Journal of Innovative Research in Engineering Sciences; Vol.4, No.1; 2018
ISSN 2476-7611

Causes of Failure and Alternative Mechanisms of Lamps

Monire Alizadeh [1*], Bahman Mostafavi [2], Adib Mostafavi [3]

[1] QC manager, Nama Noor Asia, Tehran, Iran.
[2] Head of sales, Nama Noor Asia, Tehran, Iran.
[3] Sales expert, Nama Noor Asia, Tehran, Iran.

Received: 02, August, 2017 *Accepted: 11, December, 2017* *Online Published: 09, March, 2018*

Abstract
This paper Expounds one of the first studies on the destruction of alternative lamps based on white *GaN* light emitting diodes. The results indicate that the life span of LED lamps instead of the destruction of LED chips depends essentially on the durability of the drive and the optical components, which has a constant output over time. By comparing the lamps produced by four different manufacturers at room temperature and high temperature, we found that (1) long-term placement can change the chromaticity (color) of the lamps Which is attributed to the degradation of phosphorus or central LED reflector; (2) during a period of wear, the LED drive may degrade or decrease dramatically; or (iii) properly managing the output power; Thermal and heat dispersion reduce the degradation factor; (4) spectral transfer capability measurements and visual inspection indicate the destruction of diffuse optical components due to the short wavelength of the LED emission spectrum.

Keywords: Reliability, replacement LED lamp, emitting lamps, phosphorus, LED stimulator

1. INTRODUCTION

White LEDs, based on GaN chips and yellow phosphorus conversions, which have been proven to be reliable and durable for tens of thousands of hours [1, 2]. To benefit from this, several countries and associations are promoting the development of alternate LED lamp, which can be placed on Edison's standard screwdriver socket, the latest example of which was the "L Prize" competition, launched by the US Ministry of Energy in 2008, awarded with a $ 10 million prize [3].

Alternative lamps are now available in stores. Due to the higher initial cost, ensuring the chromaticity and their intensity remain constant over the lifetime of their use for low power consumption and longer lifetime of them in Comparison with sun lamps and fluorescents is important [4].

However, several articles have investigated the degradation of high-pressure chip LEDs [5, 6], high current [7, 9], and reverse bias [13-13], so far, there are no articles that explains total long-term degradation of all kinds of Lamps.

This paper presents one of the first studies on commercially available lamp destruction mechanisms; the results enable us to identify the most important parts of the whole system, and link the failure states to specific failure mechanisms. We found that (1) the working temperature accelerates the degradation processes which are related to (2) dimming of the plastic emitting lamp, (3) the change in the chromatic characteristics of the internal phosphor or the reflector, and (4) the destruction of the LED stimulus.

2. LABORATORY DETAILS

Commercially available alternative lamps were taken from four manufacturers (A to D respectively), tested at room temperature (RT) and had acceleration tests at a higher temperature (HT). The tested light lamps have between 765 and 810 lumens and have a correlated color temperature of 2700-3000 Kelvin. The actual pressure of the temperature is variable due to the different strategies of heat dissipation and the stimulus used by the manufacturers, and the average temperature of the HT lamps is 15 degrees Celsius higher than the RT lamp. Table 1 shows the comparison between the average temperatures in different areas of the lamp for each manufacturer and the test temperature (room temperature or high temperature). These temperatures were measured using the infrared thermal camera of FLIR i50 systems. During the pressure of the lamps, they are biased in normal operation, ie they are wound in the socket and connected to the socket.

At each step of pressure, we use a one-and-a-half-millimeter Lab sphere LMS-650 laser spectrometer to integrate the sphere using the Ocean Optics USB2000 spectrometer. We performed radiometric calibration on the entire set to obtain a precise distribution of optical power over different wavelengths and the intensity of the correct power spectrum in the systems of the international system (SI). Also, after each pressure period, we measured the power consumption of the entire system, that is, the power absorbed by the LED drive from the electrical distribution network, to use LEDs using the Rohde & Schwarz HAMEG HM8115-2 was measured.

Table 1. Working temperatures in different areas of the lamp for each manufacturer during the temperature at room temperature (RT) and high temperature (HT)

Pressure conditions		Lamp	Heat sink
RT	A	38.1	82.6
	B	35.2	75.3
	C	39.2	64.4
	D	36	88.1
	B	38.1	89.1
	C	42	80.7
	D	38.4	99.8

Corresponding Author. Mail. kamaniahmad@yahoo.com
Tell: +98 9101936532

3. DESTRUCTION KINETICS

Figures 1 and 2 illustrate the destruction power of output kinetics for all test specimens at room temperature and high temperatures, respectively. Each line expresses the average process of all lamp from a manufacturer that is under pressure at an external temperature. Reliability under high operating conditions is high, 6% drop after 4500 hours at worst, and almost no damage to the C manufacturer. Compared to the initial reports on the destruction of alternative lamp that were experienced during previous technological reps These shapes signify a general improvement on systems [14], and they can support more research to achieve other improvements and expand the target market for these lighting engines.

The flux of the output light intensity is affected by faster degradation during HT pressure for all manufacturers. This indicates the important role of temperature as a degenerative accelerator, which is reported for LED chips [9], phosphor [7] and reflector [15]. Temperature distribution in lamps is measured through IR thermography, the results of which are presented in Fig. 3 with optical photography. It can be seen that, even if the emitting lamp changes slightly from the room temperature, the heat dispersion characteristics are achieved at very high temperatures (75 ° C or more). We expect the connection temperature for LEDs to be greater than this value, which may cause reliability issues for the whole system, since LEDs are graded for maximum values up to 150 ° C [16]. By comparing this destructive kinetics with the average pressures reported in Table 1, we can point to a strong correlation between the amount of light power lost and the temperature of the whole lamp during the pressure. The heat sink developed by the C (and to a lesser extent by the B producer) has a large number of cavities that can enhance the air flow through the lamp body and more effectively improve the temperature exchange between the hot sections and the external environment. This is demonstrated at lower operating temperatures (as shown in Table 1) and higher reliability (Figures 1 and 2), so this may be a good design solution to improve system lifetimes.

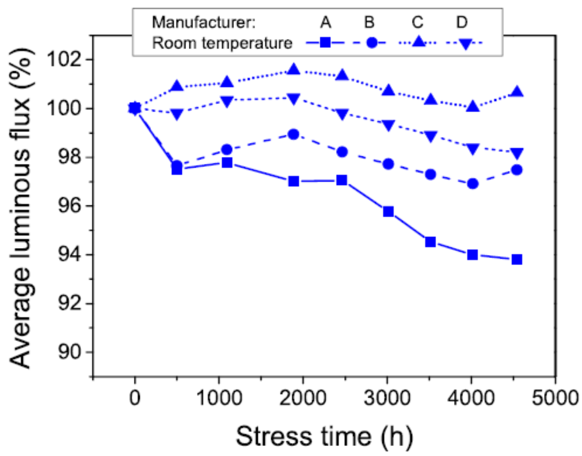

Figure 1. Reducing the output power of the tested lamps at room temperature.

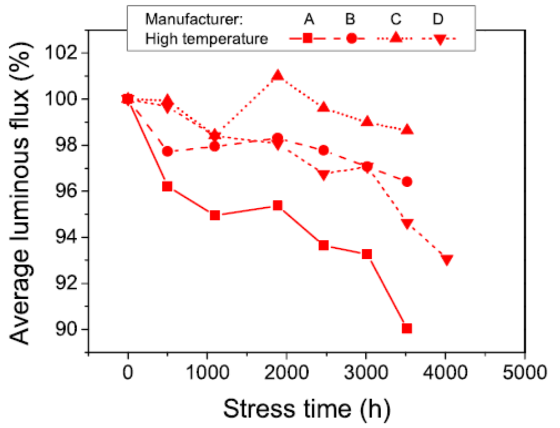

Figure 2. Reducing the output power of the tested lamp at high temperature.

4. DARKENING IN EMITTING LAMPS

We revealed continuous darkening of light emitting bulbs during the pressure time for the lamps in Producer D. In Fig. 4, an unchanged lamp has been compared for 2500 hours. Both lamps are from a unique lamp set, which is smaller in this form of the older lamp because it has cut the main body for exposure to basic LEDs for video inspection. The change in color is specific, which is non-uniform on the annular surface. Because the effect is heavier on the center and weaker on the sides, the damage is likely to be due to a short wavelength, which transmits a light emitting light higher than normal to the LED surface due to the typical Lambert release profile. We can probably leave the temperature as the only factor, since its highest value can be found at the edges of the dome (Fig. 3), with the least affected parts being darkened, as shown in Fig. 5.

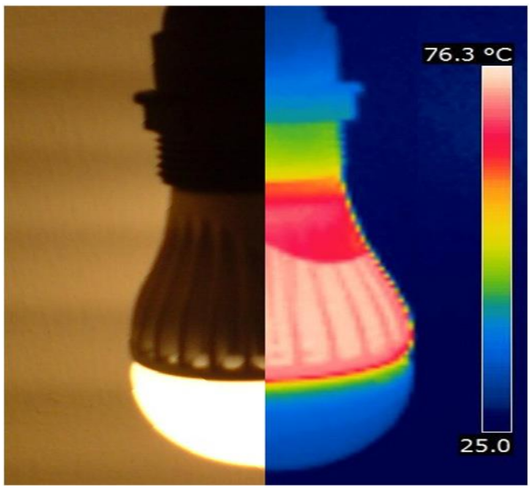

Figure 3. IR Thermogram in the RT bulb during the formation of the pressure.

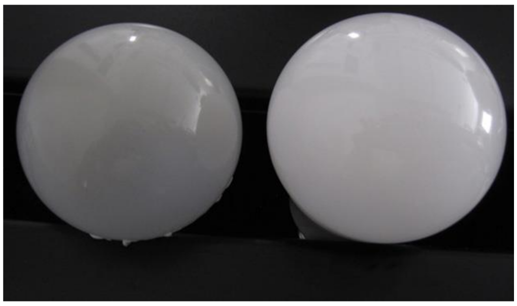

Figure 4. Photographs of the emitted old lamp (2500 hours) for the manufacturer D. darkening after the pressure is clearly visible.

Figure 6: Different amounts of light transmission is shown between the dark section (red area in Fig. 5) and the bright section (green area in Figure 5) in a lamp with the same aging under the illumination of the Ocean Optics LS-1-CAL radiometer calibration. Using external light source prevents any effect associated with LEDs or their stimuli. Dimming effectively reduces the transferability of the ring and is therefore responsible for (at least partly) reducing the flux of light.

In order to estimate the effect of dimming on the chromaticity of the lamp, the curves in Fig. 6 and the spectrum of the lamp provided by the manufacturer, we normalized them to their highest values. Then, we divide the curves into two parts of the dome with the curve of the lamp, and we obtain the percentage of change in the transferability to the maximum value. By subtracting two transitions, we can estimate the spectral distortion caused by the darkening process shown in Fig. 7. As can be seen, ring destruction not only reduces the absolute transmission but also distortion of the transmitted spectrum, which leads to a change in the chromaticity characteristics of the lamp.

5. CHROMATIC VARIATIONS FOR GROUP A LAMPS

The most commonly used degradation mechanism, are the relative change in relative participation in the output spectra; for example, a demonstration is shown in Fig. 8, indicating that the pressure Changes in chromatic features due to the faster degradation of emission in the yellow region of the spectra have been made. This degradation may be due to three different mechanisms: the change in the spectral response of the emitting lamp (high), the decrease in the conversion of phosphorus or the internal oxidation / darkening of the reflector. The emitting lamp may be omitted because the corresponding darkening is detected in "A" lamp, unlike the "D" group. Also, we found that its effect is stronger at shorter wavelengths (see Figure 7), while in Fig. 8 larger changes occur at higher values. It should be noted that the emission of 455 nm related to the blue chip does not significantly change, indicating that the GaN-based LED remains stable and affects the system's capabilities even at very high temperatures. During the operation, it does not affect. Figure 9 shows the corresponding color temperature change (CCT), which is the quantity that shows the equivalent temperature of the black body, which is very similar to the output spectra. Because the yellow part is decreasing, the CCT gradually increases to the black (and then blue) equivalent of the black body. Increased CCT may be a problem because the received light is "colder", which may not be acceptable in household applications and result in an early replacement of the lamp that still works.

Figure 5. The photographic light of the emitted lamp is not obsolete and Old (2500 hours) for D. The different levels of darkening are shown with solid color (low darkness) and with red opaque (high darkness).

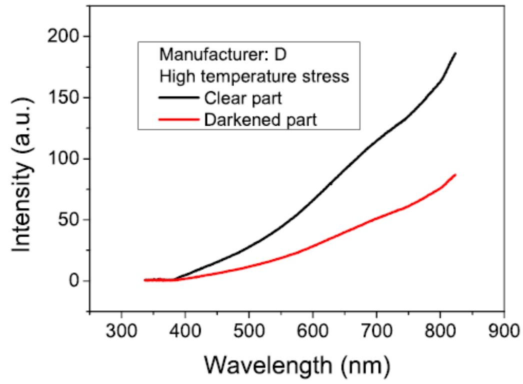

Figure 6. Light transmitted in two regions of the lamp with different levels of darkening. Light source: Radiometric calibration lamp

6. THE STIMULUS FUNCTION

The last lamp subsystem that affects the function of the lamp is the LED stimulator, ie all additional circuits needed to convert the electrical power drawn at high voltage from the source

The mains voltage is lower and compatible with the maximum working voltage limit and the flow of white LEDs. In D-lamp manufacturers, the output power meets the precision of the power consumption change shown in Fig. 10.

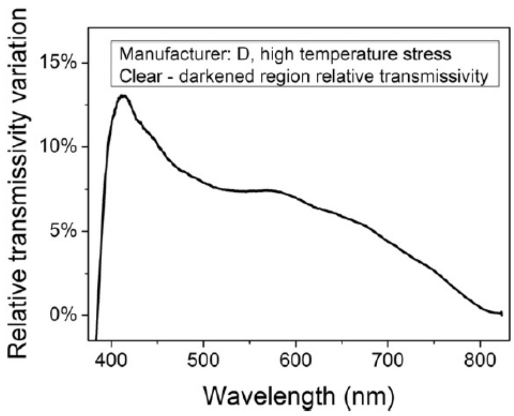

Figure 7. Changing the normalized transmitted spectrum compared to the two regions of the lamp with different levels of darkening. Light source: Radiometer calibration lamp

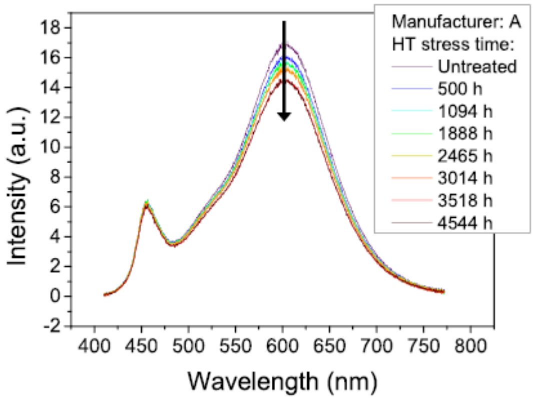

Figure 8. Spectral variation at pressure time. Reducing the yellow peak is responsible for changes in chromaticity characteristics, while the output of the LED chip (peak at 455 nm) remains stable.

This effect suggests that a decrease in the emission of LED chips or changes in the chromaticity of the lamp it does not relate to phosphorus or emitting matter, but depends on the less power of existing electricity that needs to be transformed into light. The same effect is also found in devices from other manufacturers, but in those cases, one of the reasons for the flux of light has fallen instead of the original destruction mechanism. In one case, the lamp collapsed early. The visual stimulus analysis showed that the stimulus was corrupted (see Figure 11). The red opaque around the electrolyte capacitor is drawn with a visible gap in the outer insulating layer. This is the usual form of damage caused by electrolyte evaporation, possibly due to electric power lines or excessive electrical pressures. The explosion was so strong that it could cause the material to burn, which became dark (like the red line) in white instead of other areas. The blue arrow indicates the expected color of the filler material when we remove the burned area. All of these issues prove that if the very different levels of voltage, reduced space and high operating temperature are taken into account, the proper design of the LED drive will be a very important feature for the lamp to be trusted.

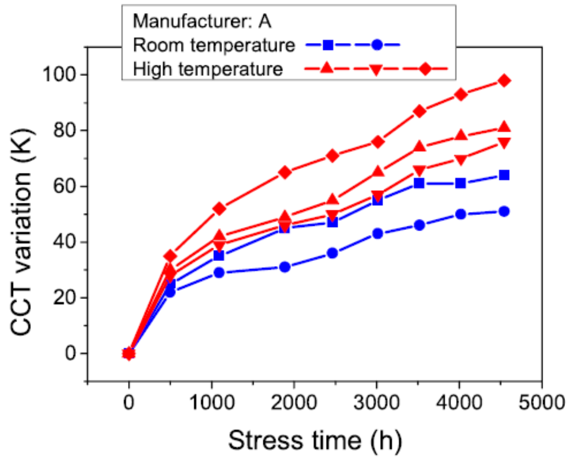

Figure 9. Change of color temperature during wear. The lamp that are pressurized at high temperatures are subject to more severe degradation.

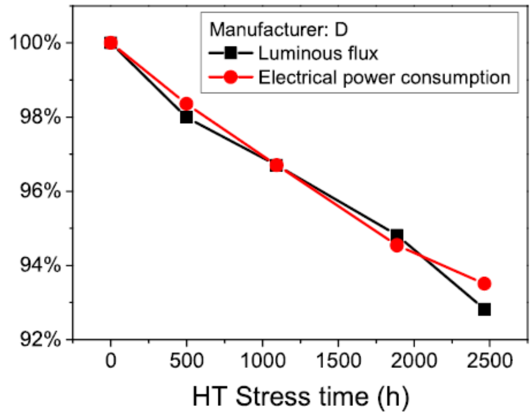

Figure 10. The relationship between reducing the output power of light and reducing the power consumption of one of the lamp tested.

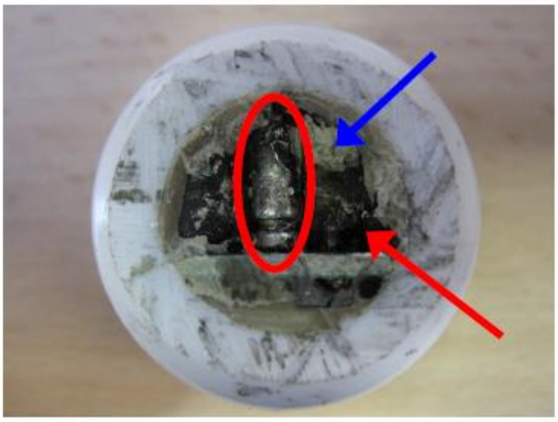

Figure 11. Damage caused by electrolyte evaporation

Comparison of the types of lamps:

1. Incandescent lamp (Incandescent Light Bulb): The incandescent light bulb is warm and uniform and has a lot to do with natural light and is therefore the best artificial light. These lamp are not economical in terms of electricity return efficiency and less than 5% of energy is changed to light. Some countries, like Australia, have replaced these lamp with higher-efficiency lamp.

2- Compact Fluorescent Lamp: These lamps are more expensive than the type of filament but have a longer life span. These lamps tend to be less energy-consuming than incandescent, but they also have many disadvantages. The main drawback of these lamps is their health hazards. Ultraviolet and mercury in these lamp is very harmful to human health.

3. Mercury-vapor Lamp: Good light-efficiency and proper life-span are the main feature of this lamp. Due to the proper color of the light, these lamps are suitable for outdoor lighting such as parks, pavements and lighting for factories. On the other hand, given the risks of mercury vapor for the environment, the production of these types of lamps in the EU member states is banned. On the other hand, the energy dissipation of these lamps is very high. This means that using these lamps is coming to an end for lighting up.

4. Sodium-vapor Lamp

In sodium vapor lamps, the gas in which the drain is made, is a sodium vapor. As a result, the light of these lamps lies within the range of yellow light. These lamps have a long life and high light gain, but due to the poor color of light and the percentage of reflection of the bad colors, these lamps are used in environments such as docks and ports and urban roads. But because the color indicator of these lamps are very low, using these lamps is not suitable for places where people travel long-distance, such as sidewalks, shopping malls, parks, etc.

5. Metal-halide lamp: Metal halide lamp is the same as mercury vapor, but it also contains some halogen salts that enhance its color quality and, on the other hand, light gain, and is now rapidly replacing with other types of lamps. These types of lamps are produced in the range of 20 to 2000 watts and are used in indoor lighting and lighting of factories, as well as urban and sports stadiums, large enclosures, and so on. Metal halide lamps have two bubbles, the outer bubble prevents ultraviolet radiation, and if broken, the use of a bulb is very dangerous and can cause serious damage to the human eye and skin.

6. LED Lamps:

LED is a type of diode that emits some energy in the form of light through the flow of current. These lamps use very little energy to produce lighting, while also producing all type of colors. Power consumption is about 10% of ordinary lamp, up to 50000 hours of life, and extreme exposure, including the benefits of using an LED bulb. For this reason, the dimensions of their use are increasing day by day, and many believe that in future, LED lamps will remove the future from the hands of other competitors. Nowadays, many large manufacturers of lighting fixtures, especially house lighting companies have focused their activities on LEDs.

In the other hand, due to the fact that LEDs can be powered by AC and low-current DC power, can also use solar power or batteries to supply their power. Also, nowadays in lighting up the passageways, streets and roads, decorating and beautification of passages and bridges and different places LEDs are used as the light sources due to the high cost of maintenance in comparison to traditional lighting sources, and because of long life and energy saving up to 90%, technical and economic justification LEDs are used much more.

LEDs and Hygiene: The LED bulb does not have normal light, although it does not have normal UV light lamp, but it does not have ultraviolet rays and IR fluorescent lamps and low power consumption.

7. CONCLUSIONS

Based on the comparison that were made between different lamps and the life-span tests used in commercially-designed replaced LED lamps, the important role of temperature as an accelerating factor in degradation as well as correct management and accurate thermal insulation to avoid damage is stressed.

The main mechanisms that can reduce performance are:

(1) Dimming the emitting lamp, which reduces the transmission of the entire dome, causing distortion of the released spectrum, resulting in chromatic aberration.

(2) Changing the chromatic features of a phosphor or reflector which reduces the efficiency of the lamp and causes a significant change in the correlated color temperature (CCT);

(3) The change in the LED's stimulus function, which if not designed well will lead to electric line waves or excessive electrical pressures and eventually premature failures. All of these effects are in accordance with the overall reliability of the system, which normally is expected to have thousands of hours of work.

FUNDING/SUPPORT

Not mentioned any Funding/Support by authors.

ACKNOWLEDGMENT

Not mentioned.

AUTHORS CONTRIBUTION

This work was carried out in collaboration among all authors.

CONFLICT OF INTEREST

The author (s) declared no potential conflicts of interests with respect to the authorship and/or publication of this paper.

References

[1] Photographs of the LED stimulator are corrupted [Scholar]

[2] C.-C. Tsai, W.-C. Cheng, J.-K. Chang, S.-Y. Huang, J.-S. Liou, G.-H. Chen, Y.-C. Huang, J.-S. Wang, W.-H. Cheng, Thermal-stability comparison of glass- and silicone-based high-power phosphor-converted white-light-emitting diodes under thermal aging, IEEE Trans. Device Mater. Reliab. 14 (1) (March 2014) 4–8.A. [Scholar]

[3] M. Meneghini, M. Dal Lago, N. Trivellin, G. Meneghesso, E. Zanoni, Degradation

mechanisms of high-power LEDs for lighting applications: an overview, IEEE Trans. Ind. Appl. 50 (1) (Jan.-Feb. 2014) 78–85. [Scholar]
[4] Fabrício P. Vahl, Lucila M.S. Campos, Nelson Casarotto Filho, Sustainability constraints in techno-economic analysis of general lighting retrofits, Energy Build. 67 (December 2013) 500–507. [Scholar]
[5] Fabrício P. Vahl, Lucila M.S. Campos, Nelson Casarotto Filho, Sustainability constraints in techno-economic analysis of general lighting retrofits, Energy Build. 67 (December 2013) 500–507. [Scholar]
[6] M. Meneghini, L.R. Trevisanello, U. Zehnder, G. Meneghesso, E. Zanoni, Reversible degradation of ohmic contacts on p-GaN for application in high-brightness LEDs, IEEE Trans. Electron Devices 54 (2007) 3245. [Scholar]
[7] M. Meneghini, L. Rigutti, L.R. Trevisanello, A. Cavallini, G. Meneghesso, E. Zanoni, A model for the thermal degradation of metal/(p-GaN) interface in GaN-based light emitting diodes, J.Appl. Phys. 103 (2008) 063703. [Scholar]
[8] N. Narendran, Y. Gu, J.P. Freyssinier, H. Yu, L. Deng, Solid-state lighting: failure analysis of white LEDs, J. Cryst. Growth 268 (3/4) (Aug. 2004) 449–456. [Scholar]
[9] S. Levada, M. Meneghini, G. Meneghesso, E. Zanoni, Analysis of DC current accelerated life tests of GaN LEDs using a Weibull-based statistical model, IEEE Trans. Device Mater. Reliab. 5 (2005) 688. [Scholar]
[10] S. Ishizaki, H. Kimura, M. Sugimoto, Lifetime estimation of high power LEDs, J. Light. Vis. Environ. 31 (1) (2007) 11–18. [Scholar]
[11] M. Meneghini, N. Trivellin, M. Pavesi, M. Manfredi, U. Zehnder, B. Hahn, G. Meneghesso, E. Zanoni, Leakage current and reverse-bias luminescence in InGaNbased light-emitting diodes, Appl. Phys. Lett. 95 (2009) 173507. [Scholar]
[12] X.A. Cao, P.M. Sandvik, S.F. LeBoeuf, S.D. Arthur, Defect generation in InGaN/GaN light-emitting diodes under forward and reverse electrical stresses, Microelectron. Reliab. 43 (12) (Dec. 2003) 1987–1991. [Scholar]
[13] M. Meneghini, U. Zehnder, B. Hahn, G. Meneghesso, E. Zanoni, Degradation of highbrightness green LEDs submitted to reverse electrical stress, IEEE Electron Device Lett. 30 (2009) 1051. [Scholar]
[14] F. Manyakhin, A. Kovalev, A.E. Yunovich, Aging mechanisms of InGaN/AlGaN/GaN [Scholar]
[15] Light-emitting diodes operating at high currents, MRS Internet J. Nitride Semicond.Res. 3 (1998) 53. [Scholar]
[16] E. Jung, M.S. Kim, H. Kim, Analysis of contributing factors for determining the reliability characteristics of GaN-based white light-emitting diodes with dual degradation kinetics, IEEE Trans. Electron Devices 60 (1) (Jan. 2013) 186–191. [Scholar]
[17] Figures from commercially-available LED datasheets: Cree XREROY, LedEngin LZ4-00B210, Lumileds LXML-PR01, Osram LD W5SM, Seoul Semiconductor D42180. Author 1 and B. Author 2, *Title of the Book*. John Wiley & Sons, pp. 100-105, 2002. [Scholar]