General Information on the Assembly and Solder Pad Design of the DRAGON Family

Application Note

Abstract

This application note gives general information on the assembly and design of the solder pad of the DRAGON product family. Suitable PCB materials will also be described.

DRAGON LED product family

The DRAGON product family has primarily been developed for applications in which there is a need for maximum light combined with small space requirements and furthermore the highest requirements in terms of life time.

With their performance and design, the DRAGON LEDs (Fig. 1) are suitable for many diverse lighting and illumination application areas.
The design of the DRAGON product family is based on a shared, thermally optimized housing concept – consisting of a prefabricated plastic housing with integrated heat sink, which acts as a heat spreader, and connection contacts (Fig. 2).

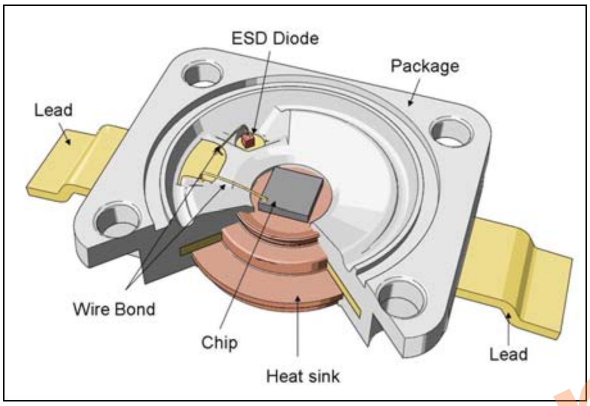

Figure 2: Principle design of the DRAGON LEDs

One of the advantages of this concept is that the products are interchangeable within the product line, which consequently increases the customer's flexibility due to the identical design of the solder pads.
With one circuit board layout, for example, several applications with different brightness requirements can be implemented.

Designed for high-volume production, the DRAGON LEDs are compatible with existing industrial SMT processing methods and it can be soldered by means of lead-free reflow technology.

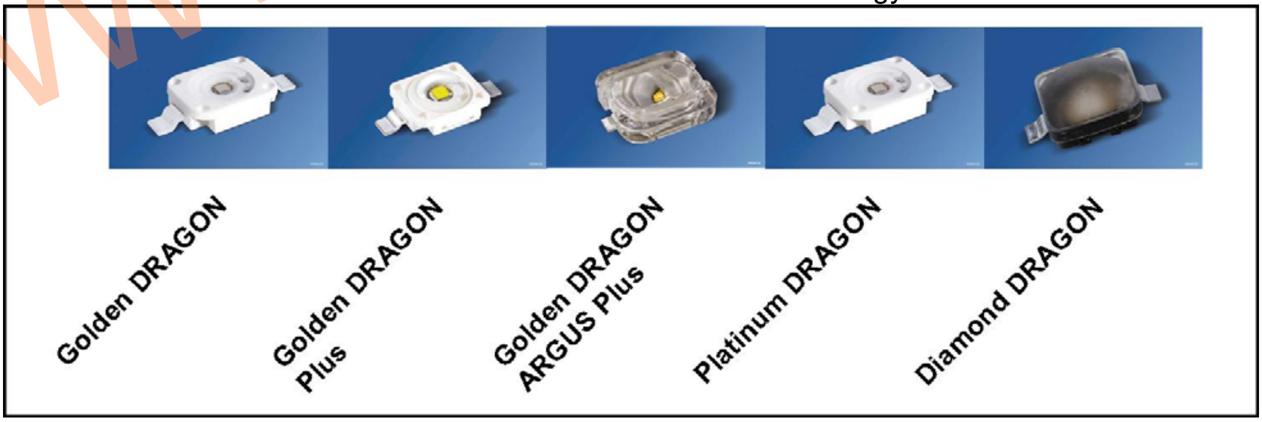

Figure 1: Overview of the DRAGON product family

Cleaning of the DRAGON LEDs should only be performed with isopropyl alcohol (see also application note "Cleaning of LEDs"). Other cleansers or ultrasonic cleaning can lead to failure of the LED.

As with all other LEDs from OSRAM Opto Semiconductors, the DRAGON family fulfills the current RoHS guidelines (European Union & China), and therefore contains no lead (Pb) or other hazardous substances.

Universal Solder Pad Design

When designing the solder pads for the DRAGON line, 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 3, the general, optimized solder pad design with solder resist and solder paste stencil is shown for the DRAGON product family.

As shown, the design features three solder points, two for the electrical contacts and a central one for the integrated heat sink to distribute the thermal power loss.

To form a good solder joint the aperture of the solder paste stencil has to be designed that there is just enough solder paste on the pad.
In this context however the solder paste volume under the heat slug has to be controlled very precise to avoid LED tiling and to get a good position accuracy after soldering.

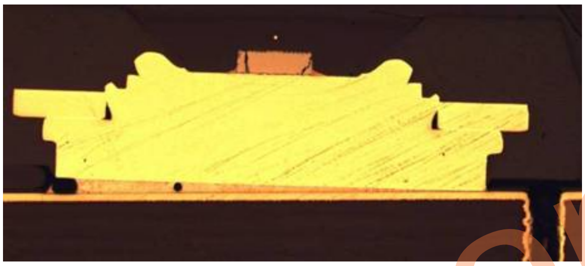

Figure 4: Cross section of a tilted DRAGON LED due to excessive solder paste

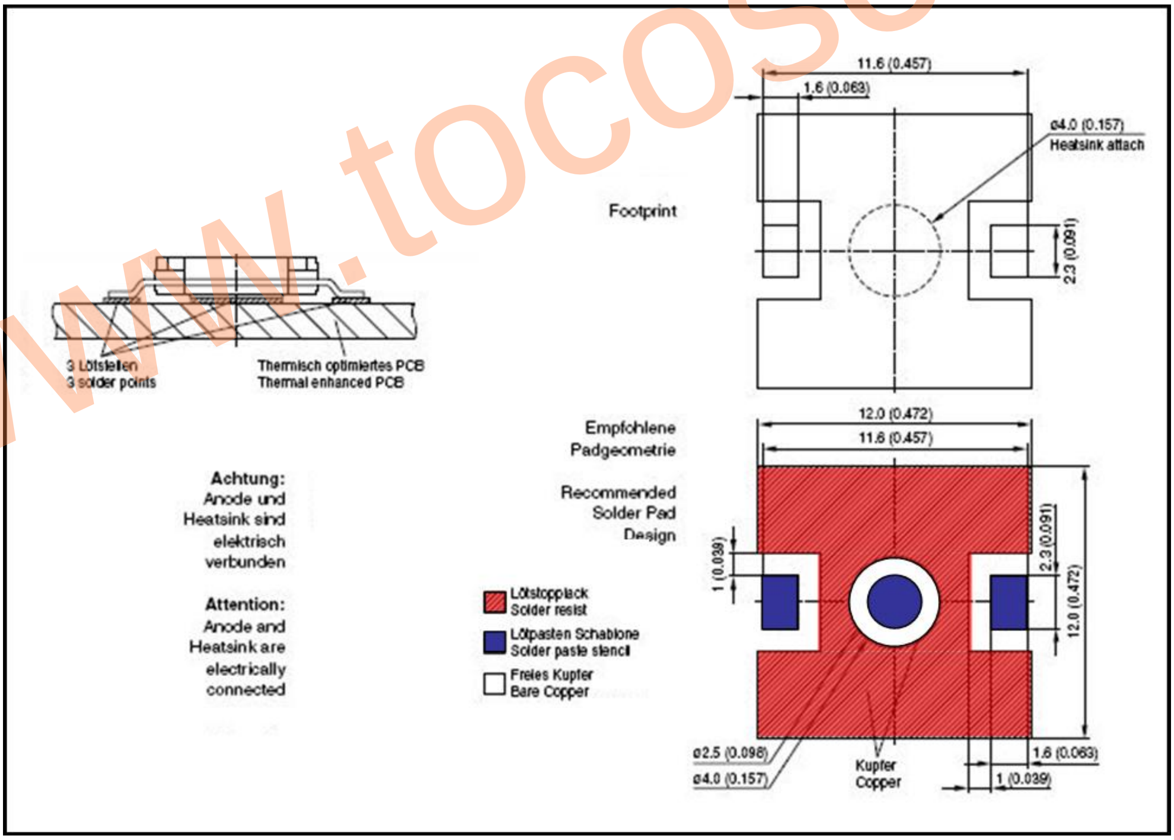

Figure 3: Universal solder pad design of the DRAGON product line

Generally the aperture design and printing process significantly affects the quality of the SMT assembly.
Figure 5 shows three design proposals for the heat slug aperture. Basis for the versions is a stencil thickness of 150µm. If other stencil thickness will be used the dimensions of the opening have to be adapted.

Figure 5: Design recommendations for the heat slug stencil aperture

In respect to the requirements for good thermal management of the DRAGON LEDs, the copper surface around the integrated heat sink should be kept as large as possible. This serves for distribution and spreading of the heat and is typically covered with solder resist.

However, 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 LEDs, one lead and the heat sink of the housing are in electrical contact, e.g. for the DRAGON LED LW W5SM the anode.

PCB material

In addition to the primary function as a mechanical fixture and electrical connecting element for the components, modern PCBs also have the function to ensure stable conditions within the circuit and to ensure efficient dissipation of the heat that is generated, especially when working with high power components.

The selection of appropriate materials for the circuit board is therefore of utmost importance, especially as the total thermal resistance of the system should be as low as possible. Materials with insufficient thermal conductivity lead to an impairment of reliability or restrict operation at optimal performance, since the heat cannot be dissipated in sufficient quantities away from the LED.

Depending on the total input power, the application conditions and requirements the DRAGON LEDs can be mounted on various PCB materials, such as:

- FR4 with thermal vias
- Flexible PCB on Aluminum/Copper
- Metal Core PCB (IMS-PCB)

In most cases insulated metal substrates (IMS-PCB) are typically used for LEDs of the DRAGON family.
These usually consist of a base plate of aluminum, a thin dielectric insulation and conducting layer of copper for the electrical connection (Fig. 6).

Compound materials of thin flexible circuit board material and metal base units are also suitable. The combination with flexible circuit board material additionally 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 line, due to their low thermal conductivity.

Cu Circuit Layer	35µm	
Dielectric	150µm	
Dielectric thermal conductivity	0,8 -1,9	W/mK
Base plate	1,5mm	Cu is preferred

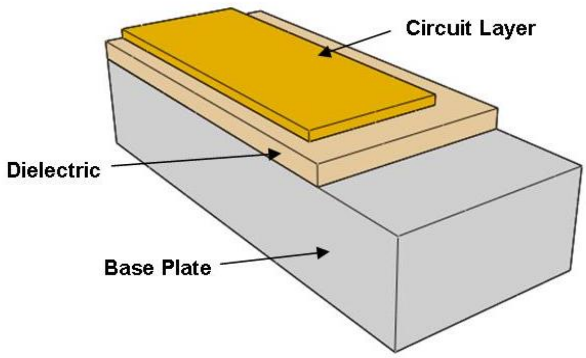

Figure 6: Typical layer construction of insulated metal substrate PCB (IMS or MCPCB)

However thin double-sided FR4 material (0.4mm ≤ d < 1.0mm) in combination with plated through holes (thermal vias) and additional cooling show that this type of construction can also be used (Fig. 7), if a good thermal path through the FR4 material can be realized.

The vias take over the heat dissipation function, thereby improving the thermal resistance of the FR4 material in the vertical direction in a targeted and localized way.

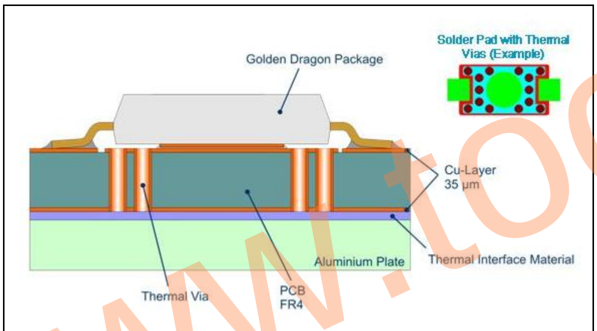

Figure 7: Conceptual layout of FR4 with thermal vias

The thermal transfer capability of the vias themselves is determined by the thickness of the copper in the through holes. In the industry standard thicknesses of 20-25µm copper are established whereas also higher wall plating thicknesses are used (Fig. 8). In this case, it can generally be said that the thicker the copper layer, the better the performance, but also at a higher cost.

As a general rule for this layout, it is also recommended to design the copper surface around the heat sink in the layout to be as large as possible in order to achieve sufficient heat distribution across the FR4.

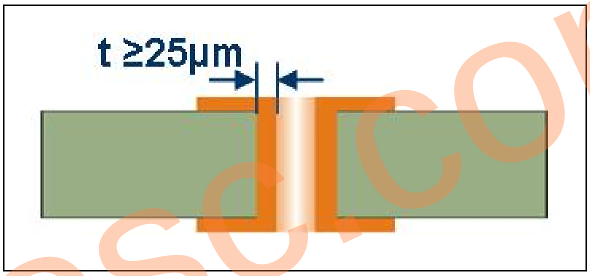

Figure 8: Schematic layout of a thermal via

Basically, the thickness of the FR4 PCBs should also be kept as thin as possible, because the thermal resistance is directly proportional to the thickness of the material. This means: the thicker the material, the greater the thermal resistance.

Figure 9 shows an exemplary comparison (simulation) of the thermal resistances of a metal core PCB, a simple double-sided FR4 material and double-sided FR4 with various numbers or types of thermal vias.

The design of the pad is based on the common basic design for DRAGON LEDs. Typically, a diameter of 0.5mm, a copper thickness of 25µm in the hole, an overall plating of 50µm and an PCB thickness of 1mm are used for the via design.

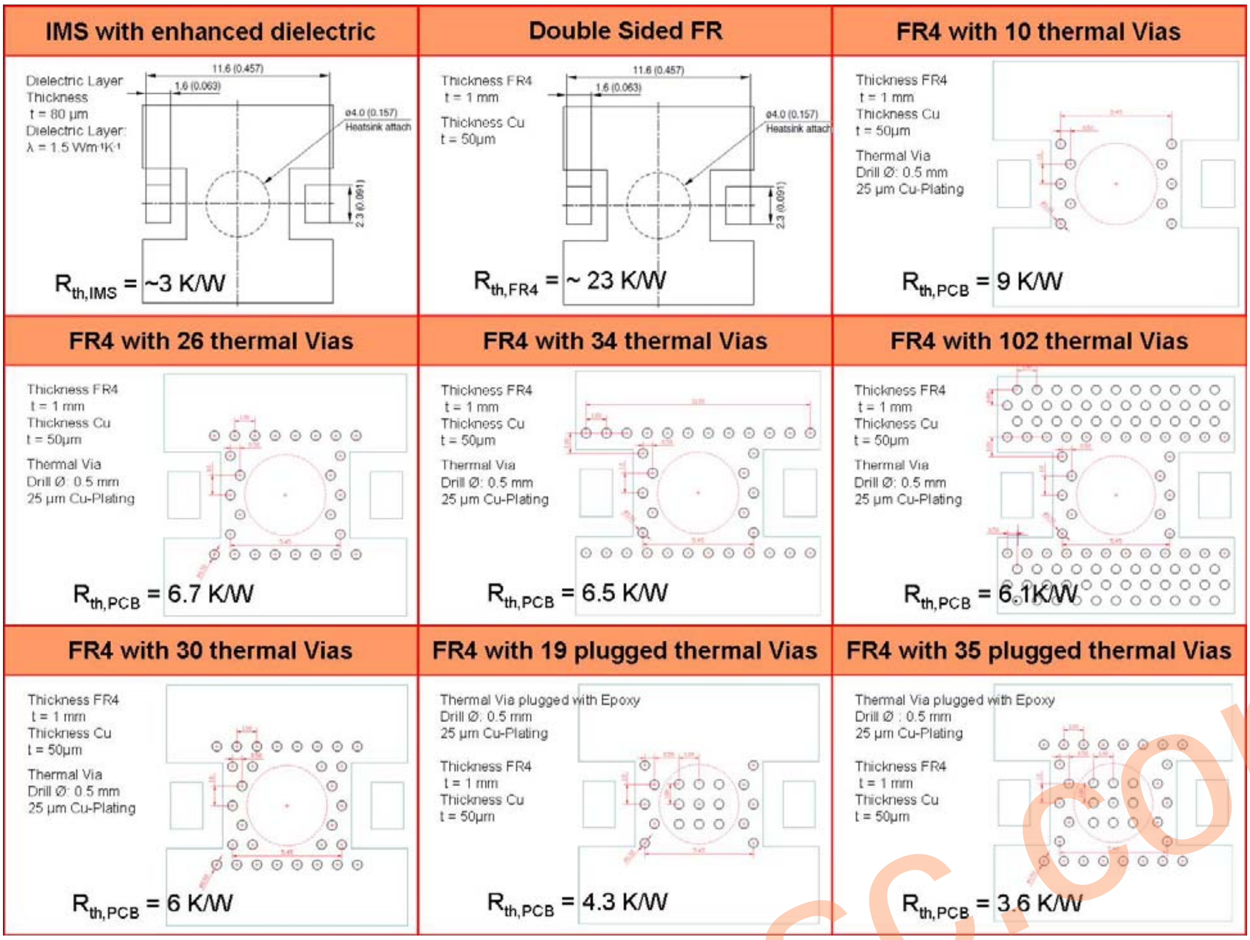

Figure 9: Comparison of thermal resistances of various FR4s with various numbers or types of vias, a simple FR4, and an MC PCB

For the thermal vias, two types of vias were considered: simple, or filled with epoxy and then capped with copper.
The filled, copper-capped vias have the important advantage that they could be arranged directly under the heat sink of the LEDs (no solder run-off), which means they can directly pass on the heat.

With regard to the thermal resistance, we can thus nearly reach the values of metal core PCBs while being more efficient in terms of overall costs commonly.

In many cases, however, the use of simple thermal vias is already sufficient to achieve a clear reduction in thermal resistance to the targeted value.
The level of the resulting thermal resistance is thereby affected by the number and position of the vias. The closer the vias are positioned to the heat source, the better and more quickly the heat can be dissipated and the lower the thermal resistance.

The simulations also show that limits exist with regard to further thermal conductivity optimization for the design of FR4 with thermal vias.

For a DRAGON LED design with thermal vias, however, it must be considered that the electrical potential is transferred to the back side of the FR4 through the vias. Therefore, it is necessary to electrically isolate the back side of the FR4 from the heat sink using thermal interface material (see Figure 7).

Since the PCB design, construction and material are essential for an optimized thermal design, it is therefore recommended to verify the total system, to improve the operational characteristics of the LED.

Conclusion

Generally, all DRAGON LEDs are compatible with existing industrial SMT processing methods, so that all current populating techniques can be used for the mounting process.
Thereby the DRAGON LEDs place no exceptional requirements with respect to processing.

However regardless of the application area, it is recommended to dissipate the heat from the DRAGON LED through appropriate thermal management. Above all, this is important in order to achieve optimal performance and reliability of the DRAGON LEDs.

Nevertheless OSRAM OPTO Semiconductors can support his customers during their development and design process to find the best solution for their specific application.

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

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About OSRAM OPTO SEMICONDUCTORS
OSRAM is part of the Industry sector of Siemens and one of the two leading lighting 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) and Penang (Malaysia). 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.