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(54) **Light-mixing LED package structure for increasing color render index and brightness**

Lichtmischende LED-Gehäusestruktur zur Erhöhung des Farbwiedergabeindex und der Helligkeit

Structure de conditionnement DEL à mélange de lumière pour augmenter l'indice de rendu des couleurs et la luminosité

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a light-mixing LED package structure, in particular, to a light-mixing LED package structure for increasing color render index and brightness.

2. Description of Related Art

[0002] The invention of the lamp greatly changed the style of building construction and the living style of human beings, allowing people to work during the night. Without the invention of the lamp, we may stay in the living conditions of ancient civilizations.

[0003] Various lamps such as incandescent bulbs, fluorescent bulbs, power-saving bulbs and etc. have been intensively used for indoor illumination. These lamps commonly have the disadvantages of quick attenuation, high power consumption, high heat generation, short working life, high fragility, and being not recyclable. Further, the rapid flow of electrons (about 120 per second) through the electrodes of a regular fluorescent bulb causes an unstable current at the onset of lighting a fluorescent bulb, resulting in a flash of light that is harmful to the sight of the eyes. In order to eliminate this problem, a high frequency electronic ballast may be used. When a fluorescent or power-saving bulb is used with high frequency electronic ballast, it saves about 20% of the consumption of power and eliminates the problem of flashing. However, the high frequency electronic ballast is not detachable when installed in a fluorescent or power-saving bulb, the whole lamp assembly becomes useless if the bulb is damaged. Furthermore, because a fluorescent bulb contains a mercury coating, it may cause pollution to the environment when thrown away after damage. Hence, LED device is created in order to solve the above-mentioned questions of the prior lamp.

[0004] WO 2008/002073 A1 discloses an artificial solar light system using light emitting diodes representing same light emission effects as the sun with time.

[0005] US 2009/0166657 A1 discloses an LED package structure comprising a substrate body having thereon a plurality of light-emitting modules, each module having a plurality of LED chips, the light-emitting modules being separated by resin frames formed by coating.

SUMMARY OF THE INVENTION

[0006] The present invention provides a light-mixing LED package structure for increasing color render index and brightness having the features as stated in the independent claim. Preferred embodiments of the present invention are featured in the dependent claims.

[0007] In view of the aforementioned issues, the present invention provides a light-mixing LED package structure for increasing color render index and brightness. The present invention provides an LED module with high color temperature and an LED module with low color temperature connected each other in series or in parallel in order to create the light-mixing LED package structure with high color render index and brightness.

[0008] Moreover, the present invention can form an annular resin frame (such as an annular white resin frame) with any shapes by coating method. In addition, the position of a translucent package resin body such as phosphor resin can be limited in the resin position limiting space by using the annular resin frame, and the shape of the translucent package resin body can be adjusted by using the annular resin frame. Therefore, the present invention can apply to increase light-emitting efficiency of LED chips and control light-projecting angle of LED chips.

[0009] To achieve the above-mentioned objectives, the present invention provides a light-mixing LED package structure for increasing color render index and brightness, including: a substrate unit, a light-emitting unit, a frame unit and a package unit. The substrate unit has at least one substrate body and at least two chip-placing areas formed on the at least one substrate body. The light-emitting unit has at least one first light-emitting module for generating a first color temperature and at least one second light-emitting module for generating a second color temperature. The at least one first light-emitting module has a plurality of first light-emitting chips electrically disposed on one of the chip-placing areas of the substrate unit, and the at least one second light-emitting module has a plurality of second light-emitting chips electrically disposed on the other chip-placing area of the substrate unit. The frame unit has at least two annular resin frames surroundingly formed on a top surface of the substrate body by coating. The at least two annular resin frames respectively surround the at least one first light-emitting module and the at least one second light-emitting module in order to form at least two resin position limiting spaces above the substrate body. The package unit has at least one first translucent package resin body and at least one second translucent package resin body both disposed on the substrate body and respectively covering the at least one first light-emitting module and the at least one second light-emitting module. The at least one first translucent package resin body and the at least one second translucent package resin body are limited in the at least two resin position limiting spaces.

[0010] To achieve the above-mentioned objectives, the present invention provides a light-mixing LED package structure for increasing color render index and brightness, including: a substrate unit, a light-emitting unit, a frame unit and a package unit. The substrate unit has at least one substrate body and at least two chip-placing areas formed on the at least one substrate body. The light-emitting unit has at least one first light-emitting module for generating a first color temperature and at least one second light-emitting module for generating a second color temperature. The at least one first light-emitting module has a plurality of first light-emitting chips electrically disposed on one of the chip-placing areas of the substrate unit, and the at least one second light-emitting module has a plurality of second light-emitting chips electrically disposed on the other chip-placing area of the substrate unit. The frame unit has at least one first annular resin frame and at least one second annular resin frame surroundingly formed on a top surface of the substrate body by coating. The at least one first annular resin frame surrounds the at least one first light-emitting module in order to form at least one first resin position limiting space above the substrate body, and the at least one second annular resin frame surrounds the at least one second light-emitting module and the at least one first annular resin frame in order to form at least one second resin position limiting space above the substrate body and between the at least one first annular resin frame and the at least one second annular resin frame. The package unit has at least one first translucent package resin body and at least one second translucent package resin body both disposed on the substrate body and respectively covering the at least one first light-emitting module and the at least one second light-emitting module. The at least one first translucent package resin body is limited in the at least one first resin position limiting space, and the at least one second translucent package resin body is limited in the at least one second resin position limiting space.

[0011] To achieve the above-mentioned objectives, the present invention provides a light-mixing LED package structure for increasing color render index and brightness, including: a substrate unit, a light-emitting unit, a frame unit and a package unit. The light-emitting unit has at least one first light-emitting module for generating a first color temperature and at least one second light-emitting module for generating a second color temperature. The at least one first light-emitting module has a plurality of first light-emitting chips electrically disposed on the substrate unit, and the at least one second light-emitting module has a plurality of second light-emitting chips electrically disposed on the substrate unit. The frame unit has at least one first annular resin frame and at least one second annular resin frame surroundingly formed on a top surface of the substrate unit. The at least one first annular resin frame surrounds the at least one first light-emitting module in order to form at least one first resin position limiting space above the substrate body, and the at least one second annular resin frame surrounds the at least one second light-emitting module and the at least one first annular resin frame in order to form at least one second resin position limiting space above the substrate body and between the at least one first annular resin frame and the at least one second annular resin frame. The package unit has at least one first translucent package resin body and at least one second translucent package resin body both disposed on the substrate body and respectively covering the at least one first light-emitting module and the at least one second light-emitting module. The at least one first translucent package resin body is limited in the at least one first resin position limiting space, and the at least one second translucent package resin body is limited in the at least one second resin position limiting space.

[0012] Hence, one light-emitting module with high color temperature and another light-emitting module with low color temperature both are connected each other in series or in parallel in order to create the light-mixing LED package structure with high color render index and brightness.

[0013] Furthermore, the translucent package resin body is limited in the resin position limiting space by using the annular resin frame in order to control the usage quantity of the translucent package resin body. In addition, the surface shape and the height of the translucent package resin body can be adjusted by control the usage quantity of the translucent package resin body in order to adjust light-projecting angles of the white light beams. Moreover, the blue light beams generated by the LED chips can be reflected by an inner wall of the annular resin frame in order to increase the light-emitting efficiency of the LED package structure of the present invention.

[0014] In order to further understand the techniques, means and effects the present invention takes for achieving the prescribed objectives, the following detailed descriptions and appended drawings are hereby referred, such that, through which, the purposes, features and aspects of the present invention can be thoroughly and concretely appreciated; however, the appended drawings are provided solely for reference and illustration, without any intention that they be used for limiting the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1A is a top, schematic view of the light-mixing LED package structure according to a first example;

FIG. 1B is a lateral, cross-sectional, schematic view of the light-mixing LED package structure according to the first example;

FIG. 1C is an xy chromaticity diagram of the light-mixing LED package structure according to the first example;

FIG. 2A is a top, schematic view of the light-mixing LED package structure according to a second example;

FIG. 2B is a lateral, cross-sectional, schematic view of the light-mixing LED package structure according to the second example;

FIG. 2C is an xy chromaticity diagram of the light-mixing LED package structure according to the second example;

FIG. 2D is a top, schematic view of the light-mixing LED package structure according to another second example;

FIG. 2E is a lateral, cross-sectional, schematic view of the light-mixing LED package structure according to the another second example;

FIG. 3A is a top, schematic view of the light-mixing LED package structure using first type of series method according to a third example;

FIG. 3B is a top, schematic view of the light-mixing LED package structure using second type of series method according to the third example;

FIG. 3C is a top, schematic view of the light-mixing LED package structure using third type of series method according to the third example;

FIG. 3D is a top, schematic view of the light-mixing LED package structure using fourth type of series method according to the third example;

FIG. 3E is a top, schematic view of the light-mixing LED package structure using fifth type of series method according to the third example;

FIG. 3F is an xy chromaticity diagram of the light-mixing LED package structure using five types of series methods according to the third example;

FIG. 3G is a top, schematic view of the light-mixing LED package structure using sixth type of series method according to the third example;

FIG. 4A is a top, schematic view of the light-mixing LED package structure according to a first embodiment of the present invention;

FIG. 4B is a lateral, cross-sectional, schematic view of the light-mixing LED package structure according to the first embodiment of the present invention;

FIG. 4C is an xy chromaticity diagram of the light-mixing LED package structure according to the first embodiment of the present invention;

FIG. 5 is a top, schematic view of the light-mixing LED package structure according to the second embodiment of the present invention;

FIG. 6A is a top, schematic view of the light-mixing LED package structure according to the third embodiment of the present invention;

FIG. 6B is a lateral, cross-sectional, schematic view of the light-mixing LED package structure according to the third embodiment of the present invention;

FIG. 7 is a lateral, cross-sectional, schematic view of the light-mixing LED package structure according to the fourth embodiment of the present invention; and

FIG. 8 is an xy chromaticity diagram of the light-mixing LED package structure according to one of the embodiments of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] Referring to FIGS. 1A and 1B, the first example provides a light-mixing LED package structure M for increasing color render index and brightness, including: a substrate unit 1, a light-emitting unit, a frame unit 3 and a package unit 4.

[0017] The substrate unit 1 has at least one substrate body 10, at least two chip-placing areas 11 formed on the at least one substrate body 10 and at least four power input pads 12 disposed on the top surface of the substrate body 10. In addition, the substrate body 10 has a circuit substrate 100, a heat-dissipating layer 101 disposed on a bottom surface of the circuit substrate 100, a plurality conductive pads 102 disposed on a top surface of the circuit substrate 100, and an insulative layer 103 disposed on the top surface of the circuit substrate 100 in order to expose the conductive pads 102. Hence, the heat-dissipating efficiency of the circuit substrate 100 is increased by using the heat-dissipating layer 101, and the insulative layer 103 is a solder mask for exposing the conductive pads 102 only in order to achieve local soldering. However, the above-mentioned definition of the substrate body 10 does not limit the present invention. Any types of substrate can be applied to the present invention. For example, the substrate body 10 can be a PCB (Printed Circuit Board), a flexible substrate, an aluminum substrate, a ceramic substrate, or a copper substrate.

[0018] Moreover, the light-emitting unit has at least one first light-emitting module 2a for generating a first color temperature and at least one second light-emitting module 2b for generating a second color temperature. The first light-emitting module 2a has a plurality of first light-emitting chips (such as LED chips) 20a electrically disposed on one of the chip-placing areas 11 of the substrate unit 1 and electrically connected to two of the at least four power input pads 12, and the second light-emitting module 2b has a plurality of second light-emitting chips (such as LED chips) 20b electrically disposed on the other chip-placing area 11 of the substrate unit 1 and electrically connected to the other two of the at least four power input pads 12.

[0019] In other words, designer can plan at least two predetermined chip-placing areas 11 on the substrate unit 1 in advance, so that the first light-emitting chips 20a and the second light-emitting chips 20b can be respectively placed on the two chip-placing areas 11 of the substrate unit 1 and are electrically connected to two of the at least four power input pads 12 and the other two of the at least four power input pads 12.

[0020] In the first example, the first light-emitting chips 20a and the second light-emitting chips 20b are respectively electrically disposed on the two chip-placing areas 11 of the substrate unit 1 by wire bonding. In addition, the first light-emitting chips 20a are electrically connected to two of the at least four power input pads 12 through one part of the circuits on the circuit substrate 100, and the second light-emitting chips 20b are electrically connected to the other two of the at least four power input pads 12 through another part of the circuits on the circuit substrate 100. Therefore, when powers with the same or different currents input into the four power input pads 12, the first light-emitting chips 20a and the second light-emitting chips 20b are selectively lighted up.

[0021] Furthermore, the frame unit 3 has at least two annular resin frames 30 surroundingly formed on a top surface of the substrate body 10 by coating. The two annular resin frames 30 respectively surround the first light-emitting module 2a and the second light-emitting module 2b in order to form at least two resin position limiting spaces 300 above the substrate body 10. In addition, the two annular resin frames 30 are selectively separated from each other or connected with each other, and the two annular resin frames 30 are disposed on the substrate body 10 in series or in parallel, according to different requirements. In the first example, the two annular resin frames 30 are separated from each other by a predetermined distance, and the two annular resin frames 30 are disposed on the substrate body 10 in parallel.

[0022] Each annular resin frame 30 has an arc shape formed on a top surface thereof. Each annular resin frame 30 has a radius tangent T and the angle 0 of the radius tangent T relative to the top surface of the substrate body 10 is between 40°C and 50°C. The maximum height of each annular resin frame 30 relative to the top surface of the substrate body 10 is between 0.3 mm and 0.7 mm. The width of a bottom side of each annular resin frame 30 is between 1.5 mm and 3 mm. The thixotropic index of each annular resin frame 30 is between 4 and 6, and each annular resin frame 30 is a white thermohardening resin frame (opaque resin frame) mixed with inorganic additive.

[0023] The method for forming each annular resin frame 30 includes: first, surroundingly coating liquid resin (not shown) on the top surface of the substrate body 10. In addition, the liquid resin can be coated on the substrate body 10 by any shapes according to different requirements (such as a circular shape, a square or a rectangular shape etc.). The thixotropic index of the liquid resin is between 4 and 6, the pressure of coating the liquid resin on the top surface of the substrate body 10 is between 350 kpa and 450 kpa, and the velocity of coating the liquid resin on the top surface of the substrate body 10 is between 5 mm/s and 15 mm/s. The liquid resin is surroundingly coated on the top surface of the substrate body 10 from a start point to a termination point, and the position of the start point and the position of the termination point are the same. Furthermore, the method further includes: hardening the liquid resin to form an annular resin frame 30, and the annular resin frame 30 surrounding the light-emitting chips (20a or 20b) that are disposed on the chip-placing area 11 to form a resin position limiting space 300 above the substrate body 10. In addition, the liquid resin is hardened by baking, the baking temperature is between 120°C and 140°C, and the baking time is between 20 minute and 40 minute.

[0024] Moreover, the package unit 4 has at least one first translucent package resin body 40a and at least one second translucent package resin body 40b both disposed on the substrate body 10 and respectively covering the first light-emitting module 2a and the second light-emitting module 2b. The first translucent package resin body 40a and the second translucent package resin body 40b are limited in the two resin position limiting spaces 300. In addition, the top surface of the first translucent package resin body 40a and the top surface of the second translucent package resin body 40b are convex surfaces.

[0025] In the first example, the light wavelengths of each first light-emitting chips 20a and each second light-emitting chip 20b can be between 400 nm and 500 nm.

[0026] In addition, each first light-emitting chip 20a is a blue light-emitting chip, the first translucent package resin body 40a is a phosphors with a first color, and light beams generated by the blue light-emitting chips pass through the first translucent package resin body 40a for generating yellow beams about 3500 color temperature. Moreover, one part of the above-mentioned elements is combined to form a first light-emitting structure N1 that is composed of the substrate body 10, the first light-emitting chips 20a, the annular resin frame 30 and the first translucent package resin body 40a.

[0027] In addition, each second light-emitting chip 20b is a blue light-emitting chip, the second translucent package resin body 40b is a phosphors with a second color, and light beams generated by the blue light-emitting chips pass through the second translucent package resin body 40b for generating white beams about 6500 color temperature. Moreover, one part of the above-mentioned elements is combined to form a second light-emitting structure N2 that is composed of the substrate body 10, the second light-emitting chips 20a, the annular resin frame 30 and the second translucent package resin body 40b.

[0028] Furthermore, the first light-emitting structure N1 and the second light-emitting structure N2 can share the substrate unit 1 as shown in the first example or use different substrate units. The first light-emitting structure N1 and the second light-emitting structure N2 are combined to form the light-mixing LED package structure M of the present invention.

[0029] The first example provides an electric current of 200 milliampere (mA) for the first light-emitting structure N1 (3500K), the second light-emitting structure N2 (6500K), and the light-mixing LED package structure M (3500K+6500K), and the relevant measurement results are shown in the following table:

Group	N1	N2	M
Luminous flux	110.457	184.166	156.138
Luminous efficiency	46.01	77.1	69.24
CIE x	0.3799	0.3118	0.3407
CIE y	0.3137	0.3388	0.3345
CCT	3390.4	6478.9	5125.2
Color render index	82.543	75.893	83.142

[0030] The unit of luminous flux is lumen; the unit of luminous efficiency is lumen/W; CIE x and CIE y respectively are x and y coordinates in xy chromaticity diagram of CIE (International Commission on Illumination); the unit of CCT (Correlated Color Temperature) is Kelvin (K); the unit of color render index is Rendering average (Ra).

[0031] Referring to FIG. 1C and the above-mentioned table, the first color temperature generated by the first light-emitting module 2a is smaller than the second color temperature generated by the second light-emitting module 2b. It means that 3500K temperature color of the yellow beams generated by the first light-emitting structure N1 is smaller than 6500K temperature color of the white beams generated by the second light-emitting structure N2. In addition, when the yellow beams and the white beams are mixed, the light-mixing LED package structure M of the first embodiment can generate good light blending effect as shown in the above-mentioned table.

[0032] Referring to FIGS. 2A and 2B, the second example provides a light-mixing LED package structure M for increasing color render index and brightness, including: a substrate unit 1, a light-emitting unit, a frame unit 3 and a package unit 4. The light-emitting unit has at least one first light-emitting module 2a for generating a first color temperature and at least one second light-emitting module 2b for generating a second color temperature. The difference between the second example and the first example is that: in the second example, the two annular resin frames 30 are connected with each other in series.

[0033] The second example provides four sets of electric current for the first light-emitting structures N1 (3500K) and the second light-emitting structure N2 (6500K) in order to form four sets of light-mixing LED package structures (A, B, C, D), and the relevant measurement results are shown in the following table:

Light-mixing LED package structure	A	B	C	D
Electric current for N1	100mA	200mA	200mA	300mA
Electric current for N2	200mA	100mA	200mA	200mA
CIE x	0.311	0.348	0.338	0.343
CIE y	0.320	0.319	0.322	0.317
CCT	6677.2	4707.76	5195.9	4962.1
Color render index	74.3	84.4	81.4	83.6

[0034] Referring to FIG. 2C and the above-mentioned table, when the 3500K temperature color of the yellow beams generated by the first light-emitting structure N1 and the 6500K temperature color of the white beams generated by the second light-emitting structure N2 are mixed, the light-mixing LED package structure M of the second example can generate good light blending effect as shown in the above-mentioned table.

[0035] Referring to FIGS. 2D and 2E, each annular resin frame 30 can be a phosphor resin. In other words, phosphor powders can be selectively add to each annular resin frame 30 according to different requirements in order to decrease dark bands that are generated between the first translucent package resin body 40a and the second translucent package resin body 40b. Hence, each annular resin frame 30 may be a phosphor resin or a light reflecting resin according to different requirements.

[0036] Referring to FIGS. 3A to 3E, the third example provides five sets of light-mixing LED package structures (M1 to M5), and each light-mixing LED package structure (M1 to M5) is composed of a first light-emitting structure N1 and a second light-emitting structure N2.

[0037] For example, the first set of light-mixing LED package structure M1 is composed of a first light-emitting structure N1 and a second light-emitting structure N2 that are connected in series. The second set of light-mixing LED package structure M2 is composed of two first light-emitting structures N1 and two second light-emitting structures N2 that are alternatively connected in series. The third set of light-mixing LED package structure M3 is composed of two second light-emitting structures N2 and two first light-emitting structures N1 that are alternatively connected in series. The fourth set of light-mixing LED package structure M4 is composed of two first light-emitting structures N1 and a second light-emitting structure N2 that are connected in series, and the second light-emitting structure N2 is arranged between the two first light-emitting structures N1. The fifth set of light-mixing LED package structure M5 is composed of a first light-emitting structure N1 and two second light-emitting structures N2 that are connected in series, and the first light-emitting structures N1 is arranged between the two second light-emitting structures N2.

[0038] The third example provides an electric current of 200 milliampere (mA) for the first light-emitting structure N1 (3500K), the second light-emitting structure N2 (6500K), and five groups of the light-mixing LED package structures M1~M5 (3500K+6500K), and the relevant measurement results are shown in the following table:

Group	N1	N2	M1	M2	M3	M4	M5
Luminous flux	105.6 8	146.4 4	124.1 0	122.6 0	130.7 2	143.2 5	112.6 0
Luminous efficiency	43.74 5	60.54 4	51.31 6	49.88 4	53.49 6	59.19 9	46.68 6
CIE x	0.381	0.311	0.367	0.367	0.362	0.351	0.343
CIE y	0.338	0.344	0.381	0.374	0.374	0.374	0.323
CCT	3644. 7	6509. 9	4418. 1	4379. 9	4528. 8	4887. 3	4987. 1
Color render index	81.20 6	77.29 0	78.55 9	78.60 6	78.63 9	76.73 0	84.69 2

[0039] Referring to FIG. 3F and the above-mentioned table, when the 3500K temperature color of the yellow beams generated by the first light-emitting structure N1 and the 6500K temperature color of the white beams generated by the second light-emitting structure N2 are mixed, the five groups of the light-mixing LED package structures (M1, M2, M3, M4, M5) of the third example can generate good light blending effect as shown in the above-mentioned table.

[0040] Referring to FIG. 3G, each annular resin frame 30 can be a phosphor resin. In other words, phosphor powders can be selectively add to each annular resin frame 30 according to different requirements in order to decrease dark bands that are generated between the first translucent package resin body 40a and the second translucent package resin body 40b. Hence, each annular resin frame 30 may be a phosphor resin or a light reflecting resin according to different requirements.

[0041] Referring to FIGS. 4A and 4B, the first embodiment of the present invention provides a light-mixing LED package structure M for increasing color render index and brightness, including: a substrate unit 1, a light-emitting unit, a frame unit 3 and a package unit 4.

[0042] The difference between the first embodiment and the first example is that: in the first embodiment, the frame unit 3 has at least one first annular resin frame 30a and at least one second annular resin frame 30b surroundingly formed on a top surface of the substrate body 10 by coating. In addition, the first annular resin frame 30a surrounds the first light-emitting module 20a in order to form at least one first resin position limiting space 300a above the substrate body 10, and the second annular resin frame 30b surrounds the second light-emitting module 2b and the first annular resin frame 30a in order to form at least one second resin position limiting space 300b above the substrate body 10 and between the first annular resin frame 30a and the second annular resin frame 30b.

[0043] Moreover, the package unit 4 has at least one first translucent package resin body 40a and at least one second translucent package resin body 40b both disposed on the substrate body 10 and respectively covering the first light-emitting module 2a and the second light-emitting module 2b. The first translucent package resin body 40a is limited in the first resin position limiting space 300a, and the second translucent package resin body 40b is limited in the second resin position limiting space 300b. In addition, the first annular resin frame 30a and the second annular resin frame 30b are arranged as concentric circles, and the second light-emitting module 2b is disposed between the first annular resin frame 30a and the second annular resin frame 30b.

[0044] Furthermore, the first annular resin frame 30a has an arc shape formed on a top surface thereof. The first annular resin frame 30a has a radius tangent T and the angle θ of the radius tangent T relative to the top surface of the substrate body 10 is between 40°C and 50°C. The maximum height of the first annular resin frame 30a relative to the top surface of the substrate body 10 is between 0.3 mm and 0.7 mm. The width of a bottom side of the first annular resin frame 30a is between 1.5 mm and 3 mm. The thixotropic index of the first annular resin frame 30a is between 4 and 6, and the first annular resin frame 30a is a white thermohardening resin frame mixed with inorganic additive.

[0045] In addition, the second annular resin frame 30b has an arc shape formed on a top surface thereof. The second annular resin frame 30b has a radius tangent T and the angle θ of the radius tangent T relative to the top surface of the substrate body 10 is between 40°C and 50°C. The maximum height of the second annular resin frame 30b relative to the top surface of the substrate body 10 is between 0.3 mm and 0.7 mm. The width of a bottom side of the second annular resin frame 30b is between 1.5 mm and 3 mm. The thixotropic index of the second annular resin frame 30b is between 4 and 6, and the second annular resin frame 30b is a white thermohardening resin frame mixed with inorganic additive.

[0046] The first embodiment provides an electric current of 700 milliampere (mA) for the first light-emitting structure N1 (3500K), the second light-emitting structure N2 (6500K), and two groups of the light-mixing LED package structures M (3500K+6500K). In addition, the radius of the first annular resin frame 30a of the first light-emitting structure N1 in Group A is 11 mm, and the radius of the first annular resin frame 30a of the first light-emitting structure N1 in Group B is 14 mm. The relevant measurement results are shown in the following table:

Group	N1	N2	A(r=11)	B(r=14)
Luminous flux	340.803	520.119	506.553	421.540
Luminous efficiency	40.357	62.039	60.540	50.257
CIE x	0.3656	0.3126	0.3198	0.3381
CIE y	0.3116	0.3530	0.3104	0.3119
CCT	3882.6	6355.9	6226.5	5180.5
Color render index	82.575	75.726	83.940	85.516

[0047] Referring to FIG. 4C and the above-mentioned table, when the 3500K temperature color of the yellow beams generated by the first light-emitting structure N1 and the 6500K temperature color of the white beams generated by the second light-emitting structure N2 are mixed, the two groups (A, B) of the light-mixing LED package structures M of the first embodiment can generate good light blending effect as shown in the above-mentioned table.

[0048] Referring to FIG. 5, the second embodiment of the present invention provides a light-mixing LED package structure M for increasing color render index and brightness. The light-mixing LED package structure M is composed of a first light-emitting structure N1 and a second light-emitting structure N2. In addition, the difference between the second embodiment and the first embodiment is that: in the second embodiment, the first light-emitting structure N1 is an outer ring to surround the second light-emitting structure N2. Hence, the second light-emitting structure N2 with high color temperature can be an outer ring to surround the first light-emitting structure N1 with low color temperature (as shown in the first embodiment) or the first light-emitting structure N1 with low color temperature can be an outer ring to surround the second light-emitting structure N2 with high color temperature (as shown in the second embodiment) according to different requirements.

[0049] Referring to FIGS. 6A and 6B, the third embodiment of the present invention provides a light-mixing LED package structure M for increasing color render index and brightness, including: a substrate unit 1, a light-emitting unit, a frame unit 3 and a package unit 4. The difference between the third embodiment and the first embodiment is that: in the third embodiment, the first annular resin frame 30a and the second annular resin frame 30b both are phosphor resins. In other words, phosphor powders can be selectively add to the first annular resin frame 30a and the second annular resin frame 30b according to different requirements in order to decrease dark bands that are generated between the first translucent package resin body 40a and the second translucent package resin body 40b.

[0050] Referring to FIG. 7, the fourth embodiment of the present invention provides a light-mixing LED package structure M for increasing color render index and brightness, including: a substrate unit 1, a light-emitting unit, a frame unit 3 and a package unit 4. The difference between the fourth embodiment and the first embodiment is that: in the fourth embodiment, the first annular resin frame 30a is a phosphor resin, and the second annular resin frame 30b is a light reflecting resin. In other words, phosphor powders can be selectively add to the first annular resin frame 30a according to different requirements in order to decrease dark bands that are generated between the first translucent package resin body 40a and the second translucent package resin body 40b. In addition, light beams generated from the light-mixing LED package structure M can be condensed by the second annular resin frame 30b.

[0051] Referring to FIG. 8 and the following table, one of the embodiments of the present invention provides different electric currents (mA) for the first light-emitting structure N1 (3500K), the second light-emitting structure N2 (6500K), and the light-mixing LED package structure M (3500K+6500K), and the relevant measurement results are shown in the following table:

condition	N1	N2	M (3500K+6500K)			
			CIE x	CIE y	CRI	CCT
1	10mA	680mA	0.316	0.356	76	6176
2	34mA	680mA	0.314	0.352	77	6296
3	340mA	680mA	0.326	0.339	82	5812
4	680mA	680mA	0.331	0.331	84	5553
5	1020mA	680mA	0.329	0.323	85	5690
6	1360mA	680mA	0.321	0.314	85	6139
7	680mA	340mA	0.314	0.313	83	6535

[0052] CIE x and CIE y respectively are x and y coordinates in xy chromaticity diagram of CIE (International Commission on Illumination); the unit of color render index is Rendering average (Ra); and the unit of CCT (Correlated Color Temperature) is Kelvin (K).

[0053] Referring to FIG. 8, when the yellow beams generated by the first light-emitting structure N1 (3500K) and the white beams generated by the second light-emitting structure N2 (6500K) are mixed, the light-mixing LED package structure M (3500K+6500K) can generate good light blending effect as shown in the above-mentioned table.

[0054] In conclusion, one light-emitting module with high color temperature and another light-emitting module with low color temperature both are connected each other in series or in parallel in order to create the light-mixing LED package structure with high color render index and brightness.

[0055] Furthermore, the present invention can form an annular resin frame (such as an annular white resin frame) with any shapes by coating method. In addition, the position of a translucent package resin body such as phosphor resin can be limited in the resin position limiting space by using the annular resin frame, and the shape of the translucent package resin body can be adjusted by using the annular resin frame. Therefore, the present invention can apply to increase light-emitting efficiency of LED chips and control light-projecting angle of LED chips. In other words, the translucent package resin body is limited in the resin position limiting space by using the annular resin frame in order to control the usage quantity of the translucent package resin body. In addition, the surface shape and the height of the translucent package resin body can be adjusted by control the usage quantity of the translucent package resin body in order to adjust light-projecting angles of the white light beams. Moreover, the blue light beams generated by the LED chips can be reflected by an inner wall of the annular resin frame in order to increase the light-emitting efficiency of the LED package structure of the present invention.

[0056] The above-mentioned descriptions merely represent solely the preferred embodiments of the present invention, without any intention or ability to limit the scope of the present invention which is fully described only within the following claims.

Claims

1. A light-mixing LED package structure (M) for increasing color render index and brightness, comprising:

   a substrate unit (1) having at least one substrate body (10) ;
   a light-emitting unit having at least one first light-emitting module (2a) for generating light of a first color temperature and at least one second light-emitting module (2b) for generating light of a second color temperature different from the first color temperature,
   wherein the at least one first light-emitting module (2a) has a plurality of first light-emitting chips (20a) electrically disposed on the substrate unit (1), and the at least one second light-emitting module (2b) has a plurality of second light-emitting chips (20b) electrically disposed on the substrate unit (1);
   a frame unit (3) having at least one first annular resin frame (30) and at least one second annular resin frame (30) surroundingly formed on a top surface of the substrate unit (1), wherein the at least one first annular resin frame (30) surrounds the at least one first light-emitting module (2a) in order to form at least one first resin position limiting space (300) above a substrate body (10) of the substrate unit (1) and surrounded by the at least one first annular resin frame (30),
   and the at least one second annular resin frame (30) surrounds the at least one second light-emitting module (2b) and the at least one first annular resin frame (30) in order to form at least one second resin position limiting space (300) above the substrate body (10) and between the at least one first annular resin frame (30) and the at least one second annular resin frame (30); and
   a package unit (4) having at least one first translucent package resin body (40a) and at least one second translucent package resin body (40b) both disposed on the substrate body (10) and respectively covering the at least one first light-emitting module (2a) and the at least one second light-emitting module (2b), wherein the at least one first translucent package resin body (40a) is limited in the at least one first resin position limiting space (300), and the at least one second translucent package resin body (40b) is limited in the at least one second resin position limiting space (300).

2. The light-mixing LED package structure (M) according to claim 1, wherein:

   the substrate unit (1) has at least one substrate body (10) and at least two chip-placing areas (11) formed on the at least one substrate body (10);
   the plurality of first light-emitting chips (20a) is electrically disposed on one of the chip-placing areas (11) of the substrate unit (1), and the plurality of second light-emitting chips (20b) is electrically disposed on the other chip-placing area (11) of the substrate unit (1); and
   the at least one first annular resin frame (30) and the at least one second annular resin frame (30) are surroundingly formed on a top surface of the substrate body (10) by coating.

3. The light-mixing LED package structure (M) according to claim 2, wherein each first light-emitting chip (20a) is a blue light-emitting chip, the at least one first translucent package resin body (40a) is a phosphors with a first color, and light beams generated by the blue light-emitting chips pass through the at least one first translucent package resin body (40a) for generating yellow beams about 3500 K color temperature, wherein each second light-emitting chip (20b) is a blue light-emitting chip, the at least one second translucent package resin body (40b) is a phosphors with a second color, and light beams generated by the blue light-emitting chips pass through the at least one second translucent package resin body (40b) for generating white beams about 6500 K color temperature, wherein the light wavelengths of each first light-emitting chip (20a) and each second light-emitting chip (20b) are between 400 nm and 500 nm, the substrate unit (1) has at least four power input pads (12) disposed on the top surface of the substrate body (10), the first light-emitting chips (20a) are electrically connected to two of the at least four power input pads (12), and the second light-emitting chips (20b) are electrically connected to the other two of the at least four power input pads (12).

4. The light-mixing LED package structure (M) according to claim 2, wherein the first color temperature generated by

the at least one first light-emitting module (2a) is smaller or larger than the second color temperature generated by the at least one second light-emitting module (2b).

5. The light-mixing LED package structure (M) according to claim 1 or 2, wherein the at least one first annular resin frame (30) and the at least one second annular resin frame (30) are arranged as concentric circles, and the at least one second light-emitting module (2b) is disposed between the at least one first annular resin frame (30) and the at least one second annular resin frame (30).

6. The light-mixing LED package structure (M) according to claim 1 or 2, wherein the at least one first annular resin frame (30) is a phosphor resin, and the at least one second annular resin frame (30) is a phosphor resin or light reflecting resin.

Patentansprüche

1. Eine lichtmischende LED-Gehäusestruktur (M) zum Erhöhen des Farbwiedergabeindex und der Helligkeit aufweisend:

   eine Substrateinheit (1) aufweisend mindestens einen Substratkörper (10);
   eine lichtemittierende Einheit aufweisend mindestens ein erstes lichtemittierendes Modul (2a) zum Erzeugen von Licht einer ersten Farbtemperatur und mindestens ein zweites lichtemittierendes Modul (2b) zum Erzeugen von Licht einer zweiten Farbtemperatur,
   die von der ersten Farbtemperatur verschieden ist,
   wobei das mindestens eine erste lichtemittierende Modul (2a) eine Mehrzahl von ersten elektrisch auf der Substrateinheit (1) angeordneten lichtemittierenden Chips (20a) aufweist, und das mindestens eine zweite lichtemittierende Modul (2b) eine Mehrzahl von zweiten elektrisch auf der Substrateinheit (1) angeordneten lichtemittierenden Chips (20b) aufweist;
   eine Rahmeneinheit (3) aufweisend mindestens einen ersten ringförmigen Harzrahmen (30) und mindestens einen zweiten ringförmigen Harzrahmen (30), der umgebend auf einer oberen Fläche der Substrateinheit (1) gebildet ist, wobei der mindestens eine erste ringförmige Harzrahmen (30) das mindestens eine erste lichtemittierende Modul (2a) umgibt, um mindestens einen ersten Harz-Anordnungs-Begrenzungsraum (300) über einem Substratkörper (10) der Substrateinheit (1) und umgeben von dem mindestens einen ersten ringförmigen Harzrahmen (30) zu bilden,
   und der mindestens eine zweite ringförmige Harzrahmen (30) das mindestens eine zweite lichtemittierende Modul (2b) und den mindestens einen ersten ringförmigen Harzrahmen (30) umgibt, um mindestens einen zweiten Harz-Anordnungs-Begrenzungsraum (300) über dem Substratkörper (10) und zwischen dem mindestens einen ersten ringförmigen Harzrahmen (30) und dem mindestens einen zweiten ringförmigen Harzrahmen (30) zu bilden; und
   eine Gehäuseeinheit (4) aufweisend mindestens einen ersten transluzenten Gehäuseharzkörper (40a) und mindestens einen zweiten transluzenten Gehäuseharzkörper (40b), die beide auf dem Substratkörper (10) angeordnet sind und jeweils das mindestens eine erste lichtemittierende Modul (2a) und das mindestens eine zweite lichtemittierende Modul (2b) bedecken, wobei der mindestens eine erste transluzente Gehäuseharzkörper (40a) in dem mindestens einen ersten Harz-Anordnungs-Begrenzungsraum (300) begrenzt ist, und der mindestens eine zweite transluzente Gehäuseharzkörper (40b) in dem mindestens einen zweiten Harz-Anordnungs-Begrenzungsraum (300) begrenzt ist

2. Die lichtmischende LED-Gehäusestruktur (M) gemäß Anspruch 1, wobei:

   die Substrateinheit (1) mindestens einen Substratkörper (10) und mindestens zwei Chip-Platzierungsbereiche (11) aufweist, die an dem mindestens einen Substratkörper (10) gebildet sind;
   die Mehrzahl der ersten lichtemittierenden Chips (20a) an einem der Chip-Platzierungsbereiche (11) der Substrateinheit (1) elektrisch angeordnet ist, und die Mehrzahl der zweiten lichtemittierenden Chips (20b) an dem anderen Chip-Platzierungsbereich (11) der Substrateinheit (1) elektrisch angeordnet ist; und
   der mindestens eine erste ringförmige Harzrahmen (30) und der mindestens eine zweite ringförmige Harzrahmen (30) umgebend auf einer oberen Fläche des Substratkörpers (10) durch Beschichten gebildet sind.

3. Die lichtmischende LED-Gehäusestruktur (M) gemäß Anspruch 2, wobei jeder erste lichtemittierende Chip (20a) ein Blaues-Licht-Emittierender-Chip ist, wobei der mindestens eine erste transluzente Gehäuseharzkörper (40a)

ein Leuchtstoff mit einer ersten Farbe ist, und von Blaues-Licht-Emittierender-Chips erzeugte Lichtstrahlen durch den mindestens einen ersten transluzenten Gehäuseharzkörper (40a) verlaufen, um gelbe Strahlen mit ungefähr 3500 K Farbtemperatur zu erzeugen, wobei jeder zweite lichtemittierende Chip (20b) ein Blaues-Licht-Emittierender-Chip ist, der mindestens zweite transluzente Gehäuseharzkörper (40b) ein Leuchtstoff mit einer zweiten Farbe ist, und von Blaues-Licht-Emittierender-Chips erzeugte Lichtstrahlen durch den mindestens einen zweiten transluzenten Gehäuseharzkörper (40b) verlaufen, um weiße Strahlen mit ungefähr 6500 K Farbtemperatur zu erzeugen, wobei die Lichtwellenlängen jedes ersten lichtemittierenden Chips (20a) und jedes zweiten lichtemittierenden Chips (20b) zwischen 400 nm und 500 nm liegt, die Substrateinheit (1) mindestens vier auf der oberen Fläche des Substratkörpers (10) angeordnete Stromeingangspads (12) aufweist, wobei die ersten lichtemittierenden Chips (20a) mit zwei der mindestens vier Stromeingangspads (12) elektrisch verbunden sind, und die zweiten lichtemittierenden Chips (20b) mit den anderen zwei der mindestens vier Stromeingangspads (12) elektrisch verbunden sind.

4. Die lichtmischende LED-Gehäusestruktur (M) gemäß Anspruch 2, wobei die erste von dem mindestens einen ersten lichtemittierenden Modul (2a) erzeugte Farbtemperatur kleiner oder größer ist als die zweite von dem mindestens einen zweiten lichtemittierenden Modul (2b) erzeugte Farbtemperatur.

5. Die lichtmischende LED-Gehäusestruktur (M) gemäß Anspruch 1 oder 2, wobei der mindestens eine erste ringförmige Harzrahmen (30) und der mindestens eine zweite ringförmige Harzrahmen (30) als konzentrische Kreise angeordnet sind, und das mindestens eine zweite lichtemittierende Modul (2b) zwischen dem mindestens einen ersten ringförmigen Harzrahmen (30) und dem mindestens einen zweiten ringförmigen Harzrahmen (30) angeordnet ist.

6. Die lichtmischende LED-Gehäusestruktur (M) gemäß Anspruch 1 oder 2, wobei der mindestens eine erste ringförmige Harzrahmen (30) ein Leuchtstoffharz ist, und der mindestens eine zweite ringförmige Harzrahmen (30) ein Leuchtstoffharz oder ein lichtreflektierendes Harz ist.

Revendications

1. Structure à LED de mixage d'éclairage (M) destinée à augmenter l'indice de rendu des couleurs et la luminosité, qui comprend :

une unité de substrat (1) qui possède au moins un corps de substrat (10) ;
une unité d'émission de lumière qui possède au moins un premier module d'émission de lumière (2a) destiné à générer une lumière d'une première température de couleur, et au moins un second module d'émission de lumière (2b) destiné à générer une lumière d'une seconde température de couleur différente de la première température de couleur,
dans laquelle ledit premier module d'émission de lumière (2a) possède une pluralité de premières puces d'émission de lumière (20a) disposées électriquement sur l'unité de substrat (1), et ledit second module d'émission de lumière (2b) possède une pluralité de secondes puces d'émission de lumière (20b) disposées électriquement sur l'unité de substrat (1) ;
une armature (3) qui possède au moins une première armature annulaire en résine (30) et au moins une seconde armature annulaire en résine (30) formée autour de et sur une surface supérieure de l'unité de substrat (1), ladite première armature annulaire en résine (30) entourant ledit premier module d'émission de lumière (2a) afin de former au moins un premier espace de limitation de position de la résine (300) au-dessus d'un corps de substrat (10) de l'unité de substrat (1), et entouré par ladite première armature annulaire en résine (30), et ladite seconde armature annulaire en résine (30) entourant ledit second module d'émission de lumière (2b) et ladite première armature annulaire en résine (30) afin de former au moins un second espace de limitation de position de la résine (300) au-dessus du corps de substrat (10) et entre ladite première armature annulaire en résine (30) et ladite seconde armature annulaire en résine (30) ; et
un boîtier (4) qui possède au moins un premier corps de boîtier en résine translucide (40a) et au moins un second corps de boîtier en résine translucide (40b) disposés sur le corps de substrat (10) et qui recouvrent respectivement ledit premier module d'émission de lumière (2a) et ledit second module d'émission de lumière (2b), ledit premier corps de boîtier en résine translucide (40a) étant limité dans ledit premier espace de limitation de position de la résine (300), et ledit second corps de boîtier en résine translucide (40b) étant limité dans ledit second espace de limitation de position de la résine (300).

2. Structure à LED de mixage d'éclairage (M) selon la revendication 1, dans laquelle :

l'unité de substrat (1) possède au moins un corps de substrat (10) et au moins deux zones de placement de puces (11) formées sur ledit corps de substrat (10) ;
la pluralité de premières puces d'émission de lumière (20a) est disposée électriquement sur l'une des zones de placement de puces (11) de l'unité de substrat (1), et la pluralité de secondes puces d'émission de lumière (20b) est disposée électriquement sur l'autre zone de placement de puces (11) de l'unité de substrat (1) ; et
ladite première armature annulaire en résine (30) et ladite seconde armature annulaire en résine (30) sont formées autour de et sur une surface supérieure du corps de substrat (10) par revêtement.

3. Structure à LED de mixage d'éclairage (M) selon la revendication 2, dans laquelle chaque première puce d'émission de lumière (20a) est une puce d'émission de lumière bleue, ledit premier corps de boîtier en résine translucide (40a) est un phosphore d'une première couleur, et les faisceaux lumineux générés par les puces d'émission de lumière bleue traversent ledit premier corps de boîtier en résine translucide (40a) afin de générer des faisceaux jaunes d'une température de couleur d'environ 3500 K, chaque seconde puce d'émission de lumière (20b) est une puce d'émission de lumière bleue, ledit second corps de boîtier en résine translucide (40b) étant un phosphore d'une seconde couleur, et les faisceaux générés par les puces d'émission de lumière bleue traversent ledit second corps de boîtier en résine translucide (40b) afin de générer des faisceaux blancs d'une température de couleur d'environ 6500 K, les longueurs d'onde de lumière de chaque première puce d'émission de lumière (20a) et de chaque seconde puce d'émission de lumière (20b) étant comprises entre 400 nm et 500 nm, l'unité de substrat (1) possède au moins quatre plots d'alimentation (12) disposés sur la surface supérieure du corps de substrat (10), les premières puces d'émission de lumière (20a) sont reliées électriquement à deux desdits quatre plots d'alimentation (12), et les secondes puces d'émission de lumière (20b) sont électriquement reliées aux deux autres desdits quatre plots d'alimentation (12).

4. Structure à LED de mixage d'éclairage (M) selon la revendication 2, dans laquelle la première température de couleur générée par ledit premier module d'émission de lumière (2a) est inférieure ou supérieure à la seconde température de couleur générée par ledit second module d'émission de lumière (2b).

5. Structure à LED de mixage d'éclairage (M) selon la revendication 1 ou 2, dans laquelle ladite première armature annulaire en résine (30) et ladite seconde armature annulaire en résine (30) sont disposées sous forme de cercles concentriques, et ledit second module d'émission de lumière (2b) est disposé entre ladite première armature annulaire en résine (30) et ladite seconde armature annulaire en résine (30).

6. Structure à LED de mixage d'éclairage (M) selon la revendication 1 ou 2, dans laquelle ladite première armature annulaire en résine (30) est une résine de phosphore, et ladite seconde armature annulaire en résine (30) est une résine de phosphore ou une résine de réflexion de la lumière.

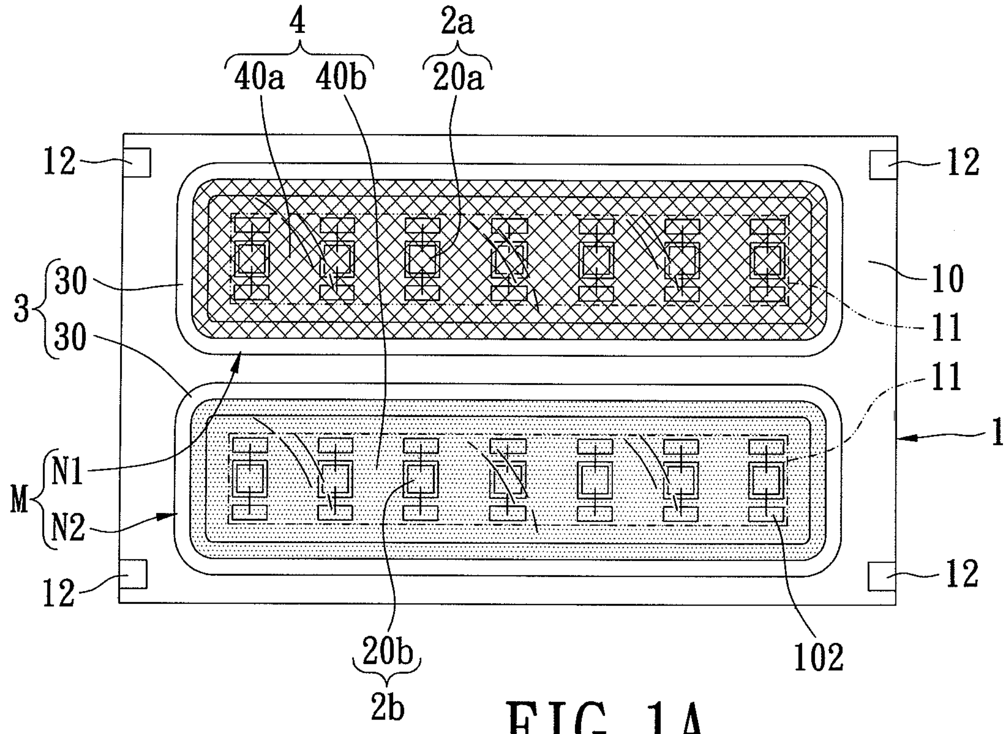

4
40a
40b
2a
20a
12
12
3
30
30
10
11
11
1
M
N1
N2
12
12
20b
2b
102

FIG. 1A

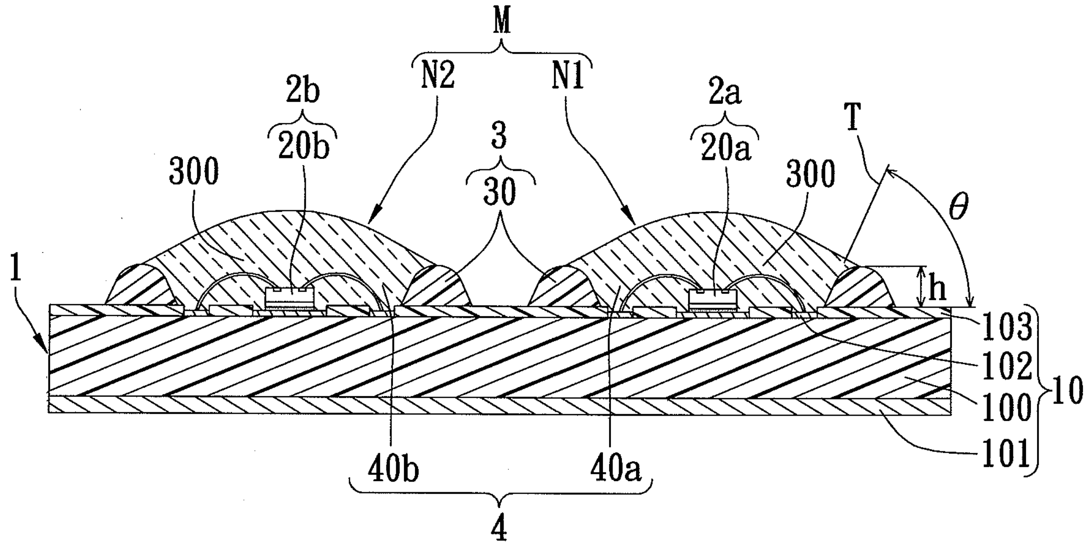

M
N2
N1
2b
20b
2a
20a
3
30
T
θ
300
300
1
h
103
102
100
10
101
40b
40a
4

FIG. 1B

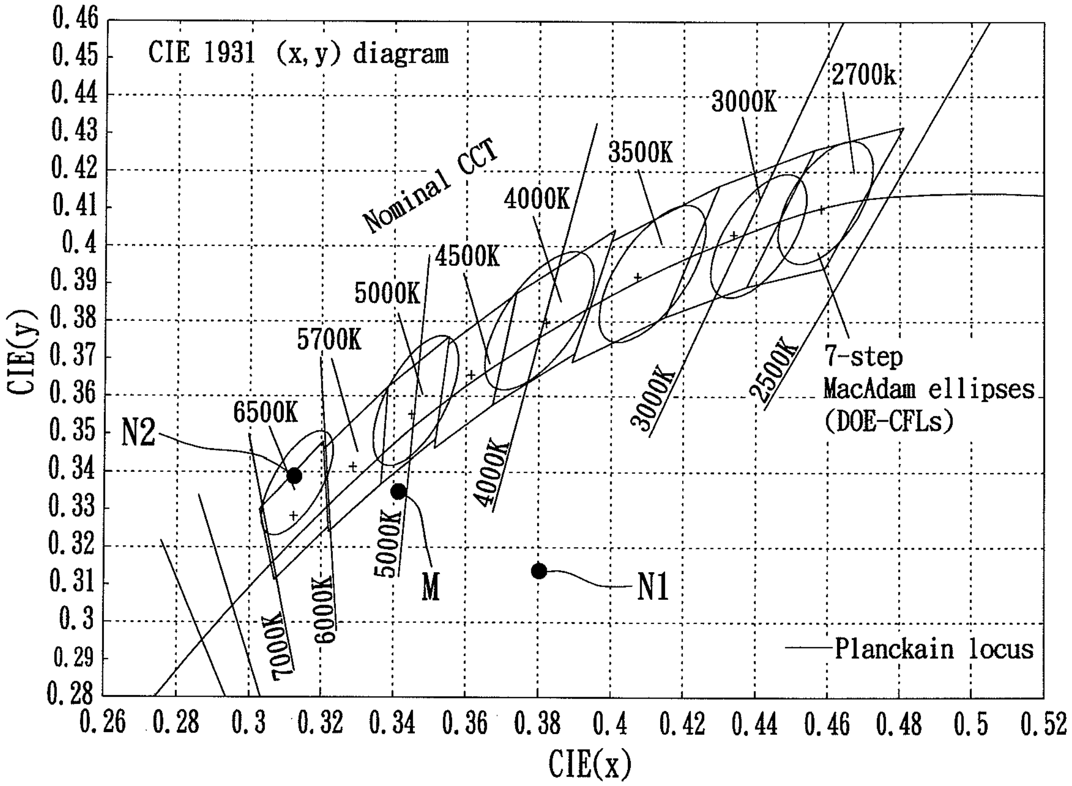

CIE 1931 (x, y) diagram
Nominal CCT
2700k
3000K
3500K
4000K
4500K
5000K
5700K
6500K
N2
M
N1
7000K
6000K
5000K
4000K
3000K
2500K
7-step
MacAdam ellipses
(DOE-CFLs)
Planckain locus
CIE(y)
CIE(x)

FIG. 1C

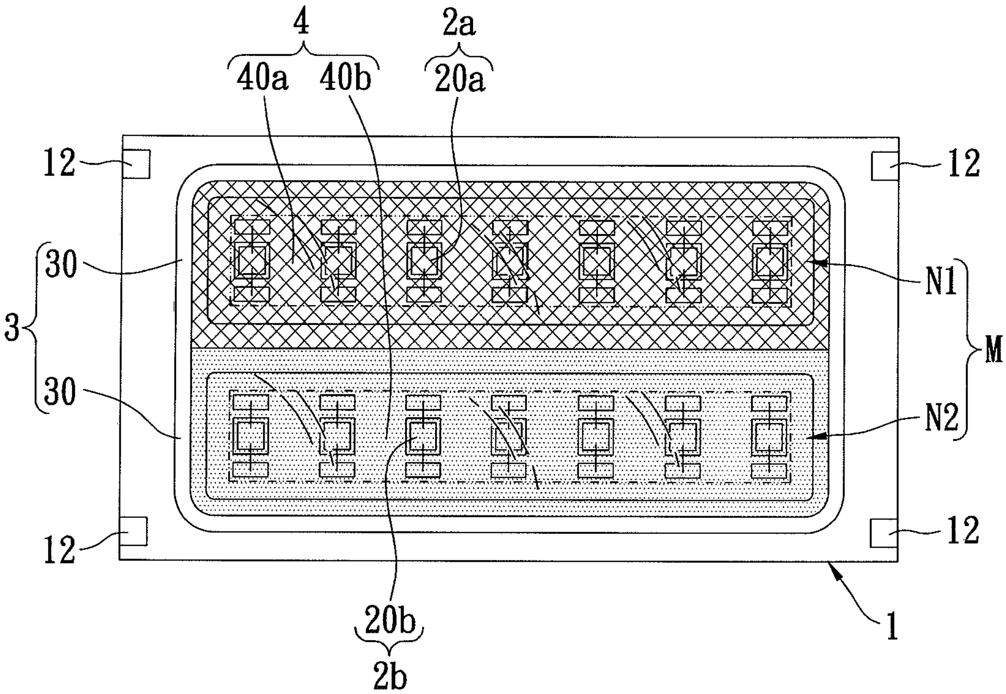


FIG. 2A

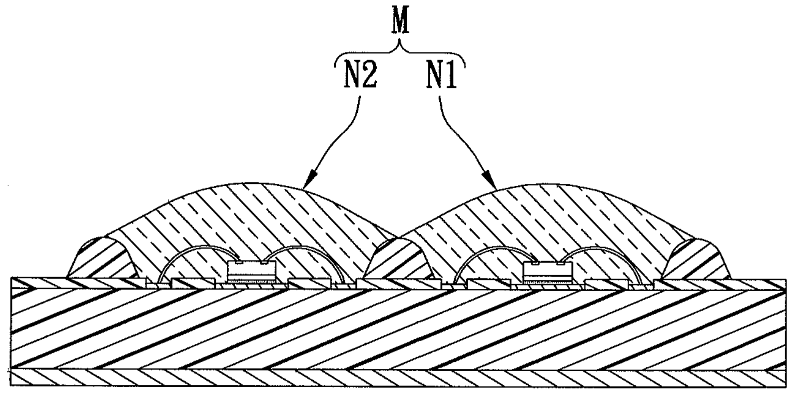


FIG. 2B

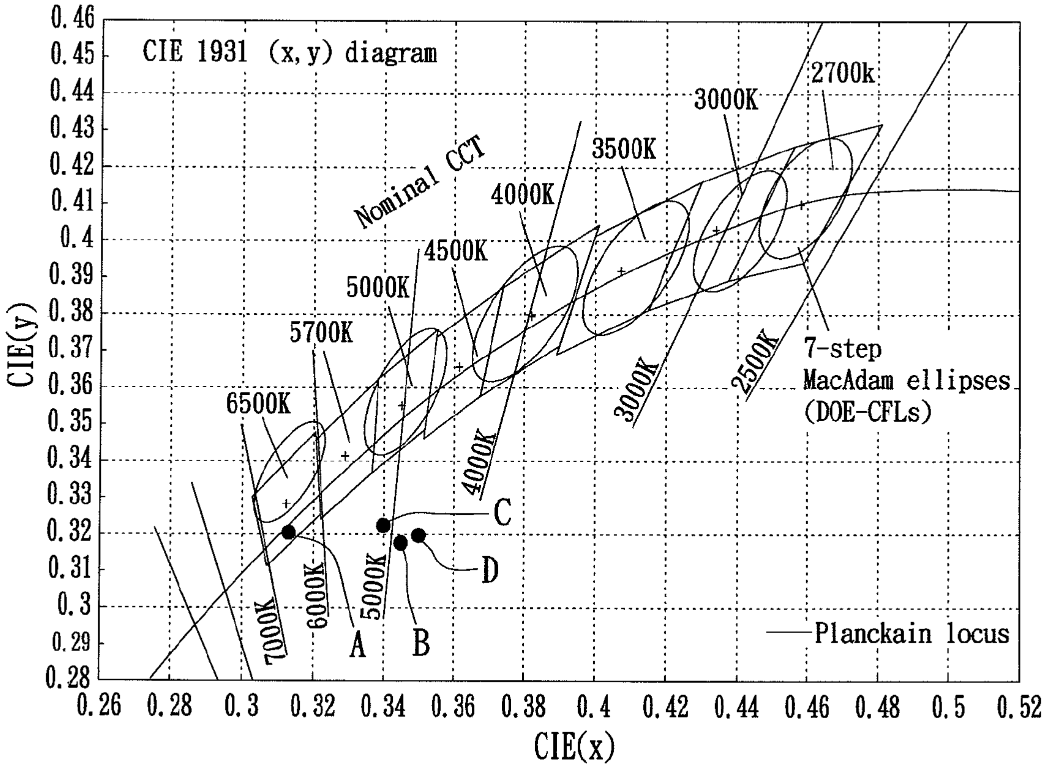

CIE 1931 (x, y) diagram
Nominal CCT
2700k
3000K
3500K
4000K
4500K
5000K
5700K
6500K
7-step
MacAdam ellipses
(DOE-CFLs)
2500K
3000K
4000K
5000K
6000K
7000K
A
B
C
D
Planckain locus
CIE(y)
CIE(x)
0.46
0.45
0.44
0.43
0.42
0.41
0.4
0.39
0.38
0.37
0.36
0.35
0.34
0.33
0.32
0.31
0.3
0.29
0.28
0.26 0.28 0.3 0.32 0.34 0.36 0.38 0.4 0.42 0.44 0.46 0.48 0.5 0.52

FIG. 2C

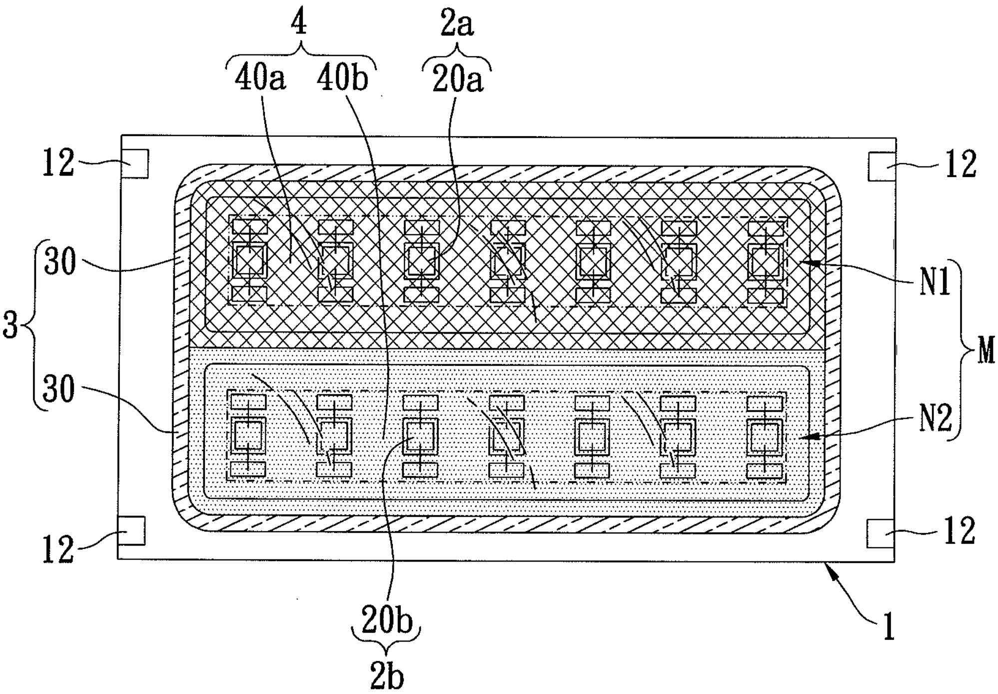

4
40a
40b
2a
20a
12
12
30
3
30
N1
M
N2
12
12
20b
2b
1

FIG. 2D

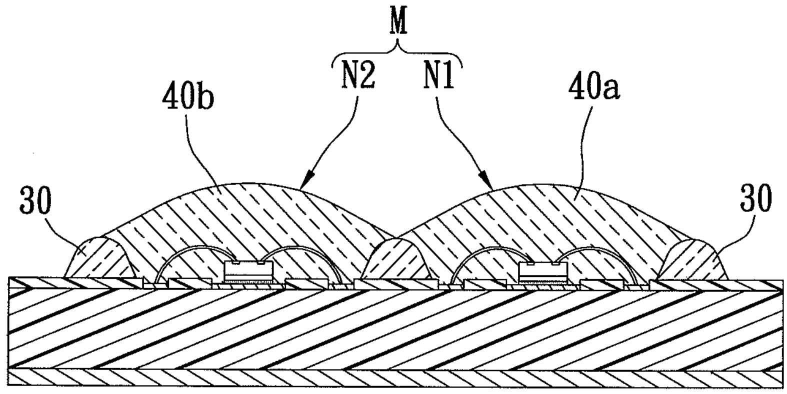

M
N2
N1
40b
40a
30
30

FIG. 2E

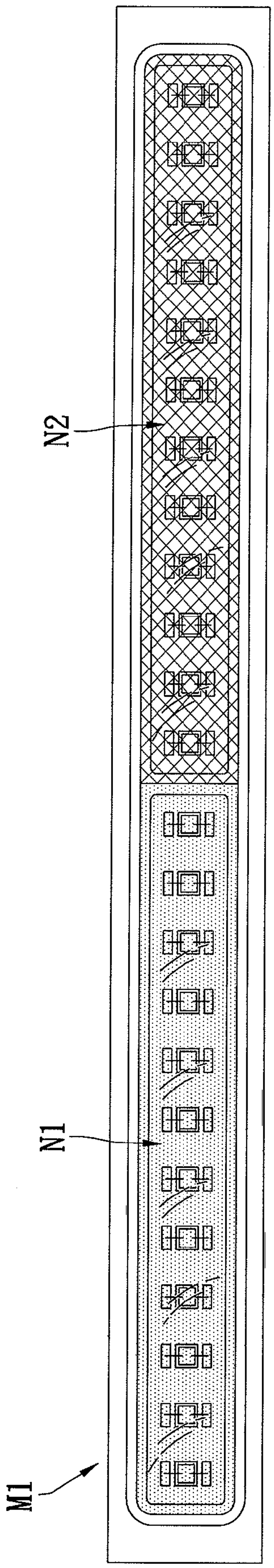


FIG. 3A

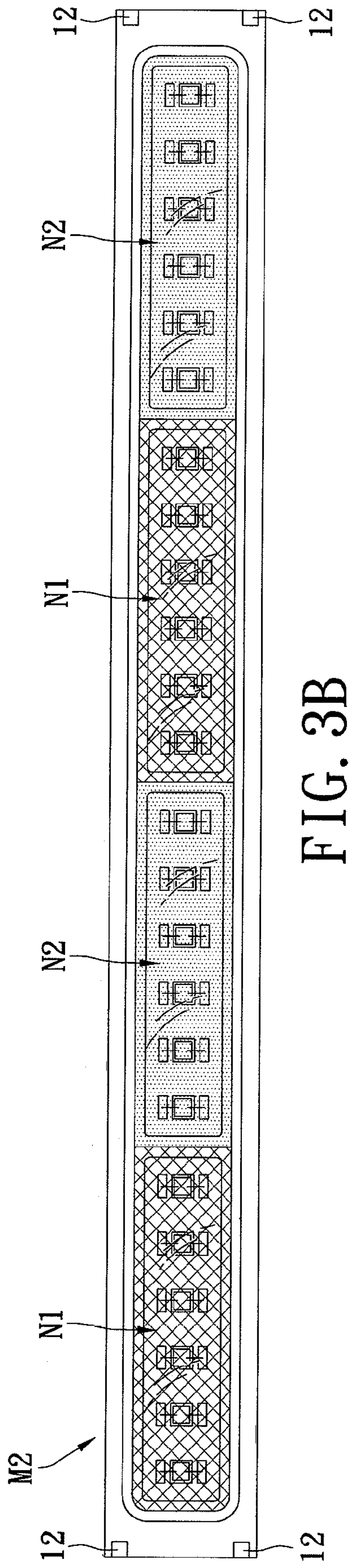


FIG. 3B

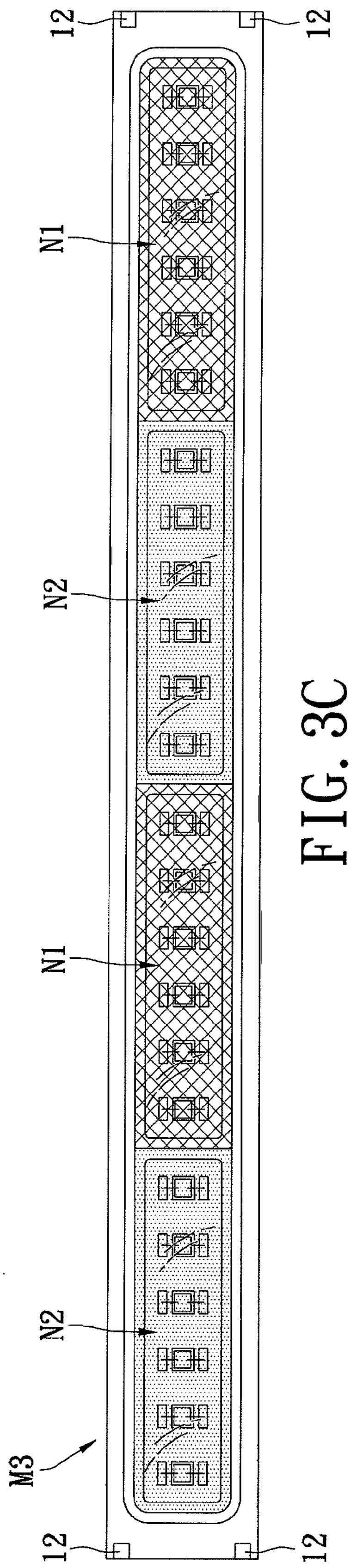


FIG. 3C

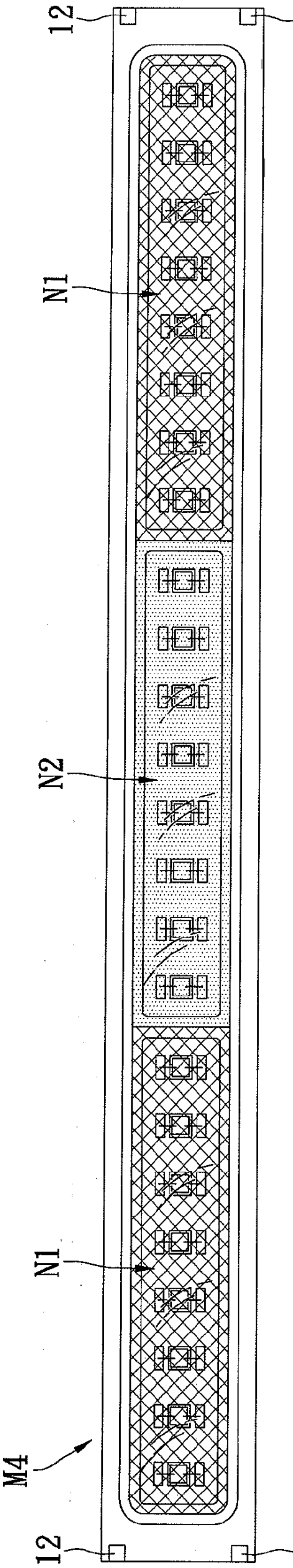


FIG. 3D

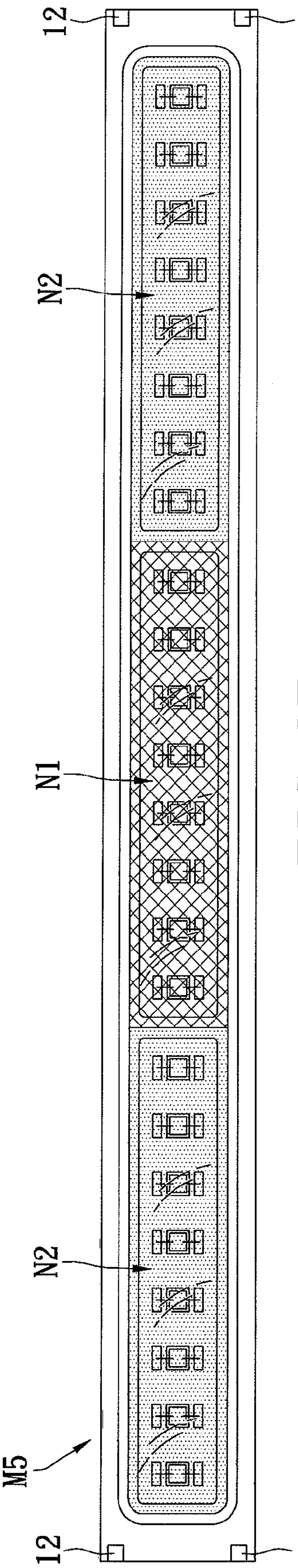


FIG. 3E

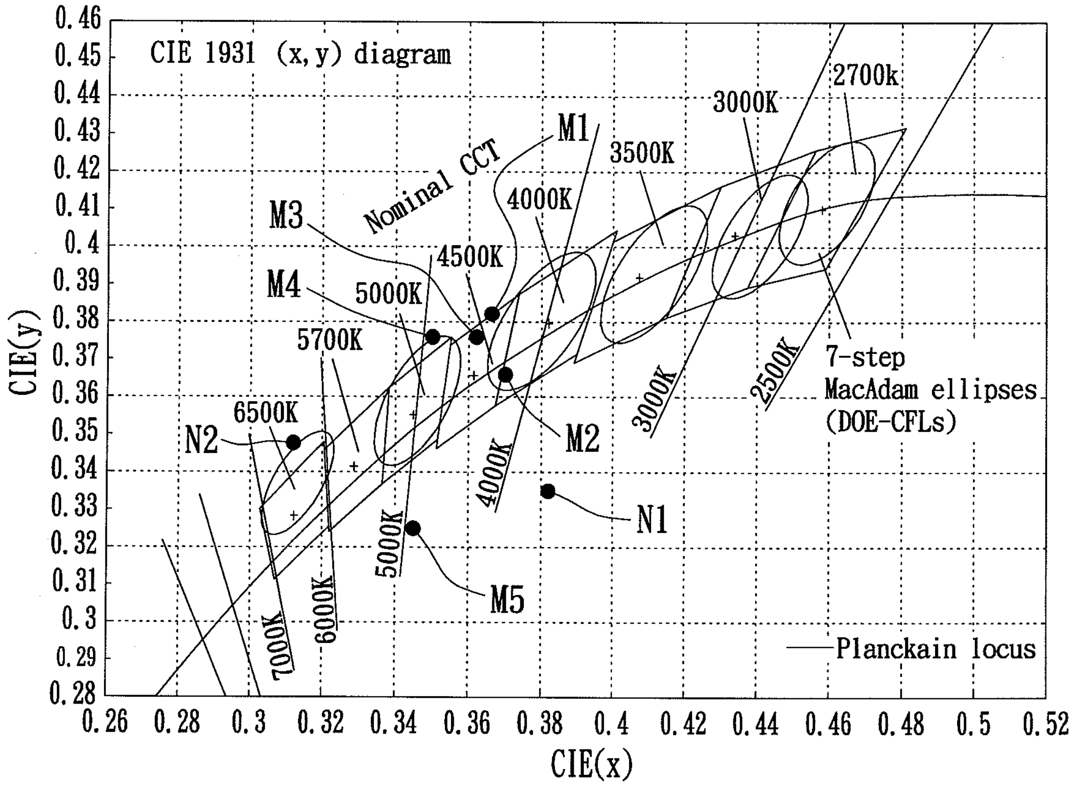

CIE 1931 (x,y) diagram
0.46
0.45
0.44
0.43
0.42
0.41
0.4
0.39
0.38
0.37
0.36
0.35
0.34
0.33
0.32
0.31
0.3
0.29
0.28
CIE(y)
0.26
0.28
0.3
0.32
0.34
0.36
0.38
0.4
0.42
0.44
0.46
0.48
0.5
0.52
CIE(x)
2700k
3000K
M1
3500K
Nominal CCT
4000K
M3
4500K
M4
5000K
5700K
6500K
N2
M2
7-step
MacAdam ellipses
(DOE-CFLs)
2500K
3000K
4000K
5000K
6000K
7000K
N1
M5
Planckain locus

FIG. 3F

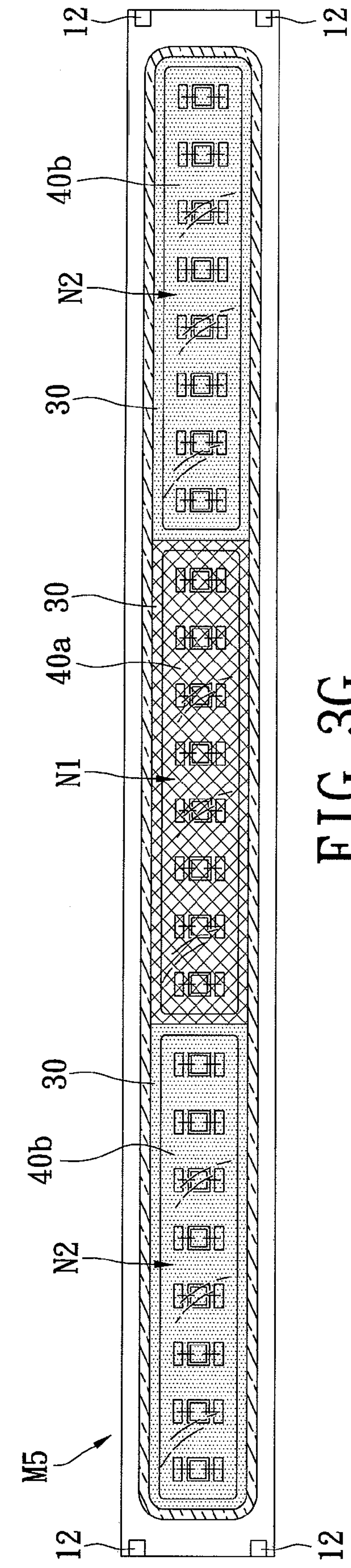


FIG. 3G

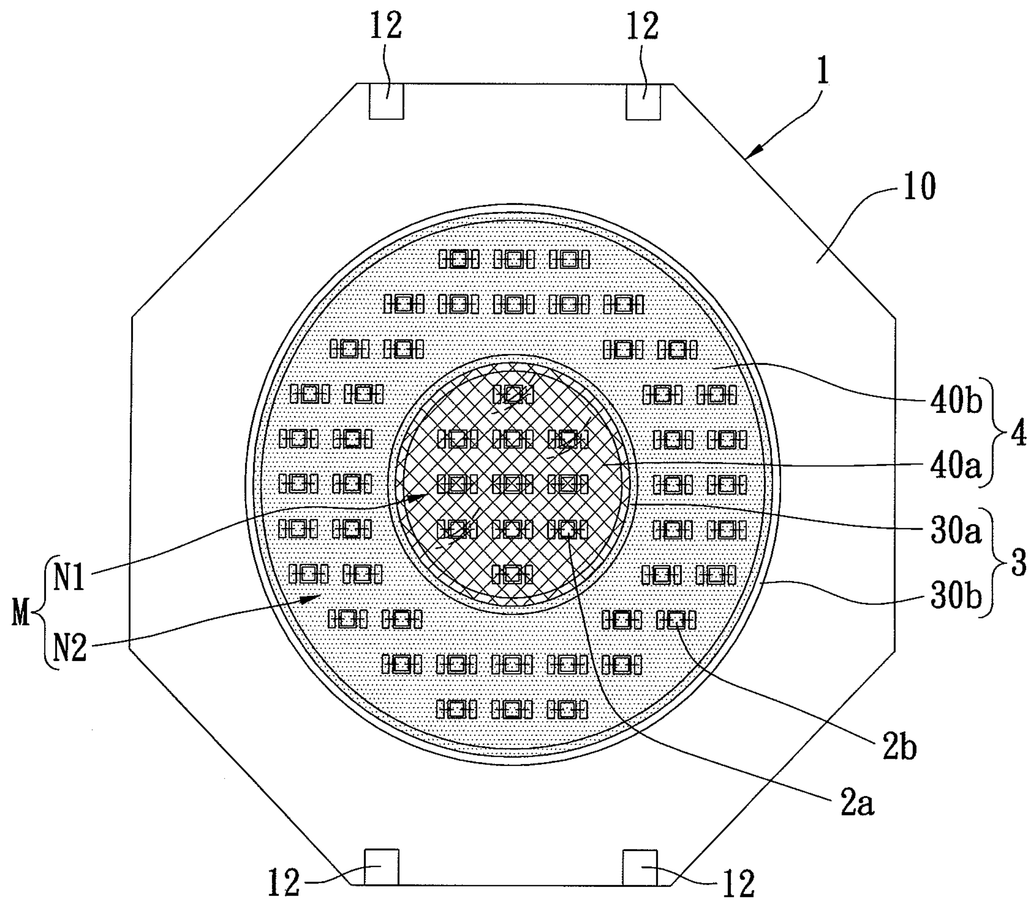

12
12
1
10
40b
4
40a
30a
3
30b
N1
M
N2
2b
2a
12
12

FIG. 4A

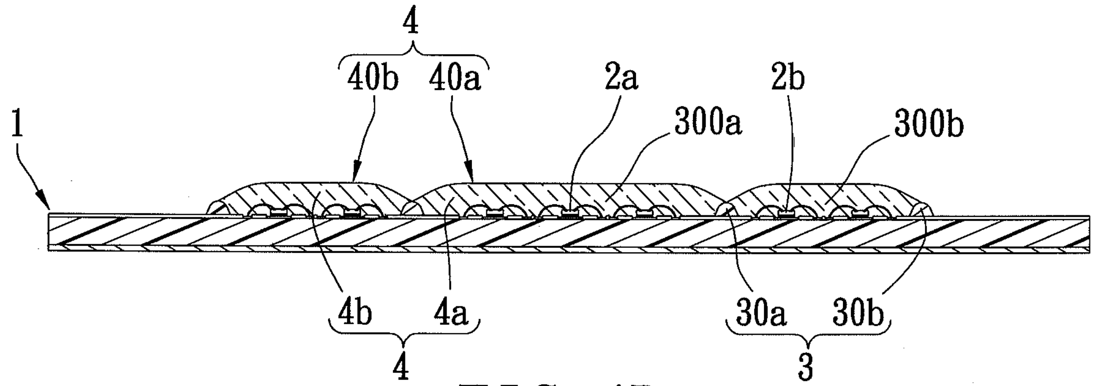

4
40b
40a
2a
2b
1
300a
300b
4b
4a
30a
30b
4
3

FIG. 4B

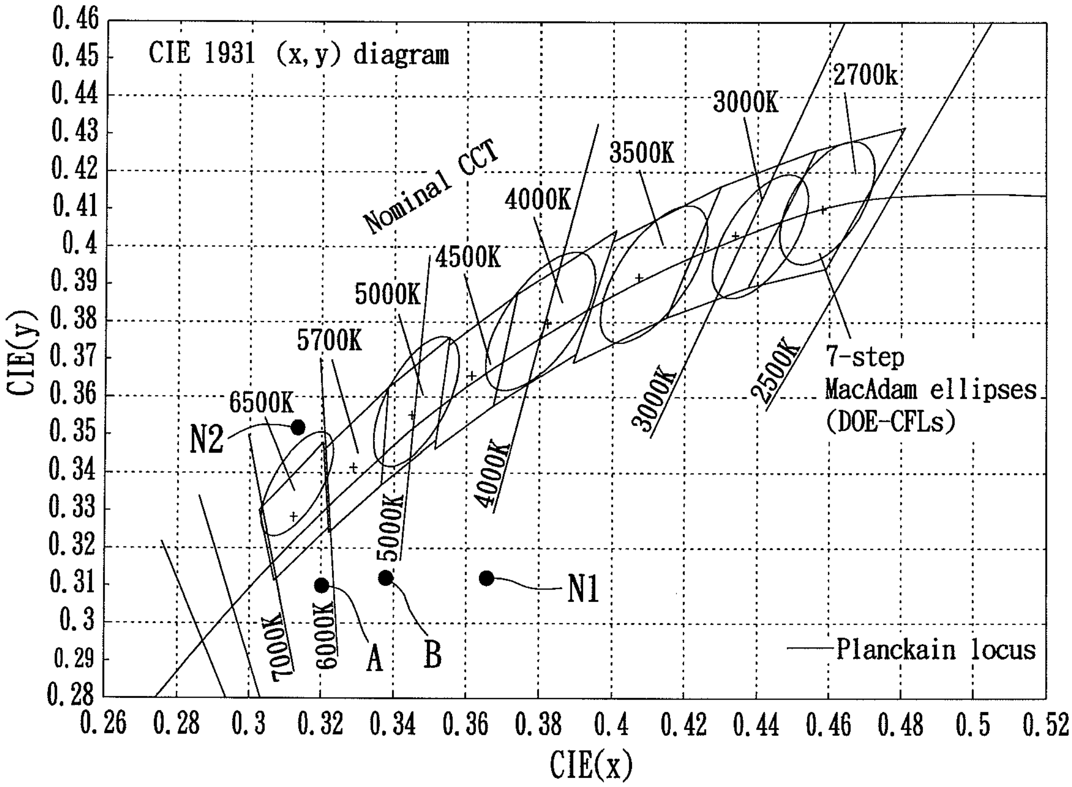

CIE 1931 (x,y) diagram
Nominal CCT
2700k
3000K
3500K
4000K
4500K
5000K
5700K
6500K
N2
N1
A
B
7000K
6000K
5000K
4000K
3000K
2500K
7-step
MacAdam ellipses
(DOE-CFLs)
Planckain locus
CIE(y)
CIE(x)
0.46
0.45
0.44
0.43
0.42
0.41
0.4
0.39
0.38
0.37
0.36
0.35
0.34
0.33
0.32
0.31
0.3
0.29
0.28
0.26
0.28
0.3
0.32
0.34
0.36
0.38
0.4
0.42
0.44
0.46
0.48
0.5
0.52

FIG. 4C

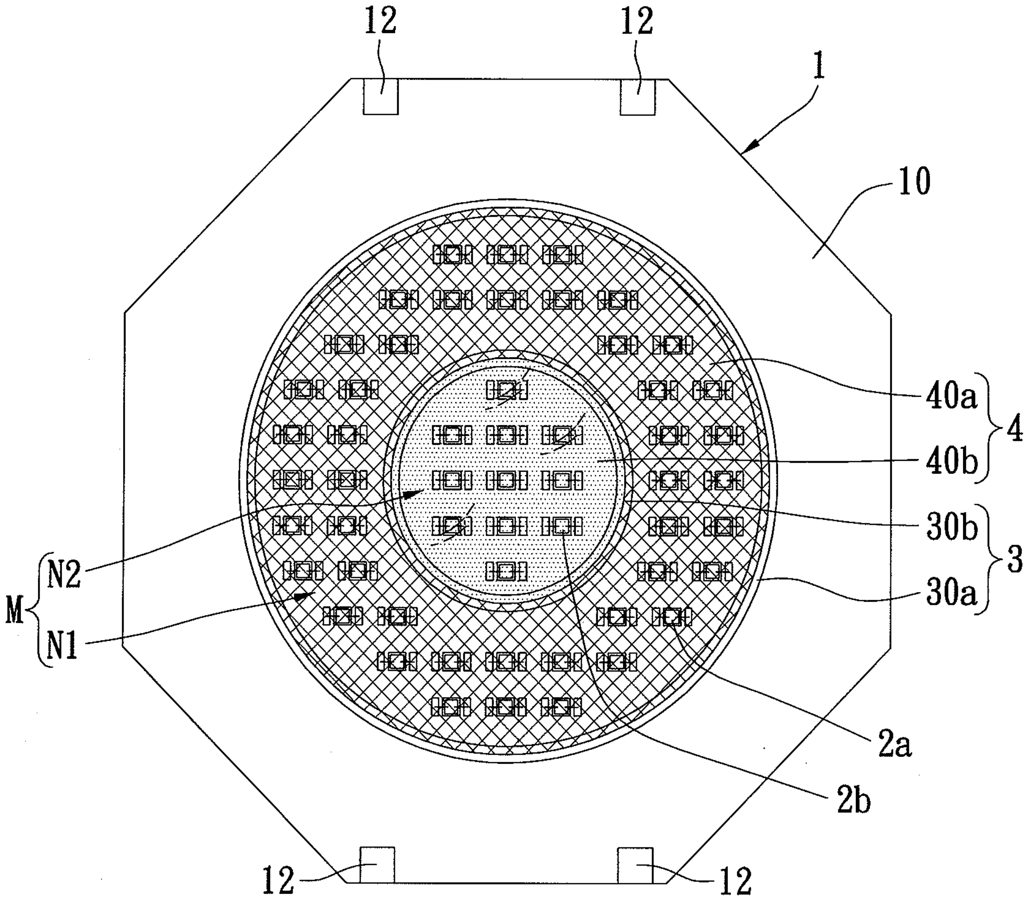


FIG. 5

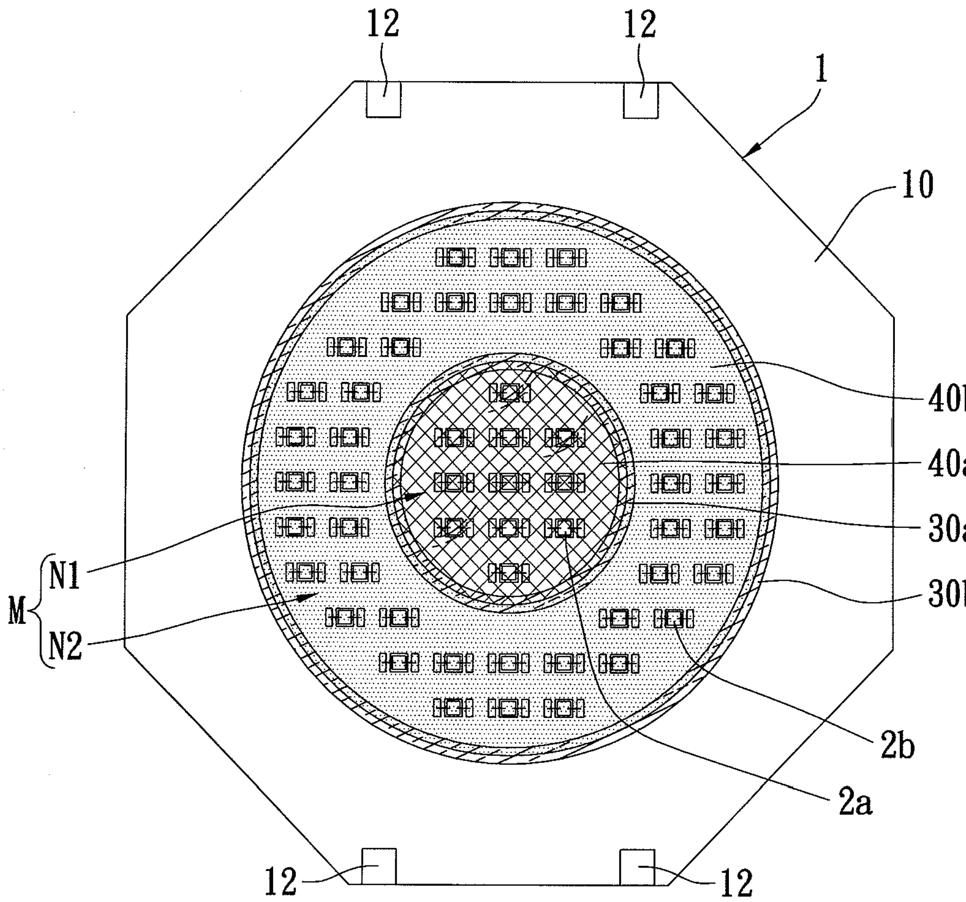

12
12
1
10
40b
4
40a
30a
3
30b
N1
M
N2
2b
2a
12
12

FIG. 6A

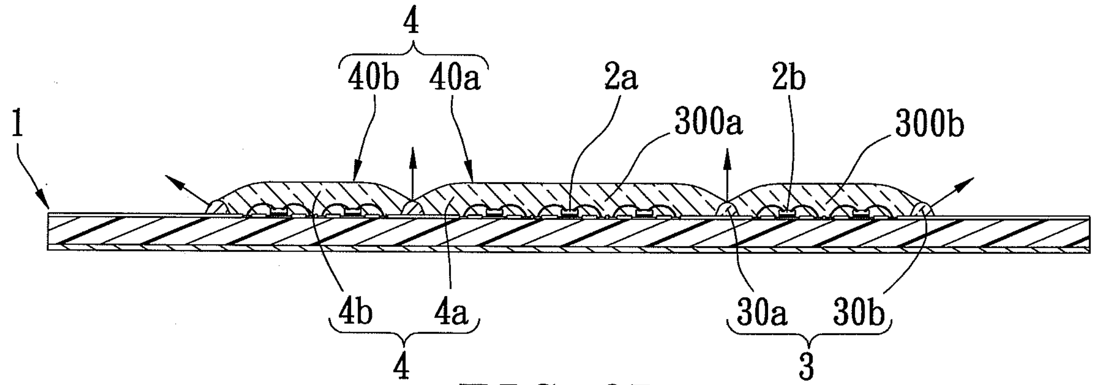

4
40b
40a
2a
2b
300a
300b
1
4b
4a
4
30a
30b
3

FIG. 6B

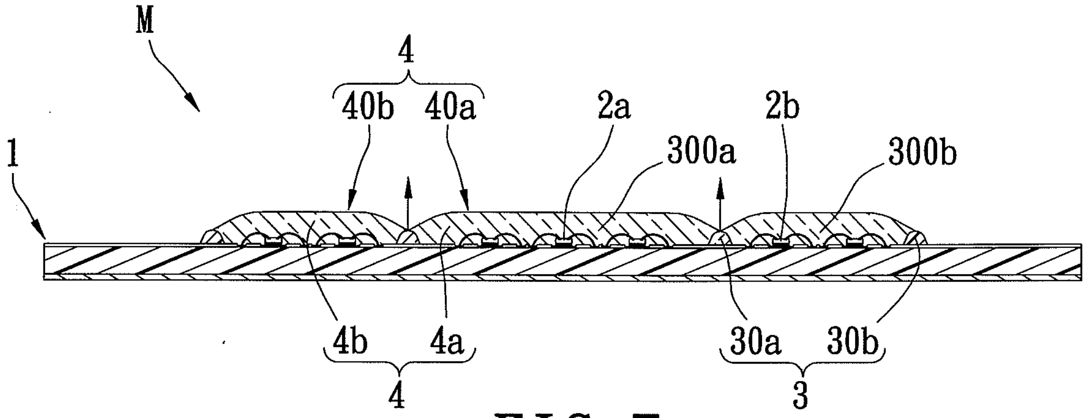
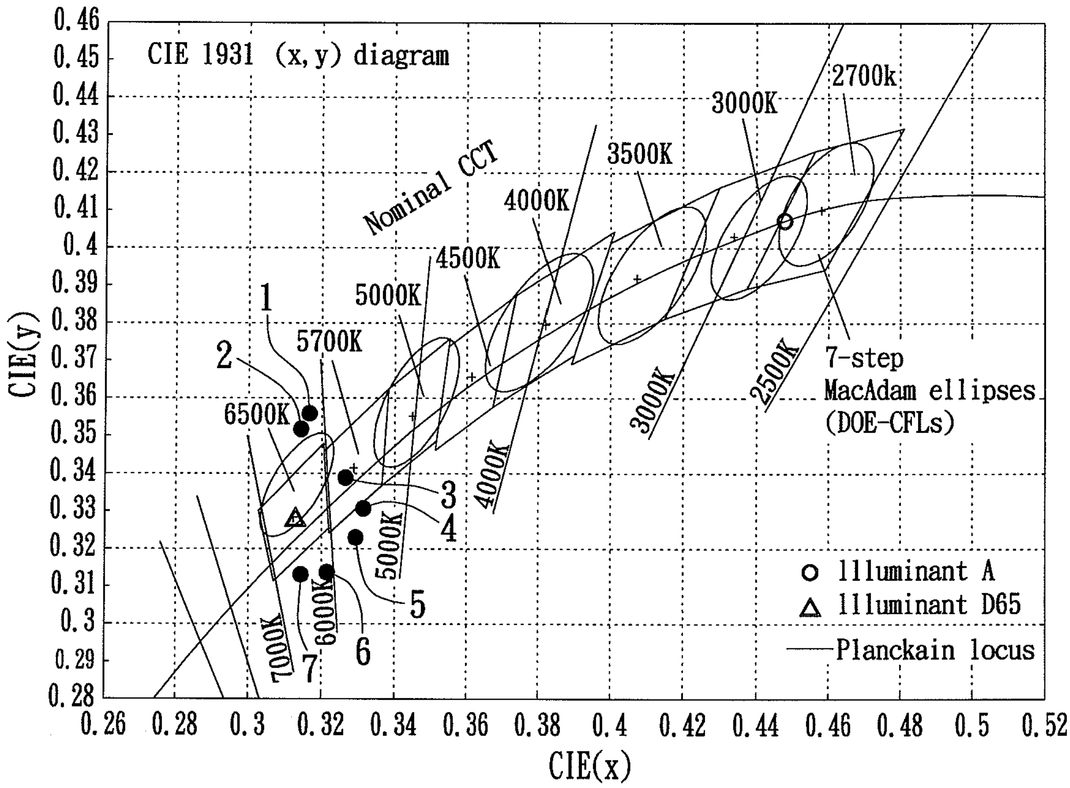


FIG. 7



CIE 1931 (x, y) diagram
Nominal CCT
2700k
3000K
3500K
4000K
4500K
5000K
5700K
6500K
1
2
3
4
5
6
7
7000K
6000K
5000K
4000K
3000K
2500K
7-step
MacAdam ellipses
(DOE-CFLs)
Illuminant A
Illuminant D65
Planckain locus
CIE(y)
CIE(x)
0.46
0.45
0.44
0.43
0.42
0.41
0.4
0.39
0.38
0.37
0.36
0.35
0.34
0.33
0.32
0.31
0.3
0.29
0.28
0.26
0.28
0.3
0.32
0.34
0.36
0.38
0.4
0.42
0.44
0.46
0.48
0.5
0.52

FIG. 8

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2008002073 A1 **[0004]**
- US 20090166657 A1 **[0005]**