Product Document

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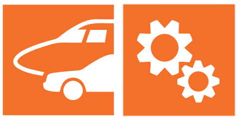
IR pulsed laser SPL DS90A_3

Application Note



Valid for:
SPL DS90A_3

Abstract

The SPL DS90A_3 laser for LiDAR applications features short pulses with high peak power — 125 W at 40 A. To ensure that this laser can be properly implemented into the application, this application note provides basic information as well as recommendations for handling and assembly.

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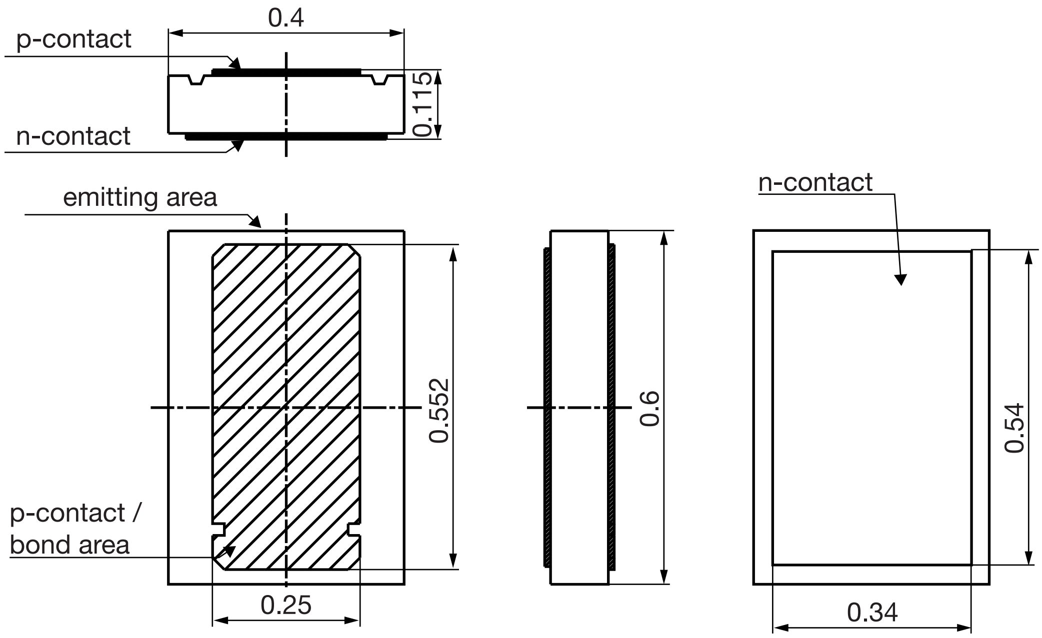
Table of contents

A. Basic information

The laser SPL DS90A_3 has been developed for high optical pulses which are required for LIDAR systems. Laser pulses are reflected by objects at high speed. The new laser helps to improve the LIDAR system with the capability of very high optical power at short pulses and is also able to provide a high repetition rate. With currents of up to 40 A it achieves an optical peak power of 125 watts and thanks to its compact design with a chip size of 400 µm x 600 µm it allows flexible integration into the application. Figure 1 shows the dimensional drawing.

Figure 1: Dimensional drawing of the SPL DS90A_3



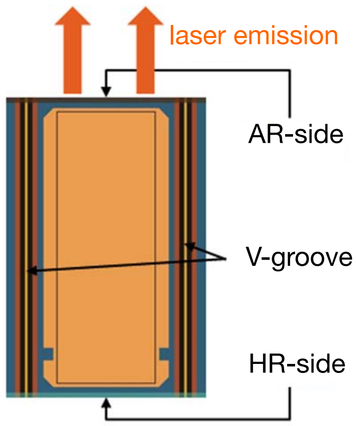
The anode (positive electrode) of the laser is the p-contact (p-side) and the cathode (negative electrode) is the n-contact (n-side).

- The p-side (anode) is also referred to as the“top-side”.
- The n-side (cathode) is also referred to as the “bottom-side”.

The dimensions of the electrodes are characterized by a circumferential reduction in relation to the nominal edge of the chip. For the n-contact this results in a pad of 340 µm x 540 µm in size. It is recommended to use the n-contact bottom-side for die attach with glue. The p-contact, recommended for wirebonding, has a pad size of 250 µm x 552 µm.

Figure 2 explains AR (anti-reflective) and HR (high reflective).

Figure 2: Laser AR (anti-reflective) and HR (high reflective)



Depending on the application, it may be necessary to cover the system. The material selection must take the high power density of the laser into account.

Optical and electrical simulation

For detailed information on the mechanical dimensions please refer to the detailed drawings available in the data sheet. To obtain CAD data and the optical rayfile, please visit the "Optical Simulation / Ray Files + Package CAD Data" webpage on the OSRAM Opto Semiconductor website.

For more information on importing the rayfiles and ray-measurement files of LEDs and lasers from OSRAM Opto Semiconductors, please refer to the application note "Importing rayfiles and ray-measurement files of LEDs from OSRAM Opto Semiconductors".

A Spice model for electrical simulations can be provided on request. Please contact OSRAM Opto Semiconductors.

Characterization methods

For the characterization of the values in the data sheet the corresponding tests are usually performed on TO56 carriers / packages at I_{max} and 100 ns.

ESD sensitivity

In common with most microelectronic components, semiconductor chips must generally be classified as sensitive to electrostatic discharge (ESD) and must be protected against any such damage.

One of the most frequent causes of electrostatic discharge is an electrical charge generated by friction, which can occur e.g. during transport, handling or processing. The external evidence of a load discharge will often take the form of a visible spark or fracture taking less than a microsecond. With sensitive semiconductor products, even discharges of a few volts are sufficient to result in destruction or damage, whereas a person will not feel a discharge until it reaches several thousand volts (approx. 3000 V) or more. The fractures created inside the semiconductor will then result in the failure of the component, either immediately or with a delay. The handling and processing of semiconductor chips should therefore be conducted in manufacturing environments with appropriate ESD protection in place, in accordance with the ESD guidelines for components at risk.

For further and more detailed information it is advisable to consult and use the appropriate standards, as well as the literature and the publications of the approved associations and committees (e.g. ANSI, JEDEC, ESDA).

When testing with a TO56 package the laser provides an ESD stability of up to 2 kV assigned to the "Class 2 HBM" category (in accordance with ANSI / ESDA / JEDEC JS-001) and 0.4 kV assigned to the "MM" category (in accordance with JESD22-A115).

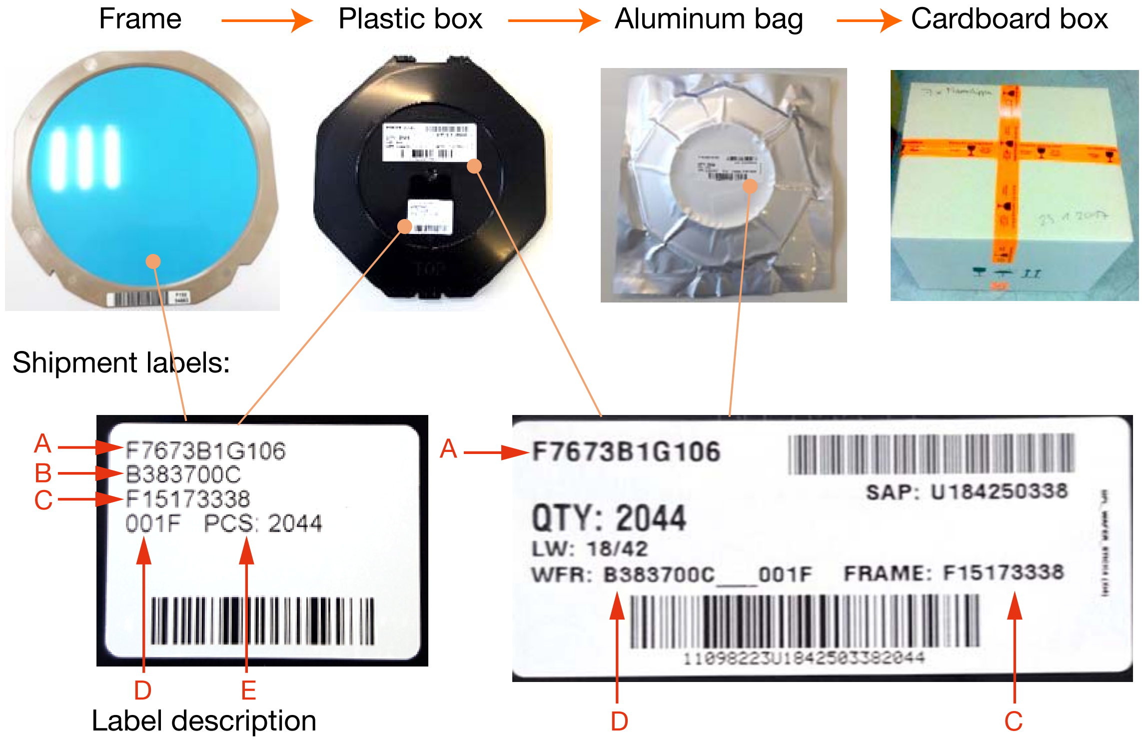
Contamination of chips

It is mandatory to handle the unprotected die in a controlled clean and dust-free environment. The chip is not suitable for any kind of wet, ultrasonic or manual cleaning. It is not allowed to use any plasma or other physical/ chemical cleaning once the laser bar has been attached. This might damage the facet area and coating. Furthermore, the cleaning of solder residue on the PCB after the die has been attach is not allowed. If contaminations of the active area exceeds more than 5 µm the chip should be rejected. Depending on the requirements of the laser, an individual failure catalog should be created to prevent contamination from affecting the functionality of the laser and the application.

B. Delivery format

The lasers are delivered on frame rings in plastic boxes, packed in aluminum bags and finally placed in cardboard boxes. Figure 3 shows the delivery packages and explains the relevant shipping labels.

Figure 3: Delivery packages with label description



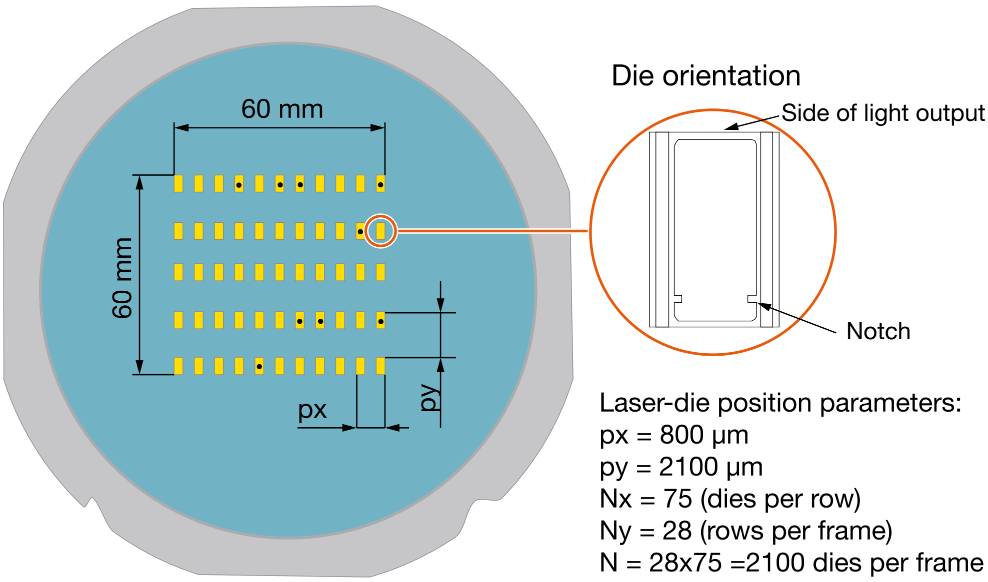
Label description
- A: Internal chip type
- B: Wafer number
- C: Frame ID
- D: Wafer number
- E: Quantity

The SPL DS90A_3 laser itself is placed on a film frame ring (wafer frame), as shown in Figure 4. The ring is a 5” single-sided plastic frame with adhesive plastic film.

Figure 4: Chip delivery on wafer frame

The individual lasers are placed on the sticky tape of the frame ring and are arranged in a matrix as shown in Figure 5.

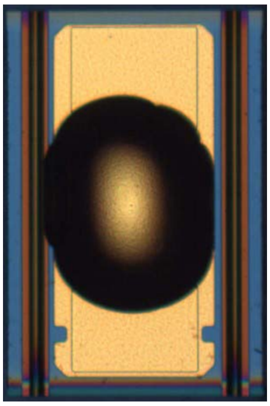
Figure 5: Matrix arrangement of the lasers



Ink-dot / Ink-out marking

Chips which are identified as non-functional during the final test are marked with an ink dot in the center of the chip (or bar), as shown in Figure 6. Those non-functional chips remain on the ring for shipment but are not included in the shipment quantity. Therefore, the quantity typically available on each ring will fluctuate slightly from ring to ring. In the case of SPL DS90A_3 there are approximately 2,000 laser chips on one single ring. This is also reflected in the minimum order quantity. Variations in lighting and microscope conditions may be required to safely identify the ink dot as a black dot.

Figure 6: Non-functional marked chips (Ink-dot)



Unpacking and handling

To protect the chips from dust particles and other contamination it is recommended to open the delivery boxes of the laser chips and to perform the further handling processes in a clean room-like environment. Any mechanical handling and mechanical stress to the device should be minimized as far as possible. Mechanical forces on the outcoupling area of the laser beam in particular must be avoided at all times.

C. Beam characteristics

Near field

The near field emission characteristic depends on the temperature and driving current. The typical field emission area dimensions are:

- Emission height: ~10 µm (FWHM)
- Emission width: ~ 220 µm (FWHM)

Figure 7 shows an example of a near field characteristic with the intensity distribution along the facet and the line scan along the slow axis at 10 A. The three individual lines of the triple-stack configuration are shown in the lower graph.

Figure 7: Example of a near field characteristic: Intensity distribution along the facet with a line scan along the slow axis (@ 10 A)

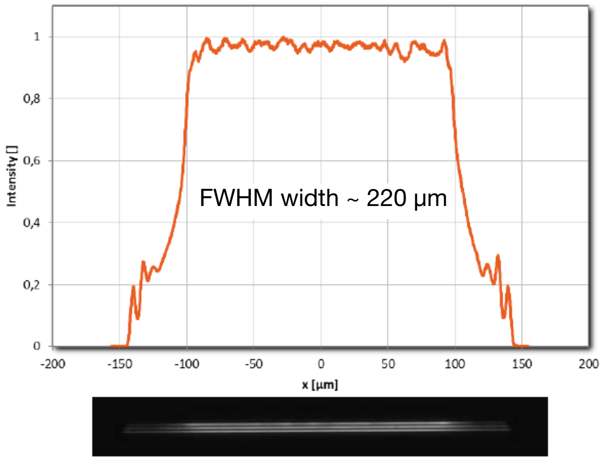
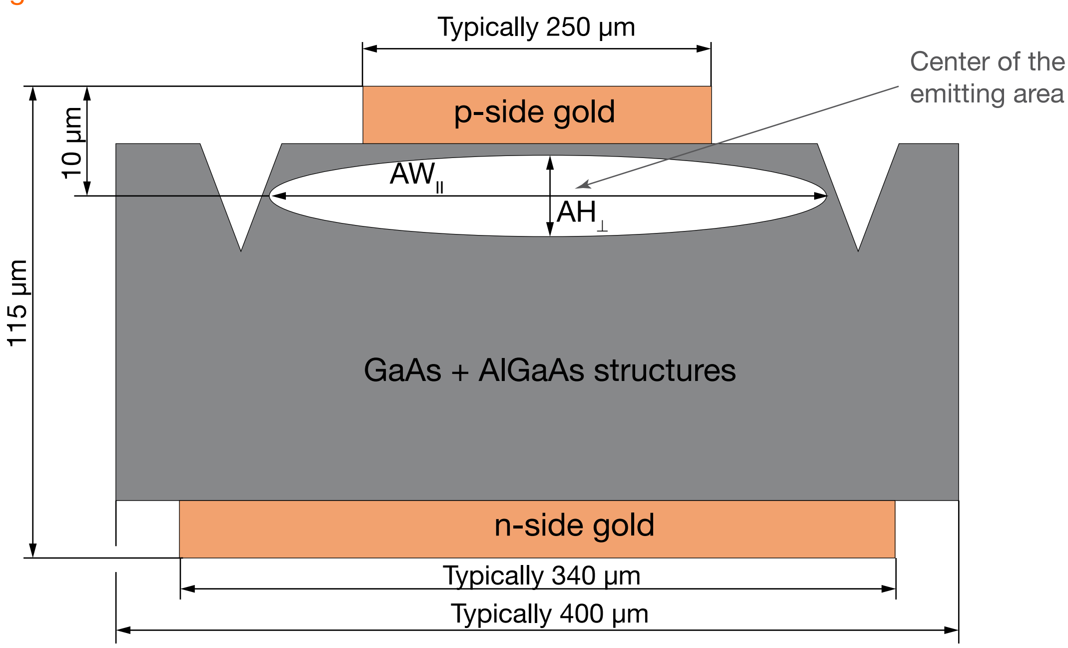


Figure 8 shows the front view of the laser emitting surface with the laser aperture height (AH) (perpendicular to the pn-junction) and laser aperture width (AW) (parallel to the pn-junction). The aperture width (AW) is typically 284 µm (98% of power included) and 220 µm at FWHM (Full Width Half Max). The aperture height (AH) is typically 10 µm (FWHM). The center of the emitting region is defined as the center of the middle emitter.

Figure 8: Geometrical AH and AW orientation



Far field

The far-field radiation patterns of the laser diodes are different in lateral (parallel to the pn-junction) and vertical (perpendicular to the pn-junction) direction. The lateral direction is defined as the slow axis SA and the vertical direction as the fast axis FA.

The far field emission is described by the following beam parameters:

- FWHM (slow axis): typically 10° (range indication 3°... 13°)
- FWHM (fast axis): typically 25° (range indication 20°... 30°) (Gauss type variation for each of the 3 stacked emitters)
- $1/e^2$ (parallel to the pn-junction): typically 13° (range indication 10°...16°)
- $1/e^2$ (perpendicular to the pn-junction): typically 40° (range indication 35°...50°)

Please refer to the corresponding data sheet for more details and information.

D. Polarization

To describe the degree of polarization of the pulsed laser it is common practice to define two components of electromagnetic waves of a laser light:

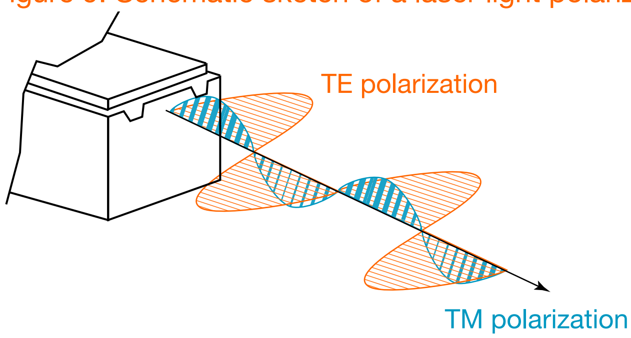
- TE = transversal electrical: electrical field parallel to the substrate plane
- TM = transversal magnetic: magnetic field perpendicular to the substrate plane

The IR-laser light has a dominant TE-polarization with:

$\frac{TE}{TE + TM} > 97\,\%$ (typically 99%)

The polarization is measured at 1 µs pulse length and a current of 20 A in a TO56 package. Figure 9 illustrates the electromagnetic waves of a laser light.

Figure 9: Schematic sketch of a laser light polarization



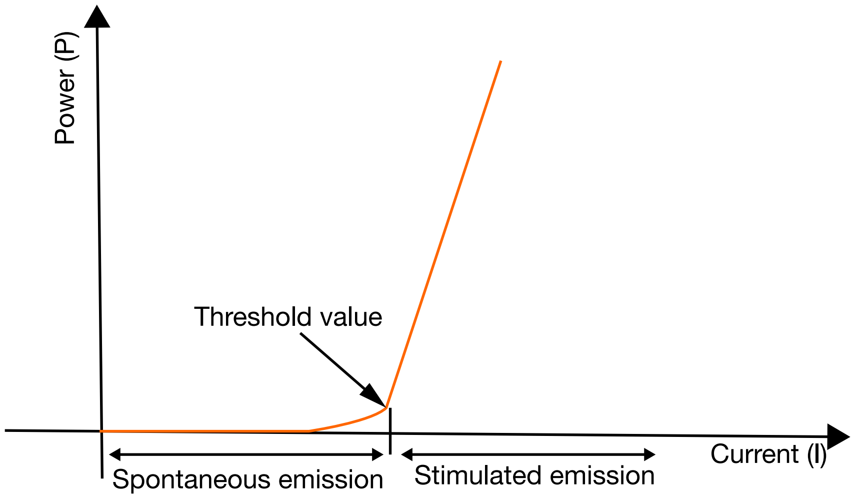
E. Electrical properties

General remark on multichannel laser bars: even though the n-side (bottom side) pad is segmented per channel in some designs, the intrinsic substrate conductivity will pull all the n-side electrodes of a multichannel bar to the same electrical potential. For individual switching of each channel, p-side control must be considered.

Threshold current

Operating the laser at very low power close to the threshold current is not recommended due to unstable system operation. Even if the laser is operating in lasing mode at room temperature, it might stop lasing at higher temperatures as we see an increase of the laser threshold as the temperature increases. It is recommend to operate at >5 times or preferably >10 times the laser threshold current. Figure 10 shows the characteristic curve of lasers with spontaneous and stimulated emission.

Figure 10: Characteristic curve of a laser diode



Overstress due to optical power feedback

Optical power feedback, which causes intensity spikes or inhomogeneity across the facet, must be avoided. In general, optical feedback should be avoided as much as possible as it causes an additional increase in field strength, which again increases the risk of COMD (catastrophic optical mirror damage).

F. Assembly

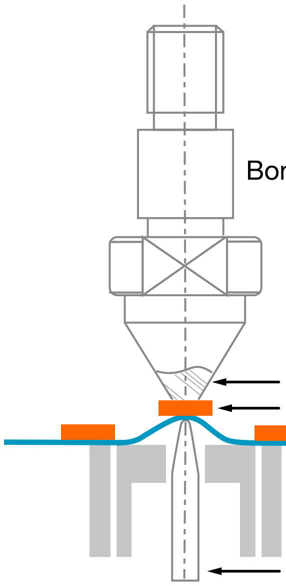
It is mandatory to handle the unprotected die in a controlled clean and dust-free environment. When processing the chips by means of automated placement machines, care should generally be taken that an appropriate pick-and-place tool is used and that the process parameters conform to the chip characteristics (Figure 11).

Any mechanical handling and mechanical stress to the device should be minimized as far as possible. Mechanical forces on the outcoupling area of the laserbeam must be avoided in all cases.

It is recommended that the atmosphere in a hermetically sealed package (like TO56) is dry air. Otherwise the laser induced decomposition of organic components (e.g. adhesive outgassing) may occur. This in turn leads to carbon deposits on the facet, resulting in COMD (catastrophic optical mirror damage).

The die attach process parameters are highly dependent on the machine model and results of process studies. Extensive care should be taken that the ejector pin leaves no marks on the back-side of the chip. We recommend the approval of bonding parameters by means of reliability tests.

Figure 11: Schematic sketch of the die pick process



It is recommended to use a rubber pick-up tool for the pick-and-place process.

Down mounting

P-side up mounting and n-side down mounting are recommended. The n-side pad thickness is 1.1 µm and its finish layer is a ~600 nm Au-layer.

If p-side down mounting is considered (the laser has not been release for this and OSRAM Opto Semiconductors do not recommend it), special care must be taken for the following points:

- Keep the facet clear of contamination (e.g. squeezed out glue, flux).
- Keep the sides of the laser chip/ top side grooves clean. There is a risk of contamination with conductive material and the short circuit across the pn-junction.
- Due to the proximity of the emitting area to the p-side contact (around 6 µm below the chip p side surface) special care must be taken to avoid shadowing of the laser beam by the substrate material. A ride out of the chip edge relative to the substrate must be considered.

Die attach

It is recommended to use conductive glue on the n-side as a die attach method. Optional die attach methods such as soldering or sintering have not been evaluated by OSRAM Opto Semiconductors and must be tested before use.

Especially with multi-channel derivatives, the warpage of the chip must be considered. Therefore, care must be taken to ensure that enough glue is used. Multi-channel derivatives may be ordered on request.

For the conductive glue method it is recommended to use the following properties:

- Epoxy-based material
- Au or Ag filling particles

The data sheet of the adhesive manufacturer must be observed during the process. It is recommended to dispense the glue by stamping or with a needle (e.g. EFD Dispensing Tip 25 Gauge).

For the gluing process, it is important to observe the following points:

- Avoid facet contamination by glue residues.
- Glue dot coverage should cover the full n-side.

Ensure that the glue coverage under the die is homogeneous.

In general it is recommended to use analysis methods such as cross sections, EDX analysis, analysis of intermetallic layers and sheer tests to characterize the mechanical and chemical properties of the die attach.

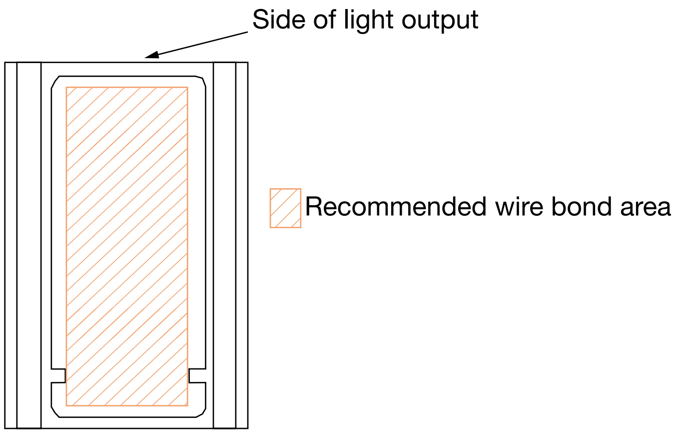
Wire bonding

It is recommended to use the p-side as the contact side for wire bonding. Multiple wire bonds help to reduce inductance and improve the spread of current. They should be positioned uniformly over the contact area. Figure 12 shows the recommended contact area.

Mechanical stress to the device should be minimized as far as possible. Wire bond process parameters should be as soft as possible as wire bonding may affect the chip polarization and reliability. Ball bonding is recommended (no wedge bonding on the laser chip). Reverse bonding or standard railhead bonding is also feasible. The recommended wire bonding material is Au with a wire diameter of 25 - 50 µm (typically 30 µm). The number of bonds is not critical, so 4, 6, etc. can be used. The following aspects should be considered:

- Au wire length and loop (from the die to the pads) should be kept as short as possible
- Arrangement in a staggered position
- Uniform distribution on the contact surface
- Bond wires must be the same length
- Bond wires must be within the rectangle on top of the die

Figure 12: Recommended wire bond area



PCB and substrate materials

For PCBs care should be taken to ensure that the contact surface adheres well to the glue used. A surface finish with copper is recommended. The design of the die bond pad should be large enough to accommodate the placement accuracy of the die bonder and glue size after the “squeezing out” of the glue. In addition, optical shadowing should be avoided in consideration of beam shape and divergence. A cutaway in the PCB may be reasonable.

G. Thermal management

The R_{th}, of the SPL DS90A_3 from the junction point to the solder point on the n-side pad is 8.7 K/W. This is based on the thermal conductivity of 0.55 $\frac{W}{cm \cdot {}^\circ C}$ as the GaAs constant.

Table 1 shows the thermal material data for the adhesive and the die.

Table 1: Thermal material data

Material	Thermal Conductivity W/mK	Density kg/m³	Heat Capacity J/kgK
Adhesive	1.8	3800	200
Die	55	5316	330

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OSRAM, Munich, Germany is one of the two leading light manufacturers in the world. Its subsidiary, OSRAM Opto Semiconductors GmbH in Regensburg (Germany), offers its customers solutions based on semiconductor technology for lighting, sensor and visualization applications. OSRAM Opto Semiconductors has production sites in Regensburg (Germany), Penang (Malaysia) and Wuxi (China). Its headquarters for North America is in Sunnyvale (USA), and for Asia in Hong Kong. OSRAM Opto Semiconductors also has sales offices throughout the world. For more information go to www.osram-os.com.

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