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(54) **Vertically aligned liquid crystal display using a bi-axial retardation compensation film**

Vertikal ausgerichtete Flüssigkristallanzeige unter Verwendung eines zweiachsigen Verzögerungskompensierungsfilms

Affichage à cristaux liquides à alignement vertical utilisant un film de compensation de retard bi-axe

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(56) References cited:
WO-A1-01/09649
JP-A- 2000 131 693
JP-A- 2002 258 045

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Description

TECHNICAL FIELD

[0001] The present invention relates to a vertically aligned liquid crystal display (hereinafter, referred to as a "VA-LCD") using a bi-axial retardation compensation film, capable of improving viewing angle characteristics.

BACKGROUND ART

[0002] As well known to those skilled in the art, a -C-plate compensation film and an A-plate compensation film have been used to compensate for a black state of a VA-LCD under the condition that small drive voltage is applied. U.S. Patent Serial No. 4,889,412 discloses a conventional VA-LCD using the -C-plate compensation film.

[0003] However, the conventional VA-LCD using the -C-plate compensation film does not completely compensate for a black state, thus having a disadvantage such as a leakage of light at a viewing angle.

[0004] Further, U.S. Patent Serial No. 6,141,075 discloses a conventional VA-LCD comprising both the -C-plate compensation film and the A-plate compensation film.

[0005] The above VA-LCD comprising both the -C-plate compensation film and the A-plate compensation film more completely achieves compensation of a black state under the condition that small drive voltage is applied.

[0006] However, the above-described conventional VA-LCDs require improvements of contrast and coloring at a front surface and a tilt angle in order to completely compensate for the black state.

[0007] JP 2000-131693A relates to LIQUID CRYSTAL DISPLAY DEVICE. Specifically, to obtain the VA mode liquid crystal display device which has its field angle and contrast optimized by arranging a specific biaxial phase difference plate almost in parallel to or almost at right angles to the axis of absorption of a polarizing plate which is arranged on the same side with the phase difference plate as for a liquid crystal layer. A phase difference compensating film 14A is inserted on one side of a liquid crystal panel 11 comprising substrates 11A and 11B and a liquid crystal layer 12 enclosed between them. The phase difference compensating film 14A has negative retardation $\Delta n.d1$ ($\Delta n=n_y-n_z=n_x-n_z$, where n_x to nx are the refractive indexes in the directions of the main axes (x) to (z) of an index elliptic body and d1 in the thickness of the retardation film) in the (z) direction, and the film 14A is arranged between the liquid crystal panel 11 and the polarizing plate 113A to compensate the birefringence of light passing through the liquid crystal panel 11. Namely, the phase difference plate is arranged almost in parallel or almost at right angles to the axis of absorption of the polarizing plate 13A arranged on the same side with the phase difference compensating film 14A as for the liquid crystal layer 12 so as to obtain a wide field angle.

[0008] WO 01/09649 A1 relates to a phase difference film which comprises one sheet of polymer film, and which has a wavelength region wherein a phase difference value is positive and a wavelength region wherein a phase difference value is negative in the range of wavelength of 400 to 800 nm.

DISCLOSURE OP THE INVENTION

[0009] 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 achromatic VA-LCD, in which contrast at a front surface and a tilt angle of the VA-LCD filled with liquid crystal having a positive or negative dielectric anisotropy is improved, and coloring at the tilt angle in a black state is minimized, thus improving of viewing angle characteristics.

[0010] In order to accomplish the above object, the present invention uses a bi-axial retardation compensation film satisfying $n_x > n_y > n_z$, $R_{in}= (n_x-n_y) \times d > 0$ and $R_{th}=(n_z-n_y) \times d < 0$, wherein n_x and n_y are in-plain refractive indexes, n_z is a thickness refractive index, R_{in} is an in-plain retardation, R_{th} is a thickness retardation and d is a thickness.

[0011] According to the present invention, there is provided a vertically aligned LCD (VA-LCD) using a multi-domain mode or a chiral additive, comprising:

(i) a vertically aligned panel formed by injecting liquid crystal having a negative dielectric anisotropy ($\Delta\varepsilon<0$) or a positive dielectric anisotropy ($\Delta\varepsilon>0$) into a cell gap between upper and lower glass substrates,
(ii) upper and lower polarizing plates arranged to face the upper and lower surfaces of the vertically aligned panel so that the vertically aligned panel is between them, the optical absorption axes of the polarizing plates being perpendicular to each other, and a cell gap in the range of 3 μm to 8 μm is maintained, and
(iii) a liquid crystal cell prepared by arranging a bi-axial retardation compensation film between the vertically aligned panel and the upper and/or lower polarizing plate,
wherein the bi-axial retardation compensation film has:

a wavelength dispersion (Rin,400/Rin,550) in the range of 0.4-0.9 at wavelengths of 400 nm and 550 nm, and

a wavelength dispersion (Rin,700/Rin,550) in the range of 1.1-1.8 at wavelengths of 700 nm and 550 nm (wherein Rin,400, Rin,550 and Rin,700 are in-plain retardations at wavelengths of 400 nm, 550 nm and 700 nm), and an in-plain retardation (Rin) in the range of 30-150 nm at a wavelength of 550 nm,
wherein the optical axis (14c) of the bi-axial retardation compensation film is perpendicular to the absorption axis of the adjacent polarizing plate,
characterized in that:

the bi-axial retardation compensation film has a reversed wavelength dispersion in which an in-plain retardation is increased in proportion to the increase of a wavelength in the range of visible rays, and has a normal wavelength dispersion in which an absolute value of the thickness retardation is decreased in proportion to the increase of a wavelength in the range of visible rays;
the total of the thickness retardation including the vertically aligned panel and the bi-axial retardation compensation film being applied in the VA-LCD is in the range of 30-150 nm in proportion of a wavelength in the range of visible rays;
the layer of liquid crystal has a retardation in the range of 80 nm to 300 nm at a wavelength of 550 nm;
a rubbed director of the liquid crystals of the vertically aligned panel has an angle of 45° with the optical absorption axes of the polarizing plate when a voltage is applied to the vertically aligned panel; and
the in-plain refraction indexes (nx, ny) and the thickness refraction index (nz) of the bi-axial retardation compensation film satisfy nx>ny>nz.

[0012] Preferably the liquid crystal cell is prepared by arranging the bi-axial retardation compensation film between either the vertically aligned panel and upper polarizing plate or between the vertically aligned panel and lower polarizing plate.

[0013] Preferably the liquid crystal is a polymer the molecules of which have a pretilt angle in the range of 75° to 90° between the upper and lower glass substrates when no voltage is applied to the vertically aligned panel.
Preferably the pretilt angle is in the range of 87° to 90°, more preferably 89° to 90°.

[0014] The bi-axial retardation compensation film has a wavelength dispersion ($R_{in,400}/R_{in,550}$) in the range of 0.4~0.9 at wavelengths of 400nm and 550nm, and a wavelength dispersion ($R_{in,700}/R_{in,550}$) in the range of 1.1~ 1.8 at wavelengths of 700nm and 550nm.

[0015] An in-plain retardation (R_{in}) of the bi-axial retardation compensation film is in the range of 30~150nm at a wavelength of 550nm.

[0016] The bi-axial retardation compensation film has a wavelength dispersion ($R_{th,400}/R_{th,550}$) in the range of 1.05~1.4 at wavelengths of 400nm and 550nm, and a wavelength dispersion ($R_{th,700}/R_{th,550}$) in the range of 0.5~ 0.95 at wavelengths of 700nm and 550nm.

[0017] A thickness retardation (R_{th}) of the bi-axial retardation compensation film is in the range of -50~-500nm at 550nm.

[0018] The bi-axial retardation compensation film can be manufactured by elongating a polymer prepared with copolymerization of a first monomer and a second monomer, wherein the first monomer has a characteristic positive of a double refraction and the second monomer has a characteristic negative of a double refraction.

[0019] The bi-axial retardation compensation film can be manufactured by elongating a polymer prepared by mixing a first monomer and a second monomer, wherein the first monomer has a characteristic positive of a double refraction and the second monomer has a characteristic negative of a double refraction.

[0020] The bi-axial retardation compensation film can be prepared by laminating more than two sheets having different dependability of a in-plane retardation (R_{in}) and a thickness retardation (R_{th}) .

[0021] Also, in a vertically aligned LCD (VA-LCD) using a multi-domain mode or a chiral additive, provided with a bi-axial retardation compensation film, in which a vertically aligned panel is formed by injecting liquid crystal having a negative dielectric anisotropy ($\Delta\varepsilon$<0) or a positive dielectric anisotropy ($\Delta\varepsilon$>0) into a gap between upper and lower glass substrates, and upper and lower polarizing plates are arranged above the upper and lower surfaces of the VA-panel so that optical absorption axes of the polarizing plates are perpendicular to each other with the VA-panel as the central figure, and a cell gap in the range of 3μm to 8μm is maintained, a liquid crystal cell is prepared by arranging a bi-axial retardation compensation film between the vertically aligned panel and a upper and lower polarizing plate in which a in-plain refraction index (n_x, n_y) and a thickness refraction index (n_z) of the bi-axial retardation compensation film is $n_x>n_y>n_z$.

[0022] And an optical axis of the bi-axial retardation compensation film is arranged to be perpendicular to an absorption axis of an adjacent polarizing plate, and the bi-axial retardation compensation film has a reversed wavelength dispersion in which a in-plain retardation is increased in proportion to the increase of a wavelength in the range of visible rays, and has a normal wavelength dispersion in which an absolute value of the thickness retardation is decreased in proportion to the increase of a wavelength in the range of visible rays.

[0023] In Example 1 of a vertically aligned LCD in accordance with the present invention, a liquid crystal cell is prepared by arranging the bi-axial retardation compensation film at one place of between the vertically aligned panel and upper polarizing plate, or between the vertically aligned panel and lower polarizing plate.

[0024] In Example 2 of a vertically aligned LCD in accordance with the present invention, a liquid crystal cell is prepared by arranging one of the individual bi-axial retardation compensation films between the vertically aligned panel and upper polarizing plate, or between the vertically aligned panel and lower polarizing plate.

[0025] In particular, the total of a thickness retardation including the vertically aligned panel and the bi-axial retardation compensation film being applied in the vertically aligned LCD is in the range of 30~150nm in proportion of a wavelength in the range of visible rays.

[0026] Also, in each of the above examples according to the present invention, directors of liquid crystalline molecules of the VA-panel, under the condition that no voltage is applied to the VA-panel, may have a pretilt angle in the range of 75° to 90° between the upper and lower glass substrates. The pretilt angle is preferably in the range of 87° to 90°, more preferably in the range of 89° to 90°.

[0027] Also, in each of the above examples according to the present invention, a liquid crystalline layer formed on the VA-panel has a retardation in the range of 80nm to 300nm, at a wavelength of 550nm.

[0028] A rubbed director of the liquid crystals of the VA-panel, under the condition that voltage is applied to the VA-panel, has an angle of 45° with the optical absorption axes of the polarizing plates.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] 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 perspective view of a VA-LCD cell comprising a bi-axial retardation compensation film in accordance with Example 1 according to the present invention;

Fig. 2 is a perspective view of a VA-LCD cell comprising a bi-axial retardation compensation film in accordance with Example 2 according to the present invention;

Fig. 3 is a reference view of a refraction index of a bi-axial retardation compensation film according to the present invention;

Fig. 4 is a graph showing a dependability of a wavelength dispersion of thickness retardation and a wavelength dispersion of a in-plain retardation of a bi-axial retardation compensation film applied in the present invention.

Fig. 5 is graphs showing the results of simulation for

(a) a transmittance according to a visual angle in a black state of the VA-LCD applying a bi-axial retardation compensation film according to the present invention, and

(b) a transmittance according to a visual angle in a black state of the VA-LCD applying a conventional bi-axial retardation compensation film.

Fig. 6 is diagrams showing the results of simulation for (a) a color variation in a black state of the VA-LCD applying a bi-axial retardation compensation film according to the present invention, and (b) a color variation in a black state of the VA-LCD applying a conventional retardation compensation film.

Fig. 7 is graphs showing the results of simulation for

(a) a transmittance in a black state according to a wavelength of the VA-LCD applying a bi-axial retardation compensation film according to the present invention, and

(b) a transmittance in a black state according to a wavelength of the VA-LCD applying a conventional bi-axial retardation compensation film.

Fig. 8 is a diagram showing the result of simulation of a contrast ratio for a structure of the VA-LCD of Example 1 at a tilt angle in the range of all azimuth angles, when applying a white ray.

Fig. 9 is a diagram showing the result of simulation of a contrast ratio for a structure of the VA-LCD, which is a modified example of Example 1, at a tilt angle in the range of 0° ~ 80° at all azimuth angles, when applying a white ray.

Fig. 10 is a graph showing the result of simulation for a color variation in a black state of a structure of the VA-LCD, which is modified example of Example 1, at a tilt angle in the range of 0° ~ 80°, which is varied by an interval of 2°, at azimuth angle of 45°, when applying a white ray.

Fig. 11 is a diagram showing the result of simulation for a contrast ratio of a structure of the VA-LCD of Example 2 at a tilt angle in the range of 0° ~ 80°at all azimuth angles, when applying a white ray.

Fig. 12 is a graph showing the result of simulation for a color variation in a black state of a structure of the VA-LCD of Example 2, at a tilt angle in the range of 0° ~ 80°, which is varied by an interval of 2°, at azimuth angle of 45°, when applying a white ray.

BEST MODE FOR CARRYING OUT THE INVENTION

[0030] Now, preferred embodiments of the present invention will be described in detail with reference to the annexed drawings.

[0031] Figs. 1a, 1b and 2 illustrate respective examples of the VA-LCD in accordance with the present invention, wherein a VA-LCD cell is prepared by arranging bi-axial retardation compensation films 14, 14a, 14b between two polarizing plates 11, 12 so that absorption axes are perpendicular to each other with the VA-panel 13 as the central figure. Here, the polarizing plates 11, 12 can be comprised of a TAC (triacetate cellulose) protection film having a characteristic thickness retardation or other protection film not having a thickness retardation.

[0032] Figs. 1a and 1b are a structure of a VA-LCD cell according to Example 1 which is prepared by arranging one of a bi-axial retardation compensation film 14 between two of upper and lower polarizing plates 11, 12 which are perpendicular to a vertically aligned panel 13 so that a cell gap of 3~8μm is maintained.

[0033] Fig. 1a illustrates an essential form of Example 1, in which a bi-axial retardation compensation film 14 is arranged between a vertically aligned panel 13 and a lower polarizing plate 11, wherein an optical axis 14c of the bi-axial retardation compensation film 14 is placed to be perpendicular to the an absorption axis 11c of the lower polarizing plate 11.

[0034] Fig. 1b illustrates other modified example of Example 1, in which a bi-axial retardation compensation film 14 is arranged between a vertically aligned panel 13 and a upper polarizing plate 12, wherein an optical axis 14c of the bi-axial retardation compensation film 14 is placed to be perpendicular to the an absorption axis 12c of the upper polarizing plate 12.

[0035] Fig. 2 is a structure of a VA-LCD cell according to Example 2 which is prepared by arranging two of bi-axial retardation compensation films 14a., 14b between two of upper and lower polarizing plates 11, 12 which are perpendicular to a vertically aligned panel 13 so that a cell gap of 3~8μm is maintained.

[0036] Fig. 2 illustrates a VA-LCD cell of Example 2 in which one of the bi-axial retardation compensation film 14a is placed between a vertically aligned panel 13 and a lower polarizing plate 11, and another bi-axial retardation compensation film 14b is placed between a vertically aligned panel 13 and a upper polarizing plate 12, wherein an optical axis 14c of the bi-axial retardation compensation film 14a, placed between the vertically aligned panel 13 and the lower polarizing plate 11, is arranged to be perpendicular to an absorption axis 11c of the lower polarizing plate 11, and an optical axis 14c of the bi-axial retardation compensation film 14b, placed between the vertically aligned panel 13 and the upper polarizing plate 12, is arranged to be perpendicular to an absorption axis 12c of the upper polarizing plate 12.

[0037] Fig. 3 shows a refraction index of a bi-axial retardation compensation film in accordance with the present invention.

[0038] As shown in Fig. 3, a bi-axial retardation compensation film 14 according to the present invention has a refraction index of $n_x > n_y > n_z$, wherein n_x and n_y are in-plain refractive indexes, n_z is a thickness refractive index.

[0039] The bi-axial retardation compensation film has the following important characteristics.

[0040] A in-plane retardation value (R_{in}=d×n_x-n_y, wherein d is a thickness of film) of the bi-axial retardation compensation film has a reversed wavelength dispersion in which retardation is increased in proportion to the increase of a wavelength in the range of visible rays.

[0041] A thickness retardation value (R_{th}=d×(n_z-n_y), wherein d is a thickness of film) of the bi-axial retardation compensation film is negative value, and has a reversed wavelength dispersion in which retardation is increased in proportion to the increase of a wavelength in the range of visible rays.

[0042] Fig. 4 is a reference view showing a dependability of a retardation value according to a wavelength of a bi-axial retardation compensation film in accordance with the present invention, which shows a wavelength dispersion ($R_{th,\lambda}/R_{th,550}$) of a thickness retardation of the bi-axial retardation compensation film, and a wavelength dispersion ($R_{in,\lambda}/P_{in,550}$) of a in-plain retardation.

[0043] As shown in Fig. 4, in a bi-axial retardation compensation film according the present invention, an appropriate wavelength dispersion of a in-plain retardation value should have a relative retardation ratio ($R_{in,400}/R_{in,550}$) in the range of 0.4~0.9 at wavelengths of 400nm and 550nm, and a relative retardation ratio ($R_{in,700}/R_{in,550}$) in the range of 1.1~1.8 at wavelengths of 700nm and 550nm, wherein $R_{in,400}$ is a in-plain retardation at a wavelength of 400nm, and $R_{in,550}$ is a in-plain retardation at a wavelength of 550nm, and $R_{in,700}$ is a in-plain retardation at a wavelength of 700nm.

[0044] An appropriate range of in-plain retardation of the bi-axial retardation compensation film according to the present invention is in the range of 30~150nm at a wavelength of 550nm.

[0045] Also, an appropriate wavelength dispersion of a thickness retardation of a bi-axial retardation compensation film according to the present invention should have a relative retardation ratio ($R_{th,400}/R_{th,550}$) in the range of 1.05~1.4 at wavelengths of 400nm and 550nm, and a relative retardation ratio ($R_{th,700}/R_{th,550}$) in the range of 0.5~0.95 at wavelengths of 700nm and 550nm.

[0046] An appropriate range of the thickness retardation value (R_{th}=d×(n_z-n_y) is in the range of -50~-550nm at a wavelength of 550nm.

[0047] Accordingly, in case of preparing a vertically aligned LCD shown in Figs. 1a, 1b and 2, by using a bi-axial retardation compensation film according to the present invention, a complete compensation in a dark state of the VA-LCD at a tilt angle is possible, and a color variation of a dark state, a bright state and a RGB color can be minimized.

[0048] Fig. 5 is the results of comparing (a) a transmittance according to a visual angle in a black state of the VA-LCD applying a bi-axial retardation compensation film according to the present invention with (b) a transmittance according to a visual angle in a black state of the VA-LCD applying a conventional bi-axial retardation compensation film. It can be known that the bi-axial retardation compensation film according to the present invention has an excellent compensation in a black state more than a conventional bi-axial retardation compensation film.

[0049] For reference, the conventional bi-axial retardation compensation film is a polycarbonate retardation film, and a wavelength dispersion ($R_{th,400}/R_{th,550}$) = ($R_{in,400}/R_{in,550}$) thereof is 1.15.

[0050] Fig. 6 is the results of comparing (a) a color variation in a black state of the VA-LCD applying a bi-axial retardation compensation film according to the present invention with (b) a color variation in a black state of the VA-LCD applying a conventional retardation compensation film. It can be known that a color variation in a black state of a bi-axial retardation compensation film of the present invention is much smaller than that of a conventional bi-axial retardation compensation film.

[0051] The reason for showing a low transmittance in a black state and a small color variation in a black state when employing a bi-axial retardation compensation film of the present invention is that a transmittance variation in accordance with a wavelength is flat.

[0052] A bi-axial retardation compensation film in accordance with the present invention can be prepared by laminating 2~3 of a conventional film having a different dependability of retardation to a wavelength.

[0053] Also, the bi-axial retardation compensation film can be manufactured by elongating a polymer prepared with copolymerization of a first monomer and a second monomer, or by elongating a polymer prepared by mixing a first monomer and a second monomer, wherein the first monomer has a characteristic positive of a double refraction and the second monomer has a characteristic negative of a double refraction.

Example 1

[0054] A VA-LCD was prepared by arranging one of a bi-axial retardation compensation film 14 between a vertically aligned panel 13 and upper and lower polarizing plates 11, 12 which are perpendicular to each other so that a cell gap of 3~8 μm is maintained.

[0055] Fig. 1a illustrates an essential form of Example 1, in which a bi-axial retardation compensation film 14 is arranged between a vertically aligned panel 13 and a lower polarizing plate 11, wherein an optical axis 14c of the bi-axial retardation compensation film 14 is placed to be perpendicular to the an absorption axis 11c of the lower polarizing plate 11.

[0056] Fig. 1b illustrates other modified example of Example 1, in which a bi-axial retardation compensation film 14 is arranged between a vertically aligned panel 13 and a upper polarizing plate 12, wherein an optical axis 14c of the bi-axial retardation compensation film 14 is placed to be perpendicular to the an absorption axis 12c of the upper polarizing plate 12.

Example 2

[0057] A VA-LCD as shown in Fig. 2 was prepared by arranging two of bi-axial retardation compensation films 14a, 14b between two of upper and lower polarizing plates 11, 12 which are perpendicular to a vertically aligned panel 13 so that a cell gap of 3~8μm is maintained.

[0058] Namely, two of bi-axial retardation compensation film was employed in this Example 2, in which one of the bi-axial retardation compensation film 14a is placed between a vertically aligned panel 13 and a lower polarizing plate 11, and another bi-axial retardation compensation film 14b is placed between a vertically aligned panel 13 and a upper polarizing plate 12, wherein an optical axis 14c of the bi-axial retardation compensation film 14a, placed between the vertically aligned panel 13 and the lower polarizing plate 11, is arranged to be perpendicular to an absorption axis 11c of the lower polarizing plate 11, and an optical axis 14c of the bi-axial retardation compensation film 14b, placed between the vertically aligned panel 13 and the upper polarizing plate 12, is arranged to be perpendicular to an absorption axis 12c of the upper polarizing plate 12.

[0059] Hereinafter, experimental examples for testing contrast characteristics of samples selected from the above examples of a VA-LCD employing a bi-axial retardation compensation film of the present invention will be described. Improvements of the contrast characteristics in the respective examples will be more easily understood by the below experimental examples. The below experimental examples will be disclosed for illustrative purposes, but do not limit the subject matter of the present invention.

Experimental Example 1

[0060] A VA-LCD of Fig. 1(a) applying one of a bi-axial retardation compensation film prepared by Example 1 was used as a sample in this Experimental Example.

[0061] The VA-LCD included a VA-panel having a cell gap of 3μm, wherein a pretilt angle was 89° , a dielectric anisotropy ($\Delta\varepsilon$) was -4.9, a refractive anisotropy (Δn) was 0.0979, and a wavelength dispersion ($\Delta n_{400}/\Delta n_{550}$) was 1.096. Accordingly, a thickness retardation ($R_{VA,550}$) of the VA-panel at a wavelength of 550nm was 297nm.

[0062] The bi-axial retardation compensation film was prepared with polycarbonate series, wherein a thickness retardation value (R_{th}(550nm)) was -270nm, a in-plain retardation value (R_{in}(550nm)) was 67nm, a wavelength dispersion of a thickness retardation (R_{th}(450nm)/R_{th}(550nm)) was 1.15, and a wavelength dispersion of a in-plain retardation (R_{in}(450nM)/ R_{in}(550nm)) was 0.652.

[0063] Fig. 8 shows the result of simulation of a contrast ratio of the VA-LCD compensated by employing the above bi-axial retardation compensation film, and Fig. 6 shows a color variation in a black state of the VA-LCD compensated by employing the above bi-axial retardation compensation film.

Modified Example of Experimental Example 1

[0064] A VA-LCD of Fig. 1(b) applying one of a bi-axial retardation compensation film prepared by Example 1 was used as a sample in this Experimental Example.

[0065] The VA-LCD included a VA-panel having a cell gap of 3μm, wherein a pretilt angle was 89° , a dielectric anisotropy ($\Delta\varepsilon$) was -4.9, a refractive anisotropy (Δn) was 0.0979, and a wavelength dispersion ($\Delta n_{400}/\Delta n_{550}$) was 1.096. Accordingly, a thickness retardation ($R_{VA,550}$) of the VA-panel at a wavelength of 550nm was 297nm.

[0066] The bi-axial retardation compensation film was prepared with triacetate cellulose (TAC) series, wherein a thickness retardation value (R_{th}(550nm)) was -241nm, a in-plain retardation value (R_{in}(550nm)) was 44nm, a wavelength dispersion of a thickness retardation (R_{th}(450nm)/R_{th}(550nm)) was 1.12, and a wavelength dispersion of a in-plain retardation (R_{in}(450nm)/ R_{in}(550nm)) was 0.61.

[0067] Fig. 9 shows the result of simulation of a contrast ratio for a structure of the VA-LCD, and also Fig. 10 shows the result of simulation for a color variation in a black state of a structure of the VA-LCD.

[0068] Table 1 comparatively shows contrasts of the sample (hereinafter, referred to as a 'first sample') employed by the Modified Example of Experimental Example 1 and a sample (hereinafter, referred to as a 'second sample') serving as a comparative example. Here, in the first sample, the retardation (R_{VA}) of the VA-panel at 550nm, the thickness retardation (R_{th}) of the bi-axial retardation film, the total retardation (R_{TOTAL}) of the two retardation (R_{VA}, R_{th}), and the in-plain retardation (R_{in}) of the bi-axial retardation film were 297, -240, +46 and 90, respectively. On the other hand, in the second sample, the retardation (R_{VA}) of the VA-panel at 550nm, the thickness retardation (R_{th}) of the bi-axial retardation film, the total retardation (R_{TOTAL}) of the two retardation (R_{VA},R_{th}), and the in-plain retardation (R_{in}) of the bi-axial retardation film were 297, -100, +197 and 0, respectively. And the minimum contrasts of the first and second samples at a tilt angle of 70° were 160 and 5, respectively.

Table 1

	R_{VA}	R_{th}	R_{TOTAL}	R_{in}	Minimum contrast (at a tilt angle of 70°)
First sample (Experimental Example)	297	-240	+46	395	160
Second sample (Comparative Example)	297	-100	+197	460	5

[0069] In Table 1, the minimum contrasts of the first and second samples at a tilt angle of 70° were 160 and 5. Since the tilt angle of 70° has the minimum contrast, other tilt angles rather than the tilt angle of 70° have contrasts higher than the minimum contrast. Accordingly, the contrasts at other tilt angles rather than the tilt angle of 70° are higher than the minimum contrast.

Experimental Example 2

[0070] A VA-LCD of Fig. 2 applying two of a bi-axial retardation compensation film prepared by Example 2 was used as a sample in this Experimental Example.

[0071] The VA-LCD included a VA-panel having a cell gap of 3μm, wherein a pretilt angle was 89°, a dielectric anisotropy ($\Delta\varepsilon$) was -4.9, a refractive anisotropy (Δn) was 0.0979, and a wavelength dispersion ($\Delta n_{400}/\Delta n_{550}$) was 1.096. Accordingly, a thickness retardation ($R_{VA,550}$) of the VA-panel at a wavelength of 550nm was 297nm.

[0072] The two of bi-axial retardation compensation films were prepared with polycarbonate series, wherein a thickness retardation value (R_{th}(550nm)) was -119nm, a in-plain retardation value (R_{in}(550nm)) was 44nm, a wavelength dispersion of a thickness retardation (R_{th}(450nm)/R_{th}(550nm)) was 1.24, and a wavelength dispersion of a in-plain retardation (R_{in}(450nm)/R_{in}(550nm)) was 0.585.

[0073] Fig. 11 shows the result of simulation of a contrast ratio for a structure of the VA-LCD, and also Fig. 12 shows the result of simulation for a color variation in a black state of a structure of the VA-LCD.

INDUSTRIAL APPLICABILITY

[0074] As apparent from the above description, the present invention provides a VA-LCD comprising a bi-axial retardation compensation film, which compensates for a dark state at a tilt angle of the VA-LCD and minimizes coloring in dark, white and RGB states, thus improving viewing angle characteristics.

Claims

1. A vertically aligned LCD (VA-LCD) using a multi-domain mode or a chiral additive, comprising:

(i) a vertically aligned panel (13) formed by injecting liquid crystal having a negative dielectric anisotropy ($\Delta\varepsilon<0$) or a positive dielectric anisotropy ($\Delta\varepsilon>0$) into a cell gap between upper and lower glass substrates,
(ii) upper and lower polarizing plates (11, 12) arranged to face the upper and lower surfaces of the vertically aligned panel so that the vertically aligned panel is between them, the optical absorption axes (11c, 12c) of the polarizing plates being perpendicular to each other, and a cell gap in the range of 3 μm to 8 μm is maintained, and
(iii) a liquid crystal cell prepared by arranging a bi-axial retardation compensation film (14a, 14b) between the vertically aligned panel (13) and the upper and/or lower polarizing plate (11, 12),
wherein the bi-axial retardation compensation film (14a, 14b) has:

a wavelength dispersion (Rin,400/Rin,550) in the range of 0.4-0.9 at wavelengths of 400 nm and 550 nm, and a wavelength dispersion (Rin,700/Rin,550) in the range of 1.1-1.8 at wavelengths of 700 nm and 550 nm (wherein Rin,400, Rin,550 and Rin,700 are in-plain retardations at wavelengths of 400 nm, 550 nm and 700 nm), and
an in-plain retardation (Rin) in the range of 30-150 nm at a wavelength of 550 nm,
wherein the optical axis (14c) of the bi-axial retardation compensation film (14a, 14b) is perpendicular to the absorption axis (11c, 12c) of the adjacent polarizing plate (11, 12),
characterized in that:

the bi-axial retardation compensation film (14a, 14b) has a reversed wavelength dispersion in which an in-plain retardation is increased in proportion to the increase of a wavelength in the range of visible rays, and has a normal wavelength dispersion in which an absolute value of the thickness retardation is decreased in proportion to the increase of a wavelength in the range of visible rays;
the total of the thickness retardation including the vertically aligned panel (13) and the bi-axial retardation compensation film (14a, 14b) being applied in the VA-LCD is in the range of 30-150 nm in proportion of a wavelength in the range of visible rays;
the layer of liquid crystal has a retardation in the range of 80 nm to 300 nm at a avelength of 550 nm;
a rubbed director of the liquid crystals of the vertically aligned panel (13) has an angle of 45° with the optical absorption axes (11c, 12c) of the polarizing plate (11, 12) when a voltage is applied to the vertically aligned panel (13); and
the in-plain refraction indexes (nx, ny) and the thickness refraction index (nz) of the bi-axial retardation compensation film (14a, 14b) satisfy nx>ny>nz.

2. The VA-LCD according to Claim 1, wherein the liquid crystal cell is prepared by arranging the bi-axial retardation compensation film (14a, 14b) between either the vertically aligned panel (13) and upper polarizing plate (11) or between the vertically aligned panel (13) and lower polarizing plate (12).

3. The VA-LCD according to Claim 1, wherein directors of the liquid crystalline molecules have a pretilt angle in the range of 75° to 90° between the upper and lower glass substrates when no voltage is applied to the vertically aligned panel.

4. The VA-LCD according to Claim 3, wherein the pretilt angle is in the range of 87° to 90°.

5. The VA-LCD according to Claim 4, wherein the pretilt angle is in the range of 89° to 90°.

Patentansprüche

1. Vertikal ausgerichtete LCD (VA-LCD) unter Verwendung eines Additivs der Multidomänenart oder eines chiralen Additivs, enthaltend:

   (i) ein vertikal ausgerichtetes Panel (13), gebildet durch Injizieren eines Flüssigkristalls mit einer negativen dielektrischen Anisotropie ($\Delta\varepsilon$>0) oder einer positiven dielektrischen Anisotropie ($\Delta\varepsilon$>0) in einen Zellzwischenraum zwischen oberen und unteres Glassubstraten,
   (ii) obere und untere Polarisierungsplatten (11, 12), die angeordnet sind, so dass sie den oberen und unteren Oberflächen des vertikal ausgerichteten Panels gegenüberliegen, so dass das vertikal ausgerichtete Panel zwischen diesen liegt, wobei die optischen Absorptionsachsen (11c, 12c) der Polarisierungsplatten zueinander senkrecht sind, und ein Zellzwischenraum im Bereich von 3 bis 8 μm aufrechterhalten wird, und
   (iii) eine Flüssigkristallzelle, hergestellt durch Anordnen eines biaxialen Retardierungs-Kompensationsfilmes (14a, 14b) zwischen dem vertikal ausgerichteten Panel (13) und der oberen und/oder der unteren Polarisierungsplatte (11, 12),
   worin der biaxiale Retardierungs-Kompensationsfilm (14a, 14b) aufweist:

      eine Wellenlängendispersion (Rin,400/Rin,550) im Bereich von 0,4 bis 0,9 bei Wellenlängen von 400 nm und 550 nm und eine Wellenlängendispersion (Rin,700/Rin,550) im Bereich von 1,1 bis 1,8 bei Wellenlängen von 700 nm und 550 nm (worin Rin,400, Rin,550 und Rin,700 In-Ebenen-Retardierungen bei Wellenlängen von 400 nm, 550 nm und 700 nm sind) und
      eine In-Ebenen-Retardierung (Rin) im Bereich von 30 bis 150 nm bei einer Wellenlänge von 550 nm,
      worin die optische Achse (14c) des biaxialen Retardierungs-Kompensationsfilmes (14a, 14b) senkrecht zu der Absorptionsachse (11c, 12c) der benachbarten Polarisierungsplatte (11, 12) ist,
      dadurch gekennzeichnet, dass
      der biaxiale Retardierungs-Kompensationsfilm (14a, 14b) eine umgekehrte Wellenlängendispersion, worin eine In-Ebenen-Retardierung in Proportion zu der Erhöhung der Wellenlänge im Bereich von sichtbaren Strahlen erhöht ist, und eine normale Wellenlängendispersion hat, worin ein Absolutwert der Dickenretardierung in Proportion zu der Erhöhung einer Wellenlänge im Bereich von sichtbaren Strahlen vermindert ist,
      die Gesamtheit der Dickenretardierung, einschließlich dem vertikal ausgerichteten Panel (13) und dem biaxialen Retardierungs-Kompensationsfilm (14a, 14b), die in der VA-LCD auferlegt ist, im Bereich von 30 bis 150 nm in Proportion einer Wellenlänge im Bereich von sichtbaren Strahlen ist,
      die Schicht des Flüssigkristalls eine Retardierung im Bereich von 80 bis 300 nm bei einer Wellenlänge von 550 nm hat,
      eine geriebene Richtung der Flüssigkristalle des vertikal ausgerichteten Panels (13) einen Winkel von 45° mit den optischen Absorptionsachsen (11c, 12c) der Polarisierungsplatte (11, 12) hat, wenn eine Spannung auf das vertikal ausgerichtete Panel (13) auferlegt wird, und
      die In-Ebenen-Refraktionsindizes (nx, ny) und der Dickenrefraktionsindex (nz) des biaxialen Retardierungs-Kompensationsfilmes (14a, 14b) nx>ny>nz erfüllt.

2. VA-LCD gemäß Anspruch 1, worin die Flüssigkristallzelle hergestellt ist durch Anordnen des biaxialen Retardierungs-Kompensationsfilmes (14a, 14b) zwischen dem vertikal ausgerichteten Panel (13) und der oberen Polarisierungsplatte (11) oder zwischen dem vertikal ausgerichteten Panel (13) und der unteren Polarisierungsplatte (12) hergestellt ist.

3. VA-LCD gemäß Anspruch 1, worin die Richtungen der flüssigkristallinen Moleküle einen Pretilt-Winkel im Bereich von 75 bis 90° zwischen den oberen und unteren Glassubstraten haben, wenn keine Spannung auf das vertikal ausgerichtete Panel auferlegt ist.

4. VA-LCD gemäß Anspruch 3, worin der Pretilt-Winkel im Bereich von 87 bis 90° ist.

5. VA-LCD gemäß Anspruch 4, worin der Pretilt-Winkel im Bereich von 89 bis 90° ist.

Revendications

1. LCD aligné verticalement (VA-LCD) utilisant un mode multi-domaines ou un additif chiral, comprenant :

(i) un panneau aligné verticalement (13) formé en injectant un cristal liquide présentant une anisotropie diélectrique négative ($\Delta\varepsilon$<0) ou une anisotropie diélectrique positive ($\Delta\varepsilon$>0) dans un espace de cellule entre des substrats de verre supérieur et inférieur,
(ii) des plaques de polarisation supérieure et inférieure (11, 12) disposées de manière à faire face aux surfaces supérieure et inférieure du panneau aligné verticalement de sorte que le panneau aligné verticalement se situe entre elles, les axes d'absorption optique (11c, 12c) des plaques de polarisation étant perpendiculaires l'un à l'autre, et un espace de cellule dans une plage de 3 μm à 8 μm étant maintenu, et
(iii) une cellule de cristaux liquides préparée en disposant un film de compensation de retardement bi-axial (14a, 14b) entre le panneau aligné verticalement (13) et la plaque de polarisation supérieure et/ou inférieure (11, 12),
dans lequel le film de compensation de retardement bi-axial (14a, 14b) présente :

une dispersion de longueur d'onde (Rin,400/Rin,550) dans la plage de 0,4-0,9 à des longueurs d'onde de 400 nm et 550 nm, et une dispersion de longueur d'onde (Rin,700/Rin,550) dans une plage de 1,1-1,8 à des longueurs d'onde de 700 nm et 550 nm (dans lequel Rin,400, Rin,550 et Rin,700 sont des retardements en plan à des longueurs d'onde de 400 nm, 550 nm et 700 nm), et
un retardement en plan (Rin) dans la plage de 30-150 nm à une longueur d'onde de 550 nm,
dans lequel l'axe optique (14c) du film de compensation de retardement bi-axial (14a, 14b) est perpendiculaire à l'axe d'absorption (11c, 12c) de la plaque de polarisation adjacente (11, 12),
caractérisé en ce que :

le film de compensation de retardement bi-axial (14a, 14b) présente une dispersion de longueur d'onde inversée dans laquelle un retardement en plan est augmenté en proportion à l'augmentation d'une longueur d'onde dans la plage de rayons visibles, et présente une dispersion de longueur d'onde normale dans laquelle une valeur absolue du retardement d'épaisseur est diminuée en proportion à l'augmentation d'une longueur d'onde dans la plage des rayons visibles ;
le total du retardement d'épaisseur comprenant le panneau aligné verticalement (13) et le film de compensation de retardement bi-axial (14a, 14b) appliqué dans le VA-LCD se situe dans la plage de 30-150 nm en proportion d'une longueur d'onde dans la plage des rayons visibles ;
la couche de cristaux liquides possède un retardement dans la plage de 80 nm à 300 nm à une longueur d'onde de 550 nm ;
un directeur de frottement des cristaux liquides du panneau aligné verticalement (13) présente un angle de 45° par rapport aux axes d'absorption optique (11c, 12c) de la plaque de polarisation (11, 12) lorsqu'une tension est appliquée au panneau aligné verticalement (13) ; et
les indices de réfraction en plan (nx, ny) et les indices de réfraction d'épaisseur (nz) du film de compensation de retardement bi-axial (14a, 14b) satisfont nx>ny>nz.

2. VA-LCD selon la revendication 1, dans lequel la cellule de cristaux liquides est préparée en disposant le film de compensation de retardement bi-axial (14a, 14b) soit entre le panneau aligné verticalement (13) et la plaque de polarisation supérieure (11), soit entre le panneau aligné verticalement (13) et la plaque de polarisation inférieure (12).

3. VA-LCD selon la revendication 1, dans lequel les directeurs des molécules cristallines liquides présentent un angle de pré-basculement dans la plage de 75° à 90° entre les substrats de verre supérieur et inférieur lorsqu'aucune tension n'est appliquée au panneau aligné verticalement.

4. VA-LCD selon la revendication 3, dans lequel l'angle de pré-basculement est dans la plage de 87° à 90°.

5. VA-LCD selon la revendication 4, dans lequel l'angle de pré-basculement est dans la plage de 89° à 90°.

FIGURE 1

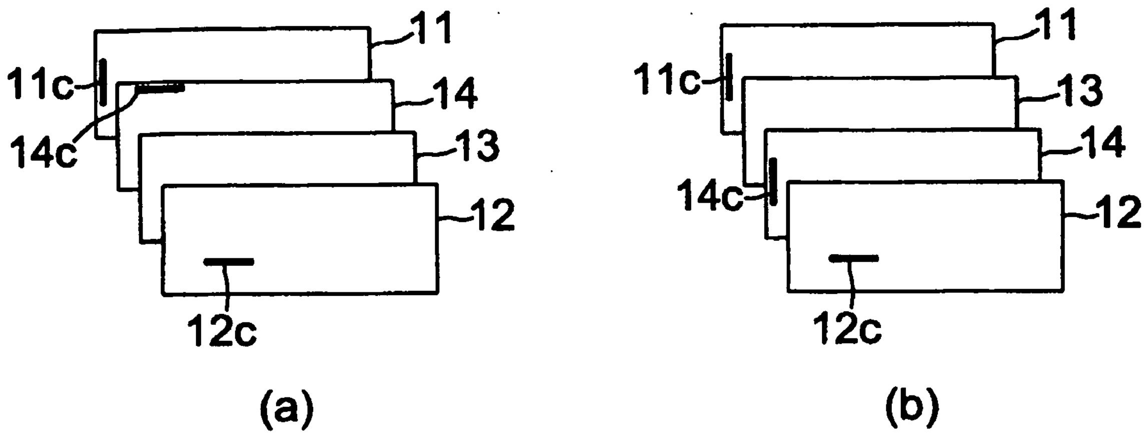


FIGURE 2

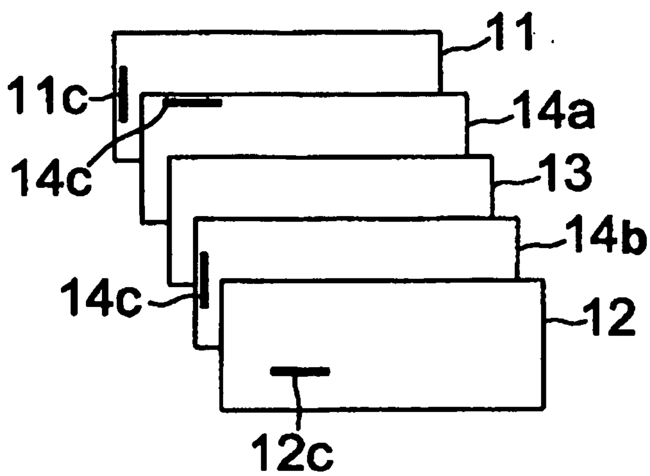


FIGURE 3

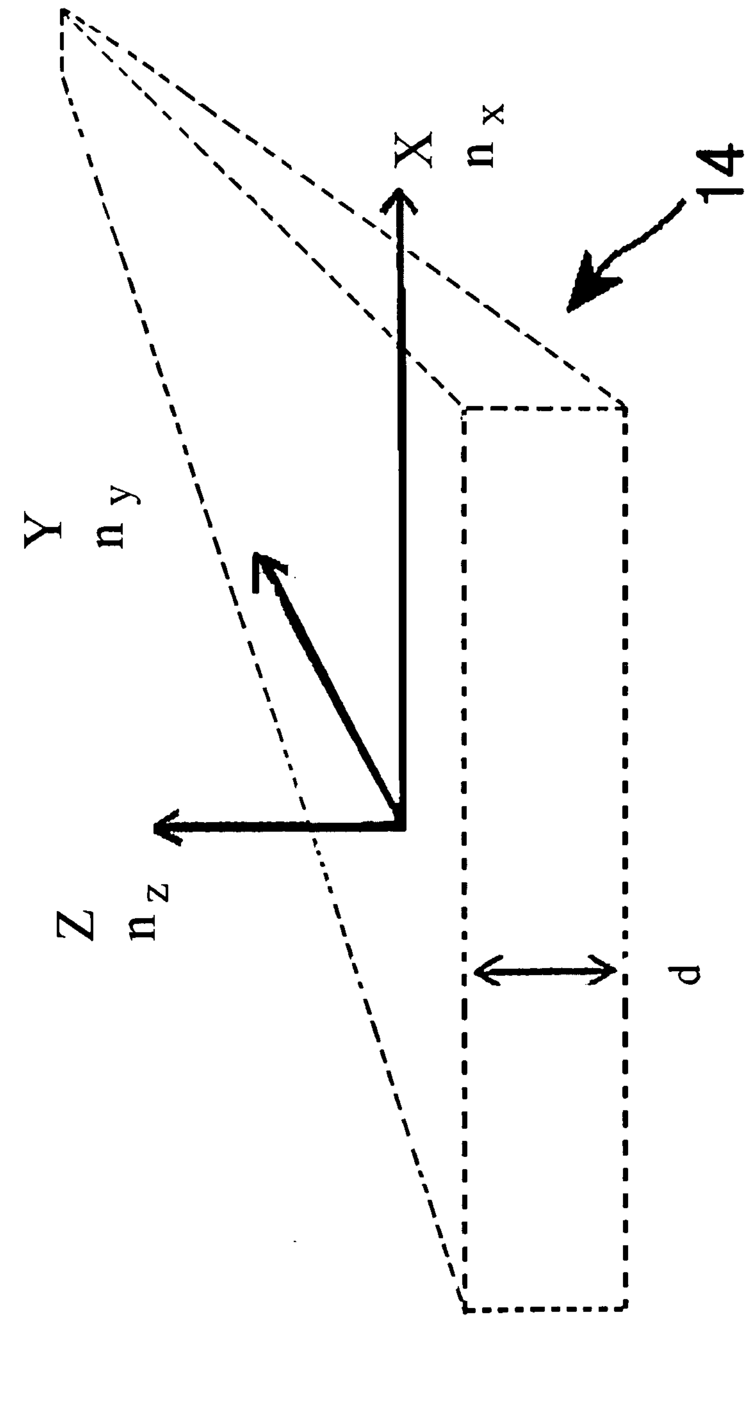


FIGURE 4

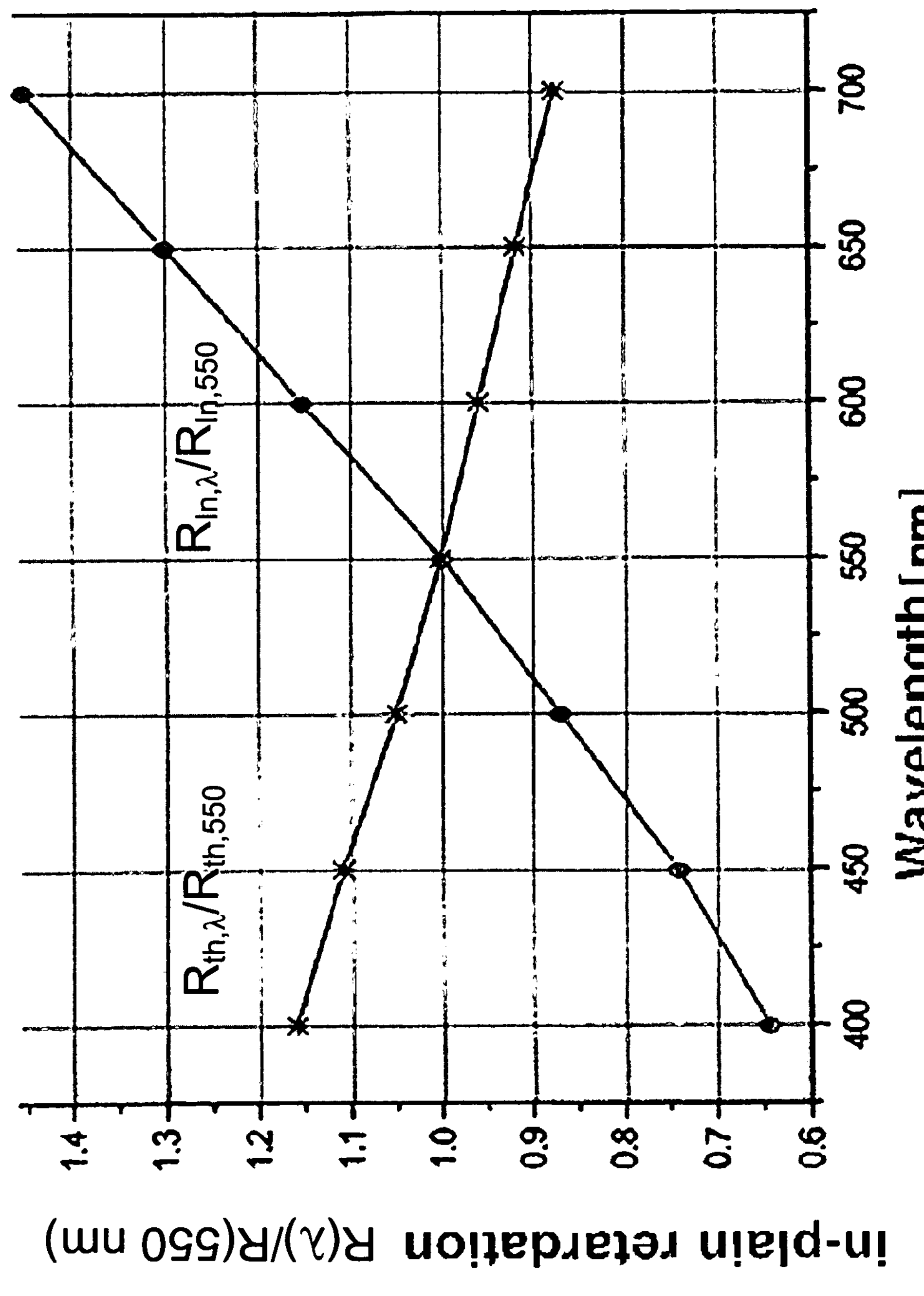
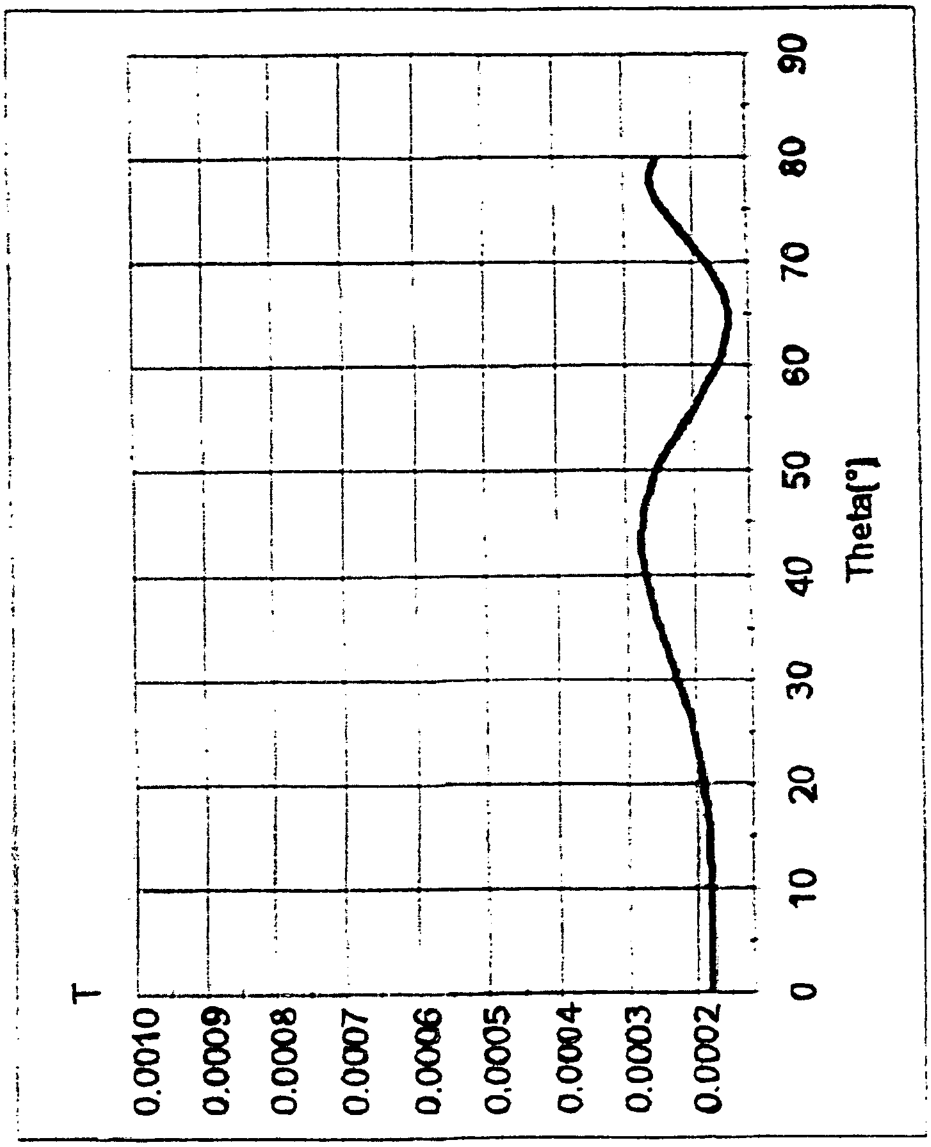
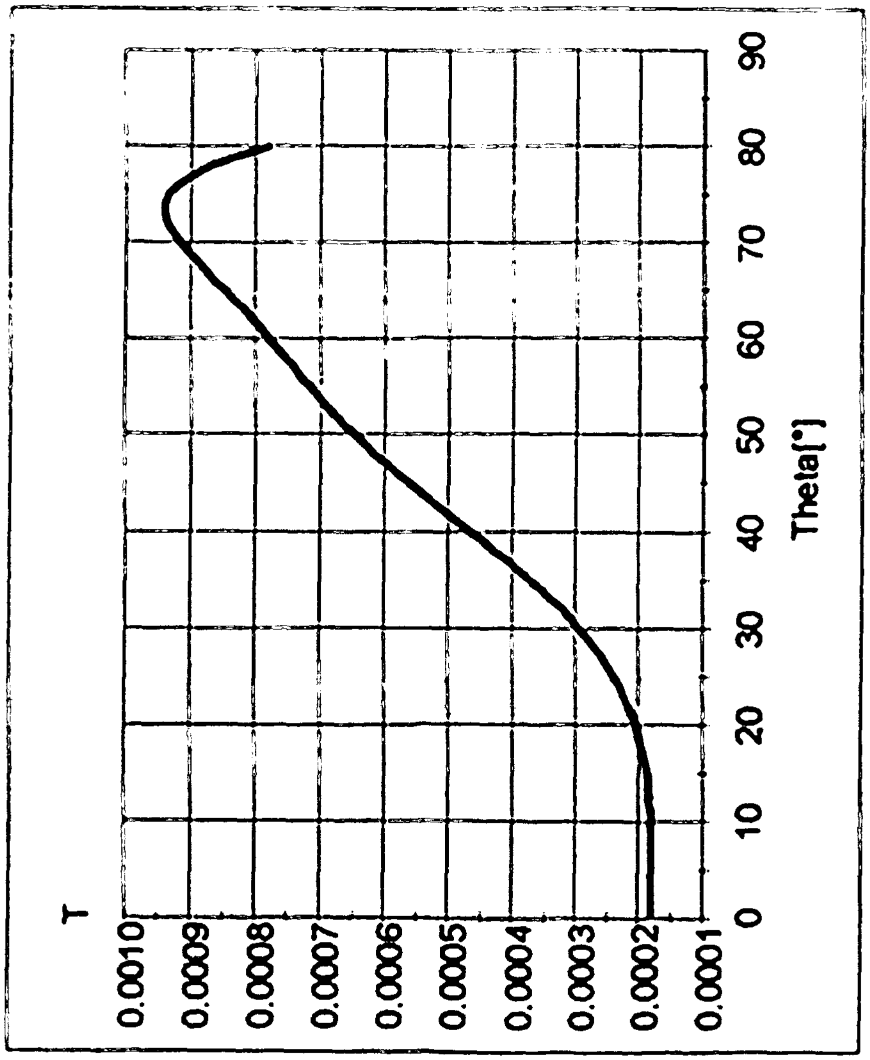

$R_{In,\lambda}/R_{In,550}$
$R_{th,\lambda}/R_{th,550}$
Wavelength [nm]
in-plain retardation R(λ)/R(550 nm)
400
450
500
550
600
650
700
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6

FIGURE 5a


T
0.0010
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0
10
20
30
40
50
60
70
80
90
Theta[°]

(a)

FIGURE 5b


T
0.0010
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
10
20
30
40
50
60
70
80
90
Theta[°]

(b)

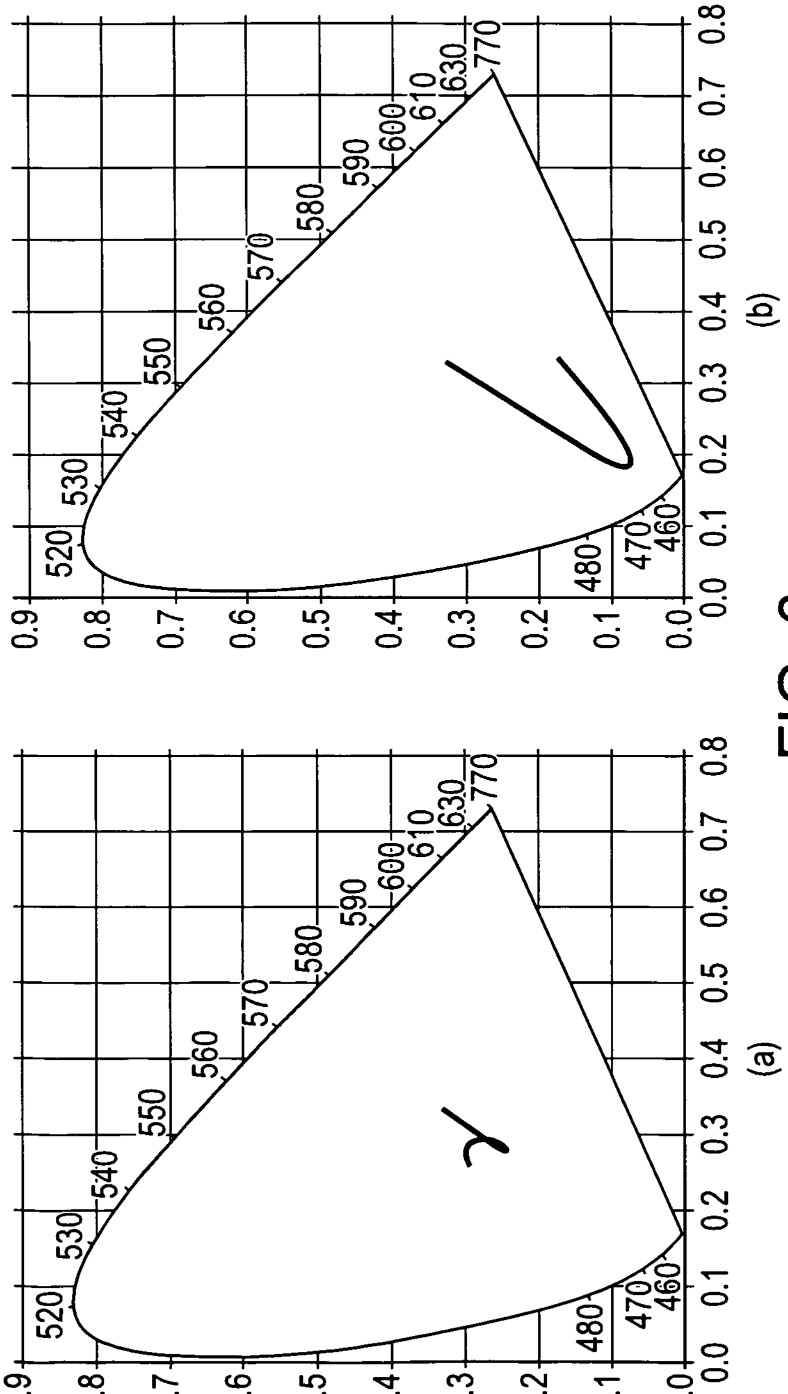


FIG. 6

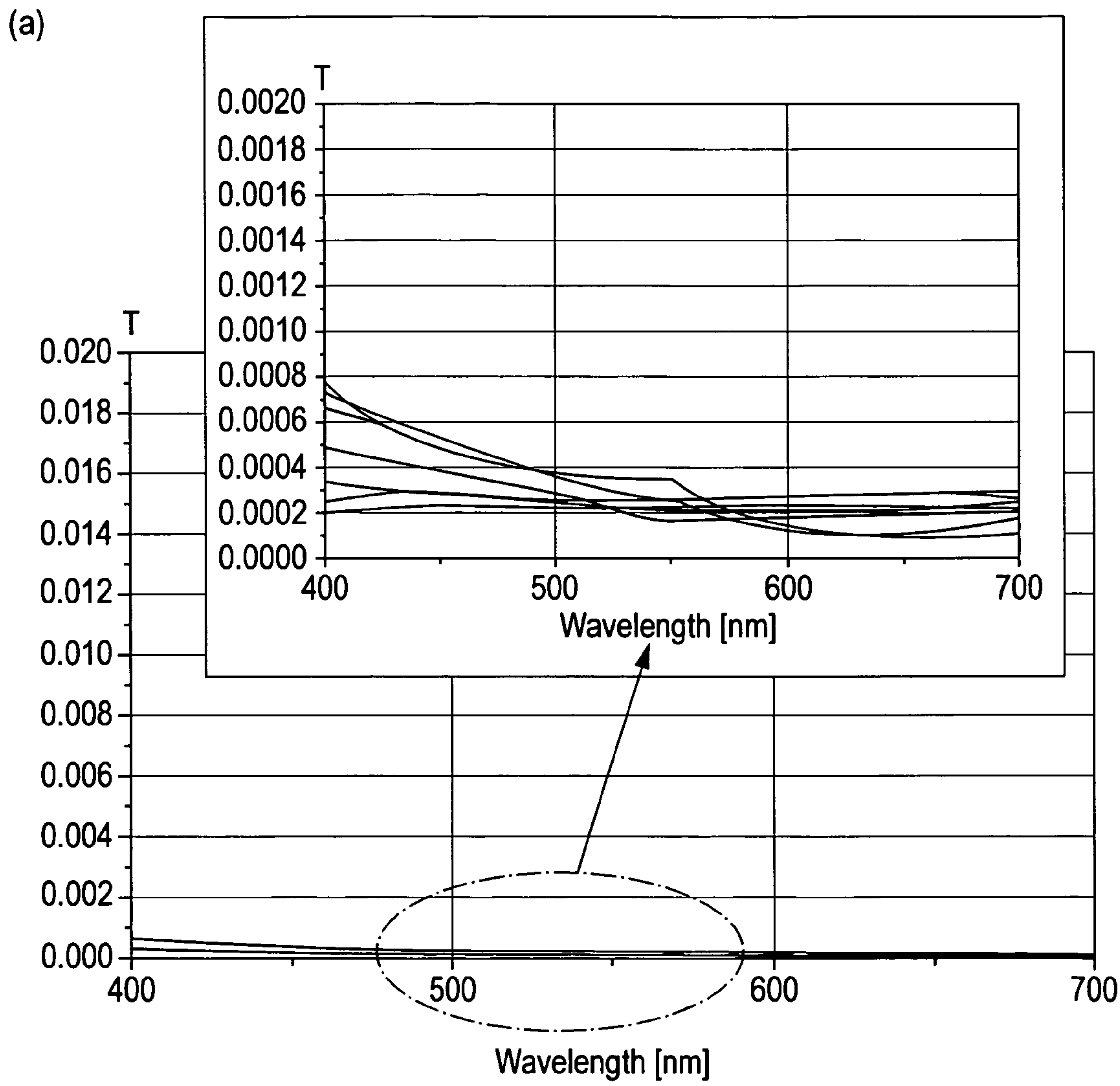

(a)
T
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
400
500
600
700
Wavelength [nm]
T
0.0020
0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
400
500
600
700
Wavelength [nm]

FIG. 7

(b)

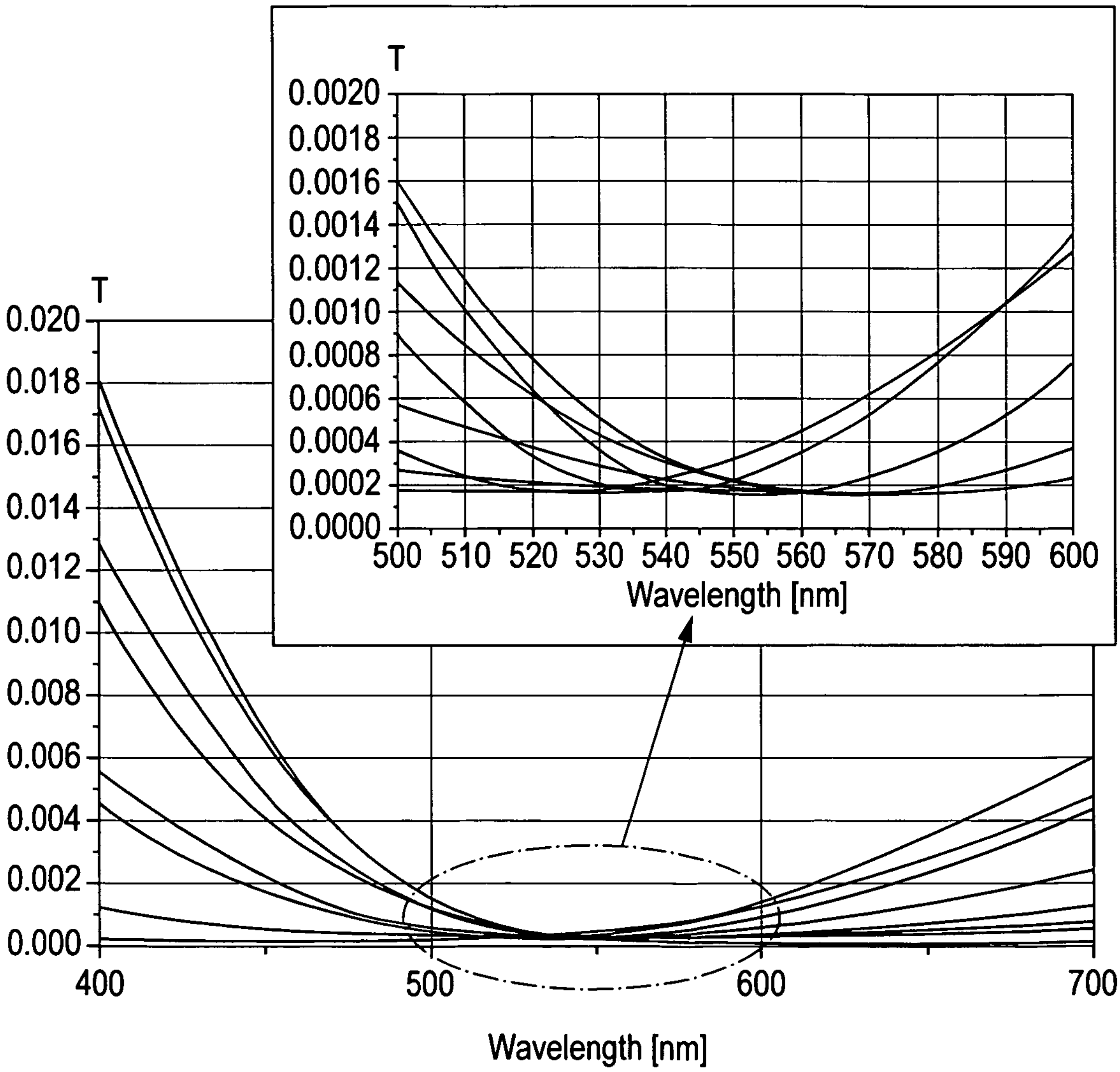

T
0.0020
0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
500 510 520 530 540 550 560 570 580 590 600
Wavelength [nm]
T
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
400
500
600
700
Wavelength [nm]

FIG. 7 Cont'd

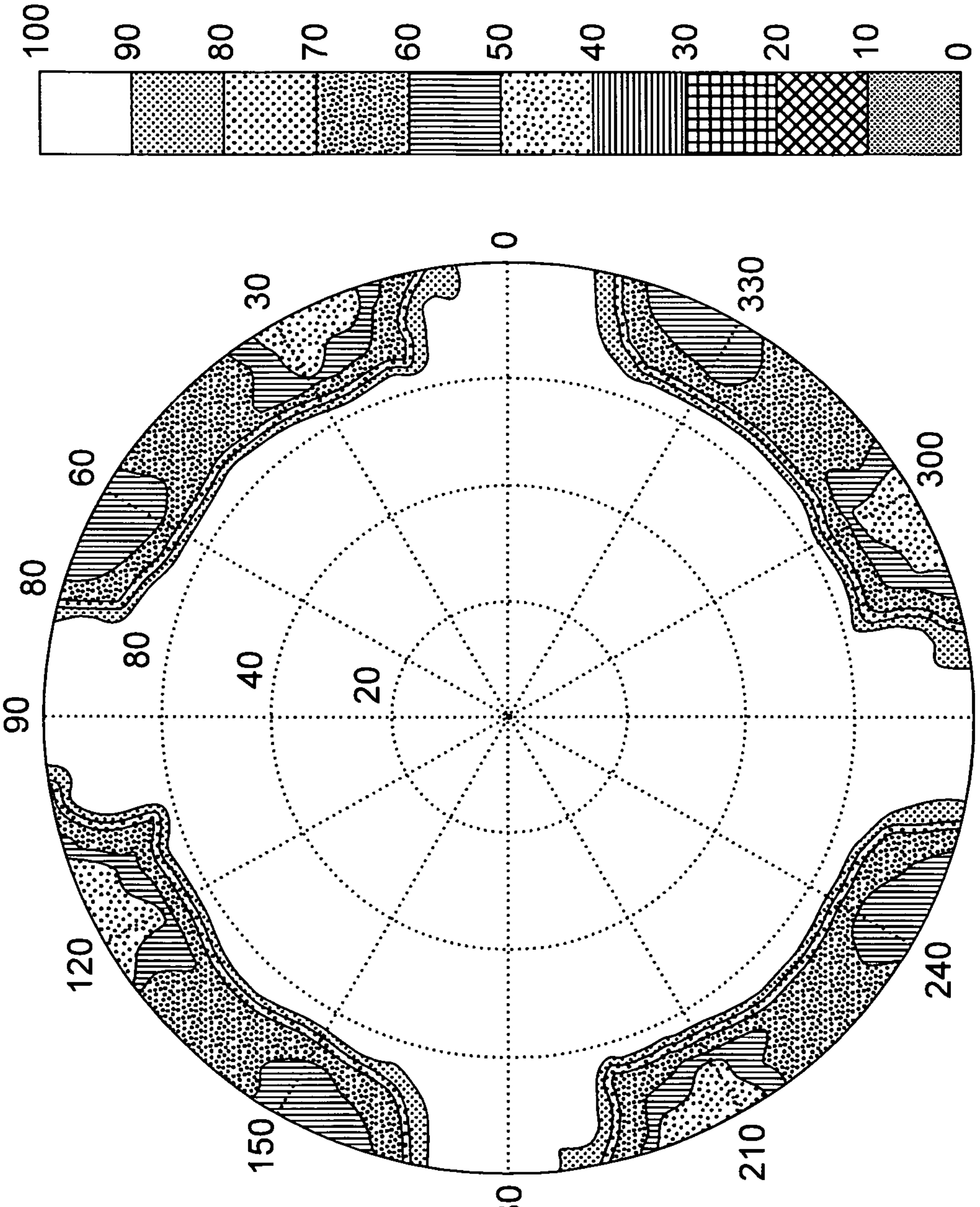

100
90
80
70
60
50
40
30
20
10
0
0
30
60
80
90
120
150
180
210
240
270
300
330
80
40
20

FIG. 8

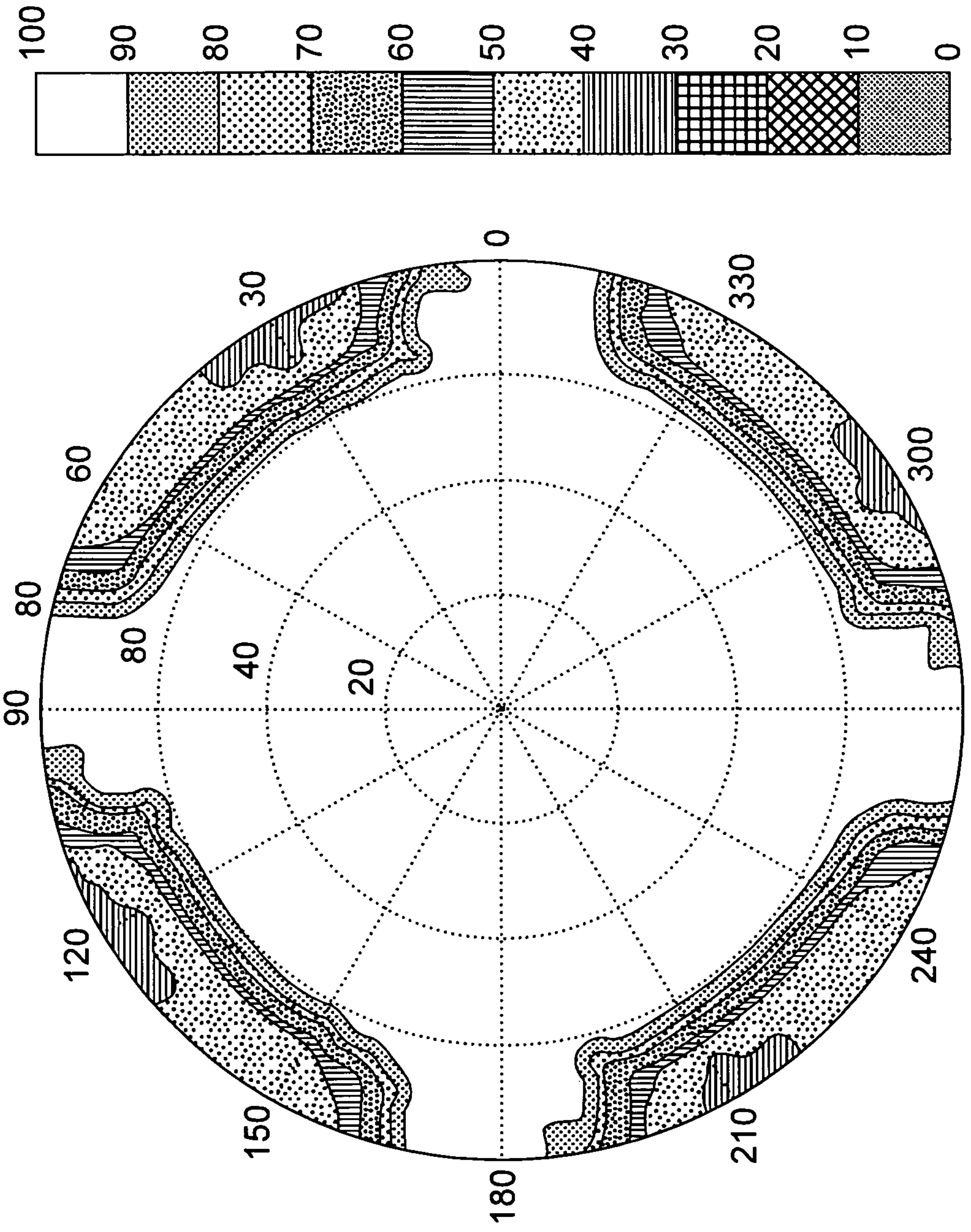
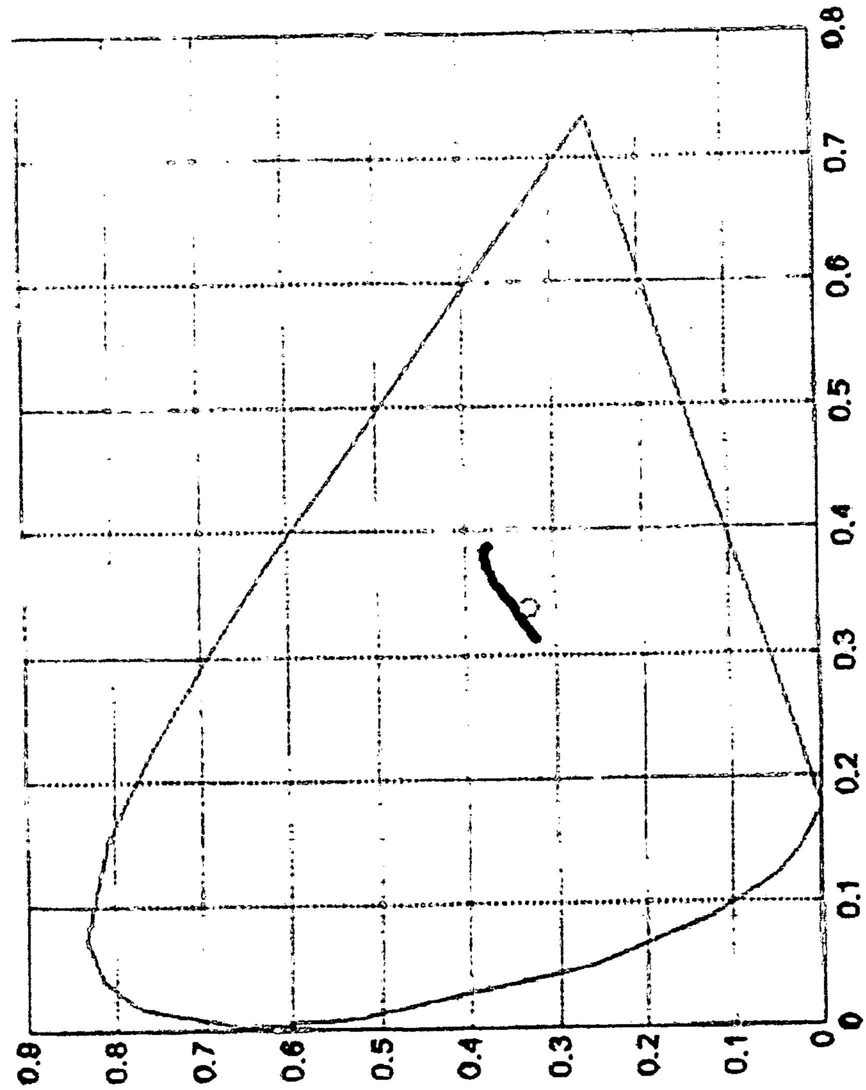

100
90
80
70
60
50
40
30
20
10
0
0
30
60
80
90
120
150
180
210
240
270
300
330
80
40
20

FIG. 9

FIGURE 10



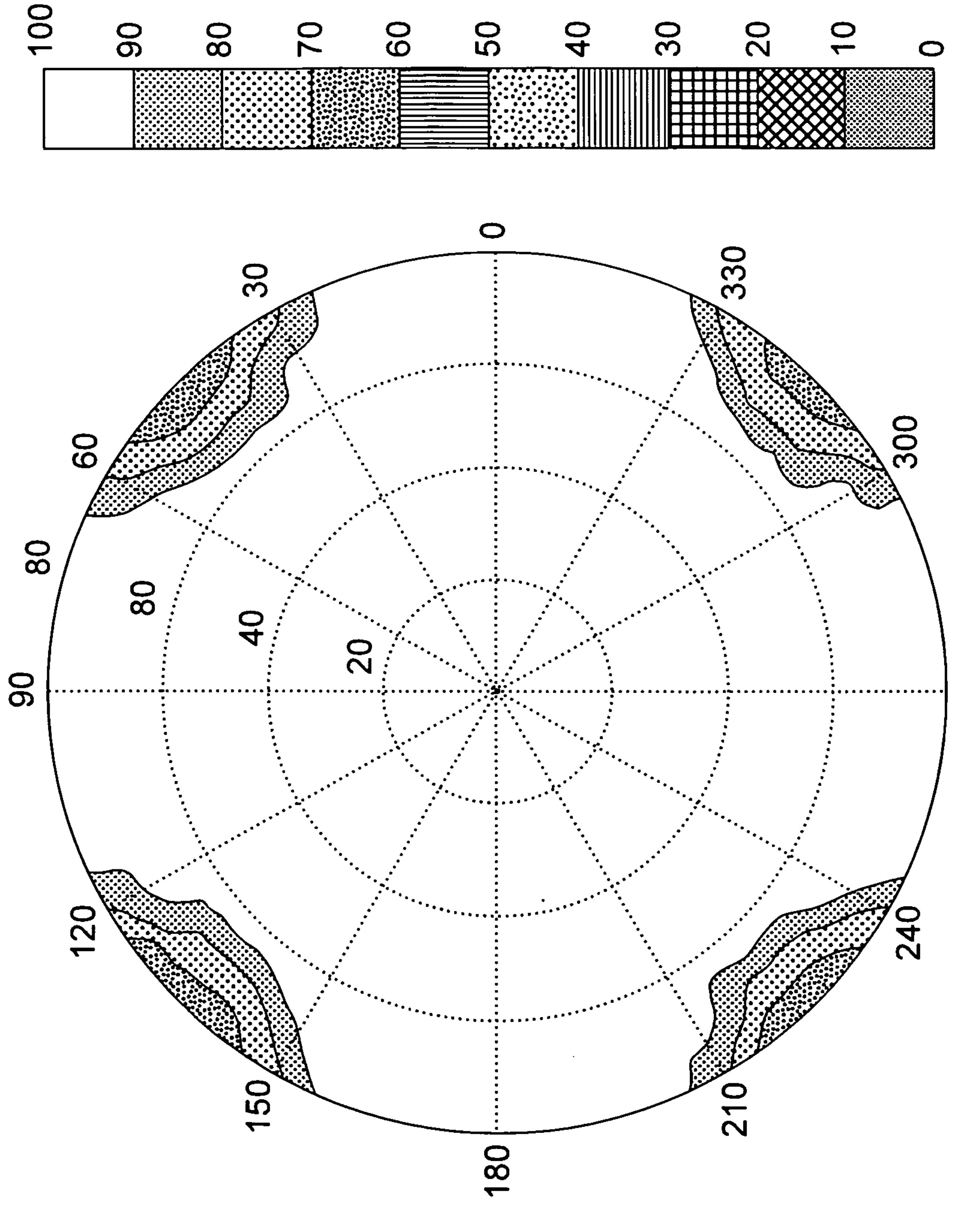
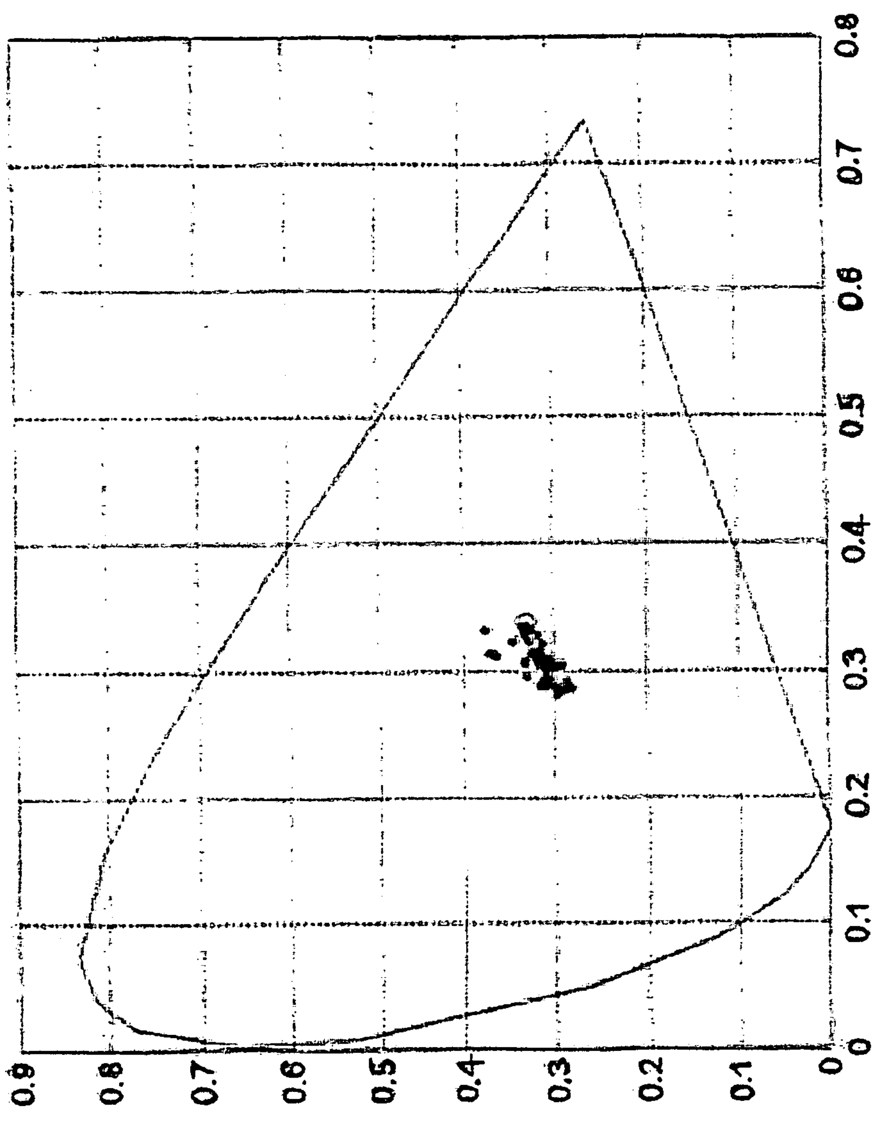

100
90
80
70
60
50
40
30
20
10
0
0
30
60
80
90
120
150
180
210
240
270
300
330
80
40
20

FIG. 11

FIGURE 12



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 4889412 A **[0002]**
- US 6141075 A **[0004]**
- JP 2000131693 A **[0007]**
- WO 0109649 A1 **[0008]**

专利名称(译)	使用双轴延迟补偿膜的垂直取向液晶显示器		
公开(公告)号	EP2485088B1	公开(公告)日	2019-12-18
申请号	EP2012154854	申请日	2004-01-27
[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 BELYAEV SERGEY YU JEONG SU		
发明人	JEON, BYOUNG-KUN BELYAEV, SERGEY YU, JEONG SU		
IPC分类号	G02F1/139 G02F1/13363		
CPC分类号	G02F1/133634 G02F1/1393 G02F2001/133637		
优先权	1020030005468 2003-01-28 KR PCT/KR2004/000133 2004-01-27 WO		
其他公开文献	EP2485088A3 EP2485088A2		
外部链接	Espacenet		

摘要(译)

公开了一种使用双轴延迟补偿膜的垂直取向液晶显示器（“VA-LCD”），其能够改善视角特性。

FIGURE 1

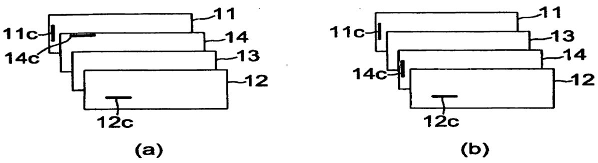

FIGURE 2