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(54) **In-plane switching liquid crystal display comprising compensation film for angular field of view using negative biaxial retardation film and (+) C-plate**

In-Plane-Schaltflüssigkristallanzeige mit Kompensationsfilm für Winkelsichtfeld unter verwendung eines negativ-biaxial-retardierungsfilms und einer (+)-C-Platte

Affichage à cristaux liquides de commutation dans le plan comprenant un film de compensation pour un champ angulaire de visualisation faisant appel à un film de retard biaxial négatif et a une plaque C+

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(73) Proprietor: **LG Chemical Co., Ltd.**
Seoul 150-721 (KR)

(72) Inventors:
- **Jeon, Byoung-Kun**
  Daejon 305 - 340 (KR)
- **Belyaev, Sergey**
  Daejon 305 - 340 (KR)
- **Yu, Jeong-Su**
  Daejeon, 305-500 (KR)
- **Malimonenko, Nikolay**
  Daejon 305-340 (KR)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

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EP 2 485 084 B1

Description

Technical Field

[0001] The present invention relates to an optical film for liquid crystal displays (LCDs), and more particularly, to an optical film for an in-plane switching liquid crystal display (IPS-LCD) filled with liquid crystals having positive dielectric anisotropy ($\Delta\varepsilon > 0$) or negative dielectric anisotropy ($\Delta\varepsilon < 0$), the optical film comprising a negative biaxial retardation film and a positive C-plate as viewing-angle compensation films for improving the viewing- angle characteristics of the display.

Background Art

[0002] IPS-LCDs are disclosed in US Patent No. 3,807,831, but this patent does not disclose the use of viewing-angle compensation films. IPS-LCDs including no viewing-angle compensation films have a disadvantage in that they have a low contrast ratio due to a relatively large light leakage in the dark state at inclination angle.

[0003] EP 1 345 048 A1 describes an optical film prepared by laminating at least one of a first retardation film (2), having a mean in-plane refractive index of n_o and refractive index in the thickness direction of n_e wherein $n_e - n_o > 0$, and at least one of a second retardation film (3) having an in-plane refractive index of n_x in the direction showing the maximum refractive index, refractive index of n_y in the direction perpendicular to the direction described just before, and refractive index in the thickness direction of n_z wherein $n_x > n_y \geq n_z$. This reportedly reduces the light leakage that occurs as the observation point is tilted from the front direction to a direction different from the direction of each absorption axis when a plolarizing film is arranged so that the absorption axes are perpendicular to each other.

[0004] US 6,285,430 B1 describes an LCD cell device configuration that reportedly reduces the deterioration in contrast when the display surface of the active matrix type liquid crystal display device of the in-plane switching mode is viewed from the direction of azimuth 45° without decreasing the viewing characteristic from a frontal direction. This is accomplished using an optical compensation film having a retardation axis which is parallel to or vertical to the transmission axes of the polarizer plates at the lower and upper side. By so selecting the in-plane retardation and the retardation in the thickness direction of the optical compensation film, the optical compensation film reportedly performs the function of a $\lambda/2$ plate, to rotate the polarizing plane of the transmitted light.

[0005] It has also been reported that viewing angle performance for in-plane switching (IPS) mode LCDs can be optimized by (i) placing the compensation films on the correct side of the display, (ii) use polarizer substrates which are non-birefringent, and (iii) ensuring the pretilt angle of the LCD is as low as possible (see Anderson and Bos in "Methods and Concerns of Compensating In-Plane Switching Liquid Crystal Displays", Jpn. J. Appl. Phys., 2000, vol. 39, pp. 6388-6392).

Brief Description of the Drawings

[0006]

FIG. 1 shows the fundamental structure of IPS-LCDs.

FIG. 2 shows the arrangement of the absorption axes of polarizers and the optical axis of liquid crystals of an IPS-LCD panel in the fundamental structure of FIG. 1.

FIG. 3 shows the refractive index of a retardation film.

FIG. 4 shows the first structure of the inventive IPS- LCD comprising viewing-angle compensation films.

FIG. 5 shows the second structure of the inventive IPS- LCD comprising viewing-angle compensation films.

FIG. 6 shows the third structure of the inventive IPS- LCD comprising viewing-angle compensation films.

FIG. 7 shows the fourth structure of the inventive IPS- LCD structure comprising viewing-angle compensation films.

Disclosure of the Invention

[0007] It is an object of the present invention to provide an optical film for an IPS-LCD, which has high-contrast characteristics and low color shift at the front side and inclination angle by minimizing light leakage in the dark state at inclination angle.

[0008] The causes of reducing the viewing-angle characteristics of IPS-LCDs are broadly classified into two classes: The first is the viewing-angle dependence of a perpendicularity between the absorption axes of two polarizers, and the second is the viewing-angle dependence of birefringent characteristics of an IPS-LCD panel.

[0009] The present inventors have recognized that a negative biaxial retardation film and a positive C-plate are required to compensate for these two causes of reducing viewing angle, and designed viewing-angle compensation films with these two kinds of the retardation compensation films in order to realize wide-viewing-angle characteristics.

[0010] Moreover, the present inventors have found that, for suitable compensation for viewing angle, the optical axis direction of the negative biaxial retardation film should be suitably determined depending on the arrangement order of the negative biaxial retardation film and the positive C-plate between polarizers and a liquid crystal cell (IPS-LCD panel). On the basis of this finding, the present invention has been completed.

[0011] The present invention provides an optical film for an IPS-LCD which overcomes the viewing-angle problem using a negative biaxial retardation film and a positive C-plate.

[0012] The optical film of the present invention comprises an upper polarizer and a viewing-angle compensation film, wherein the viewing-angle compensation film comprises a negative biaxial retardation film having a negative thickness-direction retardation value and a positive in-plane retardation value; and a positive C-plate having a positive thickness-direction retardation value, wherein the negative biaxial retardation film is arranged closer to the upper polarizer than the positive C-plate or the positive C-plate is arranged closer to the upper polarizer than the negative biaxial retardation film, wherein, when the negative biaxial retardation film is arranged closer to the upper polarizer than the positive C-plate, the optical axis of the negative biaxial retardation film is perpendicular to the absorption axis of the upper polarizer, wherein, when the positive C-plate is arranged closer to the upper polarizer than the negative biaxial retardation film, the optical axis of the negative biaxial retardation film is parallel to the absorption axis of the upper polarizer, wherein the positive C-plate has a larger thickness-direction retardation value than the absolute thickness-direction retardation value of the negative retardation film.

[0013] Contrast ratio value is the index of image sharpness, and the higher the contrast ratio value, the more sharp images can be realized. IPS-LCDs have the most inferior contrast characteristic at an inclination angle of 70°, and an improvement in the contrast characteristic at an inclination angle of 70° means an improvement in the contrast characteristics at all viewing-angles . The minimum contrast ratio at an inclination angle of 70° is less than 10:1 in the use of only polarizers, and can reach at least 20:1 when the positive C-plate and the negative biaxial retardation film are used according to the present invention. The minimum contrast ratio at an inclination angle of 70° is preferably more than 20:1.

Best Mode for Carrying Out the Invention

[0014] Hereinafter, the present invention will be described in detail. While reference may be made to IPS-LCDs containing the optical film of the invention, the invention relates to the optical film with the extent of protection being determined by the appended claims.

[0015] FIG. 1 shows the fundamental structure of IPS-LCDs.

[0016] As shown in FIG. 1, an IPS-LCD comprises the first polarizer 1, the second polarizer 2 and the liquid crystal cell 3. The absorption axis 4 of the first polarizer and the absorption axis 5 of the second polarizer are arranged perpendicularly to each other, and the absorption axis 4 of the first polarizer and the optical axis of the liquid crystal cell are arranged parallel to each other. FIG. 2 shows the absorption axes 4, 5 of the two polarizers and the optical axis 6 of the liquid crystal cell.

[0017] The liquid crystal display including the compensation films comprises the first polarizer 1, a horizontally aligned liquid crystal cell 3 having liquid crystals with positive dielectric anisotropy ($\Delta\varepsilon > 0$) or negative dielectric anisotropy ($\Delta\varepsilon < 0$) filled between two sheets of glass substrates, and the second polarizer 2, in which the optical axis 6 of the liquid crystals in the liquid crystal cell lies in a plane parallel to the polarizers. In this IPS-LCD device, the absorption axis of the first polarizer and the absorption axis of the second polarizer are perpendicular to each other, and the optical axis 6 of the liquid crystals in the liquid crystal cell is parallel to the absorption axis 4 of the adjacent first polarizer. Also, one of the first substrate 15 and the second substrate 16 has an active matrix drive electrode comprising an electrode pair, which is formed on a surface adjacent to the liquid crystal layer.

[0018] The retardation value of the liquid crystal cell (IPS- LCD panel) in the IPS-LCD preferably ranges from 200 nm to 350 nm at a wavelength of 550 nm.

[0019] This is because the retardation value of the IPS-LCD panel must be half of a wavelength of 589 nm (the brightest monochromatic light felt by people) such that the light linearly polarized to 90° through the first polarizer is linearly polarized to 0° through the liquid crystal layer upon the application of voltage to the IPS-LCD panel, thus becoming the bright state. Also, to make the light white, the retardation value of the IPS-LCD panel may be slightly longer or shorter than the half-wavelength, depending on the wavelength dispersion characteristics of the used liquid crystals. For this reason, the retardation value is preferably about 295 nm which is the half-wavelength of 598- run monochromatic light.

[0020] The LCDs include one where liquid crystals are either aligned in multi-domains or divided into multi-domains by applied voltage.

[0021] LCDs are classified according to the mode of active matrix derive electrodes into in-plane-switching (IPS), super-in-plane-switching (Super-IPS), and fringe-field- switching (FFS) LCDs. In the specification, if the term "IPS-LCD" is used, it will be construed to include super-IPS, FFS (fringe field switching), reverse TN IPS LCDs, etc.

[0022] The present invention is characterized by using the positive C-plate and the negative biaxial retardation film in combination for the viewing-angle compensation of IPS-LCDs. If the positive C-plate and the negative biaxial retardation film are used in combination for the viewing-angle compensation of IPS-LCDs, it will be possible to realize wide-viewing-angle characteristics.

[0023] The total sum of the thickness-direction retardation values of the positive C-plate and the adjacent negative biaxial retardation film is positive value, and the in-plane retardation value of the biaxial retardation film functions as an A-plate. Thus, light leakage generated in the polarizers and the IPS-LCD panel can be minimized.

[0024] The refractive index of the retardation films used for the viewing-angle compensation of IPS-LCDs will now be described with reference to FIG. 3. As shown in FIG. 3, among in-plane refractive indexes, the refractive index in the x-axis direction may be referred to as n_x 8, the refractive index in the y-axis direction as n_y 9, and the refractive index in the thickness direction (i.e., the z-axis direction) as n_z 10. Depending on the magnitudes of the refractive indexes, the characteristics of the retardation films will be determined.

[0025] A film where the refractive indexes in the two-axis directions among the refractive indexes in the three-axis directions are different from each other is referred to as an uniaxial film. The uniaxial film can be defined as follows.

(1) A film with $n_x > n_y = n_z$ is referred to as a positive A-plate, the in-plane retardation value of which is defined using the difference between two refractive indexes lying in a plane, and the thickness of the film as given in the following equation 1.

(Equation 1)

$$R_{in} = d \times \{n_x - n_y)$$

wherein d represents the thickness of the film.

(2) A film with $n_x = n_y < n_z$ is referred to as a positive C-plate, the thickness-direction retardation value of which is defined using the difference between the in-plane refractive index and the thickness-direction refractive index, and the thickness of the film as given in the following equation.

(Equation 2)

$$R_{th} = d \times \{n_z - n_y)$$

wherein d represents the thickness of the film.

[0026] The positive C-plate is a film whose in-plane retardation value is almost zero and thickness-direction retardation is positive value.

[0027] The thickness-direction retardation value of the positive C-plate which is used for the viewing-angle compensation of IPS-LCDs preferably ranges from 50nm to 500 nm at a wavelength of 550 nm.

[0028] A positive thickness-direction retardation value is required to minimize the light transmitted in the dark state of the polarizers. However, if a negative biaxial retardation film is used, there will be no positive thickness-direction retardation value. Thus, the positive C- plate needs to be used either to reduce the negative thickness-direction retardation value or to make it positive. The range of thickness-direction retardation value allowing the viewing-angle compensation of the polarizers and the IPS- LCD panel is 50 nm to 500 nm, and this range is required either to reduce the negative thickness-direction retardation value or to make it positive.

[0029] The wavelength dispersion characteristics of films may have normal wavelength dispersion, flat wavelength dispersion, or reverse wavelength dispersion.

[0030] A film whose refractive indexes in the three-axis directions are different from each other is referred to as a biaxial retardation film which is defined as follows.

[0031] Of in-plane refractive indexes, the refractive index in the x-axis direction is referred to as n_x 8, the refractive index in the y-axis direction as n_y 9, and the refractive index in the thickness direction as n_z 10. A film with $n_x > n_y > n_z$ is referred to as a negative biaxial retardation film. The negative biaxial retardation film has both in-plane retardation value (R_{in}, biaxial) and thickness-direction retardation value (R_{th}, biaxial) which are defined as follows:

$$R_{in,\ biaxial} = d \times (n_x - n_y)$$

$$R_{th,\ biaxial} = d \times (n_z - n_y)$$

wherein d represents the thickness of the film.

[0032] For the viewing-angle compensation of IPS-LCDs, the negative biaxial retardation film preferably has an in-plane retardation value ranging from 20 nm to 200 nm at a wavelength of 550 nm, and a negative thickness-direction retardation value ranging from -50 nm to -300 nm at a wavelength of 550 nm.

[0033] The wavelength dispersion characteristics of the film may have normal wavelength dispersion, flat wavelength dispersion and reverse wavelength dispersion.

[0034] The structures of the viewing-angle compensation films including the positive C-plate and the negative biaxial retardation film are shown in shown in FIGS. 4, 5, 6 and 7.

[0035] The optical axis of the liquid crystal molecules 7 in the liquid crystal cell 3 sandwiched between the two crossed polarizers is arranged parallel to the IPS-LCD panel substrate, and is aligned in the rubbing direction. An IPS-LCD where the absorption axis 4 of the first polarizer adjacent to a backlight is parallel to the rubbing direction 6 is referred to as an O-mode IPS-LCD, and an IPS-LCD where the absorption axis of the polarizer adjacent to the backlight is perpendicular to the rubbing direction 6 is referred to as an E-mode IPS-LCD. The first polarizer 1 adjacent to the backlight is referred to as a lower polarizer, and the second polarizer 2 arranged away from the backlight is referred to as an upper polarizer. Absorption axes of the two polarizers are so arranged as to be crossed with each other.

[0036] In order to function to compensate for viewing angle, the two kinds of the retardation films need to be placed between the IPS-LCD panel 3 and the polarizers.

[0037] The slow axis or optical axis 13 of the retardation films may be arranged perpendicularly or in parallel to the absorption axis 5 of the polarizer adjacent thereto. The direction of the optical axis of the retardation films is determined depending on the arrangement order of the retardation films.

[0038] In order to use the A-plate for the viewing-angle compensation of the polarizers, the optical axis of the A- plate should be so arranged as to coincide with the transmission axis of the polarizer. If the positive C-plate is adjacent to the polarizer, the optical axis of the A-plate should be perpendicular with the absorption axis of the polarizer placed away from the A-plate, and if the A plate is adjacent to the polarizer, it should be perpendicular to the polarizer adjacent thereto.

[0039] Meanwhile, among the two kinds of the retardation films which are used for the viewing-angle compensation of IPS-LCDs, the first retardation film is referred to as the negative biaxial retardation film 12, and the second retardation film is referred to as the positive C-plate 11. When the two kinds of the retardation films are stacked on each other, the absolute value of the thickness-direction retardation of the second retardation film is larger than that of the first retardation film as given in the following relation:

$$(R_{th})_{\text{positive C-plate}} > |R_{biaxial}|$$

[0040] The total sum of the thickness-direction retardation values of the compensation films is positive value in order to improve the viewing-angle characteristics of IPS-LCDs. The above condition means that the total sum of the thickness-direction retardation values of the compensation films is a positive value.

[0041] The optical film of the present invention can be used in a first embodiment of an IPS-LCD device, in which the negative biaxial retardation film 12 and the positive C-plate 11 are arranged between the liquid crystal cell 3 and the second polarizer 2, the positive C-plate is arranged between the negative biaxial retardation film 12 and the liquid crystal cell 3, and the optical axis 13 of the negative biaxial retardation film is perpendicular to the absorption axis 5 of the adjacent second polarizer 13.

[0042] The minimization of light leakage by the crossed polarizers is possible only when the optical axis of the A- plate and the transmission axis of the adjacent polarizer coincide with each other. Since the absorption axis of the polarizers makes a right angle with the transmission axis, the optical axis of the negative biaxial retardation film and the absorption axis of the adjacent second polarizer should make a right angle with respect to each other.

[0043] In this embodiment, the positive C-plate preferably has a thickness-direction retardation value ranging from 50 nm to 500 nm at a wavelength of 550 nm.

[0044] The thickness-direction retardation value of negative biaxial retardation films which can be fabricated at the present time ranges from -50 nm to -300 nm. Thus, the positive C-plate is needed for the total sum of the thickness-direction retardation values to have positive value, because it is preferred for the viewing-angle compensation of IPS-LCDs that the total sum of the thickness-direction retardation values ranges from +50 nm to +300 nm.

[0045] Moreover, the in-plane retardation value of the negative biaxial retardation film required for the viewing-angle compensation of IPS-LCDs is preferably less than 150 nm.

[0046] The first structure of IPS-LCD shown in FIG. 4, which has the compensation films, will be described as follows.

[0047] As shown in FIG. 4, the negative biaxial retardation film and the positive C-plate are arranged between the second polarizer 2 and the liquid crystal cell 3 in such a way that the negative biaxial retardation film is adjacent to the second polarizer 2. The optical axis 13 of the negative biaxial retardation film is so arranged as to be perpendicular to the absorption axis 5 of the second polarizer.

[0048] A backlight should be arranged adjacent to the first polarizer, and if the backlight is arranged adjacent to the second polarizer, the viewing-angle compensation characteristics will vary.

[0049] Simulations on this arrangement were performed while applying the actual design values of retardation films, and the results are shown in Table 1 below.

(Table 1)

Internal protective film for first polarizer	IPS-LCD panel	Retardation value of positive C-plate	Negative biaxial film		Internal protective film of second polarizer	Minimum contrast ratio at inclination angle of 70°
			R_{in} (nm)	R_{th} (nm)		
COP	290 nm	300	67	-226	COP	65
		249	69	-178		88
		200	75	-145		107
		133	110	-48		150
		108	139	-8		143
80-μm TAC		315	40	-320	COP	25
		160	60	-160		27
		120	66	-128		30
COP		133	110	-48	TAC	150
COP		153	66	-33	80 μm TAC	125
COP		226	42	-15	PNB R_{th}=160 nm	75

[0050] The viewing-angle characteristics of the IPS-LCD are determined depending on how the internal protective films for the polarizers, and the retardation values of the positive C- plate and the negative biaxial retardation film, are designed.

[0051] Table 1 above summarizes the results of simulation for viewing-angle characteristics according to the internal protective film for the first polarizer, the retardation value of the positive C-plate, the retardation value of the negative biaxial retardation film, and the internal protective film for the second polarizer. Since IPS-LCDs show low-contrast characteristics at an inclination angle of 70°, the minimum contrast ratio at an inclination angle of 70° is an index indicating the extent of an improvement in contrast characteristics. IPS-LCDs including general polarizers, to which the viewing-angle compensation films have not been applied, have a minimum contrast ratio of less than 10:1 at an inclination angle of 70°. Accordingly, it can be found that the structures given in Table 1 all have an improvement in contrast characteristics, and among these results, the structure showing the highest contrast ratio is a structure showing the most excellent contrast characteristic.

[0052] The optical film of the present invention can be used in a second embodiment of an IPS-LCD device, in which the negative biaxial retardation film 12 and the positive C-plate 11 are arranged between the liquid crystal cell 3 and the second polarizer 2, the negative biaxial retardation film is arranged between the positive C-plate and the liquid crystal cell, and the optical axis 13 of the negative biaxial retardation film is parallel to the absorption axis 5 of the second polarizer.

[0053] For the viewing-angle compensation of IPS-LCDs, the optical axis of the negative biaxial retardation film should be perpendicular to the absorption axis of the adjacent polarizer. However, due to the positive C-plate next to the second polarizer, the negative biaxial retardation film is influenced by the first polarizer.

[0054] Accordingly, the optical axis of the negative biaxial retardation film should be perpendicular to the absorption axis of the first polarizer and coincided with the absorption axis of the second polarizer.

[0055] The second structure of the IPS-LCD as shown in FIG. 5, which has the compensation films, will be described as follows.

[0056] As shown in FIG. 5, the negative biaxial retardation film and the positive C-plate are arranged between the second polarizer 2 and the IPS-liquid crystal cell 3 in such a manner that the positive C-plate is adjacent to the second polarizer 2. The optical axis 13 of the negative biaxial retardation film is arranged parallel to the absorption axis of the second polarizer. Simulations on this arrangement were performed while applying the actual design values of the retardation films, and the results are shown in Table 2 below.

(Table 2)

Internal protective film for first polarizer	IPS-LCD panel	Negative biaxial film		Retardation value of positive C-plate	Internal protective film for second polarizer	Minimum contrast ratio at inclination angle of 70°
		R_{in} (nm)	R_{th} (nm)			
COP	290 nm	77	-165	305	80 μm TAC	95
COP		77	-165	420	PNB R_{th} = 160 nm	86
80-μm TAC		90	-162	390	PNB R_{th} = 160 nm	25
COP		74	-162	230	COP	100

[0057] Table 2 above shows the results of simulation for contrast characteristics at an inclination angle of 70° according to the retardation values of the internal protective films for the polarizers, the retardation value of the positive C-plate, and the retardation value of the negative biaxial retardation film.

[0058] IPS-LCDs show the minimum contrast ratio at an inclination angle of 70°, and IPS-LCDs having general polarizers, to which the compensation plates have not been applied, show a contrast ratio of less than 10:1 at an inclination angle of 70°. Accordingly, an improvement in contrast characteristics at an inclination angle of 70°, as shown in Table 2, means an improvement in contrast characteristics in all the viewing-angle directions.

[0059] The optical film of the present invention can be used in a third embodiment of an IPS-LCD device, in which the negative biaxial retardation film 12 and the first positive C-plate 11 are arranged between the second polarizer 2 and the liquid crystal cell 3, the second positive C-plate 14 is arranged between the first polarizer 1 and the liquid crystal cell 3, the first positive C-plate 11 is arranged between the negative biaxial retardation film 12 and the liquid crystal cell 3, and the optical axis 13 of the negative biaxial retardation film is perpendicular to the absorption axis 5 of the adjacent second polarizer.

[0060] For the viewing-angle compensation of IPS-LCDs, the optical axis of the negative biaxial retardation film should coincide with the transmission axis of the adjacent polarizer. Since the transmission axis of the polarizer is perpendicular to the absorption axis thereof, the optical axis of the negative biaxial retardation film should be perpendicular to the absorption axis of the polarizer.

[0061] In this embodiment, the negative biaxial retardation film preferably has an in-plane retardation value ranging from 20 nm to 200 nm and a thickness-direction retardation value ranging from -50 nm to -300 nm. The total sum of the thickness-direction retardation values of the first and second positive C-plates preferably ranges from 50 nm to 500 nm.

[0062] Furthermore, the total sum of the thickness-direction retardation values of the two positive C-plates should be larger than the thickness-direction retardation value of the negative biaxial retardation film.

[0063] The third structure of the IPS-LCD as shown in FIG. 6, which has the compensation films, will be described as follows.

[0064] As shown in FIG. 6, the negative biaxial retardation film and the first positive C-plate 11 are arranged between the second polarizer 2 and the IPS-liquid crystal cell 3, and the negative biaxial retardation film 12 is arranged adjacent to the second polarizer 2. The optical axis 13 of the negative biaxial retardation film is arranged perpendicularly to the absorption axis 5 of the second polarizer. The second positive C-plate is arranged between the first polarizer 1 and the

IPS-LCD panel 3.

[0065] Simulations on this arrangement were performed while applying the actual design values of the retardation films, and the results are shown in Table 3 below.

(Table 3)

Internal protective film of first polarizer	Retardation value of second positive C-plate	IPS-LCD panel	Retardation value of first positive C-plate	Negative biaxial film		Internal protective film of second polarizer	Minimum contrast ratio at inclination angle OF 70°
				R_{in} (nm)	R_{th} (nm)		
80-μm TAG	145	290 nm	272	93	-128	-	94
80-μm TAG	110		215	92	-102	COP	136
80-μm TAG	76		235	77	-160	-	100
PNB	220		215	92	-102	COP	125
PNB	220		215	92	-102	80-μm TAG R_{th} = -65 nm	33

[0066] Table 3 above summarizes the results of simulation for the minimum contrast ratio at an inclination angle of 70° according to the retardation value of the internal protective film for the first polarizer, the retardation value of the internal protective films for the second polarizer, the retardation value of the first positive C-plate, the retardation value of the second positive C-plate, and the retardation value of the negative biaxial retardation film.

[0067] The optical film of the present invention can be used in a fourth embodiment of an IPS-LCD device, in which the negative biaxial retardation film 12 and the first positive C-plate 11 are arranged between the second polarizer 2 and the liquid crystal cell 3, the second positive C-plate 14 is arranged between the first polarizer 1 and the liquid crystal cell 3, the first positive C-plate 11 is arranged between the negative biaxial retardation film 12 and the second polarizer 2, and the optical axis 13 of the negative biaxial retardation film is parallel to the absorption axis 5 of the second polarizer.

[0068] In order to improve the viewing-angle characteristics of IPS-LCDs, the optical axis of the negative biaxial retardation film should be perpendicular to the absorption axis of the adjacent polarizer. As shown in FIG. 7, since the positive C-plate is arranged between the second polarizer and the negative biaxial retardation film, the negative biaxial retardation film acts with the first polarizer, and it is needed that the optical axis of the negative biaxial retardation film coincides with the transmission axis of the first polarizer. Also, since the transmission axis of the first polarizer coincides with the absorption axis of the second polarizer, the optical axis of the negative biaxial retardation film should coincide with the absorption axis of the second polarizer.

[0069] The fourth structure of the IPS-LCD as shown in FIG. 7, which has the compensation films, will be described as follows.

[0070] The negative biaxial retardation film and the first positive C-plate are arranged between the second polarizer 2 and the IPS-liquid crystal cell 3, and the first positive C-plate is arranged adjacent to the second polarizer 2. The optical axis 13 of the negative biaxial retardation film is arranged parallel to the absorption axis 5 of the second polarizer. The second positive C-plate is arranged between the first polarizer 1 and the IPS-liquid crystal cell 3.

[0071] Simulations on this arrangement were performed while applying the actual design values of retardation films, and the results are shown in Table 4 below.

(Table 4)

Internal protective film for first polarizer	Retardation value of second positive C-plate	IPS-LCD panel	Negative biaxial film		Retardation value of first positive C-plate	Internal protective film for second polarizer	Minimum contrast ratio at inclination angle of 70°
			R_{in} (nm)	R_{th} (nm)			
80-μm TAC	110	290 nm	88	-65	163	COP	150

(continued)

Internal protective film for first polarizer	Retardation value of second positive C-plate	IPS-LCD panel	Negative biaxial film		Retardation value of first positive C-plate	Internal protective film for second polarizer	Minimum contrast ratio at inclination angle of 70°
			R_{in} (nm)	R_{th} (nm)			
PNB R_{th} = -160 nm	220		88	-65	163	COP	140
PNB R_{th} = -160 nm	220		88	-65	237	80-μm TAC	135
PNB R_{th} = -160 nm	220		88	-65	350	PNB R_{th} = -160 nm	125

[0072] The IPS-LCDs shown in FIGS. 4 to 7 comprise the two crossed polarizers 1, 2, the liquid cell 3, and at least one positive C-plate 11 and at least one negative biaxial retardation film 12 arranged between the second polarizer 2 and the liquid crystal cell 3.

[0073] The diagonal direction refers to the 45° direction with respect to the absorption axes of the polarizers, and is a direction in which the viewing-angle characteristics of IPS-LCDs in the state of the crossed polarizers are most poor. When the two kinds of the retardation films are applied as viewing-angle compensation films for IPS-LCDs, the viewing-angle characteristics in the diagonal direction will be improved.

[0074] In the present invention, the polarizers may have internal and external protective films.

[0075] In order to protect a polarizing element made of stretched polyvinyl alcohol (PVA), the polarizers may comprise, as an internal protective film, triacetate cellulose (TAC) with thickness-direction retardation value, polynorbornene (PNB) or unstreched cyclo-olefin (COP) with no thickness-direction retardation value.

[0076] The viewing-angle compensation characteristics of IPS-LCDS are influenced by the protective film which is used for the protection of the polarizing element. If a protective film having thickness-direction retardation value, such as a TAC film, there will be a problem in that the viewing-angle compensation characteristics are deteriorated. If an isotropic film, such as an unstretched cyclo-olefin (COP), is used as a protective film for the polarizers, excellent viewing-angle compensation characteristics can be secured.

[0077] As the internal protective film for the first polarizer, the second polarizer or both the two polarizers, a film having a zero or negative thickness-direction retardation value is preferably used. This is because the positive C-plate adjacent to the polarizer offsets the retardation value generated by the internal protective film for the polarizer.

[0078] Meanwhile, the internal protective films for the first polarizer 1 and the second polarizer 2 is preferably made of a material selected from the group consisting of unstretched COP, 40-μm TAC, 80 μm-TAC, and PNB.

[0079] Examples of a film which can be used as the negative biaxial retardation film 12 include uniaxially stretched TAC, uniaxially stretched polynorborene (PNB), and biaxially stretched polycarbonate films. The positive C-plate 11 as the second retardation film may be made of a polymer material or an UV curable liquid crystal film, and examples thereof include a homeotropically aligned liquid crystal film, a biaxially stretched polycarbonate film, and the like.

[0080] In the present invention, the negative biaxial retardation film 12 can serve as an internal protective film for the polarizers. Since the purpose of the internal protective film for the polarizers is to protect the polarizing element, any transparent material having a function to protect the polarizers may be used as the protective material. Since the negative biaxial retardation film is made of a transparent material having a function to protect the polarizers, it can serve as a retardation film having a function to protect the polarizers.

[0081] Moreover, in the present invention, the positive C-plate 11 can serve as a protective film for the polarizers. Since the positive C-plate is made of a transparent material having a function to protect the polarizers, it can serve as a retardation film having a function to protect the polarizers.

[0082] A material which is most widely used as a protective film for general polarizers is TAC. Since TAC has negative thickness-direction retardation value, the direct use of the negative biaxial retardation film as a protective film for the polarizers has the effect of reducing the negative thickness-direction retardation value. This allows viewing- angle compensation with a small thickness-direction retardation value of the positive C-plate (see Table 1).

[0083] If the internal protective film for the polarizers has negative thickness-direction retardation value, a positive C-plate having a large retardation value should be used to make the total sum of thickness-direction retardation values larger than zero. If the thickness-direction retardation value of the internal protective film for the polarizers is zero or negative, a positive C-plate having a small retardation value may be used to improve viewing-angle characteristics.

Embodiments

Embodiment 1

[0084] The IPS-LCD shown in Table 1 above comprises the IPS liquid crystal cell which has a cell gap of 2.9 μm and is filled with liquid crystal molecules having a pretilt angle of 3°, a dielectric anisotropy (Δε) of +7 and a birefringence (Δn) of 0.1. The negative biaxial retardation film 12 is made of a stretched TAC film and has an m-plane retardation value (R_m) of 110 nm and a thickness-direction retardation value (R_{th}) of -48 nm. The positive C-plate 11 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 133 nm. Two sheets of the polarizers comprise an internal protective film of COP having a retardation value of almost zero. The result of simulation for the minimum contrast ratio at an inclination angle of 70° with respect to all azimuthal angles in the case of the application of such viewing-angle compensation films is 150:1.

Embodiment 2

[0085] The IPS-LCD shown in Table 1 above comprises the IPS liquid crystal cell which has a cell gap of 2.9 μm and is filled with liquid crystal molecules having a pretilt angle of 3°, a dielectric anisotropy (Δε) of +7 and a birefringence (Δn) of 0.1. The negative biaxial retardation film 12 is made of a stretched TAC film and has an in-plane retardation value (R_m) of 66 nm and a thickness-direction retardation value (R_{th}) of -128 nm. The positive C-plate 11 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 120 nm. An internal protective film for the first polarizer 1 is made of TAC and has a thickness-direction retardation value (R_{th}) of -65 nm. An internal protective film for the second polarizer 2 is a COP film having a retardation value of almost zero. The result of simulation for the minimum contrast ratio at an inclination angle of 70° with respect to all azimuthal angles in the case of the application of such viewing-angle compensation films is 30:1.

Embodiment 3

[0086] The IPS-LCD shown in Table 1 above comprises the IPS liquid crystal cell which has a cell gap of 2.9 μm and is filled with liquid crystal molecules having a pretilt angle of 3°, a dielectric anisotropy (Δε) of +7 and a birefringence (Δn) of 0.1. The negative biaxial retardation film 12 is made of a stretched TAC film and has an in-plane retardation value (R_m) of 110 nm and a thickness-direction retardation value (R_{th}) of -48 nm. The positive C-plate 11 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 133 nm. An internal protective film for the first polarizer 1 is made of COP, and an internal protective film for the second polarizer 2 is a stretched TAC film. The result of simulation for the minimum contrast ratio at an inclination angle of 70° with respect to all azimuthal angles in the case of the application of such viewing-angle compensation films is 150:1.

Embodiment 4

[0087] The IPS-LCD shown in Table 2 above comprises the IPS liquid crystal cell which has a cell gap of 2.9 μm and is filled with liquid crystal molecules having a pretilt angle of 3°, a dielectric anisotropy (Δε) of +7 and a birefringence (Δn) of 0.1. The negative biaxial retardation film 12 is made of a stretched TAC film and has an in-plane retardation value (R_{in}) of 77 nm and a thickness-direction retardation value (R_{th}) of -165 nm. The positive C-plate 11 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 305 nm. An internal protective film for the first polarizer 1 is made of COP, and an internal protective film for the second polarizer 2 is made of 80-μm TAC and has a thickness-direction retardation value (R_{th}) of -65 nm. The result of simulation for the minimum contrast ratio at an inclination angle of 70° with respect to all azimuthal angles in the case of the application of such viewing-angle compensation films is 95:1.

Embodiment 5

[0088] The IPS-LCD shown in Table 2 above comprises the IPS liquid crystal cell which has a cell gap of 2.9 μm and is filled with liquid crystal molecules having a pretilt angle of 3°, a dielectric anisotropy (Δε) of +7 and a birefringence (Δn) of 0.1. The negative biaxial retardation film 12 is made of a stretched TAC film and has an in-plane retardation value (Ri_n) of 77 nm and a thickness-direction retardation value (R_{th}) of -165 nm. The first positive C-plate 11 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 420 nm. An internal protective film for the first polarizer 1 is made of COP, and an internal protective film for the second polarizer 2 is a PNB film having a negative thickness-direction retardation value (R_{th}) of -160 nm. The result of simulation for the minimum contrast ratio at an inclination angle of 70° with respect to all azimuthal angles in the case of the application of such viewing-angle compensation films is 86:1.

Embodiment 6

[0089] The IPS-LCD shown in Table 2 above comprises the IPS liquid crystal cell which has a cell gap of 2.9 μm and is filled with liquid crystal molecules having a pretilt angle of 3°, a dielectric anisotropy (Δε) of +7 and a birefringence (Δn) of 0.1. The negative biaxial retardation film 12 is made of a stretched TAC film and has an in-plane retardation value (R_{in}) of 74 nm and a thickness-direction retardation value (R_{th}) of -162 nm. The positive C-plate 11 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 230 nm. An internal protective film for the first polarizer 1 is made of COP, and an internal protective film for the second polarizer 2 is made of COP. The result of simulation for the minimum contrast ratio at an inclination angle of 70° with respect to all azimuthal angles in the case of the application of such viewing-angle compensation films is 100:1.

Embodiment 7

[0090] The IPS-LCD shown in Table 3 above comprises the IPS liquid crystal cell which has a cell gap of 2.9 μm and is filled with liquid crystal molecules having a pretilt angle of 3°, a dielectric anisotropy (Δε) of +7 and a birefringence (Δn) of 0.1. The negative biaxial retardation film 12 is made of a stretched TAC film and has an in-plane retardation value (R_{in}) of 92 nm and a thickness-direction retardation value (R_{th}) of -102 nm. The second positive C-plate 11 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 110 nm. The first positive C- plate 12 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 215 nm. An internal protective film for the first polarizer 1 is made of 80-μm TCA having a thickness-direction retardation value (R_{th}) of -65 nm. An internal protective film for the second polarizer 2 is made of COP. The result of simulation for the minimum contrast ratio at an inclination angle of 70° with respect to all azimuthal angles in the case of the application of such viewing-angle compensation films is 136:1.

Embodiment 8

[0091] The IPS-LCD shown in Table 3 above comprises the IPS liquid crystal cell which has a cell gap of 2.9 μm and is filled with liquid crystal molecules having a pretilt angle of 3°, a dielectric anisotropy (Δε) of +7 and a birefringence (Δn) of 0.1. The negative biaxial retardation film 12 is made of a stretched TAC film and has an in-plane retardation value (R_m) of 92 nm and a thickness-direction retardation value (R_{th}) of -102 nm. The second positive C-plate 11 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 220 nm. The first positive C- plate 14 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 215 nm. An internal protective film for the first polarizer 1 is made of PNB and has a thickness-direction retardation value (R_{th}) of -160 nm. An internal protective film for the second polarizer 2 is made of COP. The result of simulation for the minimum contrast ratio at an inclination angle of 70° with respect to all azimuthal angles in the case of the application of such viewing-angle compensation films is 125:1.

Embodiment 9

[0092] The IPS-LCD shown in Table 4 above comprises the IPS liquid crystal cell which has a cell gap of 2.9 μm and is filled with liquid crystal molecules having a pretilt angle of 3°, a dielectric anisotropy (Δε) of +7 and a birefringence (Δn) of 0.1. The negative biaxial retardation film 12 is made of a stretched TAC film and has an in-plane retardation value (R_{in}) of 88 nm and a thickness-direction retardation value (R_{th}) of -65 nm. The second positive C-plate 11 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 110 nm. The first positive C- plate 14 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 163 nm. An internal protective film for the first polarizer 1 is made of 80-μm TAC and has a thickness-direction retardation value (R_h) of -65 nm. An internal protective film for the second polarizer 2 is made of COP. The result of simulation for the minimum contrast ratio at an inclination angle of 70° with respect to all azimuthal angles in the case of the application of such viewing-angle compensation films is 150:1.

Embodiment 10

[0093] The IPS-LCD shown in Table 4 above comprises the IPS liquid crystal cell which has a cell gap of 2.9 μm and is filled with liquid crystal molecules having a pretilt angle of 3°, a dielectric anisotropy (Δε) of +7 and a birefringence (Δn) of 0.1. The negative biaxial retardation film 12 is made of a stretched TAC film and has an in-plane retardation value (R_{th}) of 88 nm and a thickness-direction retardation value (R_{th}) of -65 nm. The second positive C-plate 11 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 220 nm. The first positive C- plate 14 is an UV cured, homeotropically aligned liquid crystal film and has a retardation value (R_{th}) of 163 nm. An internal protective film for the first polarizer 1 is made of PNB and has a thickness-direction retardation value (R_{th}) of -160 nm. An internal protective film for the second polarizer 2 is made of COP. The result of simulation for the minimum contrast ratio at an inclination angle of 70° with respect to all azimuthal angles in the case of the application of such viewing-angle compensation films is 140:1.

Industrial Applicability

[0094] As described above, according to the present invention, the use of the negative biaxial retardation film and the positive C-plate allows improvements in the contrast characteristics at the front side and inclination angle of in-plane switching liquid crystal displays. Also, it allows the minimization of color shift with viewing angle in the dark state.

Claims

1. An optical film for an in-plane switching liquid crystal display, the optical film comprising an upper polarizer and a viewing-angle compensation film,
wherein the viewing-angle compensation film comprises a negative biaxial retardation film having a negative thickness-direction retardation value and a positive in-plane retardation value; and a positive C-plate having a positive thickness-direction retardation value,
wherein the negative biaxial retardation film is arranged closer to the upper polarizer than the positive C-plate or the positive C-plate is arranged closer to the upper polarizer than the negative biaxial retardation film,
wherein, when the negative biaxial retardation film is arranged closer to the upper polarizer than the positive C-plate, the optical axis of the negative biaxial retardation film is perpendicular to the absorption axis of the upper polarizer,
wherein, when the positive C-plate is arranged closer to the upper polarizer than the negative biaxial retardation film, the optical axis of the negative biaxial retardation film is parallel to the absorption axis of the upper polarizer,
characterized in that the positive C-plate has a larger thickness-direction retardation value than the absolute thickness-direction retardation value of the negative retardation film.

2. The optical film for an in-plane switching liquid crystal display according to claim 1, wherein the negative biaxial retardation film or the positive C-plate serves as an internal protective film for the upper polarizer.

3. The optical film for an in-plane switching liquid crystal display according to claim 1 or 2, wherein the positive C plate has a thickness-direction retardation value ranging from 50 nm to 500 nm at a wavelength of 550 nm.

4. The optical film for an in-plane switching liquid crystal display according to any one of claims 1 to 3, wherein the negative biaxial retardation film has an in-plane retardation value ranging from 20 nm to 200 nm at a wavelength of 550 nm and has a thickness-direction retardation value of not less than -300 nm at a wavelength of 550 nm.

5. The optical film for an in-plane switching liquid crystal display according to any one of claims 1 to 4, wherein the negative biaxial retardation film has an in-plane retardation value ranging of less than 150 nm at a wavelength of 550 nm.

6. The optical film for an in-plane switching liquid crystal display according to any one of claims 1 to 4, wherein the negative biaxial retardation film is arranged closer to the polarizer than the positive C-plate and the sum of the thickness-direction retardation values of the negative biaxial retardation film and the positive C plate ranges from +50 nm to +300 nm at a wavelength of 550 nm.

7. The optical film for an in-plane switching liquid crystal display according to any one of claims 1 to 4, wherein the positive C-plate is arranged closer to the polarizer than the negative biaxial retardation film and the sum of the thickness-direction retardation values of the negative biaxial retardation film and the positive C plate ranges from +50 nm to +300 nm at a wavelength of 550 nm.

Patentansprüche

1. Optischer Film für eine In-Plane-Umschalt-Flüssigkristallanzeige, wobei der optische Film einen oberen Polarisator und einen Betrachtungswinkelkompensationsfilm umfasst,
wobei der Betrachtungswinkelkompensationsfilm einen negativen biaxialen Verzögerungsfilm, der einen negativen Verzögerungswert in Dickenrichtung und einen positiven In-Plane Verzögerungswert aufweist, und eine positive C-Platte mit einem positiven Verzögerungswert in Dickenrichtung umfasst,
wobei der negative biaxiale Verzögerungsfilm näher an dem oberen Polarisator angeordnet ist als die positive C-Platte oder die positive C-Platte näher an dem oberen Polarisator angeordnet ist als der negative biaxiale Verzögerungsfilm,
wobei, wenn der negative biaxiale Verzögerungsfilm näher an dem oberen Polarisator angeordnet ist als die positive C-Platte, die optische Achse des negativen biaxialen Verzögerungsfilms senkrecht zu der Absorptionsachse des oberen Polarisators verläuft,
wobei, wenn die positive C-Platte näher am oberen Polarisator angeordnet ist als der negative biaxiale Verzögerungsfilm, die optische Achse des negativen biaxialen Verzögerungsfilms parallel zur Absorptionsachse des oberen Polarisators verläuft,
dadurch gekennzeichnet, dass die positive C-Platte einen größeren Verzögerungswert in Dickenrichtung aufweist als der absolute Verzögerungswert des negativen Verzögerungsfilms in Dickenrichtung.

2. Optischer Film für eine In-Plane-Umschalt-Flüssigkristallanzeige gemäß Anspruch 1, wobei der negative biaxiale Verzögerungsfilm oder die positive C-Platte als interner Schutzfilm für den oberen Polarisator dient.

3. Optischer Film für eine In-Plane-Umschalt-Flüssigkristallanzeige gemäß Anspruch 1 oder 2, wobei die positive C-Platte einen Verzögerungswert in Dickenrichtung im Bereich von 50 nm bis 500 nm bei einer Wellenlänge von 550 nm aufweist.

4. Optischer Film für eine In-Plane-Umschalt-Flüssigkristallanzeige gemäß mindestens einem der Ansprüche 1 bis 3, wobei der negative biaxiale Verzögerungsfilm einen In-Plane Verzögerungswert im Bereich von 20 nm bis 200 nm bei einer Wellenlänge von 550 nm aufweist und einen Verzögerungswert in Dickenrichtung von nicht weniger als -300 nm bei einer Wellenlänge von 550 nm aufweist.

5. Optischer Film für eine In-Plane-Umschalt-Flüssigkristallanzeige gemäß mindestens einem der Ansprüche 1 bis 4, wobei der negative biaxiale Verzögerungsfilm einen In-Plane Verzögerungswert im Bereich von weniger als 150 nm bei einer Wellenlänge von 550 nm aufweist.

6. Optischer Film für eine In-Plane-Umschalt-Flüssigkristallanzeige gemäß mindestens einem der Ansprüche 1 bis 4, wobei der negative biaxiale Verzögerungsfilm näher am Polarisator angeordnet ist als die positive C-Platte und die Summe der Verzögerungswerte des negativen biaxialen Verzögerungsfilms und der positiven C-Platte in Dickenrichtung im Bereich von +50 nm bis +300 nm bei einer Wellenlänge von 550 nm liegt.

7. Optischer Film für eine In-Plane-Umschalt-Flüssigkristallanzeige gemäß mindestens einem der Ansprüche 1 bis 4, wobei die positive C-Platte näher am Polarisator angeordnet ist als der negative biaxiale Verzögerungsfilm und die Summe der Verzögerungswerte des negativen biaxialen Verzögerungsfilms und der positiven C-Platte in Dickenrichtung im Bereich von +50 nm bis +300 nm bei einer Wellenlänge von 550 nm liegt.

Revendications

1. Film optique pour un écran à cristaux liquides à commutation dans le plan, le film optique comprenant un polariseur supérieur et un film de compensation d'angle de visualisation,
dans lequel le film de compensation d'angle de visualisation comprend un film de retard biaxial négatif présentant une valeur négative de retard dans le sens de l'épaisseur et une valeur positive de retard dans le plan ; et une plaque C positive présentant une valeur positive de retard dans le sens de l'épaisseur,
dans lequel le film de retard biaxial négatif est agencé plus proche du polariseur supérieur que la plaque C positive ou la plaque C positive est agencée plus proche du polariseur supérieur que le film de retard biaxial négatif,
dans lequel, lorsque le film de retard biaxial négatif est agencé plus proche du polariseur supérieur que la plaque C positive, l'axe optique du film de retard biaxial négatif est perpendiculaire à l'axe d'absorption du polariseur supérieur,

dans lequel, lorsque la plaque C positive est agencée plus proche du polariseur supérieur que le film de retard biaxial négatif, l'axe optique du film de retard biaxial négatif est parallèle à l'axe d'absorption du polariseur supérieur, **caractérisé en ce que** la plaque C positive a une valeur de retard dans le sens de l'épaisseur supérieure à la valeur de retard absolue dans le sens de l'épaisseur du film de retard négatif.

2. Film optique pour un écran à cristaux liquides à commutation dans le plan selon la revendication 1, dans lequel le film de retard biaxial négatif ou la plaque C positive sert de film de protection interne pour le polariseur supérieur.

3. Film optique pour un écran à cristaux liquides à commutation dans le plan selon la revendication 1 ou 2, dans lequel la plaque C positive a une valeur de retard dans le sens de l'épaisseur dans une plage de 50 nm à 500 nm à une longueur d'onde de 550 nm.

4. Film optique pour un écran à cristaux liquides à commutation dans le plan selon l'une quelconque des revendications 1 à 3, dans lequel le film de retard biaxial négatif a une valeur de retard dans le plan dans une plage de 20 nm à 200 nm à une longueur d'onde de 550 nm et a une valeur de retard dans le sens de l'épaisseur non inférieure à-300 nm à une longueur d'onde de 550 nm.

5. Film optique pour un écran à cristaux liquides à commutation dans le plan selon l'une quelconque des revendications 1 à 4, dans lequel le film de retard biaxial négatif a une valeur de retard dans le plan inférieure à 150 nm à une longueur d'onde de 550 nm.

6. Film optique pour un écran à cristaux liquides à commutation dans le plan selon l'une quelconque des revendications 1 à 4, dans lequel le film de retard biaxial négatif est agencé plus proche du polariseur que la plaque C positive et la somme des valeurs de retard dans le sens de l'épaisseur du film de retard biaxial négatif et de la plaque C positive est dans une plage de +50 nm à +300 nm à une longueur d'onde de 550 nm.

7. Film optique pour un écran à cristaux liquides à commutation dans le plan selon l'une quelconque de revendications 1 à 4, dans lequel la plaque C positive est agencée plus proche du polariseur que le film de retard biaxial négatif et la somme des valeurs de retard dans le sens de l'épaisseur du film de retard biaxial négatif et de la plaque C positive est dans une plage de +50 nm à +300 nm à une longueur d'onde de 550 nm.

Fig. 1

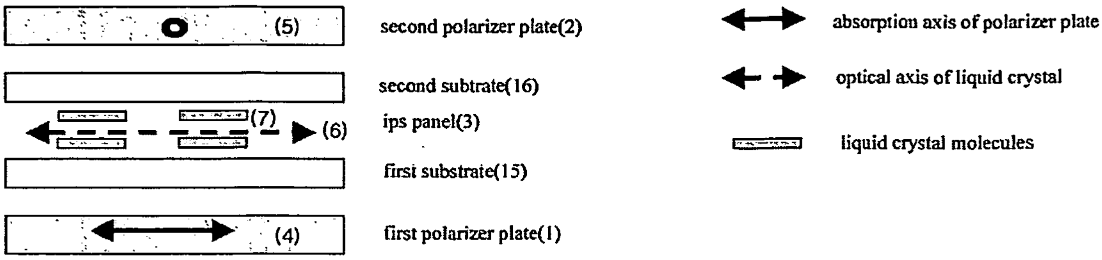


Fig. 2

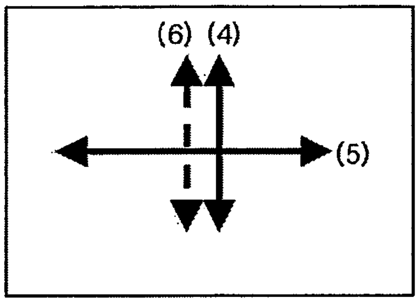


Fig. 3

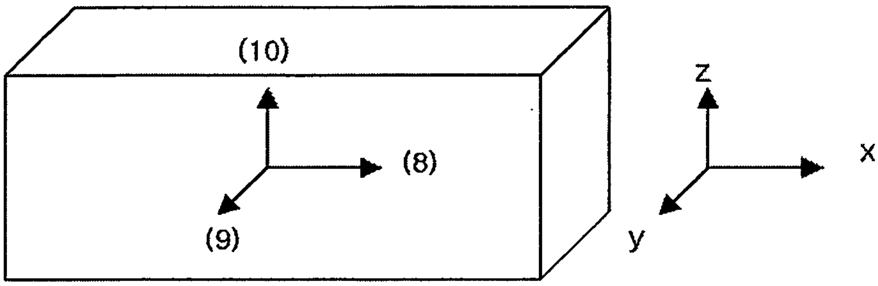


Fig. 4

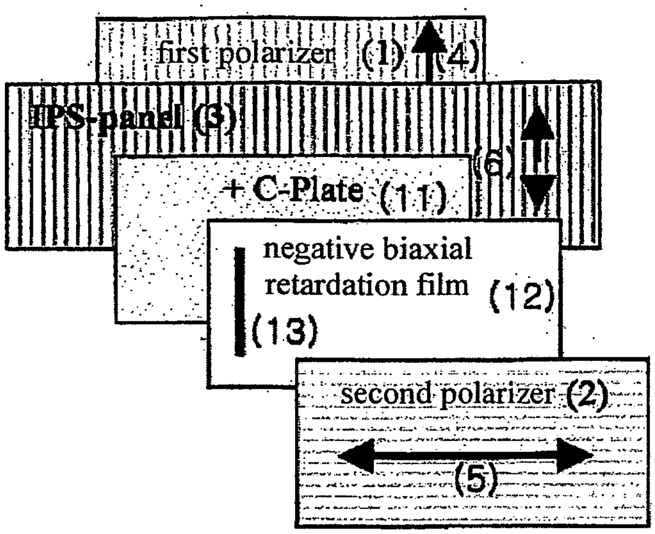

first polarizer (1)
(4)
IPS-panel (3)
(6)
+ C-Plate (11)
negative biaxial
retardation film
(12)
(13)
second polarizer (2)
(5)

Fig. 5

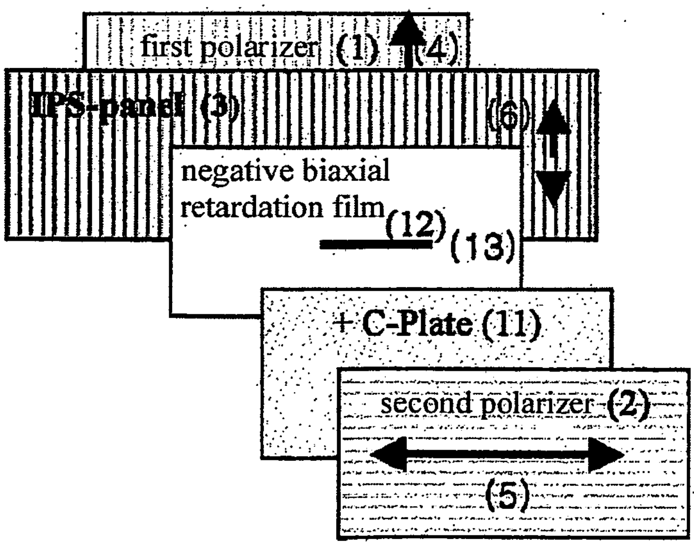
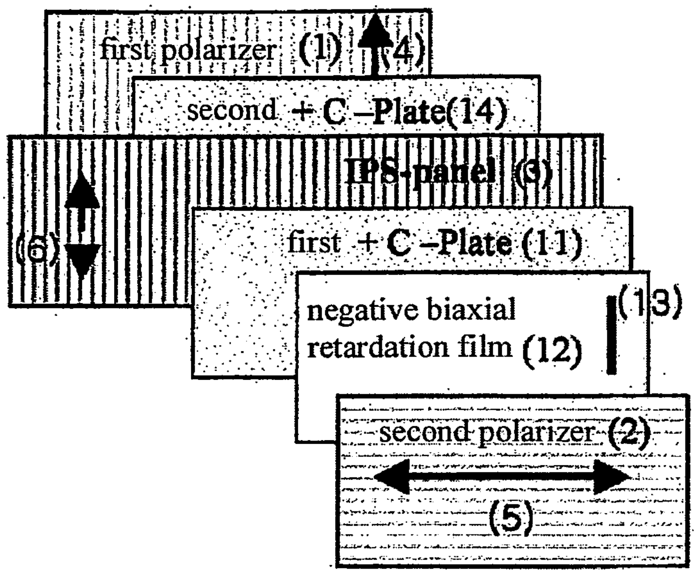

first polarizer (1)
(4)
IPS-panel (3)
(6)
negative biaxial
retardation film
(12)
(13)
+ C-Plate (11)
second polarizer (2)
(5)

Fig. 6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second +C-Plate(14)
IPS-panel (3)
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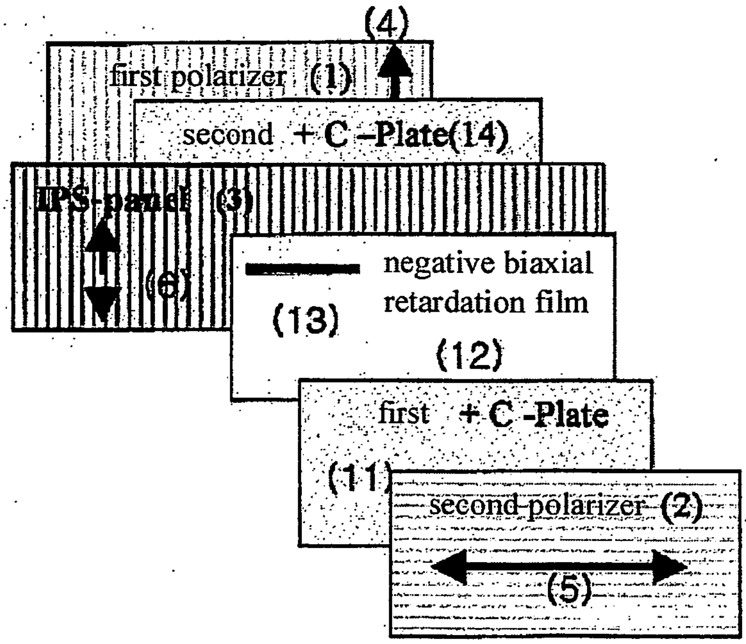
first +C-Plate (11)
negative biaxial
retardation film (12)
(13)
second polarizer (2)
(5)

Fig. 7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first polarizer (1)
second +C-Plate(14)
IPS-panel (3)
(6)
negative biaxial
retardation film
(13)
(12)
first +C-Plate
(11)
second polarizer (2)
(5)

REFERENCES CITED IN THE DESCRIPTION

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patsnap

专利名称(译)	带有补偿膜的面内切换液晶显示器，该补偿膜使用负双轴延迟膜和（+）-C板用于视角范围		
公开(公告)号	EP2485084B1	公开(公告)日	2020-03-04
申请号	EP2012003145	申请日	2005-01-07
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申请(专利权)人(译)	LG CHEMICAL CO.，LTD.		
当前申请(专利权)人(译)	LG CHEMICAL CO.，LTD.		
[标]发明人	JEON BYOUNG KUN BELYAEV SERGEY YU JEONG SU MALIMONENKO NIKOLAY		
发明人	JEON, BYOUNG-KUN BELYAEV, SERGEY YU, JEONG-SU MALIMONENKO, NIKOLAY		
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摘要(译)

平面内切换液晶显示器技术领域本发明涉及一种平面内切换液晶显示器，其包括负双轴延迟膜和正C板，作为视角补偿膜。 通过使用这种视角补偿膜，可以改善面内切换液晶显示器的前侧的对比度特性和倾斜角度，并且可以最小化在黑暗状态下随视角的色偏。

(Equation 1)

$$R_{in} = d \times \{n_x - n_y)$$