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硕 士 学 位 论 文

多路LED加速寿命在线测试系统研制

Multichannel Online Lifetime Accelerating and Testing System for Light-Emitting Diodes

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摘 要

LED寿命长达数万小时，具有高效、节能、环保、高可靠性的优点，是当前国家正在提倡和推广的照明光源。然而，LED长寿命的优点却成为寿命评估的短板，需要耗费大量时间。加速寿命可大大缩短实验时间，同时也是探索LED失效机理，进一步提升LED性能的有效手段。传统的LED加速寿命方法往往采用离线测试方法，将样品连同夹具置于高温箱中，通过高温箱控制样品的整体环境温度，但是在老化过程期间需要中断老化，将样品冷却取出对其各个参数进行测试。为了更加便捷地连续性测试，一些科研机构也提出了在线测试方法，将光电探测器置于高温箱内，进行简单的光电在线测试，但系统易受高温影响。目前，加速寿命测试耗费大量的时间和人力，测量误差较大、数据量小，无法满足现阶段工业信息化发展的步伐。本文针对LED加速寿命实验，围绕现有系统所存在的不足，开发了多路LED加速寿命在线测试系统，具体工作内容包括：

1、搭建多路LED加速寿命在线测试系统。系统包括夹具部分、加速寿命控制部分和在线综合测试部分。改造传统电流老化夹具，在老化夹具中加入加热片，通过加热片直接控制LED热沉温度，实现电流和温度加速寿命实验；使用3D打印机制作光纤固定夹具，将光纤-余弦收集器固定在样品正上方100mm处；引入脉冲结温测试方法，建立电压-结温系数，对结温进行在线监控；将光谱仪、光学复用器、数字电流源表、数据采集仪相结合，实现多通道的在线的光学、电学、色度学、热学的综合测试；采用IS公司的Spectro 320光谱仪和标准卤钨灯光源对光谱仪和光学复用器进行校正。

2、基于Delphi可视化环境开发配套控制软件。软件通过GPIB、RS-232、USB等接口与各个仪器通信传输，对实验条件、采样条件等进行设置，读取实验结果。实验开始后，无需人工干预，即可自动化完成实验，实现实验数据在线连续测试。同时，为满足海量数据的存储、读取需求，采用HDF5数据存储结构保存大数据量、多类型的数据。

3、通过大功率白光LED在线加速寿命实验验证系统功能。样品选择仿流明封装的大功率白光LED，使用InGaN蓝光芯片激发YAG黄色荧光粉，通过初筛和结温-电压敏感

系数测试后，分为3组，温度应力分别为500C、650C、800C，电流均为500mA，进行加速寿命实验。根据失效现象可将其分为单调衰减和非单调衰减，实验结果表明该样品质量和可靠性差。根据其参数变化可以看出，其主要失效来源于芯片非辐射复合增加、荧光粉黄化和透镜开裂。通过该实验可以看出，在线测试系统可以给出满意的加速寿命实验结果，相对离线测试结果而言，测试结果更加稳定，数据更加准确。

关键词：在线测试；LED；加速寿命

Abstract

As the advocated and promoted lighting source in China, LED shows excellence in high efficiency, energy saving, environmental protection, high reliability, and extra-long lifetime which can reach up to hundreds of thousands of hours. However, the advantage of long lifetime is the bottleneck for lifetime evaluation, which would consume a lot of time. LED lifetime acceleration experiments are hopeful to solve the current bottleneck of LED properties, further enhance the LED performance and explore the LED failure mechanisms. Traditional lifetime experiments commonly use off-line tests, which builds LEDs along with fixtures inside a high temperature chamber to control the overall environmental temperature. Because the testing system is independent of the high temperature chamber, the aging process needs to be repeatedly interrupted to test the LEDs optical degradation. For more convenient and continuous testing, several online testing systems have been proposed. The photodetectors are put into the high-temperature chamber to conduct photoelectric measurement. However, the photodetectors are susceptible to high temperature. Considering the high cost of time, manpower and unnecessary measurement errors, the traditional methods restrict the progress of industry and science researches. Aiming to solve the shortcoming of traditional system, a new multichannel online lifetime accelerating and testing system for LEDs is proposed in this dissertation, mainly containing the following aspects:

1. Build up hardware platform of the online system. The system can be segmented into heating and sampling module, temperature and current controlling module, and online comprehensive measuring module. The specific works include: Both electrical current and temperature stresses are adopted in this online system, among them LED sink can be directly heated by an integrating heater into the current stressing fixtures. To measure the junction temperature

online, a method of junction temperature based on the electrical pulse is combined into this online system; A sampling fixture printed by 3D printer is used to fix the optical fiber and to keep the distance from the detector to the sample at 100 mm; Combining spectrometer, optical multiplexer, current source, and electrical matrix switch, the online system integrates optical, electrical, colorimetric, and thermal properties in LED lifetime tests, to realize multiple LEDs online lifetime test and evaluation conveniently and automatically. For the purpose of ensuring the precision, we use a metrological certificated halogen tungsten spectra-irradiance lamp and a spectrometer (Spectro 320, Instrument systems Inc.) to calibrate the system.

2. A supporting software based on Delphi is developed to run the system more intelligently. A USB hub is used to send and receive messages with multiple interfaces including USB, GPIB, and RS-232. The software starts the online test and captures the relevant parameters according to settings automatically. Besides, a new file format of HDF5 is used for big volume and multi-type data processing.

3. An accelerated lifetime test for high-power LEDs has been carried out to verify the system. The InGaN blue LEDs coated with YAG:Ce phosphors are selected as samples. After pre-aging and testing junction temperature, these samples are divided into three groups applied by high-current stress (500mA) at three temperature stresses (50 °C, 65 °C, and 80 °C, respectively). After online aging, the lumen degradation can be divided into two categories: monotonic variation and non-monotonic variation. The main degradation mechanism is due to the high temperature caused yellowing or possible carbonization of silicone lens by phosphors self-heating. It can be seen from this experiment that the on-line test system can give satisfactory results to accelerate the experimental results. Compared with offline test results, the test results from online test are more stable and the data are more abundant.

Keywords: Online testing; LEDs; Lifetime Acceleration.

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