

A GLASS STRUCTURE

TECHNICAL FIELD

This invention relates generally to a glass structure that is semi-light permeable and a
5 method for forming the glass structure.

Background

Existing glass structures which coats a glass substrate with, for example coatings for
restricting or controlling light permeability, are difficult to produce in large format and
10 sizes. Further, the nature of typical coatings on glass substrates are easily damaged and do
not offer protection to outdoor environment and weathering. Further, typical coating lines
and scale are small due to the coating techniques utilized, making it difficult to produce
large area of large size products. The need for chemical oxidation reduction method for
preparation during the production process, the long production cycle, poor stability and high
15 cost renders typical production process undesirable. Further, these coatings may even be
easily damaged during application thereof to the glass substrate. Even when not exposed to
the elements, control over the semi-permeability level of the eventual product leaves much
to be desired. The materials used for the coatings are also harmful to the environment,
expensive and is inefficient to apply and process. Therefore, there exists a need for an
20 improved release method/mechanism for addressing the foregoing problems.

Summary

In accordance with a first aspect of the invention, there is disclosed a glass structure
comprising a glass substrate, a first dielectric layer formed over the glass substrate and
25 having a high refractive index, a second dielectric layer formed over the first dielectric layer
and having a low refractive index, a third dielectric layer formed over the second dielectric
layer and having a high refractive index such that the second dielectric layer interposes the
first dielectric layer and the third dielectric layer, a fourth dielectric layer formed over the
third dielectric layer and having a low refractive index such that the third dielectric layer
30 interposes the second dielectric layer and the fourth dielectric layer, and a fifth dielectric

layer formed over the fourth dielectric layer and having a high refractive index such that the fourth dielectric layer interposes the third dielectric layer and the fifth dielectric layer

- 5 In accordance with a second aspect of the invention, there is disclosed a glass structure forming method comprising forming a first dielectric layer formed having a high refractive index over a glass substrate by magnetron sputtering, forming a second dielectric layer having a low refractive index over the first dielectric layer by magnetron sputtering, forming a third dielectric layer having a high refractive index over the second dielectric layer by magnetron sputtering such that the second dielectric layer interposes the first dielectric layer and the third dielectric layer, forming a fourth dielectric layer having a low refractive index over the third dielectric layer by magnetron sputtering such that the third dielectric layer interposes the second dielectric layer and the fourth dielectric layer, and forming a fifth dielectric layer over the fourth dielectric layer and having a high refractive index such that the fourth dielectric layer interposes the third dielectric layer and the fifth dielectric layer
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Brief Description of the Drawings

- FIG. 1 shows an exemplary partial sectional view of a glass structure in accordance with an aspect of the invention with various layers being formed on a glass substrate and capped with a protective layer;
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- FIG. 2 shows an exemplary partial sectional view of the glass structure of FIG. 1 without the protective layer;
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- FIG. 3 shows an exemplary partial sectional view of the glass structure of FIG. 1 with the protective layer and when the thickness of a protective layer thereof approaches 0nm; and

- FIG. 4 shows an exemplary process flow of a glass structure forming method in accordance with another aspect of the invention for forming the glass structure of FIG. 1.
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Detailed Description

An exemplary embodiment of the present invention, a glass structure 20 and a glass structure forming method 100 is described hereinafter with reference to FIG. 1 and FIG. 4.

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The glass structure 20 comprises a glass substrate 22, a first dielectric layer 24 formed over the glass substrate 22 in a step 210 and having a high refractive index, a second dielectric layer 26 formed over the first dielectric layer 24 in a step 212 and having a low refractive index, a third dielectric layer 28 formed over the second dielectric layer 26 in a step 214 and
10 having a high refractive index such that the second dielectric layer 26 interposes the first dielectric layer 24 and the third dielectric layer 28, and a fourth dielectric layer 30 formed over the third dielectric layer 28 in a step 216 such that the third dielectric layer interposes the second dielectric layer and the fourth dielectric layer. The glass structure 20 further comprises a fifth dielectric layer 32 formed over the fourth dielectric layer 30 in a step 218
15 such that the fourth dielectric layer 30 interposes the third dielectric layer 28 and the fifth dielectric layer 32. The fourth dielectric layer 30 is formed with a low refractive index while the fifth dielectric layer 32 is formed with a high refractive index.

In preparation for the step 210, the glass substrate 22 is first cleaned and dried before being
20 placed a coating zone of a magnetron sputtering system. Through the use of an intermediate frequency AC power supply on a rotating cathode, the first dielectric layer 24 is formed on the glass substrate 22 in the step 210. Each of the second dielectric layer 26, the third dielectric layer 28, the fourth dielectric layer 30 and the fifth dielectric layer 32 is formed, or plated, one layer atop the other, also through the application of an intermediate frequency
25 AC power supply on the rotating cathode in the coating zone via magnetron sputtering.

Preferably, each of the first dielectric layer 24, the third dielectric layer 28 and the fifth dielectric layer 32 is being formed from at least one of TiO₂, NbO_x (for example NbO, NbO₂ or Nb₂O₅) and Si₃N₄ and has a refractive index of between and including 2.0 and
30 2.7. The first dielectric layer 24 is formed with a thickness of between and including 60 nm and 150 nm. However, it is preferred that the thickness of the first dielectric layer 24 be

from 80 nm to 130 nm, and more preferably be from 90 nm and 110 nm. This enables the first dielectric layer 24 to function as a coupler between the glass substrate 22 and subsequent layers to be formed thereonto. Further, the first dielectric layer 24 also functions substantially to adjust the colour reflective properties of the glass structure 20 and to function substantially as a barrier to glass diffusion of alkali metal ions to the subsequent layers of the glass structure. The third dielectric layer 28 is formed with a thickness of between and including 20nm and 120nm. However, it is preferred that the thickness of the third dielectric layer 28 be from 30 nm to 100 nm, and more preferably from 40 to 80 nm. The third dielectric layer functions to adjust optical interference and reflection color of the glass structure 20. The fifth dielectric layer 32 is formed with a thickness of not more than 100 nm. However, it is preferred that the thickness of the fifth dielectric layer 32 be not more than 80 nm, and more preferably be not more than 60nm. The fifth dielectric layer 32 functions to further adjust optical interference and reflection color of the glass structure 20.

Preferably, each of the second dielectric layer 26 and the fourth dielectric layer 30 being formed from SiO₂. The second dielectric layer 26 has a thickness of between and including 60nm and 180nm. However, it is preferred that the thickness of the second dielectric layer 26 be from 90 nm to 150 nm, and more preferably from 100 nm to 130 nm. The second dielectric layer 26 functions to adjust the optical interference and appearance color of the glass structure 20.

The fourth dielectric layer 30 has a thickness of between and including 60nm and 180nm. However, it is preferred that the thickness of the fourth dielectric layer 30 be from 70 nm to 150 nm, and more preferably from 80 nm to 120 nm. The fourth dielectric layer 30 functions also to adjust the optical interference and colour appearance of the glass structure 20.

Preferably, the glass substrate 22 further comprises a protective layer 34 formed over the fifth dielectric layer 32 in a step 220. The protective layer 34 is preferably formed from at least one of ZrO₂, Si₃N₄, SiC and TiO₂ with a thickness of between and including 5nm to 80nm preferably by via magnetron sputtering over the fifth dielectric layer 32 in the coating

zone. It is further preferred that the thickness of the fifth dielectric layer 32 be between 8 nm and 70nm, between 8nm and 70nm or between 10nm and 60nm. At least one of ZrO₂, Si₃N₄ and SiC or the like scratch resistant material is chosen for forming the protective layer 34 due to not only their scratch resistant property, but also due to their abrasion resistant and corrosion resistant properties as well. It is preferred that the thickness of the glass substrate be from 4 nm to 15 nm, and more preferably from 5 to 10 nm. The main function of the protective layer 34 enables the glass structure 20 to be used and exposed to outdoor environment, to prevent scratches and chemical corrosion to the dielectric layers, and to the coating layer scratches, chemical corrosion and other defects, to maintain optical and aesthetic integrity of the glass structure 20 during transportation and installation thereof.

It is preferred that the first dielectric layer 28 is thicker than the third dielectric layer 24 and that the second dielectric layer 30 is thicker than the fourth dielectric layer 26. Further preferably, each of the first dielectric layer 24, the second dielectric layer 26, the third dielectric layer 28 and the fourth dielectric layer 30 is at least one of formed by magnetron sputtering, formed from inorganic material and is Au and Ag free. Preferably, the largest production planar dimensions that can be achievable by the glass substrate are 3000mm*5800mm.

In a first example of an aspect of the invention, a first high refractive index dielectric layer NbO_x (for example NbO, NbO₂ or Nb₂O₅) forming the first dielectric layer 24 is plated to a thickness of 101nm on a glass substrate 22. Next, first low refractive index dielectric layer SiO₂ forming the second dielectric layer 26 is plated to a thickness of 99 nm on the first high refractive index dielectric layer. A second high refractive index dielectric layer NbO_x (for example NbO, NbO₂ or Nb₂O₅) forming the third dielectric layer 28 is plated to a thickness of 49nm on the first low refractive index dielectric layer. A second low refractive index dielectric layer SiO₂ forming the fourth dielectric layer 30 is plated to a thickness of 87nm on the second high refractive index dielectric layer. Finally, a third high refractive index dielectric layer NbO_x (for example NbO, NbO₂ or Nb₂O₅) forming the fifth dielectric layer 32 is plated to a thickness of 49.5nm on the second low refractive index

dielectric layer. A layer Si₃N₄ film forming the protective layer 34 with a thickness of 10nm is finally plated onto the third low refractive index dielectric layer. The above first example is preferably performed using the glass structure forming method 100. After completion of the glass structure forming method 100, the glass structure 20 obtained is a semi-permeable film glass structure with reflectivity and transmittance as shown in the below table:

Project	Surface Reflection				Transmittance			
Color space	Y%	L	a*	b*	Y%	L	a*	b*
Example 1	67.6	85.8	-0.4	3.5	31.9	63.3	-0.1	-4.8

In a second example of an aspect of the invention, a first high refractive index dielectric layer NbO_x (for example NbO, NbO₂ or Nb₂O₅) forming the first dielectric layer 24 is plated to a thickness of 105.5nm on a glass substrate 22. Next, first low refractive index dielectric layer SiO₂ forming the second dielectric layer 24 is plated to a thickness of 120 nm on the first high refractive index dielectric layer. A second high refractive index dielectric layer NbO_x (for example NbO, NbO₂ or Nb₂O₅) forming the third dielectric layer 28 is plated to a thickness of 57.5nm on the first low refractive index dielectric layer. A second low refractive index dielectric layer SiO₂ forming the fourth dielectric layer 30 is plated to a thickness of 75nm on the second high refractive index dielectric layer. Finally, a third high refractive index dielectric layer NbO_x (for example NbO, NbO₂ or Nb₂O₅) forming the fifth dielectric layer 32 is plated to a thickness of 66nm on the second low refractive index dielectric layer. After completion of the glass structure forming method 100, the glass structure 20 obtained is a semi-permeable film glass structure with reflectivity and transmittance as shown in the below table:

Project	Surface Reflection				Transmittance			
Color space	Y%	L	a*	b*	Y%	L	a*	b*
Example 1	60	81.8	-0.7	3.3	38.8	68.6	0	-3.0

In a third example of an aspect of the invention, a first high refractive index dielectric layer SiNx forming the first dielectric layer 24 is plated to a thickness of 111nm on a glass substrate 22. Next, first low refractive index dielectric layer SiO₂ forming the second dielectric layer 24 is plated to a thickness of 1107 nm on the first high refractive index dielectric layer. A second high refractive index dielectric layer SiNx forming the third dielectric layer 28 is plated to a thickness of 77nm on the first low refractive index dielectric layer. A second low refractive index dielectric layer SiO₂ forming the fourth dielectric layer 30 is plated to a thickness of 64.5nm on the second high refractive index dielectric layer. Finally, a third high refractive index dielectric layer SiNx forming the fifth dielectric layer 32 is plated to a thickness of 54.5nm on the second low refractive index dielectric layer. After completion of the glass structure forming method 100, the glass structure 20 obtained is a semi-permeable film glass structure with reflectivity and transmittance as shown in the below table:

Project	Surface Reflection				Transmittance			
Color space	Y%	L	a*	b*	Y%	L	a*	b*
Example 1	49.2	75.6	-1.0	1.4	48.7	75.3	-0	0.8

The semi-permeable nature of the glass structure 20 according to an aspect of the invention as aforescribed employs the glass structure forming method 100 for plating layers of inorganic materials of varying thickness on a glass surface by magnetron sputtering to achieve optical interference reflection. The layers of inorganic materials comprise a combination of high refractive index layers and low refractive index layers capped off with the protective layer 34. In accordance with application or usage requirements, the final glass structure 20 can utilize various materials applied with the required thickness and to achieve specific appearance of color effects to generate an eventual reflectivity and transmittance effect therefor. The layers of materials on the glass substrate 22 are of nano-scale thickness and does not contain Ag, Au and other precious metals.

The resultant glass structure 20 has a visible light reflectivity level within a range of 40% to 70% which is ideal for use for intelligent homes, for example glass structures or panels functioning as a screen for projected light thrown from a projector, and other interior decoration large area glass structures up to a size of, for example, 3300mm * 5200mm. The glass structure 20 is acid and alkali resistant, has excellent weatherability and can be used in outdoor or monolithic coated glass or as a glaze on structure on existent glass devices or panels which are being exposed to the outdoor environment. The glass structure forming method 100 also simplifies production preparation time, shortens production cycle and reducing cost while greatly improving production efficiency. The glass structure forming method 20 can enable the glass structure 20 to be used monolithically as well as forming part of other article and glass structures or interlayered with other glass products. The glass structure forming method 100 avoids organic chemical in the production process and materials used to thereby reduce pollutive impact on the environment. Further, the use of pure inorganic materials enables a monolithic structure to be achieved for the glass structure 20 while improving weatherability thereof while enabling follow-up processing or deep-processing of the glass structure 20 subsequent to the glass structure forming method 100.

Aspects of particular embodiments of the present disclosure address at least one aspect, problem, limitation, and/or disadvantage associated with glass structure and method for forming thereof. While features, aspects, and/or advantages associated with certain embodiments have been described in the disclosure, other embodiments may also exhibit such features, aspects, and/or advantages, and not all embodiments need necessarily exhibit such features, aspects, and/or advantages to fall within the scope of the disclosure. It will be appreciated by a person of ordinary skill in the art that several of the above-disclosed structures, components, or alternatives thereof, can be desirably combined into alternative structures, components, and/or applications. In addition, various modifications, alterations, and/or improvements may be made to various embodiments that are disclosed by a person of ordinary skill in the art within the scope of the present disclosure, which is limited only by the following claims.

Claims

1. A glass structure comprising:
 - a glass substrate;
 - 5 a first dielectric layer formed over the glass substrate and having a high refractive index;
 - a second dielectric layer formed over the first dielectric layer and having a low refractive index;
 - 10 a third dielectric layer formed over the second dielectric layer and having a high refractive index such that the second dielectric layer interposes the first dielectric layer and the third dielectric layer;
 - a fourth dielectric layer formed over the third dielectric layer and having a low refractive index such that the third dielectric layer interposes the second dielectric layer and the fourth dielectric layer; and
 - 15 a fifth dielectric layer formed over the fourth dielectric layer and having a high refractive index such that the fourth dielectric layer interposes the third dielectric layer and the fifth dielectric layer.
2. The glass substrate as in claim 1, each of the first dielectric layer, the third dielectric layer and fifth dielectric layer being formed from at least one of TiO₂, SiN₂, NbO, NbO₂ and Nb₂O₅, and having a refractive index of between and including 2.0 and 2.7.
- 25 3. The glass substrate as in claim 1, the first dielectric layer having a thickness of between and including 60 nm and 150 nm, the third dielectric layer having a thickness of between and including 20nm and 120nm and the fifth dielectric layer having a thickness of not more than 80nm.
- 30 4. The glass substrate as in claim 1, each of the second dielectric layer and the fourth dielectric layer being formed from SiO₂.

5. The glass substrate as in claim 1, the second dielectric layer having a thickness of between and including 60nm and 180nm and the fourth dielectric layer having a thickness of between and including 60nm and 180nm.
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6. The glass substrate as in claim 1, further comprising a protective layer formed over the fifth dielectric layer.
7. The glass substrate as in claim 6, the protective layer being formed from at least one of ZrO₂, Si₃N₄, SiC and TiO₂.
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8. The glass substrate as in claim 6, the protective layer having a thickness of between and including 5nm to 80nm.
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9. The glass substrate as in claim 1, the first dielectric layer being thicker than the third dielectric layer and the second dielectric layer being thicker than the fourth dielectric layer.
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10. The glass substrate as in claim 1, each of the first dielectric layer, the second dielectric layer, the third dielectric layer and the fourth dielectric layer being at least one of formed by magnetron sputtering, formed from inorganic material and is Au and Ag free.
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11. A glass structure forming method comprising:

forming a first dielectric layer formed having a high refractive index over a glass substrate by magnetron sputtering;

- 5 forming a second dielectric layer having a low refractive index over the first dielectric layer by magnetron sputtering;

forming a third dielectric layer having a high refractive index over the second dielectric layer by magnetron sputtering such that the second dielectric layer interposes the first dielectric layer and the third dielectric layer;

- 10 forming a fourth dielectric layer having a low refractive index over the third dielectric layer by magnetron sputtering such that the third dielectric layer interposes the second dielectric layer and the fourth dielectric layer; and

- forming a fifth dielectric layer over the fourth dielectric layer and having a high refractive index such that the fourth dielectric layer interposes the third dielectric layer and the fifth dielectric layer
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12. The method as in claim 11, each of the first dielectric layer and the third dielectric layer being formed from at least one of TiO_2 , SiN_2 , NbO , NbO_2 and Nb_2O_5 , and having a refractive index of between and including 2.0 and 2.3, wherein the first dielectric layer has a thickness of between and including 60 nm and 150 nm, the third dielectric layer has a thickness of between and including 20nm and 120nm and the fifth dielectric layer has a thickness of not more than 80nm.
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13. The method as in claim 11, each of the second dielectric layer and the fourth dielectric layer being formed from SiO_2 , wherein the second dielectric layer has has a thickness of between and including 60nm and 180nm and the fourth dielectric layer has a thickness of between and including 60nm and 180nm.
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14. The method as in claim 11, further comprising:
forming a protective layer formed over the fifth dielectric layer by magnetron sputtering, the protective layer being formed from at least one of ZrO_2 , Si_3N_4 , SiC and TiO_2 , and having a thickness of between and including 5nm to 80nm.

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15. The method as in claim 11, the first dielectric layer being thicker than the third dielectric layer and the second dielectric layer being thicker than the fourth dielectric layer, wherein each of the first dielectric layer, the second dielectric layer, the third dielectric layer and the fourth dielectric layer being at least one of formed from inorganic material and is Au and Ag free.

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