US 20020135723A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2002/0135723 A1
(43) Pub. Date: Sep. 26, 2002
Wong

(54) MULTI-DOMAIN FLAT DISPLAY

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(21) Appl. No.: 10/097,050

(22) Filed: Mar. 12, 2002

(30) Foreign Application Priority Data

Mar. 20, 2001 (TW) 90106432

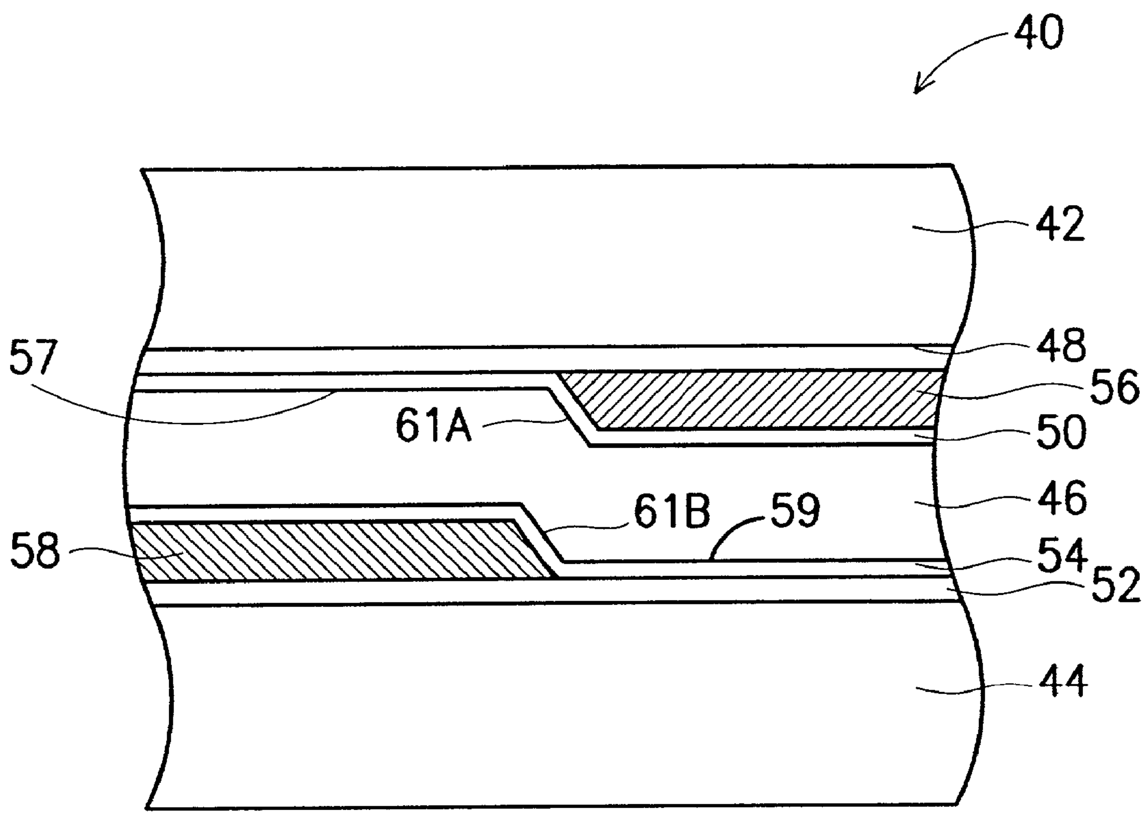
Publication Classification

(51) Int. Cl.^{7} G02F 1/1337

(52) U.S. Cl. 349/123

(57) ABSTRACT

A multi-domain liquid crystal display (LCD) has a plurality of first alignment-control structures arranged on an inner surface of an upper substrate, and a plurality of second alignment-control structures arranged on an inner surface of a lower substrate. An upper concave is formed between two adjacent first alignment-control structures, and an upper inclined plane is formed between the upper concave and the first alignment-control structure. A lower concave is formed between two adjacent second alignment-control structures, and a lower inclined plane is formed between the lower concave and the second alignment-control structure. Each first alignment-control structure is positioned above a corresponding lower concave, each second alignment-control structure is positioned under a corresponding upper concave, and the upper inclined plane is close to and faces the lower inclined plane.



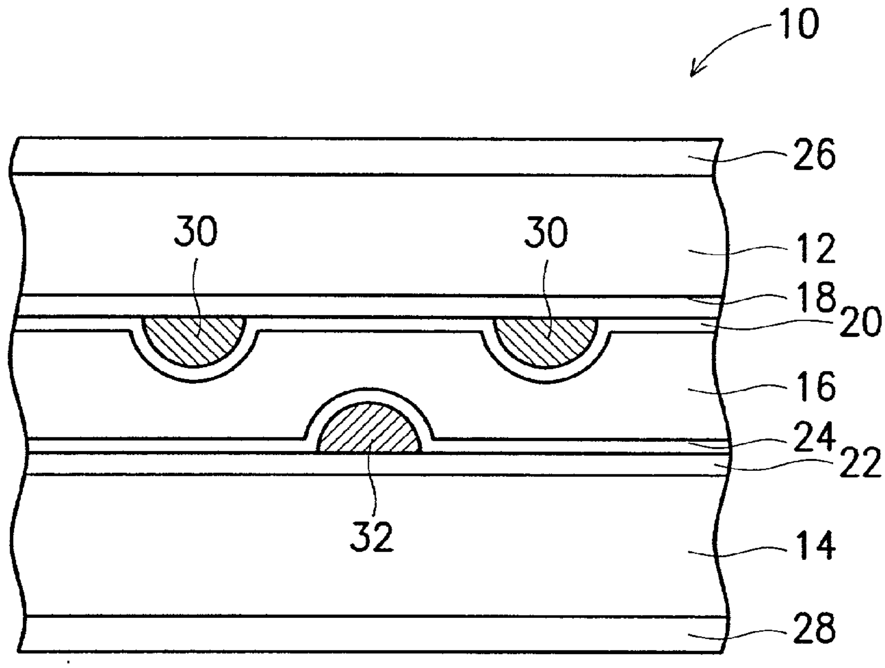


FIG. 1 (PRIOR ART)

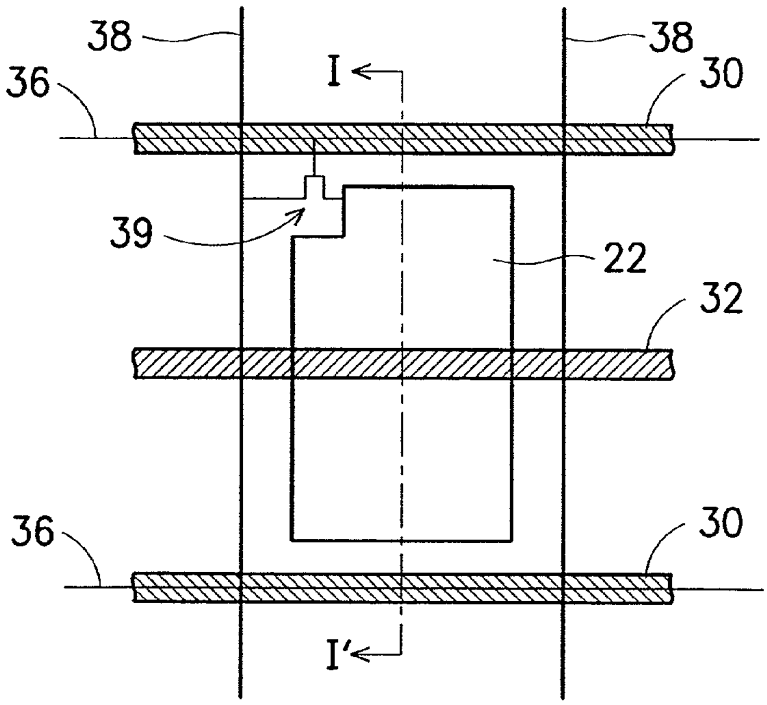


FIG. 2 (PRIOR ART)

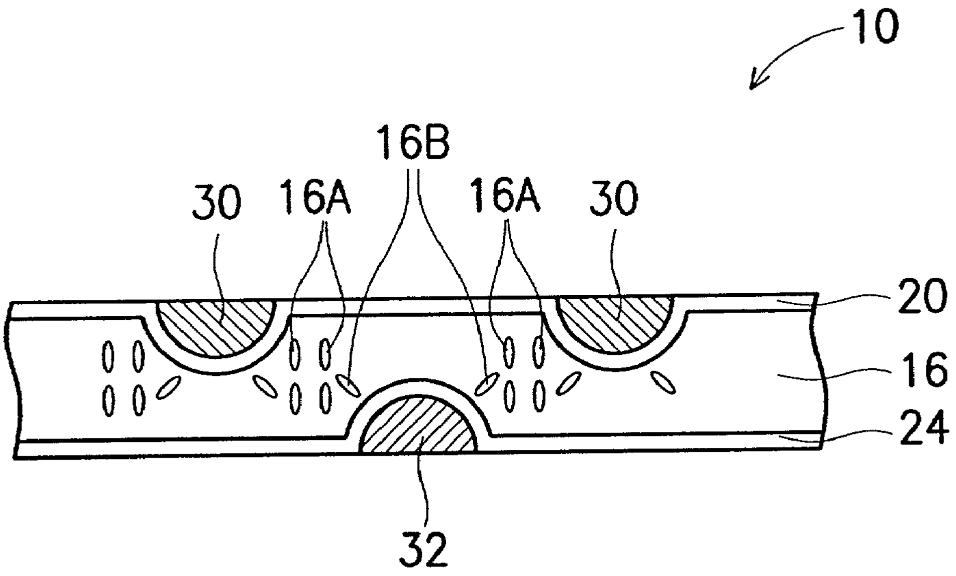


FIG. 3 (PRIOR ART)

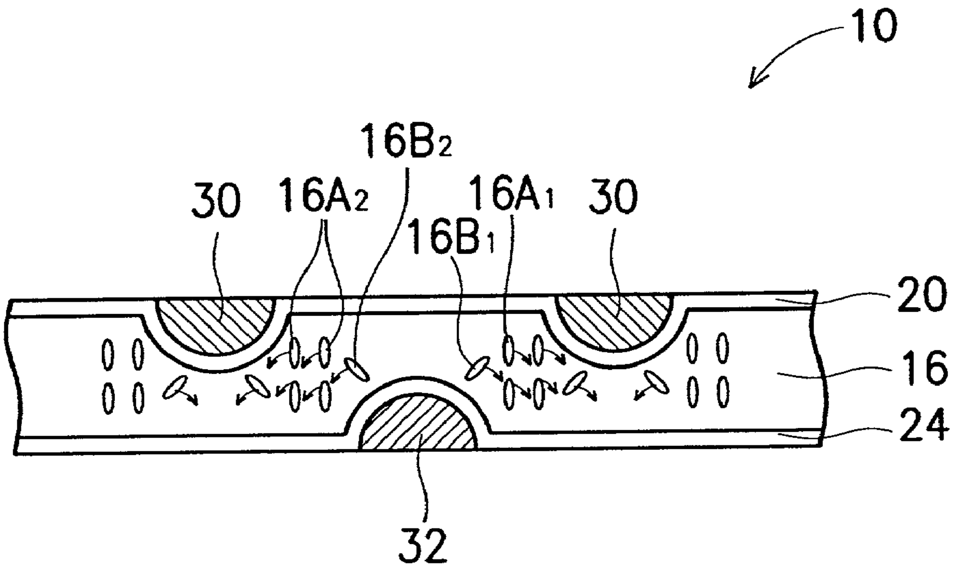


FIG. 4 (PRIOR ART)

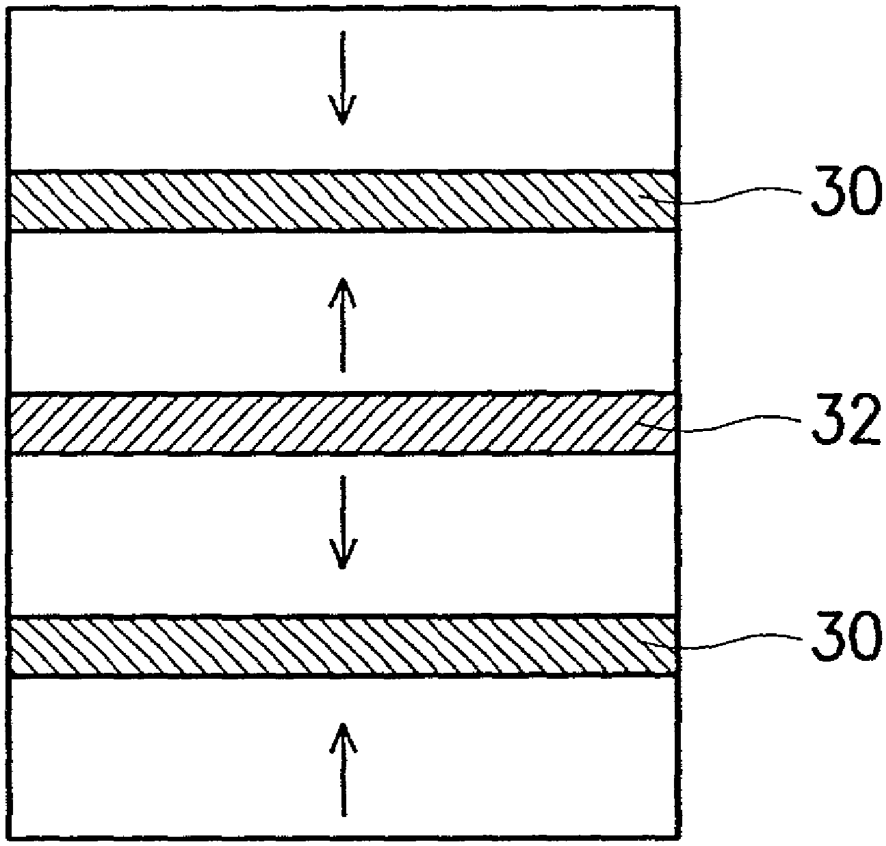


FIG. 5 (PRIOR ART)

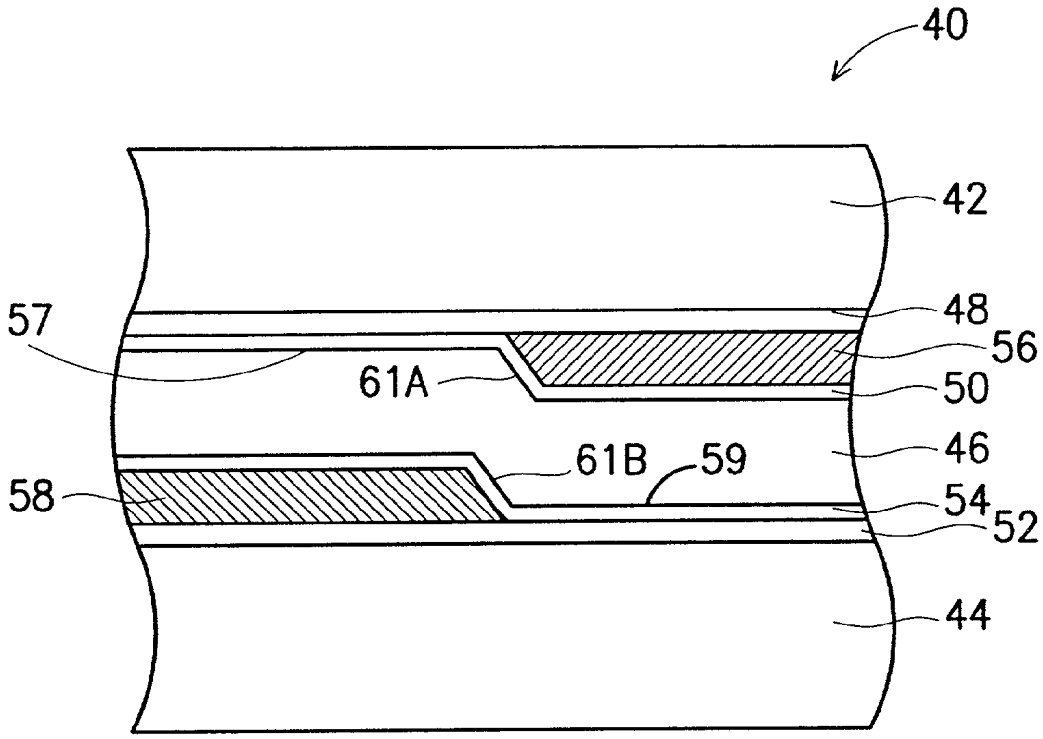

40
42
48
56
50
46
54
52
44
57
61A
58
61B
59

FIG. 6

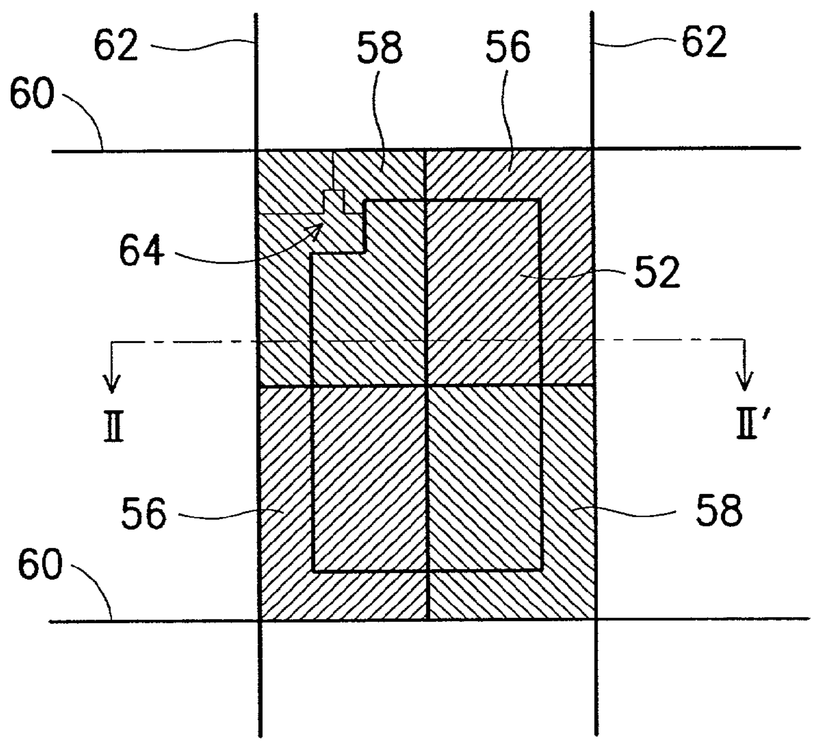

62
58
56
62
60
64
52
II
II'
56
58
60

FIG. 7

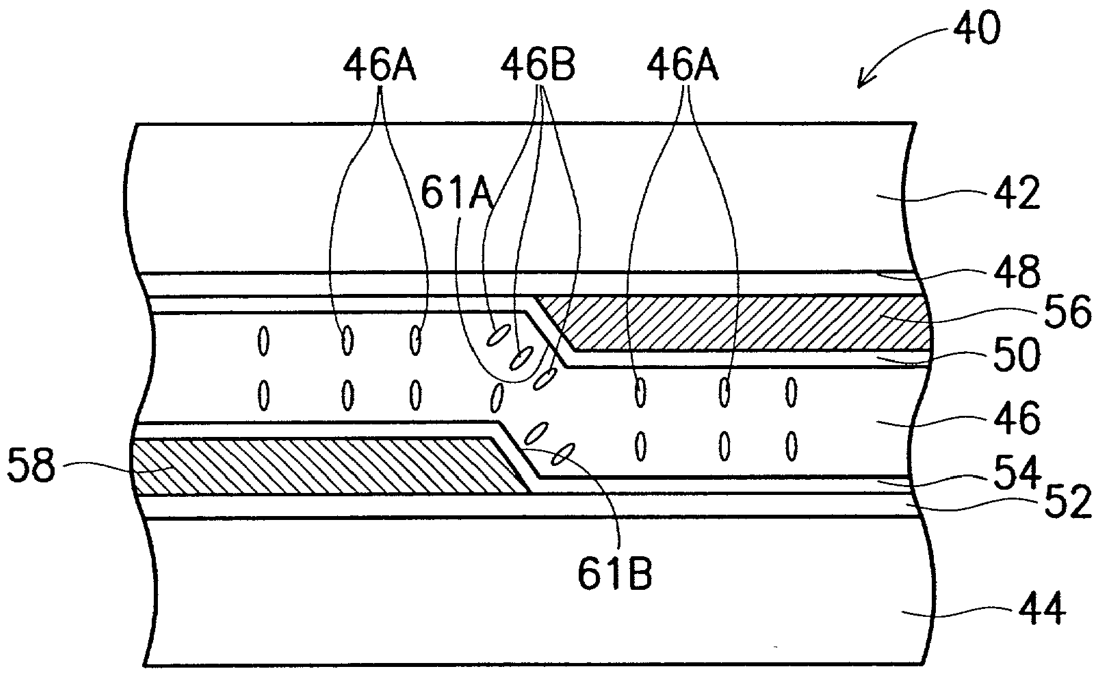

40
46A
46B
46A
61A
42
48
56
50
46
58
54
52
61B
44

FIG. 8A

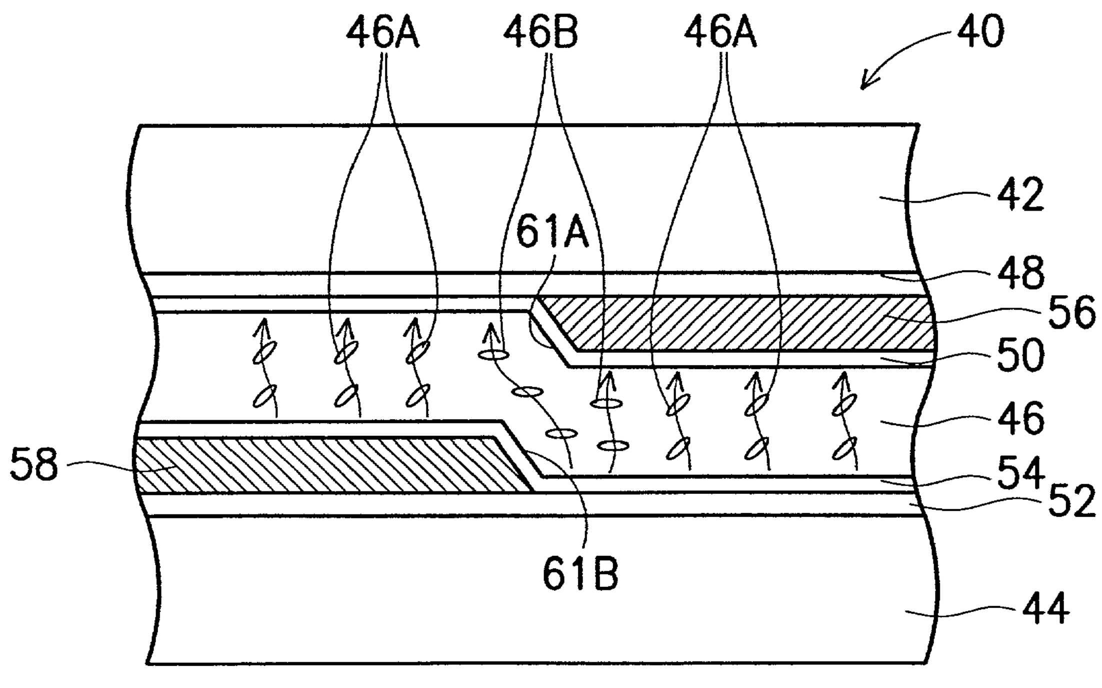

46A
46B
46A
40
42
61A
48
56
50
46
58
54
52
61B
44

FIG. 8B

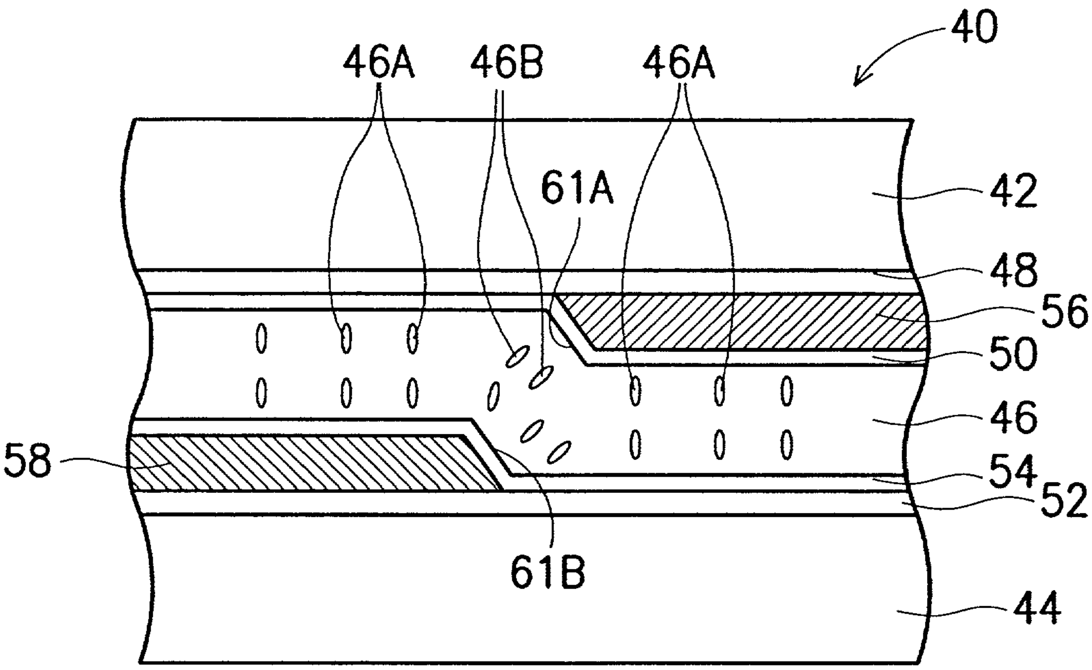

40
46A
46B
46A
61A
42
48
56
50
46
58
54
52
61B
44

FIG. 9A

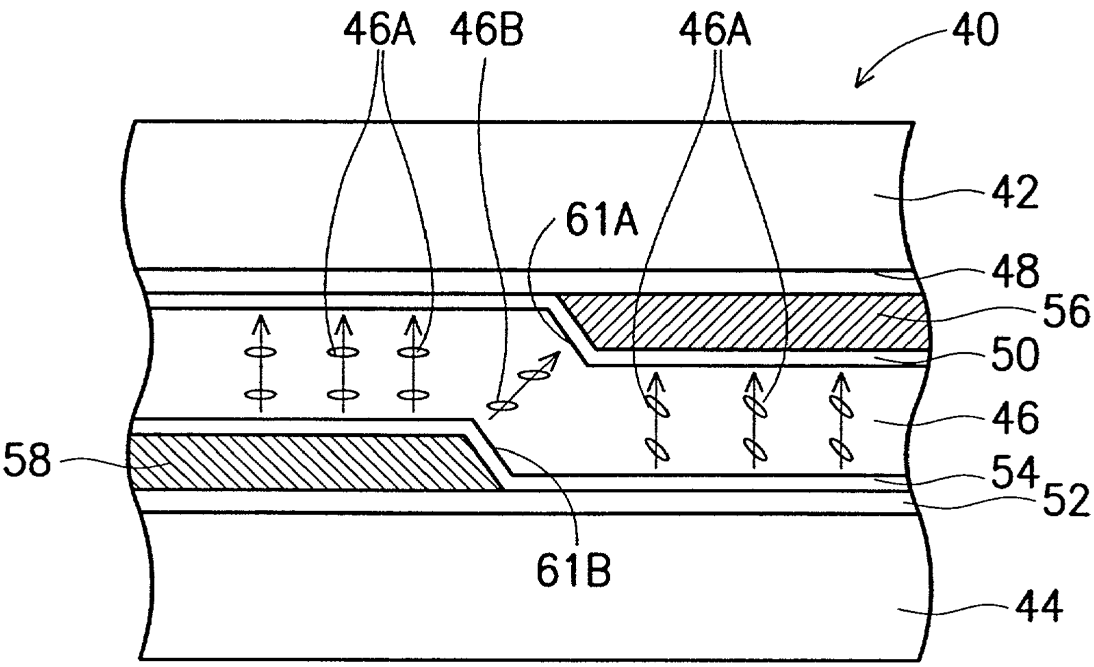

40
46A
46B
46A
61A
42
48
56
50
46
58
54
52
61B
44

FIG. 9B

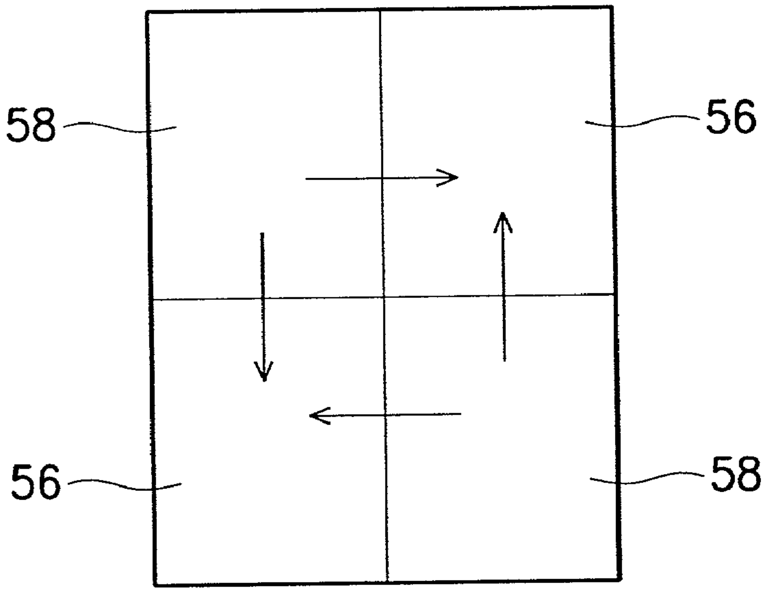


FIG. 10A

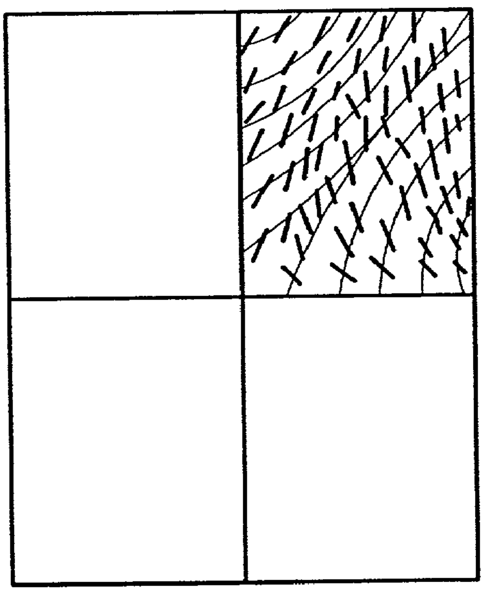


FIG. 10B

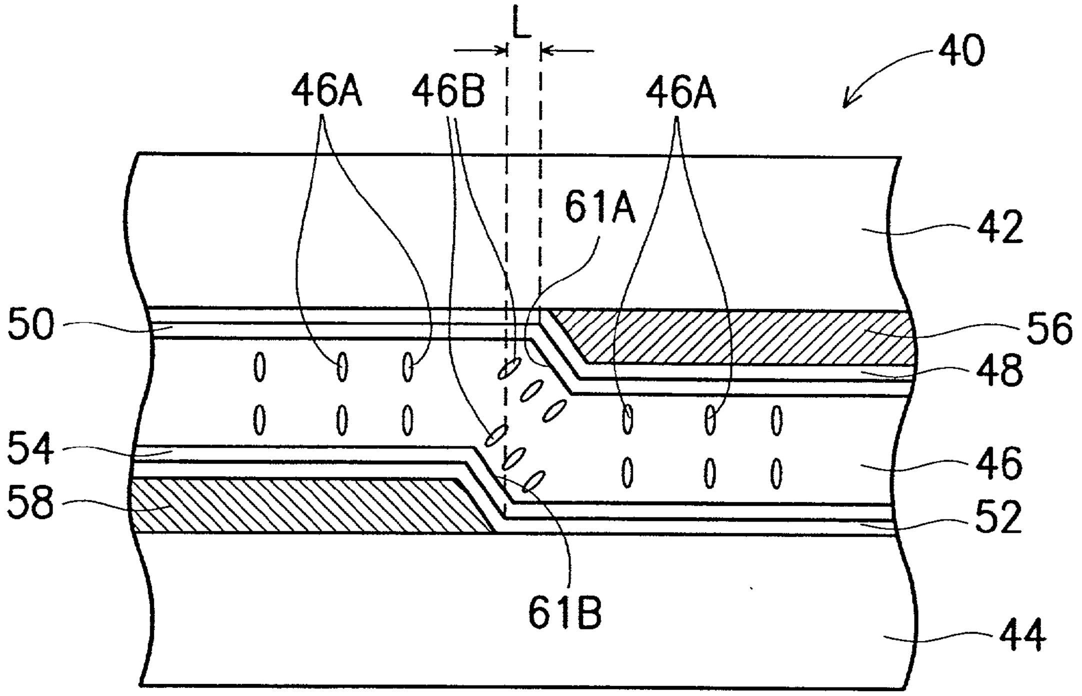

L
40
46A
46B
46A
61A
42
50
56
48
54
46
58
52
61B
44

FIG. 11

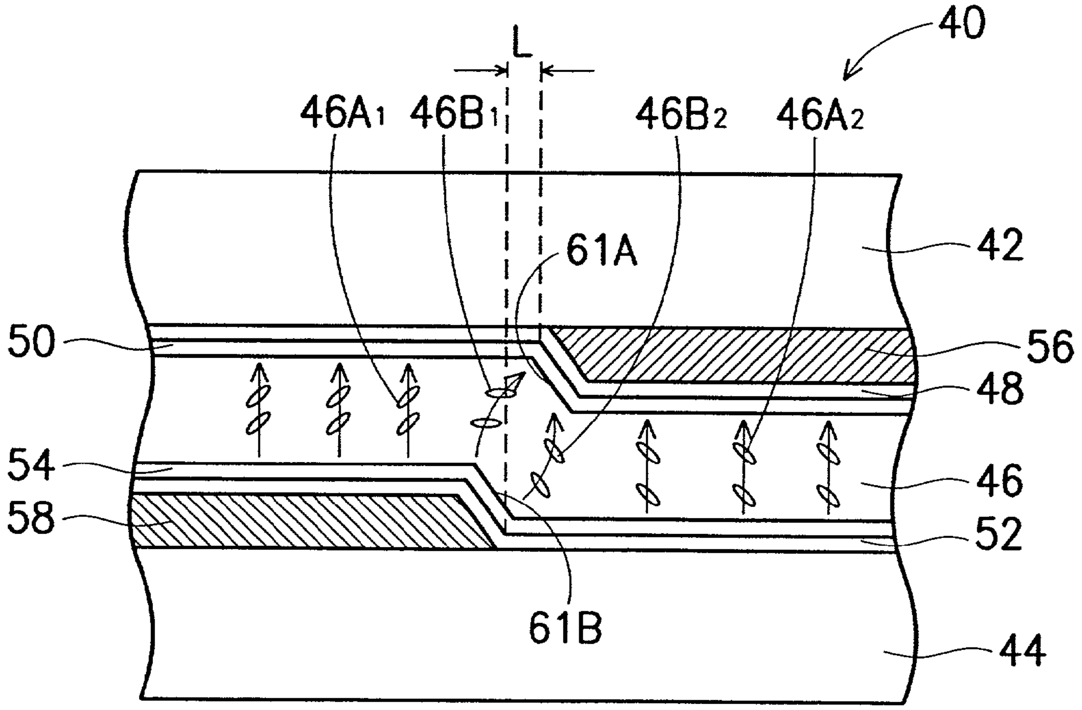

L
40
46A1
46B1
46B2
46A2
61A
42
50
56
48
54
46
58
52
61B
44

FIG. 12

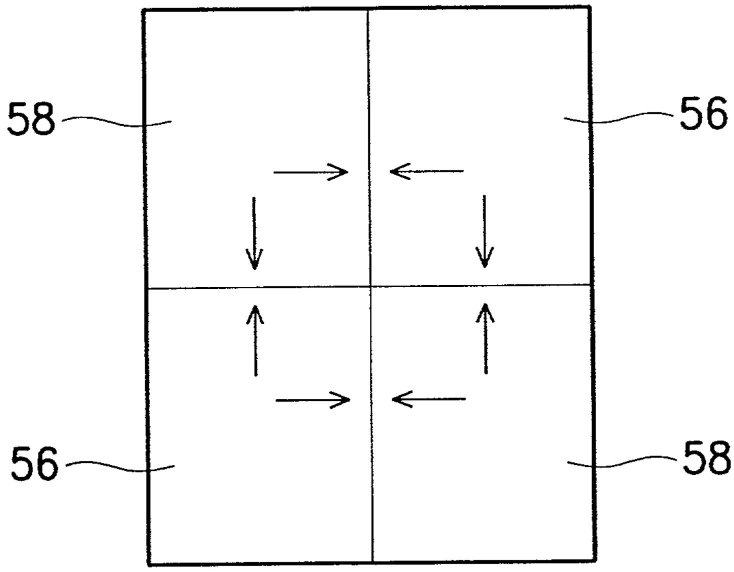


FIG. 13A

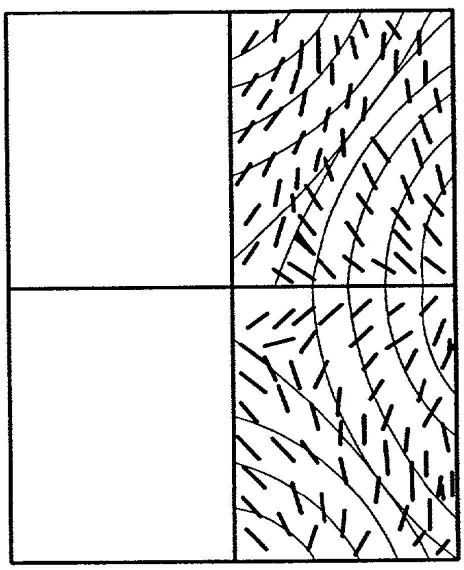


FIG. 13B

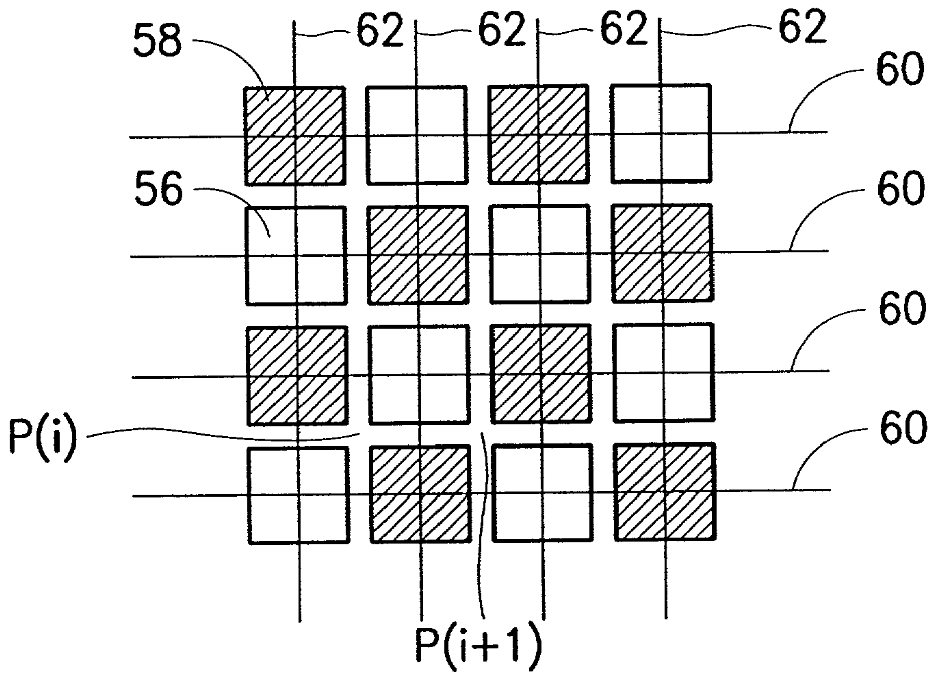


FIG. 14

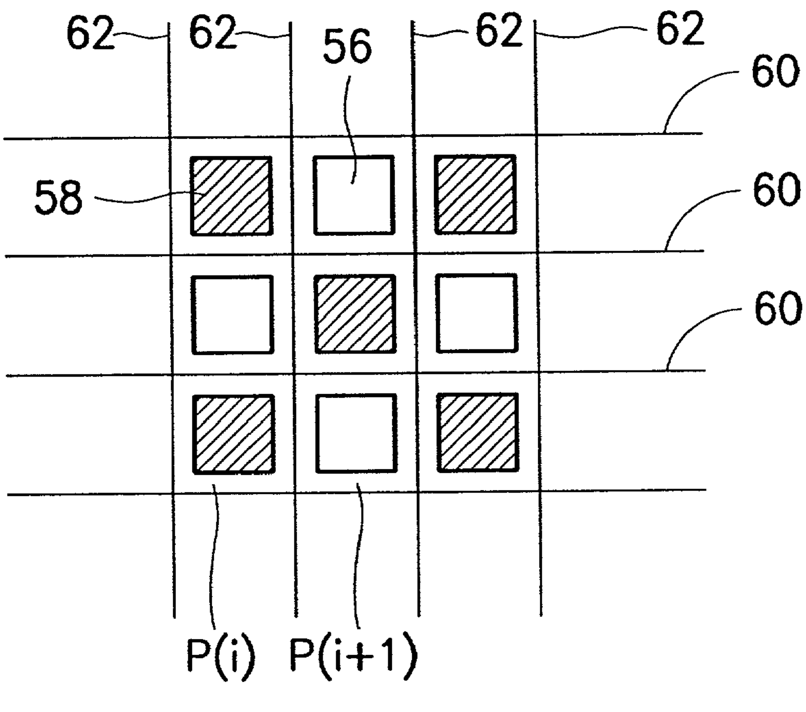


FIG. 15

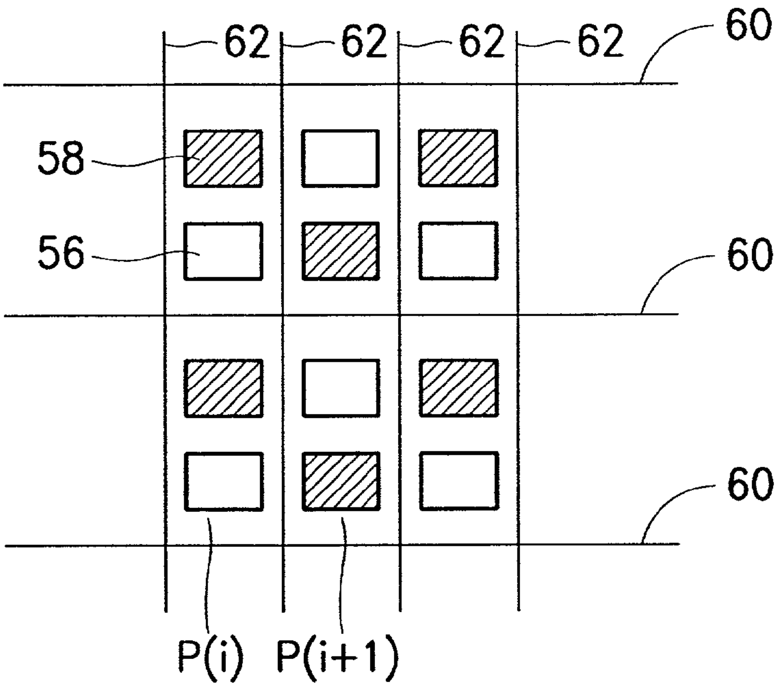


FIG. 16

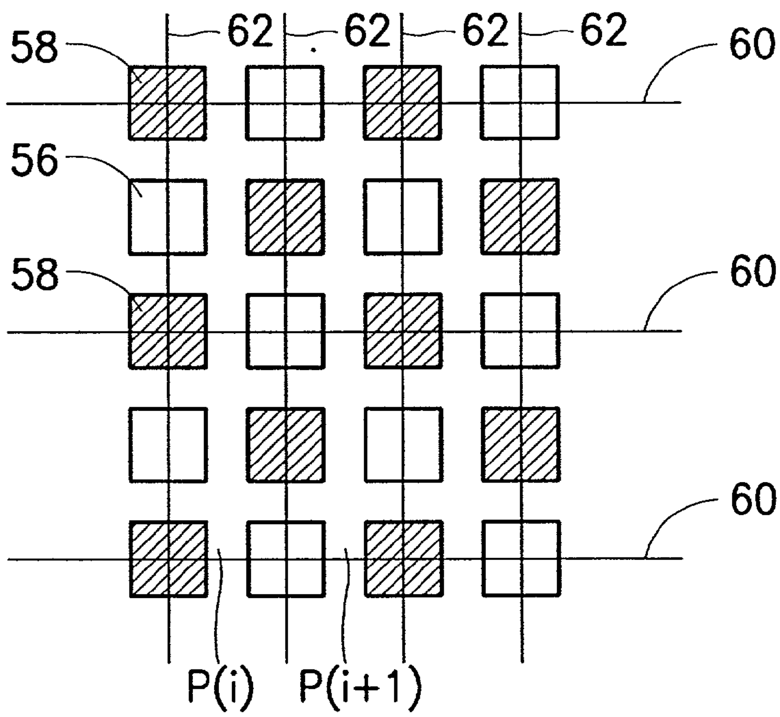


FIG. 17

MULTI-DOMAIN FLAT DISPLAY

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a liquid crystal display (LCD) and, more particularly, to a multi-domain LCD.

[0003] 2. Description of the Related Art

[0004] Applied a voltage to a liquid crystal display (LCD) changes the alignment of liquid crystal molecules, and then the resulting optical characteristics, such as double refraction, optical rotation, dichromatism, optical confusion and optical scattering cause display variations. Compared with the electric-optical materials used in other optical devices, liquid crystal molecules can distribute substantial variations in optical characteristics with low voltage and low power consumption, and without further treatments. In addition, LCD has the advantages of a thin profile and a lightweight. Therefore, as we know, LCDs play an important role in the flat display market.

[0005] Display modes in LCDs differ with each other according to different types of liquid crystal molecules utilized therein. One mode, electrically controlled birefringence (ECB), employs an applied electric field to control the multi-refraction characteristics of the liquid crystal molecules. For example, nematic liquid crystal molecules having a negative anisotropy of dielectric constant are utilized together with a vertical alignment layer. When the applied voltage exceeds a threshold voltage, the liquid crystal molecules that are originally aligned perpendicular to the vertical alignment layer will rotate to an angle corresponding to the applied electric field. As well, to further control the alignment of the liquid crystal molecules, an alignment-control structure is fabricated to increase the number of alignment domain in each pixel area. It is thus possible to reach the goals of wide view angle and high contrast.

[0006] Referring to **FIG. 1** and **FIG. 2**, **FIG. 2** is a top view of the alignment-control structure in a conventional LCD cell **10**, and **FIG. 1** is a schematic cross-sectional diagram along line I-I' of **FIG. 2**. As shown in **FIG. 1**, the LCD cell **10** comprises an upper glass substrate **12**, a lower glass substrate **14**, and a liquid crystal layer **16** with a negative anisotropy of dielectric constant filling in the space between the two glass substrates **12** and **14**. Two electrodes **18** and **22** and two vertical alignment layers **20** and **24** are respectively formed on the inner surface of the glass substrates **12** and **14**. Two polarizers **26** and **28** are respectively formed on the outer surface of the glass substrates **12** and **14**. In general, the upper glass substrate **12** serves as a color filter substrate. The lower glass substrate **14** serves as a thin film transistor (TFT) substrate where a plurality of TFTs and active matrix drive circuits are formed. The electrode **22** on the lower glass substrate **14** serves as a pixel electrode **22**. Furthermore, the LCD cell **10** has a plurality of first strip-shaped protrusions **30** and second strip-shaped protrusions **32** respectively formed above the electrodes **18** and **22** to serve as the alignment-control structures.

[0007] As shown in **FIG. 2**, two transversely-extending gate lines **36** and two lengthwise-extending signal lines **38** define a pixel area. A TFT structure **39** is formed near the intersection of the gate line **36** and the signal line **38**, and the pixel electrode **22** is formed on the pixel area. On the upper glass substrate **12**, the first strip-shaped protrusions **30** extend transversely and pass through the gate lines **36**. On the lower glass substrate **14**, the second strip-shaped protrusion **32** extends transversely and passes through the center of the pixel electrode **22**. In this way, the first protrusions **30** and the second protrusions **32** extend in parallel to each other and are arranged alternately.

[0008] **FIGS. 3 and 4** are schematic diagrams showing the variation in alignment of the liquid crystal molecules. As shown in **FIG. 3**, when no voltage is applied, the liquid crystal layer **16** having a negative anisotropy of dielectric constant is arranged between the vertical alignment layers **20** and **24**, all the liquid crystal molecules in the liquid crystal layer **16** are aligned perpendicular to the vertical alignment layers **20** and **24**, respectively. For example, the liquid crystal molecules **16A** are aligned perpendicular to the glass substrates **12** and **14**. The liquid crystal molecules **16B** above the protrusions **30** and **32** are vertical to the perpendicular alignment layers **20** and **24** above the protrusions **30** and **32**, so that the liquid crystal molecules **16B** above the protrusions **30** and **32** are positioned at an angle to the glass substrates **12** and **14**.

[0009] As shown in **FIG. 4**, after the voltage is applied to the LCD cell **10**, the liquid crystal molecules will rotate perpendicular to the electric field. The arrows show the rotating directions of the liquid crystal molecules. For example, the liquid crystal molecules $\mathbf{16B_1}$, aligned from the upper right toward the lower left in the beginning, and will be rotated in a clockwise direction after the voltage is applied so that the liquid crystal molecules $\mathbf{16B_1}$ fall in the direction parallel to the vertical alignment layers **20** and **24**. Consequently, the adjacent liquid crystal molecules $\mathbf{16A_1}$ will rotate in a clockwise direction according to the behavior of the liquid crystal molecules $\mathbf{16_{B1}}$. In a similar manner, the liquid crystal molecules $\mathbf{16B_2}$ are positioned from the upper left toward the lower right in the beginning, and then fall in the direction parallel to the vertical alignment layers **20** and **24** and rotate in a counterclockwise direction while the voltage is applied. As a result, the adjacent liquid crystal molecules $\mathbf{16A_2}$ will rotate in a counterclockwise direction according to the behavior of the liquid crystal molecules $\mathbf{16B_2}$.

[0010] **FIG. 5** is a top view showing the alignment domain of the liquid crystal layer **16**. After a voltage is applied, these liquid crystal molecules will rotate to parallel to the direction of electric field. Upon application of voltage to the LCD cell **10**, part of the liquid crystal molecules $\mathbf{16A_1}$ and $\mathbf{16B_1}$ rotate in a clockwise direction and another part of liquid crystal molecules $\mathbf{16A_2}$ and $\mathbf{16B_2}$ rotates in a counterclockwise direction. Accordingly, two alignment domains are formed both sides of the second protrusion **32** in a pixel area. The arrows show the alignment direction.

[0011] However, since the alignment-control structure only forms two domains in a pixel area, this cannot satisfy the requirements of a wide view angle and a high contrast in the LCD. Also, the alignment-control structure is the strip-shaped protrusions **30** and **32**, so the aperture ratio of the LCD is reduce, resulting in decreased brightness and lower contrast. Thus, a multi-domain LCD solving the aforementioned problems is called for.

SUMMARY OF THE INVENTION

[0012] The present invention provides rectangular protrusions in one pixel area to serve as the alignment-control structure.

[0013] The LCD includes an upper substrate having an upper electrode on the inner surface of the upper substrate, a lower substrate having a lower electrode on the inner surface of the lower substrate, and a liquid crystal layer with a negative anisotropy of dielectric constant filling the space between the upper substrate and the lower substrate. An electric field is formed between the upper electrode and the lower electrode. A plurality of first alignment-control structures are arranged on the inner surface of the upper substrate, an upper concave is formed between two adjacent first alignment-control structures, and an upper inclined plane is formed between the upper concave and the first alignment-control structure. A plurality of second alignment-control structures are arranged on the inner surface of the lower substrate, a lower concave is formed between two adjacent second alignment-control structures, and a lower inclined plane is formed between the lower concave and the second alignment-control structure. The first alignment-control structure is positioned above the lower concave, and the second alignment-control structure is positioned under the upper concave. The first alignment-control structure and the corresponding lower concave have a first substantially equal size. The second alignment-control structure and the corresponding upper concave have a second substantially equal size. The upper inclined plane is close to and faces the lower inclined plane.

[0014] Accordingly, it is an object of the invention to provide the alignment-control structures to achieve more than two domains in one pixel area.

[0015] It is another object of the invention to satisfy the requirements of a wide view angle and a high contrast

[0016] Yet another object of the invention is to improve the brightness and contrast so as to assure the display quality of the multi-domain LCD.

[0017] These and other objects of the present invention will become readily apparent upon further review of the following specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] **FIG. 1** is a schematic cross-sectional diagram showing a conventional LCD cell **10**.

[0019] **FIG. 2** is a top view of the alignment-control structure shown in **FIG. 1**.

[0020] **FIGS. 3 and 4** are schematic diagrams showing the variation in alignment of the liquid crystal molecules.

[0021] **FIG. 5** is a top view showing the alignment domain of the liquid crystal layer shown in **FIG. 1**.

[0022] **FIG. 6** is a schematic cross-sectional diagram showing an LCD cell according to the first embodiment of the present invention.

[0023] **FIG. 7** is a top view of alignment-control structures shown in **FIG. 6**.

[0024] **FIGS. 8A and 8B** are schematic diagrams showing the variation in alignment of the liquid crystal layer when no voltage is applied as shown in **FIG. 6**.

[0025] **FIGS. 9A and 9B** are schematic diagrams showing the variation in alignment of the liquid crystal layer when a voltage is applied as shown in **FIG. 6**.

[0026] **FIG. 10A** is a top view showing the alignment domain of the liquid crystal layer according to the first embodiment of the present invention.

[0027] **FIG. 10B** is a top view showing the rotating direction of the liquid crystal molecules according to the first embodiment of the present invention.

[0028] **FIGS. 11 and 12** are schematic cross-sectional diagrams showing the variation in alignment of the liquid crystal layer according to the second embodiment of the present invention.

[0029] **FIG. 13A** is a top view showing the alignment domain of the liquid crystal layer according to the second embodiment of the present invention.

[0030] **FIG. 13B** is a top view showing the rotating direction of the liquid crystal molecules according to the second embodiment of the present invention.

[0031] **FIG. 14** is a top view of the first layout of the alignment-control structure according to the present invention.

[0032] **FIG. 15** is a top view of the second layout of the alignment-control structure according to the present invention.

[0033] **FIG. 16** is a top view of the third layout of the alignment-control structure according to the present invention.

[0034] **FIG. 17** is a top view of the fourth layout of the alignment-control structure according to the present invention.

[0035] Similar reference characters denote corresponding features consistently throughout the attached drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

[0036] Referring to **FIG. 6** and **FIG. 7**, **FIG. 6** is a schematic cross-sectional diagram showing an LCD cell according to the first embodiment of the present invention. **FIG. 7** is a top view of alignment-control structures. **FIG. 6** is a schematic cross-sectional diagram along line II-II' of **FIG. 7**. As shown in **FIG. 6**, an LCD cell **40** has an upper glass substrate **42**, a lower glass substrate **44**, and a liquid crystal layer **46** with a negative anisotropy of dielectric constant filling the space between the two glass substrates **42** and **44**. Two electrodes **48**, **52** and two vertical alignment layers **50**, **54** are respectively formed on the inner surface of the glass substrates **42** and **44**. The polarizers and color filters (not shown) may be position above the glass substrates **42** and **44**. In general, the upper glass substrate **42** is a color filter substrate. The lower glass substrate **44** is a thin film transistor (TFT) substrate, and a plurality of TFTs and active matrix drive circuits are formed thereon. The electrode **42** on the lower glass substrate **44** serves as a pixel electrode **52**. Furthermore, the upper glass substrate **42** has a first rectangular protrusion **56** with plane surface formed on the electrode **48**. The first rectangular protrusion **56** is covered by the vertical alignment layer **50** to serve as a first alignment-control structure **56**. The lower glass substrate **44** has a second rectangular protrusion **58** with plane surface formed on the electrode **52**. The second rectangular protrusion **58** is and covered by the vertical alignment layer **54** to serve as a second alignment-control structure **58**

[0037] As shown in **FIG. 7**, two transversely-extending gate lines **60** and two lengthwise-extending signal lines **62** define a rectangular pixel area, a thin film transistor (TFT) **64** is formed near the intersection of the gate line **60** and the signal line **62**, and the pixel electrode **52** is formed in the pixel area. The first alignment-control structure **56** and the second alignment-control structure **58** are arranged in matrix in the pixel area. For example, the pixel area is divided into four subregions, two first alignment-control structures **56** are respectively positioned in the upper right subregion and the lower left subregion, and two second alignment-control structures **58** are respectively positioned the upper left subregion and the lower right subregion. A first concave **57** is formed on the inner surface of the upper glass substrate **42** between two adjacent first alignment-control structures **56**, and the first concave **57** is in a position faced to a corresponding second alignment-control structure **58**. Similarly, a second concave **59** is formed on the inner surface of the lower glass substrate **44** between two adjacent second alignment-control structures **58**, and the second concave **59** is in a position faced to a corresponding first alignment-control structure **56**. In addition, a first inclined plane **61A** is formed between the first alignment-control structure **56** and the first cave **57**, and a second inclined plane **61B** is formed between the second alignment-control structure **58** and the second cave **59**. In the first embodiment, the first inclined plane **61A** may overlap part of the second inclined plane **61B** or not. Therefore, each first alignment-control structure **56** and the corresponding second concave **59** have a first substantially equal size, the second alignment-control structure a**58** and the corresponding first concave **57** have a second substantially equal size, so that the upper inclined plane **61A** is close to and faces the lower inclined plane **61B**.

[0038] **FIGS. 8A and 8B** are schematic diagrams showing the structure of the liquid crystal layer **46**. The materials are designed in a condition that the electric field can easily pass through the liquid crystal molecules but difficultly pass through the alignment-control structures **56** and **58**.

[0039] As shown in **FIG. 8**A, the liquid crystal layer **46** having a negative anisotropy of dielectric constant is positioned between the vertical alignment layers **50** and **54**, all the liquid crystal molecules are aligned perpendicular to the vertical alignment layers **50** and **54** when no voltage is applied thereto. For example, the liquid crystal molecules **46**A are aligned perpendicular to the vertical alignment layers **50** and **54** and to the glass substrates **42** and **44**. The liquid crystal molecules **46**B above the inclined planes **61**A and **61**B are vertical to the vertical alignment layers **50** and **54** and are aligned at an angle to the glass substrates **42** and **44**. As shown in **FIG. 8**B, upon application of voltage to the LCD cell **40**, the liquid crystal molecules will rotate to a direction vertical to the electric field, and the direction of the electric field is shown by the arrows. Particularly, the electric field between the first inclined plane **61**A and the second inclined plane **61**B is twisted, an oblique electric field is then formed, thus the liquid crystal molecules **46**B will rotate to a specific angle corresponding to the oblique electric field. For example, when the oblique electric field is from lower right direction toward the upper left direction, the liquid crystal molecules **46**B are rotated toward the first alignment-control structure **56** in order to be vertical to the oblique electric field. As a result, the adjacent liquid crystal molecules **46**A rotate according to the behavior of the liquid crystal molecules **46**B.

[0040] **FIGS. 9A and 9B** are schematic diagrams showing the variation in alignment of the liquid crystal layer **46**. The materials are chosen in a condition that the electric field is difficult to pass through the liquid crystal molecules but easily pass through the alignment-control structures **56** and **58**.

[0041] As shown in **FIG. 9**A, the liquid crystal layer **46** having a negative anisotropy of dielectric constant is arranged between the vertical alignment layers **50** and **54**. All the liquid crystal molecules are aligned perpendicular to the vertical alignment layers **50** and **54** when no voltage is applied. As shown in **FIG. 9**B, upon application of voltage to the LCD cell **40**, the liquid crystal molecules will rotate to a direction vertical to the electric field, and the direction of the electric field is shown by the arrows. The first alignment-control structure **56** and the second alignment-control structure **58** are positioned in an interlaced way. Therefore, the electric field between the first inclined plane **61**A and the second inclined plane **61**B is twisted, an oblique electric field is then formed, and the liquid crystal molecules **46**B will rotate to a specific angle corresponding to the oblique electric field. For example, the liquid crystal molecules **46**B are aligned toward the second alignment-control structure **58**. As a result, the adjacent liquid crystal molecules **46**A will rotate according to the behavior of the liquid crystal molecules **46**B.

[0042] **FIG. 10A** is a top view showing the alignment domain of the liquid crystal layer **46** shown by the arrows, and **FIG. 10B** is a top view showing the rotating direction of the liquid crystal molecules shown by the arrows. The liquid crystal molecules **48**B between the inclined planes **61**A and **61**B rotate toward the first alignment-control structure **56** and affect the alignment of the adjacent liquid crystal molecules **46**A, thus creating a gradual variation in alignment of the liquid crystal layer **46**. As a result, the four alignment-control structures **56** and **58** in the pixel area contribute four domains.

[0043] Compared with the prior alignment-control structure, the first embodiment provides the LCD cell **40** with four domains in a pixel area to satisfy the requirements of wide view angle and high contrast. Also, since the alignment-control structures **56** and **58** are rectangular protrusions with plane surface, the aperture ratio is only reduced in the inclined planes **61**A and **61**B and no loss of the aperture ratio is happened on the plane surfaces of these alignment-control structures **56** and **58**. This improves the brightness and contrast so as to assure the display quality of the LCD cell **40**.

Second Embodiment

[0044] **FIGS. 11 and 12** are schematic cross-sectional diagrams showing the variation in alignment of the liquid crystal layer **46** according to the second embodiment of the present invention. In the LCD cell **40** of the second embodiment, the alignment-control structures **56** and **58** are respectively formed on the inner surface of the glass substrates **42** and **44**, the electrodes **48** and **52** are respectively formed on the alignment-control structures **56** and **58**, and the vertical alignment layers **50** and **54** are respectively formed on the electrodes **48** and **52**. As shown in **FIG. 11**, the vertical projections of the first inclined plane **61**A and the second inclined plane **61**B do not overlap. A distance L is formed between the vertical projections of the inclined planes **61**A and **61**B, and the distance L is about 2~3 □m. The electric field between the inclined planes **61**A and **61**B extends in an inclined direction when voltage is applied thereto because of the distance L.

[0045] As shown in **FIG. 11**, the liquid crystal layer **46** having a negative anisotropy of dielectric constant is arranged between the vertical alignment layers **50** and **54**. All the liquid crystal molecules are aligned perpendicular to the vertical alignment layers **50** and **54** when no voltage is applied. As shown in **FIG. 12**, upon application of voltage to the LCD cell **40**, an oblique electric field is formed between the first inclined plane **61**A and the second inclined plane **61**B, and the liquid crystal molecules **46**B will rotate to a specific angle corresponding to the oblique electric field. Particularly, since the electrodes **48** and **52** are formed on the alignment-control structures **56** and **58** and the electric field extends toward the direction of the minimum distance between the electrodes **48** and **52**, the electric field between the inclined planes **61**A and **61**B is twisted in two different directions. As a result, the liquid crystal molecules **46**B between the inclined planes **61**A and **61**B rotate toward two different directions. For example, the liquid crystal molecules **46**B_1 positioned on the top of the second inclined plane **61**B rotates in a clockwise direction, thus the adjacent liquid crystal molecules **46**A_1 also rotate in the clockwise direction according to the behavior of the liquid crystal molecules **46**B_1. In a similar method, the liquid crystal molecules **46**B_2 positioned on the top of the first inclined plane **61**A rotate in a counterclockwise direction, thus the adjacent liquid crystal molecules **46**A_2 also rotate in the counterclockwise direction according to the behavior of the liquid crystal molecules **46**B_2.

[0046] **FIG. 13A** is a top view showing the alignment domain of the liquid crystal layer **46** shown by the arrows, and **FIG. 13B** is a top view showing the rotating direction of the liquid crystal molecules shown by the arrows. As described above, the electric field between the inclined planes **61**A and **61**B is twisted in two different directions, the liquid crystal molecules **46**B_1 rotate in a clockwise direction, and the liquid crystal molecules **46**B_2 rotate in a counterclockwise direction. Consequently, the four alignment-control structures **56** and **58** in the pixel area contribute four domains. This satisfies the requirements of wide view angle and high contrast, and improves the brightness and contrast so as to assure the display quality of the LCD cell **40**.

[0047] **FIG. 14** is a top view of the first layout of the alignment-control structure according to the present invention. According to the design rule of the alignment-control structure in the first embodiment and the second embodiment, two of the first alignment-control structures **56** and two of the second alignment-control structures **58** are arranged in one pixel area. These first and second alignment-control structures **56** and **58** are arranged in matrix in the LCD cell **40**. For example, within the pixel area P(i), the first alignment-control structures **56** are formed on the upper right subregion and the lower left subregion, and the second alignment-control structures **58** are formed on the upper left subregion and the lower right subregion. In the adjacent pixel area P(i+1), the first alignment-control structures **56** are formed on the upper left subregion and the lower right subregion, and the second alignment-control structures **58** are formed on the upper right subregion and the lower left subregion.

[0048] In addition, the layout of the alignment-control structures may be in a variety of patterns to achieve multiple domains in a pixel area. **FIG. 15** is a top view of the second layout of the alignment-control structure according to the present invention. The first alignment-control structures **56** and the second alignment-control structures **58** are arranged in matrix in the LCD cell **40**, wherein one of the first alignment-control structures **56** or the second alignment-control structures **58** are formed on one pixel area to generate one domain. For example, the second alignment-control structures **58** are formed on the pixel area P(i), and the first alignment-control structures **56** are formed on the adjacent pixel area P(i+1).

[0049] **FIG. 16** is a top view of the third layout of the alignment-control structure according to the present invention. The first alignment-control structures **56** and the second alignment-control structures **58** are arranged in matrix in the LCD cell **40**. Only One of the first alignment-control structure **56** and only one of the second alignment-control structure **58** are formed in one pixel area to generate two domains. For example, in the pixel area P(i), the first alignment-control structure **56** is formed in the lower subregion and the second alignment-control structure **58** is formed in the upper subregion. In the adjacent pixel area P(i+1), the first alignment-control structure **56** is formed in the upper subregion and the second alignment-control structure **58** is formed on the lower subregion.

[0050] **FIG. 17** is a top view of the fourth layout of the alignment-control structure according to the present invention. The first alignment-control structures **56** and the second alignment-control structures **58** are arranged in matrix in the LCD cell **40**. In one pixel area, three of the first alignment-control structures **56** and three of the second alignment-control structures **58** are formed to generate six domains.

[0051] It is to be understood that the present invention is not limited to the embodiments described above, but encompasses any and all embodiments within the scope of the following claims.

What is claimed is:

1. A liquid crystal display (LCD) comprising:

an upper substrate having an upper electrode on an inner surface of the upper substrate;

a lower substrate having a lower electrode on an inner surface of the lower substrate, an electric field being formed between the upper electrode and the lower electrode;

a liquid crystal layer with a negative anisotropy of dielectric constant filling a space between the upper substrate and the lower substrate;

a plurality of first alignment-control structures arranged on the inner surface of the upper substrate, wherein an first concave is formed between two adjacent first alignment-control structures, and an first inclined plane is formed between each first concave and each first alignment-control structure; and a plurality of second alignment-control structures arranged on the inner surface of the lower substrate, wherein a second concave is formed between two adjacent second alignment-control structures, and a second inclined plane is formed between each second concave and each second alignment-control structure;

wherein each first alignment-control structure is positioned above a corresponding second concave, each second alignment-control structure is positioned under a corresponding first concave, the first alignment-control structure and the corresponding second concave have a first substantially equal size, the second alignment-control structure and the corresponding first concave have a second substantially equal size, and the first inclined plane is close to and faces the second inclined plane.

2. The LCD according to claim 1, wherein each of the first alignment-control structures and the second alignment-control structures is a rectangular protrusion.

3. The LCD according to claim 2, wherein each rectangular protrusion comprises a plane surface.

4. The LCD according to claim 2, wherein each rectangular protrusion comprises a tapered sidewall.

5. The LCD according to claim 1, further comprising a plurality of pixel areas, and each pixel area having at least one first alignment-control structure and at least one second alignment-control structure.

6. The LCD according to claim 1, further comprising a plurality of pixel areas, and each pixel area having two first alignment-control structures and two second alignment-control structures.

7. The LCD according to claim 1, further comprising a plurality of pixel areas, and each pixel area having three first alignment-control structures and three second alignment-control structures.

8. The LCD according to claim 1, wherein the first alignment-control structure is covered by the upper electrode and the second alignment-control structure is covered by the lower electrode.

9. The LCD according to claim 1, wherein the first alignment-control structure is formed above the upper electrode and the second alignment-control structure is formed above the lower electrode.

10. The LCD according to claim 1, further comprises an upper vertical alignment layer and a lower vertical alignment layer, wherein the liquid crystal layer with the negative anisotropy of dielectric constant is perpendicular to the upper and lower vertical alignment layers when no electrical field is applied to the LCD.

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专利名称(译)	多域平面显示		
公开(公告)号	[US20020135723A1](US20020135723A1)	公开(公告)日	2002-09-26
申请号	US10/097050	申请日	2002-03-12
[标]申请(专利权)人(译)	友达光电股份有限公司		
申请(专利权)人(译)	友达光电.		
当前申请(专利权)人(译)	友达光电.		
[标]发明人	WONG JIA FAM		
发明人	WONG, JIA-FAM		
IPC分类号	G02F1/1333 G02F1/139 G02F1/1337		
CPC分类号	G02F1/133707 G02F1/1393 G02F2001/133776		
优先权	090106432 2001-03-20 TW		
其他公开文献	US6778243		
外部链接	Espacenet USPTO		

摘要(译)

多畴液晶显示器（LCD）具有布置在上基板的内表面上的多个第一对准控制结构，以及布置在下基板的内表面上的多个第二对准控制结构。在两个相邻的第一对准控制结构之间形成上凹，并且在上凹和第一对准控制结构之间形成上倾斜平面。在两个相邻的第二对准控制结构之间形成下凹，并且在下凹和第二对准控制结构之间形成下倾斜平面。每个第一对准控制结构位于相应的下凹部上方，每个第二对准控制结构位于相应的上凹部下方，并且上倾斜平面靠近并面向下倾斜平面。