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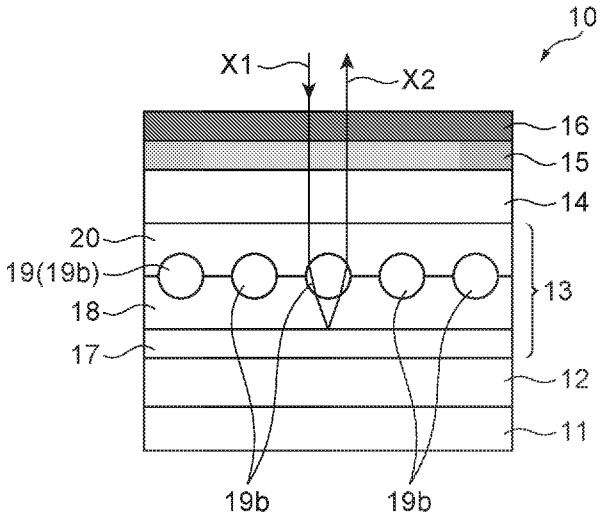

Fig. 3

(57) Abstract: To provide a retroreflective film that can improve design and safety, and a method for making the retroreflective film. A retroreflective film has a plurality of layers, the plurality of layers including an adhesion layer to be adhered to an adherend, a retroreflective layer, a first colored layer, and a second colored layer having a lower lightness than the first colored layer in this order, and the retroreflective layer retroreflects at least a portion of light incident through the second colored layer and the first colored layer toward a light source of the light.

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RETROREFLECTIVE FILM AND METHOD FOR MAKING RETROREFLECTIVE FILM

TECHNICAL FIELD

One aspect of the present disclosure relates to a retroreflective film and a method for making the retroreflective film.

BACKGROUND

Patent Document 1 describes a retroreflective sheet. The retroreflective sheet has a property that retroreflects incident light as it is directly toward a light source. The retroreflective sheet includes a top coat layer, a glass bead layer, an adhesive layer, and a backing paper in order from the front surface. The glass bead layer includes a plurality of glass beads arranged in a planar shape, a binder that is a synthetic resin filled between the glass beads, and a concave reflective film disposed on the lower side of the glass beads.

Patent Document 2 describes a retroreflective colored article. The retroreflective colored article includes a barrier layer disposed over a backing layer and the thermoplastic layer, a polymeric color layer that covers the barrier layer and the plurality of beads, a reflective layer disposed over the polymeric color layer, and a bead bond layer that covers the reflective layer. Each of the plurality of beads is partially embedded in the thermoplastic layer between the barrier layers.

SUMMARY

In some cases, it is demanded that retroreflective films looks in black or similar colors of low lightness at daytime and looks in colors other than black at nighttime. For example, it may be demand that a moving body such as an automobile looks in black or similar colors of low lightness at daytime for improving the design, and reflects light emitted from a vehicle lighting fixture at nighttime for improving the safety. As such, there is a need to improve the design and safety.

A retroreflective film in accordance with an aspect of the present disclosure has a plurality of layers, the plurality of layers including an adhesion layer to be adhered to an adherend, a retroreflective layer, a first colored layer, and a second colored layer having a lower lightness than the first colored layer in this order, and the retroreflective layer retroreflects at least a portion of light incident through the second colored layer and the first colored layer toward a light source of the light.

A method for making a retroreflective film according to an aspect of the present disclosure includes preparing a retroreflective layer, forming a first colored layer on the retroreflective layer, and forming a second colored layer on the first colored layer, the second colored layer having a lower lightness than the first colored layer, and the retroreflective layer retroreflects at least a portion of light incident through the second colored layer and the first colored layer toward a light source of light.

ADVANTAGEOUS EFFECTS OF INVENTION

According to one aspect of the present disclosure, design and safety can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view illustrating a portion of an exemplary automobile to which a retroreflective film in accordance with an embodiment is applied.

FIG. 2 is a perspective view illustrating an exemplary automobile door to which the retroreflective film in accordance with the embodiment is applied.

FIG. 3 is a view schematically illustrating a cross section of a retroreflective film in accordance with First embodiment.

FIGS. 4A and 4B are view schematically illustrating steps of a method for making the retroreflective film in FIG. 3.

FIG. 5A is a view schematically illustrating a retroreflective film and steps of a method for making the retroreflective film in accordance with Second embodiment. FIG. 5B is a view schematically illustrating a retroreflective film and steps of a method for making the retroreflective film in accordance with Third embodiment.

FIG. 6A is a view schematically illustrating a retroreflective film and steps of a method for making the retroreflective film in accordance with Fourth embodiment. FIG. 6B is a view schematically illustrating a retroreflective film and steps of a method for making the retroreflective film in accordance with Fifth embodiment.

FIGS. 7A and 7B are views schematically illustrating a retroreflective film and steps of a method for making the retroreflective film in accordance with Sixth Embodiment.

FIGS. 8A and 8B are views schematically illustrating a retroreflective film and steps of a method for making the retroreflective film in accordance with Seventh Embodiment.

FIGS. 9A to 9D are views schematically illustrating steps of a method for making the retroreflective film in accordance with Eighth Embodiment.

FIG. 10A is a view schematically illustrating a retroreflective film in accordance with Eighth embodiment. FIG. 10B is a view schematically illustrating a retroreflective film in accordance with Ninth embodiment.

FIG. 11A and FIG. 11B are views schematically illustrating a retroreflective film and steps of a method for making the retroreflective film in accordance with Tenth Embodiment.

FIG. 12A and FIG. 12B are views schematically illustrating a retroreflective film and steps of a method for making the retroreflective film in accordance with Eleventh Embodiment.

FIGS. 13A to 13C are views schematically illustrating steps of a method for making the retroreflective film in accordance with Twelfth Embodiment.

FIGS. 14A and 14B are views schematically illustrating the retroreflective film and steps of the method for making the retroreflective film in accordance with Twelfth Embodiment. FIG. 14C is a view schematically illustrating a retroreflective film in accordance with Thirteenth embodiment.

FIGS. 15A and 15B are views schematically illustrating the retroreflective film and steps of the method for making the retroreflective film in accordance with Fourteenth Embodiment.

FIGS. 16A and 16B are views schematically illustrating a retroreflective film and steps of a method for making the retroreflective film in accordance with Fifteenth Embodiment.

FIGS. 17A to 17C are views schematically illustrating steps of a method for making the retroreflective film in accordance with Sixteenth Embodiment.

FIGS. 18A and 18B are views schematically illustrating the retroreflective film and steps of the method for making the retroreflective film in accordance with Sixteenth Embodiment. FIG. 18C is a view schematically illustrating a retroreflective film in accordance with Seventeenth embodiment.

DETAILED DESCRIPTION

Various embodiments of a retroreflective film and a method for making the retroreflective film according to the present disclosure will be described below with reference to drawings. In the description of the drawings, identical or equivalent elements are denoted by the same reference signs, and duplicate descriptions of such elements are omitted. Further, the drawings are given with a portion simplified or embellished for facilitation of understanding, and the dimensional ratio and the like are not limited to those illustrated in the drawings.

"Retroreflective" indicates reflecting light in an opposite direction to a light incidence direction at incidence of the light. That is, "retroreflective" indicates retroreflecting at least a portion of the light emitted from the light source to return light black toward the light source. A "retroreflective layer" refers to a layered portion that performs retroreflection. A "colored layer" refers to a layer having a color. A "colored layer" includes, for example, a layer having a color as opaque, translucent, or colored transparent. The color may be either chromatic or

achromatic. Note that the chromatic color and the achromatic color conform to the definition in JIS Z8102: 2001.

"Lightness" is an indication of the brightness of the color, indicating that the color is closer to white as the lightness is higher, and is closer to black as the lightness is lower. "Black" includes not only black, but also colors that may be visibly recognized as black, and includes blackish blue, purple, brown, gray, and green of low lightness. "Black" may be a color having a hue or saturation, and may include a color having a predetermined lightness or less.

"Bead" indicates a spherical body provided inside the retroreflective layer, and includes, for example, transparent microsphere bead. A "bead layer" indicates a layer including beads, for example, a layer that contact with at least a portion of the beads. An "adherend" refers to an object to which a retroreflective film is applied, and is a “moving body”, for example. A “moving body” is a body that moves, and includes transportation equipment such as vehicles, ships, aircrafts, and rockets, and moving machines such as blades of a wind power plant. A "Vehicle" includes drivable machines such as automobiles, bicycles, electric trains, and new trunk lines. The present disclosure describes an example in which a retroreflective film is applied to the vehicle.

In the present disclosure, light emitted when observing the retroreflective film may be described as "normal light" or "linear light". The normal light indicates light that has various wavelengths and is emitted in various directions. As a specific example, the normal light indicates sunlight or light in environment where one is irradiated with light from general illumination. In contrast, the linear light includes light that has various wavelengths, but has a high directionality in which the light-travelling direction is aligned to a certain level or more. As a specific example, the linear light indicates light emitted from the vehicle lighting fixture. Note that coherent light such as laser beam is also included in the linear light. Hereinafter, environment irradiated with the normal light may be referred to as "under normal light" and environment irradiated with the linear light may be referred to as "under linear light".

FIG. 1 illustrates a vehicle body 1 of an automobile, which is an example of a vehicle to which the retroreflective film is applied. The vehicle body 1 has a side window 2, an A pillar 3, a B pillar 4, and a C pillar 5. For example, the side window 2 is constituted of glass, and the A pillar 3, the B pillar 4, and the C pillar 5 are made of metal.

In the present embodiment, the retroreflective film 10 may be applied to at least any one of the A pillar 3, the B pillar 4, and the C pillar 5, for example. The portion to which the retroreflective film 10 is applied looks in black when light is strong at daytime, and looks in a color having a higher lightness than black when irradiated with the linear light having a high directivity at nighttime.

The "Daytime" indicates environment under normal light. The "Daytime" indicates, for example, environment under sunlight at daytime, or environment under general illumination. The "Nighttime" may indicate, for example, a period from sunset to sunrise on the next morning, or may indicate a dark state that requires any irradiation means.

The "color having a higher lightness than black" may be yellow, green, or blue, and may further include colors other than yellow, green, and blue, such as red. Preferably, the relation between the application position and color of the retroreflective film 10 of the vehicle body 1 conforms to the security standards for road transportation vehicles in each country. Note that, in consideration of the Japanese security standards for road transportation vehicles of Japan, for example, the retroreflective film 10 of a color other than white may be applied to a rear-facing portion of the vehicle body 1. Further, the retroreflective film 10 of a color other than red may be applied to a front-facing portion of the vehicle body 1. Note that the retroreflective film 10 of any color may be applied to the A pillar 3, the B pillar 4, and the C pillar 5 that constitute the side portion of the vehicle body 1.

Note that the retroreflective film 10 in accordance with the embodiment may be observed as a color that is close to black under normal light. The retroreflective film 10 in accordance with the embodiment is retroreflected even when waves in a wavelength band other than visible light emitted from a sensor including a millimeter wave radar or a Light Detection and Ranging (LIDAR) used in a vehicle or the like are incident thereon. This is suitable for ensuring safety.

FIG. 2 is a perspective view illustrating an exemplary door 6 of the vehicle body 1. As illustrated in FIG. 2, the retroreflective film 10 may be applied to the door 6. For example, the retroreflective film 10 is applied to the inner side of the door 6. In this case, since the retroreflective film 10 faces to the rear of the vehicle body 1 when the door 6 is opened, the presence of the vehicle body 1 may be recognized by a vehicle behind due to shining of the retroreflective film 10.

For example, the retroreflective film 10 is applied to an outer edge 6d of an inner surface 6c of an outer panel 6b of the door 6. In the case where the retroreflective film 10 is applied to the outer edge 6d of the inner surface 6c of the outer panel 6b in this way, for example, opening of the door 6 can be recognized by the automobile behind due to shining of the retroreflective film 10 when irradiated with light from the vehicle light of the automobile behind at nighttime. As an example, the plurality of retroreflective films 10 may be applied to the outer edge 6d of the inner surface 6c of the outer panel 6b so as to be vertically arranged. Retroreflective films in accordance with other various embodiments will be described below.

First Embodiment

FIG. 3 is a view schematically illustrating a layered configuration of a retroreflective film 10 in accordance with First embodiment. As illustrated in FIG. 3, in the retroreflective film 10, a release liner 11, an adhesive layer 12, a retroreflective layer 13, a clear layer 14, a first colored layer 15, and a second colored layer 16 are stacked in this order from a lower side (a side of an adherend for the retroreflective film 10).

The release liner 11 is, for example, a mold release film peeled from the adhesive layer 12. The release liner 11 includes polymer or paper, for example. From the perspective of surface smoothness, the release liner 11 is preferably a polymer release liner. Examples of a release coating material of the release liner 11 include, but not limited to, a fluorine polymer, an acrylic resin, or a silicone.

The adhesive layer 12 is an adhesion layer to be adhered to an adherend. The adhesive layer 12 includes, for example, an acrylic-based adhesive, a rubber-based adhesive, a silicone-based adhesive, or an acrylic foam agent, and may further include adhesive microparticles. However, the material for the adhesive layer 12 is not particularly limited. The retroreflective film 10 is applied by peeling off the release liner 11 and applying the adhesive layer 12 to the vehicle body 1 and the like.

The retroreflective layer 13 includes a reflective layer 17 stacked on the adhesive layer 12, a space coat layer 18, a bead layer 19, and a bond layer 20. The reflective layer 17 is, for example, an aluminum deposited layer having deposited aluminum. The reflective layer 17 may be a silver deposited layer having deposited silver. The reflective layer 17 may be flat, or may be concave to cover each bead of the bead layer. The space coat layer 18 is, for example, a spacer layer defining a spacing between the reflective layer 17 and the bead layer 19. The space coat layer 18 defines a preferred spacing between the reflective layer 17 and each bead 19b in the bead layer 19 for retroreflecting light to the bead.

The bead layer 19 is a layer including a plurality of beads 19b that are microspheres, and for example, the beads 19b are glass beads made of glass. The plurality of beads 19b are arranged in a lattice or staggered manner in the space coat layer 18, for example. When light X1 having a high directivity is incident on the beads 19b in the bead layer 19, the light X1 is reflected on the reflective layer 17, reflected light X2 is incident on the beads 19b, and the reflected light X2 is emitted in the opposite direction to the incidence direction of the light X1. Since the light X1 incident on the beads 19b is emitted from the beads 19b in the opposite direction to the incidence direction as the reflected light X2, the retroreflective layer 13 achieves retroreflection with high directionality.

The bond layer 20 is a layer that covers the plurality of beads 19b of the bead layer 19, and is also referred to as a bead bond layer. Examples of the material for the bond layer 20

include urethane resin, acrylic resin, vinyl chloride resin, silicone resin, epoxy resin, fluororesin, melamine resin, alkyd resin, and mixtures thereof. The bond layer 20 is, for example, an uncolored, colorless, and transparent layer.

The clear layer 14 may be, for example, a resin film or a resin sheet that is made of a transparent resin. The material for the clear layer 14 is not particularly limited, but is PVC (polyvinyl alcohol), for example. The thickness of the clear layer 14 is, for example, 3 μm or more and 500 μm or less, and may be 58 μm as an example, and may be changed as appropriate.

The first colored layer 15 is, for example, a yellow colored layer. In the present disclosure, "yellow" includes not only pure yellows, but also yellowish colors such as yellow green and orange, meaning yellow in a broad sense. The first colored layer 15 may include, for example, a yellow pigment such as isoindoline-based pigment, a dispersing agent such as a wet dispersing agent, and a solvent. The material for the first colored layer 15 may include acrylic copolymer and ethylene glycol monobutyl ether. A thickness of the first colored layer 15 is, for example, 1 μm or more and 10 μm or less, and is 5 μm as one example.

The second colored layer 16 is a layer colored with a color having lower lightness than the color of the first colored layer 15. For example, the color of the second colored layer 16 is black. The second colored layer 16 may include a black pigment, a dispersant such as a wet dispersing agent, and a solvent. The material for the second colored layer 16 may include at least any one of polycaprolactone diol, isophorone diisocyanate, black acrylic resin, acrylic polymer, and methyl ethyl ketone.

As an example, the proportion of the mass of polycaprolactone diol in the second colored layer 16 is 47% or more and 48% or less, and the proportion of the mass of isophorone diisocyanate in the second colored layer 16 is 42% or more and 43% or less, the proportion of the mass of the black acrylic resin in the second colored layer 16 is 1% or more and 5% or less, and the proportion of the mass of the acrylic polymer in the second colored layer 16 is 0% or more and 1% or less. A thickness of the second colored layer 16 is, for example, 10 μm or more and 50 μm or less, and may be 25 μm or more and 35 μm or less.

Next, an example of a method for making the retroreflective film 10 will be described with reference to FIGS. 4A and 4B. First, as illustrated in FIG. 4A, a reflective sheet R1 in which the release liner 11, the adhesive layer 12, the retroreflective layer 13, and a clear layer 14 are stacked in advance is prepared (preparing a retroreflective layer). Then, yellow liquid L1 is coated on the clear layer 14 of the reflective sheet R1, and the coated yellow liquid L1 is dried to form the first colored layer 15 (forming the first colored layer).

Thereafter, as illustrated in FIG. 4B, black liquid L2 is coated on the first colored layer 15, and the coated black liquid L2 is dried to form the second colored layer 16 (forming the second colored layer). Note that the above-mentioned drying is performed by exposure at 80°C

for 60 minutes, for example. The second colored layer 16 is formed on the first colored layer 15 in this manner to complete the retroreflective film 10.

Effects of the retroreflective film 10 in accordance with the present embodiment will be described below. As illustrated in FIG. 3, in the retroreflective film 10, the second colored layer 16, the first colored layer 15, and the retroreflective layer 13 are stacked in this order from the side of the front layer, and the lightness of the color of the second colored layer 16 located on the side of the front layer is lower than the lightness of the color of the first colored layer 15 located on side of the retroreflective layer 13. As an example, the color of the first colored layer 15 is yellow and the color of the second colored layer 16 is black. Thus, the color of the second colored layer 16 located on the side of the front layer is visible when irradiated with normal light having a low directionality at daytime, improving design due to the color of low lightness.

On the other hand, when irradiated with light X1, which is linear light having a high directivity at nighttime, the retroreflective film 10 retroreflects the chromatic light. Specifically, when irradiated with the light X1, the retroreflective layer 13 directs the reflected light X2 toward the opposite direction to the emission direction, and the reflected light X2 passes through the first colored layer 15 and the second colored layer 16. Thus, because of the high directionality of the reflected light X2 of the light X1 at nighttime, the color having high lightness of the first colored layer 15 is visible at nighttime, improving design and safety due to the color having high lightness at nighttime.

As mentioned above, the retroreflective layer 13 may have the bead layer 19 that includes the plurality of beads 19b. As compared to the retroreflective layer without the bead layer 19, the retroreflective layer 13 including the bead layer 19 can further suppress the appearance of the lattice shape. Therefore, the visibility of the retroreflective film 10 particularly at nighttime can be increased.

As mentioned above, the color of the second colored layer 16 may be black. In this case, when the retroreflective film 10 is viewed at daytime, the retroreflective film 10 looks black, improving design.

The retroreflective coefficient of the reflected light X2 reflected by the retroreflective film 10 may be 0.3 (cd/lux/m^2) or more, 0.7 (cd/lux/m^2) or more, or 1.0 (cd/lux/m^2) or more. In this case, since the retroreflective coefficient of the reflected light X2 from the retroreflective layer 13 at nighttime is 0.3 (cd/lux/m^2) or more, the amount of light of the reflected light X2 can be increased to enhance the color having high lightness, further improving design and safety. The retroreflective coefficient of the reflected light X2 reflected from the retroreflective film 10 may be 30 (cd/lux/m^2) or less.

The retroreflective coefficient (cd/lux/m^2) is obtained by using the measurement method prescribed in JIS Z 9117 8.3 "Measurement of Retroreflective Material and Reflective

Performance". Specifically, the retroreflective coefficient is obtained by measuring the retroreflective coefficient (retroreflective coefficient R0.2) at an observation angle of 0.2 degrees and an incidence angle of 5 degrees with a retroreflective measurement device Retrosign Type 4500 (Delta Light Optics, Lyngby, Denmark). In this case, the retroreflective coefficient is obtained by irradiating the retroreflective film with light of constant luminance from a light projector and measuring the luminance of light reflected back from the retroreflective film.

The retroreflective film 10 may be applied to a moving body. In this case, the color having low lightness of the second colored layer 16 is visible at daytime, improving design of the moving body such as a vehicle. In addition, the color of high lightness of the first colored layer 15 is visible at nighttime, improving design and security of the moving body such as a vehicle.

For example, the moving body has lights on the front and back portions, but has no object emitting light at nighttime on the side portion. Thus, when the retroreflective film 10 is applied to the side portion of the moving body, the side portion can shine with color of high lightness at nighttime, improving safety and design. It is also conceivable to provide a light on the side portion of the moving body, but in this case, it is necessary to supply power to the light. However, power supply can be made unnecessary by applying the retroreflective film 10 to the side portion of the moving body.

As described above, when the retroreflective film 10 is applied to at least any one of the A pillar 3, the B pillar 4, and the C pillar 5 of the vehicle body 1, the black color of the retroreflective film 10 can be emphasized at daytime. As a result, the inner side of the side windows 2 of the vehicle body 1 can look wide, improving design of the vehicle body 1.

Further, when the retroreflective film 10 is applied to the side portion of the vehicle body 1, the side portion of the vehicle body 1 can shine with color of high lightness of the first colored layer 15 at nighttime, contributing to an improvement of safety and design of the vehicle body 1. Further, when the retroreflective film 10 is attached to the inside of the door 6 of the vehicle body 1, the inside of the door 6 opened at nighttime can shine, avoiding the possibility that the vehicle behind and the like approaches the door 6 to further improve safety.

Second Embodiment

A retroreflective film 10A in accordance with Second embodiment will be described below with reference to FIG. 5A. Note that below-mentioned exemplary various retroreflective films including the retroreflective film 10A have the same configuration as at least a portion of the retroreflective film 10 described above and thus, overlapping descriptions of the retroreflective films 10 will be hereinafter omitted as appropriate.

As illustrated in FIG. 5A, the retroreflective film 10A in accordance with Second embodiment includes a second colored layer 16A that is thicker than the second colored layer 16 described above. The thickness of the second colored layer 16A is, for example, 50 μm or more and 100 μm or less, and may be 55 μm or more and 65 μm or less. A method for making the retroreflective film 10A is the same as the above-mentioned method for making the retroreflective film 10, and the thickness of the black liquid L2 coated on the first colored layer 15 is different from the thickness in First embodiment. The retroreflective film 10A in accordance with Second embodiment has the same effects as those of the retroreflective film 10.

Third Embodiment

Subsequently, a retroreflective film 10B in accordance with Third embodiment will be described with reference to FIG. 5B. The retroreflective film 10B includes a second colored layer 26 having components that are different from the components of the second colored layer 16 described above. A thickness of the second colored layer 26 is, for example, 10 μm or more to 50 μm or less, and may be 25 μm or more and 35 μm or less. The second colored layer 26 includes the same components as the components of second colored layer 16, but the proportion of the components is different from that of the second colored layer 16.

As an example, the proportion of the mass of polycaprolactone diol in the second colored layer 26 is 45% or more and 46% or less, the proportion of the mass of the isophorone diisocyanate in the second colored layer 26 is 40% or more and 41% or less, the proportion of the mass of the black acrylic resin in the second colored layer 26 is 5% or more and 7% or less, the proportion of the mass of the acrylic polymer in the second colored layer 26 is 0% or more and 1% or less, and the proportion of the mass of methyl ethyl ketone in the second colored layer 26 is 7% or more and 8% or less.

That is, the proportion of the mass of the black acrylic resin in the second colored layer 26 is 5% or more and 7% or less, and is larger than the proportion of the mass of the black acrylic resin in the second colored layer 16 (1% or more and 5% or less). Thus, in the retroreflective film 10B provided with the second colored layer 26, even when the thickness of the second colored layer is thinner than that of the retroreflective film 10, 10A described above, black appears more easily. Note that a method for making the retroreflective film 10B is the same as the method for making the retroreflective film 10, 10A except that black liquid L3 forming the second colored layer 26 is applied. The retroreflective film 10B achieves the same effects as the retroreflective films 10, 10A.

Fourth Embodiment

A retroreflective film 10C in accordance with Fourth embodiment will be described below with reference to FIG. 6A. The retroreflective film 10C includes a third colored layer 27

instead of the bond layer 20 described above. The third colored layer 27 functions as, for example, a bond layer (bead bond layer) that covers the plurality of beads 19b of the bead layer 19.

Examples of the material for the third colored layer 27 include urethane resin, acrylic resin, vinyl chloride resin, silicone resin, epoxy resin, fluororesin, melamine resin, alkyd resin, and mixtures thereof. The lightness of the color of the third colored layer 27 may be lower than the lightness of the color of the first colored layer 15, or may be higher than the lightness of the color of the first colored layer 15. As an example, the color of the third colored layer 27 is black.

According to a method for making the retroreflective film 10C, first, a reflective sheet R2 in which the release liner 11, the adhesive layer 12, the retroreflective layer 13 having and a third colored layer 27, and the clear layer 14 are stacked is prepared. Then, the yellow liquid L1 is coated on the clear layer 14 of the reflective sheet R2, and the coated yellow liquid L1 is dried to form the first colored layer 15. Thereafter, the black liquid L2 is coated on the first colored layer 15, and the coated black liquid L2 is dried to form the second colored layer 16, completing the retroreflective film 10C.

As described above, the retroreflective film 10C in accordance with Fourth embodiment has the third colored layer 27 positioned on the opposite side to the second colored layer 16 when viewed from the first colored layer 15, and the lightness of the color of the third colored layer 27 may be lower than the lightness of the color of the first colored layer 15. In this case, the third colored layer 27 is disposed on the opposite side to the second colored layer 16 across the first colored layer 15, and the lightness of the color of the third colored layer 27 is lower than the lightness of the color of the first colored layer 15.

Thus, the first colored layer 15 is sandwiched between the second colored layer 16 and the third colored layer 27 that have a lower lightness than the lightness of the first colored layer 15. Since the first colored layer 15 is sandwiched between the second colored layer 16 and the third colored layer 27 of lower lightness, the color of lower lightness is visible at daytime, further improving design.

The third colored layer 27 may be a bond layer that covers the bead layer 19 including the plurality of beads 19b. In this case, since the third colored layer 27, which is positioned on the opposite side to the second colored layer 16 across the first colored layer 15 and has color of low lightness, is the bond layer 20 covering the bead layer 19, color irregularities can be suppressed while enhancing the black color of the retroreflective film 10C at daytime.

Fifth Embodiment

A retroreflective film 10D in accordance with Fifth embodiment will be described below with reference to FIG. 6B. The thickness of the second colored layer 16 of the

retroreflective film 10D is larger than the second colored layer 16 of the retroreflective film 10C. The thickness of the second colored layer 16 of the retroreflective film 10D is, for example, 50 μm or more and 100 μm or less, and may be 55 μm or more and 65 μm or less. The retroreflective film 10D in accordance with Fifth Embodiment has the same effects as those of the retroreflective film 10C.

Sixth Embodiment

A retroreflective film 10E in accordance with Sixth embodiment will be described below with reference to FIGS. 7A and 7B. The retroreflective film 10E includes a first colored layer 25 having a configuration that is different from that of the first colored layer 15. The first colored layer 25 is a layer formed on the clear layer 14 by printing. The first colored layer 25 may be a layer printed using an inkjet printer, for example. In this case, the first colored layer 25 is formed by applying ink in a dot pattern.

According to a method for making the retroreflective film 10E, the reflective sheet R2 in which the release liner 11, the adhesive layer 12, the retroreflective layer 13, and the clear layer 14 are stacked is prepared. Then, the reflective sheet R2 is printed by an inkjet printer to form the first colored layer 25 formed of dot-like ink on the clear layer 14. Thereafter, the black liquid L2 is coated on the first colored layer 25 and the black liquid L2 is dried to form the second colored layer 16 to complete the making of the retroreflective film 10E.

In the retroreflective film 10E, the first colored layer 25 is formed using the inkjet printer. That is, the first colored layer 25 is formed of the dot-like ink. In this case, the degree of masking by the first colored layer 25 can be increased and color irregularities of the first colored layer 25 can be reduced, further improving design of the retroreflective film 10E at nighttime.

Seventh Embodiment

A retroreflective film 10F in accordance with Seventh embodiment will be described below with reference to FIGS. 8A and 8B. The retroreflective film 10F differs from the retroreflective film 10E in that an adhesive layer 32 and a clear layer 34 are provided between the first colored layer 25 and the second colored layer 16.

The adhesive layer 32 may include, for example, an acrylic adhesive, a rubber-based adhesive, a silicone-based adhesive, or an acrylic foam agent, and may be formed from a material that is similar to the material for the adhesive layer 12 described above. A thickness of the adhesive layer 32 is, for example, 10 μm or more and 50 μm or less. The clear layer 34 is formed from PVC (polyvinyl alcohol), for example, and may be formed from the same material as the clear layer 14 described above. The thickness of the clear layer 34 may be, for example, 10 μm or more and 100 μm, such as 50 μm, and may be changed as appropriate.

According to a method for making the retroreflective film 10F, first, the first colored layer 25 is printed on the reflective sheet R2 and then, the clear layer 34 with the adhesive layer 32 is laminated onto the first colored layer 25. Thereafter, as described above, the black liquid L2 is coated and dried to form the second colored layer 16 on the clear layer 34, to complete the retroreflective film 10F. Note that in the retroreflective film 10 F, the thickness of the second colored layer 16 is, for example, 50 μm or more and 60 μm or less. The retroreflective film 10F achieves the same effects as the retroreflective film 10E.

Eighth Embodiment

Subsequently, a retroreflective film 10G in accordance with Eighth Embodiment will be described with reference to FIGS. 9A to 10A. The retroreflective film 10G differs from the retroreflective film 10F described above in that an adhesive layer 35 and a transparent resin layer 36 are further provided between the clear layer 34 and the second colored layer 16.

The adhesive layer 35 may be formed from the same material as the adhesive layer 12, 32 described above, for example, and the thickness of the adhesive layer 35 is 30 μm or more and 50 μm or less (40 μm as an example). The transparent resin layer 36 is formed from polyethylene terephthalate (PET), but may also be formed from other resin materials.

According to a method for making the retroreflective film 10G, first, as illustrated in FIGS. 9A and 9B, the first colored layer 25 is printed on the reflective sheet R2 and then, the clear layer 34 with the adhesive layer 32 is laminated onto the first colored layer 25. As illustrated in FIG. 9C, the black liquid L2 is coated on the transparent resin layer 36 and dried to form the second colored layer 16 on the transparent resin layer 36.

At this time, the black liquid L2 having a thickness of, for example, 40 μm or more and 60 μm or less is dried to form the second colored layer 16 having a thickness of 30 μm or more and 35 μm or less (as an example, 32 μm). Thereafter, as illustrated in FIGS. 9D and 10A, the adhesive layer 35 is laminated on the clear layer 34, and the transparent resin layer 36 on which the second colored layer 16 is formed is laminated onto the clear layer 34 via the adhesive layer 35. This completes the making of the retroreflective film 10G.

Ninth Embodiment

FIG. 10B is a view illustrating a retroreflective film 10H in accordance with Ninth Embodiment. The thickness of the second colored layer 16 of the retroreflective film 10H is greater than the thickness of the second colored layer 16 of the retroreflective film 10G. The thickness of the second colored layer 16 of the retroreflective film 10H is, for example, 50 μm or more and 100 μm or less, and may be 50 μm or more and 60 μm or less. The method for making the retroreflective film 10H is the same as the method for making the retroreflective film 10G.

Tenth Embodiment

A retroreflective film 10J in accordance with Tenth Embodiment will be described below with reference to FIGS. 11A and 11B. As illustrated in FIGS. 11A and 11B, the retroreflective film 10J differs from the retroreflective films described above in that a first colored layer 45 of green color is provided instead of the first colored layer 25. In the present disclosure, "green" includes not only pure green but also colors greenish colors such as blue-green, yellow green, and the like, and meaning green in a broad sense.

The first colored layer 45 is formed, for example, on the clear layer 14 by printing. In this case, the first colored layer 45 is formed by applying ink in a dot pattern. The first colored layer 45 may be, for example, a layer formed using an inkjet printer or a layer formed of green liquid (green pigment).

According to a method for making the retroreflective film 10J, for example, the reflective sheet R2 is printed using the inkjet printer to form the first colored layer 45 constituted of dot-like ink on the clear layer 14. Thereafter, the black liquid L2 is coated on the first colored layer 45 and dried to complete the making of the retroreflective film 10J.

The retroreflective film 10J includes the green first colored layer 45 and thus, can shine green at nighttime. In general, yellow has an image that enhances concentration or judgment and draws attention, whereas green has a healing and relaxing effect on the body. Thus, the retroreflective films 10 to 10H may each has the yellow first colored layer 15, advantageously calling attention. On the other hand, the retroreflective film 10J has the green first colored layer 45, increasing the relaxing and calming effects.

Eleventh Embodiment

FIGS. 12A and 12B are views illustrating a retroreflective film 10K in accordance with Eleventh Embodiment. The retroreflective film 10K differs from the retroreflective film 10J in that the adhesive layer 32 and the clear layer 34 are provided between the first colored layer 45 and the second colored layer 16. According to a method for making the retroreflective film 10K, first, the first colored layer 45 is printed on the reflective sheet R2 and then, the clear layer 34 with the adhesive layer 32 is laminated onto the first colored layer 45. Thereafter, as described above, the black liquid L2 is coated and dried to form the second colored layer 16 on the clear layer 34, to complete the retroreflective film 10K. The retroreflective film 10K achieves the same effects as the retroreflective film 10J.

Twelfth Embodiment

FIGS. 13A to 14B illustrate a retroreflective film 10L and a method for making the retroreflective film 10L in accordance with Thirteenth Embodiment. The retroreflective film 10L differs from the retroreflective film 10K in that the adhesive layer 35 and the transparent resin layer 36 are provided between the clear layer 34 and the second colored layer 16.

According to a method for making the retroreflective film 10L, as illustrated in FIGS. 13A and 13B, the first colored layer 45 is printed on the reflective sheet R2 and then, the clear layer 34 with the adhesive layer 32 is laminated onto the first colored layer 45. Further, as illustrated in FIG. 13C, the black liquid L2 is coated on the transparent resin layer 36 and dried to form the second colored layer 16 on the transparent resin layer 36.

Thereafter, as illustrated in FIGS. 14A and 14B, the adhesive layer 35 is laminated on the clear layer 34, and the transparent resin layer 36 on which the second colored layer 16 is formed is laminated onto the clear layer 34 via the adhesive layer 35. This completes the making of the retroreflective film 10L.

Thirteenth Embodiment

FIG. 14C is a view illustrating a retroreflective film 10M in accordance with Thirteenth Embodiment. The thickness of the second colored layer 16 of the retroreflective film 10M is larger than the thickness of the second colored layer 16 of the retroreflective film 10L. The thickness of the second colored layer 16 of the retroreflective film 10M is, for example, 50 μm or more and 100 μm or less, and may be 50 μm or more and 60 μm or less.

Fourteenth Embodiment

A retroreflective film 10N in accordance with Fourteenth Embodiment will be described below with reference to FIGS. 15A and 15B. As illustrated in FIGS. 15A and 15B, the retroreflective film 10N differs from the retroreflective films described above in that a blue first colored layer 55 is provided instead of the first colored layer 25 or 45.

In the present disclosure, "blue" includes not only pure blue but also blueish colors such as water blue, blue green, and dark blue, meaning blue in a broad sense. The first colored layer 55 is formed, for example, on the clear layer 14 by printing. The first colored layer 55 may be a layer formed using the inkjet printer, or may be a layer formed of blue liquid (blue pigment).

According to a method for making the retroreflective film 10N, for example, the reflective sheet R2 is printed using the inkjet printer to form the first colored layer 55 constituted of dot-like ink on the clear layer 14. Thereafter, the black liquid L2 is coated on the first colored layer 55 and dried to complete the making of the retroreflective film 10N.

The retroreflective film 10N includes the blue first colored layer 55 and thus, can shine blue at nighttime. Generally, blue has an image that increases concentration and calms mind. Thus, the retroreflective film 10N including the blue first colored layer 55 can enhance concentration and increase the relaxing effect.

Fifteenth Embodiment

FIGS. 16A and 16B are views illustrating a retroreflective film 10P in accordance with Fifteenth Embodiment. The retroreflective film 10P differs from the retroreflective film 10N in

that the adhesive layer 32 and the clear layer 34 are provided between the first colored layer 55 and the second colored layer 16. According to a method for making the retroreflective film 10P, the first colored layer 55 is printed on the reflective sheet R2 and then, the clear layer 34 with the adhesive layer 32 is laminated onto the first colored layer 55. Then, the black liquid L2 is coated and dried to form the second colored layer 16 on the clear layer 34, completing a series of making steps. The retroreflective film 10P achieves the same effects as the retroreflective film 10N.

Sixteenth Embodiment

FIGS. 17A to 17C and FIGS. 18A and 18B illustrate a retroreflective film 10Q and a method for making the retroreflective film 10Q in accordance with Sixteenth Embodiment. The retroreflective film 10Q differs from the retroreflective film 10P in that the adhesive layer 32, the clear layer 34, the adhesive layer 35, and the transparent resin layer 36 are provided between the first colored layer 55 and the second colored layer 16.

As illustrated in FIGS. 17A and 17B, for example, the first colored layer 55 is printed on the reflective sheet R2 to laminate the clear layer 34 with the adhesive layer 32 onto the first colored layer 55. As illustrated in FIG. 17C, the black liquid L2 is coated on the transparent resin layer 36 and dried to form the second colored layer 16 on the transparent resin layer 36.

Then, as illustrated in FIGS. 18A and 18B, the adhesive layer 35 is laminated onto the clear layer 34 and then, the transparent resin layer 36 on which the second colored layer 16 is formed is laminated onto the clear layer 34 via the adhesive layer 35. Through the steps described above, the making of the retroreflective film 10Q is completed.

Seventeenth Embodiment

FIG. 18C is a view illustrating a retroreflective film 10R in accordance with Seventeenth Embodiment. The thickness of the second colored layer 16 of the retroreflective film 10R is larger than the second colored layer 16 of the retroreflective film 10Q. The thickness of the second colored layer 16 of the retroreflective film 10R is, for example, 50 μm or more and 100 μm or less, and may be 50 μm or more and 60 μm or less.

EXAMPLES

Examples of the retroreflective film in accordance with the present embodiment will be described below. The present disclosure is not limited to Examples given below. In experiments in Examples, the retroreflective films in Examples were adhered to the vehicle body 1, and the color of each of the retroreflective films at daytime and nighttime was measured.

Example 1

The retroreflective film 10 illustrated in FIG. 3 was used as the retroreflective film in Example 1. Specifically, the retroreflective film 10 had the release liner 11, the adhesive layer 12, the retroreflective layer 13, the clear layer 14, the yellow first colored layer 15, and the black second colored layer 16. The thickness of the clear layer 14 was 58 μm, the thickness of the first colored layer 15 was 5 μm, and the thickness of the second colored layer 16 was 30 μm.

In Example 1, a ScotchcalTM reflective sheet white including the release liner 11, the adhesive layer 12, the retroreflective layer 13, and the clear layer 14 was used. As the material for the first colored layer 15, 3.00 mass% of organic yellow pigment (Irgaphor (registered trademark) Yellow 2R-CF manufactured by BASF Japan), 0.66 mass% of wet dispersing agent (DISPERBYK-2000 manufactured by BYK), 0.09 mass% of dispersant (solsperse (registered trademark) 22000 manufactured by Lubrizol Corporation), 16.25 mass% of paint (Joncryl 67 manufactured by BASF Japan), solvent (PMA), and 12.00 mass% of butyl cellosolve (manufactured by Wako Pure Chemical Industries, Ltd.) were used. As the material for the second colored layer 16, 47.4 mass% of a clear polycaprolactone diol solution (FPR1J clear manufactured by 3M), 42.8 mass% of isophorone diisocyanate (VENESTANATT1890E manufactured by Evonik Japan), 1.6 mass% of black acrylic resin (TX-6013 a T502 manufactured by BASF Japan), 0.5 mass% of acrylic polymer (BYK355 manufactured by BYK Japan Japan), and 7.7 mass% of methyl ethyl ketone were used.

Example 2

The retroreflective film 10A illustrated in FIG. 5A was used as the retroreflective film in Example 2. Specifically, in the retroreflective film 10A including the release liner 11, the adhesive layer 12, the retroreflective layer 13, the clear layer 14, the yellow first colored layer 15, and the black second colored layer 16, the thickness of the clear layer 14 was 58 μm, the thickness of the first colored layer 15 was 5 μm, and the thickness of the second colored layer 16 was 60 μm. The materials for the first colored layer 15 and the second colored layer 16 are the same as those in Example 1.

Example 3

The retroreflective film 10B illustrated in FIG. 5B was used as the retroreflective film in Example 3. A material for the second colored layer 26 of the retroreflective film in Example 3 differs from the material for the second colored layer 16 in Example 1. As the material for the second colored layer 26, 45.3 mass% of the clear polycaprolactone diol solution (FPR1J clear manufactured by 3M), 40.9 mass% of isophorone diisocyanate (VENESTANATT1890E manufactured by Evonik Japan), 6.0 mass% of black acrylic resin (TX-6013 a T502 manufactured by BASF Japan), 0.4 mass% of acrylic polymer (BYK355 manufactured by BYK

Japan), and 7.4 mass% of methyl ethyl ketone were used. The thickness of the second colored layer 26 was 30 μm.

Example 4

The retroreflective film 10C illustrated in FIG. 6A was used as the retroreflective film in Example 4. The thickness of the clear layer 14 was 58 μm, the thickness of the first colored layer 15 was 5 μm, and the thickness of the second colored layer 16 was 30 μm. The color of the third colored layer 27 was black.

Example 5

The retroreflective film 10D illustrated in FIG. 6B was used as the retroreflective film in Example 5. In the retroreflective film in Example 5, the thickness of the second colored layer 16 was 60 μm.

Example 6

The retroreflective film 10E illustrated in FIG. 7B was used as the retroreflective film in Example 6. The retroreflective film in Example 6 differs from the retroreflective film in Example 1 in that a first colored layer 25 formed by printing is used instead of the first colored layer 15. In Example 6, the first colored layer 25 was printed using an inkjet printer (iPD8400SE manufactured by Canon Corporation).

Example 7

The retroreflective film 10F illustrated in FIG. 8B was used as the retroreflective film in Example 7. In Example 7, the thickness of the second colored layer 16 was 54 μm, the thickness of the adhesive layer 32 was 30 μm, and the thickness of the clear layer 34 was 54 μm.

Example 8

The retroreflective film 10G illustrated in FIG. 10A was used as the retroreflective film in Example 8. In Example 8, the thickness of the clear layer 14 was 58 μm, the thickness of the adhesive layer 32 was 40 μm, the thickness of the clear layer 34 was 50 μm, the thickness of the adhesive layer 35 was 40 μm, the thickness of the transparent resin layer 36 was 50 μm, and the thickness of the second colored layer 16 was 33 μm.

Example 9

In the retroreflective film in Example 9, the thickness of the second colored layer 16 of the retroreflective film in Example 8 was 54 μm.

Example 10

The retroreflective film in Example 10 was a retroreflective film 10J including a printed green first colored layer 45 as illustrated in FIG. 11B. The thickness of the clear layer 14 was 58 μm, and the thickness of the second colored layer 16 was 54 μm.

Example 11

The retroreflective film 10K illustrated in FIG. 12B was used as the retroreflective film in Example 11. The thickness of the clear layer 14 was 58 μm, the thickness of the adhesive layer 32 was 30 μm, the thickness of the clear layer 34 was 50 μm, and the thickness of the second colored layer 16 was 54 μm.

Example 12

The retroreflective film 10M illustrated in FIG. 14B was used as the retroreflective film in Example 12. In Example 12, the thickness of the clear layer 14 was 58 μm, the thickness of the adhesive layer 32 was 35 μm, the thickness of the clear layer 34 was 50 μm, the thickness of the adhesive layer 35 was 40 μm, the thickness of the transparent resin layer 36 was 50 μm, and the thickness of the second colored layer 16 was 33 μm.

Example 13

In the retroreflective film in Example 13, the thickness of the second colored layer 16 of the retroreflective film in Example 12 was 54 μm.

Example 14

The retroreflective film in Example 14 was a retroreflective film 10N including a printed blue first colored layer 55 as illustrated in FIG. 15B. The thickness of the clear layer 14 was 58 μm, and the thickness of the second colored layer 16 was 54 μm.

Example 15

The retroreflective film 10P illustrated in FIG. 16B was used as the retroreflective film in Example 15. The thickness of the clear layer 14 was 58 μm, the thickness of the adhesive layer 32 was 30 μm, the thickness of the clear layer 34 was 50 μm, and the thickness of the second colored layer 16 was 54 μm.

Example 16

The retroreflective film 10Q illustrated in FIG. 18B was used as the retroreflective film in Example 16. In Example 16, the thickness of the clear layer 14 was 58 μm, the thickness of the adhesive layer 32 was 35 μm, the thickness of the clear layer 34 was 50 μm, the thickness of the adhesive layer 35 was 40 μm, the thickness of the transparent resin layer 36 was 50 μm, and the thickness of the second colored layer 16 was 33 μm.

Example 17

In the retroreflective film in Example 17, the thickness of the second colored layer 16 of the retroreflective film in Example 16 was 54 μm.

Comparative Example 1

A Scotchcal (registered trademark) retroreflective sheet white was used as a retroreflective film of Comparative Example 1. The retroreflective film of Comparative

Example 1 is the retroreflective film in Example 1, excluding the clear layer 14, the first colored layer 15, and the second colored layer 16.

Comparative Example 2

A Scotchcal (registered trademark) retroreflective sheet black was used as a retroreflective film of Comparative Example 2. The retroreflective film in Comparative Example 2 is the retroreflective film 10C illustrated in FIG. 6A, excluding the clear layer 14, the first colored layer 15, and the second colored layer 16.

Experiments were performed to measure the color of the retroreflective films in Examples 1 to 17 and Comparative Examples 1, 2 under normal light and linear light at nighttime. Table 1 described below illustrates the results. Note that the "○" in the row of Visible Light Evaluation in Table 1 indicates that the retroreflective film looks black under normal light and any color having a lower lightness than black (yellow, green, or blue), and "△" indicates a result other than "○". The "Color Observed Under Normal Light" in Table 1 indicates the color of the retroreflective film observed under general illumination, and the "Color Observed Under Linear Light" indicates the color of the retroreflective film observed when irradiated with linear light at nighttime.

In the measurement of the retroreflective coefficient (cd/lux/m^2), the measurement method prescribed in JIS Z 9117 8.3 "Measurement of Retroreflective Material and Reflective Performance" was used. Specifically, the retroreflective coefficient was obtained by measuring the retroreflective coefficient (retroreflective coefficient R0.2) at an observation angle of 0.2 degrees and an incident angle of 5 degrees with a retroreflective measurement device Retrosign Type 4500 (Delta Light Optics, Lyngby, Denmark). That is, the retroreflective coefficient was obtained by irradiating the retroreflective film with light of constant luminance from a light projector and measuring the luminance of light reflected back from the retroreflective film. The retroreflective coefficients in Table 1 each indicate an average value of results obtained by measuring three points under conditions where the observation angle, which is the angle difference between the light projector and a light receiver described above, is 0.2 degrees and the angle of incidence, which is the difference between the perpendicular line with respect to the retroreflective film and the angle of the light projector, is 5 degrees.

Table 1

	Color Observed Under Normal Light	Color Observed Under Linear Light	Retroreflective Coefficient	Visible Light Evaluation
Example 1	Yellow with low lightness	Yellow	28.0	Δ
Example 2	Black	Yellow with low lightness	9.0	○
Example 3	Black	Yellow with low lightness	1.3	○
Example 4	Black	Yellow	12.3	○
Example 5	Black	Yellow with low lightness	4.3	○
Example 6	Black	Yellow with low lightness	1.7	○
Example 7	Black	Yellow with low lightness	3.0	○
Example 8	Black	Yellow	3.3	○
Example 9	Black	Yellow	1.7	○
Example 10	Black	Green	1.0	○
Example 11	Black	Green	1.0	○
Example 12	Black	Green	1.0	○
Example 13	Black	Green	1.0	○
Example 14	Black	Blue	0.3	○
Example 15	Black	Blue	1.0	○
Example 16	Black	Blue	1.0	○
Example 17	Black	Blue	0.7	○
Comparative Example 1	White	White	82.3	×
Comparative Example 2	Black	White	34.0	○

As illustrated in Table 1, with the retroreflective films in Examples 1, 2, 4, and 5 that includes the yellow first colored layer 15 obtained by coating the yellow liquid L1 and the second colored layer 16 containing 1.6 mass% of black acrylic resin, and the retroreflective film in Example 3 that includes the first colored layer 15 and the second colored layer 26 with a thickness of 30 μm containing 6.0 mass% of black acrylic resin, the lightness of the color at nighttime could be made higher than the lightness of the color at daytime, bringing particularly favorable results.

Also, with the retroreflective films in Examples 6, 7 that includes the first colored layer 25 obtained using the inkjet printer and the second colored layer 16 containing 1.6 mass% of black acrylic resin, bringing the same favorable results. Also, the retroreflective films in

Examples 8, 9 that include the adhesive layer 32 and the clear layer 34 together with the second colored layer 16 having a thickness of 33 μm or 54 μm shone yellow at nighttime, bringing favorable results.

In the example provided with the green first colored layer 45, in Example 10 in which the thickness of the clear layer 14 was 58 μm and the thickness of the second colored layer 16 was 54 μm, and in Example 11 in which the adhesive layer 32 and the clear layer 34 were further provided, the retroreflective films when irradiated with linear light shone green, bringing particularly favorable results. Also, in the Examples 12, 13 in which the thickness of the adhesive layer 35 was 40 μm, the thickness of the transparent resin layer 36 was 50 μm, and the thickness of the second colored layer 16 was 33 μm or 54 μm, the same favorable results as described above were obtained.

In the example provided with the blue first colored layer 55, in Example 14 in which the thickness of the clear layer 14 was 58 μm and the thickness of the second colored layer 16 was 54 μm, and in Example 15 in which the adhesive layer 32 and the clear layer 34 were further provided, the retroreflective films when irradiated with linear light shone blue, bringing particularly favorable results. Also, in the Examples 16, 17 in which the thickness of the adhesive layer 35 was 40 μm, the thickness of the transparent resin layer 36 was 50 μm, and the thickness of the second colored layer 16 was 33 μm or 54 μm, the same favorable results as described above were obtained. As described above, it was found that in the retroreflective film provided with the yellow, green, or blue first colored layer and the black second colored layer having a lower lightness than the first colored layer, the black of the retroreflective film can be exhibited at daytime, and when irradiated with linear light, can shine with color (chromatic color) other than black, bringing favorable results.

Various Embodiments and Examples of the retroreflective film according to the present disclosure have been described. However, the present invention is not limited to Embodiments or Examples described above.

For example, in the embodiment described above, the retroreflective film 10 includes the bead layer 19. However, the retroreflective film may not include the bead layer, and may be provided with a prism layer instead of the bead layer 19. In this case, light can be retroreflected from the retroreflective layer provided with a prism, achieving the same effects as described above.

In the embodiments described above, a retroreflective film 10 including the black second colored layer 16 was illustrated. However, the color of the second colored layer may be any color other than black, and may be changed as appropriate as long as the color has a lower lightness than the color of the first colored layer. The color of the first colored layer is not

limited to yellow, green, or blue, and may be white, red, pink, brown, orange, yellow, or purple, and be changed as appropriate.

In the above-described embodiments, the retroreflective film 10 is applied to the vehicle body 1. However, the retroreflective film may be applied to an object other than the vehicle body. For example, the retroreflective film may be a retroreflective film applied to a bicycle, a retroreflective film applied to a ship, a retroreflective film applied to a railway vehicle, a retroreflective film applied to an aircraft, a retroreflective film applied to a moving machine, or a retroreflective film applied to an object other than a moving body. As described above, the adherend to which the retroreflective film is applied can be appropriately changed.

Reference Signs List

1: Vehicle body (adherend), 10, 10A, 10B, 10C, 10D, 10E, 10F, 10G, 10H, 10J, 10K, 10L, 10M, 10N, 10P, 10Q, 10R: Retroreflective film, 13: Retroreflective layer, 15, 25, 45, 55: First colored layer, 16, 16A, 26: Second colored layer, 20: Bond layer, 27: Third colored layer.

What is claimed is:

1. A retroreflective film comprising a plurality of layers,
the plurality of layers including:
an adhesion layer to be adhered to an adherend;
a retroreflective layer;
a first colored layer; and
a second colored layer having a lower lightness than the first colored layer,
in this order, and
the retroreflective layer retroreflects at least a portion of light incident through the second colored layer and the first colored layer toward a light source of the light.

2. The retroreflective film according to claim 1, further comprising a third colored layer between the first colored layer and the retroreflective layer, and
a lightness of the third colored layer is lower than a lightness of the first colored layer.

3. The retroreflective film according to claim 1 or 2, wherein the retroreflective layer includes a bead layer including a plurality of beads, a reflective layer that reflects light, and a spacer layer located between the bead layer and the reflective layer.

4. The retroreflective film according to claim 2, wherein the third colored layer is a bond layer that covers a bead layer including a plurality of beads.

5. The retroreflective film according to any one of claims 1 to 4, wherein the second colored layer is black.

6. The retroreflective film according to any one of claims 1 to 5, wherein retroreflected light becomes chromatic when white light is incident on the retroreflective film.

7. The retroreflective film according to any one of claims 1 to 6, wherein a retroreflective coefficient of the retroreflective film is 0.3 (cd/lux/m^2) or more and 30 (cd/lux/m^2) or less.

8. The retroreflective film according to claim 7, wherein a retroreflective coefficient of the retroreflective film is 1.0 (cd/lux/m^2) or more.

9. The retroreflective film according to claim 2, wherein the third colored layer is black.

10. The retroreflective film according to any one of claims 1 to 9, wherein the adherend is a moving body.

11. A method for making a retroreflective film, the method comprising:

preparing a retroreflective layer;

forming a first colored layer on the retroreflective layer; and

forming a second colored layer on the first colored layer, the second colored layer having a lower lightness than the first colored layer; and

the retroreflective layer retroreflects at least a portion of light incident through the second colored layer and the first colored layer toward a light source of the light.

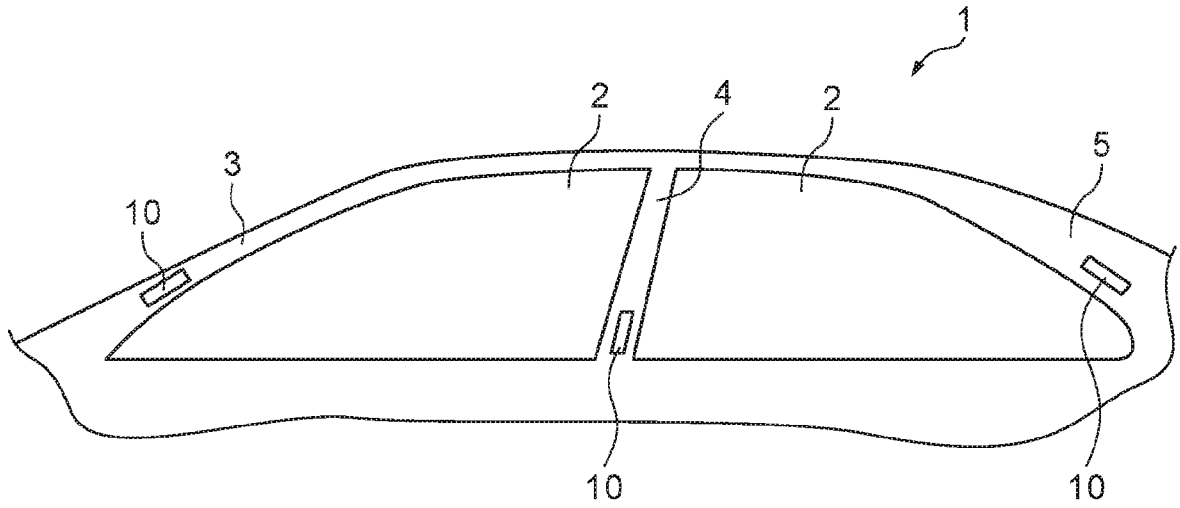


Fig. 1

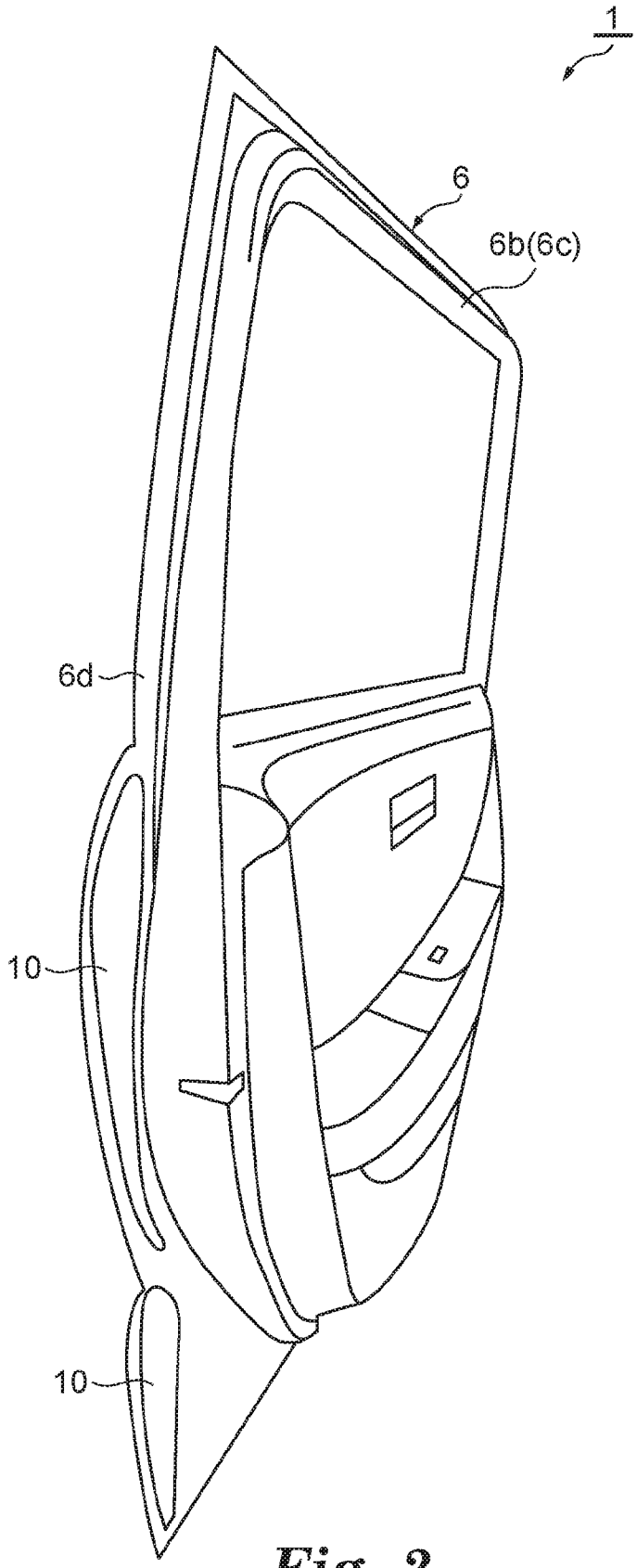


Fig. 2

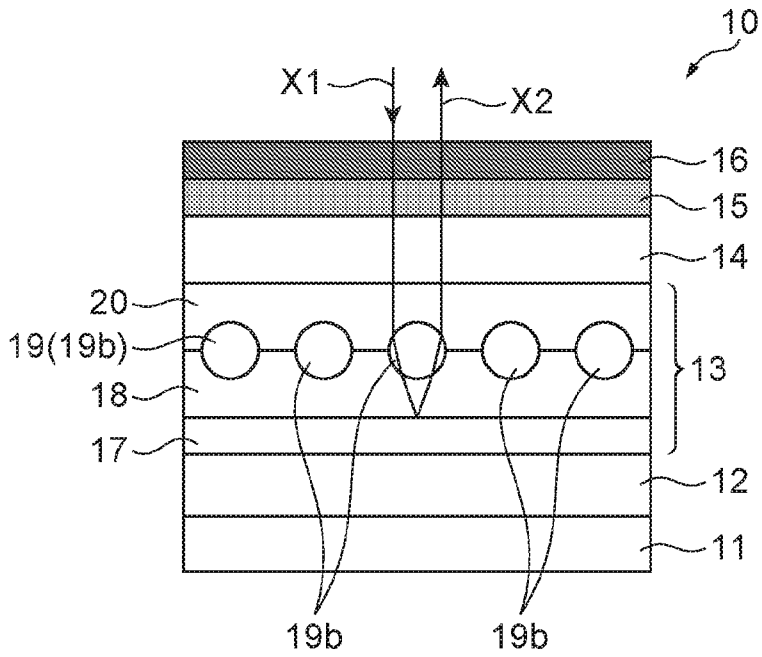


Fig. 3

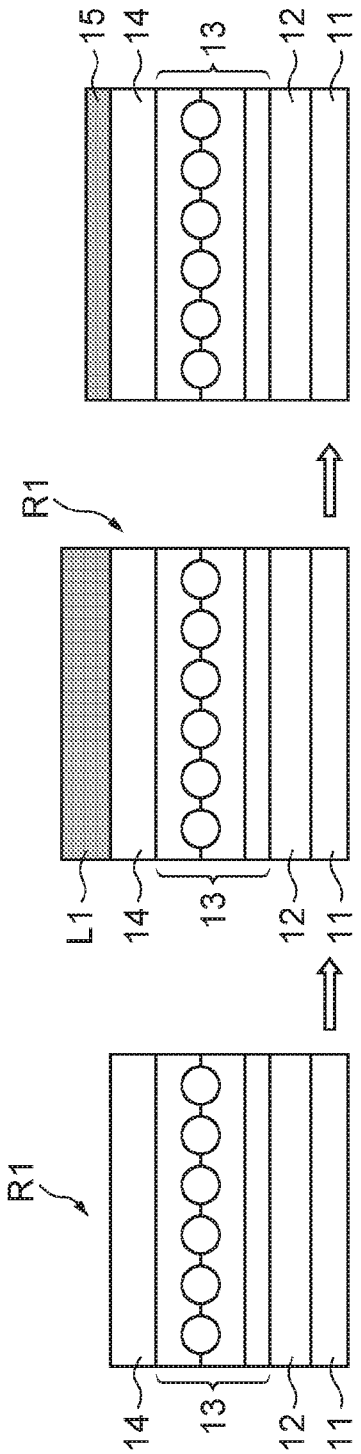


Fig. 4a

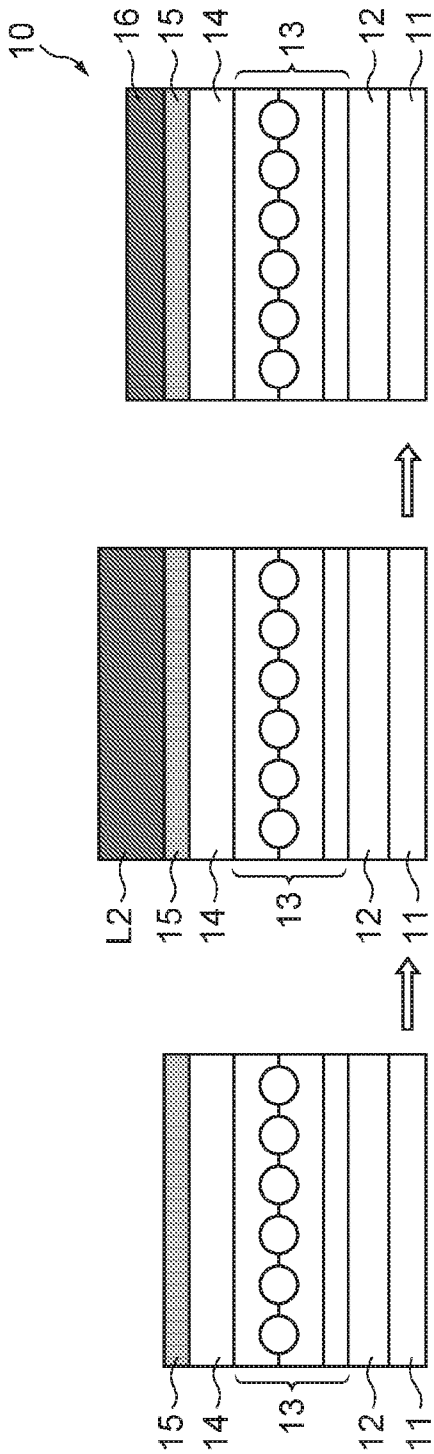


Fig. 4b

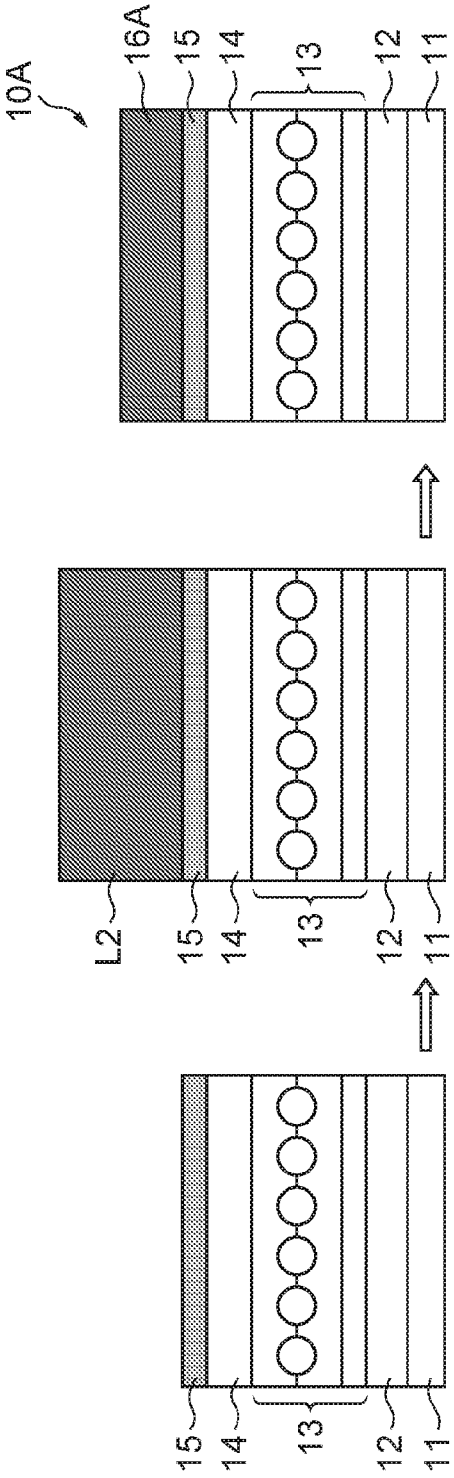

10A
16A
15
14
13
12
11
L2
15
14
13
12
11
15
14
13
12
11

Fig. 5a

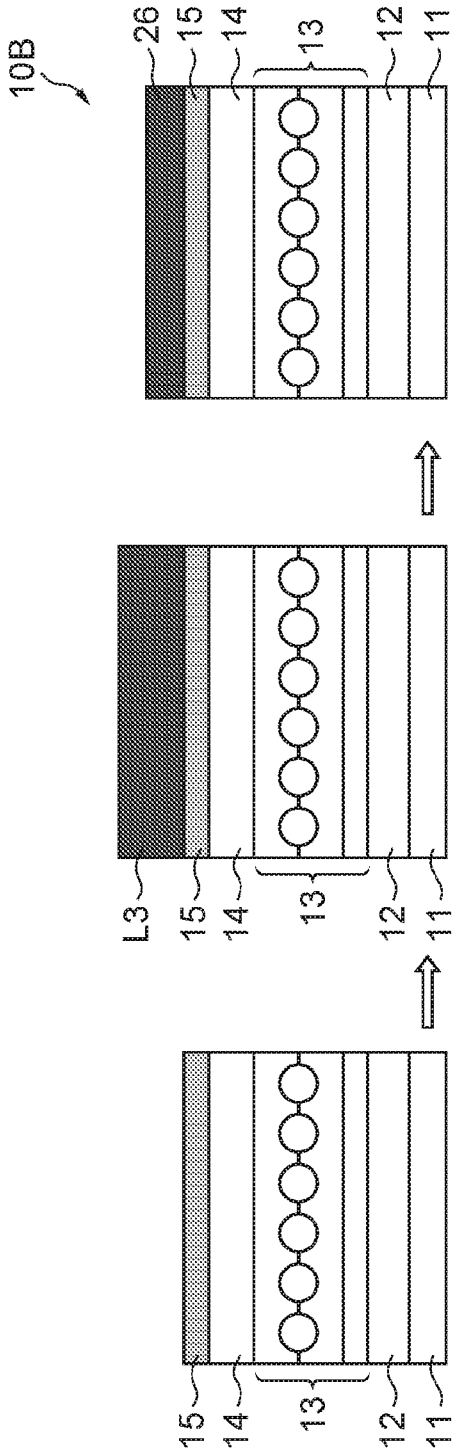

10B
26
15
14
13
12
11
L3
15
14
13
12
11
15
14
13
12
11

Fig. 5b

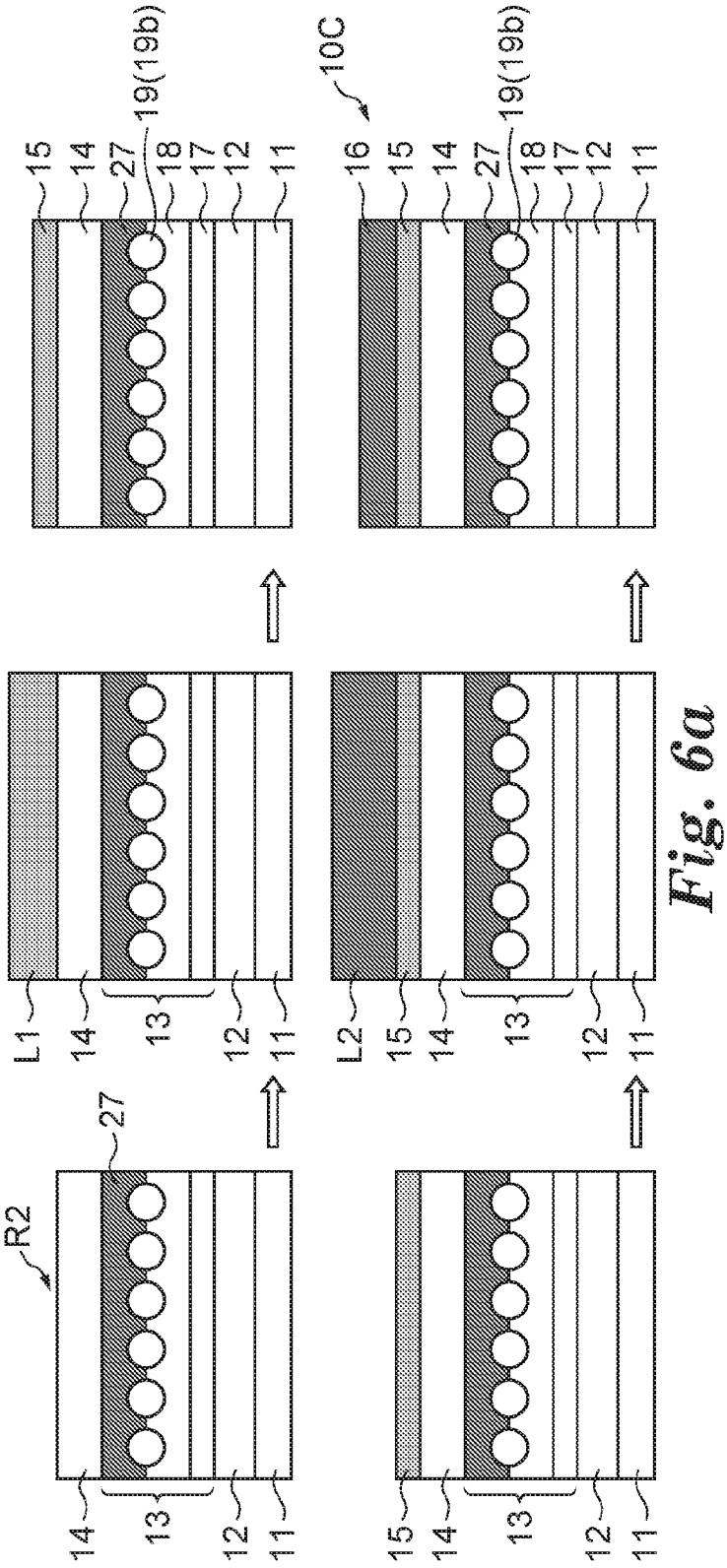
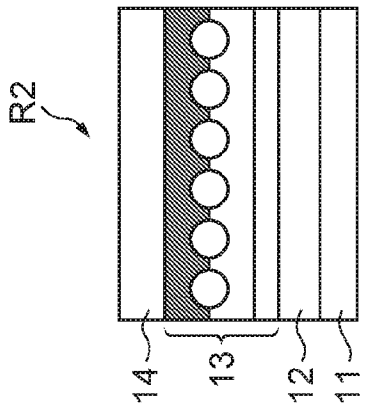

R2
27
14
13
12
11
L1
14
13
12
11
15
14
27
19(19b)
18
17
12
11
10C
15
14
13
12
11
L2
15
14
13
12
11
16
15
14
27
19(19b)
18
17
12
11
10D
15
14
13
12
11
L2
15
14
13
12
11
16
15
14
13
12
11

Fig. 6a

Fig. 6b


R2
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13
12
11

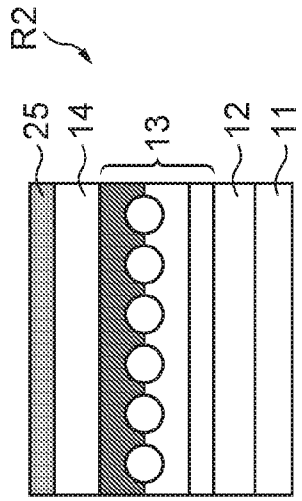
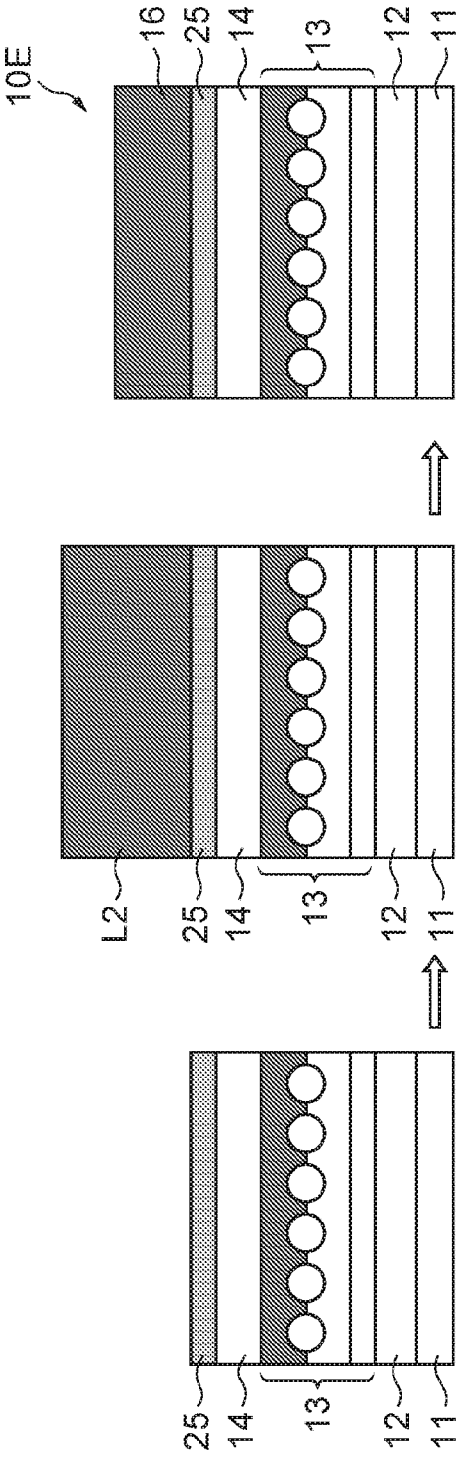

R2
25
14
13
12
11

Fig. 7a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L2
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13
12
11
25
14
13
12
11

Fig. 7b

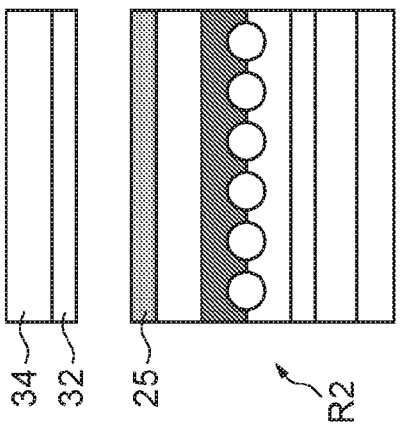
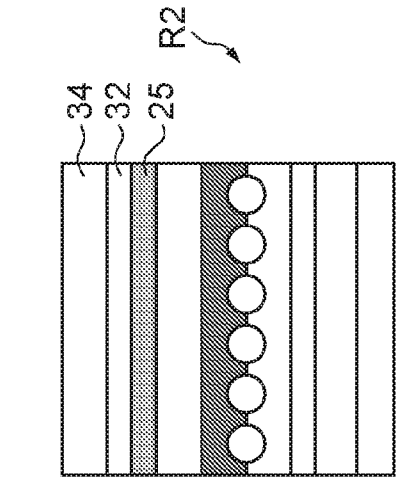
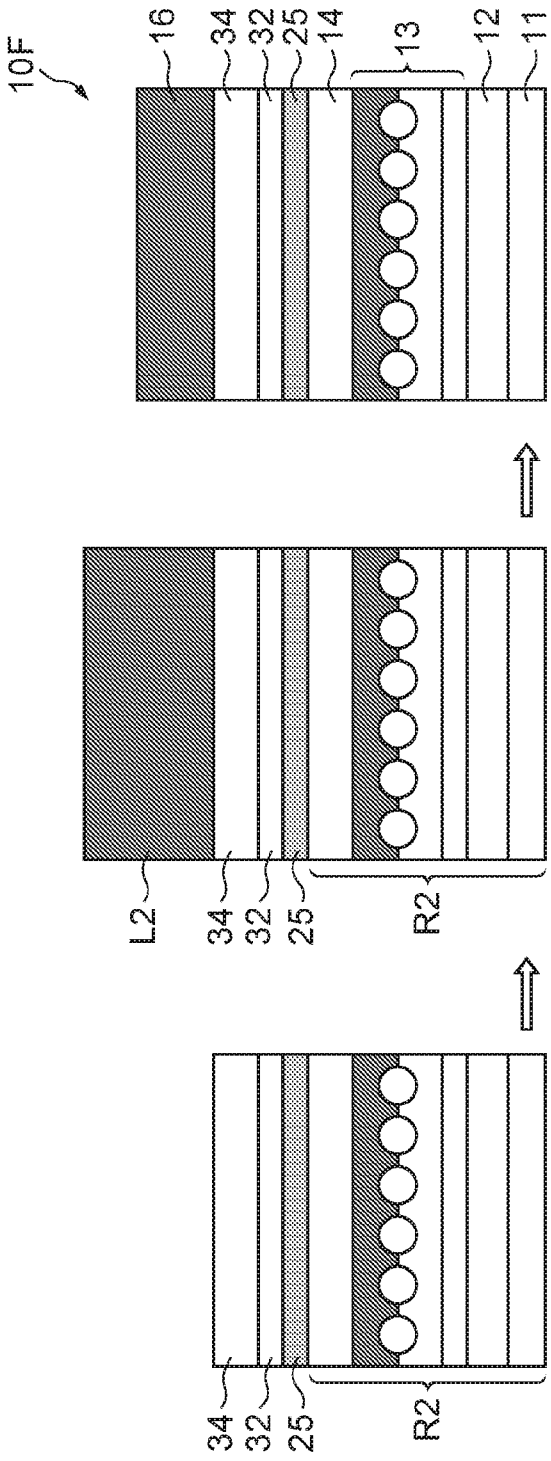

34
32
25
R2

Fig. 8a


34
32
25
R2


10F
16
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13
12
11
L2
34
32
25
R2
34
32
25
R2

Fig. 8b

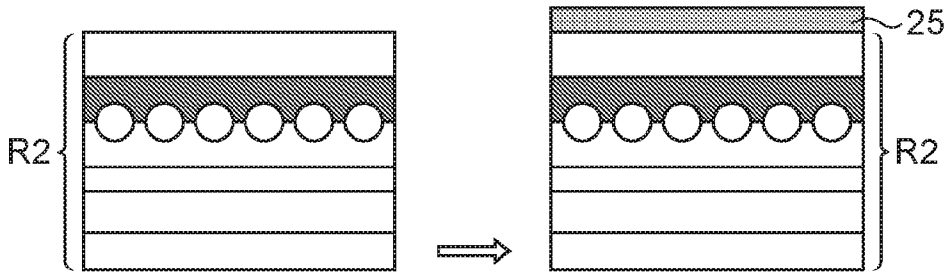


Fig. 9a

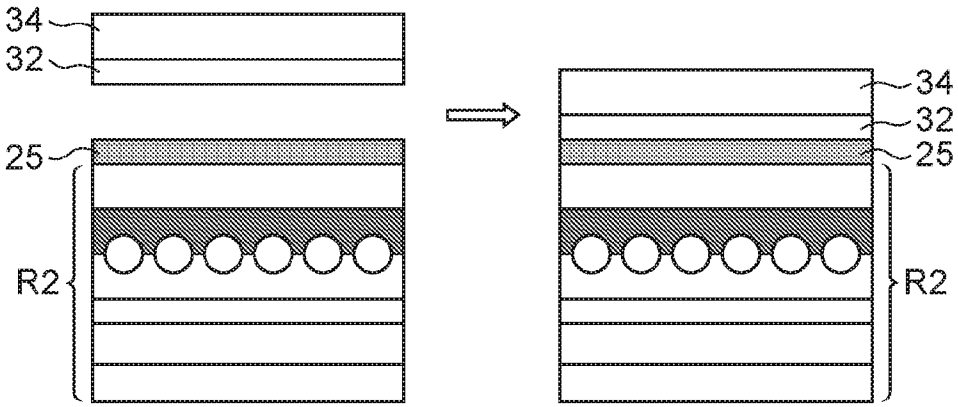


Fig. 9b

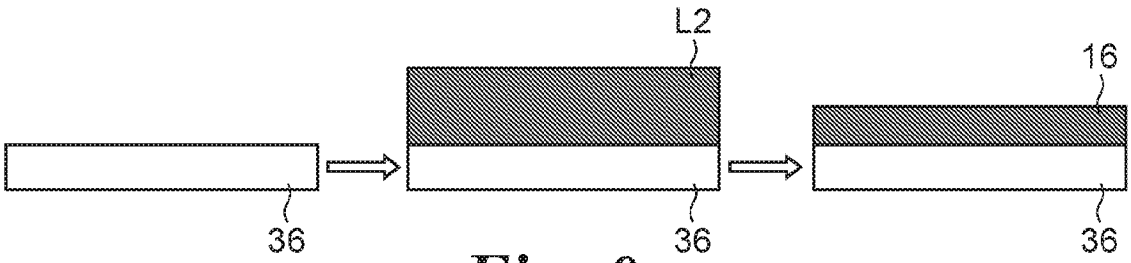


Fig. 9c

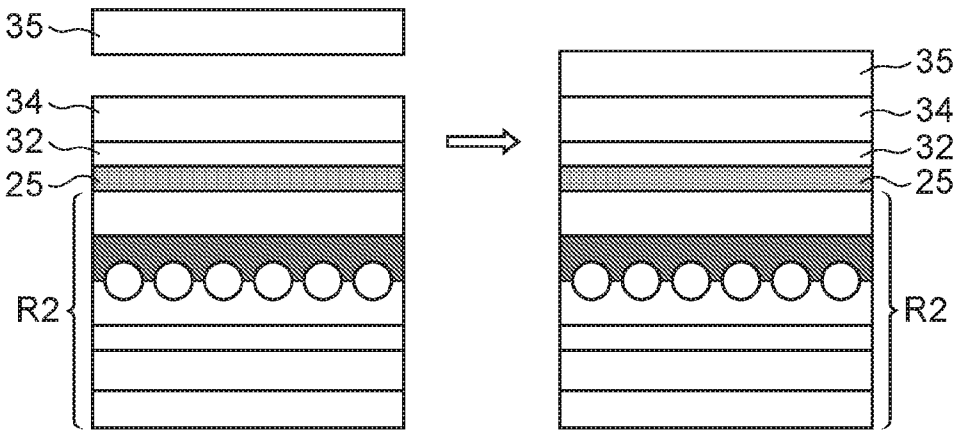


Fig. 9d

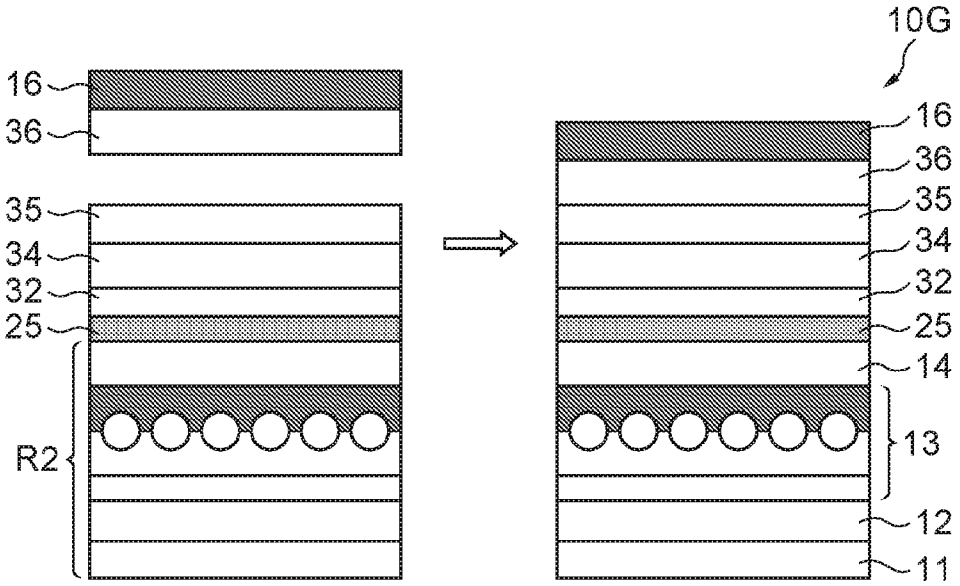


Fig. 10a

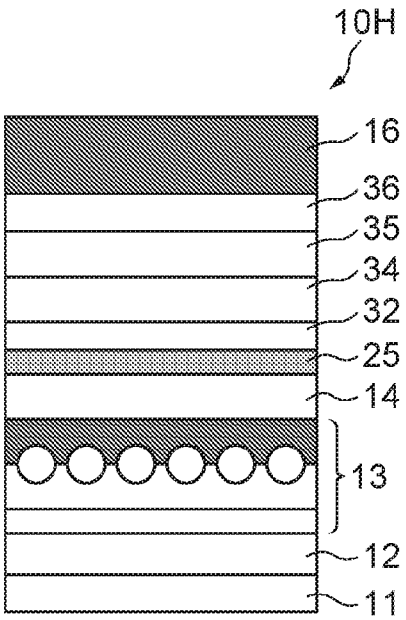


Fig. 10b

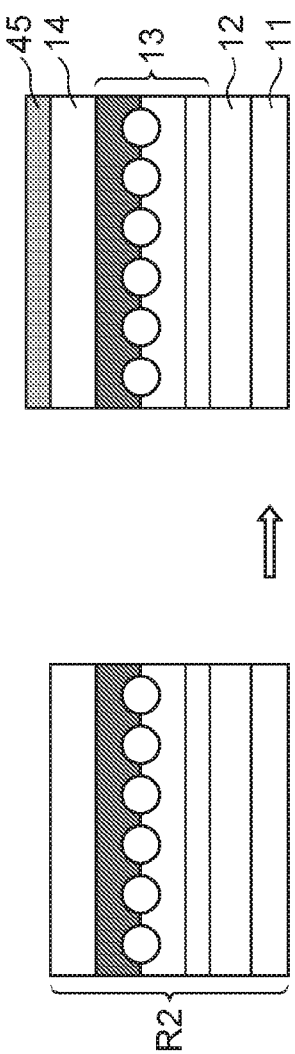


Fig. 11a

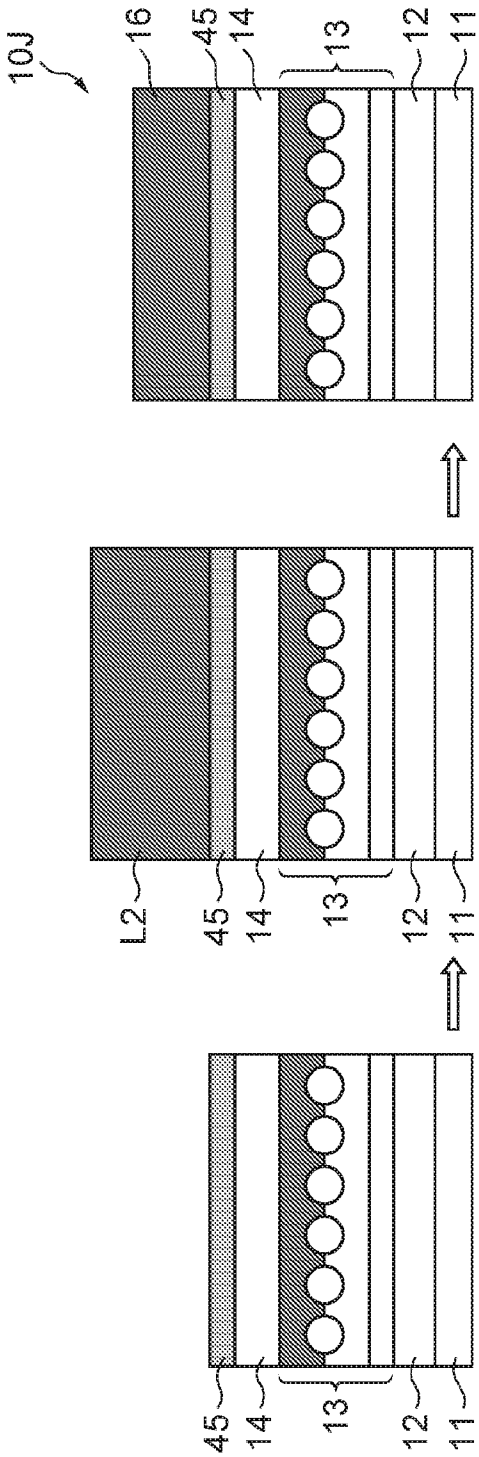
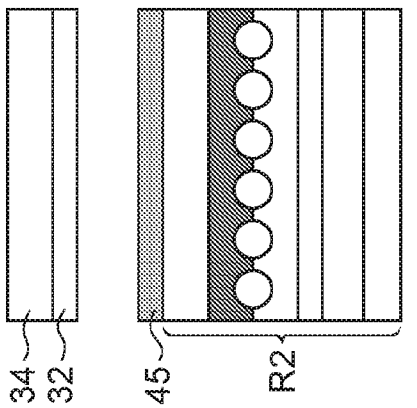


Fig. 11b



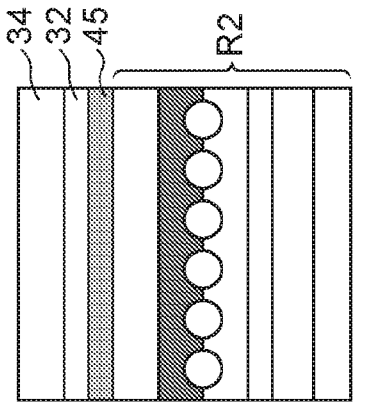


Fig. 12a

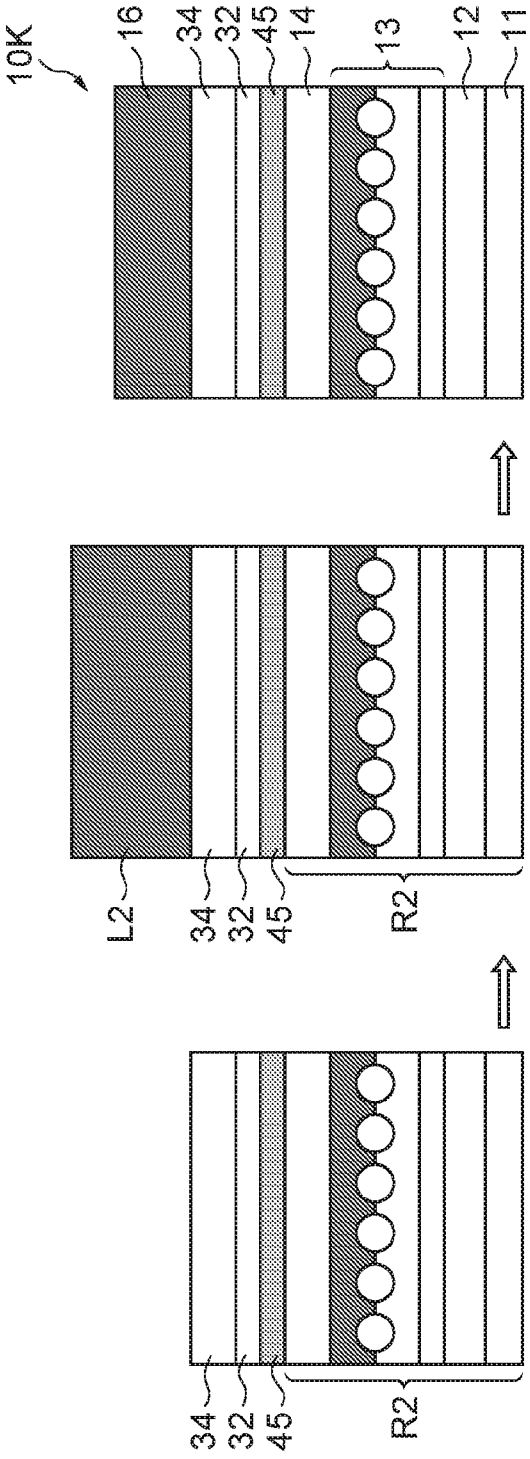
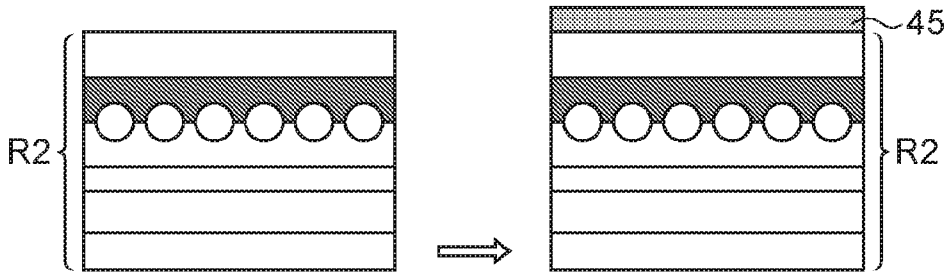


Fig. 12b



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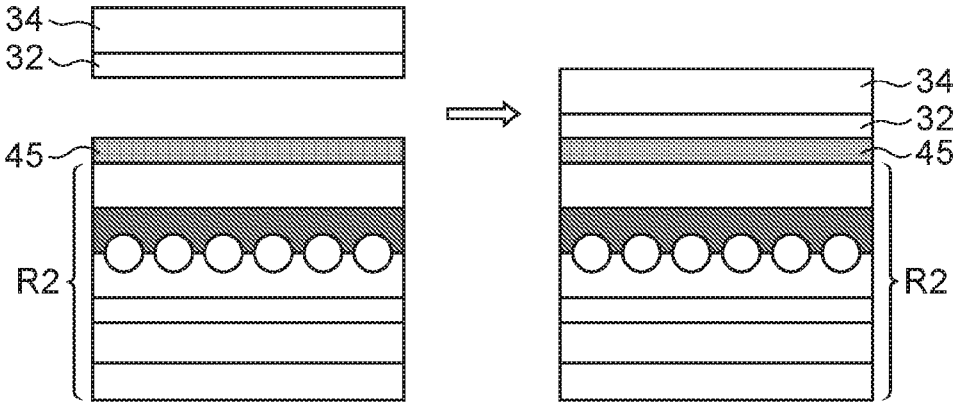


Fig. 13b

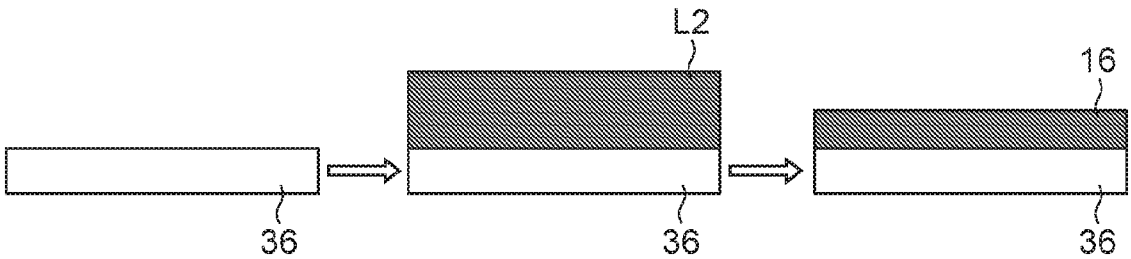


Fig. 13c

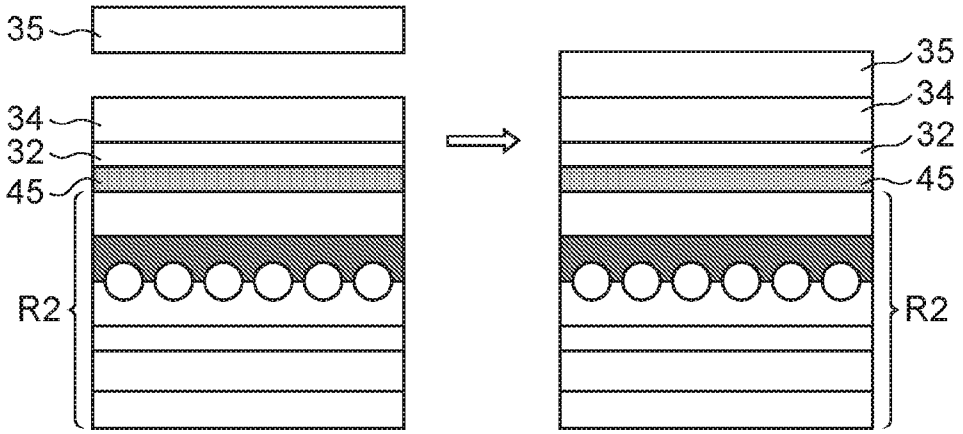


Fig. 14a

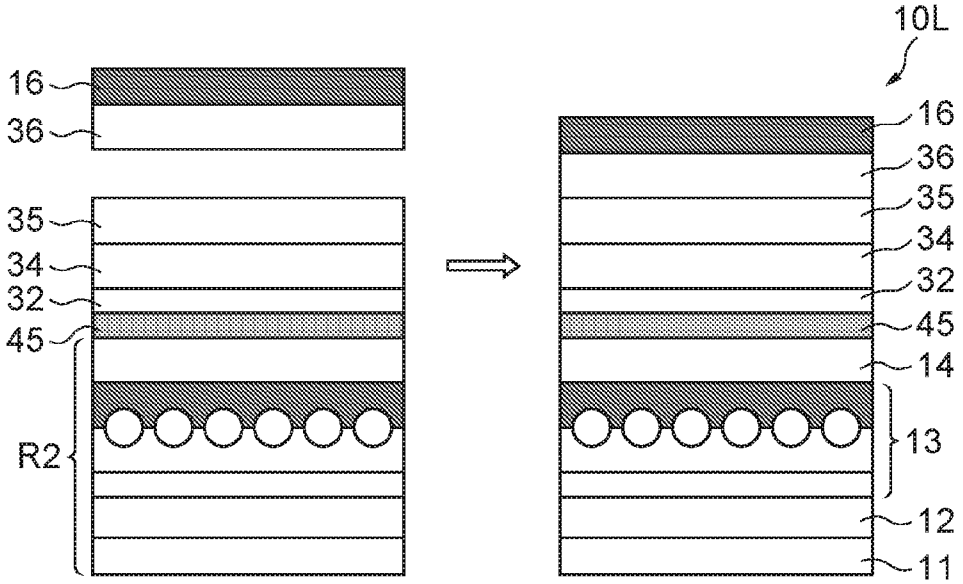
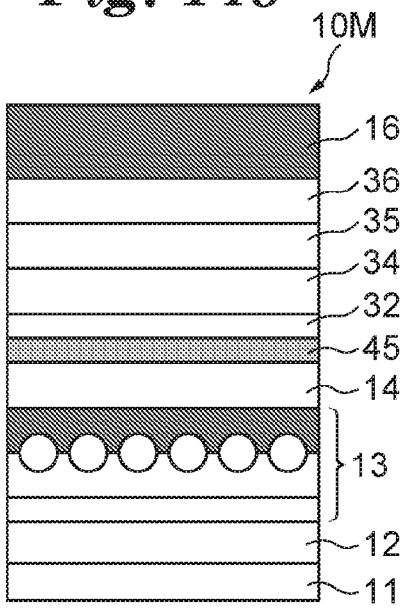


Fig. 14b



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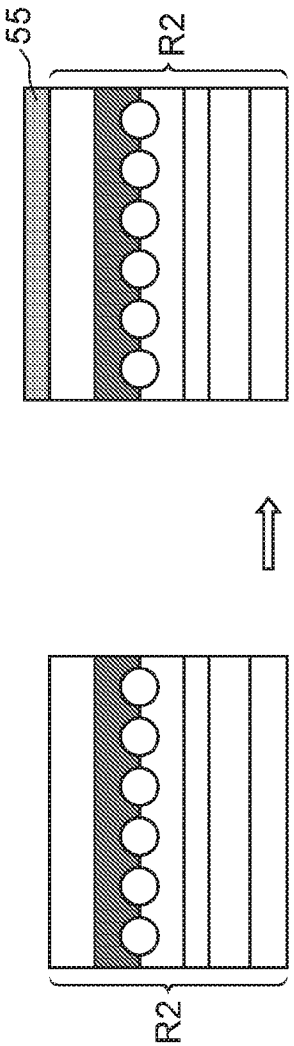

Fig. 15a

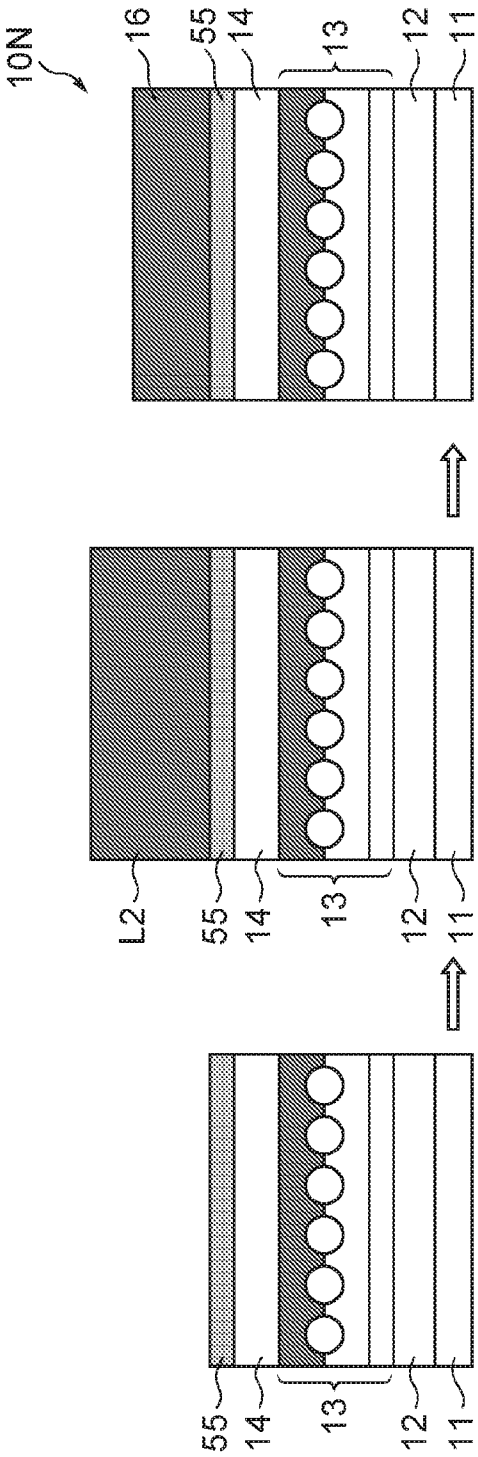

Fig. 15b

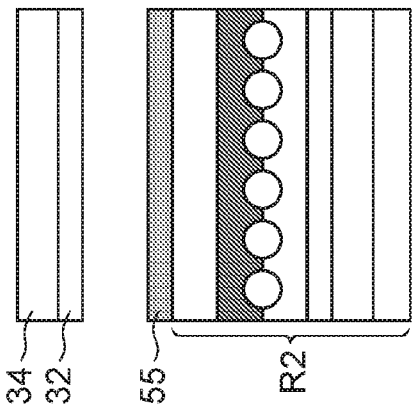

Fig. 16a

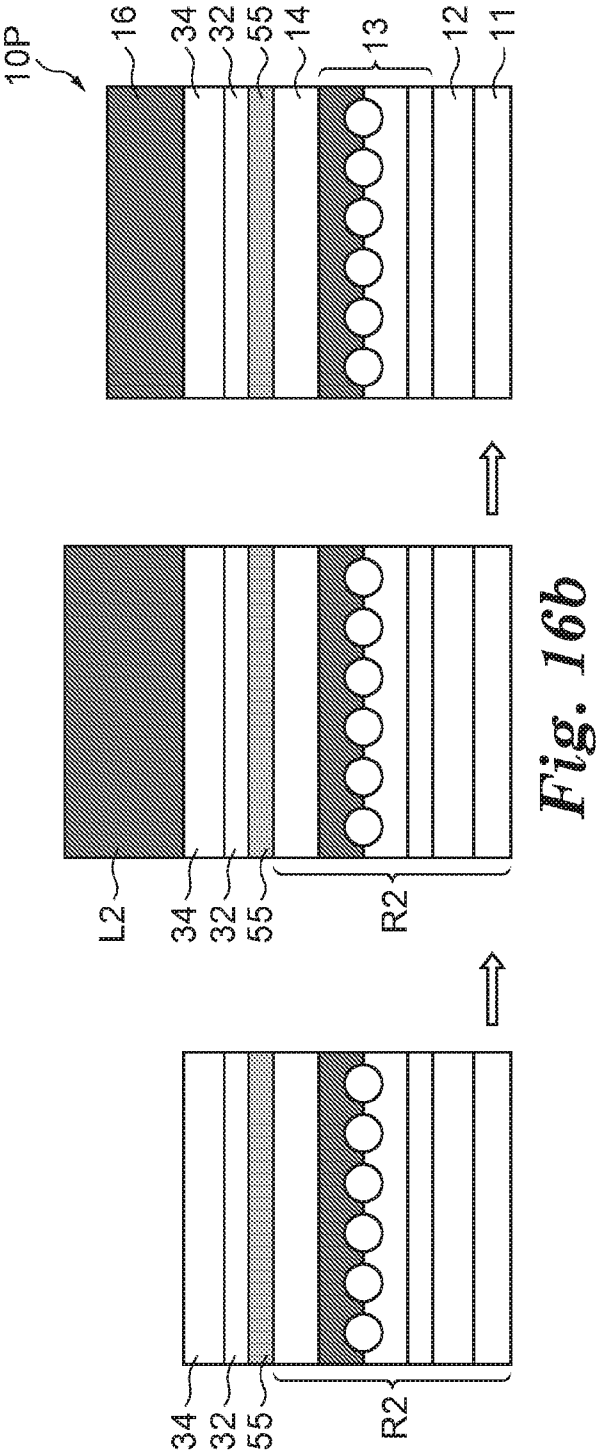

Fig. 16b

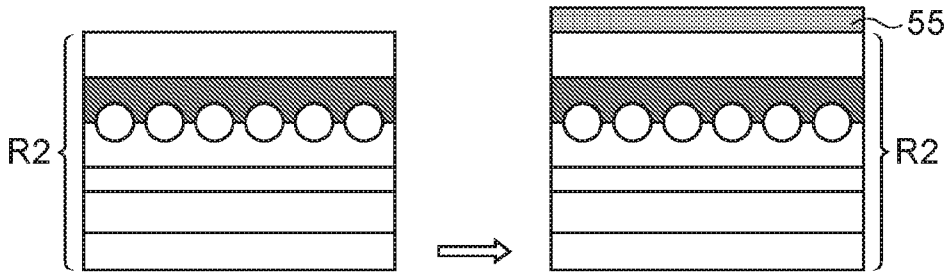

Fig. 17a

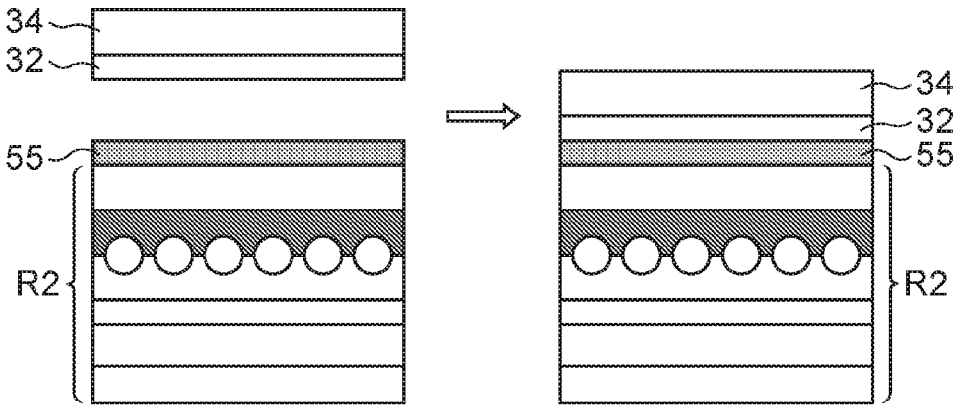

Fig. 17b

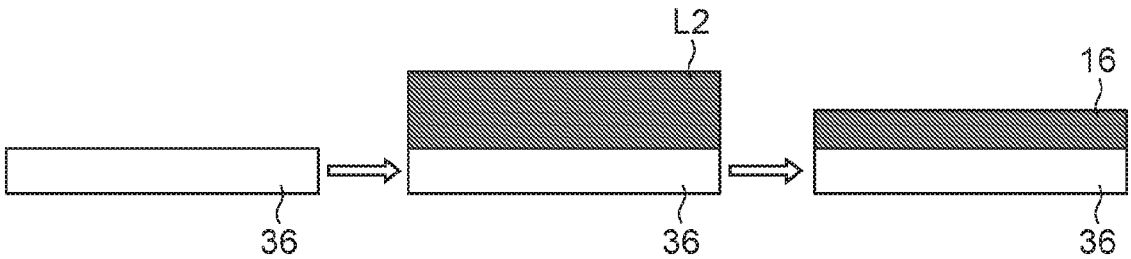

Fig. 17c

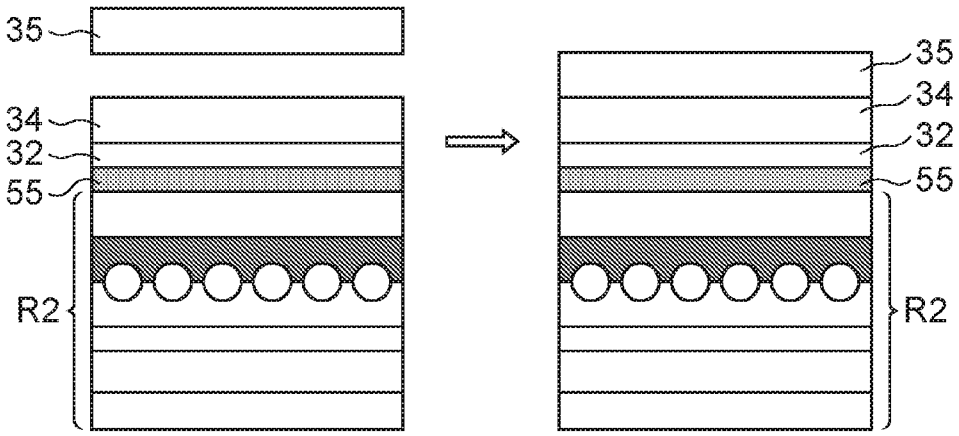

Fig. 18a

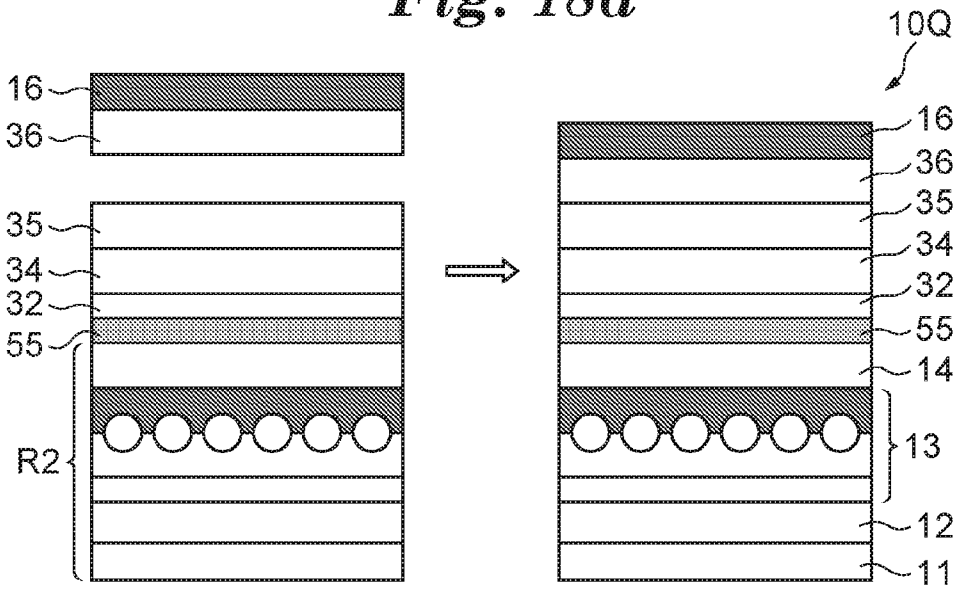

Fig. 18b

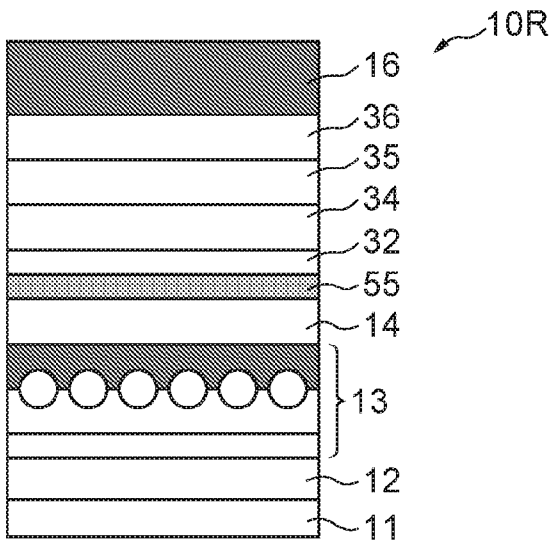

Fig. 18c

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2020/055928

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B5/128
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/050696 A2 (AVERY DENNISON CORP [US]) 3 May 2007 (2007-05-03) paragraphs [0025] - [0062]; figures 1-5	1,3,6, 10,11
X	US 2005/221042 A1 (CHIRHART DENNIS J [US] ET AL) 6 October 2005 (2005-10-06) paragraphs [0022] - [0049]; figures 4-6	1-9,11
A	US 4 268 117 A (SEVELIN CHARLES V) 19 May 1981 (1981-05-19) the whole document	1,5,9,11

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 August 2020	18/09/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Wolf, Steffen

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2020/055928

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