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FLAT BONDING METHOD OF LIGHT EMITTING DEVICE AND FLAT BONDER FOR LIGHT EMITTING DEVICE

Abstract

A flat bonding method of light emitting devices including bonding light emitting devices on a circuit board using a reflow process, and re-bonding at least a portion of the light emitting devices bonded on the circuit board using a press plate while pressing the portion of the light emitting devices.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATION [0001] This application is a continuation of and claims benefit under 35 U.S.C. § 120 to U.S. application Ser. No. 18/514,969 filed Nov. 20, 2023, which is a continuation of and claims benefit under 35 U.S.C. § 120 to U.S. application Ser. No. 17/133,657 filed Dec. 24, 2020 (now U.S. Pat. No. 11,848,398 issued Dec. 19, 2023), and claims the benefit of U.S. Provisional Application No. 62/954,609 filed Dec. 29, 2019, the entire contents of each of which are incorporated herein by reference.

BACKGROUND
Field
[0002] Exemplary embodiments of the invention relate generally to a bonding method of light emitting devices and a bonder, and more particularly, to a flat bonding method of light emitting devices and a flat bonder for light emitting devices.
Discussion of the Background
[0003] As an inorganic light source, light emitting diodes have been used in various fields including displays, vehicular lamps, general lighting, and the like. With various advantages of light emitting diodes over conventional light sources, such as longer lifespan, lower power consumption, and rapid response, light emitting diodes have been replacing conventional light sources.
[0004] Light emitting diodes have been generally used as backlight light sources in display apparatuses. However, LED display apparatuses that directly display implement an image using small-sized light emitting diodes have been recently developed.
[0005] In general, a display apparatus realizes various colors through mixture of blue, green, and red light. In order to display various images, the display apparatus includes a plurality of pixels each including sub-pixels corresponding to blue, green, and red light, respectively. In this manner, a color of a certain pixel is determined based on the colors of the sub-pixels so that images can be displayed through combination of such pixels.
[0006] LE Ds can emit light of various colors depending on their materials, and a display apparatus may be provided by arranging individual light emitting diodes emitting blue, green, and red on a two-dimensional plane, or by arranging light emitting diodes having a stacked structure, in which a blue LED, a green LED, and a red LED are stacked one above another, on a two-dimensional plane.
[0007] The number of light emitting diodes used in one display apparatus is usually more than 100,000, or more than one million even for a small-sized display. When bonding such a large number of light emitting devices to a circuit board, it is difficult to flatten upper surfaces of the light emitting devices, and accordingly, color irregularities are likely to occur on an image. More particularly, the upper surfaces of the bonded light emitting devices may be inclined when an amount of solder used to bond the light emitting devices are not precisely controlled, or due to a temperature difference for each solder location. As such, directions of light emitted from the light emitting devices may be changed, thereby causing color irregularities.
[0008] When the number of light emitting devices with the inclined upper surfaces is large, it is very difficult to individually repair them.
[0009] The above information disclosed in this Background section is only for understanding of the background of the inventive concepts, and, therefore, it may contain information that does not

constitute prior art.

SUMMARY

[0010] Flat bonders and flat bonding methods of light emitting devices according to exemplary embodiments of the invention are capable of evenly forming upper surfaces of light emitting devices.

[0011] Exemplary embodiments also provide a flat bonding method of light emitting devices capable of easily repairing light emitting devices having inclined upper surfaces and a flat bonder for light emitting devices having the same.

[0012] Additional features of the inventive concepts will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the inventive concepts.

[0013] A flat bonding method of light emitting devices according to an exemplary embodiment includes bonding light emitting devices on a circuit board using a reflow process, and re-bonding at least a portion of the light emitting devices bonded on the circuit board using a press plate while pressing the portion of the light emitting devices.

[0014] A direction of upper surfaces of the light emitting devices may be changed by the press plate while re-bonding.

[0015] The press plate may cover a plurality of light emitting devices disposed on the circuit board.

[0016] The light emitting devices on the circuit board may be re-bonded by moving the press plate in a stepper manner.

[0017] The flat bonding method may further include inspecting a bonding state of the light emitting devices on the circuit board to detect bonding failures before re-bonding, in which only the light emitting devices having the bonding failures may be re-bonded while being pressed using the press plate.

[0018] The light emitting devices may be self-arranged during the reflow process.

[0019] Each of the light emitting devices may include a substrate.

[0020] A metal bonding layer may be formed between the circuit board and the light emitting devices by the reflow process, and at least a portion of the metal bonding layer may be melted during the re-bonding process.

[0021] The press plate may apply heat to the light emitting devices to melt at least the portion of the metal bonding layer.

[0022] A display panel according to another exemplary embodiment includes a circuit board facing a first direction and including pads, light emitting devices mounted on the circuit board and including a substrate, and metal bonding layers bonding the pads to the light emitting devices, in which the substrate is disposed on an opposite side of the circuit board and is configured to transmit light generated by the light emitting device, and an angular difference between a planar direction of an upper surface of the light emitting device and the first direction is less than 5 degrees in at least 50% of the light emitting devices.

[0023] The angular difference may be less than 5 degrees in at least 95% of the light emitting devices.

[0024] A difference between an elevation of the highest upper surface and that of a next highest upper surface among the upper surfaces of the light emitting devices may be less than 1 μm.

[0025] A deviation in elevations of upper surfaces of the light emitting devices may be in a range of about 2 μm in at least 50% of the light emitting devices.

[0026] The deviation may be in a range of about 2 μm in at least 90% of the light emitting devices.

[0027] The metal bonding layers may protrude outside of the ends of the light emitting devices.

[0028] A flat bonder for light emitting devices according to yet another exemplary embodiment includes a stage to mount a circuit board to which the light emitting devices are bonded, a header disposed over the stage, and a press plate mounted on the header and configured to press the light emitting devices against the stage, in which the flat bonder is configured to change a planar

direction of upper surfaces of the light emitting devices bonded on the circuit board by a reflow process.
[0029] The stage may have movable in the lateral direction in a stepper manner.
[0030] The header may be configured to move the press plate upwards and downwards.
[0031] The stage and the press plate may include a heating device, respectively.
[0032] The flat bonder may further include a chamber accommodating the stage, the header, and the press plate, in which the chamber may have an N.sub.2 gas atmosphere.
[0033] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0034] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate exemplary embodiments of the invention, and together with the description serve to explain the inventive concepts.
[0035] FIG. **1** is a schematic plan view of a display panel according to an exemplary embodiment.
[0036] FIG. **2** is an enlarged schematic partial cross-sectional view taken along line A-A′ of FIG. **1**.
[0037] FIGS. **3**, **4**, **5**, **6**, and **7** are schematic cross-sectional views and a schematic plan view illustrating a bonding method of light emitting devices according to an exemplary embodiment.
[0038] FIG. **8** is a schematic cross-sectional view of a flat bonder for light emitting devices according to an exemplary embodiment.
[0039] FIG. **9**A is an image of a display panel manufactured according to a conventional bonding method of light emitting devices.
[0040] FIG. **9**B is an image illustrating a display panel manufactured according to an exemplary embodiment.
DETAILED DESCRIPTION
[0041] In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of various exemplary embodiments or implementations of the invention. As used herein “embodiments” and “implementations” are interchangeable words that are non-limiting examples of devices or methods employing one or more of the inventive concepts disclosed herein. It is apparent, however, that various exemplary embodiments may be practiced without these specific details or with one or more equivalent arrangements. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring various exemplary embodiments. Further, various exemplary embodiments may be different, but do not have to be exclusive. For example, specific shapes, configurations, and characteristics of an exemplary embodiment may be used or implemented in another exemplary embodiment without departing from the inventive concepts.
[0042] Unless otherwise specified, the illustrated exemplary embodiments are to be understood as providing exemplary features of varying detail of some ways in which the inventive concepts may be implemented in practice. Therefore, unless otherwise specified, the features, components, modules, layers, films, panels, regions, and/or aspects, etc. (hereinafter individually or collectively referred to as “elements”), of the various embodiments may be otherwise combined, separated, interchanged, and/or rearranged without departing from the inventive concepts.
[0043] The use of cross-hatching and/or shading in the accompanying drawings is generally provided to clarify boundaries between adjacent elements. As such, neither the presence nor the absence of cross-hatching or shading conveys or indicates any preference or requirement for

particular materials, material properties, dimensions, proportions, commonalities between illustrated elements, and/or any other characteristic, attribute, property, etc., of the elements, unless specified. Further, in the accompanying drawings, the size and relative sizes of elements may be exaggerated for clarity and/or descriptive purposes. When an exemplary embodiment may be implemented differently, a specific process order may be performed differently from the described order. For example, two consecutively described processes may be performed substantially at the same time or performed in an order opposite to the described order. Also, like reference numerals denote like elements.

[0044] When an element, such as a layer, is referred to as being “on,” “connected to,” or “coupled to” another element or layer, it may be directly on, connected to, or coupled to the other element or layer or intervening elements or layers may be present. When, however, an element or layer is referred to as being “directly on,” “directly connected to,” or “directly coupled to” another element or layer, there are no intervening elements or layers present. To this end, the term “connected” may refer to physical, electrical, and/or fluid connection, with or without intervening elements. Further, the D1-axis, the D2-axis, and the D 3-axis are not limited to three axes of a rectangular coordinate system, such as the x, y, and z-axes, and may be interpreted in a broader sense. For example, the D1-axis, the D2-axis, and the D3-axis may be perpendicular to one another, or may represent different directions that are not perpendicular to one another. For the purposes of this disclosure, “at least one of X, Y, and Z” and “at least one selected from the group consisting of X, Y, and Z” may be construed as X only, Y only, Z only, or any combination of two or more of X, Y, and Z, such as, for instance, XYZ, XYY, Y Z, and ZZ. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

[0045] Although the terms “first,” “second,” etc. may be used herein to describe various types of elements, these elements should not be limited by these terms. These terms are used to distinguish one element from another element. Thus, a first element discussed below could be termed a second element without departing from the teachings of the disclosure.

[0046] Spatially relative terms, such as “beneath,” “below,” “under,” “lower,” “above,” “upper,” “over,” “higher,” “side” (e.g., as in “sidewall”), and the like, may be used herein for descriptive purposes, and, thereby, to describe one elements relationship to another element(s) as illustrated in the drawings. Spatially relative terms are intended to encompass different orientations of an apparatus in use, operation, and/or manufacture in addition to the orientation depicted in the drawings. For example, if the apparatus in the drawings is turned over, elements described as “below” or “beneath” other elements or features would then be oriented “above” the other elements or features. Thus, the exemplary term “below” can encompass both an orientation of above and below. Furthermore, the apparatus may be otherwise oriented (e.g., rotated **90** degrees or at other orientations), and, as such, the spatially relative descriptors used herein interpreted accordingly.

[0047] The terminology used herein is for the purpose of describing particular embodiments and is not intended to be limiting. As used herein, the singular forms, “a,” “an,” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. Moreover, the terms “comprises,” “comprising,” “includes,” and/or “including,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, components, and/or groups thereof, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. It is also noted that, as used herein, the terms “substantially,” “about,” and other similar terms, are used as terms of approximation and not as terms of degree, and, as such, are utilized to account for inherent deviations in measured, calculated, and/or provided values that would be recognized by one of ordinary skill in the art.

[0048] Various exemplary embodiments are described herein with reference to sectional and/or exploded illustrations that are schematic illustrations of idealized exemplary embodiments and/or intermediate structures. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, exemplary embodiments disclosed herein should not necessarily be construed as limited to the particular illustrated shapes of regions, but are to include deviations in shapes that result from, for instance, manufacturing. In this manner, regions illustrated in the drawings may be schematic in nature and the shapes of these regions may not reflect actual shapes of regions of a device and, as such, are not necessarily intended to be limiting.

[0049] Unless otherwise defined, all 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 this disclosure is a part. Terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is 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 so defined herein.

[0050] Hereinafter, exemplary embodiments of the inventive concepts will be described in detail with reference to the accompanying drawings.

[0051] FIG. **1** is a schematic plan view of a display panel **1000** according to an exemplary embodiment, and FIG. **2** is an enlarged schematic partial cross-sectional view taken along line A-A′ of FIG. **1**.

[0052] A light emitting device **100** according to an exemplary embodiment may be used in a digital display apparatus, such as signage, and may also be used in a VR display apparatus such as a smart watch, a VR headset, or an AR display apparatus such as augmented reality glasses. However, the inventive concepts are not limited thereto, and may be used in various display devices. The display panel **1000** for displaying an image is mounted in the display apparatus.

[0053] Referring to FIGS. **1** and **2**, the display panel **1000** includes a circuit board **110** and the light emitting devices **100**. As used herein, the light emitting device **100** may be a small-sized LED. For example, the light emitting device **100** may have a size less than 500 μm×500 μm, and further, less than 200 μm×200 μm. In some exemplary embodiments, the light emitting device **100** may have a size of 100 μm×100 μm or 80 μm×120 μm. However, the inventive concepts are not limited to a particular size of the light emitting device **100**.

[0054] The circuit board **110** may include a circuit for passive matrix driving or active matrix driving. In an exemplary embodiment, the circuit board **110** may include interconnection lines and resistors therein. In another exemplary embodiment, the circuit board **110** may include interconnection lines, transistors, and capacitors. The circuit board **110** may also have pads disposed on an upper surface thereof to allow electrical connection to the circuit therein.

[0055] A plurality of light emitting devices **100** is arranged on the circuit board **110**. In an exemplary embodiment, an interval between the light emitting devices **100** may be greater than a width of at least one light emitting device **100**. However, the inventive concepts are not limited thereto, and the interval between the light emitting devices **100** may be less than or equal to the width of one light emitting device **100** in other exemplary embodiments.

[0056] In an exemplary embodiment, the light emitting devices **100** may be sub-pixels that emit light of a specific color, and these sub-pixels may form one pixel. For example, a blue LED, a green LED, and a red LED may be disposed adjacent to one another to form one pixel. However, the inventive concepts are not limited thereto. In some exemplary embodiments, each of the light emitting devices **100** may have a stacked structure emitting light of various colors. For example, each of the light emitting devices **100** may have a structure in which a blue LED, a green LED, and a red LED are stacked to overlap one another, and thus, one light emitting device **100** may form one pixel.

[0057] In an exemplary embodiment, each of the light emitting devices **100** may include a substrate **101** and a light emitting structure **103**. The substrate **101** may have a flat upper surface. The substrate **101** may be transparent and transmit light generated from the light emitting structure **103**. The substrate **101** may be, for example, a sapphire substrate, a SiC substrate, or a GaN substrate. In an exemplary embodiment, the substrate **101** may be a growth substrate for growing an epitaxial layer that forms the light emitting structure **103**.

[0058] The light emitting structure **103** may include an LED including a first conductivity type semiconductor layer, a second conductivity type semiconductor layer, and an active layer interposed therebetween. Furthermore, the light emitting structure **103** may have a stacked structure, in which a plurality of LEDs is stacked.

[0059] The light emitting device **100** may have two or more pads **105**. When the light emitting device **100** includes a single active layer, the light emitting device **100** may have two pads **105**. In another exemplary embodiment, when the light emitting device **100** has a structure in which a plurality of LEDs is stacked, the number of pads **105** may be more than two. For example, when the light emitting device **100** has a stacked structure including three active layers, the light emitting device **100** may have at least four pads **105**.

[0060] The pads **105** may be adhered to corresponding pads **115** of the circuit board **110** through bonding layers **120**. The bonding layer **120** may include, for example, a bonding material, such as AuSn, CuSn, In, or the like.

[0061] In the illustrated exemplary embodiment, upper surfaces of the light emitting devices **100**, that is, an upper surface of the substrate **101** may have substantially the same planar directions P**1** and P**2**. For example, in the display panel **1000**, a maximum angular difference between planar directions defined by upper surfaces of the light emitting device **100** may be less than 10 degrees in 50% or more, further, 70% or more, furthermore, 90% or more of the light emitting devices **100**. For example, when a planar direction of the circuit board **110** is defined as a reference planar direction Pr, an angular difference between a planar direction defined by an upper surface of the light emitting device **100** and the reference planar direction Pr may be less than 5 degrees in 50% or more, further, 70% or more, furthermore, 90% or more of the light emitting devices **100**. A light emitting device having a planar direction that deviates more than 5 degrees from the reference planar direction Pr may have severe color irregularities on a display screen.

[0062] In addition, among the upper surfaces of the light emitting devices **100**, an angular difference between a planar direction defined by the upper surface disposed at the highest elevation and the reference planar direction Pr may be 5 degrees or less.

[0063] The upper surfaces of the light emitting devices **100** may be placed at substantially the same elevation. For example, a difference (or deviation) in elevation between the upper surfaces of the light emitting devices **100** may be in a range of about 2 μm in 50% or more, further, 70% or more, further, 90% or more of the light emitting devices 100. As used herein, the elevation of the upper surface refers to an elevation of a highest portion of the upper surface of each light emitting device **100**. In particular, a difference between the upper surface having the highest elevation and the upper surface having the next highest elevation among the upper surfaces of the light emitting devices **100** may be 1 μm or less. A difference between the elevations of the upper surfaces and the elevation of the highest upper surface may not exceed about 2 μm in 50% or more, further, 70% or more, further, 90% or more of the light emitting devices **100**.

[0064] According to the illustrated exemplary embodiment, the upper surfaces of the light emitting devices **100** may be substantially parallel with an upper surface of the circuit board **110**. As such, the display panel **1000** may prevent color irregularities. Moreover, since the upper surfaces of the light emitting devices **100** are placed at substantially the same elevation from each other, the display panel **1000** may further prevent color irregularities.

[0065] FIGS. **3**, **4**, **5**, **6**, and **7** are schematic cross-sectional views and a schematic plan view illustrating a bonding method of light emitting devices according to an exemplary embodiment.

[0066] Referring to FIG. **3**, a circuit board **110** having pads **115** is provided. The circuit board **110** has circuits therein, and the pads **115** are connected to the circuits in the circuit board **110**. The pads **115** are disposed in each region of the circuit board **110** where the light emitting devices **100** are to be mounted to mount a plurality of light emitting devices **100**. The pads **115** may be formed of a metal layer including Au. For example, the pads **115** may have a multilayer structure of Cu/Ni/Au.

Furthermore, the pads **115** may include a barrier layer for preventing solder diffusion. The barrier layer may include at least one metal among Ni, Cr, Ti, Ta, Mo, and W.

[0067] In the illustrated exemplary embodiment, the pads **115** are illustrated as protruding on the surface of the circuit board **110**, but the inventive concepts are not limited thereto. In some exemplary embodiments, the pads **115** may be exposed within a region surrounded by a surface layer of the circuit board **110**, and thus, the regions of the pads **115** may be recessed.

[0068] A bonding material layer **121** is provided on the pads **115**. The bonding material layer **123** may include AuSn, CuSn, or In. The bonding material layer **123** may also include flux. The bonding material layer **121** may be formed by a dispensing method to release a solder paste, or may be formed by printing a solder paste using a screen printing technique such as a stencil. Screen printing technology may facilitate forming the bonding material layers **121** on a large number of pads **115**. However, the amount of bonding material layers **121** disposed on the pads **115** may generally be different from each other, because it is generally very difficult to dispose the exact same amount of bonding material layers **121** on the pads **115** due to the size of the pads **115** and the method of forming the bonding material layer **121**.

[0069] Referring to FIG. **4**, the light emitting devices **100** may be surface-mounted on the circuit board **110**. The light emitting devices **100** may be mounted individually or in a group on the circuit board **110**. Each of the pads **105** of the light emitting devices **100** may be disposed on the bonding material layer **121** on the circuit board **110**. For example, the light emitting devices **100** may be arranged on a temporary substrate and then be individually disposed on the circuit board **110** using a pickup and placing device.

[0070] Referring to FIG. **5**, the light emitting devices **100** are bonded to the circuit board **110** through a reflow process. The bonding material layers **121** may carry out eutectic bonding by the reflow process, and thus, a metal bonding layer **120***a* may be formed. Flux in the bonding material layers **121** may be removed by heat during an initial heating step of the reflow process.

[0071] In the illustrated exemplary embodiment, the reflow process may be carried out using a reflow soldering machine, and a heat source such as hot air infrared rays or a laser beam may be used to heat the bonding material layer **121**. In addition, the process may be carried out in an N.sub.2 atmosphere, and after the bonding is carried out, the elevated temperature may be cooled down using N.sub.2. In this case, a peak temperature may be adjusted depending on a type of solder.

[0072] After the light emitting devices **100** are arranged on the circuit board **110**, the light emitting devices **100** may be freely placed without being constrained by elements other than solder. In this case, locations of the light emitting devices **100** may be changed as the bonding material layer **121** is melted, however, the light emitting devices **100** may be self-arranged on the pads **115** of the circuit board **110** by a surface tension of the bonding material layer **121**. When there are elements that restrict a change in locations of the light emitting devices **100**, such as a support substrate, self-arrangement of the light emitting devices **100** may be constrained. However, in the illustrated exemplary embodiment, since a change of locations of the light emitting devices **100** are not constrained by other elements, the locations thereof may be determined using self-arrangement.

[0073] Meanwhile, since the amount of the bonding material layers **121** disposed on the pads **115** are different from each other, the upper surfaces of the light emitting devices **100**, that is, the upper surface of the substrate **101** may be inclined. Inclination of the upper surface of the substrate **101** may be caused by various factors, such as uneven heating and an initial location of the light emitting device **100**, as well as the bonding material layer **121**.

[0074] A conventional manufacturing process of the display panel is completed when the light emitting devices **100** bonded by the reflow process. In this case, however, a plurality of light emitting devices **100** may be bonded to the display panel while being inclined, which may cause defects on a display image.

[0075] In the illustrated exemplary embodiment, the light emitting devices **100** are bonded to the circuit board **110** by carrying out the reflow process, and re-bonding is carried out to restore the light emitting devices **100** having the inclined upper surfaces to a normal location. This will be described in more detail with reference to FIG. **6**.

[0076] Referring to FIG. **6**, as described with reference to FIG. **5**, a press plate **210** is placed on the light emitting devices **100** on which the reflow process has been carried out. The press plate **210** may be attached to a header **230**, and the header **230** may push the press plate **210** downward and press the light emitting devices **100** against the circuit board **110**.

[0077] The press plate **210** may have a width that covers at least two light emitting devices **100**. The press plate **210** may be disposed to cover the adjacent light emitting devices **100**. A shape of the press plate **210** is not particularly limited as long as the upper surfaces of the plurality of light emitting devices **100** can be placed in parallel with the upper surface of the circuit board **110**. In an exemplary embodiment, the press plate **210** may have a flat lower surface, and the flat lower surface may press the upper surfaces of the light emitting devices **100**. In another exemplary embodiment, pins disposed at narrow intervals may be provided on the lower surface of the press plate **210**. A plurality of pins may be placed on one light emitting device **100**, and thus, the inclined light emitting device **100** may be changed to the normal position. In another exemplary embodiment, the press plate **210** may have a lower surface divided into a plurality of flat regions.

[0078] The press plate **210** may also include a heating device to apply heat to the light emitting devices **100**. For example, a resistor may be embedded in the press plate **210** to heat the lower surface of the press plate **210**, and the light emitting devices **100** may be heated through the lower surface of the press plate **210**.

[0079] Heat may also be applied to the lower surface of the circuit board **110**. As such, the metal bonding layer **120***a* formed by the reflow process may be melted again at least locally. As the light emitting devices **100** are pressed by the press plate **210** while the metal bonding layer **120***a*, directions of the upper surfaces of the light emitting devices **100** may be changed. In particular, as the lower surface of the press plate **210** may be placed to be in parallel with the upper surface of the circuit board **110**, the directions of the upper surfaces of the light emitting devices **100** pressed by the press plate **210** may be changed in a direction parallel with the upper surface of the circuit board **110**.

[0080] The metal bonding layer **120** is formed by cooling the melted metal bonding layer **120***a* after changing the directions of the upper surfaces of the light emitting devices **100**. The metal bonding layers **120** bonding the light emitting devices **100** pressed by the press plate **210** may have a different structure than the metal bonding layers **120***a* formed by the reflow process. In particular, as the press plate **210** is pressed, the metal bonding layer **120** may escape to the outside of the pad **115** rather than the metal bonding layer **120***a*.

[0081] Meanwhile, a size of the press plate **210** may be smaller than a size of the circuit board **110**. As such, the process of changing inclination angles of the light emitting devices **100** using the press plate **210** may be carried out several times.

[0082] Referring to FIG. **7**, when the re-bonding process is completed for a portion of the light emitting devices **100** on the circuit board **110** using the press plate **210**, the press plate **210** may be moved to re-bond other light emitting devices **100**.

[0083] In an exemplary embodiment, the press plate **210** may re-bond each of the light emitting devices **100** on the circuit board **110** in a stepper manner. The press plate **210** may be moved while being completely separated from the light emitting devices **100** on which the re-bonding has been carried out, and may be arranged on the other light emitting devices **100**, but the inventive concepts are not limited thereto. For example, in some exemplary embodiments, the press plate **210** may be arranged to cover the portion of the light emitting devices **100** on which re-bonding has been carried out and the light emitting devices **100** on which re-bonding has not been carried out, and thereafter, re-bonding may be carried out.

[0084] In another exemplary embodiment, after the reflow process described with reference to FIG.

5 is completed, an inspection may be carried out in advance using a camera or the like to check whether bonding of the light emitting devices **100** on the circuit board **110** has failed. As such, the re-bonding process using the plate **210** may be limitedly carried out on the light emitting devices **100** having bonding failures.

[0085] According to the illustrated exemplary embodiments, the directions of the upper surfaces of the light emitting devices **100** disposed on the circuit board **110** may be changed to substantially match the direction of the circuit board **110**. Further, according to the illustrated exemplary embodiments, since the light emitting devices are re-bonded after the light emitting devices are self-arranged using the reflow process, the light emitting devices **100** may be disposed at a desired location on the circuit board **110** and the directions of the upper surfaces of the light emitting devices **100** may be arranged in a direction suitable for the display.

[0086] FIG. **8** is a schematic cross-sectional view illustrating a flat bonder for light emitting devices according to an exemplary embodiment.

[0087] Referring to FIG. **8**, the flat bonder for light emitting devices may include a stage **310**, a press plate **210**, a header **230**, and a chamber **500**.

[0088] The stage **310** may provide an area to which light emitting devices **100** bonded on a circuit board **110** by a reflow process can be mounted, and may be movable in the lateral directions. The stage **310** may also be movable in the vertical direction. The stage **310** may be moved in the lateral direction in a stepper manner, such that the light emitting devices **100** to be re-bonded may be placed under the press plate **210** in the stepper manner.

[0089] The stage **310** may have a heating device, and a metal bonding layer **120***a* formed by a reflow process may be heated using the heating device.

[0090] The header **230** may move upward and downward to press the press plate **210** towards the light emitting devices **100**. The header **230** may control an elevation of the press plate **210** with a tolerance, for example, within about 1 μm. As such, a difference between an elevation of the highest upper surface and that of the next highest upper surface among upper surfaces of the light emitting devices on the circuit board **110** may be 1 μm or less.

[0091] The press plate **210** may change directions of the upper surfaces of the light emitting devices **100** while contacting the light emitting devices **100**. The press plate **210** may have a width that covers at least two light emitting devices **100**. For example, the press plate **210** may have an area of 3 mm×3 mm or more. In an exemplary embodiment, the press plate **210** may have a flat lower surface, and the flat lower surface may press the upper surfaces of the light emitting devices **100**. In another exemplary embodiment, pins disposed at narrow intervals may be provided on the lower surface of the press plate **210**. In still another exemplary embodiment, the press plate **210** may have a lower surface divided into a plurality of flat regions. The press plate **210** may also include a heating device.

[0092] The press plate **210**, the header **230**, and the stage **310** may be disposed in the chamber **500**. An interior of the chamber **500** may be set to be an inert gas atmosphere, for example, an N.sub.2 atmosphere. Furthermore, a heating device capable of heating the interior of the chamber **500** may be mounted inside the chamber **500**.

[0093] FIG. **9**A is an image illustrating a display panel manufactured according to a conventional bonding method of light emitting devices, and FIG. **9**B is an image illustrating a display panel manufactured according to an exemplary embodiment. Light was irradiated in a direction perpendicular to a circuit board, and upper surfaces of the light emitting devices were photographed with a camera.

[0094] Referring to FIG. **9**A, among the light emitting devices bonded on the circuit board by a reflow process, about 50% or more of the light emitting devices were observed to have dark upper surfaces. However, referring to FIG. **9**B, the upper surfaces of the light emitting devices that were bonded on the circuit board by the reflow process and then subjected to a re-bonding process were generally observed bright. As such, it can be seen that the upper surfaces of the light emitting

devices are changed evenly by re-bonding, and thus, the directions of the upper surfaces thereof are changed to be substantially parallel with that of the circuit board.
[0095] According to exemplary embodiments, directions of upper surfaces of the light emitting devices may be set uniform to substantially match a direction of an upper surface of the circuit board, thereby preventing occurrence of color defects.
[0096] A Ithough certain exemplary embodiments and implementations have been described herein, other embodiments and modifications will be apparent from this description. Accordingly, the inventive concepts are not limited to such embodiments, but rather to the broader scope of the appended claims and various obvious modifications and equivalent arrangements as would be apparent to a person of ordinary skill in the art.

Claims

1. A light emitting apparatus, comprising: a circuit board extending in a planar direction and including a plurality of pads; a first light emitter electrically connected to one of the plurality of pads and including a first substrate and a first light emission source; and a second light emitter electrically connected to another one of the plurality of pads and including a second substrate and a second light emission source, wherein: the first and second substrates are configured to transmit light generated by the first and second light emission sources; a first planar direction of an upper surface of the first substrate is different from a second planar direction of an upper surface of the second substrate in a cross sectional view; and an angular difference between the first planar direction of the upper surface of the first substrate and the second planar direction of the upper surface of the second substrate is less than 10 degrees.
2. The light emitting apparatus of claim 1, wherein an interval between the first light emitter and the second light emitter is less than a width of the first light emitter.
3. The light emitting apparatus of claim 2, wherein an angular difference between the first planar direction of the upper surface of the first substrate and the planar direction of the circuit board is less than 5 degrees.
4. The light emitting apparatus of claim 2, further comprising: a first bonding layer electrically connecting the one of the plurality of pads and the first light emitter; and a second bonding layer electrically connecting the another one of the plurality of pads and the second light emitter.
5. The light emitting apparatus of claim 4, wherein an amount of the first bonding layer is different from an amount of the second bonding layer in a cross sectional view.
6. The light emitting apparatus of claim 4, wherein the first bonding layer and the second bonding layer include a material including one of AuSn, CuSn, or In.
7. The light emitting apparatus of claim 1, wherein a size of the first emitter and a size of the second emitter are less than 500×500 μm.
8. A light emitting apparatus, comprising: a circuit board extending in a planar direction and including a plurality of pads; a first light emitter electrically connected to one of the plurality of pads and including a first substrate and a first light emission source; and a second light emitter electrically connected to another one of the plurality of pads and including a second substrate and a second light emission source, wherein: the first and second substrates are configured to transmit light generated by the first and second light emission sources; a first planar direction of an upper surface of the first substrate is different from a second planar direction of an upper surface of the second substrate in a cross sectional view; and the second planar direction of the upper surface of the second substrate with respect to the first planar direction of the upper surface of the first substrate is less than 10 degrees.
9. The light emitting apparatus of claim 8, wherein an interval between the first light emitter and the second light emitter is less than a width of the first light emitter.
10. The light emitting apparatus of claim 9, wherein an angular difference between the first planar

direction of the upper surface of the first substrate and the planar direction of the circuit board is less than 5 degrees.

11. The light emitting apparatus of claim 9, further comprising: a first bonding layer electrically connecting the one of the plurality of pads and the first light emitter; and a second bonding layer electrically connecting the another one of the plurality of pads and the second light emitter.

12. The light emitting apparatus of claim 11, wherein an amount of the first bonding layer is different from an amount of the second bonding layer in a cross sectional view.

13. The light emitting apparatus of claim 11, wherein the first bonding layer and the second bonding layer include a material including one of AuSn, CuSn, or In.

14. The light emitting apparatus of claim 8, wherein a size of the first emitter and a size of the second emitter are less than 500×500 μm.

15. A light emitting apparatus, comprising: a circuit board extending in a planar direction; a first light emitter disposed on the circuit board and including a first substrate and a first light emission source; and a second light emitter disposed on the circuit board and including a second substrate and a second light emission source, wherein: the first and second substrates are configured to transmit light generated by the first and second light emission sources; a first planar direction of an upper surface of the first substrate is different from a second planar direction of an upper surface of the second substrate in a cross sectional view; and the second planar direction of the upper surface of the second substrate with respect to the first planar direction of the upper surface of the first substrate is less than **10** degrees.

16. The light emitting apparatus of claim 15, wherein an interval between the first light emitter and the second light emitter is less than a width of the first light emitter.

17. The light emitting apparatus of claim 16, wherein an angular difference between the first planar direction of the upper surface of the first substrate and the planar direction of the circuit board is less than 5 degrees.

18. The light emitting apparatus of claim 16, further comprising: a first bonding layer electrically connected to the first light emitter; and a second bonding layer electrically connected to the second light emitter.

19. The light emitting apparatus of claim 18, wherein an amount of the first bonding layer is different from an amount of the second bonding layer in a cross sectional view.

20. The light emitting apparatus of claim 15, wherein a size of the first emitter and a size of the second emitter are less than 500×500 μm.
