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(54) LIQUID CRYSTAL DISPLAYS AND FABRICATION METHODS THEREOF

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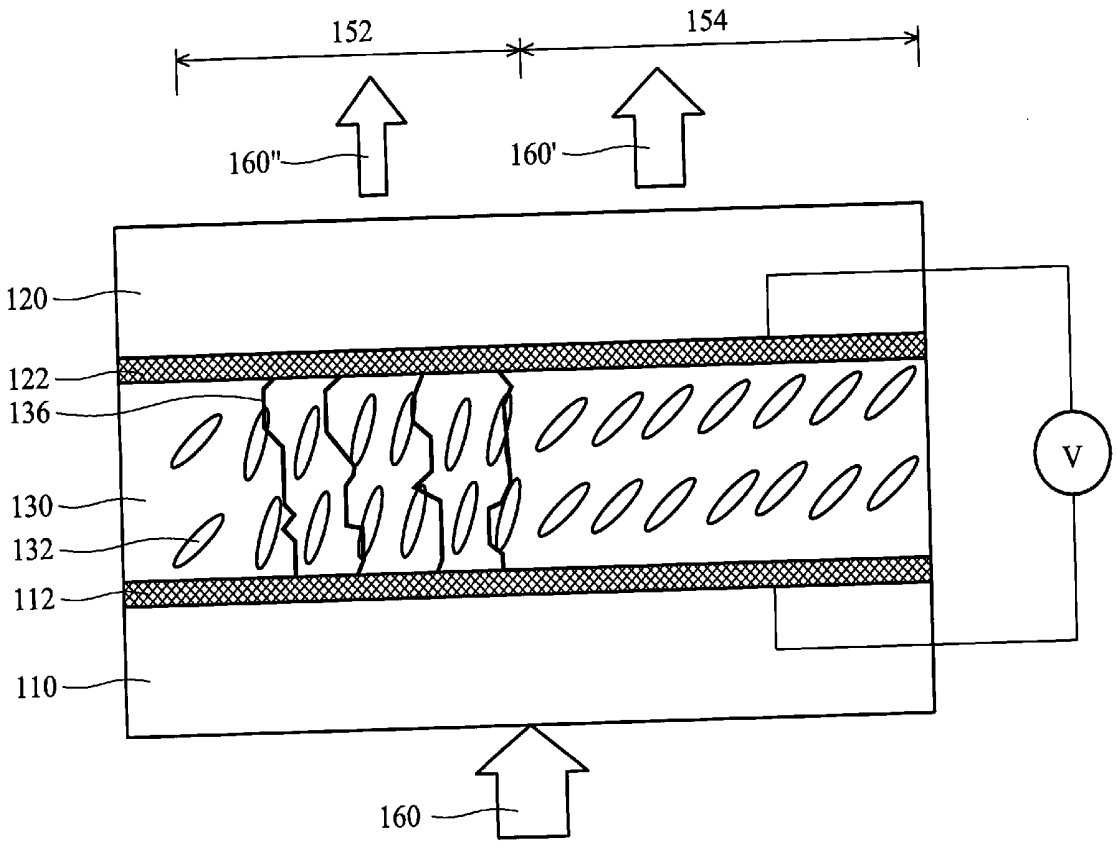
(57) **ABSTRACT**

Liquid crystal displays and fabrication methods thereof. The liquid crystal display comprises a first substrate with an active matrix of a plurality of pixels. A second substrate is provided opposing the first substrate. A liquid crystal layer is interposed between the first substrate and the second substrate. Each pixel comprises a polymer dispersed liquid crystal layer corresponding to a first liquid crystal region and a non-polymer dispersed liquid crystal layer corresponding to a second liquid crystal region.



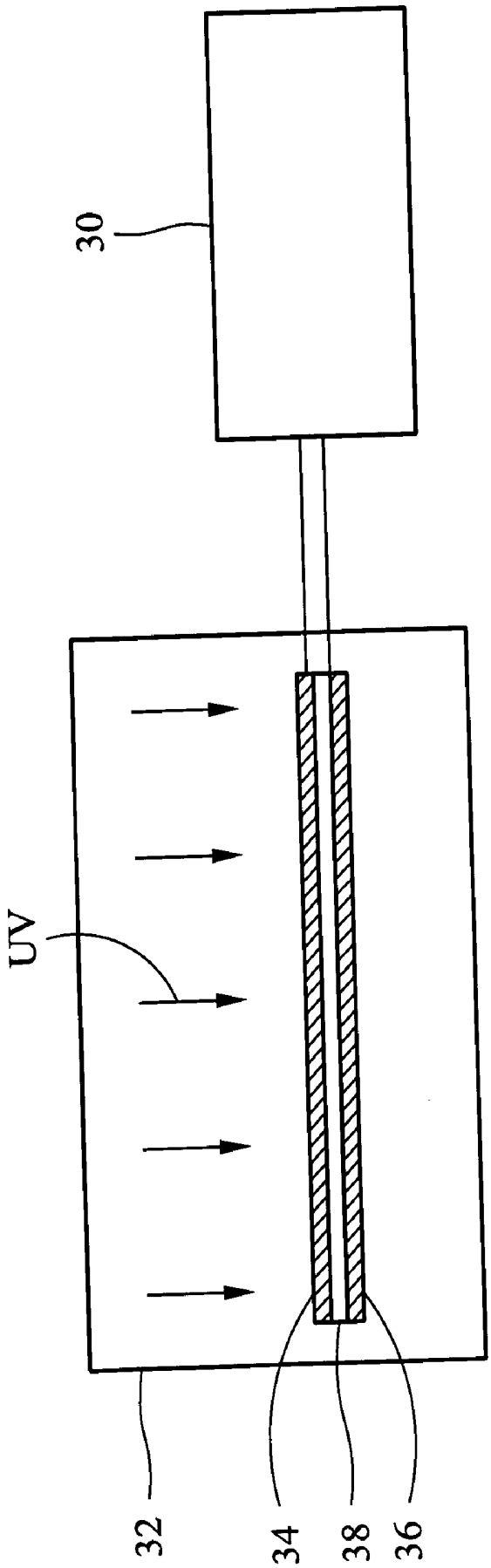


FIG. 1 (RELATED ART)

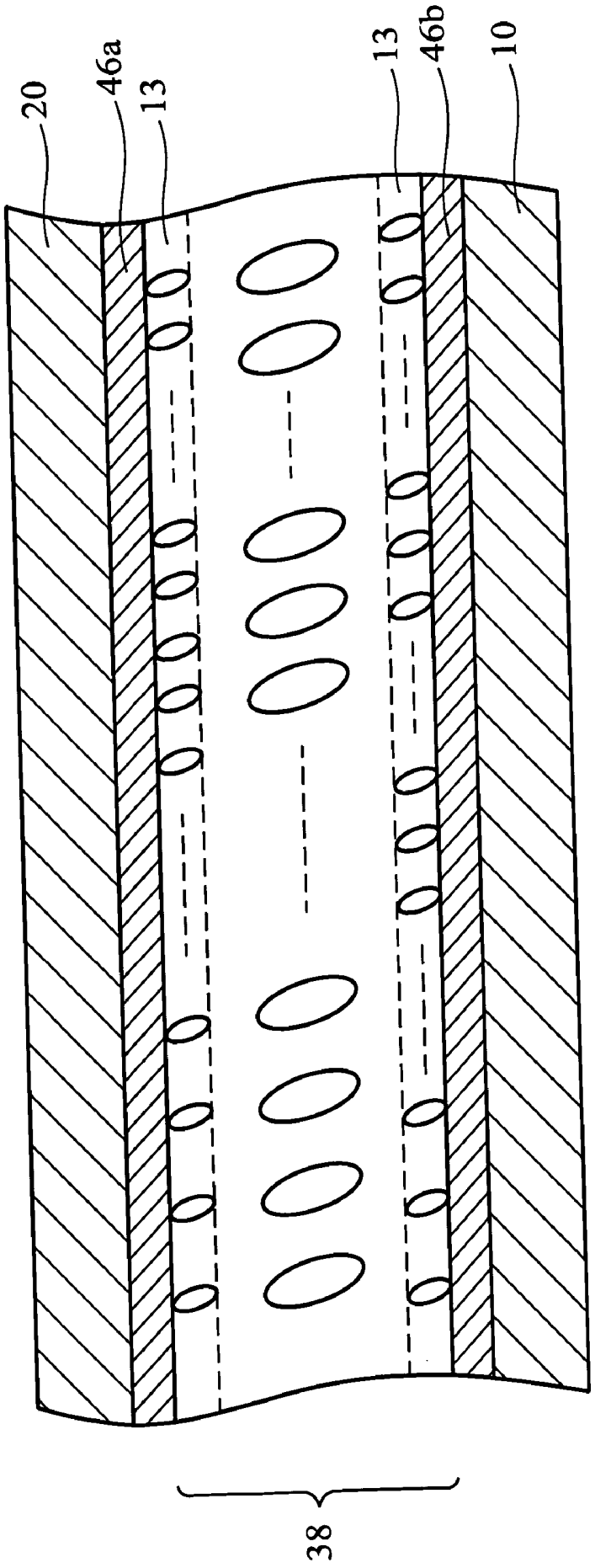


FIG. 2 (RELATED ART)

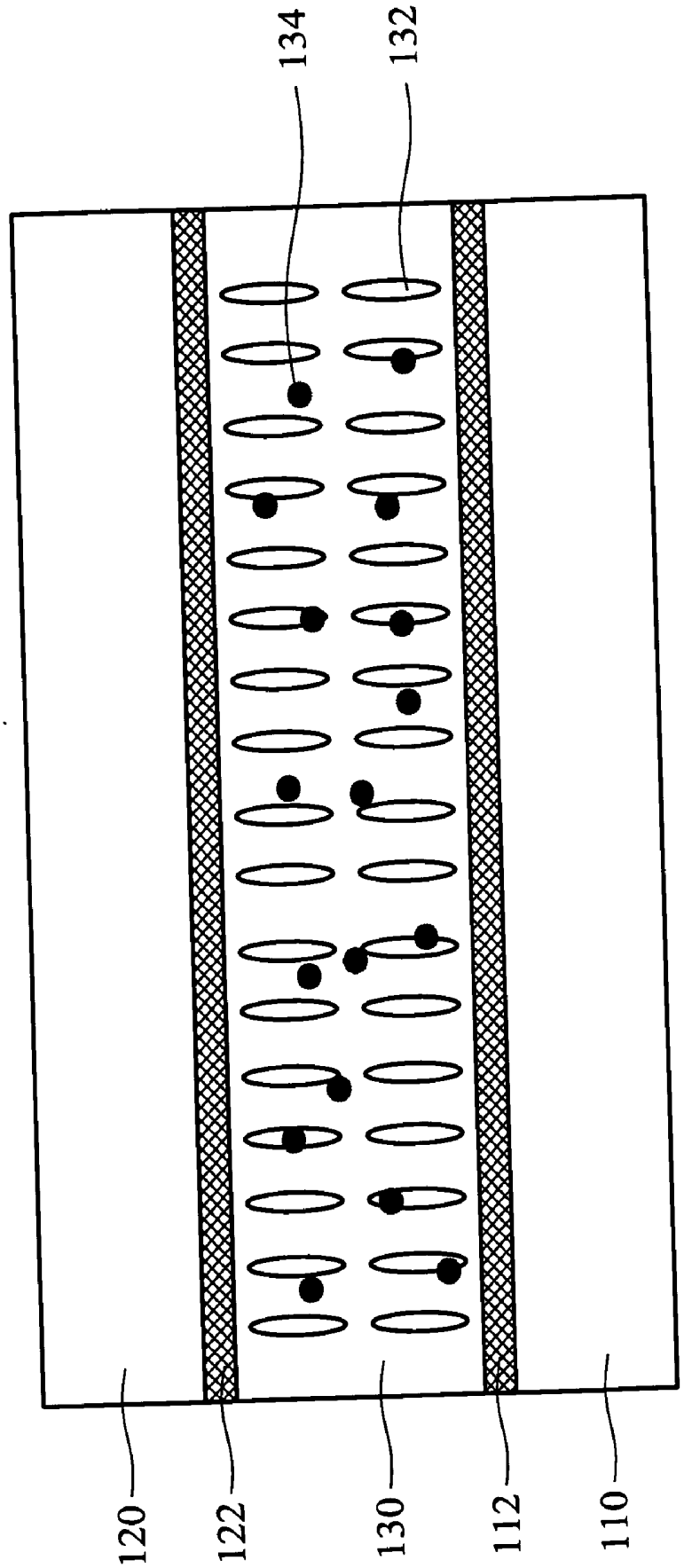


FIG. 3A

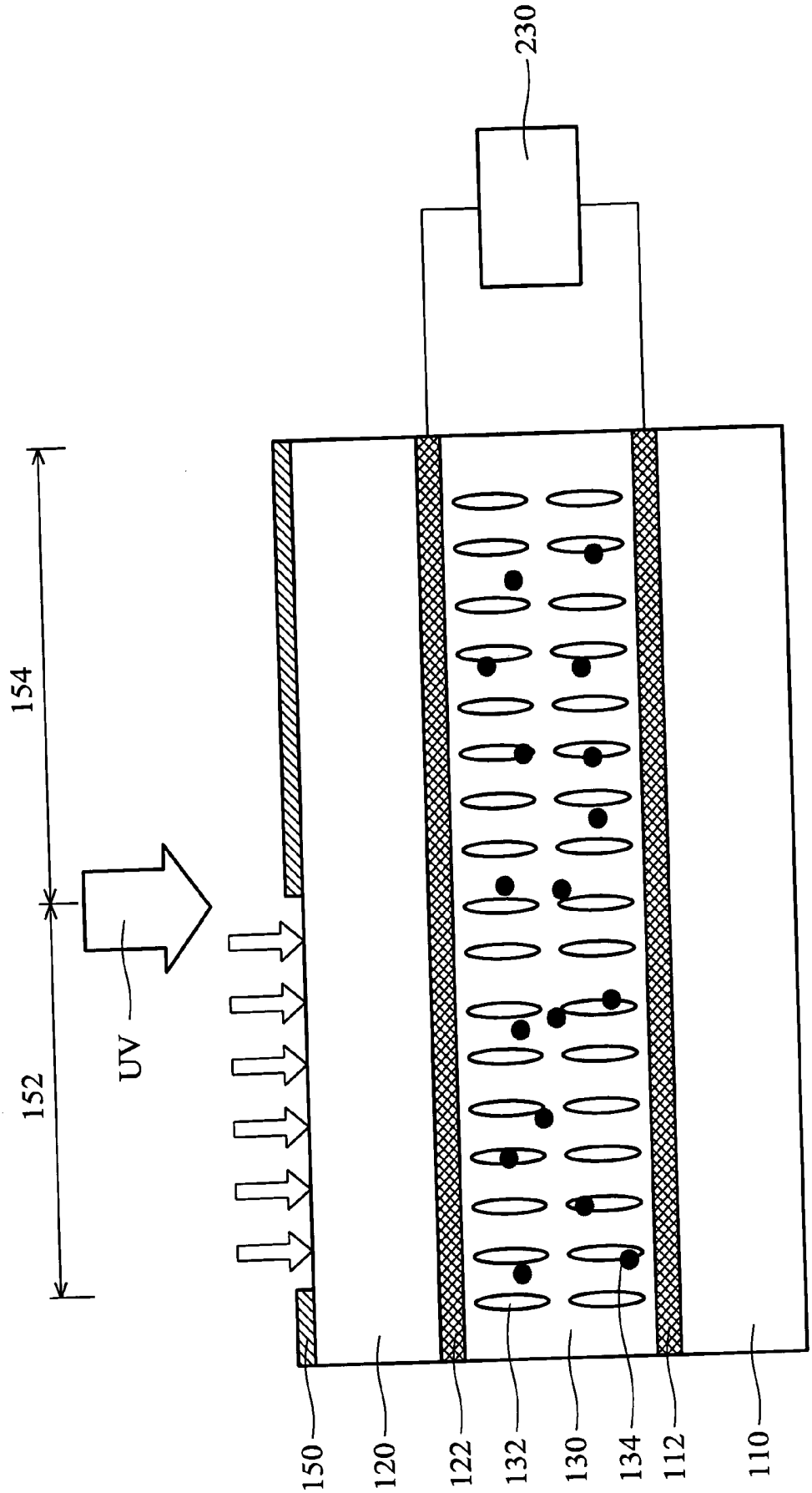


FIG. 3B

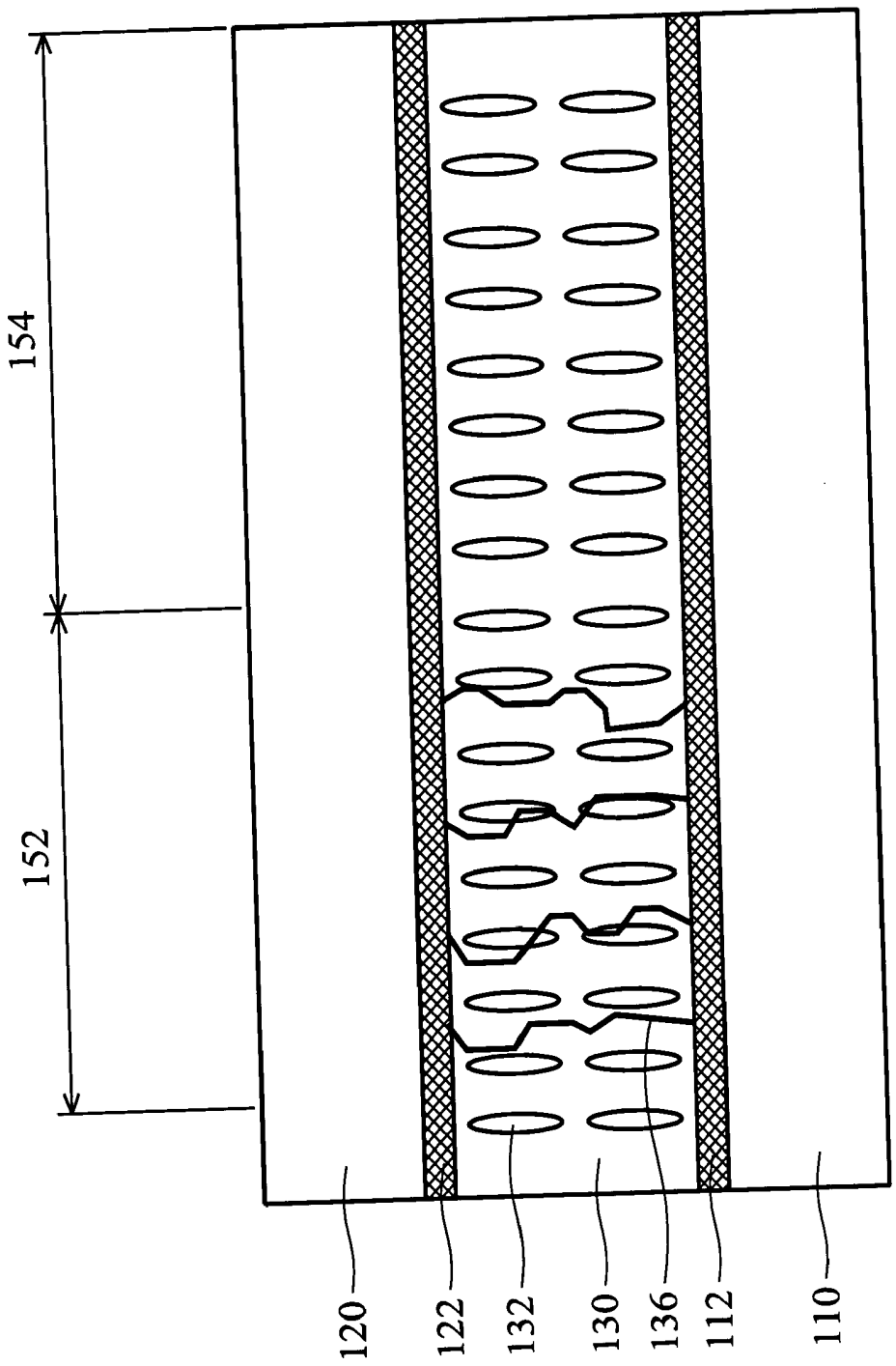


FIG. 3C

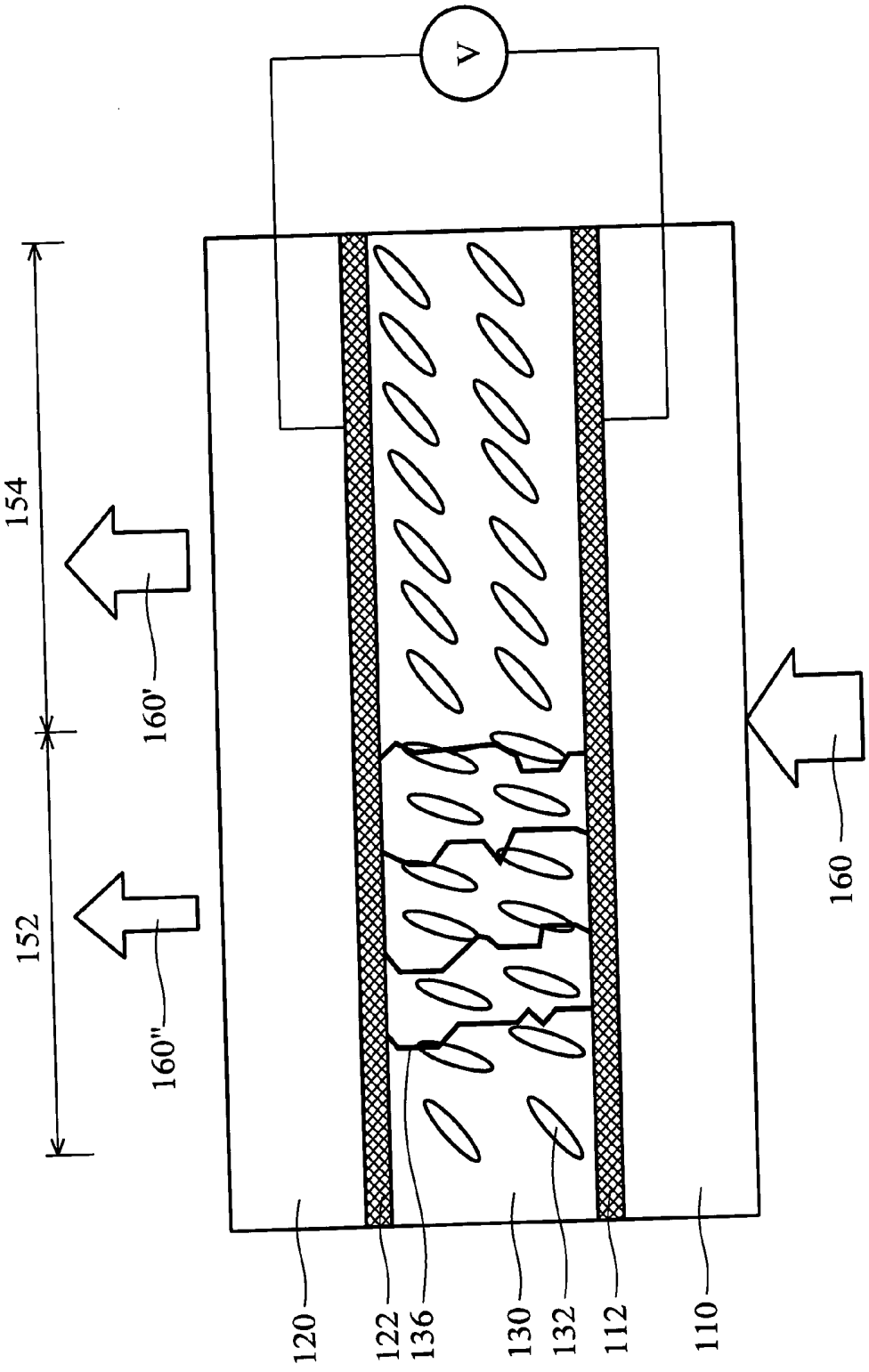


FIG. 3D

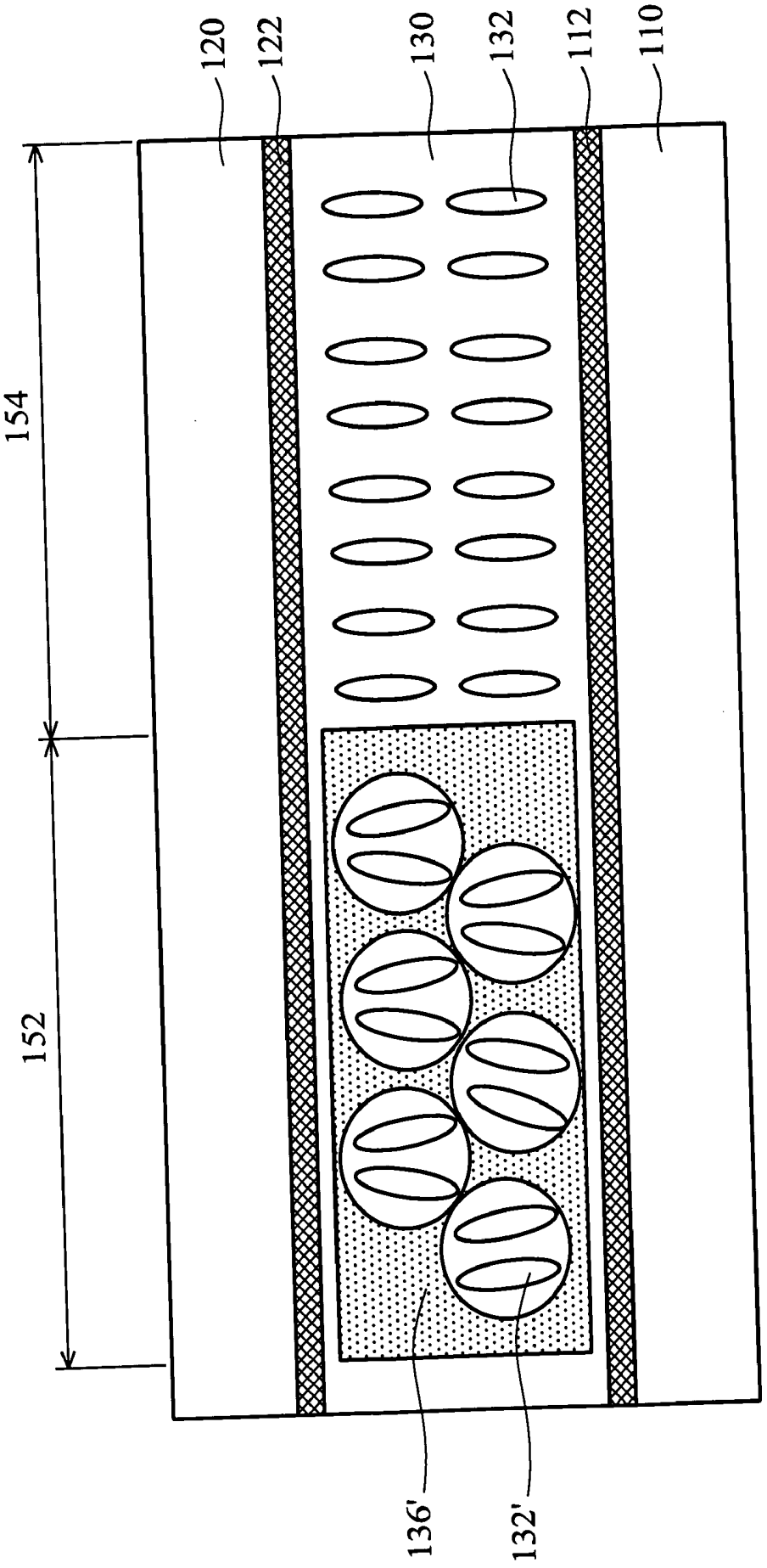


FIG. 4A

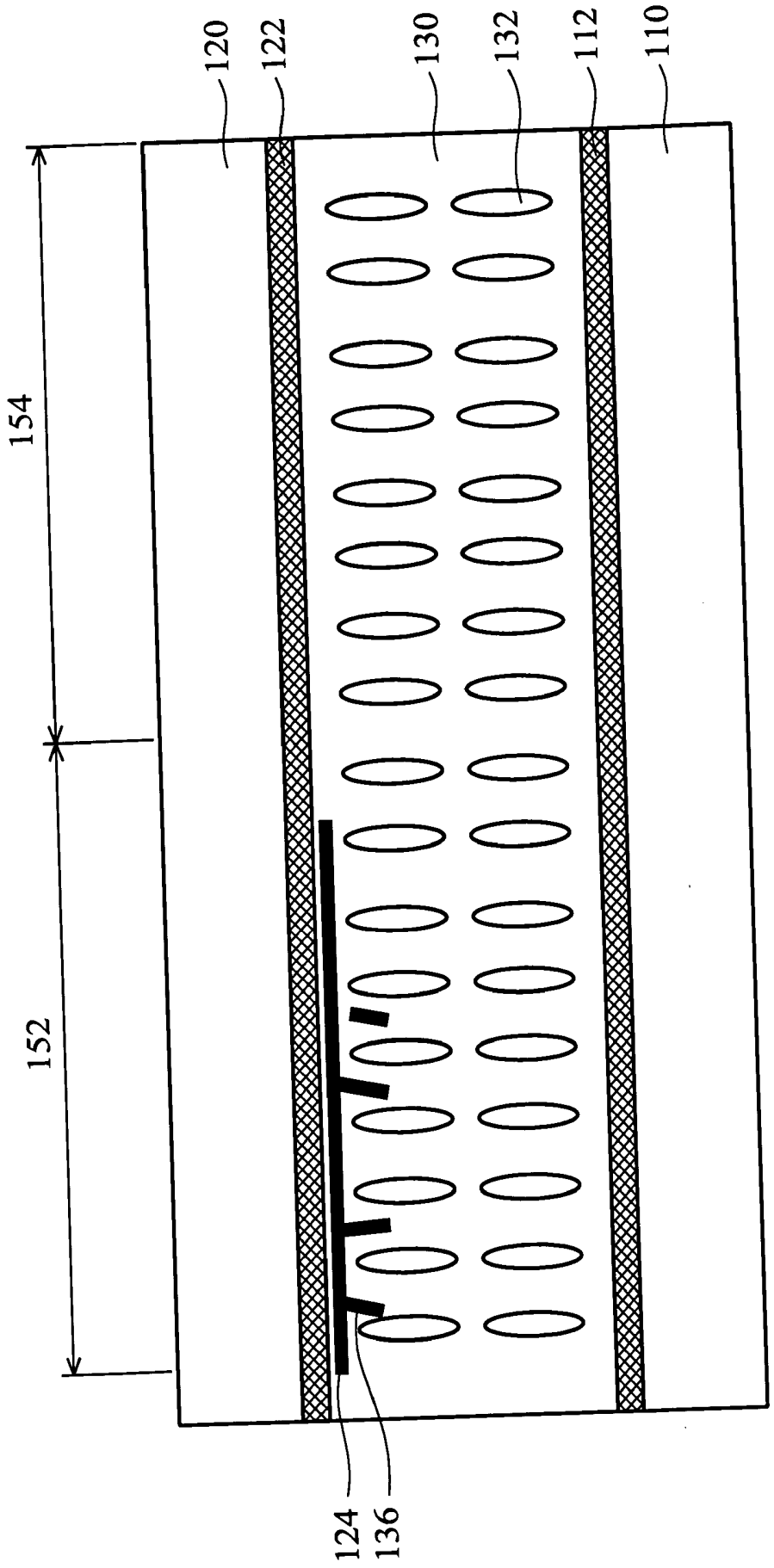


FIG. 4B

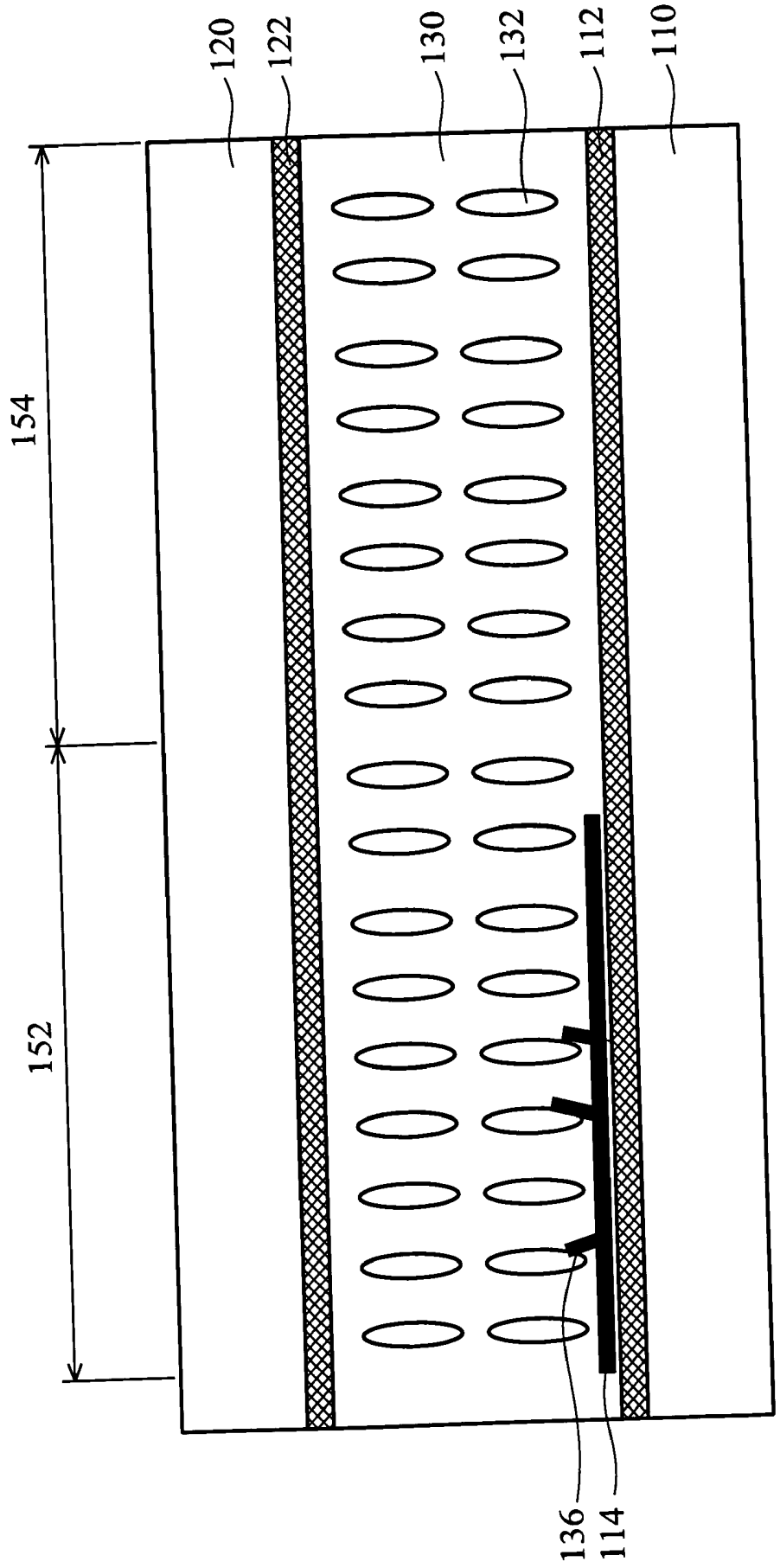


FIG. 4C

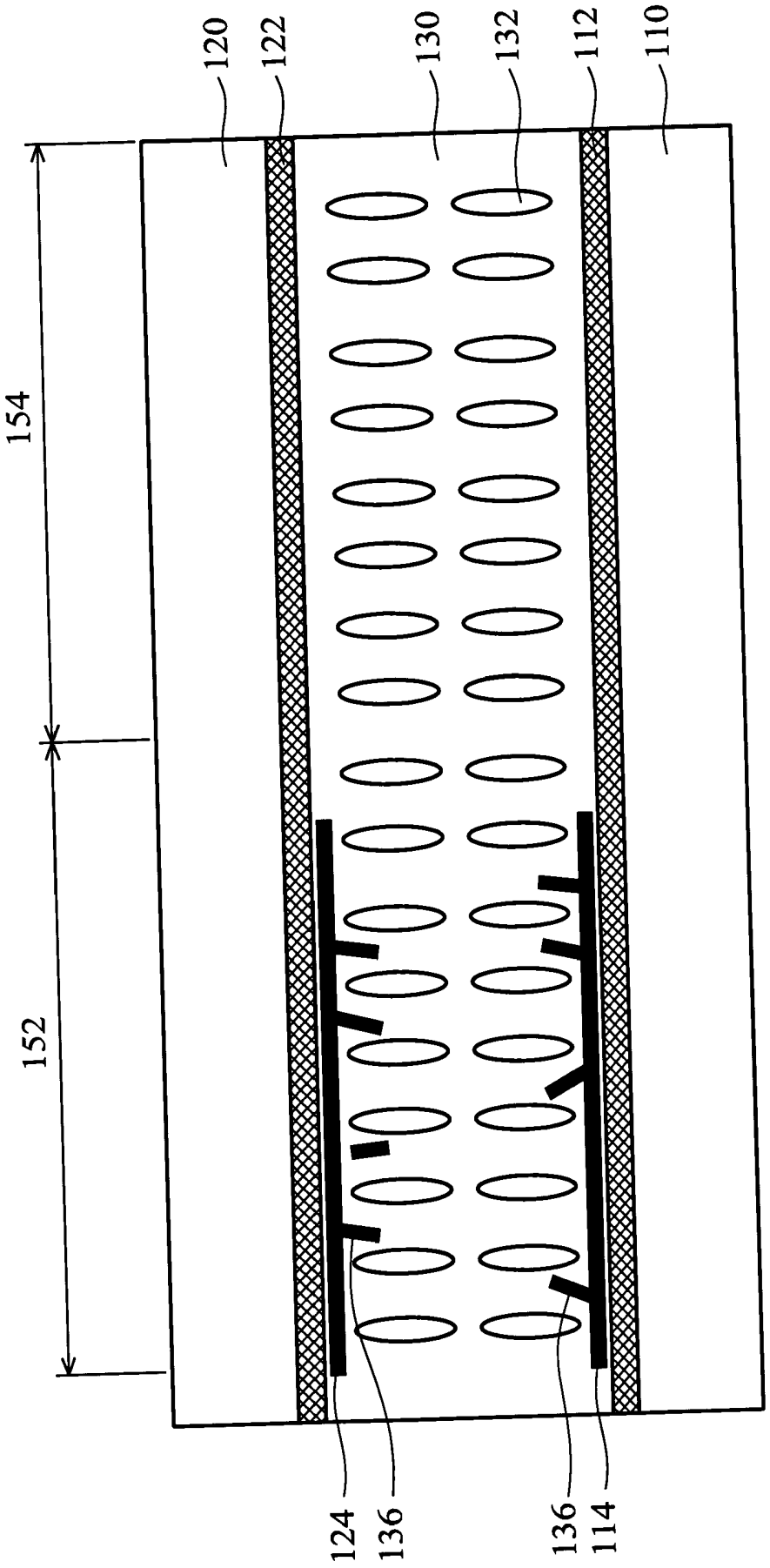


FIG. 4D

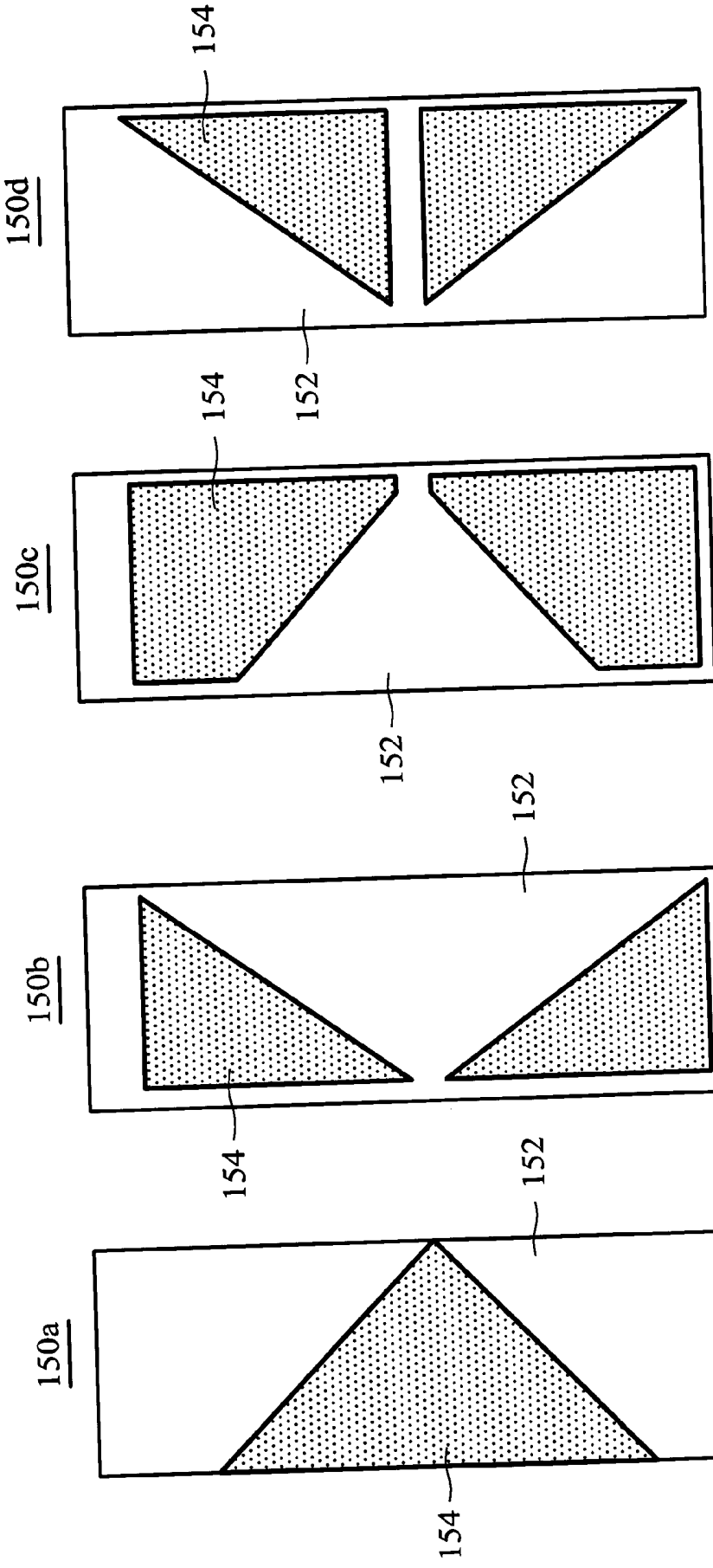


FIG. 5D

FIG. 5C

FIG. 5B

FIG. 5A

LIQUID CRYSTAL DISPLAYS AND FABRICATION METHODS THEREOF

BACKGROUND

[0001] The invention relates to liquid crystal displays and fabrication methods thereof, and more particularly, to polymer dispersed liquid crystal (PDLC) displays and fabrication methods thereof.

[0002] Among flat panel displays, liquid crystal displays (LCDs) exhibit characteristics of light weight, low power consumption, and good outdoor reliability, and are therefore widely applied in portable computers, notebooks, mobile phones, and personal digital assistances (PDAs). Conventional twisted nematic mode LCDs are disadvantageous due to their small viewing angle. Some proposed LCDs, such as, in-plane switching mode LCD (IPS-LCD) or multi-domain vertical alignment LCD (MVA-LCD) attempt to improve the viewing characteristics of conventional LCDs.

[0003] Conventional MVA-LCDs, however, possess less transparency than TN mode LCDs. Moreover, conventional MVA-LCDs image sticking may occur in display over a long period of time. U.S. Pat. No. 6,781,665, the entirety of which is hereby incorporated by reference, discloses a method for fabricating a polymer dispersed liquid crystal (PDLC) display. The polymer dispersed liquid crystal (PDLC) display is formed by mixing liquid crystal and monomer and radiating UV thereon with a bias. Polymers dispersed in liquid crystal can help liquid crystal recovery, thereby reducing imaging sticking.

[0004] **FIG. 1** is a schematic view of a conventional method for fabricating a polymer dispersed liquid crystal display. A liquid crystal display panel is disposed in an ultra-violet light irradiation chamber **32**. A power supply **30** applies a bias between an upper electrode **34** and a lower electrode **36**. A liquid crystal layer **38** between the upper electrode **34** and the lower electrode **36** comprises a mixture of liquid crystal and monomer. When the liquid display panel is irradiated by UV light, the monomer is polymerized to form a continuous network. Moreover, during polymerization, the orientation of the liquid crystal becomes more consistent with the polymer.

[0005] **FIG. 2** is a cross section of a conventional polymer dispersed liquid crystal display. After an irradiating or a heating process, monomers in the liquid crystal layer **38** between upper substrate **10** and lower substrate **20** are polymerized into polymer structures **13**. Polymer structures **13** are formed adjacent to alignment layers **46***a* and **46***b*. Polymer structures **13** can aid in liquid crystal recovery, thereby reducing image sticking.

[0006] U.S. Pat. No. 6,014,194, the entirety of which is hereby incorporated by reference, discloses a polymer dispersed liquid crystal (PDLC) display. Monomers are added into liquid crystal. The mixture of monomers and liquid crystals in each of red, green, and blue color pixels are separately polymerized with UV irradiation under different biases, thereby creating a different polymer structure in each pixel.

SUMMARY

[0007] Accordingly, the invention provides a wide viewing angle liquid crystal display. Each pixel of the wide viewing angle liquid crystal display is divided into mutiregion with different polymer density and structure. Each region has different optical characteristics to improve the viewing angle.

[0008] The invention also provides a liquid crystal display, comprising a first substrate with an active matrix of a plurality of pixels. A second substrate is provided opposing the first substrate. A liquid crystal layer is interposed between the first substrate and the second substrate. Each pixel comprises a polymer dispersed liquid crystal layer corresponding to a first liquid crystal region and a non-polymer or low-density polymer dispersed liquid crystal layer corresponding to a second liquid crystal region.

[0009] The invention further provides a method for fabricating a liquid crystal display. A first substrate is provided with an active matrix of a plurality of pixels. A second substrate is provided opposing the first substrate. A liquid crystal layer is interposed between the first substrate and the second substrate. Each pixel comprises a polymer dispersed liquid crystal layer corresponding to a first liquid crystal region and a non-polymer or low-density polymer dispersed liquid crystal layer corresponding to a second liquid crystal region.

[0010] The invention further provides a method for fabricating a liquid crystal display. A first substrate is provided with an active matrix of a plurality of pixels. A second substrate is provided opposing the first substrate. A liquid crystal layer with monomers is interposed between the first substrate and the second substrate. The monomers are selectively polymerized in the liquid crystal layer such that each pixel comprises a polymer dispersed liquid crystal layer corresponding to a first liquid crystal region and a non-polymer or low-density polymer dispersed liquid crystal layer corresponding to a second liquid crystal region.

DESCRIPTION OF THE DRAWINGS

[0011] The invention can be more fully understood by reading the subsequent detailed description in conjunction with the examples and references made to the accompanying drawings, wherein:

[0012] **FIG. 1** is a schematic view of a conventional method for fabricating a polymer dispersed liquid crystal display;

[0013] **FIG. 2** is a cross section of a conventional polymer dispersed liquid crystal display;

[0014] **FIGS. 3A-3D** are cross sections of an embodiment of a method of fabricating a polymer dispersed liquid crystal display;

[0015] **FIGS. 4A-4D** are cross sections showing various embodiments of polymer dispersed liquid crystal (PDLC) displays; and

[0016] **FIGS. 5A-5D** are schematic views showing various embodiments of the lithographic masks.

DETAILED DESCRIPTION

[0017] **FIGS. 3A-3D** are cross sections of an embodiment of a method of fabricating a polymer dispersed liquid crystal display, in which a liquid crystal display comprises a first substrate **110** with an active matrix array pixel driven, and a second substrate **120** opposing the first substrate **110**. A liquid crystal layer **130** is interposed between the first substrate **110** and the second substrate **120**. A first electrode **112** and a second electrode **122** are separately disposed on the inner surface of the first substrate **110** and the second substrate **120**. The liquid crystal layer **130** comprises liquid crystal molecules **132**, monomers **134** and inducers (not shown) to improve polymerization. Monomers **130** may

preferably comprise diacrylate, monoacrylate, or other monomers with a double bond. After irradiation, the monomers are decomposed into free radicals and react with each other. An initiator can be optionally added to improve polymerization.

[0018] Referring to **FIG. 3B**, a liquid crystal display with monomer dispersed therein is disposed in an apparatus installed by UV irradiation. A power supply **230** biases a first and a second electrode of the liquid crystal display. Each pixel of the liquid crystal can be divided into at least one LC region **152**. UV light can irradiate predetermined region and be optionally biased between the first and the second electrodes **112** and **122**. A polymer dispersed liquid crystal display is therefore formed to aid in liquid crystal recovery and reduce imaging sticking and improve the color performance in wide viewing angle.

[0019] Selective UV irradiation is performed by lithography forming a patterned mask **150** on the first substrate **110** or the second substrate **120**. An opening is formed at the predetermined first LC region **152** on the second substrate **120**. The liquid crystal configuration is then irradiated by UV polymerizing monomers **134** at the first LC region **152**.

[0020] Referring to **FIG. 3C**, a network **136** of monomer **134** is formed, when the liquid crystal layer **130** is irradiated by UV light. After the monomers **134** are polymerized, the orientation of the liquid crystal molecules **132** becomes more consistent.

[0021] In another embodiment, the light source can optionally be focused and directly irradiated at predetermined region **152**. An optional bias can be applied between the first and the second electrodes to polymerize the monomer **132**, thereby eliminating lithographic masking steps. For example, a laser beam is directly focused on the predetermined region. The unselected region does not irradiate. Alternatively, the unselected region is determined between two laser beams. Interference between the two laser beams creates energy distribution, thereby creating polymer density distribution in the liquid crystal layer. In another embodiment, monomer **134** can alternatively comprise thermally polymeric material. By locally heating the predetermined region, monomer in the liquid crystal layer can be thermally polymerized. In another embodiment, a power supply biases different voltage in different region of one pixel in the UV irradiation process. So the structures of polymer in different regions are different.

[0022] Referring to **FIG. 3D**, when driving voltage V is applied to the liquid crystal layer, liquid crystal molecules are rotated in the direction of the applied field. Liquid crystal molecules at the polymer dispersed region, i.e., at the predetermined region are rotated different from those at the non-polymer dispersed region. When a light source **160**, such as a back light, passes through the liquid crystal display the polymer dispersed region **152** and the non-polymer dispersed region **154** possess different transparencies, thereby creating different optical characteristics **160'** and **160"** to widen the viewing angle.

[0023] **FIGS. 4A-4D** are cross sections showing various embodiments of polymer dispersed liquid crystal (PDLC) displays. A PDLC region comprises a polymer structure and liquid crystal molecules. Referring to **FIG. 4A**, polymer structure **136'** is dispersed between the first and the second substrates **110** and **120**. Liquid crystal molecules **132'** in the first LC region **152** are enclosed in the polymer structure **136'**. Referring to **FIG. 4B**, polymer structures **124** and **136** are formed on an inner surface of the second substrate **120** at the first LC region **152**. The polymer structures **124** and **136** are formed at the interface between the liquid crystal layer **130** and the second substrate **120**. The polymer structure **136** has one end fixed to the polymer structure **124** and the other end extending into the liquid crystal layer **130**. Referring to **FIG. 4C**, polymer structures **114** and **136** are formed on an inner surface of the first substrate **110** at the first LC region **152**. The polymer structures **124** and **136** are formed at the interface between the liquid crystal layer **130** and the first substrate **110**. The polymer structure **136** has one end fixed to the polymer structure **114** and the other end extending into the liquid crystal layer **130**. Referring to **FIG. 4D**, polymer structures **114**, **124**, and **136** are formed on an inner surface of the first substrate **110** and an inner surface of the second substrate **120** at the first LC region **152**. The polymer structures **114**, **124**, and **136** are formed at the interface between the liquid crystal layer **130** and the first substrate **110** and the interface between the liquid crystal layer **130** and the second substrate **120**. The polymer structure **136** has one end fixed to the polymer structure **124** and the other end extending into the liquid crystal layer **130**. The polymer structure **136** has one end fixed to the polymer structure **114** and the other end extending into the liquid crystal layer **130**.

[0024] **FIGS. 5A-5D** are schematic views showing various embodiments of the lithographic masks. Each mask can be used in lithographic steps in **FIG. 3B**. Patterns on the mask corresponds to pixel regions between scanning line and data line of the liquid crystal display, and are divided into a transparent region **152** and opaque region **154**.

[0025] Referring to **FIG. 5A**, the opaque region **154** of the mask **152***a* comprises a triangular region at the center of each pixel region. The triangular region comprises a long edge parallel to the longitudinal side of each pixel region. Referring to **FIG. 5B**, the opaque region **154** of the mask **152***b* comprises two opposing right angle triangular region formed at corners of each pixel regions. The right angle edges of the right angle triangular regions are parallel to the sides of each pixel region. Referring to **FIG. 5C**, the opaque region **154** of the mask **152***c* comprises two opposing trapezoid regions formed at corners of each pixel region. The right angle edges of the trapezoid regions are parallel to the sides of each pixel region. Referring to **FIG. 5D**, the opaque region **154** of the mask **152***d* comprises two opposite right angle triangle regions formed at the center of each pixel region. The right angle edges of the right angle triangular regions are parallel to the sides of each pixel region.

[0026] After UV light irradiation, the liquid crystal layer between the first and the second electrodes is polymerized. Monomers are polymerized into a continuous polymer network. The orientation of the liquid crystal molecules become more consistent in the polymer dispersed region. The unirradiated region does not polymerize, thereby different optical characteristics are created from the polymer dispersed region to widen the viewing angle.

[0027] While the invention has been described by way of example and in terms of preferred embodiment, it is to be understood that the invention is not limited thereto. On the contrary, it is intended to cover various modifications and similar arrangements as would be apparent to those skilled in the art. Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.

What is claimed is:

1. A liquid crystal display, comprising:

a first substrate with an active matrix of a plurality of pixels;

a second substrate opposing the first substrate; and

a liquid crystal layer interposed between the first substrate and the second substrate;

wherein each pixel comprises a polymer dispersed liquid crystal layer corresponding to a first liquid crystal region and a substantially non-polymer dispersed liquid crystal layer corresponding to a second liquid crystal region.

2. The display as claimed in claim 1, wherein the first liquid crystal region comprises polymers and liquid crystal molecules.

3. The display as claimed in claim 2, wherein the polymers are adhered to the first substrate and the second substrate; and the polymers capsulate the liquid crystal molecules.

4. The display as claimed in claim 2, wherein the polymers are formed on the first substrate corresponding to the first liquid crystal region.

5. The display as claimed in claim 2, wherein the polymers are formed on the second substrate corresponding to the first liquid crystal region.

6. The display as claimed in claim 2, wherein the polymers are formed on the first substrate and the second substrate corresponding to the first liquid crystal region.

7. The display as claimed in claims **2**, wherein the polymers are photopolymers or thermal polymers.

8. A method for fabricating a liquid crystal display, comprising:

providing a first substrate with an active matrix of a plurality of pixels;

providing a second substrate opposing the first substrate; and

forming a liquid crystal layer interposed between the first substrate and the second substrate;

wherein each pixel comprises a polymer dispersed liquid crystal layer corresponding to a first liquid crystal region and a substantially non-polymer dispersed liquid crystal layer corresponding to a second liquid crystal region.

9. The method as claimed in claim 8, wherein the first liquid crystal region comprises polymers and liquid crystal molecules.

10. The method as claimed in claim 9, wherein the polymers are adhered to the first substrate and the second substrate; and the polymers capsulate the liquid crystal molecules.

11. The method as claimed in claim 9, wherein the polymers are formed on the first substrate corresponding to the first liquid crystal region.

12. The method as claimed in claim 9, wherein the polymers are formed on the second substrate corresponding to the first liquid crystal region.

13. The method as claimed in claim 9, wherein the polymers are formed on the first substrate and the second substrate corresponding to the first liquid crystal region.

14. The method as claimed in claims **9**, wherein the polymers are photopolymers or thermal polymers.

15. A method for fabricating a liquid crystal display, comprising:

providing a first substrate with an active matrix of a plurality of pixels;

providing a second substrate opposing the first substrate; and

forming a liquid crystal layer with monomers interposed between the first substrate and the second substrate;

selectively polymerizing the monomers in the liquid crystal layer such that each pixel comprises a polymer dispersed liquid crystal layer corresponding to a first liquid crystal region and a substantially non-polymer dispersed liquid crystal layer corresponding to a second liquid crystal region.

16. The method as claimed in claim 15, wherein the first liquid crystal region comprises polymers and liquid crystal molecules.

17. The method as claimed in claim 16, wherein the polymers are adhered to the first substrate and the second substrate; and the polymers capsulate the liquid crystal molecules.

18. The method as claimed in claim 16, wherein the polymers are formed on the first substrate corresponding to the first liquid crystal region.

19. The method as claimed in claim 16, wherein the polymers are formed on the second substrate corresponding to the first liquid crystal region.

20. The method as claimed in claim 16, wherein the polymers are formed on the first substrate and the second substrate corresponding to the first liquid crystal region.

21. The method as claimed in claims **16**, wherein the monomers are thermally polymerizing monomers or photopolymerizing monomers.

22. The method as claimed in claim 15, wherein the liquid crystal layer further comprises an inducer in the first liquid crystal region.

23. The method as claimed in claim 15, wherein the step of selectively polymerizing the monomers is performed by a lithographic process.

24. The method as claimed in claim 23, wherein the lithographic process comprises:

forming a mask with an opening on the first substrate or the second substrate, the opening exposing the first liquid crystal region; and

irradiating light of a predetermined wavelength on the opening to polymerize the monomer in the first liquid crystal region.

* * * * *

专利名称(译)	液晶显示器及其制造方法		
公开(公告)号	US20060203147A1	公开(公告)日	2006-09-14
申请号	US11/243086	申请日	2005-10-04
[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	CHEN YI JU LEE CHIA YU CHEN CHIEH TING CHEN PO LUN		
发明人	CHEN, YI-JU LEE, CHIA-YU CHEN, CHIEH-TING CHEN, PO-LUN		
IPC分类号	G02F1/1333		
CPC分类号	G02F1/1334 G02F1/133753 G02F1/137		
优先权	094107673 2005-03-14 TW		
其他公开文献	US7400368		
外部链接	Espacenet USPTO		

摘要(译)

液晶显示器及其制造方法。液晶显示器包括具有多个像素的有源矩阵的第一基板。提供与第一基板相对的第二基板。液晶层介于第一基板和第二基板之间。每个像素包括对应于第一液晶区的聚合物分散的液晶层和对应于第二液晶区的非聚合物分散的液晶层。