(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 February 2007 (01.02.2007)

PCT

(10) International Publication Number
WO 2007/013664 A1

(51) International Patent Classification:
H01L 33/00 (2006.01) ***G02F 1/13357*** (2006.01)
F21S 2/00 (2006.01) *F21Y 101/02* (2006.01)
F21V 29/00 (2006.01)

(21) International Application Number:
PCT/JP2006/315253

(22) International Filing Date: 26 July 2006 (26.07.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2005-217528 27 July 2005 (27.07.2005) JP
60/704,877 3 August 2005 (03.08.2005) US

(71) Applicant *(for all designated States except US)*: **SHOWA DENKO K.K.** [JP/JP]; 13-9, Shiba Daimon 1-chome, Minato-ku, Tokyo 105-8518, Japan (JP).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **SHINOZAKI, Kenji** [JP/JP]; c/o Showa Denko K.K., 1-1, Ohonodai 1-chome, Midori-ki, Chiba-shi, Chiba 267-0056 (JP).

(74) Agents: **OHIE, Kunihisa** et al.; OHIE Patent Office, Selva-Ningyocho 6F, 14-6, Nihonbashi-Ningyocho 2-chome, Chuo-ku, Tokyo 103-0013 (JP).

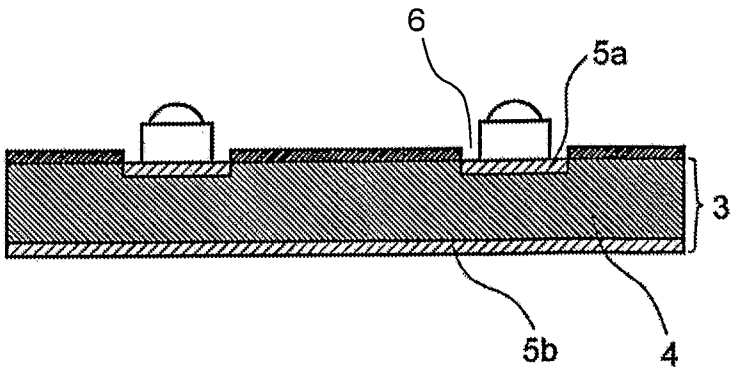
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: LIGHT-EMITTING DIODE LIGHT SOURCE



(57) Abstract: According to the light source equipped with light-emitting diode elements of the present invention, the substrate (1) for mounting light-emitting diode elements (7) comprises a circuit board (2) and a heatsink plate (3) and the heatsink plate (3) is formed from at least two materials having different heat conductivity and has an excellent balance of heat radiation performance and light weight. The present invention also provides a display device, a lighting equipment and a backlight for a liquid crystal display using the light source.

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DESCRIPTION

Light-Emitting Diode Light Source

CROSS-REFERENCE TO RELATED APPLICATIONS

This is an application filed pursuant to 35 U.S.C. Section 111(a) with claiming the benefit of U.S. provisional application Serial No. 60/704,877 filed August 3, 2005 under the provision of 35 U.S.C. 111(b), pursuant to 35 U.S.C. Section 119(e)(1).

TECHNICAL FIELD

The present invention relates to a light source equipped with light emitting diode elements. Specifically, the present invention relates to a light source equipped with light emitting diode elements, which enables efficient dissipation of the heat generated from the light-emitting diode, a display device or a lighting equipment using the light source and to a back-lighting for a liquid crystal display using the lighting equipment.

BACKGROUND ART

Recently, light emitting diode (LED) elements have been improved remarkably in terms of light emitting efficiency and have advanced to the practical stage for use in illumination and lighting. Specifically, using a light emitting diode as a backlight for a liquid crystal display can realize good color reproducibility and fast response, which enables to expect the achievement of better image quality. Also, as being free from mercury, a light emitting diode is environmentally-friendly, and has grown in use for interior light of automobiles and for a light source of headlights.

However, since a light emitting diode element yields a large amount of heat along with light emission, in a conventional method wherein LED lamps are arranged being packed (mounted) in respective packages, there was high thermal resistance from a light emitting diode element to a substrate and heat dissipation was insufficient. Accordingly, rise in so-called junction temperature of the light-emitting diode element was inevitable, which leads to a short life span of the light-emitting diode element and thereby to a short life span of the whole backlight unit. Therefore, rise in the junction temperature has been prevented by providing a powerful cooling means. However, the volume of such a cooling means is large, which makes the backlight unit larger and leads to seriously undermining the merchantability of a flat panel display such as a liquid crystal display. It also leads to increase in power consumption for cooling.

In recent years, a method of mounting light-emitting diode elements directly on a radiator plate (heatsink) has been devised in order to solve these problems (See Japanese Laid-Open Patent Publication No. H06-318770). In this method, as shown in Fig. 12 which depicts a partial sectional side view of an example, openings (6) are formed on the circuit board (2), at which the heatsink plate (3) is exposed. Placing light-emitting diode elements (7) in the opening enables to conduct heat directly to the heatsink plate without intervention by the insulating resin layer (8) which has much lower heat conductivity. Aluminum or copper is used as a material for the heatsink plate (3) from the viewpoint of heat conductivity, cost and workability. Although copper is the most preferable in terms of heat conductivity, the specific gravity of copper is about three times as large as that of aluminum, which causes a problem that the heatsink plate becomes heavier.

DISCLOSURE OF THE INVENTION

An object of the present invention is to develop a light source equipped with light-emitting diode elements which enables rapid dissipation of the heat generated by the light-emitting diode, and to provide a display device and lighting equipment using the light source and a backlight for a liquid crystal display using the lighting equipment.

The present inventors have found that a lightweight light source which is excellent in radiation performance can be produced by constructing the substrate on which light-emitting diode elements are mounted of a circuit board and a heatsink plate, and making up the heatsink plate from layers of at least two materials having different heat conductivity (a highly heat-conductive material and a low heat-conductive material).

That is, the present invention relates to a light source equipped with light-emitting diode elements, a display device, a lighting equipment and a backlight for a liquid crystal display described bellow.

1. A light source equipped with light-emitting diode elements, wherein a substrate on which light-emitting diode elements are mounted comprises a circuit board and a heatsink plate, and the heatsink plate is formed from at least two materials having different heat conductivity.

2. The light source equipped with light-emitting diode elements as described in 1 above, wherein the heatsink plate comprises a substrate made of a low heat-conductive material and a highly heat-conductive material which is provided by patterning on the surface of the substrate opposite to the circuit board.

3. The light source equipped with light-emitting diode elements as described in 1 above, wherein the light-emitting diode elements are located on a low heat-conductive material exposed on the circuit board.

4. The light source equipped with light-emitting diode elements as described in 1 above, wherein the light-emitting diode elements are located on a highly heat-conductive material exposed on the circuit board.

5. The light source equipped with light-emitting diode elements as described in 1 above, wherein the light-emitting diode elements are located on a highly heat-conductive material exposed on the circuit board; and the heatsink plate comprises a substrate made of a low heat-conductive material and a highly heat-conductive material which is provided by patterning on the surface of the substrate opposite to the circuit board.

6. The light source equipped with light-emitting diode elements as described in 5 above, wherein the highly heat-conductive material on which the light-emitting diode elements are located and the pattern-formed portion made of a highly heat-conductive material are connected by a highly heat-conductive material filled in through-holes perforated through the substrate made of a low heat-conductive material.

7. The light source equipped with light-emitting diode elements as described in any one of 1 to 6 above, wherein the highly heat-conductive material is copper and the low heat-conductive material is at least one of aluminum and aluminum nitride.

8. The light source equipped with light-emitting diode elements as described in 1 above, wherein a heat dissipation member is provided on the heatsink plate.

9. The light source equipped with light-emitting diode elements as described in 8 above, wherein the heat dissipation member is a radiating fin.

10. The light source equipped with light-emitting diode elements as described in 8 above, wherein the heat dissipation member is a heat pipe.

11. The light source equipped with light-emitting diode elements as described in 8 above, wherein the heat dissipation member is a refrigerant circulation.

12. A display device using the light source as described in any one of 1 to 11 above.

13. A lighting equipment using the light source as described in any one of 1 to 11 above.

14. A backlight for a liquid crystal display provided with the lighting equipment as described in 13 above.

15. A liquid crystal display provided with the backlight as described in 14 above.

16. A light source equipped with light-emitting diode elements, wherein a substrate on which light-emitting diode elements are mounted comprises a circuit board and a heatsink plate, and the heatsink plate is formed from a first heat-conductive material and a second heat-conductive material having higher heat conductivity than that of the first material.

17. The light source equipped with light-emitting diode elements as described in 16 above, wherein the heatsink plate comprises a substrate made of the first material and the second material which is provided by patterning on the surface of the substrate opposite to the circuit board.

18. The light source equipped with light-emitting diode elements

as described in 16 above, wherein the light-emitting diode elements are located on the first material exposed on the circuit board.

19. The light source equipped with light-emitting diode elements as described in 16 above, wherein the light-emitting diode elements are located on the second material exposed on the circuit board.

20. The light source equipped with light-emitting diode elements as described in 16 above, wherein the light-emitting diode elements are located on the second material exposed on the circuit board; and the heatsink plate comprises a substrate made of the first material and the second material which is provided by patterning on the surface of the substrate opposite to the circuit board.

21. The light source equipped with light-emitting diode elements as described in 20 above, wherein the second material on which the light-emitting diode elements are located and the pattern-formed portion made of the second material are connected by the second material filled in through-holes perforated through the substrate made of the first material.

22. The light source equipped with light-emitting diode elements as described in any one of 16 to 21 above, wherein the first material is at least one of aluminum and aluminum nitride and the second material is copper.

EFFECTS OF INVENTION

Since the light source of the present invention is compact and lightweight and excellent in heat dissipation, it enables to prolong operating life of the light-emitting diode elements and to make cooling means smaller and thereby reduce the cost.

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, the present invention will be described in more

detail by referring to the attached drawings.

The present invention relates to a light source equipped with light-emitting diode elements, which is characterized in that the substrate on which the light-emitting diode elements are mounted comprises a circuit board and a heatsink plate and that the heatsink plate comprises at least two materials different in heat conductivity; i.e., a low heat-conductive material and a highly heat-conductive material. The materials different in heat conductivity preferably constitute a laminate body having at least two layers.

Members constituting the light source equipped with light-emitting diode elements of the present invention include a light-emitting diode element, a substrate comprising a circuit board and a heatsink plate on which the light-emitting diode element is mounted, molding resin to seal the light-emitting diode element mounted on the substrate and cooling means for further improving heat dissipation performance.

The light-emitting LED diode elements used for the present invention may be selected according to purposes of the light source. For example, LED which has a high degree of color reproducibility is desirable to be used for a light source of a backlight for a liquid crystal display. One of the preferable examples is one wherein a plurality of blue, green and red light-emitting diode elements are arranged on the same board. Also, for a white light source for illumination, it is preferable to provide light-emitting diode elements of neutral colors such as yellow and orange besides the above-mentioned blue, green and red ones on the same board or to use a white light source comprising a combination of light-emitting diode elements of blue or near-ultraviolet and a fluorescent

substance.

It is preferable that the substrate of the present invention on which plural light-emitting diode elements are provided is composed of a circuit board and a heatsink plate. The circuit board is the substrate, on which a circuit is formed in order to apply electricity to the light-emitting diode elements and to which the cathode and anode of the light-emitting diode element are connected. The methods for obtaining the circuit board include a method of laminating a circuit board such as a glass epoxy substrate on a heatsink plate; and a method of coating the heatsink plate with an insulating resin, laminating a copper foil thereon and etching the copper foil in a circuit pattern.

The heatsink plate is intended for dissipating the heat generated from the light-emitting diode elements by laminating the heatsink plate made of a highly heat-conductive material on a side of the circuit board where the circuit is not formed. In the present invention, a heatsink plate comprising at least two materials different in heat conductivity (a highly heat-conductive material and a low heat-conductive material) is used. Preferable examples of the materials different in heat conductivity include metal and highly heat-conductive ceramics. The metal is preferably aluminum, copper, stainless or the like. The highly heat-conductive ceramics is preferably aluminum nitride. As a widely useful material, copper is preferable in terms of heat dissipation since it has a high heat conductivity but copper is not preferable from the viewpoint of weight saving due to its large specific gravity. The most preferable material is a combination of copper and aluminum. That is, the material most preferable from the viewpoint of heat dissipation and weight-saving is a composite material combining

copper as a highly heat-conductive material and at least one of aluminum and aluminum nitride as a low heat-conductive material.

As a method for placing plural light-emitting diode elements on a circuit board, it is preferable from the viewpoint of heat dissipation performance to place the diode element on the heatsink plate in the form of a so-called bare chip using some means for bonding instead of using a packaged device so that the light-emitting diode element directly contacts the heatsink. Specifically, through-holes are provided in the portion of the circuit board where the light-emitting diode elements are to be placed so that the heatsink plate is exposed at the through-holes when the heatsink plate and the circuit board are laminated, and the light-emitting diode elements are placed on the exposed heatsink plate. For the bonding, means having lower thermal resistance is preferable and includes, for example, silver paste and heat conductive silicone grease. The light-emitting diode elements can be electrically connected to the circuit board, for example, by wire-bonding.

It will be understood that bare chips which are not packaged should be protected in wire-bonding portion with molding resin. Such a molding resin is preferably a thermosetting transparent resin, particularly a transparent epoxy resin.

Examples of transparent epoxy resin include epoxy resin such as bisphenol-A diglycidyl ether, 2,2-bis(4-glycidyloxycyclohexyl)propane, 3,4-epoxycyclohexylmethyl-3,4-epoxyhexane carboxylate, vinylcyclohexene dioxide, 2-(3,4-epoxycyclohexane)-5,5-spiro(3,4-epoxycyclohexane)-1,3-dioxane, bis(3,4-epoxycyclohexyl) adipate, 1,2-cyclopropanedicarboxylic acid bisglycidyl ester, triglycidyl isocyanurate, monoallyldiglycydyl isocyanurate and diallylmonoglycidyl isocyanurate. Generally, these

resins are to be cured by acid anhydride such as hexahydrophthalic anhydride, methylhexahydrophthalic anhydride, trialkyltetrahydrophthalic anhydride, hydrogenated methylnadic anhydride. These epoxy resins and curing agent may be used singly or in combination of two or more thereof.

A preferable method for molding with a transparent resin is performed by dripping from a dispenser. A concave portion may be formed by laminating another substrate onto a circuit board and making holes in the substrate where LEDs are to be located.

There are several embodiments for composing a heatsink plate by combination of materials different in heat conductivity, examples of which include 1 to 4 mentioned below. The embodiments will be described by referring to the attached drawings showing examples of the light source equipped with light-emitting diode elements of the present invention.

1) An embodiment wherein a light-emitting diode element (7) is placed on a low heat-conductive material (4) which constitutes a heatsink plate (3), and a layer comprising a highly heat-conductive material (5) is formed on the side (bottom surface) of the heatsink plate (3) opposite to the side on which light-emitting diode elements are placed as shown in a sectional side view as exemplified in Fig. 1. In this case, a pattern comprising a highly heat-conductive material may be formed on the bottom surface (see Fig. 2).

2) An embodiment wherein light-emitting diode elements (7) are placed directly on a highly heat-conductive material (5) constituting a heatsink plate (3) which is exposed in the openings (6) formed in a circuit board (2), and a lightweight low heat-conductive material (4) is located around the elements as

shown in a sectional side view as exemplified in Fig. 3. In this case, a highly heat-conductive material (5) may be formed not only in the openings (6) as shown in Fig. 3 but also on the entire or at least part of the surface of the heatsink plate (3) including the openings (6).

Further, there are the following embodiments combining 1 and 2 above:

3) An embodiment wherein a substrate made of a lightweight low heat-conductive material (4) is located under a highly heat-conductive material (5a) on which light-emitting diode elements are placed, and a layer or pattern comprising of a highly heat-conductive material (5b) is formed on the low heat-conductive material substrate (4) as shown in a sectional side view of Fig. 4. In this case, a highly heat-conductive material (5) may be formed not only in the openings (6) as shown in Fig. 4 but also on the entire or at least part of the surface of the heatsink plate (3) including the openings (6).

4) An embodiment wherein, in 3) above, the highly heat-conductive material (5a) on which light-emitting diode elements (7) is located and the highly heat-conductive material (5b) located on the underside thereof are connected by a highly heat-conductive material (5c) filled in the through-holes perforated through the low heat-conductive material (4) that exists between (5a) and (5b) (refer to Fig. 5). In this case, a highly heat-conductive material (5a) may be formed not only in the openings (6) as shown in Fig. 5 but also on the entire or at least part of the surface of the heatsink plate (3) including the openings (6).

The form of the pattern provided on a heatsink plate (3) is not particularly limited, but preferable examples include a mesh

pattern. When using a material having a large specific gravity such as copper as a highly heat-conductive material, forming a pattern partially as in a case of a mesh pattern is more advantageous in weight saving than forming an all-overlaying pattern.

Furthermore, as shown in Fig.13, heat dissipation can be further improved by providing cooling means on the side opposite to the circuit side of the heatsink plate (3). The cooling means (10) include a radiating fin, a heat pipe and refrigerant circulation. A fan may be provided if desired.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional side view showing an example of the light source of the present invention equipped with light-emitting diode elements, which is constituted by a substrate (1) comprising a circuit board (2) and a heatsink plate (3) on which substrate light-emitting diode elements (7) are mounted.

Fig. 2 is a bottom view of Fig. 1.

Fig. 3 is a sectional side view showing another example of the light source equipped with light emitting diode elements of the present invention.

Fig. 4 is a sectional side view showing another example of the light source equipped with light emitting diode elements of the present invention.

Fig. 5 is a sectional side view showing another example of the light source equipped with light emitting diode elements of the present invention.

Fig. 6 is a plan view of the backlight of Example 1 wherein four linear light sources equipped with four light emitting diode elements were placed.

Fig. 7 is a schematic plan view of the plane light source substrate of the present invention.

Fig. 8 is a rear view of Fig. 7.

Fig. 9 is a cross-sectional view along the line B-B of Fig. 7.

Fig. 10 is a plan view of the back-light of Example 2.

Fig. 11 is a schematic plan view of the light source of Example 3.

Fig. 12 is a schematic cross-sectional view of a light source equipped with conventional light emitting diode elements.

Fig. 13 is a sectional side view showing an example of the light source of the present invention equipped with cooling means.

EXAMPLES

Hereinafter, the present invention will be described in more detail by referring to Examples and Comparative Examples. However, the present invention should not be construed as being limited thereto.

Example 1:

A heatsink plate (3) shown in a sectional side view of Fig. 1 was prepared. An aluminum substrate (dimension: 12 x 120 mm, thickness: 1 mm) was used as a low heat-conductive material (4), and a mesh pattern comprising a copper highly heat-conductive material (5) (thickness: 0.1 mm) was formed on the bottom surface of the substrate by electrolytic plating to thereby make a heatsink plate (3). On the upper surface of the heatsink plate (3), a circuit board (2) obtained by etching a copper foil (thickness: 0.1 mm) was provided through an insulating resin layer (not shown in the figure). Five openings (6) each having a size of 8 x 10 mm were perforated on the circuit board (2) at the same interval at which the heatsink

plate (3) was exposed. Five LED lamps (NCCW023, produced by Nichia Corporation) as light-emitting diode elements (7) were placed in the above-mentioned openings (6) directly on the heatsink plate (3) using a heat conducting adhesive to thereby produce a linear light source.

The thus-obtained four linear light sources were placed on the bottom surface of a box container for a backlight having outside dimensions of 270 x 200 mm and a depth of 30 mm formed with an aluminum plate (thickness: 1.2 mm). The schematic layout is shown in Fig. 6. As for bonding of the linear light source, heat conductive silicone grease (oil compound G-751, produced by Shin-Etsu Chemical Co., Ltd.) was used.

The obtained box container was placed in a constant-temperature bath at 25°C and constant current of 300mA was passed through all the LEDs. In this case, holes were made in the backlight container at the position immediately below the LED chips, a thermocouple was inserted in the holes so that the tips of the thermocouple came in contact with the heatsink plate (3). The temperature measured after passing electric current for two hours was about 76°C.

Comparative Example 1:

A linear light source was produced in the same way as in Example 1 except that a mesh pattern comprising a copper highly heat-conductive material (5) was not formed. The temperature measured after passing electric current in the same way as in Example 1 was 88°C at the position immediately below the LED chip.

Example 2:

As a heatsink plate (3), an aluminum substrate (dimensions:

80 x 120 mm, thickness: 1.0 mm) was used as a low heat-conductive material (4), and, on the bottom surface thereof, a mesh pattern comprising a copper highly heat-conductive material (5) (thickness: 0.1 mm) was formed in the same way as in Example 1 to thereby make a heatsink plate (3). On the upper surface of the heatsink plate (3), a circuit board (2) obtained by etching a copper foil (thickness: 0.1 mm) was provided through an insulating resin layer (not shown in the figure). Six openings (6) having a size of 5 x 5 mm and passing through the circuit board (three openings in two rows) were perforated in the circuit board (2), in which six LED chips were placed using silver paste.

The LED chips having a size of 1 mm square were placed in two rows in the order of red (TOA-1000, produced by SHOWA DENKO K. K.), green (produced by ITSWELL Co., Ltd.) and blue one (produced by ITSWELL Co., Ltd.) from the left to the right. An anode and a cathode were connected to the pad parts of the circuit board (2) by a wire bonder. Subsequently, a transparent epoxy resin (5) (NLD-L-645, produced by Sanyu Rec Co., Ltd.) was dropped from a dispenser to thereby form a lenticular molding portion (9) as shown in Fig. 9. A schematic plan view and a rear view of the obtained plane light source substrate are shown in Fig. 7 and Fig. 8 respectively. A cross-sectional view along the line B-B of Fig. 7 is also shown in Fig. 9.

The four produced plane light source substrates were put in the same container for a backlight as that in Example 1, and bonded on the bottom surface using heat conductive silicone grease (oil compound G-751, produced by Shin-Etsu Chemical Co., Ltd.). The schematic layout of the produced plane light source is shown in Fig. 10.

The obtained plane light source was placed in a constant-temperature bath at 25°C and constant current of 300mA was passed through all the LEDs. In this case, holes were made in the aluminum plate of the backlight container at the position immediately below the LED chips, a thermocouple was inserted in the holes so that the tips of the thermocouple came in contact with the heatsink plate (3). The temperature measured after passing electric current for two hours was about 66°C.

Comparative Example 2:

A plane light source was produced in the same way as in Example 2 except that a mesh pattern comprising a copper highly heat-conductive material (5) was not formed. The temperature measured after passing electric current in the same way as in Example 1 was 78°C at the position immediately below the LED chip.

Example 3:

Using as a first heatsink plate (3) a copper substrate having a size of 75 x 55 mm and a thickness of 0.7 mm comprising a highly heat-conductive material (5), a circuit board (2) obtained by etching a copper foil (thickness: 0.1 mm) was provided on the upper surface of the first heatsink plate (3) through an insulating resin layer (not shown in the figure). Three openings (6) having a size of 5 x 5 mm passing through the circuit board were perforated in the circuit board (2), in which three LED chips were placed using silver paste. The LEDs the size of 1 mm square were placed in the order of red (TOA-1000, produced by SHOWA DENKO K. K.), green (produced by ITSWELL Co., Ltd.) and blue one (produced by ITSWELL Co., Ltd.) from the left to the right. An anode and a cathode were connected to the

pad parts of the circuit board (2) by a wire bonder. Subsequently, a transparent epoxy resin (5) (NLD-L-645, produced by Sanyu Rec Co., Ltd.) was dropped from a dispenser to thereby form a lenticular molding portion (9) as shown in Fig. 9. The schematic plan view of the produced light source is shown in Fig. 11. Pairs of the produced plane light sources were bonded side-by-side on a second heatsink plate having a size of 80 x 120 mm and a thickness of 1 mm comprising an aluminum low heat-conductive material (4). On the bottom surface of the low heat-conductive material (4), the same mesh pattern made by copper as that in Example 2 was formed. That is, the heatsink plate (3) comprises a first heatsink plate, a second heatsink plate and a mesh pattern laminated in this order from the circuit board, and has a structure wherein a low heat-conductive material (4) is sandwiched by a highly heat-conductive material (5).

A plane light source similar to that in Example 2 was produced using four of the obtained plane light source substrates. The temperature measured after passing electric current in the same way as in Example 1 was 60°C at the position immediately below the LED chip.

Comparative Example 3:

LED boards were produced in the same way as in Example 3 except that an aluminum substrate was used instead of the copper substrate. The temperature measured after passing electric current in the same way as in Example 1 was 76°C at the position immediately below the LED chip.

Example 4:

A test was performed in the same way as in Example 3 except for using LED boards in which six openings of 5 mm square were perforated through the aluminum heatsink plate (3) on which a copper substrate was placed at the position immediately below each of the LED lamps and the openings were filled up with copper. The temperature measured was 58°C at the position immediately below the LED chip.

Example 5:

Six aluminum radiating fin units were provided under the bottom surface of the aluminum heatsink plate (3) in exactly the same plane light source as in Example 4. Each fin unit had an entire size of 15 x 15 mm and 10 mm high and contained ten fins having a thickness of 0.5 mm. The temperature measured after passing electric current in the same way as in Example 4 was 51°C at the position immediately below the LED chip.

Example 6:

Using the plane light source produced in Example 4, two linear heat pipes having a length of 260 mm and a cross-sectional area of 2 x 5.3 mm (CW04G-F, produced by Furukawa Electric Co., Ltd.) were screwed so that the pipes ran across the position immediately below the LED chip beneath the heatsink plate (3). The temperature measured after passing electric current in the same way as in Example 4 was 49°C at the position immediately below the LED chip.

CLAIMS

1. A light source equipped with light-emitting diode elements, wherein a substrate on which light-emitting diode elements are mounted comprises a circuit board and a heatsink plate, and the heatsink plate is formed from at least two materials having different heat conductivity.

2. The light source equipped with light-emitting diode elements according to claim 1, wherein the heatsink plate comprises a substrate made of a low heat-conductive material and a highly heat-conductive material which is provided by patterning on the surface of the substrate opposite to the circuit board.

3. The light source equipped with light-emitting diode elements according to claim 1, wherein the light-emitting diode elements are located on a low heat-conductive material exposed on the circuit board.

4. The light source equipped with light-emitting diode elements according to claim 1, wherein the light-emitting diode elements are located on a highly heat-conductive material exposed on the circuit board.

5. The light source equipped with light-emitting diode elements according to claim 1, wherein the light-emitting diode elements are located on a highly heat-conductive material exposed on the circuit board; and the heatsink plate comprises a substrate made of a low heat-conductive material and a highly heat-conductive material which

is provided by patterning on the surface of the substrate opposite to the circuit board.

6. The light source equipped with light-emitting diode elements according to claim 5, wherein the highly heat-conductive material on which the light-emitting diode elements are located and the pattern-formed portion made of a highly heat-conductive material are connected by a highly heat-conductive material filled in through-holes perforated through the substrate made of a low heat-conductive material.

7. The light source equipped with light-emitting diode elements according to any one of claims 1 to 6, wherein the highly heat-conductive material is copper and the low heat-conductive material is aluminum and/or aluminum nitride.

8. The light source equipped with light-emitting diode elements according to claim 1, wherein a heat dissipation member is provided on the heatsink plate.

9. The light source equipped with light-emitting diode elements according to claim 8, wherein the heat dissipation member is a radiating fin.

10. The light source equipped with light-emitting diode elements according to claim 8, wherein the heat dissipation member is a heat pipe.

11. The light source equipped with light-emitting diode elements

according to claim 8, wherein the heat dissipation member is a refrigerant circulation.

12. A display device using the light source as described in any one of claims 1 to 11.

13. A lighting equipment using the light source as described in any one of claims 1 to 11.

14. A backlight for a liquid crystal display provided with the lighting equipment as described in claim 13.

15. A liquid crystal display provided with the backlight as described in claim 14.

16. A light source equipped with light-emitting diode elements, wherein a substrate on which light-emitting diode elements are mounted comprises a circuit board and a heatsink plate, and the heatsink plate is formed from a first heat-conductive material and a second heat-conductive material having higher heat conductivity than that of the first material.

17. The light source equipped with light-emitting diode elements as claimed in claim 16, wherein the heatsink plate comprises a substrate made of the first material and the second material which is provided by patterning on the surface of the substrate opposite to the circuit board.

18. The light source equipped with light-emitting diode elements

as claimed in claim 16, wherein the light-emitting diode elements are located on the first material exposed on the circuit board.

19. The light source equipped with light-emitting diode elements as claimed in claim 16, wherein the light-emitting diode elements are located on the second material exposed on the circuit board.

20. The light source equipped with light-emitting diode elements as claimed in claim 16, wherein the light-emitting diode elements are located on the second material exposed on the circuit board; and the heatsink plate comprises a substrate made of the first material and the second material which is provided by patterning on the surface of the substrate opposite to the circuit board.

21. The light source equipped with light-emitting diode elements as claimed in claim 20, wherein the second material on which the light-emitting diode elements are located and the pattern-formed portion made of the second material are connected by the second material filled in through-holes perforated through the substrate made of the first material.

22. The light source equipped with light-emitting diode elements as claimed in any one of claims 16 to 21, wherein the first material is at least one of aluminum and aluminum nitride and the second material is copper.

Fig. 1

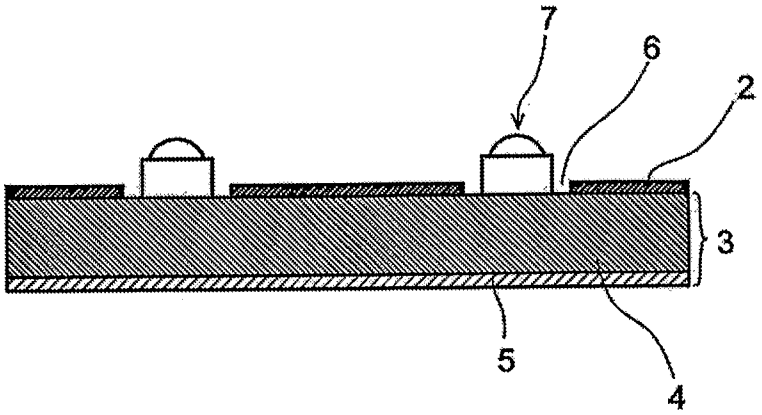


Fig. 2

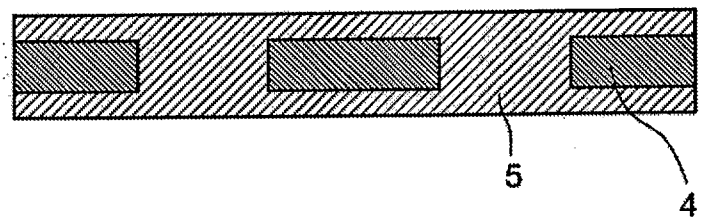


Fig. 3

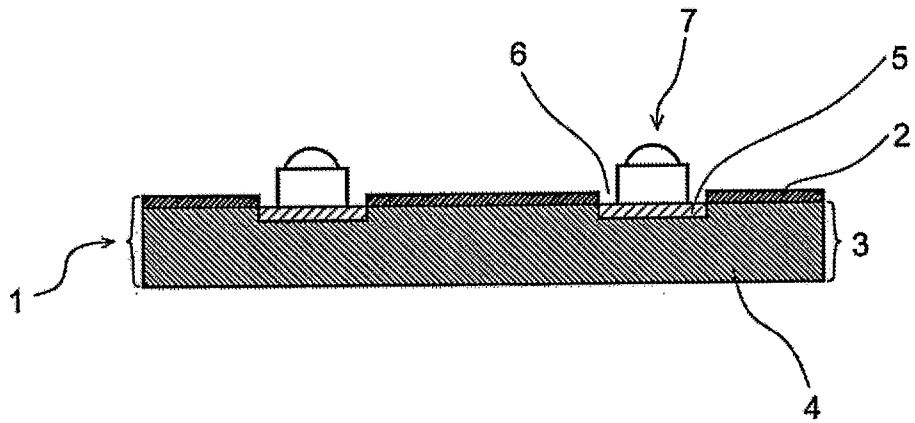


Fig. 4

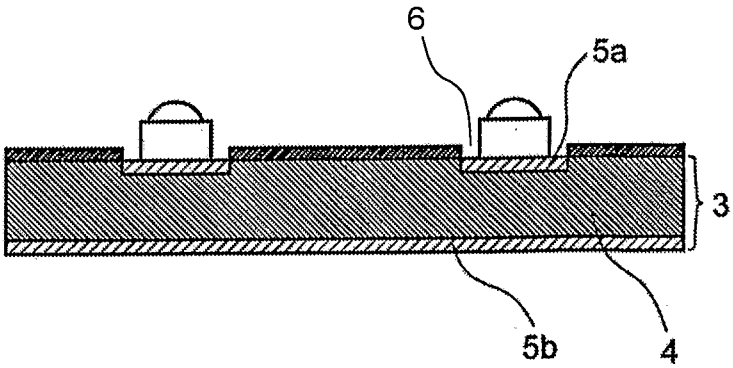


Fig. 5

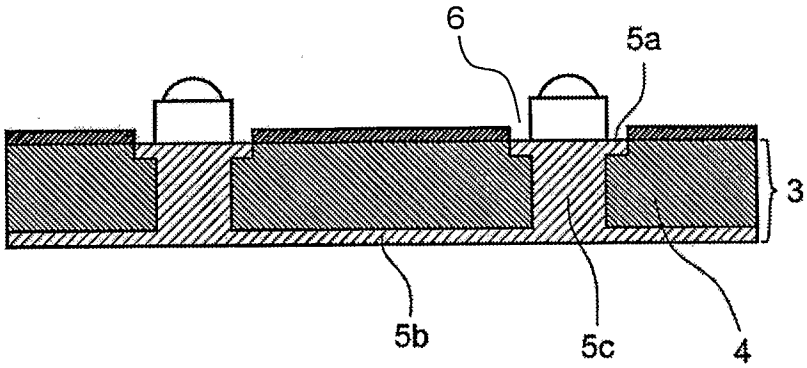


Fig. 6

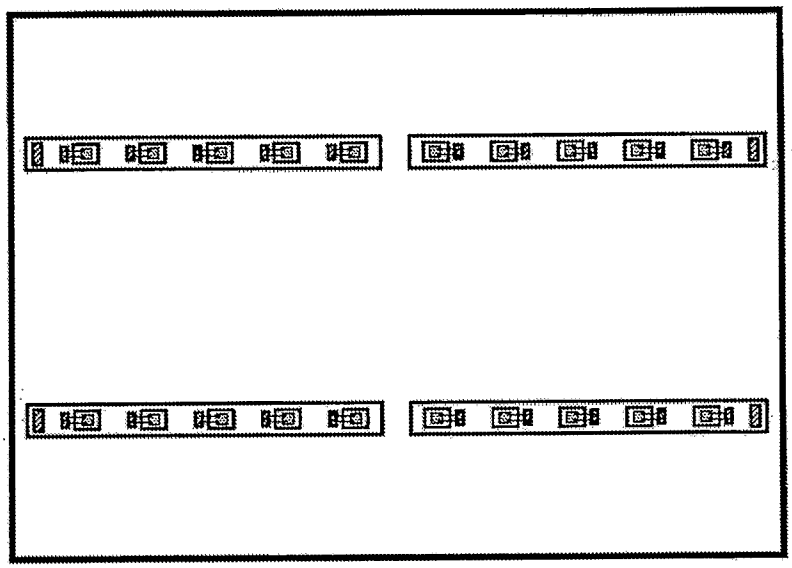


Fig. 7

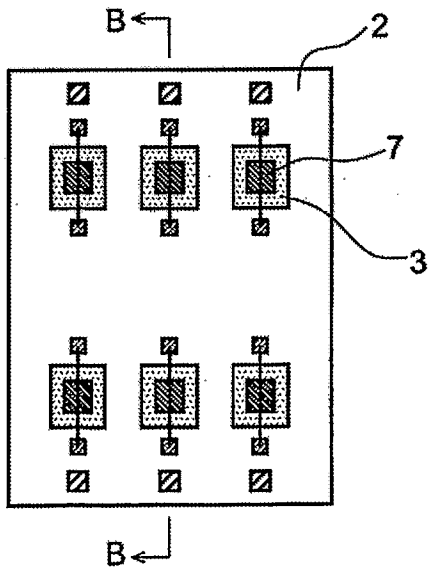


Fig. 8

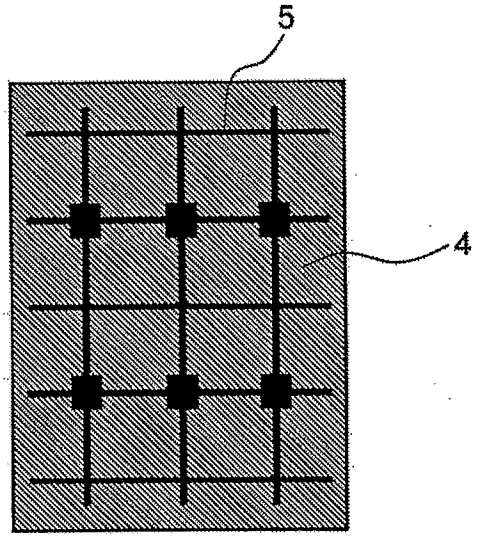


Fig. 9

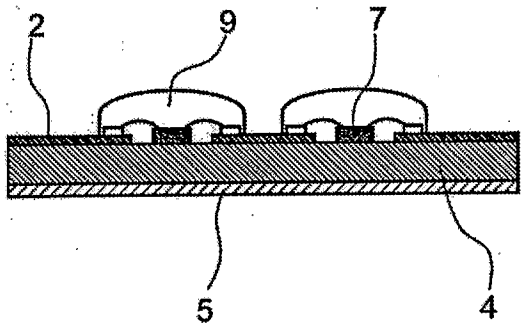


Fig. 10

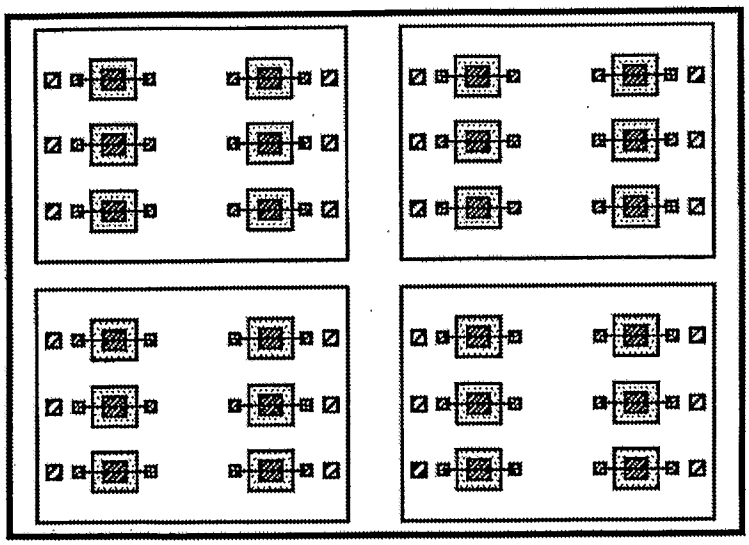


Fig. 11

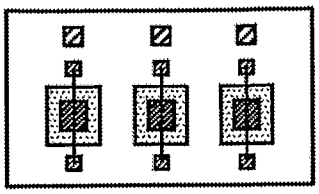


Fig. 12

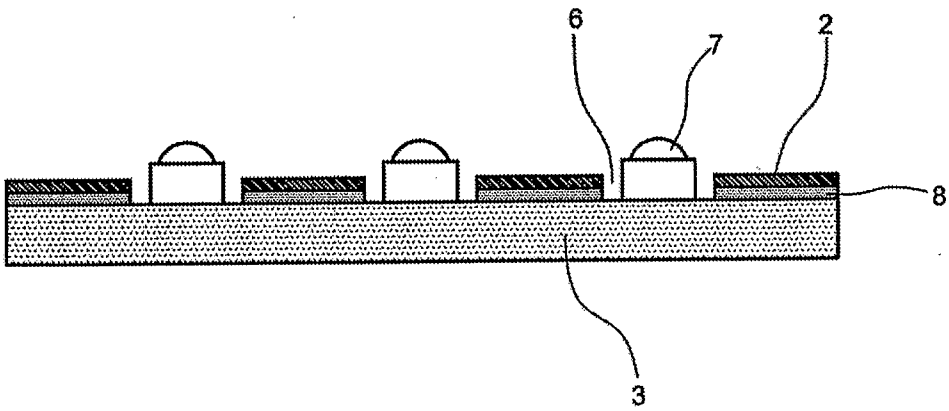
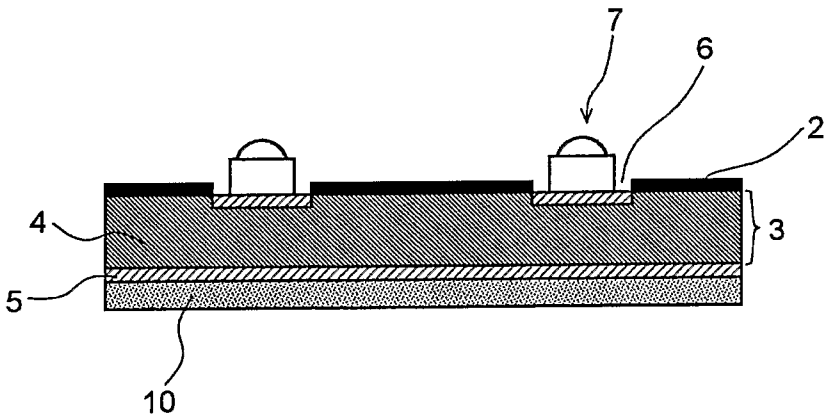


Fig. 13



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/315253

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H01L33/00(2006.01)i, F21S2/00(2006.01)i, F21V29/00(2006.01)i, G02F1/13357(2006.01)i, F21Y101/02(2006.01)n

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. H01L33/00, F21S2/00, F21V29/00, G02F1/13357, F21Y101/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2006
Registered utility model specifications of Japan 1996-2006
Published registered utility model applications of Japan 1994-2006

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2005/0023538 A1 (Citizen Electronics Co., Ltd.) 2005.02.03, Fig.7 & JP 2005-050838 A & CN 1591924 A	1-22
Y	WO 2004/082036 A1 (TOYODA GOSEI CO., LTD.) 2004.09.23, p12 Line42-p13 Line4 & US 2005-0161771 A1 & EP 1603170 A1	2,3,5,17,20
Y	JP 55-132048 A (Tokyo Shibaura Denki Kabushiki Kaisha) 1980.10.14, p1 Right lower column Line9 - p2 Left upper column line5, Fig.2 & EP 48768 A & US 4542401 A & DE 3071367 G	1,2,4-22
Y	US 2002/0050397 A1 (Noriaki Sakamoto et. al.) 2002.05.02, [0088]-[0096], Fig.5A & JP	4,6-15,19,22

☑ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
24.08.2006	05.09.2006

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Kashimoto Eigo Telephone No. +81-3-3581-1101 Ext. 3255

2K 9609

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INTERNATIONALSEARCHREPORT

International application No.
PCT/JP2006/315253

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	2002-134555 A & EP 1202349 A2 & TW 507478 A & CN 1351376 A & KR 2002-032274 A	
Y	US 2004/0227145 A1 (Tomoaki Abe et. al.) 2004.11.18, [0019]-[0022], [0035], Fig.2, Fig.5 & JP 2004-342870 A	4,6,7,19,21, 22
Y	US 2004/0169451 A1 (Nodoka Oishi et. al.) 2004.09.02, [0080], Fig.8 & JP 2004-265986 A & DE 102004009998 A1 & CN 1617362 A	10,11