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ELECTRONIC PACKAGE DEVICE

Abstract

Provided is an electronic package device including a package substrate including a flat plate and a pad on the flat plate, wherein a width of the flat plate in a first horizontal direction is greater than a width of the pad in the first horizontal direction, and a light-emitting device on the package substrate, wherein the pad includes a first portion, and a second portion positioned on a top surface of the first portion and positioned at an edge of the top surface of the first portion, and a width of the light-emitting device in the first horizontal direction is substantially equal to a width of the pad in the first horizontal direction.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based on and claims priority under 35 U.S.C. § 119 to Korean Patent Application No. 10-2024-0019832, filed on Feb. 8, 2024, in the Korean Intellectual Property Office, the disclosure of which is incorporated by reference herein in its entirety.

BACKGROUND

[0002] Embodiments of the present disclosure relate to an electronic package device, and more particularly, to a headlamp driving device.

[0003] In general, vehicles are equipped with various vehicular lamps that have a lighting function and a signaling function. The lighting function may aid in identifying objects located around the vehicle when driving at night and the signaling function may inform other vehicles or road users of the vehicle's driving status.

[0004] Among lamps mounted on vehicles, a headlamp which secures the driver's forward vision when driving at night generally has a function of simultaneously or separately emitting a low beam (low beam), which illuminates a short distance in front of the vehicle, and a high beam (upward beam), which illuminates a long distance in front of the vehicle.

[0005] From the driver's perspective, using both low beams and high beams simultaneously is ideal for visibility because it can secure the driver's view of near and far distances in front of the vehicle at the same time. However, the high beam poses the risk of dazzling drivers of oncoming vehicles or oncoming pedestrians, making them unable to secure their vision during the time required for light and dark adaptation.

[0006] In addition, the driver's repeated on/off operation of the high beam while continuously checking for oncoming vehicles or pedestrians also undermines the safety of vehicle operation and causes the driver to feel considerable discomfort.

[0007] To address these issues, driver assistance systems are being developed, such as automatically controlling high beam on/off depending on the presence or absence of oncoming and/or preceding vehicles or controlling the illumination angle and/or brightness of low beam/high beam depending on road conditions, such as city streets, highways, intersections, etc.

[0008] Recently, adaptive driving beam (ADB) technology has been evolved to detect oncoming vehicles, preceding vehicles, and pedestrians using video images from the front of the vehicle. The ADB technology may change the lamp angle or turns off the high bean in a specific area where vehicles, pedestrians, and the like are located to prevent dazzling detected road users.

SUMMARY

[0009] One or more example embodiments provide an electronic package device with reduced internal stress by reducing the deviation of the vertical thickness of the solder paste that attaches the package substrate to the light-emitting device.

[0010] According to an aspect of the present disclosure, an electronic package device may include: a package substrate including a flat plate and a pad on the flat plate, wherein a width of the flat plate in a first horizontal direction is greater than a width of the pad in the first horizontal direction; and a light-emitting device on the package substrate, wherein the pad may include: a first portion; and a second portion positioned on a top surface of the first portion and positioned at an edge of the top surface of the first portion, and a width of the light-emitting device in the first horizontal direction is substantially equal to a width of the pad in the first horizontal direction.

[0011] According to another aspect of the present disclosure, an electronic package device may include: a package substrate including a flat plate and a pad on the flat plate, wherein a width of the

flat plate in a first horizontal direction is greater than a width of the pad in the first horizontal direction; and a light-emitting device on the package substrate, wherein the light-emitting device may include a base, a plurality of phosphors disposed on the base and spaced apart from each other in the first horizontal direction, and a grid surrounding sidewalls of the plurality of phosphors; and solder paste positioned between the light-emitting device and the pad, wherein the pad may include a first portion and a second portion disposed on a top surface of the first portion and arranged in a ring shape or an annular shape along an edge of the top surface of the first portion, the solder paste fills a space defined by the top surface of the first portion and inner walls of the second portion, and the plurality of phosphors are included in the solder paste from a plan view.

[0012] According to another aspect of the present disclosure, an electronic package device may include: a package substrate including a flat plate and a pad on the flat plate, wherein a width of the flat plate in a first horizontal direction is greater than a width of the pad in the first horizontal direction; a light-emitting device on the package substrate, wherein the light-emitting device may include a base, a plurality of phosphors disposed on the base and spaced apart from each other in the first horizontal direction, a grid surrounding sidewalls of the plurality of phosphors, and an input/output pad disposed on an upper part of the base; solder paste positioned between the light-emitting device and the pad; prepreg on a top surface of the flat plate, wherein the prepreg surrounds sides of the pad; a connection wire disposed within the prepreg; a connecting member that directly connects the connection wire to the input/output pad; and a molding member covering the connecting member, wherein the pad may include a first portion and a second portion positioned on a top surface of the first portion and positioned at an edge of the top surface of the first portion, the solder paste fills a space defined by the top surface of the first portion and inner walls of the second portion, and a top surface of the second portion is in direct contact with a bottom surface of the light-emitting device.

[0013] According to another aspect of the present disclosure, an electronic device may include: a printed circuit board including a pedestal structure, wherein the pedestal structure may include: a recess that contains solder paste; and shoulders of the recess; and a light emitting device disposed on the solder paste and the shoulders of the pedestal structure.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0014] The above and/or other aspects will be more apparent by describing certain example embodiments, with reference to the accompanying drawings, in which:

[0015] FIG. **1** is a plan view of an electronic package device according to an embodiment;

[0016] FIG. **2**A is a cross-sectional view taken along line A-A′ in FIG. **1**;

[0017] FIG. **2**B is a cross-sectional view taken along line B-B′ in FIG. **1**;

[0018] FIG. **3**A is a cross-sectional view taken along line A-A′ in FIG. **1**;

[0019] FIG. **3**B is a cross-sectional view taken along line B-B′ in FIG. **1**;

[0020] FIG. **4** is a cross-sectional view taken along line A-A′ in FIG. **1**;

[0021] FIG. **5**A is a cross-sectional view taken along line A-A′ in FIG. **1**;

[0022] FIG. **5**B is a cross-sectional view taken along line B-B′ in FIG. **1**;

[0023] FIG. **6** is a plan view of an electronic package device according to an embodiment;

[0024] FIG. **7**A is a cross-sectional view taken along line C-C′ in FIG. **6**;

[0025] FIG. **7**B is a cross-sectional view taken along line D-D′ in FIG. **6**;

[0026] FIG. **8** is a plan view of an electronic package device according to an embodiment;

[0027] FIG. **9**A is a cross-sectional view taken along line E-E′ in FIG. **8**;

[0028] FIG. **9**B is a cross-sectional view taken along line F-F′ in FIG. **8**;

[0029] FIGS. **10**, **12**, **14**, and **16** are plan views illustrating a method of manufacturing an electronic

package device according to an embodiment;
[0030] FIGS. **11**A, **13**A, **15**A, and **17**A are cross-sectional views, taken along line A-A′ in FIGS. **10**, **12**, **14**, and **16**, respectively, illustrating a method of manufacturing an electronic package device according to an embodiment;
[0031] FIGS. **11**B, **13**B, **15**B, and **17**B are cross-sectional views, taken along line B-B′ in FIGS. **10**, **12**, **14**, and **16**, respectively, illustrating a method of manufacturing an electronic package device according to an embodiment;
[0032] FIG. **18** is a block diagram of a headlamp control system according to an embodiment; and
[0033] FIG. **19** is a diagram showing a vehicle including the headlamp control system of FIG. **18**.

DETAILED DESCRIPTION OF EMBODIMENTS

[0034] Hereinafter, various embodiments are described with reference to the accompanying drawings.
[0035] FIG. **1** is a plan view of an electronic package device according to an embodiment. FIG. **2**A is a cross-sectional view taken along line A-A′ in FIG. **1**. FIG. **2**B is a cross-sectional view taken along line B-B′ in FIG. **1**.
[0036] Referring to FIGS. **1**, **2**A, and **2**B, an electronic package device **10** may include a package substrate **100**, solder paste **150**, a light-emitting device **200**, a connecting member (e.g., a wire) **300**, and a molding member **310**.
[0037] The electronic package device **10** may include, for example, a headlamp driving device. The headlamp driving device may include a lamp mounted on a vehicle. A headlamp may be a lamp for securing a driver's forward vision when driving at night.
[0038] The electronic package device **10** may be a semiconductor package although its implementation is not limited to a semiconductor package.
[0039] The package substrate **100** may include, for example, a printed circuit board (PCB). Alternatively, the package substrate **100** may include a base plate made of a metal material, such as copper. As an example, the package substrate **100** may include conductive wires within a flat plate **105** and a pad **110**. The conductive wires may be electrically connected to a light-emitting device driving circuit placed externally or the light-emitting device **200** mounted on the package substrate **100** through connection wires **120**.
[0040] The package substrate **100** may include the flat plate **105**, the pad **110**, the connection wires **120**, and a prepreg **130**.
[0041] The flat plate **105** may extend along two perpendicular horizontal directions: a first horizontal direction (X) and a second horizontal direction (Y). The length of the flat plate **105** in the first horizontal direction (X) may be a first width W**1**. The length of the flat plate **105** in the second horizontal direction (Y) may be a second width W**2**. The first width W**1** may be greater than the second width W**2**.
[0042] In an embodiment, the flat plate **105** may have a rectangular planar shape. However, embodiments of the present disclosure are not limited thereto, and a planar shape of the flat plate **105** may vary, such as square, polygon, and circle.
[0043] Herein, the first horizontal direction (X) is defined as a direction parallel to a top surface **105***a* of the flat plate **105**, the second horizontal direction (Y) is defined as a direction parallel to the top surface **105***a* of the flat plate **105** and intersecting the first horizontal direction (X), and a vertical direction (Z) is defined as a direction perpendicular to the top surface **105***a* of the flat plate **105**.
[0044] The pad **110** may be disposed on the flat plate **105**. The pad **110** may be integrated with the flat plate **105**. That is, there may be no boundary between the pad **110** and the flat plate **105**. However, in another embodiment, the pad **110** and the flat plate **105** may be formed separately and then attached to each other, resulting in a visible boundary between the pad **110** and the flat plate **105**. The flat plate **105** and the pad **110** may be collectively referred to as a pedestal structure that is used to elevate and support specific components (e.g., a light-emitting device **200**), ensuring the

components are properly positioned and secured on the PCB. The pedestal structure, also referred to as a raised support structure, may include a recess RS to contain solder paste **150**. A first portion **112** of the pad **10** may be positioned under the recess RS, and shoulders of the recess RS may correspond to the second portion **114** of the pad **10**.

[0045] The length of the pad **110** in the first horizontal direction (X) may be a third width W**3**. The length of the pad **110** in the second horizontal direction (Y) may be a fourth width W**4**. The third width W**3** may be less than the first width W**1**. The third width W**3** may be greater than the fourth width W**4**. The fourth width W**4** may be less than the second width W**2**.

[0046] The pad **110** may include a first portion **112** and a second portion **114** on the first portion **112**.

[0047] The first portion **112** may be placed directly above the flat plate **105**. As an example, the first portion **112** may be integrated with the flat plate **105**.

[0048] The first portion **112** may extend in the first horizontal direction (X) and the second horizontal direction (Y). The length of the first portion **112** in the first horizontal direction (X) may be equal to the third width W**3**. The length of the first portion **112** in the second horizontal direction (Y) may be equal to the fourth width W**4**.

[0049] The second portion **114** may be placed on the first portion **112**. From a cross-sectional view, the second portion **114** may be placed at an edge of a top surface **112***a* of the first portion **112**. From a plan view, the second portion **114** may have a ring shape or an annular shape. In other words, the second portion **114** may be placed along the edge of the first portion **112**. In an embodiment, the second portion **114** may have a rectangular planar shape. However, embodiments of the present disclosure are not limited thereto, and the planar shape of the second portion **114** may vary, such as square, polygon, and circle.

[0050] Since the second portion **114** has a ring shape or an annular planar shape, at least a part of the top surface **112***a* of the first portion **112** may be exposed from the second portion **114**. Additionally, because the second portion **114** has a ring shape or an annular planar shape, the pad **110** may include a recess RS.

[0051] The recess RS may be a space defined by the top surface **112***a* of the first portion **112** and a plurality of inner walls **114***it* of the second portion **114**. Due to the recess RS, the vertical level of the top surface **112***a* of the first portion **112** may be lower than the vertical level of the top surface **114***a* of the second portion **114**.

[0052] The horizontal width of the second portion **114** may be a fifth width W**5**. The fifth width W**5** may be the minimum distance from an outer wall **114***ot* to the inner wall **114***it* of the second portion **114**. In FIGS. **1** and **2**A, the fifth width W**5** is shown as a distance in the first horizontal direction (X), but the fifth width W**5** may also be a distance in the second horizontal direction (Y).

[0053] The fifth width W**5** may be less than half of the fourth width W**4**. The fifth width W**5** may be greater than or equal to 50 μm

[0054] The vertical height of the second portion **114** may be a first height H**1**. The first height H**1** may be a vertical distance from the top surface **112***a* of the first portion **112** to the top surface **114***a* of the second portion **114**. The first height H**1** may be in a range from about 10 μm to about 500 μm.

[0055] An angle AG formed between the inner wall **114***it* of the second portion **114** and the top surface **112***a* of the first portion **112** may be a right angle or an obtuse angle. Specifically, the angle AG formed between the inner wall **114***it* of the second portion **114** and the top surface **112***a* of the first portion **112** may be about 90 degrees to about 145 degrees.

[0056] An outer wall **112***ot* of the first portion **112** and the outer wall **114***ot* of the second portion **114** may be placed on a straight line.

[0057] The solder paste **150** may fill the recess RS. The solder paste **150** may directly cover the top surface **112***a* of the first portion **112** and the inner walls **114***it* of the second

[0058] The vertical level of a top surface **150***a* of the solder paste **150** may be substantially equal to

the vertical level of the top surface **114***a* of the second portion **114**. Herein, the term "substantially equal" may include mathematical identity as well as a margin of error in the process, ranging from -50 μm to 50 μm.

[0059] The solder paste **150** may fill the space surrounded by the top surface **112***a* of the first portion **112** and the inner walls **114***it* of the second portion **114**. That is, the solder paste **150** may fill the recess RS. From a plan view, the solder paste **150** may be surrounded by the second portion **114**.

[0060] The solder paste **150** may include a solder material. For example, the solder paste **150** may include a mixture of metals, such as lead, arsenic, platinum, indium, and platinum, and resin. The solder paste **150** may further include flux.

[0061] The connection wires **120** and the prepreg **130** may be disposed on the top surface **105***a* of the flat plate **105** of the package substrate **100**. From a plan view, the prepreg **130** may surround the pad **110** of the package substrate **100**. The prepreg **130** may directly cover the outer wall **112***ot* of the first portion **112** and the outer wall **114***ot* of the second portion **114**.

[0062] The connection wires **120** may be placed within the prepreg **130**. The connection wires **120** may include one or two or more layers. The prepreg **130** may not cover the top surface **120***a* of the uppermost connection wire **120**.

[0063] The light-emitting device **200** may be disposed on the top surface **114***a* of the second portion **114** of the package substrate **100**. The light-emitting device **200** may be disposed on the top surface **150***a* of the solder paste **150**.

[0064] The light-emitting device **200** may have a structure in which light is emitted from a plurality of light-emitting structures arranged in a pixel type. For example, the light-emitting device **200** may be arranged in a pixel type to be used in an intelligent lighting system, such as a car headlamp or indoor lighting.

[0065] The light-emitting device **200** may include a base **210**, a phosphor **220**, a light-emitting diode **225**, a grid **230**, and an input/output pad **240**.

[0066] A bottom surface **210***b* of the base **210** may directly contact the top surface **114***a* of the second portion **114** and the top surface **150***a* of the solder paste **150**. The bottom surface **210***b* of the base **210** may also be referred to as a bottom surface of the light-emitting device **200**. Accordingly, the bottom surface of the light-emitting device **200** may directly contact the top surface **114***a* of the second portion **114** and the top surface **150***a* of the solder paste **150**. The bottom surface **210***b* of the base **210** may be spaced apart from the first portion **112** in the vertical direction (Z).

[0067] In some embodiments, the base **210** may include a silicon interposer and a wiring layer disposed on the silicon interposer. The wiring layer may be electrically connected to the light-emitting diode **225** and the input/output pad **240**.

[0068] In some embodiments, the width of the light-emitting device **200** in the first horizontal direction (X) may be equal to the width of the base **210** in the first horizontal direction (X). The width of the light-emitting device **200** in the second horizontal direction (Y) may be equal to the width of the base **210** in the second horizontal direction (Y). The width of the light-emitting device **200** in the first horizontal direction (X) may be greater than the width of the light-emitting device **200** in the second horizontal direction (Y). The width of the light-emitting device **200** in the second horizontal direction (Y) may be about 2 mm to about 6 mm.

[0069] The width of the light-emitting device **200** in the first horizontal direction (X) may be substantially equal to the third width W**3**. The width of the light-emitting device **200** in the second horizontal direction (Y) may be substantially equal to the fourth width W**4**. Specifically, the width of the light-emitting device **200** in the first horizontal direction (X) may be substantially equal to the width of the pad **110** in the first horizontal direction (X). The width of the light-emitting device **200** in the second horizontal direction (Y) may be substantially equal to the width of the pad **110** in the second horizontal direction (Y).

[0070] The light-emitting diode **225** and the phosphor **220** may be disposed on a top surface **210***a* of the base **210**. The light-emitting diode **225** and the phosphor **220** may be sequentially stacked on the top surface **210***a* of the base **210**.
[0071] The number of light-emitting diodes **225** and the number of phosphors **220** may be plural. The plurality of light-emitting diodes **225** may be spaced apart from each other in the first horizontal direction (X) and the second horizontal direction (Y). The plurality of light-emitting diodes **225** may be arranged in a certain arrangement in the first horizontal direction (X) and the second horizontal direction (Y).
[0072] The plurality of phosphors **220** may be spaced apart from each other in the first horizontal direction (X) and the second horizontal direction (Y). The plurality of phosphors **220** may be arranged in a certain arrangement in the first horizontal direction (X) and the second horizontal direction (Y).
[0073] The grid **230** may surround the plurality of light-emitting diodes **225** and the plurality of phosphors **220**. The grid **230** may be placed between a pair of adjacent phosphors **220** in the first horizontal direction (X) or the second horizontal direction (Y). The grid **230** may be placed between a pair of adjacent light-emitting diodes **225** in the first horizontal direction (X) or the second horizontal direction (Y).
[0074] From a plan view, the grid **230** may have a mesh shape. The plurality of light-emitting diodes **225** may be spaced apart from each other in the first horizontal direction (X) and the second horizontal direction (Y), with the grid **230** positioned in between. The plurality of phosphors **220** may be spaced apart from each other in the first horizontal direction (X) and the second horizontal direction (Y), with the grid **230** positioned in between.
[0075] The phosphor **220** may include an inorganic receptor material including an optically active dopant. For example, the phosphor **220** may include yttrium aluminum garnet Y.sub.3Al.sub.5O.sub.12 (YAG). The optically active dopant may include rare earth oxides or rare earth compounds.
[0076] The phosphor **220**, the light-emitting diode **225**, and the grid **230** may be collectively referred to as a pixel light-emitting structure. The pixel light-emitting structure may be configured to emit light upward from the top surface of the phosphor **220**, for example, to the outside of the electronic package device **10**.
[0077] The distance between the inner walls **114***it* of the pair of second portions **114** facing each other in the first horizontal direction (X) may be a sixth width W**6**. The sixth width W**6** may be equal to the width of the solder paste **150** in the first horizontal direction (X). The distance between the outermost ones of the plurality of phosphors **220** arranged in the first horizontal direction (X) may be a seventh width W**7**. The seventh width W**7** may be less than or equal to the sixth width W**6**. That is, from a plan view, all of the plurality of phosphors **220** may be placed within the solder paste **150**. From a plan view, the plurality of light-emitting diodes **225** may all be placed within the solder paste **150**. The plurality of phosphors **220** and the plurality of light-emitting diodes **225** may vertically overlap with the solder paste **150**.
[0078] According to an embodiment, the plurality of phosphors **220** may all be placed within the solder paste **150** from a plan view. Thus, heat generated from the plurality of phosphors **220** may be easily discharged to the package substrate **100** through the solder paste **150**. As a result, the thermal properties of the electronic package device **10** may be improved.
[0079] The width of the base **210** in the first horizontal direction (X) may be less than or equal to the third width W**3**. The width of the base **210** in the first horizontal direction (X) may be greater than the sixth width W**6**.
[0080] The input/output pad **240** may be placed on an upper part of the base **210**. The top surface of the input/output pad **240** may be exposed from the base **210**. The input/output pad **240** may include a conductive metal, such as copper or aluminum.
[0081] The connecting member **300** may be arranged to connect the input/output pad **240** to the

uppermost connection wire **120**. The connecting member **300** may directly connect the input/output pad **240** to the uppermost connection wire **120**. The connecting member **300** may electrically connect the input/output pad **240** to the uppermost connection wire **120**. The connecting member **300** may be formed by wire bonding.

[0082] The connecting member **300** may include a metal. For example, the connecting member **300** may include a low-resistance metal, such as gold, platinum, copper, or aluminum.

[0083] The molding member **310** covering the connecting member **300** may be placed on the light-emitting device **200**. The molding member **310** may cover the prepreg **130** and the uppermost connection wire **120**. The molding member **310** may cover the top surface **210***a* and a portion of the side surface of the base **210**. The molding member **310** may cover at least a portion of the side surface of the grid **230**.

[0084] When the pad **110** includes only the first portion **112** and omits the second portion **114**, the solder paste **150** may be disposed on the top surface **112***a* of the first portion **112**. In the process of forming the solder paste **150**, the solder paste **150** may retain fluidity. Therefore, in the absence of a structure to fix or secure the solder paste **150**, the vertical thickness of the solder paste **150** may vary gradually in the first horizontal direction (X) or the second horizontal direction (Y). This variation may lead to deviations in the vertical thickness of the solder paste **150** in the first horizontal direction (X) and/or the second horizontal direction (Y).

[0085] In a region that vertically overlaps with a portion of the solder paste **150** with a small vertical thickness, there may be increased stress on the light-emitting device **200**. On the other hand, in a region that vertically overlaps with another portion of the solder paste **150** with a large vertical thickness, increased stress may be observed on the connecting member **300**. Thus, variations in the vertical thickness of the solder paste **150** may lead to increased stress in the electronic package device **10**.

[0086] In the electronic package device **10** according to an embodiment, the pad **110** of the package substrate **100** may include the first portion **112** and the second portion **114** on the first portion **112**. The second portion **114** may have a ring shape or an annular shape in a plan view. In other words, the second portion **114** may be placed along the edge of the first portion **112**. As a result, the pad **110** may include the recess RS. The recess RS may be a space defined by the top surface **112***a* of the first portion **112** and the inner walls **114***it* of the second portion **114**. Additionally, the solder paste **150** may fill the recess RS. In this case, during the process of forming the solder paste **150**, the solder paste **150** may be fixed by the second portion **114**. As a result, the deviation in the vertical thickness of the solder paste **150** may decrease. Accordingly, stress occurring inside the electronic package device **10** may be reduced. For the above reasons, the reliability of the electronic package device **10** may be improved.

[0087] FIG. **3**A is a cross-sectional view taken along line A-A′ in FIG. **1**. FIG. **3**B is a cross-sectional view taken along line B-B′ in FIG. **1**. Hereinafter, descriptions that are substantially the same as those given with reference to FIGS. **1** to **2**B are omitted, and only the differences are described in detail.

[0088] Referring to FIGS. **1**, **3**A, and **3**B, the vertical level of a top surface of a prepreg **130** of an electronic package device **11** may be lower than the vertical level of the top surface **114***a* of the second portion **114** of the pad **110**. The prepreg **130** may cover at least a portion of the outer wall **114***ot* of the second portion **114**. Alternatively, unlike in FIGS. **3**A and **3**B, the prepreg **130** may not cover the outer wall **114***ot* of the second portion **114**.

[0089] The prepreg **130** may not cover the top surface **120***a* and side surfaces of the uppermost connection wire **120**. The uppermost connection wire **120** may be disposed on the top surface **130***a* of the prepreg **130**. The molding member **310** may cover the top surface **120***a* and the side surfaces of the uppermost connection wire **120**. The bottom surface of the uppermost connection wire **120** may contact the top surface **130***a* of the prepreg **130**.

[0090] FIG. **4** is a cross-sectional view taken along line A-A′ in FIG. **1**. Hereinafter, descriptions

that are substantially the same as those given with reference to FIGS. **1** to **2**B are omitted to focus on differences in detail. The cross-sectional view taken along line B-B′ in FIG. **1** may correspond to FIG. **2**B.

[0091] Referring to FIGS. **1**, **2**B, and **4**, the vertical level of a top surface **150***a* of a solder paste **150** of an electronic package device **12** may be higher than the vertical level of the top surface **114***a* of the second portion **114** of the pad **110**. The vertical level of the top surface **150***a* of the solder paste **150** may increase in the first horizontal direction (X). That is, the top surface **150***a* of the solder paste **150** may be inclined at a certain angle with the first horizontal direction (X).

[0092] The minimum vertical distance from the top surface **114***a* of the second portion **114** to the top surface **150***a* of the solder paste **150** may be a second height H**2**. The maximum vertical distance from the top surface **114***a* of the second portion **114** to the top surface **150***a* of the solder paste **150** may be a third height H**3**. The third height H**3** may be greater than the second height H**2**. The third height H**3** may be greater than 0 and about 80 μm or less. The difference between the third height H**3** and the second height H**2** may be less than or equal to 30 μm.

[0093] The light-emitting device **200** may be spaced apart from the second portion **114** in the vertical direction (Z) with the solder paste **150** positioned in between. The entirety of the bottom surface **210***b* of the base **210** of the light-emitting device **200** may be in contact with the top surface **150***a* of the solder paste **150**.

[0094] The thermal expansion coefficient of the base **210** of the light-emitting device **200** may be different from the thermal expansion coefficient of the second portion **114**. When the second portion **114** of the pad **110** of the package substrate **100** is not present, the difference between the third height H**3** and the second height H**2** may increase. In this case, in a region where the vertical thickness of the solder paste **150** is small, the stress occurring inside the light-emitting device **200** and the solder paste **150** may increase. This may result in deterioration of the reliability of the electronic package device **12**.

[0095] According to an embodiment, the second portion **114** of the pad **110** may secure the solder paste **150** pad. Accordingly, the tilt of the top surface **150***a* of the solder paste **150** may be reduced. Specifically, the difference between the third height H**3** (i.e., the maximum vertical distance from the top surface **114***a* of the second portion **114** to the top surface **150***a* of the solder paste **150**) and the second height H**2** (i.e., the minimum vertical distance from the top surface **114***a* of the second portion **114** to the top surface **150***a* of the solder paste **150**) may be maintained to be less than or equal to 30 μm. That is, the difference between the third height H**3** and the second height H**2** may be reduced. When the difference between the third height H**3** and the second height H**2** is less than or equal to 30 μm, stress occurring inside the light-emitting device **200** and the package substrate **100** may be greatly reduced. For the above reasons, the reliability of the electronic package device **12** may be improved.

[0096] The connecting member **300** adjacent to a portion of the solder paste **150** having the second height H**2** may include a first connecting member **300***a*. The connecting member **300** adjacent to another portion of the solder paste **150** having the third height H**3** may include a second connecting member **300***b*. Specifically, the connecting member **300** may include the first connection member **300***a* and the second connection member **300***b* positioned at two opposing sides of the connecting member **300** across the solder paste **150**.

[0097] The first connection member **300***a* may be positioned closer to the portion of the solder paste **150** with the second height H**2** than to the portion with the first height H**1**. The second connection member **300***b* may be positioned closer to the portion of the solder paste **150** with the first height H**1** than to the portion with the second height H**2**.

[0098] The vertical distance from the top surface **210***a* of the base **210** of the light-emitting device **200** to the top of the first connecting member **300***a* may be a fourth height H**4**. The vertical distance from the top surface **210***a* of the base **210** of the light-emitting device **200** to the top of the second connecting member **300***b* may be a fifth height H**5**. The fourth height H**4** may be greater

than the fifth height H**5**. The difference between the fourth height H**4** and the fifth height H**5** may be less than or equal to 30 μm.

[0099] When the difference between the fourth height H**4** and the fifth height H**5** is greater than 30 μm, the strain generated in the second connecting member **300***b* may increase. As a result, the stress acting on the second connecting member **300***b* may increase. Therefore, when the difference between the fourth height H**4** and the fifth height H**5** is less than 30 μm, the stress acting on the second connecting member **300***b* may decrease. That is, the stress acting on the connecting member **300** may be reduced. As a result, the reliability of the electronic package device **12** may be improved.

[0100] FIG. **5**A is a cross-sectional view taken along line A-A′ in FIG. **1**. FIG. **5**B is a cross-sectional view taken along line B-B′ in FIG. **1**. Hereinafter, descriptions that are substantially the same as those given with reference to FIGS. **1** to **2**B are omitted to focus on differences.

[0101] Referring to FIGS. **1**, **5**A, and **5**B, the surface of a recess RS formed in a second portion **114** of an electronic package device **13** may be rounded. Specifically, the inner wall **114***it* of the second portion **114** of the pad **110** and the top surface **112***a* of the first portion **112** may be rounded. The recess RS may be formed by wet etching.

[0102] Accordingly, the sixth width W**6**, which is the distance between the inner walls **114***it* of the pair of second portions **114** facing each other in the first horizontal direction (X), may increase and then decrease downward in the vertical direction (Z). In other words, the width of the solder paste **150** in the first horizontal direction (X) may increase and then decrease downward in the vertical direction (Z). The change in the width of the solder paste **150** in the first horizontal direction (X) may be due to the rounded surface of the recess RS.

[0103] The recess RS may also be formed in an upper part of the first portion **112**. Alternatively, unlike in FIGS. **5**A and **5**B, the recess RS may be formed only in the second

[0104] FIG. **6** is a plan view of an electronic package device according to an embodiment. FIG. **7**A is a cross-sectional view taken along line C-C′ in FIG. **6**. FIG. **7**B is a cross-sectional view taken along line D-D′ in FIG. **6**. Hereinafter, descriptions that are substantially the same as those given with reference to FIGS. **1** to **2**B are omitted to highlight differences. The cross-sectional view taken along line A-A′ in FIG. **6** may correspond to FIG. **2**A.

[0105] Referring to FIGS. **2**A, **6**, **7**A, and **7**B, a second portion **114** of an electronic package device **14** may include a first component **114**C**1** and a second component **114**C**2** spaced apart from each other in the first horizontal direction (X). In other words, the second portion **114** may be discontinuous in the first horizontal direction (X). The first component **114**C**1** and the second component **114**C**2** may be symmetrical to each other across a virtual plane with the first horizontal direction (X) as the normal line. Alternatively, the first component **114**C**1** and the second component **114**C**2** may be asymmetrical to each other across a virtual plane with the first horizontal direction (X) as the normal line.

[0106] The first component **114**C**1** may include a first end EN**1**. The second component **114**C**2** may include a second end EN**2**. The first end EN**1** may be an inner wall of the first component **114**C**1** in the first horizontal direction (X). The second end EN**2** may be an inner wall of the second component **114**C**2** in the first horizontal direction (X). The first end EN**1** of the first component **114**C**1** may be spaced apart from the second end EN**2** of the second component **114**C**2** in the first horizontal direction (X).

[0107] The recess RS may extend to a space formed by the first end EN**1**, the second end EN**2**, and the top surface **112***a* of the first portion **112**. The solder paste **150** may extend to a space formed by the first end EN**1**, the second end EN**2**, and the top surface **112***a* of the first portion **112**. As a result, the first component **114**C**1** may be spaced apart from the second component **114**C**2** in the first horizontal direction (X) with the solder paste **150** positioned in between.

[0108] FIG. **8** is a plan view of an electronic package device according to an embodiment. FIG. **9**A is a cross-sectional view taken along line E-E′ in FIG. **8**. FIG. **9**B is a cross-sectional view taken

along line F-F′ in FIG. **8**. Hereinafter, descriptions that are substantially the same as those given with reference to FIGS. **1** to **2**B are omitted to highlight differences. The cross-sectional view taken along line B-B′ in FIG. **8** may correspond to FIG. **2**B.

[0109] Referring to FIGS. **2**B, **8**, **9**A, and **9**B, a second portion **114** of an electronic package device **15** may include a third component **114**C**3** and a fourth component **114**C**4** spaced apart from each other in the second horizontal direction (Y). In other words, the second portion **114** may be discontinuous in the second horizontal direction (Y). The third component **114**C**3** and the fourth component **114**C**4** may be symmetrical to each other across a virtual plane with the second horizontal direction (Y) as the normal line. Alternatively, the third component **114**C**3** and the fourth component **114**C**4** may be asymmetrical to each other across a virtual plane with the second horizontal direction (Y) as the normal line.

[0110] The third component **114**C**3** may include a third end EN**3**. The fourth component **114**C**4** may include a fourth end EN**4**. The third end EN**3** may be an inner wall of the third component **114**C**3** in the second horizontal direction (Y). The fourth end EN**4** may be an inner wall of the fourth component **114**C**4** in the second horizontal direction (Y). The third end EN**3** of the third component **114**C**3** may be spaced apart from the fourth end EN**4** of the fourth component **114**C**4** in the second horizontal direction (Y).

[0111] The recess RS may extend to a space formed by the third end EN**3**, the fourth end EN**4**, and the top surface **112***a* of the first portion **112**. The solder paste **150** may extend to a space formed by the third end EN**3**, the fourth end EN**4**, and the top surface **112***a* of the first portion **112**. As a result, the third component **114**C**3** may be spaced apart from the fourth component **114**C**4** in the second horizontal direction (Y) with the solder paste **150** positioned therebetween.

[0112] FIGS. **10**, **12**, **14**, and **16** are plan views illustrating a method of manufacturing an electronic package device according to an embodiment. FIGS. **11**A, **13**A, **15**A, and **17**A are cross-sectional views, taken along line A-A′ in FIGS. **10**, **12**, **14**, and **16**, respectively, illustrating a method of manufacturing an electronic package device according to an embodiment. FIGS. **11**B, **13**B, **15**B, and **17**B are cross-sectional views, taken along line B-B′ in FIGS. **10**, **12**, **14**, and **16**, respectively, illustrating a method of manufacturing an electronic package device according to an embodiment.

[0113] Referring to FIGS. **10**, **11**A, and **11**B, a flat plate **105** and a preliminary pad **110**P on the flat plate **105** may be formed. Forming the flat plate **105** and the preliminary pad **110**P on the flat plate **105** may include preparing a preliminary package substrate, forming a first photo mask pattern PM**1** on the preliminary package substrate, and performing a first etching process ET**1** on the preliminary package substrate using the first photo mask pattern PM**1** as an etch mask.

[0114] The first photo mask pattern PM**1** may cover a central portion of the preliminary package substrate. The first photo mask pattern PM**1** may expose an edge of the preliminary package substrate. Accordingly, the edge of the preliminary package substrate may be etched through the first etching process ET**1**. The first etching process ET**1** may lower the vertical level of the top surface of the edge of the preliminary package substrate, and may form the flat plate **105** and the preliminary pad **110**P plate.

[0115] The vertical level of the top surface **105***a* of the flat plate **105** may be lower than the vertical level of a top surface **110**Pa of the preliminary pad **110**P.

[0116] The preliminary package substrate may be a PCB. Alternatively, the preliminary package substrate may be a copper substrate. Conductive wires may be positioned within the preliminary package substrate.

[0117] Referring to FIGS. **12**, **13**A, and **13**B, the first photo mask pattern PM**1** may be removed. Subsequently, the pad **110** may be formed from the preliminary pad **110**P. Forming the pad **110** may include forming a second photo mask pattern PM**2** on the flat plate **105** and the preliminary pad **110**P and performing a second etching process ET**2** on the preliminary pad **110**P using the second photo mask pattern PM**2** as an etch mask.

[0118] The second photo mask pattern PM**2** may cover the top surface **105***a* of the flat plate **105**

and the edge of the top surface of the preliminary pad **110**P. The second photo mask pattern PM**2** may expose a central portion of the preliminary pad **110**P. Accordingly, the central portion of the preliminary pad **110**P may be etched through the second etching process ET**2**. The second etching process ET**2** may lower the vertical level of the top surface **110**Pa of the central portion of the preliminary pad **110**P. The second etching process ET**2** may form the pad **110** from the preliminary pad **110**P, and may form a recess RS in the central portion of the preliminary pad **110**P.

[0119] The pad **110** may include a first portion **112** and a second portion **114** on the first portion **112**. The recess RS may be a space defined by the top surface **112***a* of the first portion **112** and the inner walls **114***it* of the second portion **114**.

[0120] An angle AG formed between the inner wall **114***it* of the second portion **114** and the top surface **112***a* of the first portion **112** may be a right angle or an obtuse angle. Specifically, the angle AG formed between the inner wall **114***it* of the second portion **114** and the top surface **112***a* of the first portion **112** may be about 90 degrees to about 145 degrees.

[0121] Referring to FIGS. **14**, **15**A, and **15**B, the second photo mask pattern PM**2** may be removed. Subsequently, the prepreg **130** and the connection wires **120** may be formed on the top surface **105***a* of the flat plate **105**.

[0122] The prepreg **130** may include one layer or two or more layers. The connection wires **120** may be placed within the prepreg **130** and may include one or two or more layers.

[0123] Referring to FIGS. **16**, **17**A, and **17**B, the solder paste **150** may be formed to fill the recess RS. The solder paste **150** may cover the top surface **112***a* of the first portion **112** and the inner walls **114***it* of the second portion **114**.

[0124] The light-emitting device **200** may be mounted on the top surface **114***a* of the second portion **114** and the top surface **150***a* of the solder paste **150**. The light-emitting device **200** may include a base **210**, a phosphor **220**, a light-emitting diode **225**, a grid **230**, and an input/output pad **240**. The light-emitting device **200** may be formed in another space.

[0125] A bottom surface **210***b* of the base **210** of the light-emitting device **200** may directly contact the top surface **114***a* of the second portion **114** and the top surface **150***a* of the solder paste **150**.

[0126] Referring again to FIGS. **1**, **2**A, and **2**B, the connecting member **300** may be formed to connect the input/output pad **240** of the light-emitting device **200** to the uppermost connection wire **120**. Subsequently, the molding member **310** may be formed to cover the connecting member **300**, the top surface **130***a* of the prepreg **130**, and the top surface **120***a* of the uppermost connection wire **120**. The molding member **310** may further cover the side surfaces and the top surface **210***a* of the base **210** and the side surfaces of the grid **230**. As a result, the electronic package device **10** may be manufactured.

[0127] FIG. **18** is a block diagram of a headlamp control system.

[0128] Referring to FIG. **18**, a headlamp control system **40** may include an image sensor **41**, a headlamp **42**, and a control device **43**.

[0129] The image sensor **41** may include a camera and may obtain a front image by photographing the front of the vehicle. The image sensor **41** may transmit the obtained front image to the control device **43**.

[0130] The headlamp **42** may radiate light to the front of the vehicle. The headlamp **42** may radiate light based on a radiation area set through the image sensor **41**. The headlamp **42** may include an adaptive driving beam (ADB) system that changes the illumination angle, brightness, width, and length of the lamp. Alternatively, the headlamp **42** may include a high beam assistance (HBA) system that recognizes vehicles traveling in the opposite lane and automatically switches the high beam to the low beam.

[0131] The headlamp **42** may correspond to the electronic package devices **10**, **11**, **12**, **13**, **14**, and **15** described with reference to FIGS. **1** to **9**B.

[0132] The control device **43** may perform an illumination operation of the headlamp **42** based on the front image obtained from the image sensor **41**. The control device **43** may be implemented as a

processor and/or an electronic control unit (ECU), and may provide control commands to the headlamp **42**.
[0133] FIG. **19** is a diagram showing a vehicle including the headlamp control system of FIG. **18**.
[0134] In FIG. **19**, a car is shown as a vehicle **2000**, but the inventive concept is not limited thereto. The vehicle **2000** may include a land transportation, such as two-wheeled vehicles, three-wheeled vehicles, passenger cars, crawler vehicles, trains, and trams, a marine transportation, such as ships, boats, and submarines, and an air transportation, such as airplanes and helicopters, but are specifically limited thereto.
[0135] Referring to FIG. **19**, head lamps **2020**A and **2020**B of the vehicle **2000** may be installed, a side mirror lamp **2040** may be installed, and a tail lamp **2060** may be installed. At least one of the head lamps **2020**A and **2020**B, the side mirror lamp **2040**, and the tail lamp **2060** may correspond to the electronic package devices **10**, **11**, **12**, **13**, **14**, and **15** described with reference to FIGS. **1** to **9**B.
[0136] A power device **2003** built into the vehicle **2000** may supply power to each of the head lamps **2020**A and **2020**B, the side mirror lamp **2040**, and the tail lamp **2060**. Additionally, a controller **2001** built into the vehicle **2000** may be configured to control operations including on and off of the head lamps **2020**A and **2020**B, the side mirror lamp **2040**, and the tail lamp **2060**. The controller **2001** may correspond to the control device **43** shown in FIG. **18**.
[0137] The foregoing exemplary embodiments are merely exemplary and are not to be construed as limiting. The present teaching can be readily applied to other types of apparatuses. Also, the description of the exemplary embodiments is intended to be illustrative, and not to limit the scope of the claims, and many alternatives, modifications, and variations will be apparent to those skilled in the art.

Claims

1. An electronic package device comprising: a package substrate comprising a flat plate and a pad on the flat plate, wherein a width of the flat plate in a first horizontal direction is greater than a width of the pad in the first horizontal direction; and a light-emitting device on the package substrate, wherein the pad comprises: a first portion; and a second portion positioned on a top surface of the first portion and positioned at an edge of the top surface of the first portion, and a width of the light-emitting device in the first horizontal direction is substantially equal to a width of the pad in the first horizontal direction.
2. The electronic package device of claim 1, further comprising solder paste filling a space surrounded by the top surface of the first portion and inner walls of the second portion.
3. The electronic package device of claim 2, wherein a vertical level of a top surface of the solder paste is substantially equal to a vertical level of a top surface of the second portion.
4. The electronic package device of claim 1, wherein the second portion has a ring shape or an annular shape from a plan view.
5. The electronic package device of claim 1, wherein a top surface of the second portion is in direct contact with a bottom surface of the light-emitting device.
6. The electronic package device of claim 1, wherein a width of the light-emitting device in the first horizontal direction is greater than a width of the light-emitting device in a second horizontal direction intersecting the first horizontal direction, and the width of the light-emitting device in the second horizontal direction is in a range from 2 mm to 6 mm.
7. The electronic package device of claim 1, wherein the light-emitting device comprises: a base; a plurality of phosphors disposed on the base and spaced apart from each other in the first horizontal direction; and a grid surrounding sidewalls of the plurality of phosphors.
8. The electronic package device of claim 1, wherein a vertical height of the second portion is in a range from 10 μm to 500 μm.

9. The electronic package device of claim 1, wherein the width of the pad in the first horizontal direction is a first width, the width of the pad in a second horizontal direction intersecting the first horizontal direction is a second width, a minimum distance from an outer wall to an inner wall of the second portion is a third width, the second width is less than the first width, the third width is less than half of the second width, and the third width is greater than to or equal to 50 μm.
10. The electronic package device of claim 1, further comprising solder paste filling a space surrounded by the top surface of the first portion and inner walls of the second portion, wherein a vertical level of a top surface of the solder paste is higher than a vertical level of a top surface of the second portion, the top surface of the solder paste is inclined in the first horizontal direction, a minimum distance from the top surface of the second portion to the top surface of the solder paste is a first height, a maximum distance from the top surface of the second portion to the top surface of the solder paste is a second height, and a difference between the first height and the second height is less than or equal to 30 μm.
11. The electronic package device of claim 10, wherein the light-emitting device comprises a base and input/output pads disposed on an upper part of the base, the electronic package device further comprises connection wires disposed on a top surface of the flat plate of the package substrate, the electronic package device further comprises a first connecting member that directly connects one of the connection wires to one of the input/output pads, the electronic package device further comprises a second connecting member that directly connects another one of the connection wires to another one of the input/output pads, a vertical distance from a top surface of the base to the top of the first connecting member is a third height, a vertical distance from the top surface of the base to the top of the second connecting member is a fourth height, and a difference between the third height and the fourth height is less than or equal to 30 μm.
12. An electronic package device comprising: a package substrate comprising a flat plate and a pad on the flat plate, wherein a width of the flat plate in a first horizontal direction is greater than a width of the pad in the first horizontal direction; a light-emitting device on the package substrate, wherein the light-emitting device comprises a base, a plurality of phosphors disposed on the base and spaced apart from each other in the first horizontal direction, and a grid surrounding sidewalls of the plurality of phosphors; and solder paste positioned between the light-emitting device and the pad, wherein the pad comprises: a first portion; and a second portion disposed on a top surface of the first portion and arranged in a ring shape or an annular shape along an edge of the top surface of the first portion, the solder paste fills a space defined by the top surface of the first portion and inner walls of the second portion, and the plurality of phosphors are included in the solder paste from a plan view.
13. The electronic package device of claim 12, further comprising a plurality of light-emitting diodes positioned between each of the plurality of phosphors and the base.
14. The electronic package device of claim 12, wherein a vertical level of a top surface of the solder paste is substantially equal to a vertical level of a top surface of the second portion.
15. The electronic package device of claim 12, wherein a vertical height of the second portion is in a range from 10 μm to 500 μm.
16. The electronic package device of claim 12, wherein the width of the pad in the first horizontal direction is a first width, the width of the pad in a second horizontal direction intersecting the first horizontal direction is a second width, a minimum distance from an outer wall to an inner wall of the second portion is a third width, the second width is less than the first width, the third width is less than half of the second width, and the third width is greater than or equal to 50 μm.
17. The electronic package device of claim 12, wherein a vertical level of a top surface of the solder paste is higher than a vertical level of a top surface of the second portion, the top surface of the solder paste is inclined in the first horizontal direction, a minimum distance from the top surface of the second portion to the top surface of the solder paste is a first height, a maximum distance from the top surface of the second portion to the top surface of the solder paste is a second

height, and a difference between the first height and the second height is less than or equal to 30 μm.

18. The electronic package device of claim 17, wherein the light-emitting device further comprises input/output pads disposed on an upper part of the base, the electronic package device further comprises: connection wires disposed on a top surface of the flat plate of the package substrate, a first connecting member that directly connects one of the connection wires to one of the input/output pads, a second connecting member that directly connects another one of the connection wires to another one of the input/output pads, a vertical distance from the top surface of the base to the top of the first connecting member is a third height, a vertical distance from the top surface of the base to the top of the second connecting member is a fourth height, and a difference between the third height and the fourth height is less than or equal to 30 μm.

19. An electronic package device comprising: a package substrate comprising a flat plate and a pad on the flat plate, wherein a width of the flat plate in a first horizontal direction is greater than a width of the pad in the first horizontal direction; a light-emitting device on the package substrate, wherein the light-emitting device comprises a base, a plurality of phosphors disposed on the base and spaced apart from each other in the first horizontal direction, a grid surrounding sidewalls of the plurality of phosphors, and an input/output pad disposed on an upper part of the base; solder paste positioned between the light-emitting device and the pad; prepreg on a top surface of the flat plate, wherein the prepreg surrounds sides of the pad; a connection wire disposed within the prepreg; a connecting member that directly connects the connection wire to the input/output pad; and a molding member covering the connecting member, wherein the pad comprise: a first portion; and a second portion positioned on a top surface of the first portion and positioned at an edge of the top surface of the first portion, the solder paste fills a space defined by the top surface of the first portion and inner walls of the second portion, and a top surface of the second portion is in direct contact with a bottom surface of the light-emitting device.

20. The electronic package device of claim 19, wherein a vertical level of a top surface of the solder paste is substantially equal to a vertical level of a top surface of the second portion.