US Patent & Trademark Office
Patent Public Search | Text View

United States Patent Application Publication	20250264761
Kind Code	A1
Publication Date	August 21, 2025
Inventor(s)	OTA; Takashi et al.

BACKLIGHT AND DISPLAY DEVICE

Abstract

A backlight includes: light sources planarly arranged and each capable of emitting divergent light; first lenses planarly arranged, overlapping with the respective light sources from above, and being of a shape enabling reduction of a divergence angle of the divergent light; second lenses planarly arranged, overlapping with the first lenses from above, and being of a shape enabling further reduction of the divergence angle; and a partition wall located between the first lenses and the second lenses, surrounding each of the first lenses, blocking part of the divergent light, and reducing an illumination area of the divergent light directed toward each of the second lenses.

Inventors: **OTA; Takashi (Tokyo, JP), SUZUKI; Nobuyuki (Tokyo, JP), OKADA; Masafumi (Tokyo, JP)**

Applicant: **Japan Display Inc.** (Tokyo, JP)

Family ID: **1000008437311**

Appl. No.: **19/044880**

Filed: **February 04, 2025**

Foreign Application Priority Data

JP	2024-021935	Feb. 16, 2024

Publication Classification

Int. Cl.: **G02F1/1335** (20060101)

U.S. Cl.:

CPC **G02F1/133607** (20210101);

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority from Japanese patent application JP2024-021935 filed on Feb. 16, 2024, the contents of which are hereby incorporated by reference into this application.

BACKGROUND

1. Field

[0002] This disclosure relates to a backlight and a display device.

2. Description of the Related Art

[0003] A backlight in which multiple point light sources are planarly arranged is used to achieve a surface light source (WO2012/029600, JP2018-56367A). Ideally, the backlight should emit collimated light; however, since light from the point light sources is diffusive, multiple lenses are required.

[0004] If the irradiation range of each point light source is circular, adjacent irradiation ranges partially overlap. As a result, light enters neighboring lenses, making it difficult to achieve collimated light. It should be noted that WO2012/029600 and JP2018-56367A aim to reduce luminance unevenness and do not consider the emission of collimated light.

SUMMARY

[0005] This disclosure aims to enable the emission of collimated light.

[0006] A backlight includes: light sources planarly arranged and each capable of emitting divergent light; first lenses planarly arranged, overlapping with the respective light sources from above, and being of a shape enabling reduction of a divergence angle of the divergent light; second lenses planarly arranged, overlapping with the first lenses from above, and being of a shape enabling further reduction of the divergence angle; and a partition wall located between the first lenses and the second lenses, surrounding each of the first lenses, blocking part of the divergent light, and reducing an illumination area of the divergent light directed toward each of the second lenses.

[0007] A display device includes: the backlight, and a transmissive display panel.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a partial plan view of a backlight according to an embodiment.

[0009] FIG. **2** is a sectional view taken along line II-II of the backlight in FIG. **1**.

[0010] FIG. **3** is a sectional view taken along line III-III of the backlight in FIG. **1**.

[0011] FIG. **4** is an explanatory diagram of a light illumination area of the backlight.

[0012] FIG. **5** is a schematic sectional view of a display device according to the embodiment.

[0013] FIG. **6** is a sectional view of a backlight according to modification 1.

[0014] FIG. **7** is a sectional view of a backlight according to modification 2.

DETAILED DESCRIPTION

[0015] Hereinafter, some embodiments will be described with reference to the drawings. Here, the invention can be embodied according to various aspects within the scope of the invention without departing from the gist of the invention and is not construed as being limited to the content described in the embodiments exemplified below.

[0016] The drawings are further schematically illustrated in widths, thickness, shapes, and the like of units than actual forms to further clarify description in some cases but are merely examples and do not limit interpretation of the invention. In the present specification and the drawings, the same reference numerals are given to elements having the same functions described in the previously

described drawings, and the repeated description will be omitted.
[0017] Further, in the detailed description, “on” or “under” in definition of positional relations of certain constituents, and other constituents includes not only a case in which a constituent is located just on or just under a certain constituent but also a case in which another constituent is interposed between constituents unless otherwise mentioned.
[0018] FIG. **1** is a partial plan view of a backlight according to an embodiment. FIG. **2** is a sectional view of the backlight in FIG. **1** taken along line II-II. FIG. **3** is a sectional view of the backlight in FIG. **1** taken along line III-III.
[0019] The backlight **10** includes a light source **12** (e.g., light-emitting diode). Light sources **12** are planarly arranged (e.g., in rows and columns). The light sources **12** are oriented in the same direction. The light source **12** can emit divergent light.
[0020] The divergent light (e.g., white light) spreads from an optical axis in a first direction D**1** and a second direction D**2**, which are perpendicular to each other. The light distribution angle is, for example, ±90 degrees. The light source **12** functions as a point light source.
[0021] The backlight **10** includes a first lens **14**. First lenses **14** are planarly arranged (e.g., in rows and columns). The first lenses **14** overlap with the respective light sources **12** from above. The first lens **14** is a spherical lens and is a convex lens that protrudes on the side opposite to the light source **12**. The first lens **14** is of a shape enabling reduction of the divergence angle of the divergent light emitted from the light source **12**. The light distribution angle is, for example, ±15 degrees.
[0022] The first lens **14** is of a planar shape forming a circle. The first lenses **14** are spaced apart from each other. The spacing between an adjacent pair of the first lenses **14** is wider in a direction intersecting both the first direction D**1** and the second direction D**2** than in either of those directions. The illumination area **28**A (see FIG. **4**) from the light source **12** (divergent light) on the first lens **14** is circular.
[0023] The first lenses **14** are supported by a transparent substrate **16**. For example, the front and rear surfaces of the transparent substrate **16** are flat, and the first lenses **14** are positioned on one of the front and rear surfaces. The first lenses **14** and the transparent substrate **16** may be separately formed and adhered or may be integrated. The divergent light from the light source **12** passes through the transparent substrate **16** and enters each first lens **14**, exiting the transparent substrate **16** outside each first lens **14**.
[0024] The backlight **10** includes second lenses **18**. The second lenses **18** are planarly arranged (e.g., in rows and columns). The second lenses **18** overlap with the respective first lenses **14** from above. The second lens **18** is a spherical lens and is a convex lens that protrudes on the side opposite to the light source **12**. The second lens **18** is of a shape enabling further reduction of the divergence angle of the divergent light. The light emitted from the second lens **18** is substantially collimated light with a light distribution angle of, for example, ±1.5 degrees or less.
[0025] The second lenses **18** are contiguous to each other. As shown in FIG. **1**, the second lens **18** is of a planar shape forming a rectangle (e.g., square). Edges **20** of the rectangle include a pair of first edges **20**A facing the first direction D**1** and a pair of second edges **20**B facing the second direction D**2**. An adjacent pair of the second lenses **18** are contiguous along the edge **20** of the rectangle. The second lenses **18** are integrated to form a lens array **22**, which includes second lenses **18** on one surface and a flat surface on another surface.
[0026] The backlight **10** includes a partition wall **24**. The partition wall **24** is positioned between the first lenses **14** and the second lenses **18** (lens array **22**). The partition wall **24** is fixed to the transparent substrate **16**. There is a space between the partition wall **24** and the lens array **22** (second lenses **18**). Thus, the backlight **10** is less likely to appear dark due to the shadow of the partition wall **24** when viewed from the light-emitting surface. Additionally, since both surfaces of the transparent substrate **16** are flat, it is easier to attach the partition wall **24** compared to the lens array **22**.

[0027] The partition wall **24** is of a planar shape forming a grid. The partition wall **24** surrounds each first lens **14** and specifically includes side surfaces **26** surrounding the respective first lenses **14**. Each side surface **26** includes a pair of first side surfaces **26**A facing the first direction D**1** and a pair of second side surfaces **26**B facing the second direction D**2**. The first direction D**1** and the second direction D**2** are perpendicular to each other. Between each first lens **14** and a corresponding one of the side surfaces **26**, there is a space and part of the surface of the transparent substrate **16**.

[0028] At least the surface (or material) of the partition wall **24** is black. At least the surface (or material) of the partition wall **24** is made of a light-absorbing material. The partition wall **24** blocks part of the divergent light, thereby reducing the spread of divergent light directed to each second lens **18**. Specifically, circular spread is transformed into a rectangular spread, confining the divergent light within the rectangular planar shape of the second lens **18**.

[0029] The following describes the propagation of light in the backlight **10**. The divergent light emitted from the light source **12** has a light distribution angle of, for example, ±90 degrees. The divergent light enters one surface of the transparent substrate **16**, and a portion of it exits through the first lenses **14**. The divergence angle of the divergent light is reduced by the first lenses **14** to, for example, ±15 degrees. Another portion of the divergent light exits from the opposite surface of the transparent substrate **16**. Since the front and rear surfaces of the transparent substrate **16** are flat and parallel, refractions during entry and exit cancels each other out, resulting in a light distribution angle of ±90 degrees for the light exiting the transparent substrate **16**.

[0030] FIG. **4** is an explanatory diagram of the light illumination area of the backlight **10**. In the backlight **10**, the second lens **18** is of a planar shape forming a rectangle (FIG. **1**) to achieve a surface light source. On the other hand, the illumination area **28**A (FIG. **4**) of the divergent light from the light source **12** is circular. As a result, above the first lenses **14** and the transparent substrate **16**, an edge of the illumination area **28**B (FIG. **4**) directs toward the adjacent second lens **18**, which is contiguous along the side **20** of the rectangle. If excessive light enters the adjacent second lens **18**, collimated light cannot be achieved.

[0031] In this embodiment, the partition wall **24** blocks the edges of the illumination area **28**B (FIG. **4**) of the divergent light, transforming the circular illumination area **28**B into a rectangular illumination area **28**C (FIG. **4**), thereby preventing the divergent light from entering adjacent second lenses **18**. This enables the emission of collimated light. The height and thickness of the partition wall **24** is sed not to block the divergent light too much. For example, the height and thickness are calculated to block part of the divergent light emitted from the transparent substrate **16** outside each first lens **14** (e.g., light distribution angle of ±18 degrees or more), while the divergent light emitted from each first lens **14** (e.g., light distribution angle of ±15 degrees) is not blocked.

[0032] FIG. **5** is a schematic cross-sectional view of a display device according to the embodiment. The display device includes the backlight, which includes the aforementioned second lenses **18**, and a transmissive display panel **30**. Light enters the display panel **30** from the second lenses **18**. The light is white. That is, the light incident on the display panel **30** includes red, green, and blue light. Additionally, the light entering the display panel **30** is nearly collimated.

[0033] The display panel **30** includes a color separation unit **32**. The surface of the substrate in the color separation unit **32** is provided with color separation grooves formed by a predetermined pattern of unevenness. These grooves diffract the white light, separating it into RGB wavelength components. The separated light further passes through a color filter **34**. This process produces red, green, and blue light, enabling the display panel **30** to display full-color images utilizing the optical properties of liquid crystals.

Modification 1

[0034] FIG. **6** is a cross-sectional view of a backlight according to Modification 1. There is a space between the partition wall **124** and the transparent substrate **116**. The partition wall **124** is fixed to

the lens array **122** (second lenses **118**).
Modification 2
[0035] FIG. **7** is a cross-sectional view of a backlight according to Modification 2. The partition wall **224** is fixed to both the transparent substrate **216** and the lens array **222**. There is no space between **224** and the transparent substrate **216**, nor between the partition wall **224** and the lens array **222**. The partition wall **224** functions as a spacer between the transparent substrate **216** and the lens array **222**.
[0036] The embodiments described above are not limited and different variations are possible. The structures explained in the embodiments may be replaced with substantially the same structures and other structures that can achieve the same effect or the same objective.
Outline of the Embodiment
[0037] A backlight **10** including: light sources **12** planarly arranged and each capable of emitting divergent light; first lenses **14** planarly arranged, overlapping with the respective light sources **12** from above, and being of a shape enabling reduction of a divergence angle of the divergent light; second lenses **18** planarly arranged, overlapping with the first lenses **14** from above, and being of a shape enabling further reduction of the divergence angle; and a partition wall **24** located between the first lenses **14** and the second lenses **18**, surrounding each of the first lenses **14**, blocking part of the divergent light, and reducing an illumination area **28**B of the divergent light directed toward each of the second lenses **18**.
[0038] By blocking part of the divergent light and reducing the illumination area **28**B of the divergent light, the divergent light no longer enters the adjacent second lenses **18**, making it possible to irradiate collimated light.

Claims

1. A backlight comprising: light sources planarly arranged and each capable of emitting divergent light; first lenses planarly arranged, overlapping with the respective light sources from above, and being of a shape enabling reduction of a divergence angle of the divergent light; second lenses planarly arranged, overlapping with the first lenses from above, and being of a shape enabling further reduction of the divergence angle; and a partition wall located between the first lenses and the second lenses, surrounding each of the first lenses, blocking part of the divergent light, and reducing an illumination area of the divergent light directed toward each of the second lenses.
2. The backlight according to claim 1, wherein the first lenses are spaced apart from each other, and the second lenses are contiguous to each other.
3. The backlight according to claim 2, wherein each of the second lenses is of a planar shape forming a rectangle, and an adjacent pair of the second lenses are contiguous to each other at sides of the rectangle.
4. The backlight according to claim 3, wherein the illumination area directed to the corresponding one of the second lenses is rectangular and fits within a range of the planar shape forming the rectangle.
5. The backlight according to claim 1, wherein each of the first lenses is of a planar shape forming a circle, and the illumination area directed to a corresponding one of the first lenses is circular.
6. The backlight according to claim 1, wherein the first lenses and the second lenses are spherical lenses.
7. The backlight according to claim 1, wherein the first lenses and the second lenses are convex lenses that protrude toward sides opposite to the light sources.
8. The backlight according to claim 1, further comprising a transparent substrate that supports the first lenses, wherein the second lenses are integrated and constitute a lens array.
9. The backlight according to claim 8, wherein the partition wall is fixed to the transparent substrate.

10. The backlight according to claim 9, wherein there is a space between the partition wall and the lens array.
11. The backlight according to claim 8, wherein the partition wall is fixed to the lens array.
12. The backlight according to claim 11, wherein there is a space between the partition wall and the transparent substrate.
13. The backlight according to claim 8, wherein the partition wall is fixed to both the transparent substrate and the lens array, there is no space between the partition wall and the transparent substrate, and there is no space between the partition wall and the lens array.
14. The backlight according to claim 1, wherein the partition wall is of a planar shape forming a grid.
15. The backlight according to claim 1, wherein the partition wall includes side surfaces surrounding the respective first lenses, each of the side surfaces include a pair of first side surfaces facing a first direction and a pair of second side surfaces facing a second direction, and the first direction and the second direction are perpendicular.
16. The backlight according to claim 1, wherein at least a surface of the partition wall is black.
17. The backlight according to claim 1, wherein at least a surface of the partition wall is made of a light-absorbing material.
18. A display device comprising: the backlight according to claim 1, and a transmissive display panel.