Vilnius University

Photobiologically friendly phosphor converted light-emitting diode

SUMMARY

The proposed low correlated colour temperature phosphor converted LED is characterized by a small non-visual photobiological action to humans, which manifests itself as the suppression of melatonin secretion in the pineal gland, and can be used for outdoor illumination, while only slightly disrupting the circadian rhythm of humans.

BACKGROUND

Circadian rhythm of humans is related to lighting and this rhythm is controlled by ganglion cells, located in the lower part of the eye retina. When an eye is illuminated by blue light, ganglion cells generate a signal to the brain, which then starts suppressing the secretion of melatonin in the pineal gland. Due to this, humans feel alert under bright light conditions. The disruption of the circadian rhythm and the suppression of melatonin secretion are proven by scientific research to increase the risk of cancerous diseases, therefore light with high circadian action should be avoided in the evening and during the first part of the night.

Currently, available technologies on the market that can be characterised by low correlated colour temperature and small circadian action are also characterised by either extremely low colour rendering, or spectral power distribution of three spectral components, while spectral power distribution of optimal photobiologically friendly LED consists of two spectral components.

TECHNOLOGY

The present technology provides a low correlated colour temperature (firelight) LED, which has a spectral power distribution composed of blue and orange components. These components have such peak wavelengths and ratios of radiation fluxes that the ratio of the excitation of non-visual photoreceptors in the eye retina that are controlling the circadian rhythm and the excitation of visual photoreceptors causing the visual perception would be the lowest. In this way, the minimal disruption of the human circadian rhythm is obtained.

The LED has a semiconductor chip that emits short wavelength light in the blue, violet or near UV region due to the injection electroluminescence and a wavelength converter, which converts the said short wavelength light due to photoluminescence to longer wavelength light having an orange component with the spectrum peaking in the range of about from 570 nm to 600 nm. In case of partial conversion LED, the chip generates blue light that is partially converted to orange light by one phosphor contained in the converter. In the case of complete conversion LED, the chip generates near UV light that is completely absorbed in the converter and converted by a blue phosphor and the orange phosphors.

TECHNOLOGY READINESS LEVEL

TRL 7 – prototype demonstration

PUBLICATIONS

A. Žukauskas, R. Vaicekauskas, P. Vitta, Optimization of solid-state lamps for photobiologically friendly mesopic lighting, Appl. Optics 5 1 (35), p. 8423-8432 (2012), https://doi.org/10.1364/AO.51.008423

BENEFITS

- → Optimised to have small non-visual circadian action and high luminous efficacy of radiation in the mesopic region.
- → Modest colour rendering.
- → Efficient and longevous.
- → Flexible on choosing desired Spectral Power Distribution.
- → Suitable for rapidly switching on and off.
- → Suitable for continuous dimming.
- → Does not require high voltage supply.

APPLICATION

The present phosphor converted LEDs can be used for various outdoor lighting applications:

- → Streets;
- → Pedestrian and bicycle tracks;
- → Building façades;
- → Monuments;
- → Parks;
- → Car parking lots;
- → House yards, etc.

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