



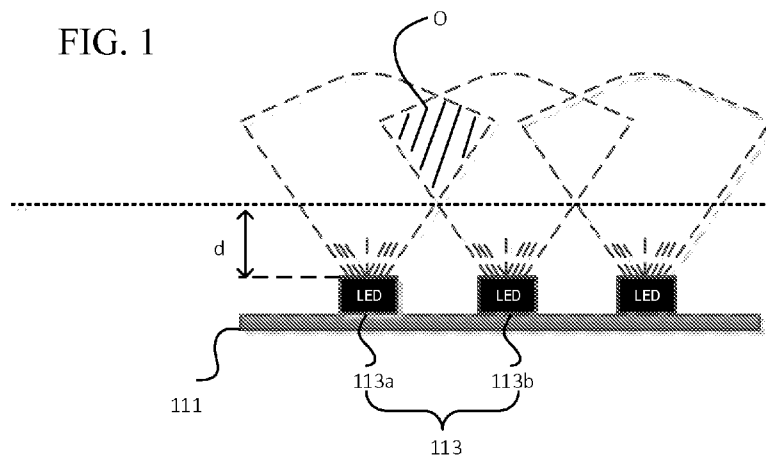
- (51) International Patent Classification:  
G02B 6/00 (2006.01)
- (21) International Application Number:  
PCT/US2015/043505
- (22) International Filing Date:  
3 August 2015 (03.08.2015)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
62/031,951 1 August 2014 (01.08.2014) US  
14/490,879 19 September 2014 (19.09.2014) US
- (71) Applicants: SCT TECHNOLOGY, LTD. [US/US]; FCM LTD., Governors Square #1-205, P.O. Box 1982, West Bay Road, Grand Cayman, KY1-1104 (KY). DISPLAY SYSTEMS AS [NO/NO]; Braanaasveien 29, Braanaas Hovedgaard, N-2019 Skedsmokorset (NO).
- (72) Inventors: NADERSHAHL, Shahnad; 168 Forrester Court, Simi Valley, California 93065 (US). EDVARDSEN, Kjetil Osa; Braanaasveien 29, Braanaas Hovedgaard, N-2019 Skedsmokorset (NO).
- (74) Agent: XUE, Allen; Novick, Kim & Lee, PLLC, 1604 Spring Hill Rd. Suite 320, Vienna, Virginia 22182 (US).

- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LI, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:  
— with international search report (Art. 21(3))

(54) Title: DISPLAY DEVICE AND METHOD FOR REDUCING MOIRÉ EFFECTS USING THE SAME

FIG. 1



(57) Abstract: A display device includes a printed circuit board (PCB) having a plurality of light emitting members, an anti-moire member spaced away from the plurality of light emitting members at about a first distance (d), and a frame member receiving the PCB such that the PCB is interposed between the anti-moire and the frame member. The anti-moire member includes a first layer disposed to face the PCB and having a first foil with a randomized pattern surface. The first distance (d) equals  $L / (2 * \tan(a))$ . The second distance (L) is a shortest distance between two adjacent light emitting members. Each of the array of light emitting members has a radiation angle a.



**DISPLAY DEVICE AND METHOD FOR REDUCING MOIRÉ EFFECTS USING  
THE SAME**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Utility Patent Application

FIELD OF THE INVENTION

[001] This invention relates generally to a display device, in particular to a display device with reduced moiré effects and a method for reducing moiré effects.

BACKGROUND OF THE INVENTION

[002] Moiré effects are interference patterns of light or other radiation that occurs when sets or patterns of lines, dots, or other repeating features are superimposed on each other. Such interference patterns could be caused by having a multiplicity of the display elements in an array on a display screen. For example, the display may be formed by laminating a number of light emitting diodes (LEDs) to a printed circuit board (PCB), and typically has a regular array of square pixels. In this case, the interference patterns may be caused by the overlaid radiated lights from the sources of LEDs.

[003] Several methods have been disclosed for reducing the moiré effects in displays. For instance, U.S. published applications No. US 2003/0132895 and No. US 2003/0184665 disclose using non-uniformly spaced pixels to avoid moiré effects between display elements such as LCDs, LEDs or TFTs and features of an image being displayed or being detected by a sensor array. U.S. Patent No. 6,075,581 discloses an optical filter for reducing moiré effects in an LCD or other displays having a matrix-like pixel pattern. Published international

application No. WO2004/051354 discloses an electrophoretic display with a two-layer structure in which laminating a top micro-cup layer to a bottom layer at an angle or a less symmetrical micro-cup array is used to avoid formation of undesirable moiré patterns.

[004] Above mentioned methods or display devices employ asymmetrical arrangement of a plurality of pixels to avoid the moiré effects. However, asymmetrical arrangement of the pixels may not be feasible for high resolution displays that requires a large scale integration of pixels. A new display device and a method for reducing moiré effects without changing the arrangement of the pixels are needed.

#### SUMMARY OF THE INVENTION

[005] In view of the aforementioned needs, the present disclosure provides a display device and a method for reducing moiré effects. According to an embodiment of the present disclosure, a display device is provided. The display device includes a printed circuit board (PCB) having a plurality of light emitting diodes (LEDs), a frame member supporting the PCB, an anti-moiré member spaced away from the LEDs at about a first distance (d). The anti-moiré member includes a first layer facing the PCB and having a first foil with a randomized pattern surface. A distance between the LEDs and the anti-moiré member equals about the first distance (d), and the anti-moiré member is transparent.

[006] According to another embodiment of the present disclosure, a display device is provided. The display device includes a printed circuit board (PCB) having a plurality of light emitting diodes (LEDs), a frame member, and the anti-moiré member.

[007] The frame member includes a first bracket and a second bracket, providing structural

support for the PCB. In one embodiment, the anti-moiré member is spaced away from the LEDs on the frame member. The anti-moiré member includes a plurality of distinct layers. In one embodiment, the anti-moiré member has a first layer, a second layer, a third layer, and a fourth layer. The first layer is disposed to face the PCB and has a first foil with a randomized pattern surface. The second layer is disposed on the first layer and has a second foil with a colored transparent film. The third layer is disposed on the second layer. The third layer is made of an untreated glass. The fourth layer is disposed on the third layer having a third foil with a matte surface. The distance between the LEDs and the anti-moiré member is about the first distance (d).

[008] In an array of LED such as in a display, the shortest distance between to adjacent LEDs is hereby defined as the second distance (L). Each of the plurality of LEDs has a radiation angle  $\alpha$ , and the first distance (d) is calculated by a following equation:

$$d=L/(2*\tan(\alpha))$$

Each of the first and the second bracket is configured to adjust a distance between the PCB and the anti-moiré member.

[009] According to another embodiment of the present disclosure, a method for reducing moiré effects includes a step of providing a display having a printed circuit board (PCB), a step of calculating a first distance (d) between the PCB and the anti-moiré member, and a step of adjusting a distance between the PCB and the anti-moiré member to about the first distance (d).

[0010] The distance between the LEDs and the anti-moiré member is adjusted to about the first distance (d) so that the LEDs substantially maintain an equal distance from the anti-

moiré member. The adjustment is accomplished by adjusting at least one of the first bracket and the second bracket.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a schematic diagram illustrating moiré effects.

[0012] FIG. 2 is a schematic cross-sectional view of the display device according to the embodiment of the present disclosure illustrating the first distance ( $d$ ) between an anti-moiré member and LEDs.

[0013] FIG. 3A is a schematic diagram illustrating a relationship among a radiation angle  $\alpha$ , the first distance ( $d$ ) between an anti-moiré member and LEDs, and the second distance ( $L$ ) between two adjacent LEDs.

[0014] FIG. 3B is an enlarged view of the portion of FIG. 3A shown in the view circle 3B.

[0015] FIG. 4 is a schematic cross-sectional view of a display device according to an embodiment of the present disclosure.

[0016] FIG. 5 is a micrograph of a first foil with a randomized pattern surface.

[0017] FIG. 6 is a schematic cross-sectional view of the display device according to the embodiment of the present disclosure including a first bracket and a second bracket.

[0018] FIG. 7 is a flowchart illustrating the method for reducing moiré effects.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0019] Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout the several views. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of the present description. Terms used herein are for descriptive purposes only and are not intended to limit the scope of the disclosure. The terms “comprises” and/or “comprising” are used to specify the presence of stated elements, steps, operations, and/or components, but do not preclude the presence or addition of one or more other elements, steps, operations, and/or components. The terms “first,” “second,” and the like may be used to describe various elements, but do not limit the elements. Such terms are only used to distinguish one element from another.

[0020] In the following description, all numbers disclosed herein are approximate values, regardless whether the word “about” or “approximate” is used in connection therewith. The value of each number may differ by 1%, 2%, 5%, 7%, 8%, 10%, 15% or 20%. Therefore, whenever a number having a value N is disclosed, any number having the value  $N\pm 1\%$ ,  $N\pm 2\%$ ,  $N\pm 3\%$ ,  $N\pm 5\%$ ,  $N\pm 7\%$ ,  $N\pm 8\%$ ,  $N\pm 10\%$ ,  $N\pm 15\%$  or  $N\pm 20\%$  is specifically disclosed, wherein “+/-” refers to plus or minus. Whenever a numerical range with a lower limit, RL, and an upper limit, RU, is disclosed, any number falling within the range is specifically disclosed. In particular, the following numbers within the range are specifically disclosed:  $R=RL+k*(RU-RL)$ , wherein k is a variable ranging from 1% to 100% with a 1% increment, i.e., k is 1%, 2%, 3%, 4%, 5%, . . . , 50%, 51%, 52%, . . . , 95%, 96%, 97%, 98%, 99%, or 100%. Moreover, any numerical range defined by two R numbers as defined above is also specifically disclosed.

[0021] In this disclosure, a light emitting member or an LED refers to a single light emitting diode or a cluster of LEDs packaged together, e.g., a RGB LED. Furthermore, the array of LED is mounted on a flat surface, such as a PCB board. Although LED is used as an example of light emitting members herewith, any other electronic component of light emitting members can be used in accordance with an embodiment of the present invention.

[0022] These and/or other aspects become apparent and are more readily appreciated by those of ordinary skill in the art from the following description of embodiments of the present disclosure, taken in conjunction with the accompanying drawings. The figures depict embodiments of the present disclosure for purposes of illustration only. One skilled in the art will readily recognize from the following description that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles of the disclosure described herein.

[0023] FIG. 1 is a schematic diagram illustrating moiré effects. As shown in FIG. 1, each of the first LED 113a and the second LED 113b forms a radiation field respectively. An overlapped radiation field O exists between the first and second LEDs 113a and 113b. In FIG. 1, a dotted line is located at about the first distance (d) from the LEDs 113 and indicates a line where the overlapped radiation field O starts. In one embodiment, an anti-moiré member can be located at about the first distance (d) above the LEDs 113 to reduce the moiré effects.

[0024] FIG. 2 is a schematic cross-sectional view of the display device according to the embodiment of the present disclosure illustrating the first distance (d) between anti-moiré member 130 and LEDs 113, and a function of anti-moiré member 130. As shown in FIG. 2, light emitted from LEDs 113 is randomly refracted after passing through anti-moiré member

130, reducing the number of repeating patterns superimposed on one another.

[0025] FIG. 3A is a schematic diagram illustrating a relationship among a radiation angle  $\alpha$ , the first distance (d) between anti-moiré member 130 and LEDs 113, and second distance (L) being the shortest distance between two adjacent LEDs 113a and 113b. FIG. 3B is an enlarged view of the portion of FIG. 3A shown in the view circle 3B.

[0026] The plurality of LEDs can be arranged in different patterns, such as in rows and columns. The distance between two adjacent LEDs in a row or in a column can be different or the same. When such a distance is different, the second distance (L) can be equal to the value of the shortest distance between two adjacent LEDs. In a display with a uniform pixel pitch, such a distance is the same, which is second distance (L).

[0027] Each of the plurality of LEDs 113 has a radiation angle  $\alpha$ . The radiation angle  $\alpha$  is half the vertex angle of the cone of light emitted at the exit face of each of LEDs 113. According to a formula of tangent, tangent  $\alpha$  can be obtained by the opposite side of the radiation angle  $\alpha$  divided by the adjacent side of the radiation angle  $\alpha$ . Thus, first distance (d) can be calculated according to equation 1

$$[\text{Equation 1}] d=L/ (2*\tan (\alpha))$$

[0028] For exemplarary purpose, radiation angle  $\alpha$  may be in a range of 45 to 50 degrees. Thus, according to the question 1, the first distance (d) may be in a range of 0.42L to 0.5L.

[0029] FIG. 4 is a schematic cross-sectional view of a display device 1 according to an embodiment of the present disclosure. The display device 1 includes a printed circuit board (PCB) 111, a frame member 120, and an anti-moiré member 130.

[0030] PCB 111 includes a plurality of light emitting diodes (LEDs) 113. LED is a two-lead

semiconductor light source. Recent developments in LEDs allow them to be used in environmental lighting. LEDs have many advantages including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. LEDs can be manufactured to be smaller size so that they can be placed with high density over flat or even shaped substrates including PCBs. A plurality of LEDs can be equidistantly mounted on PCB 111 in an array.

[0031] Frame member 120 physically supports PCB 111. The details of a structure of frame member 120 will be described later. Anti-moiré member 130 includes transparent randomized surface so that light from LEDs 113 is randomly refracted as it passes through anti-moiré member 130. The surface of anti-moiré member 130 has approximately equal luminance to all directions as light passes therethrough. The visibility of objects, except for a light-emitting objects, is primarily obtained by diffusion of a reflection of light. Diffusely-scattered light forms an image of the object in the observer's eye or the camera. Equally diffused light would not cause the moiré effects. The surface of the anti-moiré member can be fabricated with an irregular texture to equally diffuse light to all directions. The surface may be made of fibers or selected organic cells with their membranes and their complex internal structure.

[0032] In one embodiment, anti-moiré member 130 includes a first layer 131, a second layer 133, a third layer 135, and a fourth layer 137. First layer 131 is disposed to face PCB 111. First layer 131 is a first foil with a randomized pattern surface. For exemplarary purpose and not limiting thereto, Light Shaping Difusers<sup>®</sup> or LSD<sup>®</sup> manufactured by Luminit<sup>®</sup> can be used for the first foil. FIG. 5 is a picture of a first foil with a randomized pattern surface taken by scanning electron microscope (SEM).

[0033] The randomized surface of the first foil has a peak-valley height in a range of about 0

to 2  $\mu\text{m}$ . The first foil can have a transparent pressure sensitive adhesive (PSA). PSA is selected from the group consisting of an acrylic compound, a methacrylate compound, a rubber compound, a water based compound, a solvent based compound, a silicone compound, and a styrene compound.

[0034] Second layer 133 is disposed on first layer 131. In one embodiment, second layer 133 is a second foil with a colored transparent film. The colored transparent film can have a dark color and is used for enhancing contrast in color. For exemplary purpose only and not limited thereto, the colored transparent film can have a shading coefficient of about 0.65, a visible light reflected of about 5%, a visible light transmission of about 85%, an emissivity of about 0.87, and U value of about 1.09.

[0035] Third layer 135 is disposed on second layer 133. In one embodiment, third layer 135 is made of an untreated transparent glass. The untreated glass is not harden glasses and does not include iron therein. For exemplary purpose only and not limited thereto, the untreated glass can have a thickness of about 6 mm.

[0036] Fourth layer 137 is disposed on third layer 135. In one embodiment, the fourth layer has a third foil with a matte surface. For instance, PERMACOLOR<sup>®</sup> 7284 manufactured by MACTAC<sup>®</sup> can be used as the matte surface foil. The matte surface foil can be a 70 $\mu$  semi-matt PVC film coated on one side with a clear solvent acrylic pressure sensitive adhesive. The matte surface foil has anti-reflective properties. The matte surface foil can reduce color fade caused by ultraviolet light exposure.

[0037] Anti-moiré member 130 is spaced away from PCB 111. PCB 111 is mounted on frame member 120. A flange (not shown) of frame member 120 holds anti-moiré member 130 away from the PCB 111 so that anti-moiré member 130 is located at about a

predetermined distance at about the first distance (d) with the LEDs 113.

[0038] FIG. 6 is a schematic cross-sectional view of the display device according to the embodiment of the present disclosure having an adjustment mechanism. In this embodiment, the adjustment mechanism includes a first bracket 121 and a second bracket 123. A large scale display device may have difficulties in controlling bows and twists of the large scale surface thereof. Other than correcting an unevenness of the surface, keeping about same distance at about the first distance (d) between the LEDs 113 and anti-moiré member 130 is also important to avoid the moiré effects as well. First bracket 121 and second bracket 123 can help reduce an unevenness of the surface and maintain a distance between the LEDs 113 and anti-moiré member 130.

[0039] First bracket 121 and second bracket 123 provide a structural support for PCB 111. First bracket 121 and second bracket 123 are configured to intersect each other at a predetermined angle. Each of first bracket 121 and second bracket 123 can have an elongated shape. A plurality of first brackets 121 and a plurality of second brackets 123 can be stacked to enhance the mechanical strength and stability of the structure. First bracket 121 can be disposed in a vertical direction with respect to the display device. Second bracket 123 can be disposed in a horizontal direction with respect to the display device.

[0040] Each of first bracket 121 and the second bracket 123 is configured to mechanically calibrate a distance between LEDs 113 and anti-moiré member 130. For exemplary purpose only, each of first bracket 121 and second bracket 123 can include one screw rig or two screw rigs to change a location of PCB 111 such that a distance between LEDs 113 mounted on PCB 111 and anti-moiré member 130 can be adjusted. PCB 111 is configured to be movable toward anti-moiré member 130 by each of first bracket 121 and second bracket 123. Each of first bracket 121 and second bracket 123 guides PCB 111, respectively, in a perpendicular

direction to the plane formed by a surface of anti-moiré member 130. Each of first bracket 121 and the second bracket 123 is configured to adjust the distance in a range of 0 to 10 mm. First bracket can be configured to perform a coarse adjustment. Second bracket 123 can be configured to perform a fine adjustment.

[0041] In one embodiment, PCB 111 is configured to be detachably attached to frame member 120 via a magnetic connector (not shown) in four corners. The magnetic connector is configured to adjust a distance between LEDs 113 and anti-moiré member 130 in a range of 0 to 5 mm.

[0042] FIG. 7 is a schematic flowchart of the method for reducing moiré effects by calibrating a location of PCB 111. Step 210 refers to a step of providing a display having a printed circuit board (PCB). As explained above, PCB 111 includes LEDs 113, frame member 120, and anti-moiré member 130. Step 220 refers to a step of calculating a first distance (d) between LEDs 113 and anti-moiré member 130. Step 230 refers to a step of adjusting a distance between LEDs 113 and anti-moiré member 130 to about the first distance (d) so that LEDs 113 maintains an equal distance from anti-moiré member 130 across a surface of PCB111. Step 230 may include to adjust the distance with a coarse adjustment and a fine adjustment.

[0043] It is to be understood that the exemplary embodiments described herein are that for presently preferred embodiments and thus should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

What is claimed is:

1. A display device, comprising:
  - a printed circuit board (PCB) having an array of light emitting members;
  - an anti-moiré member spaced away from the array of light emitting members at about a first distance (d); and
  - a frame member receiving the PCB so that the array of light emitting members are interposed between the anti-moiré member and the frame member,
    - wherein the anti-moiré member comprises a first layer disposed to face the PCB,
    - wherein the first layer comprises a first foil with a randomized pattern surface,
    - wherein the first distance (d) equals  $L / (2 * \tan (\alpha))$ ,
    - wherein a second distance (L) is a shortest distance between two adjacent light emitting members, and
    - wherein  $\alpha$  is a radiation angle of the light emitting member.
2. The display device of claim 1, wherein the radiation angle  $\alpha$  is in a range of 45 to 50 degrees.
3. The display device of claim 1, wherein the frame member further comprises a first bracket and a second bracket, and wherein each of the first bracket and the second bracket provides a structural support for the PCB.
4. The display device of claim 3, wherein each of the first and the second bracket is configured to adjust a distance between the light emitting members and the anti-moiré member.

5. The display device of claim 3, wherein each of the first and the second bracket is configured to adjust a distance between the light emitting members and the anti-moiré member in a range of 0 to 10 mm.
6. The display device of claim 3, wherein the first bracket is a vertical bracket and the second bracket is a horizontal bracket, and wherein the first bracket is configured to perform a coarse adjustment of a distance between the light emitting members and the anti-moiré member, and the second bracket is configured to perform a fine adjustment of the distance between the light emitting members and the anti-moiré member.
7. The display device of claim 3, wherein the PCB is configured to be movable toward an anti-moiré member by each of the first bracket and the second bracket, each of the first bracket and the second bracket respectively guides the PCB in a direction perpendicular to a plane formed by a surface of the anti-moiré member.
8. The display device of claim 1, wherein the PCB is detachably attached to the frame member using a magnetic connector.
9. The display device of claim 8, wherein the magnetic connector is configured to adjust a distance between the PCB and the anti-moiré member in a range of 0 to 5 mm.
10. The display device of claim 1, wherein the first foil has the randomized pattern surface having a peak-valley height in a range of 0 to 2  $\mu\text{m}$ .
11. The display device of claim 1, wherein the first foil comprises a transparent pressure sensitive adhesive (PSA), and wherein the PSA is selected from the group consisting of

an acrylic compound, a methacrylate compound, a rubber compound, a water based compound, a solvent based compound, a silicone compound, and a styrene compound.

12. The display device of claim 1, wherein the anti-moiré member further comprises a second layer disposed on the first layer and having a second foil with a colored transparent film.

13. The display device of claim 12, wherein the colored transparent film has a shading coefficient of about 0.65, a visible light reflected of about 5%, a visible light transmission of about 85%, an emissivity of about 0.87, and U value of about 1.09.

14. The display device of claim 13, wherein the anti-moiré member further comprises a third layer disposed on the second layer and the third layer is made of an untreated transparent glass, and wherein the third layer has a thickness of about 6 mm.

15. The display device of claim 14, wherein the anti-moiré member further comprises a fourth layer disposed on the third layer and the fourth layer has a third foil with a matte surface.

16. A display device comprising:

a printed circuit board (PCB) having a plurality of light emitting members;

a frame member comprising:

a first bracket, and

a second bracket, wherein each of the first bracket and the second

bracket provides a structural support for the PCB; and

an anti-moiré member spaced away from the light emitting members at about a first distance (d), and the anti-moiré member comprising:

a first layer disposed to face the PCB and having a first foil with a randomized pattern surface,

a second layer disposed on the first layer and having a second foil with a colored transparent film,

a third layer disposed on the second layer and being made of an untreated glass, and

a fourth layer disposed on the third layer having a third foil with a matte surface,

wherein the first distance (d) is equals  $L / (2 * \tan (\alpha))$ ,

wherein a second distance (L) is a shortest distance between two adjacent light emitting members,

wherein each of the array of light emitting members has a radiation angle  $\alpha$ ,

wherein each of the first and the second bracket is configured to adjust a distance between the PCB and the anti-moiré member, and

wherein the PCB is interposed between the anti-moiré member and the frame member.

17. A method for reducing moiré effects in a light emitting diode (LED), the method comprising:

providing a display device comprising:

a printed circuit board (PCB) having an array of light emitting members,

an anti-moiré member spaced away from the array of light emitting members

at about a first distance (d), and

a frame member receiving the array of light emitting members so that the light emitting members are interposed between the anti-moiré member and the frame member;

calculating the first distance (d), wherein a second distance (L) is a shortest distance between two adjacent light emitting members, each of the array of light emitting members has a radiation angle  $\alpha$ , and the first distance (d) equals  $L / (2 * \tan(\alpha))$ ;

adjusting a distance between the light emitting members and the anti-moiré member to about the first distance (d), and

wherein the anti-moiré member comprises at least a first layer facing the PCB and having a first foil with a randomized pattern surface.

18. The method of claim 17, wherein the frame member comprises a first bracket and a second bracket, and wherein at least one of the first bracket and the second bracket is used to adjust the distance between the light emitting members and the anti-moiré member.
19. The method of claim 17, wherein the anti-moiré member further comprises a second layer disposed on the first layer and having a second foil with a colored transparent film, a third layer disposed on the second layer and being made of an untreated glass, and a fourth layer disposed on the third layer having a third foil with a matte surface.
20. The method of claim 17, wherein the radiation angle  $\alpha$  is in a range of 45 to 50 degrees.

1/5

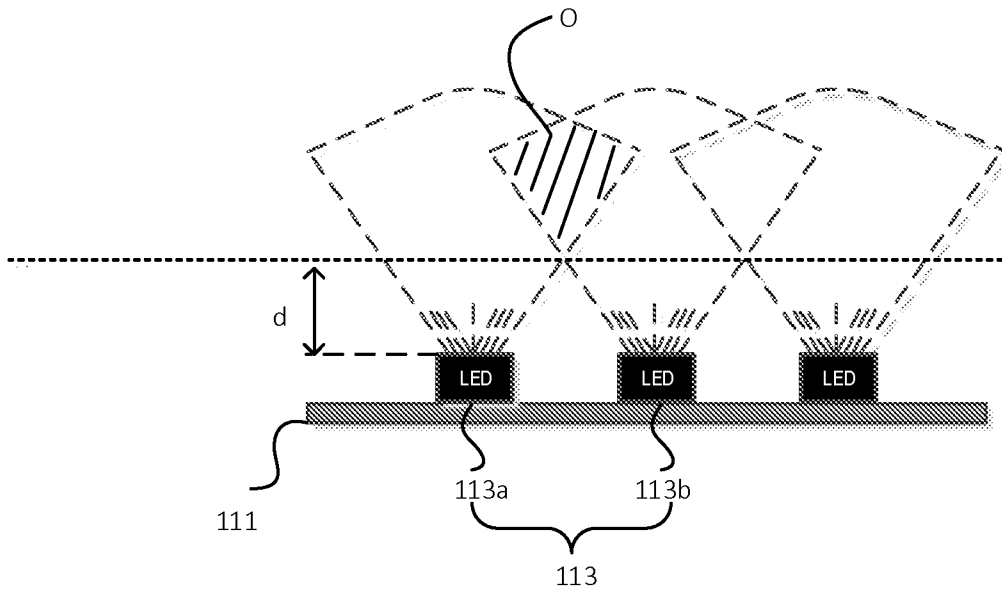


FIG. 1

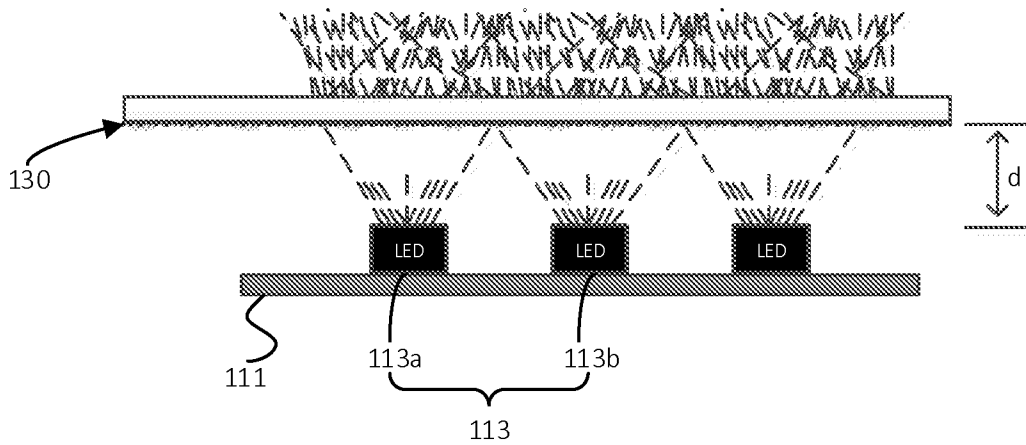


FIG. 2

2/5

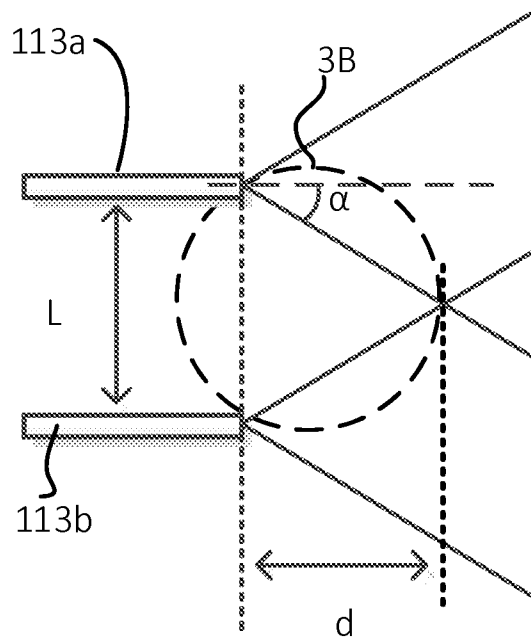


FIG. 3A

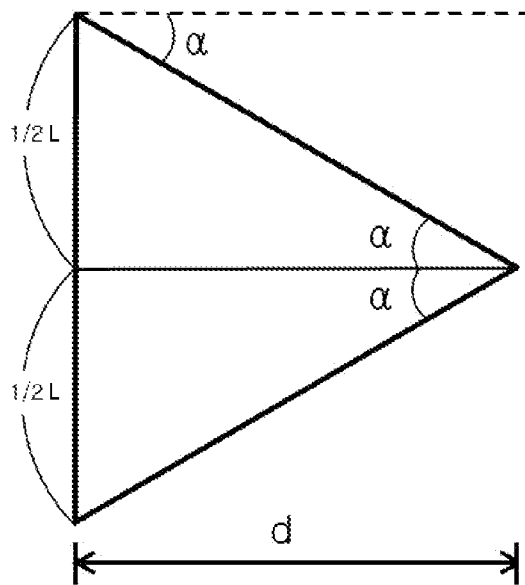


FIG. 3B

3/5

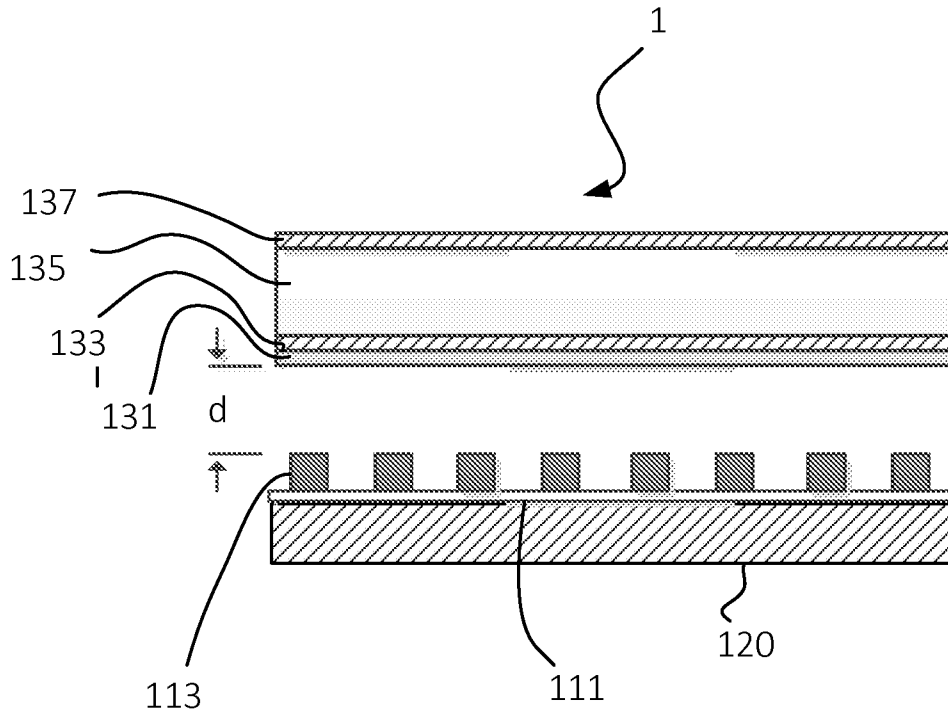


FIG. 4

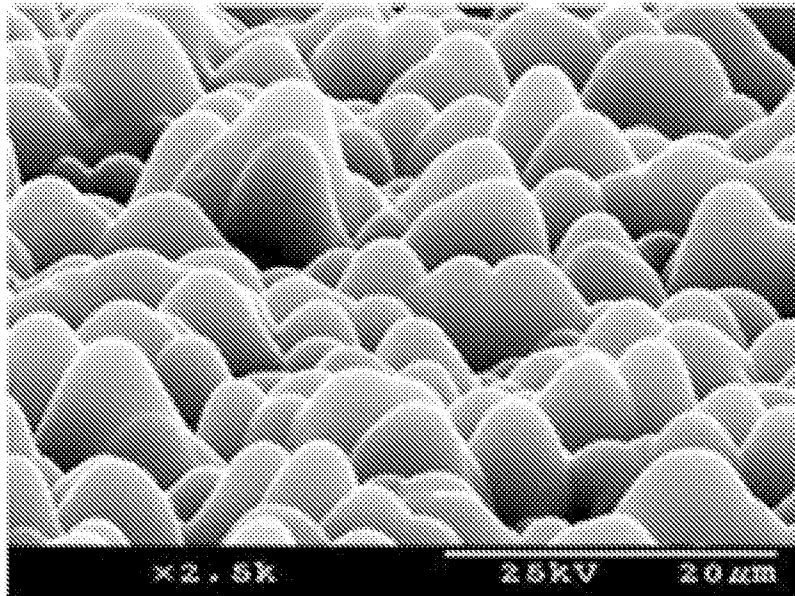


FIG. 5

4/5

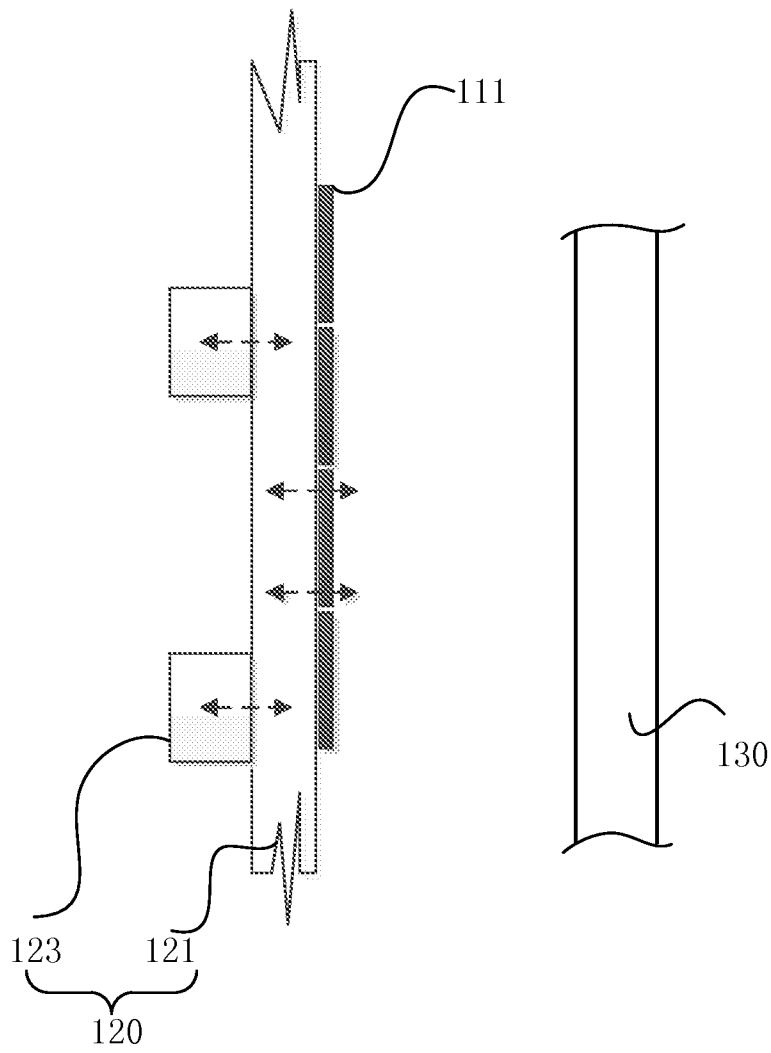


FIG. 6

5/5

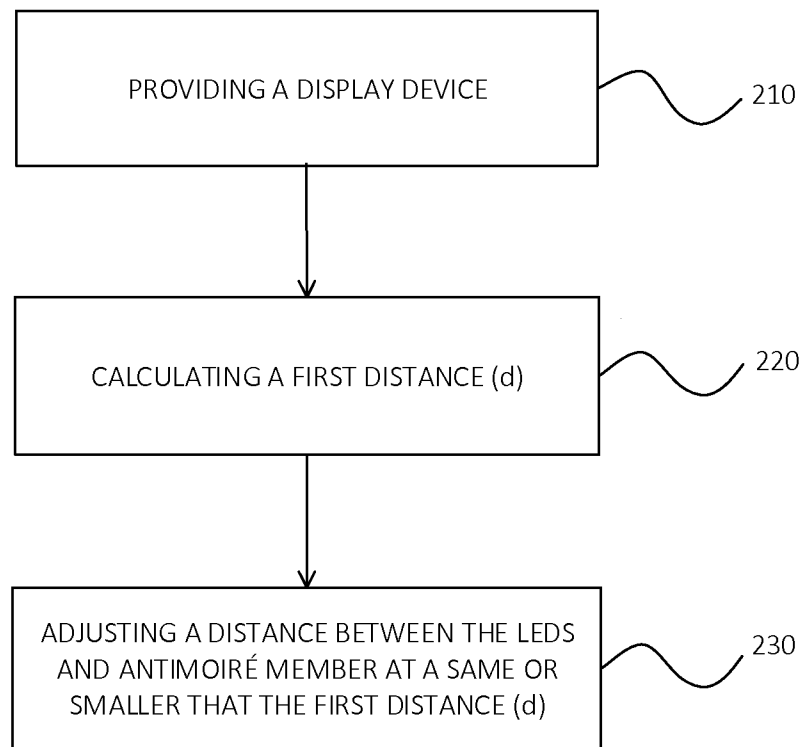


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US2015/043505

<p>A. CLASSIFICATION OF SUBJECT MATTER                  IPC(8) - G02B 6/00 (2015.01)                  CPC - G02B 6/0053 (2015.04)                  According to International Patent Classification (IPC) or to both national classification and IPC</p>																				
<p>B. FIELDS SEARCHED</p> <p>Minimum documentation searched (classification system followed by classification symbols)                  IPC(8) - F21V 5/00, 7/04, 21/30; G02B 6/00 (2015.01)                  USPC - 359/463, 619; 362/583, 607, 613, 615, 631, 633</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched                  CPC - G02B 6/0006, 6/0008, 6/0053, 6/4298 (2015.04) (keyword delimited)</p> <p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)                  Orbit, Google Patents, Google Scholar, ProQuest                  Search terms used: anti moire, angle, distance, pcb, light emitting, display, emission, pitch, interference filter, spacing</p>																				
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>US 2006/0238664 A1 (UEHARA et al) 26 October 2006 (26.10.2006) entire document</td> <td>1-20</td> </tr> <tr> <td>A</td> <td>US 2012/0002278 A1 (ZEREGA et al) 05 January 2012 (05.01.2012) entire document</td> <td>1-20</td> </tr> <tr> <td>A</td> <td>US 2014/0092629 A1 (RADIANT OPTO-ELECTRONICS CORPORATION) 03 April 2014 (03.04.2014) entire document</td> <td>1-20</td> </tr> <tr> <td>A</td> <td>US 2007/0121208 A1 (OGAWA et al) 31 May 2007 (31.05.2007) entire document</td> <td>1-20</td> </tr> <tr> <td>A</td> <td>US 8,177,408 B1 (COLEMAN) 15 May 2012 (15.05.2012) entire document</td> <td>1-20</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	A	US 2006/0238664 A1 (UEHARA et al) 26 October 2006 (26.10.2006) entire document	1-20	A	US 2012/0002278 A1 (ZEREGA et al) 05 January 2012 (05.01.2012) entire document	1-20	A	US 2014/0092629 A1 (RADIANT OPTO-ELECTRONICS CORPORATION) 03 April 2014 (03.04.2014) entire document	1-20	A	US 2007/0121208 A1 (OGAWA et al) 31 May 2007 (31.05.2007) entire document	1-20	A	US 8,177,408 B1 (COLEMAN) 15 May 2012 (15.05.2012) entire document	1-20
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.																		
A	US 2006/0238664 A1 (UEHARA et al) 26 October 2006 (26.10.2006) entire document	1-20																		
A	US 2012/0002278 A1 (ZEREGA et al) 05 January 2012 (05.01.2012) entire document	1-20																		
A	US 2014/0092629 A1 (RADIANT OPTO-ELECTRONICS CORPORATION) 03 April 2014 (03.04.2014) entire document	1-20																		
A	US 2007/0121208 A1 (OGAWA et al) 31 May 2007 (31.05.2007) entire document	1-20																		
A	US 8,177,408 B1 (COLEMAN) 15 May 2012 (15.05.2012) entire document	1-20																		
<p><input type="checkbox"/> Further documents are listed in the continuation of Box C.      <input type="checkbox"/> See patent family annex.</p>																				
<p>* Special categories of cited documents:</p> <table border="0"> <tr> <td>"A" document defining the general state of the art which is not considered to be of particular relevance</td> <td>"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</td> </tr> <tr> <td>"E" earlier application or patent but published on or after the international filing date</td> <td>"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</td> </tr> <tr> <td>"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)</td> <td>"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</td> </tr> <tr> <td>"O" document referring to an oral disclosure, use, exhibition or other means</td> <td>"&amp;" document member of the same patent family</td> </tr> <tr> <td>"P" document published prior to the international filing date but later than the priority date claimed</td> <td></td> </tr> </table>			"A" document defining the general state of the art which is not considered to be of particular relevance	"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	"E" earlier application or patent but published on or after the international filing date	"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	"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)	"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	"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family	"P" document published prior to the international filing date but later than the priority date claimed									
"A" document defining the general state of the art which is not considered to be of particular relevance	"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																			
"E" earlier application or patent but published on or after the international filing date	"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																			
"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)	"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																			
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family																			
"P" document published prior to the international filing date but later than the priority date claimed																				
<p>Date of the actual completion of the international search 06 October 2015</p>		<p>Date of mailing of the international search report <b>02 NOV 2015</b></p>																		
<p>Name and mailing address of the ISA/                  Mail Stop PCT, Attn: ISA/US, Commissioner for Patents                  P.O. Box 1450, Alexandria, Virginia 22313-1450                  Facsimile No. 571-273-8300</p>		<p>Authorized officer                  Blaine Copenheaver                  PCT Helpdesk: 571-272-4300                  PCT OSP: 571-272-7774</p>																		