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(54) IN-PLANE SWITCHING LIQUID CRYSTAL DISPLAY HAVING SIMPLE STRUCTURE

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DISPOSITIF D’AFFICHAGE A CRISTAUX LIQUIDES A COMMUTATION DANS LE PLAN POSSEDANT UNE STRUCTURE SIMPLE

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EP 1 910 892 B1

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Description**Technical Field**

5 **[0001]** The present invention relates to a liquid crystal display, and more particularly to an in-plane switching liquid crystal display (hereinafter, referred to as an "IPS-LCD", which is filled with a liquid crystal having positive dielectric constant anisotropy ($\Delta \epsilon > 0$), such as it is known from JOUN-HO LEE 1 ET AL, "P-92:Optical Configurations of TW-IPS LC Cell for Very Wide Viewing Angle in Large Size TV Application", 2005 SID INTERNATIONAL SYMPOSIUM. BOSTON, MA, MAY 24 - 27, 2005; [SID INTERNATIONAL SYMPOSIUM], SAN JOSE, CA : SID, US, (20050524), vol. XXXVI, 10 PAGE 642 - 645, XP007012519, upon which the preamble of claim 1 is based.

Background Art

15 **[0002]** In general, LCDs are divided into an in-plane switching (IPS)-LCD, a super in-plane switching (super IPS)-LCD, and a fringe field switching (FFS)-LCD according to modes of an active matrix driving electrode including pairs of electrodes. In the present invention, IPS-LCDs include the super IPS-LDS and the FFS-LCD.

[0003] FIG. 1 illustrates the basic structure of a conventional IPS-LCD. The IPS-LCD comprises a first polarizing plate 1, a second polarizing plate 2, and an IPS panel 3. An absorption axis 4 of the first polarizing plate 1 is orthogonal to an absorption axis 5 of the second polarizing plate 2, and is parallel with an optical axis 6 of a liquid crystal in the IPS panel 3.

20 **[0004]** Polarizing films in the first and second polarizing plates 1 and 2 are very thin and stretched films, thus being easily damaged by external physical and mechanical force. Accordingly, in order to protect the polarizing films of the first and second polarizing plates 1 and 2, a protective film is essentially formed on the internal surfaces of the first and second polarizing plates 1 and 2, on which the liquid crystal is formed.

25 **[0005]** In order to compensate for the light polarization of a polarizing plate to improve visibility and increase clearness of a screen, various phase retardation films are used. That is, in order to prevent light leakage and improve a contrast ratio, various phase retardation films or optical compensating films are used.

[0006] Accordingly, the polarizing plate includes various film layers, such as a polarizing film, a protective film for protecting the polarizing film, and a phase retardation film for improving optical characteristics of the polarizing plate. These various film layers increase the thickness of the polarizing plate.

30 **[0007]** This thick polarizing plate goes against the thin profile trend of the IPS-LCD. Thus, the improvement of the thick polarizing plate has been required.

[0008] In order to satisfy the above requirement, several techniques are proposed. According to one technique, the protective film is removed from the polarizing plate and the phase retardation film serves to protect the polarizing plate.

35 **[0009]** However, when the protective film is removed from the polarizing plate and the phase retardation film serves to protect the polarizing plate, the contrast ratio of the IPS-LCD is lowered. That is, the contrast ratio refers to a ratio of the luminance of the brightest portion to the luminance of the darkest portion. The higher a difference of luminances between the brightest portion and the darkest portion is, the higher the contrast ratio is. Accordingly, in order to assure the contrast ratio, it is necessary to prevent the light leakage at the darkest portion. When a phase retardation between the polarizing film and the phase retardation film is not properly controlled, the light leakage is severe according to viewable angles, thus causing a difficulty in assuring the contrast ratio.

40 **[0010]** Accordingly, an IPS-LCD comprising a polarizing plate, in which a phase retardation between a phase retardation film and a polarizing film is properly controlled, is required.

[0011] Particularly, the IPS-LCD has the worst contrast characteristic at a tilt angle of 75°. The improvement of the contrast characteristic of the IPS-LCD at a tilt angle of 75° means the improvement of the contrast characteristics of the IPS-LCD at all viewable angles. Thus, it is necessary to set the contrast characteristic of the IPS-LCD at tilt angle of 75° to more than a sufficient value.

45 **[0012]** For the above reason, a protective film is provided on the inner surfaces of the first and second polarizing plates of the IPS-LCD. In this case, the contrast ratio of the IPS-LCD is 10:1~45:1. Consequently, it is preferable that an LCD having a contrast ratio similar to the above range and a simple structure is developed.

50 **[0013]** WO 2005/038517 A1 describes an in-plane switching liquid crystal display comprising a compensation film for angular field view using a +A-plate and a +C-plate.

Disclosure of Invention

55 **Technical Problem**

[0014] Therefore, the present invention has been made in view of the above problems, and it is an object of the present

invention to provide an IPS-LCD, in which the direction of an optical axis and retardation values are adjusted according to the disposition order of a phase retardation film even when a protective film is removed from an internal surface of one polarizing plate, thus obtaining a contrast ratio similar to that of an IPS-LCD having upper and lower protective films, and having a small thickness.

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Technical Solution

[0015] In accordance with an aspect of the present invention, the above and other objects can be accomplished by the provision of an in-plane switching liquid crystal display (IPS-LCD) as defined in claim 1.

10 **[0016]** The in-plane switching liquid crystal display comprises a first polarizing plate, a second polarizing plate, an horizontally oriented IPS panel disposed between the first and second polarizing plates and filled with a liquid crystal having positive dielectric constant anisotropy ($\Delta E > 0$), and a first protective film disposed between the first polarizing plate and the IPS panel, in which an absorption axis of the first polarizing plate and an absorption axis of the second polarizing plate are orthogonal to each other, and an optical axis of the liquid crystal in the IPS panel and the absorption axis of the first polarizing plate are parallel with each other, wherein a second phase retardation film, obtained by coating a biaxial film with a uniaxial C film, is disposed between the second polarizing plate and the IPS panel and is used as a second protective film between the IPS panel and the second polarizing plate.

15 **[0017]** Thereby, the second phase retardation film plays an original role of increasing a viewable angle, and further serves as the protective film of the second polarizing plate. That is, it is possible to omit one protective film, thus reducing the thickness of the IPS-LCD, simplifying the structure of the IPS-LCD, and reducing the production costs of the IPS-LCD.

20 **[0018]** The IPS-LCD further comprises a first phase retardation film including a uniaxial A film and disposed between the IPS panel and the first polarizing plate.

25 **[0019]** The first phase retardation film including the uniaxial A film has an in-plane retardation value (R_{in}) of 30~450nm, the biaxial film of the second phase retardation film has an in-plane retardation value (R_{in}) of 50~150nm and a thickness retardation value (R_{th}) of -50~-150nm, and the uniaxial C film of the second phase retardation film has a thickness retardation value (R_{th}) of 50~170nm.

[0020] Here, the above retardation values denote retardation values at a wavelength of 550nm.

[0021] Further, preferably, an optical axis of the first phase retardation film in the direction of the X axis is parallel with the absorption axis of the first polarizing plate.

30 **[0022]** The first protective film is preferably one film selected from the group consisting of a non-stretched zero COP film, a non-stretched zero TAC film, and a TAC film having a thickness of 50 μ m. and having a thickness retardation value, and more preferably a non-stretched zero TAC film. The thickness retardation value of the TAC film is 30~40nm.

35 **[0023]** Preferably, the uniaxial A film is made of lengthwise stretched polymer, the biaxial film is made of crosswise stretched polymer, and the uniaxial C film is obtained by coating an orientation film with a liquid crystal and hardening the liquid crystal coated on the orientation film. However, the uniaxial C film may be made of a non-orientation film.

Advantageous Effects

40 **[0024]** The present invention provides an in-plane switching liquid crystal display (IPS-LCD), which uses a second phase retardation film exhibiting a broad viewable angle property as a protective film of one polarizing plate. The IPS-LCD of the present invention has a thin profile and a simple structure, and causes the reduction of the production costs thereof.

45 **[0025]** The conventional IPS-LCD having upper and lower protective films exhibits a contrast ratio of 10:1~45:1. On the other hand, the IPS-LCD of the present invention exhibits a contrast ratio of 25:1~55:1. Accordingly, the IPS-LCD of the present invention has a simple structure and exhibits a reasonably high contrast ratio.

Brief Description of the Drawings

50 **[0026]** The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic view illustrating the basic structure of a conventional IPS-LCD;

FIG. 2 is a view illustrating the disposition of absorption axes of two polarizing plates and an optical axis of an IPS panel of the IPS-LCD of FIG. 1;

55 FIG. 3 is a view illustrating the refractivities of a phase retardation film of the IPS-LCD;

FIGS. 4 to 8 are schematic views illustrating structures of IPS-LCDs, each of which has a second phase retardation film, obtained by coating a biaxial film with a uniaxial C film, between a second polarizing plate and an IPS panel, in accordance with embodiments of the present invention;

FIGS. 9 to 12 are schematic views illustrating structures of IPS-LCDs, each of which has a second phase retardation film, obtained by coating a uniaxial A film with a uniaxial C film, between a second polarizing plate and an IPS panel, in accordance with other embodiments of the present invention;

FIGS. 13A and 13B are views illustrating viewable angle characteristics of the IPS-LCDs in accordance with the first and second embodiments, as shown in FIGS. 4 and 5;

FIGS. 14A and 14B are views illustrating viewable angle characteristics of the IPS-LCDs in accordance with the third and fourth embodiments, as shown in FIGS. 6 and 7;

FIGS. 15A and 15B are views illustrating viewable angle characteristics of the IPS-LCDs in accordance with the fifth and sixth embodiments, as shown in FIGS. 8 and 9;

FIGS. 16A to 16C are views illustrating viewable angle characteristics of the IPS-LCDs in accordance with the seventh to ninth embodiments, as shown in FIGS. 10 to 12;

FIG. 17 is a view illustrating a structure of an IPS-LCD, which uses a zero COP film or a zero TAC film as an internal protective film of a first polarizing plate, and has a second phase retardation film, obtained by coating a biaxial film with a uniaxial C film, in accordance with a tenth embodiment of the present invention;

FIG. 18 is a view illustrating a structure of an IPS-LSD, which has the same structure as that of the IPS-LCD of FIG. 17 and uses a TAC film having a thickness retardation value of -30~40nm as an internal protective film of a first polarizing plate, in accordance with an eleventh embodiment of the present invention;

FIG. 19 is a view illustrating a structure of an IPS-LCD, which has the same structure as that of the IPS-LCD of FIG. 17 and uses a general TAC film having a thickness retardation value of -55~65nm as an internal protective film of a first polarizing plate, in accordance with a twelfth embodiment of the present invention;

FIG. 20 is a view illustrating a structure of an IPS-LCD, which has the same structure as that of the IPS-LCD of FIG. 17 except that an optical axis of a second internal protective film and an absorption axis of a second polarizing plate are parallel with each other, in accordance with a thirteenth embodiment of the present invention;

FIG. 21 is a view illustrating a structure of an IPS-LCD, which has the same structure as that of the IPS-LCD of FIG. 17 except that retardation values of a biaxial film and a C film of a second internal protective film deviate from the range regulated by the present invention, in accordance with a fourteenth embodiment of the present invention;

FIG. 22 is a view illustrating a structure of an IPS-LCD, which has a uniaxial A film, interposed between an internal protective film of a first polarizing plate and an IPS panel, and a second internal protective film including a uniaxial A film and a uniaxial C film, which are sequentially stacked, in accordance with a fifth embodiment of the present invention; and

FIGS. 23A to 23F are views illustrating distributions of contrast ratios of the IPS-LCDs, as shown in FIGS. 17 to 22.

Best Mode for Carrying Out the Invention

[0027] Now, preferred embodiments of the present invention will be described in detail with reference to the annexed drawings.

[0028] FIG. 2 illustrates an absorption axis 6 of a liquid crystal in an IPS panel 3 and absorption axes 4 and 5 two polarizing plates 1 and 2. The absorption axis 4 of the first polarizing plate 1 is orthogonal to the absorption axis 5 of the second polarizing plate 2, and is parallel with the optical axis 6 of the liquid crystal in the IPS panel 6.

[0029] With reference to FIGS. 1 and 2, the IPS panel 3 interposed between two polarizing plates 1 and 2, the absorption axes 4 and 5 of which are orthogonal to each other, comprises liquid molecules 7, which are disposed in parallel with first and second substrates 20 and 21 and arranged in the direction of rubbing (a method for treating the surface of the panel for arranging the liquid crystal modules in one direction). When the absorption axis of the polarizing plate adjacent to a backlighting and the rubbing direction are parallel with each other, the IPS-LCD is referred to as an "O-mode IPS-LCD", and when the absorption axis of the polarizing plate adjacent to the backlighting and the rubbing direction are orthogonal to each other, the IPS-LCD is referred to as an "E-mode IPS-LCD".

[0030] FIG. 3 is a view illustrating the refractivities of a phase retardation film for compensating for the viewable angle of the IPS-LCD. n_x represents the refractivity 8 of the phase retardation film in the direction of the X-axis, n_y represents the refractivity 9 of the phase retardation film in the direction of the Y-axis, and n_z represents the re-fractivity 10 of the phase retardation film in the direction of the Z-axis. The characteristics of the phase retardation film are determined by the degrees of the refractivities. A phase retardation film, in which the refractivities in the directions of the two axes are different, is referred to as a uniaxial phase retardation film, and a phase retardation film, in which the refractivities in the directions of the three axes are different, is referred to as a biaxial phase retardation film.

[0031] The uniaxial phase retardation film and the biaxial phase retardation film are defined as below equations.

(1) When a phase retardation film satisfies the expression of $n_x > n_y = n_z$, the phase retardation film is referred to as a uniaxial A film, and an in-plane retardation value is defined using a difference ($n_x - n_y$) between two refractivities located on a plane and a thickness (d) of the film by the below equation 1.

[Equation 1]

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

(2) When a phase retardation film satisfies the expression of $n_x = n_y < n_z$, the phase retardation film is referred to as a uniaxial C film, and a thickness retardation value is defined using a difference ($n_z - n_y$) between the refractivity located on a plane and the refractivity in the thickness direction and a thickness (d) of the film by the below equation 2.

[Equation 2]

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

(3) When a phase retardation film satisfies the expression of $n_x > n_y > n_z$, the phase retardation film is referred to as a negative biaxial phase retardation film (hereinafter, referred to as a "biaxial phase retardation film"). Since the refractivities in the directions of the three axes are different, the biaxial phase retardation film has an in-plane retardation value and a thickness retardation value, which are defined by the above equations 1 and 2, respectively.

[0032] The retardation values are affected by the wavelength of light to be used. The wavelength of light is 550nm except being specially defined.

[0033] FIGS. 4 to 8 illustrate structures of IPS-LCDs, each of which has a second phase retardation film, obtained by coating a biaxial film 17 with a uniaxial C film 11, between a second polarizing plate 2 and an IPS-panel 3, in accordance with embodiments of the present invention. Further, FIGS. 9 to 12 illustrate structures of IPS-LCDs, each of which has a second phase retardation film, obtained by coating a uniaxial A film 14 with a uniaxial C film 11, between a second polarizing plate 2 and an IPS-panel 3, in accordance with other embodiments of the present invention.

[0034] Each of the IPS-LCDs, shown in FIGS. 4 to 12, comprises a protective film, for protecting a polarizing device made of stretched polyvinyl alcohol, on the internal surface of a first polarizing plate 1. The protective film is made of TAC (triacetatecellulose) of a thickness of 50 μ m having a thickness retardation value, biaxial COP (cyclo-olefin) simultaneously having an in-plane retardation value and a thickness retardation value, TAC without a thickness retardation value (hereinafter, referred to as "zero TAC"), or COP without a thickness retardation value (hereinafter, referred to as "zero COP").

[0035] Preferably, the uniaxial A films 12 and 14 are made of lengthwise stretched polymer, the biaxial film 17 is made of crosswise stretched polymer, and the uniaxial C film 11 is obtained by coating an orientation film with a liquid crystal and hardening the liquid crystal coated on the orientation film.

[0036] Here, the stacking structures of the IPS-LCDs of FIGS. 4 and 5 and the structures of the IPS-LCDs of FIGS. 6 and 7 are the same except that the positions of an observer and a backlighting 19 are reversed. As described above, when the absorption axis of the polarizing plate adjacent to the backlighting 19 and the rubbing direction are parallel with each other, the IPS-LCD is referred to as an "O-mode IPS-LCD") and when the absorption axis of the polarizing plate adjacent to the backlighting 19 and the rubbing direction are orthogonal to each other, the IPS-LCD is referred to as an "E-mode IPS-LCD". The IPS-LCDs, as shown in FIGS. 4, 6, 8, 9, and 11, are O-mode IPS-LCDs, and the IPS-LCDs, as shown in FIGS. 5, 7, 10, and 12 are E-mode IPSLCDs. The IPS-LCDs of FIGS. 4 and 5, the IPS-LCDs of FIGS. 6 and 7, the IPSLCDs of FIGS. 9 and 10, and the IPS-LCDs of FIGS. 11 and 12 have the same structure except that one IPS-LCD is an O-mode IPS-LCD and the other IPS-LCD is an E-mode IPS-LCD, and will be thus described simultaneously.

[0037] FIGS. 4 and 5 illustrate structures of IPS-LCDs, each of which has a phase retardation film, in accordance with first and second embodiments of the present invention. Here, the optical axis 18 of the biaxial film 17 is orthogonal to the absorption axis 5 of the second polarizing plate 2, and is located at a position adjacent to the second polarizing plate 2. Further, the uniaxial C film 11 is located at a position adjacent to the IPS-panel 3.

[0038] FIGS. 6 and 7 illustrate structures of IPS-LCDs, each of which has a phase retardation film, in accordance with third and fourth embodiments of the present invention. Here, the optical axis 18 of the biaxial film 17 is parallel with the absorption axis 5 of the second polarizing plate 2, and is located at a position adjacent to the IPS-panel 3. Further, the uniaxial C film 11 is located at a position adjacent to the second polarizing plate 2.

[0039] FIG. 8 illustrates a structure of an IPS-LCD, which has a phase retardation film, in accordance with a fifth embodiment of the present invention. Here, the optical axis 18 of the biaxial film 17 and the optical axis 13 of the uniaxial A film 12 are orthogonal to the absorption axis 5 of the second polarizing plate 2. The uniaxial C film 11 is located at a position adjacent to the second polarizing plate 2, and the biaxial film 17 is located at a position adjacent to the IPS-panel 3. Further, the uniaxial A film 12 is located between the first polarizing plate 1 and the IPS-panel 3.

[0040] FIGS. 9 and 10 illustrate structures of IPS-LCDs, each of which has a phase retardation film, in accordance with sixth and seventh embodiments of the present invention. Here, the optical axis 13 of one uniaxial A film 12 adjacent to the first polarizing plate 1 is orthogonal to the absorption axis 5 of the second polarizing plate 2, and the optical axis 15 of the other uniaxial A film 14 is parallel with the absorption axis 5 of the second polarizing plate 2. The uniaxial C film 11 is located at a position adjacent to the second polarizing plate 2, and the uniaxial A film 14 is located at position adjacent to the IPS-panel 3. Further, the uniaxial A film 12 is located between the first polarizing plate 1 and the IPS-panel 3.

[0041] FIGS. 11 and 12 illustrate structures of IPS-LCDs, each of which has a phase retardation film, in accordance with eighth and ninth embodiments of the present invention. Here, the optical axis 13 of one uniaxial A film 12 adjacent to the first polarizing plate 1 and the optical axis 15 of the other uniaxial A film 14 adjacent to the second polarizing plate 2 are orthogonal to the absorption axis 5 of the second polarizing plate 2. The uniaxial A film 14 is located at position adjacent to the second polarizing plate 2, and the uniaxial C film 11 is located at a position adjacent to the IPS-panel 3. Further, the uniaxial A film 12 is located between the first polarizing plate 1 and the IPS-panel 3.

Mode for the Invention

[0042] Each of the IPS-LCDs in accordance with all the below embodiments of the present invention comprises an IPS panel including liquid crystal cells, which have a cell interval of $3.3\mu\text{m}$ are filled with a liquid crystal having a pretilt angle of 1.4° dielectric constant anisotropy ($\Delta\varepsilon = +7$), and birefringence ($\Delta n = 0.1$) at a wavelength of 550nm .

[0043] First, in order to determine whether or not the IPS-LCDs have a proper contrast ratio when an internal protective film is replaced with a phase retardation film, polarizing plates were manufactured by methods stated in the first to ninth embodiments of the present invention, and results were obtained by simulation.

(First Embodiment)

[0044] In the IPS-LCD of the first embodiment, as shown in FIG. 4, the internal protective film of the first polarizing plate 1 was made of zero COP or zero TAC. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the upper surface of the biaxial film 17, which has a thickness of $80\mu\text{m}$, an in-plane retardation value (R_{in}) of 90nm , and a thickness retardation value (R_{th}) of 75nm with the C film 11, which has a thickness retardation value (R_{th}) of 140nm . When the above obtained phase retardation film and the polarizing plates 1 and 2 were applied to an IPS-LCD, the simulated minimum contrast ratios of a tilt angle of 75° to all azimuthal angles in the IPS-LCD were 45:1.

[0045] FIG. 13A illustrates contrast characteristics of tilt angles of $0-80^\circ$ to all azimuthal angles under the above conditions. Here, the center of a circle represents contrast characteristics at a tilt angle of 0° , and the circumference of the circle represents contrast characteristics at a tilt angle of 80° . The larger the radius of the circle is, the larger the tilt angle is. Values $0-330$, which are written along the circumference of the circle, denote azimuthal angles.

[0046] Below Table 1 states simulated results showing viewable angle characteristics at a tilt angle of 75° according to retardation values of the internal protective film and the phase retardation film in the structure of the IPS-LCD of the first embodiment.

Table 1

Internal protective film of 1 st polarizing plate	IPS-L CD	Retardation value of C film	Retardation value of B film	Internal protective film of 2 nd polarizing plate	Minimum contrast ratio
Zero COP or zero TAC film	330nm	Rth=50nm	Rin=90nm, Rth=-50nm	B film + C film	45:1
		Rth=60nm	Rin=90nm, Rth=-70nm		
		Rth=80nm	Rin=90nm, Rth=-100nm		
		Rth=100nm	Rin=90nm, Rth=-120nm		
		Rth=126nm	Rin=90nm, Rth=-150nm		
		Rth=50nm	Rin=70nm, Rth=-50nm		
		Rth=80nm	Rin=70nm, Rth=-90nm		
		Rth=110nm	Rin=70nm, Rth=-120nm		
		Rth=132nm	Rin=70nm, Rth=-150nm		
		Rth=35nm	Rin=110nm, Rth=-50nm		
		Rth=60nm	Rin=110nm, Rth=-80nm		
		Rth=100nm	Rin=110nm, Rth=-130nm		
Rth=140nm	Rin=90nm, Rth=-75nm				

(Second Embodiment)

[0047] In the IPS-LCD of the second embodiment, as shown in FIG. 5, the internal protective film of the first polarizing plate 1 and the internal protective film of the second polarizing plate 2 were the same as those of the first embodiment, but have retardation values different from those of the first embodiment. That is, in the IPS-LCD of the second embodiment, as shown in FIG. 5, the internal protective film of the first polarizing plate 1 was made of zero COP or zero TAC. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the upper surface of the biaxial film 17, which has a thickness of 100 μ m an in-plane retardation value (Rin) of 90nm, and a thickness retardation value (Rth) of -100nm with the C film 11, which has a thickness retardation value (Rth) of 115nm. When this phase retardation film and the polarizing plates 1 and 2 were applied to an IPS-LCD, the simulated minimum contrast ratios of a tilt angle of 75° to all azimuthal angles in the IPS-LCD were 40:1.

[0048] FIG. 13B illustrates contrast characteristics of tilt angles of 0-80° to all azimuthal angles under the above conditions.

[0049] Below Table 2 states simulated results showing viewable angle characteristics at a tilt angle of 75° according to retardation values of the internal protective film and the phase retardation film in the structure of the IPS-LCD of the second embodiment.

Table 2

Internal protective film of 1 st polarizing plate	IPS-L CD	Retardation value of C film	Retardation value of B film	Internal protective film of 2 nd polarizing plate	Minimum contrast ratio
Zero COP or Zero TAC film	330nm	Rth=115nm	Rin=90nm,Rth=-100nm	B film + C film	40:1
		Rth=130nm	Rin=90nm,Rth=-120nm		
		Rth=160nm	Rin=90nm,Rth=-150nm		
		Rth=130nm	Rin=70nm,Rth=-120nm		
		Rth=160nm	Rin=70nm,Rth=-150nm		
		Rth=140nm	Rin= 110nm, Rth=-130nm		

(Third Embodiment)

[0050] In the IPS-LCD of the third embodiment, as shown in FIG. 6, the internal protective film of the first polarizing plate 1 was a zero COP film or a zero TAC film. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the upper surface of the biaxial film 17, which has a thickness of 80 μ m, an in-plane retardation value (Rin) of 90nm and a thickness retardation value (Rth) of -75nm, with the C film 11, which has a thickness retardation value (Rth) of 130nm. When the above obtained phase retardation film and the polarizing plates 1 and 2 were applied to an IPS-LCD, the simulated minimum contrast ratios of a tilt angle of 75° to all azimuthal angles in the IPS-LCD were 35:1~45:1. After the upper surface of the biaxial phase retardation film 17 is coated with the C film 11, a film made of zero TAC without a retardation value may be additionally stacked thereon. The IPS-LCD of this embodiment differs from the conventional IPS-LCD using TAC having a retardation value in that the IPS-LCD of this embodiment uses zero TAC without a retardation value. The contrast ratio of the IPS-LCD having the phase retardation film of the second polarizing plate, which includes the film made of zero TAC, is the same as the IPS-LCD having the phase retardation film of the second polarizing plate, which does not include the film made of zero TAC (The film made of zero TAC is applied to third to seventh embodiments).

[0051] FIG. 14A illustrates contrast characteristics of tilt angles of 0-80° to all azimuthal angles under the above conditions.

[0052] Below Table 3 states simulated results showing viewable angle characteristics at a tilt angle of 75° according to retardation values of the internal protective film and the phase retardation film in the structure of the IPS-LCD of the third embodiment.

Table 3

Internal protective film of 1 st polarizing plate	IPS-LCD	Retardation value of B film	Retardation value of C film	Internal protective film of 2 nd polarizing plate	Minimum contrast ratio
TAC film having thickness of 50μm	330nm	Rin=70nm,Rth=-90 nm	Rth=66nm	B film+C film (+zero TAC)	35:1
		Rin=70nm,Rth=-120nm	Rth=90nm		
		Rin=90nm,Rth=-100nm	Rth=70nm		
		Rin=90nm,Rth=-120nm	Rth=80nm		
		Rin=90nm,Rth=-150nm	Rth=110nm		
		Rin=110nm,Rth=-80nm	Rth=50nm		
		Rin=110nm,Rth=-120nm	Rth=70nm		
		Rin=110nm,Rth=-15nm	Rth=100nm		
		Rin=110nm,Rth=-150nm	Rth=125nm		
		Rin=110nm,Rth=-120nm	Rth=100nm		
Zero COP or zero TAC film	330nm	Rin=110nm,Rth=-80nm	Rth=70nm	B film+C film (+zero TAC)	45:1
		Rin=90nm,Rth=-150nm	Rth=132nm		
		Rin=90nm,Rth=-120nm	Rth=110nm		
		Rin=90nm,Rth=-50nm	Rth=55nm		
		Rin=70nm,Rth=-90nm	Rth=90nm		
		Rin=90nm,Rth=-75nm	Rth=130nm		

(Fourth Embodiment)

[0053] In the IPS-LCD of the fourth embodiment, as shown in FIG. 7, the internal protective film of the first polarizing plate 1 and the internal protective film of the second polarizing plate 2 were the same as those of the third embodiment, but have retardation values different from those of the third embodiment. That is, in the IPS-LCD of the fourth embodiment, as shown in FIG. 7, the internal protective film of the first polarizing plate 1 was a zero COP film or a zero TAC film. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the upper surface of the biaxial film 17, which has a thickness of 100μm, an in-plane retardation value (Rin) of 90nm, and a thickness retardation value (Rth) of -150nm, with the C film 11, which has a thickness retardation value (Rth) of 150nm. When this phase retardation film and the polarizing plates 1 and 2 were applied to an IPS-LCD, the simulated minimum contrast ratios of a tilt angle of 75° to all azimuthal angles in the IPS-LCD were 25:1~30:1.

[0054] FIG. 14B illustrates contrast characteristics of tilt angles of 0-80° to all azimuthal angles under the above conditions.

[0055] Below Table 4 states simulated results showing viewable angle characteristics at a tilt angle of 75° according to retardation values of the internal protective film and the phase retardation film in the structure of the IPS-LCD of the fourth embodiment.

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Table 4

Internal protective film of 1 st polarizing plate	IPS-LCD	Retardation value of B film	Retardation value of C film	Internal protective film of 2 nd polarizing plate	Minimum contrast ratio
TAC film having thickness of 50μm	330n	Rin=90nm, Rth=-150nm	Rth=150nm	B film + C film (+ zero TAC film)	25:1
		Rin=110nm, Rth=-150nm	Rth=100nm		
Zero COP or zero TAC film		Rin=110nm, Rth=-150nm	Rth=140nm		30:1
		Rin=110nm, Rth=-120nm	Rth=120nm		
		Rin=90nm, Rth=-150nm	Rth=140nm		
		Rin=90nm, Rth=-150nm	Rth=150nm		

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(Fifth Embodiment)

[0056] In the IPS-LCD of the fifth embodiment, as shown in FIG. 8, the biaxial film 17 was made of stretched COP, which has an in-plane retardation value (Rin) of 90nm and a thickness retardation value (Rth(550nm)) of -75nm. The internal protective film of the first polarizing plate 1 was a zero COP film or a zero TAC film. An A film 13, which has a thickness of 100μm and in-plane retardation value (Rin) of 70nm, is inserted between the first polarizing plate 1 and IPS panel 3. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the upper surface the biaxial film 17 with the C film 11, which has a thickness retardation value (Rth) of 110. When the above obtained phase retardation film and the polarizing plates 1 and 2 were applied to an IPS-LCD, the simulated minimum contrast ratios of a tilt angle of 75 to all azimuthal angles in the IPS-LCD were 48:1~52:1. After the upper surface of the biaxial film 17 is coated with the C film 11, a film made of zero TAC without a retardation value may be additionally stacked thereon.

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[0057] FIG. 15A illustrates contrast characteristics of tilt angles of 0-80° to all azimuthal angles under the above conditions.

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[0058] Below Table 5 states simulated results showing viewable angle characteristics at a tilt angle of 75° according to retardation values of the internal protective film and the phase retardation film in the structure of the IPS-LCD of the fifth embodiment.

Table 5

Internal protective film of 1 st polarizing plate	Retardation value of A	IPS-LCD	Retardation value of B film	Retardation value of C film	Internal protective film of 2 nd polarizing plate	Minimum contrast ratio
	Film(1 st polarizing plate side)			C film	film of 2 nd polarizing plate	ratio

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(continued)

	Internal protective	Retardation value of A	IPS-LCD	Retardation value of B film	Retardation value of	Internal protective	Minimum contrast
5	TAC film having thickness of 50 μ m	Rin=100nm	330nm	Rin=70nm, Rth=-90nm	Rth=80nm	B film + C film (+ zero TAC film)	48:1
10		Rin=90nm		Rin=70nm, Rth=-90nm	Rth=100nm		
		Rin=120nm		Rin=90nm, Rth=-90nm	Rth=80nm		
15		Rin=100nm		Rin=90nm, Rth=-90nm	Rth=90nm		
		Rin=70nm		Rin=90nm, Rth=-90nm	Rth=11nm		
20		Rin=150nm		Rin=110nm, Rth=-90nm	Rth=55nm		
		Rin=100nm		Rin=110nm, Rth=-90nm	Rth=70nm		
25		Rin=230nm		Rin=110nm, Rth=-90nm	Rth=130nm		
	Zero COP or zero TAC film	Rin=90nm	Rin=110nm, Rth=-90nm	Rth=125nm	52:1		
30		Rin=70nm	Rin=110nm, Rth=-90nm	Rth=100nm			
		Rin=80nm	Rin=110nm, Rth=-90nm	Rth=70nm			
35		Rin=50nm	Rin=90nm, Rth=-90nm	Rth=132nm			
		Rin=50nm	Rin=90nm, Rth=-90nm	Rth=110nm			
40		Rin=40nm	Rin=70nm, Rth=-90nm	Rth=90nm			
		Rin=70nm	Rin=90nm, Rth=-75nm	Rth=11nm			

(Sixth Embodiment)

45 [0059] In the IPS-LCD of the sixth embodiment, as shown in FIG. 9, the uniaxial A film 12 adjacent to the first polarizing plate 1 was made of stretched COP, which has an in-plane retardation value (Rin) of 160nm, and the uniaxial A film 14 adjacent to the second polarizing plate 2 was made of stretched COP, which has an in-plane retardation value (Rin) of 130nm. The internal protective film of the first polarizing plate 1 was a TAC film, which has a thickness of 50 μ m and a thickness retardation value (Rth) of -32nm. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the upper surface of the uniaxial A film 14 with the C film 11, which has a thickness retardation value (Rth) of 110nm. When the above phase retardation film and the polarizing plates 1 and 2 were applied to an IPS-LCD, the simulated minimum contrast ratios of a tilt angle of 75° to all azimuthal angles in the IPS-LCD were 45:1~55:1. A film made of zero TAC without a retardation value may be additionally stacked on the second polarizing plate 2.

50 [0060] FIG. 15B illustrates contrast characteristics of tilt angles of 0-80° to all azimuthal angles under the above conditions.

55 [0061] Below Table 6 states simulated results showing viewable angle characteristics at a tilt angle of 75° according

to retardation values of the internal protective film and the phase retardation film in the structure of the IPS-LCD of the sixth embodiment.

Table 6

Internal protective film of 1 st polarizing plate	Retardation value of A A1T(1 st polarizing plate side)	IPS-LCD	Retardation value of A film	Retardation value of C film	Internal protective film of 2 nd polarizing plate	Minimum contrast ratio
TAC film having thickness of 50 μ m	Rin=100nm	330nm	Rin=110nm	Rth=66nm	A film + C film (+ zero TAC film)	45:1
	Rin=80nm		Rin=120nm	Rth=55nm		
	Rin=160nm		Rin=130nm	Rth=100nm		
	Rin=160nm		Rin=140nm	Rth=88nm		
	Rin=100nm		Rin=90nm	Rth=77nm		
	Rin=160nm		Rin=130nm	Rth=110nm		
Zero COP or zero TAC film	Rin=50nm		Rin=110nm	Rth=88nm		55:1
	Rin=100nm		Rin=130nm	Rth=100nm		
	Rin=200nm		Rin=150nm	Rth=100nm		

(Seventh Embodiment)

[0062] In the IPS-LCD of the seventh embodiment, as shown in FIG. 10, the uniaxial A film 12 adjacent to the first polarizing plate 1 was made of stretched COP, which has an in-plane retardation value (Rin) of 160nm, and the uniaxial A film 14 adjacent to the second polarizing plate 2 was made of stretched COP, which has an in-plane retardation value (Rin(550nm)) of 130nm. The internal protective film of the first polarizing plate 1 was a TAC film, which has a thickness of 50 μ m and a thickness retardation value (Rth) of -32nm. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the upper surface of the uniaxial A film 14 with the C film 11, which has a thickness retardation value (Rth) of 110nm.

[0063] When the above obtained phase retardation film and the polarizing plates 1 and 2 were applied to an IPS-LCD, the simulated minimum contrast ratios of a tilt angle of 75° to all azimuthal angles in the IPS-LCD were 40:1~48:1. A film made of zero TAC without a retardation value may be additionally stacked on the second polarizing plate 2.

[0064] FIG. 16A illustrates contrast characteristics of tilt angles of 0-80° to all azimuthal angles under the above conditions.

[0065] Below Table 7 states simulated results showing viewable angle characteristics at a tilt angle of 75° according to retardation values of the internal protective film and the phase retardation film in the structure of the IPS-LCD of the seventh embodiment.

Table 7

Internal protective film of 1 st polarizing plate	Retardation value of A film (1 st polarizing plate side)	IPS-LCD	Retardation value of A film	Retardation value of C film	Internal protective film of 2 nd polarizing plate	Minimum contrast ratio
TAC film having thickness of 50μm	Rin=240nm	330nm	Rin=140nm	Rth=110nm	A film + C film (+ zero TAC film)	40:1
	Rin=240nm		Rin=130nm	Rth=120nm		
	Rin=220nm		Rin=120nm	Rth=100nm		
	Rin=200nm		Rin=110nm	Rth=100nm		
	Rin=180nm		Rin=90nm	Rth=100nm		
	Rin=160nm		Rin=130nm	Rth=110nm		
Zero COP or zero TAC film	Rin=30nm		Rin=110nm	Rth=90nm		48:1
	Rin=30nm		Rin=130nm	Rth=110nm		

(Eighth Embodiment)

[0066] In the IPS-LCD of the eighth embodiment, as shown in FIG. 11, the uniaxial A film 12 adjacent to the first polarizing plate 1 was made of stretched COP, which has an in-plane retardation value (Rin(550nm)) of 150nm, and the uniaxial A film 14 adjacent to the second polarizing plate 2 was made of stretched COP, which has an in-plane retardation value (Rin(550nm)) of 150nm. The internal protective film of the first polarizing plate 1 was a zero COP film or a zero TAC film. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the uniaxial A film 14 with the C film 11 having thickness retardation value of 110nm. When the above obtained phase retardation film and the polarizing plates 1 and 2 were applied to an IPS-LCD, the simulated minimum contrast ratios of a tilt angle of 75 to all azimuthal angles in the IPS-LCD were 32:1~38:1.

[0067] FIG. 16B illustrates contrast characteristics of tilt angles of 0-80° to all azimuthal angles under the above conditions.

[0068] Below Table 8 states simulated results showing viewable angle characteristics at a tilt angle of 75° according to retardation values of the internal protective film and the phase retardation film in the structure of the IPS-LCD of the eighth embodiment.

Table 8

Internal protective film of 1 st polarizing plate	Retardation value of A film (1 st polarizing plate side)	IPS-LCD	Retardation value of C film	Retardation value of A film	Internal protective film of 2 nd polarizing plate	Minimum contrast ratio
Zero COP or zero TAC film	Rin=160nm	330nm	Rth=90nm	Rin=150nm	A film + C film (+zero TAC)	38:1
	Rin=150nm		Rth=110nm	Rin=150nm		
TAC film having thickness of 50μm	Rin)=80nm			Rth=100nm		Rin=120nm

(Ninth Embodiment)

[0069] In the IPS-LCD of the ninth embodiment, as shown in FIG. 12, the uniaxial A film 12 adjacent to the first polarizing plate 1 was made of stretched COP, which has an in-plane retardation value (Rin(550nm)) of 140nm and the uniaxial A film 14 adjacent to the second polarizing plate 2 was made of stretched COP, which has an in-plane retardation value (Rin(550nm)) of 110nm. The internal protective film of the first polarizing plate 1 was a TAC film, which has a thickness of 50μm and a thickness retardation value (Rth) of -32nm. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the uniaxial A film 14 with the C film 11 having thickness

retardation value of 100nm When the above obtained phase retardation film and the polarizing plates 1 and 2 were applied to an IPS-LCD, the simulated minimum contrast ratios of a tilt angle of 75° to all azimuthal angles in the IPS-LCD were 25:1~30:1

[0070] FIG. 16C illustrates contrast characteristics of tilt angles of 0-80° to all azimuthal angles under the above conditions.

[0071] Below Table 9 states simulated results showing viewable angle characteristics at a tilt angle of 75° according to retardation values of the internal protective film and the phase retardation film in the structure of the IPS-LCD of the ninth embodiment.

Table 9

Internal protective film of 1 st polarizing plate	Retardation value of A film (1 st polarizing plate side)	IPS-LCD	Retardation value of C film	Retardation value of A film	Internal protective film of 2 nd polarizing plate	Minimum contrast ratio
Zero COP or Zero TAC film	Rin=350nm	330nm	Rth=115nm	Rin=140nm	A film + C film	30:1
	Rin=120nm		Rth=130nm	Rin=150nm		
TAC having thickness of 50μm	Rin=180nm		Rth=160nm	Rin=150nm		25:1
	Rin=130nm		Rth=130nm	Rin=130nm		
	Rin=110nm		Rth=160nm	Rin=110nm		
	Rin=80nm	Rth=140nm	Rin=90nm			
	Rin=140nm	Rth=100nm	Rin=110nm			

[0072] As described above, all the IPS-LCDs, in which the protective film of a polarizing plate is replaced with a phase retardation film, had a high contrast ratio of more than 25:1. Particularly, the IPS-LCD, which uses a zero TAC film, had a higher contrast ratio than that of the IPS-LCD, which does not use the zero TAC film. In order to confirm the above fact, polarizing plates were manufactured, and contrast characteristics of IPS-LCDs were measured and compared with each other under the conditions in accordance with below embodiments.

[0073] First, IPS-LCDs in accordance with tenth to fourteenth embodiments of the present invention, which use a phase retardation film, obtained by coating a negative biaxial film with a uniaxial C film as the internal protective film of the second polarizing plate, were analyzed.

(Tenth Embodiment)

[0074] The IPS-LCD of the tenth embodiment, as shown in FIG. 17, was manufactured, and contrast characteristics of the IPS-LCD were measured. In the IPS-LCD of the tenth embodiment, the internal protective film of the first polarizing plate 1 was made of zero COP or zero TAC. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the biaxial film 17, which has a thickness of 80μm, an in-plane retardation value (Rin) of 90nm, and a thickness retardation value (Rth) of -75nm, with the C film 11, which has a thickness retardation value (Rth) of 140nm.

(Eleventh Embodiment)

[0075] The IPS-LCD of the eleventh embodiment, as shown in FIG. 18, was manufactured, and contrast characteristics of the IPS-LCD were measured. In the IPS-LCD of the eleventh embodiment, the internal protective film of the first polarizing plate 1 was a thin TAC film, which has a thickness retardation value (Rth) of -30nm. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the biaxial film 17, which has a thickness of 80μm, an in-plane retardation value (Rin) of 90nm and a thickness retardation value, (Rth) of -75nm, with the C film 11, which has a thickness retardation value (Rth) of 140nm.

(Twelfth Embodiment)

[0076] The IPS-LCD of the twelfth embodiment, as shown in FIG. 19, was manufactured, and contrast characteristics

of the IPS-LCD were measured. In the IPS-LCD of the twelfth embodiment, the internal protective film of the first polarizing plate 1 was a general TAC film, which has a thickness retardation value (Rth) of -60nm. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the biaxial film 17, which has a thickness of 80 μ m, an in-plane retardation value (Rin) of 90nm, and a thickness retardation value (Rth) of -750nm, with the C film 11, which has a thickness retardation value (Rth) of 140nm.

(Thirteenth Embodiment)

[0077] The IPS-LCD of the thirteenth embodiment, as shown in FIG. 20, was manufactured, and contrast characteristics of the IPS-LCD were measured. In the IPS-LCD of the thirteenth embodiment, the internal protective film of the first polarizing plate 1 was a zero TAC film, which does not have a retardation value. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the biaxial film 17, which is provided with an optical axis parallel with the absorption axis of the second polarizing plate 2 and has a thickness of 80 μ m, an in-plane retardation value (Rin) of 90nm, and a thickness retardation value (Rth) of -75nm, with the C film 11, which has a thickness retardation value (Rth) of 140nm.

(Fourteenth Embodiment)

[0078] The IPS-LCD of the fourteenth embodiment, as shown in FIG. 21, was manufactured, and contrast characteristics of the IPS-LCD were measured. In the IPS-LCD of the fourteenth embodiment, the internal protective film of the first polarizing plate 1 was a zero TAC film, which does not have a retardation value. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the upper surface of the biaxial film 17, which has a thickness of 80 μ m, an in-plane retardation value (Rin) of 60nm; and a thickness retardation value (Rth) of -170nm, with the C film 11, which has a thickness retardation value (Rth) of 220nm.

(Fifteenth Embodiment)

[0079] The IPS-LCD of the fifteenth embodiment, as shown in FIG. 22, was manufactured, and contrast characteristics of the IPS-LCD were measured. In the IPS-LCD of the fifteenth embodiment, the internal protective film of the first polarizing plate 1 was a zero TAC film, which does not have a retardation value, and the A film 12, which has a thickness of 110 μ m and an in-plane retardation value (Rin) of 100nm, was located between the internal protective film of the first polarizing plate 1 and the IPS-panel 3. The internal protective film of the second polarizing plate 2 was replaced with a phase retardation film obtained by coating the upper surface of the uniaxial A film 14, which has a thickness of 100nm and an in-plane retardation value (Rin) of 130nm, with the C film 11, which has a thickness retardation value (Rth) of 100nm.

[0080] In all the above embodiments, the C film has a thickness of 1~2 μ m.

[0081] FIGS. 23A to 23F illustrate measured results of contrast ratios of the IPS-LCDs, in accordance with the tenth to fifteenth embodiments. The measured values were similar to the above simulated results, and had the tendency similar as the simulated results, although a small difference between the measured values and the simulated results exists.

[0082] FIG. 23A illustrates the measured results of the contrast ratios of the IPS-LCD of the tenth embodiment, which uses the zero TAC film as the protective film of the first polarizing plate. In the IPS-LCD, the region having the highest contrast ratio is distributed throughout the Poincare sphere. Accordingly, the IPS-LCD exhibited high contrast ratios at all viewable angles.

[0083] FIG. 23B illustrates the measured results of the contrast ratios of the IPS-LCD of the eleventh embodiment, which uses the same polarizing plates as those of the IPS-LCD of the tenth embodiment except for the thin TAC film having a thickness retardation value (Rth) of -30nm used as the protective film of the first polarizing plate. The IPS-LCD generally exhibited high contrast ratios, but low contrast ratios of less than 20:1 in some regions at azimuthal angles of 240 and 340°. Accordingly, the IPS-LCD of the eleventh embodiment exhibited comparatively high contrast ratios, although the contrast ratios of the IPS-LCD of the eleventh embodiment are not satisfactory compared to the IPS-LCD of the tenth embodiment.

[0084] FIG. 23C illustrates the measured results of the contrast ratios of the IPS-LCD of the twelfth embodiment, which uses the same polarizing plates as those of the IPS-LCD of the tenth embodiment except for the general TAC film having a thickness retardation value (Rth) of -60nm used as the protective film of the first polarizing plate. The IPS-LCD had the region exhibiting low contrast ratios, which is broader than that of the IPS-LCD of the eleventh embodiment.

[0085] FIG. 23D illustrates the measured results of the contrast ratios of the IPS-LCD of the thirteenth embodiment, which uses the same conditions as those of the IPS-LCD of the tenth embodiment except that the optical axis of the biaxial film is parallel with the absorption axis of the second polarizing plate. The IPS-LCD of the thirteenth embodiment exhibited low contrast ratios, compared to the IPS-LCDs of other embodiments. Accordingly, it was confirmed that the

dispositional direction of each of the films is an important factor for determining the contrast ratio.

[0086] FIG. 23E illustrates the measured results of the contrast ratios of the IPS-LCD of the fourteenth embodiment, which uses the zero TAC film as the protective film of the first polarizing plate, identically with the IPS-LCD of the tenth embodiment, but uses the biaxial film of the phase retardation film having a thickness retardation value being lower than the value regulated by the present invention, as the internal protective film of the second polarizing plate. The IPS-LCD of the fourteenth embodiment exhibited contrast ratios, which are higher than those of the IPS-LCD of the twelfth embodiment using the general TAC, but are lower than those of the IPS-LCDs of the tenth and eleventh embodiments, which have the most preferable condition. Accordingly, it was confirmed that the control of the retardation values of each of film layers of the phase retardation film is another important factor for determining the contrast ratio.

[0087] FIG. 23F illustrates the measured results of the contrast ratios of the IPS-LCD of the fifteenth embodiment, which uses the A film and the C film as the internal protective film of the second polarizing plate. As shown in FIG. 23F, the IPS-LCD of the fifteen embodiment exhibited high contrast ratios, similarly to the IPS-LCD of the tenth embodiment.

Industrial Applicability

[0088] As apparent from the above description, the present invention provides an in-plane switching liquid crystal display (IPS-LCD), which uses a second phase retardation film exhibiting a broad viewable angle property as a protective film of one polarizing plate. The IPS-LCD of the present invention has a thin profile and a simple structure, and causes the reduction of the production costs thereof.

[0089] The conventional IPS-LCD having upper and lower protective films exhibits a contrast ratio of 10:1~45:1. On the other hand, the IPS-LCD of the present invention exhibits a contrast ratio of 25:1~55:1. Accordingly, the IPS-LCD of the present invention has a simple structure and exhibits a reasonably high contrast ratio.

[0090] Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope of the invention as disclosed in the accompanying claims.

Claims

1. An in-plane switching liquid crystal display (IPS-LCD) comprising a first polarizing plate (1), a second polarizing plate (2), a horizontally oriented IPS panel (3) disposed between the first and second polarizing plates and filled with a liquid crystal having positive dielectric constant anisotropy ($\Delta\epsilon > 0$), a first protective film and a first phase retardation film including an uniaxial A film (12) disposed between the first polarizing plate and the IPS panel, in which an absorption axis (4) of the first polarizing plate and an absorption axis (5) of the second polarizing plate are orthogonal to each other, and an optical axis (6) of the liquid crystal in the IPS panel and the absorption axis of the first polarizing plate are parallel with each other, wherein a second phase retardation film, obtained by coating a biaxial film (17) with a uniaxial C film (11), is disposed between the second polarizing plate and the IPS panel and is used as a second protective film between the IPS panel and the second polarizing plate, **characterized in that** the first phase retardation film including the uniaxial A film has an in-plane retardation value (R_{in}) of 30~450nm, the biaxial film of the second phase retardation film has an in-plane retardation value (R_{in}) of 50~150nm and a thickness retardation value (R_{th}) of -50~-150nm, and the uniaxial C film of the second phase retardation film has a thickness retardation value (R_{th}) of 50~170nm, said retardation values denoting retardation values at a wavelength of 550nm .
2. The IPS-LCD according to claim 1, wherein an optical axis of the first phase retardation film in the direction of the X axis is parallel with the absorption axis of the first polarizing plate.
3. The IPS-LCD according to claim 1, wherein the first protective film is one film selected from the group consisting of a non-stretched zero COP film, a non- stretched zero TAC film, and a TAC film having a thickness of 50 μ m and a thickness retardation value.
4. The IPS-LCD according to claim 3, wherein the first protective film is a non-stretched zero TAC film.
5. The IPS-LCD according to claim 1, wherein the uniaxial A film is made of lengthwise stretched polymer, the biaxial film is made of crosswise stretched polymer, and the uniaxial C film is obtained by coating an orientation film with a liquid crystal and hardening the liquid crystal coated on the orientation film.

Patentansprüche

1. In-Plane-Switching-Flüssigkristallanzeige (IPS-LCD), die eine erste Polarisationsplatte (1), eine zweite Polarisationsplatte (2), ein horizontal ausgerichtetes IPS-Panel (3), das zwischen der ersten und der zweiten Polarisationsplatte angeordnet ist und mit einem Flüssigkristall, der eine positive dielektrische konstante Anisotropie hat, ($\Delta\varepsilon > 0$) gefüllt ist, einen ersten Schutzfilm und einem ersten Phasenverzögerungsfilm umfasst, der einen uniaxialen A-Film (12) einschließt, der zwischen der ersten Polarisationsplatte und dem IPS-Panel angeordnet ist, wobei eine Absorptionsachse (4) der ersten Polarisationsplatte und eine Absorptionsachse (5) der zweiten Polarisationsplatte orthogonal zueinander sind, und wobei eine optische Achse (6) des Flüssigkristalls in dem IPS-Panel und die Absorptionsachse der ersten Polarisationsplatte parallel zueinander sind, wobei ein zweiter Phasenverzögerungsfilm, der durch Beschichten eines biaxialen Films (17) mit einem uniaxialen C-Film (11) erhalten wird, zwischen der zweiten Polarisationsplatte und dem IPS-Panel angeordnet ist und als zweiter Schutzfilm zwischen dem IPS-Panel und der zweiten Polarisationsplatte verwendet wird, **dadurch gekennzeichnet, dass** der erste Phasenverzögerungsfilm, der den uniaxialen A-Film einschließt, einen In-Plane-Verzögerungswert (R_{in}) von 30 ~ 450 nm hat, der biaxiale Film des zweiten Phasenverzögerungsfilms einen In-Plane-Verzögerungswert (R_{in}) von 50 ~ 150 nm und einen Dickenverzögerungswert (R_{th}) von -50 ~ -150 nm hat, und der uniaxiale C-Film des zweiten Phasenverzögerungsfilms einen Dickenverzögerungswert (R_{th}) von 50 ~ 170 nm hat, wobei die Verzögerungswerte Verzögerungswerte bei einer Wellenlänge von 550 nm bezeichnen.
2. IPS-LCD nach Anspruch 1, wobei eine optische Achse des ersten Phasenverzögerungsfilms in der Richtung der X-Achse parallel zu der Absorptionsachse der ersten Polarisationsplatte ist.
3. IPS-LCD nach Anspruch 1, wobei der erste Schutzfilm ein Film ist, der aus der Gruppe ausgewählt ist, die aus einem nicht gestreckten Null-COP-Film, einem nicht gestreckten Null-TAC-Film und einem TAC-Film besteht, der eine Dicke von 50 μm und einen Dickenverzögerungswert hat.
4. IPS-LCD nach Anspruch 3, wobei der erste Schutzfilm ein nicht gestreckter Null-TAC-Film ist.
5. IPS-LCD nach Anspruch 1, wobei der uniaxiale A-Film aus einem in Längsrichtung gestreckten Polymer besteht, der biaxiale Film aus einem kreuzweise gestreckten Polymer besteht, und der uniaxiale C-Film durch Beschichten eines Ausrichtungsfilms mit einem Flüssigkristall und Härten des Flüssigkristalls, der auf dem Ausrichtungsfilm beschichtet ist, erhalten wird.

Revendications

1. Affichage à cristaux liquides à commutation dans le plan (IPS-LCD) comprenant une première plaque de polarisation (1), une deuxième plaque de polarisation (2), un panneau IPS orienté horizontalement (3) disposé entre les première et deuxième plaques de polarisation et rempli d'un cristal liquide ayant une anisotropie à constante diélectrique positive ($\Delta\varepsilon > 0$), un premier film protecteur et un premier film de retard de phase incluant un film uniaxial A (12) disposé entre la première plaque de polarisation et le panneau IPS, dans lequel un axe d'absorption (4) de la première plaque de polarisation et un axe d'absorption (5) de la deuxième plaque de polarisation sont orthogonaux entre eux, et un axe optique (6) du cristal liquide dans le panneau IPS et l'axe d'absorption de la première plaque de polarisation sont parallèles entre eux, dans lequel un deuxième film de retard de phase, obtenu par revêtement d'un film biaxial (17) avec un film uniaxial C (11), est disposé entre la deuxième plaque de polarisation et le panneau IPS et est utilisé comme un deuxième film protecteur entre le panneau IPS et la deuxième plaque de polarisation, **caractérisé en ce que** le premier film de retard de phase incluant le film uniaxial A a une valeur de retard dans le plan (R_{in}) de 30-450 nm, le film biaxial du deuxième film de retard de phase a une valeur de retard dans le plan (R_{in}) de 50 ~ 150 nm et une valeur de retard d'épaisseur (R_{th}) de -50 ~ -150 nm, et le film uniaxial C du deuxième film de retard de phase a une valeur de retard d'épaisseur (R_{th}) de 50-170 nm, lesdites valeurs de retard indiquant des valeurs de retard à une longueur d'onde de 550 nm.
2. IPS-LCD selon la revendication 1, dans lequel un axe optique du premier film de retard de phase dans la direction de l'axe X est parallèle à l'axe d'absorption de la première plaque de polarisation.
3. IPS-LCD selon la revendication 1, dans lequel le premier film protecteur est un film sélectionné dans le groupe constitué d'un film en polymère de cyclooléfine (PCO) à zéro non étiré, d'un film en triacétate de cellulose (TAC) à

EP 1 910 892 B1

zéro non étiré, et d'un film TAC ayant une épaisseur de 50 μm et une valeur de retard d'épaisseur.

4. IPS-LCD selon la revendication 3, dans lequel le premier film protecteur est un film TAC à zéro non étiré.

5 5. IPS-LCD selon la revendication 1, dans lequel le film uniaxial A est fait de polymère étiré longitudinalement, le film biaxial est fait de polymère étiré transversalement, et le film uniaxial C est obtenu par revêtement d'un film d'orientation avec un cristal liquide et par durcissement du cristal liquide appliqué en revêtement sur le film d'orientation.

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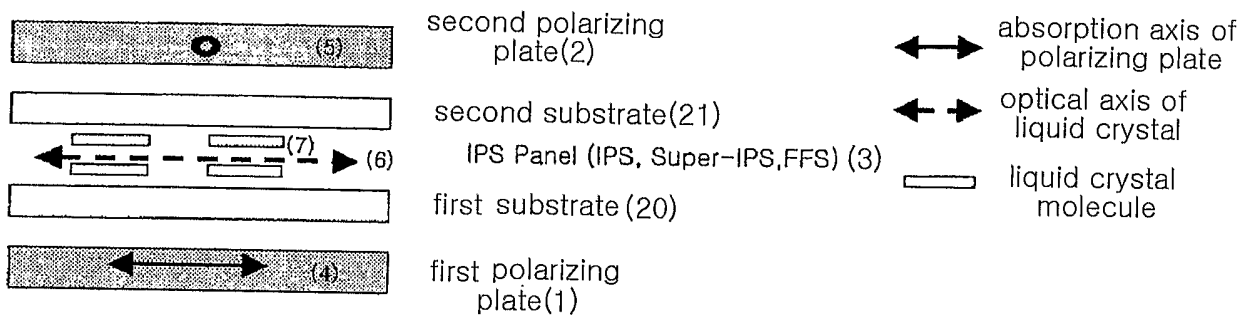


FIG. 1

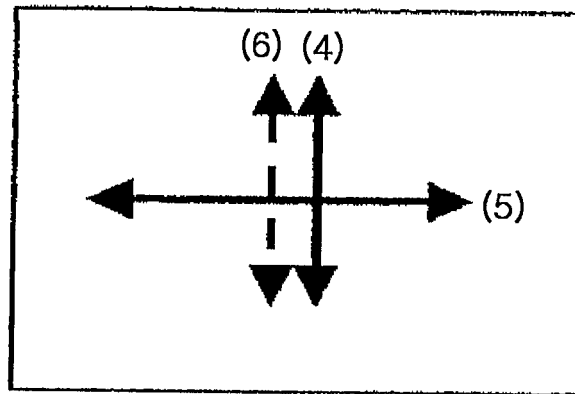


FIG. 2

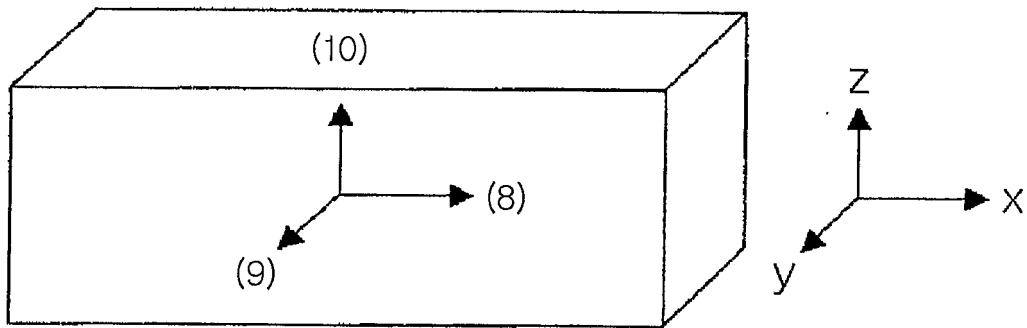


FIG. 3

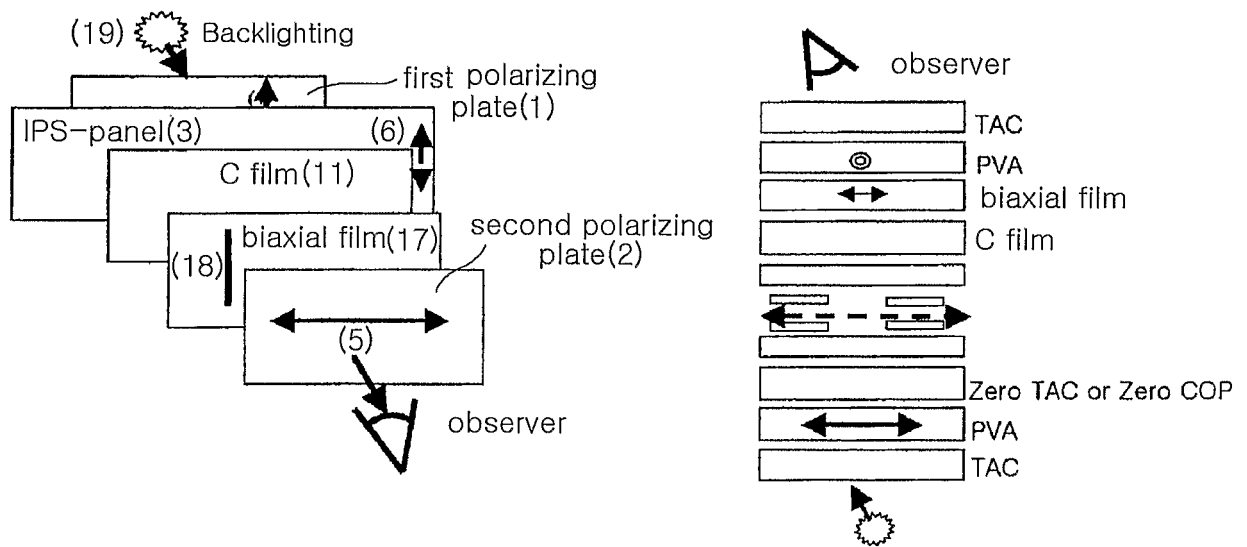


FIG. 4

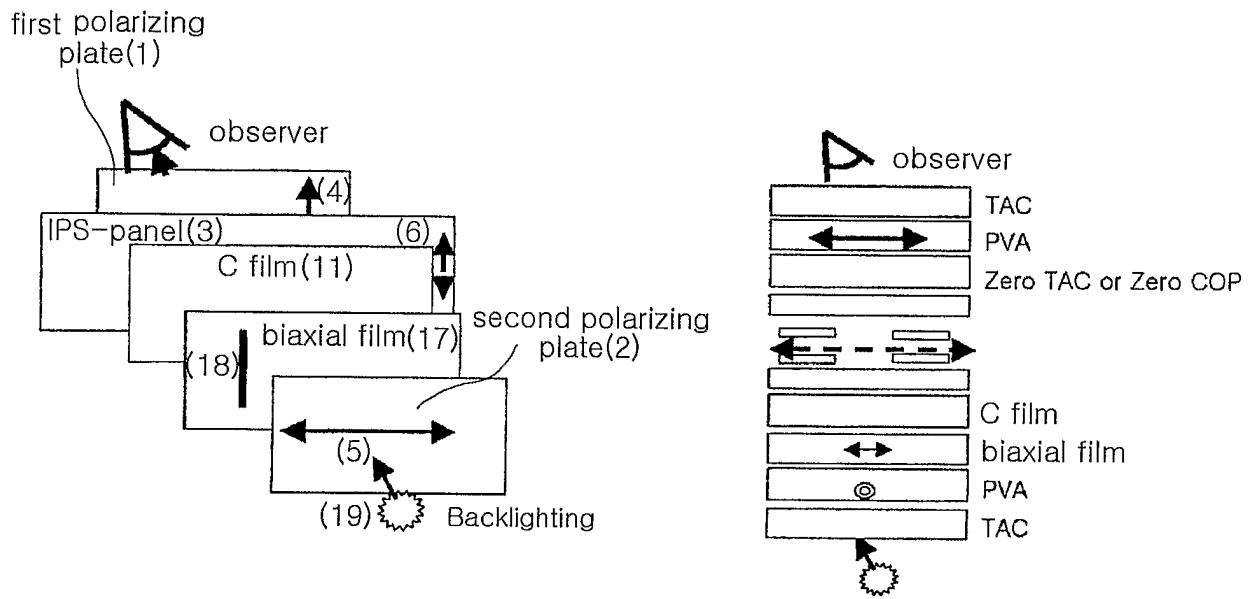


FIG. 5

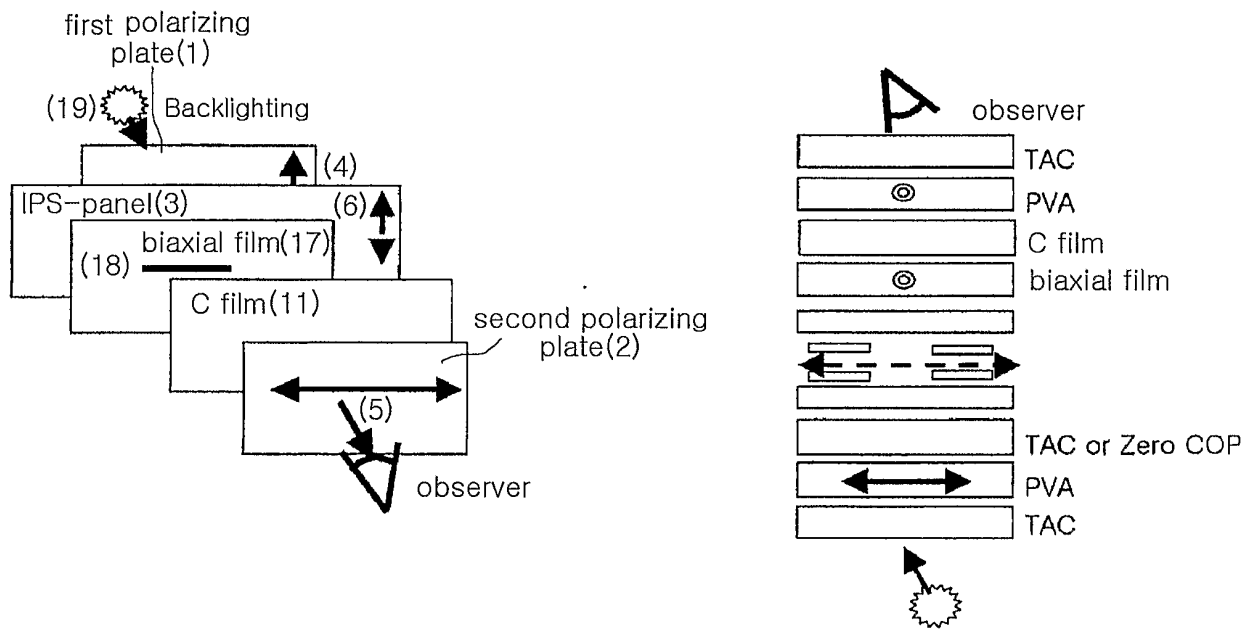


FIG. 6

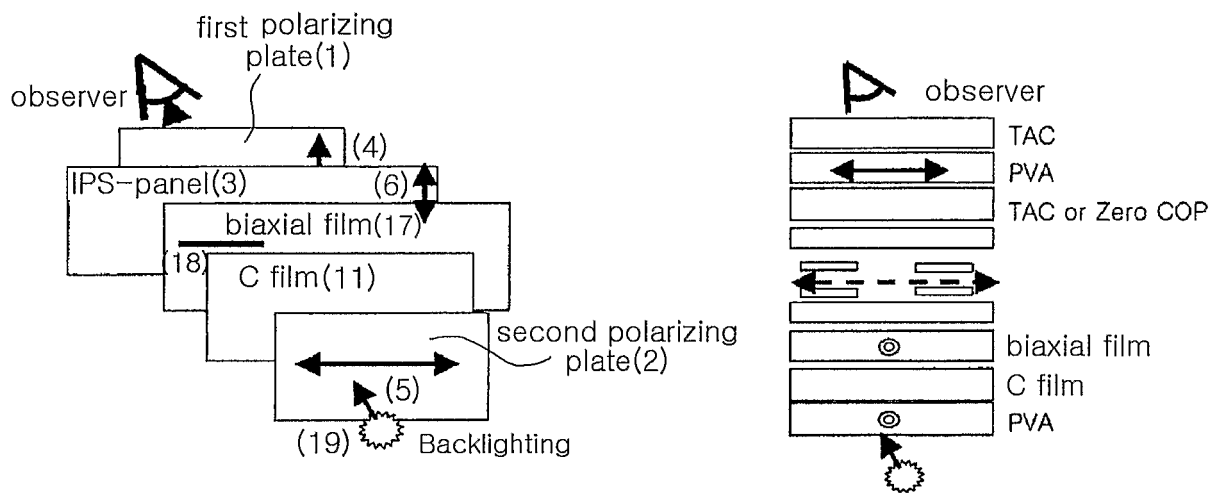


FIG. 7

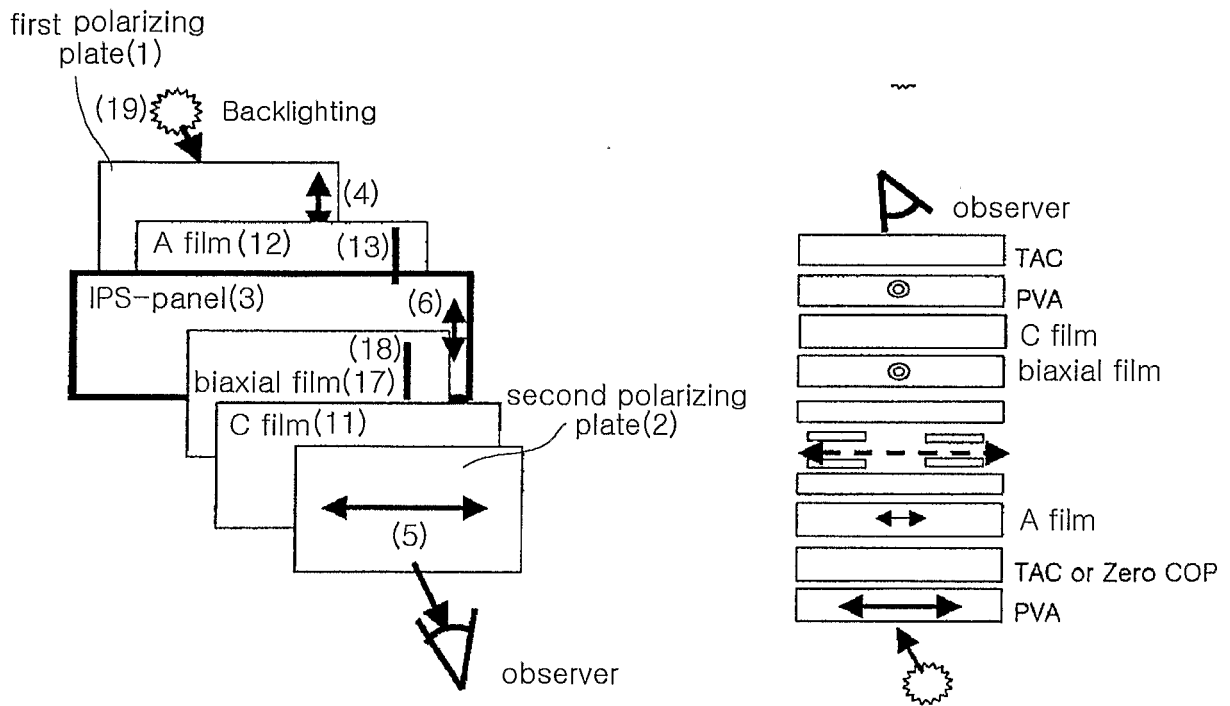


FIG. 8

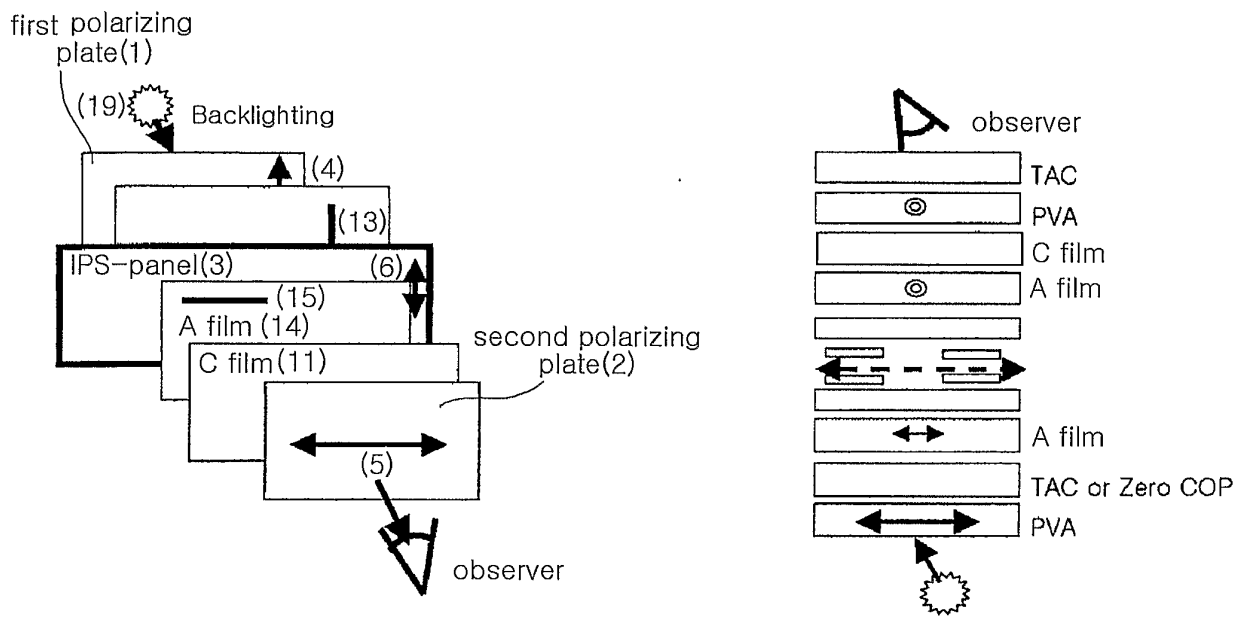


FIG. 9

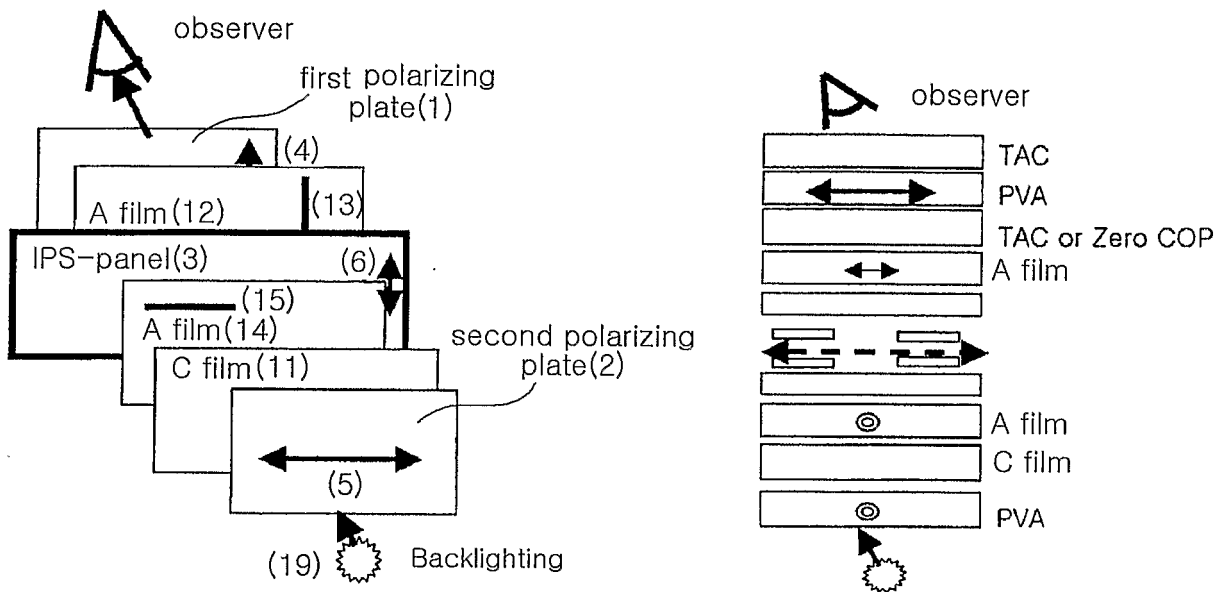


FIG. 10

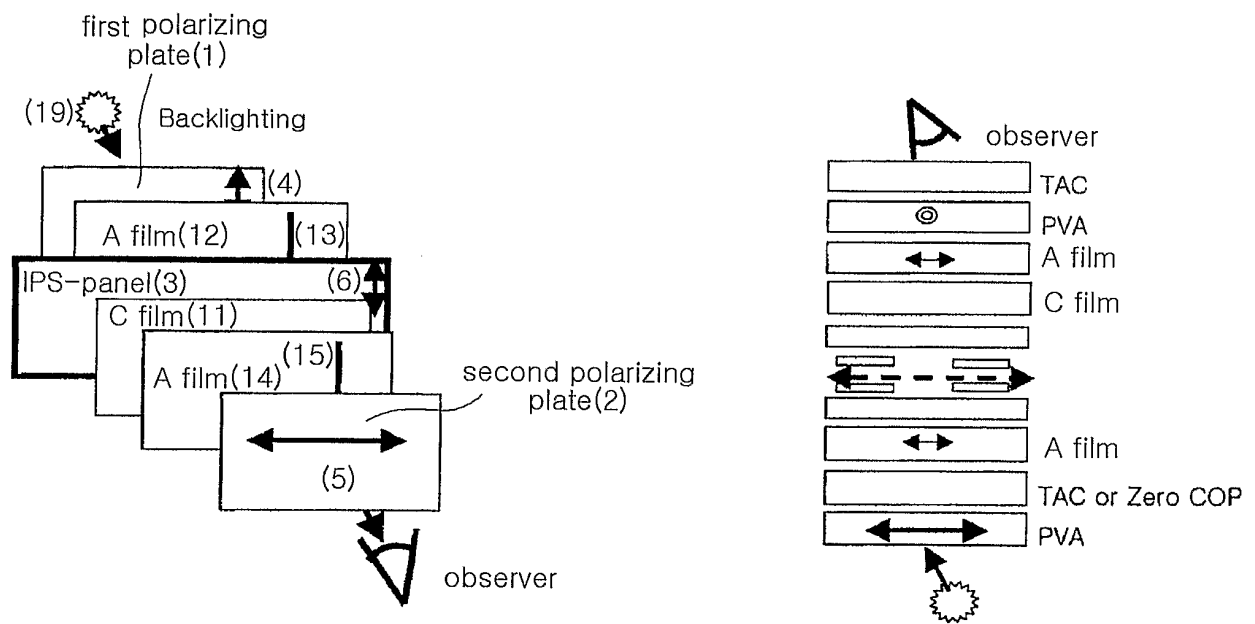


FIG. 11

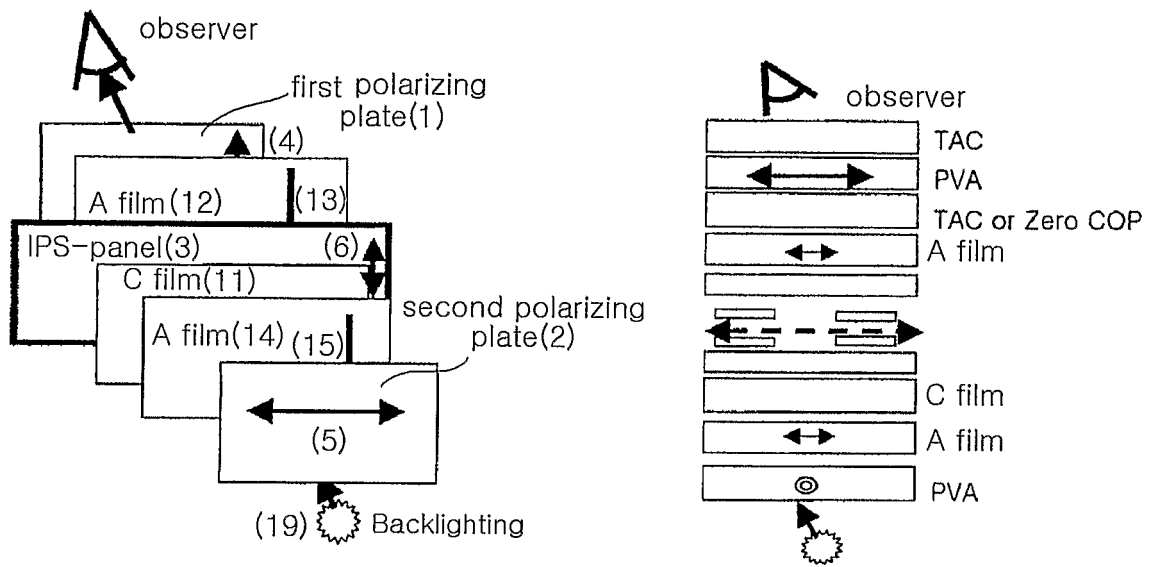
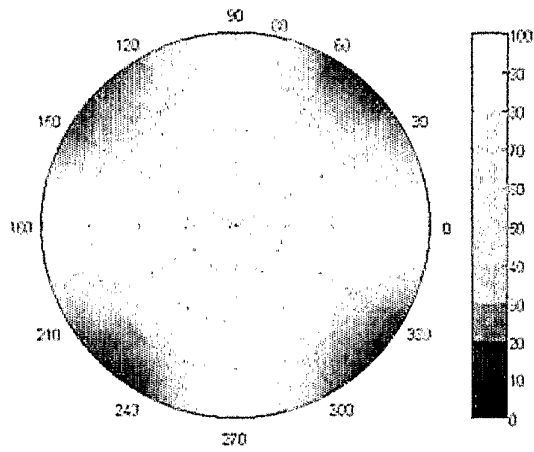


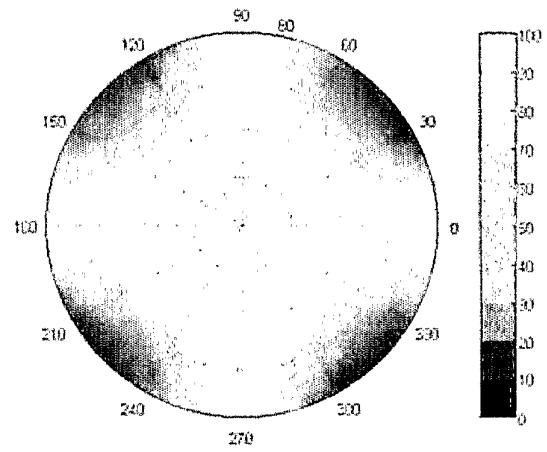
FIG. 12

(a)



viewable angle characteristics of IPS-LCD of first embodiment

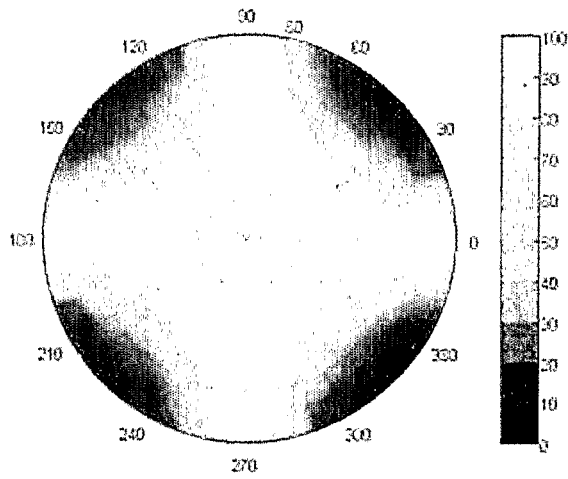
(b)



viewable angle characteristics of IPS-LCD of second embodiment

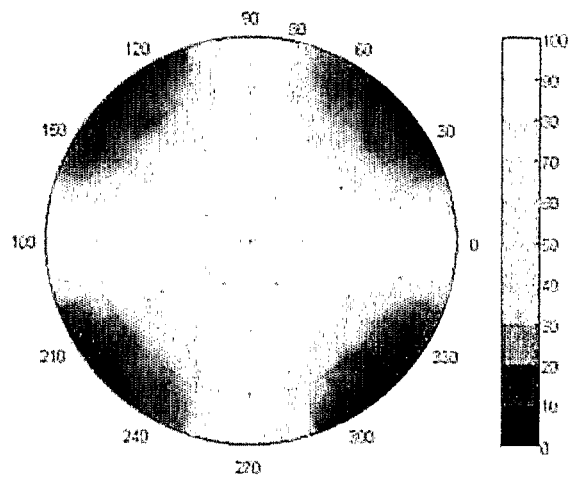
FIG. 13

(a)



viewable angle characteristics of IPS-LCD of third embodiment

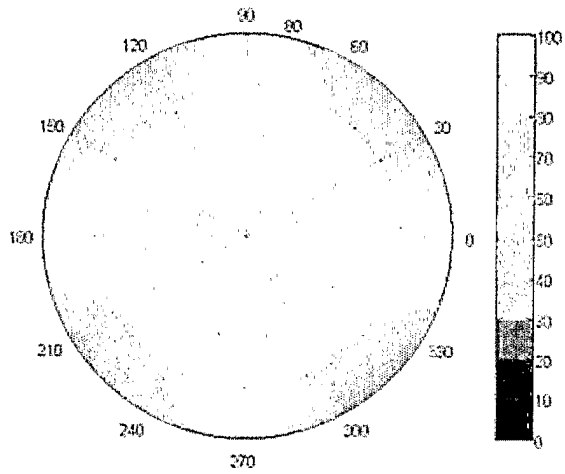
(b)



viewable angle characteristics of IPS-LCD of fourth embodiment

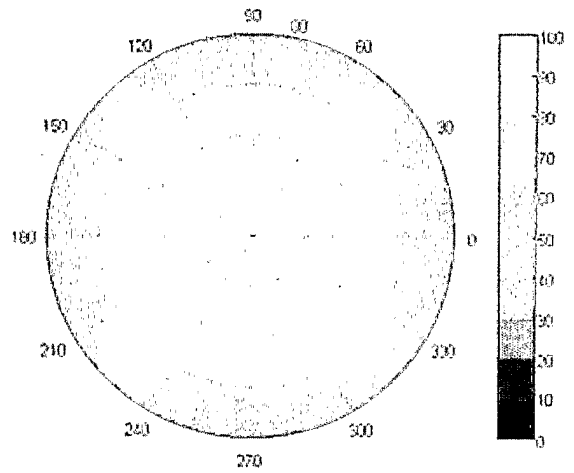
FIG. 14

(a)



viewable angle characteristics of IPS-LCD of fifth embodiment

(b)



viewable angle characteristics of IPS-LCD of sixth embodiment

FIG. 15

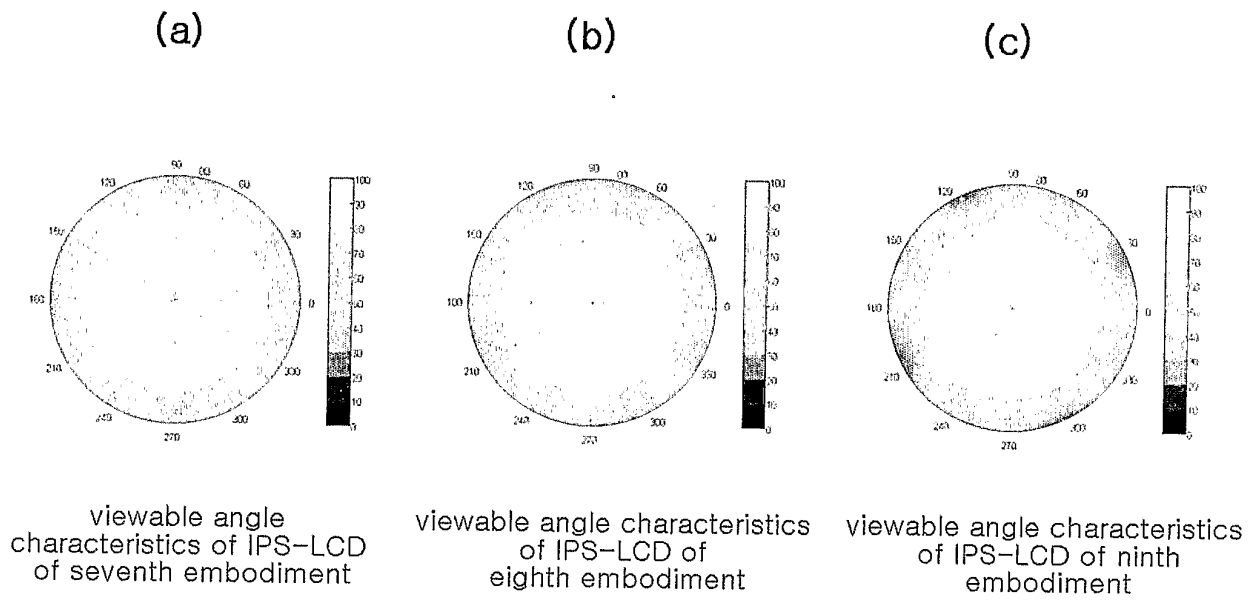


FIG. 16

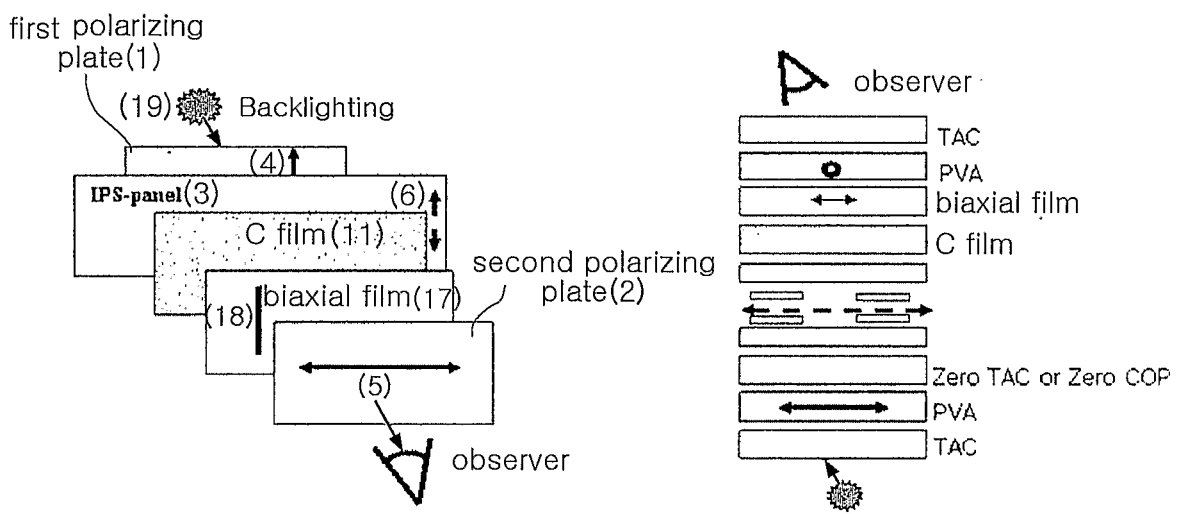


FIG. 17

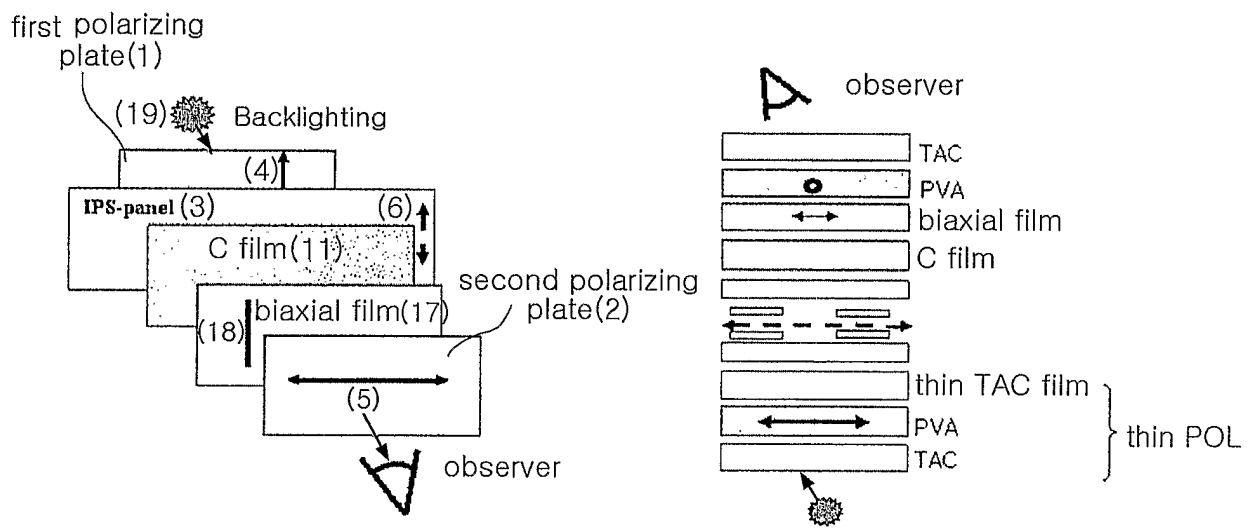


FIG. 18

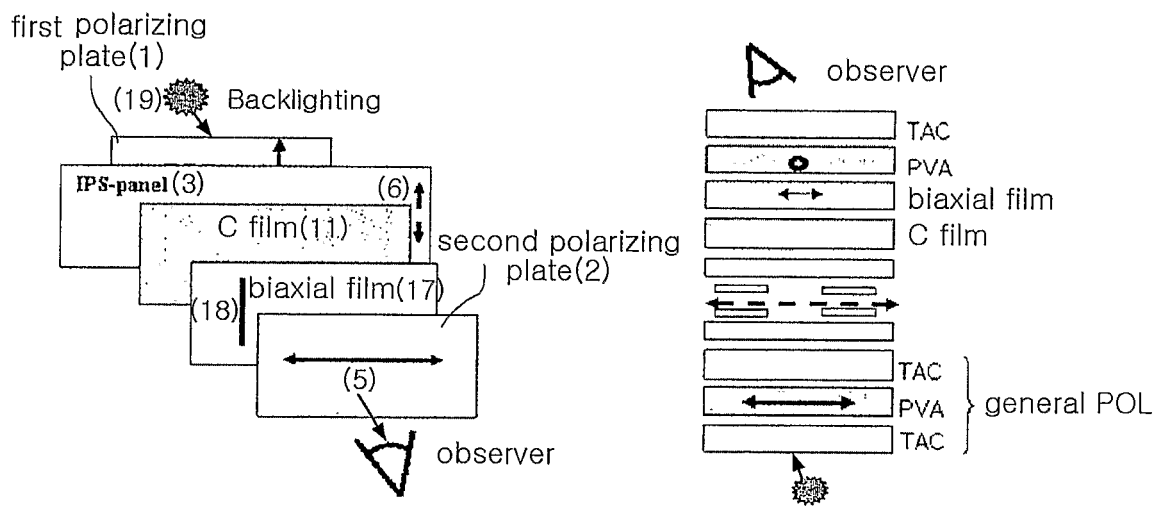


FIG. 19

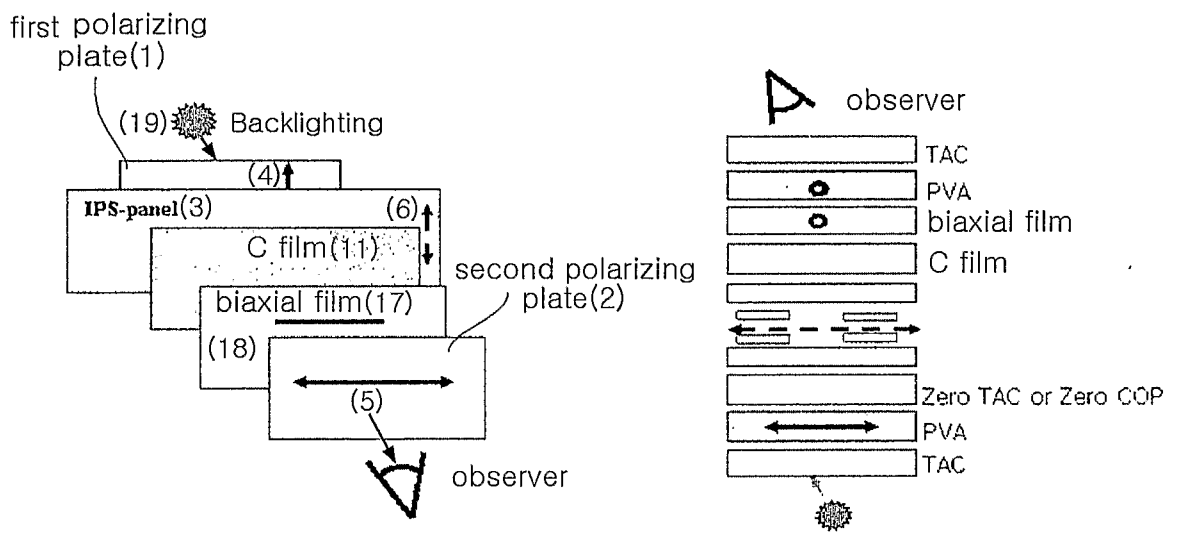


FIG. 20

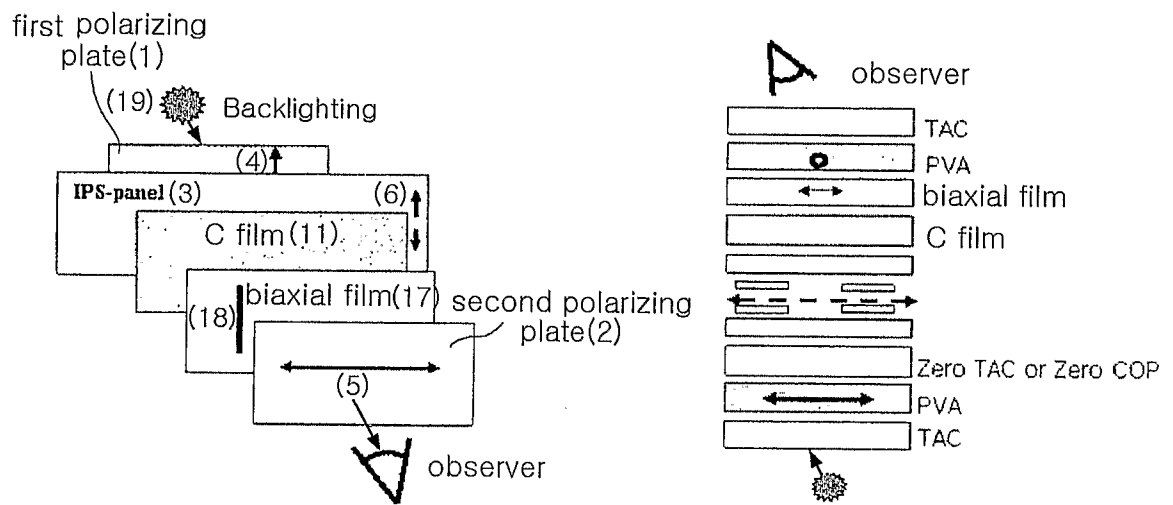


FIG. 21

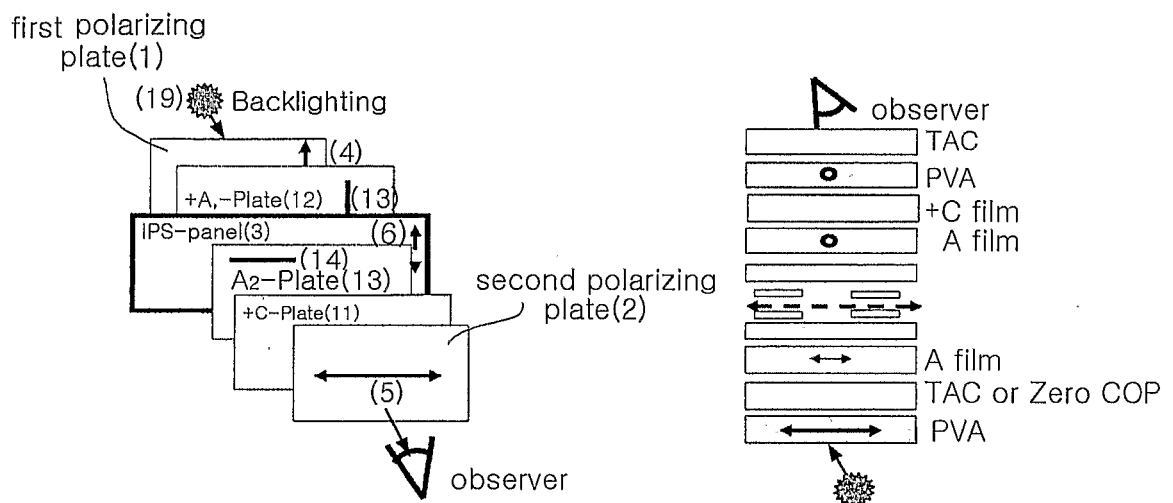


FIG. 22

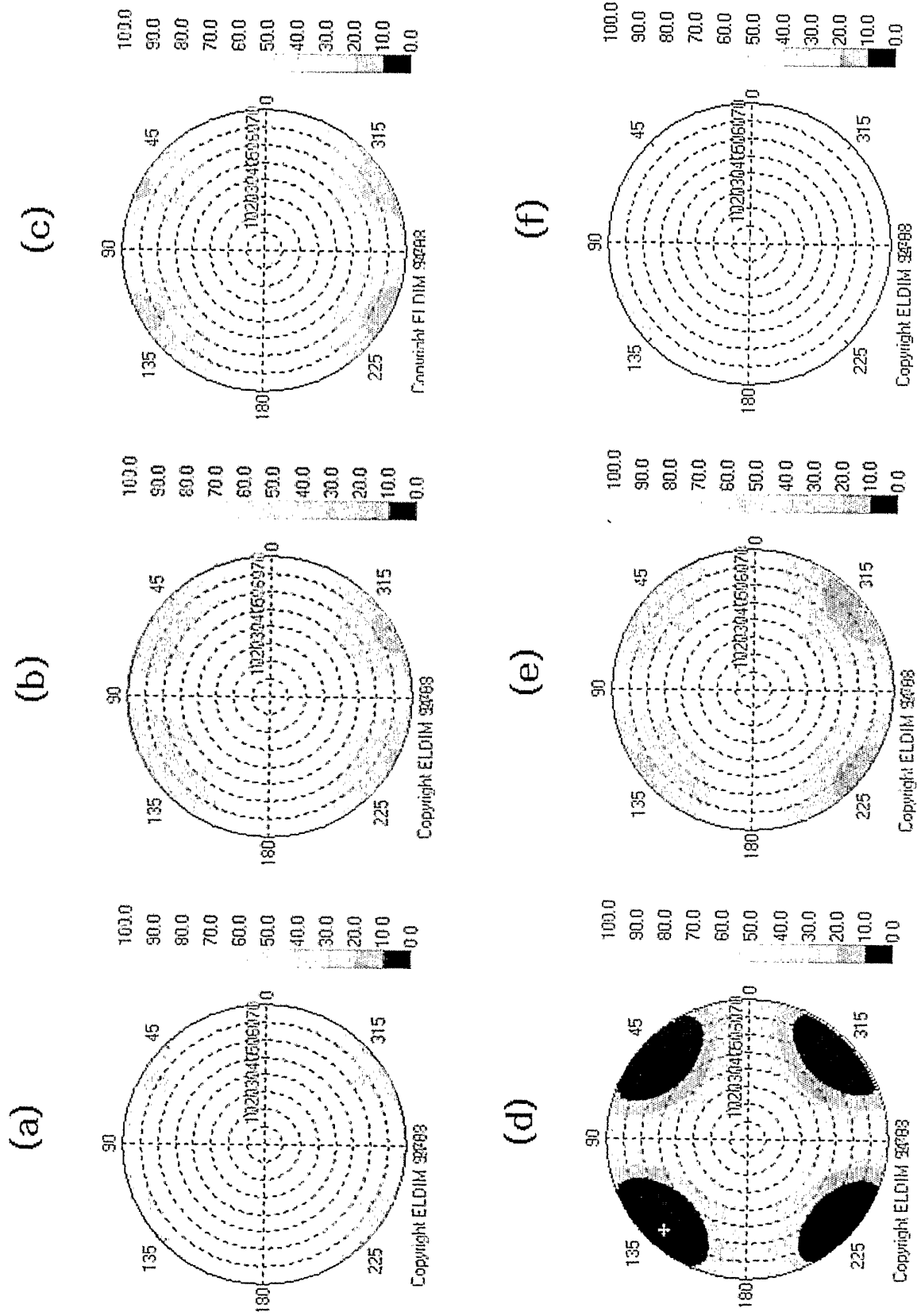


FIG. 23

REFERENCES CITED IN THE DESCRIPTION

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- WO 2005038517 A1 [0013]

Non-patent literature cited in the description

- **JOUN-HO LEE 1 et al.** P-92:Optical Configurations of TW-IPS LC Cell for Very Wide Viewing Angle in Large Size TV Application. *2005 SID INTERNATIONAL SYMPOSIUM*, 24 May 2005, vol. XXXVI, 642-645 [0001]

专利名称(译)	面内切换液晶显示器结构简单		
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申请号	EP2006783446	申请日	2006-07-28
[标]申请(专利权)人(译)	乐金化学股份有限公司		
申请(专利权)人(译)	LG化学有限公司.		
当前申请(专利权)人(译)	LG化学有限公司.		
[标]发明人	CHANG JUN WON JEON BYOUNG KUN JANG SOO JIN		
发明人	CHANG, JUN-WON JEON, BYOUNG-KUN JANG, SOO-JIN		
IPC分类号	G02F1/1335		
CPC分类号	G02F1/13363 G02F1/134363 G02F2001/133635 G02F2413/03		
优先权	1020050069278 2005-07-29 KR		
其他公开文献	EP1910892A1 EP1910892A4		
外部链接	Espacenet		

摘要(译)

IPS-LCD，其中光轴的方向和延迟值根据替换一个保护膜的相位延迟膜的布置来调整，获得类似于具有上保护膜和下保护膜的IPS-LCD的对比度，并且厚度很小。IPS-LCD包括第一和第二偏振板（1,2），IPS面板（3）和第一保护膜。第一和第二偏振板（1,2）的吸收轴（4,5）彼此正交，并且IPS面板（3）中的液晶的光轴和吸收轴（4）平行于彼此。通过用双轴C膜（11）涂覆双轴膜（17）获得的第二相位延迟膜设置在第二偏振板（2）和IPS板（3）之间，并用作第二保护膜。

[Equation 1]

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