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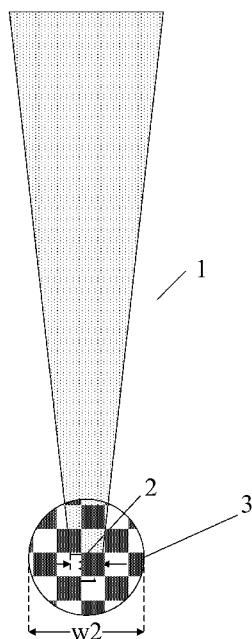
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(54) Title: NEEDLE FOR REPAIRING ALIGNMENT LAYER, ALIGNMENT LAYER REPAIRING APPARATUS, AND METHOD FOR REPAIRING ALIGNMENT LAYER

FIG. 1



(57) Abstract: A needle (1) for repairing an alignment layer on a liquid crystal display substrate. The needle (1) includes a needle tip (2); and a flexible material coating (3) surrounding the needle tip (2).

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NEEDLE FOR REPAIRING ALIGNMENT LAYER, ALIGNMENT LAYER REPAIRING APPARATUS, AND METHOD FOR REPAIRING ALIGNMENT LAYER

TECHNICAL FIELD

[0001] The present invention relates to display technology, and more particularly, to a needle for repairing an alignment layer, an alignment layer repairing apparatus, and a method for repairing an alignment layer.

BACKGROUND

[0002] A liquid crystal display apparatus produces an image by applying an electric field to a liquid crystal layer between an array substrate and a package substrate (e.g., a color filter substrate). The electric field changes an alignment direction of the liquid crystal molecules in a liquid crystal layer. Light transmittance of the liquid crystal layer is adjusted when the alignment direction of the liquid crystal molecules changes. The liquid crystal molecules in a liquid crystal display apparatus should be pre-aligned in a direction to normally operate the liquid crystal between two display substrates. Typically, an alignment layer is formed on a liquid crystal display substrate to pre-align the liquid crystal molecules in the liquid crystal display apparatus.

SUMMARY

[0003] In one aspect, the present disclosure provides a needle for repairing an alignment layer on a liquid crystal display substrate, comprising a needle tip; and a flexible material coating surrounding the needle tip.

[0004] Optionally, the flexible material coating comprises a cured polymer material made from a curable fluid polymer material.

[0005] Optionally, the curable fluid polymer material is curable by ultraviolet irradiation.

[0006] Optionally, the flexible material coating comprises an elastomer.

[0007] Optionally, the needle tip has a diameter in a range of approximately 10 μm to approximately 20 μm .

[0008] Optionally, the flexible material coating has a diameter in a range of approximately 10 μm to approximately 100 μm .

[0009] In another aspect, the present disclosure provides an alignment layer repairing apparatus, comprising the needle described herein.

[0010] Optionally, the alignment layer repairing apparatus further comprises a defect detection device configured to detect a defect in the alignment layer and determine a relative position of the defect in the alignment layer on the liquid crystal display substrate.

[0011] In another aspect, the present disclosure provides a method of repairing an alignment layer on a liquid crystal display substrate, comprising providing a needle having a needle tip and a flexible material coating surrounding the needle tip; and coating a defect in the alignment layer with an alignment layer repairing agent using the needle having the flexible material coating surrounding the needle tip.

[0012] Optionally, prior to providing the needle, the method further comprises forming the flexible material coating surrounding the needle tip.

[0013] Optionally, forming the flexible material coating surrounding the needle tip comprises applying a curable fluid polymer material surrounding the needle tip; and curing the curable fluid polymer material thereby forming the flexible material coating surrounding the needle tip.

[0014] Optionally, applying the curable fluid polymer material comprises pushing the curable fluid polymer material out of the needle through the needle tip, thereby forming a liquid layer of the curable fluid polymer material surrounding the needle tip.

[0015] Optionally, prior to coating the defect, the method further comprises applying the alignment layer repairing agent on the flexible material coating.

[0016] Optionally, applying the alignment layer repairing agent on the flexible material coating comprises dipping the flexible material coating in an alignment layer repairing agent.

[0017] Optionally, subsequent to applying the alignment layer repairing agent on the flexible material coating, the method further comprises contacting the flexible material coating with the liquid crystal display substrate at a position corresponding to the defect in the alignment layer.

[0018] Optionally, subsequent to coating the defect, the method further comprises curing the alignment layer repairing agent coated in the defect thereby repairing the defect in the alignment layer.

[0019] Optionally, prior to coating the defect, the method further comprises detecting the defect in the alignment layer; and determining a relative position of the defect in the alignment layer on the liquid crystal display substrate.

[0020] Optionally, the needle tip has a diameter in a range of approximately 10 μm to approximately 20 μm .

[0021] In another aspect, the present disclosure provides a method of fabricating a needle for repairing an alignment layer on a liquid crystal display substrate, comprising providing a needle having a needle tip; applying a curable fluid polymer material surrounding the needle tip; and curing the curable fluid polymer material thereby forming a flexible material coating surrounding the needle tip.

[0022] Optionally, applying the curable fluid polymer material comprises pushing the curable fluid polymer material out of the needle through the needle tip, thereby forming a liquid layer of the curable fluid polymer material surrounding the needle tip.

BRIEF DESCRIPTION OF THE FIGURES

[0023] The following drawings are merely examples for illustrative purposes according to various disclosed embodiments and are not intended to limit the scope of the present invention.

[0024] FIG. 1 is a schematic diagram illustrating the structure of a needle for repairing an alignment layer in some embodiments according to the present disclosure.

[0025] FIG. 2 is a schematic diagram illustrating the structure of a needle for repairing an alignment layer in some embodiments according to the present disclosure.

[0026] FIG. 3 is a schematic diagram illustrating the structure of a needle for repairing an alignment layer in some embodiments according to the present disclosure.

[0027] FIG. 4 is a schematic diagram illustrating the structure of an alignment layer repairing apparatus in some embodiments according to the present disclosure.

[0028] FIGs. 5A to 5C illustrate a process of fabricating a needle for repairing an alignment layer in some embodiments according to the present disclosure.

[0029] FIG. 6 is a diagram illustrating the structure of an alignment layer having a defect on a liquid crystal display substrate in some embodiments according to the present disclosure.

[0030] FIGs. 7A to 7D illustrate a process of repairing an alignment layer on a liquid crystal display substrate.

DETAILED DESCRIPTION

[0031] The disclosure will now be described more specifically with reference to the following embodiments. It is to be noted that the following descriptions of some embodiments are presented herein for purpose of illustration and description only. It is not intended to be exhaustive or to be limited to the precise form disclosed.

[0032] In the process of preparing an alignment layer on a liquid crystal display substrate, defects may form on the alignment layer. For example, the defects may be caused by physical damages such as scratches or bubbles formed on the alignment layer. The alignment layer has a typical thickness in a range of approximately 500 Å to approximately 1000 Å. To repair a defect such as an indentation (a hole) on the alignment layer is difficult using a conventional ink-repairing method because the conventional ink-repairing method can only form a layer of a thickness in the micrometer scale at the indentation. Accordingly, when the defects occur on the alignment layer, the entire alignment layer has to be removed, and a new alignment layer has to be formed, significantly increasing the manufacturing costs.

[0033] Accordingly, the present disclosure provides, *inter alia*, a needle for repairing an alignment layer, an alignment layer repairing apparatus, and a method for repairing an alignment layer that substantially obviate one or more of the problems due to limitations and disadvantages of the related art. In one aspect, the present disclosure provides a needle for repairing an alignment layer on a liquid crystal display substrate. In some embodiments, the needle for repairing an alignment layer on a liquid crystal display substrate includes a needle tip and a flexible material coating surrounding the needle tip. As used herein, the term “needle” refers to a needle-shaped object such as an elongated, cylindrical or non-cylindrical object. The needle-shaped object may be hollow or non-hollow. The cross-section of the needle-shaped object may be of any appropriate shape and size. Examples of needles include, but are not limited to, capillaries, micro-pipets, ultra-thin injection needles, micro-syringes,

and microelectrodes. Optionally, the liquid crystal display substrate is a liquid crystal array substrate. Optionally, the liquid crystal display substrate is a package substrate (e.g., a color filter substrate). As used herein, the term “flexible material” refers to an elastic and deformable material, such as an elastomer.

[0034] FIG. 1 is a schematic diagram illustrating the structure of a needle for repairing an alignment layer in some embodiments according to the present disclosure. Referring to FIG. 1, the needle 1 includes a needle tip 2 and a flexible material coating 3 surrounding the needle tip 2. The needle tip 2 and the flexible material coating 3 may be formed separately, as shown in FIG. 1. Optionally, the needle tip 2 and the flexible material coating 3 may be integrally formed, e.g., formed into a single piece. Optionally, the needle tip 2 and the flexible material coating 3 may be made of different materials or formed in different processes. Optionally, the needle tip 2 and the flexible material coating 3 may be made of a same material or formed in a single process.

[0035] Referring to FIG. 1, the needle tip 2 has a diameter w_1 , and the flexible material coating 3 has a diameter w_2 . Optionally, w_1 is in a range of approximately 10 μm to approximately 20 μm . Optionally, w_2 is in a range of approximately 10 μm to approximately 100 μm . Optionally, w_2 has a value that is approximately 1.05 to 10 times of that of w_1 .

[0036] Various appropriate flexible materials may be used for making the flexible material coating 3. Examples of suitable flexible materials include elastomers (i.e., viscoelastic polymers) such as polyimides, polysilicones, polysiloxanes, rubbers, urethane polyimides, polyepoxides, and so on. Optionally, the flexible material coating 3 is made of polyimide.

[0037] In some embodiments, the flexible material coating 3 is a cured polymer material made from a curable fluid polymer material. The curable fluid polymer material may be applied as a layer or a droplet surrounding the needle tip 2, and cured to form the flexible material coating 3. Various curing methods may be used to cure the curable fluid polymer material, e.g., by heat, by irradiation (e.g., UV irradiation), by chemicals (e.g., crosslinking by sulfur), and so on. In one example, the flexible material coating 3 includes polyimide, and the curing is performed by UV irradiation. In another example, the flexible material coating 3 includes rubber, the curable fluid polymer material includes unsaturated rubber, and the curing is performed by cross-linking the unsaturated rubber. In another example, the curable fluid polymer material is an alignment layer repairing agent for repairing the alignment layer.

[0038] FIG. 2 is a schematic diagram illustrating the structure of a needle for repairing an alignment layer in some embodiments according to the present disclosure. Referring to FIG. 2, the needle 1 in FIG. 2 has an opening O extending from the needle tip 2 through the flexible material coating 3 surrounding the needle tip 2. The opening O allows a fluid (e.g., an alignment layer repairing agent) contained in the needle to be dispensed out of the needle. As a comparison, the needle 1 in FIG. 1 does not have an opening extending through the flexible material coating 3. Thus, the needle 1 in FIG. 1 is a needle sealed at one end.

[0039] FIG. 3 is a schematic diagram illustrating the structure of a needle for repairing an alignment layer in some embodiments according to the present disclosure. Referring to FIG. 3, the needle 1 in some embodiments is a non-hollow needle not having a hollow chamber to hold a liquid. As a comparison, the needle 1 in FIG. 1 or FIG. 2 is a hollow needle capable of holding a liquid in a hollow chamber.

[0040] The flexible material coating 3 may have any appropriate shape. Examples of suitable shapes for the flexible material coating 3 include, but are not limited to, the shapes of sphere, bead, ring, cylinder, granule, particulate, or an irregular shape. The surface of the flexible material coating 3 may be smooth. Optionally, the flexible material coating 3 has a textured surface.

[0041] In some embodiments, a ratio of w2 (a diameter of the flexible material coating 3) to w1 (a diameter of the needle tip 2) is in a range of approximately 1.05:1 to approximately 10:1, e.g., approximately 1.05:1 to approximately 5:1, approximately 1.05:1 to approximately 2:1, approximately 1.1:1 to approximately 2:1, and approximately 1.2:1 to approximately 1.5:1. Optionally, w2 is in a range of approximately 10 μm to approximately 100 μm , e.g., approximately 10 μm to approximately 50 μm , approximately 10 μm to approximately 40 μm , approximately 10 μm to approximately 30 μm , and approximately 15 μm to approximately 20 μm .

[0042] In another aspect, the present disclosure provides an alignment layer repairing apparatus. In some embodiments, the alignment layer repairing apparatus includes a needle described herein or fabricated by a method described herein. Optionally, the alignment layer repairing apparatus further includes a defect detection device configured to detect a defect in the alignment layer and determine a relative position of the defect in the alignment layer on the liquid crystal display substrate.

[0043] FIG. 4 is a schematic diagram illustrating the structure of an alignment layer repairing apparatus in some embodiments according to the present disclosure. Referring to FIG. 4, the alignment layer repairing apparatus in some embodiments includes a defect detection device 10, a driver circuit 20, and an alignment layer repairing agent coating apparatus 30. The alignment layer repairing agent coating apparatus 30 includes a needle 1 described herein or fabricating by a method described herein. Optionally, the alignment layer repairing agent coating apparatus 30 further includes other components such as a rack for holding the needle 1 and optionally tubing for connecting the needle 1 with a liquid. The defect detection device 10 in some embodiments includes a defect position detecting circuit 10-1 and an imaging system 10-2. The imaging system 10-2 detects a defective position of the alignment layer, and the defect position detecting circuit 10-1 records a signal indicating the coordinate corresponding to the defective position. Movements of the alignment layer repairing agent coating apparatus 30 is controlled by the driver circuit 20. The driver circuit 20 is configured to receive the signal indicating the coordinate corresponding to the defective position from the defect position detecting circuit 10-1, and is configured to control the alignment layer repairing agent coating apparatus 30 to move the alignment layer repairing agent coating apparatus 30 above the defective position. Optionally, the imaging system 10-2 includes a camera, e.g., a charge coupling device (CCD). Optionally, the alignment layer repairing apparatus includes an automated optical inspection system.

[0044] In another aspect, the present disclosure provides a method of fabricating a needle for repairing an alignment layer on a liquid crystal display substrate. In some embodiments, the method includes providing a needling having a needle tip; applying a curable fluid polymer material surrounding the needle tip; and curing the curable fluid polymer material thereby forming a flexible material coating surrounding the needle tip. Optionally, the step of applying the curable fluid polymer material comprises pushing the curable fluid polymer material out of the needle through the needle tip, thereby forming a liquid layer of the curable fluid polymer material surrounding the needle tip.

[0045] FIGs. 5A to 5C illustrate a process of fabricating a needle for repairing an alignment layer in some embodiments according to the present disclosure. Referring to FIG. 5A, a needle 1 having a needle tip 2 is provided. The needle tip 2 has a diameter w_1 . Optionally, the diameter w_1 is in a range of approximately 10 μm to approximately 20 μm . A curable fluid polymer material CL is dispensed into the needle 1. Referring to FIG. 5B, a pressure is applied inside the chamber of the needle 1, thereby pushing a certain amount of curable fluid

polymer material CL through the opening of the needle tip 2. The curable fluid polymer material CL pushed out of the needle tip 2 attaches to the external surface of the needle tip 2, forming a droplet or a layer 3' of the curable fluid polymer material CL surrounding the needle tip 2. The droplet or the layer 3' of the curable fluid polymer material CL has a diameter w_2 . Optionally, the diameter w_2 is in a range of approximately 10 μm to approximately 100 μm . Referring to FIG. 5C, the droplet or the layer of the curable fluid polymer material CL is then cured by UV irradiation, thereby forming the flexible material coating 3 surrounding the needle tip 2.

[0046] FIG. 6 is a diagram illustrating the structure of an alignment layer having a defect on a liquid crystal display substrate in some embodiments according to the present disclosure. Referring to FIG. 6, the alignment layer 5 on the liquid crystal display substrate 6 contains a defect 7. As shown in FIG. 6, the defect 7 is an indentation in the alignment layer 5, e.g., the material of the alignment layer 5 is missing in a region corresponding to the defect 7.

[0047] In another aspect, the present disclosure provides a method of repairing an alignment layer on a liquid crystal display substrate. In some embodiments, the method includes providing a needle having a needle tip and a flexible material coating surrounding the needle tip; and coating a defect in the alignment layer with an alignment layer repairing agent using the needle having the flexible material coating surrounding the needle tip. Optionally, prior to providing the needle, the method further includes forming the flexible material coating surrounding the needle tip. Optionally, the step of forming the flexible material coating surrounding the needle tip includes applying a curable fluid polymer material surrounding the needle tip; and curing the curable fluid polymer material thereby forming the flexible material coating surrounding the needle tip. Optionally, the step of applying the curable fluid polymer material comprises pushing the curable fluid polymer material out of the needle through the needle tip, thereby forming a liquid layer of the curable fluid polymer material surrounding the needle tip. Optionally, prior to coating the defect, the method further includes applying the alignment layer repairing agent on the flexible material coating. Optionally, the step of applying the alignment layer repairing agent on the flexible material coating includes dipping the flexible material coating in an alignment layer repairing agent. Optionally, subsequent to applying the alignment layer repairing agent on the flexible material coating, the method further includes contacting the flexible material coating with the liquid crystal display substrate at a position corresponding to the defect in the alignment layer. Optionally, subsequent to coating the defect, the method further includes curing the

alignment layer repairing agent coated in the defect thereby repairing the defect in the alignment layer. Optionally, prior to coating the defect, the method further includes detecting the defect in the alignment layer; and determining a relative position of the defect in the alignment layer on the liquid crystal display substrate. Optionally, the needle tip has a diameter in a range of approximately 10 μm to approximately 20 μm . Optionally, the alignment layer repairing agent includes polyimide.

[0048] FIGs. 7A to 7D illustrate a process of repairing an alignment layer on a liquid crystal display substrate. As shown in FIG. 6, a defect 7 is detected in the alignment layer 5, and the relative position of the defect 7 is determined. Referring to FIG. 7A, a needle 1 having a needle tip 2 and a flexible material coating 3 surrounding the needle tip 2 is used for repairing the defect in the alignment layer. A layer 4 of alignment layer repairing agent is applied on the flexible material coating 3, for example, by dipping the flexible material coating 3 in the alignment layer repairing agent. Referring to FIG. 7B, the needle 1 having the layer 4 of alignment layer repairing agent applied on the flexible material coating 3 is moved to a position corresponding to the defect 7 on the alignment layer 5. The repairing method in some embodiments further includes coating the alignment layer repairing agent on the portion of the alignment layer 5 corresponding to the defect 7, thereby repairing the alignment layer 5. Optionally, the needle 1 is made to be in contact with the defect 7 in order to better repair the defect 7 on the alignment layer 5. Optionally, the needle 1 is moved around at the position corresponding to the defect 7, e.g., in a S-shape pattern, thereby evenly coating the alignment layer repairing agent on the portion of the alignment layer 5 corresponding to the defect 7. Because the needle 1 has a flexible material coating 3, the movement of the needle 1 will not damage the alignment layer 5. Referring to FIG. 7C, once the alignment layer repairing agent is coated on the alignment layer 5, the needle 1 can be moved away from the alignment layer. Subsequently, a repaired portion 4' (made of the alignment layer repairing agent) coated on the portion of the alignment layer 5 corresponding to the defect is cured, e.g., by UV irradiation, thereby repairing the alignment layer. As shown in FIG. 7C, the present needle 1 having the flexible material coating 3 surrounding the needle tip 2 is capable of forming a repaired portion 4' having a thickness substantially the same as other portions of the alignment layer 5, e.g., a thickness in a range of approximately 500 Å to approximately 1000 Å. FIG. 7D shows an alignment layer repaired by the present method. As shown in FIG. 7D, the alignment layer repaired by the present method has a smooth and even surface, and a substantially uniform thickness.

[0049] In some embodiments, the method further includes calibrating a position of the needle relative to the liquid crystal display substrate (and the alignment layer thereon). In one example, the needle can be moved to a selected position on the liquid crystal display substrate, e.g., manually. In one example, a distance between the needle tip and the substrate can be gradually decreased until the needle tip is just in contact with the surface of the substrate. For example, when the needle tip is just touching the surface of the substrate, a slight vibration motion of the needle may be observed or detected. The relative position of the needle corresponding to the touch position may be recorded by the imaging system (e.g., a camera). Once the position of the needle relative to the liquid crystal display substrate is calibrated, the needle can be used for repairing a defect in the alignment layer once the defect position is determined.

[0050] Optionally, a plurality of needles may be prepared for repairing one alignment layer. Optionally, at least two of the plurality of needles are of different sizes (e.g., diameters).

[0051] The present method may be used to repair various types of defects on the alignment layer. In some embodiments, the defect is one other than an indentation on the alignment layer. For example, the defect in some embodiments is a bulge on the alignment layer, e.g., one caused by a bubble or a particle underneath the alignment layer. In some embodiments, the method of repairing the alignment layer on a liquid crystal display substrate further includes first removing a bulge on the alignment layer, e.g., using a high energy plasma, thereby forming an indentation on the alignment layer. Subsequently, the indentation may be filled by the method described above, e.g., using a needle having a flexible material coating surrounding its needle tip.

[0052] The foregoing description of the embodiments of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form or to exemplary embodiments disclosed. Accordingly, the foregoing description should be regarded as illustrative rather than restrictive. Obviously, many modifications and variations will be apparent to practitioners skilled in this art. The embodiments are chosen and described in order to explain the principles of the invention and its best mode practical application, thereby to enable persons skilled in the art to understand the invention for various embodiments and with various modifications as are suited to the particular use or implementation contemplated. It is intended that the scope of the invention be defined by the claims appended hereto and their equivalents in which all terms are meant

in their broadest reasonable sense unless otherwise indicated. Therefore, the term “the invention”, “the present invention” or the like does not necessarily limit the claim scope to a specific embodiment, and the reference to exemplary embodiments of the invention does not imply a limitation on the invention, and no such limitation is to be inferred. The invention is limited only by the spirit and scope of the appended claims. Moreover, these claims may refer to use “first”, “second”, etc. following with noun or element. Such terms should be understood as a nomenclature and should not be construed as giving the limitation on the number of the elements modified by such nomenclature unless specific number has been given. Any advantages and benefits described may not apply to all embodiments of the invention. It should be appreciated that variations may be made in the embodiments described by persons skilled in the art without departing from the scope of the present invention as defined by the following claims. Moreover, no element and component in the present disclosure is intended to be dedicated to the public regardless of whether the element or component is explicitly recited in the following claims.

WHAT IS CLAIMED IS:

1. A needle for repairing an alignment layer on a liquid crystal display substrate, comprising:
 - a needle tip; and
 - a flexible material coating surrounding the needle tip.
2. The needle of claim 1, wherein the flexible material coating comprises a cured polymer material made from a curable fluid polymer material.
3. The needle of claim 2, wherein the curable fluid polymer material is curable by ultraviolet irradiation.
4. The needle of claim 1, wherein the flexible material coating comprises an elastomer.
5. The needle of claim 1, wherein the needle tip has a diameter in a range of approximately 10 μm to approximately 20 μm .
6. The needle of claim 1, wherein the flexible material coating has a diameter in a range of approximately 10 μm to approximately 100 μm .
7. An alignment layer repairing apparatus, comprising the needle of any one of claims 1 to 6.
8. The alignment layer repairing apparatus of claim 7, further comprising a defect detection device configured to detect a defect in the alignment layer and determine a relative position of the defect in the alignment layer on the liquid crystal display substrate.
9. A method of repairing an alignment layer on a liquid crystal display substrate, comprising:
 - providing a needle having a needle tip and a flexible material coating surrounding the needle tip; and
 - coating a defect in the alignment layer with an alignment layer repairing agent using the needle having the flexible material coating surrounding the needle tip.
10. The method of claim 9, prior to providing the needle, further comprising forming the flexible material coating surrounding the needle tip.

11. The method of claim 10, wherein forming the flexible material coating surrounding the needle tip comprises:

applying a curable fluid polymer material surrounding the needle tip; and
curing the curable fluid polymer material thereby forming the flexible material coating surrounding the needle tip.

12. The method of claim 11, wherein applying the curable fluid polymer material comprises pushing the curable fluid polymer material out of the needle through the needle tip, thereby forming a liquid layer of the curable fluid polymer material surrounding the needle tip.

13. The method of claim 9, prior to coating the defect, further comprising applying the alignment layer repairing agent on the flexible material coating.

14. The method of claim 13, wherein applying the alignment layer repairing agent on the flexible material coating comprises dipping the flexible material coating in an alignment layer repairing agent.

15. The method of claim 13, subsequent to applying the alignment layer repairing agent on the flexible material coating, further comprising contacting the flexible material coating with the liquid crystal display substrate at a position corresponding to the defect in the alignment layer.

16. The method of claim 9, subsequent to coating the defect, further comprising curing the alignment layer repairing agent coated in the defect thereby repairing the defect in the alignment layer.

17. The method of claim 9, prior to coating the defect, further comprising detecting the defect in the alignment layer; and

determining a relative position of the defect in the alignment layer on the liquid crystal display substrate.

18. The method of claim 9, wherein the needle tip has a diameter in a range of approximately 10 μm to approximately 20 μm .

19. A method of fabricating a needle for repairing an alignment layer on a liquid crystal display substrate, comprising:

providing a needle having a needle tip;
applying a curable fluid polymer material surrounding the needle tip; and
curing the curable fluid polymer material thereby forming a flexible material coating surrounding the needle tip.

20. The method of claim 19, wherein applying the curable fluid polymer material comprises pushing the curable fluid polymer material out of the needle through the needle tip, thereby forming a liquid layer of the curable fluid polymer material surrounding the needle tip.

FIG. 1

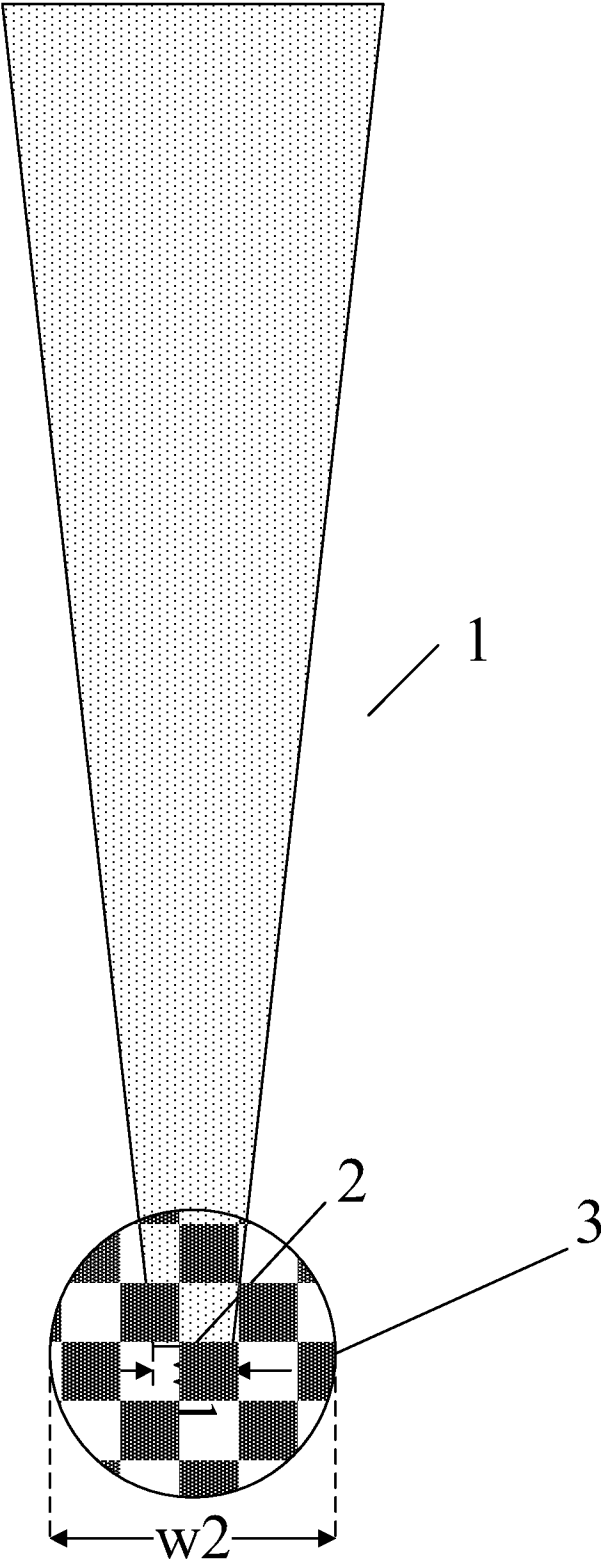


FIG. 2

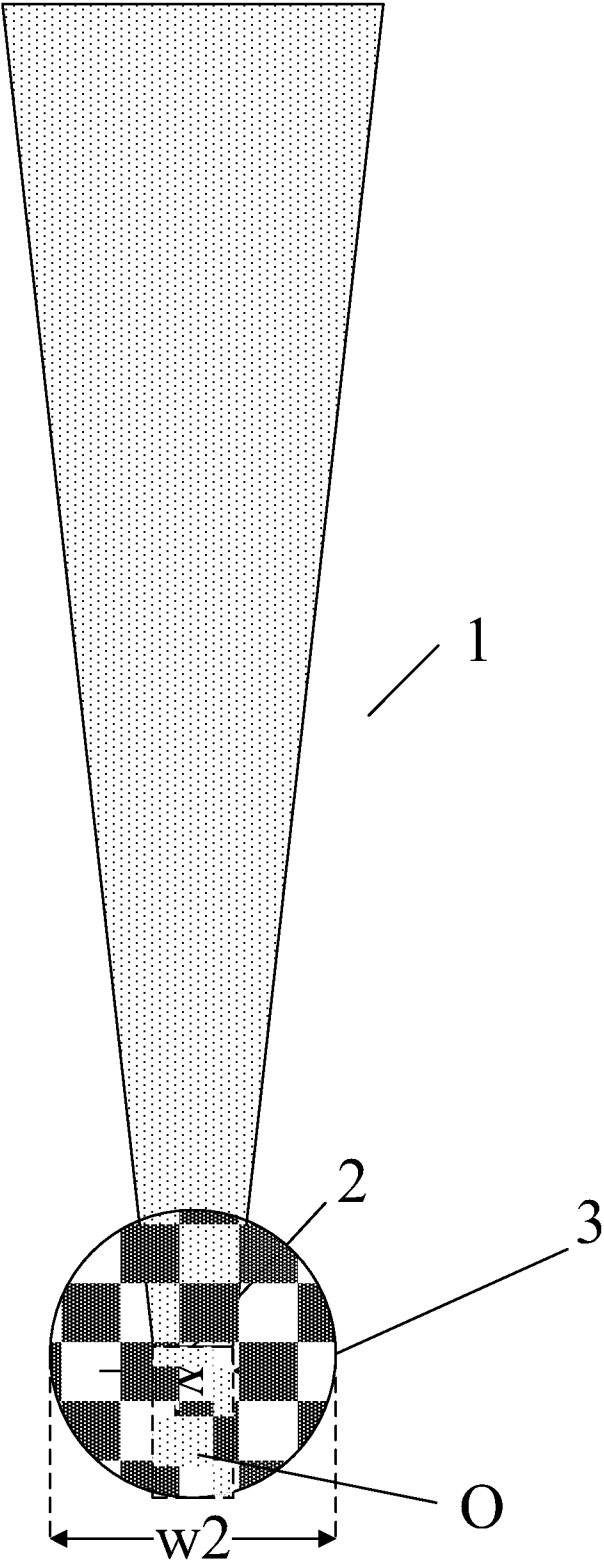


FIG. 3

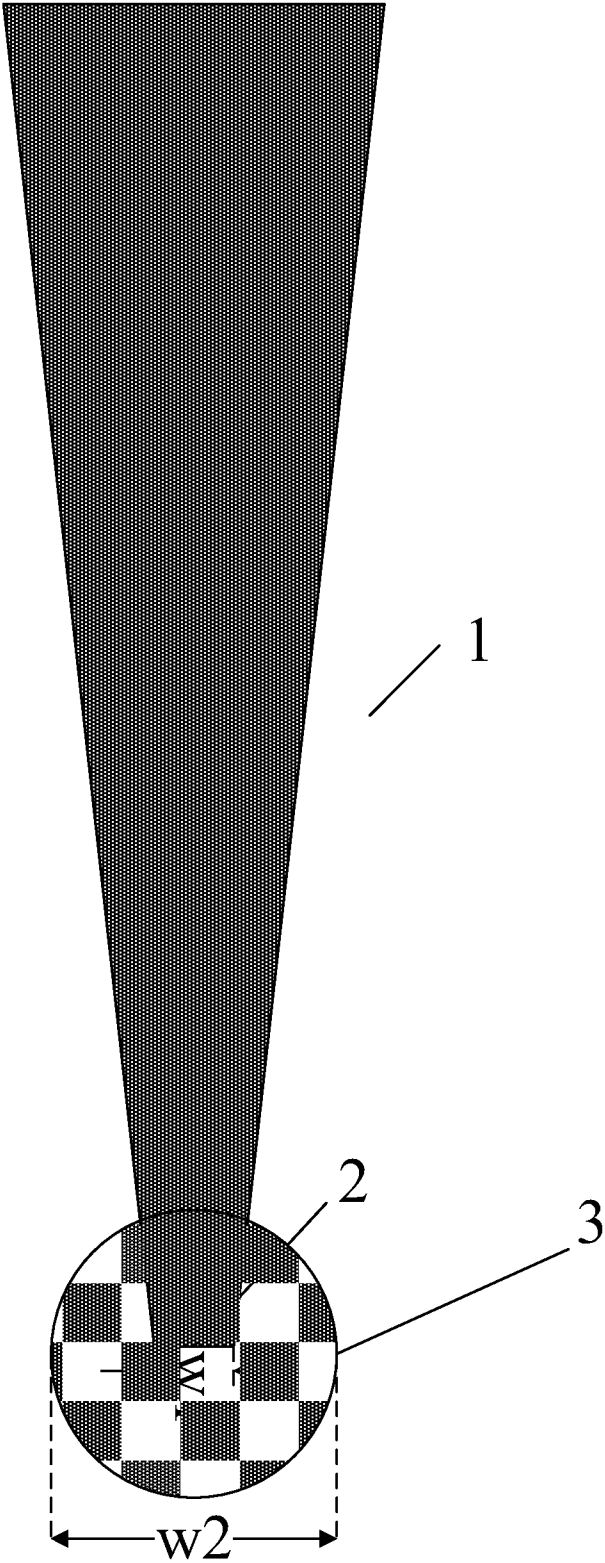


FIG. 4

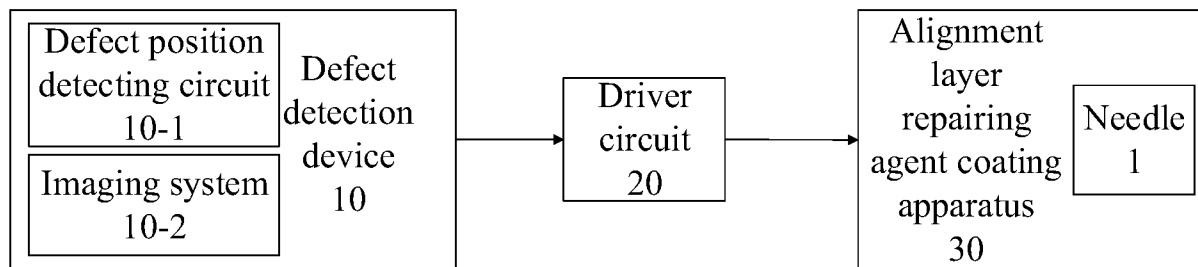


FIG. 5A

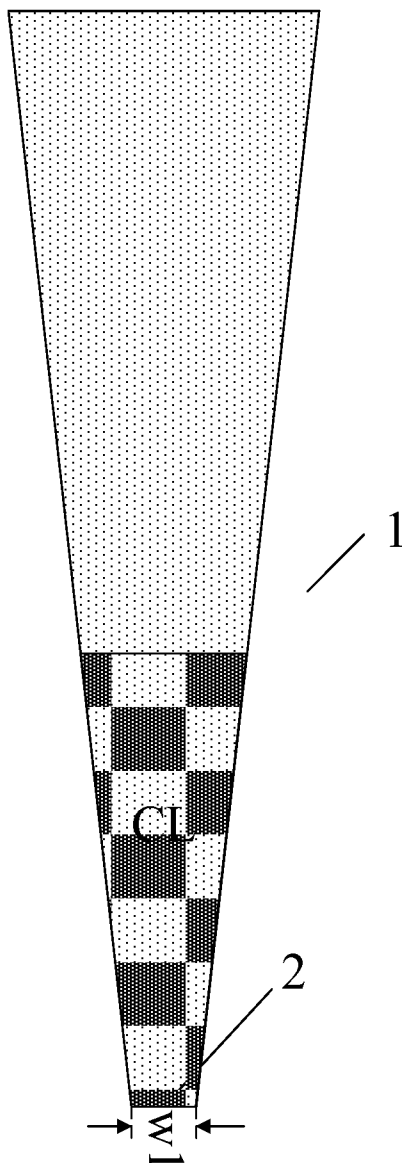


FIG. 5B

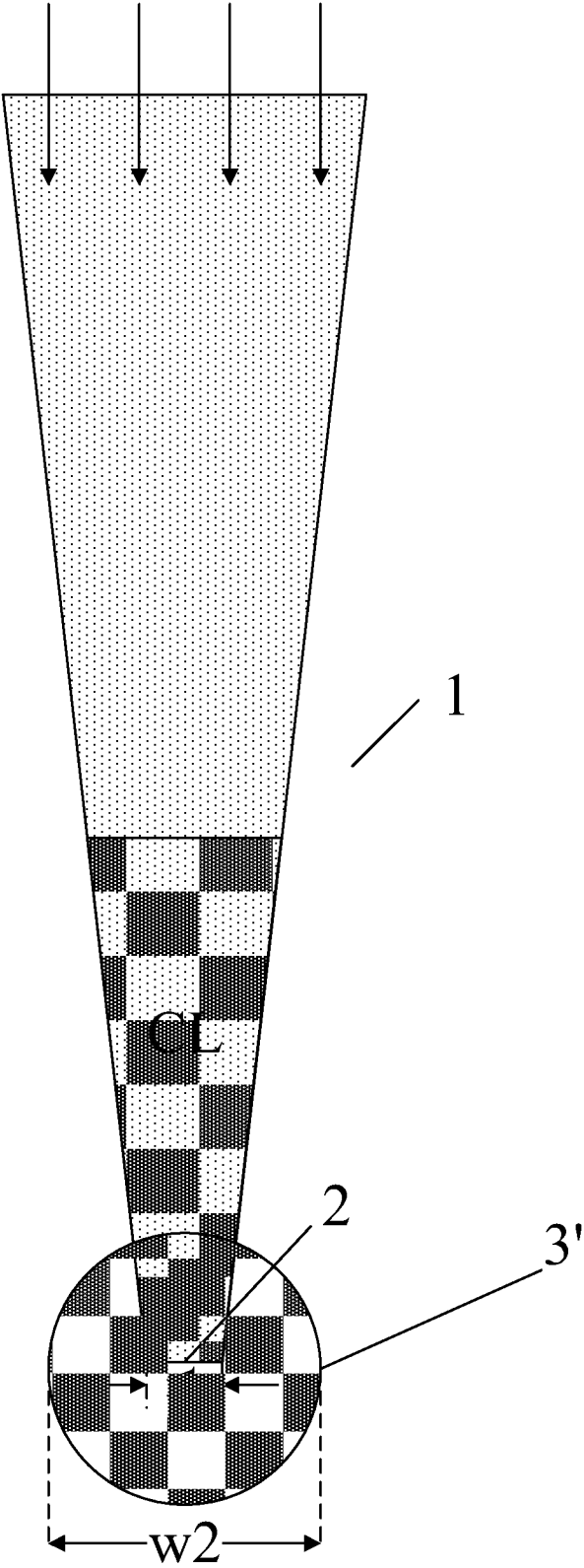


FIG. 5C

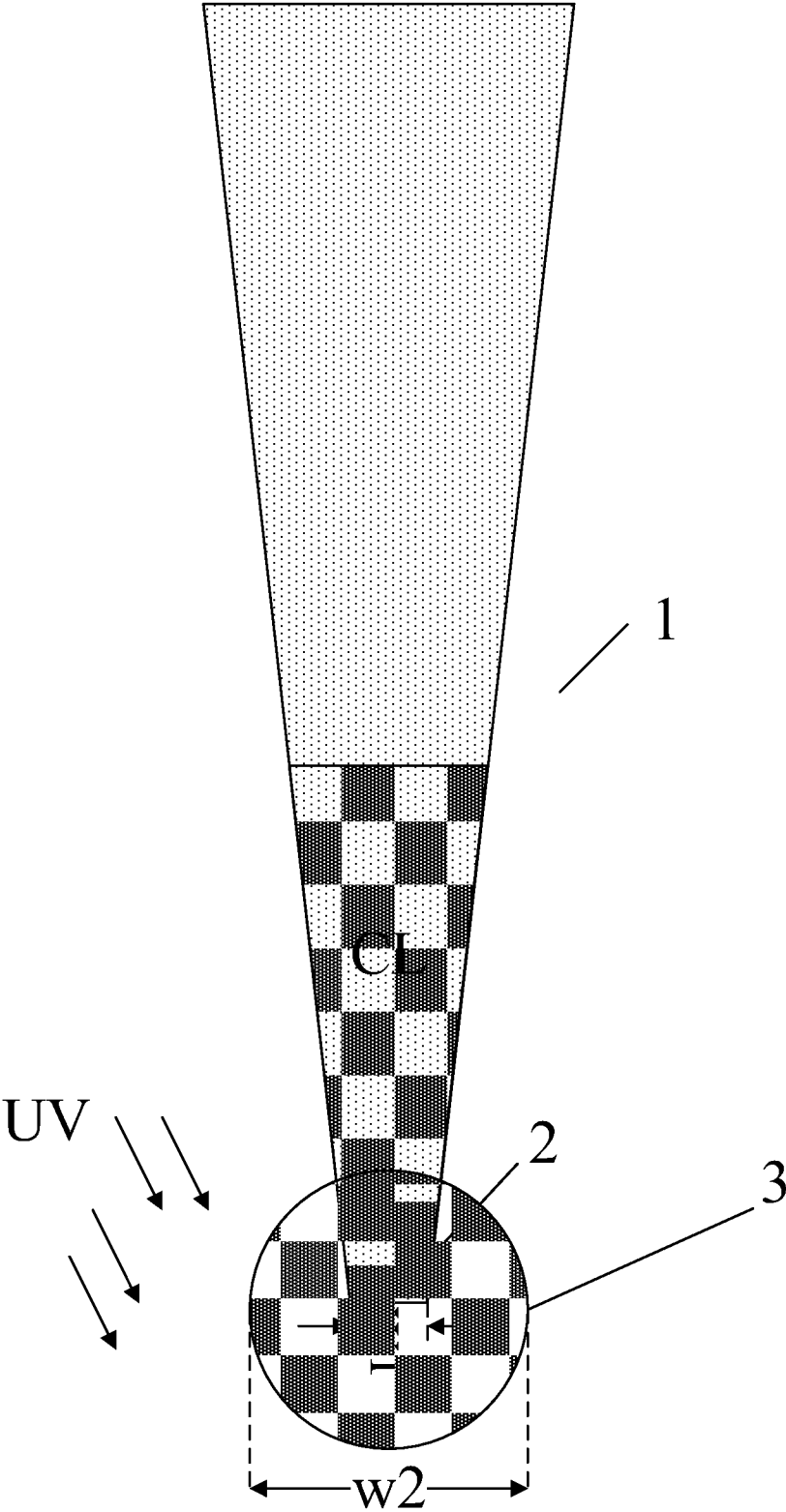


FIG. 6

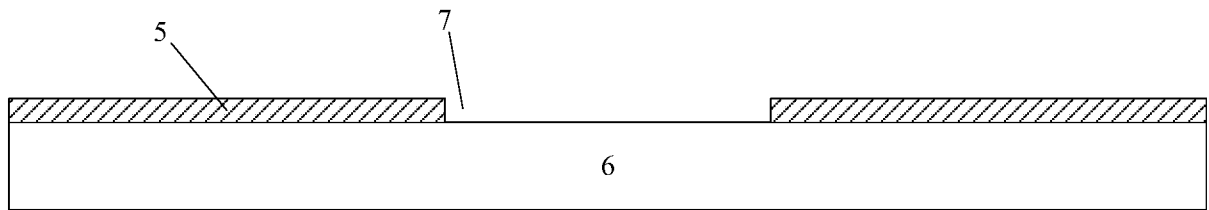


FIG. 7A

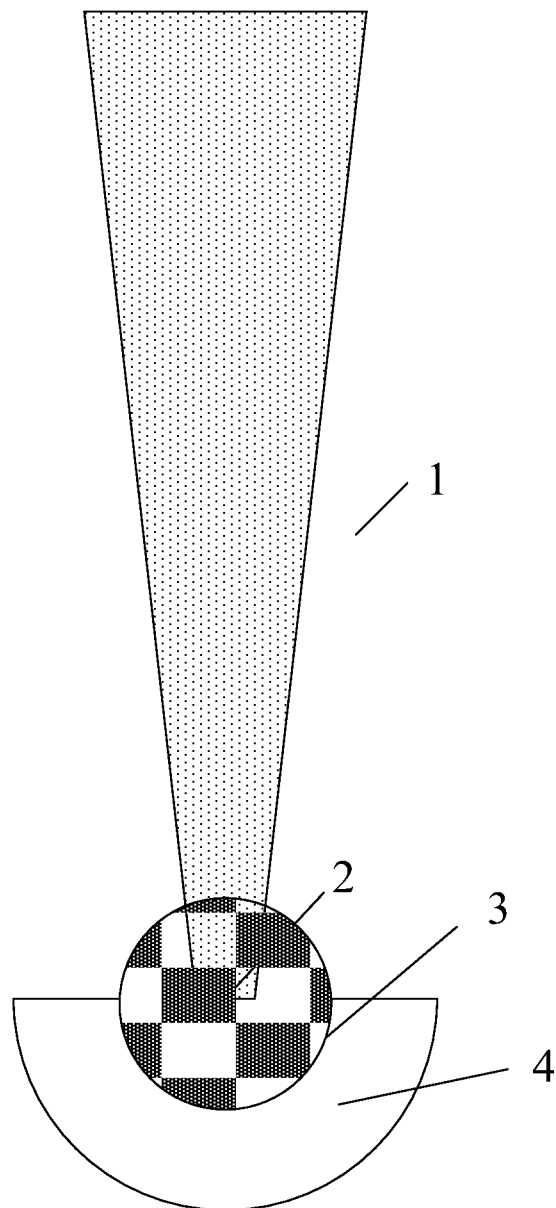


FIG. 7B

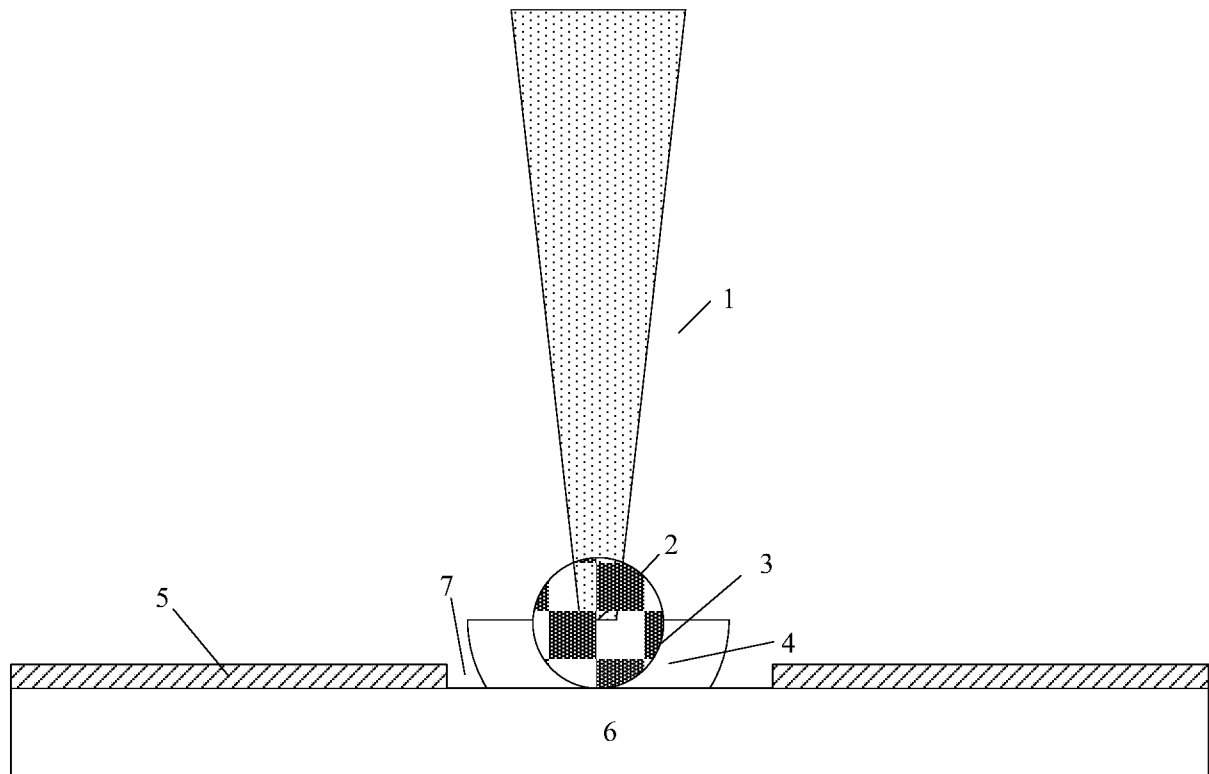


FIG. 7C

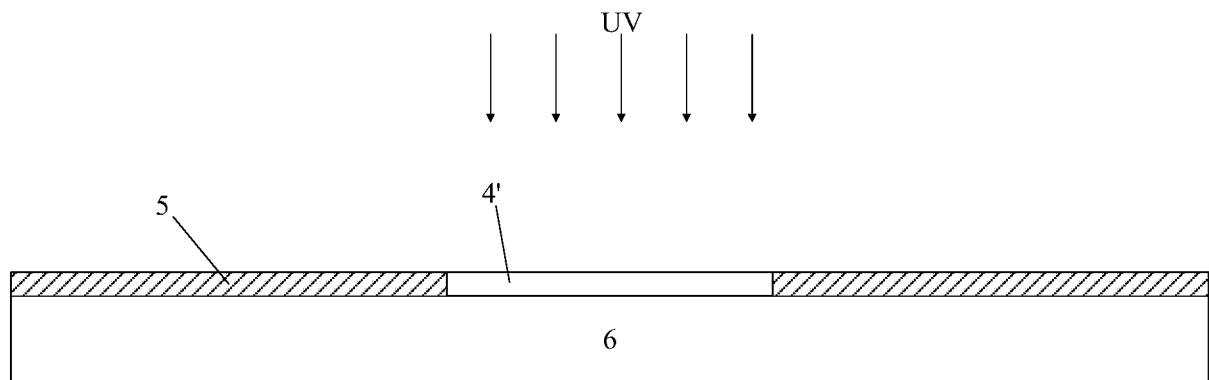
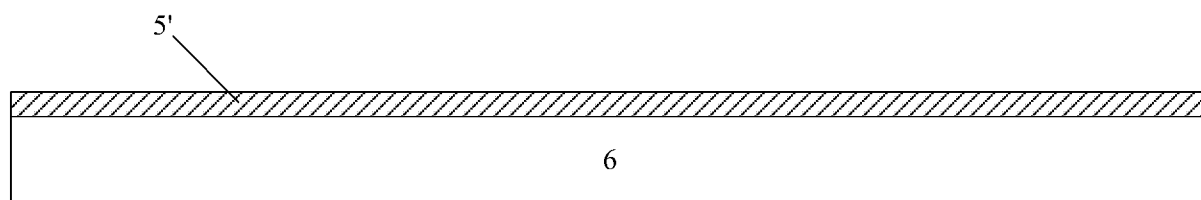


FIG. 7D

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2017/101020

A. CLASSIFICATION OF SUBJECT MATTER

B23B 43/00(2006.01)i; B05C 5/00(2006.01)i; B05C 11/00(2006.01)i; G02F 1/1337(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B23B; B05C; G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNTXT, CNKI, EPODOC, WPI: needle?, repair???, alignment, layer?, liquid, crystal, tip, flexible, coat???, surround???, polymer, position, defect, test???, out, push???, cure

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010294417 A1 (SHARP KABUSHIKI KAISHA) 25 November 2010 (2010-11-25) description, paragraphs [0047]-[0105], figures 1-17	1-20
A	US 2013139752 A1 (SONG, YU) 06 June 2013 (2013-06-06) the whole document	1-20
A	CN 102792216 A (SHARP KABUSHIKI KAISHA) 21 November 2012 (2012-11-21) the whole document	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

16 May 2018

Date of mailing of the international search report

06 June 2018

Name and mailing address of the ISA/CN

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Telephone No. 86-(10)-53962384

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2017/101020

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				JP	WO2007132586	A1	24 September 2009
				HK	1127131	A1	21 December 2012
				US	8023097	B2	20 September 2011
				EP	2023185	A1	11 February 2009
				CN	101416099	B	29 September 2010
				CN	101806965	A	18 August 2010
				CN	101416099	A	22 April 2009
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				CN	101916018	B	27 March 2013
				CN	101916018	A	15 December 2010
				KR	100948734	B1	22 March 2010
				US	2009021680	A1	22 January 2009
				WO	2007132586	A1	22 November 2007
				JP	4260219	B2	30 April 2009
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				US	7880844	B2	01 February 2011
				HK	1128772	A1	14 January 2011
				KR	100949641	B1	26 March 2010
US	2013139752	A1	06 June 2013	None			
CN	102792216	A	21 November 2012	JP	WO2011125983	A1	11 July 2013
				WO	2011125983	A1	13 October 2011
				JP	5619143	B2	05 November 2014
				CN	102792216	B	28 January 2015