

LED-technologies for bright light therapy

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Abstract: The significance of the LED-based medical equipment design is caused by the need to make up for the sunshine shortfall in many areas of Russia (Siberia, the Far East, the Extreme North) that will allow reducing dramatically the risk of seasonal affective disorders. The sunshine is the essential synchronizer of the human biological rhythms, the abnormality of which plays an important role in the seasonal affective disorder nature. The study allows proving the object database development able to meet the human demand for a comfortable and high-quality placemaking as well as the health potential recoverability.

1. Introduction

The high prevalence rate of depressive disorders is an onerous economic burden for the modern society. The efficacy lack of synthetic antidepressants during mental depression therapy determined the necessity to develop new efficient approaches to the mental depression therapy.

The use of the bright light as a therapeutic agent in case of depressive disorders is based on the data demonstrating that the natural cycle “light - darkness” is the main external synchronizer of the biological rhythms. The abnormality of these rhythms plays an important role in the seasonal affective disorder nature [1]. The perfect example of the chronobiological disorders is the co-called seasonal affective disorders, in other words, the clinical cases when at a certain time of year, a person has autumn – winter depressions [2,3]. The studies show that the seasonal affective disorders are a quite generalized mental disorder that the population of mid-latitudes has [4]. The rise in a winter depression prevalence rate towards the north latitudes can be explained by an increasing sunshine deprivation during the short light days in wintertime [5].

The study results prove that the sunshine shortage in autumn – wintertime plays an important role in the affective disorder nature, and the most efficient therapy mode of this disorder is a bright light therapy where the artificial daylight rate is 2500-10000 lux. The bright light, especially in the morning, can regulate the inadequate biological rhythms, influence the central nervous system efficiency and eliminate depression symptoms. The theoretical foundation that allowed studying the light therapy efficiency at seasonal and non-seasonal depressions was the data obtained in 1980 that showed that the bright light (>2000 lux) can inhibit the chromatophoretic hormone secretion – an



important neurohormone that plays one of the crucial roles in the human biological rhythm synchronization [3].

2. LED-technologies in bright light therapy

The bright light therapy can be conducted as a “light therapy room”. In this room, the light panels able to produce the necessary light intensity (between 2500 – 10000 lux) are used as a light source [6]. The modern technical achievements allow using the co-called light boxes where the light panels with the total light intensity of 10 000 lux are used. It provides an opportunity to reduce dramatically the bright light exposure time (up to 15 – 60 minutes compared to 2 – 4 hours a day at the light intensity of 2000-2500 lux). The recent study showed a good efficiency of more compact equipment during the affective disorder therapy. The operating principle of this equipment is based on LED-technology (5000 lux, the 464 nm wave length light – medium blue band – dominates in the radiated light spectrum [7, 8]. It is thought that the light waves of this spectrum completely inhibit the chromatophoretropic hormone secretion and influence in the optimal way the non-visual photoreceptors in special purpose retinal ganglion cells containing melanopsin that play an important role in light flux data communication from retina to the hypothalamus suprachiasmatic nucleus. Nevertheless, the leading experts in the light therapy of affective disorders think that they do not have enough data to advocate for certain such super compact devices and light devices that integrate the medium blue light spectrum in emission, for general consumption. It is related to the fact that when the light device size is minimized, the minor head or eye rotation sideway or the distance from the device can dramatically change the luminosity that lands in the eye retina of the corresponding patient, and the biological effect of the medium blue part of the light spectrum is not obvious yet [9].

Thus, it is still a relevant objective to develop some safe and efficient equipment to conduct the bright light therapy and the operating principle of this equipment should be based on LED-technology. The use of cost-effective, physiologically friendly, chronobiology-oriented therapy and preventive measures in case of seasonal depressions can be beneficent in areas of severe weather conditions that place strong demands on the human coping.

3. LED matrix parameters

The light panel design was based on LED-technology that is used when the light-emitting devices are developed. Compared to the standard incandescent-filament lamp that emits in wide spectrum, the led light initially belongs to a narrow spectrum band and depends on materials used for semiconductor p-n-junctions. The possibility to simulate the solar spectrum by the semiconductor selection provided the basis for the bright light therapy that allows solving an important issue of treatment and preventives measures of seasonal depressions by means of illuminating devices simulating the sunshine.

The main task of light panels is to provide the interior comfort that becomes possible due to the simulation of the natural diffuse sunlight (the most convenient for people). The light panel spectrum is maximum close to the solar one and that provides the required solar exposure level measured by the amount of energy units that impinge on the area unit in a unit time.

To solve the solar energy shortfall problem, the special purpose lamps with the emission close to the solar one by brightness and spectral content are offered. The color rendering index shows to what extent other colors are seen in the lamp light. It is measured percentage-wise from 0% to 100%. The color-rendering index comfortable for people must be higher than 80%.

The use of LED-technology allows solving the problem of brightness and light spectral content.

LED-lamps with the required brightness level allow simulating the natural sun light and are suitable for the bright light therapy. To create the illuminated area, the authors suggest using the LED matrix, the mock-up specimen of which is displayed in figure 1.

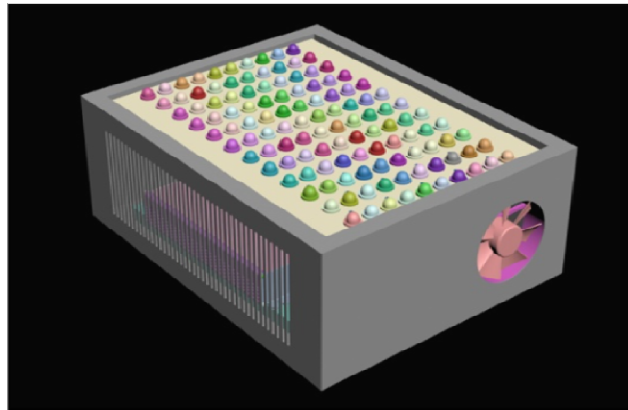


Figure 1. LED matrix mock-up specimen

The luminous density at the operating distance (0.6 m) from the device without any secondary optical components is calculated with the DIALux program and is shown in figure 2.

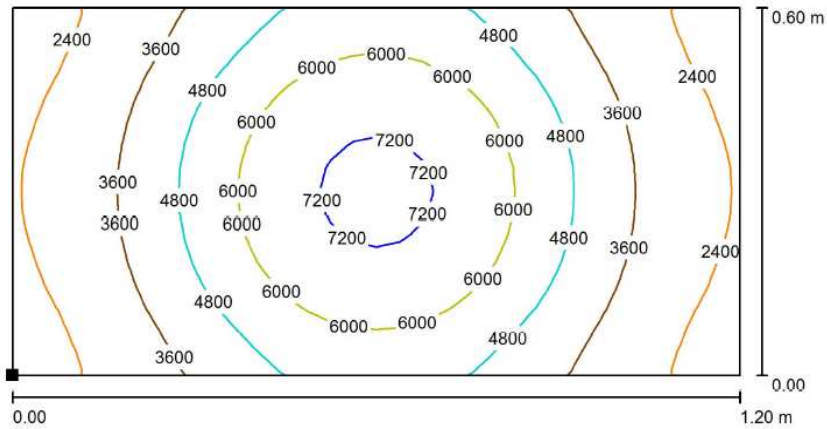


Figure 2. Luminous density

The light flux of the mock-up specimen has a color temperature of 3057 K, the luminous density is at the distance of 0.6 m with the secondary optical components of 13000 lux.

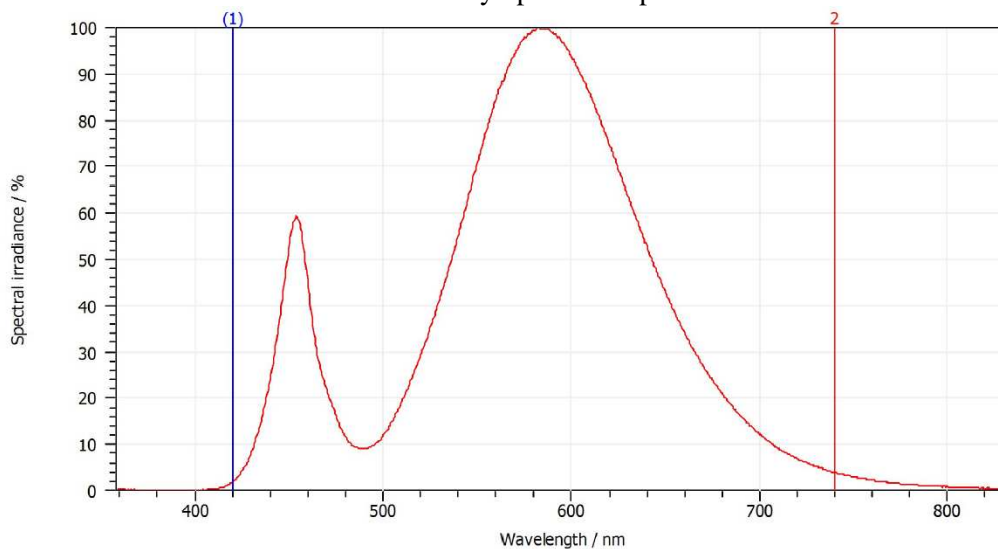


Figure 3. A spectral-response characteristic of the mock-up specimen

The spectral-response characteristic displayed in figure 3 allows concluding based on studies [7] that these characteristics of LED spectrum are optimum for the bright light therapy.

4. Design of the LED matrix – based light panel

The LED-based light panel case was designed with the following technical characteristics that allow providing the line supply of 220V, 50Hz, the power input of 35 Watt, the luminous density of 5000-10000 lux. The panel case is made of plastic.

The necessity of the light panel design is connected to the necessity to develop the visually comfortable environments that are provided with conditions mentioned in studies [10, 11, 12].



Figure 4. Light panel case design for the bright light therapy: on the left – table layout option, on the right – wall layout option

Figure 4 shows the light panel case design for the bright light therapy in two options: table layout option and wall layout option. The characteristic of the light panel case design makes it possible to supply the day light douche, simulate the sun light (10 000 lux at the distance of 0.6 m), and provide the bright and uniform emission.

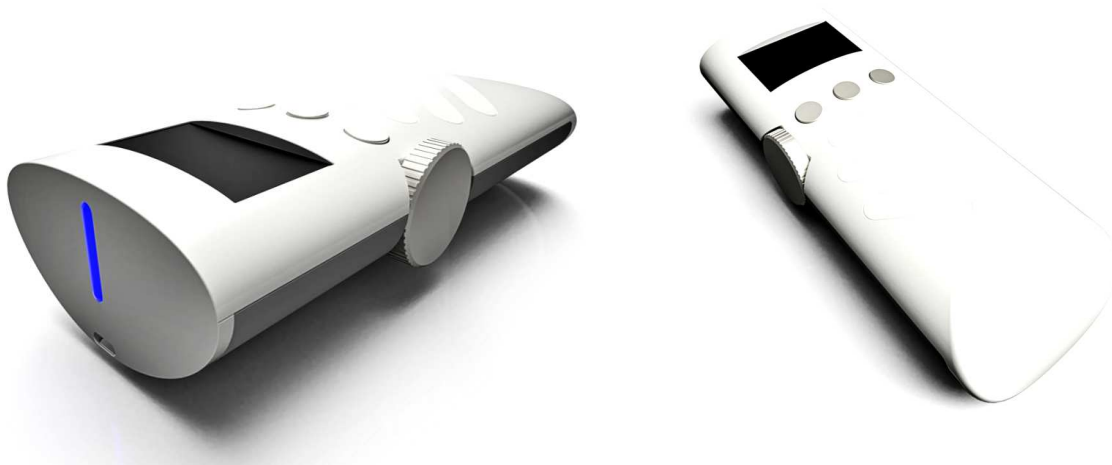


Figure 5. Design of the light panel remote control for the bright light therapy

Figure 5 presents the design of the remote control that guarantees the flicker free powering (the instantaneous stroboscope free pleasant light switching). The comfortable control is provided by the flat panel display that shows the luminous density set by the control device in the shape of the rotating barrel and buttons that provide the manipulation timing.

5. Conclusion

To solve the sunshine shortfall issue and to improve the human biological rhythm synchronization, the authors suggest using the light panels, the emission of which is very close by its spectrum content to the sunlight. The use of LED-technologies allows solving the problem of the necessary brightness level as well as the light spectrum content. The article studies the technical possibilities of the bright light therapy that reduce the total economic expenses related to the affective disorder therapy and autumn-winter depressions.

The significance of the study is in the light panel design that boosts the medical procedure efficiency in the medical treatment existing system and takes into account the up-to-date social circumstances on the make of the person-centered system of values in various therapy areas.

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