Diamond DRAGON® - The Brightest Star of the DRAGON® Family

Application Note

Abstract

This application note provides insight into the Diamond DRAGON®, a high performance LED from the DRAGON® product family.
A fundamental overview of the construction, handling and processing of the LED is presented. In addition, advice concerning thermal characteristics, influence of the junction temperature, reliability and lifetime is given.

Diamond DRAGON®

The Diamond DRAGON®, currently the brightest single-chip LED from OSRAM Opto Semiconductors, was specially developed for the following application areas in lighting technology:

General Lighting
- Indoor and outdoor lighting
- Retrofits, especially where space is a premium
- Stage lighting
- Architectural illumination
- Glass cabinet lighting
- Spotlights

Automotive exterior
- Daytime running lights
- Front turn indicators

Industry and signs
- Emergency lighting
- Warning lights i.e. road works, light house, buoys
- Video walls on building facades
- Signal and symbol luminaire

Above all, the Diamond Dragon® is predestined for use in applications in which high brightness combined with minimum space is needed or an extremely long lifetime is required.

Additional applications with high contrast requirements are supported through the black SMD housing.

The Diamond DRAGON® is available in all colors of the rainbow, including several variations of white.

LED Type	Color	Wavelength
LR W5AP	Red	625 nm
LA W5AP	Amber	617 nm
LY W5AP	Yellow	590 nm
LT W5AP	True Green	528 nm
LB W5AP	Blue	470 nm
LD W5AP	Deep Blue	455 nm
LW W5AP	White	x/y 0.32/0.31*
LUW W5AP	Ultra White	x/y 0.31/0.32*
LCW W5AP	Warm White	2700-4200K**

**Color coordinates acc. to CIE 1931; **Color temperature*

Table 1: Available color variants of the Diamond Dragon®

Features and Construction

As with all LEDs of the product family, the Diamond DRAGON® is based on the same thermally optimized package design – consisting of a prefabricated plastic housing with an integrated heat sink and connection contacts.

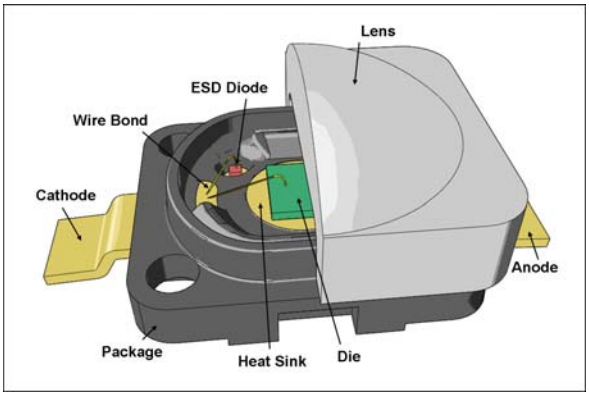

Figure 1: Internal construction of the Diamond DRAGON®

With a common design basis, exchangeability with the Golden DRAGON® or Platinum DRAGON® LEDs is achieved. At the same time, the design flexibility is increased due to identical solder pad layouts.

With one circuit board layout for example, three applications with different brightness requirements can be implemented.

Deviating from the previous DRAGON® platform, the DRAGON® employs a black housing. This has the advantage that in applications, particularly for use in displays, the contrast is increased.

As the center and single light source of the Diamond DRAGON®, highly efficient 2 mm² semiconductor chips of the latest thin film technology, ThinGaN® or Thinfilm from OSRAM Opto Semiconductors are employed.

In order to guarantee an optimal heat transfer within the housing, the semiconductor chips are mounted directly to the heat sink.
This results in a typical thermal resistance for the Diamond DRAGON® of 2.5 K/W.

Differing from previous DRAGON® LEDs, the Diamond DRAGON® is already equipped with a long lifetime lens.

Figure 2 shows the radiation characteristics of the Diamond DRAGON® LED, depending on the chip technology.

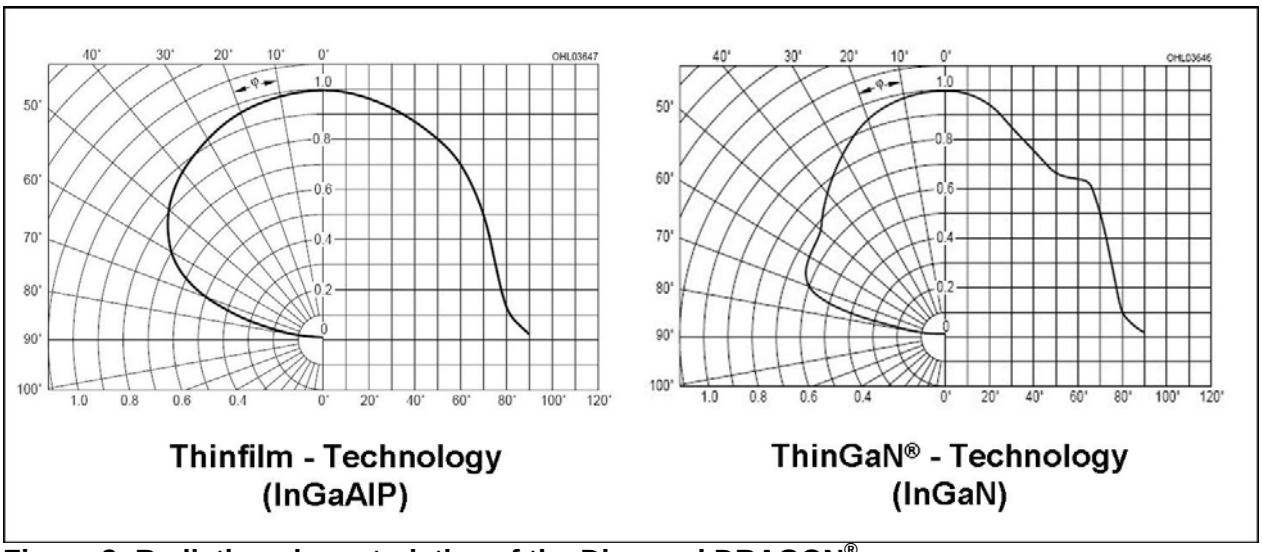

Figure 2: Radiation characteristics of the Diamond DRAGON®

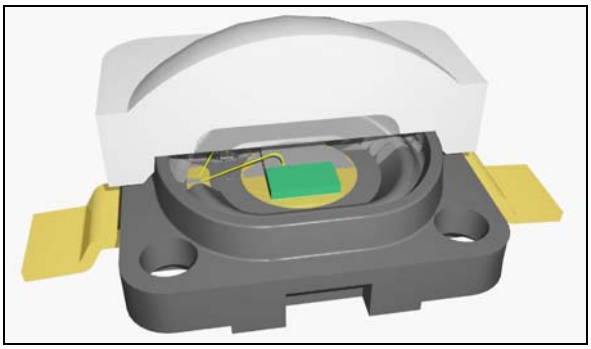

Figure 3: Cross section through Diamond DRAGON®, mounting of the lens over the functional area

If a gap occurs in the contact adhesion that is located primarily in the frame area, this can usually be recognized after processing of the component (appearance of light spots or pattern formations).

Figure 4 shows an example of a component containing several areas without this contact adhesion, recognizable by the light areas at the edge of the lens (above, lower left and lower right side) outside the lens cap.

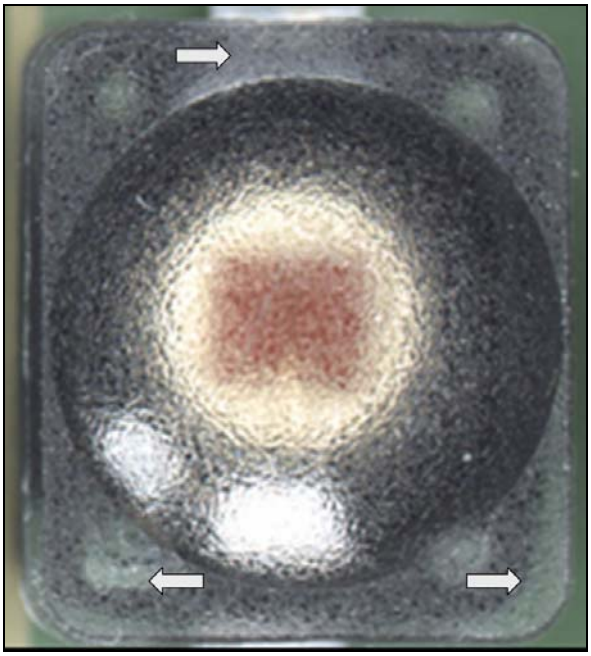

Figure 4: Selective gaps in contact adhesion between the boundary of the lens and housing after soldering

Furthermore it can occur that the encapsulation contains tiny bubbles. These however impair neither the optical nor the mechanical performance.

The characteristics specified above do not result in any impairment of the functionality or lifetime of the LED, as was also confirmed in tests and examinations.

Due to its optimized construction combined with excellent thermal characteristics and the use of proven materials, the Diamond DRAGON® can be operated at junction temperatures up to 160°C (continuous operation) and for short periods, up to 175°C.

Furthermore, as with all other LEDs from OSRAM Opto Semiconductors, the Diamond DRAGON®, fulfills the current RoHS guidelines, containing no lead or other hazardous substances.

Handling

In order to protect the semiconductor chip from environmental influences, the Diamond Dragon® is equipped with a silicone encapsulant in addition to its lens.
Due to its elasticity, however, mechanical stress to the silicone should be minimized or avoided as far as possible during handling (see Application Note "Handling of Silicone Resin LEDs“). This is particularly true for the functional area of the lens (lens cap).

In general, sharp objects of all types should not be used in order to prevent damage or penetration of the encapsulant, since this can lead to a malfunction of the component.

Figure 5 shows the recommended design of the pick and place tool for damage-free processing of the Diamond DRAGON® (e.g. from SIPLACE Nozzle 03046421).

In operation, it must additionally be guaranteed that sufficient cooling is provided for the Diamond DRAGON®.
Extended operation without cooling can lead to overheating, even at low currents,

depending on the given circumstances, thus leading to damage or failure of the component.

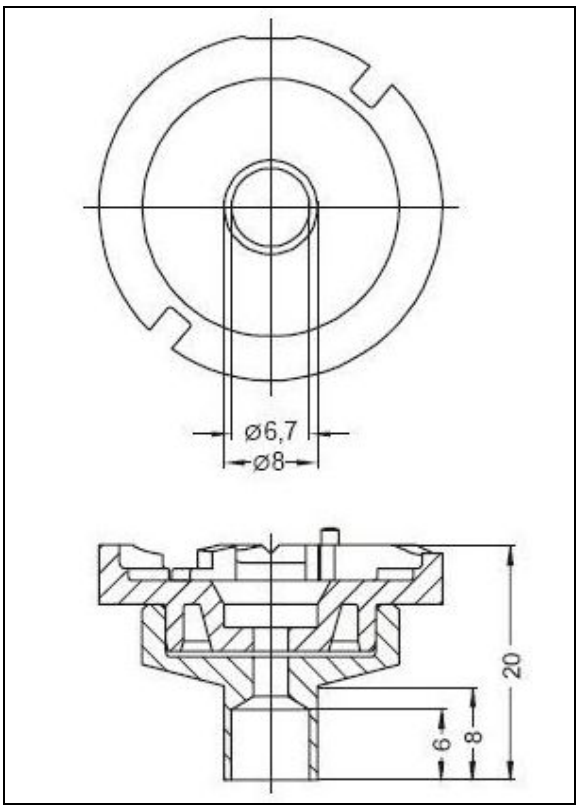

Figure 5: Recommended design for the pick & place tool of the Diamond DRAGON®

Processing

The Diamond DRAGON® is generally supplied in tape and reel format.
Each reel contains only one brightness group and one wavelength group for each color.
That means that of the available family groups consisting of several brightness groups, a reel contains only one of the brightness groups.

The Diamond DRAGON® is generally compatible with existing industrial SMT processing, so that all established placement techniques can be used for assembly.
For attaching the components, a reflow standard soldering process is recommended, in which a typical SnAgCu metal alloy solder is used.

Figure 6 shows the soldering requirements and the temperature curve for lead-free soldering of the Diamond DRAGON®.

As the profile shows the maximum solder temperature of 260°C and solder time of 30s must not exceed.

Preparatory handling of the LED should correspond to JEDEC Level 2.

For optimal mounting of the Diamond DRAGON® to the circuit board and therefore, to guarantee the performance of the LED, it is advantageous to use the recommended solder pads in most cases.

When designing the solder pads for the DRAGON® product family, the goal was to achieve a balance between good processability, the smallest possible position tolerance and a reliable solder connection.

In addition, however, the requirements for good thermal management should also be fulfilled.

In Figure 7, the general, optimized solder pad design is shown for the DRAGON® product family.

In order to fulfill the requirements for good thermal management with the Diamond DRAGON® LEDs, the copper surface around the integrated heat sink should be kept as large as possible. This serves to distribute and spread the heat which accumulates and is typically covered with solder resist.

In addition, it should be noted that the copper surfaces around the heat sink must be isolated from other solder pads or heat sink surfaces.
The reason is that with the DRAGON® product family, the anode and the heat sink of the housing are in electrical contact.

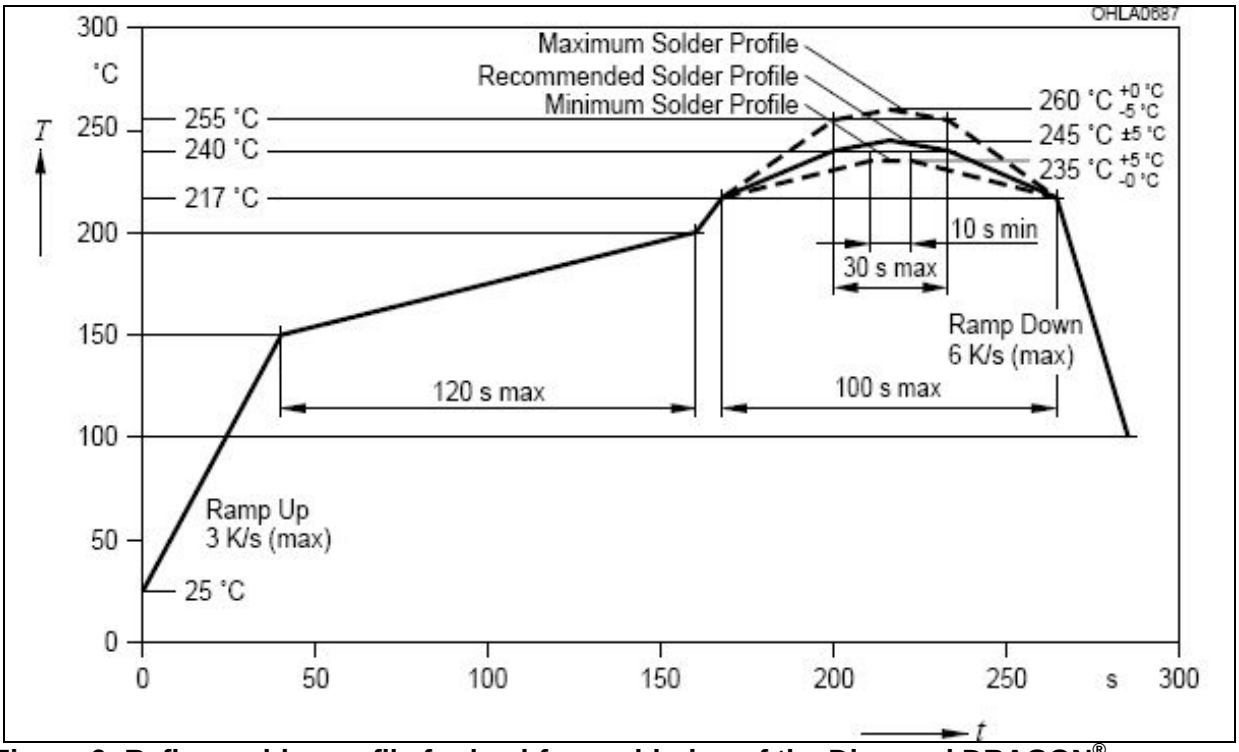

Figure 6: Reflow solder profile for lead-free soldering of the Diamond DRAGON®

Since power losses of up to 10 Watts can arise for Diamond DRAGON® LEDs depending on the chosen operating parameters, further heat transfer and distribution via the circuit board is definitely required.

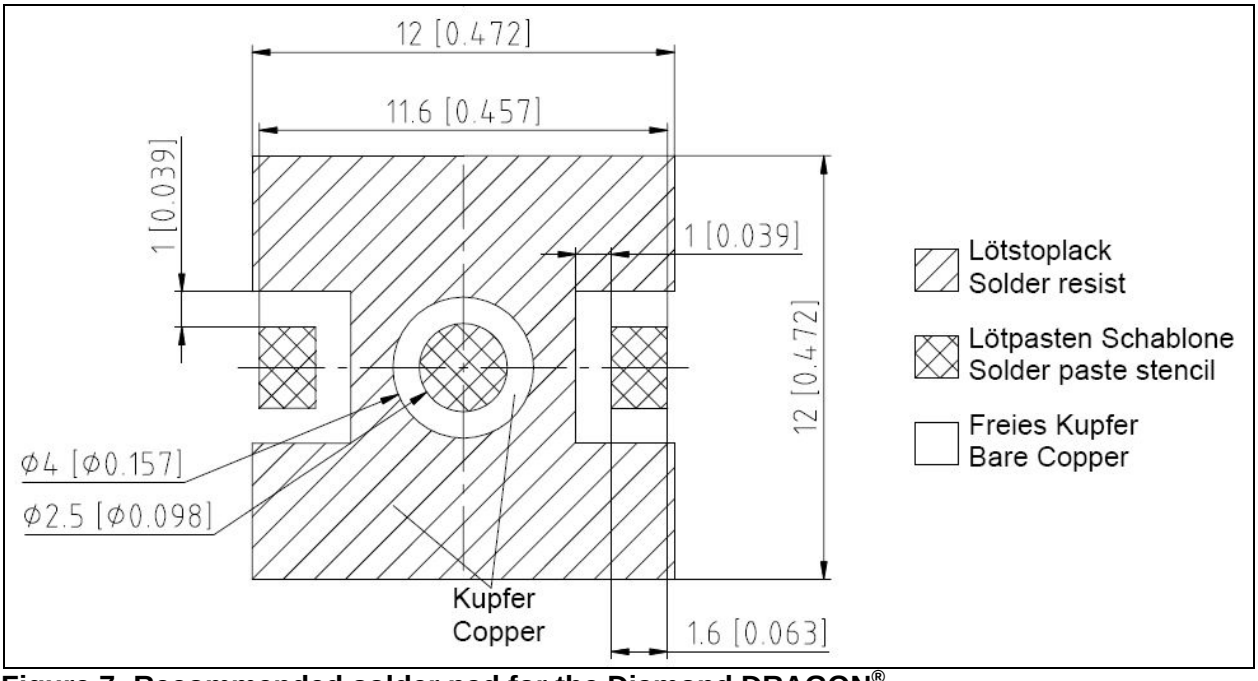

Figure 7: Recommended solder pad for the Diamond DRAGON®

The selection of appropriate materials for the circuit board is therefore of utmost importance. Materials with too little thermal conductivity lead to an impairment of reliability or restrict operation at optimal performance, since the heat which arises cannot be dissipated in sufficient quantities.

For this reason, insulated metal substrates (IMS-PCB) are typically used for high power LEDs of the DRAGON® product family.

These usually consist of a base plate of aluminum, a thin dielectric insulation and conducting layer of copper for the electrical connection.
Compound materials of thin flexible circuit board material and metal base units are also suitable, however. The combination with flexible circuit board material offers the advantage that three-dimensional light source designs are possible, for example.

Standard substrates such as FR4 are normally not suitable for use with high power LEDs such as the DRAGON® product family, due to their low thermal conductance.

Tests at OSRAM Opto Semiconductors with thin FR4 material in combination with metal through contacts (thermal vias) and additional cooling show that this type of construction can also be used (Figure 8), if a good thermal coupling between the FR4 material and the cooling unit is guaranteed by means of a thermal interface material (see also the Application Note "Thermal Management of Golden DRAGON® LED").

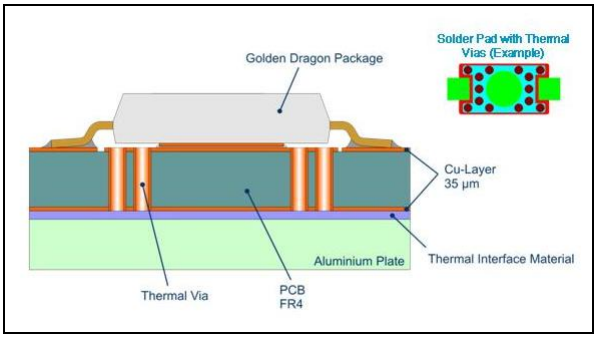

Figure 8: Conceptual layout of FR4 with thermal vias

Compared to IMS-PCBs, a cost advantage of around a factor of 3 can be attained.

Thermal Considerations

In order to achieve reliability and optimal performance with high power LEDs such as the Diamond DRAGON®, suitable thermal management is necessary.
Basically, there is a principal limitation for the maximum allowable temperature for the Diamond DRAGON® - the junction temperature must not exceed 175°C.

The warming of the Diamond DRAGON® generally arises from two sources, in which one is due to an external cause (existing ambient temperature), and the other is due to internal processes (current-dependent power losses).
As a result, not all operating conditions are appropriate or allowable for a particular ambient temperature.
In the data sheets, the maximum permissible current for DC operation and various pulse loads is given for two solder point temperatures (T_S =25°C and T_S = 85°C).

For intermediate cases, the maximum operating conditions can be estimated by interpolation of the curves.

Influence of Junction Temperature

Basically, the maximum permissible junction temperature must not be exceeded, since this can lead to irreversible damage and spontaneous failure of LED.
Due to the underlying physical dependencies with the function of light emitting diodes, a change in the junction temperature T_J within the permissible temperature range has an effect on several LED parameters.
The forward voltage, luminous flux, color coordinates and lifetime of an LED is influenced by the junction temperature.

Depending on the specified requirements, this can ultimately also have an effect on the application.

The amount of influence is stated or shown graphically in the Diamond DRAGON® data sheets; if required, current information can be obtained there.

Reliability and Lifetime

With regard to aging, reliability and performance, it is not recommended that the LEDs are driven at their maximally allowable junction temperature. With increasing temperature, a reduction in lifetime can be observed.
It should also be avoided that the temperature of the circuitry or the LED is less than the ambient temperature, since this can lead to condensation, ultimately damaging the LED.
Primarily designed and developed for the area of general lighting, the Diamond DRAGON® possesses the necessary lifetime to provide many years of service.
In Figure 9, the exemplary median lifetime for a brightness group of the Diamond DRAGON® is shown.

Bedingungen Conditions	mittlere Lebensdauer median Lifetime	Einheit Unit
I_F = 1000 mA T_S = 25°C	>50.000	Betriebsstunden operating hours
I_F = 1600 mA T_S = 85°C	20.000	Betriebsstunden operating hours
I_F = 1800 mA T_S = 125°C T_J = 175°C	200	Betriebsstunden operating hours

Figure 9: Exemplary median lifetime of the Diamond DRAGON®

Summary

With its optimized thermal design and its excellent lifetime of more than 50,000 hours in normal operation, the Diamond DRAGON® LED is predestined for general lighting.
With currents of up to two Amperes and extreme thermal loading, however, it also shows remarkable functionality and utilizability.

With its optical and electrical characteristics, it opens up many application areas to developers and designers that were previously reserved to conventional lighting.

Regardless of the application area, it is recommended to dissipate the heat which arises from the housing through appropriate thermal management.
Above all, this is important in order to achieve and guarantee optimal performance and reliability of the LED.

Appendix

Don't forget: LED Light for you is your place to be whenever you are looking for information or worldwide partners for your LED Lighting project.

www.ledlightforyou.com

Author: Andreas Stich

About OSRAM Opto Semiconductors
OSRAM Opto Semiconductors GmbH, Regensburg, is a wholly owned subsidiary of OSRAM GmbH, one of the world's three largest lamp manufacturers, and offers its customers a range of solutions based on semiconductor technology for lighting, sensor and visualisation applications. The company operates facilities in Regensburg (Germany), San José (USA) and Penang (Malaysia). Further information is available at www.osram-os.com.