LED Measurement

L. M. So and L. W. Ma
Christian Alliance Cheng Wing Gee College,
12-14 Chik Wan Street,
Tai Wai, Shatin, N.T.

Supervised by: Dr. K.W. Cheah, BU

Abstract

This experiment is aimed at comparing the wavelength of light coming from different types of LEDs and laser beam and investigating their constituent colour. We also found whether the LEDs are precisely fabricated by comparing angles corresponding to the value of v_o/e, v_o is the maximum light intensity, e the natural logarithm.

The experiment consists of two parts—measurement of spectrum of light emitted from different types of LEDs and a laser with various angles and measurement of maximum light intensity of different LEDs and the laser.

After obtaining the results from experiment, we plotted two sets of graphs—one comparing the different wavelengths of LEDs and the laser, and the other set of graphs contains the light intensity of 6 types of LEDs measured from various angles.

We also calculated the 3dB point of the intensity (v_o/e, where v_o is the maximum light intensity, e the natural logarithm) and found from the set of graphs of light intensity against various angles, the corresponding intensity as a function of angle for different types of LEDs, and hence the accuracy of fabrication of the LEDs.

Introduction

The purpose of the experimental investigation on the performance of LEDs and laser beam described in the following report were as follows:

The establishment of a series of experimental values derived from models and intended for use as a basis for (1) comparison between the wavelength of light coming from different types of LEDs and a laser, (2) investigating their constituent colour, and (3) finding if the LEDs' light emission is evenly distributed with different angles.

The report comprises of three parts, as follows:

I. The equipment installed with special reference to test on LEDs and the laser.

II. Tests on 6 types of LEDs and a laser, with analysis and discussion of results and presentation of the same in graphical form.

III. A brief discussion of the properties of LEDs and lasers.

The design of the instrumental equipment, the planning of the experimental work on the LEDs and laser, together with the preparation of the report in its present form, are the joint work of the present authors and of Prof. K. W. Cheah and Mr. H. L. Tam, at the Hong Kong Baptist University.

Properties of LED

Light emitting diodes, commonly called LEDs, are tiny semiconductor light bulbs that fit easily into an electrical circuit. But unlike ordinary incandescent bulbs, they do not have a filament that will burn out, and they do not get especially hot. They last much longer and are illuminated solely by the movement of electrons in a semiconductor material.

Doping is a process of addition of impurities (atoms of another material) to a poor conductor (such as silicon). In pure silicon, all of the silicon atoms bond perfectly to their neighbors, leaving no free electrons to conduct electric current. In doped silicon, additional atoms change the balance, either adding free electrons or creating holes where electrons can go. n-type material and p-type material are respectively semiconductors with extra electrons and with extra holes. In n-type material, free electrons move from a negatively charged area to a positively charged area while the holes in p-type material appear to move from a positively charged area to a negatively charged area.

The essential part of a LED, the LED chip, is composed of a diode, which is a sort of semiconductor. And, a diode comprises a section of n-type material connected to a section of p-type material, with electrodes on each end. This arrangement conducts electricity in only one direction. Free electrons moving across a diode can fall into empty holes from the p-type layer. This involves a drop from the conduction band to a lower orbital, so the electrons release energy in the form of photons. A greater energy drop releases a higher-energy photon, which is characterized by a higher frequency, and vice versa. Therefore, the size of the gap between the conduction band and the lower orbitals determines the frequency of the photon and hence the colour of light emitted by the LED.

<u>Experiment</u>

In this experiment we are going to measure the LED spectrum. We should prepare Fiber Optics Spectrometer, optical fiber, A/D converter, operating software, LED and sampling optics.

First, we should set up the appliances like fig1.

Fig.1(a) Setup for measurement of LEDs

Fig.1(b) Research radiometer

<u>Procedures of setting up the appliances</u>

- *Install the operating software in the computer*
- *Connect the optical fiber with the spectrum and plugs the spectrometer directly into computer*
- *Place the light source face to the optical fiber*

Light enters the optical fiber and is transmitted to the spectrometer and disperses via a fixed grating across the linear CCD array detector. In the spectrometer, a spherical mirror collimates the divergent light emerging from the optical fiber. A plane grating diffracts the collimated light, the resulting diffracted light is focused by a second spherical mirror. The data is then transferred to a computer through an A/D card. An analog-to-digital converter is necessary to interface spectrometers to computer. It integrates curette holder and light source.

Results & discussion

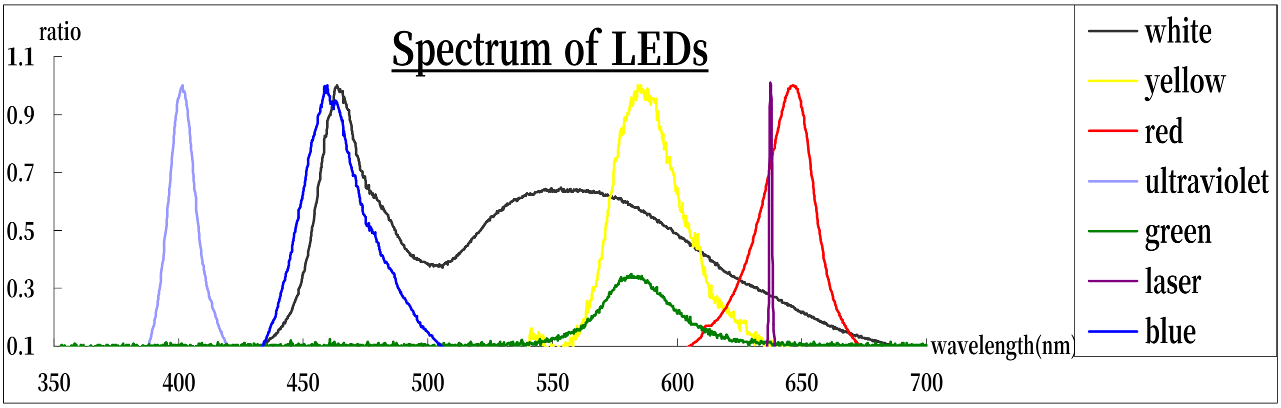


Fig. 2 The spectrum of LEDs

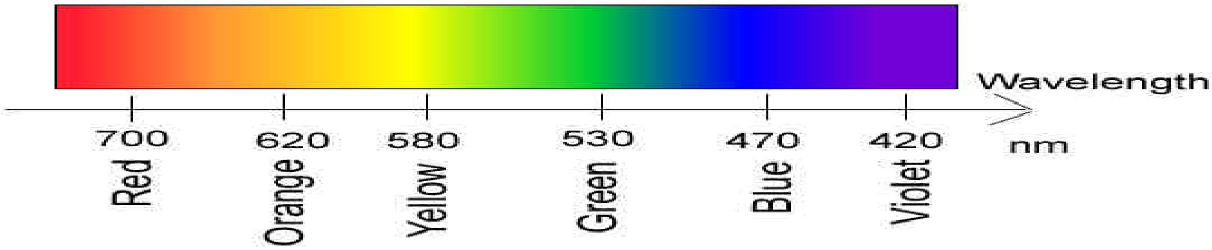


Fig.3 The visible spectrum in the electromagnetic spectrum

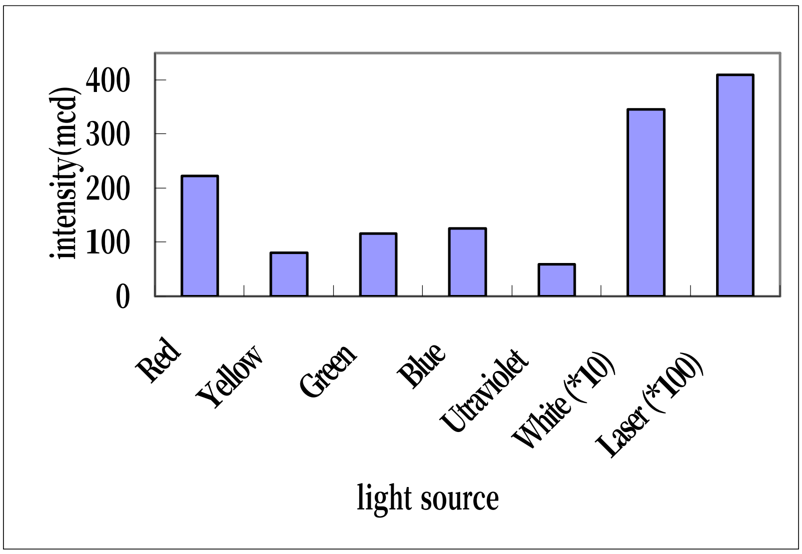
In this experiment, we noticed that different-colored LEDs have different spectrum. White LED has two peaks, this is because it is composed of many color. So it has the widest wavelength range. He-Ne laser has the narrowest wavelength range. This is because the form of light emission of laser is stimulated emission. The emission of laser consists of two types of light emission—either spontaneous or stimulated one. Spontaneous emission occurs as the principle of LED light emission, and the photons from flashtubes inside the laser tube stimulate the emission of more photons with the same frequency. This is called stimulated emission. The laser beam intensity is strengthened due to continuous reflection by a total reflector and a partial reflector. The laser beam can escape from the tube when the intensity is high enough. This results in a monochromatic, high intensity, coherent beam of electromagnetic energy. And each

LED has the peak at the corresponding wavelength at fig.3.

The frequency of light is related to the wavelength of light .It is inversely related to wavelength $f = \frac{v}{l}$, where f is frequency, v is velocity of light and l is wavelength. The higher the frequency of the signal, the shorter the wavelength The spectrometer can be used to examine the light from the LED, and to estimate the peak wavelength of the light emitted by the LED.

Light source	$1/l_n e$	$1/l_n e$
Red	23.354282	-16.5797
Yellow	26.2859	-27.5175
Green	21.2942	-29.0987
Blue	13.5292	-15.312
Ultraviolet	36.4279	-14.9158
White	15.9062	-7.2301
Laser	1.52720	-1.5582

Fig.4 The angular distribution of LED intensity



Light source	Integrated intensity
Red	223
Yellow	80.5
Green	115.8
Blue	125.7
Ultraviolet	59
White	3460
Laser	40960

Fig.5 The maximum intensity of LEDs

Laser has the highest intensity, while ultraviolet has the lowest. Intensity also shows the brightness of the LEDs. This shows why laser is widely used today. White LED also has high intensity. It is bright, so some types of white LED can replace fluorescence/incandescent light.

Conclusion

In this experiment, we know that different LEDs have different spectrum. Different color spectrums have peaks at the corresponding wavelength of visible light.

LEDs consume less power than lamp. So many lamps will be replaced by LEDs. This also can save energy. So scientists are going to invent brighter LEDs.

Fig 6 Different types of LEDs

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