

Description

Title of Invention: OPTICAL LAMINATE AND IMAGE DISPLAY DEVICE

Technical Field

[0001] The present invention relates to an optical laminate and an image display apparatus using the optical laminate.

Background Art

[0002] In recent years, along with widespread use of thin displays, a display having an organic EL panel mounted thereon (organic EL display apparatus) has been proposed. The organic EL panel has a metal layer having high reflectivity, and hence is liable to cause a problem of, for example, reflection of ambient light or reflection of a background. In view of the foregoing, it has been known that such problem is prevented by arranging a circularly polarizing plate on a viewer side. Meanwhile, there has been a growing demand for a so-called inner touch panel-type input display apparatus obtained by incorporating a touch sensor between an image display cell (e.g., an organic EL cell) and a polarizing plate. The input display apparatus having such configuration can impart a natural input operation feeling to a user because a distance between the image display cell and the touch sensor is short. In addition, the input display apparatus having the configuration can reduce an influence of reflected light resulting from a conductive pattern formed in the touch sensor.

[0003] The touch sensor in the input display apparatus having the configuration generally includes a sensor film including a substrate and a conductive layer formed on the substrate. An isotropic substrate is frequently used as the substrate. When the isotropic substrate is optically completely isotropic, an antireflection function is sufficiently exhibited by a circularly polarizing plate. In actuality, however, owing to an influence of, for example, a conductive layer-forming step or treatment for improving the toughness of the substrate, slight anisotropy is expressed even in a substrate intended to show isotropy. As a result, the following problem may occur. Even when the circularly polarizing plate is arranged, a problem, such as ambient light reflection or background reflection, is not solved.

Citation List

Patent Literature

[0004] [PTL 1] JP 2003-311239 A

 [PTL 2] JP 2002-372622 A

 [PTL 3] JP 3325560 B2

 [PTL 4] JP 2003-036143 A

Summary of Invention

Technical Problem

[0005] The present invention has been made to solve the

conventional problems, and a primary object of the present invention is to provide an optical laminate excellent in antireflection function despite including a substrate having optical anisotropy (hereinafter sometimes referred to as "anisotropic substrate").

Solution to Problem

[0006] According to one embodiment of the present invention, there is provided an optical laminate, including, in this order: a polarizing plate including a polarizer and a protective layer arranged on at least one side of the polarizer; a retardation layer; a conductive layer; and a substrate, wherein the substrate has an in-plane retardation $Re(550)$ of more than 0 nm, and wherein an angle formed by a slow axis of the substrate and a slow axis of the retardation layer is from -40° to -50° or from 40° to 50° .

In one embodiment, an angle formed by an absorption axis of the polarizer and the slow axis of the retardation layer is from 38° to 52° .

In one embodiment, the retardation layer has a ratio " $Re(450)/Re(550)$ " of 0.8 or more and less than 1.

In one embodiment, the retardation layer has a ratio " $Re(650)/Re(550)$ " of more than 1 and 1.2 or less.

In one embodiment, the retardation layer includes a polycarbonate-based resin.

According to another embodiment of the present invention, there is provided an image display apparatus. The image display apparatus includes the optical laminate.

Advantageous Effects of Invention

[0007] According to the present invention, an optical laminate excellent in antireflection function despite including an anisotropic substrate can be provided by optimizing the slow axis angle of the anisotropic substrate.

Brief Description of Drawings

[0008] FIG. 1 is a schematic sectional view of an optical laminate according to one embodiment of the present invention.

FIGS. 2 are graphs for showing the results of Example 1 and Comparative Example 1.

FIG. 3 is a graph for showing the results of Example 1 and Comparative Example 1.

FIG. 4 is a graph for showing the results of Example 2 and Comparative Example 2.

FIG. 5 is a graph for showing the results of Example 3 and Comparative Example 3.

Description of Embodiments

[0009] Embodiments of the present invention are described below. However, the present invention is not limited to these embodiments.

[0010] (Definitions of Terms and Symbols)

The definitions of terms and symbols used herein are as described below.

(1) Refractive Indices (n_x , n_y , and n_z)

" n_x " represents a refractive index in a direction in which an in-plane refractive index is maximum (that is, slow axis direction), " n_y " represents a refractive index in a direction perpendicular to the slow axis in the plane (that is, fast axis direction), and " n_z " represents a refractive index in a thickness direction.

(2) In-plane Retardation (Re)

" $Re(\lambda)$ " refers to an in-plane retardation measured at 23°C with light having a wavelength of λ nm. For example, " $Re(550)$ " refers to an in-plane retardation measured at 23°C with light having a wavelength of 550 nm. The $Re(\lambda)$ is determined from the equation " $Re(\lambda) = (n_x - n_y) \times d$ " when the thickness of a layer (film) is represented

by d (nm).

(3) Thickness Direction Retardation (R_{th})

" $R_{th}(\lambda)$ " refers to a thickness direction retardation measured at 23°C with light having a wavelength of λ nm. For example, " $R_{th}(550)$ " refers to a thickness direction retardation measured at 23°C with light having a wavelength of 550 nm. The $R_{th}(\lambda)$ is determined from the equation " $R_{th}(\lambda) = (n_x - n_z) \times d$ " when the thickness of a layer (film) is represented by d (nm).

(4) N_z Coefficient

An N_z coefficient is determined from the equation " $N_z = R_{th}/R_e$ ".

[0011] A. Overall Configuration of Optical Laminate

FIG. 1 is a schematic sectional view of an optical laminate according to one embodiment of the present invention. An optical laminate **100** of this embodiment includes, in this order, a polarizing plate **11**, a retardation layer **12**, a conductive layer **21**, and a substrate **22**. The polarizing plate **11** includes a polarizer **1**, a first protective layer **2** arranged on one side of the polarizer **1**, and a second protective layer **3** arranged on the other side of the polarizer **1**. One of the first protective layer **2** and the second protective layer **3** may be omitted in accordance with purposes. For example, when the retardation layer **12** can also function as a protective layer of the polarizer **1**, the second protective layer

3 may be omitted. The conductive layer **21** and the substrate **22** may each be used as a single layer to serve as a constituent element for the optical laminate **100**, or may be introduced as a laminate of the substrate **22** and the conductive layer **21** into the optical laminate **100**. The laminate of the substrate **22** and the conductive layer **21** can function as, for example, a sensor film **20** of a touch sensor. For ease of viewing, a ratio among the thicknesses of the respective layers in the drawing is different from an actual one. In addition, the respective layers forming the optical laminate may be laminated through intermediation of any appropriate adhesion layer (an adhesive layer or a pressure-sensitive adhesive layer: not shown). Meanwhile, the substrate **22** may be laminated on the conductive layer **21** while being brought into close contact therewith. The phrase "laminated while being brought into close contact" as used herein means that two layers are laminated directly without through intermediation of an adhesion layer (e.g., an adhesive layer or a pressure-sensitive adhesive layer) and fixedly.

[0012] A laminate **10** of the polarizing plate **11** and the retardation layer **12** can function as a circularly polarizing plate. In addition, the substrate **22** may be optically anisotropic. In the present invention, there can be provided such an optical laminate that even when the optical laminate includes the anisotropic substrate **22**, the antireflection function of the circularly polarizing plate is sufficiently exhibited by setting an angle formed

by the slow axis of the substrate **22** and the slow axis of the retardation layer **12** within a specific range (from -40° to -50° or from 40° to 50° as described later), and hence ambient light reflection, background reflection, and the like can be effectively prevented. The substrate **22** has an in-plane retardation (e.g., an in-plane retardation $R_e(550)$ of more than 0 nm and 10 nm or less). Details about the foregoing are described later.

[0013] The total thickness of the optical laminate is preferably 220 μm or less, more preferably from 40 μm to 180 μm .

[0014] The optical laminate may have an elongate shape (e.g., a roll shape), or may have a sheet shape.

[0015] Now, the respective layers forming the optical laminate and an optical film are described in more detail.

[0016] B. Polarizing Plate

B-1. Polarizer

Any appropriate polarizer may be adopted as the polarizer **1**. For example, a resin film forming the polarizer may be a single-layer resin film, or may be a laminate of two or more layers.

[0017] Specific examples of the polarizer including a single-layer resin film include: a polarizer obtained by subjecting

a hydrophilic polymer film, such as a polyvinyl alcohol (PVA)-based film, a partially formalized PVA-based film, or an ethylene-vinyl acetate copolymer-based partially saponified film, to dyeing treatment with a dichroic substance, such as iodine or a dichroic dye, and stretching treatment; and a polyene-based alignment film, such as a dehydration-treated product of PVA or a dehydrochlorination-treated product of polyvinyl chloride. A polarizer obtained by dyeing the PVA-based film with iodine and uniaxially stretching the resultant is preferably used because the polarizer is excellent in optical characteristics.

[0018] The dyeing with iodine is performed by, for example, immersing the PVA-based film in an aqueous solution of iodine. The stretching ratio of the uniaxial stretching is preferably from 3 times to 7 times. The stretching may be performed after the dyeing treatment, or may be performed while the dyeing is performed. In addition, the dyeing may be performed after the stretching has been performed. The PVA-based film is subjected to swelling treatment, cross-linking treatment, washing treatment, drying treatment, or the like as required. For example, when the PVA-based film is immersed in water to be washed with water before the dyeing, contamination or an antiblocking agent on the surface of the PVA-based film can be washed off. In addition, the PVA-based film is swollen and hence dyeing unevenness or the like can be prevented.

[0019] The polarizer obtained by using the laminate is specifically, for example, a polarizer obtained by using a laminate of a resin substrate and a PVA-based resin layer (PVA-based resin film) laminated on the resin substrate, or a laminate of a resin substrate and a PVA-based resin layer formed on the resin substrate through application. The polarizer obtained by using the laminate of the resin substrate and the PVA-based resin layer formed on the resin substrate through application may be produced by, for example, a method involving: applying a PVA-based resin solution onto the resin substrate; drying the solution to form the PVA-based resin layer on the resin substrate, thereby providing the laminate of the resin substrate and the PVA-based resin layer; and stretching and dyeing the laminate to turn the PVA-based resin layer into the polarizer. In this embodiment, the stretching typically includes the stretching of the laminate under a state in which the laminate is immersed in an aqueous solution of boric acid. The stretching may further include the aerial stretching of the laminate at high temperature (e.g., 95°C or more) before the stretching in the aqueous solution of boric acid as required. The resultant laminate of the resin substrate and the polarizer may be used as it is (i.e., the resin substrate may be used as a protective layer for the polarizer). Alternatively, a product obtained as described below may be used: the resin substrate is peeled from the laminate of the resin substrate and the polarizer, and any appropriate protective layer in accordance with purposes is laminated on the peeling surface. Details of such

method of producing a polarizer are described in, for example, JP 2012-73580 A. The entire description of the laid-open publication is incorporated herein by reference.

[0020] The thickness of the polarizer is preferably 15 μm or less, more preferably from 1 μm to 12 μm , still more preferably from 3 μm to 12 μm , particularly preferably from 5 μm to 12 μm .

[0021] The boric acid content of the polarizer is preferably 18 wt% or more, more preferably from 18 wt% to 25 wt%. When the boric acid content of the polarizer falls within such range, by a synergistic effect with an iodine content to be described later, the appearance durability of the polarizing plate at the time of its heating can be improved while the ease with which the curling thereof at the time of its bonding is adjusted is satisfactorily maintained, and the curling thereof at the time of the heating is satisfactorily suppressed. The boric acid content may be calculated, for example, as the amount of boric acid contained per unit weight of the polarizer through the use of the following expression on the basis of a neutralization method.

$$\{ (\text{Dropping amount (mL) of aqueous solution of NaOH} \times \text{concentration (mol/L) of aqueous solution of NaOH} \times 10^{-3}) / \text{weight (g) of polarizer} \} \times \text{molecular weight (g/mol) of boric acid} \times 100$$

[0022] The iodine content of the polarizer is preferably 2.1 wt% or more, more preferably from 2.1 wt% to 3.5 wt%. When the iodine content of the polarizer falls within such range, by a synergistic effect with the boric acid content, the appearance durability of the polarizing plate at the time of its heating can be improved while the ease with which the curling thereof at the time of its bonding is adjusted is satisfactorily maintained, and the curling thereof at the time of the heating is satisfactorily suppressed. The term "iodine content" as used herein means the amount of all iodine contained in the polarizer (PVA-based resin film). More specifically, in the polarizer, iodine is present in the forms of an iodide ion (I^-), an iodine molecule (I_2), polyiodide ions (I_3^- and I_5^-), and the like, and the term "iodine content" as used herein means the amount of iodine encompassing all of those forms. The iodine content may be calculated by, for example, a calibration curve method for X-ray fluorescence analysis. The polyiodide ions are each present in a state of forming a PVA-iodine complex in the polarizer. Through the formation of such complex, absorption dichroism can be expressed in the wavelength range of visible light. Specifically, a complex of PVA and a triiodide ion ($PVA \cdot I_3^-$) has an absorption peak around 470 nm, and a complex of PVA and a pentaiodide ion ($PVA \cdot I_5^-$) has an absorption peak around 600 nm. As a result, the polyiodide ions can absorb light in a wide range of visible light depending on their forms. Meanwhile, the iodide ion (I^-) has an absorption peak around 230 nm, and is not substantially involved

in the absorption of visible light. Therefore, the polyiodide ions each present in a state of a complex with PVA can be mainly involved in the absorption performance of the polarizer.

[0023] The polarizer preferably shows absorption dichroism at any wavelength in the wavelength range of from 380 nm to 780 nm. As described above, the single layer transmittance of the polarizer is from 43.0% to 46.0%, preferably from 44.5% to 46.0%. The polarization degree of the polarizer is preferably 97.0% or more, more preferably 99.0% or more, still more preferably 99.9% or more.

[0024] B-2. First Protective Layer

The first protective layer **2** is formed of any appropriate film that may be used as a protective layer for a polarizer. A material serving as a main component of the film is specifically, for example: a cellulose-based resin, such as triacetylcellulose (TAC); a transparent resin, such as a polyester-based, polyvinyl alcohol-based, polycarbonate-based, polyamide-based, polyimide-based, polyether sulfone-based, polysulfone-based, polystyrene-based, polynorbornene-based, polyolefin-based, (meth)acrylic, or acetate-based transparent resin; or a thermosetting resin or a UV-curable resin, such as a (meth)acrylic, urethane-based, (meth)acrylic urethane-based, epoxy-based, or silicone-based thermosetting resin or UV-curable resin. A further example thereof is a glassy polymer, such as a siloxane-based polymer.

In addition, a polymer film described in JP 2001-343529 A (WO 01/37007 A1) may be used. For example, a resin composition containing a thermoplastic resin having a substituted or unsubstituted imide group on a side chain thereof, and a thermoplastic resin having a substituted or unsubstituted phenyl group and a nitrile group on side chains thereof may be used as the material for the film, and the composition is, for example, a resin composition having an alternating copolymer formed of isobutene and N-methylmaleimide, and an acrylonitrile-styrene copolymer. The polymer film may be, for example, an extrudate of the resin composition.

[0025] As described later, the optical laminate of the present invention is typically arranged on the viewer side of an image display apparatus, and the first protective layer **2** is typically arranged on its viewer side. Therefore, the first protective layer **2** may be subjected to surface treatment, such as hard coat treatment, antireflection treatment, anti-sticking treatment, or antiglare treatment, as required. Further/alternatively, the first protective layer **2** may be subjected to treatment for improving viewability when the display screen of the apparatus is viewed through polarized sunglasses (typically the impartment of a circular (elliptical) polarization function or the impartment of an ultra-high retardation) as required. When such treatment is performed, even in the case where the display screen is viewed through a polarizing lens, such as polarized sunglasses, excellent

viewability can be achieved. Therefore, the optical laminate is suitably applicable even to an image display apparatus that may be used outdoors.

[0026] Any appropriate thickness may be adopted as the thickness of the first protective layer. The thickness of the first protective layer is, for example, from 10 μm to 50 μm , preferably from 15 μm to 40 μm . When the first protective layer is subjected to surface treatment, its thickness is a thickness including the thickness of a surface-treated layer.

[0027] B-3. Second Protective Layer

The second protective layer **3** is also formed of any appropriate film that may be used as a protective layer for a polarizer. A material serving as a main component of the film is as described in the section B-2 regarding the first protective layer. It is preferred that the second protective layer **3** be substantially optically isotropic. The phrase "be substantially optically isotropic" as used herein refers to having an in-plane retardation $R_e(550)$ of from 0 nm to 10 nm and a thickness direction retardation $R_{th}(550)$ of from -10 nm to +10 nm.

[0028] The thickness of the second protective layer is, for example, from 15 μm to 35 μm , preferably from 20 μm to 30 μm . A difference between the thickness of the first protective layer and

the thickness of the second protective layer is preferably 15 μm or less, more preferably 10 μm or less. When the difference between the thicknesses falls within such range, the curling of the polarizing plate at the time of its bonding can be satisfactorily suppressed. The thickness of the first protective layer and the thickness of the second protective layer may be identical to each other, the first protective layer may be thicker than the other, or the second protective layer may be thicker than the other. The first protective layer is typically thicker than the second protective layer.

[0029] C. Retardation Layer

The retardation layer **12** may have any appropriate optical characteristics and/or mechanical characteristics depending on purposes. The retardation layer **12** typically has a slow axis. In one embodiment, an angle θ formed by the slow axis of the retardation layer **12** and the absorption axis of the polarizer **1** is preferably from 38° to 52° , more preferably from 42° to 48° , still more preferably about 45° . When the angle θ falls within such range, through the use of the retardation layer as a $\lambda/4$ plate as described later, an optical laminate having an extremely excellent circular polarization characteristic (consequently an extremely excellent antireflection characteristic) can be obtained.

[0030] The retardation layer preferably has a refractive index characteristic of showing a relationship of $n_x > n_y \geq n_z$. The

retardation layer is typically arranged in order to impart an antireflection characteristic to the polarizing plate, and in one embodiment, may function as a $\lambda/4$ plate. In this case, the in-plane retardation $R_e(550)$ of the retardation layer is preferably from 80 nm to 200 nm, more preferably from 100 nm to 180 nm, still more preferably from 110 nm to 170 nm. Herein, " $n_y=n_z$ " encompasses not only the case where n_y and n_z are exactly equal to each other, but also the case where n_y and n_z are substantially equal to each other. Therefore, a relationship of $n_y < n_z$ may be satisfied without impairing the effect of the present invention.

[0031] The n_z coefficient of the retardation layer is preferably from 0.1 to 3, more preferably from 0.2 to 1.5, still more preferably from 0.3 to 1.3. When such relationship is satisfied, in the case of using the optical laminate to be obtained for an image display apparatus, an extremely excellent reflection hue can be achieved.

[0032] The retardation layer may show a reverse wavelength dispersion characteristic, i.e., a retardation value increasing with an increase in wavelength of measurement light, may show a positive wavelength dispersion characteristic, i.e., a retardation value decreasing with an increase in wavelength of measurement light, or may show a flat wavelength dispersion characteristic, i.e., a retardation value hardly changing even when the wavelength of measurement light changes. In one embodiment, the retardation layer

shows a reverse wavelength dispersion characteristic. In this case, the ratio "Re(450)/Re(550)" of the retardation layer is preferably 0.8 or more and less than 1, more preferably 0.8 or more and 0.95 or less. In addition, the ratio "Re(650)/Re(550)" of the retardation layer is preferably more than 1 and 1.2 or less, more preferably 1.05 or more and 1.2 or less. With such configuration, an extremely excellent antireflection characteristic can be achieved. In addition, the effect is made significant by combining the retardation layer having a reverse wavelength dispersion characteristic as described above and a substrate whose slow axis angle has been appropriately adjusted (described later). The wavelength dispersion characteristic of the retardation layer may be controlled by, for example, using a polycarbonate-based resin film as the resin film as described later, and adjusting the content of a structural unit forming the polycarbonate-based resin film.

[0033] The retardation layer contains a resin having an absolute value of its photoelastic coefficient of preferably 2×10^{-11} m²/N or less, more preferably from 2.0×10^{-13} m²/N to 1.5×10^{-11} m²/N, still more preferably from 1.0×10^{-12} m²/N to 1.2×10^{-11} m²/N. When the absolute value of the photoelastic coefficient falls within such range, a retardation change is less liable to be generated in the case where a shrinkage stress is generated at the time of heating. As a result, heat unevenness in an image display apparatus to be obtained can be satisfactorily prevented.

[0034] The thickness of the retardation layer is preferably 60 μm or less, more preferably from 30 μm to 55 μm . When the thickness of the retardation layer falls within such range, the curling of the retardation layer at the time of its bonding can be satisfactorily adjusted while the curling thereof at the time of its heating is satisfactorily suppressed.

[0035] The retardation layer may include any appropriate resin film that can satisfy the characteristics described above. Typical examples of such resin include a cyclic olefin-based resin, a polycarbonate-based resin, a cellulose-based resin, a polyester-based resin, a polyvinyl alcohol-based resin, a polyamide-based resin, a polyimide-based resin, a polyether-based resin, a polystyrene-based resin, and an acrylic resin. When the retardation layer includes a resin film showing a reverse wavelength dispersion characteristic, the polycarbonate-based resin may be suitably used.

[0036] Any appropriate polycarbonate resin may be used as the polycarbonate resin as long as the effect of the present invention is obtained. The polycarbonate resin preferably contains: a structural unit derived from a fluorene-based dihydroxy compound; a structural unit derived from an isosorbide-based dihydroxy compound; and a structural unit derived from at least one dihydroxy

compound selected from the group consisting of an alicyclic diol, an alicyclic dimethanol, di-, tri-, or polyethylene glycol, and an alkylene glycol or spiroglycol. The polycarbonate resin more preferably contains: a structural unit derived from a fluorene-based dihydroxy compound; a structural unit derived from an isosorbide-based dihydroxy compound; and a structural unit derived from an alicyclic dimethanol and/or a structural unit derived from di-, tri-, or polyethylene glycol. The polycarbonate resin still more preferably contains: a structural unit derived from a fluorene-based dihydroxy compound; a structural unit derived from an isosorbide-based dihydroxy compound; and a structural unit derived from di-, tri-, or polyethylene glycol. The polycarbonate resin may contain a structural unit derived from any other dihydroxy compound as required. Details of the polycarbonate resin that may be suitably used in the present invention are described in, for example, JP 2014-10291 A and JP 2014-26266 A. The descriptions of the laid-open publications are incorporated herein by reference.

[0037] The glass transition temperature of the polycarbonate resin is preferably 120°C or more and 190°C or less, more preferably 130°C or more and 180°C or less. When the glass transition temperature is excessively low, the heat resistance of the resin tends to deteriorate, and hence the resin may cause a dimensional change after its forming into a film. In addition, the image quality of an image display apparatus to be obtained may deteriorate. When

the glass transition temperature is excessively high, the forming stability of the resin at the time of its forming into a film may deteriorate. In addition, the transparency of the film may be impaired. The glass transition temperature is determined in conformity to JIS K 7121 (1987).

[0038] The molecular weight of the polycarbonate resin may be expressed as a reduced viscosity. The reduced viscosity is measured with an Ubbelohde viscometer at a temperature of $20.0^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$ after precise adjustment of a polycarbonate concentration to 0.6 g/dL through the use of methylene chloride as a solvent. The lower limit of the reduced viscosity is generally preferably 0.30 dL/g, more preferably 0.35 dL/g or more. The upper limit of the reduced viscosity is generally preferably 1.20 dL/g, more preferably 1.00 dL/g, still more preferably 0.80 dL/g. When the reduced viscosity is lower than the lower limit value, there may arise a problem of a reduction in mechanical strength of a formed article. Meanwhile, when the reduced viscosity is higher than the upper limit value, there may arise a problem in that fluidity during forming is decreased to decrease productivity and formability.

[0039] A commercially available film may be used as a polycarbonate-based resin film. Specific examples of the commercially available product include products available under the product names "PURE-ACE WR-S", "PURE-ACE WR-W", and "PURE-ACE

WR-M" from Teijin Limited, and a product available under the product name "NRF" from Nitto Denko Corporation.

[0040] The retardation layer is obtained by, for example, stretching a film formed from the polycarbonate-based resin. Any appropriate forming method may be adopted as a method of forming a film from the polycarbonate-based resin. Specific examples thereof include a compression molding method, a transfer molding method, an injection molding method, an extrusion molding method, a blow molding method, a powder forming method, a FRP molding method, a cast coating method (such as a casting method), a calender molding method, and a hot-press method. Of those, an extrusion molding method or a cast coating method is preferred. This is because the extrusion molding method or the cast coating method can increase the smoothness of the film to be obtained and provide satisfactory optical uniformity. Forming conditions may be appropriately set depending on, for example, the composition and kind of the resin to be used, and the desired characteristics of the retardation layer. As described above, for the polycarbonate-based resin, many film products are commercially available, and hence the commercially available films may each be subjected to stretching treatment as it is.

[0041] The thickness of the resin film (unstretched film) may be set to any appropriate value depending on, for example, the desired thickness and desired optical characteristics of the retardation

layer, and stretching conditions to be described later. The thickness is preferably from 50 μm to 300 μm .

[0042] Any appropriate stretching method and stretching conditions (such as a stretching temperature, a stretching ratio, and a stretching direction) may be adopted for the stretching. Specifically, one kind of various stretching methods, such as free-end stretching, fixed-end stretching, free-end shrinkage, and fixed-end shrinkage, may be employed alone, or two or more kinds thereof may be employed simultaneously or sequentially. With regard to the stretching direction, the stretching may be performed in various directions or dimensions, such as a lengthwise direction, a widthwise direction, a thickness direction, and an oblique direction. When the glass transition temperature of the resin film is represented by T_g , the stretching temperature falls within a range of preferably from $T_g-30^\circ\text{C}$ to $T_g+60^\circ\text{C}$, more preferably from $T_g-30^\circ\text{C}$ to $T_g+50^\circ\text{C}$, still more preferably from $T_g-15^\circ\text{C}$ to $T_g+30^\circ\text{C}$.

[0043] A retardation film having the desired optical characteristics (such as a refractive index characteristic, an in-plane retardation, and an N_z coefficient) can be obtained by appropriately selecting the stretching method and stretching conditions.

[0044] In one embodiment, the retardation film is produced by

subjecting a resin film to uniaxial stretching or fixed-end uniaxial stretching. The fixed-end uniaxial stretching is specifically, for example, a method involving stretching the resin film in its widthwise direction (lateral direction) while running the film in its lengthwise direction. The stretching ratio is preferably from 1.1 times to 3.5 times.

[0045] In another embodiment, the retardation film may be produced by continuously subjecting a resin film having an elongate shape to oblique stretching in the direction of the angle θ with respect to a lengthwise direction. When the oblique stretching is adopted, a stretched film having an elongate shape and having an alignment angle that is the angle θ with respect to the lengthwise direction of the film (having a slow axis in the direction of the angle θ) is obtained, and for example, roll-to-roll manufacture can be performed in its lamination with the polarizer. As a result, the manufacturing process can be simplified. The angle θ may be an angle formed by the absorption axis of the polarizer and the slow axis of the retardation layer in the polarizing plate with a retardation layer. As described above, the angle θ is preferably from 38° to 52° , more preferably from 42° to 48° , still more preferably about 45° .

[0046] As a stretching machine to be used for the oblique stretching, for example, there is given a tenter stretching machine

capable of applying feeding forces, or tensile forces or take-up forces, having different speeds on left and right sides in a lateral direction and/or a longitudinal direction. Examples of the tenter stretching machine include a lateral uniaxial stretching machine and a simultaneous biaxial stretching machine, and any appropriate stretching machine may be used as long as the resin film having an elongate shape can be continuously subjected to the oblique stretching.

[0047] Through appropriate control of each of the speeds on the left and right sides in the stretching machine, a retardation layer (substantially a retardation film having an elongate shape) having the desired in-plane retardation and having a slow axis in the desired direction can be obtained.

[0048] The stretching temperature of the film may be changed depending on, for example, the desired in-plane retardation value and thickness of the retardation layer, the kind of the resin to be used, the thickness of the film to be used, and a stretching ratio. Specifically, the stretching temperature is preferably from $T_g-30^{\circ}\text{C}$ to $T_g+60^{\circ}\text{C}$, more preferably from $T_g-30^{\circ}\text{C}$ to $T_g+50^{\circ}\text{C}$, still more preferably from $T_g-15^{\circ}\text{C}$ to $T_g+30^{\circ}\text{C}$. When the stretching is performed at such temperature, a retardation layer having characteristics appropriate in the present invention can be obtained. T_g refers to the glass transition temperature of a constituent

material for the film.

[0049] D. Conductive Layer

The conductive layer may be formed by forming a metallic oxide film on any appropriate substrate through any appropriate film forming method (e.g., a vacuum vapor deposition method, a sputtering method, a CVD method, an ion plating method, and a spraying method). After the film formation, heating treatment (e.g., at from 100°C to 200°C) may be performed as required. When the heating treatment is performed, an amorphous film can be crystallized. Examples of the metal oxide include indium oxide, tin oxide, zinc oxide, indium-tin composite oxide, tin-antimony composite oxide, zinc-aluminum composite oxide, and indium-zinc composite oxide. An indium oxide may be doped with a divalent metal ion or a tetravalent metal ion. The metal oxide is preferably an indium-based complex oxide, more preferably an indium-tin complex oxide (ITO). The indium-based complex oxide has features of having a high transmittance (e.g., 80% or more) in a visible light region (380 nm to 780 nm) and having a low surface resistance value per unit area.

[0050] When the conductive layer contains the metal oxide, the thickness of the conductive layer is preferably 50 nm or less, more preferably 35 nm or less. The lower limit of the thickness of the conductive layer is preferably 10 nm.

[0051] The surface resistance value of the conductive layer is preferably 300 ohms per square ($\Omega/\square$) or less, more preferably 150 $\Omega/\square$ or less, still more preferably 100 $\Omega/\square$ or less.

[0052] The conductive layer may be patterned as required. Through the patterning, a conductive part and an insulating part may be formed. Any appropriate method may be adopted as a patterning method. Specific examples of the patterning method include a wet etching method and a screen printing method.

[0053] E. Substrate

 The substrate has a slow axis. In the present invention, there can be provided an optical laminate in which even when a substrate having a slow axis, that is, an anisotropic substrate is used, the antireflection function of the circularly polarizing plate is sufficiently exhibited, and hence ambient light reflection, background reflection, and the like can be effectively prevented. Therefore, according to the present invention, unlike the related art, there is no need to select a constituent material for the substrate while placing emphasis on optical isotropy, and hence various materials can be selected in accordance with desired characteristics.

[0054] In addition, the substrate may be a substrate inevitably

having a slow axis despite being produced with the following as a target: the substrate is optically isotropic (has an in-plane retardation $R_e(550)$ of 0 nm). When the conductive layer is formed on the substrate by the formation of the metallic oxide film (i.e., when the substrate and the conductive layer are laminated while being brought into close contact with each other), an unnecessary slow axis may occur in the substrate through, for example, heating in the film-forming step. The slow axis that has thus occurred inhibits the antireflection function of the circularly polarizing plate. In addition, its direction is typically difficult to control, and the difficulty may be a cause for a reduction in production stability of the optical laminate. In the present invention, even in the case of the substrate in which the slow axis has occurred, the antireflection function of the circularly polarizing plate is sufficiently exhibited. In the present invention as described above, the conductive layer can be formed while the occurrence of the slow axis is permitted, and hence restrictions on the conditions under which the conductive layer is formed can be reduced.

[0055] The above-mentioned effect is obtained by optimizing the angle formed by the slow axis of the substrate and the slow axis of the retardation layer. The present invention is particularly useful because the antireflection function of the circularly polarizing plate is sufficiently exhibited no matter what direction the slow axis of the substrate occurs in.

[0056] The angle formed by the slow axis of the substrate and the slow axis of the retardation layer is from -40° to -50° or from 40° to 50° , preferably from -42° to -48° or from 42° to 48° , more preferably from -44° to -46° or from 44° to 46° , particularly preferably -45° or 45° . When the angle falls within such range, there can be provided an optical laminate in which the antireflection function of the circularly polarizing plate is sufficiently exhibited, and hence ambient light reflection, background reflection, and the like can be effectively prevented. In this description, an angle in a clockwise direction relative to the slow axis of the substrate is defined as a positive angle, and an angle in a counterclockwise direction relative thereto is defined as a negative angle.

[0057] The refractive index characteristic of the substrate preferably shows a relationship of $n_x > n_y \geq n_z$. The in-plane retardation $R_e(550)$ of the substrate is more than 0 nm. According to the present invention, there can be obtained an optical laminate in which even when a substrate having an in-plane retardation R_e is used, the antireflection function of the circularly polarizing plate is sufficiently exhibited as described above. In one embodiment, the in-plane retardation $R_e(550)$ of the substrate is 3 nm or more. In another embodiment, the in-plane retardation $R_e(550)$ of the substrate is 5 nm or more. An upper limit for the in-plane

retardation $Re(550)$ of the substrate is preferably, for example, 10 nm. When the in-plane retardation $Re(550)$ of the substrate is 10 nm or less (more preferably 8 nm or less, still more preferably 6 nm or less), the antireflection function of the circularly polarizing plate becomes higher.

[0058] Any appropriate resin film may be used as the substrate. A constituent material for the substrate is, specifically, for example, a cyclic olefin-based resin, a polycarbonate-based resin, a cellulose-based resin, a polyester-based resin, or an acrylic resin.

[0059] The substrate has a thickness of preferably from 10 μm to 200 μm , more preferably from 20 μm to 60 μm .

[0060] A hard coat layer (not shown) may be arranged between the conductive layer **21** and the substrate **22** as required. A hard coat layer having any appropriate configuration may be used as the hard coat layer. The thickness of the hard coat layer is, for example, from 0.5 μm to 2 μm . Fine particles for reducing a Newton ring may be added to the hard coat layer as long as the haze of the layer falls within an allowable range. Further, an anchor coat layer for improving the adhesiveness of the conductive layer and/or a refractive index-adjusting layer for adjusting a refractive index may be arranged between the conductive layer **21** and the substrate

22 (the hard coat layer if present) as required. Any appropriate configuration may be adopted for each of the anchor coat layer and the refractive index-adjusting layer. The anchor coat layer and the refractive index-adjusting layer may be thin layers each having a thickness of from several nanometers to several tens of nanometers.

[0061] Another hard coat layer may be arranged on the side of the substrate **22** opposite to the conductive layer **21** (outermost side of the optical laminate) as required. The hard coat layer typically contains a binder resin layer and spherical particles, and the spherical particles protrude from the binder resin layer to form protruded portions. Details about such hard coat layer are described in JP 2013-145547 A, and the description of the laid-open publication is incorporated herein by reference.

[0062] F. Others

The optical laminate according to the embodiment of the present invention may further include any other layer. Practically, a pressure-sensitive adhesive layer (not shown) for bonding the substrate **22** to a display cell is arranged on its surface. A release film is preferably bonded to the surface of the pressure-sensitive adhesive layer until the optical laminate is used.

[0063] G. Image Display Apparatus

The optical laminate described in the section A to the section

F may be applied to an image display apparatus. Therefore, the present invention encompasses an image display apparatus using such optical laminate. Typical examples of the image display apparatus include a liquid crystal display apparatus and an organic EL display apparatus. An image display apparatus according to an embodiment of the present invention includes, on its viewer side, the optical laminate described in the section A to the section G. The optical laminate is laminated so that the conductive layer is arranged on a display cell (e.g., liquid crystal cell or organic EL cell) side (so that the polarizer is arranged on the viewer side). That is, the image display apparatus according to the embodiment of the present invention may be a so-called inner touch panel-type input display apparatus obtained by incorporating a touch sensor between the display cell (e.g., a liquid crystal cell or an organic EL cell) and a polarizing plate. In this case, the touch sensor may be arranged between the conductive layer (or the conductive layer with a substrate) and the display cell. Detailed description of the configuration of the touch sensor is omitted because a configuration well known in the art may be adopted.

Examples

[0064] Now, the present invention is specifically described by way of Examples. However, the present invention is not limited by these Examples.

[0065] [Example 1]

The reflection characteristics of an optical laminate having a configuration shown in Table 1 below were evaluated from the front hues a and b of the optical laminate with an optical simulator (manufactured by Shintec Co., Ltd., product name: "LCD Master V8").

The following configuration was adopted: a light source (D65 light source registered in the "LCD Master V8") was arranged on the side of a polarizing plate opposite to a retardation layer, and a reflector (Idea-Reflector registered in the "LCD Master V8") was arranged on the side of a substrate opposite to the retardation layer.

In addition, front hues a and b were determined by using the same configuration as that in Table 1 except that no substrate was incorporated, and the results were defined as references.

In this evaluation, as described later, a simulation is performed while the slow axis angle of the substrate is changed, and then the reflection characteristics of the optical laminate are evaluated by comparison with the references.

[0066]

Table 1

	In-plane retardation Re (550) (nm)	Wavelength dispersion characteristic Re (450) /Re (550)	Wavelength dispersion characteristic Re (650) /Re (550)	Slow axis angle relative to absorption axis of polarizer of polarizing plate (°)
Polarizing plate (transmittance: 45%)	-	-	-	-
Retardation layer	140	0.89	1.04	45
Substrate	5	-	-	-5 to 170

[0067] [Example 1-1]

An angle formed by the slow axis of the substrate and the absorption axis of the polarizer of the polarizing plate was set to 90°. That is, an angle formed by the slow axis of the substrate and the slow axis of the retardation layer was set to 45°.

[0068] [Example 1-2]

An angle formed by the slow axis of the substrate and the absorption axis of the polarizer of the polarizing plate was set to 0°. That is, an angle formed by the slow axis of the substrate and the slow axis of the retardation layer was set to -45°.

[0069] [Example 1-3]

An angle formed by the slow axis of the substrate and the absorption axis of the polarizer of the polarizing plate was set to 85°. That is, an angle formed by the slow axis of the substrate and the slow axis of the retardation layer was set to 40°.

[0070] [Example 1-4]

An angle formed by the slow axis of the substrate and the absorption axis of the polarizer of the polarizing plate was set to 95° . That is, an angle formed by the slow axis of the substrate and the slow axis of the retardation layer was set to 50° .

[0071] [Example 1-5]

An angle formed by the slow axis of the substrate and the absorption axis of the polarizer of the polarizing plate was set to -5° . That is, an angle formed by the slow axis of the substrate and the slow axis of the retardation layer was set to -50° .

[0072] [Example 1-6]

An angle formed by the slow axis of the substrate and the absorption axis of the polarizer of the polarizing plate was set to 5° . That is, an angle formed by the slow axis of the substrate and the slow axis of the retardation layer was set to -40° .

[0073] [Comparative Example 1]

The angle formed by the slow axis of the substrate and the absorption axis of the polarizer of the polarizing plate was changed within the ranges of from 10° to 80° and from 100° to 170° , and reflection characteristics at the respective angles were evaluated.

[0074] The plots of the front hues a and b for the results of Example 1 and Comparative Example 1 are shown in FIGS. 2. In addition, a graph for showing the axis angle dependence of a Δab is shown in FIG. 3. The Δab is calculated from the equation " $\Delta ab = \{(\text{front hue a} - \text{reference front hue a})^2 + (\text{front hue b} - \text{reference front hue b})^2\}^{1/2}$." A lower Δab means that an influence of an isotropic substrate is smaller and hence the optical laminate is more excellent in antireflection characteristic.

[0075] As is apparent from FIGS. 2 and FIG. 3, the optical laminate of the present invention has an excellent antireflection function.

[0076] [Example 2]

 The reflection characteristics of an optical laminate were evaluated in the same manner as in Example 1 (Examples 1-1 to 1-6) except that: the $\text{Re}(550)$ of the retardation layer was set to 139 nm; the wavelength dispersion characteristic " $\text{Re}(550)/\text{Re}(450)$ " of the retardation layer was set to 0.85; and the wavelength dispersion characteristic " $\text{Re}(650)/\text{Re}(550)$ " thereof was set to 1.06.

[0077] [Comparative Example 2]

 The reflection characteristics of an optical laminate were evaluated in the same manner as in Example 2 except that: the $\text{Re}(550)$ of the retardation layer was set to 139 nm; the wavelength dispersion

characteristic "Re(550)/Re(450)" of the retardation layer was set to 0.85; and the wavelength dispersion characteristic "Re(650)/Re(550)" thereof was set to 1.06.

[0078] A graph for showing the axis angle dependence of the Δab for the results of Example 2 and Comparative Example 2 is shown in FIG. 4.

[0079] [Example 3]

The reflection characteristics of an optical laminate were evaluated in the same manner as in Example 1 (Examples 1-1 to 1-6) except that: the wavelength dispersion characteristic "Re(550)/Re(450)" of the retardation layer was set to 0.82; and the wavelength dispersion characteristic "Re(650)/Re(550)" thereof was set to 1.08.

[0080] [Comparative Example 3]

The reflection characteristics of an optical laminate were evaluated in the same manner as in Comparative Example 2 except that: the wavelength dispersion characteristic "Re(550)/Re(450)" of the retardation layer was set to 0.82; and the wavelength dispersion characteristic "Re(650)/Re(550)" thereof was set to 1.08.

[0081] A graph for showing the axis angle dependence of the Δab for the results of Example 3 and Comparative Example 3 is shown

in FIG. 5.

Industrial Applicability

[0082] The optical laminate of the present invention is suitably used in image display apparatus, such as a liquid crystal display apparatus and an organic EL display apparatus, and can be suitably used particularly as the antireflection film of the organic EL display apparatus. Further, the optical laminate of the present invention can be suitably used in an inner touch panel-type input display apparatus.

Reference Signs List

[0083]	1	polarizer
	2	first protective layer
	3	second protective layer
	11	polarizing plate
	12	retardation layer
	21	conductive layer
	22	substrate
	100	optical laminate

Claims

[Claim 1] An optical laminate, comprising, in this order:

a polarizing plate including a polarizer and a protective layer arranged on at least one side of the polarizer;

a retardation layer;

a conductive layer; and

a substrate,

wherein the substrate has an in-plane retardation $Re(550)$ of more than 0 nm, and

wherein an angle formed by a slow axis of the substrate and a slow axis of the retardation layer is from -40° to -50° or from 40° to 50° .

[Claim 2] The optical laminate according to claim 1, wherein an angle formed by an absorption axis of the polarizer and the slow axis of the retardation layer is from 38° to 52° .

[Claim 3] The optical laminate according to claim 1, wherein the retardation layer has a ratio " $Re(450)/Re(550)$ " of 0.8 or more and less than 1.

[Claim 4] The optical laminate according to claim 1, wherein the retardation layer has a ratio " $Re(650)/Re(550)$ " of more than 1 and 1.2 or less.

[Claim 5] The optical laminate according to claim 1, wherein the retardation layer includes a polycarbonate-based resin.

[Claim 6] An image display apparatus, comprising the optical laminate of claim 1.