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The Design of Optical System of UVBLED Germicidal Lamp

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Abstract

The ultraviolet light tube used in the traditional ultraviolet light germicidal equipment is a special gas discharge lamp, which has problems of low light efficiency, large power consumption, poor seismic resistance, short life and filling hazards to the environment. In order to solve these problems, this paper adopts UVBLED as the light source of the ultraviolet light germicidal equipment, and performs light distribution design on the array composed of UVBLED, aiming at obtaining the required sterilization surface of the ultraviolet germicidal equipment, and solving the problems of low utilization rate of light energy, low irradiation intensity and heat dissipation.

Keywords

UVBLED, germicidal, light distribution, heat dissipation.

1. Introduction

Traditional germicidal methods generally use heating, dosing, etc., but these treatment methods take a long time, which may cause adverse changes to the treated object, and may also produce pollution to the environment. The wavelength of ultraviolet light is between 100nm and 400nm, which can be divided into three categories: UV-A (wavelength 315-400nm, called long-wave ultraviolet light), UV-B (wavelength 280-315nm, called medium-wave ultraviolet light), UV-C (wavelength 100-280nm, called short-wave ultraviolet light or deep ultraviolet light). Microorganisms are derived from DNA (deoxyribonucleic acid) or RNA (ribonucleic acid). The principle of ultraviolet light sterilization is to directly radiate microorganisms such as bacteria through deep ultraviolet light (200-290nm), penetrate the cell membrane of bacteria and viruses, and directly destroy the molecular structure of DNA or RNA of microorganisms such as bacteria, so that microorganisms such as bacteria can not replicate multiply or die, in order to achieve the purpose of the sterilization, deep ultraviolet sterilization belongs to physical sterilization [1].

2. Deep Ultraviolet LED

Ultraviolet light sterilization equipment, because the light source used is mostly ultraviolet light tube, there are many drawbacks and defects. With the rapid development of LED technology, using LED as a light source has become a powerful means to save energy and extend the service life of equipment. Deep ultraviolet LED refers to light-emitting diodes with wavelengths between 240 and 290 nm, including UVCLED and UVBLED. They are the leading technology in the field of LED. It can release the deep ultraviolet light that cannot be observed by the naked eye, which can effectively kill bacteria. Deep ultraviolet LED has many advantages compared with ultraviolet light tube: concentrated spectrum, ultraviolet light accounts for more than all light output, there is no infrared radiation incident attached to ultraviolet light tube; long service life, more than 20,000 hours, The life span of the ultraviolet light tube is 100-1000 hours;

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the volume is small, and can be assembled into various forms of lamp arrays at random, which are applied to different needs; the main wave peak is narrow and single, and more than 90% of the light output is concentrated in the range of ±10nm near the main wave peak; DC low-voltage drive, it is suitable for portable equipment; the output power is stable and continuously adjustable; the instant light is emitted, no preheating time, and the response time is microsecond; environmental protection does not contain mercury, no heavy metal pollution [2].

3. UVBLED Germicidal Light Source

3.1. Light Distribution

The UV germicidal light source needs to provide uniform high-intensity ultraviolet light, and the light source system is required to have the ability to irradiate the surface optical power. Since the radiation power of single-tube LED is generally difficult to meet the sterilization requirements, it is required to have a certain uniform luminous flux and illumination in the sterilization area, in order to achieve sufficient uniformity and radiation intensity to ensure the sterilization of the sterilization area is completed, the optical structure of the spatial LED array distribution is adopted, and designed to achieve the accumulation of optical power on the irradiated surface of the LED to improve the uniformity of illumination. The number of LED can accurately meet the requirements of the optical power density of the irradiated surface, and the reasonable calculation of the single-tube focusing system and its spatial arrangement size can effectively control the beam quality such as the size and uniformity of the irradiation spot. In order to meet the requirements of the intensity of the irradiation surface, it is usually implemented by an LED array or an LED lens array scheme, such as mounting an LED chip or an LED lens array on a curved surface or a plane to achieve superposition of energy. The installation of arrays on curved surfaces is complex technology and high cost, so this article discusses the case of planar arrays. The deep ultraviolet light source must have large irradiation intensity in the specified spectral range, long service life, good output power stability, shape and size suitable for use conditions, less auxiliary equipment required, and simple operation, etc.

UVBLED uses ceramic SMT package, size (35mm × 35mm), peak wavelength (280nm) working voltage (6V), working current (30mA), optical power (1.8mW), Angle of light (130°), and quartz glass flat lens used. The quartz glass encapsulated on the light-emitting surface of the UVBLED is equivalent to a convex lens, due to the function of the convex lens, it has a strong directivity, wherein the light intensity in the normal direction is the strongest, and the angle of intersection with the horizontal plane is 1300. When deviating from the normal direction by a different angle, the light intensity also changes. The optical characteristics of UVBLED are mainly expressed by the spatial distribution of light intensity, that is, by the light distribution curve. As far as UVBLED is concerned, it is a light source with the normal light axis where the normal light intensity is located as the rotational symmetry axis, and the light intensity value in the same direction as the included angle of the axis on the plane perpendicular to the axis is equal, therefore, the distribution curve of the light intensity on a measuring surface of the axis can be used to explain the distribution of its light intensity in space.

The main task of the light distribution design is to select the illuminator with the appropriate light distribution and arrange it reasonably so that the illuminated surface obtains a brightness distribution that meets the sterilization requirements. The actual lighting device contains many reflective surfaces of the illuminator. The light transmission process is quite complicated, so more complicated calculations are needed to determine the brightness distribution of the illuminated surface. First of all, computer simulation is used to fit the light intensity distribution data obtained by UVBLED light source experimental test with the aid of computer, so as to obtain the approximate calculation formula of the light intensity distribution of UVBLED light

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source. The position of the UVBLED is reasonably arranged by the calculation of the illuminance, and the optical device is reasonably added to meet the needs of the sterilization surface.

According to the shape and size of the sterilized irradiation surface area, a linear layout is adopted to facilitate the integration and splicing. A module capable of soldering 20 single UVLED devices is selected, that is, the substrate structure of the 20-core UVBLED light-emitting module is as shown in FIG.1. The 20 pieces of UVBLED are arranged evenly and the angle in the axial direction is zero, and it is installed on the plane substrate to form a surface luminous light source with a certain area. The system uses five UVBLED light-emitting module substrates to provide the light source. All UVBLEDs are mounted on an aluminum-based PCB board and then mounted on an aluminum heat sink. According to the light output characteristics and application needs of the lighting fixtures, five UVBLED surface light-emitting units are uniformly mounted on the aluminum-aluminum heat sink, and form uniform and divergent irradiation effect in the direction of the plane through the glass lamp shade [3].

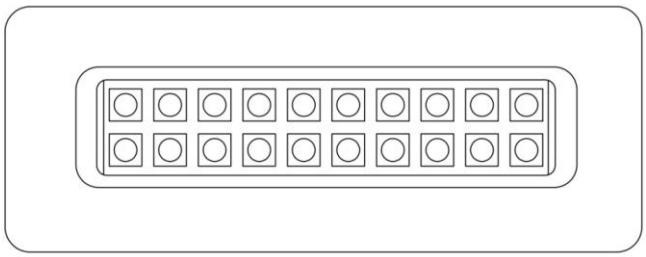

Figure 1. Schematic diagram of the structure of the 20-core UVBLED light-emitting module substrate.

3.2. Heat Dissipation

As the UVBLED is very sensitive to temperature, the junction temperature rise will affect the UVBLED's parameters such as the light effect, light color and lifetime. If the temperature is too high and exceeds the bearing temperature of the chip, it is easy to reduce the luminous efficiency and luminous flux of UVBLED and a significant light decay phenomenon is generated, which may cause permanent damage. According to the size of the UVBLED module, a suitable heat sink is selected, and the heat dissipating wings are used for heat dissipation, and the heat generated by the UVBLED is dissipated as quickly as possible. The heat generated by the UVBLED luminaire is mainly conducted through the UVBLED substrate and the heat sink mounted on the UVBLED. A good heat sink can greatly extend the life of the UVBLED, so the heat sink plays a vital role in the performance of the UVBLED light source. The heat sink has at least the following functions: the heat dissipation channel of the UVBLED; the electrical connection substrate of the UVBLED; and the physical support of the UVBLED. The aluminum-based PCB board of the UVBLED used must have high electrical insulation properties, high stability, high thermal conductivity, and thermal expansion coefficient similar to that of the chip, and flatness and high strength. The aluminum alloy heat sink used in the design arranges the heat dissipation fins on the sterilization irradiation surface to increase the contact heat dissipation area, and the structure is as shown in Figure 2.

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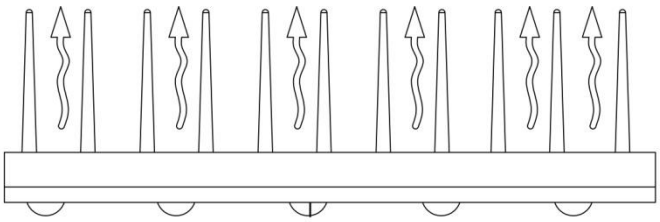

Figure 2. Schematic diagram of aluminum alloy heat sink structure.

The UVALED is closely attached to the aluminum alloy heat sink through the aluminum-based PCB board, and the heat conduction efficiency of the UVALED to the aluminum alloy heat sink is mainly achieved by the coating of the thermal conductivity silicone grease; Reducing the heat resistance between the aluminum alloy radiator and the lamp support is mainly to improve the heat conduction efficiency between the bracket and the lamp support. Since the surface of the bracket and the aluminum substrate seem to be smooth, but there are many uneven places on the surface. If the UVALED is directly welded on the aluminum substrate, the heat transfer effect is not good, so it is necessary to add a layer of heat conduction silicone grease to conduct heat. But the besmear thickness of heat conduction cream is not thicker had better, in order to fill up the place with two uneven surface so far. At the same time, when welding and fixing the UVALED particles, it is necessary to hold the particles with a tool to make them in close contact with the aluminum PCB board, because if there is air between the bracket and the UVALED particles, the thermal resistance between the two is increased. Similarly, when the aluminum-based PCB board is fixed to the lamp holder, in order to reduce the thermal resistance of lamp holder due to the low heat conduction efficiency caused by the surface roughness, the surface of lamp holder surface needs to be polished first, and then A layer of thermal paste is applied between the aluminum-based PCB board and the lamp holder to fill the unevenness that is not visible to the naked eye. At the same time, when the aluminum substrate is fixed by screws, also necessary to make the two close contact to avoid the thermal resistance caused by air between the two [4].

3.3. Package

UVBLED germicidal light source is continually changing the temperature, dust, pollutants and water vapor during use to affect the UVBLED germicidal light source lamp housing. In particular, water vapor is deposited on the inner wall of the casing and condensed into water droplets. This will seriously affect the performance of the germicidal light source. In order to protect the light source, realize the electrical protection of the whole lamp and improve its service life, it is necessary to package design the whole light source, that is, the selection and shape design of the lamp cover material. Due to the low cost of the lampshade made of glass material, the outer shape is formed easily, and after a certain treatment, the emitted light can be made uniform and do not suffer temperature influence almost. At the same time, since the UVBLED germicidal light source has unidirectionality, in order to make its emitted light can be uniformly emitted in all directions, no glare is generated, and the germicidal area is enlarged. The UVBLED germicidal light source lamp with different lampshade shape package has different luminous flux distribution. This design adopts quartz glass material as the lampshade material to make a flat body lampshade. The uneven UVBLED emitting light is processed uniformly to obtain the uniform brightness, prevent glare, and make the light softer and more evenly diverge to the space, and make the light scatter out to the maximum extent.

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4. Conclusion

The optimized UVBLED germicidal light source has the advantages of obvious sterilization effect, low power consumption, long life and small volume, and has a good prospect of research and development and promotion. UVBLED combined product design has great development space, rational use of deep ultraviolet technology, making UVBLED a civilian daily product, forming a real industrial ecology [5]. Especially the deep ultraviolet LED sterilization small home appliances, not only has a broad market space, but also to promote energy conservation and environmental protection, family health, personal safety and other important significance.

Acknowledgements

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References

[1] Wang Ying: Study on air disinfection technology with dynamic ultraviolet irradiation in air duct(MS., Tianjin University, China 2012), p.40.

[2] He Biao: LED lighting germicidal lamp and its key technology research(MS., Beijing Jiaotong University, China 2014), p.81.

[3] Li Le: Application of sterilizing system based on deep ultraviolet LED in automobile(MS., Huazhong University of Science and Technology, China 2017), p.59.

[4] Xiang Changming: UV LED curing optical system design(MS., South China University of Technology, China 2016), p.65.

[5] Xu Yuefeng: Business plan for small ultraviolet sterilizing function small household appliances project(MS., South China University of Technology, China 2016), p.66.