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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 November 2005 (17.11.2005)

PCT

(10) International Publication Number
WO 2005/109529 A1

(51) International Patent Classification[7]: H01L 33/00

(21) International Application Number:
PCT/IB2005/051444

(22) International Filing Date: 3 May 2005 (03.05.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
04101978.7 7 May 2004 (07.05.2004) EP

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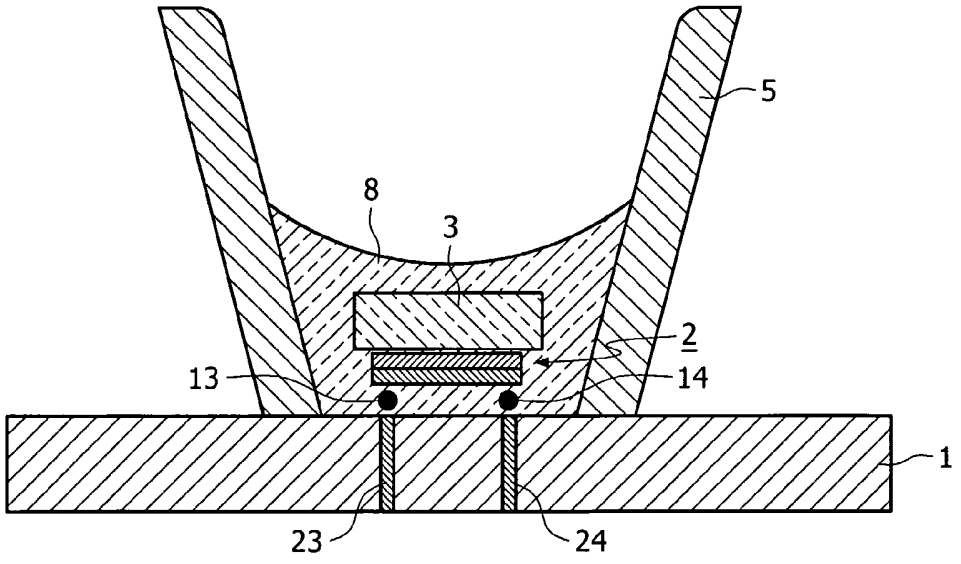
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK,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

[Continued on next page]

(54) Title: LIGHT-EMITTING-DIODE CHIP PACKAGE AND A COLLIMATOR



(57) Abstract: A high-temperature light-emitting-diode chip package has a base (1), at least one light-emitting-diode chip (2) disposed on the base, and a collimator (5) for collimating the light emitted by the light-emitting-diode chip. The collimator and the base are made from a ceramic material capable of withstanding temperatures above 250°C. Preferably, the ceramic material is aluminum oxide, aluminum nitride, or aluminum silicate. Preferably, the collimator is made from or is coated with mullite, $3Al_2O_3.2SiO_2$, with a diffuse reflectivity above 99%. Preferably, the light-emitting-diode chip package comprises a light-coupling medium (8) for transferring light from the light-emitting-diode chip to the collimator, the light-coupling medium (8) being made of glass.

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FR, GB, GR, HU, IE, IS, IT, LT, LU, 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).

Declaration under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations 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, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)*

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

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Light-emitting-diode chip package and a collimator

The invention relates to a light-emitting-diode chip package comprising at least one light-emitting-diode chip and a collimator for collimating the light emitted by the light-emitting-diode chip.

The invention also relates to a collimator for use in the light-emitting-diode chip package.

Such light-emitting-diode chip packages are known conventionally. They are used as light sources, inter alia, in backlight-emitting panels in (picture) display devices, for example for TV sets and monitors. Such light-emitting-diode chip packages are particularly suitable for use as light sources in backlights for non-emissive displays such as liquid crystal display devices, also denoted LCD panels, which are used in (portable) computers or (portable) telephones.

Such light-emitting-diode chip packages are also used as light sources in luminaires for general lighting purposes or for shop lighting, for example shop window lighting or lighting of (transparent or semi-transparent) plates of glass or of (transparent) plates of glass or of (transparent) synthetic resin on which items, for example jewelry, are displayed. Such light-emitting-diode chip packages are further used as light sources for window panes, for example for causing a glass wall to radiate light under certain conditions, or to reduce or block out the view through the window by means of light. A further alternative application is the use of such light-emitting-diode chip packages as light sources for illuminating advertising boards. In addition, the light-emitting-diode chip packages can be used for interior lighting, in particular for home lighting.

A light-emitting-diode chip package is known from US patent application US-A 2003/0 076 034. The known light-emitting-diode chip package includes a base, an array of LED chips disposed on the base, and a collimator mounted on the base, over the array of light-emitting-diode chips. The collimator is generally configured as a rectangular, horn-like member and typically includes walls that collimate the light emitted by the LED chips. The collimator in the known light-emitting-diode chip package is typically

manufactured from a plastic as a single solid member with a cavity for the LED chips. In addition, the cavity is typically filled with a transparent silicone material.

A disadvantage of the known light-emitting-diode chip package is that the LED chips cannot be operated at sufficiently high powers.

The invention has for its object to eliminate the above disadvantage wholly or partly. According to the invention, a light-emitting-diode chip package comprises:

a base,

at least one light-emitting-diode chip disposed on the base,

a collimator for collimating the light emitted by the light-emitting-diode chip,

the collimator being made from a ceramic material that is able to withstand temperatures above 250°C.

There is a tendency in light-emitting-diode chip packages to increase the (power) output level of the light-emitting-diode chips. Such LED chips when driven at nominal power have a radiant power output in the range from 100 mW to 5 W. This may result in temperatures of parts of the light-emitting-diode chip package in the immediate vicinity which may rise to well above 200°C. In the light-emitting-diode chip package according to the invention, the LED chip is placed in a ceramic collimator. High-power LED chips can be used and temperature is no longer a constraint of the light-emitting-diode chip package in that the collimator is manufactured from a ceramic material able to withstand temperatures above 250°C.

Generally, light-emitting-diode chip packages comprise LED chips encapsulated in organic compounds. This implies that that the LED chips cannot be operated at temperatures higher than 120°C. Such temperatures hamper the operation of the light-emitting-diode chip package with high power LED chips.

Preferably, the material of the collimator is selected from the group formed by aluminum oxide, aluminum nitride, and aluminum silicate. These materials can withstand high temperatures.

A preferred embodiment of the light-emitting-diode chip package according to the invention is characterized in that the collimator is provided with a reflective layer of aluminum oxide or of aluminum silicate at a side facing the light-emitting-diode chip. Preferably, such a reflective layer has a high diffuse reflectivity.

It is desirable to make not only the collimator, but also the base of the light-emitting-diode chip package of a ceramic material. To this end a preferred embodiment of the light-emitting-diode chip package according to the invention is characterized in that the base is made from a ceramic material able to withstand temperatures above 250°C. Preferably, the material of the base is selected from the group formed by aluminum oxide, aluminum nitride, and aluminum silicate. These materials can withstand high temperatures.

A very favorable embodiment of the light-emitting-diode chip package according to the invention is characterized in that the base is made from aluminum nitride and the collimator is made from aluminum silicate.

When LED chips are used in an optical system, normally a so-called light-coupling medium, for instance a gel, is used to transfer the light from the light-emitting-diode chip into the collimator. Normally, plastics are used to encapsulate the light-emitting-diode chip. However, if the temperature of parts of the light-emitting-diode chip package in the immediate vicinity of the light-emitting-diode chip rises to temperatures well above 200°C, plastics can no longer be used. A preferred embodiment of the light-emitting-diode chip package according to the invention is therefore characterized in that the light-emitting-diode chip package comprises a light-coupling medium for transferring light from the light-emitting-diode chip to the collimator, the light-coupling medium being made of glass.

Preferably, a refractive index and a thermal expansion coefficient of the light-coupling medium substantially match the refractive index and the thermal expansion coefficient of the material of the collimator.

Preferably, the radiant power output of the light-emitting-diode chip when driven at nominal power is in the range from 100 mW to 5 W.

The invention will now be explained in more detail with reference to a number of embodiments and a drawing, in which:

Fig. 1 is a cross-sectional view of a first embodiment of the light-emitting-diode chip package according to an embodiment of the invention, and

Fig. 2 is a cross-sectional view of a second embodiment of the light-emitting-diode chip package according to an embodiment of the invention.

The Figures are purely diagrammatic and not drawn true to scale. Some dimensions are particularly strongly exaggerated for reasons of clarity. Equivalent components have been given the same reference numerals as much as possible in the Figures.

Figure 1 schematically shows a cross-sectional view of a first embodiment of the light-emitting-diode chip package according to an embodiment of the invention. The light-emitting-diode chip package comprises a base 1 and at least one light-emitting-diode (LED) chip 2 disposed on the base 1. In the example of Figure 1, the LED chip 2 comprises a (single-crystal) sapphire substrate upon which two layers are grown, preferably in an epitaxial manner. The two layers comprise, for instance, a p-type layer and a n-type layer.

In the example of Figure 1, the LED chip 2 is contacted via connection means 13, 14 which are connected to current-supply conductors 23, 24. In the example of Figure 1, the current-supply conductors 23, 24 are made via bumps instead of via the well-known wire bonds. This further enhances the light-emitting-diode chip package for the purpose of withstanding high temperatures.

The light-emitting-diode chip package further comprises a collimator 5 for collimating the light emitted by the light-emitting-diode chip 2. The collimator 5 is made from a ceramic material able to withstand temperatures above 250°C. High-power LEDs can be used and temperature is no longer a constraint of the light-emitting-diode chip package in that the collimator 5 is manufactured from a ceramic material able to withstand temperatures above 250°C. As LED chips 2 will be used having a radiant power output in the range from 1 to 5 W when driven a nominal power, the temperature of parts of the light-emitting-diode chip package in the immediate vicinity may rise to well above 200°C. In addition, the ceramic collimator 5 can be manufactured at the packaging level.

The material of the collimator 5 is preferably selected from the group formed by aluminum oxide, aluminum nitride, and aluminum silicate. These materials can withstand high temperatures.

In the example of Figure 1, both the base 1 and the collimator 5 are made in one piece. In this manner, the base 1 is made from the same ceramic material as the collimator. Preferably, the material of the base 1 and the collimator 5 is selected from the group formed by aluminum oxide, aluminum nitride, and aluminum silicate.

In order to give the collimator a high diffuse reflectivity, a side of the collimator 5 facing the light-emitting-diode chip 2 is provided with a reflective layer 15 of aluminum oxide or of aluminum silicate. Such a reflective layer 15 has a high diffuse reflectivity, in particular if the reflective layer is made from the aluminum silicate known as

mullite, i.e. $3Al_2O_3.2SiO_2$. The diffuse reflectivity of the reflective layer 15 made of mullite is as high as 99%.

In the example of Figure 1, the light-emitting-diode chip package further comprises a light-coupling medium 8 for transferring light emitted by the sapphire 3 from the light-emitting-diode chip 2 to the collimator 5. Preferably, the light-coupling medium 8 is made from glass, preferably of a so-called low-melting glass, preferably with a refractive index of 1.8 or higher. Suitable glasses are oxifluoride glasses of Pb, Sb, Sn, Te, Bi and/or Se. In addition, the refractive index and the thermal expansion coefficient of the light-coupling medium 8 substantially match the refractive index and the thermal expansion coefficient of the material of the collimator 5.

Figure 2 schematically shows a cross-sectional view of a second embodiment of the light-emitting-diode chip package according to an embodiment of the invention. In the example of Figure 2, the base 1 and the collimator 5 are made in two pieces. Preferably, the base 1 is made from aluminum nitride and the collimator 5 is made from an aluminum silicate. In order to give the collimator 5 a high diffuse reflectivity, the collimator 5 is made from the aluminum silicate known as mullite, i.e. $3Al_2O_3.2SiO_2$. The diffuse reflectivity of the collimator 5 made of mullite is as high as 99%.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The invention may be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

CLAIMS:

1. A light-emitting-diode chip package comprising:
a base (1),
at least one light-emitting-diode chip (2) disposed on the base (1),
a collimator (5) for collimating the light emitted by the light-emitting-diode chip (2),
the collimator (5) being made from a ceramic material that is able to withstand temperatures above 250°C.

2. A light-emitting-diode chip package as claimed in claim 1, wherein the material of the collimator (5) is selected from the group formed by aluminum oxide, aluminum nitride, and aluminum silicate.

3. A light-emitting-diode chip package as claimed in claim 2, wherein the collimator (5) is provided with a reflective layer (15) of aluminum oxide or of aluminum silicate at a side facing the light-emitting-diode chip (2).

4. A light-emitting-diode chip package as claimed in claim 1 or 2, wherein the base (1) is made from a ceramic material that is able to withstand temperatures above 250°C.

5. A light-emitting-diode chip package as claimed in claim 1, wherein the material of the base (1) is selected from the group formed by aluminum oxide, aluminum nitride, and aluminum silicate.

6. A light-emitting-diode chip package as claimed in claim 1, wherein the base (1) is made from aluminum nitride and the collimator (5) is made from aluminum silicate.

7. A light-emitting-diode chip package as claimed in claim 1 or 2, wherein the light-emitting-diode chip package comprises a light-coupling medium (8) for transferring

light from the light-emitting-diode chip (2) to the collimator (5), the light-coupling medium (8) being made of glass.

8. A light-emitting-diode chip package as claimed in claim 6, wherein a refractive index and a thermal expansion coefficient of the light-coupling medium (8) substantially match the refractive index and the thermal expansion coefficient of the material of the collimator (5).

9. A light-emitting-diode chip package as claimed in claim 1 or 2, wherein the radiant power output of the light-emitting-diode chip when driven a nominal power is in the range from 100 mW to 5 W.

10. A collimator (5) for use in a light-emitting-diode chip package as claimed in claim 1 or 2.

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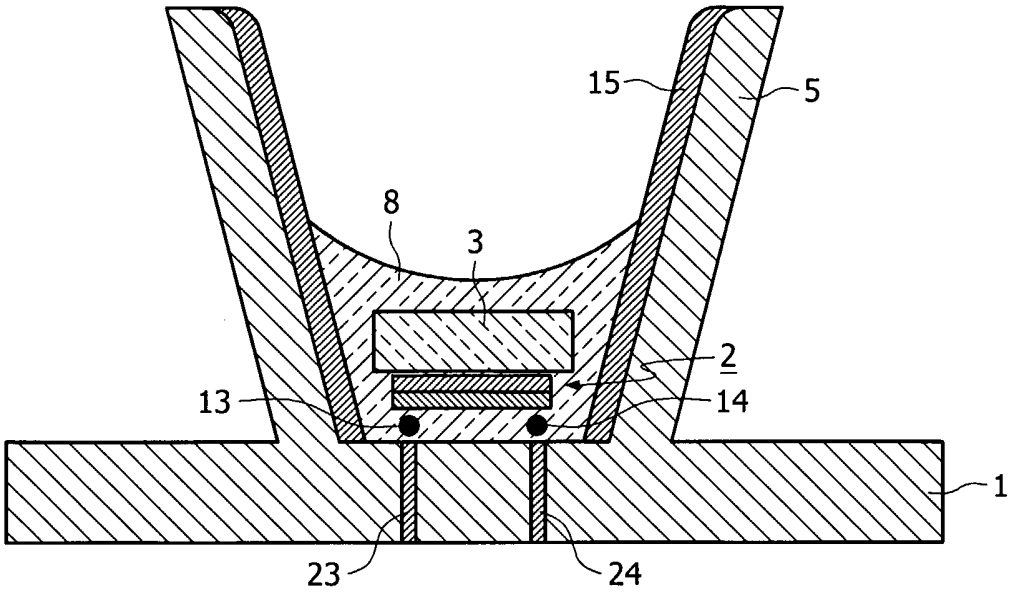

FIG. 1

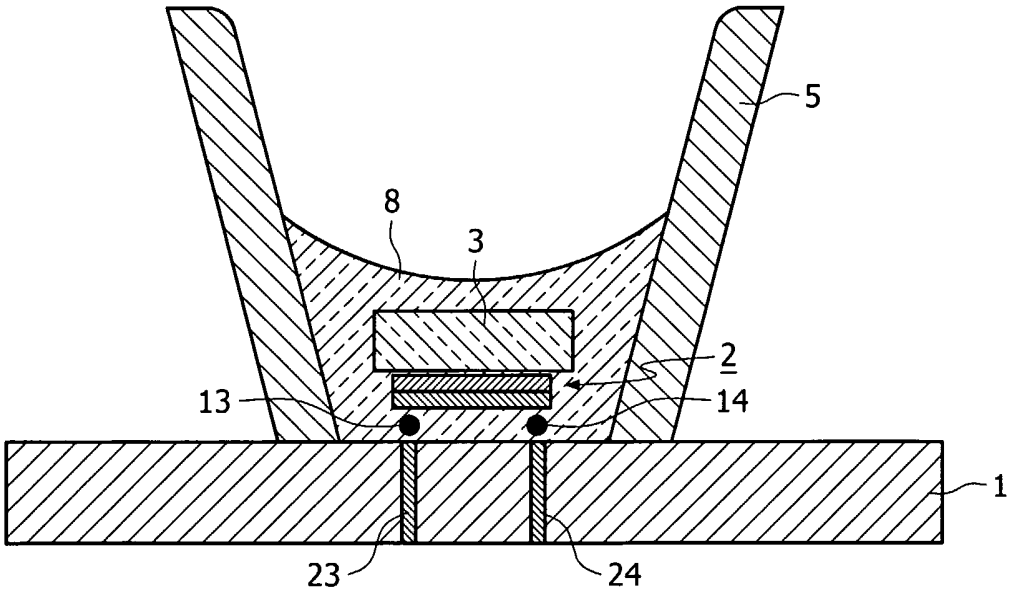

FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB2005/051444

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01L33/00

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)
IPC 7 H01L

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 335 548 B1 (ROBERTS JOHN K ET AL) 1 January 2002 (2002-01-01) column 9, line 1 - line 45 column 9, line 67 - column 10, line 3 column 10, line 43 - column 11, line 6 column 12, line 3 - line 20; figure 3 column 22, line 5 - line 41	1-10
X	US 2003/116769 A1 (SONG KYUNG SUB ET AL) 26 June 2003 (2003-06-26) paragraph '0013! - paragraph '0014! paragraph '0036!; figure 3	1,2,4,5, 9,10
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents .

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 October 2005	27/10/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Rodríguez-Gironés, M

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB2005/051444

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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