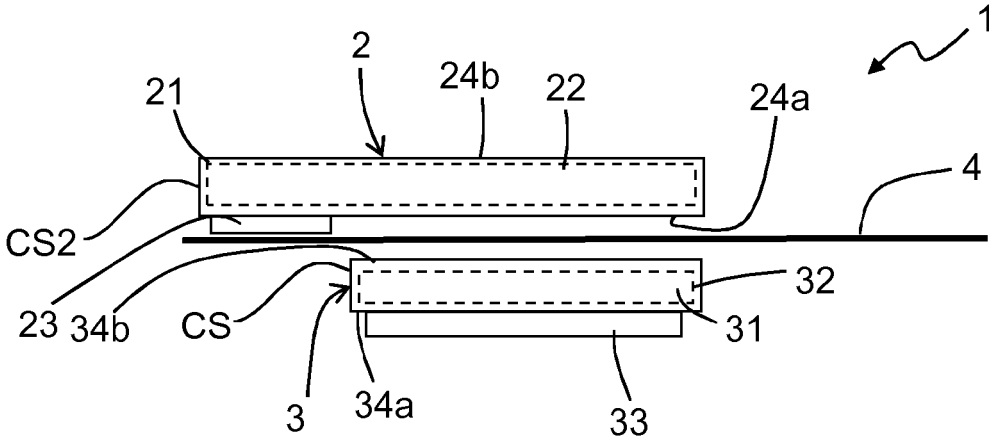

FIGURE 2

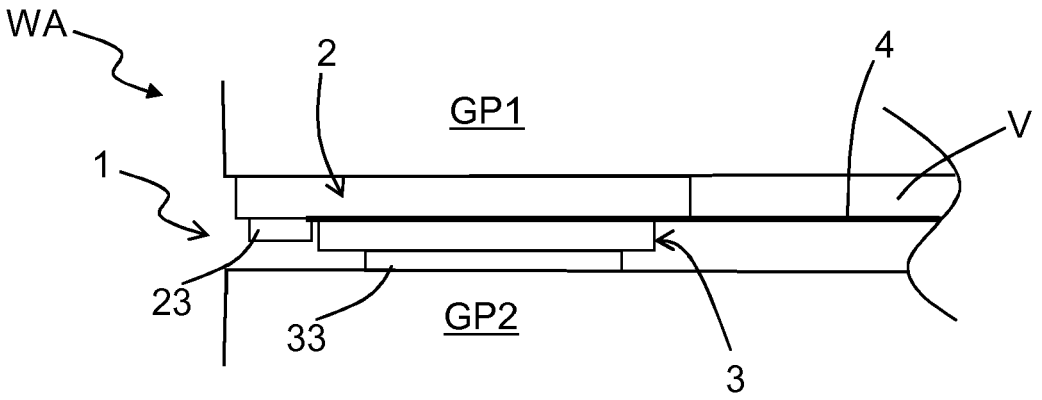

FIGURE 3

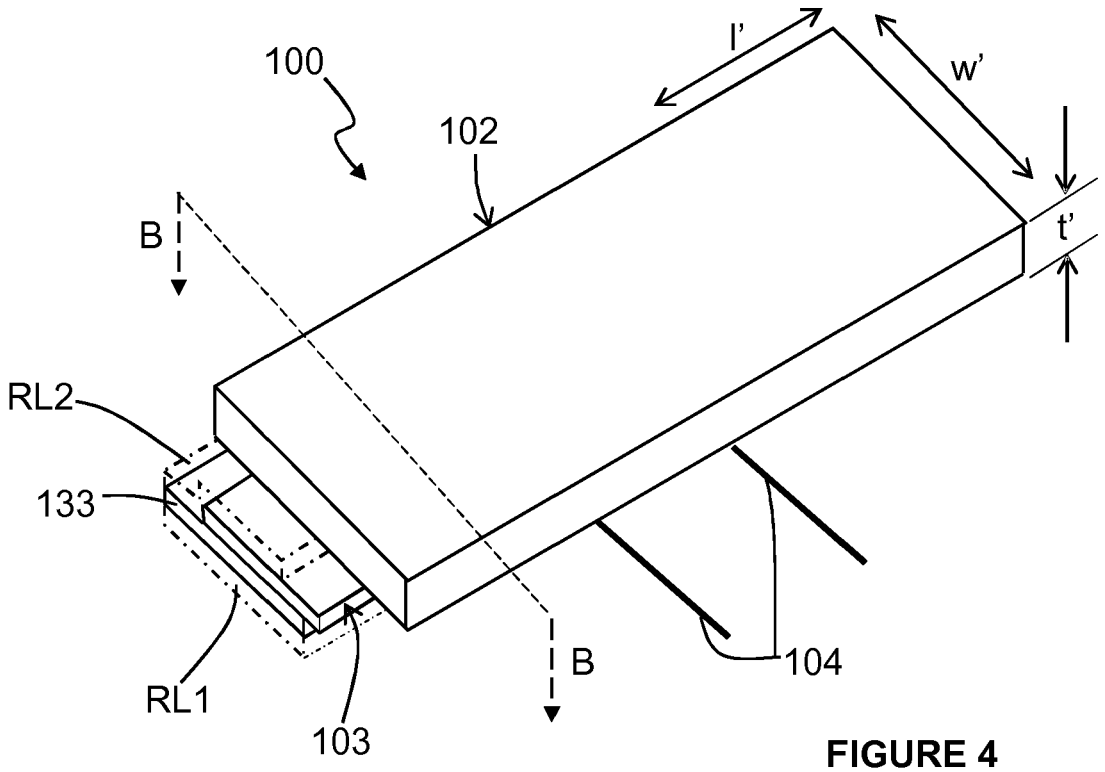

FIGURE 4

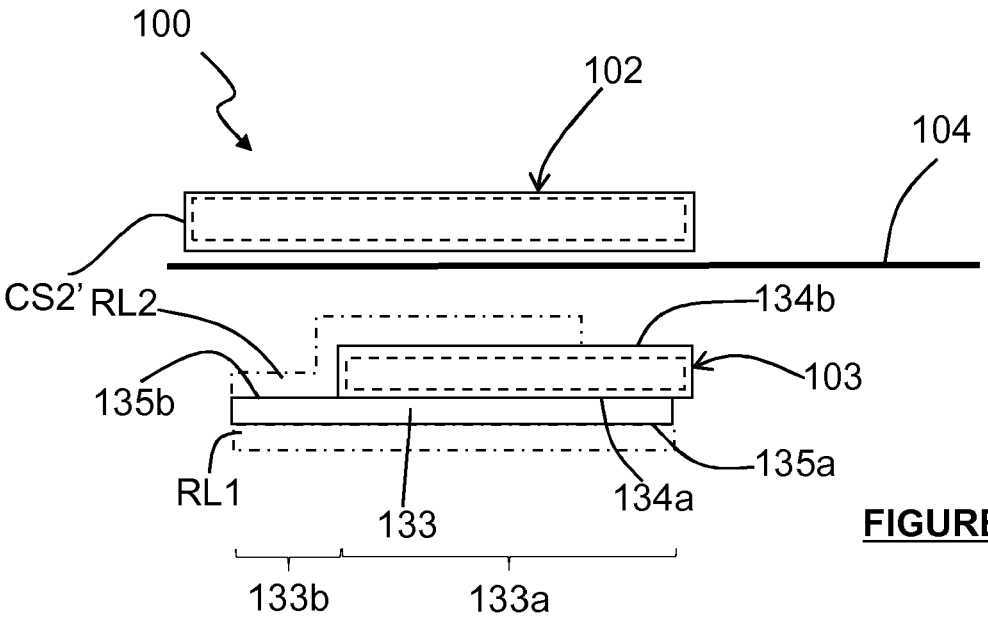

FIGURE 5

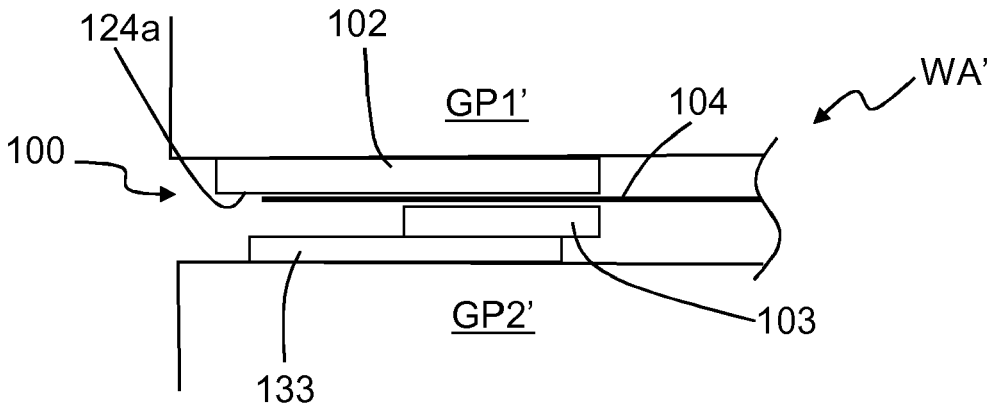

FIGURE 6

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EUROPEAN SEARCH REPORT

Application Number
EP 16 19 2578

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	7 March 2017	Barzic, Florent

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