Reliability of the DRAGON Product Family

Application Note

Introduction

This application note provides an overview of the performance of the DRAGON product family (in this case, LEDs without plastic lenses) as well as a summary of the most important customer-relevant LED data with respect to its effect on LED lifetime.

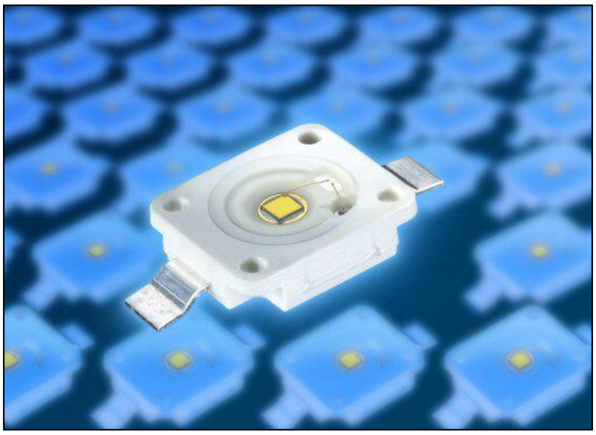
In general, it should be noted that in spite of the high reliability of LEDs, a high total or system reliability can only be achieved if all factors and parameters are taken into consideration (see Application Note "Reliability and Lifetime of LEDs").

A possible influence on the reliability of the LED by the user is essentially specified by the chosen operating conditions, by consideration of the processing details, and for high power LEDs such as the DRAGON product family, for example, by the provision of adequate thermal management.

DRAGON product family

The DRAGON product family was primarily developed for applications which require maximum light combined with low space requirements and the highest demands on lifetime.
Due to their performance and design, DRAGON LEDs are suitable for diverse areas of lighting and illumination technology, ranging from general lighting to automotive applications and the replacement of miniature incandescent lamps.

Designed for high-volume production, they can be processed with all established populating techniques and mounted by



means of lead-free IR reflow soldering techniques.

As with all other LEDs from OSRAM Opto Semiconductors, the DRAGON product line also fulfills current RoHS guidelines and contains no lead or other hazardous substances.

Construction and aging mechanisms of DRAGON LEDs

The construction of the DRAGON product family is based on a thermally-optimized package design, consisting of a prefabricated plastic package with an integrated heat sink and connection contacts (Figure 1).

An advantage of this design is that it permits mutual exchangeability within the product family, thus increasing customer flexibility due to identical solder pad layouts.

A primary factor which influences the lifetime of an LED is the temperature of the light-emitting layer or junction temperature (T_j) with which the LED is driven in the application.

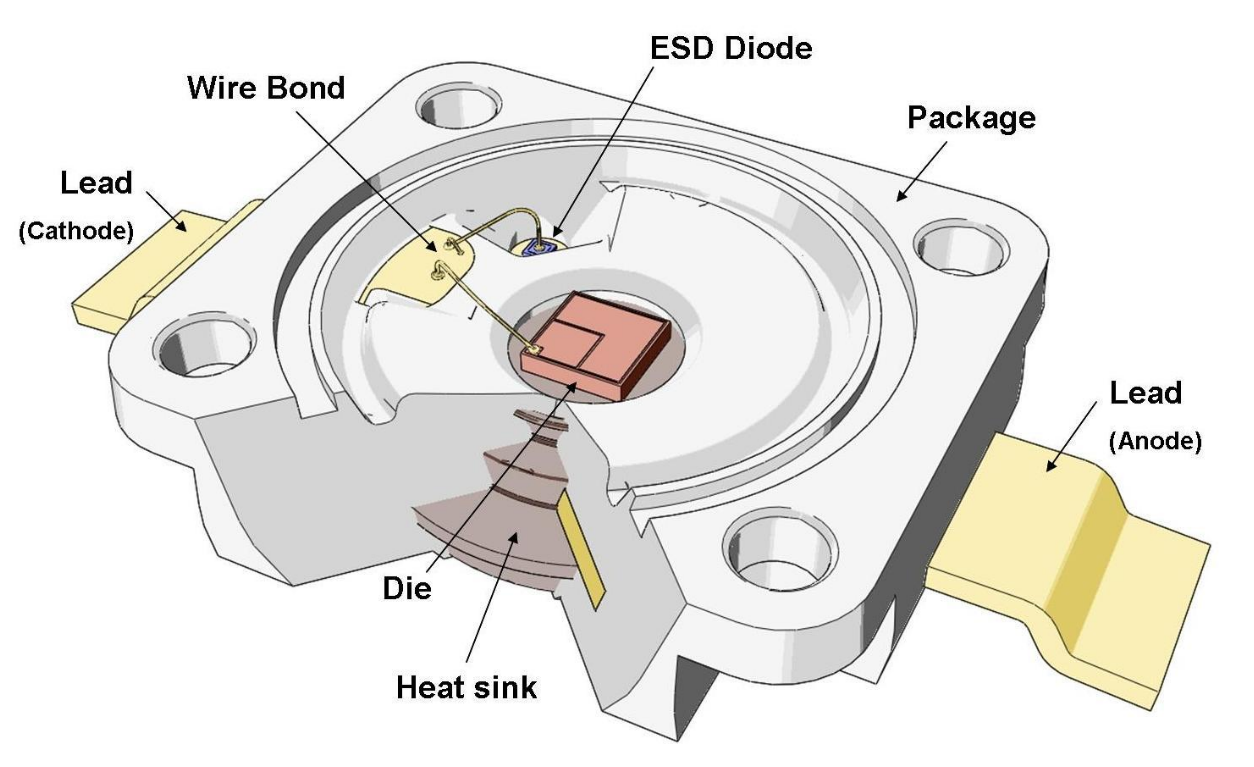


Figure 1: DRAGON basic package – thermally optimized

With a lower junction temperature, the expected lifetime of the LED is increased. Therefore, it is important that good thermal management is not only implemented within the LED, but also on the part of the system in the application (see "Thermal Management of Golden DRAGON LEDs").

Since it is not possible to measure the junction temperature within an application, it is recommended that the temperature be measured at an external reference point instead.
For OSRAM Opto Semiconductors, this reference point is the temperature T_S of the "solder point". The "solder point" represents the transition from the active thermal path of the LED package to the solder pads of the circuit board, and is dependent on the packaging technology.
With the DRAGON LEDs, it is recommended to measure the solder point temperature directly next to the long side of the package, by means of a thermocouple.

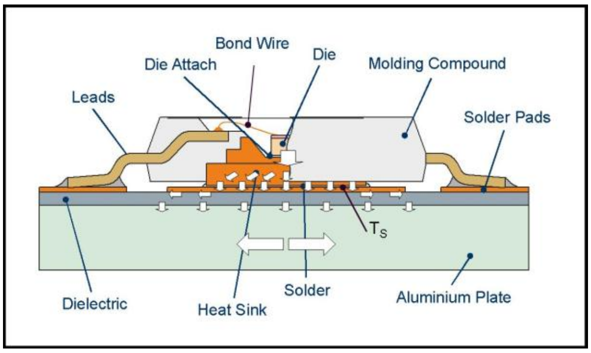


Figure 2: Primary heat flow in the DRAGON products

If the operating current is increased in an environment that remains constant, the dissipation increases and the junction temperature rises as a result. This means that the choice of operating current has an effect on the degradation behavior of the LED.

Figure 3 shows the brightness levels and thermal behavior of the individual LED types within the DRAGON product family.

When considering the aging characteristics of an LED, not only must the thermal aging of the chips be take into account, but the aging of the package material must be considered as well.
Here, the wavelength of the light source employed plays a decisive role.
Short wavelengths lead to aging of the reflector in the package. It can be observed here, that the shorter the wavelength of the emitted radiation, the faster the aging process occurs.

A degradation of the reflective properties of the package takes place, which in turn leads to a decrease in intensity of the emitted light. This behavior has been observed with blue, green and white devices.

After the conclusion of reflector aging, chip aging becomes the determining factor for the further aging behavior of the LED.

Reflector aging appears in white/light packages. The short wavelength radiation leads to a browning of the reflector.

In black packages, this effect is not noticeable, since the reflector is already dark to begin with (e.g. the Diamond DRAGON).

With long-wavelength chips ($\lambda > 550$ nm) the initial reflector aging does not occur.

Reflector aging also occurs for longer-wavelength devices, but this is primarily influenced by temperature and progresses more slowly than with shorter wavelengths.
This occurs in parallel to chip aging or to a minimal extent after chip aging and is therefore not observable as a separate process by the user.

As a light source, highly efficient semiconductor chips of the latest thin film technology from OSRAM Opto Semiconductors are employed in the DRAGON LEDs.
For the colors Deep Blue, Blue, True Green, and White, the chip technology is based on the semiconductor material indium gallium nitrite (ThinGaN); for the colors Amber, Yellow and Red, it is based on aluminum indium gallium phosphide (ThinFilm).

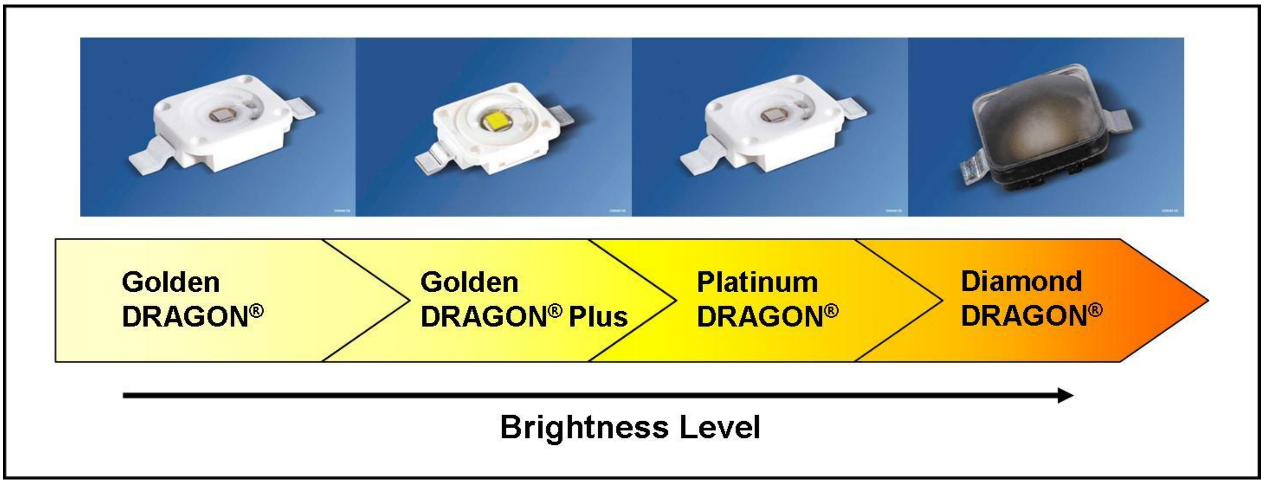


Figure 3: Brightness level within the DRAGON product family

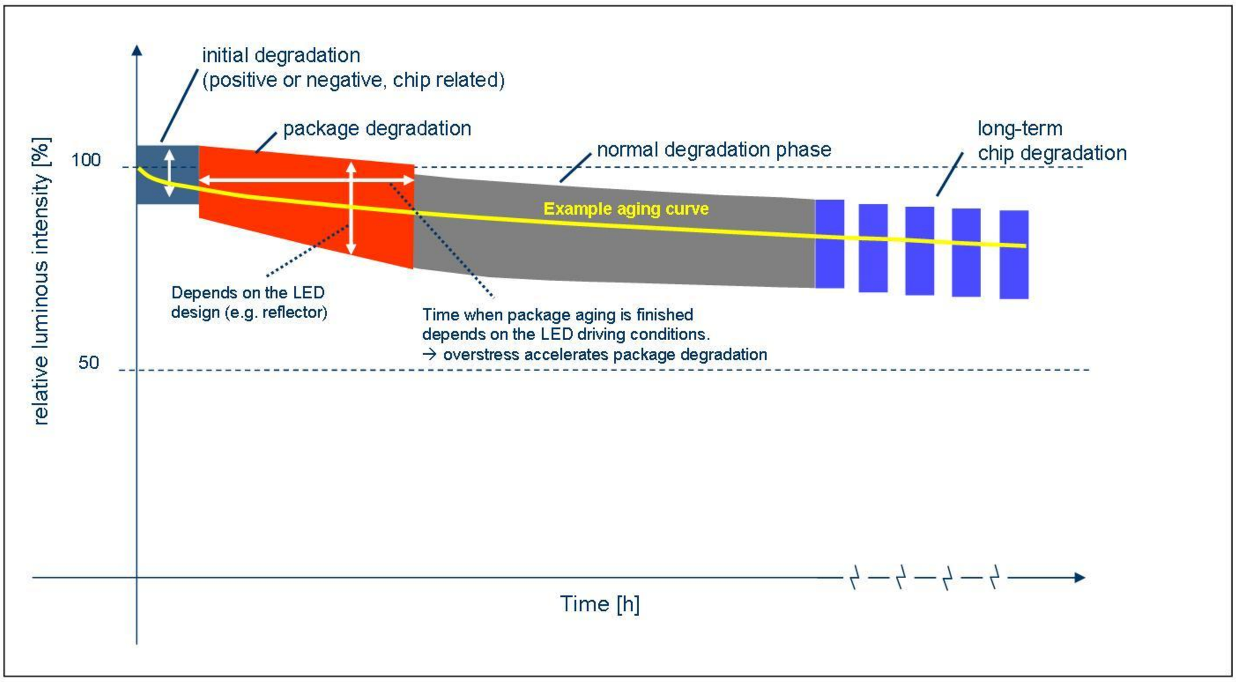


Figure 4a: Degradation characteristics of the DRAGON products with ThinGaN semiconductor chips with a white package

In Figure 4, the typical degradation characteristics for the molded silicon DRAGON products with ThinGaN (4a) and ThinFilm (4b) are schematically shown.
Table 1 summarizes the individual phases of the aging characteristics of the DRAGON product family, with respect to technology (or packaging).

Additional information about factors which influence the lifetime and reliability of LEDs as well as the failure parameters " lumen maintenance (L)" and "mortality" (B) can be found in the application note "Reliability and Lifetime of LEDs".

The following sections provide specific information about the lifetime and degradation characteristics of the DRAGON product family.
Here, a distinction is made between the ThinGaN (Deep Blue, Blue, True Green and White) and ThinFilm technologies (Amber, Yellow and Red).

	ThinGaN technology with white package	**Thinfilm and ThinGaN technology with dark package**
Phase I	Initial chip aging (positive or negative)	Initial chip aging (positive or negative)
Phase II	Reflector aging	
Phase III	Normal degradation phase	Normal degradation phase
Phase IV	Chip aging	Chip aging

Table 1: Degradation phases of DRAGON LEDs

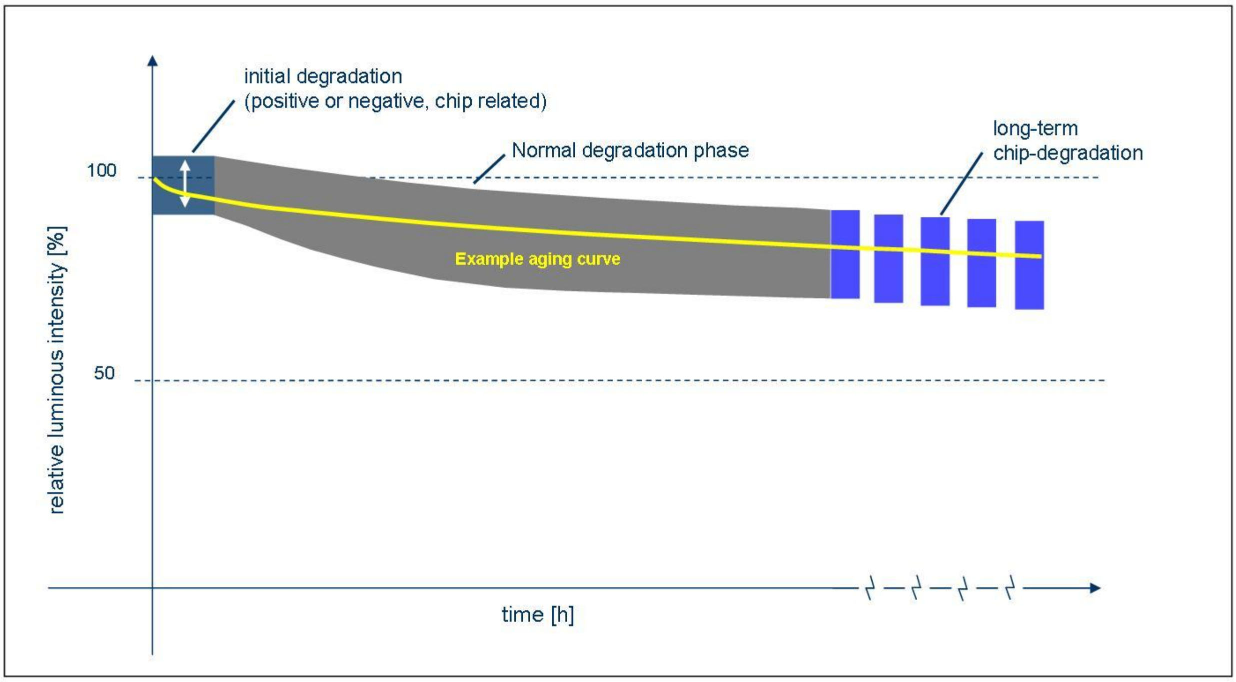


Figure 4b: Degradation characteristics of DRAGON products with ThinFilm or ThinGaN semiconductor technology with a black package

Lifetime and degradation characteristics of DRAGON LEDs with ThinGaN technology

The diagrams in Figure 5 graphically show the expected lifetime L70/B50 of the individual DRAGON LED types LEDs with ThinGaN technology in relationship to the solder point temperature T_S

The resulting T_S curves are displayed in color for different operating conditions.

The typical R_{th} value of the DRAGON type was used as a basis for calculation of the curves. For operating currents, various typical currents such as the minimum and maximum allowable current or the grouping current and half-grouping current were used.

Example: A blue Golden DRAGON (LB W5SM) is driven with a current of 350 mA. A solder point temperature of $T_S = 55°C$ was measured. In this case, the expected lifetime L70/B50 amounts to 90 khrs(*).

For the application, the degradation characteristics of the LED over the lifetime are important. In this regard, OSRAM Opto Semiconductors has carried out intensive long-term analyses and developed models that reflect the expected lifetime of the LED.

The following degradation diagrams for the individual DRAGON LED types (Figures 6a - 6d) are based on T_S=55° and T_S=85°C for various operating currents such as the minimum and maximum permissible current, the respective grouping current and the half or doubled grouping current. The dashed lines represent the L70/B50 and L50/B50 limits.

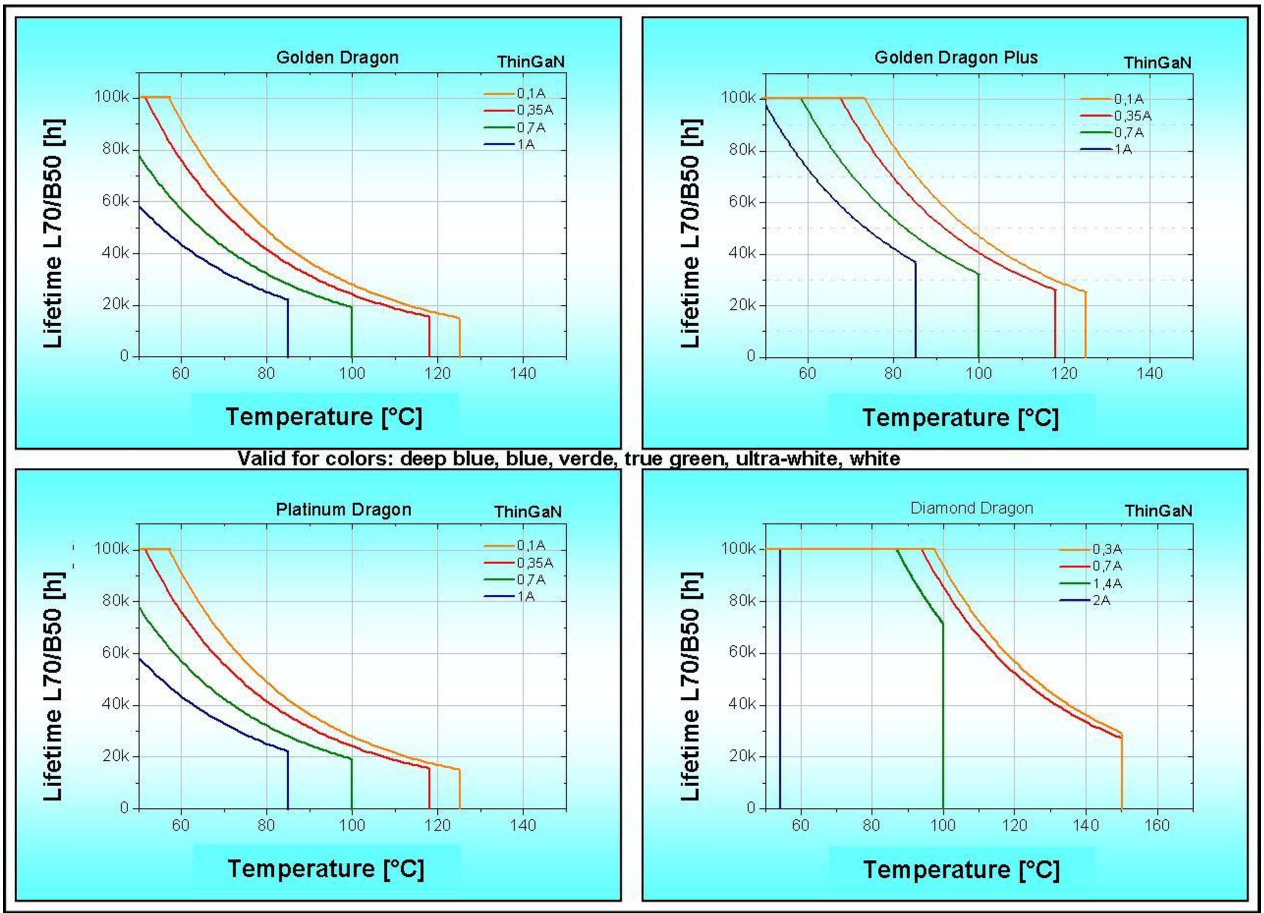


Figure 5: Lifetimes(*) for various DRAGON LED types with ThinGaN technology with respect to T_S

The diagrams depicted describe estimates based on extrapolations and represent average value curves (B50). The actual values may differ due to specific application conditions, product variations, selected brightness binning, humidity and other influencing factors.

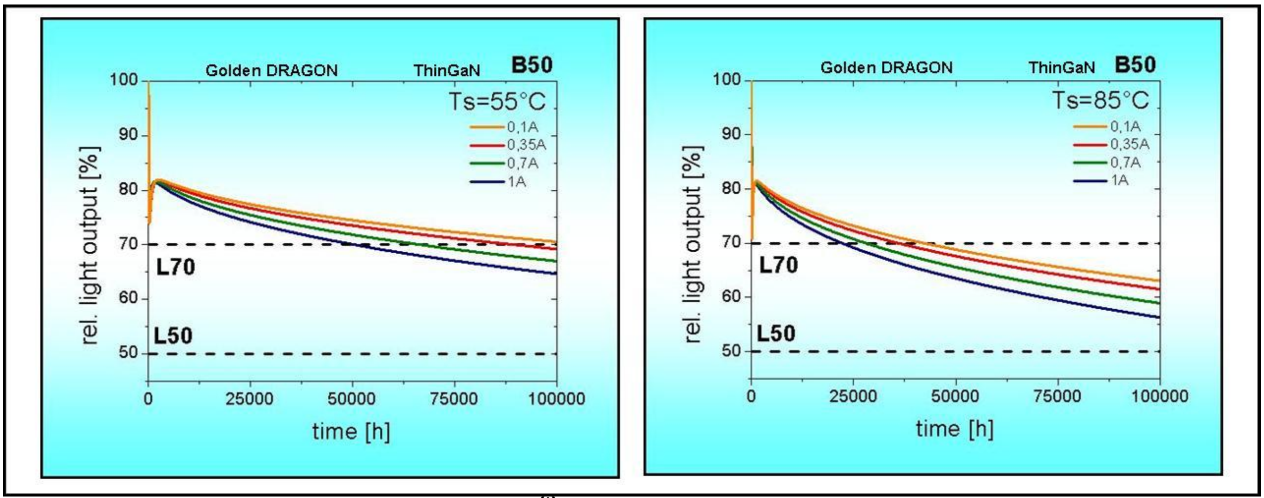


Figure 6a: Degradation characteristics(*) of the Golden DRAGON with ThinGaN technology for T_S = 55°C and T_S = 85°C (grouping current I_F = 0.35 A)

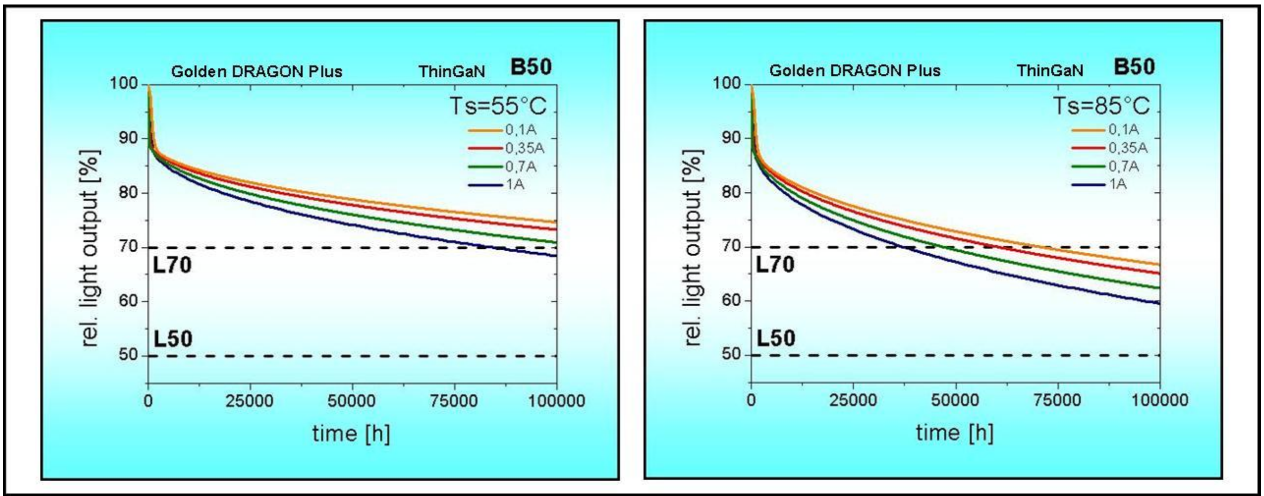


Figure 6b: Degradation characteristics(*) of the Golden DRAGON Plus with ThinGaN technology for T_S = 55°C and T_S = 85°C (grouping current I_F = 0.35 A)

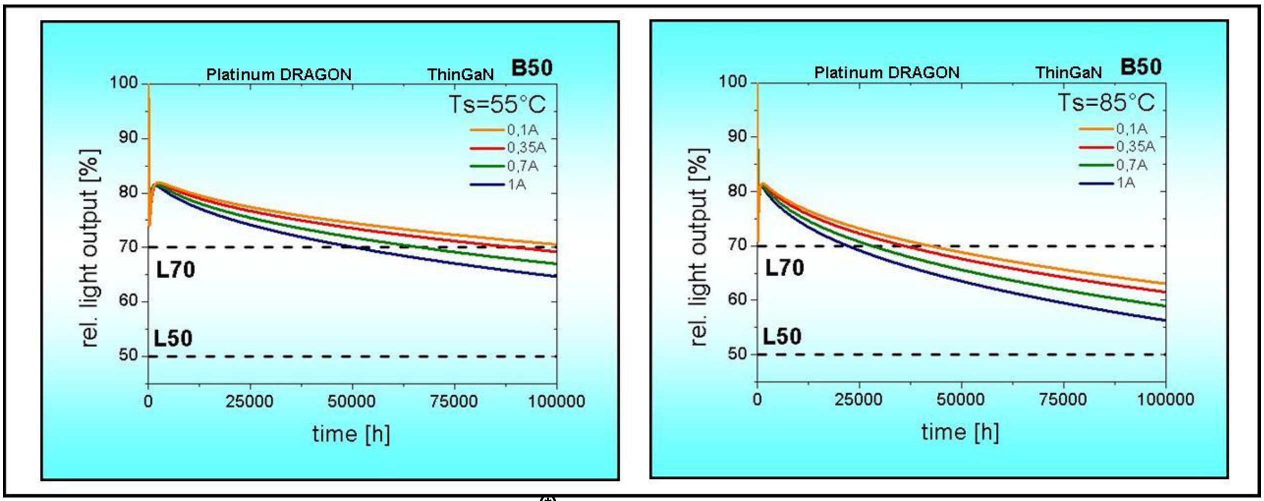


Figure 6c: Degradation characteristics(*) of the Platinum DRAGON with ThinGaN technology for T_S = 55°C and T_S = 85°C (grouping current I_F = 0.7 A)

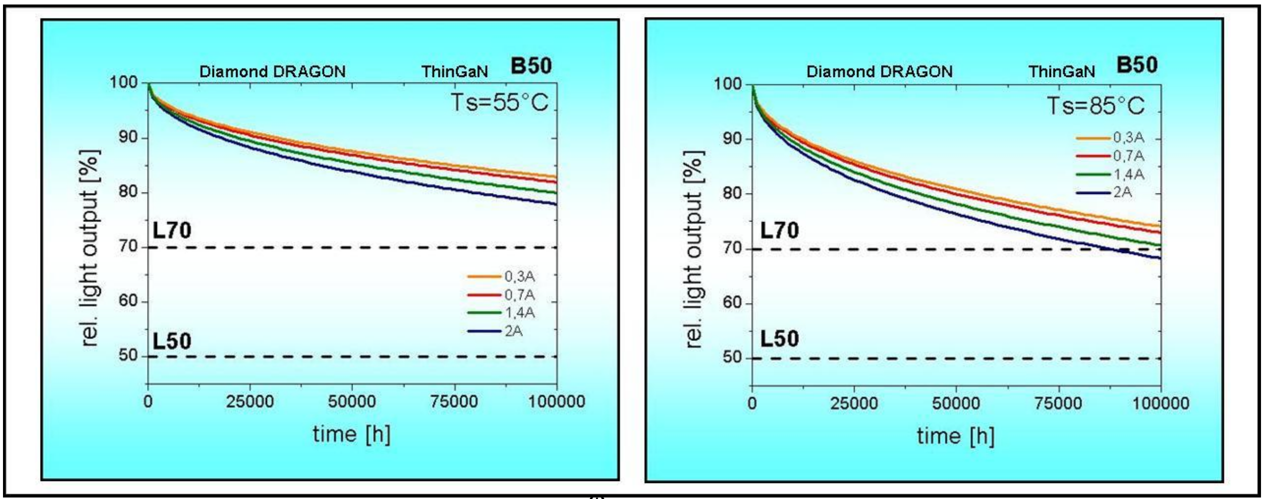


Figure 6d: Degradation characteristics(*) of the Diamond DRAGON with ThinGaN technology for T_S = 55°C and T_S = 85°C (grouping current I_F = 1.4 A)

Lifetime and degradation characteristics of DRAGON LEDs with ThinFilm technology

The diagrams in Figure 7 graphically show the expected lifetime L70/B50 of the individual DRAGON products with ThinFilm technology (InGaAlP) in relationship to the solder point temperature T_S.
For the ThinFilm technology, the aging characteristics are not only dependent on the junction temperature but also on the current density.

The resulting T_S curves are displayed in color for different operating conditions.

For operating currents, various typical currents such as the grouping current for the type or the minimum and maximum permissible current were used.

The measuring principle is the same as for the ThinGaN technology.

The following degradation diagrams (Figures 8a – 8d) for the individual Dragon LED types are based on solder point temperatures of T_S=55° and T_S=85°C for various operating currents (analogous to the currents shown in the diagrams of Figure 7). The L70/B50 and L50/B50 limits are shown with dashed lines.

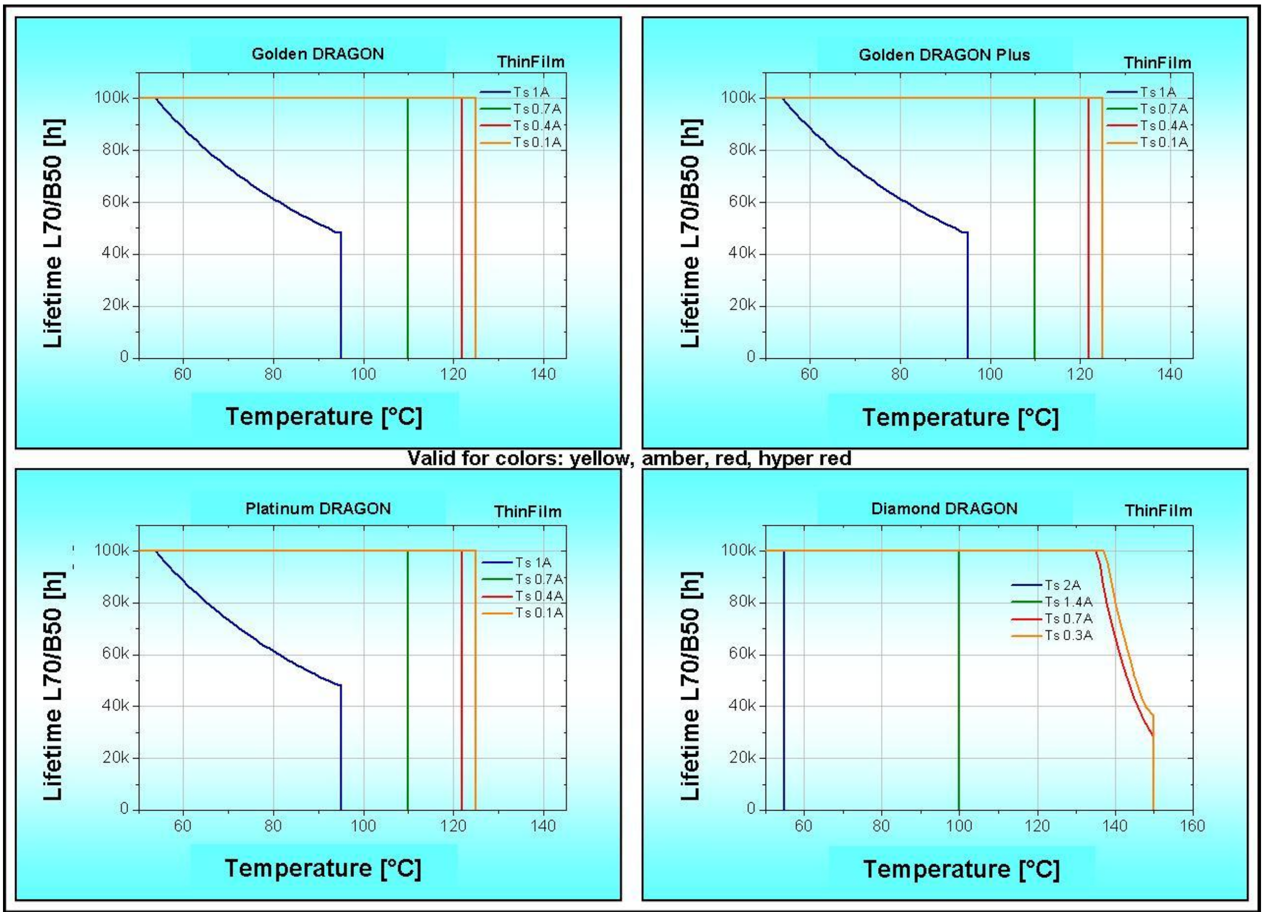


Figure 7: Lifetimes(*) of various DRAGON LED with ThinFilm technology with respect to T_S

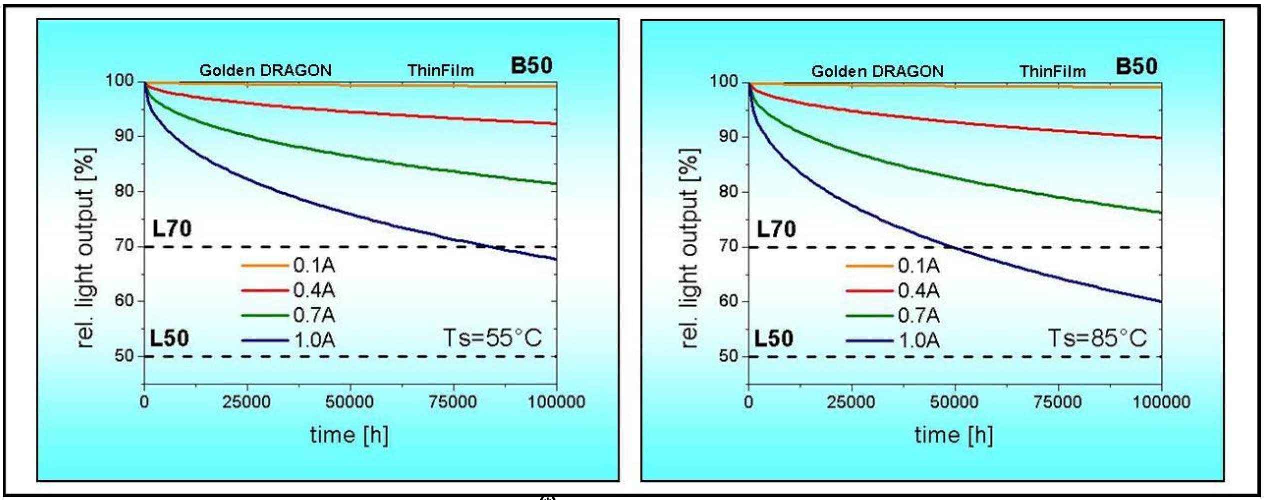


Figure 8a: Degradation characteristics(*) of the Golden DRAGON with ThinFilm technology for T_S = 55°C and T_S = 85°C (grouping current I_F = 0.35 A)

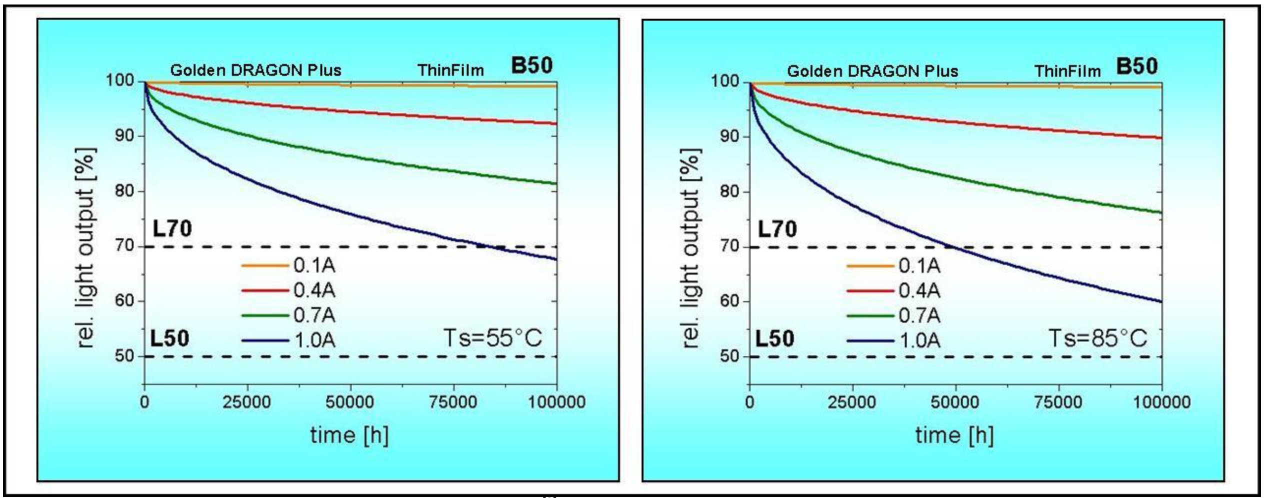


Figure 8b: Degradation characteristics(*) of the Golden DRAGON Plus with ThinFilm technology for T_S = 55°C and T_S = 85°C (grouping current I_F = 0.35 A)

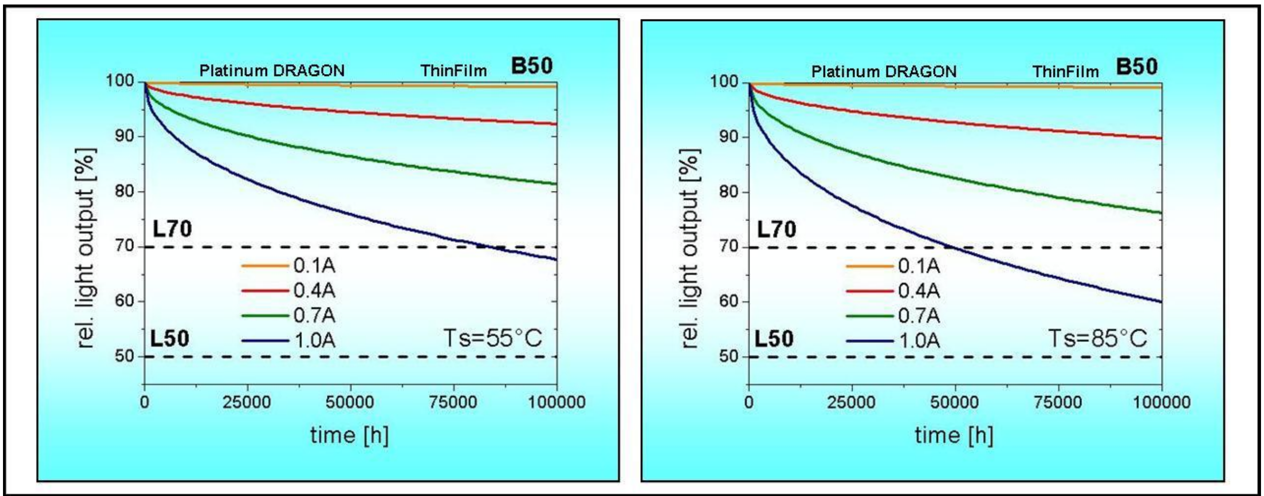


Figure 8c: Degradation characteristics(*) of the Platinum DRAGON with ThinFilm technology for T_S = 55°C and T_S = 85°C (grouping current I_F = 0.7 A)

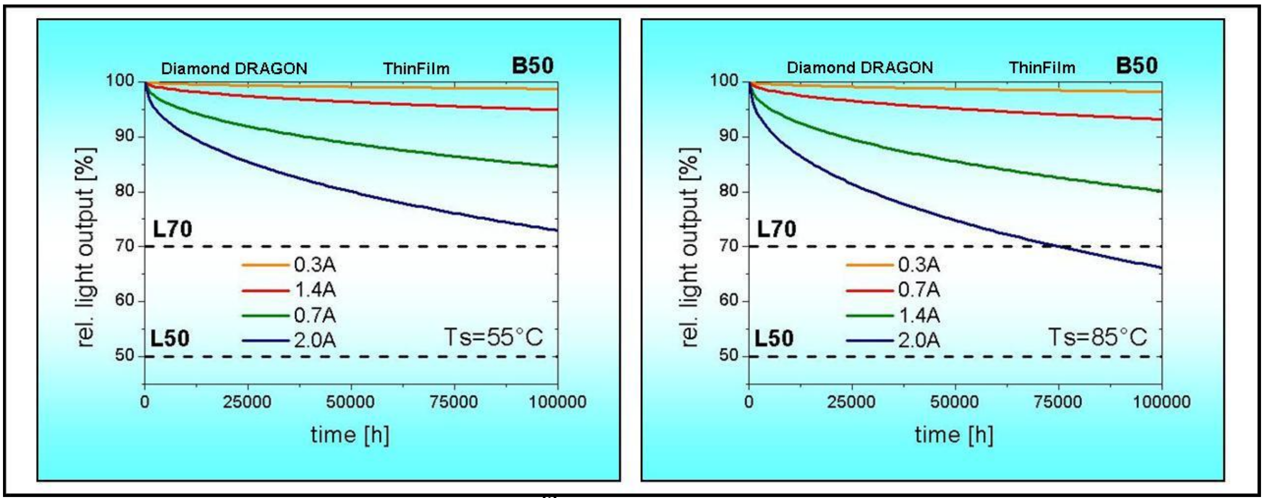


Figure 8d: Degradation characteristics[*] of the Diamond DRAGON with ThinFilm technology for T_S = 55°C and T_S = 85°C (grouping current I_F = 1.4 A)

Overview of typical lifetime values of the DRAGON devices

Produkt Type	Package	$T_{j,max}$ [°C] to achieve > **70 khr** L70/B50	$T_{j,max}$ [°C] to achieve > **50 khr** L70/B50	$T_{j,max}$ [°C] to achieve > **30 khr** L70/B50
Golden DRAGON	LR W5SM	135[1]	135[2]	135[3]
	LA W5SM			
	LY W5SM			
	LUW W5SM	65	80	95
	LW W5SM			
	LB W5SM	65	80	95
	LT W5SM			
	LD W5SM			
Platinum DRAGON	LR W5SN	135[4]	135[5]	135[6]
	LA W5SN			
	LY W5SN			
	LW W5SN	65	80	95
	LB W5SN	65	80	95
	LT W5SN			
	LD W5SN			
	LV W5SN			

[1] T_S = 70°C; I_F = 750 mA **[2] T_S = 70°C; I_F = 850 mA;** **[3] T_S = 70°C; I_F = 1000 mA;**
[4] T_S = 95°C; I_F = 600 mA **[5] T_S = 95°C; I_F = 700 mA;** **[6] T_S = 95°C; I_F = 900 mA;**

Produkt Type	Package	$T_{j,max}$ [°C] to achieve > **70 khr** L70/B50	$T_{j,max}$ [°C] to achieve > **50 khr** L70/B50	$T_{j,max}$ [°C] to achieve > **30 khr** L70/B50
Diamond DRAGON	LR W5AP	140[7]	140[8]	150[9]
	LA W5AP			
	LY W5AP			
	LUW W5AP	110	125	145
	LW W5AP			
	LB W5AP	110	125	145
	LT W5AP			
	LD W5AP			
Golden DRAGON Plus	LR W5AM	135[10]	135[11]	135[12]
	LA W5AM			
	LY W5AM			
	LUW W5AM	85	95	115
	LW W5AM			
	LB W5AM	85	95	115
	LV W5AM			
	LT W5AM			
	LD W5AM			

[7] T_S = 55°C; I_F = 1000 mA; [8] T_S = 55°C; I_F = 1400 mA; [9] T_S = 125°C; I_F = 1000 mA;
[10] T_S = 70°C; I_F = 750 mA; [11] T_S = 70°C; I_F = 850 mA; [12] T_S = 70°C; I_F = 1000 mA;

Summary

Due to their thermally optimized package design, the LEDs of the DRAGON product family offer the designer or developer an excellent starting point for the design of highly-efficient, reliable light sources with exceptionally long lifetimes.
In addition to their robustness and reliability the package of the DRAGON line permits unprecedented flexibility for the customer. With just one circuit board layout, a variety of requirements with respect to brightness and lifetime can be fulfilled in one or more application areas.

As can be seen from the diagrams, the LEDs of the DRAGON group achieve an average lifetime of up to 100,000 hours in combination with adequate thermal management and depending on the chosen operating conditions. This corresponds to around 11.5 years of continuous operation.

(*) The failure criterion is the specified percentage of the initial luminous intensity. The numbers above represent estimations based on extrapolations. The actual value can differ depending on, but not limited to selected brightness binning, temperature at the LED, forward current, humidity, production variations and specific application conditions. As a result, these values can not be warranted or guaranteed.

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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