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(54) **Title:** A THERMALLY PROCESSABLE LOW-E COATING AND PRODUCTION METHOD THEREOF

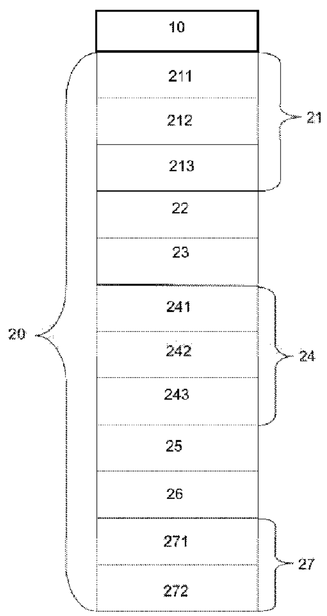

Figure 1

(57) **Abstract:** The present invention relates to a low-e coated glass which transmits visible region of solar energy spectrum in an efficient manner and which reflects near infrared region and infrared region in an efficient manner, and relates to the production method thereof.

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A THERMALLY PROCESSABLE LOW-E COATING AND PRODUCTION METHOD THEREOF

TECHNICAL FIELD

The present invention relates to a low-emissivity (low-e) coating with solar control having infrared reflective layers therein and used as thermal isolation glass and which transmits daylight.

PRIOR ART

One of the factors which differentiates optic characteristics of glasses is the coatings applied onto the glass surface. One of the coating applications is the magnetic field supported sputtering method in vacuum medium. This is a method frequently used particularly in the production of architecture and automotive coatings having low-e characteristic. By means of said method, the transmittance and reflection values of the coated glasses in the visible, near infrared and infrared region can be obtained at the targeted levels.

Besides transmittance and reflectance values, selectivity value is also an important parameter in coated glasses. In ISO 9050 (2003) standard, selectivity is defined as the ratio of the transmittance value of the visible region to the solar factor. The selectivity values of coatings can be kept at the targeted levels by means of the number of Ag layers included, the type of the coring layer used and the parametric optimizations of the layers.

In the invention with publication no US9499899, disclosed herein are systems, methods, and apparatus for forming low emissivity panels that may include a substrate and a reflective layer formed over the substrate. The low emissivity panels may further include a top dielectric layer formed over the reflective layer such that the reflective layer is formed between the top dielectric layer and the substrate. The top dielectric layer may include a ternary metal oxide, such as zinc tin aluminum oxide. The top dielectric layer may also include aluminum. The concentration of aluminum may be between about 1 atomic % and 15 atomic % or between about 2 atomic % and 10 atomic %. An atomic ratio of zinc to tin in the top dielectric layer may be between about 0.67 and about 1.5 or between about 0.9 and about 1.1.

BRIEF DESCRIPTION OF THE INVENTION

The present invention relates to a low-e coated glass with solar control, for bringing new advantages to the related technical field.

An object of the present invention is to provide a low-e coated glass which transmits visible light in an efficient manner and which reflects solar energy in an efficient manner.

In order to realize all of the abovementioned objects and the objects which are to be deducted from the detailed description below, the present invention is a low-e coated glass. Accordingly, said invention is characterized in that said low-e coating respectively comprises outwardly from the glass;

- first dielectric layer selected from Si_xN_y, SiO_xN_y, $ZnSnO_x$, TiO_x, TiN_x, ZrN_x;
- first coring layer selected from NiCr, $NiCrO_x$, TiO_x, $ZnAlO_x$, ZnO_x;
- first infrared reflective layer;
- first barrier layer selected from NiCr, $NiCrO_x$, TiO_x, $ZnAlO_x$;
- third dielectric layer selected from Si_xN_y, TiN_x, ZrN_x, $ZnSnO_x$, $ZnAlO_x$, SiO_xN_y, TiO_x, ZnO_x;
- fourth dielectric layer selected from Si_xN_y, TiN_x, ZrN_x, $ZnSnO_x$, $ZnAlO_x$, SiO_xN_y, TiO_x, ZnO_x;
- second coring layer selected from NiCr, $NiCrO_x$, TiO_x, $ZnAlO_x$, ZnO_x;
- second infrared reflective layer;
- second barrier layer selected from NiCr, $NiCrO_x$, TiO_x, $ZnAlO_x$;
- fifth dielectric layer selected from $ZnSnO_x$, $ZnAlO_x$, SiO_xN_y, ZrOx, SiO_x, Si_xN_y, TiO_x, ZnO_x;
- upper dielectric layer comprising SiO_xN_y.

In another preferred embodiment of the present invention, said low-e coating respectively comprises outwardly from the glass:

- first dielectric layer comprising Si_xN_y;
- first coring layer comprising $ZnAlO_x$;
- first infrared reflective layer comprising Ag;
- first barrier layer comprising $NiCrO_x$;
- third dielectric layer comprising $ZnAlO_x$;
- fourth dielectric layer comprising Si_xN_y;
- second coring layer comprising $ZnAlO_x$;
- second infrared reflective layer comprising Ag;

- second barrier layer comprising $NiCrO_x$;
- fifth dielectric layer comprising $ZnAlO_x$;
- upper dielectric layer comprising SiO_xN_y.

In a preferred embodiment of the present invention, said low-e coating respectively comprises outwardly from the glass:

- first dielectric layer comprising Si_xN_y;
- second dielectric layer comprising TiO_x;
- first coring layer comprising $ZnAlO_x$;
- first infrared reflective layer comprising Ag;
- first barrier layer comprising $NiCrO_x$;
- third dielectric layer comprising $ZnAlO_x$;
- fourth dielectric layer comprising Si_xN_y;
- second coring layer comprising $ZnAlO_x$;
- second infrared reflective layer comprising Ag;
- second barrier layer comprising $NiCrO_x$;
- fifth dielectric layer comprising $ZnAlO_x$;
- upper dielectric layer comprising SiO_xN_y.

In a preferred embodiment of the present invention, said low-e coating respectively comprises outwardly from the glass:

- first dielectric layer, comprising Si_xN_y, with thickness between 10 nm – 20 nm;
- second dielectric layer, comprising TiO_x, with thickness between 0 nm – 10 nm;
- first coring layer, comprising $ZnAlO_x$, with thickness between 8 nm – 20 nm;
- first infrared reflective layer, comprising Ag, with thickness between 8 nm – 20 nm;
- first barrier layer, comprising $NiCrO_x$, with thickness between 0.8 nm – 2.0 nm;
- third dielectric layer, comprising $ZnAlO_x$, with thickness between 15 nm – 30 nm;
- fourth dielectric layer, comprising Si_xN_y, with thickness between 30 nm – 50 nm;
- second coring layer, comprising $ZnAlO_x$, with thickness between 15 nm – 30 nm;
- second infrared reflective layer, comprising Ag, with thickness between 8 nm – 20 nm;
- second barrier layer, comprising $NiCrO_x$, with thickness between 0.8 nm – 2.0 nm;
- fifth dielectric layer, comprising $ZnAlO_x$, with thickness between 10 nm – 20 nm;
- upper dielectric layer, comprising SiO_xN_y, with thickness between 20 nm – 35 nm.

In a preferred embodiment of the present invention, said low-e coating respectively comprises outwardly from the glass:

- first dielectric layer, comprising Si_xN_y, with thickness between 10 nm – 20 nm;
- second dielectric layer, comprising TiO_x, with thickness between 2 nm – 8 nm;
- first coring layer, comprising $ZnAlO_x$, with thickness between 8 nm – 20 nm;
- first infrared reflective layer, comprising Ag, with thickness between 8 nm – 20 nm;
- first barrier layer, comprising $NiCrO_x$, with thickness between 0.8 nm – 2.0 nm;
- third dielectric layer, comprising $ZnAlO_x$, with thickness between 15 nm – 30 nm;
- fourth dielectric layer, comprising Si_xN_y, with thickness between 30 nm – 50 nm;
- second coring layer, comprising $ZnAlO_x$, with thickness between 15 nm – 30 nm;
- second infrared reflective layer, comprising Ag, with thickness between 8 nm – 20 nm;
- second barrier layer, comprising $NiCrO_x$, with thickness between 0.8 nm – 2.0 nm;
- fifth dielectric layer, comprising $ZnAlO_x$, with thickness between 10 nm – 20 nm;
- upper dielectric layer, comprising SiO_xN_y, with thickness between 20 nm – 35 nm.

In order to realize all of the abovementioned objects and the objects which are to be deducted from the detailed description below, the present invention is a production method of the low-e coated glass where said method is not limited with the abovementioned sequencing alternatives. Accordingly, the subject matter production method is characterized in that during coating of the first barrier layer and the second barrier layer, the ratio of O_2 flow speed / power density is smaller than 8 sccm/(Watt*cm^{-2}).

BRIEF DESCRIPTION OF THE FIGURE

Figure 1 is a general view of low-e layer sequencing.

REFERENCE NUMBERS

10 Glass
20 Low-e coating
  21 Lower dielectric structure
    211 First dielectric layer
    212 Second dielectric layer
    213 First coring layer
  22 First infrared reflective layer
  23 First barrier layer
  24 Middle dielectric structure

241 Third dielectric layer
242 Fourth dielectric layer
243 Second coring layer
25 Second infrared reflective layer
26 Second barrier layer
27 Upper dielectric structure
271 Fifth dielectric layer
272 Upper dielectric layer

DETAILED DESCRIPTION OF THE INVENTION

In this detailed description, the subject matter low-e coated (20) glass (10) is explained with references to examples without forming any restrictive effect only in order to make the subject more understandable.

The production of low-e coated (20) glasses (10) related to architecture and automotive is realized by means of “sputtering” method. The present invention essentially relates to low-e coated (20) glasses (10) with double silver whose thermal process resistance is high and used as thermal insulation glass (10) which transmits daylight and relates to the ingredient and application of said low-e coating (20). The subject matter low-e coated (20) glass (10) can be used in thermal glass unit and laminated structures for architecture and automotive sectors.

In the present invention, a low-e coating (20) is developed comprising pluralities of metal, metal oxide and/or metal nitride/oxy-nitride layers positioned on the glass (10) surface by using sputtering method in order to obtain a low-e coated (20) glass (10) having solar control characteristic and designed in a thermally processable manner and having substantially visible light transmittance in order to be applied onto the surface of a glass (10). Said layers are collected on each other respectively under vacuum. As the thermal process, at least one of and/or a number of tempering, partial tempering, annealing, bending and lamination processes can be used. The subject matter solar controlled low-e coated (20) glass (10) can be used as architecture and automotive glass (10).

In terms of the production easiness and in terms of optic characteristics, in order to develop a low-e coating (20) sequencing with solar control characteristics and which is thermally processable, the following data has been detected as a result of experimental studies.

In the subject matter low-e coating (20); the solar energy spectrum is a first infrared reflective layer (22) and a second infrared reflective layer (25) providing thermal radiation reflection (by transmitting less radiation) in the infrared region and providing transmittance of the visible region (hereafter, it will be called T_{vis}%) at the targeted level. Ag layer is used as the first infrared reflective layer (22) and as the second infrared reflective layer (25), and the thermal emissivity thereof is low.

In the subject matter low-e coated (20) glass (10); the refraction indices of all layers are determined by using calculated methods through optic constants obtained from single-layer measurements taken. Said refraction indices are the refraction index data at 550 nm.

In the subject matter low-e coating (20); there is a lower dielectric structure (21) in a manner contacting glass (10). In said lower dielectric structure (21), a first dielectric layer (211) is used as the bottom layer. Said first dielectric layer (211) comprises at least one of the following materials: Si_xN_y, $SiAlN_x$, $SiAlO_xN_y$, SiO_xN_y, $ZnSnO_x$, TiO_x, TiN_x, ZrN_x. In the preferred application, the first dielectric layer (211) comprises Si_xN_y. The first dielectric layer (211) comprising Si_xN_y behaves as diffusion barrier and serves to prevent alkali ion migration which becomes easy at high temperature. Thus, the first dielectric layer (211) comprising Si_xN_y supports resistance of the low-e coating (20) against thermal processes. The variation range of the first dielectric layer (211) comprising Si_xN_y is between 2.00 and 2.10. In the preferred structure, the variation range for the refraction index of the first dielectric layer (211) comprising Si_xN_y is between 2.02 and 2.07.

The thickness of the first dielectric layer (211) comprising Si_xN_y is between 10 nm and 20 nm. In the preferred application, the thickness of the first dielectric layer (211) comprising Si_xN_y is between 12 nm and 18 nm. In a further preferred application, the thickness of the first dielectric layer (211) comprising Si_xN_y is between 13 nm and 17 nm.

At least one first coring layer (213) is positioned between the first dielectric layer (211), comprising Si_xN_y, and the Ag layer which is the first infrared reflective layer (22). In an application of the present invention, the first coring layer (213) directly contacts the first dielectric layer (211) comprising Si_xN_y. The first coring layer (213) comprises at least one of NiCr, $NiCrO_x$, TiO_x, $ZnSnO_x$, $ZnAlO_x$, ZnO_x. In the preferred application, the first coring layer (213) comprises $ZnAlO_x$. The thickness of the first coring layer (213) is between 8 nm and 20 nm. In the preferred application, the thickness of the first coring layer (213) is between 9 nm and 16 nm. In a further preferred application, the thickness of the first coring layer (213) is between 10 nm and 15 nm.

In another application of the present invention, a second dielectric layer (212) is positioned between the first coring layer (213) and the first dielectric layer (211) comprising Si_xN_y. Said second dielectric layer (212) comprises at least one of TiO_x, ZrO_x, NbO_x layers. In the preferred application, TiO_x is used as the second dielectric layer (212). Since TiO_x is a material whose refraction index is high, the same optical performance is obtained with less total physical thickness and plays a role which increases T_{vis}% of the low-e coating (20). The refraction index of TiO_x layer is between 2.40 and 2.60. In the preferred application, it is determined as between 2.45 and 2.55. The thickness of TiO_x layer which is the second dielectric layer (212) is between 0 nm and 10 nm. In the preferred application, thickness of TiO_x layer is between 2 nm and 8 nm. In a further preferred application, the thickness of TiO_x layer is between 2 nm and 7 nm.

When the first dielectric layer (211) comprising Si_xN_y which are the first and second layers after glass and the TiO_x layer which is the second dielectric layer (212) are used together, thanks to the high refraction index of TiO_x layer which is the second dielectric layer (212), the optimization of the optic performance becomes possible by using the first dielectric layer (211) comprising thinner Si_xN_y. Even if the T_{vis}% values of the low-e coated (20) glass (10) do not change under the mentioned thickness value, important changes are observed in the color and optic performance. In case said T_{vis}% values are above the mentioned thickness value, the transmittance color b* value in CIELAB space among the color values or in other words, the "Tb" value is shifted to the positive region, in other words, it is shifted to the yellow color and the uncoated side reflection in the visible region (hereafter, it will be called Rg_{vis}%) increases.

The visible region light transmittance decreases, in other words, T_{vis}% decreases and this leads to diverging from the targeted performance.

There is a middle dielectric structure (24) positioned between the first infrared reflective layer (22) and the second infrared reflective layer (25) and which separates the first infrared reflective layer (22) and the second infrared reflective layer (25) from each other and which provides reaching of the low-e layer (20) sequencing to the targeted performance. Said middle dielectric structure (24) comprises at least one dielectric layer. In an application of the present invention, the middle dielectric structure (24) comprises at least one second coring layer (243) positioned in the vicinity of the dielectric layer together with at least one dielectric layer. The second coring layer (243) comprises at least one of NiCr, $NiCrO_x$, TiO_x, $ZnAlO_x$, ZnO_x. The preferred second coring layer (243) comprises $ZnAlO_x$.

In the preferred application of the present invention, the middle dielectric layer structure (24) comprises at least two dielectric layers selected from Si_xN_y, TiN_x, ZrN_x, $ZnSnO_x$, $ZnAlO_x$, $SiAlN_x$, $SiAlO_xN_y$, SiO_xN_y, TiO_x, ZnO_x. The selected two dielectric layers contact each other. The middle dielectric structure (24) comprises a third dielectric layer (241), a fourth dielectric layer (242) and a second coring layer (243). The middle dielectric structure (24) is positioned in a manner directly contacting Ag layer which is the second infrared reflective layer (25). In the preferred embodiment of the present invention, the third dielectric layer (241) comprises $ZnAlO_x$ and the fourth dielectric layer (242) comprises Si_xN_y. The thickness of the $ZnAlO_x$ layer which is the third dielectric layer (241) is between 15 nm and 30 nm. In the preferred application, the thickness of the $ZnAlO_x$ layer which is the third dielectric layer (241) is between 17 nm and 27 nm. In the further preferred application, the thickness of the $ZnAlO_x$ layer which is the third dielectric layer (241) is between 19 nm and 26 nm. The thickness of the fourth dielectric layer (242) comprising Si_xN_y is between 30 nm and 50 nm. In the preferred application, the thickness of the fourth dielectric layer (242) comprising Si_xN_y is between 35 nm and 46 nm. In a further preferred application, the thickness of the fourth dielectric layer (242) comprising Si_xN_y is between 39 nm and 43 nm.

The thickness of the $ZnAlO_x$ layer which is the second coring layer (243) is between 15 nm and 30 nm. In the preferred application, the thickness of the $ZnAlO_x$ layer which is the second coring layer (243) is between 17 nm and 27 nm. In a further preferred application, the thickness of the $ZnAlO_x$ layer which is the second coring layer (243) is between 19 nm and 26 nm.

The thicknesses and structures of the dielectric layers comprised by said middle dielectric structure (24) are optimized separately and the reflection and color values of the glass (10) side and the coating side create greater number of options for obtaining the targeted values. Besides providing optimization of the reflection and color values targeted in the sandwich form of the middle dielectric structure (24), it is required for improving opto-electronic characteristics of Ag layer which is the second infrared reflective layer (25).

In other words;

In case the middle dielectric structure (24) is formed by a single and thick layer, the middle dielectric structure (24) targeted to be amorphous is more probable to show a crystalline structure partially and/or completely. The layer, used as the coring which is in direct contact with the Ag which is the second infrared reflective layer (25), grows on the layer which contacts the other surface thereof, this layer is preferred to have amorphous structure in order not to be affected by the crystallization of this layer. In the present invention, the Ag layer which is the second infrared reflective layer (25) and the $ZnAlO_x$ which is the second coring layer (243) are in direct contact. The fourth dielectric layer (242), comprising Si_xN_y which is in amorphous structure, contacts the other surface of $ZnAlO_x$ which is the second coring layer (243). Thus, a problem like crystalline incompliancy and thus, the probability of affecting the crystallization of the second coring layer (243) structure and the probability of formation of undesired residue tension are reduced. The sensitivity in terms of the second coring layer (243) provides growing of the second infrared layer (25) in the required crystallographic orientation. The middle dielectric structure (24) totally has a thickness between 75 nm and 105 nm. In the preferred application, the middle dielectric structure (24) totally has a thickness between 80 nm and 100 nm. More preferably, the middle dielectric structure (24) totally has a thickness between 85 nm and 95 nm.

A first barrier layer (23) is positioned on the first infrared reflective layer (22) and a second barrier layer (26) is positioned on the second infrared reflective layer (25). The first barrier layer (23) and the second barrier layer (26) comprise at least one of the materials of NiCr, $NiCrO_x$, TiO_x, $ZnAlO_x$. In the preferred application, as the first barrier layer (23) and as the second barrier layer (26), $NiCrO_x$ is used. The thicknesses of $NiCrO_x$ layers which are the first barrier layer (23) and the second barrier layer (26) are between 0.8 nm and 2.0 nm. In the preferred application, the thicknesses of $NiCrO_x$ layers which are the first barrier layer (23) and the second barrier layer (26) are between 0.9 nm and 1.9 nm. In the preferred application, the thicknesses of $NiCrO_x$ layers which are the first barrier layer (23) and the second barrier layer (26) are between 1.0 nm and 1.8 nm.

$NiCrO_x$ layers which are the first barrier layer (23) and the second barrier layer (26) are used for preventing affecting of Ag layers by the process gases used for production of layers provided after the Ag layers which are the first infrared reflective layer (22) and the second infrared reflective layer (25). At the same time, $NiCrO_x$ layers provide structural compliancy in metallic and dielectric passage between the dielectric layers provided after Ag layers and said $NiCrO_x$ layers eliminate probable adhesion weakness before the thermal process. Moreover, $NiCrO_x$ layers are primarily oxidized in the thermal processes like tempering, bending, etc. and thus, Ag layers are prevented from being oxidized and deteriorated.

An upper dielectric structure (27) is positioned on the second barrier layer (26). Said upper dielectric structure (27) comprises a fifth dielectric layer (271) and an upper dielectric layer (272). The fifth dielectric layer (271) comprises at least one of $ZnSnO_x$, $ZnAlO_x$, SiO_xN_y, ZrO_x, SiO_x, Si_xN_y, TiO_x, ZnO_x.

In case layer comprising SiO_xN_y is preferred as the upper dielectric layer (272) and in case said layer is used in a directly contacted manner with $NiCrO_x$ which is a second barrier layer (26), $NiCrO_x$ layer and the layer comprising SiO_xN_y show incompliant behavior with each other and have weak mechanical and thermal process resistance. For this reason, the fifth dielectric layer (271) is added between the upper dielectric layer (272) comprising SiO_xN_y and the $NiCrO_x$ layer which is the second barrier layer (26) in the low-e coating (20) which is the subject of the patent, and the low-e coating (20) shows stable thermal process behavior. As the fifth dielectric layer (271), $ZnAlO_x$ layer is used. $ZnAlO_x$ layer which is the fifth dielectric layer (271) has a thickness between 10 nm and 20 nm. In the preferred application, the thickness of the $ZnAlO_x$ layer which is the fifth dielectric layer (271) is between 11 nm and 19 nm. In a further preferred application, the thickness of the $ZnAlO_x$ layer which is the fifth dielectric layer (271) is between 12 nm and 18 nm.

In case layer comprising SiO_xN_y is used instead of layer comprising Si_xN_y as the upper dielectric layer (272), since the refraction index of the layer comprising SiO_xN_y is lower than the layer comprising Si_xN_y, the same optic behavior can be obtained by means of the layer comprising a thicker SiO_xN_y. Thus, by using a thicker upper dielectric layer (272), the mechanical resistance of the coating is increased. The thickness of the upper dielectric layer (272) comprising SiO_xN_y is between 20 nm and 35 nm. In the preferred application, the thickness of the upper dielectric layer (272) comprising SiO_xN_y is between 20 nm and 32 nm. In a further preferred application, the thickness of the upper dielectric layer (272) comprising SiO_xN_y is between 22 nm and 30 nm.

The refraction index range for $ZnAlO_x$ used as the first coring layer (213), the third dielectric layer (241), the second coring layer (243) and the fifth dielectric layer (271) is between 1.90 and 2.10. In the preferred embodiment, the refraction index range for $ZnAlO_x$ used as the first coring layer (213), the third dielectric layer (241), the second coring layer (243) and the fifth dielectric layer (271) is between 1.95 and 2.05.

In order to obtain the targeted transmittance and reflection values for the low-e coated (20) products which is related to the architecture and automotive usage, the thicknesses of the first infrared reflective layer (22) and the second infrared reflective layer (25) are between 8 nm and 20 nm. In the preferred application, the thicknesses of the first infrared reflective layer (22) and the second infrared reflective layer (25) are between 9 nm and 18 nm. More specifically, in order to reach the targeted performance value and in order to obtain low inner and outer reflection values in the visible region and the desired color characteristics, the thicknesses of the first infrared reflective layer (22) and the second infrared reflective layer

(25) are between 10 nm and 17 nm. In order to obtain the targeted selectivity and optic performance, the product shall have two separate independent infrared reflective layers comprising silver. The ratio of the thickness of the first infrared reflective layer (22) to the thickness of the second infrared reflective layer (25) is between 0.7 and 1.4. Preferably, the ratio of the thickness of the first infrared reflective layer (22) to the thickness of the second infrared reflective layer (25) is between 0.8 and 1.3.

The performance value targeted by means of the abovementioned layer sequencing is 6 mm for single glass (10) and the visible region transmittance value for lower glass (10) usage is preferred to be between 63% and 75% prior to thermal process. More preferably, it shall be between 65% and 71%. For the usage of 6 mm lower glass (10) as the single glass (10), the direct solar energy transmittance value prior to thermal process is preferred to be between 30% and 41%. In the further preferred application, it shall be between 33% and 39%. Moreover, by means of the optimization of all other dielectric layers, obtaining of this performance shall be supported.

The characteristics of the topmost dielectric layer (272) of the low-e coating (20) are substantially important in terms of the storage lifetime, thermal processability, resistance and visual aesthetics of the low-e coated (20) glass (10) since said characteristics determine the character of the coated glass (10) during thermal process.

Another role of the first barrier layer (23) and the second barrier layer (26) is that the opto-electronic characteristics of the first infrared reflective layer (22) and the second infrared reflective layer (25) of the low-e coating (20) are protected during the secondary processes and during the usage lifetime in a stable manner. The coating conditions of the first barrier layer (23) and the second barrier coating (26) of the low-e coating (20) are other critic parameters which determine the character of the coated glass (10) during the thermal process and which affect the opto-electronic characteristics of the low-e coated (20) glass (10). For the targeted T_{vis}% value, the absorbing behavior of the first barrier layer (23) and the second barrier layer (26) in the low-e coating (20) shall be minimized by means of improving the material characteristic. In order to increase the T_{vis}% and in order to increase selectivity, the absorption effect coming from the first barrier layer (23) and the second barrier layer (26) is optimized and O_2 flow speed / power density proportion shall be reduced during coating the first barrier layer (23) and the second barrier layer (26) in order to provide fixation of the thickness homogeneity of the first infrared reflective layer (22) and the second infrared reflective layer (25) during the thermal process and without compromising infrared reflection characteristic of the low-e coating (20).

As the oxygen amount of the first barrier layer (23) and the second barrier layer (26) increases, the absorption characteristics of the layers can be increased to levels which are necessary for the visible region transmittance of the low-e coating (20), however, there is diffraction above a specific value and this leads to silver agglomeration during the thermal process. As shown in Table 1 through different examples, O_2 flow speed / power density ratio in the pressure range between $2.5E^{-3}$ mbar and $4.5\ E^{-3}$ mbar shall be smaller than 9 in terms of the transmittance of the low-e coating (20), selectivity and visual aesthetic balance. In the preferred application, the ratio of O_2 flow speed / power density shall be smaller than 8.

Table 1: The effect of the parameters of barrier layers on the thickness homogeneities of infrared reflective layers during and after thermal processes during coating by means of sputtering.

O_2 flow speed / Power density sccm/(Watt*cm^{-2})	Fault Type	Number of Faults in 140µ x 180µ Area
Medium without oxygen	Silver agglomeration	0
3	Silver agglomeration	3
4	Silver agglomeration	4
7	Silver agglomeration	5
8	Silver agglomeration	20
9	Silver agglomeration	>230
15	Silver agglomeration	>230

The protection scope of the present invention is set forth in the annexed claims and cannot be restricted to the illustrative disclosures given above, under the detailed description. It is because a person skilled in the relevant art can obviously produce similar embodiments under the light of the foregoing disclosures, without departing from the main principles of the present invention.

CLAIMS

1. The present invention is a thermally processable low-e coated (20) glass (10), wherein said low-e coating (20) respectively comprises outwardly from the glass (10):

- first dielectric layer (211) selected from Si_xN_y, SiO_xN_y, $ZnSnO_x$, TiO_x, TiN_x, ZrN_x;
- first coring layer (213) selected from NiCr, $NiCrO_x$, TiO_x, $ZnAlO_x$, ZnO_x;
- first infrared reflective layer (22);
- first barrier layer (23) selected from NiCr, $NiCrO_x$, TiO_x, $ZnAlO_x$;
- third dielectric layer (241) selected from Si_xN_y, TiN_x, ZrN_x, $ZnSnO_x$, $ZnAlO_x$, SiO_xN_y, TiO_x, ZnO_x;
- fourth dielectric layer (242) selected from Si_xN_y, TiN_x, ZrN_x, $ZnSnO_x$, $ZnAlO_x$, SiO_xN_y, TiO_x, ZnO_x;
- second coring layer (243) selected from NiCr, $NiCrO_x$, TiO_x, $ZnAlO_x$, ZnO_x;
- second infrared reflective layer (25);
- second barrier layer (26) selected from NiCr, $NiCrO_x$, TiO_x, $ZnAlO_x$;
- fifth dielectric layer (271) selected from $ZnSnO_x$, $ZnAlO_x$, SiO_xN_y, ZrOx, SiO_x, Si_xN_y, TiO_x, ZnO_x;
- upper dielectric layer (272) comprising SiO_xN_y.

2. A low-e coated (20) glass (10) according to claim 1, wherein said low-e coating (20) respectively comprises outwardly from the glass (10):

- first dielectric layer (211) comprising Si_xN_y;
- first coring layer (213) comprising $ZnAlO_x$;
- first infrared reflective layer (22) comprising Ag;
- first barrier layer (23) comprising $NiCrO_x$;
- third dielectric layer (241) comprising $ZnAlO_x$;
- fourth dielectric layer (242) comprising Si_xN_y;
- second coring layer (243) comprising $ZnAlO_x$;
- second infrared reflective layer (25) comprising Ag;
- second barrier layer (26) comprising $NiCrO_x$;
- fifth dielectric layer (271) comprising $ZnAlO_x$;
- upper dielectric layer (272) comprising SiO_xN_y.

3. A low-e coated glass according to claim 1, wherein the following layers are provided:

- first dielectric layer (211) comprising Si_xN_y;
- second dielectric layer (212) comprising TiO_x;
- first coring layer (213) comprising $ZnAlO_x$;

- first infrared reflective layer (22) comprising Ag;
- first barrier layer (23) comprising $NiCrO_x$;
- third dielectric layer (241) comprising $ZnAlO_x$;
- fourth dielectric layer (242) comprising Si_xN_y;
- second coring layer (243) comprising $ZnAlO_x$;
- second infrared reflective layer (25) comprising Ag;
- second barrier layer (26) comprising $NiCrO_x$;
- fifth dielectric layer (271) comprising $ZnAlO_x$;
- upper dielectric layer (272) comprising SiO_xN_y.

4. A low-e coated glass according to any one of the preceding claims, wherein said low-e coating (20) respectively comprises outwardly from the glass (10):

- first dielectric layer (211), comprising Si_xN_y, with thickness between 10 nm – 20 nm;
- second dielectric layer (212), comprising TiO_x, with thickness between 0 nm – 10 nm;
- first coring layer (213), comprising $ZnAlO_x$, with thickness between 8 nm – 20 nm;
- first infrared reflective layer (22), comprising Ag, with thickness between 8 nm – 20 nm;
- first barrier layer (23), comprising $NiCrO_x$, with thickness between 0.8 nm – 2.0 nm;
- third dielectric layer (241), comprising $ZnAlO_x$, with thickness between 15 nm – 30 nm;
- fourth dielectric layer (242), comprising Si_xN_y, with thickness between 30 nm – 50 nm;
- second coring layer (243), comprising $ZnAlO_x$, with thickness between 15 nm – 30 nm;
- second infrared reflective layer (25), comprising Ag, with thickness between 8 nm – 20 nm;
- second barrier layer (26), comprising $NiCrO_x$, with thickness between 0.8 nm – 2.0 nm;
- fifth dielectric layer (271), comprising $ZnAlO_x$, with thickness between 10 nm – 20 nm;
- upper dielectric layer (272), comprising SiO_xN_y, with thickness between 20 nm – 35 nm.

5. A low-e coated glass according to any one of the preceding claims, wherein said low-e coating (20) respectively comprises outwardly from the glass (10):

- first dielectric layer (211), comprising Si_xN_y, with thickness between 10 nm – 20 nm;
- second dielectric layer (212), comprising TiO_x, with thickness between 2 nm – 8 nm;
- first coring layer (213), comprising $ZnAlO_x$, with thickness between 8 nm – 20 nm;
- first infrared reflective layer (22), comprising Ag, with thickness between 8 nm – 20 nm;
- first barrier layer (23), comprising $NiCrO_x$, with thickness between 0.8 nm – 2.0 nm;
- third dielectric layer (241), comprising $ZnAlO_x$, with thickness between 15 nm – 30 nm;
- fourth dielectric layer (242), comprising Si_xN_y, with thickness between 30 nm – 50 nm;
- second coring layer (243), comprising $ZnAlO_x$, with thickness between 15 nm – 30 nm;
- second infrared reflective layer (25), comprising Ag, with thickness between 8 nm – 20 nm;
- second barrier layer (26), comprising $NiCrO_x$, with thickness between 0.8 nm – 2.0 nm;
- fifth dielectric layer (271), comprising $ZnAlO_x$, with thickness between 10 nm – 20 nm;
- upper dielectric layer (272), comprising SiO_xN_y, with thickness between 20 nm – 35 nm.

6. A production method for a low-e coated (20) glass (10) according to claim 1, wherein during coating of the first barrier layer (23) and the second barrier layer (26), the ratio of O_2 flow speed / power density is smaller than 8 sccm/(Watt*cm^{-2}).

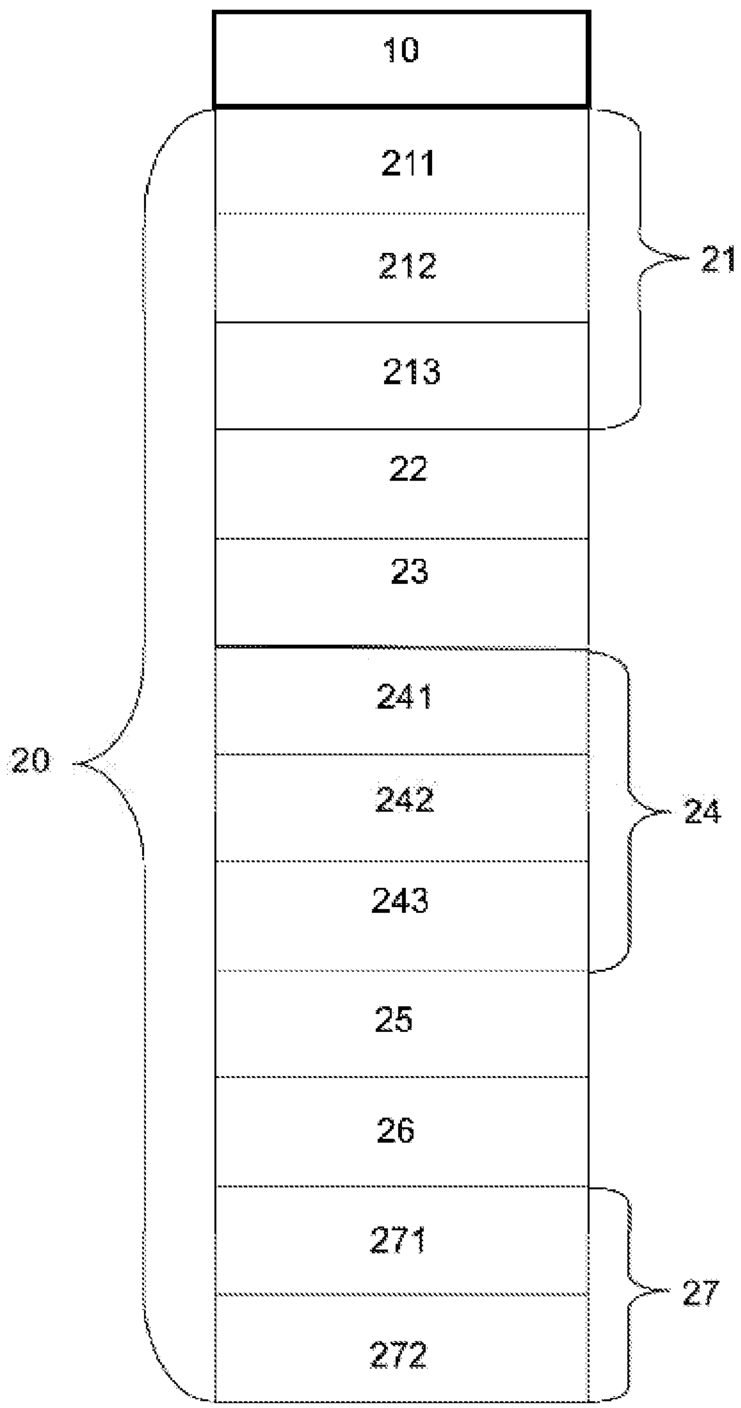

Figure 1