Manufacture of Red LEDs from a GaAs Substrate

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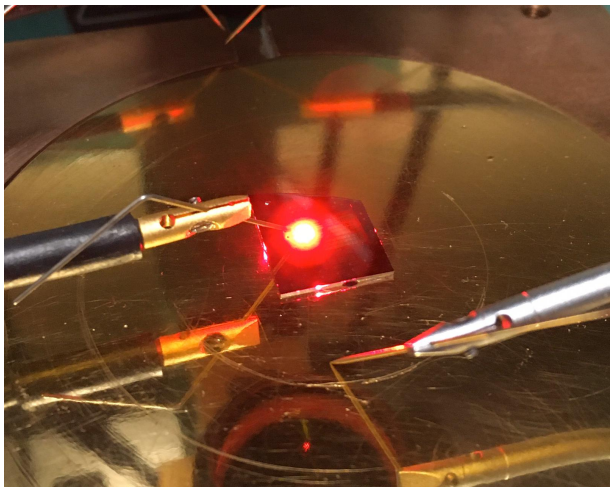

Completed in partial fulfilment of the Degree of Master of Engineering in Electronics with Music

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1 Introduction

12.5%

Describe the motivation for making red LEDs [500 Words max + Figures]

[1]

2 Fabrication

2.1 Cleanrooms

3.125%

Briefly describe why fabrication takes place within a cleanroom. [100 words max]

The clean rooms minimise contamination

there are different scales of cleanroom and so the results from fabrication can be more predictable, e.g. in terms of the likelihood of devices having errors. ¡– is this true?

2.2 Cleans

3.125%

Briefly describe why we carry out steps 1 and 9. [100 words max]

Prior to spinning the photoresist for both the p-contact and the mesa etch, the substrates were cleaned to ensure that there was no contamination on the surface and to ensure that the photoresist is deposited correctly.

The cleaning process comprised of 3 minutes in an ultrasonic bath

What is the purpose of optoclear. what is the purpose of acetone what is the purpose of IPA what is the purpose of RO what is the purpose of Ashing in O2

2.3 Photolithography

9.375%

Briefly describe the processes carried out in steps 2 and 10. Comment on the exposure parameters and choice of developer. [250 words max + Figures]

Vacuum chuck, suit Spin Microposit S1818 at 4000rpm for 30 seconds. According to the S1800 series datasheet [2], the resist thickness will be the desired $1.8\mu m$.

After spinning the back of the sample was cleaned with cotton bud soaked with acetone. This removes any unwanted photoresist and stops the back of the sample contaminating or sticking to the hotplate.

After spinning the substrate is baked on a hotplate at $115°C$ for 120 seconds. This hardens the photoresist enough so that it does not stick to the photomask and so that the structure does not colapse and distort after exposing.

The SUSS MicroTec MJB4 mask aligner was used to align the masks on the substrate

2.4 Etching

9.375%

In step 11, describe the choice of this etch process. What other process choices are there? Why do you think that this one was chosen? What advantages does this process have over other options? [250 words max]

The blank was etched using a H_2SO_4:H_2O_2:H_2O 1:8:40 solution.

2.5 Metallisation

6.25%

What role does our choice of process flow have in the contact formation process? What role does the annealing step have? How have you measured it's effect in your work? [100 words max]

2.6 Lift-Off

9.375%

Describe the concept of the lift-off process, using schematics as required. [150 words max + Figures]

Suggest possible alternative process steps to achieve the same result as obtained in the lift-off process you have used. [50 words max]

3 Test

3.1 Apparatus

6.25%

Draw a schematic of the test apparatus. Comment upon the power measurement process. [150 words max + Figures]

3.2 I-V Characteristics

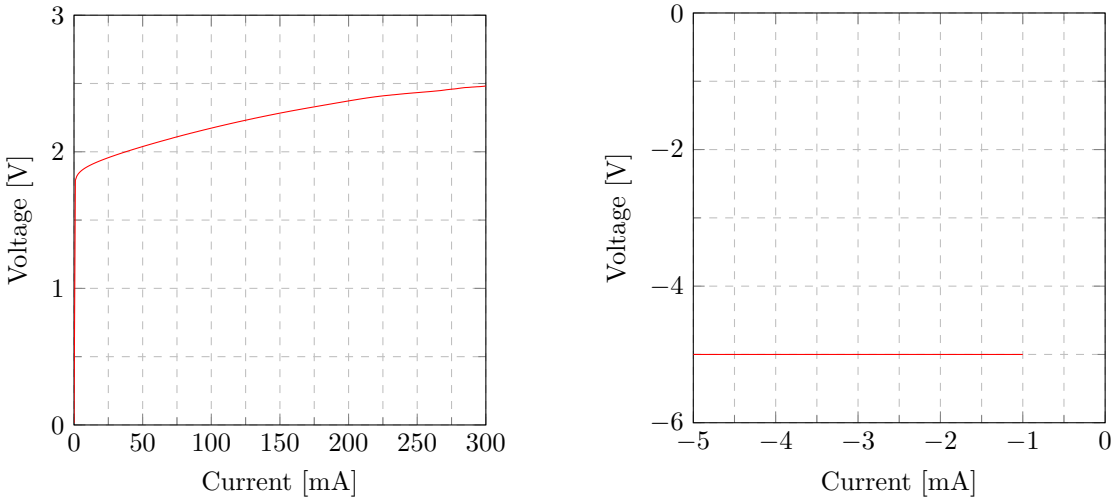
6.25%

Plot the forward and reverse bias VI characteristics of one of your diodes. Describe the salient features of the graphs [150 words max + Figures]

3.3 LI Characteristics

6.25%

Plot the output light power as a function of forward bias for one of your LEDs (or the standard). Describe the salient features of the graph. [150 words max + Figures].



(a) Forward Current

(b) Reverse Current

Figure 1: IV

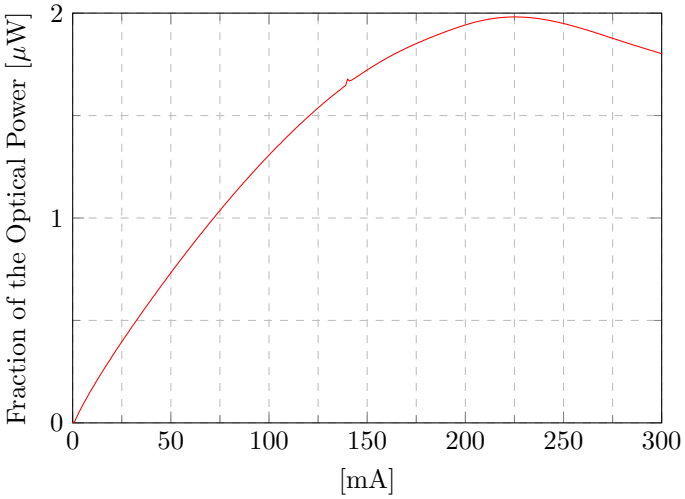


Figure 2: LI Characteristics

3.4 Spectral Characteristics

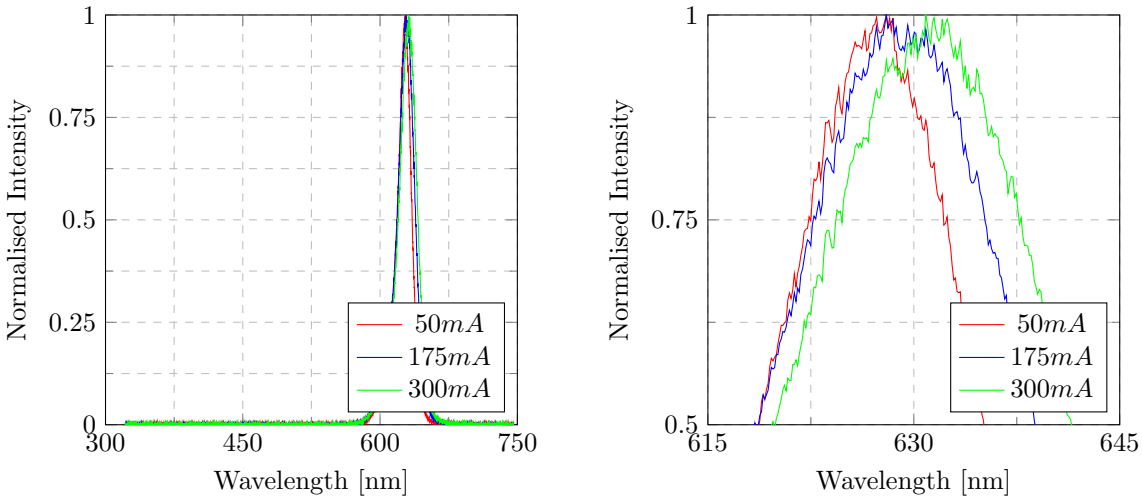
6.25%

Plot the emission spectra of your device as a function of current. Describe the salient features of the graph, and comment on any relationship to previous plots. Comment upon the collected power, system collection efficiency, and emitted power from the LED. [100 words max + Figures]

3.5 Contact Resistance

6.25%

Plot CTLM results for one device from your group. Why do we use CTLMs over TLMs? Describe the salient features of the graph, and comment on any relationship to previous plots. Comment on why only the p-contact is analysed. [150 words max + Figures]



(a) Spectral Characteristics

(b) Spectral Characteristics

Figure 3: Spectrum

4 Commentary

15.625%

Highlight any process steps that you think may need more attention should you repeat the fabrication process. How would you redesign the process sequence if the scribe and break at process number 8 could be moved to the end? Comment upon how the LED operation varies with mesa diameter. Suggest how you may make the LED operate more efficiently. [300 words max + Figures].

References

[1] A. Einstein, "Zur Elektrodynamik bewegter Körper. (German) [On the electrodynamics of moving bodies]," *Annalen der Physik*, vol. 322, no. 10, pp. 891–921, 1905.

[2] Shipley microposit s1800 series photo resists. [Online]. Available: https://amolf.nl/wp-content/uploads/2016/09/datasheets_S1800.pdf