(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 685 441 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
03.10.2018 Bulletin 2018/40

(21) Application number: **04819017.7**

(22) Date of filing: **17.11.2004**

(51) Int Cl.:
G02F 1/1343 $^{(2006.01)}$ ***G02F 1/13363*** $^{(2006.01)}$

(86) International application number:
PCT/KR2004/002971

(87) International publication number:
WO 2005/050302 (02.06.2005 Gazette 2005/22)

(54) IN-PLANE SWITCHING LIQUID CRYSTAL DISLPAY COMPRISING COMPENSATION FILM FOR ANGULAR FIELD OF VIEW USING POSITIVE BIAXIAL RETARDATION FILM

IN-PLANE-WECHSELFLÜSSIGANZEIGE MIT KOMPENSATIONSFILM FÜR EIN ABGEWINKELTES SICHTFELD UNTER VERWENDUNG EINES POSITIV-BIAXIALRETARDIERUNGSFILMS

AFFICHAGE A CRISTAUX LIQUIDES DE COMMUTATION DANS LE PLAN COMPRENANT UN FILM DE COMPENSATION POUR UN CHAMP ANGULAIRE DE VISUALISATION FAISANT APPEL A UN FILM DE RETARD BIAXIAL POSITIF

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LU MC NL PL PT RO SE SI SK TR

(30) Priority: **21.11.2003 KR 2003083023**

(43) Date of publication of application:
02.08.2006 Bulletin 2006/31

(60) Divisional application:
14166307.0 / 2 762 966
14166311.2 / 2 762 962
16195465.6 / 3 153 920

(73) Proprietor: **LG Chem, Ltd.**
Seoul 07336 (KR)

(72) Inventors:
- **JEON, Byoung-Kun,**
  203,LG Chemical Shinyeolrip Apt
  Daejeon 305-340 (KR)
- **BELYAEV, Sergey,**
  6-201, LG Chemical Apartment
  Daejeon 305-340 (KR)
- **YU, Jeong-Su,**
  107-1501, Hanwool Apartment
  Daejeon 305-707 (KR)
- **MALIMONENKO, Nikolay,**
  6-203, LG Chemical Apartment
  Daejeon 305-340 (KR)

(74) Representative: **Prinz & Partner mbB**
Patent- und Rechtsanwälte
Rundfunkplatz 2
80335 München (DE)

(56) References cited:
EP-A- 1 489 437
EP-A- 1 553 432
EP-A- 1 586 939
US-A- 2003 210 370
US-A1- 2002 080 310
US-B1- 6 285 430
US-B1- 6 512 561

Printed by Jouve, 75001 PARIS (FR)

Description

Technical Field

[0001] The present invention relates to a liquid crystal display (LCD), and more particularly to an in-plane switching liquid crystal display (IPS-LCD) including a compensation film, which uses a positive biaxial retardation film while adjusting an optical axis direction and a retardation value of the positive biaxial retardation film in order to improve a viewing angle characteristic of the in-plane switching liquid crystal display having a liquid crystal cell filled with liquid crystal of positive dielectric anisotropy ($\Delta\varepsilon>0$) or negative dielectric anisotropy ($\Delta\varepsilon<0$).

Background Art

[0002] Electrodes of an IPS-LCD are aligned in such a manner that an electric field is applied in parallel to a liquid crystal plane of the IPS-LCD. Surfaces of a liquid crystal layer adjacent to two substrates have pretilt angles in a range of 0° to 5° as disclosed in U.S. Patent No. 6,078,375. An IPS panel (liquid crystal cell) has an active matrix drive electrode comprising a pair of electrodes aligned in the same plane. In addition, the active matrix drive electrode provides IPS (In-Plain Switching), S-IPS (Super-In-Plain Switching) and FFS (Fringe Field Switching) modes to a liquid crystal layer formed between two glass substrates. According to the S-IPS mode, a two-domain liquid crystal alignment can be obtained by forming a zig-zag type electrode pattern, so an IPS color shift in a white state(Bright State) may be minimized.

[0003] The IPS-LCD is disclosed in U.S. Patent No. 3,807,831. However, the IPS-LCD disclosed in U.S. Patent No. 3,807,831 does not use a compensation film. Accordingly, the IPS-LCD represents a low contrast ratio at a predetermined inclination angle due to a relatively great amount of light leakage.

[0004] U.S. Patent No. 5,189,538 discloses an LCD including two kinds of retardation films, such as a +A-plate and a positive biaxial retardation film, but it does not disclose information or technologies about the IPS-LCD.

[0005] U.S. Patent No. 5,440,413 discloses a TN-LCD having two positive biaxial retardation films in order to improve the contrast characteristic and color characteristic of the TN-LCD at a predetermined inclination angle.

[0006] An IPS-LCD compensation film using one positive biaxial retardation film is disclosed in U.S. Patent No. 6,285,430. Characteristics of the IPS-LCD are as follows:

- One positive biaxial retardation film is aligned between a polarizer plate and a liquid crystal layer.
- An in-plane retardation value of the biaxial retardation film is about 190nm to 390nm.
- An in-plane retardation value of the biaxial retardation film increases in proportional to an absolute value of a retardation in a direction of thickness of a polarizer plate protection film.

[0007] EP 1 553 432 A1 is a post-published document and discloses an optical film for a liquid crystal display obtained by laminating a polarizing plate and a retardation film so that an absorption axis of the polarizing plate and a slow axis of the retardation film are perpendicular or parallel to each other. The polarizing plate comprises a transparent protective film on both surfaces of the polarizer.

[0008] EP 1 586 939 A1 is a post-published document and is directed to a liquid crystal display device comprising a pair of polarization plates each including a polarizer and a pair of protective layers laminated over the polarizer, wherein the protective layers perform as a negative retardation film, and wherein a biaxial retardation film is disposed between the liquid crystal plane and anyone of the polarization plates for compensating the dependence upon the viewing angle for incident light forming an angle with the viewing-angular direction.

[0009] EP 1 489 437 A1 is also a post-published document and is directed to a laminated optical film for laminating with polarizing plates to be used as an elliptically polarizing plate.

[0010] US2003/0122991 A1 discloses the preamble of claim 1.

[0011] A main object of using the biaxial retardation film is to improve a contrast characteristic of the IPS-LCD at an inclination angle in all azimuthal angles, especially 45°, 135°, 225° and 315°. Although the contrast characteristic of the IPS-LCD can be improved at the above azimuthal angles, the IPS-LCD in a black state represents a great amount of light leakage at other azimuthal angles. For this reason, a contrast ratio of the IPS-LCD is relatively reduced at other azimuthal angles. Therefore, the above IPS-LCD has a disadvantage in that the IPS-LCD represents a relatively low contrast ratio at specific azimuthal angles due to relatively great light leakage in the black state.

Brief Description of the Drawings

[0012]

FIG. 1 is a view illustrating a basic structure of an IPS-LCD.

FIG. 2 is a view illustrating an alignment of an absorption axis of a polarizer plate and an optical axis of liquid crystal in IPS-LCD panel of Fig. 1.

FIG. 3 is a view illustrating a refractive index of a retardation film.

FIGS. 4a and 4b are views illustrating a structure of a IPS-LCD including a viewing angle compensation film according to one embodiment of the present invention.

FIGS. 5 and 6 are graphs representing simulation results for a contrast characteristic at inclination angles of about 0° to 80° in all azimuthal angles when a white light is used in an IPS-LCD structure including a viewing angle compensation film according to one embodiment of the present invention, in which FIG. 5 is a simulation result of an IPS-LCD structure, and FIG. 6 is a simulation result of an IPS-LCD structure.

Disclosure of the Invention

[0013] It is an object of the present invention to provide an IPS-LCD capable of obtaining a high contrast characteristic at all inclination angles in all azimuthal angles as well as at a front position.

[0014] Another object of the present invention is to provide an IPS-LCD representing low transmittance in a black state at all inclination angles in all azimuthal angles.

[0015] The present invention accomplishes the above object by using a positive biaxial retardation film while adjusting an optical axis direction and the retardation value of the positive biaxial retardation film.

[0016] In order to accomplish the above object, there is provided an in-plane switching liquid crystal display according to claim 1.

[0017] In order to compensate for the viewing angle of the in-plane switching liquid crystal display (IPS-LCD) in a black state, the present invention is characterized by using positive biaxial retardation films in which an optical axis direction and a retardation value of the positive biaxial retardation films are

[0018] EP 1 553 432 A1 is a post-published document and discloses an optical film for a liquid crystal display obtained by laminating a polarizing plate and a retardation film so that an absorption axis of the polarizing plate and a slow axis of the retardation film are perpendicular or parallel to each other. The polarizing plate comprises a transparent protective film on both surfaces of the polarizer.

[0019] EP 1 586 939 A1 is a post-published document and is directed to a liquid crystal display device comprising a pair of polarization plates each including a polarizer and a pair of protective layers laminated over the polarizer, wherein the protective layers perform as a negative retardation film, and wherein a biaxial retardation film is disposed between the liquid crystal plane and anyone of the polarization plates for compensating the dependence upon the viewing angle for incident light forming an angle with the viewing-angular direction.

[0020] EP 1 489 437 A1 is also a post-published document and is directed to a laminated optical film for laminating with polarizing plates to be used as an elliptically polarizing plate.

[0021] adjusted according to upper and lower polarizer plates and an alignment order of the positive biaxial retardation films.

[0022] A contrast ratio is an index representing a degree of definition for an image, and a high contrast ratio allows a high definition image. The contrast characteristic of the IPS-LCD is most deteriorated at an inclination angle of 70°. Thus, if the IPS-LCD represents an improved contrast characteristic at the inclination angle of 70°, it means that the contrast characteristic of the IPS-LCD is improved at all viewing angles. Accordingly, comparison of improvement for viewing angle characteristics of IPS-LCDs is preferably carried out with the inclination angle of 70°. When the IPS-LCD uses the only polarizer plates, a minimum contrast ratio at the inclination angle of 70° is equal to or less than 10:1. However, the IPS-LCD of the present invention uses the positive biaxial retardation film while adjusting the optical axis and the retardation value thereof, so the IPS-LCD of the present invention may represent a minimum contrast ratio above 20:1. Preferably, the IPS-LCD of the present invention represents the minimum contrast ratio above 20:1 at the inclination angle of 70°.

[0023] Reference will now be made in detail to the present invention.

[0024] FIG. 1 is a view illustrating a basic structure of an IPS-LCD.

[0025] The IPS-LCD includes a first polarizer plate 1, a second polarizer plate 2 and a liquid crystal cell 3. An absorption axis 4 of the first polarizer plate 1 is aligned in perpendicular to the an absorption axis 5 of the second polarizer plate 2 and the absorption axis 4 of the first polarizer plate 1 is parallel to an optical axis 6 of the liquid crystal cell 3. In FIG. 2, two absorption axes 4 and 5 of two polarizer plates and one optical axis 6 of one liquid crystal cell are shown.

[0026] The liquid crystal display using a compensation film according to the present invention includes the first polarizer plate 1, the liquid crystal cell 3, which is horizontally aligned between two glass substrates and filled with liquid crystal of positive dielectric anisotropy ($\Delta\varepsilon>0$) or negative dielectric anisotropy ($\Delta\varepsilon<0$), and the second polarizer plate 2. The optical axis 6 of the liquid crystal filled in the liquid crystal cell 3 is aligned in-plane in parallel to the polarizer plates. The absorption axis 4 of the first polarizer plate 1 is aligned in perpendicular to the absorption axis 5 of the second polarizer plate 2 and the absorption axis 4 of the first polarizer plate 1 is parallel to the optical axis 6 of the liquid crystal filled in the liquid crystal cell 3. In addition, one of the first and second substrates includes an active matrix drive electrode having a pair of electrodes, which is formed on a surface of the substrate adjacent to a liquid crystal layer.

[0027] A retardation value of the liquid crystal layer is defined as $R_{LC} = (n_{x,LC}-n_{y,LC}) \times d$, wherein d is a thickness of the liquid crystal layer. Preferably, the liquid crystal layer of the IPS panel according to the present invention has a retardation value in a range of 200nm to 400nm at a wavelength of 550nm.

[0028] In order to make a white state when voltage is applied to the IPS-LCD panel, the light linearly polarized at 90° after passing through the first polarizer plate must be linearly polarized into 0° after it has passed through the liquid crystal layer. Further, in order to achieve the state of light polarized as described above, the retardation value of the liquid crystal layer of the IPS-LCD must be a half wavelength of 589nm (a monochromatic light representing a highest brightness which a person can feel). Therefore, in order to allow the light to produce a white color, the retardation value of the liquid crystal layer of the IPS-LCD can be adjusted to be somewhat shorter or longer than the half wavelength of 589nm. Therefore, the retardation value is preferably in the range around 295nm corresponding to the half wavelength of 589nm.

[0029] The LCD of the present invention may align the liquid crystal in multi-directions, or the liquid crystal may be divided into multi-regions by voltage applied thereto.

[0030] The LCDs can be classified into IPS (In-Plain Switching) LCDs, Super-IPS (Super-In-Plain Switching) LCDs and FFS (Fringe Field Switching) LCDs according to modes of the active matrix drive electrode including a pair of electrodes. In the present invention, the IPS-LCD may include the Super-IPS LCD, the FFS LCD, and a reverse TN IPS LCD.

[0031] FIG. 3 illustrates a refractive index of a retardation film used for compensating for a viewing angle of the IPS-LCD. Referring to FIG. 3, a refractive index in an x-axis direction is n_x(8), a refractive index in a y-axis direction is n_y(9), and a refractive index in a z-axis direction is n_z(10). The characteristic of the retardation film depends on the refractive index.

[0032] A biaxial retardation film represents mutually different refractive indexes in x-axis, y-axis and z-axis directions. The biaxial retardation film is defined as follows:

Equation 1

$$n_x \neq n_y \neq n_z$$

[0033] A negative biaxial retardation film is defined as follows:

Equation 2

$$n_x \neq n_y > n_z$$

[0034] A positive biaxial retardation film is defined as follows:

Equation 3

$$n_x \neq n_y < n_z$$

[0035] The positive biaxial retardation film satisfying Equation 3 represents mutually different refractive indexes in x-axis, y-axis and z-axis directions, so it has an in-plane retardation value and a thickness retardation value. The in-plane retardation value can be defined as follows by using in-plane refractive indexes of n_x(8) and n_y(9).

Equation 4

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

wherein d is a thickness of a film.

[0036] The thickness retardation value can be defined as follows by using refractive indexes of n_y(9) and n_z(10).

Equation 5

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

wherein d is a thickness of a film.

[0037] The positive biaxial retardation film signifies a film having the positive in-plane retardation value and the positive thickness retardation value.

[0038] The wavelength dispersion characteristic of the positive biaxial retardation film includes normal wavelength dispersion, flat wavelength dispersion, and reverse wavelength dispersion. The unlimited example of the positive biaxial retardation film includes an UV curable liquid crystal film using a nematic liquid crystal and a biaxially oriented PC (polycarbonate).

[0039] According to the present invention, the direction of the optical axis of the retardation film is determined according to an alignment order of the retardation film.

[0040] According to an embodiment of the present invention, there is provided an in-plane switching liquid crystal display including a first positive biaxial retardation film 11 aligned between an IPS panel 3 and a first polarizer plate 1, and a second positive biaxial retardation film 13 aligned between the IPS panel 3 and a second polarizer plate 2, in which an optical axis 12 of the first positive biaxial retardation film 11 is parallel to an absorption axis 4 of the first polarizer plate 1 and an optical axis 14 of the second positive biaxial retardation film 13 is parallel to an absorption axis 5 of the second polarizer plate 2, with the first positive biaxial retardation film 11 having an in-plane retardation value equal to or less than 150nm at a wavelength of 550nm and the second positive biaxial retardation film 13 having an in-plane retardation value in a range of 200 to 350nm at a wavelength of 550nm.

[0041] The optical axis of first positive biaxial retardation film must be aligned in parallel to the absorption axis of the first polarizer plate in order to convert the light into an elliptically polarized light, which is required for generating the linearly polarized light after the light passes through the second positive biaxial retardation film.

[0042] The elliptically polarized light created by the first positive biaxial retardation film can be converted into the linearly polarized light through two methods. A first method is to align the optical axis of the second positive biaxial retardation film in perpendicular to the absorption axis of the second polarizer plate and a second method is to align the optical axis of the second positive biaxial retardation film in parallel to the absorption axis of the second polarizer plate. In this case, the design value of the first method is different from that of the second method.

[0043] The retardation value of the first positive biaxial retardation film may vary depending on the design value of the second positive biaxial retardation film and the first positive biaxial retardation film having the in-plane retardation value equal to or less than 150nm can create the elliptically polarized light required for generating the linearly polarized light, which is parallel to the absorption axis of the second polarizer plate, after the light has passed through the second positive biaxial retardation film.

[0044] In addition, the retardation value of the second positive biaxial retardation film is determined according to the retardation value of the first positive biaxial retardation film and the second positive biaxial retardation film having the retardation value in a range of about 200nm to 350nm can create the linearly polarized light, which matches with the absorption axis of the second polarizer plate.

[0045] The embodiment of the present invention is illustrated in FIGS. 4a and 4b, and the structures of the IPS-LCDs shown in FIGS. 4a and 4b are substantially identical to each other, except for positions of a backlight unit and an observer.

[0046] Table 1 shows a simulation result when practical design values of a retardation film are applied to the IPS-LCD structure shown in FIG. 4a or 4b.

Table 1

Internal protective film of 1st polarizer plate	Positive biaxial retardation film			IPS-Panel	Positive biaxial retardation film			Internal protective film of 2nd polarizer plate	Minimum contrast ratio at angle of 70°
	R_{in} (nm)	R_{th} (nm)	Nz		R_{in} (nm)	R_{th} (nm)	Nz		
COP	35	17	0.5	290nm	250	125	0.5	COP	278
	44	22	0.5		310	155	0.5	40um TAC	234
	75	37	0.5		334	167	0.5	80um TAC	100
40um TAC	100	50	0.5		241	120	0.5	COP	259
	120	60	0.5		282	141	0.5	40um TAC	235
	145	72	0.5		314	157	0.5	80um TAC	94
80um TAC	123	62	0.5		180	90	0.5	COP	136
	145	72	0.5		239	120	0.5	40um TAC	100

[0047] The above simulation is carried out with conditions representing the superior viewing angle characteristic at all inclination angles in all azimuthal angles by taking the retardation values of internal protective films of the first and second polarizer plates 1 and 2, the in-plane retardation value and the thickness retardation value of the positive biaxial retardation film, and an Nz representing biaxiality into consideration. In order to simplify the simulation, "Nz = 0.5" is adopted in Table 1. However, it is also possible to use other values of the Nz.

[0048] Table 1 shows the minimum CR values at the inclination angle of 70° according to the design values when the absorption axis of the first polarizer plate is parallel to the optical axis of the first positive biaxial retardation film and the absorption axis of the second polarizer plate is parallel to the optical axis of the second positive biaxial retardation film. The minimum CR value at the inclination angle of 70° may vary according to the design values of the first and second positive biaxial retardation films and the polarizer plate internal protective film. The most superior viewing angle characteristic is represented when a non oriented COP (cyclo olefin polymer) film, which has no in-plane retardation value, is used for the polarizer plate internal protective film.

[0049] The polarizer plate may use internal and external protective films having unique negative thickness retardation values or internal and external protective films, which do not have the thickness retardation values.

[0050] The unlimited example of internal protective film includes non oriented COP (cyclo olefin polymer), 40um TAC(triacetate cellulose), 80um TAC(triacetate cellulose) or PNB (polynobonene).

[0051] The thickness retardation value of the polarizer plate internal protective film is a very important factor when designing the retardation film such that the IPS-LCD represents low transmittance under a dark state at all inclination in all azimuthal angles.

[0052] The internal protective film of the first polarizer plate 1 preferably has a thickness retardation value of 0 or a negative thickness retardation value. This is because the positive biaxial retardation film adjacent to the first polarizer plate 1 may compensate for the retardation value generated from the inner protective film of the first polarizer plate 1.

[0053] In addition, the positive biaxial retardation film can be used as an inner protective film of at least one polarizer plate.

[0054] Preferably, the positive biaxial retardation films 11 and 13 are made from polymer materials or UV curable liquid crystal films.

[0055] The Nz ($N_z = \frac{(n_x - n_z)}{(n_x - n_y)}$) representing the biaxiality of the biaxial retardation film in the present LCD may have various values.

Best Mode for Carrying Out the Invention

[0056] Hereinafter, preferred embodiments of the present invention will be described. However, it is noted that the preferred embodiments described below are used for illustrative purpose and the present invention is not limited thereto.

Embodiment 1

[0057] The IPS-LCD shown in FIG. 4a includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of

2.9μm, a pretilt angle of 3°, dielectric anisotropy of $\Delta\varepsilon = +7$, and a birefringence of $\Delta n = 0.1$. An UV curable liquid crystal film having an in-plane retardation value R_{in} = 87nm and a thickness retardation value R_{th} = 17.5nm at a wavelength of 550nm is used for a first positive biaxial retardation film 11. In addition, an UV curable liquid crystal film having an in-plane retardation value R_{in} = 241nm and a thickness retardation value R_{th} = 120nm at a wavelength of 550nm is used for a second positive biaxial retardation film 13. An internal protective film of a first polarizer plate 1 is made from 40μm TAC having a thickness retardation value R_{th} = -32nm, and the second positive biaxial retardation film 13 is used as an internal protective film of a second polarizer plate 2.

[0058] When a white light is used, the simulation result for the contrast characteristic of an IPS-LCD structure including a viewing angle compensation film at an inclination angle of about 0° to 80° in all azimuthal angles is illustrated in FIG. 5.

Embodiment 2

[0059] The IPS-LCD shown in FIG. 4b includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 2.9μm, a pretilt angle of 3°, dielectric anisotropy of $\Delta\varepsilon = +7$, and a birefringence of $\Delta n = 0.1$. An UV curable liquid crystal film having an in-plane retardation value R_{in} = 35nm and a thickness retardation value R_{th} = 17.5nm at a wavelength of 550nm is used for a first positive biaxial retardation film 11. In addition, an UV curable liquid crystal film having an in-plane retardation value R_{in} = 240nm and a thickness retardation value R_{th} = 120nm at a wavelength of 550nm is used for a second positive biaxial retardation film 13. Internal protective films of first and second polarizer plates 1 and 2 are made from COP.

[0060] When a white light is used, the simulation result for the contrast characteristic of an IPS-LCD structure including a viewing angle compensation film at an inclination angle of about 0° to 80° in all azimuthal angles is illustrated in FIG. 6.

Industrial Applicability

[0061] As can be seen from the foregoing, the in-plane switching liquid crystal display according to the present invention uses the positive biaxial retardation film while adjusting the optical axis direction and the retardation value of the positive biaxial retardation film, so the in-plane switching liquid crystal display can improve the contrast characteristic at a predetermined angular position as well as at a front position thereof, so that a color shift according to the viewing angle in the black state can be minimized.

[0062] While this invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not limited to the disclosed embodiment and the drawings, but, on the contrary, it is intended to cover various modifications and variations within the scope of the appended claims.

40um TAC		160	88	0.45	40um TAC	83
		124	102	0.18	80um TAC	79
		118	139	-0.17	120um TAC	65
80um TAC		160	49	0.72	COP	33
		155	78	0.5	40um TAC	30
		110	77	0.3	80um TAC	30

[0063] The simulation is carried out with conditions representing the superior viewing angle characteristic at all inclination angles in all azimuthal angles by taking the retardation values of internal protective films of the first and second polarizer plates 1 and 2, the in-plane retardation value and the thickness retardation value of the positive biaxial retardation film 11, and an Nz representing biaxiality into consideration.

[0064] Herein, the Nz is an index representing biaxiality of the positive biaxial retardation film, which can be defined as follows by using the refractive indexes of the film in three axis directions.

Equation 6

$$N_z = \frac{(n_x - n_z)}{(n_x - n_y)}$$

[0065] Table 1 shows the improvement in the viewing angle characteristic according to the design values of the polarizer plate protective film and the positive biaxial retardation film. Referring to Table 1, since the IPS-LCD which does not use the viewing angle compensation film has a minimum CR (contrast ratio) of about 7 : 1, if the IPS-LCD represents the CR above 30 : 1 at an inclination angle of 70°, it means that the CR value above 30 : 1 can be obtained in all viewing angles, resulting in a much improvement of the viewing angle characteristic.

[0066] In addition, Table 2 shows a simulation result when practical design values of a retardation film are applied to the IPS-LCD structure shown in FIG. 4b.

Table 2

Internal protective film of 1st polarizer plate	IPS-Panel	Positive biaxial retardation film			Internal protective film of 2nd polarizer plate	Minimum contrast ratio at inclination angle of 70°
		R_{in} (nm)	R_{th} (nm)	Nz		
40um TAC	250	170	76	0.55	40um TAC	83
	290	160	88	0.45		83
	330	155	102	0.34		83

[0067] Table 2 shows the improvement in the viewing angle characteristic according to the design values of the polarizer plate protective film and the positive biaxial retardation film. If 40um TAC (triacetate cellulose) is used as a polarizer plate protective film, the polarizer plate protective film has a negative R_{th} lower than an R_{th} of the polarizer plate protective film of 80um TAC, so the design value of the positive biaxial retardation film is changed. Accordingly, it is possible to obtain a superior viewing angle characteristic by varying the design values. In detail, it is possible to obtain the CR more than 80 : 1 at an inclination angle of 70° by adjusting the design values of the polarizer plate protective film and the positive biaxial retardation film.

[0068] According to a second embodiment of the present invention, there is provided an in-plane switching liquid crystal display including a first positive biaxial retardation film 11 aligned between an IPS panel 3 and a first polarizer plate 1, and a second positive biaxial retardation film 13 aligned between the IPS panel 3 and a second polarizer plate 2, in which an optical axis 12 of the first positive biaxial retardation film 11 is parallel to an absorption axis 4 of the first polarizer plate 1 and an optical axis 14 of the second positive biaxial retardation film 13 is perpendicular to an absorption axis 5 of the second polarizer plate 2, with the first positive biaxial retardation film 11 having an in-plane retardation value equal to or less than 190nm at a wavelength of 550nm and the second positive biaxial retardation film 13 having an in-plane retardation value in a range of 150 to 350nm at a wavelength of 550nm.

[0069] The viewing angle characteristic of the IPS-LCD may be lowered due to a geometrical problem of the polarizer plate depending on the viewing angle and a dependency of the retardation value of the IPS-LCD panel to the viewing angle. The black state of the LCD is obtained by using two polarizer plates, in which a light generated from the backlight unit and linearly polarized by the first polarizer plate is absorbed by means of the absorption axis of the second polarizer plate. However, unlike a vertical incident light, a slantingly incident light creates a rotated linearly polarized light which has been rotated after passing through the polarizer plate, and experiences the absorption axis of the second polarizer plate rotated. Therefore, the linearly polarized light introduced through the first polarizer plate is not perpendicular to the absorption axis of the second polarizer plate, so a light component, which is parallel to a transmission axis, is created. As the inclination angle becomes enlarged, the linearly polarized light greatly deviates from the perpendicular state with respect to the transmission axis, so light components in parallel to the transmission axis may increase. For this reason, the light leakage may occur in the black state.

[0070] The light leakage under the black state of the LCD is a main factor causing deterioration of the viewing angle characteristic of the LCD. The light leakage increases according to an increase of the inclination angle and the increase of the light leakage lowers the CR and increases a color shift. Thus, it is possible to improve the viewing angle characteristic by minimizing the light leakage under the black state depending on the inclination angle. In order to improve the viewing angle characteristic, the light which has been linearly polarized after passing through the first polarizer plate must match with the absorption axis of the second polarizer plate. To this end, the present invention utilizes the positive biaxial retardation film. In order to allow the light, which has been linearly polarized, to match with the absorption axis of the second polarizer plate according to the inclination angle, the in-plane retardation value and the thickness retardation value are necessary.

[0071] The absorption axis of the first polarizer plate must match with the optical axis of the first positive biaxial retardation film, so as that a predetermined elliptically polarized light can be created through the first positive biaxial retardation film. Then, the elliptically polarized light turns into a linearly polarized light matching with the absorption axis of the polarizer plate through the second positive biaxial retardation film. To this end, the optical axis of the second positive biaxial retardation film must be aligned perpendicularly to the absorption axis of the second positive biaxial retardation film. If the first positive biaxial retardation film having an in-plane retardation value equal to or less than 190nm is employed, the first positive biaxial retardation film converts the light, which has been linearly polarized through the first polarizer plate, into an elliptically polarized light, which is required for generating the linearly polarized light which matches with the absorption axis of the second polarizer plate after the light has passed through the second positive biaxial retardation film.

[0072] The second positive biaxial retardation film converts the elliptically polarized light formed through the first positive biaxial retardation film into the linearly polarized light. In addition, if the second positive biaxial retardation film having the retardation value in a range of about 150nm to 350nm is used according to the polarizing state of the light created by the first positive biaxial retardation film, it is possible to obtain the linearly polarized light which matches with the absorption axis of the second polarizer plate.

[0073] The second embodiment of the present invention is illustrated in FIGS. 5a and 5b, and the structures of the IPS-LCDs shown in FIGS. 5a and 5b are substantially identical to each other, except for positions of a backlight unit and an observer.

[0074] Table 3 shows a simulation result when practical design values of a retardation film are applied to the second IPS-LCD structure shown in FIG. 5a or 5b.

Table 3

Internal protective film of 1st polarizer plate	Positive biaxial retardation film			IPS-Panel	Positive biaxial retardation film			Internal protective film of 2°° polarizer plate	Minimum contrast ratio at angle of 70°
	R_{in} (nm)	R_{th} (nm)	Nz		R_{in} (nm)	R_{th} (nm)	Nz		
COP	25	12.5	0.5	290nm	285	142	0.5	COP	238
	35	17	0.5		230	115	0.5	40um TAC	160
	60	30	0.5		200	100	0.5	80um TAC	55
40um TAC	160	88	0.45		302	151	0.5	COP	214
	124	102	0.18		250	125	0.5	40um TAC	136
	118	139	-0.17		220	110	0.5	80um TAC	50
80um TAC	160	49	0.72		350	175	0.5	COP	100
	155	78	0.5		300	150	0.5	40um TAC	68

[0075] The above simulation is carried out with conditions representing the superior viewing angle characteristic at all inclination angles in all azimuthal angles by taking the retardation values of internal protective films of the first and second polarizer plates 1 and 2, the in-plane retardation value and the thickness retardation value of the first and second positive biaxial retardation films 11 and 13, and an Nz representing biaxiality into consideration.

[0076] Table 3 shows the minimum CR values at the inclination angle of 70° according to the design values (in-plane retardation value, thickness retardation value and internal protective film) of the first and second positive biaxial retardation films in the IPS-LCD. The most superior viewing angle characteristic is represented when a non oriented COP (cyclo olefin polymer) film having a thickness retardation value of 0 is used for the polarizer plate internal protective film.

[0077] According to a third embodiment of the present invention, there is provided an in-plane switching liquid crystal display including a first positive biaxial retardation film 11 aligned between an IPS panel 3 and a first polarizer plate 1, and a second positive biaxial retardation film 13 aligned between the IPS panel 3 and a second polarizer plate 2, in which an optical axis 12 of the first positive biaxial retardation film 11 is parallel to an absorption axis 4 of the first polarizer plate 1 and an optical axis 14 of the second positive biaxial retardation film 13 is parallel to an absorption axis 5 of the second polarizer plate 2, with the first positive biaxial retardation film 11 having an in-plane retardation value equal to or less than 150nm at a wavelength of 550nm and the second positive biaxial retardation film 13 having an in-plane retardation value in a range of 200 to 350nm at a wavelength of 550nm.

[0078] The optical axis of first positive biaxial retardation film must be aligned in parallel to the absorption axis of the first polarizer plate in order to convert the light into an elliptically polarized light, which is required for generating the linearly polarized light after the light passes through the second positive biaxial retardation film.

[0079] The elliptically polarized light created by the first positive biaxial retardation film can be converted into the linearly polarized light through two methods. A first method is to align the optical axis of the second positive biaxial retardation film in perpendicular to the absorption axis of the second polarizer plate and a second method is to align the optical axis of the second positive biaxial retardation film in parallel to the absorption axis of the second polarizer plate. In this case, the design value of the first method is different from that of the second method.

[0080] The retardation value of the first positive biaxial retardation film may vary depending on the design value of the second positive biaxial retardation film and the first positive biaxial retardation film having the in-plane retardation value equal to or less than 150nm can create the elliptically polarized light required for generating the linearly polarized light, which is parallel to the absorption axis of the second polarizer plate, after the light has passed through the second positive biaxial retardation film.

[0081] In addition, the retardation value of the second positive biaxial retardation film is determined according to the retardation value of the first positive biaxial retardation film and the second positive biaxial retardation film having the retardation value in a range of about 200nm to 350nm can create the linearly polarized light, which matches with the absorption axis of the second polarizer plate.

[0082] The third embodiment of the present invention is illustrated in FIGS. 6a and 6b, and the structures of the IPS-LCDs shown in FIGS. 6a and 6b are substantially identical to each other, except for positions of a backlight unit and an observer.

[0083] Table 4 shows a simulation result when practical design values of a retardation film are applied to the third IPS-LCD structure shown in FIG. 6a or 6b.

Table 4

Internal protective film of 1st polarizer plate	Positive biaxial retardation film			IPS-Panel	Positive biaxial retardation film			Internal protective film of 2nd polarizer plate	Minimum contrast ratio at angle of 70°
	R_{in} (nm)	R_{th} (nm)	Nz		R_{in} (nm)	R_{th} (nm)	Nz		
COP	35	17	0.5	290nm	250	125	0.5	COP	278
	44	22	0.5		310	155	0.5	40um TAC	234
	75	37	0.5		334	167	0.5	80um TAC	100
40um TAC	100	50	0.5		241	120	0.5	COP	259
	120	60	0.5		282	141	0.5	40um TAC	235
	145	72	0.5		314	157	0.5	80um TAC	94
80um TAC	123	62	0.5		180	90	0.5	COP	136
	145	72	0.5		239	120	0.5	40um TAC	100

[0084] The above simulation is carried out with conditions representing the superior viewing angle characteristic at all inclination angles in all azimuthal angles by taking the retardation values of internal protective films of the first and second polarizer plates 1 and 2, the in-plane retardation value and the thickness retardation value of the positive biaxial retardation film, and an Nz representing biaxiality into consideration. In order to simplify the simulation, "Nz = 0.5" is adopted in Table 4. However, it is also possible to use other values of the Nz.

[0085] Table 4 shows the minimum CR values at the inclination angle of 70° according to the design values when the absorption axis of the first polarizer plate is parallel to the optical axis of the first positive biaxial retardation film and the absorption axis of the second polarizer plate is parallel to the optical axis of the second positive biaxial retardation film. The minimum CR value at the inclination angle of 70° may vary according to the design values of the first and second positive biaxial retardation films and the polarizer plate internal protective film. The most superior viewing angle characteristic is represented when a non oriented COP (cyclo olefin polymer) film, which has no in-plane retardation value, is used for the polarizer plate internal protective film.

[0086] The polarizer plate may use internal and external protective films having unique negative thickness retardation values or internal and external protective films, which do not have the thickness retardation values.

[0087] The unlimited example of internal protective film includes non oriented COP (cyclo olefin polymer), 40um TAC(triacetate cellulose), 80um TAC(triacetate cellulose) or PNB (polynobonene).

[0088] The thickness retardation value of the polarizer plate internal protective film is a very important factor when designing the retardation film such that the IPS-LCD represents low transmittance under a dark state at all inclination in all azimuthal angles.

[0089] The internal protective film of the first polarizer plate 1 preferably has a thickness retardation value of 0 or a negative thickness retardation value. This is because the positive biaxial retardation film adjacent to the first polarizer plate 1 may compensate for the retardation value generated from the inner protective film of the first polarizer plate 1.

[0090] In addition, the positive biaxial retardation film can be used as an inner protective film of at least one polarizer plate.

[0091] Preferably, the positive biaxial retardation films 11 and 13 are made from polymer materials or UV curable liquid crystal films.

[0092] The Nz ($N_z = \frac{(n_x - n_z)}{(n_x - n_y)}$) representing the biaxiality of the biaxial retardation film in the present LCD may have various values.

Best Mode for Carrying Out the Invention

[0093] Hereinafter, preferred embodiments of the present invention will be described. However, it is noted that the preferred embodiments described below are used for illustrative purpose and the present invention is not limited thereto.

Embodiment 1

[0094] The IPS-LCD shown in FIG. 4a includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 2.9μm, a pretilt angle of 3°, dielectric anisotropy of $\Delta\varepsilon = +7$, and a birefringence of $\Delta n = 0.1$. An UV curable liquid crystal film having an in-plane retardation value R_{in} = 180nm and a thickness retardation value R_{th} = 144nm at a wavelength of 550nm is used for a positive biaxial retardation film 11. A COP internal protective film having a retardation value of almost 0 is used as an internal protective film of a first polarizer plate 1 and 80μm TAC having a thickness retardation value of R_{th} = -64nm at a wavelength of 550nm is used as an internal protective film of a second polarizer plate 2. When a white light is used, the simulation result for the contrast characteristic of a first IPS-LCD structure including a viewing angle compensation film at an inclination angle of about 0° to 80° in all azimuthal angles is illustrated in FIG. 7 and Table 1.

[0095] Referring to FIG. 7, a center of a circle corresponds to an inclination angle of 0, and the inclination angle increases as a radius of the circle becomes enlarged. Numerals 20, 40, 60 and 80 marked along the radius of the circle in FIG. 7 represent the inclination angles.

[0096] In addition, numerals 0 to 360 marked along a circumference of the circle represent the azimuthal angles. FIG. 7 shows the contrast characteristic in all viewing directions (inclination angles of 0° to 80° and azimuthal angles of 0° to 360°) when an upper polarizer plate is aligned in a direction of an azimuthal angle of 0°, and a lower polarizer plate is aligned in a direction of an azimuthal angle of 90°. An IPS-LCD, which exclusively uses two polarizer plates, represents a contrast ratio equal to or less than 10:1 at an inclination angle of 70°. However, the IPS-LCD of the present invention represents a contrast ratio above 166:1 at an inclination angle of 70° as shown in FIG. 7 and Table 1.

Embodiment 2

[0097] The IPS-LCD shown in FIG. 5b includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 2.9μm, a pretilt angle of 3°, dielectric anisotropy of $\Delta\varepsilon = +7$, and a birefringence of $\Delta n = 0.1$. An UV curable liquid crystal film having an in-plane retardation value R_{in} = 20nm and a thickness retardation value R_{th} = 10nm at a wavelength of 550nm is used for a first positive biaxial retardation film 11. In addition, an UV curable liquid crystal film having an in-plane retardation value R_{in} = 288nm and a thickness retardation value R_{th} = 144nm at a wavelength of 550nm is used for a second positive biaxial retardation film 13. Internal protective films of polarizer plates 1 and 2 are made from COP. When a white light is used, the simulation result for the contrast characteristic of a second IPS-LCD structure including a viewing angle compensation film at an inclination angle of about 0° to 80° in all azimuthal angles is illustrated in FIG. 8.

Embodiment 3

[0098] The IPS-LCD shown in FIG. 6a includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 2.9μm, a pretilt angle of 3°, dielectric anisotropy of $\Delta\varepsilon = +7$, and a birefringence of $\Delta n = 0.1$. An UV curable liquid crystal film having an in-plane retardation value R_{in} = 87nm and a thickness retardation value R_{th} = 17.5nm at a wavelength of 550nm is used for a first positive biaxial retardation film 11. In addition, an UV curable liquid crystal film having an in-plane retardation value R_{in} = 241nm and a thickness retardation value R_{th} = 120nm at a wavelength of 550nm is used for a second positive biaxial retardation film 13. An internal protective film of a first polarizer plate 1 is made from 40μm TAC having a thickness retardation value R_{th} = -32nm, and the second positive biaxial retardation film 13 is used as an internal protective film of a second polarizer plate 2.

[0099] When a white light is used, the simulation result for the contrast characteristic of a third IPS-LCD structure including a viewing angle compensation film at an inclination angle of about 0° to 80° in all azimuthal angles is illustrated in FIG. 9.

Embodiment 4

[0100] The IPS-LCD shown in FIG. 6b includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 2.9μm, a pretilt angle of 3°, dielectric anisotropy of $\Delta\varepsilon = +7$, and a birefringence of $\Delta n = 0.1$. An UV curable liquid crystal film having an in-plane retardation value R_{in} = 35nm and a thickness retardation value R_{th} = 17.5nm at a wavelength of 550nm is used for a first positive biaxial retardation film 11. In addition, an UV curable liquid crystal film having an in-plane retardation value R_{in} = 240nm and a thickness retardation value R_{th} = 120nm at a wavelength of 550nm is used for a second positive biaxial retardation film 13. Internal protective films of first and second polarizer plates 1 and 2 are made from COP.

[0101] When a white light is used, the simulation result for the contrast characteristic of a third IPS-LCD structure including a viewing angle compensation film at an inclination angle of about 0° to 80° in all azimuthal angles is illustrated in FIG. 10.

Industrial Applicability

[0102] As can be seen from the foregoing, the in-plane switching liquid crystal display according to the present invention uses the positive biaxial retardation film while adjusting the optical -axis direction and the retardation value of the positive biaxial retardation film, so the in-plane switching liquid crystal display can improve the contrast characteristic at a predetermined angular position as well as at a front position thereof, so that a color shift according to the viewing angle in the black state can be minimized.

[0103] While this invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not limited to the disclosed embodiment and the drawings, but, on the contrary, it is intended to cover various modifications and variations within the scope of the appended claims.

Claims

1. An in-plane switching liquid crystal display comprising:

    a first polarizer plate (1);
    a second polarizer plate (2); and
    a liquid crystal cell (3), which is horizontally aligned and filled with liquid crystal of positive dielectric anisotropy ($\Delta\varepsilon>0$) or negative dielectric anisotropy ($\Delta\varepsilon<0$), an optical axis (6) of the liquid crystal filled in the liquid crystal cell (3) being aligned in-plane in parallel to the first and second polarizer plates (1, 2),
    wherein an absorption axis (4) of the first polarizer plate (1) is perpendicular to an absorption axis (5) of the second polarizer plate (2), the optical axis (6) of the liquid crystal filled in the liquid crystal cell (3) is parallel to the absorption axis (4) of the first polarizer plate (1), a first positive biaxial retardation film (11) defined by a following Equation is aligned between the liquid crystal cell (3) and the first polarizer plate (1), a second positive biaxial retardation film (13) defined by the following Equation is aligned between the liquid crystal cell (3) and the second polarizer plate (2), **characterized in that**
    an optical axis (12) of the first positive biaxial retardation film (11) is parallel to the absorption axis (4) of the first polarizer plate (1), an optical axis (14) of the second positive biaxial retardation film (13) is parallel to the absorption axis (5) of the second polarizer plate (2), an in-plane retardation value of the first positive biaxial retardation film (11) is equal to or less than 150 nm at a wavelength of 550 nm, and an in-plane retardation value of the second positive biaxial retardation film (13) is in a range of 200 nm to 350 nm at a wavelength of 550 nm.
    Equation $n_x \neq n_y \neq n_z$ and $n_x > n_y$ and $n_z > n_y$,
    wherein n_x and n_y are in-plane refractive indexes, n_z is a thickness refractive index, and the positive biaxial retardation film (11, 13) has a positive in-plane retardation value ($R_{in} = d \times (n_x - n_y)$) and a positive thickness retardation value ($R_{th} = d \times (n_z - n_y)$) in which d is a thickness of a film,
    wherein both positive biaxial retardation films (11, 13) are used as protective films for the polarizer plates (1, 2).

2. The in-plane switching liquid crystal display as claimed in claim 1, wherein a retardation value of the liquid crystal cell (3) is in a range of 200 nm to 400 nm at a wavelength of 550 nm.

3. The in-plane switching liquid crystal display as claimed in claim 1, wherein an internal protective film of the first polarizer plate has a thickness retardation value of 0 or a negative thickness retardation value.

Patentansprüche

1. In der Ebene schaltende Flüssigkristallanzeige mit:

    einer ersten Polarisationsplatte (1),
    einer zweiten Polarisationsplatte (2) und
    einer Flüssigkristallzelle (3), die horizontal ausgerichtet und mit Flüssigkristall positiver dielektrischer Anisotropie ($\Delta\varepsilon>0$) oder negativer dielektrischer Anisotropie ($\Delta\varepsilon<0$) gefüllt ist, wobei eine optische Achse (6) des in die Flüssigkristallzelle (3) gefüllten Flüssigkristalls in der Ebene parallel zu der ersten und der zweiten Polarisationsplatte (1, 2) ausgerichtet ist,
    wobei eine Absorptionsachse (4) der ersten Polarisationsplatte (1) senkrecht zu einer Absorptionsachse (5) der zweiten Polarisationsplatte (2) ist, die optische Achse (6) des in die Flüssigkristallzelle (3) gefüllten Flüssigkristalls parallel zur Absorptionsachse (4) der ersten Polarisationsplatte (1) ist, ein durch eine nachstehende Gleichung definierter erster positiver, biaxialer Verzögerungsfilm (11) zwischen der Flüssigkristallzelle (3) und der ersten Polarisationsplatte (1) ausgerichtet ist, ein durch die nachstehende Gleichung definierter zweiter positiver, biaxialer Verzögerungsfilm (13) zwischen der Flüssigkristallzelle (3) und der zweiten Polarisationsplatte (2) ausgerichtet ist, **dadurch gekennzeichnet, dass**
    eine optische Achse (12) des ersten positiven, biaxialen Verzögerungsfilms (11) parallel zur Absorptionsachse (4) der ersten Polarisationsplatte (1) ist, eine optische Achse (14) des zweiten positiven, biaxialen Verzögerungsfilms (13) parallel zur Absorptionsachse (5) der zweiten Polarisationsplatte (2) ist, ein Verzögerungswert in der Ebene des ersten positiven, biaxialen Verzögerungsfilms (11) kleiner oder gleich 150 nm bei einer Wellenlänge von 550 nm ist und ein Verzögerungswert in der Ebene des zweiten positiven, biaxialen Verzögerungsfilms (13) in einem Bereich von 200 nm bis 350 nm bei einer Wellenlänge von 550 nm liegt,
    Gleichung $n_x \neq n_y \neq n_z$ und $n_x > n_y$ und $n_z > n_y$,
    wobei r_x und n_y Brechungsindizes in der Ebene sind, n_z ein Dickenbrechungsindex ist und der positive, biaxiale Verzögerungsfilm (11, 13) einen positiven Verzögerungswert in der Ebene ($R_{in} = d \times (n_x - n_y)$) und einen positiven Dickenverzögerungswert ($R_{th} = d \times (n_z - n_y)$) hat, bei dem d eine Dicke eines Films ist,
    wobei beide positiven, biaxialen Verzögerungsfilme (11, 13) als Schutzfilme für die Polarisationsplatten (1, 2) verwendet werden.

2. In der Ebene schaltende Flüssigkristallanzeige nach Anspruch 1, bei der ein Verzögerungswert der Flüssigkristallzelle (3) in einem Bereich von 200 nm bis 400 nm bei einer Wellenlänge von 550 nm liegt.

3. In der Ebene schaltende Flüssigkristallanzeige nach Anspruch 1, bei der ein innerer Schutzfilm der ersten Polarisationsplatte einen Dickenverzögerungswert von 0 oder einen negativen Dickenverzögerungswert hat.

Revendications

1. Ecran à cristaux liquides à commutation dans le plan, présentant :

    une première plaque de polariseur (1) ;
    une deuxième plaque de polariseur (2) ; et
    une cellule à cristal liquide (3) qui est alignée horizontalement et qui est remplie de cristal liquide à anisotropie diélectrique positive ($\Delta\varepsilon>0$) ou à anisotropie diélectrique négative ($\Delta\varepsilon<0$), un axe optique (6) du cristal liquide rempli dans la cellule à cristal liquide (3) étant aligné dans le plan parallèlement à la première et à la deuxième plaque de polariseur (1, 2),
    un axe d'absorption (4) de la première plaque de polariseur (1) étant perpendiculaire à un axe d'absorption (5) de la deuxième plaque de polariseur (2), l'axe optique (6) du cristal liquide rempli dans la cellule à cristal liquide (3) étant parallèle à l'axe d'absorption (4) de la première plaque de polariseur (1), un premier film de retard biaxial positif (11) défini par une équation qui suit étant aligné entre la cellule à cristal liquide (3) et la première plaque de polariseur (1), un deuxième film de retard biaxial positif (13) défini par l'équation qui suit étant aligné entre la cellule à cristal liquide (3) et la deuxième plaque de polariseur (2), **caractérisé en ce que**
    un axe optique (12) du premier film de retard biaxial positif (11) est parallèle à l'axe d'absorption (4) de la

première plaque de polariseur (1), un axe optique (14) du deuxième film de retard biaxial positif (13) est parallèle à l'axe d'absorption (5) de la deuxième plaque de polariseur (2), une valeur de retard dans le plan du premier film de retard biaxial positif (11) est égale ou inférieure à 150 nm à une longueur d'onde de 550 nm, et une valeur de retard dans le plan du deuxième film de retard biaxial positif (13) est comprise dans une plage de 200 nm à 350 nm à une longueur d'onde de 550 nm
équation $n_x \neq n_y \neq n_z$ et $n_x > n_y$ et $n_z > n_y$,
n_x et n_y étant des indices de réfraction dans le plan, n_z étant un indice de réfraction d'épaisseur, et le film de retard biaxial positif (11, 13) ayant une valeur de retard dans le plan positive ($R_{in}=d\times(n_x-n_y)$) et une valeur de retard d'épaisseur positive ($R_{th}=d\times(n_z-n_y)$), d étant une épaisseur d'un film,
les deux films de retard biaxiaux positifs (11 ; 13) étant utilisés en tant que films protecteurs pour les plaques de polariseur (1, 2).

2. Ecran à cristaux liquides à commutation dans le plan selon la revendication 1, dans lequel une valeur de retard de la cellule à cristal liquide (3) est comprise dans une plage de 200 nm à 400 nm à une longueur d'onde de 550 nm.

3. Ecran à cristaux liquides à commutation dans le plan selon la revendication 1, dans lequel un film protecteur interne de la première plaque de polariseur a une valeur de retard d'épaisseur de 0 ou une valeur de retard d'épaisseur négative.

FIG. 1

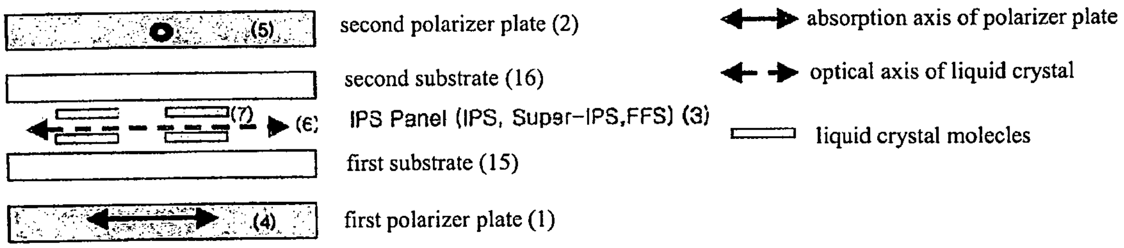


FIG. 2

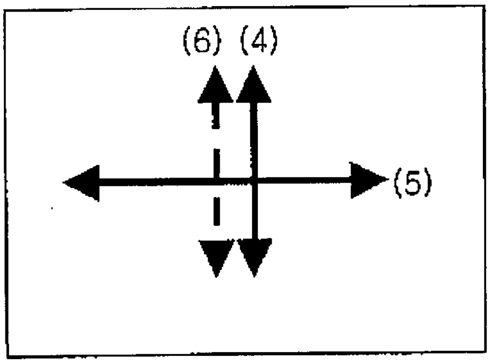


FIG. 3

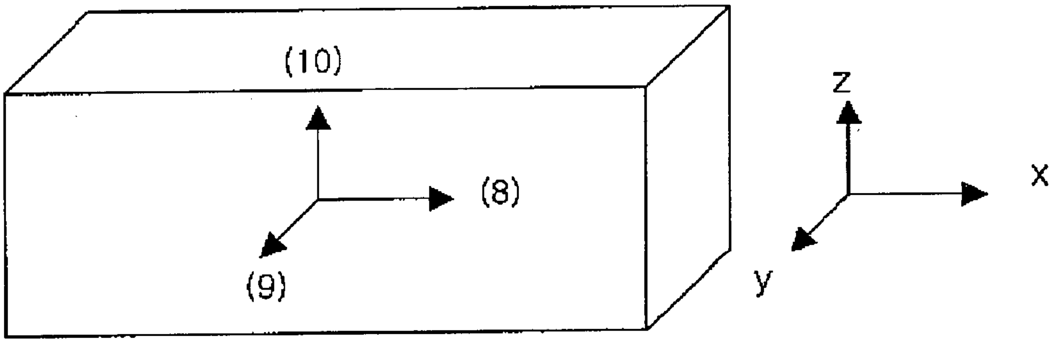


FIG. ~~6a~~ 4a

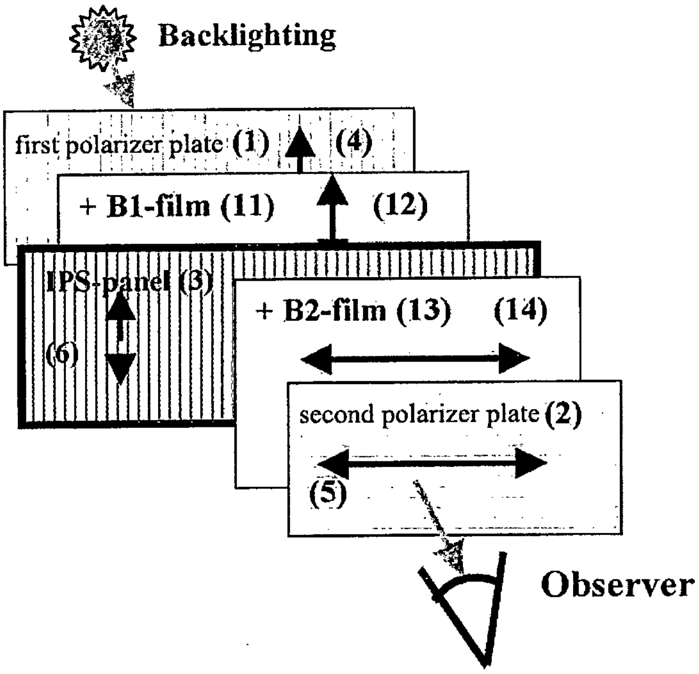


FIG. ~~6b~~ 4b

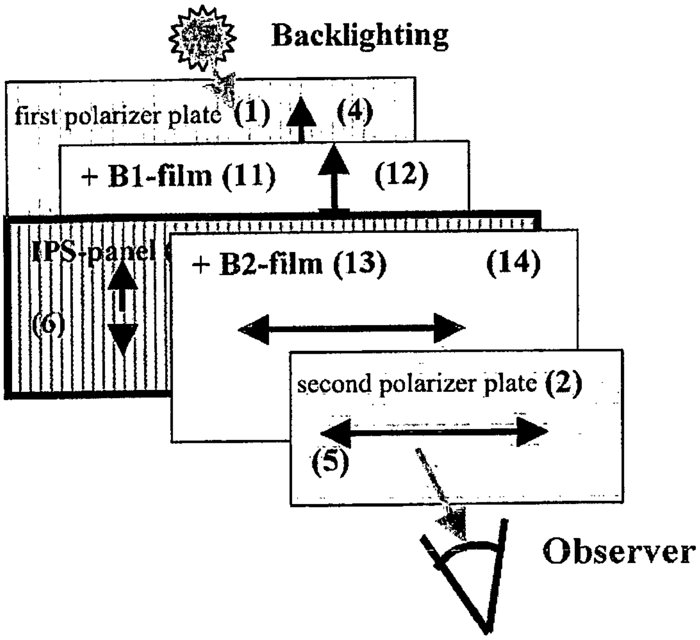


FIG. ~~9~~ 5

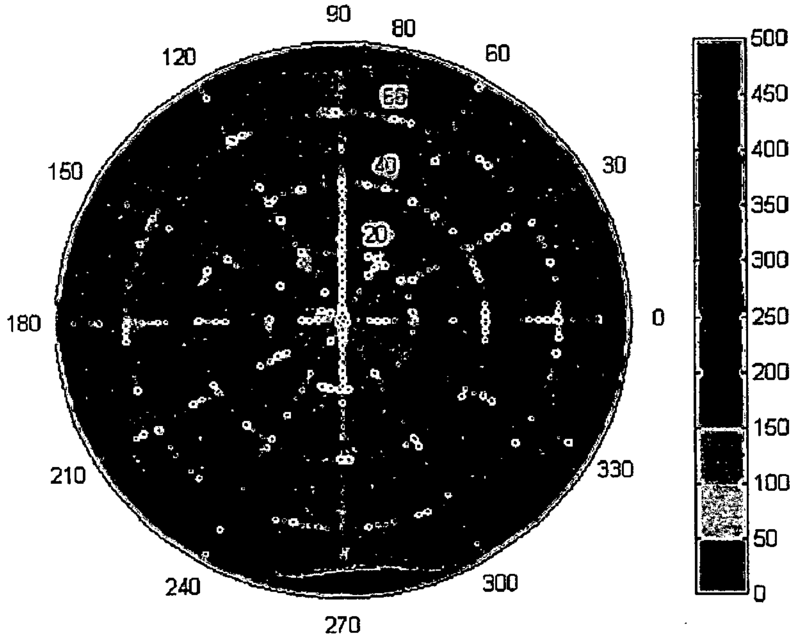
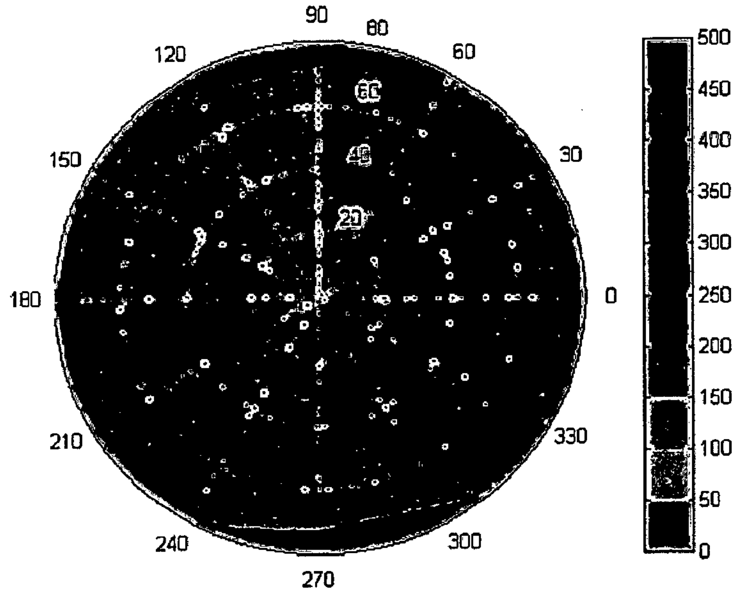


FIG. ~~10~~ 6



REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 6078375 A **[0002]**
- US 3807831 A **[0003]**
- US 5189538 A **[0004]**
- US 5440413 A **[0005]**
- US 6285430 B **[0006]**
- EP 1553432 A1 **[0007] [0018]**
- EP 1586939 A1 **[0008] [0019]**
- EP 1489437 A1 **[0009] [0020]**
- US 20030122991 A1 **[0010]**

patsnap

专利名称(译)	面内切换液晶显示器，包括使用正单轴延迟膜的用于角视场的补偿膜		
公开(公告)号	EP1685441B1	公开(公告)日	2018-10-03
申请号	EP2004819017	申请日	2004-11-17
[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	JEON BYOUNG KUN 203 LG CHEM SHINYEOLRIP APT		
发明人	JEON, BYOUNG-KUN, 203,LG CHEMICAL SHINYEOLRIP APT BELYAEV, SERGEY, 6-201, LG CHEMICAL APARTMENT YU, JEONG-SU, 107-1501, HANWOOL APARTMENT MALIMONENKO, NIKOLAY, 6-203, LG CHEMICAL APARTMENT		
IPC分类号	G02F1/1343 G02F1/13363		
CPC分类号	G02F1/134363 G02F1/133634 G02F2201/124 G02F2202/40		
优先权	1020030083023 2003-11-21 KR		
其他公开文献	EP1685441A4 EP1685441A1		
外部链接	Espacenet		

摘要(译)

公开了一种面内切换液晶显示器，其使用正双轴延迟膜同时调节正双轴延迟膜的光轴方向和延迟值。面内切换液晶显示器改善了预定角度位置处以及其前面位置处的对比度特性，因此使得根据黑色状态下的视角的色移最小化。

Equation 1

$$n_x \neq n_y \neq n_z$$