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Device of Blue light Measurement and It's Application

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ABSTRACT

Blue light is one of the most dangerous visible lights to the human eyes. Therefore, it has extremely high energy, so it can penetrate the lens to directly reach the retina. When it radiates the retina, free radial will be generated, which will decay the retinal pigment epithelial cells. The five-point average illumination measurement method is used to promote the measurement accuracy. It can reach up to 1.28%, which is very stable and reliable.

Keywords: blue-light sensor, IR-code, five-point measurement method, bluetooth to smartphone

INTRODUCTION

Blue light does not mean that the light with blue color, but the high-energy visible light with 400-500nm wavelength, which can penetrate the lens to reach the retina, and then result in optical damage and increase the oxidation of the cells of the macula area [1]. Blue light is one of the most dangerous visible lights to the human eye. Blue light has extremely high energy, so it can penetrate the lens to directly reach the retina. When it radiates the retina, free radial will be generated, which will decay the retinal pigment epithelial cells; accordingly, the photoreceptor cells will be lack of nutrition, so the vision acuity will be damaged, which is irreversible.

The cut blue light glasses will be not enough to avoid the damage from blue light. We should understand that blue light damages which we suffer in our environment cannot be blocked by the cut blue light glasses, or the cut blue light glasses cannot properly function; besides, we may not know which products will emit the blue light. Therefore, we need a detector that we can always carry and the operation of the detector cannot be too complicated. Accordingly, we decide to develop a product combined with glasses and the common people can also easily operate the product and carry the product.

LITERATURE REVIEW

Scientists in the light energy and visual fields provided a lot of studies on blue light damaging human's eyes [1]. The lens and cornea [2] will filter most of UVA and UVB to reduce the chance that the macular degeneration takes place; however, blue light will still enter the retina to result in the macular degeneration

Medical researches [3] show the high-energy light will damage our retina and will particularly increase the chance that the macular degeneration occurs. The macular degeneration will seriously damage the vision acuity of the middle-aged and elderly. According to the report conducted by the national health and nutrition, it investigated 3087 45-year-old or above participants and the results show that the age is proportional to the morbidity rate of the macular degeneration; on the contrary, the genetic disorder is relatively not so relevant to the morbidity rate of the macular degeneration

However, the macular degeneration will not form in one day, but a period of time. Thus, we should protect our eyes in our daily life to reduce the energy of blue light, which can effectively decrease the damage from it [4]. In general, it is impossible to use the cut blue light glasses to completely block

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blue light and the cut blue light glasses will influence the colors which we see by our eyes. Since the experiments based on blue light and human body may have a lot of problems and dangers [5], therefore, most of the studies were conducted the animal tests. According to the experiment using low-illumination mixed light to radiate the eyes of guinea pigs [6] and the experiment using high-illumination mixed light to radiate the eyes of guinea pigs and pure white light to radiate the eyes of guinea pigs [7], guinea pigs radiated by the blue light for a long period of time became blind. According to the experiments using single color lights to radiate the eyes of guinea pigs, the green light and red light will not damage the eyes of guinea pigs, but the blue light will obviously damage the eyes of guinea pigs.

RELEVANT PRINCIPLES AND DISCUSSION

In order to investigate how the high-energy blue light and different light sources influence the eyes of creature, the experiment using different light sources to radiate the eyes of guinea pigs was provided [8]. In the experiment, after the mice were under anesthesia, the light lens and the adjustable filter sheet were used to generate blue light wavelength and green light wavelength, which were blue light (403nm±10nm) and the green light (550nm±10nm) respectively; the exposure strengths were 3.1mw/cm2 and 33mw/cm2 for blue light, and 8.7mw/cm2 and 47mw/cm2 for green light; which were used to conduct the experiment on the left eye of the mice. The experiment was used to investigate how the blue light, green light and mixed light influenced the retina of the mice under different time periods.

In the study, two experiments were conducted; one was used blue light added into the light sources for both a short-time and long-time periods, and the other one was only used green light without blue light. 120 minutes for green light only; 5 minutes for green light with 60, 90, and 120 minutes blue light individually. Afterward, the retinas of the mice were prepared for sectioning. The results of the experiment show that the retina of the guinea pig radiated by the green light for 5 minutes and the blue light for 120 minutes has serious cell contraction and mutation; on the contrary, the retina of the guinea pigs radiated by the green light for 120 minutes has no mutation. Thus, blue light will result in serious damage to the mice but green light will not damage the mice at all.

PRINCIPLE OF BLUE LIGHT MEASUREMENT

Take the intersection of each parting line as one point, and the total quantity of the points is 9~50. The direction or place with higher blue light illumination change is defined as a small interval, and the direction or place with lower blue light illumination change is defined as a large interval. The calculation of the average blue light illumination E of a constant blue light source should use the five-point average illumination measurement method; thus, the blue light value monitoring and cut blue light glasses will be measured by the measurement method to calculate the values.

The equation is shown as follows,

$$\mathrm{Eo} = \frac{1}{6}(\mathrm{E}_{m1} + \mathrm{E}_{m2} + \mathrm{E}_{m3} + \mathrm{E}_{m4} + 2\mathrm{E}_g) = \frac{1}{6}(\sum_{i=1}^{i=4} \mathrm{E}_{mi} + 2\mathrm{E}_g) \quad (1)$$

E_o is the blue light illumination vale of the reference plane; where E_g is the value displayed by the blue light detector and the cut blue light glasses; and E_{m1},E_{m2},E_{m3},E_{m4} is center point adjacent to up, left, down, right respectively. The equation (2) is used to calculate the error displayed by the blue light illumination detector and the cut blue light glasses and determine the error rate of the blue light illumination detector and the cut blue light glasses.

The equation is shown as follows,

$$\mathrm{error} = \frac{\mathrm{E} - \mathrm{E}_o}{\mathrm{E}_o} \times 100(\%) \quad (2)$$

GaN BLUE LIGHT SENSOR (GaN PD)

The GaN blue light sensor is shown in Fig. 1; the light response diagram of the InGaN/GaN blue light sensor under different wavelengths is shown in Fig. 2; according to Fig. 2, the blue light wavelength range between 400-450nm has high response, which shows that the sensor has great sensing ability for blue light.

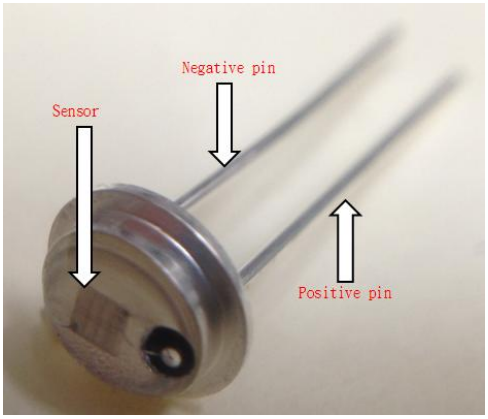

Fig1. *The GaN blue light sensor*

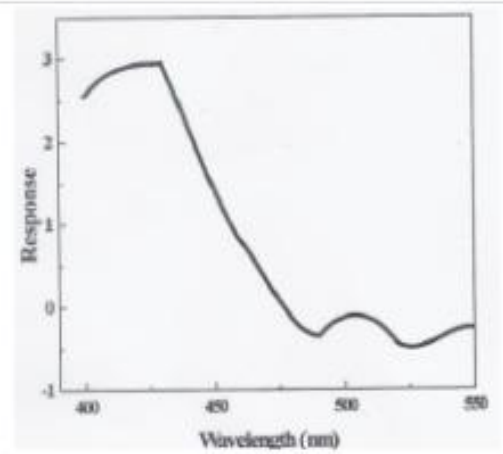

Fig2. *The light response diagram of the InGaN/GaN blue light sensor*

HARDWARE STRUCTURE

The hardware structure of the blue light value monitor system includes five components: a blue light sensor, switch circuit, a LCD module, a Bluetooth module and boost circuit.

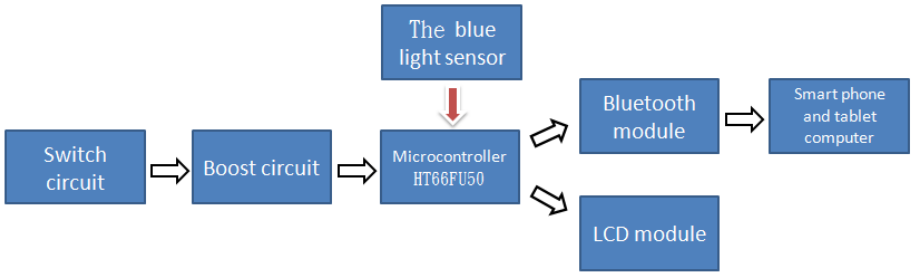

Fig3. *The hardware structure diagram of the blue light value monitor*

ENTITY OF BLUE LIGHT MONITOR

The button A (as in figure 4) is used for wake-up interruption and the button B is used to activate the value reading and Bluetooth transmission; the sensor is the GaN blue light sensor for receiving the external blue conversion value; the monitor also includes a glass display for displaying the values.

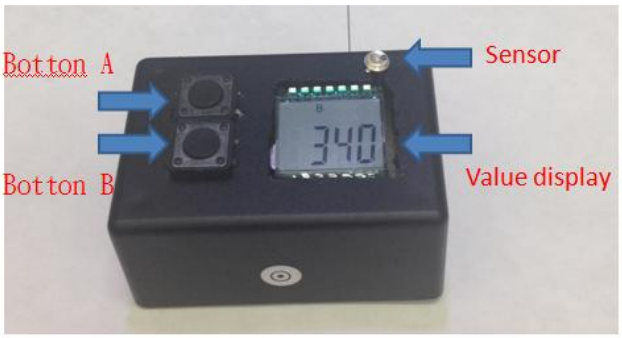

Fig4. *The entity diagram of the blue light value monitor*

ENTITY OF CUT BLUE LIGHT GLASSES

The button A (as in figure 5) is used for wake-up interruption and to activate the value reading and Infrared transmission; the sensor is the GaN blue light sensor for receiving the external blue conversion value; the monitor also includes a seven-segment display for Infrared receiving and value displaying.

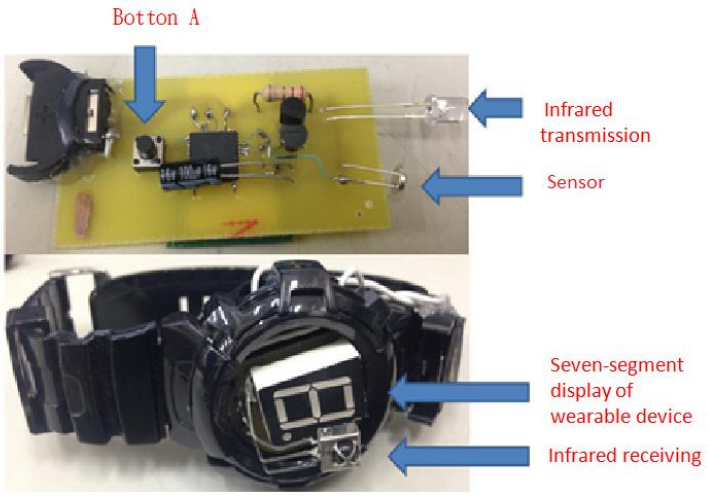

Fig5. *Entity of the cut blue light glasses*

FIVE-POINT MEASUREMENT METHOD

For the purpose of bettering the accuracy of the blue light value monitor, we use the five-point average illumination measurement method of the CNS illumination measurement method standard, which is suitable for the single light measurement; therefore, it is very suitable for the single blue light measurement. The illumination around the light source and in the center of the light source are summed up and averaged, and the calculated data are shown in Fig. 6 and Fig. 7.

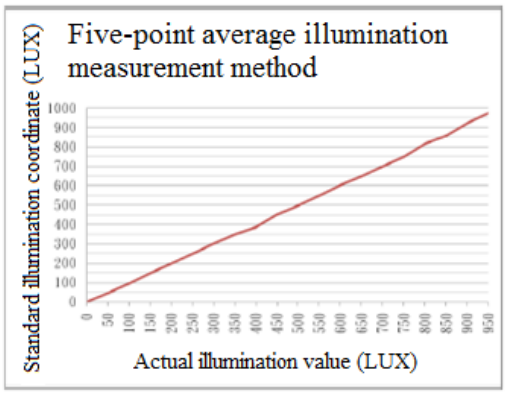

Fig6. *The diagram for the blue light illumination measurement*

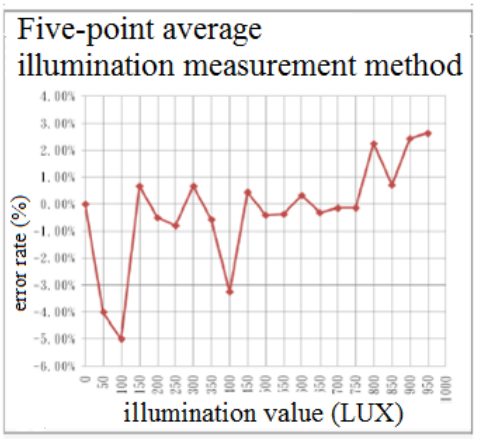

Fig7. *The diagram for the blue light illumination measurement*

REPEATABILITY AND REPRODUCIBILITY

To enhance the accuracy and stability of the blue light value monitor and the cut blue light glasses, we use the MSA measurement system [10] for three operators to conduct analysis from 50 blue light illumination to 500 blue light illumination to obtain the repeatability (EV) and reproducibility (AV) and total variation (TV). The repeatability (EV) is that the same operator uses the same measurement tool to conduct the measurement for many times in a short time; the reproducibility (AV) is that different operators use the same measurement tool to conduct the measurement for many times in a short time; the total variation is that the components suffer abnormality in manufacturing process, loss or oxidation or other environmental problems. Substitute the EV, AV and TV values into the equation (3) and use the equation (4) to calculate the analysis value (Gauge Repeatability and Reproducibility) of the measurement system; we find the accuracy measurement (GR&R) value of the blue light monitoring and alarm device is lower than 10%, the result as in figure 8. According to the MSA measurement system [10], it considers the analysis result of the GR&R measurement system of QS9000 is proved acceptable to QS9000.

$$\mathrm{R\&}R = \sqrt{\mathrm{EV}^2 + \mathrm{AV}^2} \tag{3}$$

$$\mathrm{GR\&}R = \frac{\mathrm{R\&}R}{\mathrm{TV}} \times 100(\%) \tag{4}$$

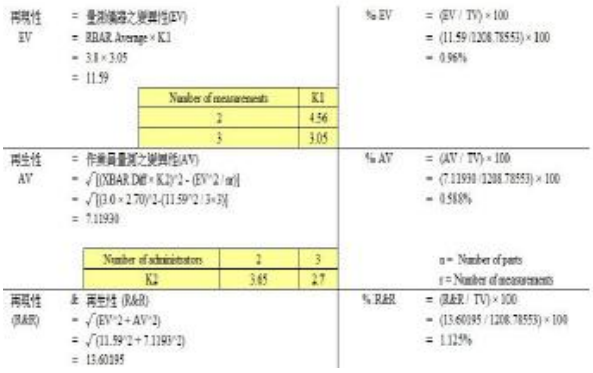

Fig8. *Measurement data of blue light GR&R*

BLUE LIGHT MONITORING APPLICATION SOFTWARE

After the blue light monitor transmits the data to the mobile phone via Bluetooth; the values should be displayed by the application of the mobile phone, which needs some simple operations to execute and to display the values. After the blue light monitoring software is successfully activated, the ten pieces of data from the blue light value monitor will be orderly displayed, and stay at the last value, as shown in Fig. 9.

Fig9. *The schematic view of successful connection*

CONCLUSION

Among the data of the experiments, we can see the stability that the error rate is between 1.8% and 2.8% which is very reliable according to the accuracy analysis; after the five-point average illumination measurement method is used, the accuracy can be up to 1.28%, which is very stable and reliable; the reliability of the accuracy within 4% is level AA; several data with higher floating difference can be modified in the future to decrease the error rate and the value stability floating area.

In the MSA analysis report, three operators conducted the analysis from 50 blue light illumination to 500 blue light illumination, and then conducted assessment by the repeatability and reproducibility (R&R); then, compared the results with the total variation (TV) to obtain the value of % R&R with 1.125%; the measurement system can have high reliability if the %R&R indicator value is lower than 10%.

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