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(54)

AN INSULATING GLASS UNIT AND A PROCESS FOR MANUFACTURING AN INSULATING GLASS UNIT

(57) An insulating glass unit comprising at least two parallel glass panes (1), a space between the at least two parallel glass panes being the interpane space (2), said at least two parallel glass panes being held structurally together along their perimeters by an edge seal, the edge seal extending along the whole perimeter of the at least two glass panes, whereby the interpane space is sealed from the outside by the edge seal, the edge seal comprising:

a first thermoplastic material (3),

a second thermoplastic material (4) and

a thermoset plastic material (5),

wherein the first thermoplastic material (3) defines the distance (6) between the at least two glass panes (1) and defines a first layer of the edge seal, the first layer of the edge seal being situated within the interpane space and adhering to the surfaces of the at least two parallel glass

panes facing the interpane space,

wherein the second thermoplastic material (4) is contacting the first thermoplastic material (3) and defines a second layer of the edge seal, the second layer of the edge seal being situated within the interpane space and adhering to the surface of the at least two parallel glass panes facing the interpane space, and

wherein the thermoset plastic material (5) is contacting the second thermoplastic material (4),

the thermoset plastic material adhering to at least a first glass surface on the two parallel glass panes not facing the interpane space, said first glass surface (7) defining the thickness of each of the two glass panes, the thermoset plastic material defining a third layer of the edge seal. The invention moreover relates to a process for manufacturing an insulating glass unit.

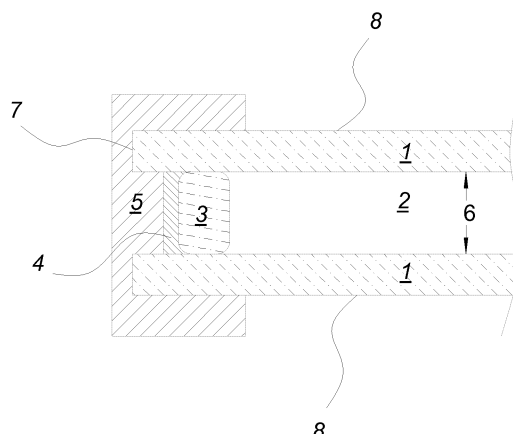


Fig. 1a

Description**FIELD OF THE INVENTION**

[0001] The invention relates to insulated glass units for doors and windows and a process for manufacturing an insulating glass unit.

BACKGROUND

[0002] Insulating glass units (IGU's) typically consist of multiple glass panes held together structurally along their perimeters. The space between the glass panes is sealed from the outside space using various sealant materials and designs.

[0003] Typically a space bar is positioned between the glass panes to hold them at a fixed distance from each other. Most often, the space bar is a metal profile. The role of the sealant is to bond together the space bar and the glass pane and to provide a high level of moisture vapor - and gas diffusion resistance. Also, the sealant may provide flexibility to allow movement of the glass panes due to, for example thermal expansion.

[0004] Most often, desiccant is provided, for example inside a hollow space bar, to prevent the glass surfaces facing each other in the IGU from fogging resulting from condensation of vapors in the inter-pane space.

[0005] One reason for failure of IGU's is such condensation when the seal is no longer effective to prevent, for example, water vapor from the outside environment to enter the inter-pane space.

[0006] Also, the thermal performance of the edge seal design is important. Space bars may for example have high thermal conductivity when made of metal thus creating a thermal bridge that may negatively influence the insulating capability of the IGU. Importantly, the structural integrity of the IGU during transportation, under changing weather conditions and the like also depends on the ability of the spacer/sealing-design to accommodate movement of the glass panes without the seal being damaged.

[0007] A thermoplastic spacer (TPS) may be used instead of a metal spacer. To compensate for the inferior strength of such TPS, US 4 909 875 discloses a method for providing a peripheral joint around the edges of the glass panes based on a reactive molding technique.

[0008] There still exists a need for improving IGU's with respect to e.g. service life, thermal performance and production costs.

SUMMARY

[0009] In a first aspect the invention relates to an insulating glass unit comprising at least two parallel glass panes, a space between the at least two parallel glass panes being the interpane space, said at least two parallel glass panes being held structurally together along their perimeters by an edge seal, the edge seal extending along the whole perimeter of the

at least two glass panes, whereby the interpane space is sealed from the outside by the edge seal, the edge seal comprising:

a first thermoplastic material,
a second thermoplastic material and
a thermoset plastic material,
wherein the first thermoplastic material defines the distance between the at least two glass panes and defines a first layer of the edge seal, the first layer of the edge seal being situated within the interpane space and adhering to the surfaces of the at least two parallel glass panes facing the interpane space, wherein the second thermoplastic material is contacting the first thermoplastic material and defines a second layer of the edge seal, the second layer of the edge seal being situated within the interpane space and adhering to the surface of the at least two parallel glass panes facing the interpane space, and wherein the thermoset plastic material is contacting the second thermoplastic material, the thermoset plastic material adhering at least to a first glass surface on the two parallel glass panes not facing the interpane space, said first glass surface defining the thickness of each of the two glass panes, the thermoset plastic material defining a third layer of the edge seal.

[0010] The present invention provides an insulating glass unit having improved thermal properties. A thermoplastic material with low thermal conductivity is used as a spacer between the glass panes of the insulating glass unit.

[0011] A second thermoplastic material is used to provide surprisingly good sealant properties with respect to moisture penetration from the outside into the interpane space, while preserving low thermal conductivity of the seal. The very good sealing properties of the second layer are achieved in synergy with an improved mechanical stability of the whole edge seal. The good adhesion of the second layer to both the first layer and the third layer due to improved chemical compatibility ensures that the seal is not broken during handling other mechanical stress on the insulating glass unit.

[0012] In connection with thermal expansion/contraction of the components of the insulating glass unit, the second layer is flexible enough to follow the movement of the glass and the first and third layers at the same time without disrupting the sealing capacity of layer two and/or the whole seal.

[0013] The whole seal is made from plastic materials thereby providing advantageous thermal properties when compared to prior art insulating glass units using metal parts as spacers between the glass panes. The thermal performance of the insulating glass unit is affected by the effective thermal conductivity of the edge seal which may be 5 - 10 times lower for the inventive unit when compared to units having metal spacers.

[0014] According to the present invention, advantageous thermal properties are obtained by using an insulating glass unit sealed with an edge seal comprising three layers of plastic material.

[0015] One of the most important reasons for failure of insulating glass units is the penetration of moisture into the interpane space due to seal failure. Such failure may occur over time caused by thermal stress, strong winds or, for example, during transportation due to mechanical stress.

[0016] The insulating glass unit according to the present invention may have excellent life time expectancy, in particular due to the combination of three layers of plastic material making up a very stable seal both mechanically and over time.

[0017] The adhesion of the plastic materials of the first and the second layers and the second and the third layer to glass and to each other ensures a long service time for the insulating glass unit and is preferably of cohesive character.

[0018] The strengthening and stabilizing of the whole seal in particular due to the second layer of the edge seal may increase the life time of the insulating glass unit by up to 5 years or even more when compared to units not having the second layer.

[0019] The thermoset plastic material of the third layer of the edge seal provides mechanical strength to the insulating glass unit.

[0020] While layer 1 and layer 2 may be comparatively soft, especially at elevated temperatures, the thermoset material will provide stability and limit the stress on layer 1 and 2, for example, during successive expansions and contractions of the gas in the interpane space.

[0021] In some embodiments, the insulating glass unit may comprise more than two parallel glass panes, such as e.g. three or four parallel glass panes.

[0022] The interpane space is thus defined by two of the at least two parallel glass panes as the space between these two parallel glass panes. In embodiments with more than two parallel glass panes, two or more interpane spaces are defined, each being the space between two adjacent glass panes.

[0023] In embodiments with more than two parallel glass panes, the first thermoplastic material may be present between the all of the parallel glass panes and may thus define first layers of the edge seal being present between all of the glass panes. Each of the first layers of the edge seal may thus adhere to the surfaces of two parallel glass panes facing the interpane space in which it is situated. Similarly, the second thermoplastic material may be present between the all of the parallel glass panes and may thus define second layers of the edge seal being present between all of the glass panes. Each of the second layers of the edge seal may thus adhere to the surfaces of two parallel glass panes facing the interpane space in which it is situated. Also, each of the second layers of the edge seal may thus contact the corresponding first thermoplastic material situated in the same in-

terpane space.

[0024] Generally, the terms "layer 1", "layer one", and "first layer" may be used interchangeably. Similarly, the terms "layer 2", "layer two", and "second layer" may be used interchangeably.

[0025] Also, the terms "thermoset plastic material" and "thermoset material" may be used interchangeably.

[0026] In some embodiments of the invention it is possible to keep the width of the edge seal narrower than in prior art constructions. Thereby, advantageous designs may be possible, because the framing required covering the edge seal can be kept narrow as well.

[0027] Furthermore, the effective window area becomes larger, when it is possible to reduce the size of the frames, which may also have architectural advantages.

[0028] The weight of the insulating glass unit may be reduced as a consequence of the edge seal used according to embodiments of the invention.

[0029] In an advantageous embodiment of the invention, the thermoset plastic material may extend from the interpane space to outside the interpane space and adhering at least to a first glass surface on the two parallel glass panes not facing the interpane space, said first glass surface defining the thickness of each of the two glass panes, the thermoset plastic material defining a third layer of the edge seal.

[0030] Thus, it should be understood according to the above embodiment that the first glass surface of one of the at least two glass panes defining the thickness that glass pane is a surface none-parallel to the surface of that glass pane facing the interpane space. Typically, the first glass surface being the side surface of the glass pane would be orthogonal to the surface of the glass pane facing towards the interpane space and to the surface of the glass pane facing away from the interpane space.

[0031] According to an embodiment of the invention, the thermoset material extends into the interpane space.

[0032] According to an embodiment of the invention, the thermoset material is situated substantially outside the interpane space.

[0033] In an embodiment of the invention the first thermoplastic material comprises polyisobutylene and the polyisobutylene comprises a desiccant.

[0034] In advantageous embodiments of the invention, the first thermoplastic material comprises polyisobutylene with desiccant incorporated. An examples of such a material is Koedispace 4SG from Koemmerling Chemische Fabrik GMBH, Germany.

[0035] The desiccant absorbs moisture trapped between the glass panes during manufacture and moisture penetrating the edge seal.

[0036] In an embodiment of the invention the second thermoplastic material is a hot-melting material selected from the group consisting of synthetic rubber, synthetic polymer, synthetic elastomers and any combination thereof.

[0037] According to an embodiment of the invention, the second thermoplastic material adheres to the first thermoplastic material.

[0038] According to an embodiment of the invention, the second thermoplastic material adheres to the thermoset plastic material.

[0039] According to an embodiment of the invention, the second thermoplastic material adheres to the first thermoplastic material and the thermoset plastic material.

[0040] It is important, according to an embodiment of the invention, that the second thermoplastic material adheres well to the first thermoplastic material and to the thermoset material as well as to the glass.

[0041] In some embodiments, the second thermoplastic material may adhere only slightly to the first thermoplastic material and/or to the thermoset material, or may not adhere to the first thermoplastic material and/or to the thermoset material. However, the second thermoplastic material will still adhere to the glass.

[0042] It should also have a certain elasticity to accommodate stress on the seal.

[0043] The synthetic materials mentioned may also have the lowest water vapor transmission rate of the materials comprised in the edge seal.

[0044] In an embodiment of the invention the second thermoplastic material comprises a hot-melting polyisobutylene.

[0045] It has been found by the present inventor that butyl-based materials are particularly useful as the second thermoplastic material, combining elasticity and softness with excellent adhesion to glass and the other plastic materials and at the same time having a low water vapor transmission rate, whereby the service time of the insulating glass unit may be prolonged.

[0046] In an embodiment of the invention the thermoset material is selected from the group consisting of polyurethane, polyester, epoxy and any combination thereof. The thermoset material provides mechanical strength to the seal.

[0047] The thermoset material is harder than the first and second thermoplastic materials and ensures the structural integrity of the insulating glass unit. Due to the good adhesion of the thermoset material to the glass panes, it becomes difficult for water to penetrate the interface between the glass and the thermoset material, whereby there is a synergy between seal-properties and structural properties of the thermoset material.

[0048] In an embodiment of the invention the thermoset material is polyurethane.

[0049] Polyurethane is particularly useful as the thermoset material, because the properties of the material can be fine-tuned through proper selection of polyols, isocyanates and additives. For example, by using aliphatic isocyanate as opposed to aromatic isocyanate, good UV-resistance may be obtained which in certain applications may be important.

[0050] In an embodiment of the invention the third layer

further adheres to a second glass surface on at least one of the two parallel glass panes outside the interpane space, such as both of the two parallel glass panes outside the interpane space, the second glass surface being parallel to the surface of the glass pane facing the interpane space.

[0051] By letting the thermoset material extend around the edge of one of the glass panes and onto the face of the glass pane, a particularly structurally stable insulating glass unit may be obtained.

[0052] Thus, in some embodiments, the third layer adheres to a second glass surface on one of the two parallel glass panes outside the interpane space, whereas in other embodiments the third layer adheres to a second glass surface on each of the two parallel glass panes outside the interpane space.

[0053] Furthermore, if the third layer is arranged to extend around both edges of the two glass panes and onto the face of both glass panes, the thermoset material arranged in this way may mask the other layers of the edge seal when the unit is viewed from the outside. In this way, the visual quality of the first- and second layers may become less important. Also, a particularly structurally stable insulating glass unit may be obtained.

[0054] In some embodiments, the insulating glass unit may comprise three or more parallel glass panes, whereby two or more interpane spaces is defined between adjacent parallel glass panes. In such embodiments, at least one of the two or more interpane spaces is according to the invention. Thus, the third layer may adhere to a second glass surface on one of the three or more parallel glass panes outside one of the interpane spaces, or the third layer may adhere to a second glass surface on two of the three or more parallel glass panes outside one of the interpane spaces, or three of the three or more parallel glass panes outside one of the interpane spaces.

[0055] In an embodiment of the invention the first layer has a width of 1-30 mm, such as 2-20 mm, such as 3 - 15 mm when measured parallel to the glass panes.

[0056] The width of the first layer may be varied depending on a desired seal properties and other design considerations.

[0057] In an embodiment of the invention the width of the second layer when measured parallel to the glass panes is between 0.5 - 15 mm, such as 0.8 - 10 mm, such as 1 - 5 mm.

[0058] The second layer, according to embodiments of the invention, is narrower than the first layer.

[0059] In an embodiment of the invention the third layer extends at least 2 mm onto said second glass surface (8), such as at least 10 mm, such as at least 20 mm.

[0060] In an embodiment of the invention the first thermoplastic material has a thermal conductivity of less than $0.3 \text{ Wm}^{-1}\text{K}^{-1}$, the second thermoplastic material has a thermal conductivity of less than $0.3 \text{ Wm}^{-1}\text{K}^{-1}$ and the thermoset material has a thermal conductivity of less than $0.3 \text{ Wm}^{-1}\text{K}^{-1}$.

[0061] In advantageous embodiments of the invention,

a low thermal conductivity for all plastic materials comprised in the edge seal ensures good insulation around the edges of the insulating glass unit and may improve the U-value of the whole insulating glass unit significantly.

[0062] In an embodiment of the invention the second thermoplastic material has a water vapor transmission rate at least 5 times less than the thermoset material, such as at least 10 times less, when measured according to ASTM F1249.

[0063] In an embodiment of the invention the second thermoplastic material has a higher density than the first thermoplastic material.

[0064] The second thermoplastic material may be more dense than the first thermoplastic material, and at the same time be more flexible and elastic. For example, the first thermoplastic material may have a density between 0.9 and 1.1 g/cm³, while the second thermoplastic material has a density of about 1.2 g/cm³.

[0065] Thereby, the second thermoplastic material has a good resistance towards gas permeation.

[0066] In an embodiment of the invention the edge seal is free from metal components. The thermal insulation properties of the edge seal may be best, if no metal is present within the edge seal.

[0067] Such metal could, for example, be metal inserts for fastening the unit to a window frame or metal foils for gas sealing.

[0068] In an embodiment of the invention the edge seal comprises inserts and said inserts are made of non-metal composite material.

[0069] By using composite inserts, for example made from fiber re-enforced plastics or carbon fiber, the thermal insulation properties of the edge seal are less compromised.

[0070] According to an embodiment of the invention, the first layer is in contact with the at least two glass panes along or near the entire periphery of the at least two glass panes.

[0071] According to an embodiment of the invention, the second layer is in contact with the at least two glass panes along or near the entire periphery of the at least two glass panes.

[0072] According to an embodiment of the invention, the third layer is in contact with the at least two glass panes along or near the entire periphery of the at least two glass panes.

[0073] According to an embodiment of the invention, the each of the first layer, the second layer, and the third layer is in contact with the at least two glass panes along or near the entire periphery of the at least two glass panes.

[0074] According to an embodiment of the invention, the second thermoplastic material is softer than the first thermoplastic material.

[0075] Thus, one advantage of the above embodiment may be that the second thermoplastic material may function as a buffer between the first thermoplastic material and the thermoset plastic material, i.e. the second layer

may due to its softness act as a buffer zone between the first layer and the third layer, whereby movements in the third layer is to a lesser degree transferred to the first layer. For example, according to one embodiment, the first thermoplastic material has a Young's modulus of at least 20 % higher than the Young's modulus of the second thermoplastic material, such as at least 50% higher, such as at least 80% higher.

[0076] According to some embodiments the second layer may be thinner than the first layer. However, according to other embodiments, the second layer may have a comparable or even greater thickness compared to the first layer.

[0077] Generally, it should be understood that a "glass pane" is a pane made wholly of glass or partially of glass.

[0078] According to an embodiment, the at least two parallel glass panes are panes consisting of glass or laminated panes comprising one or more glass layers. Example of non-glass layers in laminated panes comprise transparent thermoplastics, such as poly(methyl methacrylate), also referred to as PMMA or Plexiglas. In an embodiment one important feature is that the surfaces of the at least two parallel glass panes facing the interpane space are glass-surfaces.

[0079] According to one embodiment, the at least two parallel glass panes are panes consisting substantially of glass.

[0080] According to a further aspect the invention relates to a process for manufacturing an insulating glass unit comprising the steps of:

- Cleaning a first- and a second glass pane,
- Extruding a hot first thermoplastic material in a profile preform along the perimeter of the first glass pane,
- Placing the second glass pane parallel to the first glass pane on the extruded profile,
- Filling the interpane space with gas,
- Pressing the two glass panes together thereby sealing the interpane space form the exterior environment,
- Applying by extrusion a second thermoplastic material contacting the first thermoplastic material, thereby further sealing the interpane space form the exterior environment,
- Cleaning the edge regions of the first - and second glass pane with solvent to remove excess thermoplastic material,
- Cleaning the edge regions of the first - and second glass pane in a plasma treatment,
- Placing the first - and second glass pane in a mould,
- Applying by reactive injection moulding a thermoset material contacting the second thermoplastic material and further contacting at least a first glass surface on the two parallel glass panes not facing the interpane space, said first glass surface defining the thickness of each of the two glass panes (7),
- Removing the first - and second glass pane from the mould, whereby an insulated glass unit is obtained.

[0081] This process has distinct advantages because insulating glass units with uniform thickness may be obtained. When glass panes are fixed with respect to each other in the mould before applying the thermoset material, the first - and second materials are flexible and are adapted for dispersing any stress resulting from placing the panes at a fixed distance from each other. Thus, breaking of glass panes or severe build-up of stress in the insulating glass unit is minimized. Accordingly more uniform products with less product failure during the production process are obtained. The process may reduce both material costs and costs related to scrap and products not conforming to quality standards.

[0082] As such, the process may be economically attractive compared to prior art processes applying rigid materials for sealing the interpane space.

[0083] The edge regions of the glass panes are cleaned and plasma treated to ensure good adhesion of the thermoset material to the glass.

[0084] In an advantageous embodiment of the invention, said step of applying by reactive injection moulding a thermoset material contacting the second thermoplastic material may moreover comprise that the thermoset material is further arranged to contact the surface of the at least two parallel glass panes facing the interpane space.

[0085] Various gasses may be applied, according to various embodiments, for filling the interpane space, hereunder Argon and Krypton. In some embodiments atmospheric air may be used as the gas for filling the interpane space.

[0086] According to an embodiment of the invention the process further comprising the steps of:

- Applying a silane primer to the cleaned edge regions after the cleaning steps and
- Drying the applied primer in an oven.

[0087] According to some embodiments of the invention, the use of a silane primer will even further enhance the bonding between the glass and the thermoset material.

[0088] This may significantly enhance the adhesion between the thermoset material and the glass surface, thereby further increasing the edge seal properties with respect to, for example, minimizing water penetration along the interface between thermoset material and glass.

[0089] In an embodiment of the invention the process further comprises the step of:

- Placing inserts in the edge regions of the first - and second glass pane after placing the first - and second glass pane in the mould and before injecting thermoset material.

[0090] The thermoset material may partly encapsulate inserts providing extra functionality to the insulating glass

unit, such as means for easy mounting in a window frame, for example a mechanical connection part.

THE FIGURES

[0091] Aspects of the present disclosure will be described in the following with reference to the figures 1a, 1b, 2a and 2b which illustrate sectional views of various embodiments of an insulating glass unit according to embodiments of the invention.

DETAILED DESCRIPTION

[0092] Figure 1a describes a sectional view of an insulating glass unit having two parallel glass panes 1.

[0093] Between the glass panes there is an interpane space 2 sealed for the outside by a first thermoplastic material 3, a second thermoplastic material 4 and a thermoset material 5.

[0094] The distance 6 between glass panes 1 is defined by the thickness of the thermoplastic material 3.

[0095] In this embodiment of the invention the thermoset material 3 extends both onto surfaces 7 and surface 8 on both glass panes. Furthermore, the thermoset material also fills part of the interpane space. Moreover, the first glass surface 7 defines the thickness of each of the two glass panes.

[0096] This embodiment provides a structurally strong insulating glass unit.

[0097] The distance 6 between the glass panes may be varied and will often be dictated by the tooling used in the production of the unit, such as the mould fixing the unit before material 5 is injected in a reactive injection process.

[0098] Due to the elasticity of materials 3 and 4, tolerances in for example glass thickness are well accommodated during processing.

[0099] Also, in the production process involving fixation in a mould of the glass panes having extruded strings of material 3 and material 4 between them already sealing off the interpane space from the outside, the fixation will not cause any significant mechanical stress on the glass or in the materials because of the flexibility of the elastomeric materials. Thereby, the manufacturing process itself becomes flexible, and glass breakage and the like is more or less avoided.

[0100] Material 3 may in advantageous embodiments comprise desiccant to absorb moisture present in the interpane space 2 or penetrating the seal from the outside through materials 5 and 4 or along the interfaces between the glass panes and materials 5 and 4. Such moisture may condensate on the glass surfaces facing the interpane space 2 and lead to failure of the insulating glass unit.

[0101] Since materials 3, 4 and 5 are all plastics comprised of primarily organic polymers, the thermal conductivity of the edge seal is very low and advantageous insulation properties are obtained along the edge region

of the insulating glass unit and for the unit as a whole.

[0102] The edge seal may accommodate inserts for mounting the insulating glass unit or providing other mechanical functions to the unit.

[0103] The width of the layers formed by material 3, 4 and 5 respectively, is variable, but typically, the layer formed by material 4 will be about equal to or less than the width of the layer formed by material 3.

[0104] Material 5 extending onto surface 8 and adhering to the surface, may extend onto surface 8 in a varying degree. As indicated on fig 1a, material 5 may extend onto surface 8 just enough to cover seal materials 3 and 4 when viewed from the outside. The thermoplastic materials 3 and 4 are both soft and flexible, the second thermoplastic material 4 typically being the most flexible of the two. Flexibility is achieved by using elastomeric compounds for both materials, typically of synthetic nature.

[0105] Polyisobutylene-based materials are well suited for both material 3 and 4, the two layers being made from different grades and compositions with respect to each other. Typically, material 4 will have the lowest water vapor transmission rate of the three polymeric materials 3, 4, and 5.

[0106] Figure 1b shows an embodiment differing from that of fig. 1a in that the dimensions of material 5 is varied with respect to the side of the insulating glass unit. For example it may be advantageous to vary the dimensions on the side facing the exterior of the structure into which the unit has been installed with respect to the side facing the interior.

[0107] Figure 2a shows an embodiment differing from that of fig. 1a in that material 5 does not extend to the surface outside the interpane space and parallel to the glass surface facing the interpane space on one side of the insulating glass unit. This may provide a thinner insulating glass unit and save weight.

[0108] Figure 2b differs from the embodiment of fig. 2a in that the thermoset material is substantially situated outside the interpane space. Such a unit may result in a seal having a minimum width because the interpane space only needs to accommodate materials 3 and 4.

[0109] It is generally to be understood that one or more of the above described aspects may be combined in a multitude of varieties with the scope of the invention.

LIST

[0110] On figures 1a, 1b, 2a and 2b:

1. : Glass pane;
2. : Interpane space;
3. : First thermoplastic material
4. : Second thermoplastic material
5. : Thermoset material
6. : Distance between the glass panes
7. : A first glass surface, defining the thickness of the glass pane
8. : A second glass surface outside the interpane

space and parallel to the glass surface facing the interpane space.

Claims

1. An insulating glass unit comprising at least two parallel glass panes (1), a space between the at least two parallel glass panes being the interpane space (2), said at least two parallel glass panes being held structurally together along their perimeters by an edge seal, the edge seal extending along the whole perimeter of the at least two glass panes, whereby the interpane space is sealed from the outside by the edge seal, the edge seal comprising:

a first thermoplastic material (3),
a second thermoplastic material (4) and
a thermoset plastic material (5),
wherein the first thermoplastic material (3) defines the distance (6) between the at least two glass panes (1) and defines a first layer of the edge seal, the first layer of the edge seal being situated within the interpane space and adhering to the surfaces of the at least two parallel glass panes facing the interpane space,
wherein the second thermoplastic material (4) is contacting the first thermoplastic material (3) and defines a second layer of the edge seal, the second layer of the edge seal being situated within the interpane space and adhering to the surface of the at least two parallel glass panes facing the interpane space, and
wherein the thermoset plastic material (5) is contacting the second thermoplastic material (4), the thermoset plastic material adhering to at least a first glass surface on the two parallel glass panes not facing the interpane space, said first glass surface (7) defining the thickness of each of the two glass panes, the thermoset plastic material defining a third layer of the edge seal.

2. An insulating glass unit according to claim 1, wherein the first thermoplastic material comprises polyisobutylene and the polyisobutylene comprises a desiccant.

3. An insulating glass unit according to claims 1 - 2, wherein the second thermoplastic material is a hot-melting material selected from the group consisting of synthetic rubber, synthetic polymer, synthetic elastomers and any combination thereof.

4. An insulating glass unit according to any of the claims 1 - 3, wherein the second thermoplastic material comprises a hot-melting polyisobutylene.

5. An insulating glass unit according to claim any of the claims 1 - 4, wherein the thermoset material is selected from the group consisting of polyurethane, polyester, epoxy and any combination thereof.

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6. An insulating glass unit according to any of the claims 1 - 5, wherein the thermoset material is polyurethane.

7. An insulating glass unit according to any of the claims 1 - 6, wherein the third layer further adheres to a second glass surface (8) on at least one of the two parallel glass panes outside the interpane space, such as both of the two parallel glass panes outside the interpane space, the second glass surface being parallel to the surface of the glass pane facing the interpane space.

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8. An insulating glass unit according to any of the claims 1 - 7, wherein the first layer has a width of 1-30 mm, such as 2-20 mm, such as 3 - 15 mm when measured parallel to the glass panes.

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9. An insulating glass unit according to any of the claims 1 - 8, wherein the width of the second layer when measured parallel to the glass panes is between 0.5 - 15 mm, such as 0.8 -10 mm, such as 1 - 5 mm.

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10. An insulating glass unit according to claim 7, wherein the third layer extends at least 2 mm onto said second glass surface (8), such as at least 5 mm, such as at least 10 mm.

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11. An insulating glass unit according to any of the claims 1 - 10, wherein the first thermoplastic material has a thermal conductivity of less than $0.3 \text{ Wm}^{-1}\text{K}^{-1}$, the second thermoplastic material has a thermal conductivity of less than $0.3 \text{ Wm}^{-1}\text{K}^{-1}$ and the thermoset material has a thermal conductivity of less than $0.3 \text{ Wm}^{-1}\text{K}^{-1}$.

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12. An insulating glass unit according to any of the claims 1 - 11, wherein the second thermoplastic material has a water vapor transmission rate at least 5 times less than the thermoset material, such as at least 10 times less, when measured according to ASTM F1249.

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12. An insulating glass unit according to any of the claims 1 - 11, wherein the second thermoplastic material has a higher density than the first thermoplastic material.

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13. An insulating glass unit according to any of the claims 1 - 12, wherein the edge seal is free from metal components.

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14. An insulating glass unit according to any of the claims 1 - 13, wherein the edge seal comprises inserts and said inserts are made of non-metal composite material.

15. An insulating glass unit according to any of the claims 1 - 14, wherein the second thermoplastic material (4) is softer than the first thermoplastic material (3).

16. Process for manufacturing an insulating glass unit according to any of the claims 1 - 15 comprising the steps of:

- Cleaning a first- and a second glass pane,
- Extruding a hot first thermoplastic material in a profile preform along the perimeter of the first glass pane,
- Placing the second glass pane parallel to the first glass pane on the extruded profile,
- Filling the interpane space with gas,
- Pressing the two glass panes together thereby sealing the interpane space from the exterior environment,
- Applying by extrusion a second thermoplastic material contacting the first thermoplastic material, thereby further sealing the interpane space from the exterior environment,
- Cleaning the edge regions of the first - and second glass pane with solvent to remove excess thermoplastic material,
- Cleaning the edge regions of the first - and second glass pane in a plasma treatment,
- Placing the first - and second glass pane in a mould,
- Applying by reactive injection moulding a thermoset material contacting the second thermoplastic material and further contacting at least a first glass surface on the two parallel glass panes not facing the interpane space, said first glass surface defining the thickness of each of the two glass panes,
- Removing the first - and second glass pane from the mould, whereby an insulated glass unit is obtained.

17. Process according to claim 16, the process further comprising the steps of:

- Applying a silane primer to the cleaned edge regions after the cleaning steps and
- Drying the applied primer in an oven.

18. Process according to claims 16 - 17 further comprising the step of:

- Placing inserts in the edge regions of the first - and second glass pane after placing the first -

and second glass pane in the mould and before injecting thermoset material.

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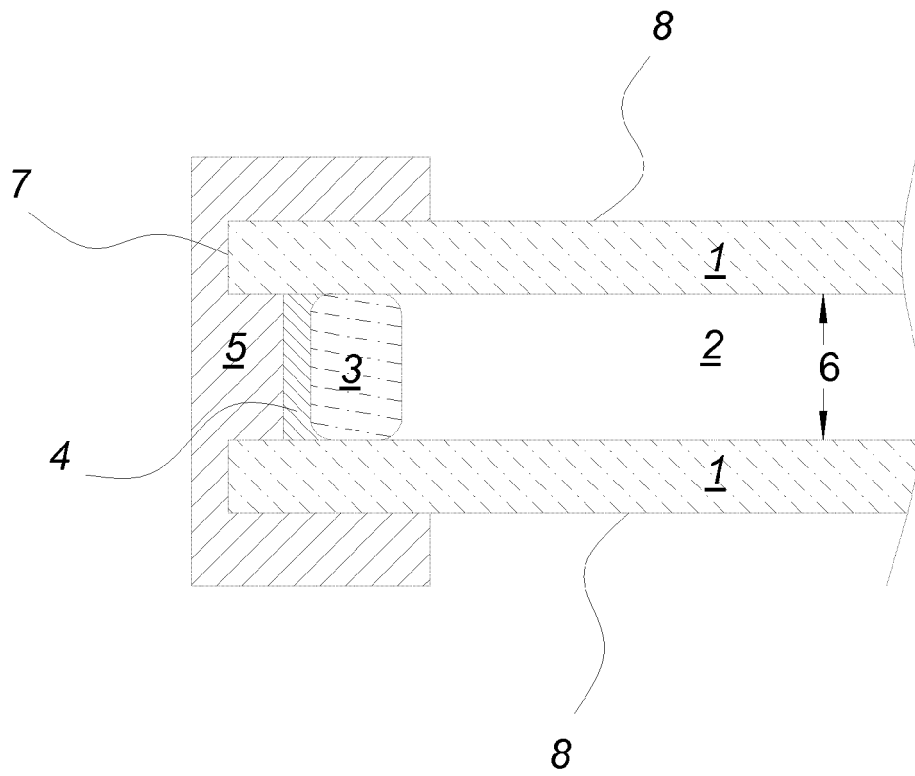


Fig. 1a

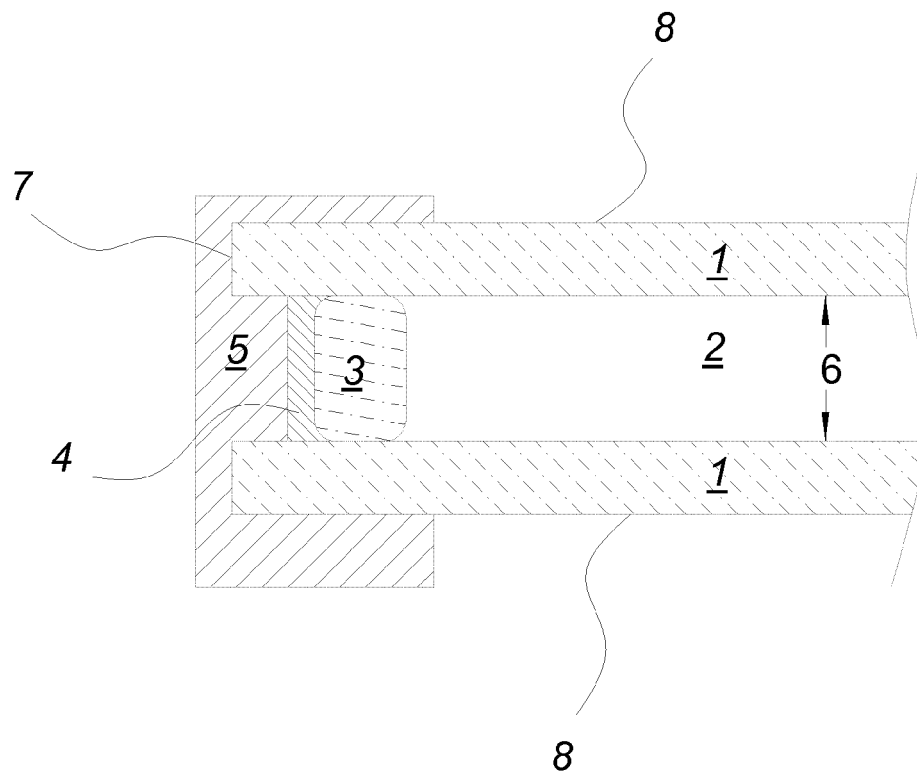


Fig. 1b

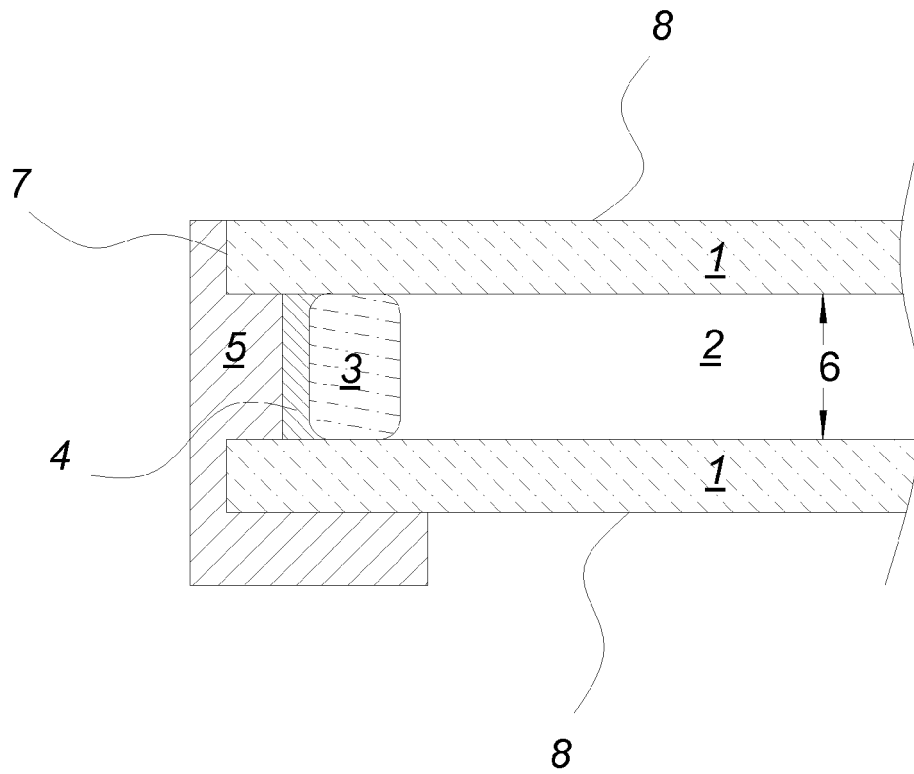


Fig. 2a

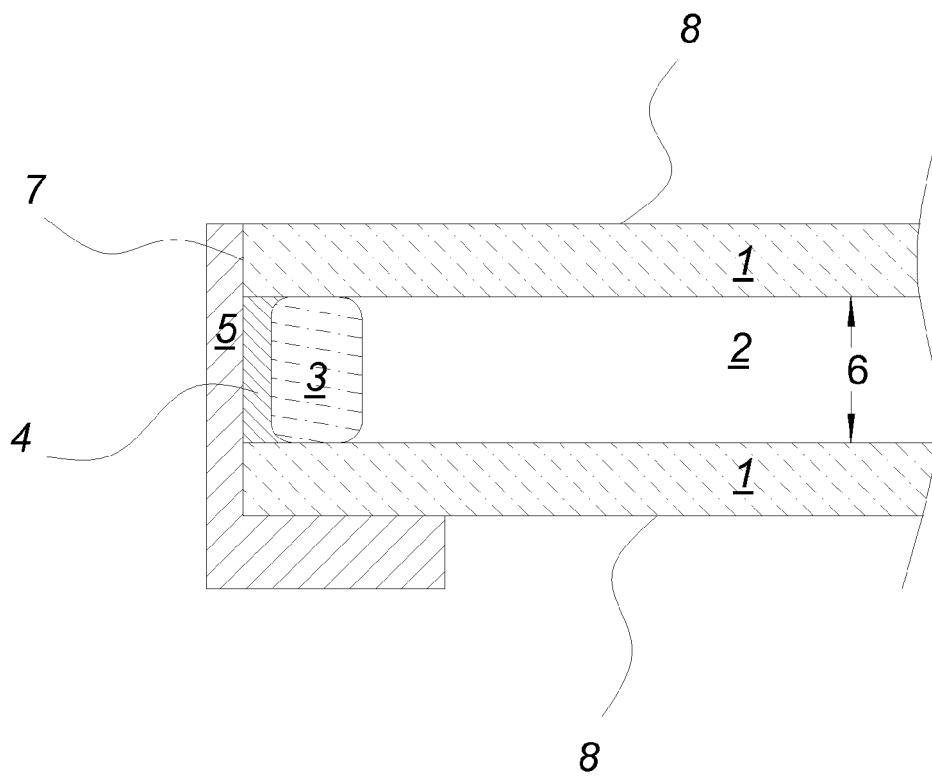


Fig. 2b



EUROPEAN SEARCH REPORT

Application Number
EP 15 17 3067

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The Hague		28 October 2015	Jülich, Saskia
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