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Controlling Colour Temperature of LED-luminaire

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INTRODUCTION

Light emitting diodes (LED) are rapidly coming to general lighting. Small size, long lifetime, good efficacy and cold light are advantages that are commonly mentioned. LEDs offer also some other advantages compared to traditional light sources. White light can be made from LEDs either using blue or UV LED and phosphors or mixing different colours of LEDs. Using the latter implementation, it is possible to attain better efficacy and use of different colours gives some additional benefits. When white light is created mixing several different colours, it is possible to change colour and colour temperature.
The possibility to change colour temperature will give designers new possibilities. Artificial light can be matched to daylight variations, atmosphere of restaurant and other places can be easily changed. Before, systems capable of such variations have been complex and expensive.

COLOUR RENDERING OF LEDS

Colour rendering index (CRI) have been developed for traditional light sources. It has been pointed out, that it is not totally adequacy for solid state lighting [1]. High CRI will not necessary mean that light is preferred by humans and vice versa [2]. However, CRI is still the widest use of method measuring colour rendering properties of light. That is why we also refer to that and try to attain high values of it.
Reach for the high values of CRI also means that highest possible efficacy cannot achieve. The optimization between these two values is always a trade off. [3]
Because of the narrow emission line of LEDs, it is difficult to attain good colour rendering. Žukauskas et a. [3] has shown that using three different colours it is possible to attain CRI value of over 80. Four colours will improve CRI over 95. Fifth and more colours will not improve CRI significantly. However, use of more that four colours can be justifiable in some special lighting applications.

CHANGE OF COLOUR TEMPERATURE

In many places, such as shops, restaurants, offices etc. it would be convenience to be able to control, not just the amount of light but also the colour of light. For example in retail lighting is a strong need to adapt the lighting according to target group, product range or time of the day. In display windows different colours and different colour temperatures are widely used and changed according to products. In those places high CRI is required. [4] In offices dynamic lighting can increase productivity and even in home people are towards to more individual lighting. [5]
One of these special applications, where more colours are justified, is light sources with changing colour temperature. Using only three different colours good colour rendering can be attained at some colour temperature. If some other colour temperature is needed and good CRI is to be maintained, the required three colours can be different. Our studies indicate that use of five different colours could give good colour rendering in large scale of colour temperatures. For the moment, one great obstacle is lack of powerful LEDs in different colours.
Changing the colour temperature means that intensities of LEDs are changed. That leads to lower light output than the maximum in most of the cases. The combination of LEDs should be such that when all LEDs are in their full power, the result would be white light with good colour rendering and common colour temperature. In any cases, the light output should not drop significantly from this maximum value.
The mixing different colour makes it challenging to get uniform colour and illumination [6]. The size of current high brightness LEDs package is big compared to size of the chip that produces the actual light. This leads to need for some optical elements. When the intensity of LEDs varies according to colour of LED and according to desired colour temperature, mixing the colours will become even more challenging.

OBJECTIVES

LEDs are totally different light sources than any previous one. Those are offering possibilities that were not considered even possible before. Our objective will be to utilize some of these possibilities. Main focus will be the dynamic change of colour temperature. There is a little research in effect of dynamic control of the colour temperature. The main reason probably is that only now it is coming possible to do it without large, bulky and expensive installation. We will implement a luminaire where it is possible to change, not just the intensity of light, but also the colour and the colour temperature.
Constructed prototype will be made with currently available LEDs, but analysis will be possible to extend also to upcoming LEDs. A comprehensive analysis of possibilities of dynamic change of colour temperature will serve as a basis to upcoming research and development.

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