Insulated glazing units comprising first and second sheets of glazing material with a low pressure space there between are described. The major surface of the second sheet of glazing material not facing the low pressure space has a low emissivity coating comprising at least one layer of fluorine doped tin oxide thereon. There is a first anti-iridescence coating between the low emissivity coating and the second sheet of glazing material. Also described are insulated glazing units comprising three (first, second and third) sheets of glazing material with a low pressure space between first and second sheets of glazing material, and a second space between the first and third sheets of glazing material. There is a low emissivity coating on one or both major surfaces facing the low pressure space. The third sheet of glazing material has a low emissivity coating on both opposed major surfaces thereof.
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The present invention relates to an insulated glazing unit having improved thermal insulation properties.

Insulated glazing units are known comprising at least two spaced apart sheets of glass. One such type of insulated glazing unit comprises two sheets of glass spaced apart by perimeter seals and are conventionally known as double glazed units.

Another type of insulated glazing unit comprises two sheets of glass spaced apart by an evacuated space. Disposed in the evacuated space is a plurality of spacers to maintain a spacing of around 0.2 mm between the two sheets of glass. The periphery of the two glass sheets may be sealed with a solder glass, for example as described in EP0860406B1 or an organic material as described in EP1630344A1. This type of insulated glazing unit is often referred to as a vacuum insulated glazing unit, or VIG. VIG's are also described in W095/15296A1 and EP0999330A1.

It is also known that a VIG may be one pane of a double glazed unit, for example as described in EP086040B1, EP103023A1 and US8,377,524B2. The VIG is spaced apart from another pane, such as a glass sheet. This type of insulated glazing unit has an evacuated low pressure space and an air space (typically filled with an inert gas such as argon or krypton).

It is known that the external surfaces of insulated glazing units such as double glazing units may become fogged due to condensation forming on the outer surfaces. This is a consequence of the emission of heat from the outer glazing. For the surface of a double glazing unit facing the outside i.e. the outer surface, if insufficient heat flows from the internal space to the outer surface, as is the case with insulated glazing units with low U values, the temperature of the outside surface drops. When there is a sufficiently high relative external atmospheric humidity this leads to fogging i.e. condensation or frost deposition, as a result of the temperature of the outer surface falling below the dew point.

The present invention provides an insulated glazing unit having improved thermal performance.

Accordingly from a first aspect the present invention provides an insulated glazing unit comprising a first sheet of glazing material and a second sheet of glazing material, there being a first space between the first sheet of glazing material and the second sheet of glazing material, wherein the first sheet of glazing material has a first major surface and an opposing second major surface, and the second sheet of glazing material has a first major surface and an opposing second major surface, wherein the second major surface of the first sheet of glazing material and the first major surface of the second sheet of glazing material face the first space, wherein the first space is a low pressure space having a pressure less than atmospheric pressure, there being a plurality of spacers disposed in the first space, characterised in that the second major surface of the second sheet of glazing material has a low
emissivity coating thereon, the low emissivity coating comprising at least one layer of fluorine doped tin oxide and there is a first anti-iridescence coating in between the low emissivity coating and the second sheet of glazing material.

The provision of the low emissivity coating on the second major surface of the second sheet of glazing material reduces the U-value of the insulated glazing unit compared to the same insulated glazing unit without the low emissivity coating on the second major surface of the second sheet of glazing material.

Such an insulated glazing unit may be installed in a building. When installed in a building, it is preferred that the first major surface of the first sheet of glazing material faces the exterior of the building, and the second major surface of the second sheet of glazing material faces the interior of the building. Alternatively, the insulated glazing unit may be installed in a building such that the first major surface of the first sheet of glazing material faces the interior of the building, and the second major surface of the second sheet of glazing material faces the exterior of the building. When the insulated glazing unit is configured such that the second major surface of the second sheet of glazing material faces the exterior of a building in which the insulated glazing unit is installed, the provision of a low emissivity coating on the second major surface of the second sheet of glazing material helps reduce the formation of condensation on the second major surface of the second sheet of glazing material because the temperature of the second sheet of glazing material may be raised.

Suitably the first sheet of glazing material is spaced apart from the second sheet of glazing material by less than 1mm, preferably by 0.05mm to 0.5mm, more preferably by 0.1mm to 0.3mm.

Suitably an hermetic seal extending around the periphery of each the first and second sheets of glazing material joins the first sheet of glazing material to the second sheet of glazing material. The hermetic seal ensures the first space is maintained at suitably low pressure. The spacers disposed in the first space prevents the second major surface of the first sheet of glazing material coming into contact with the first major surface of the second sheet of glazing material.

It is to be understood within the context of the present invention that when a coating has a layer A on a layer B, this does not rule out the possibility of there being one or more other layers i.e. layers C, D, E etc in between layer A and layer B. Similarly, when a surface of a sheet of glazing material has a layer A thereon, this does not rule out the possibility of there being one or more other layers i.e. layers B, C, D, E etc in between layer A and the surface of the sheet of glazing material.

For clarity, the first major surface of the first sheet of glazing material is also referred to as surface / of the insulated glazing unit. For clarity, the second major surface of the first sheet of glazing material is also referred to as surface ii of the insulated glazing unit. For clarity, the first major surface of the second sheet of glazing material is also referred to as surface iii of the insulated glazing unit. For
clarity, the second major surface of the first sheet of glazing material is also referred to as surface iv of the insulated glazing unit.

Using this notation for referring to the major surfaces of the sheets of glazing material, and for the avoidance of doubt, an insulated glazing unit according to the first aspect of the present invention has a low emissivity coating on surface iv.

Again for the avoidance of doubt, depending upon the orientation of the insulated glazing unit when installed in a building or the like, surface i may face either the interior of the building or the exterior of the building.

As is conventional in the art, the surface of an insulated glazing unit configured to directly face the external environment of a structure in which the insulated glazing unit is installed is referred to as surface 1. The surface opposite surface 1 is referred to as surface 2 i.e. surface 1 is one major surface of a glazing pane and surface 2 is the opposing major surface of the glazing pane. The surface of the insulating glazing unit opposite surface 2 is referred to as surface 3. The surface opposite surface 3 is referred to as surface 4, and so on for additional glazing panes. For example, for an insulated glazing unit having two spaced apart glazing panes i.e. glass, surface 1 of the insulated glazing unit faces the exterior of the structure in which the insulated glazing unit is installed and surface 4 faces the interior of the structure in which the insulated glazing unit is installed. In relation to the naming convention adopted in the present application, surface i or surface iv of the insulated glazing unit of the first aspect of the present invention may be surface 1.

Preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface iv is between 100nm and 600nm.

In some embodiments preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface iv is between 100nm and 300nm, more preferably between 100nm and 290nm, even more preferably between 100nm and 250nm.

By having a thin layer of fluorine doped tin oxide the low emissivity coating is less susceptible to surface damage because the coating is less rough. In addition costs are reduced because less coating is required to achieve the anti-condensation properties. Furthermore the G value of the insulated glazing unit is higher compared to the same insulated glazing unit with a thicker layer of fluorine doped tin oxide.

In some embodiments preferably the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on surface iv is between 300nm and 400nm, more preferably between 300nm and 350nm.
In some embodiments preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface iv is between 400nm and 600nm, more preferably between 500nm and 580nm.

Preferably the first anti-iridescence layer comprises a first layer and a second layer, wherein the first layer of the first anti-iridescence layer has a higher refractive index than the second layer of the first anti-iridescence layer and the second layer of the first anti-iridescence layer is in between the first layer of the first anti-iridescence layer and the first low emissivity coating.

Preferably the first layer of the first anti-iridescence layer comprises tin oxide.

Preferably the second layer of the first anti-iridescence layer comprises silica.

Preferably the first layer of the first anti-iridescence layer has a geometric thickness of between 10nm and 50nm, preferably between 15nm and 35nm.

Preferably the second layer of the first anti-iridescence layer has a geometric thickness of between 10nm and 50nm, preferably between 15nm and 35nm.

Preferably there is a first haze reducing layer in between the second sheet of glazing material and the first anti-iridescence layer.

Preferably the first haze reducing layer comprises silica.

Preferably the geometric thickness of the first haze reducing layer is between 5nm and 50nm, more preferably between 5nm and 25nm.

In some embodiments there is a low emissivity coating on surface Hi.

Preferably there is an anti-iridescence coating in between the low emissivity coating on surface Hi and the second sheet of glazing material.

The anti-iridescence coating in between the low emissivity coating on surface iii and the second sheet of glazing material has the same preferable features as described above in relation to the first anti-iridescence coating.

Preferably the low emissivity coating on surface Hi comprises at least one silver layer and/or at least one fluorine doped tin oxide layer.

When the low emissivity coating on surface iii comprises at least one silver layer, preferably the geometric thickness of the at least one silver layer is between 5nm and 20nm.
When the low emissivity coating on surface $H_i$ comprises at least one fluorine doped tin oxide layer preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface $H_i$ is between 100nm and 600nm.

In some embodiments preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface $H_i$ is between 100nm and 300nm, more preferably between 100nm and 290nm, even more preferably between 100nm and 250nm.

In some embodiments preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface $H_i$ is between 250nm and 350nm.

In some embodiments preferably the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on surface $H_i$ is between 300nm and 400nm, more preferably between 300nm and 350nm.

In some embodiments preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface $H_i$ is between 400nm and 600nm, more preferably between 500nm and 580nm.

When the low emissivity coating on surface $H_i$ comprises at least one fluorine doped tin oxide layer, preferably there is an anti-iridescence layer of SiCOx between the low emissivity coating on surface 3 and the second sheet of glazing material. Preferably the SiCOx layer has a geometric thickness between 50nm and 100nm.

In some embodiments there is a low emissivity coating on surface $ii$.

Preferably there is an anti-iridescence coating in between the low emissivity coating on surface $ii$ and the first sheet of glazing material.

The anti-iridescence coating in between the low emissivity coating on surface $ii$ and the first sheet of glazing material has the same preferable features as described above in relation to the first anti-iridescence coating.

Preferably the low emissivity coating on surface $ii$ comprises at least one silver layer and/or at least one fluorine doped tin oxide layer.

When the low emissivity coating on surface $ii$ comprises at least one silver layer, preferably the geometric thickness of the at least one silver layer is between 5nm and 20nm.

When the low emissivity coating on surface $ii$ comprises at least one fluorine doped tin oxide layer preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface $ii$ is between 100nm and 600nm. In some embodiments preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on
surface is between 100nm and 300nm, more preferably between 100nm and 290nm, even more preferably between 100nm and 250nm.

In some embodiments preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface is between 250nm and 350nm.

In some embodiments preferably the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on surface is between 300nm and 400nm, more preferably between 300nm and 350nm.

In some embodiments preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface is between 400nm and 600nm, more preferably between 500nm and 580nm.

When the low emissivity coating on surface comprises at least one fluorine doped tin oxide layer, preferably there is an anti-iridescence layer of SiCOx between the low emissivity coating on surface and the first sheet of glazing material. Preferably the SiCOx layer has a geometric thickness between 50nm and 100nm.

In some embodiments there is a low emissivity coating on surface.

When the insulated glazing unit is configured such that the first major surface of the first sheet of glazing material (i.e. surface) faces the exterior of a building in which the insulated glazing unit is installed, the provision of a low emissivity coating on the first major surface of the first sheet of glazing material helps reduce the formation of condensation on the first major surface because the temperature of the first sheet of glazing material may be raised.

Preferably there is an anti-iridescence coating in between the low emissivity coating on surface and the first sheet of glazing material.

The anti-iridescence coating in between the low emissivity coating on surface and the first sheet of glazing material has the same preferable features as described above in relation to the first anti-iridescence coating.

In some embodiments there is a low emissivity coating on surface comprising at least one layer of fluorine doped tin oxide.

Preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface is between 100nm and 600nm.

Preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface is between 100nm and 300nm, more preferably between 100nm and 290nm, even more preferably between 100nm and 250nm.
By having a thin layer of fluorine doped tin oxide the low emissivity coating is less susceptible to surface damage because the coating is less rough. In addition costs are reduced because less coating is required to achieve the anti-condensation properties. Furthermore the G value of the insulated glazing unit is higher compared to the same insulated glazing unit with a thicker layer of fluorine doped tin oxide.

In some embodiments preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface $i$ is between 300nm and 400nm, more preferably between 300nm and 350nm.

In some embodiments preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on surface $i$ is between 400nm and 600nm, more preferably between 500nm and 580nm.

Insulated glazing units according to the first aspect of the present invention have other preferable features.

In some embodiments there are no other layers on the low emissivity coating on surface $iv$.

In some embodiments, there is a layer of silica on the low emissivity coating on surface $iv$. Preferably the layer of silica on the low emissivity coating on surface $iv$ has a geometric thickness of between 5nm and 50nm.

In some embodiments, there is a layer of titania on the low emissivity coating on surface $iv$. Preferably the layer of titania on the low emissivity coating on surface $iv$ has a geometric thickness of between 5nm and 50nm.

In embodiments where there is a low emissivity coating on surface $i$, preferably there is a layer of silica on the low emissivity coating on surface $i$. Preferably the layer of silica on the low emissivity coating on surface $i$ has a geometric thickness of between 5nm and 50nm.

In embodiments where there is a low emissivity coating on surface $i$, preferably there is a layer of titania on the low emissivity coating on surface $i$. Preferably the layer of titania on the low emissivity coating on surface $i$ has a geometric thickness of between 5nm and 50nm.

In embodiments where there is a low emissivity coating on surface $i$, preferably there is no other layer on the low emissivity coating on surface $i$.

In some embodiments, there is an antireflection coating on the low emissivity coating on surface $iv$.

Preferably the antireflection coating on the low emissivity coating on surface $iv$ comprises at least four layers.
Preferably the antireflection coating on the low emissivity coating on surface $iv$ comprises in sequence, a first layer of tin oxide, a second layer of silica, a third layer of fluorine doped tin oxide and a fourth layer of silica, wherein the first layer of tin oxide is between the second layer of silica and the low emissivity coating on surface $iv$.

Preferably the first layer of tin oxide of the antireflection coating on the low emissivity coating on surface $iv$ has a geometric thickness between 10nm and 15nm.

Preferably the second layer of silica of the antireflection coating on the low emissivity coating on surface $iv$ has a geometric thickness between 20nm and 30nm.

Preferably the third layer of fluorine doped tin oxide of the antireflection coating on the low emissivity coating on surface $iv$ has a geometric thickness between 100nm and 150nm.

Preferably the fourth layer of silica of the antireflection coating on the low emissivity coating on surface $iv$ has a geometric thickness between 80nm and 100nm.

In embodiments where there is a low emissivity coating on surface $i$, preferably there is an antireflection coating on the low emissivity coating on surface $i$.

Preferably the antireflection coating on the low emissivity coating on surface $i$ comprises at least four layers.

Preferably the antireflection coating on the low emissivity coating on surface $i$ comprises in sequence, a first layer of tin oxide, a second layer of silica, a third layer of fluorine doped tin oxide and a fourth layer of silica, wherein the first layer of tin oxide is between the second layer of silica and the low emissivity coating on surface $i$.

Preferably the first layer of tin oxide of the antireflection coating on the low emissivity coating on surface $z$ has a geometric thickness between 8nm and 15nm, more preferably between 11nm and 13nm.

Preferably the second layer of silica of the antireflection coating on the low emissivity coating on surface $z$ has a geometric thickness between 20nm and 30nm, more preferably between 22nm and 27nm.

Preferably the third layer of fluorine doped tin oxide of the antireflection coating on the low emissivity coating on surface $z$ has a geometric thickness between 100nm and 150nm, more preferably between 120nm and 140nm.

Preferably the fourth layer of silica of the antireflection coating on the low emissivity coating on surface $z$ has a geometric thickness between 70nm and 120nm, more preferably between 80nm and 100nm.
In some embodiments the roughness of the low emissivity coating on surface iv is less than 20nm, more preferably between 3nm and 15nm, even more preferably between 5nm and 12nm.

In embodiments where the is a low emissivity coating on surface i, preferably the roughness of the low emissivity coating on surface i is less than 20nm, more preferably between 3nm and 15nm, even more preferably between 5nm and 12nm.

In some embodiments of the first aspect of the present invention the insulated glazing unit comprises a third sheet of glazing material facing the first sheet of the glazing material and being separated therefrom by a second space, the third sheet of glazing material having a first major surface and a second major surface, wherein the insulated glazing unit is configured such that the second major surface of the third sheet of glazing material and the first major surface of the first sheet of glazing material (i.e. surface /) face the second space.

Preferably the second space is an air space.

Preferably the second space is filled with an inert gas such as argon or krypton.

Preferably the third sheet of glazing material is spaced from the first sheet of glazing material by more than 2mm, preferably by 5mm to 50mm, more preferably by 5mm to 25mm.

Preferably the first major surface of the third sheet of glazing material has a low emissivity coating thereon.

Preferably the second major surface of the third sheet of glazing material has a low emissivity coating thereon. Preferably the low emissivity coating on the second major surface of the third sheet of glazing material comprises at least one layer of silver and/or at least one layer of fluorine doped tin oxide.

Embodiments of the first aspect of the present invention having a third sheet of glazing material having a low emissivity coating on the first major surface of the third sheet of glazing material have other preferable features.

Preferably there is an anti-iridescence coating in between the low emissivity coating on the first major surface of the third sheet of glazing material and the third sheet of glazing material.

Preferably the anti-iridescence layer comprises a first layer and a second layer, wherein the first layer of the anti-iridescence layer has a higher refractive index than the second layer of the anti-iridescence layer and the second layer of the anti-iridescence layer is in between the first layer of the anti-iridescence layer and the low emissivity coating on the first major surface of the third sheet of glazing material.

Preferably the first layer of the anti-iridescence layer comprises tin oxide.
Preferably the second layer of the anti-iridescence layer comprises silica.

Preferably the first layer of the anti-iridescence layer has a geometric thickness of between 10nm and 50nm, preferably between 15nm and 35nm.

Preferably the second layer of the anti-iridescence layer has a geometric thickness of between 10nm and 50nm, preferably between 15nm and 35nm.

Preferably there is a haze reducing layer in between the third sheet of glazing material and the anti-iridescence coating on the first major surface of the third sheet of glazing material.

Preferably the haze reducing layer comprises silica.

Preferably the thickness of the haze reducing layer is between 5nm and 50nm, more preferably between 5nm and 25nm.

When the first major surface of the third sheet of glazing material has a low emissivity coating thereon, preferably the low emissivity coating on the first major surface of the third sheet of glazing material comprises at least one layer of fluorine doped tin oxide.

Preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on the first major surface of the third sheet of glazing material is between 100nm and 600nm.

Preferably the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the first major surface of the third sheet of glazing material is between 100nm and 300nm, more preferably between 100nm and 290nm, even more preferably between 100nm and 250nm.

By having a thin layer of fluorine doped tin oxide the low emissivity coating on the first major surface of the third sheet of glazing material is less susceptible to surface damage because the coating is less rough. In addition costs are reduced because less coating is required to achieve the anti-condensation properties. Furthermore the G value of the insulated glazing unit is higher compared to the same insulated glazing unit with a thicker layer of fluorine doped tin oxide.

Preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on the first major surface of the third sheet of glazing material is between 300nm and 400nm, more preferably between 300nm and 350nm.

Preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on the first major surface of the third sheet of glazing material is between 400nm and 600nm, more preferably between 500nm and 580nm.
Preferably there are no other layers on the low emissivity coating on the first major surface of the third sheet of glazing material.

Preferably there is a layer of silica on the low emissivity coating on the first major surface of the third sheet of glazing material. Preferably the layer of silica on the low emissivity coating on the first major surface of the third sheet of glazing material has a geometric thickness of between 5nm and 50nm.

Preferably there is a layer of titania on the low emissivity coating on the first major surface of the third sheet of glazing material. Preferably the layer of titania on the low emissivity coating on the first major surface of the third sheet of glazing material has a geometric thickness of between 5nm and 50nm.

Preferably there is an antireflection coating on the low emissivity coating on the first major surface of the third sheet of glazing material.

Preferably the antireflection coating on the low emissivity coating on the first major surface of the third sheet of glazing material comprises at least four layers.

Preferably the antireflection coating on the low emissivity coating on the first major surface of the third sheet of glazing material comprises in sequence, a first layer of tin oxide, a second layer of silica, a third layer of fluorine doped tin oxide and a fourth layer of silica, wherein the first layer of tin oxide is between the second layer of silica and the low emissivity coating on the first major surface if the third sheet of glazing material.

Preferably the first layer of tin oxide of the antireflection coating on the low emissivity coating on the first major surface of the third sheet of glazing material has a geometric thickness between 10nm and 15nm.

Preferably the second layer of silica of the antireflection coating on the low emissivity coating on the first major surface of the third sheet of glazing material has a geometric thickness between 20nm and 30nm.

Preferably the third layer of fluorine doped tin oxide of the antireflection coating on the low emissivity coating on the first major surface of the third sheet of glazing material has a geometric thickness between 100nm and 150nm.

Preferably the fourth layer of silica of the antireflection coating on the low emissivity coating on the first major surface of the third sheet of glazing material has a geometric thickness between 80nm and 100nm.

Embodiments of the first aspect of the present invention having a third sheet of glazing material having a low emissivity coating on the second major surface thereof have other preferable features.
Preferably there is an anti-iridescence coating in between the low emissivity coating on the second major surface of the third sheet of glazing material and the third sheet of glazing material.

Preferably the anti-iridescence layer comprises a first layer and a second layer, wherein the first layer of the anti-iridescence layer has a higher refractive index than the second layer of the anti-iridescence layer and the second layer of the anti-iridescence layer is in between the first layer of the anti-iridescence layer and the low emissivity coating on the second major surface of the third sheet of glazing material.

Preferably the first layer of the anti-iridescence layer comprises tin oxide.

Preferably the second layer of the anti-iridescence layer comprises silica.

Preferably the first layer of the anti-iridescence layer has a geometric thickness of between 10nm and 50nm, preferably between 15nm and 35nm.

Preferably the second layer of the anti-iridescence layer has a geometric thickness of between 10nm and 50nm, preferably between 15nm and 35nm.

Preferably there is a haze reducing layer in between the third sheet of glazing material and the anti-iridescence coating on the second major surface of the third sheet of glazing material.

Preferably the haze reducing layer comprises silica.

Preferably the thickness of the haze reducing layer is between 5nm and 50nm, more preferably between 5nm and 25nm.

In some embodiments the low emissivity coating on the second major surface of the third sheet of glazing material comprises at least one layer of fluorine doped tin oxide.

Preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on the second major surface of the third sheet of glazing material is between 100nm and 600nm.

Preferably the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the second major surface of the third sheet of glazing material is between 100nm and 300nm, more preferably between 100nm and 290nm, even more preferably between 100nm and 250nm.

By having a thin layer of fluorine doped tin oxide the low emissivity coating on the second major surface of the third sheet of glazing material is less susceptible to surface damage (for example when being transported or during assembly of the insulated glazing) because the coating is less rough. In addition costs are reduced because less coating is required to achieve the anti-condensation properties.
Furthermore the G value of the insulated glazing unit is higher compared to the same insulated glazing unit with a thicker layer of fluorine doped tin oxide.

Preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on the second major surface of the third sheet of glazing material is between 300nm and 400nm, more preferably between 300nm and 350nm.

In some embodiments preferably the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on the second major surface of the third sheet of glazing material is between 400nm and 600nm, more preferably between 500nm and 580nm.

Preferably there are no other layers on the low emissivity coating on the second major surface of the third sheet of glazing material.

Preferably there is a layer of silica on the low emissivity coating on the second major surface of the third sheet of glazing material. Preferably the layer of silica on the low emissivity coating on the second major surface of the third sheet of glazing material has a geometric thickness of between 5nm and 50nm.

Preferably there is a layer of titania on the low emissivity coating on the second major surface of the third sheet of glazing material. Preferably the layer of titania on the low emissivity coating on the second major surface of the third sheet of glazing material has a geometric thickness of between 5nm and 50nm.

From a second aspect the present invention provides an insulated glazing unit comprising a first sheet of glazing material and a second sheet of glazing material, there being a first space between the first sheet of glazing material and the second sheet of glazing material, wherein the first sheet of glazing material has a first major surface and an opposing second major surface, and the second sheet of glazing material has a first major surface and an opposing second major surface, wherein the second major surface of the first sheet of glazing material and the first major surface of the second sheet of glazing material face the first space, wherein the first space is a low pressure space having a pressure less than atmospheric pressure, there being a plurality of spacers disposed in the first space, wherein the first major surface of the second sheet of glazing material and/or the second major surface of the first sheet of glazing material has a low emissivity coating thereon, the insulated glazing unit further comprising a third sheet of glazing material facing the first sheet of the glazing material and being separated therefrom by a second space, the third sheet of glazing material having a first major surface and a second major surface, wherein the second major surface of the third sheet of glazing material and the first major surface of the first sheet of glazing material face the second space, and wherein the second major surface of the third sheet of glazing material has a low emissivity coating thereon, characterised in that the first major surface of the third sheet of glazing material has a low emissivity coating thereon.
Suitably the first sheet of glazing material is spaced apart from the second sheet of glazing material by less than 1mm, preferably by 0.05mm to 0.5mm, more preferably by 0.1 to 0.3mm.

Preferably the second space is an air space.

Preferably the second space is filled with an inert gas such as argon or krypton.

Preferably the third sheet of glazing material is spaced from the first sheet of glazing material by more than 2mm, preferably by 5mm to 50nm, more preferably by 5mm to 25mm.

Preferably there is a low emissivity coating on the second major surface of the first sheet of glazing material comprising at least one silver layer and/or at least on fluorine doped tin oxide layer.

Preferably there is a low emissivity coating on the first major surface of the second sheet of glazing material comprising at least one silver layer and/or at least on fluorine doped tin oxide layer.

Preferably there is an anti-iridescence coating in between the low emissivity coating on the first major surface of the third sheet of glazing material and the third sheet of glazing material.

Preferably the anti-iridescence layer comprises a first layer and a second layer, wherein the first layer of the anti-iridescence layer has a higher refractive index than the second layer of the anti-iridescence layer and the second layer of the anti-iridescence layer is in between the first layer of the anti-iridescence layer and the low emissivity coating on the first major surface of the third sheet of glazing material.

Preferably the first layer of the anti-iridescence layer comprises tin oxide.

Preferably the second layer of the anti-iridescence layer comprises silica.

Preferably the first layer of the anti-iridescence layer has a geometric thickness of between 10nm and 50nm, preferably between 15nm and 35nm.

Preferably the second layer of the anti-iridescence layer has a geometric thickness of between 10nm and 50nm, preferably between 15nm and 35nm.

Preferably there is a haze reducing layer in between the third sheet of glazing material and the anti-iridescence coating on the first major surface of the third sheet of glazing material.

Preferably the haze reducing layer comprises silica.

Preferably the thickness of the haze reducing layer is between 5nm and 50nm, more preferably between 5nm and 25nm.
In some embodiments of the second aspect of the present invention the low emissivity coating on the first major surface of the third sheet of glazing material comprises at least one layer of fluorine doped tin oxide.

Preferably the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the first major surface of the third sheet of glazing material is between 50nm and 600nm.

Preferably the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the first major surface of the third sheet of glazing material is between 100nm and 300nm, more preferably between 100nm and 290nm, even more preferably between 100nm and 250nm.

By having a thin layer of fluorine doped tin oxide the low emissivity coating is less susceptible to surface damage because the coating is less rough. In addition costs are reduced because less coating is required to achieve the anti-condensation properties. Furthermore the G value of the insulated glazing unit is higher compared to the same insulated glazing unit with a thicker layer of fluorine doped tin oxide.

In some embodiments of the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the first major surface of the third sheet of glazing material is between 250nm and 350nm.

In some embodiments the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the first major surface of the third sheet of glazing material is between 300nm and 400nm, more preferably between 300nm and 350nm.

In some embodiments the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the first major surface of the third sheet of glazing material is between 400nm and 600nm, preferably between 500nm and 580nm.

In some embodiments of the second aspect of the present invention there are no other layers on the low emissivity coating on the first major surface of the third sheet of glazing material.

In some embodiments of the second aspect of the present invention, there is a layer of silica on the low emissivity coating on the first major surface of the third sheet of glazing material. Preferably the layer of silica on the low emissivity coating on the first major surface of the third sheet of glazing material has a geometric thickness of between 5nm and 50nm.

In some embodiments of the second aspect of the present invention, there is a layer of titania on the low emissivity coating on the first major surface of the third sheet of glazing material. Preferably the layer of titania on the low emissivity coating on the first major surface of the third sheet of glazing material has a geometric thickness of between 5nm and 50nm.
In some embodiments of the second aspect of the present invention, there is an antireflection coating on the low emissivity coating on the first major surface of the third sheet of glazing material.

Preferably the antireflection coating on the low emissivity coating on the first major surface of the third sheet of glazing material comprises at least four layers.

Preferably the antireflection coating on the low emissivity coating on the first major surface of the third sheet of glazing material comprises in sequence, a first layer of tin oxide, a second layer of silica, a third layer of fluorine doped tin oxide and a fourth layer of silica, wherein the first layer of tin oxide is between the second layer of silica and the low emissivity coating on the first major surface if the third sheet of glazing material.

Preferably the first layer of tin oxide has a geometric thickness between 10nm and 15nm.

Preferably the second layer of silica has a geometric thickness between 20nm and 30nm.

Preferably the third layer of fluorine doped tin oxide has a geometric thickness between 100nm and 150nm.

Preferably the fourth layer of silica has a geometric thickness between 80nm and 100nm.

Preferably there is an anti-iridescence coating in between the low emissivity coating on the second major surface of the third sheet of glazing material and the third sheet of glazing material.

Preferably the anti-iridescence layer comprises a first layer and a second layer, wherein the first layer of the anti-iridescence layer has a higher refractive index than the second layer of the anti-iridescence layer and the second layer of the anti-iridescence layer is in between the first layer of the anti-iridescence layer and the low emissivity coating on the second major surface of the third sheet of glazing material.

Preferably the first layer of the anti-iridescence layer comprises tin oxide.

Preferably the second layer of the anti-iridescence layer comprises silica.

Preferably the first layer of the anti-iridescence layer has a geometric thickness of between 10nm and 50nm, preferably between 15nm and 35nm.

Preferably the second layer of the anti-iridescence layer has a geometric thickness of between 10nm and 50nm, preferably between 15nm and 35nm.

In some embodiments of the second aspect of the present invention, preferably there is a haze reducing layer in between the third sheet of glazing material and the anti-iridescence coating on the second major surface of the third sheet of glazing material.
Preferably the haze reducing layer comprises silica.

Preferably the thickness of the haze reducing layer is between 5nm and 50nm, more preferably between 5nm and 25nm.

In some embodiments of the second aspect of the present invention the low emissivity coating on the second major surface of the third sheet of glazing material comprises at least one layer of fluorine doped tin oxide.

Preferably the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the second major surface of the third sheet of glazing material is between 100nm and 600nm.

Preferably the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the second major surface of the third sheet of glazing material is between 100nm and 300nm, more preferably between 100nm and 290nm, even more preferably between 100nm and 250nm.

By having a thin layer of fluorine doped tin oxide the low emissivity coating is less susceptible to surface damage because the coating is less rough. In addition costs are reduced because less coating is required to achieve the anti-condensation properties. Furthermore the G value of the insulated glazing unit is higher compared to the same insulated glazing unit with a thicker layer of fluorine doped tin oxide.

Preferably the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the second major surface of the third sheet of glazing material is between 300nm and 400nm, more preferably between 300nm and 350nm.

Preferably the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the second major surface of the third sheet of glazing material is between 400nm and 600nm, more preferably between 500nm and 580nm.

In some embodiments of the second aspect of the present invention there are no other layers on the low emissivity coating on the second major surface of the third sheet of glazing material.

In some embodiments, there is a layer of silica on the low emissivity coating on the second major surface of the third sheet of glazing material. Preferably the layer of silica on the low emissivity coating on the second major surface of the third sheet of glazing material has a geometric thickness of between 5nm and 50nm.

In some embodiments, there is a layer of titania on the low emissivity coating on the second major surface of the third sheet of glazing material. Preferably the layer of titania on the low emissivity
coating on the second major surface of the third sheet of glazing material has a geometric thickness of between 5nm and 50nm.

Embodiments of the first and second aspects of the present invention have other preferable features. These other preferable features may be may be used in any combination and with the first and/or second aspects of the present invention.

In the first and second aspects of the present invention, suitable glazing material is glass, in particular soda-lime-silica glass or borosilicate glass. A typical soda-lime-silica glass composition is (by weight), SiO₂ 69 - 74 %; Al₂O₃ 0 - 3 %; Na₂O 10 - 16 %; K₂O 0 - 5 %; MgO 0 - 6 %; CaO 5 - 14 %; S0₃ 0 - 2 %; Fe₂O₃ 0.005 - 2 %.

Preferably the sheets of glazing material used in the first and second aspects of the present invention have a thickness between 2mm and 10mm, more preferably between 3mm and 8mm, even more preferably between 3mm and 6mm.

For a particular insulated glazing unit, the sheets of glazing material may have the same or different thickness.

For a particular insulated glazing unit, the sheets of glazing material may have the same or different glass composition.

An insulated glazing according to the first and second aspects of the present invention may comprise more than three sheets of glazing material.

An insulated glazing according to the first and second aspects of the present invention may comprise two or more low pressure spaces.

An insulated glazing according to the first and second aspects of the present invention may comprise two or vacuum insulated glazing panels.

A glazing unit according to the first and second aspects of the present invention may be used as a window in a building with the second major surface of the second sheet of glazing material facing the interior of the building.

Any of the coatings described herein may be deposited using known deposition techniques, such as atmospheric pressure chemical vapour deposition (APCVD) or sputtering. As is known in the art, oxide layers are typically deposited using APCVD. Silver layers may be deposited using known sputtering techniques.

In the context of the present invention U-values were determined in accordance with EN12898 and EN673.
In the context of the present invention roughness values were determined using an Atomic Force Microscope and defined in terms of parameters in accordance with ISO/DIS 25178-2 (2007).

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings (not to scale), in which:

Figure 1 shows a schematic representation of part of a vacuum insulated glazing according to the first aspect of the present invention;

Figure 2 shows a schematic representation of part of another vacuum insulated glazing according to the first aspect of the present invention;

Figure 3 shows a schematic representation of part of an insulated glazing unit according to the first aspect of the present invention;

Figure 4 shows a schematic representation of part of another vacuum insulated glazing according to the first aspect of the present invention;

Figure 5 shows a schematic representation of part of an insulated glazing unit according to the second aspect of the present invention;

Figure 6 shows a schematic representation of a coated glass sheet for use in an insulated glazing according to the first or second aspects of the present invention; and

Figure 1 shows a schematic representation of part of an insulated glazing unit according to the first aspect of the present invention. In this particular example, the insulated glazing unit is a vacuum insulated glazing unit 1 (VIG). The manufacture of such a VIG is described, for example, in EP0999330A1.

The VIG 1 has a first sheet of glass 3 and a second sheet of glass 5. The first sheet of glass 3 has a first major surface 7 and an opposing second major surface (not labelled in the figure). The second sheet of coated glass has a first major surface and an opposing second major surface (both not labelled in the figure).

Each sheet of glass 3, 5 is a soda-lime-silica composition having been made using the float process. Each glass sheet 3, 5 is 3mm thick.

The first sheet of glass 3 is spaced apart from the second sheet of glass 5 by a plurality of stainless steel spacers 11 (only five of which are shown in figure 1). The spacers maintain a space 12 between the two glass sheets 3, 5. The space 12 is a low pressure space, having been evacuated during construction of the VIG 1. A peripheral seal 10 of solder glass or the like ensures the space 12 remains at low pressure i.e. the peripheral seal 10 is a hermetic seal.
On the second major surface of the first sheet of glass 3 is a low emissivity coating 13. On the second major surface of the second sheet of glass 5 is a low emissivity coating 15.

The VIG 1 is configured such that in use the first major surface 7 of the first sheet of coated glass 3 faces the exterior of the building in which the VIG 1 is installed, and the second major surface of the second sheet of coated glass 5 (and consequently the low emissivity coating 15) faces the interior of the building in which the VIG is installed.

Using conventional naming nomenclature for the surfaces of the VIG, the first major surface 7 is surface 1 of the VIG, the second opposing major surface of the first sheet of glass 3 is surface 2 of the VIG, the first major surface of the second sheet of coated glass 5 is surface 3 of the VIG and the outer surface of the low emissivity coating 15 on the second major surface of the second glass sheet 5 is surface 4 of the VIG. The outer surface of the low emissivity coating 15 is labelled with the numeral 9 on figure 1.

Using the notation adopted in the present application, first major surface 7 may correspond to surface /, in which case the second opposing major surface of glass sheet 3 corresponds to surface ii, the first major surface of the second sheet of coated glass 5 corresponds to surface iii (i.e. the surface of coated glass sheet 5 facing space 12) and the opposing major surface of glass sheet 5 corresponds to surface iv.

The low emissivity coating 13 comprises a single layer of sputtered silver, but may comprise a double layer or triple layer of sputtered silver. Each silver layer may have a thickness between 5nm and 20nm. Examples of such coatings are described in US5,344,718 and US5,557,462. Alternatively the low emissivity coating 13 comprises at least one layer of fluorine doped tin oxide that has been deposited on the glass surface using atmospheric chemical deposition. The low emissivity coating 13 may be the same as the low emissivity coating 15. The low emissivity coating 13 may consist of an undercoat layer of SiCOx having a geometric thickness of 75nm and a low emissivity layer, on the undercoat layer, of fluorine doped tin oxide (SnO₂:F) having a geometric thickness of 320nm i.e. the glass sheet 3 with low emissivity coating 13 on the second major surface having a structure glass/SiCOx(75nm)/SnO₂:F(320nm).

The low emissivity coating 15 is described in more detail with reference to figure 6.

In an alternative to the embodiment shown in figure 1, there is no low emissivity coating 13 on the second major surface of the first sheet of glass 3, for example the sheet of glass 3 may be an uncoated sheet of glass.

In another alternative to the embodiment shown in figure 1, the orientation of the glazing is changed such that the first major surface 7 of the first sheet of coated glass 3 faces the interior of the building in which the VIG 1 is installed, and the second major surface of the second sheet of coated glass
5 (and consequently the low emissivity coating 15) faces the exterior of the building in which the VIG is
installed i.e. the low emissivity coating 15 faces the sun. When the VIG is configured this way, the low
emissivity coating on the exterior facing major surface of the VIG may help reduce the formation of
condensation thereon because the temperature of the sheet of glass 5 may be raised. In this alternative,
the glass sheet 3 may be an uncoated sheet of glass.

In any of the alternative described above in relation to figure 1, there may be a low emissivity
coating on the first major surface of the glass sheet 5 i.e. the surface of the glass sheet 5 facing the space
12.

Figure 2 shows a schematic representation of part of another insulated glazing unit according to
the first aspect of the present invention. The insulated glazing unit is also a vacuum insulated glazing
unit 21 (VIG).

The VIG 21 has a first sheet of glass 23 and a second sheet of glass 25. The first sheet of glass
23 has a first major surface and an opposing second major surface (both not labelled in the figure). The
second sheet of glass has a first major surface and an opposing second major surface (both not labelled in
the figure).

Each sheet of glass 23, 25 is a soda-lime-silica composition having been made using the float
process. Each glass sheet 3, 5 is 3mm thick but may be 6mm thick.

The first sheet of glass 23 is spaced apart from the second sheet of glass 25 by a plurality of
stainless steel spacers 22 (only five of which are shown in figure 2, the spacers 22 being the same at the
spacers 11 in figure 1). The spacers 22 maintain a space 32 between the two glass sheets 23, 25. The
space 32 is a low pressure space, having been evacuated during construction of the VIG 21. A peripheral
seal 30 of solder glass or the like ensures the space 32 remains at low pressure i.e. the peripheral seal 30
is a hermetic seal.

On the first major surface of the first sheet of glass 23 is a low emissivity coating 31. On the
second major surface of the first sheet of glass 23 is a low emissivity coating 33. On the second major
surface of the second sheet of glass 25 is a low emissivity coating 35.

The VIG 21 is configured such that in use the first major surface of the first sheet of coated glass
23 (and consequently the low emissivity coating 31) faces the exterior of the building in which the VIG
21 is installed, and the second major surface of the second sheet of coated glass 25 (and consequently the
low emissivity coating 35) faces the interior of the building in which the VIG 21 is installed.

The low emissivity coating 33 comprises a single layer of sputtered silver, but may comprise a
double layer or triple layer of sputtered silver. Each silver layer may have a thickness between 5nm and
20nm. Examples of such coatings are described in US5,344,718 and US5,557,462. Alternatively the low
emissivity coating 33 comprises at least one layer of fluorine doped tin oxide that has been deposited on
the glass surface using atmospheric chemical deposition, typically when the glass is produced by the
float process. The low emissivity coating 33 may be the same as the low emissivity coating 35. The low
emissivity coating 33 may consist of an undercoat layer of SiCOx having a geometric thickness of 75nm
and a low emissivity layer, on the undercoat layer, of fluorine doped tin oxide having a geometric
thickness of 320nm i.e. the glass sheet 23 with low emissivity coating 33 on the second major surface
thereof having a structure glass/SiCOx(75nm)/SnO2:F(320nm).

The low emissivity coatings 31 and 35 are described in more detail with reference to figure 6.

Figure 3 shows part of an insulated glazing unit 41. The insulated glazing unit 41 comprises a
sheet of 3mm soda-lime-silica glass 43 having a low emissivity coating 45 on a major surface thereof
and a VIG 1 as described with reference to figure 1. Such an insulated glazing unit is typically referred to
as a triple glazed insulated glazing unit because there are three sheets of glazing material and two spaces
between the sheets.

The VIG 1 is spaced about 12mm apart from the coated glass sheet by a metal spacer 44 and a
perimeter seal 410 of polyurethane or the like, thereby creating a space 42. The space 42 is an air space
and may be filled with an inert gas such as argon or krypton.

The low emissivity coating 45 is on the major surface of the glass sheet 43 that faces the space
42.

The low emissivity coating 45 comprises a single layer of sputtered silver, but may comprise a
double layer or triple layer of sputtered silver. Each silver layer may have a thickness between 5nm and
20nm. Examples of such coatings are described in US5,344,718 and US5,557,462. Alternatively the low
emissivity coating 45 comprises at least one layer of fluorine doped tin oxide that has been deposited on
the glass surface using atmospheric chemical deposition, typically when the glass is produced by the
float process. The low emissivity coating 45 may be the same as the low emissivity coating 15. The low
emissivity coating 45 may consist of an undercoat layer of SiCOx having a geometric thickness of 75nm
and a low emissivity layer, on the undercoat layer, of fluorine doped tin oxide having a geometric
thickness of 320nm i.e. the glass sheet 43 with low emissivity coating 45 on the second major surface
thereof having a structure glass/SiCOx(75nm)/SnO2:F(320nm).

The insulated glazing unit 41 is configured such that in use, the uncoated surface of the glass
sheet 43 faces the exterior of the building. This is referred to a surface 1. The coated surface of the glass
sheet 43 faces the air space 42 and is referred to as surface 2. The surface of the glass sheet 3 of VIG 1
acrossing the air space 42 is referred to as surface 3. The coated surface of glass sheet 3 of the VIG 1 facing
the low pressure space 12 is referred to as surface 4. The uncoated surface of the glass sheet 5 of the
VIG 1 facing the low pressure space 12 is referred to as surface 5 and the coated surface of the glass
sheet 5 of the VIG 1 is referred to as surface 6 and faces the interior of the building.
This is conventional nomenclature for naming the surfaces of a triple glazed insulated glazing unit.

The low emissivity coatings 45, 13 and 15 on surface 2, 4 and 6 respectively reduce the U-value of the insulated glazing unit 41.

In a variant to the example shown in figure 3, the sheet of glass 43 may be coated on both major surfaces with a low emissivity coating i.e. surface 1 has a low emissivity coating thereon.

In this variant, the low emissivity coating on surface 1 may be the same as the low emissivity coating 45. It is preferred that the low emissivity coating on the major surface of glass sheet 43 facing the airspace comprises at least one fluorine doped tin oxide layer, and is preferably the same as low emissivity coating 15 described with reference to figure 6. Preferably the low emissivity coating on surface 1 is the same as coating 15 described with reference to figures 1 and 6. The provision of a low emissivity coating on surface 1 helps raise the temperature of glass sheet 43 thereby helping reduce the formation of condensation thereon.

In another variant to the insulated glazing shown in figure 3, the positions of the sheet of glass 43 and the VIG 1 may be reversed.

Figure 4 shows a schematic representation of another insulated glazing unit according to the first aspect of the present invention. In this particular example, the insulated glazing unit is a vacuum insulated glazing unit 51 (VIG) and is similar to the VIG 1 and VIG 21 described above.

The VIG 51 has a first sheet of glass 53 and a second sheet of glass 55. The first sheet of glass 53 has a first major surface and an opposing second major surface (both not labelled in the figure). The second sheet of coated glass has a first major surface and an opposing second major surface (both not labelled in the figure).

Each sheet of glass 53, 55 is a soda-lime-silica composition having been made using the float process. Each glass sheet 53, 55 is 3mm thick.

The first sheet of glass 53 is spaced apart from the second sheet of glass 55 by a plurality of stainless steel spacers 52 (only five of which are shown in figure 4). The spacers maintain a space 62 between the two glass sheets 53, 55 of about 0.2mm. The space 62 is a low pressure space, having been evacuated during construction of the VIG 51. A peripheral seal 60 of solder glass or the like ensures the space 62 remains at low pressure i.e. the peripheral seal 60 is a hermetic seal.

The second major surface of glass sheet 53 faces the space 62. The first major surface of the glass sheet 55 faces the space 62.
Both major surfaces of glass sheet 53 are uncoated. On the first major surface of glass sheet 55 is a low emissivity coating 63. On the second major surface of the glass sheet 55 is a low emissivity coating 65.

The VIG 51 is configured such that in use the first major surface of the first sheet of glass 53 faces the exterior of the building in which the VIG 51 is installed, and the second major surface of the second sheet of glass 55 (and consequently the low emissivity coating 65) faces the interior of the building in which the VIG 51 is installed.

The low emissivity coating 63 comprises a single layer of sputtered silver, but may comprise a double layer or triple layer of sputtered silver. Each silver layer may have a thickness between 5nm and 20nm. Examples of such coatings are described in US5,344,718 and US5,557,462. Alternatively the low emissivity coating 63 comprises at least one layer of fluorine doped tin oxide that has been deposited on the glass surface using atmospheric chemical deposition. The low emissivity coating 63 may be the same as the low emissivity coating 65. The low emissivity coating 63 may consist of an undercoat layer of SiCOx having a geometric thickness of 75nm and a low emissivity layer, on the undercoat layer, of fluorine doped tin oxide having a geometric thickness of 320nm i.e. the glass sheet 55 with low emissivity coating 63 on the first major surface thereof having a structure glass/SiCOx(75nm)/SnO₂:F(320nm).

The low emissivity coating 65 is described in more detail with reference to figure 6.

In an alternative to the embodiment shown in figure 4, the orientation of the VIG 51 may be reversed such that in use i.e. when installed in a building, the low emissivity coating 65 faces the exterior of the building and the uncoated major surface of the first glass sheet 53 not facing the space 62 faces the interior of the building in which the VIG is installed.

In another embodiment, and with reference to figures 2, 3 and 4, the VIG 1 of figure 3 may be replaced with the VIG 21 of figure 2 or the VIG 51 of figure 4.

Figure 5 shows a schematic representation of part of an insulated glazing unit 71 according to the second aspect of the present invention.

The insulated glazing unit 71 comprises a sheet of 3mm thick soda-lime-silica glass 73 spaced 12mm apart from a VIG 81 by a metal spacer 72 and a perimeter seal 74. There is an air space 76 between the glass sheet 73 and the VIG 81.

The glass sheet 73 has first and second opposing major surfaces. The second major surface of the glass sheet 73 faces the air space 76. There is a low emissivity coating 75 on the first major surface of the glass sheet 73 and a low emissivity coating 77 on the second major surface of the glass sheet 73.
The low emissivity coating 77 comprises a single layer of sputtered silver, but may comprise a double layer or triple layer of sputtered silver. Each silver layer may have a thickness between 5nm and 20nm. Examples of such coatings are described in US5,344,718 and US5,557,462. Alternatively the low emissivity coating 77 comprises at least one layer of fluorine doped tin oxide that has been deposited on the glass surface using atmospheric chemical deposition. The low emissivity coating 77 may be the same as the low emissivity coating 75. The low emissivity coating 77 may consist of an undercoat layer of SiCOx having a geometric thickness of 75nm and a low emissivity layer, on the undercoat layer, of fluorine doped tin oxide having a geometric thickness of 320nm i.e. the SiCOx layer being in contact with the glass surface, and the Sn0.2:F layer being on the SiCOx layer.

The low emissivity coating 75 is described in more detail with reference to figure 6.

The VIG 81 comprises a first sheet of glass 83 and a second sheet of glass 85 spaced apart from each other by about 0.2mm by a plurality of stainless steel spacers 82. The spacers maintain a space 92 between the two glass sheets 83, 85. The space 92 is a low pressure space, having been evacuated during construction of the VIG 81. A peripheral seal 80 of solder glass or the like ensures the space 92 remains at low pressure i.e. the peripheral seal 80 is a hermetic seal.

Glass sheet 83 has a first major surface facing the air space 76 and a second major surface facing the low pressure space 92. On the second major surface of glass sheet 83 is a low emissivity coating 93. The low emissivity coating may be the same as the low emissivity coating 77.

Glass sheet 85 has a first major surface facing the low pressure space 92 and a second opposing major surface. Both major surfaces of the glass sheet 85 are uncoated.

In use, the second major surface of the glass sheet 85 faces the interior of the building in which the insulated glazing unit 71 is installed.

In figure 5 the additional low emissivity coating 75 on surface 1 helps raise the temperature of glass sheet 73 to reduce the formation of condensation thereon.

Figure 6 shows a cross-sectional representation of a coated glass sheet useful as a pane in an insulated glazing according to either the first or second aspect of the present invention.

With reference to figure 6, a coated pane 101 comprising a sheet of 3mm thick clear float glass 105 was coated with a coating structure 115 using atmospheric chemical vapour deposition in the float bath region of a float furnace, for example as described in W097/42357A1.

The composition of glass sheet 105 was a conventional clear float glass composition (soda-lime-silica glass) having an Fe2O3 content of 0.11% by weight, although in another embodiment the Fe2O3 content was between 0.001% by weight and 0.1% by weight, typically about 0.05% by weight. In
another example a higher Fe₂O₃ content float glass composition was used, having an Fe₂O₃ content by weight of about 0.18%.

The hot float glass ribbon was first coated with a layer 102 of SiO₂ having a geometric thickness of 15nm. This layer 102 is a haze reducing layer such that a coated glass sheet according to the present invention has less haze than a coated glass sheet without this layer. Other such coatings may be used, for example Si₃N₄.

Next a layer 104 of SnO₂ having a geometric thickness of 25nm was deposited on the SiO₂ layer. This layer forms part of the anti-iridescence coating structure. Next a layer 106 of SiO₂ having a geometric thickness of 30nm was deposited on the SnO₂ layer 104. The combination of the 25nm layer of SnO₂ and 30nm layer of SiO₂ is an anti-iridescence coating. The layer 104 is a first layer of the anti-iridescence coating and the layer 106 is a second layer of the anti-iridescence coating.

Finally a layer 108 of fluorine doped tin oxide (SnO₂:F) was deposited on the 30nm thick SiO₂ layer. The SnO₂:F layer 108 had a geometric thickness of 230nm.

The layers 102, 104, 106 and 108 form the coating structure 115. The coating structure 115 is a low emissivity coating.

The coating structure 115 corresponds to the low emissivity coating 15 in figure 1, the low emissivity coating 31 and/or the low emissivity coating 35 in figure 2, the low emissivity coating 65 in figure 4 and the low emissivity coating 75 in figure 5.

If the SnO₂:F layer 108 is too thick, it has more of a tendency to be damaged, for example when being handled or cleaned. Consequently it is not necessary to use any additional coating layers on the low emissivity coating 108. Other coating layers may be deposited on the low emissivity coating 108 although this increases costs and manufacturing complexity.

As the low emissivity SnO₂:F layer 108 becomes thinner, the durability of the coating increases but the emissivity increases, which is not desirable. For the coated substrate shown in figure 6, the emissivity of the coating is 0.22.

The roughness of the SnO₂:F layer was determined to be about 10nm. The roughness may be measured using an Atomic Force Microscope and defined in terms of parameters in accordance with ISO/DIS 25178-2 (2007).

The same coating as described above was deposited onto a 3.92mm thick sheet of low iron float glass (having 0.02% by weight Fe₂O₃). The visible light transmission of this coated sheet was 84.6%, calculated according to EN410(201 1)/673 (CEN).

In an alternative to the coating structure 115 shown in figure 6, there may be not be a layer 102 of SiO₂, instead the layer 104 is in contact with the surface of the glass sheet 105. In this embodiment the
geometric thickness of the layer 104 of SnO₂ may be between 20nm and 30nm and the geometric thickness of the layer 106 of SiO₂ on the layer 104 may have a geometric thickness of between 10nm and 30nm. The layer 108 of fluorine doped tin oxide (SnO₂:F) on the SiO₂ layer 106 may have a geometric thickness between 300nm and 400nm, typically about 320nm. Alternatively the layer 108 of fluorine doped tin oxide (SnO₂:F) on the SiO₂ layer 106 may have a geometric thickness greater than 400nm, typically up to about 600nm i.e. within the range 500-580nm.

The coating structure 115 as described may be used as a low emissivity coating on one or more major surface of glazing material in accordance with the first and second aspects of the present invention.

The examples of the present invention have reduced U-values compared to the equivalent insulated glazing unit without a low emissivity coating on an exposed surface thereof. The provision of a low emissivity coating on an exterior facing surface (i.e. surface 1) of the insulated glazing unit has the advantage that anti-condensation properties can be provided to the insulated glazing unit without the need to overcoat the low emissivity coating on said surface. This reduces manufacturing costs and manufacturing complexity. By using a relatively thin low emissivity layer, the coating is relatively smooth and less susceptible to damage that may otherwise occur to a similar thicker coating being exposed to the external environment.

In summary, from a first aspect insulated glazing units comprising first and second sheets of glazing material with a low pressure space therebetween are described herein. The major surface of the second sheet of glazing material not facing the low pressure space has a low emissivity coating comprising at least one layer of fluorine doped tin oxide thereon. There is a first anti-iridescence coating between the low emissivity coating and the second sheet of glazing material. Also from a second aspect insulated glazing units comprising three (first, second and third) sheets of glazing material with a low pressure space between first and second sheets of glazing material, and a second space between the first and third sheets of glazing material are described herein. In the second aspect there is a low emissivity coating on one or both major surfaces facing the low pressure space and the third sheet of glazing material has a low emissivity coating on both opposed major surfaces thereof.
CLAIMS

1. An insulated glazing unit comprising a first sheet of glazing material and a second sheet of glazing material, there being a first space between the first sheet of glazing material and the second sheet of glazing material, wherein the first sheet of glazing material has a first major surface and an opposing second major surface, and the second sheet of glazing material has a first major surface and an opposing second major surface, wherein the second major surface of the first sheet of glazing material and the first major surface of the second sheet of glazing material face the first space, wherein the first space is a low pressure space having a pressure less than atmospheric pressure, there being a plurality of spacers disposed in the first space, characterised in that the second major surface of the second sheet of glazing material has a low emissivity coating thereon, the low emissivity coating comprising at least one layer of fluorine doped tin oxide and there is a first anti-iridescence coating in between the low emissivity coating and the second sheet of glazing material.

2. An insulated glazing unit according to claim 1, wherein the geometric thickness of the at least one layer of fluorine doped tin oxide is between 100nm and 600nm.

3. An insulated glazing according to claim 1 or claim 2, wherein the geometric thickness of the at least one layer of fluorine doped tin oxide is between 100nm and 300nm, preferably between 100nm and 290nm, more preferably between 100nm and 250nm.

4. An insulated glazing unit according to claim 1 or claim 2, wherein the geometric thickness of the at least one layer of fluorine doped tin oxide is between 250nm and 350nm.

5. An insulated glazing unit according to claim 1 or claim 2, wherein the geometric thickness of the at least one layer of fluorine doped tin oxide is between 300nm and 400nm, preferably between 300nm and 350nm.

6. An insulated glazing unit according to claim 1 or claim 2, wherein the geometric thickness of the at least one layer of fluorine doped tin oxide is between 400nm and 600nm, preferably between 500nm and 580nm.

7. An insulated glazing unit according to any of the preceding claims, wherein the first anti-iridescence coating comprises a first layer and a second layer, wherein the first layer of the first anti-iridescence coating has a higher refractive index than the second layer of the first anti-iridescence coating and the second layer of the first anti-iridescence coating is in between the first layer of the first anti-iridescence coating and the low emissivity coating.
8. An insulated glazing unit according to claim 7, wherein the first layer of the first anti-iridescence coating comprises tin oxide.

9. An insulated glazing according to claim 7 or claim 8, wherein the second layer of the first anti-iridescence coating comprises silica.

10. An insulated glazing unit according to any of the claims 7 to 9, wherein the first layer of the first anti-iridescence coating has a geometric thickness of between 10nm and 50nm, preferably between 15nm and 35nm.

11. An insulated glazing unit according to any of claims 7 to 10, wherein the second layer of the first anti-iridescence coating has a geometric thickness of between 10nm and 50nm, preferably between 15nm and 35nm.

12. An insulated glazing unit according to any of the preceding claims, further comprising a first haze reducing layer in between the second sheet of glazing material and the first anti-iridescence coating.

13. An insulated glazing unit according to claim 12, wherein the first haze reducing layer comprises silica.

14. An insulated glazing unit according to claim 12 or claim 13, wherein the geometric thickness of the first haze reducing layer is between 5nm and 50nm, preferably between 5nm and 25nm.

15. An insulated glazing unit according to any of the preceding claims, wherein there is a low emissivity coating on the second major surface of the first sheet of glazing material and/or a low emissivity coating on the first major surface of the second sheet of glazing material.

16. An insulated glazing unit according to claim 15, wherein the low emissivity coating on the second major surface of the first sheet of glazing material and/or the low emissivity coating on the first major surface of the second sheet of glazing material comprises at least one silver layer and/or at least one fluorine doped tin oxide layer.

17. An insulated glazing unit according to claim 16, wherein the low emissivity coating on the second major surface of the first sheet of glazing material and/or the low emissivity coating on the first major surface of the second sheet of glazing material comprises at least one silver layer having a geometric thickness between 5nm and 20nm.

18. An insulated glazing unit according to claim 16 or claim 17, wherein the low emissivity coating on the second major surface of the first sheet of glazing material and/or the low emissivity coating on the first major surface of the second sheet of glazing material comprises at least one fluorine doped tin oxide layer having a geometric thickness between 100nm and 600nm.
19. An insulated glazing according to any of the preceding claims, comprising a low emissivity coating on the first major surface of the first sheet of glazing material.

20. An insulated glazing unit according to claim 19, comprising a second anti-iridescence coating in between the low emissivity coating on the first major surface of the first sheet of glazing material and the first sheet of glazing material.

21. An insulated glazing unit according to claim 20, wherein the second anti-iridescence coating comprises a first layer and a second layer, wherein the first layer of the second anti-iridescence coating has a higher refractive index than the second layer of the second anti-iridescence coating and wherein the second layer of the second anti-iridescence coating is in between the first layer of the second anti-iridescence coating and the low emissivity coating on the first major surface of the first sheet of glazing material.

22. An insulated glazing unit according to claim 20 or claim 21, further comprising a second haze reducing layer in between the first sheet of glazing material and the second anti-iridescence coating.

23. An insulated glazing unit according to any of the claims 19 to 22, wherein the low emissivity coating on the first major surface of the first sheet of glazing material comprises at least one layer of fluorine doped tin oxide.

24. An insulated glazing unit according to claim 23, wherein the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on the first major surface of the first sheet of glazing material is between 100nm and 600nm.

25. An insulated glazing unit according to claim 23 or claim 24, wherein the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on the first major surface of the first sheet of glazing material is between 100nm and 300nm, preferably 100nm and 290nm, more preferably between 100nm and 250nm.

26. An insulated glazing unit according to claim 23 or claim 24, wherein the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on the first major surface of the first sheet of glazing material is between 300nm and 400nm, preferably between 300nm and 350nm.

27. An insulated glazing unit according to claim 23 or claim 24, wherein the geometric thickness of the at least one fluorine doped tin oxide layer of the low emissivity coating on the first major surface of the first sheet of glazing material is between 400nm and 600nm, preferably between 500nm and 580nm.
28. An insulated glazing unit according to any of the claims 19 to 27, wherein there is a layer of silica or a layer of titania on the low emissivity coating on the first major surface of the first sheet of glazing material.

29. An insulated glazing unit according to any of the claims 19 to 28, wherein there is an antireflection coating on the low emissivity coating on the first major surface of the first sheet of glazing material.

30. An insulated glazing unit according to any of the claims 19 to 27, wherein there is no other layer on the low emissivity coating on the first major surface of the first sheet of glazing material.

31. An insulated glazing unit according to any of the claims 19 to 30, wherein the low emissivity coating on the first major surface of the first sheet of glazing material has a roughness less than 20nm, preferably between 3nm and 15nm, more preferably between 5nm and 12nm.

32. An insulated glazing unit according to any of the preceding claims, wherein there is a layer of silica or a layer of titania on the low emissivity coating on the second major surface of the second sheet of glazing material.

33. An insulated glazing unit according to any of the preceding claims, wherein there is an antireflection coating on the low emissivity coating on the second major surface of the second sheet of glazing material.

34. An insulated glazing unit according to any of the claims 1 to 31, wherein there are no other layers on the low emissivity coating on the second major surface of the second sheet of glazing material.

35. An insulated glazing according to any of the preceding claims, wherein the low emissivity coating on the second major surface of the second sheet of glazing material has a roughness less than 20nm, preferably between 3nm and 15nm, more preferably between 5nm and 12nm.

36. An insulated glazing according to any of the preceding claims, comprising a third sheet of glazing material facing the first sheet of the glazing material and being separated therefrom by a second space, the third sheet of glazing material having a first major surface and a second major surface, wherein the insulated glazing unit is configured such that the second major surface of the third sheet of glazing material and the first major surface of the first sheet of glazing material face the second space.

37. An insulated glazing unit according to claim 36, wherein the first major surface of the third sheet of glazing material and/or the second major surface of the third sheet of glazing material has a low emissivity coating thereon.
38. An insulated glazing unit according to claim 37, wherein the first major surface of the third sheet of glazing material has a low emissivity coating comprising at least one layer of fluorine doped tin oxide thereon.

39. An insulated glazing unit according to claim 38, wherein the geometric thickness of the at least one layer of fluorine doped tin oxide on the first major surface of the third sheet of glazing material is between 100nm and 600nm.

40. An insulated glazing unit according to any of the claims 36 to 39, wherein the low emissivity coating on the second major surface of the second sheet of glazing material is on surface 6 of the insulated glazing unit.

41. An insulated glazing unit according to any of the claims 1 to 35, wherein the low emissivity coating on the second major surface of the second sheet of glazing material is on surface 4 of the insulated glazing unit.

42. An insulated glazing unit comprising a first sheet of glazing material and a second sheet of glazing material, there being a first space between the first sheet of glazing material and the second sheet of glazing material, wherein the first sheet of glazing material has a first major surface and an opposing second major surface, and the second sheet of glazing material has a first major surface and an opposing second major surface, wherein the second major surface of the first sheet of glazing material and the first major surface of the second sheet of glazing material face the first space, wherein the first space is a low pressure space having a pressure less than atmospheric pressure, there being a plurality of spacers disposed in the first space, wherein the first major surface of the second sheet of glazing material and/or the second major surface of the first sheet of glazing material has a low emissivity coating thereon, the insulated glazing unit further comprising a third sheet of glazing material facing the first sheet of the glazing material and being separated therefrom by a second space, the third sheet of glazing material having a first major surface and a second major surface, wherein the second major surface of the third sheet of glazing material and the first major surface of the first sheet of glazing material face the second space, and wherein the second major surface of the third sheet of glazing material has a low emissivity coating thereon, characterised in that the first major surface of the third sheet of glazing material has a low emissivity coating thereon.

43. An insulated glazing unit according to claim 42, wherein the low emissivity coating on the first major surface of the third sheet of glazing material comprises at least one layer of fluorine doped tin oxide.

44. An insulated glazing unit according to claim 43, wherein the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the first major surface of the third sheet of glazing material is between 100nm and 600nm.
45. An insulated glazing unit according to claim 43 or claim 44, wherein the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the first major surface of the third sheet of glazing material is between 100nm and 300nm, preferably between 100nm and 290nm, more preferably between 100nm and 250nm.

46. An insulated glazing unit according to claim 43 or claim 44, wherein the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the first major surface of the third sheet of glazing material is between 300nm and 400nm, preferably between 300nm and 350nm.

47. An insulated glazing unit according to claim 43 or claim 44, wherein the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the first major surface of the third sheet of glazing material is between 400nm and 600nm, preferably between 500nm and 580nm.

48. An insulated glazing unit according to claim 43 or claim 44, wherein the geometric thickness of the at least one layer of fluorine doped tin oxide of the low emissivity coating on the first major surface of the third sheet of glazing material is between 250nm and 350.

49. An insulated glazing unit according to any of the preceding claims, wherein one or more of the sheets of glazing material is a sheet of glass, preferably soda-lime-silica glass or borosilicate glass.
### INTERNATIONAL SEARCH REPORT

**International application No:**

PCT/GB2015/052960

### A. CLASSIFICATION OF SUBJECT MATTER

INV. B32B17/10 C03C17/36

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B32B C03C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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### Further documents are listed in the continuation of Box C.

**X** See patent family annex.

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**Date of the actual completion of the international search:**

18 December 2015

**Date of mailing of the international search report:**

04/01/2016

**Name and mailing address of the ISA/Authorized officer:**

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