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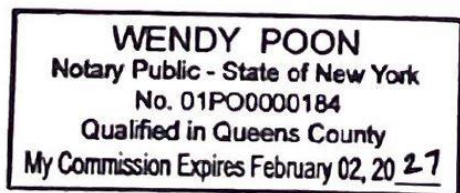


Jacqueline Yorke

Sworn to before me this
October 9, 2024



Signature, Notary Public



Stamp, Notary Public

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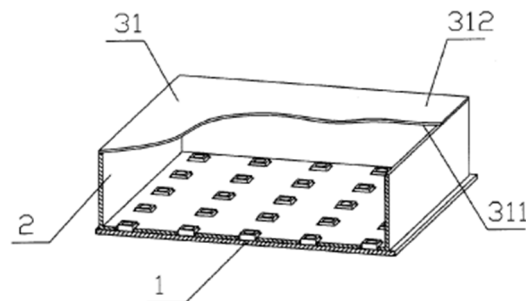
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Claims 2 pages Specification 7 pages Attached
drawings 5 pages

[54] Title of Invention An LCD Backlight System
Using Three-Primary-Color (RGB)
unit-packaged LEDs

(57) Abstract

The present disclosure provides an LCD backlight system using three-primary-color (RGB) unit-packaged LEDs, comprising a light source module, a reflector, and a light diffuser, characterized in that the light source module comprises a plurality of light source devices, with each light source device being composed of RGB LED chips. The RGB LEDs are packaged in a unit device, and the unit device is arranged to form a light source. The RGB chips of each LED light source can be independently driven and controlled, allowing the RGB light to be initially mixed in the unit-packaged structure to achieve the desired color temperature and brightness before being emitted to the backlight system. The light diffuser comprises a refraction-diffraction hybrid light guide plate, which itself is a light refractive element and has a micro-step array structure on its surface. To achieve further light uniformity, different scattering layers or brightness enhancement films (BEFs) can be used.



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1. An LCD backlight system using three-primary-color (RGB)-packaged LEDs, comprising a light source module, a reflector, and a light diffuser, characterized in that the reflector is a square box, with the top being open and bottom having a plurality of small apertures corresponding to the positions of the LED light sources in the light source module, and the inner wall of the reflector has a smooth reflective surface; the light source module comprises a plurality of light source devices, with each light source device being composed of RGB LED chips, with the RGB LEDs being packaged in a unit device, and the unit device being arranged to form a light source; the diffuser comprises a refraction-diffraction hybrid light guide plate, which is arranged on one side of the reflector's opening, and the incident surface of the refraction-diffraction hybrid light guide plate has a plurality of grooves, the positions and shapes of which correspond to the positions and shapes of the LED light sources on the aluminum-based PCB.

2. The backlight system according to Claim 1, characterized in that the RGB chips of each LED light source can be independently driven and controlled, allowing the RGB light to be initially mixed in the unit-packaged structure to achieve the desired color temperature and brightness before being emitted to the backlight system.

3. The backlight system according to Claim 1, characterized in that the dominant wavelengths of the red, green and blue color chips packaged in each light source device can be selected in the ranges of 580 – 630 nm, 500 – 540 nm, and 450 – 485 nm, respectively, at the rated operating current.

4. The backlight system according to Claim 1, characterized in that the RGB unit-packaged LED light sources in the module are arranged such that the light directly illuminates the rear surface of the LCD panel.

5. The backlight system according to Claim 4, characterized in that the module is arranged with the RGB unit-packaged LED light sources such that these LED light sources form a light-emitting dot matrix with their optical axes parallel to each other.

6. The backlight system according to Claim 1, characterized in that the light source module is placed such that the light-emitting dot matrix is located in the reflector, and light emitted by the dot matrix is reflected and mixed in the reflector.

7. The backlight system according to Claim 6, characterized in that the RGB unit-packaged LEDs are connected to an aluminum-based PCB that has corresponding circuits.

8. The LCD backlight system according to Claim 7, characterized in that a heat sink is connected to the rear of the PCB.

9. The backlight system according to Claim 1, characterized in that the depth range of the reflector is 1.5 to 2 times the spacing between the unit-packaged LED light sources.

10. The backlight system according to Claim 9, characterized in that there is a scattering layer or a brightness enhancement film (BEF), or a scattering layer and a BEF, at the reflector's opening.

11. The backlight system according to Claim 9, characterized in that the refraction-diffraction hybrid light guide plate itself is a light refractive element with a micro-step array structure on its surface, thereby constituting a micro-optical array for light diffraction.

12. The backlight system according to Claim 11, characterized in that the unit aperture size of the micro-step array structure is on the order of microns.

13. The backlight system according to Claim 1, characterized in that the incident surface of the refraction-diffraction hybrid light guide plate of the light diffuser has a plurality of grooves, the positions and shapes of which correspond to the positions and shapes of the LED light sources on the aluminum-based PCB, such that the light emitted by the LEDs directly enters the light guide plate through the grooves and is mixed and diffused in the light guide plate, thereby producing a uniform light with an appropriate color temperature from the emission surface of the light guide plate.

14. The backlight system according to Claim 1, characterized in that the bottom of the reflector is closed, and the light source module is located on the bottom plane in the reflector, with a partition added above the light source module, and the partition has a plurality of small apertures corresponding to the positions of the LED light sources on the aluminum-based PCB.

An LCD Backlight System Using Three-Primary-Color (RGB) Unit-Packaged LEDs

Technical Field

The present disclosure relates to a backlight system for a semiconductor light source, and specifically relates to an LCD backlight light source using RGB unit-packaged LEDs and a light diffuser, as well as its preparation method and usage.

Background Art

With the gradual maturation of ultra-bright LED technology, prices have continued to fall. LEDs have gradually replaced CCFL backlight sources thanks to their advantages such as RGB emission, good color reproduction, low power consumption, long lifespan, compact and lightweight design, environmental friendliness, etc. and demonstrated significant potential in the field of LCD displays.

Due to low brightness, the use of LEDs as backlight source in the past had been limited to small displays. With the rapid development of semiconductor technology, coupled with new concepts in packaging design, the brightness and efficiency of LEDs have significantly improved, with a broader range of applications of LED backlight sources.

An LED is a remarkable choice for LCD backlight sources, especially when white is composed of red, green, and blue LEDs, which improve the color and brightness performance of the display. If RGB LEDs are used as the LCD backlight source, three spectral components can be designed to be at around their dominant wavelengths, and all their spectra outside the peak spectrum at the subpixel level of the LCD screen can be eliminated, thereby achieving high brightness while expanding the color reproduction rate, making it superior to CCFL in this regard.

Since multimedia, television and graphic art have different color temperature requirements for white field displays, it is necessary to adjust the color temperature of the white field accordingly. However, controlling the spectral distribution of an LCD with CCFL as the backlight source is difficult, and the color reproduction and grayscale dynamic range of the LCD have to be sacrificed in order to achieve good control of the white field color temperature. However, in the case of LEDs, the color temperature of the white field can be controlled by dimming the brightness of each color LED individually, so it is undoubtedly better than CCFL in this regard.

The service life of large-size LCD monitor is generally 50,000 to 60,000 hours, while the current service life of CCFL backlight sources is generally only 20,000 hours. The theoretical service life of LED products is 100,000 hours. Considering other factors, the actual service life is 50,000 to 60,000 hours, which matches the requirements of LCD displays.

So far, there have been only a handful of companies in the world that use LED backlight sources to make large-size LCD displays. However, in China, the field of large-size LCD displays with LED backlight sources has remained undeveloped.

As a backlight source, an LED can be broadly divided into three types: white, monochromatic, and polychromatic LEDs.

The circuit is relatively simple when using white LED backlighting. However, the principle of emitting white light is that part of the blue light emitted by the chip is converted into yellow light through a medium, and the mixture of blue and yellow light producing white light. The color coordinates (white point) depend on the ratio of blue to yellow light. The color gradation of the display screen is limited, and the white field color temperature is fixed, which is similar to that of CCFL.

RGB backlighting with monochromatic LEDs also exhibits particular disadvantages: due to the interleaved arrangement of colors, additional space is required for color mixing to produce uniformly mixed light. The size of the color mixing area depends on the distance between two LEDs of the same color and their emission angles. For modules with a light guide plate, the surface area of the light guide plate must be increased; for the reflector structure, the thickness must be increased.

In contrast, the color mixing of polychromatic LEDs and white LEDs occurs in their package structure, thus, much less space is required to compensate for the light emission characteristics.

In general, among the three types of LEDs, polychromatic LEDs are the best choice for color display backlighting.

As LEDs are point light sources with a conical radiation pattern, the key to LED backlighting is to achieve a uniformly illuminated surface. At present, the mainstream LED backlight system has used a combination of monochromatic LED light sources and light guide plates in a side-lit LED backlight source.

Light guide plates are an effective way to improve color uniformity, but due to the loss of light during propagation in the plate, their light utilization rate is relatively low. If the target is a television set, its brightness should be at least 400 to 500 cd/m². Therefore, in order to achieve high brightness, the solution of using LEDs to directly illuminate behind the LCD monitor is superior to that of using light guide plates.

Chinese Patent 200410048713.3 provides a backlight source assembly and an LCD display with this backlight source assembly, which is a side-lit backlight source, and does not specify the light source used. The backlight source described in Patent 03106671.2 is set on the rear side of the illuminated body, composed of LEDs in any of the following colors: green, turquoise, blue, orange, red, or yellow-green, and its LCD display device is monochromatic. The backlight source described in Chinese Patent 02152111.5 is a side-lit backlight source with a plurality of LEDs and it does not propose using multicolor LEDs as the light source. There are also CN1558284, CN1383501 and JP8-211361. The LEDs used in these backlight components or systems of [the above patents] all involve the method of arranging monochromatic chips according to a certain pattern and then mixing the light to produce white light. The disadvantage of this method is that it requires a certain distance to mix the light; otherwise a relatively uniform white light cannot be achieved. That is to say, in the prior art of the backlight systems, none of them uses RGB LEDs in a single unit, nor uses a light diffuser that simultaneously uses both refraction and diffraction.

Summary of the Invention

The objective of the present disclosure is to provide an LCD backlight system using three-primary-color (RGB) unit-packaged LEDs. The backlight system of the present disclosure comprises a light source module, a reflector, and a light diffuser, wherein the light source module comprises a plurality of light source devices, with each light source device being composed of RGB LED chips. The RGB LED chips are packaged in a unit device, and the unit device is arranged to form a light source.

Another objective of the present disclosure is to provide a backlight system with RGB unit-packaged LEDs, wherein the RGB chips of each LED light source can be independently driven and controlled, allowing the RGB light to be initially mixed in the unit-packaged structure, achieving the

required color temperature and brightness before being emitted into the backlight system, thereby realizing a wide color gamut and high brightness for the LCD backlight system. Additionally, when the red, green, and blue chips packaged in each LED light source are at the rated operating current, the dominant wavelength ranges that can be selected are 580 – 630 nm, 500 – 540 nm, and 450 – 485nm, respectively. The matching of optical/electrical characteristics (e.g., dominant wavelength, luminous flux, light intensity, drive current, voltage, etc.) of the RGB chips can also be determined according to different design schemes and usage requirements; the packaging structure (including electrical structure, optical structure, mechanical structure) of the LED light source can also be determined according to different design schemes and usage requirements.

Yet another objective of the present disclosure is to provide a backlight system in which a light diffuser, comprising a refraction-diffraction hybrid light guide plate, is placed on one side of the reflector's opening, thereby achieving uniform light on the light emission surface. The refraction-diffraction hybrid light guide plate itself is a light refractive element and has a micro-step array structure on its surface, thereby constituting a micro-optical array for light diffraction.

The current backlight source system, which consists of a plurality of RGB monochrome LEDs for light mixing, requires strict matching of the luminous flux and other properties of each LED. It also has high requirements for light mixing and light guide systems, making it prone to uneven light mixing, color temperature deviation and other defects.

An LCD backlight system using RGB unit-packaged LED light sources has a direct backlight structure, that is, the RGB unit-packaged LED light sources are arranged such that the light directly illuminates the rear surface of the LCD panel. The structure of the backlight system comprises a light source module 1, a reflector 2, and a light diffuser 3. The light source module comprises a plurality of the above RGB unit-packaged LED light sources 11 arranged on the same plane according to a certain pattern and certain spacing. These LED light sources form a light-emitting dot matrix with their optical axes parallel to each other. The certain pattern and spacing refer to selections made according to user requirements and are not strictly limited in practice. In a preferred embodiment, the light source module is placed such that the light-emitting dot matrix is located in the reflector 2, and light emitted by the dot matrix is reflected and mixed in the reflector. Uniform illumination on the display surface is achieved through a regularly spaced LED dot array and a reflector with a corresponding depth. The depth of the reflector depends mainly on the spacing and emission angle of the LEDs. To achieve further uniform light distribution, different scattering layers or special brightness enhancement films (BEFs) can be used. These are commercially available products and are well-known to those skilled in the art. By appropriately combining different films, the depth of the reflector can be reduced. Direct backlighting is mainly applied in systems that require high brightness (greater than 500 cd/m²), with a moderate size and limited space.

With direct LED backlighting schemes, color uniformity remains a key issue. Usually, the LEDs are tightly arranged to facilitate color mixing, but the tighter the arrangement, the more concentrated the heat source is, requiring a complex heat dissipation structure. If the LED spacing is larger, it will be much more beneficial to heat dissipation, but uneven color will become a problem. A balance between color and heat is reached through an appropriate design. The present disclosure uses RGB unit-packaged LEDs and a light diffuser to effectively solve this problem. The unit packaging enables early mixing and greatly reduces the mixing distance. The prior art involves only arranging monochromatic LEDs according to a pattern, resulting in overall color mixing with a

significant mixing distance. In terms of the mixing distance, compared with the prior art, the present disclosure can shorten the distance by 3.5 times under the same mixing structure. If the prior art requires a mixing distance of 28 mm, the present disclosure only requires 8 mm. This is of great significant to reduction of the thickness of the finished products of instruments. In addition, due to the use of a light diffuser, not only more uniform light is achieved, but also color temperature is ensured. Moreover, the LED chip of each color can be controlled individually so that the colors are not distorted.

The light diffuser of the present disclosure is a binary optical element (BOE). It is a phase-type diffractive optical element. It operates based on the diffraction effect of light, with the diffractive phase profile of the element designed based on the analysis of optical wavefronts. The fundamental principle of binary optics is based on the perspective of wave optics. It involves designing a binary micro-relief structure using a computer according to the requirements of the optical wavefront, with dimensions smaller than the wavelength of light. This structure is then etched onto a substrate, either made of a dielectric or metal, using a micromachining technique. At present, the methods of making binary optical elements mainly include the etching method in microelectronics processing, the coating method, high-precision diamond turning with computer-controlled cutting, etc. Among them, the etching method in microelectronics processing technology is the primary technique currently used. As the actual fabricated phase profile is quantized in multiples of two and approximates a stepped shape of the ideal continuous phase profile, it is referred to as a 'binary optical element'. For the principles and structure of the light diffuser, refer to another patent application by the inventors, that is, 200510034628.4, submitted on May 20, 2005, titled "An LED Light Source Using a Light Diffuser", the contents of which are referred herein.

Description of the Attached Drawings

FIG. 1 is a schematic structural diagram of one embodiment of the LCD backlight system of the present disclosure.

FIG. 2 is a schematic structural diagram of an RGB unit-packaged LED light source of the present disclosure.

FIG. 3 is a top view of an RGB unit-packaged LED light source of the present disclosure.

FIG. 4 is a schematic diagram of a light source module of the LCD backlight system.

FIG. 5 is a schematic diagram of the reflector of the LCD backlight system.

FIG. 6 is a schematic structural diagram of another embodiment of the LCD backlight system of the present disclosure.

FIG. 7 is a schematic diagram illustrating the principles of the refraction-diffraction hybrid light guide plate in the LCD backlight system of the present disclosure.

FIG. 8 is a schematic diagram of the refraction-diffraction hybrid light guide plate with a plurality of grooves.

FIGS. 9, 10, and 11 are schematic structural diagrams of other embodiments of the LCD backlight system of the present disclosure.

Specific Embodiments

The present disclosure is described in further detail below with reference to the attached drawings and the embodiments.

Embodiment 1

Please refer to FIG. 1, where the composition structure of the backlight system from bottom to top is: light source module 1, reflector 2, and scattering layer 31.

Please refer to FIG. 2 and 3, showing the RGB unit-packaged LED light sources 11, the red,

green, and blue chips 111, 112, and 113 packaged in each LED, with dominant wavelengths of 615 – 625 nm, 520 – 535 nm, and 460 – 475 nm, respectively, at a rated operating current of 20 mA. The light intensities are 180 – 450 mcd, 450 – 1120 mcd, and 71 – 180 mcd, respectively. The LEDs are mounted in a surface mount technology (SMT) format, with a 6-pin package structure, where each pair of pins independently controls one chip. The light emission angle (FWMH) is 120°.

Please refer to FIG. 4, where a plurality of several RGB unit-packaged LEDs are soldered onto an aluminum-based PCB 12 by an SMT process. This aluminum-based PCB has been designed with corresponding circuits according to the arrangement of the LEDs and is responsible for the input of the LED light source driving power and the output of feedback signals (such as temperature, color, etc.). The aluminum-based PCB is selected because its thermal conductivity is superior to that of ordinary PCBs, which makes it more conducive to the heat dissipation of LEDs. The proper arrangement and spacing of the LEDs are set based on the size of the LCD monitor and the optical requirements. At the same time, it is important to consider the balance between the need for color uniformity and the need for heat dissipation.

For example, for a 15-inch LCD monitor, the diagonal length of the monitor is 381 mm, the monitor aspect ratio is 3:4, and the height and width are 229 mm and 306 mm, respectively. The LEDs are arranged in parallel with a spacing of 10 mm between rows and columns, the light-emitting dot matrix size is 230 mm × 310 mm, and the number of the LED light sources is $24 \times 32 = 768$. For a 17-inch LCD monitor, the diagonal length of the monitor is 443 mm, the aspect ratio is 3:4, and the height and width are 271 mm and 338 mm, respectively. The LEDs are arranged in parallel with a spacing of 10 mm between rows and columns, and light-emitting dot matrix size is 270 mm × 340 mm, and the number of light source of the LED is $28 \times 35 = 980$.

In this example, the LEDs are arranged in parallel on the aluminum-based PCB, with a spacing of 10 mm between rows and columns. In order to enhance heat dissipation, a heat sink is connected to the rear of the PCB.

The light source module 1 of the LCD backlight system is completed as shown above.

The reflector 2 is a square box, as shown in FIG. 5. The reflector's top is open and its bottom has a plurality of small apertures 21, corresponding to the positions of the LED light sources on the aluminum-based PCB. The inner wall of the reflector has a smooth reflective surface, which reduces the loss of light in it. The depth of the reflector depends mainly on the spacing and emission angle of the LEDs. When initially estimating the depth of a reflector with lensless SMT-LEDs, a measurement of 1.5 to 2 times the spacing of the LEDs is generally used. This depth can allow production of good uniform light illuminance. Therefore, the depth of the reflector in this embodiment is set as 18 mm.

A scattering layer 31 is mounted on one side of the reflector's opening. The function of this scattering layer is to diffuse the light illuminated on the incident surface 311, thereby achieving relatively uniform light on the light emission surface 312. When the above backlight system operates, the array of RGB unit-packaged LEDs in the light source module is driven by the appropriate current provided by a circuit according to the display requirements, and the emitted mixed light enters the reflector, where it is reflected and further mixed, before illuminating the incident surface of the scattering layer. After diffusion, uniform light with an appropriate color temperature is obtained from the emission surface, thereby providing ideal backlighting for the LCD monitor.

In the above backlight system, as the light sources utilize the RGB unit-packaged LEDs, color mixing occurs in their packaging structure. After reflection and mixing in the reflector, the emission characteristics of the light are compensated for before passing through the scattering layer for diffusion. This configuration adequately meets the need for LCD backlighting, without the need for a light guide plate for color mixing. As a result, light loss is reduced, the structure of the LCD backlight system is significantly simplified and the costs are greatly lowered.

To achieve further light uniformity, different scattering layers or BEFs can be used. By appropriately combining different films, the depth of the reflector can be reduced. This will be explained in the following embodiments.

Embodiment 2

Please refer to FIG. 6, where the composition structure of the backlight system from bottom to top is: light source module 1, reflector 2, and refraction-diffraction hybrid light guide plate 32.

The light source module of the LCD backlight system is the same as that in Embodiment 1.

A refraction-diffraction hybrid light guide plate 32 is mounted on one side of the reflector's opening. The function of the light guide plate is to mix and diffuse the light illuminated on the incident surface 321, thereby obtaining relatively uniform light on the light emission surface 322.

The refraction-diffraction hybrid system is composed of a combination of diffractive optical elements and traditional refractive optical elements, that is, the surface of the plate is made into a diffractive optical element 32a, while the plate itself is designed as a refractive optical element 32b. Specifically, the light guide plate itself is a refractive element, with some micro-optical array structures carefully designed on the light emission surface of the light guide plate, as shown in FIG. 7. The aperture size of the unit is on the order of microns, which allows the surface of the light guide plate to have diffraction elements. By utilizing the opposing effects of refraction and diffraction on dispersion (negative Abbe number), chromatic aberration can be effectively eliminated, the color gamut can be widened, and color reproduction can be enhanced.

The refraction-diffraction hybrid system utilizes both the refractive and diffractive characteristics of light, with unique dispersive characteristics, excellent thermal performance, and the ability to correct monochromatic aberrations. It increases design flexibility in optical design, enables multifunctional integration, reduction of size, and lowering of costs. The unique dispersive properties of the diffractive optical lens can be used for achromatic correction.

In the backlight system described above, due to the use of refraction-diffraction hybrid light guide plates, the light mixing effect is enhanced and the space required for light mixing is reduced. As a result, the depth of the reflector can be reduced, leading to reduction of thickness of LCD backlight system.

Embodiment 3

The structure is basically the same as that in Embodiment 2, except that a plurality of grooves 3211 are provided on the incident surface 321 of the refraction-diffraction hybrid light guide plate 32, as shown in FIG. 8. The position and shape of the grooves correspond to the position and shape of the LED light sources on the aluminum-based PCB in the light source module, with the function of collecting light emitted by the LEDs.

After being mounted, the LEDs on the light source module are directly embedded in the grooves 3211 on the incident surface 321 of the refraction-diffraction hybrid light guide plate, and the light emitted by the LEDs enter the light guide plate through the grooves, where it is mixed and diffused in the plate, before achieving uniform light with an appropriate color temperature from the emission surface 322 of the light guide plate.

As the LEDs are directly embedded in the grooves on the incident surface of the light guide plate, all the light emitted by the LEDs enters the light guide plate, minimizing light loss.

This structure does not require space above the light source module to compensate for the emission characteristics of light. The light is mixed directly by the refraction-diffraction hybrid light guide plate, further reducing the thickness of the LCD backlight system.

Embodiment 4

The structure is basically the same as that in Embodiment 2, except that there is also a special BEF 33 on the emission surface 322 of the refraction-diffraction hybrid light guide plate 32, as shown in FIG.9. The BEF increases the brightness and improves the uniformity of the emitted light, resulting in more ideal illuminated light in the LCD monitor.

Embodiment 5

The structure is basically the same as that in Embodiment 1, except that there is also a special BEF 33 on the emission surface 312 of the scattering layer 31, as shown in FIG. 10. The BEF increases the brightness and improves the uniformity of the emitted light, resulting in more ideal illuminated light in the LCD monitor.

Embodiment 6

Referring to FIG. 11, where the structure is basically the same as that in Embodiment 1, except that the bottom of the reflector is closed, and the light source module is located on the bottom plane in the reflector, with a partition 4 added above the light source module, and the partition has a plurality of small apertures corresponding to the positions of the LED light sources on the aluminum-based PCB. The surface of the partition is a smooth reflective surface that reduces light reflection losses. The advantage of this structure is that it can reduce light leakage.

Embodiment 7

The structure is basically the same as that in Embodiment 1, except that above each RGB unit-packaged LED light source in the light source module, there is a lens (light diffuser) designed using the principles of a binary optical system. The optical structure of this lens can be designed according to actual needs, resulting in a specific and relatively uniform radiation pattern, which greatly simplifies subsequent optical design.

The light source and backlight structure of the present disclosure have been described in detail above, and it is apparent that those skilled in the art can make many modifications and variations without departing from the spirit and scope of the present disclosure. For example, the shape can be changed to rectangular, circular, elliptical shapes, etc.

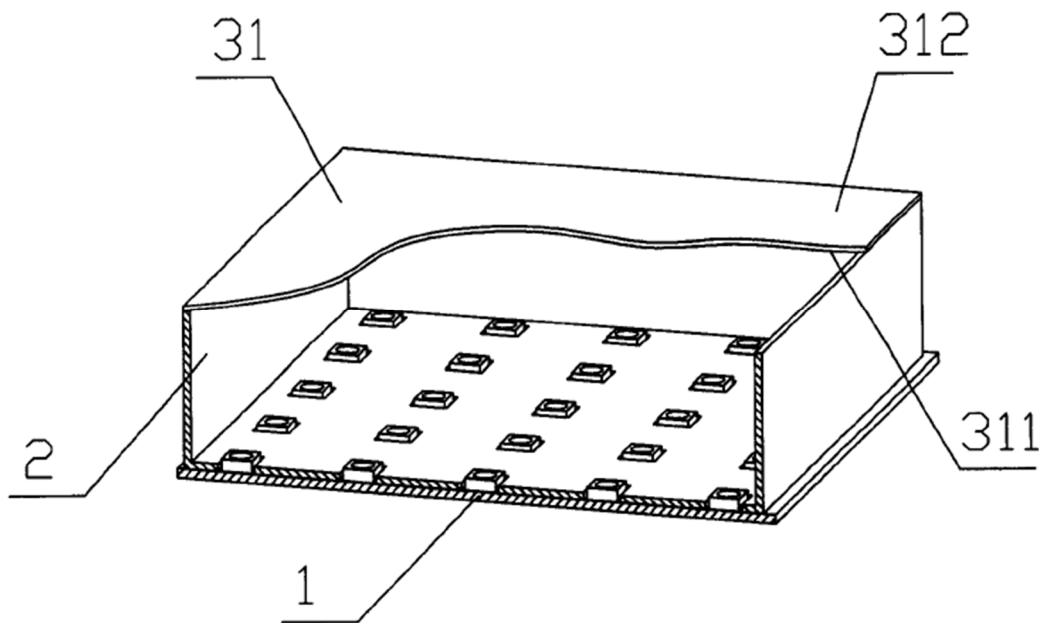


FIG. 1

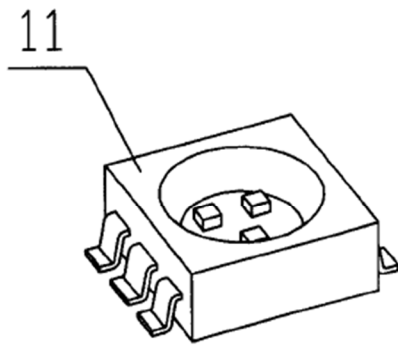


FIG. 2

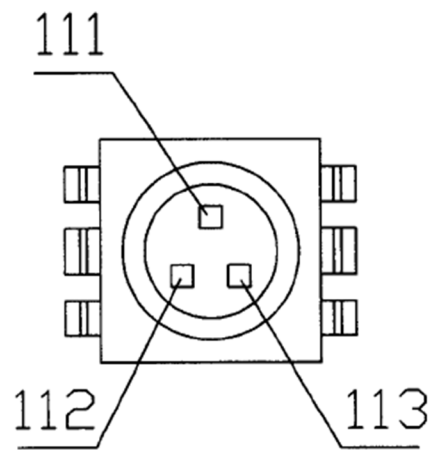


FIG. 3

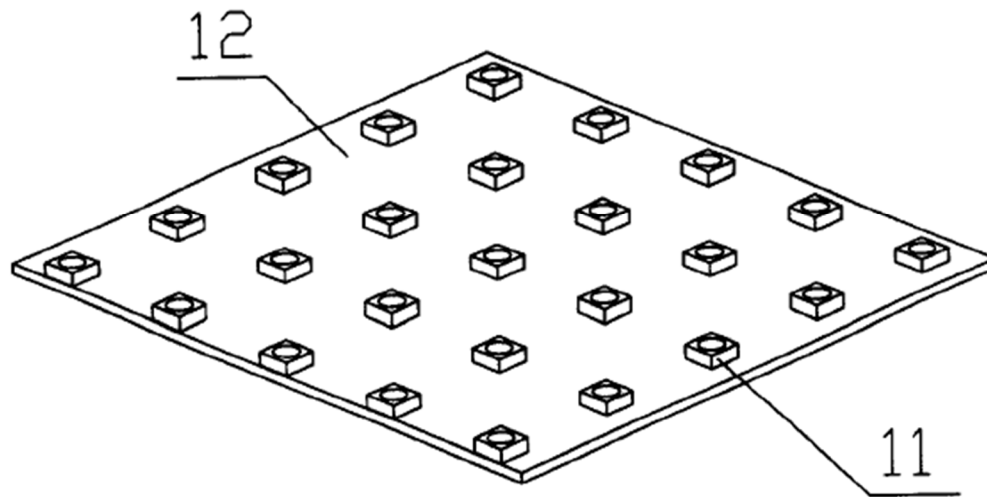


FIG. 4

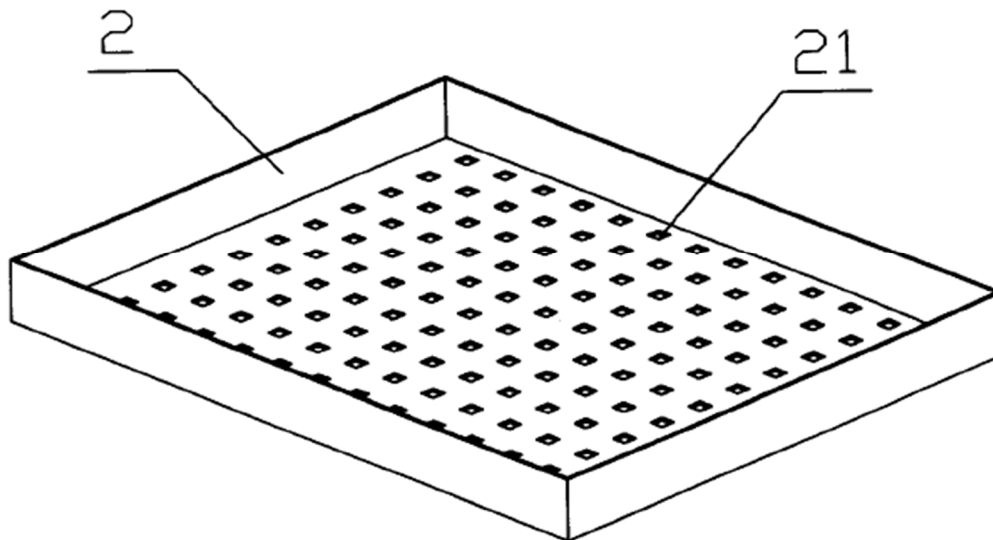


FIG. 5

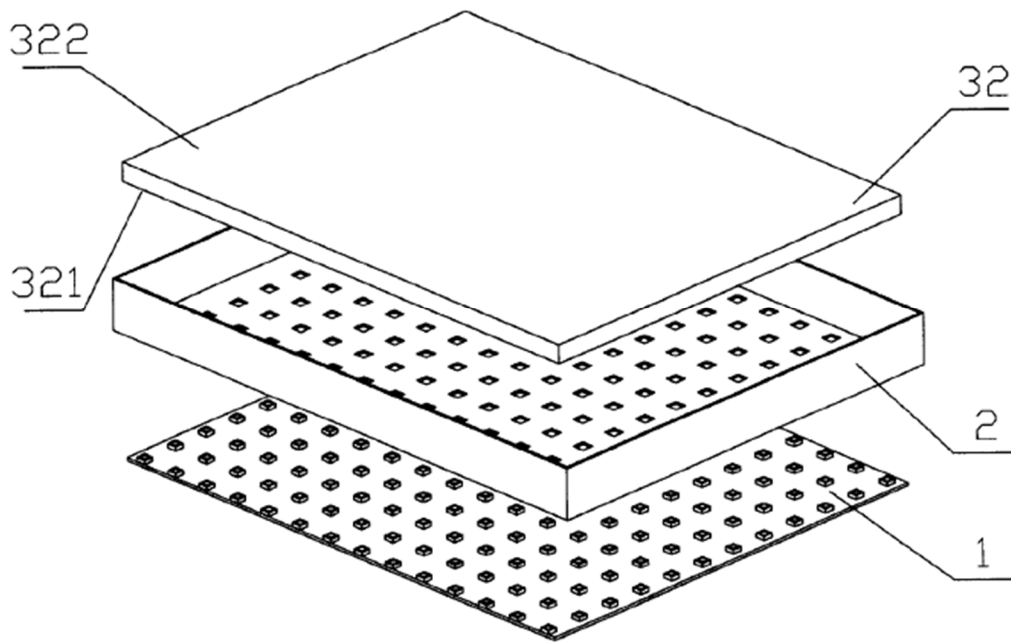


FIG. 6

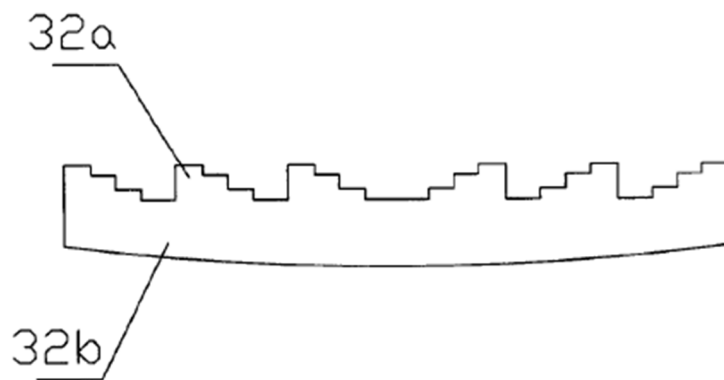


FIG. 7

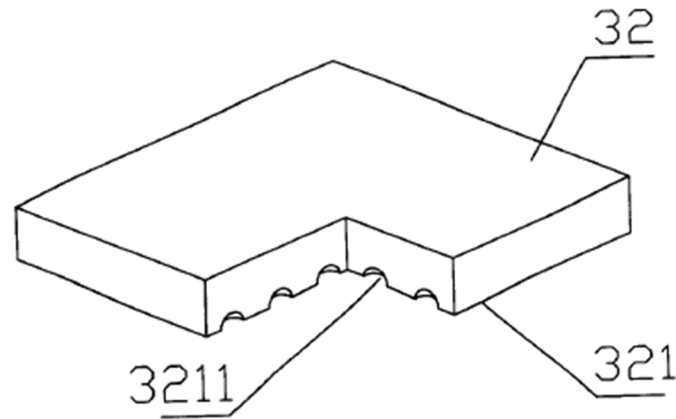


FIG. 8

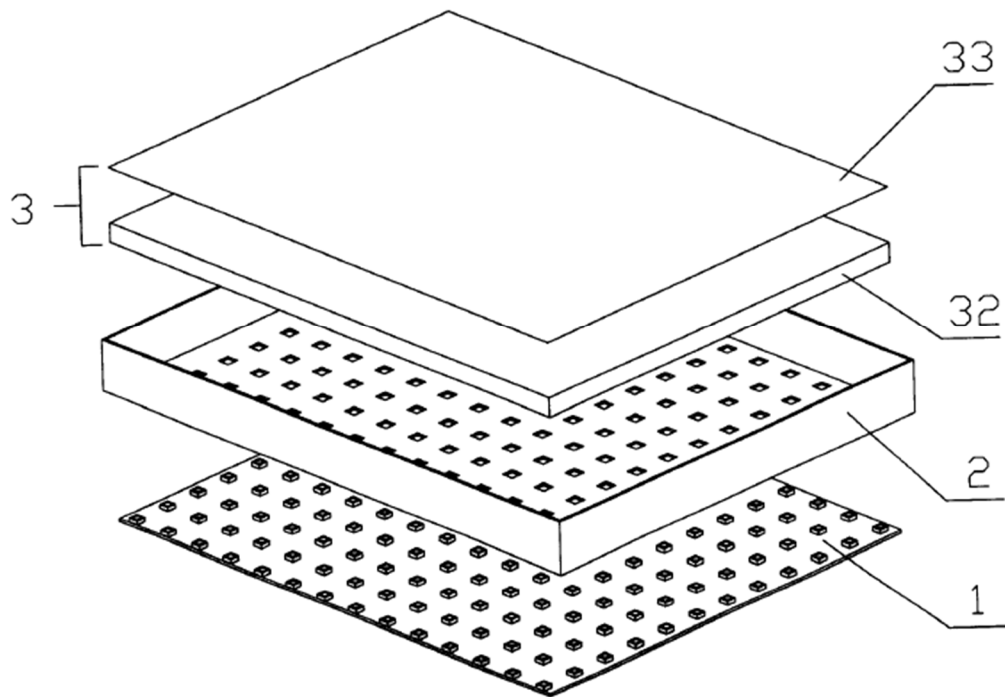


FIG. 9

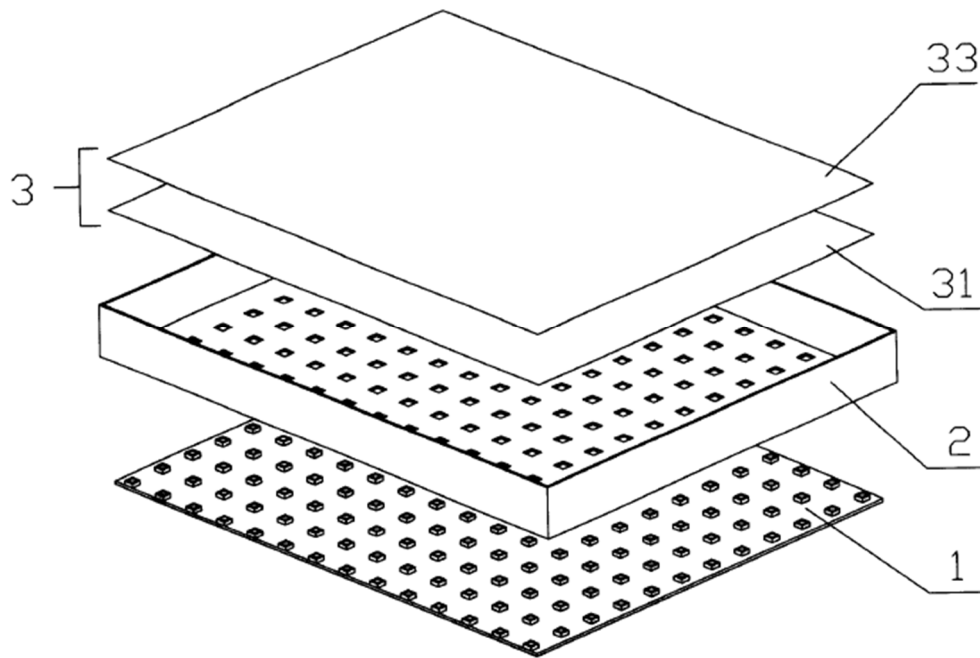


FIG. 10

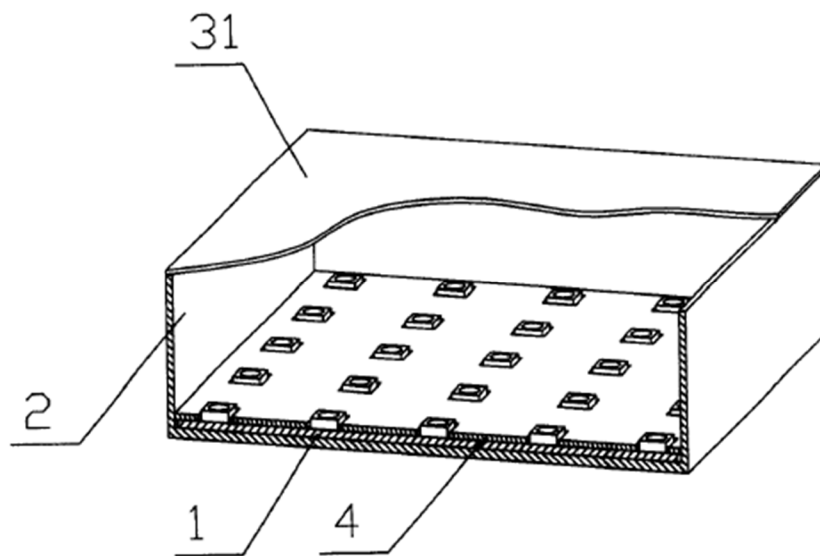


FIG. 11