The present invention relates to a halftone mask and a manufacturing method of the same configured to reduce the number of half permeation materials having a multi half permeation part and the number of processes, thereby reducing the manufacturing cost, wherein the halftone mask comprises a substrate, a transmissive area formed on the substrate for transmitting irradiated light of a predetermined wavelength, a half permeation area formed on the substrate with a plurality of layers alternatively stacked with two or more half permeation materials, and having a half permeation area formed with a multi half permeation part having a different transmittance according to the number of stacked half permeation materials, and a blocking area having a blocking layer formed at a plurality of half permeation materials that are alternatively stacked.
Description

Title of Invention: HALF TONE MASK AND MANUFACTURING METHOD OF THE SAME

Technical Field

The present invention relates to a half tone mask and a manufacturing method of the same configured to reduce the number of half permeation materials having a multi half permeation part and the number of processes, thereby reducing the manufacturing cost.

Background Art

Generally, a liquid crystal display (LCD) controls the light transmittance of a liquid crystal having a dielectric anisotropy using an electric field to thereby display a picture. To this end, the LCD includes a liquid crystal display panel for displaying a picture using a liquid crystal cell matrix and a driving circuit to drive the liquid crystal display panel. A related art liquid crystal display panel includes a color filter substrate and a thin film transistor substrate that are joined to each other having a liquid crystal therebetween.

The color filter substrate includes a black matrix, a color filter and a common electrode that are sequentially provided on an upper glass substrate.

The thin film transistor substrate includes a thin film transistor and a pixel electrode provided for each cell defined by a gate line crossing a data line on a lower glass substrate. The thin film transistor applies a data signal from the data line to the pixel electrode in response to a gate signal from the gate line. The pixel electrode formed from a transparent conductive layer supplies a data signal from the thin film transistor to drive the liquid crystal.

The thin film transistor substrate is formed through many mask processes, where, processes of forming a source and a drain electrode and a semiconductor pattern are employed by a single half tone mask to reduce the number of mask processes.

Disclosure of Invention

Technical Problem

At this time, the half tone mask includes a blocking area for blocking ultraviolet, a half permeation area for allowing a partial transmission of the ultraviolet, and a transmission area for allowing the ultraviolet. The half permeation area of the half tone mask may be formed with multiple half permeation parts each having a different transmittance.
Half permeation materials each having a different transmittance are used to form the multiple half permeation parts. That is, three half permeation materials each having different half permeation materials are needed to form a half tone mask having three different transmittances.

A method for forming a half tone mask having three different transmittances may include stacking a first half permeation material, patterning the first half permeation material by performing photolithograph and etching processes, stacking a second half permeation material thereon, patterning the second half permeation material by performing photolithograph and etch processes, stacking a third half permeation material, and patterning the third half permeation material by performing photolithograph and etch processes.

Thus, the conventional method of forming the half tone mask has disadvantages in that the number of processes, time and manufacturing cost are increased because several photolithography and etching processes must be implemented to form the multiple half permeation parts each having different half permeation materials.

Solution to Problem

The present invention is disclosed to obviate the above-mentioned disadvantages, and an advantage of the present invention is to provide a half tone mask and a manufacturing method of the same configured to reduce the number of half permeation materials having a multi half permeation part and the number of processes, thereby reducing the manufacturing cost.

In one general aspect of the present invention, there is provided a half tone mask, comprising: a substrate; a substrate; a transmissive area formed on the substrate for transmitting irradiated light of a predetermined waveband; and a half permeation area formed on the substrate with a plurality of layers alternatively stacked with two or more half permeation materials, and having a half permeation area formed with a multi half permeation part having a different transmittance according to the number of stacked half permeation materials.

In some exemplary embodiments, the half tone mask may further include a blocking area having a blocking layer formed at an upper surface or a bottom surface with a plurality of half permeation materials that are alternatively stacked.
In some exemplary embodiments, the multi half permeation part may be so formed as to have a light transmittance difference in the range of 5% ~ 80% according to the stacked number.

In some exemplary embodiments, the half permeation material may include as a main element Cr, Si, Mo, Ta, Ti, and Al, or include a combined material mixed with at least the two or more elements, or may be a material added with at least one of Cox, Ox, Nx to the main element.

In some exemplary embodiments, each of the at least two or more half permeation materials may be formed with a half permeation material having a different etching ratio.

In some exemplary embodiments, the half permeation area may include a first half permeation part alternatively stacked with a first half permeation material and a second half permeation material to allow light to be transmissive as much as X %, in case the half permeation area is alternatively formed with the first half permeation material and the second half permeation material, a second half permeation part alternatively stacked with the first half permeation material and the second half permeation material to allow light to be transmissive as much as Y %, in case the second half permeation part has a fewer number of half permeation materials than that of the first half permeation part, and a third half permeation part alternatively stacked with the first half permeation material and the second half permeation material to allow light to be transmissive as much as Z %, in a case the third half permeation part has a fewer number of half permeation materials than that of the second half permeation part.

In another general aspect of the present invention, a manufacturing method of a half tone mask, comprising: alternatively stacking on a substrate at least two or more half permeation materials in a multiple layer; stacking a blocking layer on the alternatively stacked at least two or more half permeation materials; and etching step by step the number of alternatively stacked two or more half permeation materials to form multiple half permeation parts each having a different height.

In some exemplary embodiments, the multiple half permeation part is so formed as to have a light transmittance in the range of 5% -80% according to the number of stacked half permeation materials.

In some exemplary embodiments, the step of etching step by step the number of alternatively stacked two or more half permeation materials to form multiple half
permeation units each having a different height comprises: stacking photo-resists on the blocking layer alternatively stacked at least with the two or more half permeation materials to allow each of the photo-resists to have a sill; and using the sill-formed photo-resist as a mask to sequentially etch the exposed blocking layer and the alternatively stacked two or more translucent materials to allow the blocking layer and the half permeation materials to have a mutually different height.

[34]

In some exemplary embodiments, each of the at least two or more half permeation materials has a different etching ratio.

[35]

In some exemplary embodiments, the half permeation material is a material having as a main element one of Cr, Si, Mo, Ta, or Al, or is a combined material mixed with at least the two or more elements, or is a material added with at least one of Cox, Ox, Nx to the main element.

Advantageous Effects of Invention

[38] The present invention is advantageous in that a half permeation mask includes multiple half permeation part alternatively stacking two half permeation materials and differentiating a light transmittance according to stacked heights of the two half permeation materials, such that alternatively stacked two half permeation materials are etched step by step to form a different stacked height and to form multiple half permeation parts each having a different transmittance, whereby multiple half permeation parts having respectively different transmittances by using at least two or more half permeation materials and by etching step by step, thereby reducing the number of half permeation materials and manufacturing processes, and enhancing the productivity as a result of reduced time and cost.

Brief Description of Drawings

[39] FIG. 1 is a cross-sectional view illustrating a half tone mask according to an exemplary embodiment of the present invention.

[40] FIGS. 2 to 12 are cross-sectional views illustrating a manufacturing process of a half tone mask according to the exemplary embodiment of FIG.1.

[41] FIG. 13 is a cross-sectional view illustrating a half tone mask according to another exemplary embodiment of the present invention.

Best Mode for Carrying out the Invention

[42] Configuration and operation of the present invention will be described in detail with reference to the accompanying drawings.

[43] FIG. 1 is a cross-sectional view illustrating a half tone mask according to an
exemplary embodiment of the present invention.

Referring to FIG. 1, a half tone mask (100) includes a blocking area (S1) on a substrate (102), half permeation area (S3, S4, S5) having multiple half permeation parts and a transmissive area (S2).

The substrate (102) may be a transparent substrate, for example, a quartz, that is capable of completely transmitting irradiated light of a predetermined waveband. However, the substrate is not limited to the quartz but may be any material that can transmit light.

The half permeation areas (S3, S4, S5) may include multiple half permeation parts to transmit light irradiated to the substrate in a predetermined waveband in mutually different transmittances. The half permeation areas (S3, S4, S5) may be formed by photo-resist patterns each having a different thickness after a development process by partially transmitting the ultraviolet in the exposing process of the photo-resist process.

To be more specific, the half permeation areas (S3, S4, S5) may include multiple half permeation parts each having a different transmittance by using at least two or more half permeation materials (112, 114). That is, the half permeation areas (S3, S4, S5) are alternatively stacked with the at least two or more half permeation materials (112, 114), and the multiple half permeation parts each having a different transmittance may be formed according to the number of the at least two or more half permeation materials (112, 114) that are alternatively formed.

Now, the half permeation areas (S3, S4, S5) are exemplified by a case where the first and second half permeation materials (112, 114) are alternatively stacked in 4 layers.

That is, the half permeation areas (S3, S4, S5) includes a first half permeation part (53) alternatively stacked on a substrate (102) with a first half permeation material (114) to allow light to be transmissive as much as X %, a second half permeation part (54) alternatively stacked on the first half permeation part (114) to allow light to be transmissive as much as Y %, and a third half permeation part (55) alternatively stacked in 3 layers with the first half permeation material (114) and the second half permeation material (112) to allow light to be transmissive as much as Z %, where each of X %, Y % and Z % respectively defines a transmittance that the irradiated light is transmissive in the range of 5% ~ 80%. That is, the multiple half permeation part may be formed to have a difference of light transmittance in the range of 5% ~ 80%.
according to the number of stacked layers.

At this time, the first and second half permeation materials (112, 114) may be a material having as a main element one of Cr, Si, Mo, Ta, Ti, Al or a combined material mixed with at least the two or more elements, or a material added with at least one of Cox, Ox, Nx to the main element material or the combined material, where x is a natural number that changes according to combination of elements.

A composition of the first and second half permeation materials (112, 114) may be variably formed as long as part of the irradiated light of a predetermined wavelength is transmissive. In the present invention, the composition of the first and second half permeation materials (112, 114), for example, the stacked half permeation materials (112, 114) may be a composition of any one from a group of Cr$_x$O$_y$, Cr$_x$CO$_y$, Cr$_x$O$_y$N$_z$, Si$_x$O$_y$, Si$_x$O$_y$N$_z$, Si$_x$COy, Si$_x$COyN$_z$, Mo$_x$Si$_y$, Mo$_x$O$_y$N$_z$, Mo$_x$COy, Mo$_x$OyN$_z$, Mo$_x$SiOz, Mo$_x$SiO$_y$N$_z$, Mo$_x$SiOyN$_z$, Mo$_x$SiOyCO$_z$N$_z$, Mo$_x$SiOyCO$_z$, Ta$_x$O$_y$, Ta$_x$O$_y$N$_z$, Ta$_x$COy, Ta$_x$OyN$_z$, Al$_x$O$_y$, Al$_x$COy, Al$_x$OyN$_z$, Al$_x$COyN$_z$, Ti$_x$Oy, Ti$_x$OyN$_z$, Ti$_x$COy, or a combination thereof, where the suffix x, y and z is a natural number and defines the number of each chemical element.

Preferably, in a case the first and second half permeation materials (112, 114) are formed by Cr$_x$O$_y$, Cr$_x$CO$_y$ and Cr$_x$O$_y$N$_z$, the second half permeation material (114) selectively etchable with Cr among the listed half permeation materials may be used. That is, each of the first and second half permeation materials (112, 114) must be formed with half permeation materials each having a different etching ratio out of the listed half permeation materials.

As noted above, a first to m th half permeation parts may be formed each having a different transmittance according to the number of stacked layers by alternatively forming a plurality of first and second half permeation materials (112, 114), where m is a natural number larger than 1, which will be explained with reference to FIG. 13.

Referring to FIG. 13, the half permeation areas (S3, S4, S5) may include a first half permeation part (S1) alternatively stacked with a plurality of first half permeation materials (112) and a plurality of second half permeation materials (114) to allow light to be transmissive as much as X %, in case the half permeation area is alternatively formed with the first half permeation materials and the second half permeation materials, a second half permeation area (S4) alternatively stacked with the first half permeation materials and the second half permeation materials to allow light to be
transmissive as much as $Y\%$, in case the second half permeation area has a fewer number of half permeation materials than that of the first half permeation area, and a third half permeation area (S5) alternatively stacked with the first half permeation materials and the second half permeation materials to allow light to be transmissive as much as $Z\%$, in case the third half permeation area has a fewer number of half permeation materials than that of the second half permeation area.

That is, a half tone mask may be formed having multiple half permeation parts each having a different transmittance according to the number of stacked layers by alternatively stacking at least two or more half permeation materials.

The blocking area (SI) is left with a photo-resist pattern after development process by blocking the ultraviolet during exposing process. To this end, the blocking area (SI) blocks the ultraviolet by allowing blocking layers to be stacked on the plurality of first half permeation materials (114) and the plurality of second half permeation materials (112).

Now, a process of forming a half tone mask including the transmissive area (S2), the blocking area (SI) and the half permeation areas (S3, S4, S5) will be described with reference to FIGS. 2 to 12.

FIGS. 2 to 12 are cross-sectional views illustrating a manufacturing process of a half tone mask according to the exemplary embodiment of FIG.1.

Although the plurality of layers may be formed by alternatively stacking the first and second half permeation materials, but in the present exemplary embodiment, description will be given on a case where the first and second half permeation materials are alternatively stacked to form four layers.

Referring to FIG. 2, the first and second half permeation materials (114, 112) are alternatively stacked on the substrate (102) to form four layers by sputtering, chemical vapor deposition and the like, and a blocking layer (110) and a photo-resist (120) are sequentially stacked thereon.

To be more specific, the first and second half permeation materials (112, 114) may be a material having as a main element one of Cr, Si, Mo, Ta, Ti, Al or a combined material mixed with at least the two or more elements, or a material added with at least one of Cox, Ox, Nx to the main element material or the combined material, where $x$ is
a natural number that changes according to combination of elements.

[81] A composition of the first and second half permeation materials (112, 114) may be
variably formed as long as part of the irradiated light of a predetermined wavelength is
transmissive. In the present invention, the composition of the first and second half
permeation materials (112, 114) may be a composition of any one from a group of \( \text{Cr}_x \O_y \), \( \text{Cr}_x \text{CO}_y \), \( \text{Cr}_x \text{O}_y \text{N}_z \), \( \text{Si}_x \O_y \), \( \text{Si}_x \text{O}_y \text{N}_z \), \( \text{Si}_x \text{CO}_y \), \( \text{Si}_x \text{CO}_y \text{N}_z \), \( \text{Mo}_x \text{Si}_y \), \( \text{Mo}_x \O_y \), \( \text{Mo}_x \text{O}_y \text{N}_z \), \( \text{Mo}_x \text{CO}_y \), \( \text{Mo}_x \text{O}_y \text{N}_z \), \( \text{Mo}_x \text{Si}_y \text{O}_z \), \( \text{Mo}_x \text{Si}_y \text{O}_z \text{N}_z \), \( \text{Mo}_x \text{Si}_y \text{CO}_z \), \( \text{Ta}_x \O_y \text{N}_z \), \( \text{Ta}_x \text{CO}_y \), \( \text{Ta}_x \text{O}_y \text{N}_z \), \( \text{Al}_x \O_y \), \( \text{Al}_x \text{CO}_y \), \( \text{Al}_x \text{O}_y \text{N}_z \), \( \text{Al}_x \text{CO}_y \text{N}_z \), \( \text{Ti}_x \O_y \text{N}_z \), \( \text{Ti}_x \text{CO}_y \), or a combination thereof.

[82] Preferably, in a case the first and second half permeation materials (112, 114) are
formed by \( \text{Cr}_x \O_y \), \( \text{Cr}_x \text{CO}_y \), and \( \text{Cr}_x \text{O}_y \text{N}_z \), the second half permeation material (114) se-
lectively etchable with Cr among the listed half permeation materials may be used.
That is, each of the first and second half permeation materials (112, 114) must be
formed with half permeation materials each having a different etching ratio out of the
listed half permeation materials.

[83] Furthermore, the blocking layer (110) may be formed with a material capable of
blocking the ultraviolet, and for example, the blocking layer may be formed by a film
formed with Cr and \( \text{Cr}_x \O_y \).

[84] Referring to FIG.3, first and second photo-resist patterns (120a, 120b) each having a
sill may be formed after the photo-resist (120) formed on the blocking layer (110) is
drawn and developed, and the blocking layer is exposed at a position where the transmissevie area (S2) is formed.

[85] To be more specific, the first and second photo-resist patterns (120a, 120b) each
having a different thickness are formed by irradiating the laser beam to the photo-resist
(120) by adjusting the intensity of the laser beam. The first photo-resist pattern (120a)
is positioned at where the blocking area (S1), the first half permeation part (S3) and the
third half permeation part (S5) are supposed to be formed, and the second photo-resist
pattern (120b) is positioned at where the second half permeation part (S4) is supposed
to be formed. The blocking layer (110) is exposed at a position where the transmissiv
ea area (S2) is supposed to be formed.

[86] Referring to FIG.4, the blocking layer (110) and the first and second half permeation
materials (112, 114) exposed by using the first and second photo-resist patterns (120a,
120b) remaining on the blocking layer (110) as masks are removed by etching process.

To be more specific, the transmissive area (S2) is formed by exposing the substrate (120) through an etching process using the blocking layer (110) and the first and second photo-resist patterns of the first and second half permeation materials (120a, 120b) as masks.

Referring to FIG.5, the first photo-resist pattern (120a) is thinned by an etching process using oxygen (O₂) plasma, and the second photo-resist pattern (120b) is removed. The blocking layer (120) is exposed at where the second half permeation part (S4) having a Y% transmittance is formed by removing the second photo-resist pattern (120b).

Referring to FIG.6, the blocking layer (110) exposed at where the third half permeation part (S5) is supposed to be formed, the second half permeation material (112) and the first half permeation material (114) are sequentially removed through etching process using the first photo-resist pattern (120a) left on the blocking layer (110) as a mask. As a result, the second half permeation part (S4) is formed on which the first and second half permeation materials (112, 114) are stacked on the substrate (102). Successively, the first photo-resist pattern (120a) remaining on the substrate (102) is removed through a stripping process.

Referring to FIG.7, the photo-resist (120) is formed on the substrate (102) formed with the blocking area (S1), the transmissive area (S2) and the second half permeation part (S4) are formed. The first and second photo-resist patterns (120a, 120b) each having a sill, are formed after the photo-resist (120) is drawn and developed.

To be more specific, the first and second photo-resist patterns (120a, 120b) each having a different thickness are formed by irradiating the laser beam to the photo-resist (120) by adjusting the intensity of the laser beam. The first photo-resist pattern (120a) is positioned at where the blocking area (S1), the transmissive area (S2) and the second half permeation part (S4) are supposed to be formed, and the second photo-resist pattern (120b) is positioned at where the third half permeation part (S5) is supposed to be formed. The blocking layer (110) is exposed at a position where the first half permeation part (S3) is supposed to be formed.

Referring to FIG.8, the blocking layer (110) exposed using the first and second photo-resist patterns (120a, 120b) as a mask on the substrate (102), the second half
permeation material (112) and the first half permeation material (114) are sequentially removed through etching process. As a result, the first and second half permeation materials (112, 114) are left on where the first half permeation part (S3) is supposed to be formed.

Referring to FIG.9, the first photo-resist pattern (120a) is thinned by an etching process using oxygen (O₂) plasma, and the second photo-resist pattern (120b) is removed. The blocking layer (120) is exposed at where the third half permeation part (S5) having a Z% light transmittance is formed by removing the second photo-resist pattern (120b).

Referring to FIG.10, the blocking layer (110) exposed by using the first photo-resist pattern (120a) as a mask on the substrate (102) is removed by the etching process and the second half permeation material (112) is then removed as shown in FIG. 11.

Successively referring to FIG. 12, the first photo-resist (120a) remaining on the substrate (102) is removed by a stripping process to form a half tone mask having multiple half permeation parts each having a different transmittance. As a result, a transmissive area (S2) exposing the substrate (102) for the light irradiated to the substrate (102) to be transmissive, and first and second half permeation materials (112, 114) on the substrate (102) are alternatively stacked in 4 layers, and the blocking area (S1) formed with the blocking layer (120) is formed thereon.

Furthermore, a half permeation areas having multiple half permeation parts each having a different transmittance are formed with a first half permeation part (S3) having an X% transmittance by stacking first half permeation material on the substrate, a second half permeation part (S4) having a Y% transmittance by stacking first and second half permeation materials (112, 114) on the substrate, and a third half permeation part (S5) having a Z% transmittance by alternatively stacking first and second half permeation materials (112, 114) in 3 layers on the substrate.

As noted above, the first and second half permeation materials (112, 114) may form multiple half permeation parts each having a different transmittance through gradual step-by-step etching process after forming the half permeation materials each having a different etching ratio in a plurality of layers.

That is, the half tone mask having multiple half permeation parts each having a different transmittance may be provided by using only the first and second half
permeation materials.

Meanwhile, although the present exemplary embodiments has described a method forming only the first, second and third half permeation parts using the first and second half permeation materials, multiple half permeation parts each having a different transmittance may be formed according to the number of stacked layers of first and second half permeation materials.

Furthermore, multiple half permeation parts having first to m th half permeation part may be formed by stacking and step-by-step etching first to n th half permeation materials in addition to the first and second half permeation materials, where n and m are natural number larger than 1.

Industrial Applicability

The present invention is industrially applicable in that a half permeation mask includes multiple half permeation parts alternatively stacking two half permeation materials and differentiating a light transmittance according to stacked heights of the two half permeation materials, such that alternatively stacked two half permeation materials are etched step by step to form a different stacked height and to form multiple half permeation parts each having a different transmittance, whereby multiple half permeation parts having respectively different transmittances by using at least two or more half permeation materials and by etching step by step, thereby reducing the number of half permeation materials and manufacturing processes, and enhancing the productivity as a result of reduced time and cost.
Claims

[Claim 1] A half tone mask comprising: a substrate; a transmissive area formed on the substrate for transmitting irradiated light of a predetermined wavelength; and a half permeation area formed on the substrate with a plurality of layers alternatively stacked with two or more half permeation materials, and having a half permeation area formed with a multi half permeation part having a different transmittance according to the number of stacked half permeation materials.

[Claim 2] The half tone mask of claim 1, wherein the half tone mask further includes a blocking area having a blocking layer formed at an upper surface or a bottom surface with a plurality of half permeation materials that are alternatively stacked.

[Claim 3] The half tone mask of claim 1, wherein the multi half permeation part is so formed as to have a light transmittance difference in the range of 5% ~ 80% according to the number of stacking.

[Claim 4] The half tone mask of claim 1, wherein the half permeation material includes as a main element one of Cr, Si, Mo, Ta, Ti, Al, Zr, Sn, Zn, In, Mg, Hf, V, Nd, Ge, MgO-Al₂O₃ or Si₃N₄, or a combined material mixed with at least the two or more elements, or includes the single main element or the combined material added with at least one of Cox, Ox, Nx, Cx, Fx, and Bx, where suffix x is a natural number and defines the number of each chemical element.

[Claim 5] The half tone mask of claim 1, wherein each of the at least two or more half permeation materials is formed with a half permeation material having a different etching ratio.

[Claim 6] The half tone mask of claim 1, wherein the half permeation area includes a first half permeation part alternatively stacked with a first half permeation material and a second half permeation material to allow light to be transmissive as much as X %, in case the half permeation area is alternatively formed with the first half permeation material and the second half permeation material, a second half permeation part alternatively stacked with the first half permeation material and the second half permeation material to allow light to be transmissive as much as Y %, in case the second half permeation part has a fewer number of half permeation materials than that of the first half permeation part, and a third half permeation part alternatively stacked with the first half permeation material and the second half
permeation material to allow light to be transmissive as much as Z %, in a case the third half permeation part has a fewer number of half permeation materials than that of the second half permeation part.

[Claim 7] A manufacturing method of a half tone mask, comprising: alternatively stacking on a substrate at least two or more half permeation materials in a multiple layer; stacking a blocking layer on the alternatively stacked at least two or more half permeation materials; and etching step by step the number of alternatively stacked two or more half permeation materials to form multiple half permeation parts each having a different height.

[Claim 8] The method of claim 7, wherein the multiple half permeation part is so formed as to have a light transmittance in the range of 5% - 80% according to the number of stacked half permeation materials.

[Claim 9] The method of claim 7, wherein the step of etching step by step the number of alternatively stacked two or more half permeation materials to form multiple half permeation units each having a different height comprises: stacking photo-resists on the blocking layer alternatively stacked at least with the two or more half permeation materials to allow each of the photo-resists to have a sill; and using the sill-formed photo-resist as a mask to sequentially etch the exposed blocking layer and the alternatively stacked two or more translucent materials to allow the blocking layer and the half permeation materials to have a mutually different height.

[Claim 10] The method of claim 7, wherein each of the at least two or more half permeation materials has a different etching ratio.

[Claim 11] The method of claim 7, wherein the half permeation material includes as a main element one of Cr, Si, Mo, Ta, Ti, Al, Zr, Sn, Zn, In, Mg, Hf, V, Nd, Ge, MgO-Al₂O₃ or Si₃N₄ or a combined material mixed with at least the two or more elements, or includes the single main element or the combined material added with at least one of Cox, Ox, Nx, Cx, Fx, and Bx, where suffix x is a natural number and defines the number of each chemical element.