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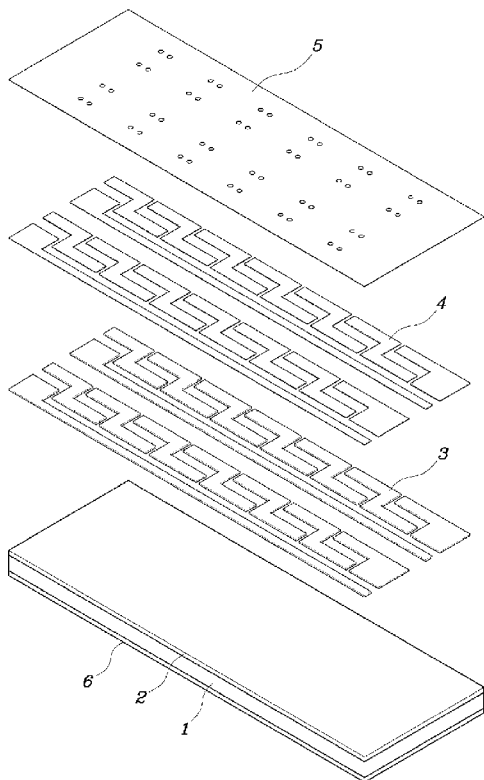
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(54) Title: A LED ARRAY BOARD

[Fig. 1]



(57) Abstract: The present invention directed to a LED array board provides a LED array board comprising an aluminum base layer, an alumina insulating layer formed by anodizing monolithically on the aluminum base layer and a layer of electric circuit printed directly on the insulating layer with paste including conductive particles and heat-resistant binder. The present invention provides a LED array board with efficient structure for heat radiation by forming an insulating layer monolithically on the base layer, which can be as a densely arrayed board for high brightness. Forming electrode circuit by direct printing with conductive paste comprising conductive particles and heat resistant binder, integrated with the structure of board mentioned above, simplifies the manufacturing process, shortens cost and time for manufacture, and minimizes waste, while the binder of the paste increases the insulation of the alumina layer and adhesion force on the alumina layer.



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Description

Title of Invention: A LED ARRAY BOARD

Technical Field

- [1] The present invention is directed to a LED array board, especially to a LED array board which, while effective in heat-radiation, can be prepared through simple processes.

Background Art

- [2] Light Emitting Diodes("LED") with merits such as good effectiveness, long life span and so on, have been used in various fields, for examples, as indicators with various colors in electronic appliances and as light sources in large displays. Recently, their applications have been enlarged to backlighting for liquid crystal displays("LCD") and to various lightings.
- [3] Multiple LEDs are arrayed on a board for LCD backlighting or various lightings in order to implement high brightness and planar lighting. Heat-radiation in a single-chip LED package is known as a very important factor to such qualities as endurance and efficiency of LED. When multiple LED packages constitute an array on a board, effective radiation of heat through the board is one of the key points since heat generated from the LED packages are overlapped in some area of the board.
- [4] Various solutions by selections of material and structures have been proposed to radiate effectively heat generated from a single-chip LED package encapsulating a single LED chip. However, even if architecture for heat radiation is implemented for a single-chip LED package, problems of heat radiation through substrate boards accommodating multiple LED packages in array for bright planar lighting should be solved.
- [5] In order to accommodate multiple LEDs on a board, a metal core printed circuit board ("MCPCB") having base metal substrate is generally used instead of PCB prepared from Copper Clad Laminate ("CCL"). Such MCPCB has three layers of a metal base layer, an insulating layer and a layer of electrode circuit etched and formed from thin film of copper. The insulating layer often adopts epoxy or silicone resin filled with heat-conductive particles to increase heat-conductivity through the board. However, such MCPCB has limitations in heat-radiation due to the insulating layer on resinous base. Still, like PCB, forming electrode circuit in MCPCB by lithographic technology consisting of resist patterning, etching and so on is so complicated and causes problems concerning disposal of massive waste.
- [6] Mounting and packaging multiple LED chips directly on a fabricated MCPCB or a ceramic complex board consisting of a metal layer and LTCC("low temperature co-fired ceramic") has been attempted by applying chip-on-board("COB") technology,

which is used in semiconductor industry to directly assemble microchips or dies on a circuit board, to LED array boards. For applying COB technology to LED array packages, complicated and precise processes such as forming respective grooves on an array board in order to house LED chips and in order to form reflectors, metalizing for a conductive layer, etching the conductive layer for electrodes, encapsulation over the grooves after mounting LED chips and casting lens should be involved. Such complication and precision requisite make the adaptability of the technology lower and make the production cost higher. For an array board adopting COB technology, for example, grooves according to size and numbers of LED chips, reflectors and electrical contacts for LED chips are precisely formed in the board. The entire package may fail even if one of the LED chips is mounted erroneously. Still, the resinous insulating layer of MCPCB or relatively thick LTCC of ceramic complex board has limitations of low heat- conductivity.

Disclosure of Invention

Technical Problem

- [7] It is an object of the present invention to provide a LED array board with high efficiency of heat radiation.
- [8] It is another object of the present invention to provide a LED array board having good adaptability to use and low production cost due to simple processes without layering of copper film, metalizing or etching, yet with excellent heat-conductivity.

Solution to Problem

- [9] According to the present invention, there is provided a LED array board comprising an aluminum base layer, an alumina insulating layer formed monolithically on the aluminum base layer by anodizing and a layer of electric circuit printed directly on the insulating layer with paste including conductive particles and heat-resistant binder. The said LED array board may further comprise the other alumina insulating layer at its rear face by the same anodizing to prevent the board from bending or to utilize the rear face. If necessary, the LED array board may further comprise another layer of electric circuit formed in the same way as the front one beneath the rear alumina insulating layer. In the present invention, "electric circuit" means electrode line to power LEDs or signal line to control LEDs. The said rear electric circuit may be used as electrode line or signal line for LEDs mounted on the front face of the board, or may be used for LEDs mounted on the rear face of the board as the case may be. Connecting the circuits on both of the faces to each other can be carried out by traditional conduction technologies via holes.
- [10] After anodizing, if necessary, the alumina insulating layer is sealed with sealant before or after printing electric circuit to promote dielectric withstanding voltage of the

insulation. According to the present invention, the said LED array board may further comprise a metal electro-plated layer on the electric circuit in the same pattern as the electric circuit to strengthen conductivity and solderability. The said LED array board may further comprise a protective insulating layer to protect the layer of electric circuit on it. This protective insulating layer is desirably formed by printing as pattern to expose contacts to LEDs on the array board.

- [11] The aluminum base layer is made of aluminum or aluminum alloy. The rear portion of the aluminum base layer may have multiple fins processed monolithically on the aluminum base layer to enlarge contact area with the air. For cooling, heat pipes or thermo-elements may be inserted or attached to the aluminum base layer.
- [12] Printing electric circuit on the alumina layer with the conductive paste before sealing has advantages to strengthen the adhesion force of the binder of conductive paste on the porous surface of the alumina layer and to make the binder act as a sealant aid. Remaining pores may be further treated with sealant. Sealing the alumina layer is generally carried out with solution of metal salts, and then with boiling heated water.
- [13] The alumina insulating layer is formed by anodizing the surfaces of the aluminum base layer. More specifically, applying plus voltage to an aluminum plate in solution of sulfuric acid, oxalic acid, acetic acid, phosphoric acid or chromic acid, most preferably in oxalic acid solution, accelerates oxidation and make form alumina layers on the surfaces of the surfaces of the aluminum plate. If necessary, additives such as copper sulfate, lactic acid, citric acid, acetic acid, aluminum sulfate, magnesium sulfate and so on may be added to the oxalic acid solution. The alumina insulating layer may be formed as pattern or partially on the aluminum base layer by masking this. An alumina insulating layer at its rear face of the aluminum base layer may be formed by the same anodizing to prevent the board from bending or to utilize the rear face. Such formed alumina layer is very sturdy, anti-corrosive and porous. The pores, about several tens of nm in diameter, generally should be sealed since they worsen the electric insulation of the layer. However, the sealing may be omitted or may be carried out, if necessary, after printing electric circuit on the alumina layer.
- [14] The conductive paste composition for forming electric circuit preferably comprises 0.01 to 96 w% of conductive particles, 0.5 to 96 w% of heat-resistant binder and residual organic solvent. The heat-resistant binder is, for example, polyacrylates, polyurethanes, polyepoxys, polyimides or their derivatives. Herein, "conductive particles" mean particles of electrically conductive material. The material has no limitation as long as it has electric conductivity as solid state. The material is metal or nonmetal inclusive of carboneous particle such as carbon black and graphite. Conductive particles are, for example, particles of gold, aluminum, copper, indium, antimony, magnesium, chrome, tin, nickel, silver, iron, titanium and alloys thereof. As

carboneous particles, there are, for example, natural graphite flake, expanded graphite, graphene, carbon black, nano-carbon and carbon nanotube. The shape of particles, not specially restricted, is, for example, plain, fibrous or nano-sized. Such particles may be used solely or in combination. The conductive particles are, preferably silver platelets of 0.1 to 10 μ m in diameter.

- [15] Direct printing includes screen printing, flexography, rotary screen printing, gravure printing, offset printing and inkjet printing. The conductive paste printed as pattern of electric circuit on the alumina insulating layer is cured by heating or light radiation. The binder ingredient in conductive paste fixes the conductive particles and helps them to form an electric circuit and increases the insulation by partially filling the pores of the alumina insulating layer. To promote conductivity, the electric circuit may be metal electro-plated in a plating bath by applying voltages to the electric circuit printed. The metal for electro-plating is preferably nickel or copper.
- [16] A protective insulating layer may be printed above the electric circuit as pattern to expose contacts to LEDs to protect the layer of electric circuit with thermoset resinous binders or varnishes. The contacts are not restricted to electrical contacts. The contacts may be formed on the naive alumina layer.
- [17] LED packages having leads, complete or semi-complete, are mounted on the LED array board according to the present invention by various technology known in the art including soldering and SMT (Surface Mounting Technology). For example, the contacts exposed on the array board are coated with solder cream, and the leads of LED packages are located on the contacts and then soldered by reflow of the solder. Before soldering and coating the contacts with solder cream, the contacts may be treated with such primer agent as OSP(organic solder preserve), ENIG(Electro-less Nickel Immersion Gold) and ENEPIG(Electro-less Nickel Electro-less Palladium Immersion Gold) to promote the adhesion.

Advantageous Effects of Invention

- [18] The present invention provides a LED array board with efficient structure for heat radiation by forming an insulating layer monolithically on the base layer, which can be used as a densely arrayed board for high brightness. In the LED array board, in addition, forming electrode circuit by direct printing with conductive paste comprising conductive particles and heat resistant binder, integrated with the structure of board mentioned above, simplifies the manufacturing process, shortens cost and time for manufacture, and minimizes waste, while the binder of the paste increases the insulation of the alumina layer and adhesion force on the alumina layer.

Brief Description of Drawings

- [19] FIG. 1 is a conceptual perspective view showing separate layers of the LED array

board embodying the present invention.

[20] FIG. 2 is a schematic assembly perspective view of the LED array board in Figure 1.

[21] *Brief Description for Numerals in Drawings

[22] 1; aluminum plate 2; alumina layer

[23] 3; electrode circuit 4; plating layer

[24] 5; protective insulating layer 6; rear alumina layer

[25] 10; LED array board 11; LED package

[26] 12; electrical contact

Mode for the Invention

[27] Hereinafter, the present invention is described in detail by examples and the accompanying drawings.

[28] Example 1

[29] An aluminum plate 1(305mm X 255mm X 1mm) is immersed in degreaser SZ-9 manufactured by Jinyoung Chemical consisting of NaOH, NaHCO₃, Na₂CO₃, surfactant and water and is degreased for 15 minutes at 50~60°C. The degreased aluminum plate 1 is washed, immersed in NaOH aqua solution of 10 g/L concentration at about 60°C for 3 minutes, and then washed with water. The aluminum plate 1 is immersed into 10% sulfuric acid aqua solution at room temperature, and by applying plus voltage to the aluminum plate 1 at current density of 0.5 A/dm² for 60minutes, alumina layers 2, 6 are obtained on the front face and on the rear face of the aluminum plate 1 with thickness of 33.2 and 31.7 μ m respectively.

[30] 650 g of silver platelet powder having an average particle size of 1.97 μ m, 240 g of an epoxy binder which is prepared by diluting epoxy resin of KER1009 manufactured by Keumho P&B in normal terpeneol to be of 50 weight% concentration and a residual amount of Butyl Cellosolve®(brand name of 2-butoxyethanol) are thoroughly mixed together to be 1Kg of silver paste. The silver paste composition was printed as electrode circuit 3 on the alumina layer 2 of the aluminum plate. Then, the aluminum plate is heat-treated at 190°C for 12 minutes so that the adhesion force, the hardness and the surface electric resistance of the electrode circuit are respectively 5B, 5H and 8.6X10⁻⁵ Ω ·cm.

[31] For sealing, the aluminum plate with electric circuit printed on is immersed in nickel acetate aqua solution in concentration of 2g/L for 5 minutes, and then is treated in distilled water at 95°C for 10 minutes. The withstanding insulation voltage between the front and the rear face of the sealed aluminum plate is measured by CHROMA AC/DC/IR HIPOT TESTER model 19052 to be 2.71 Kv/mm.

[32] The aluminum plate is printed by screen printer with SCR-1000W, thermoset resinous solder-resist, manufactured by Seoul Chemistry Research Center to form a

protective insulating layer **5** on the electrode circuit, and then is heat-treated at 150°C for 50 minutes.

[33] The electrical contacts **12** are coated with solder cream. LED packages of 1608 type **11** made by Seoul Semi-Conductor are located in array on the exposed electrical contacts **12** of the finished LED array board **10** and are soldered by reflow process.

[34] Example 2

[35] An aluminum plate **1**(305mm X 255mm X 1mm) is immersed in degreaser SZ-9 manufactured by Jinyoung Chemical consisting of NaOH, NaHCO₃, Na₂CO₃, surfactant and water and is degreased for 15 minutes at 50~60°C. The degreased aluminum plate **1** is washed, immersed in NaOH aqua solution of 10 g/L concentration at about 60°C for 3 minutes, and then washed with water. The aluminum plate is immersed into aqua solution of 50g oxalic acid, 10 g boric acid, 3 g lactic acid and 1 g magnesium sulfate in 1 liter of water at room temperature, and by applying plus voltage to the aluminum plate **1** at current density of 0.5 A/dm² for 60minutes, alumina layers **2**, **6** are obtained on the front face and on the rear face of the aluminum plate **1** with thickness of 33.6 and 32.5 μ m respectively.

[36] 650 g of silver platelet powder having an average particle size of 1.97 μ m, 240 g of an epoxy binder which is prepared by diluting epoxy resin of KER1009 manufactured by Keumho P&B in normal terpeneol to be of 50 weight% concentration and a residual amount of Butyl Cellosolve (brand name of 2-butoxyethanol) are thoroughly mixed together to be 1Kg of silver paste. The silver paste composition was printed as electrode circuit **3** on the alumina layer **2** of the aluminum plate. Then, the aluminum plate is heat-treated at 190°C for 12 minutes so that adhesion force, hardness and surface electric resistance of the electric circuit are respectively 5B, 5H and 8.4X10⁻⁵ Ω ·cm.

[37] For sealing, the aluminum plate with electric circuit printed on is immersed in nickel fluoride aqua solution in concentration of 5g/L for 20 minutes, and then is treated in nickel acetate aqua solution at 90°C for 20 minutes. The withstanding insulation voltage between the front and the rear face of the sealed aluminum plate is measured by CHROMA AC/DC/IR HIPOT TESTER model 19052 to be 2.66 Kv/mm. Heat conductivity through the board at an electrical contact is 56.49W/m·k. The heat conductivity for the board of the present invention is superior to that of general MCPCB which is below 2.0W/m·k.

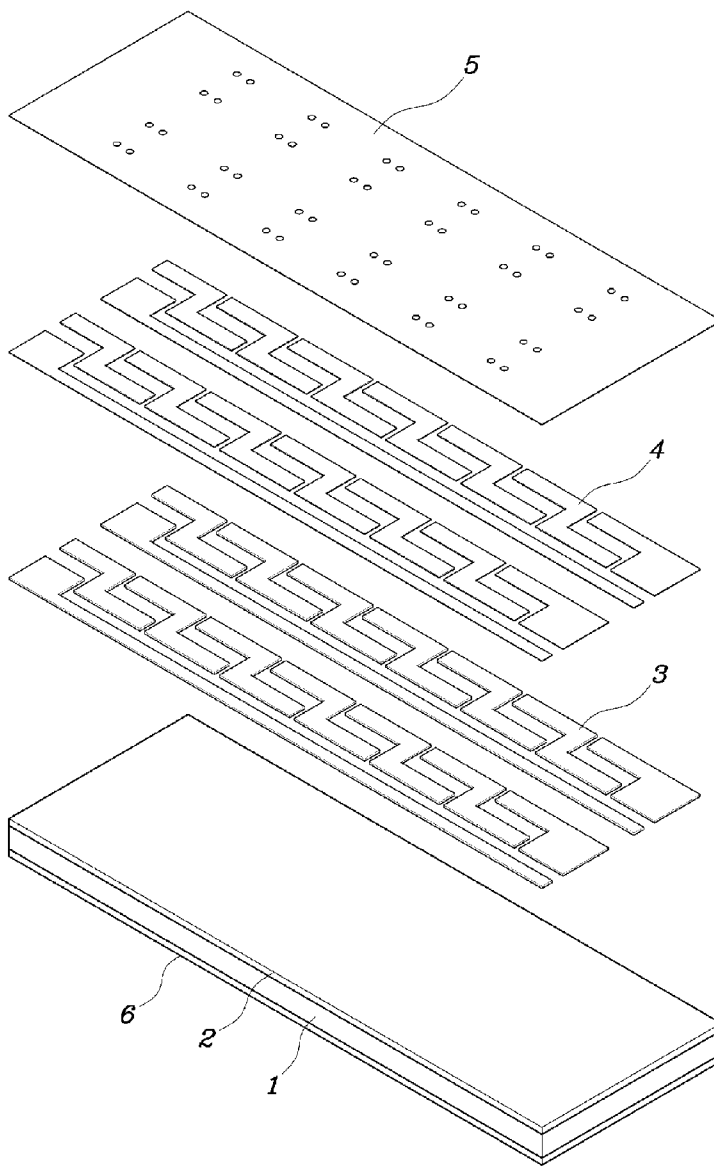
[38] The sealed aluminum plate is immersed in a plating bath of 220g copper sulfate, 63g sulfate, 10ppm chlorine and, as rust inhibitor, 10 g 5007-MU, 0.5 g 5000-A and 0.5 g 5007-B made by IBC in 1liter of water and is applied by current of 5 A/dm² for 30minutes, and thus a copper plated layer **4** of 3 μ m thick having surface electric resistance of 5X10⁻⁶ Ω ·cm is obtained.

- [39] The aluminum plate is printed by screen printer with SCR-1000W, thermoset resinous solder-resist, manufactured by Seoul Chemistry Research Center to form a protective insulating layer **5** on the electrode circuit, and then is heat-treated at 150°C for 50 minutes.
- [40] The electrical contacts **12** are coated with solder cream. LED packages of 1608 type **11** made by Seoul Semi-Conductor are located in array on the exposed electrical contacts **12** of the finished LED array board **10** and are soldered by reflow process. The adhesion strength is measured to be 2.67Kg_f.

Claims

- [Claim 1] A LED array board comprising an aluminum base layer, an alumina insulating layer formed monolithically on the aluminum base layer by anodizing and a layer of electric circuit printed directly on the insulating layer with conductive paste including conductive particles and heat-resistant binder.
- [Claim 2] According to Claim 1, the LED array board further comprising another alumina insulating layer at the rear face of the aluminum plate.
- [Claim 3] According to Claim 1, the LED array board wherein the alumina insulating layer is sealed with metal salt after printing electric circuit.
- [Claim 4] According to Claim 2, the LED array board further comprising another layer of electric circuit beneath the rear alumina insulating layer.
- [Claim 5] According to Claim 4, the LED array board wherein the rear electric circuit is used as electrode lines or signal lines for LEDs to be mounted on the front face of the board.
- [Claim 6] According to Claim 1, the LED array board wherein the alumina insulating layer is formed as pattern or partially by masking the aluminum base layer.
- [Claim 7] According to Claim 1, the LED array board further comprising a metal electro-plated layer on the electric circuit.
- [Claim 8] According to Claim 1, the LED array board further comprising a protective insulating layer printed as pattern to expose contacts to LEDs.
- [Claim 9] According to Claim 8, the LED array board wherein the contacts are treated with such primer agent as OSP(organic solder preserve), ENIG(Electro-less Nickel Immersion Gold) or ENEPIG(Electro-less Nickel Electro-less Palladium Immersion Gold).
- [Claim 10] According to Claim 1, the LED array board wherein the rear portion of the aluminum base layer has multiple fins.
- [Claim 11] According to Claim 9, the LED array board wherein the alumina insulating layer is formed by anodizing the surfaces of the aluminum base layer in solution of oxalic acid and an additive selected from a group consisting of copper sulfate, lactic acid, citric acid, acetic acid, aluminum sulfate, magnesium sulfate and their mixture.
- [Claim 12] According to Claim 1, the LED array board wherein the conductive particles are silver platelets of 0.1 to 10 μ m in diameter.

[Fig. 1]



[Fig. 2]

