Research on thermal resistance Rth_{j-c} of high power semiconductor light sources

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Abstract. The article presents the results of Rth_{j-c} thermal resistance tests for selected high power semiconductor light sources. The thermal resistance between the junction and the casing of semiconductor light sources is one of the key parameters determining the correct junction temperature of the LED sources and its influence on the basic light and electric parameters of semiconductor light sources. The tests were carried out in accordance with the international standard JEDEC JESD51-14 using the Mentor Graphics measuring equipment.

INTRODUCTION

Semiconductor light sources are currently the most dynamically developing group of light sources in lighting technology. High energy efficiency of the mentioned light sources, high luminous efficiency and long life make these sources widely used in both indoor and outdoor lighting [1]. Despite numerous advantages, LED sources have some limitations, which in particular include the high temperature of the junction, affecting, among others, lighting parameters and lifetime [2]. The junction temperature of semiconductor light sources depends directly on the thermal resistance Rth_{j-c} between the junction and the LED source casing. The mentioned parameter is defined by the procedures in the datasheet, however, it is often defined in a way that is not very precise, without key information, among others, for which forward current and for what power has the mentioned thermal resistance been determined. The reliable value of the above parameter is necessary for the correct determination of the junction temperature during the operation of the semiconductor light source. This parameter can also be used for simulation studies of thermal LED sources using software based on the Finite Element Method or Computational Fluid Mechanics. For two selected high power semiconductor light sources, Rth_{j-c} thermal resistance tests have been carried out. The tests were carried out on a measuring stand with the T3Ster thermal tester of the Mentor Graphics company and using a measuring station for measuring the optical power of the GL Optic company.

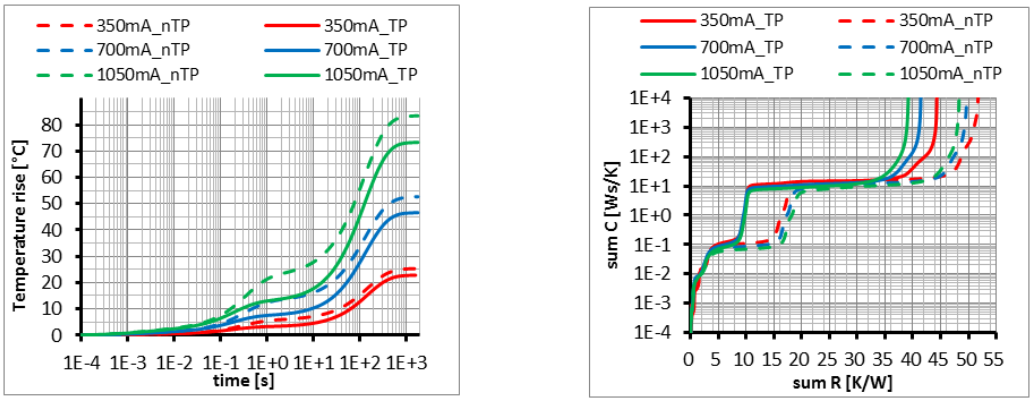
METHODOLOGY AND RESEARCH RESULTS

The Rth_{j-c} thermal resistance tests of two tested LED sources were carried out for the actual thermal power of semiconductor light sources, in accordance with the JEDEC JESD51-14 and JEDEC JESD51-51 standard [3]. The thermal power of the tested LED sources was determined using a measuring stand with an integrating sphere with a diameter of 50 cm and a GL Optic spectrophotometer. Rth_{j-c} thermal resistance measurements were made using the T3Ster thermal tester of the Mentor Graphics company. Then, in order to determine the tested thermal resistance Rth_{j-c}, two LED sources of the same type were soldered to the MCPCB substrate in various ways. For the first source, all pads were soldered, while in the case of the second source, only electrical pads were soldered, without a thermal pad. The aforementioned method for installing LED sources allows to determine the thermal resistance between the junction and the LED source casing, due to the change of the heat flow path, and the read out point of the heating curves, allows direct reading of the tested thermal resistance Rth_{j-c}. Figure 1 presents the measurement

stands used for the tests, while Figure 2 presents the final characteristics processed by the software, allowing determination of the thermal resistance Rth_{j-c}.

(a) (b)

FIGURE 1. Measuring positions: a) with a GL Optic integrating sphere and spectrometer, b) T3Ster thermal tester of the Mentor Graphics company



(a) (b)

FIGURE 2. Determination of thermal resistance Rth_{j-c} of the tested LED source: a) characteristics of heating curves, b) determined function of cumulative structures

CONCLUSIONS

The determined thermal resistance Rth_{j-c} of the LED sources tested had a higher value than declared by the manufacturers in the datasheet, which is related to the actual thermal power of LED sources. This resistance is also dependent on the forward current and with its rise, its value also increases. The actual value of the thermal resistance Rth_{j-c} is an indispensable element in the correct determination of the junction temperature at which the semiconductor light source works.

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