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(54) **Title**: CIRCUIT BOARD, ELECTRONIC MODULE, ILLUMINATING DEVICE, AND METHOD FOR MANUFACTURING THE CIRCUIT BOARD

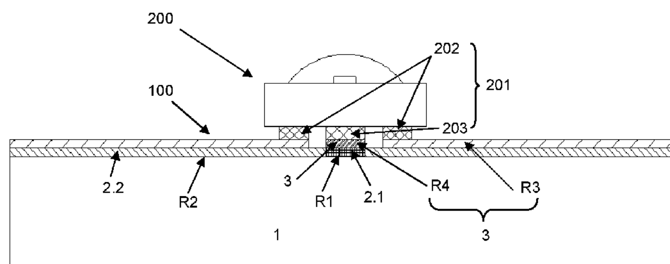

Figure 1

(57) **Abstract**: The present invention relates to a circuit board (100), comprising a base (1) and a heat-conducting layer (3), characterized in that the base (1) has a first region (R1) and second regions (R2) on a surface thereof facing the heat- conducting layer (3), the first region (R1) is provided with a first insulating layer (2.1), respective second region (R2) is provided with a second insulating layer (2.2), and the first insulating layer (2.1) and the second insulating layer (2.2) have different thermal conductivities. In addition, the present invention further relates to an electronic module and an illuminating device comprising such circuit board. The present invention also relates to a method for manufacturing such circuit board.

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Description

Circuit Board, Electronic Module, Illuminating Device, and Method for Manufacturing the Circuit Board

5

Technical Field

The present invention relates to a circuit board, an electronic module and an illuminating device having the circuit board. In addition, the present invention further relates to
10 a method for manufacturing the circuit board.

Background Art

In the current illuminating devices, especially in the large-power LED illuminating devices, most of the total thermal resistance of the illuminating device is the thermal resistance
15 of the circuit board. Taking the conventional metal-based circuit board (MCPCB) as an example, heat generated by LED chips that can be regarded as heat sources during operation must be transferred to the base by passing through an electric-conducting layer and an insulating layer that are ar-
20 ranged in sequence on a surface of the metal base, such as on an aluminum base. Since the insulating layer is usually made from polymer, its thermal conductivity is quite low. This leads to relatively big thermal resistance between the LED chips and the metal base. Taking a relatively new ceramic-
25 based circuit board (ceramic PCB) as an example, though heat generated by the LED chips that also can be regarded as heat sources during operation can be transferred to the ceramic base by passing through an electric-conducting layer arranged on a surface of the ceramic base, due to the restrictions of
30 ceramic, the ceramic base has relatively low thermal conductivity compared with the metal base, such as aluminum base,

thus, the whole illuminating device still has high thermal resistance. Moreover, such ceramic-based circuit board is also easily broken or damaged and has a relatively big dead-weight.

5 **Summary of the Invention**

Therefore, one object of the present invention lies in providing a circuit board. The circuit board is easily manufacture and has a low cost and a light weight as well as the advantage of low thermal resistance. Heat generated by an op-
10 erative electronic component mounted in such circuit board can be quickly conducted to the external environment to realize good heat dissipating effect.

The circuit board in accordance with the present invention comprises a base and an electric-conducting layer, character-
15 ized in that the base has a first region and second regions on a surface thereof facing the electric-conducting layer, a first insulating layer is formed on the first region, a second insulating layer is formed on respective second region, and the first insulating layer and the second insulating lay-
20 ers have different thermal conductivities. Thermal resistance in local area of the circuit board can be targetedly reduced by covering the base with insulating layers having different thermal conductivities, as a result, a highly-effective heat-conducting path is provided for the electronic component in a
25 precondition of not affecting electrical connection between the circuit board and the electronic component on the circuit board. Such simply-structured circuit board is particularly suited to bear large-power electronic components.

In accordance with one preferred solution of the present in-
30 vention, the first insulating layer has a higher thermal con-

ductivity than the second insulating layer. Accordingly, the electronic component to dissipate heat can be in thermal contact with the first insulating layer so as to dissipate heat mainly through the first insulating layer having a high thermal conductivity.

In accordance with one preferred solution of the present invention, the base is made from a metal. Since metal is characterized by high thermal conductivity and high rigidity, it is especially suited to be used as base of the circuit board. In addition, as the first and second insulating layers are formed between the electric-conducting layer and the base, the metallicity of the base will not affect the electric-conducting performance of the whole circuit board. The thermal conductivity of the metal base can reach 140-398 K/(W*m). The base herein preferably can be made from a material selected from aluminum, aluminum alloy and copper.

In accordance with one preferred solution of the present invention, the first insulating layer is a ceramic insulating layer. The ceramic insulating layer, for instance, can have a thermal conductivity of 20-39 K/(W*m). Preferably, the first insulating layer is made from Al_2O_3. The first insulating layer also can be made from AlN, and thus, the ceramic insulating layer can have a thermal conductivity of, for example, 150-180 K/(W*m).

In accordance with another preferred solution of the present invention, the second insulating layer is a polymer insulating layer that has a thermal conductivity of usually less than 3 K/(W*m).

In accordance with another preferred solution of the present invention, the electric-conducting layer comprises at least

two first adjoining regions and a second adjoining region, and any two adjoining regions of the first and second adjoining regions are spaced apart from each other. The electric-conducting layer generally is a printed circuit layer, wherein two first adjoining regions, for instance, can be in electrical connection with positive and negative pins of the electronic component, as a result, the two first adjoining regions are configured to be separated from each other, and also preferably spaced apart from the second adjoining region.

In accordance with one preferred solution of the present invention, the second adjoining region is formed over the first insulating layer and respective first adjoining region is formed over the second insulating layer. Since the first adjoining regions are mainly used for electrical connection with the electronic component, they are preferably formed over the second insulating layers having relative small thermal conductivity; and the second adjoining region is configured to be in thermal contact with the electronic component that generates heat, and therefore it is preferably formed over the first insulating layer having relatively big thermal conductivity.

In accordance with one preferred solution of the present invention, the second adjoining region at least partially covers a surface of the first insulating layer. Accordingly, the electric-conducting layer that also has heat-conducting performance is enabled to be in contact, with a surface area as big as is possible, with the first insulating layer, so as to transfer a large of amount of heat to the base through the first insulating layer.

In addition, the present invention further relates to an

electronic module comprising at least one electronic component, characterized by further comprising the above circuit board for carrying the electronic component.

In accordance with one preferred solution of the present invention, the electronic component has a first electric-conducting portion, a second electric-conducting portion and a heat-conducting portion, the first and second electric-conducting portions are connected with the first adjoining regions, respectively, and the heat-conducting portion is connected with the second adjoining region. As a result, heat generated by the electronic component during operation can be transferred to the second adjoining regions of the circuit board through the heat-conducting portion, while assuring the electronic component to be in electrical connection with the first adjoining region of the circuit board, for highly effectively dissipating heat.

In addition, the present invention further relates to an illuminating device, characterized by comprising the above electronic module, wherein the electronic component comprises LED chips as light sources. By mounting the circuit board according to the present invention in the illuminating device, heat dissipation can be carried out for high-power LED chips and other electronic parts, thus prolonging the service lifetime of the whole illuminating device.

Another object of the present invention lies in providing a method for manufacturing the above circuit board, characterized by comprising steps of:

a) providing a base, wherein the base has a first region and second regions on a surface thereof facing the electric-conducting layer,

b) forming a first insulating layer on the first region and forming a second insulating layer on respective second region, and

c) forming the electric-conducting layer over the first and second insulating layers.

In accordance with one preferred solution of the present invention, the step b) comprises:

b1) covering the first region and the second region completely with the second insulating layer;

b2) removing the second insulating layer covering the first region to form a recess ; and

b3) filling the recess with the first insulating layer.

In accordance with one preferred solution of the present invention, the first insulating layer has a higher thermal conductivity than the second insulating layer.

In accordance with one preferred solution of the present invention, in the step b2) the second insulating layer is removed through a laser processing manner or a mechanical manner. Similar processing manners also include milling and drilling.

In accordance with one preferred solution of the present invention, the step b3) further comprises:

b3.1) providing ceramic powders, wherein the ceramic powders are placed in the recess;

b3.2) melting the ceramic powders through a laser cladding

process; and

b3.3) cooling the ceramic powders in melted state to form the first insulating layer.

Therefore, the cooled first insulating layer is firmly connected with the base and a circumferential wall of the recess, further forming a complete insulating layer with different thermal conductivities.

In accordance with one preferred solution of the present invention, in the step c), the electric-conducting layer comprises at least two first adjoining regions and a second adjoining region, wherein the second adjoining region is formed over the first insulating layer, and respective first adjoining region is formed over respective second insulating layers.

The circuit board manufactured through such method has the advantages that it can highly-effectively and targetedly dissipate heat from the electronic component mounted thereon and has a high rigidity especially suited to bear high-power electronic components.

Brief Description of the Drawings

The accompanying drawings constitute a part of the present Description and are used to provide further understanding of the present invention. Such accompanying drawings illustrate the embodiments of the present invention and are used to describe the principles of the present invention together with the Description. In the accompanying drawings the same components are represented by the same reference numbers. As shown in the drawings:

Fig. 1 is a sectional view of a first embodiment of an electronic module in accordance with the present invention, wherein the electronic module comprises the circuit board according to the present invention; and

5 Fig. 2a-2e are flow charts of manufacturing the circuit board and the electronic module in accordance with the present invention.

Detailed Description of the Embodiments

In the following detailed description, reference is made to
10 the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. In this regard, directional terminology, such as "top", "bottom", "inner", "outer", is used in reference to the orientation of the fig-
15 ures being described. Because components of embodiments of the present invention can be positioned in a number of different orientations, the directional terminology is used for purposes of illustration and is in no way limiting. It is to be understood that other embodiments may be utilized and
20 structural or logical changes may made without departing from the scope of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

25 It is to be understood that the features of the various exemplary embodiments described herein may be combined with each other, unless specifically noted otherwise

Fig. 1 is a sectional view of a first embodiment of an electronic module in accordance with the present invention,

wherein the electronic module comprises the circuit board according to the present invention. In the electronic module 200, a circuit board 100 used to bear an electronic component 201 is configured to have a heat-conducting path with relatively small local thermal resistance for the electronic component 201 to dissipate heat. Specifically, the circuit board 100 comprises a metal-made base 1 and an electric-conducting layer 3 configured as a printed circuit layer, and the base 1 is configured to have, on a surface facing the electric-conducting layer 3, a first insulating layer 2.1 and second insulating layers 2.2 with different thermal conductivities. As a result, heat generated by the electronic component 201 can be transferred, through the electric-conducting layer 3 that also can conduct heat, to the first insulating layer 2.1 and the second insulating layers 2.2, and further is transferred, mainly through the first insulating layer 2.1 that has relatively high thermal conductivity, to the metal base 1 with high thermal resistance.

In order to effectively dissipate heat from the electronic component 201 during normal operation, the first insulating layer 2.1 is particularly formed over a first region R1 of the base 1, and the second insulating layers 2.2 are formed over second regions R2, respectively. The first region R1 is corresponding to a heat-conducting portion 203 of the electronic component 201 in connection with a second adjoining region R4 of the electric-conducting layer 3, and electric-conducting portions 202 of the electronic component 201 are configured for electrical connection with first adjoining regions R3 of the electric-conducting layer 3 and they are corresponding to the second regions R2 of the base 1. The first and second adjoining regions R3, R4 can be fixedly connected by a solder with the electric-conducting regions 202 and the heat-conducting region 203. Herein, the two first adjoining

regions R3 spaced apart from each other can be positive and negative pins of the electronic component 201. The first insulating layer 201 as heat-conducting layer below the electronic component 201 as shown in Fig. 1 transfers heat generated by the electronic component 201 during operation from the second adjoining region R4 to the base 1 for good heat dissipation.

The first insulating layer 2.1 in the present embodiment is, for instance, a ceramic heat-conducting layer made from Al_2O_3 or AlN. Such insulating layer usually has a thermal conductivity of 20-39 K/(W*m) or 150-180 K/(W*m), and thus, apart from having good electric-insulating performance, it also can be used for heat transfer. The second insulating layers 2.2 in the present embodiment are polymer insulating layers with thermal conductivity of usually less than 3 K/(W*m). Such insulating layers have good electric-insulating performance but substantially cannot conduct heat.

In the present embodiment, the first insulating layer 2.1 and the second insulating layers 2.2 have the same thickness, for instance, they can have a thickness of 76-200μm, and then a flat insulating layer completely covering an upper surface of the metal base 1 can be formed. The electric-conducting layer 3 partially covering the second insulating layers 2.2 can have a thickness of, for example, 35-70μm.

In one embodiment not shown, the first insulating layer 2.1 and the second insulating layers 2.2 also can have different thicknesses, and correspondingly, the first adjoining regions R3 and the second adjoining region R4 forming the electric-conducting layer 3 also preferably have different thicknesses for cooperation with corresponding first insulating layer 2.1 and second insulating layers 2.2, so that the electronic com-

ponent 201 can be steadily fixed on the circuit board 100.

Fig. 2a-2e are a flow charts of manufacturing the circuit board and the electronic module in accordance with the present invention. Firstly in Fig. 2a, the second insulating layer 2.2 is formed on the whole surface of the metal base 1 made from, for instance, aluminum, and then in Fig. 2b, the second insulating layer 2.2 is processed through manners such as milling and drilling to remove the second insulating layer 2 covering the first region R1 of the base 1, thus forming a region recessed with respect to the remaining second insulating layers 2.2. Subsequently in Fig. 2a, the first insulating layer 2.1 can be formed in the recessed region formed thereby. The first insulating layer 2.1 preferably can be prepared by laser hot-melting ceramic powders so that it can be fixedly connected with the second insulating layers 2.2 and the first region R1 of the base 1.

Next in Fig. 2d, the electric-conducting layer 3 is formed on the first insulating layer 2.1 and the second insulating layers 2.2, wherein the second adjoining region R4 of the electric-conducting layer 3 covers the first insulating layer 2.1, two first adjoining regions R3 of the electric-conducting layer 3 partially covers the second insulating layers 2.2 formed enclosing the first insulating layer 2.1, and the second adjoining region R4 is located between the two first adjoining regions R3 with an interval therebetween. Thus, the circuit board 100 in accordance with the present invention can be formed.

Thereafter in Fig. 2e, the electronic component 201 is mounted on the circuit board 100 to form the electronic module 200 in accordance with the present invention. The electronic component 201 has, on one side facing the circuit

board 100, two electric-conducting portions 202 configured as positive and negative pins and one heat-conducting portion 23 between the electric-conducting portions 202. By means of a solder, the two electric-conducting portions 202 can be connected with the first adjoining regions R3 on the circuit board 100, and the heat-conducting portion 203 can be connected with the second adjoining region R4.

In addition, while a particular feature or aspect of an embodiment of the invention may have been disclosed with respect to only one of several implementations, such feature or aspect may be combined with one or more other features or aspects of the other implementations as may be desired and advantageous for any given or particular application. Furthermore, to the extent that the terms "include", "have", "with", or other variants thereof are used in either the detailed description or the claims, such terms are intended to be inclusive in a manner similar to the term "comprise".

The above is merely preferred embodiments of the present invention but not to limit the present invention. For the person skilled in the art, the present invention may have various alterations and changes. Any alterations, equivalent substitutions, improvements, within the spirit and principle of the present invention, should be covered in the protection scope of the present invention.

List of reference signs

1	base
2.1	first insulating layer
2.2	second insulating layer
3	electric-conducting layer
100	circuit board
200	electronic module
201	electronic component
202	electric-conducting portion
203	heat-conducting portion
R1	first region
R2	second region
R3	first adjoining region
R4	second adjoining region

Claims

1. A circuit board (100), comprising a base (1) and an electric-conducting layer (3), characterized in that the base (1) has a first region (R1) and second regions (R2) on a surface thereof facing the electric-conducting layer (3), a first insulating layer (2.1) is formed on the first region (R1), a second insulating layer (2.2) is formed on respective second region (R2), and the first insulating layer (2.1) and the second insulating layers (2.2) have different thermal conductivities.

2. The circuit board (100) according to Claim 1, characterized in that the first insulating layer (2.1) has a higher thermal conductivity than the second insulating layer (2.2).

3. The circuit board (100) according to Claim 1 or 2, characterized in that the base (1) is made from a metal.

4. The circuit board according to Claim 1 or 2, characterized in that the first insulating layer (2.1) is a ceramic insulating layer.

5. The circuit board (100) according to Claim 4, characterized in that the ceramic insulating layer has a thermal conductivity of 20-39 K/(W*m) or 150-180 K/(W*m).

6. The circuit board (100) according to Claim 4, characterized in that the first insulating layer (2.1) is made from Al_2O_3 or AlN.

7. The circuit board (100) according to Claim 1 or 2, characterized in that the second insulating layer (2.2) is a polymer insulating layer.

8. The circuit board (100) according to Claim 3, characterized in that the base (1) has a thermal conductivity of 140-398K/(W*m).

9. The circuit board (100) according to Claim 3, characterized in that the base (1) is made from a material selected from aluminum, aluminum alloy and copper.

10. The circuit board (100) according to Claim 1 or 2, characterized in that the electric-conducting layer (3) comprises at least two first adjoining regions (R3) and a second adjoining region (R4), and any two adjoining regions of the first and second adjoining regions (R3, R4) are spaced from each other.

11. The circuit board (100) according to Claim 10, characterized in that the second adjoining region (R4) is formed over the first insulating layer (2.1) and respective first adjoining region (R3) is formed over respective second insulating layer (2.2).

12. The circuit board (100) according to Claim 11, characterized in that the second adjoining region (R4) at least partially covers a surface of the first insulating layer (2.1).

13. An electronic module (200) comprising at least one electronic component (201), characterized by further comprising the circuit board (100) according to any of Claims 1-12 for carrying the electronic component (201).

14. The electronic module (200) according to Claim 13, characterized in that the electronic component (201) has a plurality of electric-conducting portions (202) and a heat-

conducting portion (203), the electric-conducting portions (202) are connected with the first adjoining regions (R3), respectively, and the heat-conducting portion (203) is connected with the second adjoining region (R4).

5 15. An illuminating device, characterized by comprising the electronic module (200) according to Claim 13 or 14, wherein the electronic component (201) comprises LED chips as light sources.

16. A method for manufacturing the circuit board (100) according to any of Claims 1-12, characterized by comprising steps of:

a) providing a base (1), wherein the base (1) has a first region (R1) and second regions (R2) on a surface thereof facing the electric-conducting layer (3),

15 b) forming a first insulating layer (2.1) on the first region (R1) and forming a second insulating layer (2.2) on respective second region (R2), and

c) forming the electric-conducting layer (3) over the first and second insulating layers (2.1, 2.2).

20 17. The method according to Claim 16, characterized in that the step b) comprises:

b1) covering the first region (R1) and the second region (R2) completely with the second insulating layer (2.2);

b2) removing the second insulating layer (2.2) covering the first region (R1) to form a recess (A); and

b3) filling the recess (A) with the first insulating layer (2.1).

18. The method according to Claim 16 or 17, characterized in that the first insulating layer (2.1) has a higher thermal conductivity than the second insulating layer (2.2).

19. The method according to Claim 17, characterized in that in the step b2) the second insulating layer (2.2) is removed through a laser processing manner or a mechanical manner.

20. The method according to Claim 17, characterized in that the step b3) further comprises:

b3.1) providing ceramic powders, wherein the ceramic powders are placed in the recess (A);

b3.2) melting the ceramic powders through a laser cladding process; and

b3.3) cooling the ceramic powders in melted state to form the first insulating layer (2.1).

21. The method according to Claim 16, characterized in that in the step c), the electric-conducting layer (3) comprises at least two first adjoining regions (R3) and a second adjoining region (R4), wherein the second adjoining region (R4) is formed over the first insulating layer (2.1), and respective first adjoining region (R3) is formed over the second insulating layers (2.2).

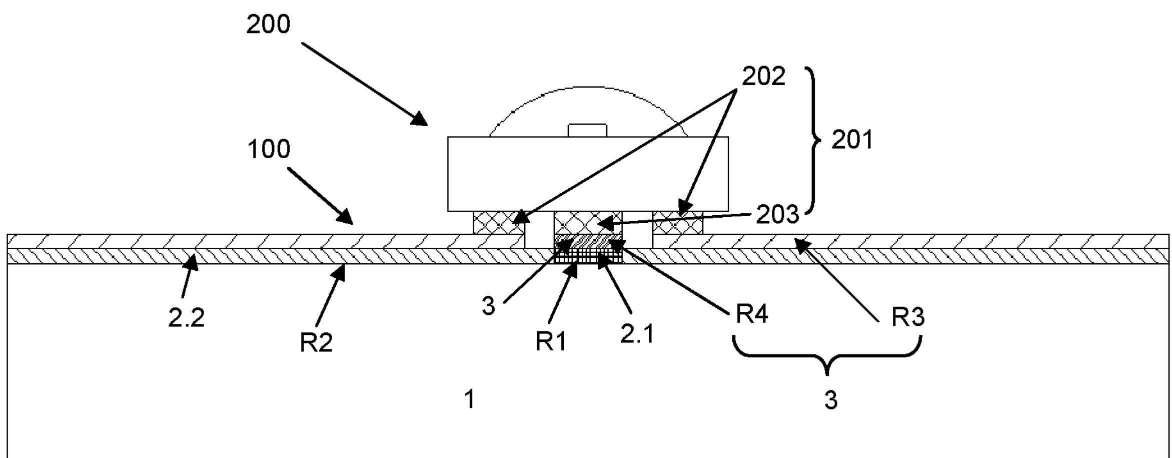

Figure 1

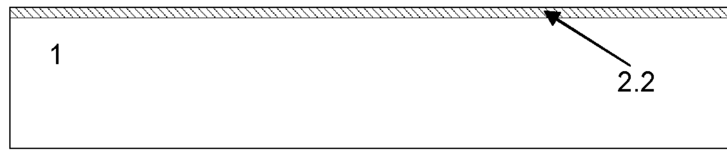

Figure 2a

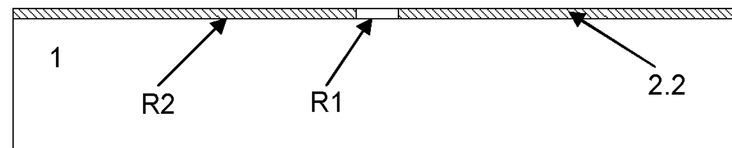

Figure 2b

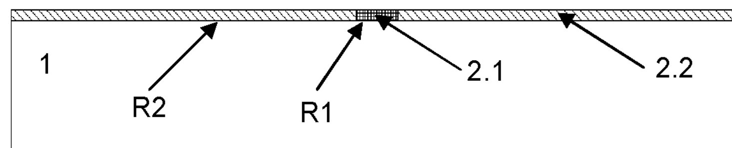

Figure 2c

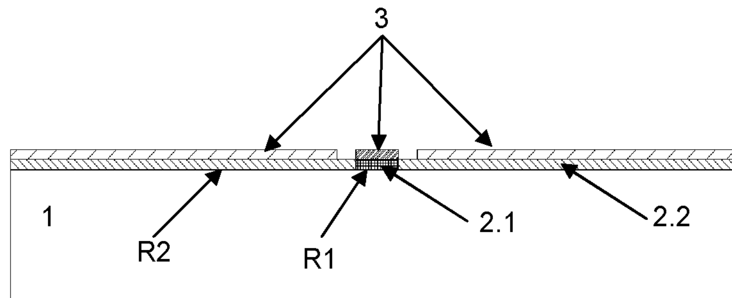

Figure 2d

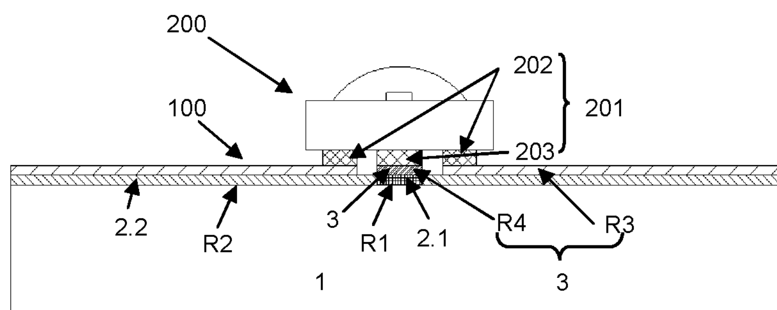

Figure 2e

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/060092

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05K1/02
ADD. H05K1/05

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)
H05K

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 2 416 630 A1 (UNIMICRON TECHNOLOGY CORP [TW]) 8 February 2012 (2012-02-08) paragraphs [0012] - [0015], [0017], [0019], [0020], [0022], [0023], [0029] - [0032], [0052], [0053], [0056] - [0059]; figures 1,2,5A-5C -----	1-16,18, 21 17,19,20
Y	US 2004/259317 A1 (DING YI-CHUAN [TW]) 23 December 2004 (2004-12-23) paragraphs [0015], [0016]; figures 3C-3G -----	17,19,20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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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
14 August 2013	30/08/2013

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, Fax: (+31-70) 340-3016	Batev, Petio

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2013/060092

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2416630 A1	08-02-2012	NONE	
US 2004259317 A1	23-12-2004	TW I226101 B	01-01-2005
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