a plurality of films laminated together, wherein

the plurality of films includes:

a low refractive index film, and

a high refractive index film having a refractive index higher than that of the low refractive index film,

the low refractive index film is formed of a mixture including silicon dioxide (SiO_2) and yttrium oxide (Y_2O_3), where some of the yttrium (Y) atoms in the yttrium oxide (Y_2O_3) are substituted with Group 4 element atoms, and

at least one of the films adjacent to the high refractive index film has a refractive index lower than that of the high refractive index film.

[0008] The present disclosure also provides a laminate including the reflectance adjustment film of the present disclosure, the reflectance adjustment film being formed on at least one surface of a substrate.

[0009] The present disclosure also provides a method for producing the reflectance adjustment film of the present disclosure, including:

forming the low refractive index film, and

forming the high refractive index film, wherein

the low refractive index film is formed by sputtering in the forming the low refractive index film, and

the high refractive index film is formed by sputtering in the forming the high refractive index film.

Advantageous Effects of Invention

[0010] The present disclosure can provide a reflectance adjustment film having high hardness, a laminate in which the reflectance adjustment film is formed, and a method for producing the reflectance adjustment film.

BRIEF DESCRIPTION OF DRAWINGS

[0011] [FIG. 1] FIG. 1 is a cross-sectional view showing an example of the reflectance adjustment film of the present disclosure and the laminate of the present disclosure.

[FIG. 2] FIG. 2 is a cross-sectional view showing an example of the laminate of the present disclosure including a hard coat layer and a reflectance adjustment film.

DESCRIPTION OF EMBODIMENTS

[0012] As used herein, "on" or "on a surface" may refer to a state of direct contact on or on a surface, and may also refer to a state of contact via another layer or the like.

[0013] As used herein, "suppression" of some phenomena is not limited to reduction of the

However, the present disclosure is not limited thereto, and for example, the reflectance adjustment film 10 may be laminated on the substrate 20 via a layer other than the low refractive index film 11 and the high refractive index film 12. However, it is preferable that the reflectance adjustment film of the present disclosure and the laminate of the present disclosure do not include a layer other than the low refractive index film and the high refractive index film, from the viewpoint of suppressing foreign matters derived from the other layer or the like being mixed into the reflectance adjustment film.

[0023] FIG. 2 shows an example of the laminate of the present disclosure including a hard coat layer and a reflectance adjustment film. As shown in FIG. 2, in this laminate 100a, a hard coat layer 30 is formed on one surface of a substrate 20, and a reflectance adjustment film 10a is formed on the surface of the hard coat layer 30 opposite to the surface facing the substrate 20. The reflectance adjustment film 10a is formed by alternately laminating a low refractive index film 11a and a high refractive index film 12a. In FIG. 2, the film adjacent to the hard coat layer 30 (closest to the substrate 20) and the film farthest from the substrate 20 are the low refractive index films 11a.

[0024] When the hard coat layer is used as a layer separate from the reflectance adjustment film as shown in FIG. 2, for example, the hardness of the reflectance adjustment film can be increased, and the scratch resistance and the like can be improved. However, in the case of providing the hard coat layer, the production processes accordingly increase, as described above. In addition, in the case of forming the reflectance adjustment film on the hard coat layer, foreign matters may be mixed into the reflectance adjustment film. In this respect, the reflectance adjustment film 10 of FIG. 1 has high hardness even without the hard coat layer, and thus solves such problems.

[0025] In the reflectance adjustment film of the present disclosure, as described above, the low refractive index film is formed of a mixture including silicon dioxide (SiO_2) and yttrium oxide (Y_2O_3), where some of the yttrium (Y) atoms in the yttrium oxide (Y_2O_3) are substituted with Group 4 element atoms. In the yttrium oxide (Y_2O_3), some of the oxygen (O) atoms may also be substituted with nitrogen (N) atoms. By substituting some of the oxygen (O) atoms in the yttrium oxide (Y_2O_3) with nitrogen (N) atoms, it is expected to impart low adhesion with a substance having basicity, and antifouling property with respect to a certain kind of substance. It is considered that the adhesion and the antifouling property are imparted, for example, by deactivation of a hydroxyl group, which is an active group on the surface of the reflectance adjustment film, due to the substitution of some of the oxygen (O) atoms with nitrogen (N) atoms.

[0026] Note that, yttrium oxide (Y_2O_3) has higher hardness than that of silicon dioxide (SiO_2). Therefore, the film formed of a mixture including yttrium oxide (Y_2O_3) and silicon dioxide (SiO_2) is considered to have higher hardness than that of a low refractive index film composed only of silicon dioxide (SiO_2). Further, when some of the yttrium (Y) atoms in the yttrium oxide (Y_2O_3) are substituted with Group 4 element atoms, for example, bonding of crystals forming the low refractive index film is strengthened. For this, when some of the yttrium (Y) atoms in the low refractive index film are substituted with Group 4 element atoms, the hardness is considered to be higher than that in a case where none of the yttrium atoms are substituted.

[0027] The hardness of the reflectance adjustment film of the present disclosure is not particularly limited. However, when the substrate is glass, the hardness of the reflectance adjustment film is preferably 6.0 GPa or more, and more preferably 6.1 GPa or more. The upper limit thereof is, for example, 11 GPa or less.

[0028] In the present disclosure, the hardness is a numerical value measured by the method described in Examples below. However, in the present disclosure, the hardness may be measured by a method other than the measurement method described below.

[0029] The reflectance adjustment film of the present disclosure may be an antireflection film, but not limited thereto. For example, the reflectance adjustment film of the present disclosure may have light transmittance of approximately 0%. The reflectance adjustment film may be, for example, a mirror having light reflectance of approximately 100%. In the reflectance adjustment film of the present disclosure, reflectance of light, transmittance of light, and the like can be adjusted by, for example, appropriately setting the number, the film thickness, the refractive index, the lamination order, or the like of each of the low refractive index film and the high refractive index film. In addition, in the reflectance adjustment film of the present disclosure, reflectance of light, transmittance of the light, and the like can be adjusted, for example, so as to vary with the wavelength of light.

[0030] In the reflectance adjustment film of the present disclosure, the reflectance is adjusted by, for example, the following method. As described above, the reflectance adjustment film of the present disclosure is formed by laminating a plurality of films. The refractive indices of the plurality of films adjacent to each other are different from each other. Here, when light is incident from one film to another, and the refractive indices of the two adjacent films are different from each other, part of the incident light is reflected at the boundary between the two adjacent films. The larger the difference between the refractive indices of the two adjacent layers, the larger the intensity of the reflected light becomes. Further, the film thickness of the plurality of laminated films affects phase of the reflected light generated at the boundary between

(Y_2O_3), where some of the yttrium (Y) atoms in yttrium oxide (Y_2O_3) are substituted with Group 4 element atoms. In the yttrium oxide (Y_2O_3), some of the oxygen (O) atoms may also be substituted with nitrogen (N) atoms. The content of the yttrium oxide in the low refractive index film is not particularly limited, and for example, the lower limit thereof is preferably 1.0 mol% or more, and more preferably 1.1 mol% or more, and from the viewpoint of improving the antireflection property, the upper limit thereof is preferably less than 10 mol%, and more preferably less than 6 mol%.

[0037] In the present disclosure, the content of atoms in the film can be, for example, a numerical value measured by an X-ray photoelectron spectrometer. Examples of the X-ray photoelectron spectrometer include an X-ray photoelectron spectrometer (trade name: PHI5000 VersaProbe2) manufactured by ULVAC-PHI, Inc. Using the X-ray photoelectron spectrometer, a sample is irradiated with X-rays, and the energy of the photoelectrons emitted from the surface of the sample is measured, whereby information on the composition and the chemical bonding state of the surface can be obtained. Thus, the content of atoms in the film can be measured. In the present disclosure, the content of atoms in the film may be measured by a method other than the following measurement method.

[0038] The low refractive index film in the reflectance adjustment film of the present disclosure may or may not necessarily include a component other than silicon dioxide (SiO_2) and yttrium oxide (Y_2O_3). Examples of the other component include magnesium fluoride (MgF_2).

[0039] In the reflectance adjustment film of the present disclosure, some of the yttrium (Y) atoms in the yttrium oxide (Y_2O_3) included in the low refractive index film are substituted with Group 4 element atoms. The Group 4 element atoms are not particularly limited and may be, for example, at least one type selected from the group consisting of titanium (Ti), zirconium (Zr) and hafnium (Hf), and preferably at least one of zirconium (Zr) or hafnium (Hf), and particularly preferably zirconium (Zr). These atoms or these forming materials may be used alone or in combination of two or more of these atoms and these forming materials.

[0040] In the reflectance adjustment film of the present disclosure, some of the yttrium (Y) atoms in the yttrium oxide (Y_2O_3) included in the low refractive index film are substituted with Group 4 element atoms, and thus, for example, high hardness (scratch resistance or the like) can be obtained. The reason for this is considered to be that, for example, when some of the yttrium (Y) atoms are substituted with Group 4 element atoms (e.g., zirconium (Zr)), the hardness becomes higher than that when using the yttrium oxide (Y_2O_3).

[0041] Further, the low refractive index film in the reflectance adjustment film of the present disclosure may be, for example, crystalline. The crystallinity of the low refractive index film can

be determined by a general crystallinity evaluation method such as X-ray diffraction, electron diffraction, and Raman spectroscopy. Whether the low refractive index film includes yttrium oxide that contains nitrogen and Group 4 elements can be determined by, for example, Secondary Ion Mass Spectrometry (SIMS).

[0042] In the low refractive index film, the ratio of the substitution of the yttrium (Y) atoms with the Group 4 element atoms (content of the Group 4 element atoms) in the yttrium oxide (Y_2O_3) is not particularly limited as long as it is larger than 0, and the upper limit thereof may be, for example, 20 mol% or less, 15 mol% or less, 10 mol% or less, or 5 mol% or less.

[0043] When some of the oxygen (O) atoms in the yttrium oxide (Y_2O_3) in the low refractive index film are substituted with nitrogen (N) atoms, the ratio of the substitution of the oxygen (O) atoms with the nitrogen (N) atoms (content ratio of the nitrogen atoms) in the yttrium oxide (Y_2O_3) is not particularly limited as long as it is larger than 0, and may be 1 at% or more, and the upper limit thereof may be, for example, 10 at% or less, 5 at% or less, 3 at% or less, or 2 at% or less.

[0044] The low refractive index film may be free of metal elements that are allergenic or toxic, such as Hg, Ni, Cr, Co, Cu, Sn, Au, Pt, Pd, Sb, Ag, Fe, and Zn.

[0045] The physical film thickness of the low refractive index film is not particularly limited and can be appropriately selected depending on the desired optical properties.

[0046] In the present disclosure, the physical film thickness can be a numerical value measured by a spectroscopic film thickness meter. Using the spectroscopic film thickness meter, a sample is irradiated with light, a phase shift is generated based on the difference between optical paths of the reflected light and the irradiated light, an optical interference phenomenon is caused by the phase shift, and the optical interference phenomenon is measured to obtain the reflection spectrum and the refractive index, wherefrom the film thickness can be determined. Examples of the spectroscopic film thickness meter include a reflective spectroscopic film thickness meter (trade name: FE-3000) manufactured by Otsuka Electronics Co., Ltd. However, in the present disclosure, the physical film thickness may be measured by a method other than the above-described measurement method.

[0047] [1-3. High Refractive Index Film]

Hereinafter, the high refractive index film in the reflectance adjustment film of the present disclosure will be described with illustrative examples.

[0048] The refractive index of the high refractive index film is not particularly limited as long as it is higher than that of the low refractive index film, and for example, the lower limit of the refractive index with respect to light having a wavelength of 500 nm is preferably 1.9 or more,

not limited to, the following supplementary notes.

(Supplementary Note 1)

A reflectance adjustment film for adjusting reflectance of light, including:

a plurality of films laminated together, wherein

the plurality of films includes:

a low refractive index film, and

a high refractive index film having a refractive index higher than that of the low refractive index film,

the low refractive index film is formed of a mixture including silicon dioxide (SiO_2) and yttrium oxide (Y_2O_3), where some of the yttrium (Y) atoms in the yttrium oxide (Y_2O_3) are substituted with Group 4 element atoms, and

at least one of the films adjacent to the high refractive index film has a refractive index lower than that of the high refractive index film.

(Supplementary Note 2)

The reflectance adjustment film according to Supplementary Note 1, wherein

some of the oxygen atoms in the yttrium oxide (Y_2O_3) are substituted with nitrogen (N) atoms.

(Supplementary Note 3)

The reflectance adjustment film according to Supplementary Note 1 or 2, wherein

content of the yttrium oxide (Y_2O_3) in the low refractive index film is 1.0 mol% or more.

(Supplementary Note 4)

The reflectance adjustment film according to any one of Supplementary Notes 1 to 3, wherein

the Group 4 element atoms in the low refractive index film are zirconium (Zr) atoms.

(Supplementary Note 5)

A reflectance adjustment film for adjusting reflectance of light, including:

a plurality of films laminated together, wherein

the plurality of films includes:

a low refractive index film, and

a high refractive index film having a refractive index higher than that of the low refractive index film,

at least one of the films adjacent to the high refractive index film has a refractive index lower than that of the high refractive index film, and

hardness of the reflectance adjustment film is 6.0 GPa or more.

(Supplementary Note 6)

The reflectance adjustment film according to any one of Supplementary Notes 1 to 4, wherein

CLAIMS

[Claim 1] A reflectance adjustment film for adjusting reflectance of light, comprising:

a plurality of films laminated together, wherein

the plurality of films includes:

a low refractive index film, and

a high refractive index film having a refractive index higher than that of the low refractive index film,

the low refractive index film is formed of a mixture including silicon dioxide (SiO_2) and yttrium oxide (Y_2O_3), where some of the yttrium (Y) atoms in the yttrium oxide (Y_2O_3) are substituted with Group 4 element atoms, and

at least one of the films adjacent to the high refractive index film has a refractive index lower than that of the high refractive index film.

[Claim 2] The reflectance adjustment film according to claim 1, wherein

some of the oxygen atoms in the yttrium oxide (Y_2O_3) are substituted with nitrogen (N) atoms.

[Claim 3] The reflectance adjustment film according to claim 1 or 2, wherein

content of the yttrium oxide (Y_2O_3) in the low refractive index film is 1.0 mol% or more.

[Claim 4] The reflectance adjustment film according to any one of claims 1 to 3, wherein

the Group 4 element atoms in the low refractive index film are zirconium (Zr) atoms.

[Claim 5] The reflectance adjustment film according to any one of claims 1 to 4, wherein

the refractive index of the low refractive index film with respect to a wavelength of 500 nm is in a range of 1.47 to 1.58.

[Claim 6] The reflectance adjustment film according to any one of claims 1 to 5, wherein

the high refractive index film is formed of tantalum pentoxide (Ta_2O_5).

[Claim 7] The reflectance adjustment film according to any one of claims 1 to 6, the

reflectance adjustment film being an antireflection film for preventing reflection of light.

[Claim 8] A laminate comprising the reflectance adjustment film according to any one of claims 1 to 7, the reflectance adjustment film being formed on at least one surface of a substrate.

[Claim 9] The laminate according to claim 8, wherein

a film farthest from the substrate in the plurality of films in the reflectance adjustment film is the low refractive index film.

[Claim 10] A method for producing the reflectance adjustment film according to any one of claims 1 to 7, comprising:

forming the low refractive index film, and

forming the high refractive index film, wherein

the low refractive index film is formed by sputtering in the forming the low refractive index film, and

the high refractive index film is formed by sputtering in the forming the high refractive index film.