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(54) **DISPLAY APPARATUS**

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(57) **ABSTRACT**

A display apparatus is provided, which may improve light extraction efficiency of light emitted from a light emitting element layer. The display apparatus may include a substrate, pixels having a plurality of subpixels, a pattern portion disposed on the substrate and formed to be concave between the plurality of subpixels, and a reflective portion disposed to be inclined on the pattern portion. The plurality of subpixels may include a first layer and a second layer. The first layer may be adjacent to the reflective portion on the substrate and may include a plurality of concave portions. The second layer may be on the first layer. An inclination angle θ of the reflective portion may satisfy

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$$\text{Taper Angle } (\theta) = \frac{180 \times \log \sqrt{0.11 \times T_L^2 + T_H^2}}{\pi}$$

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wherein T_H is a maximum thickness of the second layer in the concave portion, T_L is a thickness of the first layer on an extension line of T_H , and π is a circular constant.

I-I'

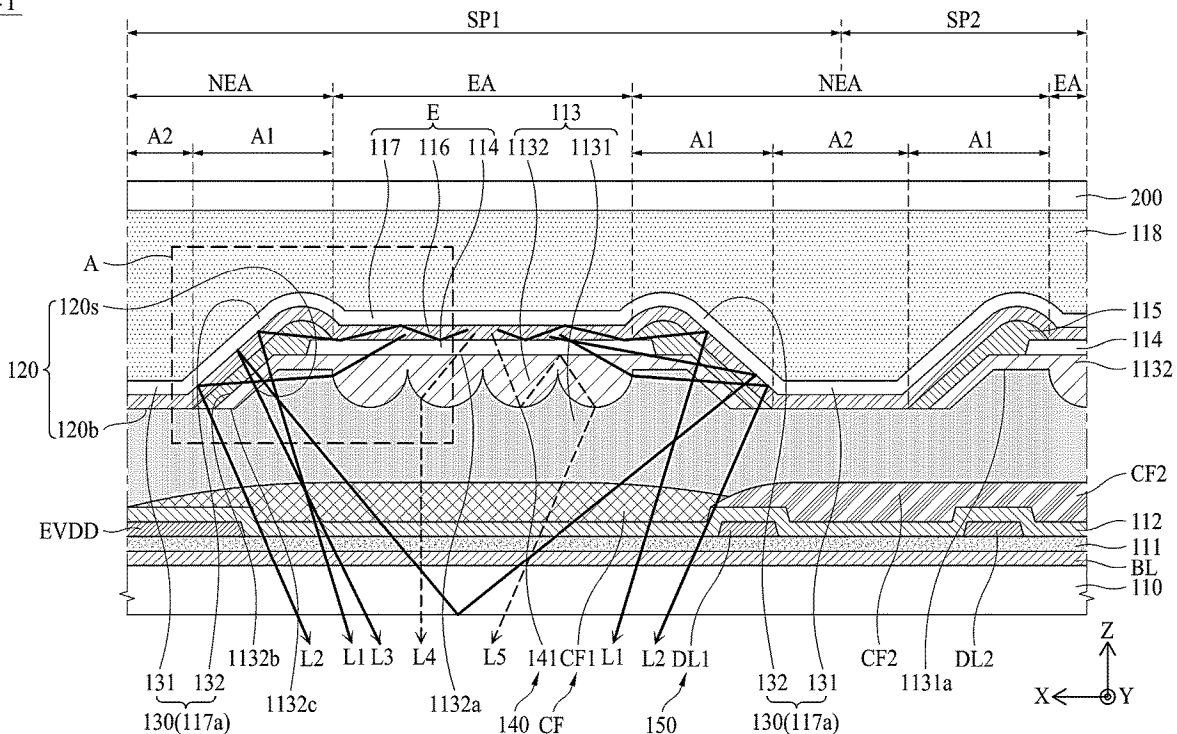


FIG. 1

100

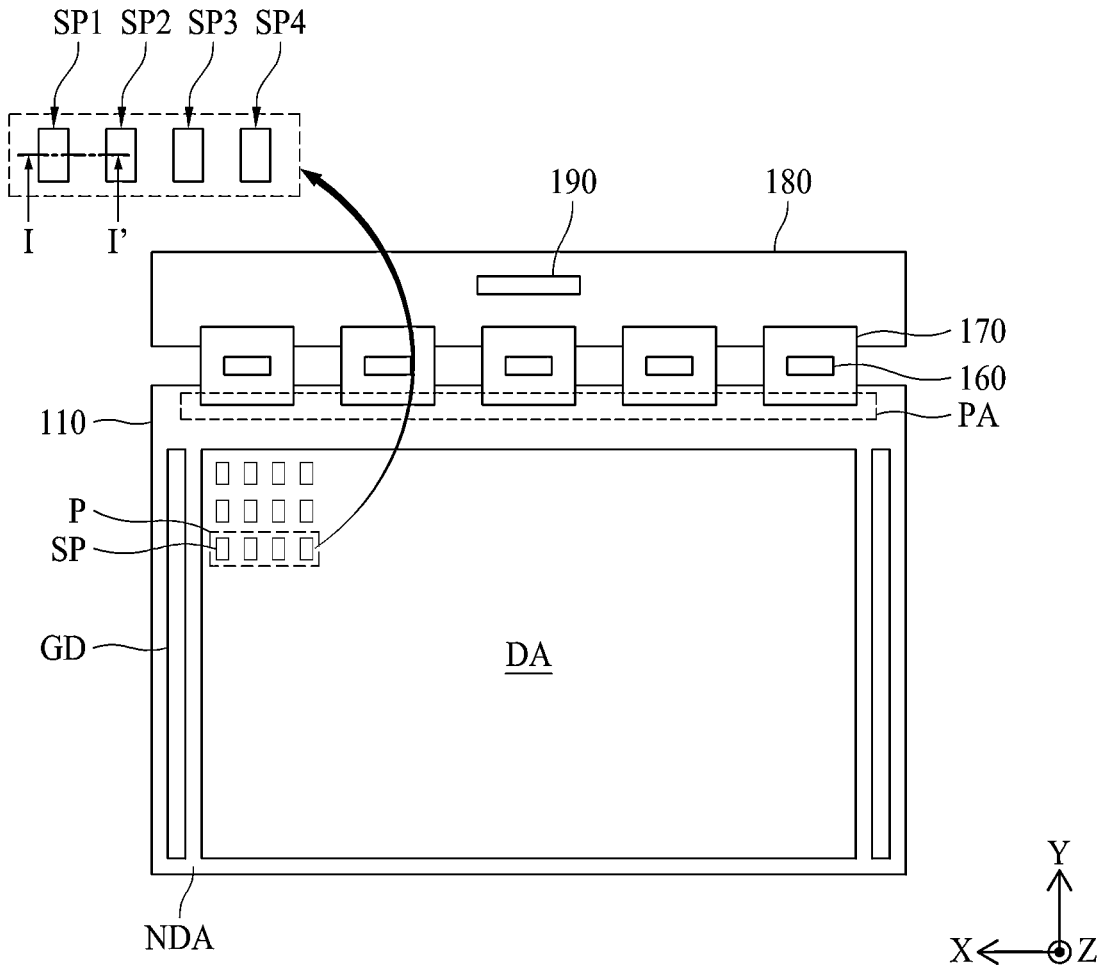


FIG. 2

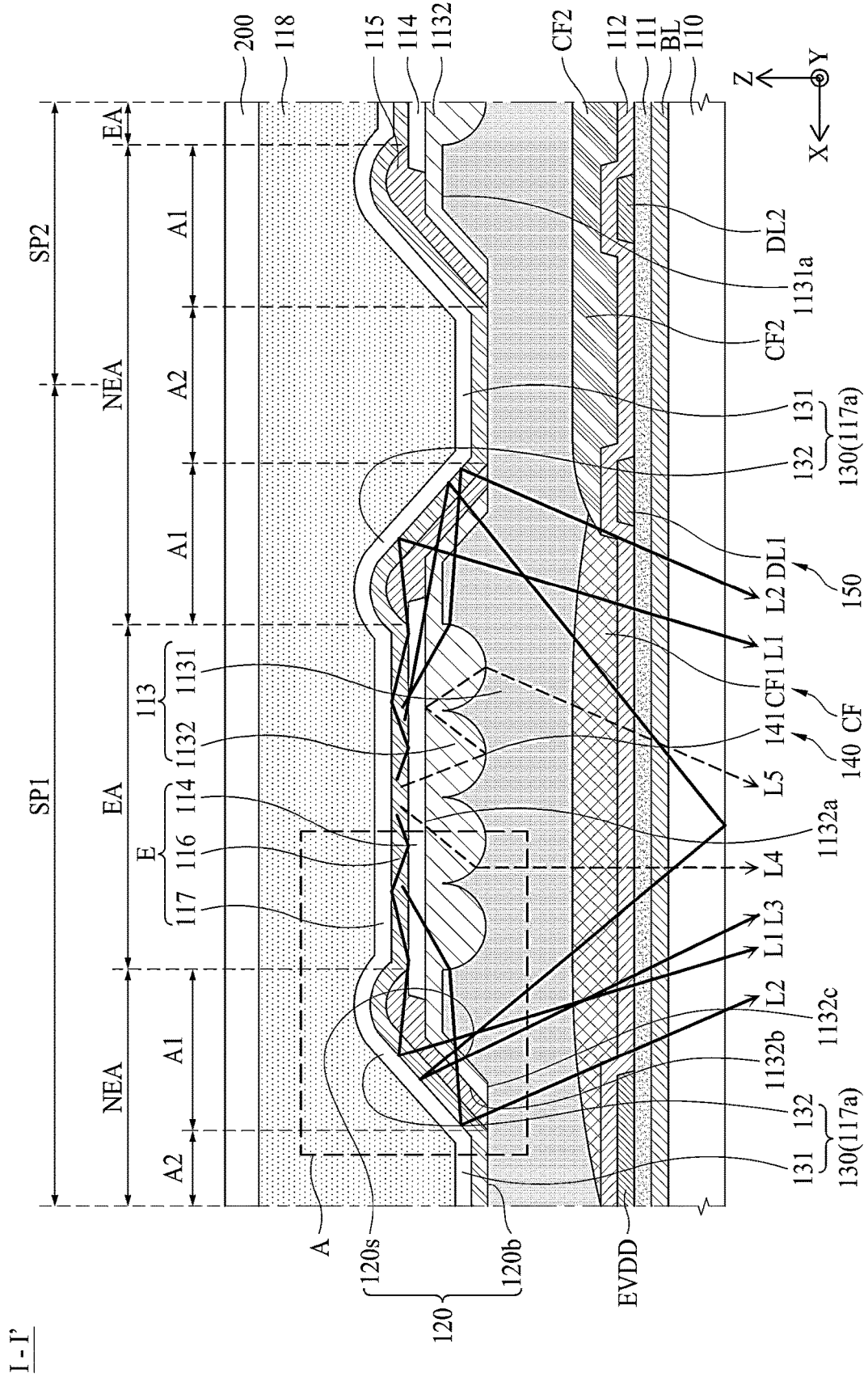


FIG. 3

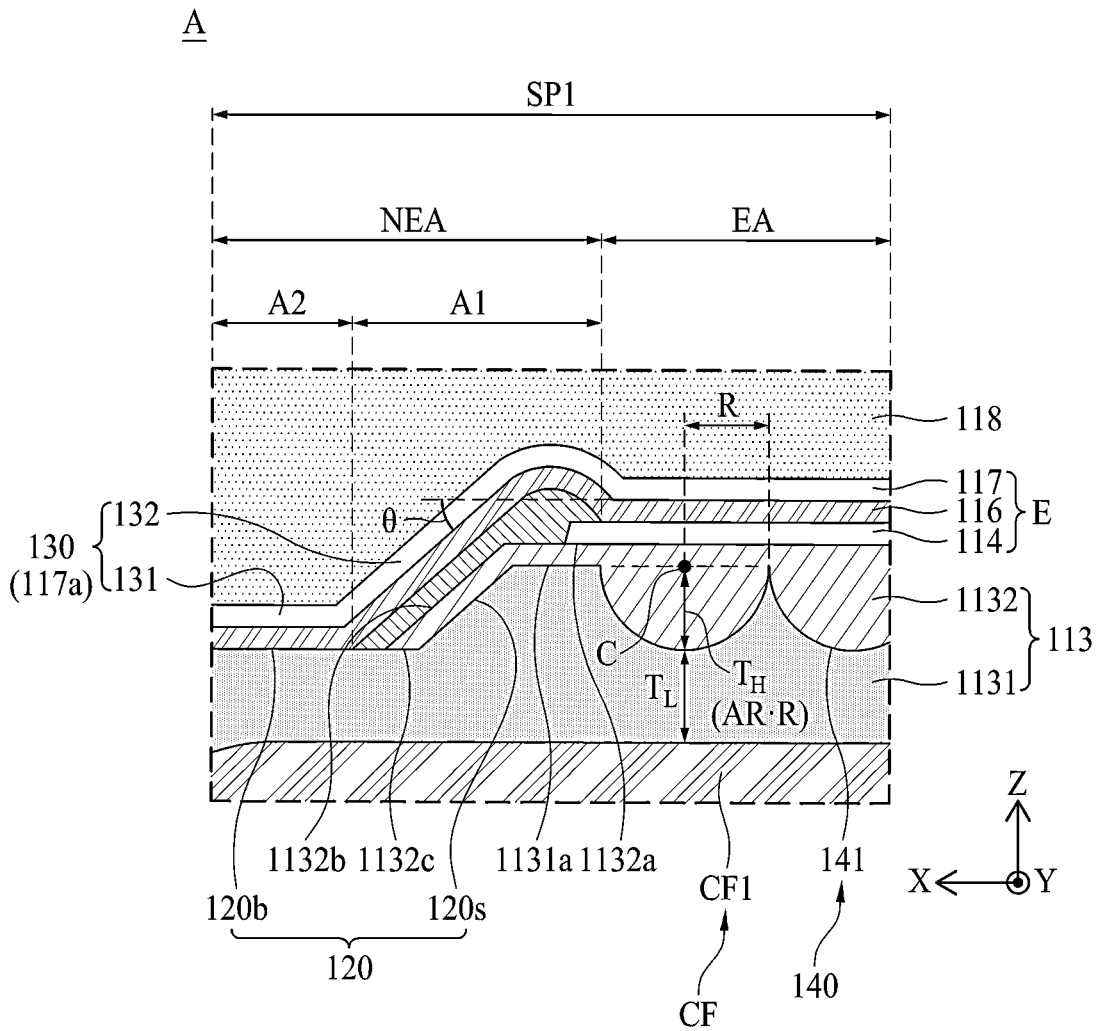


FIG. 4A

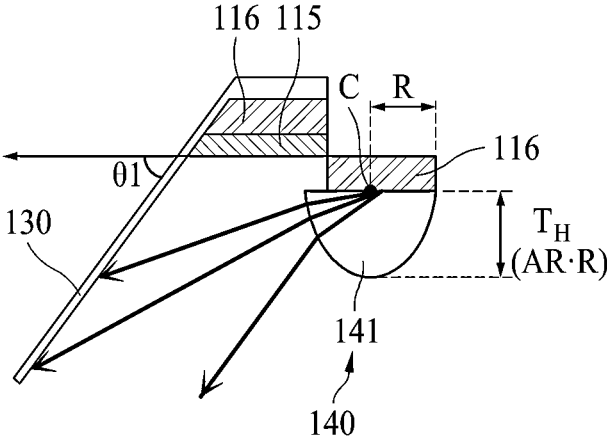


FIG. 4B

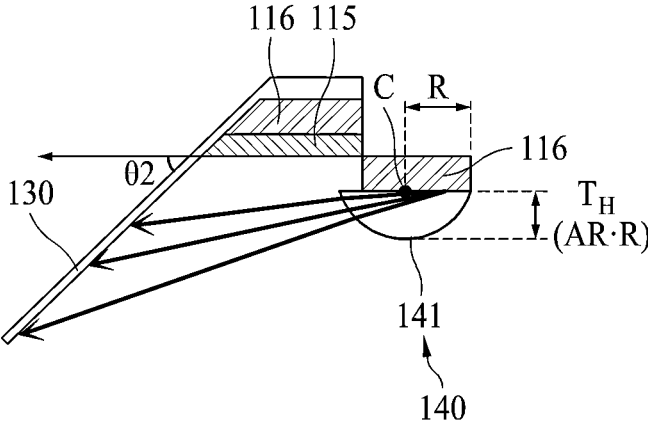


FIG. 5

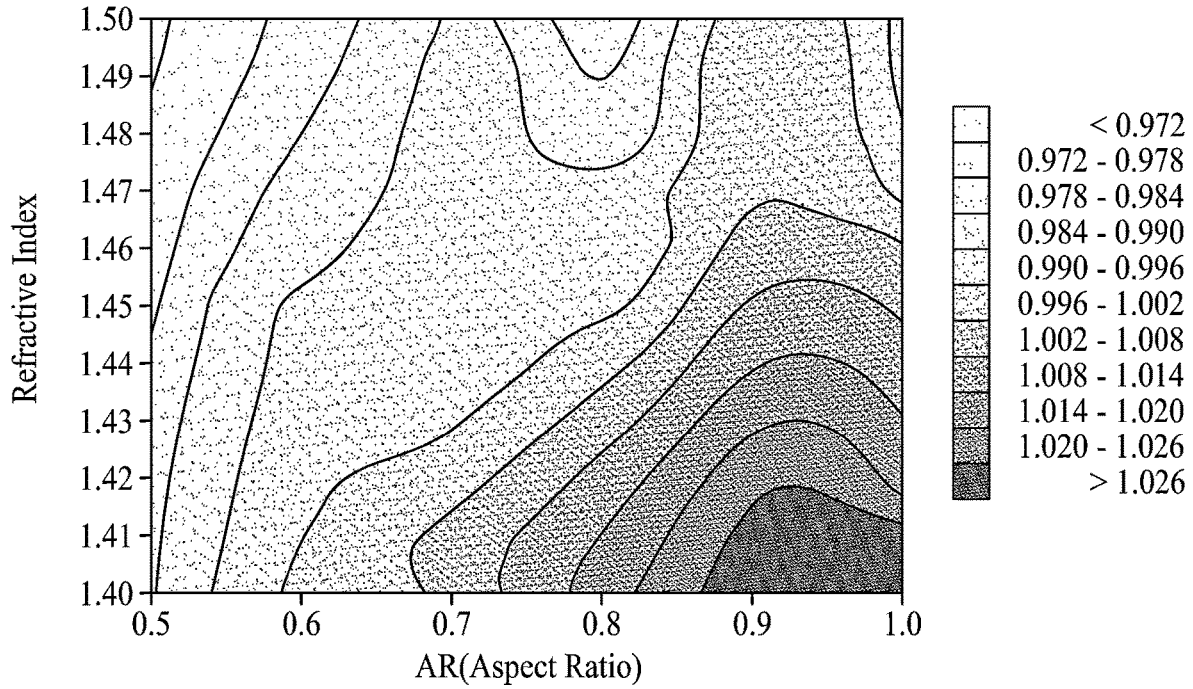
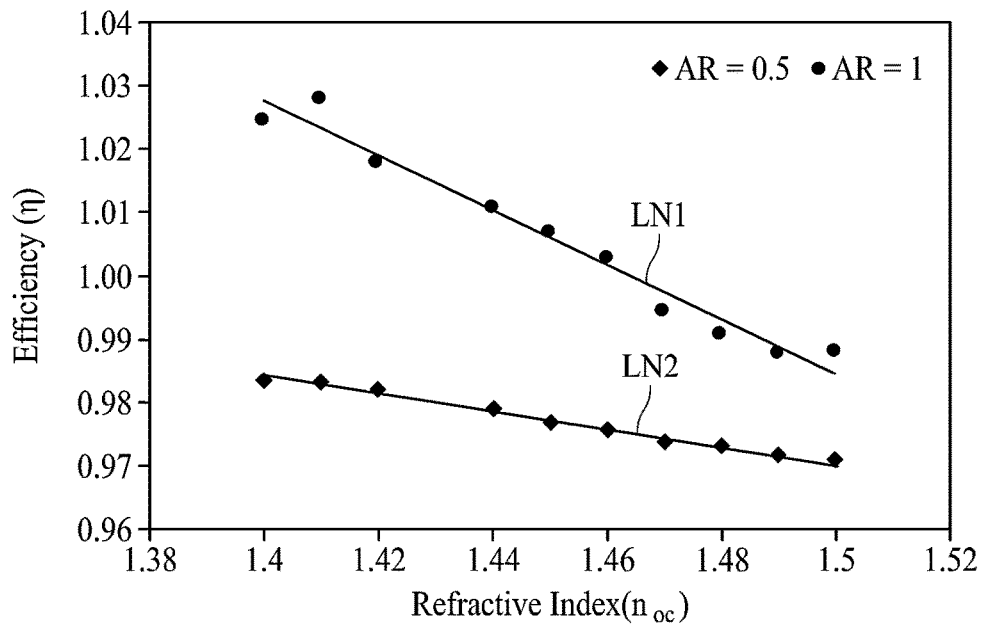


FIG. 6



DISPLAY APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of and priority to Korean Patent Application No. 10-2022-0190860 filed on Dec. 30, 2022, the entirety of which is incorporated herein by reference for all purposes as if fully set forth herein.

BACKGROUND

1. Technical Field

[0002] The present disclosure relates to an apparatus and particularly to, for example, without limitation, a display apparatus for displaying an image.

2. Description of the Related Art

[0003] Since an organic light emitting display apparatus has a high response speed and low power consumption and self-emits light without requiring a separate light source unlike a liquid crystal display apparatus, there is typically no problem with its viewing angle, and thus the organic light emitting display apparatus has received attention as a next-generation flat panel display apparatus.

[0004] Such a display apparatus displays an image through light emission of a light emitting element layer that includes a light emitting layer interposed between two electrodes.

[0005] Meanwhile, light extraction efficiency of the display apparatus is reduced as some of light emitted from the light emitting element layer is not emitted to the outside due to total reflection on the interface between the light emitting element layer and an electrode and/or between a substrate and an air layer.

[0006] The description provided in the discussion of the related art section should not be assumed to be prior art merely because it is mentioned in or associated with that section. The discussion of the related art section may include information that describes one or more aspects of the subject technology, and the description in this section does not limit the invention.

SUMMARY

[0007] The inventors of the present disclosure have recognized the problems and disadvantages of the related art, have performed extensive research and experiments, and have developed a new invention. Accordingly, one or more aspects of the present disclosure are directed to a display device that substantially obviate one or more of the problems due to limitations and disadvantages of the related art.

[0008] In one or more aspects, an object of the present disclosure is to provide a display apparatus that may improve light extraction efficiency of light emitted from a light emitting element layer.

[0009] In one or more aspects, another object of the present disclosure is to provide a display apparatus that may further improve light extraction efficiency through light extraction from a non-light emission area.

[0010] In one or more aspects, yet another object of the present disclosure is to provide a display apparatus that may reduce overall power consumption through light extraction from a non-light emission area.

[0011] In addition to the objects of the present disclosure as mentioned above, additional objects, aspects, features and

advantages of the present disclosure are set forth in the present disclosure and will also be apparent from the present disclosure or may be learned by practice of the inventive concepts provided herein. Other aspects, features and advantages of the present disclosure may be realized and attained by the descriptions provided in the present disclosure, including the claims and the drawings.

[0012] In accordance with one or more aspects of the present disclosure, the above and other objects and advantages can be accomplished by the provision of a display apparatus comprising a substrate, a plurality of pixels having a plurality of subpixels, a pattern portion disposed on the substrate and formed to be concave between the plurality of subpixels, and a reflective portion disposed to be inclined on the pattern portion. The plurality of subpixels may include a first layer adjacent to the reflective portion on the substrate, including a plurality of concave portions, and a second layer on the first layer, and an inclination angle θ of the reflective portion may be provided to satisfy

$$\text{Taper Angle } (\theta) = \frac{180 \times \log \sqrt{0.11 \times T_L^2 + T_H^2}}{\pi},$$

wherein T_H is a maximum thickness of the second layer in the concave portion, T_L is a thickness of the first layer on an extension line of T_H , and π is a circular constant.

[0013] In accordance with one or more aspects of the present disclosure, the above and other objects and advantages can be accomplished by the provision of a display apparatus comprising a substrate, a plurality of pixels having a plurality of subpixels, a pattern portion disposed on the substrate and formed to be concave between the plurality of subpixels, and a reflective portion disposed to be inclined on the pattern portion. The plurality of subpixels may include a first layer adjacent to the reflective portion on the substrate, including a plurality of concave portions, and a second layer on the first layer, and an inclination angle of the reflective portion may be proportional to a maximum thickness of the second layer and a thickness of the first layer in the concave portion.

[0014] It is to be understood that both the foregoing description and the following description of the present disclosure are exemplary and explanatory, and are intended to provide further explanation of the disclosure as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The accompanying drawings, which are included to provide a further understanding of the disclosure, are incorporated in and constitute a part of this disclosure, illustrate aspects and embodiments of the disclosure, and together with the description serve to explain principles of the disclosure. In the drawings:

[0016] FIG. 1 is a schematic plan view illustrating a display apparatus according to an example embodiment of the present disclosure;

[0017] FIG. 2 is an example of a schematic cross-sectional view taken along line I-I shown in FIG. 1;

[0018] FIG. 3 is an example of an enlarged view illustrating a portion A of FIG. 2;

[0019] FIG. 4A is a comparative example illustrating that an aspect ratio of a concave portion exceeds 1;

[0020] FIG. 4B is a view illustrating that an aspect ratio of a concave portion of a display apparatus according to an example embodiment of the present disclosure exceeds 0 and is less than 1;

[0021] FIG. 5 is a light efficiency map illustrating a refractive index of a concave portion with respect to an aspect ratio of the concave portion of a display apparatus according to an example embodiment of the present disclosure; and

[0022] FIG. 6 is a graph illustrating light efficiency with respect to a refractive index of a first layer of a display apparatus according to an example embodiment of the present disclosure.

[0023] Throughout the drawings and the detailed description, unless otherwise described, the same drawing reference numerals should be understood to refer to the same elements, features, and structures. The sizes, lengths, and thicknesses of layers, regions and elements, and depiction thereof may be exaggerated for clarity, illustration, and convenience.

DETAILED DESCRIPTION

[0024] Reference is now made in detail to embodiments of the present disclosure, examples of which may be illustrated in the accompanying drawings. In the following description, when a detailed description of well-known methods, functions, structures or configurations may unnecessarily obscure aspects of the present disclosure, the detailed description thereof may have been omitted for brevity. Further, repetitive descriptions may be omitted for brevity. The progression of processing steps and/or operations described is a non-limiting example.

[0025] The sequence of steps and/or operations is not limited to that set forth herein and may be changed to occur in an order that is different from an order described herein, with the exception of steps and/or operations necessarily occurring in a particular order. In one or more examples, two operations in succession may be performed substantially concurrently, or the two operations may be performed in a reverse order or in a different order depending on a function or operation involved.

[0026] Unless stated otherwise, like reference numerals may refer to like elements throughout even when they are shown in different drawings. In one or more aspects, identical elements (or elements with identical names) in different drawings may have the same or substantially the same functions and properties unless stated otherwise. Names of the respective elements used in the following explanations are selected only for convenience and may be thus different from those used in actual products.

[0027] Advantages and features of the present disclosure, and implementation methods thereof, are clarified through the embodiments described with reference to the accompanying drawings. The present disclosure may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are examples and are provided so that this disclosure may be thorough and complete to assist those skilled in the art to understand the inventive concepts without limiting the protected scope of the present disclosure.

[0028] Shapes, dimensions (e.g., sizes, lengths, widths, heights, thicknesses, locations, radii, diameters, and areas), ratios, angles, numbers, the number of elements, and the like

disclosed herein, including those illustrated in the drawings, are merely examples, and thus, the present disclosure is not limited to the illustrated details. It is, however, noted that the relative dimensions of the components illustrated in the drawings are part of the present disclosure.

[0029] When the term “comprise,” “have,” “include,” “contain,” “constitute,” “made of,” “formed of,” “composed of,” or the like is used with respect to one or more elements, one or more other elements may be added unless a term such as “only” or the like is used. The terms used in the present disclosure are merely used in order to describe particular example embodiments, and are not intended to limit the scope of the present disclosure. The terms of a singular form may include plural forms unless the context clearly indicates otherwise. The word “exemplary” is used to mean serving as an example or illustration. Embodiments are example embodiments. Aspects are example aspects. “Embodiments,” “examples,” “aspects,” and the like should not be construed to be preferred or advantageous over other implementations. An embodiment, an example, an example embodiment, an aspect, or the like may refer to one or more embodiments, one or more examples, one or more example embodiments, one or more aspects, or the like, unless stated otherwise. Further, the term “may” encompasses all the meanings of the term “can.”

[0030] In one or more aspects, unless explicitly stated otherwise, an element, feature, or corresponding information (e.g., a level, range, dimension, size, or the like) is construed to include an error or tolerance range even where no explicit description of such an error or tolerance range is provided. An error or tolerance range may be caused by various factors (e.g., process factors, internal or external impact, noise, or the like). In interpreting a numerical value, the value is interpreted as including an error range unless explicitly stated otherwise.

[0031] In describing a positional relationship, where the positional relationship between two parts (e.g., layers, films, regions, components, sections, or the like) is described, for example, using “on,” “upon,” “on top of,” “over,” “under,” “above,” “below,” “beneath,” “near,” “close to,” “adjacent to,” “beside,” “next to,” or the like, one or more other parts may be located between the two parts unless a more limiting term, such as “immediate(ly),” “direct(ly),” or “close(ly),” is used. For example, when a structure is described as being positioned “on,” “on a top of,” “upon,” “on top of,” “over,” “under,” “above,” “below,” “beneath,” “near,” “close to,” “adjacent to,” “beside,” or “next to” another structure, this description should be construed as including a case in which the structures contact each other directly as well as a case in which one or more additional structures are disposed or interposed therebetween. Furthermore, the terms “front,” “rear,” “back,” “left,” “right,” “top,” “bottom,” “downward,” “upward,” “upper,” “lower,” “up,” “down,” “column,” “row,” “vertical,” “horizontal,” and the like refer to an arbitrary frame of reference.

[0032] Spatially relative terms, such as “below,” “beneath,” “lower,” “on,” “above,” “upper” and the like, can be used to describe a correlation between various elements (e.g., layers, films, regions, components, sections, or the like) as shown in the drawings. The spatially relative terms are to be understood as terms including different orientations of the elements in use or in operation in addition to the orientation depicted in the drawings. For example, if the elements shown in the drawings are turned over, elements

described as “below” or “beneath” other elements would be oriented “above” other elements. Thus, the term “below,” which is an example term, can include all directions of “above” and “below.” Likewise, an exemplary term “above” or “on” can include both directions of “above” and “below.”

[0033] In describing a temporal relationship, when the temporal order is described as, for example, “after,” “subsequent,” “next,” “before,” “preceding,” “prior to,” or the like, a case that is not consecutive or not sequential may be included and thus another event may occur therebetween, unless a more limiting term, such as “just,” “immediate(ly),” or “direct(ly),” is used.

[0034] It is understood that, although the terms “first,” “second,” and the like may be used herein to describe various elements (e.g., layers, films, regions, components, sections, or the like), these elements should not be limited by these terms. These terms are used only to distinguish one element from another. For example, a first element could be a second element, and, similarly, a second element could be a first element, without departing from the scope of the present disclosure. Furthermore, the first element, the second element, and the like may be arbitrarily named according to the convenience of those skilled in the art without departing from the scope of the present disclosure. For clarity, the functions or structures of these elements (e.g., the first element, the second element, and the like) are not limited by ordinal numbers or the names in front of the elements.

[0035] In describing elements of the present disclosure, the terms “first,” “second,” “A,” “B,” “(a),” “(b),” or the like may be used. These terms are intended to identify the corresponding element(s) from the other element(s), and these are not used to define the essence, basis, order, or number of the elements.

[0036] For the expression that an element (e.g., layer, film, region, component, section, or the like) is “connected,” “coupled,” “attached,” “adhered,” or the like to another element, the element can not only be directly connected, coupled, attached, adhered, or the like to another element, but also be indirectly connected, coupled, attached, adhered, or the like to another element with one or more intervening elements disposed or interposed between the elements, unless otherwise specified.

[0037] For the expression that an element (e.g., layer, film, region, component, section, or the like) “contacts,” “overlaps,” or the like with another element, the element can not only directly contact, overlap, or the like with another element, but also indirectly contact, overlap, or the like with another element with one or more intervening elements disposed or interposed between the elements, unless otherwise specified.

[0038] The phrase that an element (e.g., layer, film, region, component, section, or the like) is “provided in,” “disposed in,” or the like in another element may be understood as that at least a portion of the element is provided in, disposed in, or the like in another element, or that the entirety of the element is provided in, disposed in, or the like in another element. The phrase that an element (e.g., layer, film, region, component, section, or the like) “contacts,” “overlaps,” or the like with another element may be understood as that at least a portion of the element contacts, overlaps, or the like with a least a portion of another element, that the entirety of the element contacts, overlaps, or the like with a least a

portion of another element, or that at least a portion of the element contacts, overlaps, or the like with the entirety of another element.

[0039] The terms “first direction,” “second direction,” and the like, such as the terms “first horizontal axis direction,” “second horizontal axis direction,” “vertical axis direction,” “X-axis direction,” “Y-axis direction,” “Z-axis direction,” and other similar terms, should not be interpreted only based on a geometrical relationship in which the respective directions are perpendicular to each other, and may be meant as directions having wider directivities within the range within which the components of the present disclosure can operate functionally.

[0040] The term “at least one” should be understood as including any and all combinations of one or more of the associated listed items. For example, each of the phrases “at least one of a first item, a second item, or a third item” and “at least one of a first item, a second item, and a third item” may represent (i) a combination of items provided by two or more of the first item, the second item, and the third item or (ii) only one of the first item, the second item, or the third item.

[0041] The expression of a first element, a second elements “and/or” a third element should be understood as one of the first, second and third elements or as any or all combinations of the first, second and third elements. By way of example, A, B and/or C may refer to only A; only B; only C; any of A, B, and C (e.g., A, B, or C); some combination of A, B, and C (e.g., A and B; A and C; or B and C); or all of A, B, and C. Furthermore, an expression “A/B” may be understood as A and/or B. For example, an expression “A/B” may refer to only A; only B; A or B; or A and B.

[0042] In one or more aspects, the terms “between” and “among” may be used interchangeably simply for convenience unless stated otherwise. For example, an expression “between a plurality of elements” may be understood as among a plurality of elements. In another example, an expression “among a plurality of elements” may be understood as between a plurality of elements. In one or more examples, the number of elements may be two. In one or more examples, the number of elements may be more than two. Furthermore, when an element (e.g., layer, film, region, component, sections, or the like) is referred to as being “between” at least two elements, the element may be the only element between the at least two elements, or one or more intervening elements may also be present.

[0043] In one or more aspects, the phrases “each other” and “one another” may be used interchangeably simply for convenience unless stated otherwise. In one or more examples, the number of elements involved in the foregoing expression may be two. In one or more examples, the number of elements involved in the foregoing expression may be more than two. In one or more aspects, the phrases “one or more among” and “one or more of” may be used interchangeably simply for convenience unless stated otherwise.

[0044] The term “or” means “inclusive or” rather than “exclusive or.” That is, unless otherwise stated or clear from the context, the expression that “x uses a or b” means any one of natural inclusive permutations. For example, “a or b” may mean “a,” “b,” or “a and b.” For example, “a, b or c” may mean “a,” “b,” “c,” “a and b,” “b and c,” “a and c,” or “a, b and c.”

[0045] Features of various embodiments of the present disclosure may be partially or entirely coupled to or combined with each other, may be technically associated with each other, and may be variously operated, linked or driven together. The embodiments of the present disclosure may be implemented or carried out independently of each other or may be implemented or carried out together in a co-dependent or related relationship. In one or more aspects, the components of each apparatus and device according to various embodiments of the present disclosure are operatively coupled and configured.

[0046] Unless otherwise defined, the terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which example embodiments belong. It is further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is, for example, consistent with their meaning in the context of the relevant art and should not be interpreted in an idealized or overly formal sense unless expressly defined otherwise herein.

[0047] The terms used herein have been selected as being general in the related technical field; however, there may be other terms depending on the development and/or change of technology, convention, preference of technicians, and so on. Therefore, the terms used herein should not be understood as limiting technical ideas, but should be understood as examples of the terms for describing example embodiments.

[0048] Further, in a specific case, a term may be arbitrarily selected by an applicant, and in this case, the detailed meaning thereof is described herein. Therefore, the terms used herein should be understood based on not only the name of the terms, but also the meaning of the terms and the content hereof.

[0049] In the following description, various example embodiments of the present disclosure are described in detail with reference to the accompanying drawings. With respect to reference numerals to elements of each of the drawings, the same elements may be illustrated in other drawings, and like reference numerals may refer to like elements unless stated otherwise. The same or similar elements may be denoted by the same reference numerals even though they are depicted in different drawings. In addition, for convenience of description, a scale, dimension, size, and thickness of each of the elements illustrated in the accompanying drawings may be different from an actual scale, dimension, size, and thickness, and thus, embodiments of the present disclosure are not limited to a scale, dimension, size, and thickness illustrated in the drawings.

[0050] FIG. 1 is a schematic plan view illustrating a display apparatus according to an example embodiment of the present disclosure, FIG. 2 is an example of a schematic cross-sectional view taken along line I-I shown in FIG. 1, and FIG. 3 is an example of an enlarged view illustrating a portion A of FIG. 2.

[0051] Referring to FIGS. 1 to 3, a display apparatus 100 according to an example embodiment of the present disclosure includes a substrate 110, a plurality of pixels P having a plurality of subpixels SP, a pattern portion 120 disposed on the substrate 110 and formed to be concave between the plurality of subpixels SP, and a reflective portion 130 disposed to be inclined on the pattern portion 120.

[0052] The plurality of subpixels SP may include a first layer 1131 and a second layer 1132. The first layer 1131 is adjacent to the reflective portion 130 on the substrate 110. The first layer 1131 includes a plurality of concave portions 141. The second layer 1132 is on the first layer 1131. As shown in FIGS. 2 and 3, since the plurality of concave portions 141 may be provided in the form of a parabola, the plurality of concave portions 141 may be expressed as terms such as a parabolic or parabolic structure. An inclination angle θ of the reflective portion 130 may be provided to satisfy

$$\text{Taper Angle } (\theta) = \frac{180 \times \log \sqrt{0.11 \times T_L^2 + T_H^2}}{\pi}$$

The Taper Angle(θ) may represent the inclination angle θ . The inclination angle θ of the reflective portion 130 may be a crossing angle between the upper surface of the substrate 110 and the reflective portion 130 on the pattern portion 120. Alternatively, as shown in FIG. 3, the inclination angle θ of the reflective portion 130 may be a crossing angle between an extension line of a lower surface of a reflective electrode 117 in the light emission area EA of the plurality of subpixels SP and the reflective portion 130 disposed in the non-light emission area NEA, which is adjacent to the light emission area EA. As shown in FIG. 3, T_H may be a maximum thickness of the second layer 1132 in the concave portion 141. T_L may be a thickness of the first layer 1131 on an extension line of T_H . π may be a circular constant. In one or more aspects, π (or a circular constant) may be a ratio of a circle's circumference to its diameter, and may be approximately 3.1415926535. T_H and T_L may respectively represent a thickness of the second layer 1132 and a thickness of the first layer 1131 in a direction parallel with a third direction (Z-axis direction).

[0053] In the display apparatus 100 according to an example embodiment of the present disclosure, the inclination angle θ of the reflective portion 130 may be proportional to the maximum thickness T_H of the second layer 1132 and the thickness T_L of the first layer 1131 in the concave portion 141. Therefore, in the display apparatus 100 according to an example embodiment of the present disclosure, as the reflective portion 130 disposed in the non-light emission area NEA may be provided at an optimal angle, light extraction efficiency for light emitted from the light emission area EA and directed toward an adjacent sub pixel SP may be improved, whereby overall light efficiency may be improved.

[0054] While referencing FIGS. 1 to 3, the display apparatus 100 according to an example embodiment of the present disclosure is described in more detail below.

[0055] Each of the plurality of subpixels SP according to an example embodiment may include a light emission area EA, a non-light emission area NEA adjacent to the light emission area EA and a light extraction portion 140 that overlaps the light emission area EA and includes a plurality of concave portions 141. The light emission area EA is an area from which light is emitted, and may be included in the display area DA. The non-light emission area NEA is an area from which light is not emitted, and may be an area adjacent to the light emission area EA. The non-light emission area NEA may be referred to as a peripheral area. The reflective portion 130 may be adjacent to the light extraction portion

140 in the non-light emission area NEA, and may be spaced apart from the light emission area EA.

[0056] Therefore, in the display apparatus **100** according to an example embodiment of the present disclosure, since the reflective portion **130** disposed in the non-light emission area NEA may reflect light, which is directed toward the subpixel adjacent thereto among light emitted from the light emission area EA, toward the subpixel SP for emitting light, light efficiency (or light extraction efficiency) of the subpixel SP for emitting light may be improved.

[0057] The reflective portion **130** according to an example embodiment may be provided to be inclined on the pattern portion **120** in the non-light emission area NEA. When the inclination angle θ of the reflective portion **130** disposed to be inclined is too small, reflectance of the light directed toward the adjacent subpixel SP is reduced, whereby light extraction efficiency may be reduced. On the contrary, when the inclination angle θ of the reflective portion **130** disposed to be inclined is too large, reflectance of the light directed toward the adjacent subpixel SP is increased. However, as the reflective portion **130** is positioned to be too close to a line for driving the pixel, parasitic capacitance may be generated. When parasitic capacitance is generated, a signal for driving the pixel P may be delayed.

[0058] For example, the inclination angle θ of the reflective portion **130** may be 40° to 75° . As described above, when the inclination angle θ of the reflective portion **130** is less than 40° , reflectance of light by the reflective portion **130** may be reduced, whereby light efficiency may be deteriorated. In contrast, when the inclination angle θ of the reflective portion **130** exceeds 75° , the reflective portion **130** on the pattern portion **120** becomes close to the line, whereby parasitic capacitance is generated and thus the signal may be delayed.

[0059] Therefore, in the display apparatus **100** according to an example embodiment of the present disclosure, as the inclination angle θ of the reflective portion **130** disposed in the non-light emission area NEA is provided at an optimal angle of 40° to 75° , occurrence of parasitic capacitance may be avoided and light extraction efficiency for the light emitted from the light emission area EA and directed toward the adjacent subpixel SP may be improved.

[0060] The inclination angle θ of the reflective portion **130** may be derived by an equation related to the maximum thickness T_H of the second layer **1132** and the thickness T_L of the first layer **1131** in the concave portion **141**. This is described in more detail later.

[0061] The non-light emission area NEA according to an example may include a first area A1 adjacent to the light emission area EA and a second area A2 adjacent to the first area A1 and spaced apart from the light emission area EA. The first area A1 according to an example may be a bank area in which a bank (or a bank covering an edge of the pixel electrode) defining the light emission area EA is disposed. The second area A2 according to an example may be a bank-less area in which a bank is not disposed.

[0062] The pattern portion **120** according to an example may be formed to be concave in the non-light emission area NEA. For example, the pattern portion **120** may be formed to be concave in an overcoat layer **113** (shown in FIG. 2) on the substrate **110**. The pattern portion **120** may be disposed to be spaced apart from the light emission area EA. The pattern portion **120** according to an example may be provided to surround the light emission area EA in the form of

a slit or a trench. For example, a width of the pattern portion **120** may be formed to be reduced from the reflective portion **130** toward the substrate **110**. Furthermore, as shown in FIG. 2, the pattern portion **120** may include an area exposed without being covered by the bank **115**. Therefore, the pattern portion **120** may be expressed as terms such as a groove, a slit, a trench, a bank slit and a bank trench. As shown in FIG. 2, the pattern portion **120** may include an inclined surface **120s** formed in the first area A1 and a bottom surface **120b** extending from the inclined surface **120s** to the second area A2.

[0063] The reflective portion **130** according to an example may be formed to be concave along a profile of the pattern portion **120** formed to be concave in the non-light emission area NEA, thereby being formed to be concave in the non-light emission area NEA. The reflective portion **130** may be made of a material capable of reflecting light, and may reflect light, which is emitted from the light emission area EA and directed toward the adjacent subpixel SP, toward the light emission area EA for emitting light. As shown in FIG. 2, since the reflective portion **130** is disposed to be inclined on the pattern portion **120** while surrounding the light emission area EA, the reflective portion **130** may be expressed as terms such as a side reflective portion or an inclined reflective portion.

[0064] Meanwhile, the display apparatus **100** according to an example embodiment of the present disclosure may be implemented in a bottom emission type in which light emitted from the light emission area EA is emitted to the lower surface of the substrate **110**. Therefore, in the display apparatus **100** according to an example embodiment of the present disclosure, the light emitted to the lower surface of the substrate **110** may be the light in which direct light emitted from the light emission area EA and directly emitted to the lower surface of the substrate **110** and reflective light obtained by reflecting the light, which is emitted from the light emission area EA and directed toward the adjacent subpixel SP, by the reflective portion **130** and emitting the light to the lower surface of the substrate **110** are combined with each other. Therefore, the display apparatus **100** according to an example embodiment of the present disclosure may enhance light extraction efficiency more than a display apparatus in which the reflective portion **130** formed to be concave is not provided.

[0065] Referring to FIGS. 1 and 2, the display apparatus **100** according to an example embodiment of the present disclosure may include a display panel having a gate driver GD, a light extraction portion **140** overlapping a light emission area EA, a plurality of lines **150**, a source drive integrated circuit (hereinafter, referred to as an "IC") **160**, a flexible film **170**, a circuit board **180**, and a timing controller **190**.

[0066] The display panel may include a substrate **110** and an opposite substrate **200** (shown in FIG. 2).

[0067] The substrate **110** may include a thin film transistor, and may be a transistor array substrate, a lower substrate, a base substrate, or a first substrate. The substrate **110** may be a transparent glass substrate or a transparent plastic substrate. The substrate **110** may include, or may be provided in or at, a display area DA and a non-display area NDA.

[0068] The display area DA is an area where an image is displayed, and may be a pixel array area, an active area, a pixel array unit, a display unit, or a screen. For example, the

display area DA may be disposed at a central portion of the display panel. The display area DA may include a plurality of pixels P.

[0069] The opposite substrate 200 may encapsulate (or seal) the display area DA disposed on the substrate 110. For example, the opposite substrate 200 may be bonded to the substrate 110 via an adhesive member (or clear glue). The opposite substrate 200 may be an upper substrate, a second substrate, or an encapsulation substrate.

[0070] The gate driver GD supplies gate signals to the gate lines in accordance with the gate control signal input from the timing controller 190. The gate driver GD may be formed on one side of the light emission area EA or in the non-light emission area NEA outside both sides of the light emission area EA in a gate driver in panel (GIP) configuration, as shown in FIG. 1.

[0071] The non-display area NDA is an area on which an image is not displayed, and may be a peripheral area, a signal supply area, an inactive area or a bezel area. The non-display area NDA may be configured to be in the vicinity of the display area DA. That is, the non-display area NDA may be disposed to surround the display area DA.

[0072] A pad area PA may be disposed in the non-display area NDA. The pad area PA may supply a power source and/or a signal for outputting an image to the pixel P provided in the display area DA. Referring to FIG. 1, the pad area PA may be provided above the display area DA.

[0073] The source drive IC 160 receives digital video data and a source control signal from the timing controller 190. The source drive IC 160 converts the digital video data into analog data voltages in accordance with the source control signal and supplies the analog data voltages to the data lines. When the source drive IC 160 is manufactured as a driving chip, the source drive IC 160 may be packaged in the flexible film 170 in a chip on film (COF) configuration or a chip on plastic (COP) configuration.

[0074] Pads, such as data pads, may be formed in the non-display area NDA of the display panel. Lines connecting the pads with the source drive IC 160 and lines connecting the pads with lines of the circuit board 180 may be formed in the flexible film 170. The flexible film 170 may be attached to the pads by using an anisotropic conducting film, whereby the pads may be connected to the lines of the flexible film 170.

[0075] The circuit board 180 may be attached to the flexible films 170. A plurality of circuits implemented as driving chips may be packaged in the circuit board 180. For example, the timing controller 190 may be packaged in the circuit board 180. The circuit board 180 may be a printed circuit board or a flexible printed circuit board.

[0076] The timing controller 190 receives the digital video data and a timing signal from an external system board through a cable of the circuit board 180. The timing controller 190 generates a gate control signal for controlling an operation timing of the gate driver GD and a source control signal for controlling the source drive ICs 160 based on the timing signal. The timing controller 190 supplies the gate control signal to the gate driver GD, and supplies the source control signal to the source drive ICs 160.

[0077] Referring to FIG. 2, the substrate 110 according to an example may include, or may be provided in, the light emission area EA and the non-light emission area NEA.

[0078] The light emission area EA is an area from which light is emitted, and may be an area that is not covered by

a bank 115. A light emitting element layer E, which includes a pixel electrode 114, a light emitting layer 116 and a reflective electrode 117, may be disposed in the light emission area EA. When an electric field is formed between the pixel electrode 114 and the reflective electrode 117, the light emitting layer 116 in the light emission area EA may emit light. The light emitting layer 116 and the reflective electrode 117 may also be extended to and be disposed in the non-light emission area NEA.

[0079] The light emission area EA according to an example may include gate lines, data lines, pixel driving power lines, and a plurality of pixels P. Each of the plurality of pixels P may include a plurality of subpixels SP that may be defined by the gate lines and the data lines.

[0080] Meanwhile, according to an example, at least four subpixels, which are provided to emit different colors and disposed to be adjacent to one another, among the plurality of subpixels SP may constitute one pixel P (or unit pixel). One pixel P may include, but is not limited to, a red subpixel, a green subpixel, a blue subpixel and a white subpixel. One pixel P may include three subpixels SP provided to emit light of different colors and disposed to be adjacent to one another. For example, one pixel P may include a red subpixel, a green subpixel and a blue subpixel.

[0081] Each of the plurality of subpixels SP includes a thin film transistor and a light emitting element layer E connected to the thin film transistor. Each of the plurality of subpixels may include a light emitting layer (or an organic light emitting layer) interposed between the pixel electrode and the reflective electrode.

[0082] The light emitting layer respectively disposed in the plurality of subpixels SP may individually emit light of different colors or emit white light in common. Since the light emitting layer of each of the plurality of subpixels SP commonly emits white light, each of the red subpixel, the green subpixel and the blue subpixel may include a color filter CF (or wavelength conversion member CF) for converting white light into light of its respective different color. In this case, the white subpixel may not include a color filter.

[0083] In the display apparatus 100 according to an example embodiment of the present disclosure, an area provided with a red color filter may be a red subpixel or a first subpixel, an area provided with a green color filter may be a green subpixel or a second subpixel, an area provided with a blue color filter may be a blue subpixel or a third subpixel, and an area in which the color filter is not provided may be a white subpixel or a fourth subpixel.

[0084] Each of the subpixels SP supplies a predetermined current to the organic light emitting element in accordance with a data voltage of the data line when a gate signal is input from the gate line by using the thin film transistor. For this reason, the light emitting layer of each of the subpixels may emit light with a predetermined brightness in accordance with the predetermined current.

[0085] The plurality of subpixels SP according to an example may be disposed to be adjacent to each other in a first direction (X-axis direction). The first direction (X-axis direction) may be a horizontal direction as illustrated in FIG. 1. The horizontal direction may be a direction in which a gate line is disposed.

[0086] A second direction (Y-axis direction) is a direction crossing the first direction (X-axis direction), and may be a vertical direction as illustrated in FIG. 1. The vertical direction may be a direction in which a data line is disposed.

[0087] A third direction (Z-axis direction) is a direction crossing each of the first direction (X-axis direction) and the second direction (Y-axis direction), and may be a thickness direction of the display apparatus 100.

[0088] The plurality of subpixels SP may include a first subpixel SP1, a second subpixel SP2, a third subpixel SP3 and a fourth subpixel SP4 arranged adjacent to each other in the first direction (X-axis direction). For example, the first subpixel SP1 may be a red subpixel, the second subpixel SP2 may be a green subpixel, the third subpixel SP3 may be a blue subpixel and the fourth subpixel SP4 may be a white subpixel, but the present disclosure is not limited thereto. However, the arrangement order of the first subpixel SP1, the second subpixel SP2, the third subpixel SP3 and the fourth subpixel SP4 may be changed.

[0089] Each of the first to fourth subpixels SP1 to SP4 may include a light emission area EA and a circuit area. The light emission area EA may be disposed at one side (or an upper side) of a subpixel area, and the circuit area may be disposed at the other side (or a lower side) of the subpixel area. For example, the circuit area may be disposed at the lower side of the light emission area EA with respect to the second direction Y. The light emission areas EA of the first to fourth subpixels SP1 to SP4 may have the same size (or area) as each other, or different sizes (or areas) from each other.

[0090] The first to fourth subpixels SP1 to SP4 may be disposed to be adjacent to one another along the first direction (X-axis direction). For example, two data lines extended along the second direction (Y-axis direction) may be disposed in parallel with each other between the first subpixel SP1 and the second subpixel SP2 and between the third subpixel SP3 and the fourth subpixel SP4. A pixel power line extended along the first direction (X-axis direction) may be disposed between the light emission area EA and the circuit area of each of the first to fourth subpixels SP1 to SP4. The gate line and a sensing line may be disposed below the circuit area. The pixel power line EVDD (shown in FIG. 2) extended along the second direction (Y-axis direction) may be disposed at one side of the first subpixel SP1 or the fourth subpixel SP4. A reference line extended along the second direction (Y-axis direction) may be disposed between the second subpixel SP2 and the third subpixel SP3. The reference line may be used as a sensing line for sensing a change of characteristics of a driving thin film transistor and/or a change of characteristics of the light emitting element layer, which is disposed in the circuit area, from the outside in a sensing driving mode of the pixel P. The data lines, the pixel power line EVDD and the reference line may be included in the plurality of lines 150. The data lines may include a first data line DL1 for driving the first subpixel SP1, a second data line DL2 for driving the second subpixel SP2, a third data line for driving the third subpixel SP3 and a fourth data line for driving the fourth subpixel SP4.

[0091] A plurality of lines 150 may be provided below the pattern portion 120. Each of the plurality of lines 150 may at least partially overlap the pattern portion 120 below the pattern portion 120. For example, as shown in FIG. 2, the first data line DL1 may partially overlap the bottom surface 120b of the pattern portion 120 between the first subpixel SP1 and the second subpixel SP2. The second data line DL2 may partially overlap the inclined surface 120s of the pattern portion 120. The pixel power line EVDD or the reference

line may partially overlap the bottom surface 120b and the inclined surface 120s of the pattern portion 120.

[0092] In the display apparatus 100 according to an example embodiment of the present disclosure, each of the plurality of subpixels SP may include the light extraction portion 140. The light extraction portion 140 may be formed on the overcoat layer 113 (shown in FIG. 2) to overlap the light emission area EA of the subpixel. The light extraction portion 140 may be formed on the overcoat layer 113 of the light emission area EA to have a curved (or uneven) shape, thereby changing a propagation path of light emitted from the light emitting element layer E to increase light extraction efficiency. For example, the light extraction portion 140 may be a non-flat portion, an uneven pattern portion, a micro lens portion, or a light scattering pattern portion.

[0093] The light extraction portion 140 may include a plurality of concave portions 141. The plurality of concave portions 141 may be formed to be concave inside the overcoat layer 113. For example, the plurality of concave portions 141 may be formed or configured to be concave from an upper surface 1131a of a first layer 1131 included in the overcoat layer 113. Therefore, the first layer 1131 may include a plurality of concave portions 141. The first layer 1131 may be disposed between the substrate 110 and the light emitting element layer E in the third direction (Z-axis direction). The concave portions 141 may be disposed adjacent to the pattern portion 120 in the first direction (X-axis direction).

[0094] A second layer 1132 of the overcoat layer 113 may be disposed between the first layer 1131 and a light emitting element layer E (or a pixel electrode 114 shown in FIG. 2). The second layer 1132 according to an example may be formed to be wider than the pixel electrode 114 in a first direction (X-axis direction). Thus, a portion of the second layer 1132 may overlap the light emissive area EA, and the other portion of the second layer 1132 may be in contact with a portion of the bottom surface 120b while covering the inclined surface 120s of the pattern portion 120. That is, as shown in FIG. 2, the second layer 1132 may be extended from the light emission area EA to the first area A1 and thus may be in contact with a portion of the bottom surface 120b while covering the inclined surface 120s of the pattern portion 120. Since an upper surface 1132a of the second layer 1132 is provided flat, the pixel electrode 114 disposed on the upper surface 1132a of the second layer 1132 may also be provided flat. The light emitting layer 116 may be disposed on the second layer 1132.

[0095] Meanwhile, a refractive index of the second layer 1132 may be greater than that of the first layer 1131. Therefore, as shown in FIG. 2, a path of light emitted from a light emitting layer 116 and directed toward the substrate 110 may be changed toward the reflective portion 130 due to a difference in refractive indexes between the second layer 1132 and the first layer 1131 of the light extraction portion 140. Therefore, the light having a path formed in the reflective portion 130 by the light extraction portion 140 may be reflected in the reflective portion 130 and emitted toward the light emission area EA of the subpixel SP for emitting light. Hereinafter, the light reflected in the reflective portion 130 and emitted toward the substrate 110 may be referred to as the reflective light.

[0096] As shown in FIG. 2, the reflective light may include first reflective light L1 (or WG mode extraction light L1) reflected from the reflective portion 130 and emitted to

the substrate **110** after being subjected to optical waveguide through total reflection between the pixel electrode **114** and the reflective electrode **117**, second reflective light **L2** reflected from the reflective portion **130** and emitted to the substrate **110** after its path is changed by the light extraction portion **140**, and third reflective light **L3** (or substrate mode extraction light) emitted from the light emitting layer **116**, primarily reflected by the reflective portion **130**, secondarily reflected on a boundary surface between the lower surface of the substrate **110** and the air layer, thirdly reflected by the reflective portion **130** and then emitted to the substrate **110**. The first reflective light **L1**, the second reflective light **L2** and the third reflective light **L3**, which are shown in solid lines in FIG. 3, may be the reflective light extracted by being reflected by the reflective portion **130**.

[0097] As shown in FIG. 2, the first reflective light **L1** according to an example may be emitted from the light emission area **EA**. The second reflective light **L2** may be emitted from a position spaced apart from the light emission area **EA**. That is, the second reflective light **L2** may be emitted from the non-light emission area **NEA** or the peripheral area. However, the present disclosure is not limited to the above example. The first reflective light **L1** may be emitted toward the substrate **110** from the position spaced apart from the light emission area **EA**. The third reflective light **L3** may be emitted from the light emission area **EA** or the non-light emission area **NEA**.

[0098] The display apparatus **100** according to an example embodiment of the present disclosure may further include light which is emitted to the substrate **110** through the light extraction portion **140** without being reflected by the reflective portion **130**. For example, as shown by the dotted lines in FIG. 2, the display apparatus **100** may further include primary extraction light **L4** emitted from the light emitting layer **116**, refracted on a boundary surface between the plurality of concave portions **141** included in the light extraction portion **140** and the first layer **1131** and then emitted to the substrate **110**, and recycle light **L5** emitted from the light emitting layer **116**, primarily refracted on the boundary surface between the plurality of concave portions **141** and the first layer **1131**, secondarily reflected on the lower surface of the pixel electrode **114**, refracted on the boundary surface between the plurality of concave portions **141** and the first layer **1131** and then emitted to the substrate **110**. Therefore, the display apparatus **100** according to an example embodiment of the present disclosure may improve the overall light extraction efficiency through the light extraction portion **140** and the reflective portion **130**.

[0099] In the display apparatus **100** according to an example embodiment of the present disclosure, since the pattern portion **120** is disposed to surround the light emission area **EA**, at least a portion of the reflective portion **130** on the pattern portion **120** may be disposed to surround the light emission area **EA**. Therefore, the reflective light may be emitted toward the substrate **110** from the position spaced apart from the light emission area **EA** while surrounding at least a portion of the light emission area **EA**. Therefore, in the display apparatus **100** according to an example embodiment of the present disclosure, since light dissipated by waveguide (or optical waveguide) and/or light dissipated by the interface total reflection may be emitted from the non-light emission area **NEA** in the form of reflective light through the reflective portion **130** surrounding at least a

portion of the light emission area **EA**, light extraction efficiency may be improved and the overall light emission efficiency may be increased.

[0100] A structure of each of the plurality of subpixels **SP** is described in further detail below.

[0101] Referring to FIG. 2, the display apparatus **100** according to an example embodiment of the present disclosure may further include a buffer layer **BL**, a circuit element layer, a thin film transistor (not shown), a pixel electrode **114**, a bank **115**, a light emitting layer **116**, a reflective electrode **117**, an encapsulation layer **118** and a color filter **CF**.

[0102] In more detail, each of the subpixels **SP** according to an example embodiment may include a circuit element layer provided on an upper surface of a buffer layer **BL**, including a gate insulating layer (not shown), an interlayer insulating layer **111** and a passivation layer **112**, an overcoat layer **113** provided on the circuit element layer, a pixel electrode **114** provided on the overcoat layer **113**, a bank **115** covering an edge of the pixel electrode **114**, a light emitting layer **116** on the pixel electrode **114** and the bank **115**, a reflective electrode **117** on the light emitting layer **116**, and an encapsulation layer **118** on the reflective electrode **117**.

[0103] The thin film transistor for driving the subpixel **SP** may be disposed on the circuit element layer. The circuit element layer may be expressed in terms of an inorganic film layer. The pixel electrode **114**, the light emitting layer **116** and the reflective electrode **117** may be included in the light emitting element layer **E**.

[0104] The buffer layer **BL** may be formed between the substrate **110** and the gate insulating layer to protect the thin film transistor. The buffer layer **BL** may be disposed on the entire surface (or front surface) of the substrate **110**. The pixel power line **EVDD** for pixel driving may be disposed between the buffer layer **BL** and the passivation layer **112**. The buffer layer **BL** may serve to block diffusion of a material contained in the substrate **110** into a transistor layer during a high temperature process of a manufacturing process of the thin film transistor. Optionally, the buffer layer **BL** may be omitted in some cases.

[0105] The thin film transistor (or a drive transistor) according to an example may include an active layer, a gate electrode, a source electrode, and a drain electrode. The active layer may include a channel area, a drain area and a source area, which are formed in a thin film transistor area of a circuit area of the subpixel **SP**. The drain area and the source area may be spaced parallel to each other with the channel area interposed therebetween.

[0106] The active layer may be formed of a semiconductor material based on any one of amorphous silicon, polycrystalline silicon, oxide and organic material.

[0107] The gate insulating layer may be formed on the channel area of the active layer. As an example, the gate insulating layer may be formed in an island shape only on the channel area of the active layer, or may be formed on an entire front surface of the substrate **110** or the buffer layer **BL**, which includes the active layer.

[0108] The gate electrode may be formed on the gate insulating layer to overlap the channel area of the active layer.

[0109] The interlayer insulating layer **111** may be formed to partially overlap the gate electrode and the drain area and source area of the active layer. The interlayer insulating

layer **111** may be formed over the entire light emission area where light is emitted in the circuit area and the subpixel SP.

[0110] The source electrode may be electrically connected to the source area of the active layer through a source contact hole provided in the interlayer insulating layer overlapped with the source area of the active layer. The drain electrode may be electrically connected to the drain area of the active layer through a drain contact hole provided in the interlayer insulating layer **111** overlapped with the drain area of the active layer.

[0111] The drain electrode and the source electrode may be made of the same metal material. For example, each of the drain electrode and the source electrode may be made of a single metal layer, a single layer of an alloy or a multi-layer of two or more layers, which is the same as or different from that of the gate electrode.

[0112] In addition, the circuit area may further include first and second switching thin film transistors disposed together with the thin film transistor, and a capacitor. Since each of the first and second switching thin film transistors is provided on the circuit area of the subpixel SP to have the same structure as that of the thin film transistor, its description is omitted. The capacitor (not shown) may be provided in an overlap area between the gate electrode and the source electrode of the thin film transistor, which overlap each other with the interlayer insulating layer **111** interposed therebetween.

[0113] Additionally, in order to prevent a threshold voltage of the thin film transistor provided in a pixel area from being shifted by light, the display panel or the substrate **110** may further include a light shielding layer (not shown) provided below the active layer of at least one of the thin film transistor, the first switching thin film transistor or the second switching thin film transistor. The light shielding layer may be disposed between the substrate **110** and the active layer to shield light incident on the active layer through the substrate **110**, thereby minimizing a change in the threshold voltage of the transistor due to external light. Furthermore, since the light shielding layer is provided between the substrate **110** and the active layer, the thin film transistor may be prevented from being seen by a user.

[0114] The passivation layer **112** may be provided on the substrate **110** to cover the pixel area. The passivation layer **112** covers a drain electrode, a source electrode and a gate electrode of the thin film transistor, and the buffer layer. The reference line may be disposed between the passivation layer **112** and the interlayer insulating layer **111**. The reference line may be disposed at a position symmetrical to the pixel power line EVDD based on the light emission area EA or a similar position symmetrical to the pixel power line EVDD. Therefore, the reference line and the pixel power line EVDD may be disposed below the bank **115** without covering the light emitting area EA. The passivation layer **112** may be formed over the circuit area and the light emission area. The passivation layer **112** may be omitted. The color filter CF may be disposed on the passivation layer **112**.

[0115] The overcoat layer **113** may be provided on the substrate **110** to cover the passivation layer **112** and the color filter CF. When the passivation layer **112** is omitted, the overcoat layer **113** may be provided on the substrate **110** to cover the circuit area. The overcoat layer **113** may be formed in the circuit area in which the thin film transistor is disposed and the light emission area EA. In addition, the overcoat

layer **113** may be formed in the other non-display area NDA except a pad area PA of the non-display area NDA and the entire display area DA. For example, the overcoat layer **113** may include an extension portion (or an enlarged portion) extended or enlarged from the display area DA to the other non-display area NDA except the pad area PA. Therefore, the overcoat layer **113** may have a size relatively wider than that of the display area DA.

[0116] The overcoat layer **113** according to an example may be formed to have a relatively thick thickness, thereby providing a flat surface on the display area DA and the non-display area NDA. For example, the overcoat layer **113** may be made of an organic material such as photo acrylic, benzocyclobutene, polyimide and fluorine resin.

[0117] The overcoat layer **113** formed in the display area DA (or the light emission area EA) may include a plurality of concave portions **141**. The plurality of concave portions **141** are the elements of the light extraction portion **140** for increasing light efficiency of the light emission area EA, and may be formed inside the overcoat layer **113**. In detail, as shown in FIG. 3, the plurality of concave portions **141** may be formed in a concave shape on the first layer **1131** of the overcoat layer **113**. The plurality of concave portions **141** are provided to be connected to each other so that an embossed shape may be formed in the first layer **1131**.

[0118] The second layer **1132** having a refractive index higher than that of the first layer **1131** may be formed on the first layer **1131**. A path of the light, which is directed toward the adjacent subpixel SP, among the light emitted from the light emitting element layer E may be changed toward the reflective portion **130** in accordance with a difference in the refractive index between the second layer **1132** and the first layer **1131**. The second layer **1132** may be provided to cover the embossed shape of the first layer **1131** and thus the upper surface **1132a** may be provided to be flat.

[0119] The pixel electrode **114** is formed on the upper surface **1132a** of the second layer **1132** so that the pixel electrode **114** may be provided to be flat, and the light emitting layer **116** and the reflective electrode **117**, which are formed on the pixel electrode **114**, may be provided to be also flat. Since the pixel electrode **114**, the light emitting layer **116**, the reflective electrode **117**, that is, the light emitting element layer E is provided to be flat in the light emission area EA, a thickness of each of the pixel electrode **114**, the light emitting layer **116** and the reflective electrode **117** in the light emission area EA may be uniformly formed. Therefore, the light emitting layer **116** may be uniformly emitted without deviation in the light emission area EA.

[0120] The plurality of concave portions **141** may be formed on the first layer **1131** through a photolithographic process using a mask having an opening portion and then a pattern (or etching) or ashing process after the first layer **1131** is coated to cover the passivation layer **112** and the color filter CF. The plurality of concave portions **141** may be formed in an area overlapped with the color filter CF and/or an area that is not overlapped with the bank **115** of the non-light emission area NEA, but the present disclosure is not limited thereto. A portion of the plurality of concave portions **141** may be formed to overlap the bank **115**.

[0121] Referring back to FIG. 2, the color filter CF disposed in the light emission area EA may be provided between the substrate **110** and the overcoat layer **113**. Therefore, the color filter CF may be disposed between the pixel power line EVDD, for example, the pixel power line

EVDD and the reflective portion **130** or between the pixel driving line and the pattern portion **120**. The color filter CF may include a red color filter (or a first color filter) CF1 for converting white light emitted from the light emitting layer **116** into red light, a green color filter (or a second color filter) CF2 for converting white light into green light, and a blue color filter (or a third color filter) CF3 for converting white light into blue light. The fourth subpixel, which is a white subpixel, may not include a color filter since the light emitting layer **116** emits white light.

[0122] As shown in FIG. 2, the display apparatus **100** according to an example embodiment of the present disclosure may be provided such that color filters having different colors partially overlap each other at a boundary portion of the plurality of subpixels SP. In this case, the display apparatus **100** according to an example embodiment of the present disclosure may prevent the light emitted from each subpixel SP from being emitted to the adjacent subpixel SP due to the color filters overlapped with each other at the boundary portion of the subpixels SP, thereby preventing color mixture between the subpixels SP from occurring.

[0123] The pixel electrode **114** of the subpixel SP may be formed on the overcoat layer **113**. The pixel electrode **114** may be connected to a drain electrode or a source electrode of the thin film transistor through a contact hole passing through the overcoat layer **113** and the passivation layer **112**. The edge portion of the pixel electrode **114** may be covered by the bank **115**.

[0124] Because the display apparatus **100** according to an example embodiment of the present disclosure is configured as the bottom emission type, the pixel electrode **114** may be formed of a transparent conductive material (or TCO), such as indium tin oxide (ITO) or indium zinc oxide (IZO) capable of transmitting light, or a semi-transmissive conductive material such as magnesium (Mg), silver (Ag), or an alloy of Mg and Ag.

[0125] Meanwhile, the material constituting the pixel electrode **114** may include molybdenum and titanium (or MoTi). The pixel electrode **114** may be a first electrode or an anode electrode.

[0126] The bank **115** is an area from which light is not emitted, and may be provided to surround each of the light emitting portions (or the concave portions **141**) of each of the plurality of subpixels SP. That is, the bank **115** may partition (or define) the concave portions **141** of each of the light emitting portion or the subpixels SP. The light emitting portion may be a portion where the pixel electrode **114** and the reflective electrode **117** are in contact with each of the upper surface and the lower surface of the light emitting layer **116** with the light emitting layer **116** interposed therebetween.

[0127] The bank **115** may be formed to cover the edge of each pixel electrode **114** of each of the subpixels SP and expose a portion of each of the pixel electrodes **114**. That is, the bank **115** may partially cover the pixel electrode **114**. Therefore, the bank **115** may prevent the pixel electrode **114** and the reflective electrode **117** from being in contact with each other at the end of each pixel electrode **114**. The exposed portion of the pixel electrode **114**, which is not covered by the bank **115**, may be included in the light emitting portion (or the light emission area EA). As shown in FIG. 2, the light emitting portion may be formed on the plurality of concave portions **141**, and thus the light emitting portion (or the light emission area EA) may overlap the

concave portions **141** in a thickness direction (or the third direction (Z-axis direction)) of the substrate **110**.

[0128] After the bank **115** is formed, the light emitting layer **116** may be formed to cover the pixel electrode **114** and the bank **115**. Therefore, the bank **115** may be provided between the pixel electrode **114** and the light emitting layer **116**. The bank **115** may be referred to as a pixel defining layer. The bank **115** according to an example may include an organic material and/or an inorganic material. As shown in FIG. 2, the bank **115** may be formed to be concave or inclined along the profile of the pattern portion **120** (or the second layer **1132**).

[0129] Referring again to FIG. 2, the light emitting layer **116** may be formed on the pixel electrode **114** and the bank **115**. The light emitting layer **116** may be provided between the pixel electrode **114** and the reflective electrode **117**. Thus, when a voltage is applied to each of the pixel electrode **114** and the reflective electrode **117**, an electric field is formed between the pixel electrode **114** and the reflective electrode **117**. Therefore, the light emitting layer **116** may emit light. The light emitting layer **116** may be formed of a plurality of subpixels SP and a common layer provided on the bank **115**.

[0130] The light emitting layer **116** according to an example embodiment may be provided to emit white light. The light emitting layer **116** may include a plurality of stacks which emit lights of different colors. For example, the light emitting layer **116** may include a first stack, a second stack, and a charge generating layer (CGL) provided between the first stack and the second stack. The light emitting layer may be provided to emit the white light, and thus, each of the plurality of subpixels SP may include a color filter CF suitable for a corresponding color.

[0131] The first stack may be provided on the pixel electrode **114** and may be implemented with a structure where a hole injection layer (HIL), a hole transport layer (HTL), an emission layer (EML(B)), and an electron transport layer (ETL) are sequentially stacked.

[0132] The charge generating layer may supply an electric charge to the first stack and the second stack. The charge generating layer may include an N-type charge generating layer for supplying an electron to the first stack and a P-type charge generating layer for supplying a hole to the second stack. The N-type charge generating layer may include a metal material as a dopant.

[0133] The second stack may be provided on the first stack and may be implemented in a structure where a hole transport layer (HTL), a yellow-green (YG) emission layer (EML(YG)), and an electron injection layer (EIL) are sequentially stacked.

[0134] In the display apparatus **100** according to an example embodiment of the present disclosure, because the light emitting layer **116** is provided as a common layer, the first stack, the charge generating layer, and the second stack may be arranged all over the plurality of subpixels SP.

[0135] The reflective electrode **117** may be formed on the light emitting layer **116**. The reflective electrode **117** may be disposed in the light emission area EA and the non-light emission area NEA. The reflective electrode **117** according to an example may include a metal material. The reflective electrode **117** may reflect the light emitted from the light emitting layer **116** in the plurality of subpixels SP toward the lower surface of the substrate **110**. Therefore, the display

apparatus **100** according to an example embodiment of the present disclosure may be implemented as a bottom emission type display apparatus.

[0136] The display apparatus **100** according to an example embodiment of the present disclosure is a bottom emission type and hence reflects light emitted from the light emitting layer **116** toward the substrate **110**, and thus the reflective electrode **117** may be made of a metal material having high reflectance. The reflective electrode **117** according to an example may be formed of a metal material having high reflectance such as a stacked structure (Ti/Al/Ti) of aluminum and titanium, a stacked structure (ITO/Al/ITO) of aluminum and ITO, an Ag alloy and a stacked structure (ITO/Ag alloy/ITO) of Ag alloy and ITO. The Ag alloy may be an alloy such as silver (Ag), palladium (Pd) and copper (Cu). The reflective electrode **117** may be expressed as terms such as a second electrode, a cathode electrode and a counter electrode.

[0137] Meanwhile, in the display apparatus **100** according to an example embodiment of the present disclosure, the reflective portion **130** may be a portion of the reflective electrode **117**. Therefore, the reflective portion **130** may reflect light, which is directed toward the adjacent subpixel SP, toward the light emission area EA of the subpixel SP for emitting light. Since the reflective portion **130** is a portion of the reflective electrode **117**, as shown in FIG. 2, the reflective portion **130** may be denoted by a reference numeral **117a**. In one or more aspects of the present disclosure, the reflective portion **130** may be the reflective electrode **117** that overlaps the pattern portion **120**. In particular, the reflective portion **130** may be the reflective electrode **117** that is inclined while being overlapped with the pattern portion **120**. Therefore, as shown in FIG. 3, the reflective portion **130** may reflect light that is directed toward the adjacent subpixel SP, or light that is dissipated through total reflection between interfaces, toward the light emission area EA (or the non-light emission area NEA) of the subpixel SP for emitting light.

[0138] The encapsulation layer **118** is formed on the reflective electrode **117**. The encapsulation layer **118** serves to prevent oxygen or moisture from being permeated into the light emitting layer **116** and the reflective electrode **117**. To this end, the encapsulation layer **118** may include at least one inorganic film and at least one organic film.

[0139] Meanwhile, as shown in FIG. 2, the encapsulation layer **118** may be disposed not only in the light emission area EA but also in the non-light emission area NEA. The encapsulation layer **118** may be disposed between the reflective electrode **117** and an opposing substrate **200**.

[0140] Hereinafter, the pattern portion **120** and the reflective portion **130** of the display apparatus **100** according to an example embodiment of the present disclosure are described in further detail with reference to FIGS. 2 and 3.

[0141] In the display apparatus **100** according to an example embodiment of the present disclosure, the pattern portion **120** may be provided near the light emission area EA (or the non-light emission area NEA) and the reflective portion **130** may be provided on the pattern portion **120** in order to prevent light extraction efficiency from being reduced as some of the light emitted from the light emitting element layer is not discharged to the outside due to total reflection on an interface between the light emitting element layer and the electrode and/or an interface between the substrate and the air layer. The reflective portion **130** may be

disposed to be inclined along the profile of the pattern portion **120**. Furthermore, as the inclination angle θ of the reflective portion **130** is provided at an optimal angle in proportion to the maximum thickness of the second layer **1132** and the thickness of the first layer **1131**, light extraction efficiency may be improved without parasitic capacitance.

[0142] Referring to FIG. 2, the pattern portion **120** may be formed to be concave in the first layer **1131** of the overcoat layer **113**. As shown in FIG. 2, the pattern portion **120** may be disposed near the non-light emission area NEA. That is, the pattern portion **120** may be disposed to surround the light emission area EA while being adjacent to the light extraction portion **140**. The pattern portion **120** may be formed in the non-light emission area NEA together with the plurality of concave portions **141** when the plurality of concave portions **141** are formed in the light emission area EA. The pattern portion **120** may include a bottom surface **120b** and an inclined surface **120s**.

[0143] The bottom surface **120b** of the pattern portion **120** according to an example embodiment is a surface formed to be closest to the substrate **110**, or may be disposed to be closer to the substrate **110** (or the upper surface of the substrate) than the pixel electrode **114** (or the lower surface of the pixel electrode **114**) in the light emission area EA. Therefore, as shown in FIG. 3, the bottom surface **120b** of the pattern portion **120** may be provided to have a depth equal to or similar to that of each of the plurality of concave portions **141**. However, when the depth of the pattern portion **120** is lower than that of the concave portion **141**, since an area of the reflective portion **130** is reduced, light extraction efficiency may be reduced. Therefore, in the display apparatus **100** according to an example embodiment of the present disclosure, the depth of the pattern portion **120** may be provided to be equal to or deeper than that of the concave portion **141**.

[0144] The inclined surface **120s** of the pattern portion **120** may be disposed between the bottom surface **120b** and the light extraction portion **140**. Therefore, the inclined surface **120s** of the pattern portion **120** may be provided to surround the light emission area EA or the plurality of concave portions **141**. As shown in FIG. 2, the inclined surface **120s** may be connected to the bottom surface **120b**. The inclined surface **120s** may form a predetermined angle with the bottom surface **120b**. For example, the angle formed by the inclined surface **120s** and the bottom surface **120b** may be an obtuse angle. Therefore, a width of the pattern portion **120** may be gradually reduced toward a direction (or the third direction (Z-axis direction)) from the opposing substrate **200** (or the reflective portion **130**) toward the substrate **110**. As the obtuse angle is formed by the inclined surface **120s** and the bottom surface **120b**, the light emitting element layer E (or the light emitting element layer E including the reflective portion **130**) including the second layer **1132**, the bank **115** and the reflective portion **130**, which are formed in a subsequent process, may be formed to be concave along the profile of the pattern portion **120**. Therefore, the light emitting element layer E may be formed to be concave on the pattern portion **120** formed to be concave in the non-light emission area NEA (or the peripheral area). The light emitting element layer E formed to be concave in the pattern portion **120** may mean that it includes at least one of the pixel electrode **114**, the light emitting layer **116** or the reflective electrode **117**.

[0145] As shown in FIG. 2, the pattern portion 120 may be provided to surround the light emission area EA. As the pattern portion 120 is provided to surround the light emission area EA, at least a portion of the reflective portion 130 disposed to be inclined on the pattern portion 120 may be provided to surround the light emission area EA. Therefore, in the display apparatus 100 according to an example embodiment of the present disclosure, since light may be extracted even from the non-light emission area NEA near the light emission area EA, overall light efficiency may be improved. Therefore, the display apparatus 100 according to an example embodiment of the present disclosure may have the same light emission efficiency or further enhanced light emission efficiency even with low power as compared with a general display apparatus having no pattern portion 120 and reflective portion 130, whereby overall power consumption may be reduced.

[0146] In addition, the display apparatus 100 according to an example embodiment of the present disclosure may allow the light emitting element layer E to emit light even with low power, thereby improving lifespan of the light emitting element layer E.

[0147] Since the pattern portion 120 is disposed to surround the light emission area EA, the pattern portion 120 may be disposed between the subpixels SP for emitting light of different colors. Therefore, the reflective portion 130 disposed to be inclined on the pattern portion 120 may be disposed between the subpixels SP for emitting light of different colors, whereby the reflective portion 130 may prevent light of different colors from being emitted to other adjacent subpixels SP. Therefore, the display apparatus 100 according to the present disclosure may prevent color mixture (or color distortion) from occurring between the subpixels SP for emitting light of different colors, thereby improving color purity.

[0148] The second layer 1132 of the overcoat layer 113 may be further extended from the light emission area EA to the non-light emission area NEA to partially cover the inclined surface 120s of the pattern portion 120. Therefore, as shown in FIG. 3, an end 1132c of the second layer 1132 may be in contact with the bottom surface 120b of the pattern portion 120. In this case, the end 1132c of the second layer 1132 may be in contact with only a portion of the bottom surface 120b. When the second layer 1132 entirely covers the bottom surface 120b, the depth of the reflective portion 130 formed on the pattern portion 120 may be relatively lowered, thereby reducing reflective efficiency. Therefore, in the display apparatus 100 according to an example embodiment of the present disclosure, the second layer 1132 is provided to be in contact with only a portion of the bottom surface 120b without entirely covering the bottom surface 120b of the pattern portion 120 and thus the reflective portion 130 formed in a subsequent process may be formed to be close to the bottom surface 120b, whereby reflective efficiency may be improved.

[0149] The bank 115 may be extended to cover the inclined surface 1132b of the second layer 1132 covering the inclined surface 120s of the pattern portion 120 while covering the edge of the pixel electrode 114. Therefore, the bank 115 may be in contact with a portion of the bottom surface 120b of the pattern portion 120, which is not covered by the second layer 1132. When the bank 115 entirely covers the bottom surface 120b, the depth of the reflective portion 130 formed on the pattern portion 120 is lowered, whereby

reflective efficiency may be reduced. Therefore, as shown in FIG. 3, each of the second layer 1132 and the bank 115 at or on the bottom surface 120b of the pattern portion 120 may be discontinuously provided. That is, each of the second layer 1132 and the bank 115 may be disconnected on the bottom surface 120b of the pattern portion 120. As a result, in the display apparatus 100 according to an example embodiment of the present disclosure, the bank 115 is provided to be in contact with only a portion of the bottom surface 120b without entirely covering the bottom surface 120b, so that the reflective portion 130 formed in a subsequent process may be formed to be close to the bottom surface 120b, whereby reflective efficiency may be improved.

[0150] Since the bank 115 is provided to be in contact with only a portion of the bottom surface 120b of the pattern portion 120, the bank 115 may be disconnected from the pattern portion 120 as shown in FIG. 2. As the bank 115 is disconnected from the pattern portion 120, the reflective portion 130 disposed on the second pattern line 122 may be disposed to be close to the bottom surface 120b of the pattern portion 120. Therefore, the reflective portion 130 may be formed as deep as possible in the pattern portion 120 as compared with the case that the bank is not disconnected from the pattern portion 120, and thus reflective efficiency may be improved. As shown in FIG. 2, since the pattern portion 120 is disposed between the subpixels SP, the second layer 1132, the bank 115, the light emitting layer 116 and the reflective portion 130 may be provided to be symmetrical based on the center of the pattern portion 120 (or the center of the second area A2).

[0151] In the display apparatus 100 according to an example embodiment of the present disclosure, the plurality of lines 150 may be disposed so as not to cover the light emission area EA (or so as not to overlap the light emission area EA). When the plurality of lines 150 overlap or cover the light emission area EA, the light reflected by the reflective portion 130 may be blocked by the plurality of lines 150 and thus cannot be emitted toward the substrate 110. Therefore, in the display apparatus 100 according to an example embodiment of the present disclosure, the plurality of lines 150 may be disposed in the non-light emission area NEA so as not to overlap the light emission area EA, whereby light extraction efficiency may be maximized. Furthermore, in the display apparatus 100 according to an example embodiment of the present disclosure, the plurality of lines 150 may be provided so as not to overlap the light emission area EA, whereby an aperture ratio may be enlarged as compared with the case that the plurality of lines overlap the light emission area, and thus luminance may be improved. Although the arrangement structure of the plurality of lines 150 in the first subpixel SP1 and the second subpixel SP2 has been described with reference to FIG. 2, the above described structure may be equally applied to the third subpixel SP3 and the fourth subpixel SP4. However, a line having a wide width, which is disposed among the first to fourth subpixels may be the reference line.

[0152] Meanwhile, as the bank 115 is disconnected from the pattern portion 120, the light emitting layer 116 and the reflective portion 130 (or the reflective electrode 117) formed in a subsequent process may be formed along a profile of the bottom surface 120b of the pattern portion 120 and the bank 115.

[0153] The reflective portion **130** according to an example may be formed to be concave on the pattern portion **120** along the profile of the pattern portion **120** formed to be concave in or near the non-light emission area NEA, thereby being formed to be concave in or near the non-light emission area NEA. The reflective portion **130** may be made of a material capable of reflecting light to reflect light, which is emitted from the light emission area EA and directed toward the subpixel SP adjacent thereto, toward the light emission area EA of the subpixel SP for emitting light. As shown in FIG. 2, the reflective portion **130** may include a flat surface **131** disposed at a central portion of the second area A2 and an inclined surface **132** connected to the flat surface **131**. The flat surface **131** may be disposed in parallel with the bottom surface **120b** (shown in FIG. 2) of the pattern portion **120**. The inclined surface **132** may be formed to be inclined along the profile of the inclined surface **120s** of the pattern portion **120**. Most of the light, which is directed toward the subpixel SP adjacent thereto among the light emitted from the subpixel SP for emitting light, may be reflected by the inclined surface **132** of the reflective portion **130** and then emitted to the light emission area EA of the subpixel SP for emitting light or the non-light emission area NEA of the subpixel SP for emitting light.

[0154] In the display apparatus **100** according to an example embodiment of the present disclosure, the inclination angle θ of the reflective portion **130** disposed to be inclined in the non-light emission area NEA may be optimized, whereby parasitic capacitance between the reflective portion **130** and the line **150** may be avoided and overall light efficiency (or light extraction efficiency) of the subpixel SP for emitting light may be improved. The inclination angle θ of the reflective portion **130** may be derived by an equation related to the maximum thickness T_H of the second layer **1132** and the thickness T_L of the first layer **1131** in the concave portion **141**.

[0155] For example, the inclination angle θ of the reflective portion disposed to be inclined on the pattern portion **120** may be provided to satisfy

$$\text{Taper Angle } (\theta) = \frac{180 \times \log \sqrt{0.11 \times T_L^2 + T_H^2}}{\pi}$$

[0156] T_H may be the maximum thickness of the second layer **1132** in each of the concave portions **141**, T_L may be the thickness of the first layer **1131** on an extension line of T_H and π may be a circular constant.

[0157] As shown in FIG. 3, T_H may be a value (or multiplied value) obtained by multiplying an aspect ratio AR of the concave portion **141** and a radius R of the concave portion **141**.

[0158] The radius R of the concave portion **141** according to an example may be a distance from a center C of the concave portion **141** on an extension line of a flat upper surface **1131a** of the first layer **1131** to the concave portion adjacent thereto.

[0159] The aspect ratio AR of the concave portion **141** according to an example is related to a shape of the concave portion **141**. For example, the aspect ratio AR of the concave portion **141** may be provided to exceed 0 and be 1 or less. That is, the aspect ratio AR of the concave portion **141** may be provided to satisfy an equation of $0 < AR \leq 1$. When the aspect ratio AR of the concave portion **141** is 1, the concave

portion **141** may have a complete hemispherical shape. When the aspect ratio AR of the concave portion **141** is 0, the concave portion **141** may have a flat shape. Therefore, the case that the aspect ratio AR of the concave portion **141** exceeds 0 and is 1 or less may mean that the concave portion **141** may have a complete hemispherical shape or a hemispherical shape between the complete hemispherical shape and a flat shape. For example, when the aspect ratio AR of the concave portion **141** is less than 1, the maximum thickness (or maximum depth) of the concave portion **141** in FIG. 3 may be smaller than the radius R. When the aspect ratio AR of the concave portion **141** is 1, the maximum thickness (or the maximum depth) of the concave portion **141** in FIG. 3 may be equal to the radius R.

[0160] Referring back to FIG. 3, T_L may be the thickness of the first layer **1131** on the extension line of T_H . That is, the thickness T_L of the first layer **1131** may be a distance from the upper surface **1131a** of the first layer **1131** at the maximum thickness T_H (or maximum depth) of the concave portion **141** to the upper surface of the color filter CF. Alternatively, the thickness T_L of the first layer **1131** may be the shortest distance of the first layer **1131** disposed below the concave portion **141**.

[0161] “ π ” is a circular constant, and may be about 3.14.

[0162] Meanwhile, in the display apparatus **100** according to an example embodiment of the present disclosure, a value obtained by adding the maximum thickness T_H of the second layer **1132** in the concave portion **141** and the thickness T_L of the first layer **1131** on the extension line of T_H may be 2 μm to 7 μm .

[0163] In addition, the radius R of each of the concave portions **141** or the thickness T_L of the first layer **1131** may be 1 μm or more. When the maximum value of the aspect ratio AR of the concave portion **141** is 1, the aspect ratio AR of the concave portion **141** is equal to the radius R of the concave portion **141**. Therefore, when the aspect ratio AR of the concave portion **141** is 1 and the radius R of the concave portion **141** is 1 μm , the maximum thickness T_H of the second layer **1132** may be 1 μm . In this case, the thickness T_L of the first layer **1131** on the extension line of T_H may be 1 μm or more. Therefore, a value obtained by summing the maximum thickness T_H of the second layer **1132** in the concave portion **141** and the thickness T_L of the first layer **1131** on the extension line of T_H may be 2 μm or more. The radius R of the concave portion **141** or the thickness T_L of the first layer **1131** cannot be formed to be less than 1 μm due to limitations in a process. This is because that the concave portion **141** is not formed in a photolithographic process and a pattern (or etching) or ashing process after the photolithographic process when the thickness of the first layer **1131** is less than 1 μm .

[0164] Therefore, in the display apparatus **100** according to an example embodiment of the present disclosure, as the radius R of each of the concave portions **141** or the thickness T_L of the first layer **1131** is provided to be 1 μm or more, the concave portion **141** for refracting light without limitation in a process may be formed on the first layer **1131**.

[0165] Meanwhile, when the sum of the maximum thickness T_H of the second layer **1132** in the concave portion **141** and the thickness T_L of the first layer **1131** on the extension line of T_H is less than 2 μm , the inclination angle θ of the reflective portion **130** is too low (or reduced), whereby reflectivity of the light directed toward the adjacent subpixel SP may be deteriorated.

[0166] The value obtained by summing the maximum thickness T_H of the second layer 1132 in the concave portion 141 and the thickness T_L of the first layer 1131 on the extension line of T_H may be $7\ \mu\text{m}$ or less by limitation in a process. The first layer 1131 or the second layer 1132 should be formed once more so that the sum of the maximum thickness T_H of the second layer 1132 in the concave portion 141 and the thickness T_L of the first layer 1131 on the extension line of T_H exceeds $7\ \mu\text{m}$. In this case, steps in the process may be increased, whereby a tact time and a manufacturing cost may be increased.

[0167] Therefore, in the display apparatus 100 according to an example embodiment of the present disclosure, the value obtained by summing the maximum thickness T_H of the second layer 1132 in the concave portion 141 and the thickness T_L of the first layer 1131 on the extension line of T_H may be $2\ \mu\text{m}$ to $7\ \mu\text{m}$, whereby reflectance of the light directed toward the adjacent subpixel SP may be prevented from being deteriorated, and the tact time and the manufacturing cost may be prevented from being increased.

[0168] Hereinafter, the aspect ratio AR of the concave portion 141 and the inclination angle θ of the reflective portion 130 are described in further detail with reference to FIGS. 4A and 4B.

[0169] FIG. 4A is a comparative example illustrating that an aspect ratio of a concave portion exceeds 1, and FIG. 4B is a view illustrating that an aspect ratio of a concave portion of a display apparatus according to an example embodiment of the present disclosure exceeds 0 and is less than 1.

[0170] As shown in FIG. 4A, when the aspect ratio AR of the concave portion 141 exceeds 1, the concave portion 141 may have a bell shape other than a complete hemispherical shape. That is, the maximum depth T_H of the concave portion 141 may be greater than the radius R of the concave portion 141.

[0171] Meanwhile, as shown in FIG. 4A, when light incident from a right side based on the center C of the concave portion 141 is emitted from the concave portion 141, the light may be emitted by being bent downward due to a difference in refractive index from the first layer. In case of FIG. 4A, since the concave portion 141 has a bell shape, an angle bent by the difference in refractive index may be greater in a downward direction. Therefore, as shown in FIG. 4A, when the aspect ratio AR of the concave portion 141 exceeds 1, a portion of the light emitted through the concave portion 141 may be emitted toward the adjacent subpixel without being reflected by the reflective portion 130 even though an inclination angle θ_1 of the reflective portion 130 is great. Therefore, in case of FIG. 4A, color mixture may be generated between the subpixel for emitting light and the adjacent subpixel.

[0172] On the contrary, in case of FIG. 4B, since the aspect ratio AR of the concave portion 141 exceeds 0 and is less than 1, the concave portion 141 may have a bowl shape having a wider width than the depth. That is, the maximum depth T_H of the concave portion 141 may be smaller than the radius R of the concave portion 141.

[0173] In this case, when light incident from the right side based on the center C of the concave portion 141 is emitted from the concave portion 141 as shown in FIG. 4B, the light may be emitted by being bent downward due to the difference in refractive index from the first layer. However, in case of FIG. 4B, since the concave portion 141 has a bowl shape, an angle bent due to the difference in refractive index may

not be greater than that of FIG. 4A even though the concave portion 141 moves downward. Therefore, as shown in FIG. 4B, when the aspect ratio AR of the concave portion 141 exceeds 0 and is less than 1, the light emitted through the concave portion 141 may be reflected by the reflective portion 130 and then emitted toward the subpixel for emitting light even though an inclination angle θ_2 of the reflective portion 130 is smaller than the inclination angle θ_1 of the reflective portion 130 of FIG. 4A. Therefore, in case of 4B, light extraction efficiency (or light efficiency) of the subpixel for emitting light may be improved without producing color mixture between the subpixel for emitting light and the adjacent subpixel.

[0174] As a result, in the display apparatus 100 according to an example embodiment of the present disclosure, the inclination angle of the reflective portion 130 may be proportional to the aspect ratio AR of each of the concave portions 141. Meanwhile, when the aspect ratio AR of the concave portion 141 is 0, the concave portion 141 is provided in a flat shape so that light is not refracted in a predetermined direction and thus light efficiency may be rather deteriorated. Therefore, in the display apparatus 100 according to an example embodiment of the present disclosure, the aspect ratio AR of the concave portion 141 may exceed 0 and be 1 or less, and thus the inclination angle of the reflective portion 130 may be 40° to 75° , proportionally. As a result, the display apparatus 100 according to an example embodiment of the present disclosure may improve light extraction efficiency (or light efficiency) of the subpixel for emitting light while preventing color mixture from occurring between the subpixel for emitting light and the adjacent subpixel.

[0175] FIG. 5 is a light efficiency map illustrating a refractive index of a concave portion with respect to an aspect ratio of the concave portion of a display apparatus according to an example embodiment of the present disclosure.

[0176] Referring to FIG. 5, a horizontal axis represents the aspect ratio AR of the concave portion 141, and a vertical axis represents the refractive index of the first layer 1131. FIG. 5 is a light efficiency map illustrating the refractive index of the first layer 1131 according to the aspect ratio AR of the concave portion 141 in a state that the refractive index of the second layer 1132 is fixed. For example, the inventors of a display apparatus of the present disclosure measured light efficiency while changing each of the aspect ratio AR of the concave portion 141 and the refractive index of the first layer 1131 in a state that the refractive index of the second layer 1132 is fixed to 1.63. As shown in FIG. 5, it can be seen that when the aspect ratio AR of the concave portion 141 is great and the refractive index of the first layer 1131 is low, a shade representing light efficiency becomes dark. It can be seen that light efficiency is increased to 1.0 or more as the shade becomes dark. As shown in FIG. 5, it can be seen that when the aspect ratio AR of the concave portion 141 is 1 and the refractive index of the first layer 1131 is 1.40, the shade is the darkest in the light efficiency map and light efficiency exceeds 1.026. Therefore, the display apparatus 100 according to an example embodiment of the present disclosure may maximize light extraction efficiency (or light efficiency) as the aspect ratio AR of the concave portion 141 is 1 and the difference in refractive index between the second layer 1132 and the first layer 1131 is 0.23 or more.

[0177] FIG. 6 is a graph illustrating light efficiency with respect to a refractive index of a first layer of a display apparatus according to an example embodiment of the present disclosure.

[0178] Referring to FIG. 6, a horizontal axis represents a refractive index n_{oc} of the first layer 1131, and a vertical axis represents a light efficiency η . In this case, LN1 represents light efficiency with respect to the refractive index n_{oc} of the first layer 1131 when the aspect ratio AR of the concave portion 141 is 1. When the aspect ratio AR of the concave portion 141 is 1, the concave portion 141 has a complete hemispherical shape, and the maximum depth T_H of the concave portion 141 and the radius of the concave portion 141 may be the same as each other. LN2 represents light efficiency for the refractive index n_{oc} of the first layer 1131 when the aspect ratio AR of the concave portion 141 is 0.5. As shown in FIG. 6, it can be seen that even though the refractive index n_{oc} of the first layer 1131 is increased, light efficiency of LN1 is higher than that of LN2. That is, it can be seen that the greater the aspect ratio of the concave portion 141 is, the higher light efficiency is. For example, as shown in FIG. 6, when the refractive index n_{oc} of the first layer 1131 is 1.4, since LN1 represents light efficiency of about 1.025 and LN2 represents light efficiency of about 0.983, it can be seen that light efficiency of LN1 is higher than that of LN2 as much as about 0.042. In addition, when the refractive index n_{oc} of the first layer 1131 is 1.5, since LN1 represents light efficiency of about 0.987 and LN2 represents light efficiency of about 0.972, it can be seen that light efficiency of LN1 is higher than that of LN2 as much as about 0.015.

[0179] However, as described above, when the aspect ratio AR of the concave portion 141 exceeds 1, the concave portion 141 may have a bell shape and the maximum depth T_H of the concave portion 141 may be greater than the radius R of the concave portion 141. In this case, even though the inclination angle θ_1 of the reflective portion 130 is great, a portion of the light emitted through the concave portion 141 may be emitted toward the adjacent subpixel without being reflected by the reflective portion 130, whereby color mixture may be generated between the subpixel for emitting light and the adjacent subpixel.

[0180] Therefore, in the display apparatus 100 according to an example embodiment of the present disclosure, the aspect ratio AR of the concave portion 141 is 1 and the difference in refractive index between the second layer 1132 and the first layer 1131 is 0.23 or more, whereby color mixture between the subpixel for emitting light and the adjacent subpixel may be avoided and light extraction efficiency (or light efficiency) may be maximized.

[0181] According to one or more aspects of the present disclosure, the following advantageous effects may be obtained.

[0182] In the display apparatus according to one or more example embodiments of the present disclosure, the reflective portion disposed in the non-light-emission area may be provided at an optimal angle, whereby light extraction efficiency in the non-light emission area may be improved and thus overall light efficiency may be improved.

[0183] In the display apparatus according to one or more example embodiments of the present disclosure, since the light may be extracted even from the non-light emission area, the display apparatus according to the present disclosure may have the same light emission efficiency or further

enhanced light emission efficiency even with low power as compared with the display apparatus having no reflective portion, whereby overall power consumption may be reduced.

[0184] In the display apparatus according to one or more example embodiments of the present disclosure, each of the plurality of subpixels includes the light extraction portion that includes the plurality of concave portions, so that light extraction efficiency of the light emitted from the light emitting element layer may be maximized.

[0185] It will be apparent to those skilled in the art that the present disclosure described above is not limited by the above-described embodiments and the accompanying drawings and that various substitutions, modifications and variations can be made in the present disclosure without departing from the spirit or scope of the disclosure. Consequently, the scope of the present disclosure is defined by the accompanying claims and it is intended that all variations or modifications derived from the meaning, scope and equivalent concept of the claims fall within the scope of the present disclosure.

What is claimed is:

1. A display apparatus, comprising:

- a substrate;
 - a plurality of pixels having a plurality of subpixels;
 - a pattern portion disposed on the substrate and formed to be concave between the plurality of subpixels; and
 - a reflective portion disposed to be inclined on the pattern portion,
- wherein:
- the plurality of subpixels include a first layer and a second layer;
 - the first layer is adjacent to the reflective portion on the substrate;
 - the first layer includes a plurality of concave portions;
 - the second layer is on the first layer; and
 - an inclination angle θ of the reflective portion is provided to satisfy

$$\text{Taper Angle } (\theta) = \frac{180 \times \log \sqrt{0.11 \times T_L^2 + T_H^2}}{\pi},$$

wherein the Taper Angle(θ) represents the inclination angle θ , T_H is a maximum thickness of the second layer in one of the plurality of concave portions, T_L is a thickness of the first layer on an extension line of the T_H , and π is a circular constant.

2. The display apparatus of claim 1, wherein the inclination angle θ of the reflective portion is a crossing angle between an upper surface of the substrate and the reflective portion on the pattern portion.

3. The display apparatus of claim 1, wherein the inclination angle θ of the reflective portion is 40° to 75°.

4. The display apparatus of claim 1, wherein the plurality of concave portions overlap a light emission area of the plurality of subpixels.

5. The display apparatus of claim 1, wherein the pattern portion surrounds a light emission area.

6. The display apparatus of claim 1, wherein the pattern portion is disposed to be spaced apart from a light emission area.

7. The display apparatus of claim 1, wherein a width of the pattern portion is reduced in a direction directed toward the substrate from the reflective portion.

8. The display apparatus of claim 1, further comprising a light emitting element layer in the plurality of subpixels, wherein the light emitting element layer includes:
a pixel electrode in a light emission area;
a light emitting layer on the pixel electrode and in a non-light emission area; and
a reflective electrode on the light emitting layer, and the reflective portion is a portion of the reflective electrode.

9. The display apparatus of claim 8, wherein the plurality of subpixels include the light emission area and the non-light emission area adjacent to the light emission area, the reflective electrode is disposed in the light emission area and the non-light emission area, and the inclination angle θ of the reflective portion is a crossing angle between an extension line of a lower surface of the reflective electrode in the light emission area and the reflective portion arranged in the non-light emission area.

10. The display apparatus of claim 1, wherein a value obtained by summing the T_H and the T_L is $2\ \mu\text{m}$ to $7\ \mu\text{m}$.

11. The display apparatus of claim 1, wherein a radius of each of the plurality of concave portions or the T_L is $1\ \mu\text{m}$ or more.

12. The display apparatus of claim 1, wherein the inclination angle θ of the reflective portion is proportional to an aspect ratio of each of the plurality of the concave portions.

13. The display apparatus of claim 1, wherein the T_H is a value obtained by multiplying an aspect ratio of one of the plurality of concave portions and a radius of the one of the plurality of concave portions.

14. The display apparatus of claim 13, wherein an aspect ratio of each of the plurality of concave portions exceeds 0 and is 1 or less.

15. The display apparatus of claim 9, wherein the non-light emission area includes a first area adjacent to the light emission area and a second area adjacent to the first area and spaced apart from the light emission area,

the plurality of concave portions are disposed to be adjacent to the pattern portion,

the pattern portion includes an inclined surface and a bottom surface,

the inclined surface is formed in the first area, and

the bottom surface extends from the inclined surface to the second area.

16. The display apparatus of claim 15, wherein the second layer is disposed between the first layer and the pixel electrode, and

the second layer extends to the first area and is in contact with a portion of the bottom surface of the pattern portion while covering the inclined surface of the pattern portion.

17. The display apparatus of claim 15, wherein the inclined surface of the pattern portion forms an obtuse angle with respect to the bottom surface.

18. The display apparatus of claim 16, further comprising a bank covering an edge of the pixel electrode,

wherein the bank covers the second layer covering the inclined surface and is in contact with a portion of the bottom surface of the pattern portion.

19. The display apparatus of claim 18, wherein each of the second layer and the bank at the bottom surface of the pattern portion is discontinuous.

20. A display apparatus, comprising:

a substrate;

a plurality of pixels having a plurality of subpixels;

a pattern portion disposed on the substrate and formed to be concave between the plurality of subpixels; and

a reflective portion disposed to be inclined on the pattern portion,

wherein:

the plurality of subpixels include a first layer and a second layer;

the first layer is adjacent to the reflective portion on the substrate;

the first layer includes a plurality of concave portions;

the second layer is on the first layer; and

an inclination angle of the reflective portion is proportional to a maximum thickness of the second layer and a thickness of the first layer in one of the plurality of concave portions.

21. The display apparatus of claim 20, wherein the inclination angle of the reflective portion is provided to satisfy

$$\text{Taper Angle } (\theta) = \frac{180 \times \log \sqrt{0.11 \times T_L^2 + T_H^2}}{\pi},$$

wherein the Taper Angle(θ) represents the inclination angle, T_H is the maximum thickness of the second layer in the one of the plurality of concave portions, T_L is the thickness of the first layer on an extension line of the T_H , and π is a circular constant.

22. The display apparatus of claim 21, wherein the plurality of subpixels include a light emission area, a non-light emission area adjacent to the light emission area, and a reflective electrode arranged in the light emission area and the non-light emission area, and

wherein the reflective portion is a portion of the reflective electrode.

23. The display apparatus of claim 22, wherein the inclination angle of the reflective portion is an inclination angle between the reflective portion disposed in the non-light emission area and an extension line of a lower surface of the reflective electrode in the light emission area.

24. The display apparatus of claim 22, wherein the non-light emission area includes a first area adjacent to the light emission area and a second area adjacent to the first area and spaced apart from the light emission area,

the plurality of concave portions are disposed to be adjacent to the pattern portion,

the pattern portion includes an inclined surface and a bottom surface,

the inclined surface is formed in the first area, and

the bottom surface extends from the inclined surface to the second area.

25. The display apparatus of claim 24, wherein the second layer is disposed between the first layer and the reflective electrode, and

the second layer is extended to the first area and is in contact with a portion of the bottom surface of the pattern portion while covering the inclined surface of the pattern portion.

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