Strip Pattern VCSELs

used in Structured Light or direct-TOF applications

04/06/2020

Light is OSRAM

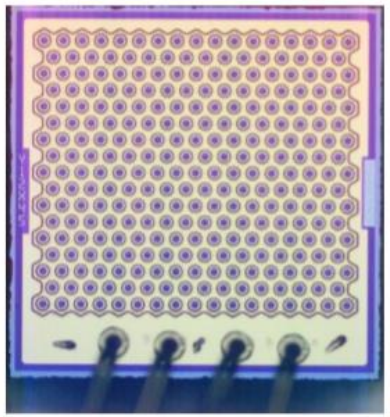
Vixar

OSRAM
Opto Semiconductors

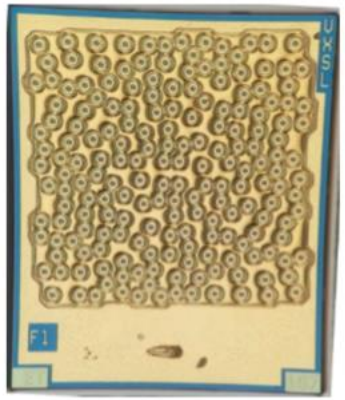
VCSELs with strip pattern VS. normal circular apertures.

Usual VCSEL power arrays consist of an arrangement of circular apertures on a chip and can be arrange in a hexagonal or matrix arrangement (A) or in a pseudo random array (B). The advantage of designing a linear apertures (C) is a more efficient use of the actual chip area and an easy to detect pattern for structured light cameras.

Strip pattern VCSEL are used in structured light applications, in which a camera detects 3D depth information using triangulation between different stripes and/or pattern changes on the observed object in the far field.



(A) Normal Power Array
Round-apertures in hexagonal arrangement
Applications: 3Dsensing, ToF, structured light



(B) Pseudo Random Array
Round-aperture in “random” arrangement
Application: 3D sensing structured light

(C) Strip Pattern Array
linear-aperture in matrix arrangement
Application: 3D sensing, structured light, Tof

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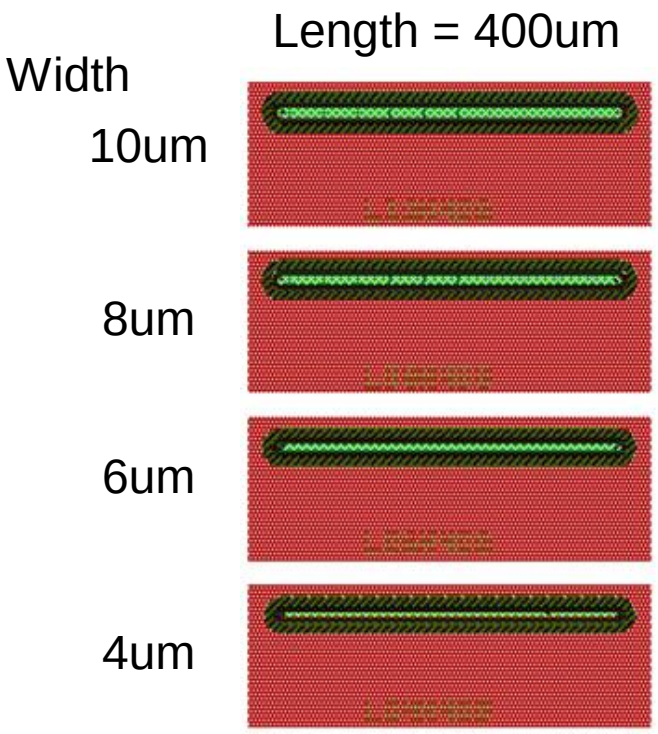
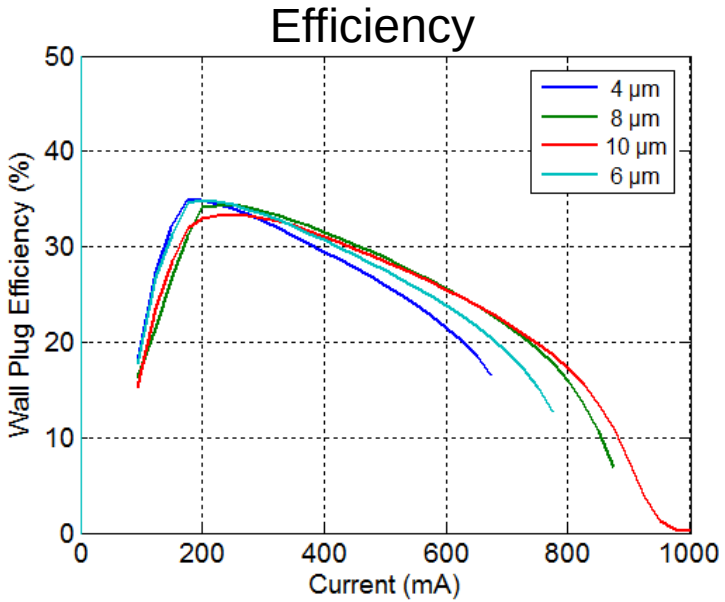
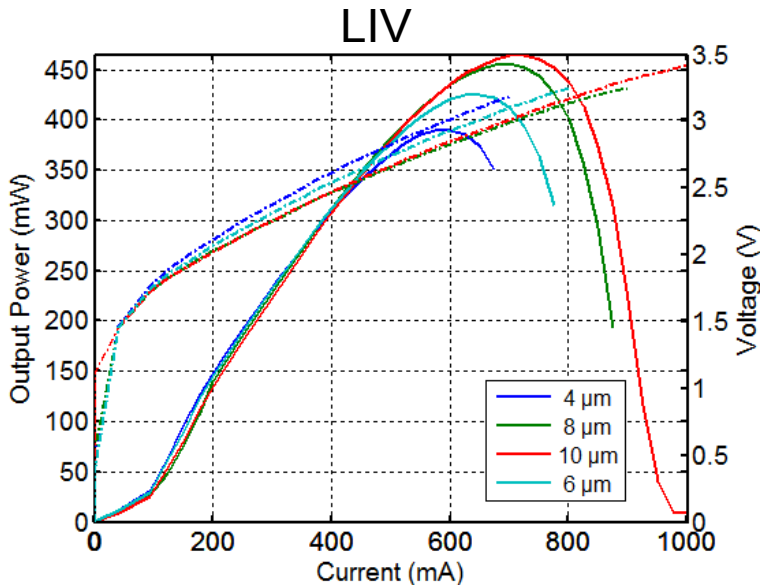
Strip pattern VCSEL – LIV Performance @ long pulses

Example: 850nm Stripe VCSEL in test. Similar performance can be expected for a 940nm epitaxy.







Comparison of power and efficiency for various stripe widths under pulsed operation
Pulse width = 100us, Duty cycle = 10%, Temperature = 25C

Conclusion:

- Very little change in performance vs. stripe width
- The optical power of a strip scales with the length of the strip ~ **1mW / µm-strip-length (almost independent of the strip width)**

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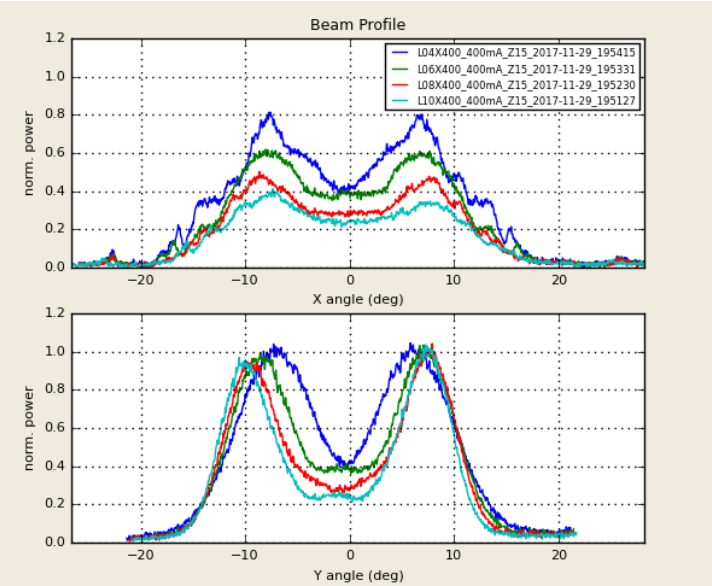
Far Field Behavior VS Near Field

Near Field: the near field shows a very homogeneous light distribution. Just if the aperture size goes in the range of 10µm width a dark spot in the center can be observed. (not displayed here)

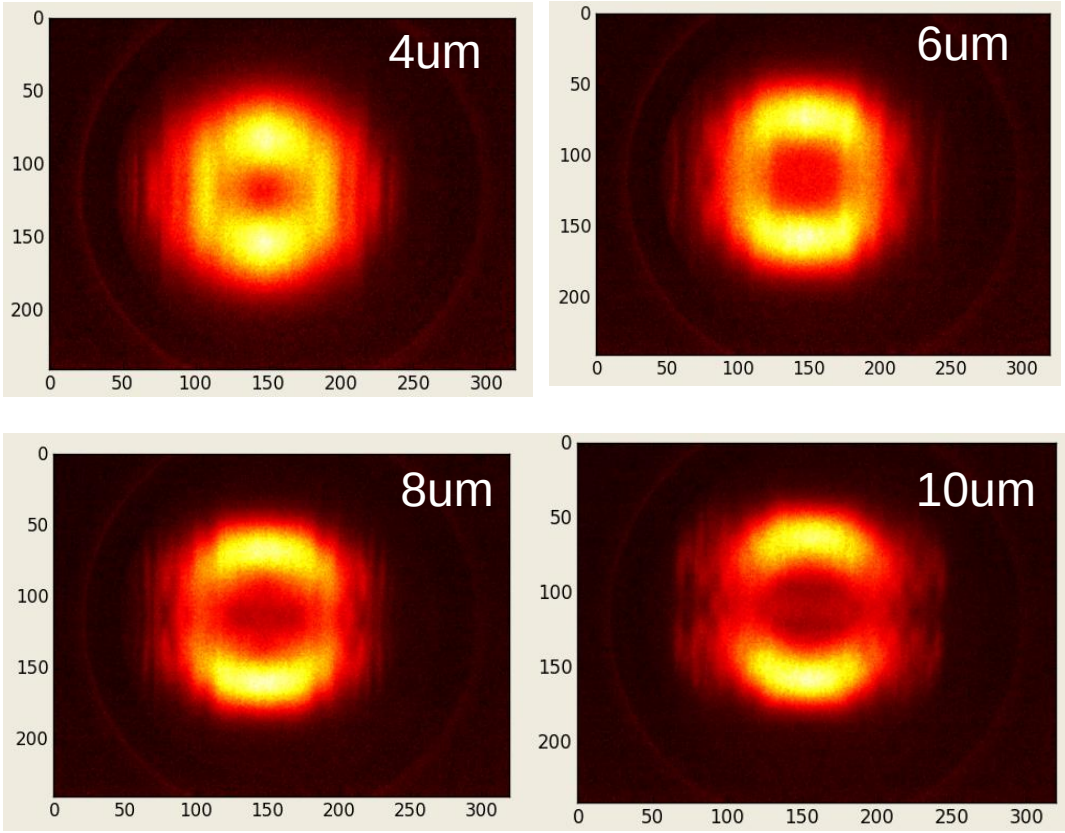
Far Field: Comparison of beam profile for different stripe widths (pictures on the slide)

- Propagation distance
  - 100mm
- Pulse condition
  - 400mA, 100us, 10%

Far Field



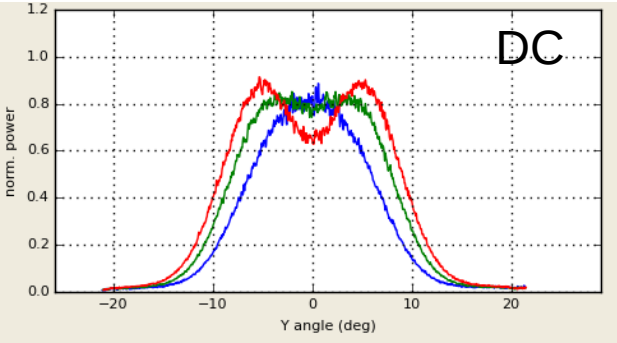
Far Field

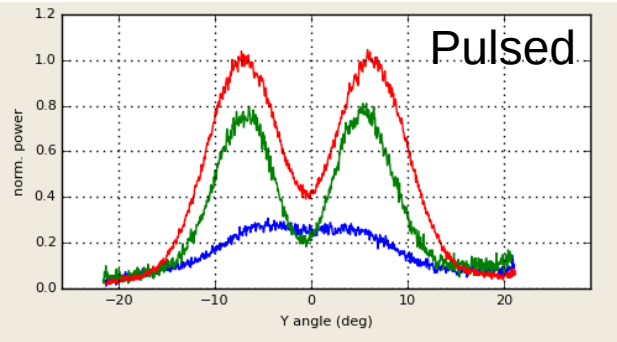


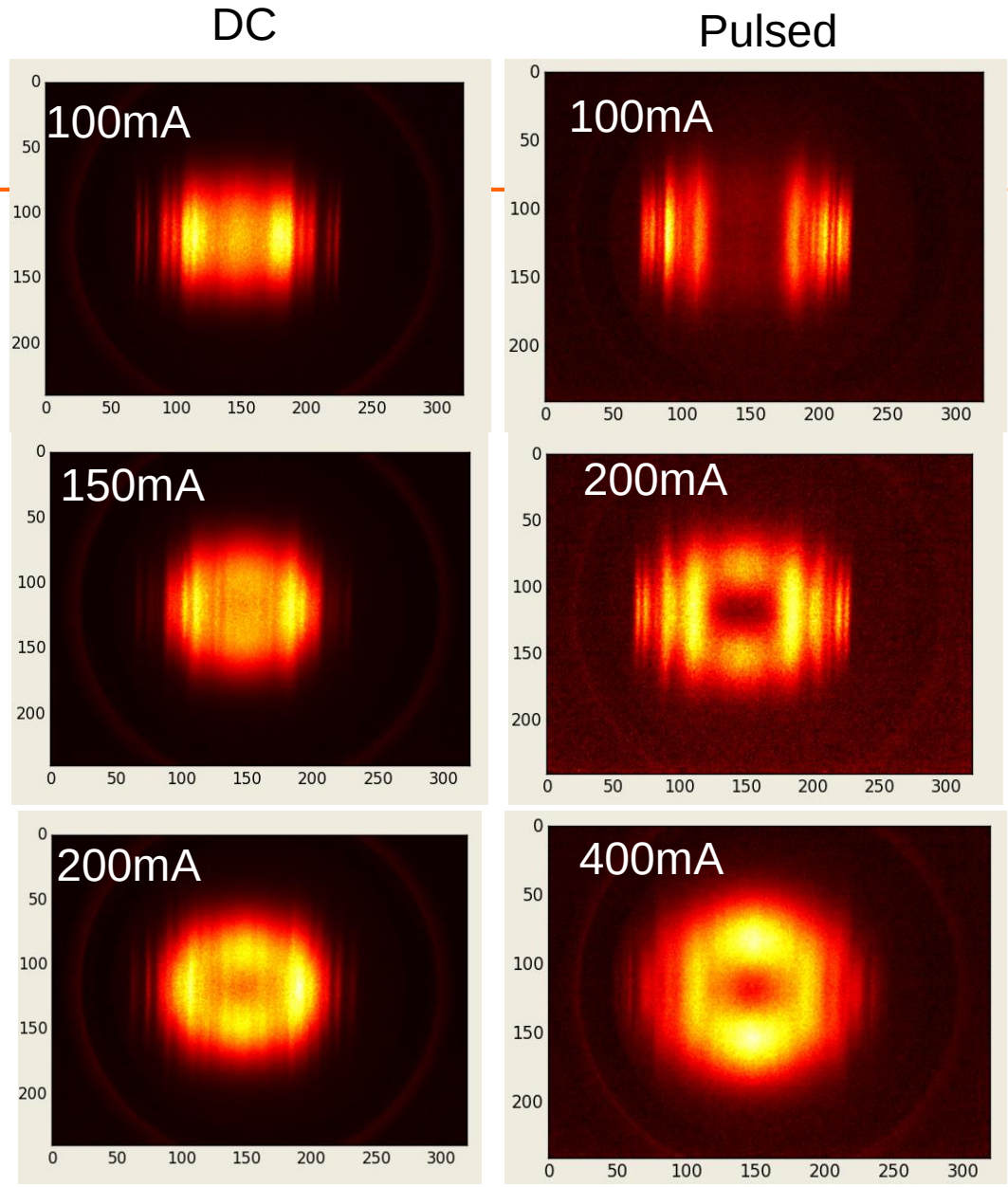
Far field

4um aperture width)

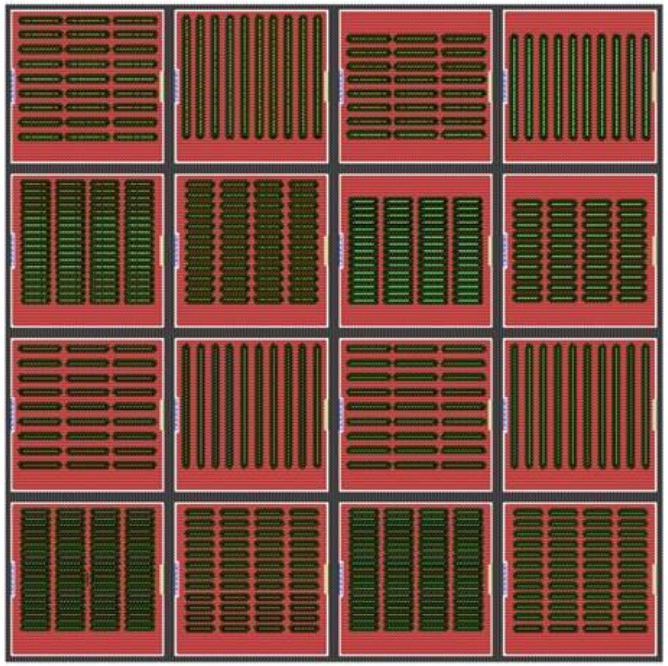
Comparison of beam shape of 4um stripe under DC and pulsed operation. Beams are more Gaussian with DC bias. Stripes wider than 4um were not gaussian under any bias condition.







Possible strip pattern VCSEL designs



Stripe width

4 – 10µm (wider need to be tested)

Stripe length

up to 2.5 mm tested. More is possible. The aspect ratio of the die need to considered for assembly.

PowerBoost Technology

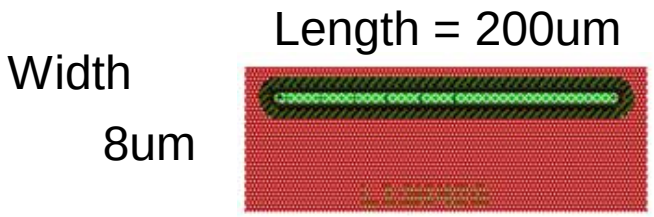
all stripe pattern can also be supported with a **multi-junction** epi configurations

Strip Pattern under short pulse operations

Vixar has shown in previous publications (Matt Dummer: High efficiency multijunction VCSEL arrays for 3D sensing, shown on the Photonics West 2020, see next page) that VCSELs – using the *PowerBoost* technology (multi-junctions) - driven under short pulse and high currents can achieve high power densities. This learning can also be applied to VCSELs with a strip pattern.

Theoretical Excurse:

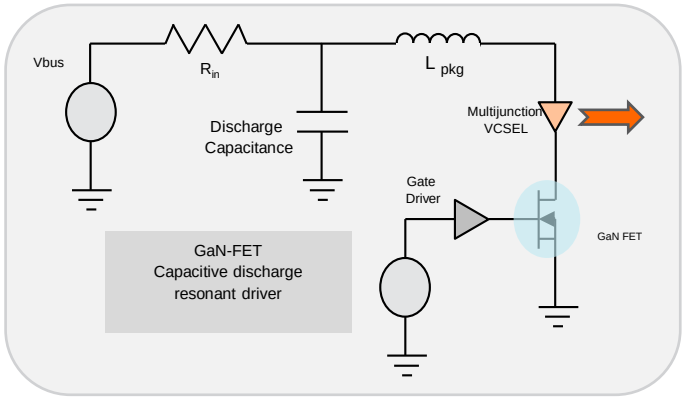
Chip:	1x stripe
Epitaxy configuration:	triple junction
Slope Efficiency:	3 – 3.2W/A
Stripe length:	200µm
Stripe width:	8µm
Stripe power at 100ms and 10% DC:	200mW
Stripe power at 3.6 ns and 0.1% DC:	15 W

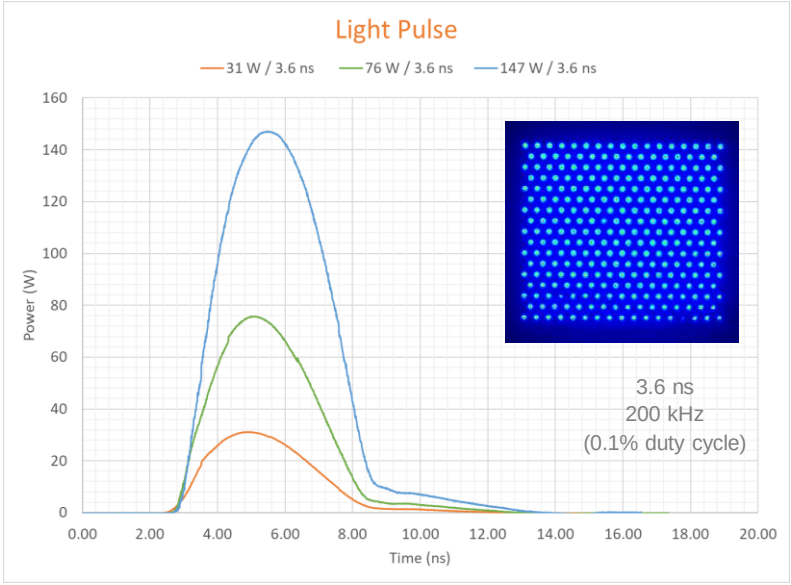


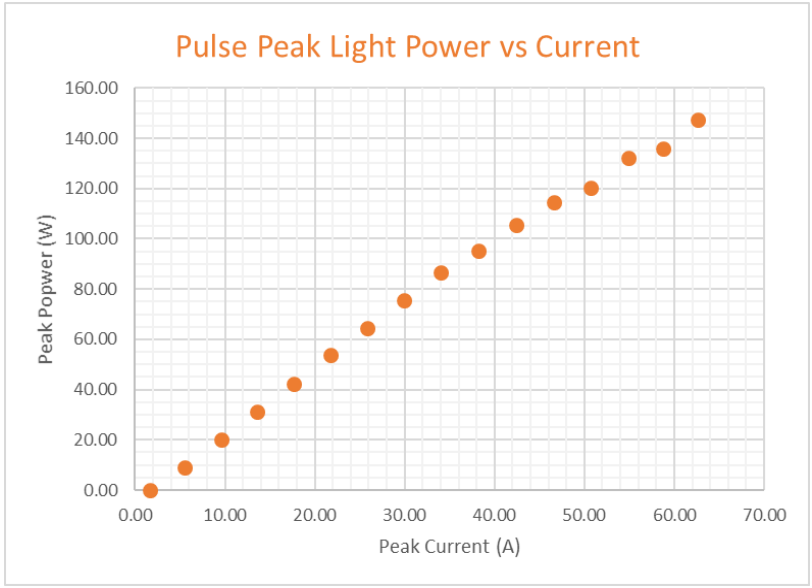
Note: Based on the measurements from page 8 Vixar shows that a normal 2W power array can be driven at 147 W peak power under short pulse conditions (3.6ns and 0.1% duty cycle). This represent extreme conditions for the VCSEL, and the individual recommended driving conditions need to be adjusted for the individual applications.

Reference: Matt Dummer: High efficiency multijunction VCSEL arrays for 3D sensing, shown on the Photonics West 2020

High power drive circuit







- High power pulsing experiments conducted with GaN-FET based driver
- Triple Junction VCSEL array driven with 3.6ns pulses, 0.1% duty cycle
  - Peak pulse power of **147W** recorded for 64 A peak current
    - No rollover observed (power limited by driver)
- Equivalent irradiance: **281W/mm²**
  - Emission area: 0.77 x 0.68 mm²

Thank you.