

DESCRIPTION

Title of Invention

OPTICAL MEMBER

5 Technical Field

The present invention relates to an optical member.

Background Art

Recently, window films for shielding sunlight have been widely used for the
10 purpose of reducing loads of air conditioning (see, for example, PTL 1). As window
films for shielding sunlight, there are films that absorb sunlight and films that
reflect sunlight. The films that absorb sunlight have a problem that the film is
heated to heat a peripheral part of a window, as sunlight is absorbed, and a glass
window tends to crack (heat cracking) due to a difference in thermal expansion
15 between a low temperature part and a high temperature part.

On the other hand, the films that reflect sunlight tend not to cause heat
cracking. Regarding the films that reflect sunlight, techniques using an optical
multi-layer film, a metal-containing film, or a transparent conductive film is used
as a wavelength-selective reflective layer have been already known. However, the
20 wavelength-selective reflective layer can only regular-reflect incident sunlight,
because the wavelength-selective reflective layer is typically disposed on planar
glass. Therefore, the light emitted from the sky and regular-reflected by the
wavelength-selective reflective layer reaches another building outside or ground,
and absorbed by the building or the ground to transformed into heat to increase a
25 temperature of the surroundings. As a result, a local increase in the temperature
is caused in the surrounding area of buildings having windows, to entire areas of
which the above-described wavelength-selective reflective layers are bonded. In

the city, therefore, the heat island effect is accelerated, and problems are caused, such as lawns do not grow only in the area where reflected light is applied.

In order to prevent the acceleration of the heat island effect due to the regular reflection, techniques for directionally reflect sunlight in the directions other than regular reflection have been proposed. As a method for improving reflection to the sky, for example, a reflection structure of a grooved surface using an optical refractive index film of a crystalline layer has been proposed (see, for example, PTL 2 to PTL 4).

In case of the above-described reflection structure, however, absorption of sunlight increases, and there is a possibility that a glass window may cause heat cracking as in the case of the films that absorb sunlight.

Moreover, the above-described films each have a laminate structure. In case of the laminate structure, there are problems that inconvenience occurs on handling during installation or production, and appearance and long-term reliability are impaired, if interlayer adhesion is not sufficient.

Citation List

Patent Literature

PTL 1 International Publication No. WO 05/087680

PTL 2 Japanese Patent Application Laid-Open (JP-A) No. 2010-160467

PTL 3 JP-A No. 2012-3024

PTL 4 JP-A No. 2011-175249

Summary of Invention

Technical Problem

The present invention aims to solve the above-described various problems in the conventional art, and achieve the following object. Specifically, the present

invention has an object to provide an optical member, which directionally reflects sunlight in a direction other than a direction of regular reflection, absorbs a small quantity of sunlight, and has excellent interlayer adhesion.

5 Solution to Problem

The means for solving the above-described problems are as follows.

<1> An optical member including:

a first optical transparent layer having convex-concave shapes, and being transparent to visible light;

10 a wavelength-selective reflective layer, which is formed on the convex-concave shapes of the first optical transparent layer, and is configured to selectively reflect certain wavelengths of infrared light; and

a second optical transparent layer formed on the wavelength-selective reflective layer,

15 wherein the wavelength-selective reflective layer includes at least an amorphous high-refractive-index layer, a metal layer, and a crystalline high-refractive-index layer in contact with the second optical transparent layer.

<2> The optical member according to <1>,

20 wherein a material of the crystalline high-refractive-index layer is a metal oxide, a metal nitride, or both.

<3> The optical member according to <1> or <2>,

wherein a material of the amorphous high-refractive-index layer is a metal oxide, a metal nitride, or both.

<4> The optical member according to any one of <1> to <3>,

25 wherein an average thickness of the metal layer is from 5 nm to 85 nm.

<5> The optical member according to any one of <1> to <4>,

wherein an average thickness of the metal layer is from 5 nm to 60 nm.

<6> The optical member according to any one of <1> to <5>, wherein an average thickness of the metal layer is from 5 nm to 40 nm.

<7> The optical member according to any one of <1> to <6>, wherein an average thickness of the metal layer is from 5 nm to 25 nm.

5 <8> The optical member according to any one of <1> to <7>, wherein the convex-concave shapes of the first optical transparent layer are formed with a one-dimensional alignment or a two-dimensional alignment of a plurality of structures, and the structures have prism shapes, lenticular shapes, hemispherical shapes, or corner cube shapes.

10 <9> The optical member according to any one of <1> to <8>, wherein a material of the crystalline high-refractive-index layer is ZnO, or a complex metal oxide, or both, and wherein the complex metal oxide includes ZnO, and at least one metal oxide selected from Al_2O_3 and Ga_2O_3 , and an amount of the metal oxide in the complex metal oxide is 6% by mass or less relative to the ZnO.

15 <10> The optical member according to any one of <1> to <9>, wherein a material of the amorphous high-refractive-index layer is at least one selected from the group consisting of: a complex metal oxide including In_2O_3 and 10% by mass to 40% by mass of CeO_2 relative to the In_2O_3 ; a complex metal oxide including In_2O_3 and 3% by mass to 10% by mass of SnO_2 relative to the In_2O_3 ; a complex metal oxide including ZnO and 20% by mass to 40% by mass of SnO_2 relative to the ZnO; a complex metal oxide including ZnO and 10% by mass to 20% by mass of TiO_2 relative to the ZnO; In_2O_3 ; and Nb_2O_5 .

25 Advantageous Effects of the Invention

The present invention can solve the above-described various problems in the conventional art, achieve the above-mentioned object, and provide an optical

member, which directionally reflects sunlight in a direction other than a direction of regular reflection, absorbs a small quantity of sunlight, and has excellent interlayer adhesion.

5 Brief Description of Drawings

FIG. 1A is a perspective view illustrating an example of shapes of structures formed in a first optical transparent layer.

FIG. 1B is a cross-sectional view illustrating a direction of inclination of a main axis of the structure formed in the first optical transparent layer.

10 FIG. 2A is a perspective view illustrating an example of shapes of structures formed in a first optical transparent layer.

FIG. 2B is a perspective view illustrating an example of shapes of structures formed in a first optical transparent layer.

15 FIG. 2C is a perspective view illustrating an example of shapes of structures formed in a first optical transparent layer.

FIG. 3 is a cross-sectional view illustrating one example of a function of an optical member.

FIG. 4 is a cross-sectional view illustrating one example of a function of an optical member.

20 FIG. 5 is a cross-sectional view illustrating one example of a function of an optical member.

FIG. 6 is a cross-sectional view illustrating one example of a function of an optical member.

25 FIG. 7A is a cross-sectional view illustrating a relationship between the ridge line of the pillar-shaped structure, incident light, and reflected light.

FIG. 7B is a cross-sectional view illustrating a relationship between the ridge line of the pillar-shaped structure, incident light, and reflected light.

FIG. 8 is a perspective view illustrating a relationship between incident light entering an optical member and reflected light reflected by the optical member.

FIG. 9A is a process diagram for explaining one example of the production method of an optical member of the present invention.

FIG. 9B is a process diagram for explaining one example of the production method of an optical member of the present invention.

FIG. 9C is a process diagram for explaining one example of the production method of an optical member of the present invention.

FIG. 9D is a process diagram for explaining one example of the production method of an optical member of the present invention.

FIG. 9E is a process diagram for explaining one example of the production method of an optical member of the present invention.

FIG. 9F is a process diagram for explaining one example of the production method of an optical member of the present invention.

FIG. 10 is a schematic view illustrating one structural example of a production device for the optical member of the present invention.

FIG. 11 is a schematic view illustrating one structural example of a production device for the optical member of the present invention.

FIG. 12 is a cross-sectional view illustrating one structural example of the optical member according to the first embodiment of the present invention.

FIG. 13A is a plan view illustrating one structural example of structures of the optical member according to the second embodiment of the present invention.

FIG. 13B is a cross-sectional view of the structures of the optical member of FIG. 13A cut along the line B-B.

FIG. 13C is a cross-sectional view of the structures of the optical member of FIG. 13A cut along the line C-C.

FIG. 14A is a plan view illustrating one structural example of structures of the optical member according to the second embodiment of the present invention.

FIG. 14B is a cross-sectional view of the structures of the optical member of FIG. 14A cut along the line B-B.

5 FIG. 14C is a cross-sectional view of the structures of the optical member of FIG. 14A cut along the line C-C.

FIG. 15A is a plan view illustrating one structural example of structures of the optical member according to the second embodiment of the present invention.

10 FIG. 15B is a cross-sectional view of the structures of the optical member of FIG. 15A cut along the line B-B.

FIG. 16 is a cross-sectional view illustrating one structural example of the optical member according to the third embodiment of the present invention.

FIG. 17 is a cross-sectional view illustrating one structural example of the optical member according to the fourth embodiment of the present invention.

15 FIG. 18 is a perspective view illustrating one structural example of structures of the optical member according to the fourth embodiment of the present invention.

FIG. 19 is a cross-sectional view illustrating one structural example of the optical member according to the fifth embodiment of the present invention.

20 FIG. 20A is a cross-sectional view illustrating one structural example of the optical member according to the sixth embodiment of the present invention.

FIG. 20B is a cross-sectional view illustrating one structural example of the optical member according to the sixth embodiment of the present invention.

25 FIG. 20C is a cross-sectional view illustrating one structural example of the optical member according to the sixth embodiment of the present invention.

FIG. 21 is a cross-sectional view illustrating one structural example of the optical member according to the seventh embodiment of the present invention.

FIG. 22A is a cross-sectional view illustrating one structural example of the optical member according to the eighth embodiment of the present invention.

FIG. 22B is a cross-sectional view illustrating one structural example of the optical member according to the eighth embodiment of the present invention.

5 FIG. 23 is a cross-sectional view illustrating one structural example of the optical member according to the ninth embodiment of the present invention.

FIG. 24 is a cross-sectional view illustrating one structural example of the optical member according to the ninth embodiment of the present invention.

10 FIG. 25 is a cross-sectional view illustrating one structural example of the optical member according to the tenth embodiment of the present invention.

FIG. 26 is a cross-sectional view illustrating one structural example of the optical member according to the eleventh embodiment of the present invention.

FIG. 27A is a cross-sectional view illustrating a shape of a molding surface of the aluminium mold of Example 1.

15 FIG. 27B is a cross-sectional view illustrating a shape of a molding surface of the aluminium mold of Example 1.

Description of Embodiments

(Optical member)

20 The optical member of the present invention includes a first optical transparent layer, a wavelength-selective reflective layer, a second optical transparent layer, and may further include other layers according to the necessity.
<First optical transparent layer>

25 The first optical transparent layer has convex-concave shapes and is transparent to visible light.

The first optical transparent layer is not particularly limited and may be appropriately selected depending on the intended purpose, as long as the first

optical transparent layer is a support for supporting the wavelength-selective reflective layer.

Examples of a material of the first optical transparent layer include resins, such as thermoplastic resins, active energy ray-curable resins, and thermosetting resins.

In the present specification, the term “convex-concave shapes” means that the first optical transparent layer has convex shapes, or concave shapes, or both. For example, the “convex-concave shapes” include a case where a plurality of convex shapes are formed on a flat surface but concave shapes are not formed on appearance, and a case where a plurality of concave shapes are formed on a flat surface but convex shapes are not formed on appearance.

The first optical transparent layer may have characteristics that the first optical transparent layer absorbs light of a certain wavelength within the visible region for the purpose of giving designs to an optical member or a window material, as long as the absorption of light does not adversely affect transparency of the first optical transparent layer to visible light.

Giving a design, i.e., characteristics that the first optical transparent layer absorbs light having a certain wavelength within the visible region, can be achieved, for example, by adding a pigment to the first optical transparent layer.

The pigment is preferably dispersed in the resin.

The pigment dispersed in the resin is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the pigment include inorganic-based pigments and organic-based pigments. The pigment is particularly preferably an inorganic-based pigment where a pigment itself has high weather resistance.

The inorganic-based pigment is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the

inorganic-based pigment include zircon gray (Co and Ni-doped ZrSiO_4), praseodymium yellow (Pr-doped ZrSiO_4), chrome titanium yellow (Cr and Sb-doped TiO_2 or Cr and W-doped TiO_2), chrome green (Cr_2O_3 etc.), peacock ((CoZn)O(AlCr) $_2\text{O}_3$), Victoria green ((Al, Cr) $_2\text{O}_3$), Prussian blue ($\text{CoO} \cdot \text{Al}_2\text{O}_3 \cdot \text{SiO}_2$),
5 vanadium zircon blue (V-doped ZrSiO_4), chrome in pink (Cr-doped $\text{CaO} \cdot \text{SnO}_2 \cdot \text{SiO}_2$), manganese pink (Mn-doped Al_2O_3), and salmon pink (Fe-doped ZrSiO_4).

The organic-based pigment is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the organic-based pigment include azo-based pigments and phthalocyanine-based
10 pigments.

A shape of the first optical transparent layer is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the shape include a film shape, a sheet shape, a plate shape, and a block shape. The first optical transparent layer has preferably a film shape or a sheet shape
15 considering that a resulting optical member can be easily bonded to a window material.

The first optical transparent layer includes one-dimensionally aligned structures, for example, on a surface of the first optical transparent layer where the wavelength-selective reflective layer is formed. The pitch P of the structures is not
20 particularly limited and may be appropriately selected depending on the intended purpose. The pitch P is preferably 30 μm or greater but 5 mm or less, more preferably 50 μm or greater but 1 mm or less, and particularly preferably 50 μm or greater but 500 μm or less. When the pitch of the structures is less than 30 μm , it is difficult to obtain desired shapes of the structures, and part of transmissive
25 wavelengths may be reflected because it is typically difficult to make wavelength-selective properties of the wavelength-selective reflective layer sharp. When the above-described unintentional reflection is occurred, diffraction occurs

and therefore reflection of high order is visually observed. Therefore, transparency of such an optical member tends to be appeared poor. When the pitch of the structures is greater than 5 mm, moreover, a required film thickness is thick considering shapes of structures necessary for directional reflection, to thereby loose flexibility of a resultant optical member, and therefore it may be difficult to bond such the optical member to a rigid body such as a window material.

A shape of each structure is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the shape include a prism shape, a lenticular shape, a hemispherical shape, and a corner cube shape. In the case where each structure has a prism shape, for example, an inclined angle of the prism-shaped structure is preferably 45° or greater. In the case where an optical member is applied for a window material, the structure preferably has a flat surface or curved surface inclined at 45° or greater, considering that the lager amount of light incident from the sky is reflected and returned back to the sky. Since the structures have the above-described shapes, most of incident light is returned back to the sky with one reflection, the incident light can be efficiently reflected to the direction towards the sky with the wavelength-selective reflective layer that does not have relatively high reflectance, and absorption of light by the wavelength-selective reflective layer can be reduced.

As illustrated in FIG. 1A, moreover, a shape of the structure 11 may be an asymmetric shape relative to perpendicular line l_1 perpendicular to the incident surface S1 of the optical member. In this case, the main axis l_m of the structure is inclined to the aligned direction a of the structure with the perpendicular line l_1 being a standard. In the present specification, the main axis l_m of the structure means a straight line passing through a middle point of the bottom side of the cross-section of the structure 11 and an apex of the structure 11. In the case where the optical member is bonded to a window material arranged perpendicular to the

ground, the main axis l_m of the structure 11 is preferably inclined to the bottom side (the ground side) of the window material with the perpendicular line l_1 being a standard, as illustrated in FIG. 1B. The period that the amount of heat transmitted through windows is large is typically about noon or later, and the angle of the sun is often higher than 45° during this period. Therefore, the light incident from the high angle can be efficiently reflected to the upper side by adapting the shape as illustrated in FIG. 1A. FIGs. 1A and 1B illustrate the examples where the prism-shaped structures 11 are asymmetric relative to the perpendicular line l_1 . Note that, the structures 11 having shapes other than the prism shapes may be used and such the structures 11 for use may be asymmetric to the perpendicular line l_1 . For example, corner cubes may be used and may be asymmetric to the perpendicular line l_1 .

Moreover, one shape of the structures 11 may be used or two or more shapes of the structures 11 may be used in combination. In the case where a plurality of shapes of structures are disposed at a surface of the first optical transparent layer, the structures may be arranged in a manner that the predetermined pattern composed of the plurality of the shapes of the structures is periodically repeated. Moreover, the plurality of shapes of the structures may be randomly (aperiodically) arranged depending on the desired characteristics.

FIGs. 2A to 2C are perspective views illustrating examples of shapes of the structures contained in the first optical transparent layer. The structure 11 is a convex pillar extending one direction. The pillar-shaped structures 11 are one-dimensionally arranged along one direction. Since a wavelength-selective reflective layer is formed on the structures, a shape of the wavelength-selective reflective layer is identical to the surface shape of the structures 11.

In FIGs. 1B, 2A, 2B, and 2C, reference numeral 3 is a wavelength-selective reflective layer, reference numeral 4 is a first optical transparent layer, and

reference numeral 5 is a second optical transparent layer. Hereinafter, the same members are assigned with the same numerical reference in the drawings of the present specification.

<Wavelength-selective reflective layer>

5 The wavelength-selective reflective layer includes at least an amorphous high-refractive-index layer (a high-refractive-index layer that is amorphous), a metal layer, and a crystalline high-refractive-index layer (a high-refractive-index layer that is crystalline).

 The wavelength-selective reflective layer is formed on the convex-concave
10 shapes of the first optical transparent layer.

 The wavelength-selective reflective layer selectively reflects certain wavelengths of infrared light.

 The crystalline high-refractive-index layer is in contact with the second optical transparent layer.

15 For example, the wavelength-selective reflective layer includes the amorphous high-refractive-index layers and the metal layers, which are alternately laminated, and the crystalline high-refractive-index layer disposed to be in contact with the second optical transparent layer.

 When a crystalline high-refractive-index layer, which has been generally
20 used in the art, is formed on the convex-concave shapes of the first optical transparent layer, the high-refractive-index layer does not have a uniform thickness. A metal layer formed on the high-refractive-index layer is not also uniformly formed. Therefore, absorption of sunlight by a resultant optical member is large.

25 As a result of researches diligently conducted by the present inventors, the present inventors have found that a thickness of an amorphous high-refractive-index layer is uniform, a metal layer disposed on the amorphous

high-refractive-index layer is uniformly formed, and absorption of sunlight by a resultant optical member is small, when the amorphous high-refractive-index layer is formed on the convex-concave shapes of the first optical transparent layer.

The present inventors however have confirmed that interlayer adhesion of an optical member that is a laminate structure reduces when a thickness of each layer in the wavelength-selective reflective layer is uniform (i.e., smoothness of each layer is improved).

When the interlayer adhesion of the optical member is low, problems occurs in handling during installation or production, and external appearance and long-term reliability are degraded.

Accordingly, the present inventors have conducted further researches and found that the interlayer adhesion (particularly adhesion between a second optical transparent layer and a crystalline high-refractive-index layer) is improved by using the crystalline high-refractive-index layer as the high-refractive-index layer in contact with the second optical transparent layer, based upon which the present invention has been accomplished.

An average thickness of the wavelength-selective reflective layer is not particularly limited and may be appropriately selected depending on the intended purpose. The average thickness is preferably 20 μm or less, more preferably 5 μm or less, and particularly preferably 1 μm or less. When the average thickness of the wavelength-selective reflective layer is greater than 20 μm , a light path where transmitted light is refracted becomes long and thus a transmission image tends to be seen deformed.

The number of projected areas in the metal layer of the wavelength-selective reflective layer is preferably 10 or less per 200 nm (10/200 nm or less). When the number of the projected areas is greater than 10/200 nm, reflectance may be low influenced by the surface roughness of the metal layer.

The number of the projected areas can be measured by observing a cross-sectional image of the metal layer under a transmission electron microscope (TEM). Specifically, the number of the projected areas is measured by the following method.

5 A cross-sectional image of the metal layer is obtained by TEM. When two straight lines are drawn at the top and the bottom in the metal layer of the cross-sectional image, a standard line is determined as the straight line of the upper side with setting the two straight lines where the area of the metal layer sandwiched between the two straight lines is the maximum value. A partial area
10 of the metal layer projected from the standard line by $1/2$ or greater the thickness of the metal layer is determined as a “projected area.” Then, the number of the projected areas on the standard line having a length of 200 nm in the cross-sectional image is counted. The cross-section observation by TEM is performed at one position on each metal layer in the wavelength-selective reflective
15 layer, and the number of the projected areas per 200 nm in the metal layer which has the largest number of the projected areas is taken as the number of the projected areas.

<<Metal layer>>

A material of the metal layer is not particularly limited and may be
20 appropriately selected depending on the intended purpose. Examples of the material include single metals and alloys.

The single metals are not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the single metals include Au, Ag, Cu, Al, Ni, Cr, Ti, Pd, Co, Si, Ta, W, Mo, and Ge.

25 The alloys are not particularly limited and may be appropriately selected depending on the intended purpose. The alloys are preferably Ag-based materials, Cu-based materials, Al-based materials, Si-based materials, or Ge-based materials,

and more preferably AlCu, AlTi, AlCr, AlCo, AlNdCu, AlMgSi, AgPdCu, AgPdTi, AgCuTi, AgPdCa, AgPdMg, or AgPdFe. Moreover, a material, such as Ti and Nd, is preferably added to the metal layer in order to prevent corrosion of the metal layer. Especially when Ag is used as a material of the metal layer, addition of Ti or Nd to the metal layer is preferable.

An average thickness of the metal layer is not particularly limited and may be appropriately selected depending on the intended purpose. The average thickness is preferably from 5 nm to 85 nm. When the average thickness of the metal layer is less than 5 nm, light is transmitted and not reflected even when a surface of the metal layer is smooth. The metal layer having the average thickness of 85 nm means that transmittance of visible light in the metal layer is about 40%. In the case where the optical member is used as a film bonded to a window, visible light transmittance of the above-mentioned degree may be useful depending on the intended use.

Moreover, the average thickness of the metal layer is more preferably 60 nm or less, more preferably 40 nm or less, and particularly preferably 25 nm or less.

A measuring method of the average thickness of the metal layer is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the measuring method include a cross-section measurement by means of a transmission electron microscope, a measurement by a fluorescent X-ray coating thickness gauge, and X-ray reflectivity.

A formation method of the metal layer is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the formation method include sputtering, vapor deposition, chemical vapor deposition (CVD), dip coating, die coating, wet coating, and spray coating.

<<Amorphous high-refractive-index layer>>

The amorphous high-refractive-index layer is an amorphous

high-refractive-index layer that has a high refractive index in a visible region, and functions as an antireflection layer. A material of the amorphous high-refractive-index layer is not particularly limited and may be appropriately selected depending on the intended purpose, and examples of the material include metal oxides and metal nitrides. The metal oxides are not particularly limited and may be appropriately selected depending on the intended purpose, and examples of the metal oxides include niobium oxide, tantalum oxide, titanium oxide, indium tin oxide, silicon dioxide, cerium oxide, tin oxide, and aluminium oxide. The metal nitrides are not particularly limited and may be appropriately selected depending on the intended purpose, and examples of the metal nitrides include silicon nitride, aluminium nitride, and titanium nitride.

Moreover, a material that tends to be formed into an amorphous film after controlling elements to be added or amounts of elements is preferably used.

Examples of such a material include a complex metal oxide including In_2O_3 and 10% by mass to 40% by mass of CeO_2 relative to the In_2O_3 , a complex metal oxide including In_2O_3 and 3% by mass to 10% by mass of SnO_2 relative to the In_2O_3 , a complex metal oxide including ZnO and 20% by mass to 40% by mass of SnO_2 relative to the ZnO , a complex metal oxide including ZnO and 10% by mass to 20% by mass of TiO_2 relative to the ZnO , In_2O_3 , and Nb_2O_5 .

The amorphous nature of the high-refractive-index layer can be confirmed by obtaining an electron beam diffraction image using a transmission electron microscope (TEM).

For example, the high refractive index means a refractive index of 1.7 or higher.

An average thickness of the amorphous high-refractive-index layer is not particularly limited and may be appropriately selected depending on the intended purpose, but the average thickness is preferably from 10 nm to 200 nm, more

preferably from 15 nm to 150 nm, and particularly preferably from 20 nm to 130 nm.

A formation method of the amorphous high-refractive-index layer is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the formation method include sputtering, vapor deposition, chemical vapor deposition (CVD), dip coating, die coating, wet coating and spray coating.

<<Crystalline high-refractive-index layer>>

The crystalline high-refractive-index layer is a crystalline high-refractive-index layer that has a high refractive index in a visible region, and functions as an antireflection layer. A material of the crystalline high-refractive-index layer is not particularly limited and may be appropriately selected depending on the intended purpose, and examples of the material include metal oxides and metal nitrides. The metal oxides are not particularly limited and may be appropriately selected depending on the intended purpose, and examples of the metal oxides include niobium oxide, tantalum oxide, titanium oxide, indium tin oxide, silicon dioxide, cerium oxide, tin oxide, aluminium oxide, and zinc oxide (ZnO). The metal nitrides are not particularly limited and may be appropriately selected depending on the intended purpose, and examples of the metal nitrides include silicon nitride, aluminium nitride, and titanium nitride.

Moreover, a material that tends to be formed into a crystalline film after controlling elements to be added or amounts of elements is preferably used. Examples of such a material include a complex metal oxide, which includes ZnO, and at least one metal oxide selected from Al_2O_3 and Ga_2O_3 , and in which an amount of the metal oxide in the complex metal oxide is 6% by mass or less relative to the ZnO.

The crystallinity of the high-refractive-index layer can be confirmed by

obtaining an electron beam diffraction image using a transmission electron microscope (TEM).

For example, the high refractive index means a refractive index of 1.7 or higher.

5 An average thickness of the crystalline high-refractive-index layer is not particularly limited and may be appropriately selected depending on the intended purpose, but the average thickness is preferably from 1 nm to 200 nm, more preferably from 5 nm to 100 nm, and particularly preferably from 10 nm to 100 nm.

10 Moreover, the average thickness of the crystalline high-refractive-index layer is preferably 10 nm or greater because excellent interlayer adhesion (particularly adhesion between the crystalline high-refractive-index layer and the second optical transparent layer) is obtained.

15 A formation method of the crystalline high-refractive-index layer is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the formation method include sputtering, vapor deposition, chemical vapor deposition (CVD), dip coating, die coating, wet coating and spray coating.

<Second optical transparent layer>

20 For example, the second optical transparent layer has shapes to fill the convex-concave shapes of the first optical transparent layer.

25 The second optical transparent layer is a layer configured to improve clarity of transmitted images or a total light transmittance, as well as protecting the wavelength-selective reflective layer. A material of the second optical transparent layer is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the material include resins, such as thermoplastic resins (e.g., polycarbonate) and active energy ray-curable resin (e.g., acryl). Moreover, the second optical transparent layer may function as an

adhesive layer, a resulting optical member may have a structure where the optical member is bonded to a window material via the adhesive layer. A material of the adhesive layer is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the material include pressure sensitive adhesives (PSA) and ultraviolet ray-curing resins.

The second optical transparent layer may have characteristics that the second optical transparent layer absorbs light of a certain wavelength within the visible region for the purpose of giving designs to an optical member or a window material, as long as the absorption of light does not adversely affect transparency of the second optical transparent layer to visible light.

Giving a design, i.e., characteristics that the second optical transparent layer absorbs light having a certain wavelength within the visible region, can be achieved, for example, by adding a pigment to the second optical transparent layer.

The pigment is preferably dispersed in the resin.

The pigment dispersed in the resin is not particularly limited and may be appropriately selected depending on the intended purpose, and examples of the pigment include the pigments listed as examples in the descriptions of the first optical transparent layer.

A difference in a refractive index between the first optical transparent layer and the second optical transparent layer is not particularly limited and may be appropriately selected depending on the intended purpose, but the difference is preferably 0.010 or less, more preferably 0.008 or less, and particularly preferably 0.005 or less. When the difference in the refractive index is greater than 0.010, a transmitted image may appear blurred. When the difference in the refractive index is greater than 0.008 but 0.010 or less, there is no problem with lighting in ordinary life although it depends on brightness of outside. When the difference in the refractive index is greater than 0.005 but 0.008 or less, outer sceneries can be

clearly seen although diffraction patterns are observed on only extremely blight objects, such as light sources. Diffraction patterns are almost unnoticeable when the difference in the refractive index is 0.005 or less. Among the first optical transparent layer and the second optical transparent layer, the optical transparent layer disposed at the side of the optical member to be bonded, such as the side bonded with window material, may contain a pressure sensitive adhesive as a main component. Since the optical transparent layer has the above-described structure, the optical member can be bonded to a window material, etc. with the optical transparent layer containing the pressure sensitive adhesive as a main component.

The first optical transparent layer and the second optical transparent layer preferably have the same optical properties, such as a refractive index. More specifically, the first optical transparent layer and the second optical transparent layer are composed of the same material having transparency in the visible region. The refractive indexes of the first optical transparent layer and the second optical transparent layer can be made identical by forming the first optical transparent layer and the second optical transparent layer using the same material, and therefore transparency of the optical member with visible light can be improved. However, attentions should be paid because a refractive index of a final film may be different depending on curing conditions in film forming process, even though the formation of the film is started with the same material. When the first optical transparent layer and the second optical transparent layer are formed using mutually different materials, on the other hand, refractive indexes of the first optical transparent layer and the second optical transparent layer are different. Therefore, light is refracted at the wavelength-selective reflective layer as a boundary, and a transmission image tends to be blurred. Particularly, there is a problem that a diffraction pattern is significantly observed when an object close to a point light source, such as an electric light, present far.

The first optical transparent layer and the second optical transparent layer preferably have transparency in the visible light region. In the present specification, the definition of transparency has two meanings. One is that absorption of light is small, and the other is that scattering of light is small. The transparency typically denotes only the former, but the transparency preferably denotes the both in the present invention. Currently used retroreflectors, such as road signs and night-shift work clothes, aim to visualize displayed reflected light, and therefore the reflected light can be visualized as long as the retroreflectors are in contact with the underlying reflectors, even though the retroreflectors have, for example, scattering. This is the same principle to, for example, that an image can be visualized even when antiglare treatment is performed on a front surface of an image display device for the purpose of providing anti-glare properties. However, the optical member of the present invention is characterized in that the optical member passes through light other than light having a certain wavelength range that causes directional reflection, the optical member is adhered to a transparent body that mainly transmits the transmissive wavelengths to observe the transmitted light. Therefore, it is necessary that there is no scattering of light. However, scattering properties can be intentionally applied only to the second optical transparent layer depending on the intended use.

<Other layers>

The above-mentioned other layers are not particularly limited and may be appropriately selected depending on the intended purpose, and examples of other layers include a functional layer.

<<Functional layer>>

The functional layer is not particularly limited and may be appropriately selected depending on the intended purpose, as long as the functional layer is a layer containing, as a main ingredient, a chromic material that reversibly changes

reflection characteristics upon application of external stimula.

The chromic material is not particularly limited and may be appropriately selected depending on the intended purpose, as long as the chromic material is a material that reversibly changes a structure upon application of external stimula, such as heat, light, and penetrating molecules. Examples of the chromic material include photochromic materials, thermochromic materials, and electrochromic materials.

An arrangement position of the functional layer is not particularly limited and may be appropriately selected depending on the intended purpose.

The optical member has transparency. The transparency is preferably transparency having the range of the below-described clarity of transmitted images.

The optical member is preferably used by bonding to a rigid body (e.g., a window material) having transparency to mainly light, which is other than light having a certain wavelength range, transmitted via a pressure sensitive adhesive. The window material is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the window material include window materials for building, such as skyscrapers and houses, and window materials for vehicles. In the case where the optical member is applied for the window material for buildings, the optical member is particularly preferably applied for a window material arranged towards any of the directions between east and west via south (e.g., south east to south west). Since the window material is applied at the aforementioned position, heat rays can be more effectively reflected. The optical member can be used not only on a single-layer glass window, but also on special glass, such as multi-layer glass. Moreover, the window material is not limited to a material formed of glass, and a material formed of a polymer material having transparency may be used as the window material. When the first optical

transparent layer and the second optical transparent layer have transparency in the visible light region, visible light is transmitted, and light collection can be secured from sunlight in the case where the optical member is bonded to the window material, such as a glass window. Moreover, a surface to which the optical member is bonded is not only an outer surface of glass but also an inner surface of glass. In the case where the optical member is bonded to the inner surface of the glass, the optical member needs to be bonded in the manner that the front and back of the convex and concave of structures and the in-plane direction are aligned to make the directional reflection direction the predetermined direction.

The optical member preferably has flexibility considering that the optical member can be easily bonded to a window material. A shape of the optical member is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the shape include a film shape, a sheet shape, a plate shape, and a block shape. However, the shape of the optical member is not limited to the above-listed examples.

Moreover, the optical member can be used in combination with other heat ray-cut films. For example, a light-absorbing film can be disposed at an interface between the air and the first optical transparent layer. Moreover, the optical member can be also used in combination with a hard coating layer, a UV-cut layer, or a surface antireflection layer. In the case where these functional layers are used in combination, these functional layers are preferably disposed at an interface between the optical member and the air. However, the UV-cut layer needs to be disposed closer to the side of sun than the optical member. In the case where the optical member is bonded to an inner surface of a glass window for outdoor or indoor use, particularly, the UV-cut layer is desirably disposed between the inner surface of the glass window and the optical member. In this cases, an ultraviolet ray-absorbing agent may be kneaded into a pressure sensitive adhesive layer

between the surface of the glass window and the optical member.

Moreover, color may be applied to the optical member depending on the intended use of the optical member to give a design to the optical member. In the case where a design is provided as described, the optical member preferably has a structure where the optical transparent layer absorbs only light having a certain wavelength range as long as transparency of the optical member is not impaired.

<Functions of optical member>

FIGs. 3 and 4 are cross-sectional views for explaining one example of functions of the optical member. In the present specification, a case where a shape of each structure is a prism shape having an inclined angle of 45° is taken as an example, and such an example is explained.

As illustrated in FIG. 3, among the sunlight incident to the optical member 1, whereas part of light L₁ reflecting to the sky is reflected directionally to the direction of the sky similar to the incident direction, light L₂ not reflecting to the sky, transmits the optical member 1.

As illustrated in FIG. 4, moreover, light, which incidents on the optical member 1 and is reflected with a reflective film surface of the wavelength-selective reflective layer 3, is separated into light L₁ reflecting to the sky and light L₂ not reflecting to the sky at a ratio depending on the incident angle. The light L₂ not reflecting to the sky is totally reflected at an interface between the second optical transparent layer 5 and the air, then finally reflected to the direction different from the incident direction.

When the incident angle of light is α , the refractive index of the first optical transparent layer 4 is n , and the reflectance of the wavelength-selective reflective layer is R , a ratio x of the light L₁ reflecting to the sky relative to the total incident components is represented by the following formula (1).

$$x = (\sin(45 - \alpha') + \cos(45 - \alpha')/\tan(45 + \alpha'))/(\sin(45 - \alpha') + \cos(45 - \alpha')) \times R^2$$

Formula (1)

With the proviso that, $\alpha' = \sin^{-1}(\sin\alpha/n)$

As the ratio of the light L_1 not reflecting to the sky increases, the ratio of the incident light reflecting to the sky decreases. In order to improve the ratio of the light reflecting to the sky, it is effective to modify the shape of the wavelength-selective reflective layer 3, namely, the shapes of the structures of the first optical transparent layer 4. In order to improve the ratio of the light reflecting to the sky, for example, the shapes of the structures 11 are cylindrical shapes illustrated in FIG. 2C, or asymmetric shapes illustrated in FIGs. 1A and 1B. Since the structures have the above-mentioned shapes, the ratio of the light reflecting to the upper side relative to the light incident on a window material for buildings from the upper side can be increased even through the light cannot be reflected to the identical direction to the incident light. The two shapes illustrated in FIGs. 2C, 1A and 1B can achieve that the number of reflections of the incident light with the wavelength-selective reflective layer 3 is once, as illustrated in FIGs. 5 and 6. Therefore, the final reflection component can be increased compared to the shapes with which light is reflected twice as illustrated in FIG. 3. In the case where the material that reflects light twice is used, for example, the reflectance to the sky is 64%, when the reflectance of the wavelength-selective reflective layer to the certain wavelengths is 80%. If the reflection occurs only once, the reflectance to the sky becomes 80%.

FIGs. 7A and 7B illustrate a relationship between the ridge line l_3 of a pillar-shaped structure, incident light L , and light L_1 reflected to the sky. The optical member preferably transmits light L_2 not reflecting to the sky, amount the incident light L incident on the incident surface $S1$ at the incident angle (θ, ϕ) , whereas the optical member selectively directionally reflects light L_1 reflecting to the sky in the direction of $(\theta_0, -\phi)$ ($0^\circ < \theta_0 < 90^\circ$). Since the above-described

relationship is satisfied, light having a certain wavelength range can be reflected to the sky direction. Note that, θ is an angle formed between the perpendicular line l_1 relative to the incident surface S1 and the incident light L or the light L_1 reflecting to the sky; and ϕ is an angle formed between the straight line l_2 orthogonal to the ridge line l_3 of the pillar-shaped structure within the incident surface S1, and the incident light L or a component obtained by projecting the light L_1 reflecting to the sky onto the incident surface S1. Note that, the angle θ rotated clockwise with the perpendicular line l_1 as the standard is determined as “+ θ ,” and the angle θ rotated anticlockwise with the perpendicular line l_1 is determined as “- θ ”; and the angle ϕ rotated clockwise with the straight line l_2 as the standard is determined as “+ ϕ ” and the angle ϕ rotated anticlockwise with the straight line l_2 as the standard is determined as “- ϕ .”

FIG. 8 is a perspective view illustrating the relationship between the incident light entering the optical member 1 and the reflected light reflected by the optical member. The optical member has the incident surface S1 on which the incident light L is applied. The optical member 1 transmits the light L_2 not reflecting to the sky among the incident light L incident on the incident surface S1 at the incident angle (θ, ϕ) , whereas the optical member 1 selectively directionally reflect the light L_1 reflecting to the sky to the direction other than the direction of regular reflection $(-\theta, \phi + 180^\circ)$. Moreover, the optical member 1 has transparency to light other than the light having the certain wavelength range. The transparency is preferably transparency having the below-mentioned range of clarity of transmitted images. Note that, θ is an angle formed between the perpendicular line l_1 relative to the incident surface S1 and the incident light L or the light L_1 reflecting to the sky; and ϕ is an angle formed between the certain straight line l_2 within the incident surface S1, and the incident light L or a component obtained by projecting the light L_1 reflecting to the sky onto the incident

surface S1. In the present specification, the certain straight l_2 within the incident surface is an axis with which the reflection intensity to the direction of ϕ becomes the maximum, when the incident angle (θ, ϕ) is fixed, and the optical member is rotated using the perpendicular line l_1 relative to the incident surface S1 of the optical member as an axis (see FIGs. 1A to 1B, and FIGs. 2A to 2C). In the case where there are plurality of axes (directions) with which the reflection intensity becomes the maximum, one of the axis is selected as the straight line l_2 . Note that, the angle θ rotated clockwise with the perpendicular line l_1 as the standard is determined as “+ θ ,” and the angle θ rotated anticlockwise with the perpendicular line l_1 is determined as “- θ ”; and the angle ϕ rotated clockwise with the straight line l_2 as the standard is determined as “+ ϕ ” and the angle ϕ rotated anticlockwise with the straight line l_2 as the standard is determined as “- ϕ .”

The light having a certain wavelength range, which is selectively directionally refracted, and the certain light transmitted are different depending on the intended use of the optical member. In the case where the optical member is applied for a window material, for example, the light having a certain wavelength range, which is directionally reflected, is preferably near infrared light, and the light having a certain wavelength, which is transmitted, is preferably visible light. Specifically, the light having a certain wavelength range, which is selectively directionally reflected, is preferably near infrared light having a main wavelength range of 780 nm to 2,100 nm. Since the near infrared rays are reflected, an increase in a temperature within a building can be prevented, when the optical member is bonded to a window material, such as a glass window. Accordingly, loads of air conditioners can be reduced, and energy saving can be achieved. In the present specification, the directional reflection means that the intensity of the reflected light to the certain direction other than regular reflection is stronger than the intensity of regularly reflected light, and is sufficiently stronger than the

intensity of diffuse reflection with no directivity. In the present specification, to reflect means that the reflectance in the certain wavelength range, such as the near infrared range, is preferably 30% or greater, more preferably 50% or greater, and even more preferably 80% or greater. To transmit means that the transmittance
5 in the certain wavelength range, such as the visible range, is preferably 30% or greater, more preferably 50% or greater, and even more preferably 70% or greater.

The direction ϕ_0 of the directional reflection with the optical member is preferably -90° or greater but 90° or less. This is because the light having the certain wavelength range among the light incident from the sky can be returned to
10 the sky direction, when the optical member is bonded to a window material. In the case where there is no tall buildings in the surrounding area, the optical member having the above-mentioned range is effective. Moreover, the direction of the directional reflection with the optical member is preferably adjacent to $(\theta, -\phi)$. The adjacent is preferably within 5 degrees, more preferably within 3 degrees, and
15 particularly preferably within 2 degrees from $(\theta, -\phi)$. Since the direction of the directional reflection is within the above-mentioned range, among the light incident from the sky of a building in the area where the buildings of similar heights are present, the light having the certain wavelength range can be efficiently return back to the sky of other buildings, when the optical member is bonded to a window
20 material. In order to the above-mentioned directional reflection, three-dimensional structures, such as spherical surfaces, part of hyperboloids, triangular pyramids, square pyramids, and cones, are preferably used as the structures. The light incident from the (θ, ϕ) direction ($-90^\circ < \phi < 90^\circ$) can be reflected to the (θ_0, ϕ_0) direction ($0^\circ < \theta_0 < 90^\circ, -90^\circ < \phi_0 < 90^\circ$) depending on the
25 shapes of the structures. Alternatively, the structures are preferably pillars extending along one direction. The light incident from the (θ, ϕ) direction ($-90^\circ < \phi < 90^\circ$) can be reflected to the $(\theta_0, -\phi)$ direction ($0^\circ < \theta_0 < 90^\circ$) depending on the

inclined angle of the pillar.

The directional reflection of the light having a certain wavelength range with the optical member is preferably the direction adjacent to retroreflection (specifically, the reflection direction of the light having a certain wavelength range is adjacent (θ, ϕ) , relative to the light incident on the incident surface S1 at the incident angle (θ, ϕ)). This is because the optical member can return the light having a certain wavelength range to the sky among the light incident from the sky, when the optical member is bonded to a window material. In the present specification, the adjacent is preferably within 5 degrees, more preferably within 3 degrees, and particularly preferably within 2 degrees. Since the direction is within the above-mentioned range, the light having a certain wavelength range can be efficiently returned to the sky among the light incident from the sky, when the optical member is bonded to a window materials. Moreover, in the case where an infrared light irradiation unit and a light receiving unit are adjacent to each other, such as infrared sensors or infrared imaging devices, a retroreflection direction needs to be identical to an incident direction. In the case where it is not necessary to perform sensing from a certain direction, as in the present invention, the retroreflection direction and the incident direction do not need to be strictly the same direction.

A value of the optical member when an optical comb of 0.5 mm is used to determine clarity of a transmitted image with light having a wavelength range having transparency is not particularly limited and may be appropriately selected depending on the intended purpose, but the value is preferably 50 or greater, more preferably 60 or greater, and particularly preferably 75 or greater. When the value of the clarity of the transmitted image is less than 50, the transmission image tends to be seen blurred. When the value of the clarity of the transmitted image is 50 or greater but less than 60, there is no problem with lighting in ordinary life although

it depends on brightness of outside. When the value of the clarity of the transmitted image is 60 or greater but less than 75, outer sceneries can be clearly seen although diffraction patterns are observed on only extremely blight objects, such as light sources. When the value of the clarity of the transmitted image is 75 or greater, diffraction patterns are almost unnoticeable. Furthermore, a total value of the clarity of the transmitted image measured using the optical combs of 0.125 mm, 0.5 mm, 1.0 mm, and 2.0 mm is not particularly limited and may be appropriately selected depending on the intended purpose, but the total value is preferably 230 or greater, more preferably 270 or greater, and particularly preferably 350 or greater. When the total value of the clarity of the transmitted image is less than 230, the transmission image tends to appear blurred. When the total value of the clarity of the transmitted image is 230 or greater but less than 270, there is no problem with lighting in ordinary life although it depends on brightness of outside. When the total value of the clarity of the transmitted image is 270 or greater but less than 350, outer sceneries can be clearly seen although diffraction patterns are observed on only extremely blight objects, such as light sources. When the total value of the clarity of the transmitted image is 350 or greater, diffraction patterns are almost unnoticeable. In the present specification, the value of the clarity of the transmitted image is a value measured by means of ICM-1T available from Suga Test Instruments Co., Ltd. according to JIS K7105. In the case where the wavelength to be transmitted is different from a wavelength of a light source D65, the measurement is preferably performed after calibrating the light using a filter for a wavelength to be transmitted.

The haze of the optical member to the light having the wavelength range having transparency is not particularly limited and may be appropriately selected depending on the intended purpose, but the haze is preferably 6% or less, more preferably 4% or less, and particularly preferably 2% or less. When the haze is

greater than 6%, the transmitted light is scattered, and the optical member appears cloudy. In the present specification, the haze is a value measured using HM-150 available from MURAKAMI COLOR RESERCH LABORATORY according to the measuring method specified in JIS K7136. In the case where the wavelength to be transmitted is different from a wavelength of a light source D65, the measurement is preferably performed after calibrating the light using a filter for a wavelength to be transmitted.

The incident surface S1 of the optical member, preferably the incident surface S1 and the light-emitting surface S2 of the optical member, preferably have a degree of smoothness that does not reduce the clarity of the transmitted image. Specifically, the arithmetic average roughness Ra of the incident surface S1 and the light-emitting surface S2 is not particularly limited and may be appropriately selected depending on the intended purpose, but the arithmetic average roughness Ra is preferably 0.08 μm or less, more preferably 0.06 μm or less, and particularly preferably 0.04 μm or less. Note that, the arithmetic average roughness Ra is a value obtained by measuring surface roughness of the incident surface, obtaining a roughness curve from the two-dimensional cross-section curve, and calculating as a roughness parameter. Note that, the measuring conditions are according to JIS B0601:2001. The measuring device and measuring conditions are described below.

Measuring device: automatic microfigure measuring instrument (SURFCORDER ET4000A, available from Kosaka Laboratory Ltd.)

$\lambda_c = 0.8 \text{ mm}$, evaluation length: 4 mm, cut-off: $\times 5$

data sampling gap: 0.5 μm

The transmission color of the optical member is preferably as neutral as possible, and even when the optical member is tinted, the transmission color is preferably a pale color tone, such as blue, blueish green, and green, which gives refreshing feeling. In order to obtain the above-mentioned color tone, chromaticity

coordinates x and y of the transmitted light entered from the incident surface S1, passed through the optical transparent layer and the wavelength-selective reflective layer, and emitted from the light-emitting surface S2, and the reflected light, for example, by radiation of the D65 light source, is not particularly limited and may be appropriately selected depending on the intended purpose, but the chromaticity coordinates are preferably $0.20 < x < 0.35$ and $0.20 < y < 0.40$, more preferably $0.25 < x < 0.32$ and $0.25 < y < 0.37$, and particularly preferably $0.30 < x < 0.32$ and $0.30 < y < 0.35$. In order to avoid a reddish color tone, the chromaticity coordinates are preferably $y > x - 0.02$, and more preferably $y > x$. If a color tone of reflection changes depending on an incident angle, for example in the case where the optical member is applied for a window of a building, the color tone is different depending on a location, and the color seen by people changes as the people walk. Therefore, such change of color tone is not preferable. In view of preventing the change of color tone, an absolute value of a difference in the color coordinate x and an absolute value of difference in the color coordinate y of the regularly reflected light, which enters from the incident surface S1 or light-emitting surface S2 at an incident angle θ of 0° or greater but 60° or less and reflected by the first optical transparent layer, the second optical transparent layer, and the wavelength-selective reflective layer are not particularly limited and may be appropriately selected depending on the intended purpose on the both surfaces of the optical member, but the absolute values are preferably 0.05 or less, more preferably 0.03 or less, and particularly preferably 0.01 or less. The above-described numeral ranges associates with the color coordinates x and y of the reflected light are desirably satisfied on both surfaces of the incident surface S1 and the light-emitting surface S2.

(Production method of optical member)

A production method of an optical member associated with the present

invention includes at least a first optical transparent layer forming step, a wavelength-selective reflective layer forming step, and a second optical transparent layer forming step, and may further include other steps according to the necessity.

<First optical transparent layer forming step>

5 The first optical transparent layer forming step is not particularly limited and may be appropriately selected depending on the intended purpose, as long as the first optical transparent layer forming step is a step including forming a first optical transparent layer having convex-concave structures. Examples of the first optical transparent layer forming step includes a step including forming a first
10 optical transparent layer having convex-concave structures using a mold having identical or reverse shapes of the convex-concave shapes.

<Wavelength-selective reflective layer forming step>

 The wavelength-selective reflective layer forming step is not particularly limited and may be appropriately selected depending on the intended purpose, as
15 long as the wavelength-selective reflective layer forming step is a step including forming a wavelength-selective reflective layer on the first optical transparent layer.

 In the wavelength-selective reflective layer forming step, for example, an amorphous high-refractive-index layer and a crystalline high-refractive-index layer
20 are formed by sputtering.

 In order to make a formed high-refractive-index layer amorphous in sputtering, sputtering is performed by setting a temperature of the first optical transparent layer to 60°C or lower. A method for setting the temperature of the first optical transparent layer to 60°C or lower is not particularly limited and may
25 be appropriately selected depending on the intended purpose. Examples of the method include a method, in which the first optical transparent layer is supported by a supporting member (e.g., a roll) whose temperature is adjusted to 60°C or

lower. In the process above, the temperature condition, 60°C or lower, may be a temperature of the supporting member.

Note that, when a high-refractive-index layer is formed by using a material having a low crystallization temperature, such as ZnO, the obtained high-refractive-index layer becomes crystalline even though the temperature condition is 60°C or lower.

<Second optical transparent layer forming step>

The second optical transparent layer forming step is not particularly limited and may be appropriately selected depending on the intended purpose, as long as the second optical transparent layer forming step is a step including forming a second optical transparent layer on the wavelength-selective reflective layer. Examples of the second optical transparent layer forming step include a step including applying an active energy curable resin onto the wavelength-selective reflective layer, and curing the active energy curable resin.

One example of the production method of the optical member is explained with reference to drawings.

First, a mold, which has been processed by cutting using a cutting tool or laser processing to have identical or reverse shapes of convex shapes of structures 11 is provided.

Next, the convex shapes of the mold are transferred to a film-shaped or sheet-shaped resin material, for example, by melt extrusion, or transferring. Examples of the transferring include: a method where an active energy ray-curable resin composition is flown into a mold, and active energy rays are applied to cure the active energy ray-curable resin composition; and a method where heat or pressure is applied to a resin to transfer shapes. As a result, a first optical transparent layer 4 having structures 11 on a main surface of the first optical transparent layer 4 is formed as illustrated in FIG. 9A.

Next, a wavelength-selective reflective layer 3 is formed on a main surface of the first optical transparent layer 4 as illustrated in FIG. 9B. Examples of a formation method of a metal layer of the wavelength-selective reflective layer 3 include sputtering, vapor deposition, chemical vapor deposition (CVD), dip coating, die coating, wet coating, and spray coating. Examples of a formation method of a high-refractive-index layer of the wavelength-selective reflective layer 3 include sputtering. In the sputtering, for example, an amorphous high-refractive-index layer and a crystalline high-refractive-index layer are formed at 60°C or lower.

Next, a base 5a is arranged above the wavelength-selective reflective layer 3 to form a nip as illustrated in FIG. 9C.

Next, a resin 5b', which is an active energy ray-curable resin, is supplied into the nip, as illustrated in FIG. 9D.

Next, UV light is applied to the resin 5b' over the base 5a by means of a light source 23 to cure the resin 5b', as illustrated in FIG. 9D.

As a result, a second optical transparent layer 5 having a smooth surface is formed on the wavelength-selective reflective layer 3, as illustrated in FIG. 9F.

As described above, the optical member, in which the wavelength-selective reflective layer 3 of the predetermined shape is disposed, is obtained.

Another example of the production method of an optical member is described.

First, a mold processed by cutting using a cutting tool or laser processing to have identical or reverse shapes of convex shapes of structures is provided.

Next, the convex shapes of the mold are transferred to a film-shaped or sheet-shaped resin material by melt extrusion, or transferring. Examples of the transferring method include: a method where an active energy ray-curable resin composition is flown into a mold, and active energy rays are applied to cure the active energy ray-curable resin composition; and a method where heat or pressure

is applied to a resin to transfer shapes. As a result, a first optical transparent layer having convex-shaped structures on a main surface of the first optical transparent layer is formed.

A first optical transparent layer with a wavelength-selective reflective layer is produced by means of a production device illustrated in FIG. 11 in the following manner.

The production device illustrated in FIG. 11 is a production device for sputtering, and contains a feed roll 101, a support roll 102, a wind-up roll 103, and a sputtering target 104.

A long first optical transparent layer 4 is sent out to the support roll 102 in the state that the first optical transparent layer 4 is in contact with the feed roll 101, and is subjected to sputtering using the sputtering target 104 in the state that the first optical transparent layer 4 is in contact with the support roll 102 to thereby form a high-refractive-index layer on the convex shapes (structures) of the first optical transparent layer 4. During the formation of the high-refractive-index layer, a temperature of the support roll 102 was set to 60°C or lower, to thereby form the high-refractive-index layer in an amorphous state. The first optical transparent layer 4 to which the amorphous high-refractive-index layer has been formed is transported to the wind-up roll 103 via the support roll 102, and then wound up.

Moreover, a metal layer and an amorphous high-refractive-index layer are alternately laminated in the above-described manner. Furthermore, a crystalline high-refractive-index layer is formed as an outermost layer of the wavelength-selective reflective layer, to thereby form a wavelength-selective reflective layer 3 on the first optical transparent layer 4.

Subsequently, an optical member 1 is produced using the production device illustrated in FIG. 10 in the following manner.

First, the structure of the production device is described. The production device contains a feed roll 51, a feed roll 52, a wind-up roll 53, laminate rolls 54 and 55, guide rolls 56 to 60, a coating device 61, and an irradiation device 62.

Around the feed roll 51 and the feed roll 52, a strip of a base 5a and a strip of a first optical transparent layer with a wavelength-selective reflective layer 9 are respectively wound up in the form of rolls. The feed rolls 51 and 52 are disposed in a manner that the base 5a and the first optical transparent layer with a wavelength-selective reflective layer 9 can be continuously sent out by the guide rolls 56 and 57. In FIG. 10, the arrow indicates a direction to which the base 5a and the first optical transparent layer with a wavelength-selective reflective layer 9 are transported. The first optical transparent layer with a wavelength-selective reflective layer 9 is a first optical transparent layer, in which a wavelength-selective reflective layer is formed on convex shapes (structures) of the first optical transparent layer.

The wind-up roll 53 is disposed in a manner that the wind-up roll 53 can wind up a strip of the optical member 1 produced by this production device. The laminate rolls 54 and 55 are disposed in a manner that the laminate rolls 54 and 55 can nip the first optical transparent layer with a wavelength-selective reflective layer 9 sent from the feed roll 52 and the base 5a sent from the feed roll 51. The guide rolls 56 to 60 are disposed in a transporting path within the production device in a manner that a strip of the first optical transparent layer with a wavelength-selective reflective layer 9, a strip of the base 5a, and a strip of the optical member 1 can be transported. Materials of the laminate rolls 54 and 55, and the guide rolls 56 to 60 are not particularly limited, metals, such as stainless steel, rubbers, or silicones are appropriately selected as the materials depending on the desired properties of the rolls.

As the coating device 61, for example, a device including a coating unit, such

as coater, can be used. As the coater, for example, a coater, such as a gravure coater, a wire bar coater, and a die coater, can be appropriately used considering physical properties of a resin composition to coat. Examples of the irradiation device 62 includes irradiation devices applying active energy rays, such as electron beams, ultraviolet rays, visible rays, and gamma rays.

Subsequently, a production method of an optical member using the above-described production device is described.

First, a base 5a is sent out from the feed roll 51. The base 5a sent out passes through below the coating device 61 via the guide roll 56. Next, an active energy ray-curable resin is applied on the base 5a passing through below the coating device 61, by means of the coating device 61. Next, the base 5a, on which the active energy ray-curable resin has been applied, is transported towards the laminate roll. Meanwhile, a first optical transparent layer with a wavelength-selective reflective layer 9 is sent out from the feed roll 52, and is transported towards the laminate rolls 54 and 55 via the guide roll 57.

Next, the transported base 5a and first optical transparent layer with a wavelength-selective reflective layer 9 are nipped together with the laminate rolls 54 and 55 not to include air bubbles between the base 5a and the first optical transparent layer with a wavelength-selective reflective layer 9, to laminate the first optical transparent layer with a wavelength-selective reflective layer 9 on the base 5a. Next, the base 5a, on which the first optical transparent layer with a wavelength-selective reflective layer 9 has been laminated, is transported along the peripheral surface of the laminate roll 55, and at the same time, active energy rays are applied on the active energy ray-curable resin from the side of the base 5a by means of the irradiation device 62 to cure the active energy ray-curable resin. As a result, the base 5a and the first optical transparent layer with a wavelength-selective reflective layer 9 are bonded together with a resin layer

(referred to as a resin layer 5b hereinafter) that is a cured product of the active energy ray-curable resin to thereby produce a target optical member 1. Next, a strip of the produced optical member 1 is transported to the wind-up roll 53 via the guide rolls 58, 59, and 60, and the optical member 1 is wound up with the wind-up roll 53.

The base and the resin layer mentioned in the production method of an optical member are specifically described below.

<<Base>>

A shape of the base 4a is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the shape include a film shape, a sheet shape, a plate shape, and a block shape. As a material of the base 4a, a conventional polymer material can be used. The conventional polymer is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the polymer material include triacetyl cellulose (TAC), polyester (TPEE), polyethylene terephthalate (PET), polyimide (PI), polyamide (PA), aramid, polyethylene (PE), polyacrylate, polyether sulfone, polysulfone, polypropylene (PP), diacetyl cellulose, polyvinyl chloride, acrylic resins (PMMA), polycarbonate (PC), epoxy resins, urea resins, urethane resins, and melamine resins. An average thickness of each of the base 4a and the base 5a is not particularly limited and may be appropriately selected depending on the intended purpose. The average thickness is preferably from 38 μm to 100 μm in view of productivity. The base 4a or the base 5a preferably has transparency to active energy rays. As a result, an active energy ray-curable resin can be cured, when active energy rays are applied to the active energy ray-curable resin present between the base 4a or the base 5a, and the wavelength-selective reflective layer 3 from the side of the base 4a or the base 5a.

<<Resin layer>>

For example, the resin layer 4b and the resin layer 5b have transparency.

For example, the resin layer 4b is obtained by curing a resin composition between the base 4a and the wavelength-selective reflective layer 3. For example, the resin layer 5b is obtained by curing a resin composition between the base 5a and the wavelength-selective reflective layer 3. The resin composition is not particularly limited and may be appropriately selected depending on the intended purpose. In view of easiness of production, the resin composition is preferably an active energy ray-curable resin that can be cured by light or electron beams, or a heat-curable resin that can be cured by heat. The active energy ray-curable resin is not particularly limited and may be appropriately selected depending on the intended purpose, but the active energy ray-curable resin is preferably a photosensitive resin composition that can be cured by light, and more preferably an ultraviolet ray-curable resin composition that can be cured by ultraviolet rays.

The resin composition preferably further contains a phosphoric acid-containing compound, a succinic acid-containing compound, and a butyrolactone-containing compound for the purpose of improving adhesion between the resin layer 4b or the resin layer 5b and the wavelength-selective reflective layer 3. The phosphoric acid-containing compound is not particularly limited and may be appropriately selected depending on the intended purpose, but the phosphoric acid-containing compound is preferably phosphoric acid-containing (meth)acrylate, and more preferably a (meth)acryl monomer or oligomer containing phosphoric acid in a functional group. The succinic acid-containing compound is not particularly limited and may be appropriately selected depending on the intended purpose, but the succinic acid-containing compound is preferably succinic acid-containing (meth)acrylate, and more preferably a (meth)acryl monomer or oligomer having succinic acid in a functional group. The butyrolactone-containing compound is not particularly limited and may be appropriately selected depending on the intended

purpose, but the butyrolactone-containing compound is butyrolactone-containing (meth)acrylate, preferably a (meth)acryl monomer having butyrolactone in a functional group. At least one of the resin layer 4b and the resin layer 5b contains a functional group having high polarity, and an amount of the functional group in the resin layer 4b is preferably different from an amount of the functional group in the resin layer 5b. Both the resin layer 4b and the resin layer 5b contains a phosphoric acid-containing compound, and an amount of the phosphoric acid-containing compound in the resin layer 4b is preferably different from an amount of the phosphoric acid-containing compound in the resin layer 5b. The amount of the phosphoric acid is preferably different twice or more, more preferably 5 times or more, and particularly preferably 10 times or more between the resin layer 4b and the resin layer 5b.

In the case where at least one of the resin layer 4b and the resin layer 5b contains a phosphoric acid-containing compound, the wavelength-selective reflective layer 3 preferably contains an oxide, nitride, or oxynitride at a surface being in contact with the resin layer 4b or resin layer 5b containing the phosphoric acid-containing compound. The wavelength-selective reflective layer 3 particularly preferably has a thin film containing oxide of zinc at a surface being in contact with the resin layer 4b or resin layer 5b containing the phosphoric acid-containing compound.

Ingredients of the ultraviolet ray-curable resin composition are not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the ingredients include (meth)acrylate and a photopolymerization initiator. Moreover, the ultraviolet ray-curable resin composition may optionally further contain a photostabilizer, a flame retardant, a leveling agent, and an antioxidant.

As the (meth)acrylate, a monomer and/or oligomer having 2 or more

(meth)acryloyl groups is preferably used. The monomer and/or oligomer is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the monomer and/or oligomer include urethane (meth)acrylate, epoxy (meth)acrylate, polyester (meth)acrylate, polyol (meth)acrylate, polyether (meth)acrylate, and melamine (meth)acrylate. In the present specification, the (meth)acryloyl group means either an acryloyl group or a methacryloyl group. In the present specification, the oligomer means a molecule having a molecular weight of 500 or greater but 60,000 or smaller.

The photopolymerization initiator is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the photopolymerization initiator include benzophenone derivatives, acetophenone derivatives, and anthraquinone derivatives. The above-listed compounds may be used alone or in combination. A blending amount of the polymerization initiator is not particularly limited and may be appropriately selected depending on the intended purpose, but the blending amount is preferably 0.1% by mass or greater but 10% by mass or less in the solids. When the blending amount is less than 0.1% by mass, light curability is low, and it is not substantially suitable for industrial productions. When the blending amount is greater than 10% by mass, on the other hand, odor tends to be remained on a coating film in the case where an irradiation dose is small. The solids mean all the solids constituting the hard coating layer 12 after curing. Specifically, for example, the solids are acrylate and a photopolymerization initiator.

The resin used for the resin layer 4b is preferably a resin that does not deform at a process temperature for forming the wavelength-selective reflective layer 3, and does not cause cracks. When the glass transition temperature of the resin is low, a resulting optical member may be deformed at a high temperature after the installation, or a shape of the resin is changed during formation of the

wavelength-selective reflective layer 3. Therefore, the resin having low glass transition temperature is not preferable. The resin having high glass transition temperature is not preferable because cracks may be formed, or the resin may be peeled from an interface. Specifically, the glass transition temperature is preferably 60°C or higher but 150°C or lower, and more preferably 80°C or higher but 130°C or lower.

The resin is not particularly limited and may be appropriately selected depending on the intended purpose. The resin is preferably a resin that can transfer a structure upon application of energy rays or heat, and is more preferably a vinyl-based resin, an epoxy-based resin, or a thermoplastic resin.

An oligomer may be added to the resin for minimizing cure shrinkage. The resin may contain polyisocyanate as a curing agent. Moreover, hydroxyl group-containing vinyl-based monomers, carboxyl group-containing vinyl-based monomers, phosphoric acid group-containing vinyl-based monomers, polyhydric alcohols, carboxylic acid, coupling agents (e.g., silane, aluminium, and titanium), or various chelating agents may be added in view of adhesion with a base.

The vinyl-based resin is not particularly limited and may be appropriately selected depending on the intended purpose, but the vinyl-based resin is preferably a (meth)acryl-based resin. As the (meth)acryl-based resin, a hydroxyl group-containing vinyl-based monomer is suitably listed. Specific examples of the (meth)acryl-based resin include various unsaturated α,β -ethylene carboxylic acid hydroxyalkylesters, such as 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 3-hydroxypropyl (meth)acrylate, 2-hydroxybutyl (meth)acrylate, 3-hydroxybutyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, 3-chloro-2-hydroxypropyl (meth)acrylate, di-2-hydroxyethylfumarate, mono-2-hydroxyethyl-monobutyl fumarate, polyethylene glycol mono(meth)acrylate, polypropylene glycol mono(meth)acrylate, adducts of any of the above-listed

compounds and ϵ -caprolactone, and “Placel FM or FA monomer” [product name of caprolactone-added monomer, available from DAICEL CORPORATION].

The carboxyl group-containing vinyl-based monomer is not particularly limited and may be appropriately selected depending on the intended purpose.

5 Examples of the carboxyl group-containing vinyl-based monomer include: various unsaturated mono- or di-carboxylic acid, such as (meth)acrylic acid, crotonic acid, maleic acid, fumaric acid, itaconic acid, and citraconic acid; dicarboxylic acid monoesters, such as monoethyl fumarate, and monobutyl maleate; the above-listed hydroxyl group-containing (meth)acrylates; and adducts with anhydrides of various
10 polycarboxylic acid, such as succinic acid, maleic acid, phthalic acid, hexahydrophthalic acid, tetrahydrophthalic acid, benzene tricarboxylic acid, benzene tetracarboxylic acid, “HIMIC ACID,” and tetrachlorophthalic acid.

The phosphoric acid group-containing vinyl-based monomer is not particularly limited and may be appropriately selected depending on the intended
15 purpose. Examples of the phosphoric acid group-containing vinyl-based monomer include dialkyl[(meth)acryloyloxyalkyl]phosphates, (meth)acryloyloxyalkyl acid phosphates, dialkyl[(meth)oxyalkyl]phosphites, and (meth)acryloyloxyalkyl acid phosphites.

As the polyhydric alcohols, for example, one or two or more of various
20 polyhydric alcohols, such as ethylene glycol, propylene glycol, glycerin, trimethylol ethane, trimethylol propane, neopentyl glycol, 1,6-hexanediol, 1,2,6-hexanetriol, pentaerythritol, and sorbitol, can be used. Although they are not alcohols, various fatty acid glycidyl esters, such as “Curdura E” [product name of fatty acid glycidyl ester, available from Shell, Netherland] can be used instead of alcohols.

25 The carboxylic acid is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the carboxylic acid include various carboxylic acids, such as benzoic acid, p-tert-butyl benzoate,

phthalic acid (anhydride), hexahydrophthalic acid (anhydride), tetrahydrophthalic acid (anhydride), tetrachlorophthalic acid (anhydride), hexachlorophthalic acid (anhydride), tetrabromophthalic acid (anhydride), trimellitic acid, “HIMIC ACID” [a product of Hitachi Chemical Co., Ltd.; “HIMIC ACID” is the registered
5 trademark of Hitachi Chemical CO., Ltd.], succinic acid (anhydride), maleic acid (anhydride), fumaric acid, itaconic acid (anhydride), adipic acid, sebacic acid, and oxalic acid. The above-listed monomers may be used alone, or in combination as a copolymer.

Examples of the copolymerizable monomer include: styrene-based
10 monomers, such as styrene, vinyl toluene, p-methyl styrene, ethyl styrene, propyl styrene, isopropyl styrene, and p-tert-butyl styrene; alkyl (meth)acrylates, such as methyl (meth)acrylate, ethyl (meth)acrylate, propyl (meth)acrylate, iso (i)-propyl (meth)acrylate, n-butyl (meth)acrylate, i-butyl (meth)acrylate, tert-butyl (meth)acrylate, sec-butyl (meth)acrylate, octyl (meth)acrylate, 2-ethylhexyl
15 (meth)acrylate, lauryl (meth)acrylate, “Acryester SL” [product name of a C12-/C13 methacrylates mixture, available from MITSUBISHI RAYON CO., LTD.], and stearyl (meth)acrylate; (meth)acrylates having no functional group in side chains, such as cyclohexyl (meth)acrylate, 4-tert-butylcyclohexyl (meth)acrylate, isobornyl (meth)acrylate, adamantyl (meth)acrylate, and benzyl (meth)acrylate; bifunctional
20 vinyl-based monomers, such as ethylene-di(meth)acrylate; various alkoxyalkyl (meth)acrylates, such as methoxyethyl (meth)acrylate, ethoxyethyl (meth)acrylate, and methoxybutyl (meth)acrylate; diesters of various dicarboxylic acids represented by maleic acid, fumaric acid, or itaconic acid, and monovalent alcohols, such as dimethyl maleate, diethyl maleate, diethyl fumarate, di(n-butyl) fumarate,
25 di(i-butyl) fumarate, and dibutyl itaconate; various vinyl esters, such as vinyl acetate, vinyl benzoate, “VeoVa” [product name of vinyl ester of branched aliphatic monocarboxylic acid, available from Shell, Netherland], and (meth)acrylonitrile;

N,N-alkylaminoalkyl (meth)acrylates, such as N-dimethylaminoethyl (meth)acrylate, and N,N-diethylaminoethyl (meth)acrylate; and nitrogen-containing vinyl-based monomers, such as amide bond-containing vinyl-based monomers (e.g., (meth)acryl amide, butyl ether of N-methylol (meth)acryl amide, and dimethylaminopropyl acryl amide.

An amount of the above-listed monomers can be appropriately adjusted depending on the properties of the amorphous high-refractive-index layer, the metal layer, and the crystalline high-refractive-index layer.

The base 4a or the base 5a preferably has the lower moisture vapor transmission rate than the resin layer 4b or the resin layer 5b. In the case where the resin layer 4b is formed with the active energy ray-curable resin, such as urethane acrylate, for example, the base 4a is preferably formed with a resin that has the lower moisture vapor transmission rate than the resin layer 4b, and has transmittance to active energy rays, such as polyethylene terephthalate (PET). Since the bases for use are as described above, diffusion of moisture from the incident surface S1 or the light-emitting surface S2 to the wavelength-selective reflective layer 3 can be reduced, and deterioration of metal contained in the wavelength-selective reflective layer 3 can be prevented. Therefore, durability of the optical member 1 can be improved. A moisture vapor transmission rate of 75 μm -thick PET is about 10 g/m²/day (40°C, 90%RH).

First to eleventh embodiments of the present invention are described with reference to the drawings hereinafter.

<First embodiment>

FIG. 12 is a cross-sectional view illustrating one structural example of the optical member according to the first embodiment of the present invention. As illustrated in FIG. 12, the optical member 1 includes an optical transparent layer, and a wavelength-selective reflective layer formed in an inner area of the optical

transparent layer. The optical member 1 has an incident surface S1 from which light, such as sunlight, enters, and a light-emitting surface S2 from which light passed through the first optical transparent layer 4 is emitted out of the light entered from the incident surface S1.

5 FIG. 12 illustrates the example where the second optical transparent layer 5 contains a pressure sensitive adhesive as a main component, and the optical member is bonded to a window material, etc. with the second optical transparent layer 5. In the case where the optical member has the above-described structure, a difference in the refractive index between the pressure sensitive adhesive and the
10 first optical transparent layer is preferably within the above-mentioned range.

The first optical transparent layer 4 and the second optical transparent layer 5 preferably have the same optical properties, such as a refractive index. More specifically, the first optical transparent layer 4 and the second optical transparent layer 5 are composed of the same material having transparency in the
15 visible region. The refractive indexes of the first optical transparent layer 4 and the second optical transparent layer 5 can be made identical by forming the first optical transparent layer 4 and the second optical transparent layer 5 using the same material, and therefore transparency of the optical member with visible light can be improved. However, attentions should be paid because a refractive index of
20 a final film may be different depending on curing conditions in a film forming process, even though the formation of the film is started with the same material. When the first optical transparent layer 4 and the second optical transparent layer 5 are formed using mutually different materials, on the other hand, refractive indexes of the first optical transparent layer and the second optical transparent
25 layer are different. Therefore, light is refracted with the wavelength-selective reflective layer as a boundary, and a transmission image tends to be blurred. Especially when an object close to a point light source, such as an electric light,

present far away is observed, there is a problem that a diffraction pattern is significantly observed.

The first optical transparent layer 4 and the second optical transparent layer 5 preferably have transparency in the visible region. In the present

5 specification, the transparency has two means, and one is that absorption of light is small and the other is that scattering of light is small. The transparency typically denotes only the former, but the transparency preferably denotes the both in the present invention. Currently used retroreflectors, such as road signs and night-shift work clothes, aim to visualize displayed reflected light, and therefore
10 the reflected light can be visualized as long as the retroreflectors are in contact with the underlying reflectors, even though the retroreflectors have, for example, scattering. This is the same principle to, for example, that an image can be visualized even when antiglare treatment is performed on a front surface of an image display device for the purpose of providing anti-glare properties. However,
15 the optical member of the present invention is characterized in that the optical member passes through light other than light having a certain wavelength range that causes directional reflection, the optical member is adhered to a transparent body that mainly transmits the transmissive wavelengths to observe the transmitted light. Therefore, it is necessary that there is no scattering of light.
20 However, scattering properties can be intentionally applied only to the second optical transparent layer depending on the intended use.

The optical member is preferably used by bonding to a rigid body, such as a window material, having transparency to mainly light, which is other than light having a certain wavelength range, transmitted via a pressure sensitive adhesive.
25 Examples of the window material include window materials for building, such as skyscrapers and houses, and window materials for vehicles. In the case where the optical member is applied for the window material for buildings, the optical

member is particularly preferably applied for a window material arranged towards any of the directions between east and west via south (e.g., south east to south west). Since the window material is applied at the aforementioned position, heat rays can be more effectively reflected. The optical member can be used not only on a single-layer glass window, but also on special glass, such as multi-layer glass. Moreover, the window material is not limited to a material formed of glass, and a material formed of a polymer material having transparency may be used as the window material. The first optical transparent layer and the second optical transparent layer preferably have transparency to light in the visible light region. Since the first optical transparent layer and the second optical transparent layer have the above-described transparency, visible light is transmitted, and light collection can be secured from sunlight in the case where the optical member is bonded to the window material, such as a glass window. Moreover, a surface to which the optical member is bonded is not only an outer surface of glass but also an inner surface of glass. In the case where the optical member is bonded to the inner surface of the glass, the optical member needs to be bonded in the manner that the front and back of the convex and concave of structures and the in-plane direction are aligned to make the directional reflection direction the predetermined direction.

The optical member preferably has flexibility considering that the optical member can be easily bonded to a window material. A shape of the optical member is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the shape include a film shape, a sheet shape, a plate shape, and a block shape, but the shape is not particularly limited to the above-listed examples.

Moreover, the optical member can be used in combination with other heat ray-cut films. For example, a light-absorbing film can be disposed at an interface between the air and the optical transparent layer. Moreover, the optical member

can be used in combination with a hard coating layer, a UV-cut layer, or a surface antiwavelength-selective reflective layer. In the case where these functional layers are used in combination, these functional layers are preferably disposed at an interface between the optical member and the air. The UV-cut layer however
5 needs to be arranged closer to the side of sun than the optical member. In the case where the optical member is used as a member for bonding to an inner surface of a glass window for outdoor or indoor use, particularly, the UV-cut layer is desirably disposed between the glass window surface and the optical member. In this case, an ultraviolet ray-absorbing agent may be kneaded into a pressure sensitive
10 adhesive layer between the surface of the glass window and the optical member.

Moreover, color may be applied to the optical member depending on the intended use of the optical member to give a design to the optical member. In the case where a design is provided as described, the optical member preferably has a structure where the optical transparent layer absorbs only light having a certain
15 wavelength range as long as transparency of the optical member is not impaired.

<Second embodiment>

FIGs. 13 to 15 are cross-sectional views illustrating structural examples of structures of the optical member according to the second embodiment of the present invention. The second embodiment is different from the first embodiment in that
20 the structures are two-dimensionally arranged on the main surface of the first optical transparent layer 4.

On the main surface of the first optical transparent layer 4, the structures 11 are two-dimensionally arranged. This arrangement is preferably an arrangement of the most densely packed state. For example, on a main surface of
25 the first optical transparent layer 4, a densely-packed array, such as a square densely-packed array, a delta densely-packed array, and a hexagon densely-packed array, are formed by two-dimensionally arrange the structures 11 in the most

densely packed state. The square densely-packed array is an array obtained by arranging the structures 11 each having a square bottom surface in the square packed form. The delta densely-packed array is an array obtained by arranging the structures 11 each having a triangle bottom surface in the hexagonally packed form. The hexagon densely-packed array is an array obtained by arranging the structures 11 each having a hexagonal bottom surface in the hexagonally packed form.

For example, the structure 11 is a convex in the shape of a corner cube, a hemisphere, a semi-ellipsoid, a prism, a free surface, a polygon, a cone, a pyramid, a circular truncated cone, or a paraboloid. Examples of a shape of the bottom surface of the structure 11 include a circle, an ellipse, and polygons, such as a triangle, a square, a hexagon, and an octagon. Note that, FIG. 13 illustrates an example of a square densely-packed array, in which the structures 11 each having a square bottom surface are two-dimensionally arranged in the most densely packed state. Moreover, FIG. 14 illustrates an example of a delta densely-packed array, in which the structures each having a hexagonal bottom surface are two-dimensionally arranged in the most densely packed state. Furthermore, FIG. 15 illustrates an example of a hexagon densely-packed array, in which the structures 11 each having a triangular bottom surface are two-dimensionally arranged in the most densely packed state. The pitch P1 or P2 of the structures 11 is preferably appropriately selected depending on the desired optical properties. In the case where a main axis of the structure 11 is inclined relative to the perpendicular line perpendicular to the incident surface of the optical member, the main axis of the structure 11 is preferably inclined along at least one of the alignment directions within the two-dimensional alignment of the structures 11. In the case where the optical member is bonded to a window material arranged perpendicular to the ground, the main axis of the structure 11 is preferably inclined

to the bottom side (the ground side) of the window material with the perpendicular line being a standard.

<Third embodiment>

FIG. 16 is a cross-sectional view illustrating one structural example of the optical member according to the third embodiment of the present invention. As illustrated in FIG. 16, the third embodiment is different from the first embodiment in that the optical member has beads 31 instead of the structures 11.

The beads 31 are embedded in a main surface of the base 4c in a manner that parts of the beads 31 are projected from the main surface, and the first optical transparent layer 4 is formed with the base 4c and the beads 31.

A focal layer 32, a wavelength-selective reflective layer 3, and a second optical transparent layer 5 are sequentially laminated on the main surface of the first optical transparent layer 4. For example, the beads 31 have spherical shapes. The beads 31 preferably have transparency. For example, the beads 31 have an inorganic material, such as glass, or an organic material, such as a polymer resin, as a main component.

<Fourth embodiment>

FIG. 17 is a cross-sectional view illustrating one structural example of the optical member according to the fourth embodiment of the present invention. The fourth embodiment is different from the first embodiment in that a plurality of wavelength-selective reflective layers 3 inclined to the light incident surface are disposed between the first optical transparent layer 4 and the second optical transparent layer 5, and these wavelength-selective reflective layers 3 are arranged parallel to each other.

FIG. 18 is a perspective view illustrating one structural example of structures of the optical member according to the fourth embodiment of the present invention. Each of the structures 11 is a convex in the shape of a triangular prism

extending one direction, and these pillar-shaped structures 11 are one-dimensionally aligned along one direction. For example, the cross-section vertical to the extending direction of the structure 11 preferably has a right-angled triangle shape. A wavelength-selective reflective layer is formed by a thin film formation having directivity, such as vapor deposition and sputtering, performed on the inclined plane of the structure 11 at the side of the acute angle.

According to the fourth embodiment, a plurality of wavelength-selective reflective layers are arranged parallel within the optical member. As a result, the number of reflections by the wavelength-selective reflective layer can be reduced compared to a case where structures of corner cube shapes or prism shapes are formed. Accordingly, reflectance can be made high, and absorption of light by the wavelength-selective reflective layer can be reduced.

<Fifth embodiment>

FIG. 19 is a cross-sectional view illustrating one structural example of the optical member of the fifth embodiment of the present invention. As illustrated in FIG. 19, the fifth embodiment is different from the first embodiment in that a self-cleaning effect layer 6 exhibiting a cleaning effect is further disposed on the incident surface of the optical member 1. For example, the self-cleaning effect layer 6 contains a photocatalyst. As the photocatalyst, for example, TiO_2 can be used.

As described above, the optical member has characteristics that the optical member selectively directionally reflects light having a certain wavelength range. When the optical member is used for outdoor or a room with a lot of dirt, light is scattered by the dirt attached to a surface of the optical member to lose directional reflection properties. Therefore, a surface of the optical member is preferably always optically transparent. Accordingly, the surface of the optical member is preferably excellent in water repellency or hydrophilicity, as well as exhibiting a

self-cleaning effect.

According to the fifth embodiment, water repellency or hydrophilicity can be provided to an incident surface of the optical member, because the self-cleaning effect layer 6 is formed on the incident surface of the optical member. Therefore, depositions of dirt on the incident surface can be prevented, and deterioration in the directional reflection can be suppressed.

<Sixth embodiment>

The sixth embodiment is different from the first embodiment in that light other than the light having a certain wavelength range is scattered instead of directionally reflecting the light other than the light having a certain wavelength. The optical member 1 contains a light scattering body configured to scatter incident light. The light scattering body is disposed, for example, at at least one position selected from a surface of the first optical transparent layer 4 or the second optical transparent layer 5, inside the first optical transparent layer 4 or the second optical transparent layer 5, and between the wavelength-selective reflective layer 3 and the first optical transparent layer 4 or the second optical transparent layer 5. The light scattering body is preferably disposed at at least one position selected from between the wavelength-selective reflective layer 3 and the second optical transparent layer 4, inside the second optical transparent layer 5, and a surface of the second optical transparent layer 5. In the case where the optical member 1 is bonded to a support, such as window material, the optical member can be applied for both the indoor side and the outdoor side. In the case where the optical member 1 is bonded at the outdoor side, the light scattering body configured to scatter light other than light having a certain wavelength range is preferably disposed only between the wavelength-selective reflective layer 3 and the support, such as a window material. This is because directional reflection properties are impaired by the presence of the light scattering body between the

wavelength-selective reflective layer 3 and the incident surface, when the optical member 1 is bonded to the support, such as a window material. In the case where the optical member 1 is bonded at the indoor side, moreover, the light scattering body is preferably disposed between the light-emitting surface, which is an opposite side to the surface of the optical member bonded to the adherend, and the wavelength-selective reflective layer 3.

FIG. 20A is a cross-sectional view illustrating a first structural example of the optical member according to the sixth embodiment of the present invention. As illustrated in FIG. 20A, the second optical transparent layer 5 contains a resin and particles 12. The particles 12 have a refractive index different from the refractive index of the resin, which is a main constitutional material of the second optical transparent layer 5. As the particles 12, for example, at least one kind of organic particles or inorganic particles can be used. Moreover, hollow particles may be used as the particles 12. Examples of the particles 12 include inorganic particles, such as silica and alumina, and organic particles, such as styrene, acryl, and copolymers of styrene or acryl. The particles are particularly preferably silica particles.

FIG. 20B is a cross-sectional view illustrating a second structural example of the optical member according to the sixth embodiment of the present invention. As illustrated in FIG. 20B, the optical member 1 further includes a light diffusing layer 7 arranged on a surface of the second optical transparent layer 5. For example, the light diffusing layer 7 contains a resin and particles. As the particles, the same particles to the particles in the first structural example can be used.

FIG. 20C is a cross-sectional view illustrating a third structural example of the optical member according to the sixth embodiment of the present invention. As illustrated in FIG. 20C, the optical member 1 further includes a light diffusing layer 7 between the wavelength-selective reflective layer 3 and the second optical

transparent layer 5. For example, the light diffusing layer 7 contains a resin and particles. As the particles, the same particles to the particles in the first structural example can be used.

According to the sixth embodiment, light having a certain wavelength range, such as infrared rays, can be directionally reflected, and light other than the light having a certain wavelength range, such as visible light, can be scattered. Accordingly, the optical member 1 is clouded to give a design to the optical member 1.

<Seventh embodiment>

FIG. 21 is a cross-sectional view illustrating one structural example of the optical member according to the seventh embodiment of the present invention. The seventh embodiment is different from the first embodiment in that the wavelength-selective reflective layer 3 is directly formed on a window material 41 serving as the first optical transparent layer.

The window material 41 had structures 42 on a main surface of the window material. On the main surface where the structures 42 are formed, a wavelength-selective reflective layer 3 and a second optical transparent layer 43 are sequentially laminated. A shape of each structure 42 is not particularly limited and may be appropriately selected depending on the intended purpose. Examples of the shape include a shape reversing the convex and concave of the structure 11 in the first embodiment. The second optical transparent layer 43 is configured to improve clarity of transmitted images or total light transmittance, as well as protecting the wavelength-selective reflective layer 3. The second optical transparent layer 43 is a layer formed by curing a resin containing, for example, a thermoplastic resin, or an active energy ray-curable resin, as a main component.

<Eighth embodiment>

FIGs. 22A and 22B are cross-sectional views illustrating a structural

example of the optical member 1 according to the eighth embodiment of the present invention. The eighth embodiment is different from the first embodiment in that at least one of the first optical transparent layer 4 and the second optical transparent layer 5 has a two-layer structure. FIGs. 22A and 22B illustrate an example where the first optical transparent layer 4 at the side of the incident surface S1 of external light has a two-layer structure. As illustrated in FIGs. 22A and 22B, the two-layer structure of the first optical transparent layer 4 contains, for example, a smooth base 4a that is disposed at a surface side, and a resin layer 4b formed between the base 4a and the wavelength-selective reflective layer 3.

For example, the optical member 1 is bonded to an indoor side or outdoor side of the window material 10 that is an adherend via the joining layer 8. As the joining layer 8, for example, an adhesive layer containing an adhesive as a main component, or a pressure sensitive adhesive layer containing a pressure sensitive adhesive as a main component can be used. In the case where the joining layer 8 is a pressure sensitive adhesive layer, for example, the optical member 1 preferably further contains a joining layer 8 (pressure sensitive adhesive layer) formed on the incident surface S1 or the light-emitting surface S2, and a release layer formed on the pressure sensitive adhesive layer, as illustrated in FIGs. 22B and 23B. Since the optical member has the above-described structure, the optical member 1 can be easily bonded to an adherend, such as a window material 10 via the joining layer 8 (pressure sensitive adhesive layer) only by peeling the release layer.

In view of a further improvement of adhesion between the optical member 1 and the joining layer 8, a primer layer is further formed between the optical member 1 and the joining layer 8. In similar view of a further improvement of adhesion between the optical member 1 and the joining layer 8, moreover, the incident surface S1 or light-emitting surface S2 composed of the joining layer 8 of the optical member 1 is preferably subjected to a conventional physical

pretreatment. The conventional physical pretreatment is not particularly limited and may be appropriately selected depending on the intended purpose, and examples of the conventional physical pretreatment include a plasma treatment and a corona treatment.

<Ninth embodiment>

FIG. 23 is a cross-sectional view illustrating a first structural example of the optical member according to the ninth embodiment of the present invention. FIG. 24 is a cross-sectional view illustrating a second structural example of the optical member according to the ninth embodiment of the present invention. The ninth embodiment is different from the eighth embodiment in that a barrier layer 71 is further disposed on the incident surface S1 or light-emitting surface S2, to either of which an adherent, such as the window material 10, is bonded, or between the incident surface S1 or light-emitting surface S2 and the wavelength-selective reflective layer 3. FIG. 23 illustrates an example where the optical member 1 further contains a barrier layer 71 on the incident surface S1, to which an adherent, such as the window material 10 is bonded. FIG. 24 illustrates the example where the optical member 1 further has the barrier layer 71 between the base 4a and the resin layer 4b, where the base 4a is the side to be bonded to an adherend, such as the window material 10.

As for a material of the barrier layer 71, for example, an inorganic oxide containing at least one selected from the group consisting of alumina (Al_2O_3), silica (SiO_x), and zirconia, or a resin material containing at least one selected from the group consisting of polyvinylidene chloride (PVDC), polyvinyl fluoride resins, and ethylene-vinyl acetate copolymer partial hydrolysates can be used. As a material of the barrier layer 71, for example, a dielectric material containing at least one selected from the group consisting of SiN, ZnS-SiO₂, AlN, Al₂O₃, a composite oxide (SCZ) composed of SiO₂-Cr₂O₃-ZrO₂, a composite oxide (SIZ) composed of

$\text{SiO}_2\text{-In}_2\text{O}_3\text{-ZrO}_2$, TiO_2 , and Nb_2O_5 can be used.

In the case where the optical member 1 has the barrier layer 71 on the incident surface S1 or the light-emitting surface S2 as described above, the first optical transparent layer 4 or the second optical transparent layer 5, on which the barrier layer 71 is formed, preferably satisfies the following relationship.

Specifically, a moisture vapor transmission rate of the base 4a or the base 5a, to which the barrier layer 71 is formed, is preferably made lower than a moisture vapor transmission rate of the resin layer 4b or the resin layer 5b. When the above-described relationship is satisfied, diffusion of moisture from the incident surface S1 or light-emitting surface S2 of the optical member 1 to the wavelength-selective reflective layer 3 can be further reduced.

In the ninth embodiment, the optical member 1 contains the barrier layer 71 at the incident surface S1 or the light-emitting surface S2. Therefore, diffusion of moisture from the incident surface S1 or the light-emitting surface S2 into the wavelength-selective reflective layer 3 can be reduced, and deterioration of metal contained in the wavelength-selective reflective layer 3 can be prevented. Accordingly, durability of the optical member 1 can be improved.

<Tenth embodiment>

FIG. 25 is a cross-sectional view illustrating one structural example of the optical member according to the tenth embodiment of the present invention. The tenth embodiment is different from the eighth embodiment that the optical member 1 further contains a hard coating layer 72 disposed on at least one of the incident surface S1 and the light-emitting surface S2 of the optical member 1. Note that, FIG. 25 illustrates an example where the hard coating layer 72 is formed on the light-emitting surface S2 of the optical member 1.

Pencil hardness of the hard coating layer 72 is preferably 2H or higher, and more preferably 3H or higher in view of a scratch resistance of the optical member.

The hard coating layer 72 is obtained by applying a resin composition onto at least one of the incident surface S1 and light-emitting surface S2 of the optical member 1, and curing the resin composition. Examples of the resin composition include resin compositions disclosed in Japanese Patent Publication Application (JP-B) Nos.

5 50-28092, 50-28446, and 51-24368, JP-A No. 52-112698, JP-B No. 57-2735, and JP-A No. 2001-301095. Specific examples of the resin composition include: organosilane-based heat-curable resins, such as methyltriethoxysilane, and phenyltriethoxysilane; melamine-based heat-curable resins, such as etherified methylol melamine; and polyfunctional acrylate-based ultraviolet ray-curable resin,
10 such as polyol acrylate, polyester acrylate, urethane acrylate, and epoxy acrylate.

The resin composition preferably further contains an antifouling agent for the purpose of giving the hard coating layer 72 an antifouling performance. The antifouling agent is not particularly limited and may be appropriately selected depending on the intended purpose, but a silicone oligomer and/or fluorooligomer
15 containing one or more (meth)acryl groups, vinyl groups, or epoxy groups is preferably used. A blended amount of the silicone oligomer and/or fluorooligomer is preferably 0.01% by mass or greater but 5% by mass or less in the solids. When the blended amount is less than 0.01% by mass, an antifouling performance tends to be insufficient. When the blended amount is greater than 5% by mass, on the
20 other hand, hardness of a coating film tends to be low. As the antifouling agent, for example, RS-602 and RS-751-K available from DIC Corporation, CN4000 available from SARTOMER, OPTOOL DAC-HP available from DAIKIN INDUSTRIES, LTD., X-22-164E available from Shin-Etsu Chemical Co., Ltd., FM-7725 available from CHISSO CORPORATION, EBECRYL350 available from
25 Daicel SciTech Co., Ltd., and TEGORad2700 available from Degussa AG are preferably used. A pure water contact angle of the hard coating layer 72 to which the antifouling performance is given is preferably 70° or greater and more

preferably 90° or greater. The resin composition may optionally further contain additives, such as a photostabilizer, a flame retardant, and an antioxidant.

In the tenth embodiment, the hard coating layer 72 is formed on at least one of the incident surface S1 and light-emitting surface S2 of the optical member 1, scratch resistance can be provided to the optical member 1. In the case where the optical member 1 is bonded to an inner side of a window, for example, occurrences of scratches can be prevented when the surface of the optical member 1 is touched, or cleaned. In the case where the optical member 1 is bonded to an outer side of the window, moreover, occurrences of scratches can be similarly prevented.

<Eleventh embodiments>

FIG. 26 is a cross-sectional view illustrating one structural example of the optical member according to the eleventh embodiment of the present invention. The eleventh embodiment is different from the tenth embodiment in that an antifouling layer 74 is further arranged on the hard coating layer 72. Moreover, a coupling agent layer (primer layer) 73 is further disposed between the hard coating layer 72 and the antifouling layer 74 for the purpose of improving adhesion between the hard coating layer 72 and the antifouling layer 74.

In the eleventh embodiment, the optical member 1 further contains the antifouling layer 74 on the hard coating layer 72, and therefore an antifouling performance can be provided to the optical member 1.

Examples

Examples of the present invention are explained below, but the present invention is not limited to Examples in any way.

(Example 1)

First, groove structures as illustrated in FIGs. 27A and 27B were provided along an axial direction of a mold roll formed of Ni-P by cutting using a cutting tool.

Next, a PET film (A4300, available from TOYOBOKO CO., LTD.) having an average thickness of 75 μm was fed between the mold roll and a nip roll, and urethane acrylate (ARONIX, available from TOAGOSEI CO., LTD., refractive index after curing: 1.533) was supplied between the mold roll and the PET film to run with nipping. Then, UV light was applied from the side of the PET film to cure the resin, to thereby produce a film (first optical transparent layer) to which convex-shapes were formed.

Next, a high-refractive-index layer 1 [$\text{ZnO}(\text{TiO}_2)$, 40 nm], a metal layer 1 [AgPdCu , 10 nm], a high-refractive-index layer 2 [$\text{ZnO}(\text{TiO}_2)$, 80 nm], a metal layer 2 [AgPdCu , 10 nm], a high-refractive-index layer 3 [$\text{ZnO}(\text{TiO}_2)$, 20 nm], and a high-refractive-index layer 4 [AZO, 20 nm] were formed on a surface of the first optical transparent layer, to which the convex shapes had been formed, in this order by vacuum sputtering to thereby form a wavelength-selective reflective layer, which had the high-refractive-index layer 1 [$\text{ZnO}(\text{TiO}_2)$, 40 nm], the metal layer 1 [AgPdCu , 10 nm], the high-refractive-index layer 2 [$\text{ZnO}(\text{TiO}_2)$, 80 nm], the metal layer 2 [AgPdCu , 10 nm], the high-refractive-index layer 3 [$\text{ZnO}(\text{TiO}_2)$, 20 nm], and the high-refractive-index layer 4 [AZO, 20 nm] in this order in the direction vertical to the 35° inclined surface.

For the formation of the high-refractive-index layers 1, 2, and 3 [$\text{ZnO}(\text{TiO}_2)$], a ceramic target [$\text{ZnO}:\text{TiO}_2 = 100:20$ (mass ratio)], in which 20% by mass of TiO_2 was added to ZnO , was used.

For the formation of the metal layers 1 and 2 [AgPdCu], an alloy target having a composition of $\text{Ag/Pd/Cu} = 98.1\% \text{ by mass}/0.9\% \text{ by mass}/1.0\% \text{ by mass}$ was used.

For the formation of the high-refractive-index layer 4 (AZO), a ceramic target [$\text{ZnO}:\text{Al}_2\text{O}_3 = 100:2$ (mass ratio)], in which 2% by mass of Al_2O_3 was added to ZnO , was used.

The high-refractive-index layer was formed by using a roll a temperature of which was maintained at 60°C in a state where a back surface of a film forming surface of the PET film, which was a base, was supported by the roll.

In the manner as described, the first optical transparent layer with the wavelength-selective reflective layer was obtained.

After forming the first optical transparent layer with the wavelength-selective reflective layer, the first optical transparent layer with the wavelength-selective reflective layer and a PET film having an average thickness of 50 nm (A4300, available from TOYOBO CO., LTD.) was fed between nip rolls to face the convex-shaped surface of the first optical transparent layer to which the wavelength-selective reflective layer had been layer and the PET film, and a resin (ARONIX, available from TOAGOSEI CO., LTD., refractive index after curing: 1.533) identical to the resin used for forming the convex shaped of the first optical transparent layer was supplied between the first optical transparent layer and the PET film and run with nipping to thereby push air bubbles out from the resin. Thereafter, UV light was applied over the PET film to cure the resin to thereby form a second optical transparent layer. As a result, an optical member was obtained.

(Examples 2 to 7 and Comparative Examples 1 to 4)

Optical members were obtained in the same manner as in Example 1, except that a layer structure of the wavelength-selective reflective layer was changed to the layer structure presented in Table 1.

In Examples 2 and 6 and Comparative Example 2, a ceramic target [$\text{In}_2\text{O}_3\text{:CeO}_2 = 100\text{:}30$ (mass ratio)], in which 30% by mass of CeO_2 was added to In_2O_3 , was used for the formation of the high-refractive-index layer (ICO).

In Examples 3, 4, and 7, and Comparative Example 3, Nb_2O_5 was used for the formation of high-refractive-index layer [Nb_2O_5].

<Confirmation of crystallinity and amorphous nature>

The crystallinity of the high-refractive-index layer was confirmed by observing a cross-section of a sample under TEM to obtain an electron beam diffraction image of each high-refractive-index layer. When there was a bright spot in a shape of a ring in the electron beam diffraction image, the high-refractive-index layer was determined as crystalline. When there was no bright spot, the high-refractive-index layer was determined as amorphous.

For the measurement, a transmission electron microscope (EM-002B, available from JEOL Ltd., 200 kV) was used.

Results are presented in Table 1.

<Adhesion>

A short side of the rectangular optical member (area: 5 cm × 10 cm) was slightly torn at a center part of the short side, and the first optical transparent layer and the second optical transparent layer were respectively nipped with chucks, and the two chucks were pulled at the speed of 30 cm/min to perform a 180° peeling test, and a result was evaluated based on the evaluation criteria.

Results are presented in Table 1.

[Evaluation criteria]

A: Either the first optical transparent layer or the second optical transparent layer was torn.

B: The second optical transparent layer and the high-refractive-index layer in contact with the second optical transparent layer were separated only a little, but either the first optical transparent layer or the second optical transparent layer was eventually torn when the test was continued.

C: The second optical transparent layer and the high-refractive-index layer in contact with the second optical transparent layer were kept being separated until the test was finished.

<Optical properties>

Evaluated was how small absorption of sunlight was. Specifically, reflectance of the optical member was measured by a spectrophotometer (U-4100, available from Hitachi High-Tech Science Corporation). The reflectance of the optical member with light having a wavelength of 500 nm and the reflectance of the optical member with light having a wavelength of 1,000 nm were measured, and the difference [(Reflectance with 1,000 nm)–(reflectance with 500 nm)] was determined and evaluated based on the following criteria.

Results are presented in Table 1.

[Evaluation criteria]

I: The difference was 20% or greater

II: The difference was less than 20%

Note that, a wavelength of 500 nm is a typical value of a visible light range, and a wavelength of 1,000 nm is a typical value of an infrared light range.

Therefore, the large reflectance difference [(Reflectance with 1,000 nm)–(reflectance with 500 nm)] means small sunlight absorption.

Table 1

	Example							Comparative Example			
	1	2	3	4	5	6	7	1	2	3	4
High-refractive-index layer 4 (average thickness)	crystalline										
	AZO										
	20 nm			4 nm							
High-refractive-index layer 3 (average thickness)	amorphous			crystalline			amorphous			crystalline	
	ZnO(TiO ₂)	ICO	Nb ₂ O ₅	Nb ₂ O ₅	AZO			ZnO(TiO ₂)	ICO	Nb ₂ O ₅	AZO
	20 nm			36 nm	40nm						
Metal layer 2 (average thickness)	AgPdCu										
	10 nm										
High-refractive-index layer 2 (average thickness)	amorphous										crystalline
	ZnO(TiO ₂)	ICO	Nb ₂ O ₅	Nb ₂ O ₅	ZnO(TiO ₂)	ICO	Nb ₂ O ₅	ZnO(TiO ₂)	ICO	Nb ₂ O ₅	AZO
	80 nm										
Metal layer 1 (average thickness)	AgPdCu										
	10 nm										
High-refractive-index layer 1 (average thickness)	amorphous										crystalline
	ZnO(TiO ₂)	ICO	Nb ₂ O ₅	Nb ₂ O ₅	ZnO(TiO ₂)	ICO	Nb ₂ O ₅	ZnO(TiO ₂)	ICO	Nb ₂ O ₅	AZO
	40 nm										
Adhesion	A	A	A	B	A	A	A	C	C	C	A
Optical properties	I	I	I	I	I	I	I	I	I	I	II

In Examples 1 to 7, the optical members having high infrared reflectance and small sunlight absorption could be obtained by using the amorphous high-refractive-index layers as the high-refractive-index layers other than the high-refractive-index layer in contact with the second optical transparent layer. Moreover, the optical members having excellent interlayer adhesion could be

obtained by using the crystalline high-refractive-index layer as the high-refractive-index layer in contact with the second optical transparent layer.

When the average thickness of the crystalline high-refractive-index layer was 10 nm or greater, more excellent results of interlayer adhesion was obtained (Examples 1 to 3 and 5 to 7).

In Comparative Examples 1 to 3, the optical members having high infrared reflectance and small sunlight absorption could be obtained by using the amorphous high-refractive-index layers for all of the high-refractive-index layers, but interlayer adhesion was insufficient.

In Comparative Example 4, interlayer adhesion of the optical member was excellent because all of the high-refractive-index layers were the crystalline high-refractive-index layers, but infrared reflectance was high and sunlight absorption was large.

Industrial Applicability

The optical member of the present invention directionally reflects sunlight in a direction other than a direction of regular reflection, absorbs a small quantity of sunlight, and has excellent interlayer adhesion. Therefore, the optical member can be suitably used, for example, as a film bonded to a window.

Description of the Reference Numeral

- 1 optical member
- 3 wavelength-selective reflective layer
- 4 first optical transparent layer
- 4a base
- 4b resin layer
- 4c base

	5	second optical transparent layer
	5a	base
	5b	resin layer
	5b'	resin
5	6	self-cleaning effect layer
	7	light scattering layer
	8	joining layer
	9	first optical transparent layer with wavelength-selective reflective layer
10	10	window material
	11	structure
	12	particles
	23	light source
	31	beads
15	32	focal layer
	41	window material
	42	structure
	43	second optical transparent layer
	51	feed roll
20	52	feed roll
	53	wind-up roll
	54	laminate roll
	55	laminate roll
	56	guide roll
25	57	guide roll
	58	guide roll
	59	guide roll

	60	guide roll
	61	coating device
	62	irradiation device
	71	barrier layer
5	72	hard coating layer
	73	coupling agent layer
	74	antifouling layer
	81	release layer
	101	feed roll
10	102	support roll
	103	wind-up roll
	104	sputtering target
	S	incident light
	S1	incident surface
15	S2	light-emitting surface
	L	incident light
	L ₁	light reflecting to the sky
	L ₂	light not reflecting to the sky

CLAIMS

1. An optical member comprising:
a first optical transparent layer having convex-concave shapes, and being transparent to visible light;
5 a wavelength-selective reflective layer, which is formed on the convex-concave shapes of the first optical transparent layer, and is configured to selectively reflect certain wavelengths of infrared light; and
a second optical transparent layer formed on the wavelength-selective reflective layer,
10 wherein the wavelength-selective reflective layer includes at least an amorphous high-refractive-index layer, a metal layer, and a crystalline high-refractive-index layer in contact with the second optical transparent layer.
2. The optical member according to claim 1,
wherein a material of the crystalline high-refractive-index layer is a metal oxide, a
15 metal nitride, or both.
3. The optical member according to claim 1 or 2,
wherein a material of the amorphous high-refractive-index layer is a metal oxide, a metal nitride, or both.
4. The optical member according to any one of claims 1 to 3,
20 wherein an average thickness of the metal layer is from 5 nm to 85 nm.
5. The optical member according to any one of claims 1 to 4,
wherein an average thickness of the metal layer is from 5 nm to 60 nm.
6. The optical member according to any one of claims 1 to 5,
wherein an average thickness of the metal layer is from 5 nm to 40 nm.
- 25 7. The optical member according to any one of claims 1 to 6,
wherein an average thickness of the metal layer is from 5 nm to 25 nm.
8. The optical member according to any one of claims 1 to 7,

wherein the convex-concave shapes of the first optical transparent layer are formed with a one-dimensional alignment or a two-dimensional alignment of a plurality of structures, and the structures have prism shapes, lenticular shapes, hemispherical shapes, or corner cube shapes.

- 5 9. The optical member according to any one of claims 1 to 8,
wherein a material of the crystalline high-refractive-index layer is ZnO, or a complex metal oxide, or both, and
wherein the complex metal oxide includes ZnO, and at least one metal oxide selected from Al₂O₃ and Ga₂O₃, and an amount of the metal oxide in the complex
10 metal oxide is 6% by mass or less relative to the ZnO.
10. The optical member according to any one of claims 1 to 9,
wherein a material of the amorphous high-refractive-index layer is at least one selected from the group consisting of: a complex metal oxide including In₂O₃ and 10% by mass to 40% by mass of CeO₂ relative to the In₂O₃; a complex metal oxide
15 including In₂O₃ and 3% by mass to 10% by mass of SnO₂ relative to the In₂O₃; a complex metal oxide including ZnO and 20% by mass to 40% by mass of SnO₂ relative to the ZnO; a complex metal oxide including ZnO and 10% by mass to 20% by mass of TiO₂ relative to the ZnO; In₂O₃; and Nb₂O₅.