LED | REPORT

Introduction

This report will outline the methodology behind the procedures used to test manufactured LEDs. It will include the process of preparing a test sample using the material used to manufacture the LEDs and will describe the electrical and optical test performed to ensure that the quality standards are met. Furthermore, justification for the acceptance or rejection of wafers and further testing procedures during quality control/assurance testing will be addressed.

Test Sample Preparation

To produce a test sample, a small sample is removed from the wafer and a small metal contact is added to enable electrical conduction. This is achieved by bonding a small piece of indium onto the P-type side of the sample, with indium being appropriate for these testing procedures due to the fact it can have an effect on the metal-to-semiconductors boundary because it can easily diffuse into its surface. This indium is then bonded to the semiconductor using heat.

Electrical & Optical Tests

To ensure that the wafer can conform to the technical and operational requirements, its electrical and optical properties are tested.

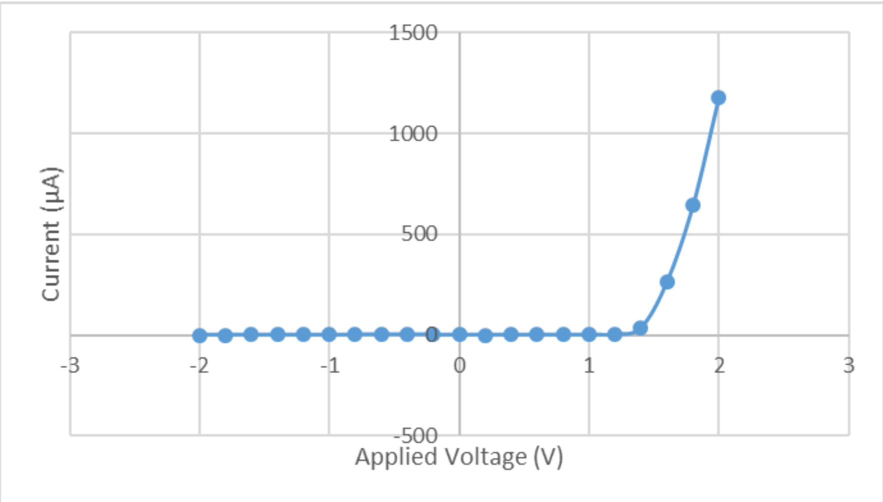

Figure 1: IV Characteristics graph of red LED sample.

Applied Voltage (V)	Current (µA)
2	1178.200
1.8	642.345
1.6	263.056
1.4	34.475
1.2	1.609
1	0.298
0.8	0.394
0.6	0.356
0.4	0.294
0.2	0.126
0	0.361
-0.2	0.527
-0.4	0.458
-0.6	0.442
-0.8	0.512
-1	0.253
-1.2	0.355
-1.4	0.365
-1.6	0.693
-1.8	0.051
-2	0.069

Figure 2: Electrical test measurements.

Firstly, to electrically test the sample, the IV characteristics are measured by varying the voltage across the sample and measuring the resulting current, such as the example table in *figure 2*. To perform this test, the sample is placed on to a probe station and the P-type and N-type faces of the sample are connected to a source measurement unit (SMU) using the probes. The voltage can then be varied over a range above and below 0Vm with the current being measured at each interval.

The resulting graph in *figure 1* can be inspected to ensure that the sample behaves as expected with the correct conduction properties and turn on voltage.

Secondly, to measure an LEDs optical properties, both optical spectrum and optical power tests are performed. For these tests, the LED is given a current of 50mA, and the voltage across the LED when 50mA is flowing is measured.

The optical spectrum test measures the LEDs peak wavelength, which is done using a spectrometer. To measure this, the LED is given to and is pointed directly into an optical fibre cable which then measures the intensity of the LEDs

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output over the optical spectrum. The data is then displayed on a computer on a graph of intensity over wavelength. The peak intensity and therefore peak wavelength can be identified and recorded.

The optical power test measure the optical power that the LED can emit, which is done using an optical power meter. To measure this, the peak wavelength of the LED previously calculated is entered into the optical power meter so that it measured the power at that specific frequency. The meter is then calibrated by measuring the ambient optical power at that wavelength so that the meter can be zeroed. Then, the LED is aimed into the input of the optical sensor and the reading is recorded.

All this data can be recorded into a table, such as the example table in *figure 3*, where different LEDs can be compared and data can be calculated such as efficiency and resistance.

LED	$V_{turn\text{-}on}$ (V)	$V_{forward}$ (50mA)	Colour	Peak Wavelength (nm)	Line width (nm)	Optical power (I = 50mA) (mW)
A	1.90	2.77270	Green	567	26.492	0.01032
B	1.35	1.44812	Infrared	867	40.315	4.56
C	2.68	3.48284	Blue	464	23.885	4.64
D	2.60	3.38711	White	454 & 572	32.187 & 123.898	5.25 & 2.81

Figure 3: Electrical test measurements.

Sampling

From the data measured, the wafer sample behaved exactly as expected, therefore being acceptable for further production/fabrication. The reasons for this include the fact that the wafer sample produced the expected IV characteristics graph and had a suitable “turn on” voltage. Furthermore, the optical tests showed that the sample had an expected wavelength (with the correct visible colour) and a suitable optical output power. Due to the number of LEDs that are able to be fabricated out of a single wafer, testing a sample per 2-3 wafers would be a suitable sampling rate to ensure that the maximum capacity of LEDs that are in specification are produced without the time and cost associated with testing affecting this.

Further Tests

<u>Temperature:</u>

The temperature of the junction within an LED can have a big impact on its colour and optical output power. An “integrating sphere” with a thermal controller can test the LEDs optical output characteristics under a range of different temperature and currents. This is important to ensure that the characteristics of the LED do not go outside of the specification when the LED is being operated in conditions with temperature fluctuations. [1]

<u>Total Luminous Flux:</u>

A “integrating sphere” can be used to test the optical light output of an LED at different angles around its package and calculator the perceived brightness in lumens and therefore calculate the LED’s luminous efficacy. This is essential for applications such as street lights where the light needs to maintain its intensity over a wide area. This measuring process involves placing the LED inside a dome and rotating an optical power metre around it at all angles to see how the light is dispersed. [2]

References:

[1] LaserFocusWorld. (2011, 2nd January). *LED Test & Measurement* [Online]. Available: http://www.laserfocusworld.com/articles/2011/02/led-test-measurement-optical-testing-is-an-essential-aspect-of-making-leds.html

[2] LED-Professional. (Unknown Date). *Measurement of LEDs* [Online]. Available: https://www.led-professional.com/resources-1/articles/measurement-of-leds