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Research Article

Design of Light Source of Agricultural UVALED Pest Control Lamp in Food Production

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Abstract: In this study, we have a research of the design of light source of agricultural UVALED pest control lamp in food production. The traditional agricultural black light lamp is a special gas discharge lamp, which can emit 320~400 nm ultraviolet light to trap the pests. However, the traditional agricultural black light lamp has such problems as low light efficiency, large power consumption; poor shock resistance, short life span and the filler harming the environment. To solve these problems, this study adopted 365 nm (UV) emission wavelengths in -line metal agricultural UVALED to design pest control light source based on the insects phototaxis response curve so as to trap the pests in food production.

Keywords: Agricultural UVLED, black light lamp, food production, light distribution, pests, ultraviolet light

INTRODUCTION

Phototaxis is an important ecological characteristics of nocturnal insects, is the selectivity of insects to environmental conditions and it is an instinct of species formed during long-term adaptation (Shi, 2012). The light trap uses the characteristics of insects to trap and kill the pests, so as to control pests and insect borne diseases, so that the density and oviposition amount of the pests is greatly reduced, reducing and avoiding the direct harm or disease spread done by the pests to people and crops (Zhao, 2008). Studies have shown that the 320~400 nm wavelength UV light which is invisible to humans has a stronger trapping force to hundreds of species of insects, but does little harm to beneficial insects, especially Lepidoptera and Coleopteran are more sensitive to this band (Wang, 2012). Therefore, it is needed to specifically design the pest control lights which can emit the 320~400 nm light wave so as to trap and kill the majority of pests. Since the 1960s, the agricultural black light lamp has been widely used as the light source to trap and kill pests. The traditional agricultural black light lamp is a special gas discharge lamp and its structure and electrical properties are the same as those of fluorescent lamp, only their tube walls are covered with different fluorescent powders inside, the power can emit ultraviolet light after electricity (He, 2011). However, the traditional agricultural black light lamp has such problems as low light efficiency, large power consumption; most of electric energy being converted into thermal energy; the filler existing mercury and other heavy metals which do harm to human health and the environment when the lamp is damaged or abandoned after the use; the components of glass bulb, filament, are easily damaged with fragile, poor shock resistance, short service life of 3000 h or so (Egea *et al*., 2011). A glass bulb, the filament, easily damaged parts, fragile the shock resistance, poor, life is short, generally only about 3000 h (Qian *et al*., 2012).

In this study, we have a research of the design of light source of agricultural UVALED pest control lamp in food production. The traditional agricultural black light lamp is a special gas discharge lamp, which can emit 320~400 nm ultraviolet light to trap the pests. However, the traditional agricultural black light lamp has such problems as low light efficiency, large power consumption; poor shock resistance, short life span and the filler harming the environment. To solve these problems, this study adopted 365 nm (UV) emission wavelengths in -line metal agricultural UVALED to design pest control light source based on the insect's phototaxis response curve so as to trap the pests in food production.

METHODOLOGY

UVALED: LED is a kind of electroluminescent light source, is a semiconductor device which can directly convert the electrical energy into visible light and radiation energy? The light source which directly converts the electrical energy into light energy belongs to cold light source. Compared with other lighting ways, the light source of LED has many advantages, is an ideal lighting appliance. UVLED i.e., UV light emitting diode, is an LED, with the wavelength range

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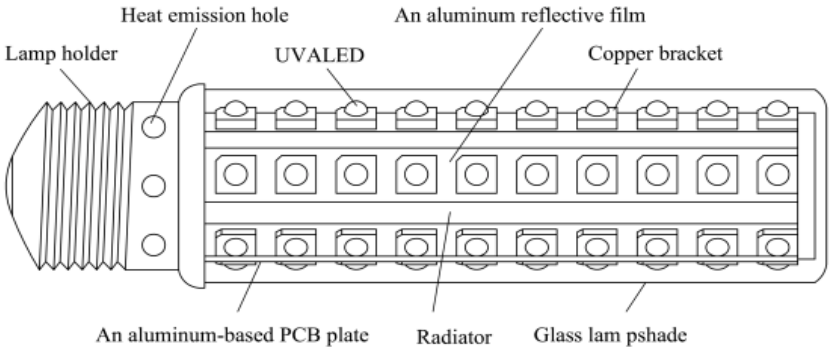

Fig. 1: Schematic diagram of light source of UVALED pest control lamp structure

of 10~400 nm, the common wavelength of UVLED has 400, 395, 390, 385, 380, 375, 365, 310 and 254 nm, respectively and the like. When the wavelength of UVA in 320~390 nm, which is also known as long-wave ultraviolet light of the shading effect. It has a strong penetration, can penetrate most transparent glass and plastic. Long-wave ultraviolet light exists in sunlight, more than 98% it can penetrate the ozone layer and the clouds and reach the surface of the earth. Three hundred and sixty nanometer-wavelengths UVA ultraviolet conforms to the phototaxis response curve of insects and can be used as the light source pest control lamp. Three hundred to four hundred and twenty nanometer wavelength UVA light can penetrate the special colored glass tubes which completely cut off the visible light and it only can radiate the ultraviolet light centered at the wavelength of 365 nm.

In this study, the inline metal UVALED was adopted directly (model: YCL-365a, 1500 uW light power and the wavelength of 1500 to 365 nm to 370 nm, voltage from 3.3 to 3.7 to 4.5 V, 20 mA current, light angle from 10^0 to 100^0, the quartz glass was used to package it, glass packaging reduced the optical loss of violet reduce compared with the resin package, enhanced uv light, on the shell, there was the a layer of plating nickel alloy material and gilding technique was used in two pins, in order to prevent rusting and increase the heat conduction performance of the pin as well.) to design the pest control lamp as the light source, for trapping and killing pests.

The power of a single UVALED is very small, when used as a trap lighting, it is needed to have the uniform flux and illuminance in the lighting area, but the single UVALED has a strong direction, it is difficult to make the light intensity evenly distribute in the three-dimensional space as the traditional agricultural black light lamp. So it is needed to adopt the LED array structure to increase the brightness and luminous area, improving the uniformity of illumination. Therefore, it is needed to re distribute the light path of UVALED, making the light emitted from the surface the UVALED light source fill the space, similar to the light effect of the traditional agricultural black light lamp. Starting from the aspect of optical design, through the design of the optical system, the UVALED light source was installed and distributed in the three-dimensional space, under the premise of not affecting the UVALED heat radiating performance, keeping the simple installation method of UVALED and high light efficiency, the whole light output of the light source can have great beam angle.

LIGHT SOURCE OF UVALED PEST CONTROL LAMP

The light source of UVALED pest control lamp is mainly composed of a constant current power, a lamp holder, UVALED, a bracket, a radiator, an aluminum reflective film, an aluminum-based PCB plate, a glass lampshade and the constant current power is installed inside the lamp holder, the lamp power is drilled with radiating holes, as shown in Fig. 1. UVALED can be changed according to requirements in the aspects of the shape design of lighting angle, brightness transformation and so on. The light source of UVALED is composed of UVALED and related lighting accessory equipment, its main function is to re-distribute the luminous flux of UVALED so as to achieve the purpose of reasonably using the light source and avoid the dazzle, as well as fix and protect the UVALED, making it suitable for a certain environment.

Light distribution: The in-line metal UVALED used is a cylindrical package, the quartz glass packaged on the UVALED luminous surface is equivalent to a convex lens, the effect of the convex lens has a very strong directivity, with the strongest light intensity in the normal direction and the horizontal plane angle is 90^0. When an angle deviates from the positive normal direction, the light intensity changes correspondingly. The optical property of UVALED is mainly expressed by the intensity space distribution, which is represented by the light distribution curve. As far as UVALED is concerned, it is a light source with the axis of rotational symmetry of luminescence intensity of the optical axis, which is equal to the light intensity value in the plane vertical to the axis and the angle between the same direction, therefore, it is only needed to explain the

distribution the light intensity in space by using the light intensity distribution curve on the surface of a light plane axis. The main task of light distribution design is to choose the illuminator with suitable light distribution and is rationally laid out, so that the area of illumination can get the brightness distribution which meets the trap requirements. The actual lighting device comprises many of the reflecting surfaces of the illuminator, the light transfer process is quite complex, so it is needed to conduct the complex calculations to determine the brightness distribution of the area of illumination. The introduction of computer simulation, by the aid of a computer, the light intensity distribution data obtained by the UVALED light source test were fitted, resulting in a light intensity distribution approximate calculation of the UVALED light source. Illuminance calculation was used to reasonably arrange the position of UVALED and reasonably add optic devices to meet the needs of lighting.

The system was powered with six UVALED light emitting units, each UVALED unit consists of 10 light-emitting UVALEDs and all of the UVALED was installed in aluminum PCB plate and then installed on the aluminum heat column. According to the optical output characteristics and the application needs of the illuminators, 10 UVALEDs were evenly laid out; the angle in the axial direction was zero, which was installed on the plane of the substrate, forming a light source with an area. Six UVALED surface emitting units were respectively evenly installed on 6 cylinders (aluminum alloy radiators), through the cylinder glass lampshade. The lighting effect evenly emitted in the direction of the cylinder was formed.

Heat dissipation: Since UVALED is very sensitive to temperature, the rise in the junction temperature will affect UVALED light efficiency, light color, color temperature, forward voltage, injection current, life span and other parameters. Too high temperature exceeds the bearing temperature of the chip, it is easy to reduce the emission efficiency of UVALED and reduce the luminous flux, resulting in obvious light failure phenomenon and may cause permanent damage. The heat generated by UVALED lamp emitting is conducted out mainly through UVALED substrates and heat sink mounted on UVALED. And the good radiator can greatly extend the life of UVALED, so the radiator performance plays a crucial role in UVALED light source. A radiator at least has the following functions: the cooling channel of UVALED; the substrate of UVALED electrical connections; the physical support of UVALED. The PCB plat of UVALED aluminum base used must have high electrical insulation properties, high stability, high thermal conductivity and a thermal expansion coefficient close to the chip as well as smoothness and high strength. The aluminum alloy radiator used in this study laid out the cooling fins in the cylindrical in walls to increase the contact area of dissipation structure, as shown in Fig. 2.

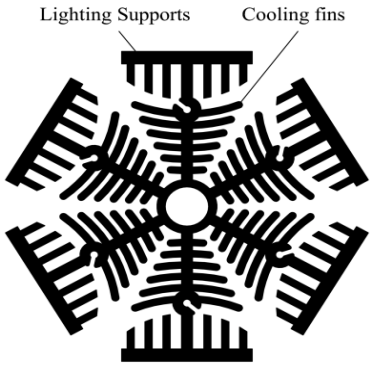

Fig. 2: Schematic diagram of aluminum alloy radiator structure

To increase the heat conduction efficiency from UVALED copper bracket is mainly realized by the coating of thermal conductive silicone; the reduction of the thermal resistance from the copper bracket to the lighting support is mainly realized by improving the heat conduction efficiency from the copper bracket to lighting support. As the surfaces of the copper bracket and the aluminum substrate look smooth, but their surfaces have many potholes, if UVALED is directly welded on the aluminum substrate, the heat transfer effect is poor; therefore, it is needed to add a layer of thermal conductive silicone to increase the effect of heat conduction. But the coating thickness of thermal grease is not the thicker, the better, it is OK to fill the two uneven surfaces. At the same time in welding the UVALED particles, it is needed to hold the particles with hands, so that it has a close contact with the aluminum based PCB plate, because if there is air between the copper bracket and UVALED particles, which can increase the thermal resistance between the two. Similarly, when the aluminum based PCB plate is fixed to the lamp holder, in order to reduce the increase in the thermal resistance brought the low heat conduction efficiency caused by the unsmooth surfaces, firstly it is needed to conduct the polishing processing on the surface of lighting supports and then coat a layer of thermal paste between the aluminum based PCB plate and the lamp holder to fill the rugged places which cannot be observed by the naked eyes and when the aluminum based plate is fix with screws, it is also needed to make both closely contact, in order to avoid the thermal resistance brought by the air between them.

Packaging: UVALED pest control lamp is used in the field, the field environment is complex and relatively harsh and the constantly changing temperatures, dust, dirt and moisture affect the lampshade of UVALED pest control lamp. For example, the rainfall will result in an abrupt temperature drop of a lampshade. Dramatically reduction in the temperature will lead to 150 mbar or even greater vacuum generated inside the lampshade. Thus, air and moisture will enter inside the

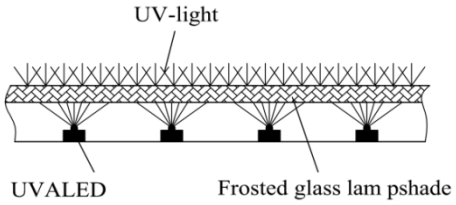

Fig. 3: Schematic diagram of the light beam of the frosted glass lampshade conclusion

enclosure by sealing clearance. Moisture is attached to the inner wall and condenses into water droplets. This will seriously affect the performance of pest control lamp. To protect the light source, to achieve the electrical protection of the entire light, to improve its service life, it is needed to design the entire luminaire package, that is the material selection and shape design of the lampshade. Due to the low cost of glass-material lampshade, easy shape molding, after a certain treatment, the soft light can be emitted evenly, almost independent of temperature. Because the light source of UVALED is unidirectional, in order to make the emitting light be emitted uniformly in all directions, with no dazzle, it is needed to expand the trapping area. The luminous flux distribution of UVALED packaged by different lampshades is not the same, in this study, the glass-material lampshade was used to make a cylindrical lampshade and grind arenaceous processing was conducted for the glass lampshade, shown in Fig. 3. The uneven UVALED emitting light was uniformly processed, the obtained uniform brightness can prevent dazzle, make the light more soft and more evenly spread into space, make the light emitted maximally.

With the rapid development of China ecological agriculture, the pest phototaxis, was used, the selection of light source and wavelength with strong trapping effect on pests was used to trap and kill the pests, which has become a new kind of physical measures with the advantages of high efficiency, economic, environmental protection etc. The use of the optimal light source of UVALED pest control lamp can trap and kill pests, the control is convenient, the effect is obvious and there are good prospects for the development and promotion of research.

CONCLUSION

In this study, we have a research of the design of light source of agricultural UVALED pest control lamp in food production. The traditional agricultural black light lamp is a special gas discharge lamp, which can emit 320~400 nm ultraviolet light to trap the pests. However, the traditional agricultural black light lamp has such problems as low light efficiency, large power consumption; poor shock resistance, short life span and the filler harming the environment. To solve these problems, this study adopted 365 nm (UV) emission wavelength in-line metal agricultural UVALED to design pest control light source based on the insects phototaxis response curve so as to trap the pests in food production.

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