DESIGN OF MICROSCOPE ILLUMINATION SYSTEM BASED ON LED LIGHT SOURCE AND COLLIMATOR USING ZEMAX SOFTWARE

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ABSTRACT

In this work, we study how to achieve a high quality lighting system construction capable of efficiently collects and focus the light emitted from an extended source in order to completely and homogeneously fill the condenser aperture diaphragm with axial and parallel light. The Zemax® optics simulation software is utilized to design a collimating optical system for the LED light source using the Non-Sequential Components. The simulation of the collimated light source is obtained of various parameters: the optical efficiency, light power and irradiance.

Keywords:*Illumination of microscope, LED, collimator, Zemax® optical design software*

1. INTRODUCTION

Illumination of the optical microscope is a very important parameter which must be fulfilled in order to obtain optimum performance. There are different light sources available for lighting microscopes, both for surveys and routine observation. In general, microscope illumination systems are optimized to produce the maximum light intensity, from a relatively small source, such as incandescent lamp filament, Arc lamps, lasers or the surface area of light - emitting diodes (LEDs) for two illuminating systems: critical illuminating system and Kohler illuminating. The illumination and orientation of light rays through the optical microscope can be controlled with lenses, diaphragms, prisms and other optical components strategically placed to achieve the desired degree [1,2] .

Among the most promising of emerging technologies for illumination systems in optical microscopy is the light- emitting diode (LED). LED-based illumination sources targeted at microscopy utilize three optical collimators to reflect and collimate the light generated inside the semiconductor die [3, 4]. In this study, a collimation optical system for LED source is presented. The design of collimating optical system for the LED light source by Zemax® optics simulation software is carried. The behavior of some parameters that characterize the performance of the optical system is assessed.

2. THEORY

The objective of this study is to design a free-form lens (collimator) for LEDs to be used as an optical microscope illumination system, in which highly collimated light is required.

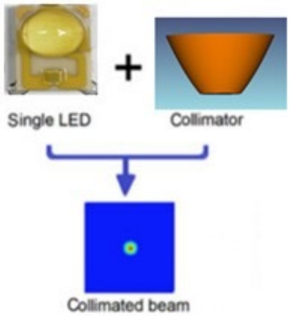


Figure 1. The principle of proposed uniform LED illumination system.

The present work used a Rebel LED Cool White, for illustration purposes. As shown in Table 1, the main features of the Rebel LED include a wavelength Range of 4500K to 10000K (Cool White),an optical power of 700mW, and a radiation angle of 120°. Figure 2. Shows the mechanical dimension of the led.

Table 1. Main features of Rebel LED

Parameter	Cool-White
LED color	Cool-White
Typical Lumens	180lm
Typical Wavelength	6500K
Wavelength Range	4500K to 10000K
Beam Angle	120°
Typical Forward Voltage	3Vf
Maximum Forward Voltage	3.99Vf

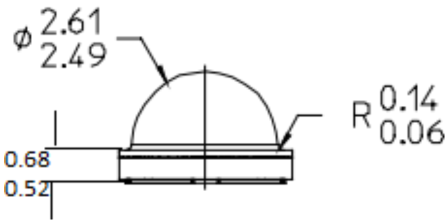


Figure 2. Mechanical dimension of the led.

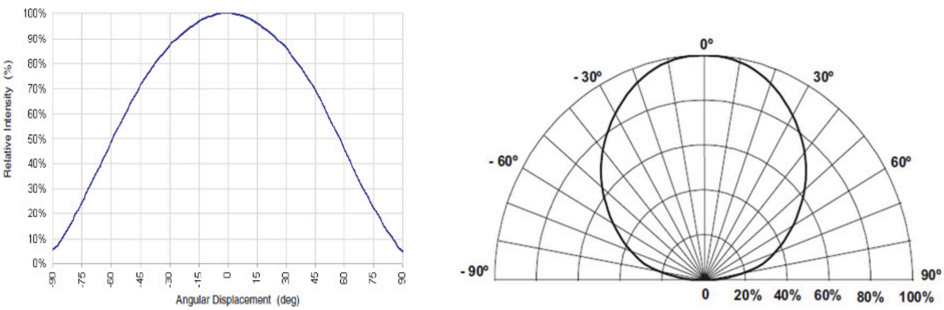
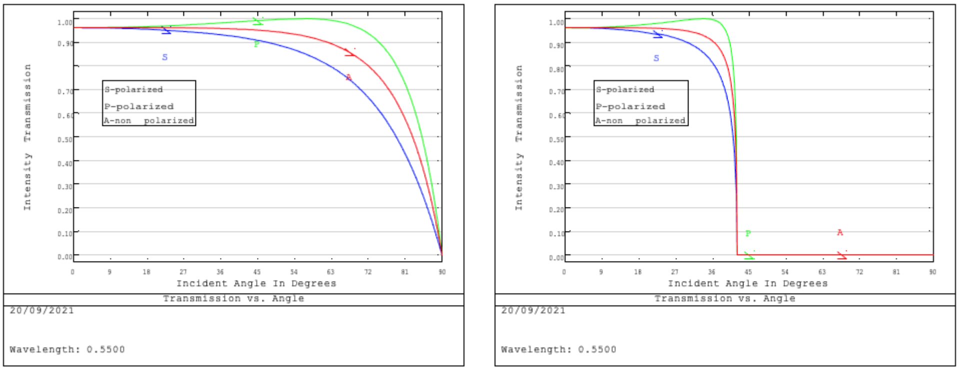


Figure 3.Typical representative spatial and polar radiation pattern for cool-white lambertian

3. RESULTS AND DISCUSSION

The Zemax® optics simulation software is utilized to design a collimating optical system for the LED light source using the Non-Sequential Components. The collimator designed in this study is manufactured in PMMA which is a poly(methyl methacrylate) material with an optical refraction index of 1.51 at 365 nm [5]. Figure 4 (a) and

(b) illustrate the calculated Fresnel optical transmittance of the chosen material at the air/PMMA and PMMA/air interfaces, respectively, as a function of the incident angle. The total reflection angle at the PMMA / air interface is approximately 41°.



a) b)

Figure 4. Optical transmission coefficients as function of incident angle for: a) Air to poly PMMA interface, and b)PMMA to air interface.

The collimator is imported in the software and simulations are performed for the radial source to check the performance of the freeform lens. Parameters selected for the simulation are listed in Table 2.

Table 2. Parameters selected for the simulation

Parameter	Description
Source type	Rebel LED
Radiation pattern	Lambertian
Collimator diameter	20 mm
Collimator length	10 mm
Material	PMMA
Number of LEDs	1
Tracing ray	1.000.000

Figure 5 shows the ray tracing through the whole system. In this design, we set the power is 3 watt. All light rays can be transferred to parallel rays after the collimating optical system, which results in a circular shape beam. The beam diameter coinciding with the diameter of the reflector. Since the LED is a Lambertian light source, the beam energy is focused in the center of the circular beam.

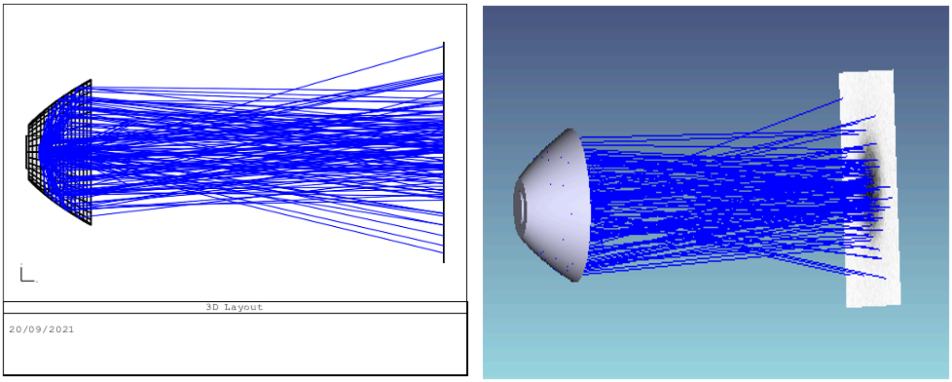


Figure 5. Ray trace layout of collimator lens with LED

With ray file consisting of 1 million rays is placed 80 mm away from the lens, Fig. 6 shows spot size and incoherent irradiance distribution obtained at the detector. Simulation results indicated that the light intensity distribution concentrate in the centre. According to this result, we can obtain through the whole collimating optical system uniform illumination.

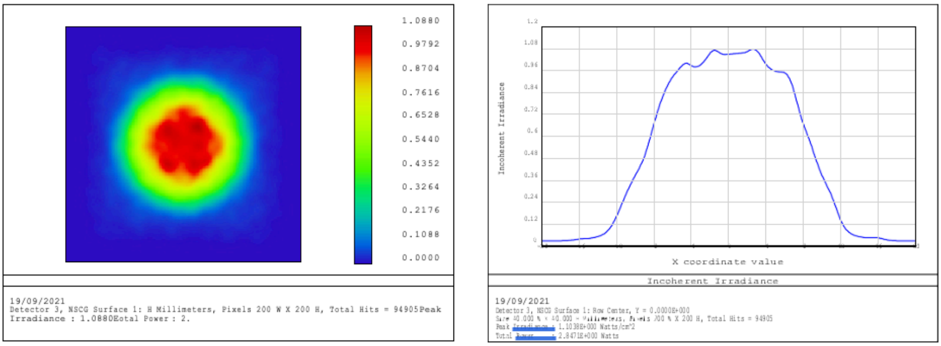


Figure 6.incoherent irradiance distribution from a radial source with Lambertian pattern when combined with a freeform lens

For characterized the quality of the beam that emerges from the optical system, two parameters must becalculated [6]:

-The optical efficiency, defined as the ratio of the luminous flux emitted by LED and the collected luminous flux is obtained by:

$$\text{optical efficiency} = F_C / FL \qquad (1)$$

Where FL and Fc , are respectively, the luminous flux emitted by LED and the collected luminous flux.

-The uniformity of the beam after passing through the system is obtained by:

$$Uniformity = \frac{Eave}{Emax} \qquad (2)$$

Where E ave and E max , the maximum and average values of the irradiance along the flat area of the beam. After the calculation, the optical efficiency of the overall optical system is approximately 80.3%. Then, the uniformity of rays that travel through the lens system to the detector is 14%

4. CONCLUSION

This paper presented a freeform lens for collimating light emitted from a LED.The optical performance of the proposed freeform lens (PMMA) was simulated by ZEMAX® for a LED (Cool White) with a power 3 W and a full radiation angle of 120°. The parameters which characterize the quality of the beam exiting the optical system were calculated by a virtual detector (40x40mm) positioned behind the optical system at 80 mm.

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