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EFFECT OF RISE IN JUNCTION TEMPERATURE RISE ON THE LIFE OF LIGHT EMITTING DIODES

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ABSTRACT

Light Emitting Diodes (LEDs) has been replacing fluorescent lamps gradually in order to address issues of energy efficiency. However the impact of ambient temperature on the life of Light Emitting Diodes (LEDs) is explored in this paper. From the research conducted so far it is understood that the life of LEDs is dependent on the junction temperature. This feature is one of the most important aspects pertaining to the usage of LEDs as alternative artificial light source. The measurement of junction temperature is however a difficult task. From the work done by the researchers so far it has been concluded that the junction temperature is dependent on the shift in colour and peak wavelength of the LED. In this paper the measurement of junction temperature is achieved with the measurement of the shift in the peak wavelength of the LEDs. As learnt from the extensive study conducted that the life of LEDs is dependent on the thermal management of the junction temperature. So the impact of junction temperature is a point of major concern for implementation of these light sources extensively for indoor and outdoor applications.

Keywords—*junction temperature; ambient temperature; colour shift; peak wavelength*

INTRODUCTION

The advent of light emitting diodes in the lighting industry has opened up various aspects of lighting with all the pros and cons. The advantages of LEDs are many but when it comes to the aspect of life certain drawbacks still remain unaddressed. This is so because LEDs are basically diodes which is sensitive to any change in temperature. It has been observed by reserachers that a 10° C change in temperature would reduce the life of LEDs by 50% [1] [2]. The methods to check the undesirable effects of temperature is an arduous task for most researchers. It has also been explored by researchers that the intensity of emission is also reduced with increase in temperature.

In this paper an attempt has been made to draw attention regarding the shift in peak wavelength of the LEDs with change in temperature. This as understood would bring out the most difficult aspect in the use of LED as a light source. Because any change in the peak wavelength is also associated with the corresponding change in the correlated color temperature and subsequently the quality of light output. For these purpose four sub- miniature type power LEDs of 1W each are selected for the experiment.

The primary objective of this study was to verify that wavelength shift could be used to estimate accurately the junction temperature of LEDs. In this study, the junction temperature was increased by changing the surrounding temperature inside an Environmental chamber. Experimental results showed that for commercial LEDs, peak wavelengths shift proportionally to junction temperature regardless of how the temperature is created at the junction, and that this linear relationship could be used as a direct measure of the junction temperature. Because the primary cause for the degradation of LEDs is junction heat, the light output degradation rate of these types of LEDs can be predicted by measuring the spectral shift. One of the consequences of heating the p n-junction is that the output spectrum of the light is affected. Studies have shown that the peak wavelength shifts as a function of junction temperature. This effect is attributed to two primary mechanisms: lattice dilation and lattice vibration. Since the peak wavelength shifts proportional to the junction temperature, and the primary cause for the degradation of LEDs is junction heat, the light output degradation rate of the LED can be predicted by measuring the spectral shift. The junction temperature of a LED is affected by the electrical power that is dissipated at the junction and by the ambient temperature.

EXPERIMENTAL PROCEDURE

The electrical characteristics of the LEDs are measured using LED Data Analyzer. For the photometric characteristics the following instruments are used: (a) Small Integrating Sphere (b) Lux Meter (c) Chroma Meter. The LEDs used for the test are placed inside the Environmental Chamber and the temperature inside the chamber is increased by use of external means [3] [4] [5]. A hot blower is used and the rise in temperature is monitored manually using k-type thermocouple. The following figures (Fig. 1 – Fig.3) gives an insight about the process of test adopted. The LEDs are marked as LED1, LED2, LED3, LED4.

Fig.1. LED Data Analyzer

Fig.2. LuxMeter attached with the Environmental Test Chamber

Fig.3. Environmental Test Chamber

Results

The results obtained are tabulated and plotted. The series of plots hence obtained are as shown in Fig.4. The correlated colour temperature (CCT in kelvin), CIE x and CIE y were measured by the Chroma meter. The initial values were measured at the starting of the test. The data were obtained after 100 hours and continued till 200 hours. The result are plotted using McAdam Ellipse.

Discussion

The results obtained are plotted using McAdam Ellipse and the shifting in wavelength and colour for the LEDs are observed. As evident from the plot as in Fig. 4 the rise in temperature within a span of 200 hours corresponds to the change in peak wavelength and spectral shift. Table1 illustrates the chromaticity values at the beginning and end of the life study. As seen LED1 and LED2, the colour shifts towards yellow. In case of power LEDs it is not clear exactly what the reason for this change is [6] [7]. Some recent studies have speculated that the change in LED reflector colour could be one reason. If the shift is towards blue, the yellow part of the spectrum is reducing with respect to the blue, indicating that the phosphor efficiency is decreasing with rise in temperature and time.

TABLE I

		LED 1	LED 2	LED 3	LED 4
	CCT(K)	7514	5560	6120	3140

Zero Hours	CIE x CIE y	0.3001 0.3099	0.3411 0.3647	0.3113 0.3480	0.4242 0.4067
100 Hours	CIE x CIE y	0.2993 0.3163	0.3320 0.3553	0.3178 0.3592	0.4373 0.4160
200 Hours	CIE x CIE y	0.2939 0.3164	0.3316 0.3640	0.3218 0.3629	0.4402 0.4163

Conclusions

The experiment conducted so far reveals that the LEDs when subjected to prolong use are not as effective as a light source as compared to fluorescent lamps. This is primarily because of the shift in wavelength and colour shifting which restrains it from using in application where CRI (colour rendering index) is an important parameter. This shift in colour also makes the LEDs not suitable for any application. The reason for such shift may be assigned to the design of the reflector or due to the electronic properties of the junction. The rise in temperature thus makes the LEDs almost unwanted for any suitable application.
In the future if LEDs are required to be replaced by fluorescent lamps on account of the energy management issues than the aspects of thermal management needs to be dealt with more effectively

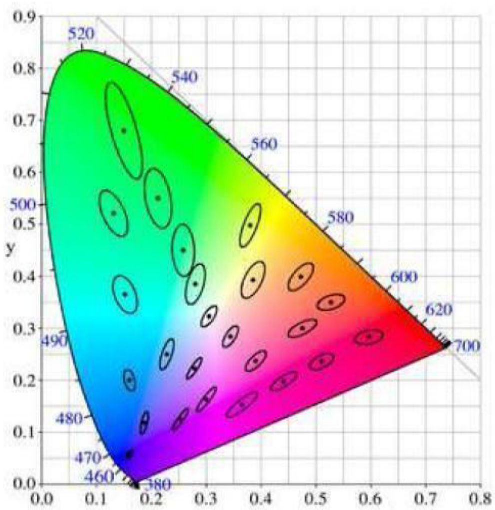

Fig.4. McAdam Ellipse plotted in the CIE (1931) Chromacity Diagram

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