

SELF-HEALING APPROACH FOR ENHANCED RELIABILITY OF LIGHT EMITTING DIODES

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ABSTRACT

Light Emitting Diodes (LED) are multi-components systems that produce light due to radiative charge recombination at a semiconductor junction. Low energy consumption, high luminous efficacy (~150 lm/W) and long life time (~50.000 h) of LEDs are the main factors that are usually highlighted as advantages compared to usual lighting devices. Due to the phasing out of the good old incandescent bulb lights, these types of solid state lighting are and will be of major interest worldwide from an economic and environmental point of view [1].

Most of the R&D done in this field has been devoted to increase LED internal quantum efficiency and to implement new design assembly to further optimize light extraction efficiency and thus LED luminous efficacy. However, as many electronic systems, pushing the limit of LED devices to increase efficiency involve reliability issues that need to be solve to guaranty optimal light emission in time. LEDs being multi-components system, failures can occur at different level from the semiconductor die to the packaging involving simultaneous functionality degradation (e.g. electrical and thermal conduction, transparency, adhesion and chemical protection).

Origin of LED failures is mainly related to the presence of defects in the crystalline structure of the semi-conductor based die. As a consequence, non-radiative charge recombination occur producing heat instead of light. This thermal stress affects negatively LED's packaging component properties and induces mechanical stress due to differences in coefficient of thermal expansion between all LED and LED package constituents [2-4]. Sensibility to thermal stress is nowadays the bottleneck that prevents LEDs to exhibit high level of reliability. Add to this, environmental aggression/stress (e.g. moisture) can further decrease reliability.

Until now, self-healing concepts in material science have been mainly applied for structural materials which carry loads [5] or materials that have a protective function [6]. To circumvent failures and further improve reliability of LEDs, a new elegant way could be to introduce materials presenting self-healing properties. As an example, development of hybrid system presenting thermal and electrical conduction properties as well as self-healing adhesive functionality will be of great interest (Fig. 1). At a certain extend, the heat generated during LED operation could be used to trigger self-healing before critical failure occurs.

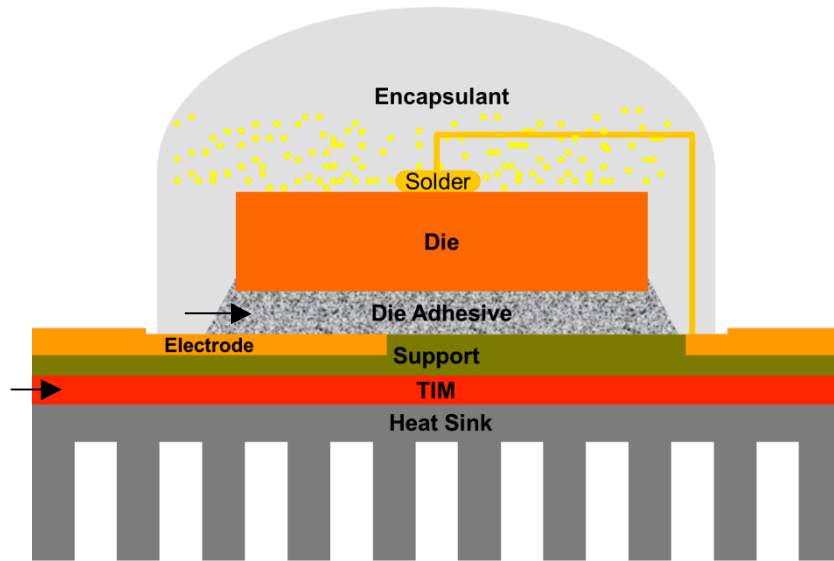


Figure 1: LED schematic representation. Arrows indicate where self-repairing adhesive could be of interest.

In this work, strategic routes to develop and implement self-healing hybrid materials in the LED package have been identified in order to prevent and manage physical and chemical problems in LEDs induced by thermo-mechanical stresses [7]. The initial experimental work focuses on reversible adhesion to combat delamination at the various interfaces.

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