Drive characteristics of InGaN Micro-stripe Light Emitting Diodes and Integration With Light Emitting Polymers

Basic Technology Research Programme
RESEARCH COUNCILS UK
A 1000 micro-emitters per square millimetre

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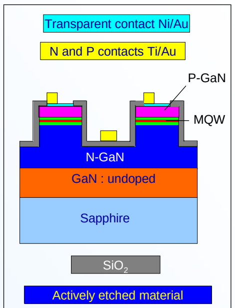
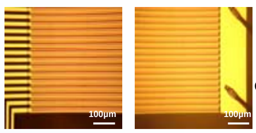
We have fabricated striped micron-scale Light Emitting Diode (LED) devices with 120 individually addressable elements from InGaN wafers emitting in UV (370nm), blue (470nm), and green(520nm) wavelengths. These devices are highly flexible in their ability to produce programmed microscopic lighting patterns for applications such as structured illumination microscopy, and offer light output levels comparable to conventional LEDs. Hybrid LED/Light Emitting Polymer devices are also demonstrated, and initial pulse characteristics of the stripe LEDs are reported.

Stripe LED Fabrication and Performance



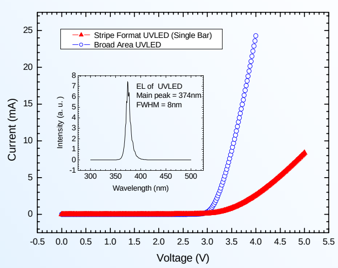
Device schematic

The stripe LEDs are fabricated in parallel from an InGaN wafer. A Cl_2/Ar plasma was used to etch the device structure before an isolating SiO_2 layer was deposited by Plasma Enhanced Chemical Vapour Deposition. Finally, transparent Ni/Au contacts were evaporated onto the stripes and Ti/Au stripe connections deposited by a sputtering and lift-off process [1].

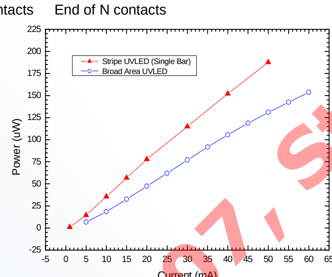


End of P contacts   End of N contacts

Stripe length= 3600µm
Width = 24µm
Centre-centre pitch = 34µm



I-V curve of single UV (370nm) stripe LED compared to broad area LED fabricated from same wafer.



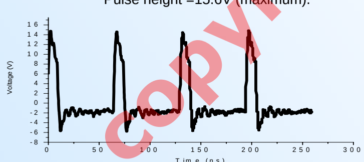
L-I plot of UV single stripe LED bar compared to broad area LED fabricated from same wafer.

Pulsed Output

Input electrical pulse- 470nm stripe

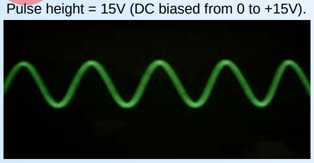
Short Pulse

Optimum frequency is 8.73MHz (probably related to R-L-C characteristics of stripe).
Pulse width =9.3ns.
Pulse height =15.6V (maximum).



Sinusoidal Pulse

Frequency of 10MHz.
Pulse height = 15V (DC biased from 0 to +15V).



Direct Current

Maximum current before device failure: I=140mA, V=13V.

Optical output power

Average output power = 55.5µW.

This gives an energy per pulse of E=Power/frequency= 6.36pJ.

Stripe under pulsed operation.

Average output power = 740µW.

Energy per pulse E= 74pJ.

Output power = 1400µW.

Power density output

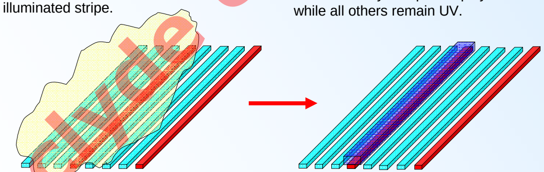
Area of single stripe = 6.103×10^{-4} cm^2.
Short pulse gives 55×10^{-3} mW / 6.103×10^{-4} cm^2 = 90 $mWcm^{-2}$.
Sine pulse gives 740×10^{-3} mW / 6.103x10-4 cm^2 = 1212 $mWcm^{-2}$.
DC current gives 1400×10^{-3} mW / 6.103×10^{-4} cm^2 = 2294 $mWcm^{-2}$.

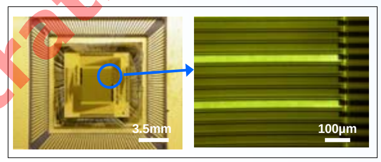
Direct writing of Light Emitting Polymers

A UV- curable polymer, courtesy of Strathclyde Chemistry, is mixed with a light emitting polyfluorene (F8DP, Dow Chemical Co.) and spun onto a UV stripe device. After curing the residual polymer is washed off, leaving a directly written stripe of light emitting polymer for colour conversion from UV to blue at 440nm.

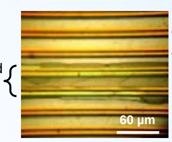
Polymer/polyfluorene blend is cured in registry with illuminated stripe.

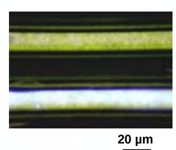
One hybrid element is colour converted by strip of polyfluorene while all others remain UV.



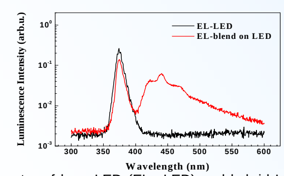


A UV device is turned on with one stripe covered by curable polymer.





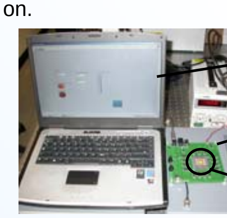
Picture of device with two different elements on.

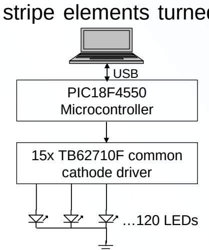


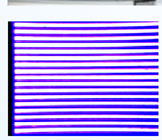
Spectra of bare LED (EL –LED) and hybrid LED (EL- blend on LED).

Programmable Drive Electronics

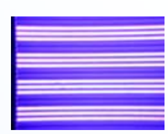
A LabVIEW™ interface is connected via a USB cable to a PIC driver board, which contains constant current driver chips for providing current to each of the 120 stripes of an LED array. The interface can be programmed to produce scrolling patterns of stripes on the array, with varying scroll speed, brightness, and period of stripe elements turned on.



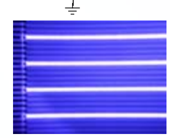




Blue device being driven.
On = All elements



Period = 5
On = 3 elements
Off = 2 elements



Period = 5
On = 1 element
Off = 4 elements

References

1) H. X. Zhang et al. 'Microstripe-Array InGaN Light Emitting Diodes with Individually-Addressable Elements', submitted to *IEEE Phot. Tech. Lett.*