US 20150233174A1

(19) United States
(12) Patent Application Publication
STARK
(10) Pub. No.: US 2015/0233174 A1
(43) Pub. Date: Aug. 20, 2015

(54) METHOD AND APPARATUS FOR SPACERS FOR INTER-PANE CAVITY OF VACUUM INSULATING GLASS UNITS AND VACUUM INSULATING GLASS UNITS INCORPORATING SAME

(71) Applicant: EVERSEALED WINDOWS, INC., Evergreen, CO (US)

(72) Inventor: DAVID H. STARK, EVERGREEN, CO (US)

(21) Appl. No.: 14/622,858

(22) Filed: Feb. 14, 2015

Related U.S. Application Data

(60) Provisional application No. 61/940,268, filed on Feb. 14, 2014.

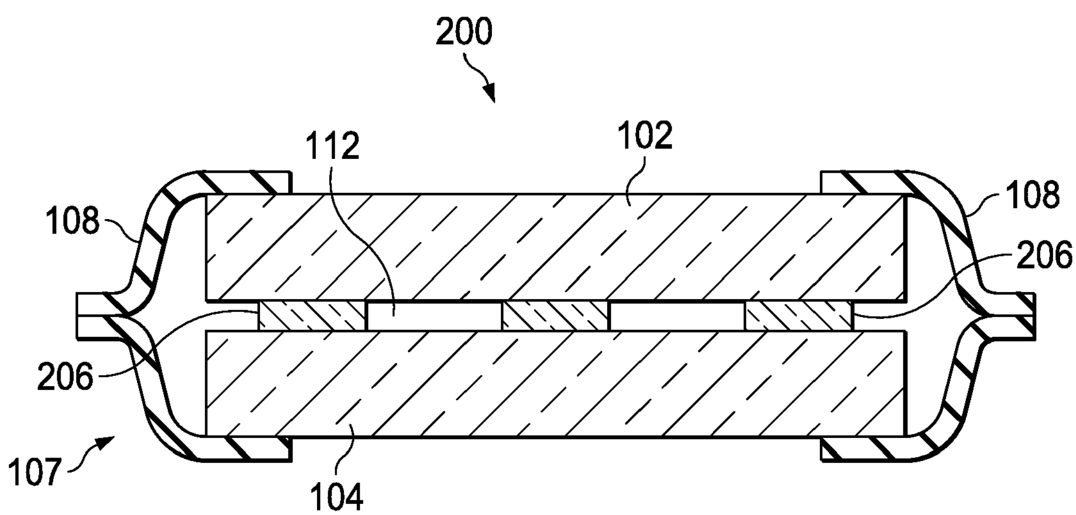
Publication Classification

(51) Int. Cl.
E06B 3/677 (2006.01)

(52) U.S. Cl.
CPC *E06B 3/677* (2013.01)

(57) ABSTRACT

A vacuum insulating glass unit comprises a first lite of transparent material having an inner surface and a periphery and a second lite of transparent material having an inner surface and a periphery. The second lite is spaced apart from the first lite to define a cavity between the opposing inner surfaces. An edge seal assembly hermetically joins the peripheries continuously around the cavity. A plurality of stand-offs are disposed within the cavity, each stand-off having a filament body having a rectangular cross-section including a relatively flat top surface, a relatively flat bottom surface, and relatively flat sides. The filament body has a curved shape, when viewed perpendicular to the inner surfaces. At least one adherence point on one of the top surface or bottom surface of the filament body is affixed to at least one of the inner surfaces of the adjacent first or second lites.



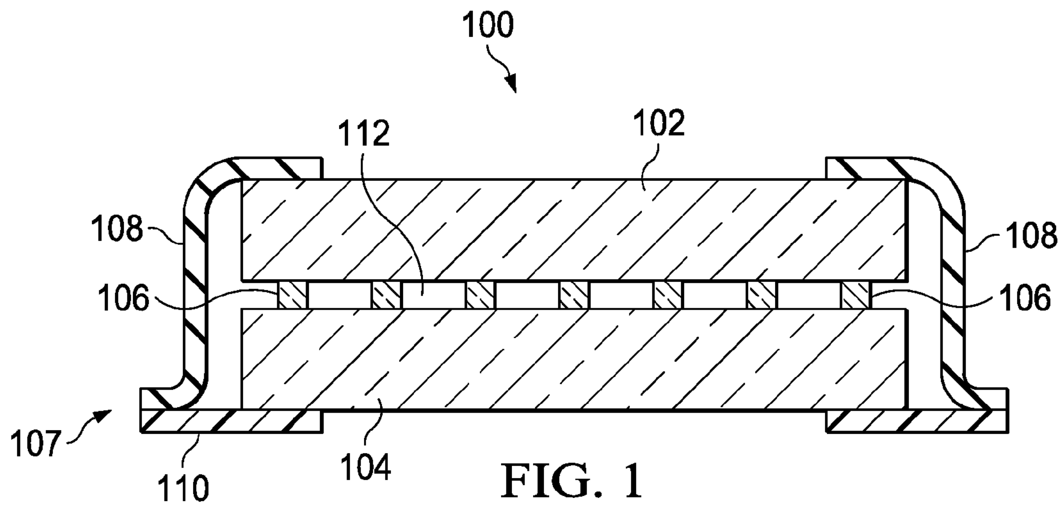


FIG. 1
(PRIOR ART)

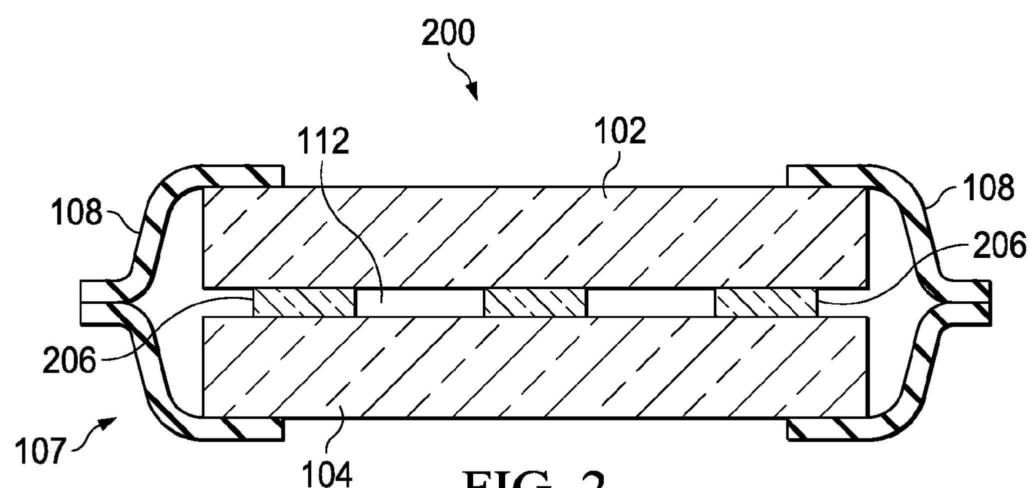


FIG. 2

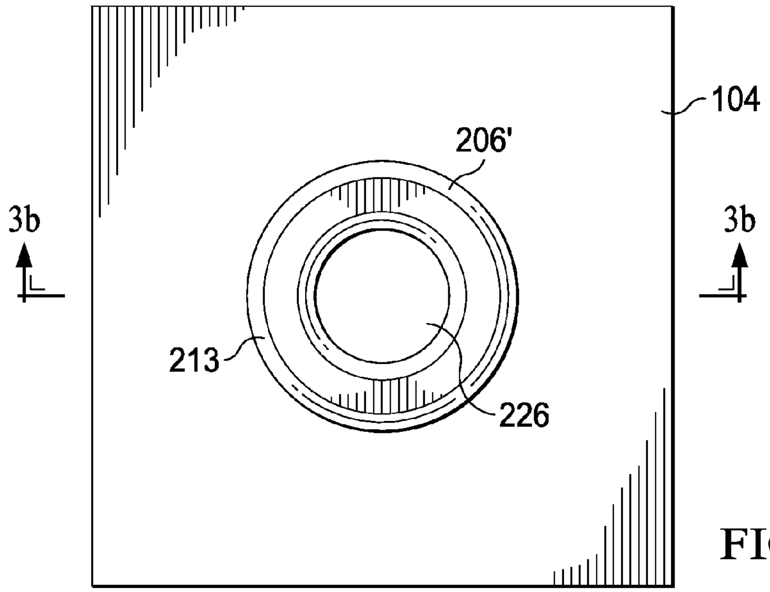


FIG. 3a

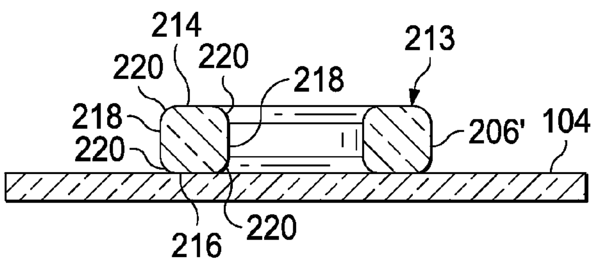


FIG. 3b

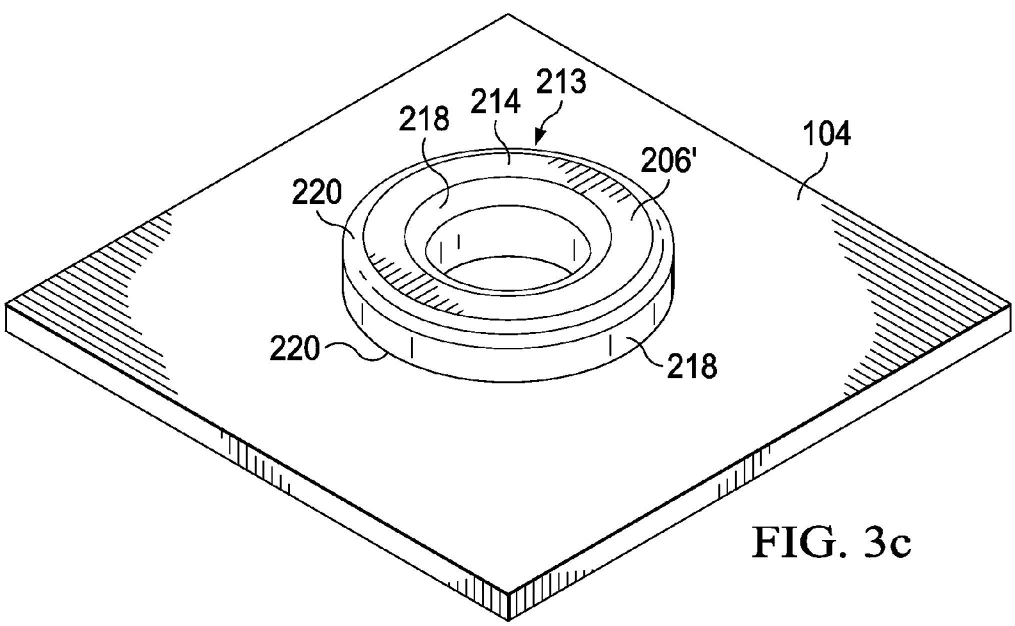


FIG. 3c

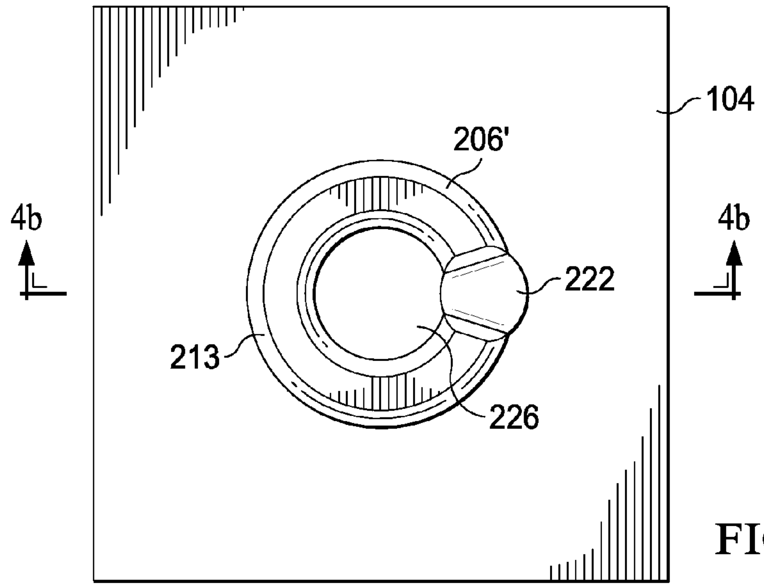


FIG. 4a

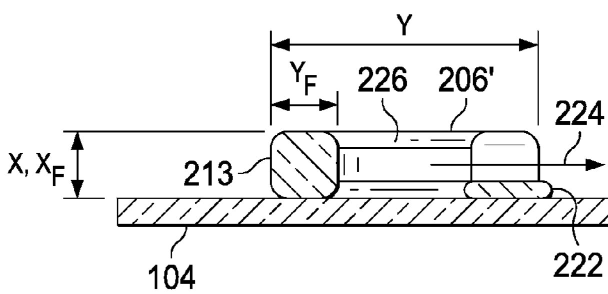


FIG. 4b

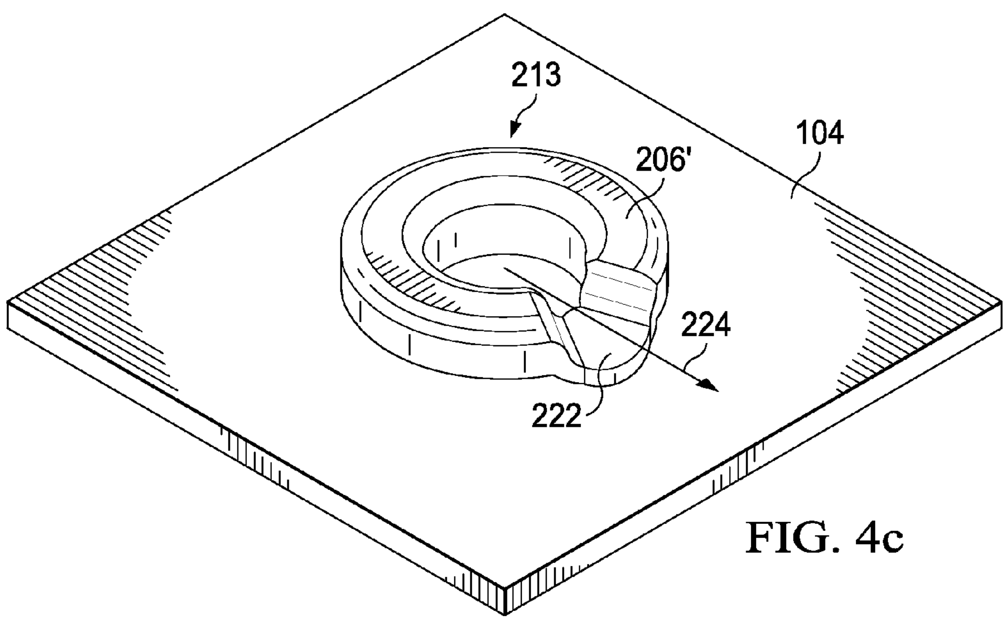


FIG. 4c

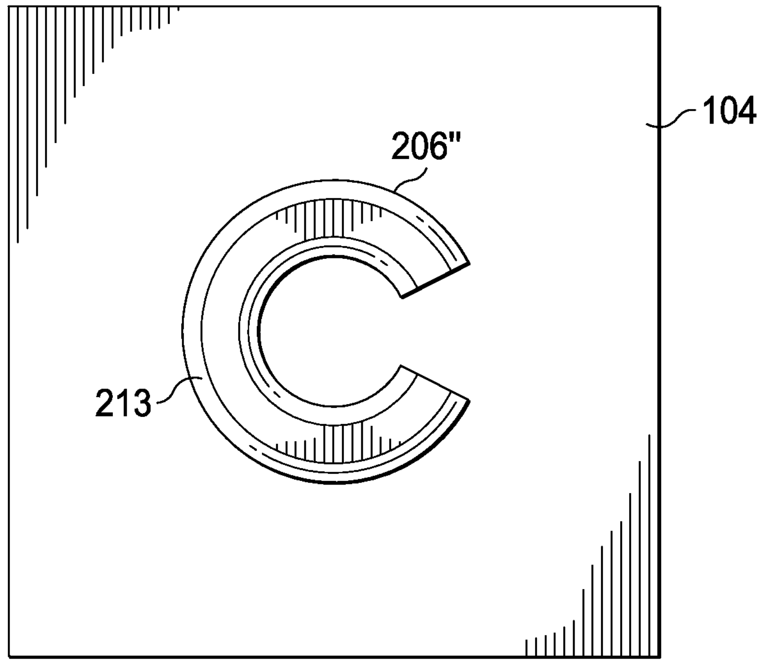


FIG. 5a

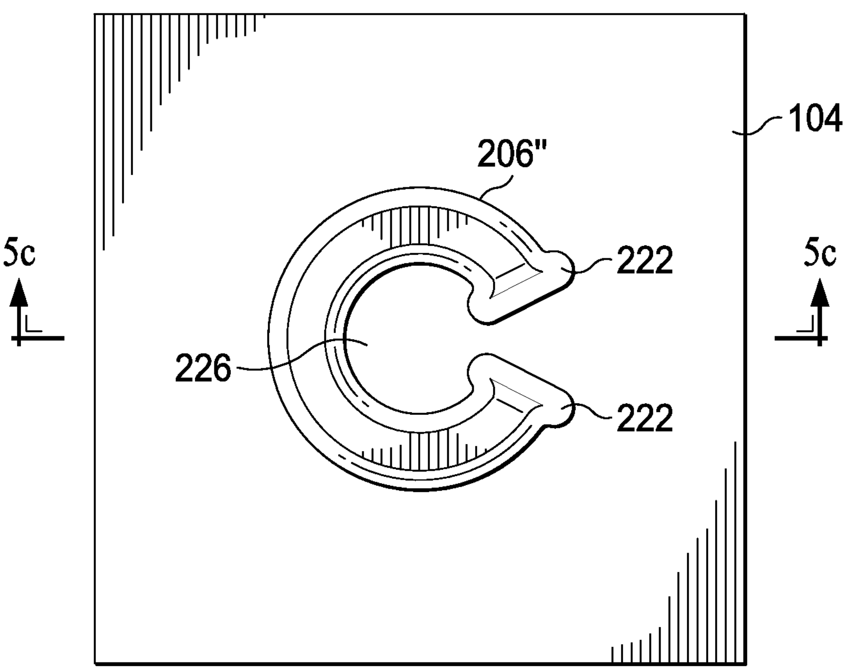


FIG. 5b

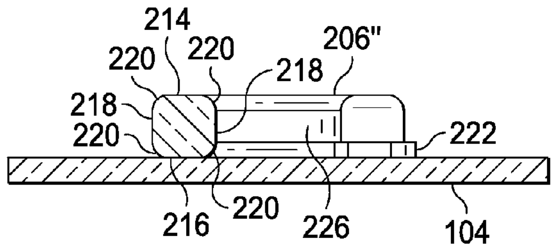

214
220
220
206"
218
218
220
222
216
220
226
104

FIG. 5c

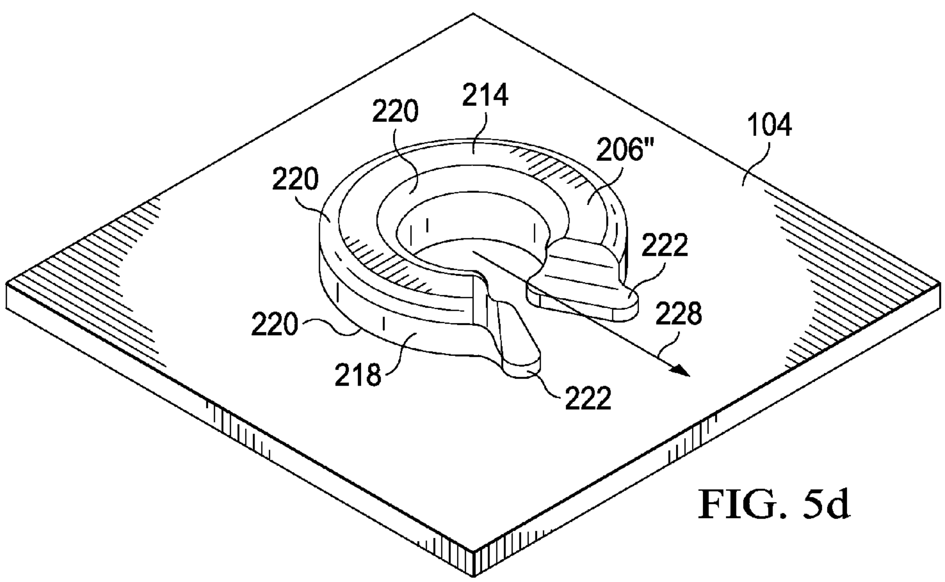

220
214
104
206"
220
222
228
220
218
222

FIG. 5d

METHOD AND APPARATUS FOR SPACERS FOR INTER-PANE CAVITY OF VACUUM INSULATING GLASS UNITS AND VACUUM INSULATING GLASS UNITS INCORPORATING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/940,268, filed on Feb. 14, 2014, entitled METHOD AND APPARATUS FOR SPACERS FOR INTER-PANE CAVITY OF VACUUM INSULATING GLASS UNITS AND VACUUM INSULATING GLASS UNITS INCORPORATING SAME (Atty. Dkt. No. STRK-32025), which is hereby incorporated by reference.

TECHNICAL FIELD

[0002] The current invention relates to multi-pane vacuum insulating glass units ("VIGUs" or "VIGs") for use in fenestration applications (e.g., windows and doors for buildings); windows for transportation vehicles (e.g., buses, trucks, automobiles, planes, trains, ships); solar collector panels; supermarket refrigeration systems; insulating glass units for beverage vending machines; and any other application where a VIGU might be used.

BACKGROUND

[0003] Vacuum insulated glass units ("VIGUs") are of interest for window applications because of their extremely high thermal insulating properties, with center-of-glass R values as high as R 13 or more. A VIGU may comprise two spaced-apart glass sheets, between which are disposed a series of stand-offs. A sealing system may include compliant members and/or rigid members disposed around the edges of the glass sheets and hermetically bonded thereto to form a hermetically sealed cavity between the glass sheets. The cavity of the VIGU may then be evacuated to a pressure of 1×10^{-3} torr or below. The stand-offs in the cavity must allow evacuation of the atmosphere within the cavity.

[0004] Once the VIGU is evacuated, the glass sheets are subject to one atmosphere of pressure on both sides of the unit. The role of the stand-offs between the glass sheets (lites) is to prevent the lites from bowing inward and touching each other under this pressure, as direct physical contact between the sheets will result in a thermal short that degrades the windows insulating performance. Further, the high stresses pressing inwards on the glass can result in glass breakage.

[0005] The stand-offs themselves also create a thermal path between the two lites. Therefore it is particularly advantageous to use as few as stand-offs as possible, with minimum cross-sectional area in contact with the glass. This requirement means that there is intense compressive force placed on each stand-off, and the stand-offs must have a sufficiently high compressive yield strength to accommodate the large loads.

[0006] Further, during diurnal cycling of the windows, the outer lite will be exposed to the outside environment, and become relatively hotter and/or colder than the inner lite. This relative expansion/contraction of the outer lite versus the inner lite means that the stand-offs may scrape back and forth across one or both lites during thermal cycling. For VIGUs designed with a flexible edge seal, the stand-offs can travel as much as 0.5 mm during cycling of a 1 m^2 unit in an extreme climate such as Eli, Nev. Thus, it is critical to ensure that the interface between the stand-off and the glass sufficiently lubricated that the glass or any coating on the glass is not scratched or otherwise damaged during this cycling.

[0007] Finally, these stand-offs must be applied to (i.e., positioned on) at least a first glass sheet during VIGU fabrication, where the second sheet is positioned atop the stand-offs before sealing. For stand-offs that adhere poorly to the glass, it becomes difficult to handle the glass after stand-off placement, and this imposes significant restrictions on the manufacturing flow of the VIGU. If the stand-offs are not bonded to the VIGU, the window should not be moved before vacuum is applied (after which the pressure of the glass on the stand-offs hold them in place). Any technology for bonding the stand-offs to glass requires that a completely non-outgassing material be used for the stand-off and its lubricant coating, and that a very simple manufacturing flow be employed. As a result, in the literature there is no simple means suggested for bonding stand-offs to glass prior to subsequent handling.

[0008] It is the purpose of this invention to describe a stand-off construction and means for manufacturing stand-offs and VIGUs with stand-offs that resolve many of the aforementioned problems.

SUMMARY

[0009] In one aspect, a vacuum insulating glass unit (VIGU) comprises a first lite of a first transparent material having a first inner surface and a first periphery and a second lite of a second transparent material having a second inner surface and a second periphery. The second lite is spaced apart from the first lite to define a cavity between the opposing first and second inner surfaces. An edge seal assembly hermetically joins the first periphery to the second periphery continuously around the cavity. A plurality of stand-offs are disposed within the cavity, each stand-off having a filament body, the filament body having a rectangular cross section, when viewed parallel to the first or second inner surface, including a relatively flat top surface, a relatively flat bottom surface, and relatively flat sides. The filament body has a curved shaped, when viewed perpendicular to the first or second inner surface. The stand-off further has at least one adherence point on one of the top surface or bottom surface of the filament body, the at least one adherence point being affixed to at least one of the inner surfaces of the adjacent first or second lites.

[0010] In one embodiment, the curved shape of the filament body is "0-shaped" when viewed parallel to the first or second inner surface

[0011] In another embodiment, a height of the stand-off at the at least one adherence point, measured perpendicular to the surfaces of the adjacent lites, is less than the height of remaining filament body.

[0012] In still another embodiment, all of the adherence points have a total area affixed to the surface of the adjacent lite that is less than 25% of the total surface area of the stand-off contacting that lite.

[0013] In yet another embodiment, all of the adherence points have a total area affixed to the surface of the adjacent lite that is less than 10% of the total surface area of the stand-off contacting that lite.

[0014] In a further embodiment, the rectangular cross-section of the filament body includes radiused corners.

[0015] In another embodiment, the curved shape of the filament body is "C-shaped" when viewed parallel to the first or second inner surface

[0016] In still another embodiment, the filament body is coated with one of indium or a tin-indium alloy

[0017] In another aspect, a method for vacuum insulating glass unit (VIGU) comprises the steps of providing a first lite of a first transparent material having a first inner surface and a first periphery, and positioning a plurality of stand-offs on the first inner surface within the first periphery. Each stand-off has a filament body, the filament body having a rectangular cross section, when viewed parallel to the first inner surface, including a relatively flat top surface, a relatively flat bottom surface, and relatively flat sides. The filament body has a curved shape, when viewed perpendicular to the first inner surface. Each stand-off further has at least one adherence point on one of the top surface or bottom surface of the filament body. The method further comprises providing a second lite of a second transparent material having a second inner surface and a second periphery, the second lite being spaced apart from the first lite to define a cavity between the opposing first and second inner surfaces, adhering the at least one adherence point on each of the plurality of stand-offs to at least one of the inner surfaces of the adjacent first or second lites, and hermetically joining an edge seal assembly between the first periphery and the second periphery continuously around the cavity.

[0018] In one embodiment, the step of adhering the adherence point on each stand-offs to the inner surface of the adjacent lite includes heating the adherence point using contact heating.

[0019] In another embodiment, the step of adhering the adherence point on each stand-offs to the inner surface of the adjacent lite includes heating the adherence point using directed energy.

[0020] In still another embodiment, the directed energy for heating the adherence point is a laser beam.

[0021] In yet another embodiment, the laser beam is directed at the adherence point through open space.

[0022] In a further embodiment, the laser beam is directed at the adherence point through the adjacent lite.

[0023] In another embodiment, the filament body of the stand-off is formed into the curved shape before being positioned on the first inner surface or adhered to the inner surface of the adjacent lite.

[0024] In yet another embodiment, the filament body of the stand-off is formed into the curved shape after having at least one adherence point affixed to the first inner surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] For a more complete understanding, reference is now made to the following description taken in conjunction with the accompanying Drawings in which:

[0026] FIG. **1** illustrates a VIGU in accordance with the prior art;

[0027] FIG. **2** illustrates a VIGU in accordance with one aspect of the current invention;

[0028] FIG. **3***a* is a top view of an "O-shaped" stand-off in accordance with one embodiment for use in the VIGU of FIG. **2**, the stand-off being disposed on a portion of the lower lite before adherence;

[0029] FIG. **3***b* is a cross-sectional side view of the stand-off and lite of FIG. **3***a* taken along line **3***b*-**3***b* of FIG. **3***a;*

[0030] FIG. **3***c* is a perspective view of the stand-off and lite of FIG. **3***a;*

[0031] FIG. **4***a* is a top view of the "O-shaped" stand-off of FIG. **3***a* after adherence to the lower lite;

[0032] FIG. **4***b* is a cross-sectional side view of the stand-off and lite of FIG. **4***a* taken along line **4***b*-**4***b* of FIG. **4***a;*

[0033] FIG. **4***c* is a perspective view of the stand-off and lite of FIG. **4***a;*

[0034] FIG. **5***a* is a top view of a "C-shaped" stand-off in accordance with another embodiment for use in the VIGU of FIG. **2**, the stand-off being disposed on a portion of the lower lite before adherence;

[0035] FIG. **5***b* is a top view of the "C-shaped" stand-off of FIG. **5***a* disposed on a portion of the lower lite after adherence;

[0036] FIG. **5***c* is a cross-sectional side view of the stand-off and lite of FIG. **5***b* taken along line **5***c*-**5***c* of FIG. **5***b*; and

[0037] FIG. **5***d* is a perspective view of the "C-shaped" stand-off and lite of FIG. **5***b* after adherence.

DETAILED DESCRIPTION

[0038] Referring to FIG. **1**, there is illustrated a VIGU **100** in accordance with the Prior Art. The VIGU **100** may comprise two spaced-apart glass sheets **102** and **104**, between which are disposed a series of stand-offs **106**. A sealing system **107** including compliant members **108** and/or rigid members **110** is disposed around the edges of the glass sheets **102**, **104** and hermetically bonded thereto to form a hermetically sealed cavity **112** between the glass sheets. The cavity **112** of the VIGU **100** may then be evacuated to a pressure of 1×10^{-3} torr or below. The stand-offs **106** in the cavity **112** must allow evacuation of the atmosphere within the cavity. It will be appreciated that the dimensions of the VIGU, including the dimensions of the sheets, stand-offs, cavity, etc. are not drawn to scale in FIG. **1**.

[0039] Referring now to FIG. **2**, a VIGU is illustrated in accordance with one embodiment. Except as otherwise described, the VIGU **200** may be substantially similar to the Prior Art VIGU **100** previously described. The VIGU **200** may comprise two spaced-apart glass sheets **102** and **104**, between which are disposed a series of stand-offs **206** as further described herein. A sealing system **107** including compliant members **108** and/or rigid members **110** (not shown) is disposed around the edges of the glass sheets **102**, **104** and hermetically bonded thereto to form a hermetically sealed cavity **112** between the glass sheets. The cavity **112** of the VIGU **200** may then be evacuated to a pressure of 1×10^{-3} torr or below. The stand-offs **206** in the cavity **112** must allow evacuation of the atmosphere within the cavity. It will be appreciated that the dimensions of the VIGU **200**, including the dimensions of the sheets, stand-offs, cavity, etc. are not drawn to scale in FIG. **2**

[0040] In the illustrated embodiment of this invention, the stand-offs **206** for the VIGU **200** are created as a glass filament or glass ribbon having a rectangular cross section. The filament may have a substantially square cross-section area with some or all of the corners being rounded (i.e., being a radius or containing a radius).

[0041] In another embodiment, the filament's rectangular cross section is not square, but rather, its width is wider than its height. The width dimension ("Y") of the filament may be the length of the part of the cross-section of the filament that is positioned parallel to the surface of the glass sheet, e.g., sheet **104**, onto which the filament is eventually placed. The height dimension ("X") of the filament may be the length of the part of the cross-section of the filament that is positioned perpendicular to the surface of the glass **104** onto which the filament is placed.

[0042] The aspect ratio of a rectangular stand-off is the ratio of the height X of the standoff to the width Y of the standoff. The presence or absence of radiused corners on a stand-off does not affect its aspect ratio.

[0043] In yet another embodiment of the invention, a stand-off **206** for a VIGU **200** is created using a low-friction coating with a preferred but not required melting point≥265° C. In one such embodiment, the coating is composed of one of the many chemical composition of silanes or silozanes. But other low coefficient-of-friction ("COF") coating may also be deposited on and/or into the surfaces of the glass filaments.

[0044] In another embodiment, stand-offs **206** are provided with a low COF coating including indium having a melting point less than 265° C. To form stand-offs **206** having such a low COF coating, indium may be applied to a spool of glass filament by running the filament from one reel onto another as the glass filament is submersed in one of: (a) an electroless solution plating bath of indium; (b) a molten bath of indium; (c) a solder fountain of indium; (d) a molten ultrasonic energy-agitated bath of indium; or (e) by other known means of creating a layer of indium onto the surface of the glass filaments.

[0045] In other embodiments similar to that just described, other low COF metallic coatings that may be provided on stand-offs **206** include, but are not limited to, metal alloys. One example is a tin-indium metal alloy.

[0046] In other embodiments, stand-offs **206** are provided with thin films of low melting temperature alloys, particularly those containing indium or bismuth, which anchor the stand-offs effectively to glass yet provide for good lubricity. These properties are understood to result from the particular mechanism for friction reduction in these films: the materials themselves are actually quite adherent, but when they are coated to conform to a first rough surface, they will have very little total surface area in contact with any other surface that they are placed against. Further, because these low melting alloys have low shear strength, they may fail cohesively when rubbed, allowing for easy sliding. This combination of low contact area and low strength may provide the stand-off **206** with an exemplary coefficient of friction of 0.3 or less.

[0047] In still other embodiments, the shape of the glass filaments or ribbons that are adhered to one of the two cavity-facing surfaces of the pairs of glass lites of the VIG will be formed to be compliant (i.e., flexible with our without exposure to changes in its temperature).

[0048] Depending on how and where on the glass ribbon standoffs that the standoffs are adhered to the surface of the glass lite, e.g., sheet **104**, the standoffs **206** may be very complaint to mechanical forces including changes in their temperatures and differential movements of the two panes of glass **102**, **104** of which the stand-offs maintain separation. The principal design goal for the standoffs **206** is that the formed standoff's dimensions be allowed to change in size due to changes in their temperature. Thus, in conjunction with their low-COF coating that allow the non-adhered sections on the standoffs **206** to slide or move relative to both pairs or lites **102**, **104** of the VIGUs, the glass standoffs where not intentionally or unintentionally adhered to either lite may expand or contract with changes in their temperature.

[0049] Many compliant shapes are known. Shapes for the glass ribbon standoffs **206** include, but are not limited to circles, rounded shapes such as the English alphabet letters "C", "J", "O" and "S" and "U" as well as English alphabet letters that do not have one or more straight segments, including the letters "B", "D", "E", "H" "K", "L", "M", "N", "P", "R", "T", "V", "W", "X", "Y" and "Z". However, the preferred shapes are round in area as they provide the greatest ratio surface area of the stand-off **206** itself to the overall or total area which they occupy on the surface of the glass **102**, **104** with few exceptions, such as straight lines. Thus, either the a round shape such as the an unbroken circle adhered to the surface of the glass (or coating on the glass) in one spot or two opposite sides of the circle, or a rounded letter "C" which is a circle with an opening it its circumference, are the preferred shapes for the glass filament or glass ribbon standoffs. In the case of the rounded letter "C", it would be adhered to the surface of the glass or the coating on the glass at the two ends of the letter "C".

[0050] Referring now to FIGS. **3***a*, **3***b* and **3***c*, there is illustrated an "O-shaped" stand-off **206'** in accordance with one embodiment for use in the VIGU of FIG. **2**. Specifically, FIG. **3***a* is a top view (plan view), FIG. **3***b* is a cross-sectional side view taken along line **3***b*-**3***b* of FIG. **3***a* and FIG. **3***c* is a perspective view, all showing the stand-off **206'** prior to adherence to the lite **104**. As best seen in FIG. **3***b*, the filament body **213** of the illustrated "O-shaped" standoff **206'** has a substantially square cross-section, with a substantially flat top **214**, a substantially flat bottom **216** and substantially flat sides **218**, however, the corners **220** are radiused. A square cross-section means the filament body **213** has a perpendicular-to-lite dimension, "X_F", and a parallel-to-lite dimension, "Y_F", (see FIG. **4***b*) that are approximately equal. In other embodiments, other rectangular cross-sections may be used for the filament body **213**.

[0051] Referring now to FIGS. **4***a*, **4***b* and **4***c*, the "O-shaped" stand-off **206'** of FIG. **3***a* is shown after adherence to the lower lite **104**. Specifically, FIG. **4** is a top view, FIG. **4***b* is a cross-sectional side view taken along line **4***b*-**4***b* of FIG. **4***a* and FIG. **4***c* is a perspective view. In the illustrated embodiment, the stand-off **206'** is attached to the lower lite **104** at a single adherence point or bond point **222**. In other embodiments, multiple bond points may be used. Preferably, the bond point(s) affix only a small percentage of the total lite-contacting surface area of the top **214** or bottom **216** of the stand-off **206'** to the surface of the respective lite **102**, **104**. In some embodiments, the total area of the bond points **222** affixed to the surface of a lite **102**, **104** for each stand-off **206'** is less than 25% of the total surface area of that stand-off contacting that lite. In other embodiments, the total area of the bond points **222** affixed to the surface of a lite **102**, **104** for each stand-off **206'** is less than 10% of the total surface area of that stand-off contacting that lite. This structure maintains the general position of the stand-off **206** on the lite **102**, **104**, but allows the un-affixed portions of the stand-off to "float", or move, relative to the lite to accommodate relative movement between the lites.

[0052] At the bond point **222**, the filament body **213** of the stand-off **206'** may be partially flattened. This flattening may be caused by localized heating of the stand-off **206'**, e.g., by the application of contact heating or by directed energy such as a laser beam, with or without the application of localized pressure. In the case of heating with directed energy, including heating with a laser beam, in some embodiments the heating energy may be directed onto the bond point on the stand-off through open space, whereas in other embodiments, the heating energy may be directed onto the bond point through the adjacent lite. The heating (and pressure, if applicable) may cause the filament body **213** of the stand-off **206'** and/or the adjacent area of the lite **104** to soften or melt when the bond point **222** becomes affixed to the surface of the lite (or lite coating). The flattening of the filament body **213** creates a channel or passageway **224** through the wall of the stand-off **206'** allowing the atmosphere within the interior **226** of the stand-off to be evacuated even when the stand-off is contacting both lites **102** and **104**.

[0053] Referring now to FIGS. **5***a*, **5***b*, **5***c* and **5***d*, there is illustrated a "C-shaped" stand-off **206"** in accordance with another embodiment for use in the VIGU of FIG. **2**. Specifically, FIG. **5***a* is a top view of the stand-off **206"** prior to adherence to the lower lite **104**, FIG. **5***b* is a top view of the stand-off after adherence, FIG. **5***c* is a cross-sectional side view taken along line **5***c*-**5***c* of FIG. **5***b* and FIG. **5***d* is a perspective view. As best seen in FIG. **5***c*, the filament body **213** of the "C-shaped" standoff **206"** has a substantially square cross-section similar to that of standoff **206'** just described, with a substantially flat top **214**, a substantially flat bottom **216**, substantially flat sides **218** and radiused corners **220**.

[0054] The "C-shaped" stand-off **206"** of FIG. **5***b* may be attached to the lite **104** with one or more bond points **222**. In the illustrated embodiment, two bond points **222** are used, one at each end of the body filament **213**. Preferably, the bond point(s) affix only a small percentage of the total lite-contacting surface area of the top **214** or bottom **216** of the stand-off **206"** to the surface of the respective lite **102**, **104**. In some embodiments, the total area of the bond points **222** affixed to the surface of a lite **102**, **104** for each stand-off **206"** is less than 25% of the total surface area of that stand-off contacting that lite. In other embodiments, the total area of the bond points **222** affixed to the surface of a lite **102**, **104** for each stand-off **206"** is less than 10% of the total surface area of that stand-off contacting that lite.

[0055] In the illustrated embodiment, the stand-off **206"** is partially flattened at the bond points **222**. As previously described, this flattening may be caused by localized heating of the stand-off **206"** with or without the application of localized pressure. In other embodiments, however, the "C-shaped" stand-off **206"** may be adhered to the lite **104** without flattening or partial flattening. In contrast to the "O-shaped" stand-off **206'**, the "C-shaped" stand-off **206"** does not require flattening to produce a channel or passageway **226** from the interior **226** of the stand-off to the exterior. Thus, a passageway **228** is present even if the stand-off **206"** is adhered with no flattening.

[0056] Several different types or sources of light (i.e., wavelengths of light) may shine on, or interact with the glass standoffs **206** in the VIGU **200**. These sources include, but are not limited to incandescent, fluorescent, LED, LCD, plasma and solar light sources. In some incidents, tints such as films and coating may be involved. In every instance, the angles of incidence may not be fixed by may be moving, such as is almost always the case with solar light sources. Thus if nothing is done, undesirable optical effects could occur which could be annoying to individuals looking at or through the VIGUs.

[0057] In another aspect, glass standoffs **206** are made or modified to be non-reflective. Two methods to accomplish non-reflectivity are to coat the glass (or other material) of the stand-offs **206** with a non-reflective coating and/or to add a dye (or tint or other coloring agent) to the glass during its fabrication to make it opaque enough or to embellish it with anti-reflective ("A/R") properties. As it is desired that the surface of the glass of the stand-off **206** have a low COF against the surface of the glass or glass coating to which it is not intentionally adhered (e.g., sheet **102**) to during assembly of the VIGU **200**, the low COF coating or coatings may be applied to the glass standoff material after any A/R coatings or dyes are applied to or into the glass filaments or ribbons.

[0058] In another aspect, stand-offs **206** are adhered at one or more places along the standoff itself onto the surface of the glass or glass coating, e.g., the inner surface of sheet **104**. The adhering may be accomplished by methods including, but are not limited to: (a) using a modified wedge- or ribbon wedge-bonder such as is known to those skilled in the art of semiconductor packaging, but further modifying the bonding mechanism by mounting it on a moving mechanism including but not limited to a robotic arm or gantry system in an appropriate fashion to accommodate and be used on a piece of glass much larger than the small parts, packages and substrates used in the semiconductor industry; (b) one or more lasers of the appropriate wavelengths, used with or without mechanical mechanisms to place and/or pull apart the glass of the stand-off at the last bonding location; (c) heating tooling such as electrical resistance heating elements (e.g., a soldering iron) with or without inclusion of ultrasonic energy; or (d) other heating and adherence tools and mechanisms.

[0059] In each instance of adherence to the surface of the glass of the VIGU or a coating on the surface of the glass **104**, the stand-off filament or ribbon glass may be supplied by its producer on spools or reels. In order to place it onto the glass or coating surface, the standoff ribbon may be fed though a guide mechanism such as a bonder's capillary tube. In some embodiments, the compliant shape of the standoff **206** is created during the placement of the glass ribbon onto the VIGU's cavity-facing glass surface or coated glass surface **102** or **104**; as such the placement mechanism must be capable of forming the compliant shape while keeping at least one of the two Y-axis surfaces (e.g., tops **214** and bottoms **216**) of the ribbon parallel to the glass or coated glass surface, i.e., the ribbon stand-off placement mechanism must sufficiently prevent twisting of the ribbon such that once the VIGU **200** is assembled and the glass standoffs **206** are in between a pair of glass lites **102** and **104**, the standoffs are all flat and their Y-dimensions or surfaces (e.g., tops **214** and bottoms **216**) are all parallel to the surfaces (not perimeters) of the lites and their X-dimensions or surfaces (e.g., sides **218**) are all perpendicular to the surfaces) of the lites.

[0060] In some aspects, the glass filament or glass ribbon standoffs **206** for this application are fabricated into rounded shapes prior to placement and then adherence onto one surface of one glass lite or onto the coated surface of one glass lite. I.e., they are pre-fabricated and supplied as a completed shape (such as, but not limited to a circle or rounded letter "C") to the stand-off attachment process of the VIG's assembly procedure. Then after appropriate placement onto the surface of one lite, e.g., sheet **104**, one of the adherence methods described above may be employed to adhere the pre-fabricated standoffs **206** onto the surface of the glass or coated glass lite **102** or **104**.

[0061] In some embodiments, when a coating or coating to be applied to the glass filament or ribbon for A/R, low COF or other purposes, the coating may be removed in the areas where the glass filament **206** is to be adhered to the glass **102** or **104**. Many processes for this removal step may be used including, but not limited to, mechanical abrasive remove methods, laser ablation and chemical removal processes.

[0062] In still other embodiments, the process of adhering the glass filament standoff **206** onto the lite **102** and/or **104** of the VIGU **200** reduces the cross-section height of the stand-off **206** where the adherence by heat, soldering, ultrasonic scrubbing or another appropriate method is used. The cross-section height is the X-axis dimension of the stand-off (i.e., X or X_F).

[0063] The glass used to make the filament or ribbon glass stand-offs **206** may be a variety of types of glass. The glass lites **102**, **104** of a VIGU **200** are typically made from soda-lime float glass. Although basically generic, the coefficient of thermal expansion of the soda-lime glass can vary among geographic regions of the globe due to differences in the sand used to make the soda-lime glass. The glass filaments used for the stand-offs **206** could be made from local, regional or distant-region soda-lime glass.

[0064] A preferred glass for producing the filament or ribbon glass stand-offs **206** is a borosilicate glass. This glass is also sometimes called a sodium borosilicate glass. Compared to soda-lime glass, borosilicate glasses have almost one third the coefficient of thermal expansion ("CTE") of soda lime glasses which make the borosilicate glasses more dimensionally stable. In addition, borosilicate's lower CTEs also help to make them less prone to stress caused by them expansion and less vulnerable to cracking from thermal shock.

[0065] It should be noted that the filament or ribbon-shaped material used to make the stand-offs **206** for VIGUs **200** need not be made of glass or quartz glass. However, glass has a lower thermal conductivity than almost any other non-out-gassing material, which is a principal advantage for using glass standoffs that come in physical contact with the interior or cavity-facing surfaces of the pairs of glass lites of a VIGU.

[0066] Although the preferred embodiment has been described in detail, it should be understood that various changes, substitutions and alterations can be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A vacuum insulating glass unit (VIGU) comprising:

a first lite of a first transparent material having a first inner surface and a first periphery;

a second lite of a second transparent material having a second inner surface and a second periphery, the second lite being spaced apart from the first lite to define a cavity between the opposing first and second inner surfaces;

an edge seal assembly hermetically joining the first periphery to the second periphery continuously around the cavity; and

a plurality of stand-offs disposed within the cavity, each stand-off having

a filament body,

the filament body having a rectangular cross section, when viewed parallel to the first or second inner surface, including a relatively flat top surface, a relatively flat bottom surface, and relatively flat sides, and

the filament body having a curved shape, when viewed perpendicular to the first or second inner surface; and

at least one adherence point on one of the top surface or bottom surface of the filament body, the at least one adherence point being affixed to at least one of the inner surfaces of the adjacent first or second lites.

2. A VIGU in accordance with claim **1**, wherein the curved shape of the filament body is "O-shaped" when viewed parallel to the first or second inner surface

3. A VIGU in accordance with claim **2**, wherein a height of the stand-off at the at least one adherence point, measured perpendicular to the surfaces of the adjacent lites, is less than the height of remaining filament body.

4. A VIGU in accordance with claim **2**, wherein all of the adherence points have a total area affixed to the surface of the adjacent lite that is less than 25% of the total surface area of the stand-off contacting that lite.

5. A VIGU in accordance with claim **4**, wherein all of the adherence points have a total area affixed to the surface of the adjacent lite that is less than 10% of the total surface area of the stand-off contacting that lite.

6. A VIGU in accordance with claim **1**, wherein the rectangular cross-section of the filament body includes radiused corners.

7. A VIGU in accordance with claim **1**, wherein the curved shape of the filament body is "C-shaped" when viewed parallel to the first or second inner surface

8. A VIGU in accordance with claim **1**, wherein the filament body is coated with one of indium or a tin-indium alloy.

9. A method for vacuum insulating glass unit (VIGU), the method comprising the following steps:

providing a first lite of a first transparent material having a first inner surface and a first periphery;

positioning a plurality of stand-offs on the first inner surface within the first periphery, each stand-off having

a filament body,

the filament body having a rectangular cross section, when viewed parallel to the first inner surface, including a relatively flat top surface, a relatively flat bottom surface, and relatively flat sides, and

the filament body having a curved shape, when viewed perpendicular to the first inner surface; and

at least one adherence point on one of the top surface or bottom surface of the filament body,

providing a second lite of a second transparent material having a second inner surface and a second periphery, the second lite being spaced apart from the first lite to define a cavity between the opposing first and second inner surfaces;

adhering the at least one adherence point on each of the plurality of stand-offs to at least one of the inner surfaces of the adjacent first or second lites; and

hermetically joining an edge seal assembly between the first periphery and the second periphery continuously around the cavity.

10. A method in accordance with claim **9**, wherein the step of adhering the adherence point on each stand-offs to the inner surface of the adjacent lite includes heating the adherence point using contact heating.

11. A method in accordance with claim **9**, wherein the step of adhering the adherence point on each stand-offs to the inner surface of the adjacent lite includes heating the adherence point using directed energy.

12. A method in accordance with claim **11**, wherein the directed energy for heating the adherence point is a laser beam.

13. A method in accordance with claim **12**, wherein the laser beam is directed at the adherence point through open space.

14. A method in accordance with claim **12**, wherein the laser beam is directed at the adherence point through the adjacent lite.

15. A method in accordance with claim **9**, wherein the filament body of the stand-off is formed into the curved shape before being positioned on the first inner surface or adhered to the inner surface of the adjacent lite.

16. A method in accordance with claim **9**, wherein the filament body of the stand-off is formed into the curved shape after having at least one adherence point affixed to the first inner surface.

* * * * *