Processing Instructions for Mounting of Through-Hole LEDs

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INTRODUCTION

Through-hole LED cases usually consist of epoxy casting compounds with duroplastic properties. It is in the nature of things that optical semiconductor devices require transparent materials with the best possible optical features. Unlike standard IC mold compounds, which use reinforcing fillers like class fibers to achieve better mechanical stability, these optical materials must not be filled. In addition, due to the very small component dimensions, the wall thickness of the casted resin body is also small. All this results in some special aspects regarding mechanical stability during the soldering process to be considered for the processing of leaded LEDs.

THERMAL PROPERTIES OF CURED EPOXY

The chemical cross-linking of thermosetting materials does not allow a real melting when reheated after curing. However, cross-linked materials suffer a softening at an elevated temperature, which is already far below the natural decomposition temperature. The corresponding softening temperature is called the glass transition temperature (T_G). The T_G is not a sharply defined thermodynamic transition, but rather a temperature range over which the mobility of the polymer chains increases significantly, and the base material changes from rigid / glassy to a more rubbery / soft state.

Above T_G, the coefficient of thermal expansion (CTE) of the epoxy increases significantly.

A typical value for T_G is ~ 130 °C and for the increase of CTE from ~ 60 ppm/K to ~ 180 ppm/K below and above T_G, which corresponds to an increase of three times.

KNOWN FAILURE MODES

If the T_G is exceeded too fast, package cracks could emerge, especially from edges of the lead frame, bond wire, or LED chip.

With increasing temperature, the epoxy softens around the highly heat-conductive lead frame, and could be partially detached from the metal so that a delamination could occur. At this stage, previously introduced mechanical tensions (e.g. due to spring effect) may be released, causing the lead frame to slightly move inside the casting resin, and thus bond wires could easily break.

Considering the filigree nature of the bond wire with only about one micro-inch diameter, it is easily comprehensible how important it is to avoid any mechanical stress that could be released during the soldering process.

The following pictures (Fig. 1 to Fig. 4) illustrate the failure modes, based on a practical example:

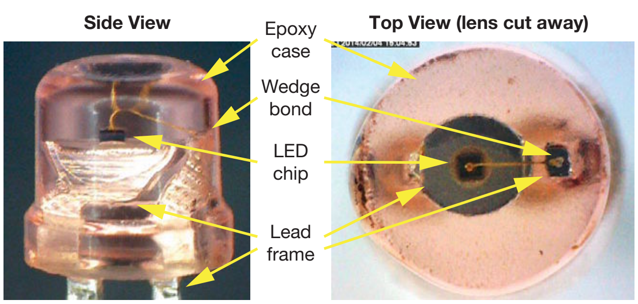

Fig. 1 - Overview Picture of the LEDs

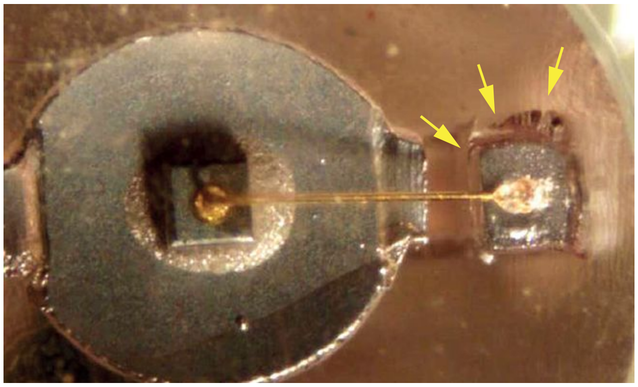

Fig. 2 - Detail View Showing Gaps and Cracks Around Leadframe Post, Indicated by Yellow Arrows

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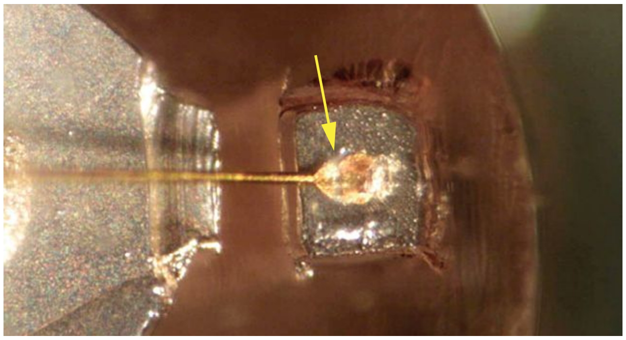

Fig. 3 - Detail View Showing Broken Wedge

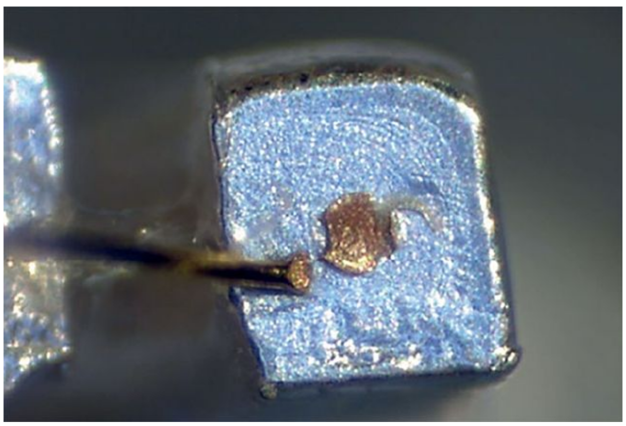

Fig. 4 - Another Example of Broken Wedge After Chemical De-Capsulation

This failure mode could cause immediate open rejects, intermittent behavior, or rather rarely, early fatigue break after some thermal cycles in less severe manifestation, where the bond wire is only pre-damaged after soldering.

ROOT CAUSES

In the example shown above, a plastic holder touching the lower rim of the epoxy case and additional crimping of the LED pins have been used to fix the LEDs on the PCB. Both a spring force applied by the plastic holder and a too-strong crimping of the LED pins contributed to the mechanical damages shown. Even if the maximum temperatures and timing of the soldering profile are within the allowed limits, the described mechanical forces could cause these failure modes.

Furthermore, considering the CTE = 13 ppm/K of steel as a typical lead frame material, an approximate elongation of $\Delta L = \alpha \times L \times \Delta T \approx 30\ \mu m$ happens per 10 mm lead length during the soldering process with 260 °C peak temperature. If the LED is rigidly fixed at the epoxy case by a stiff holder, a pull force occurs during the cooling-down phase while the slower responding epoxy is still in a soft stage.

Further signs of damage could sometimes be observed in the form of cracks at the rim of the epoxy case, at the entry point of the leads into the epoxy case, and as bulging or cracks at points with small wall thickness of the epoxy case.

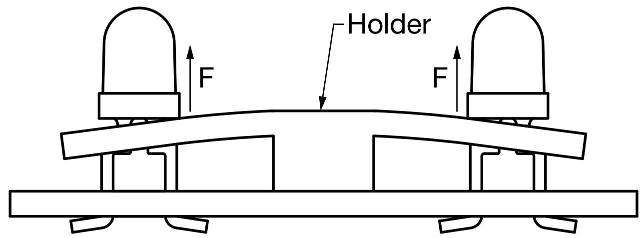

Fig. 5 - Very Critical Holder Design Applying Mechanical Spring Forces to the LEDs

PROCESSING INSTRUCTIONS

The following recommendations should be considered to prevent the LEDs from mechanical stress:

TABLE 1 - RECOMMENDATIONS FOR LED FORMING AND MOUNTING

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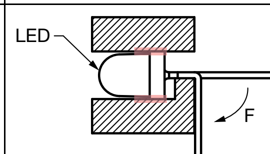
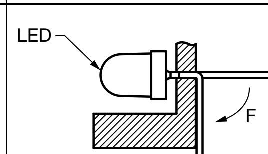
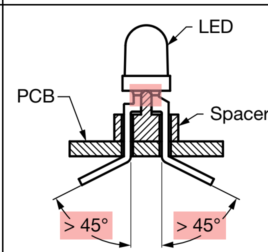
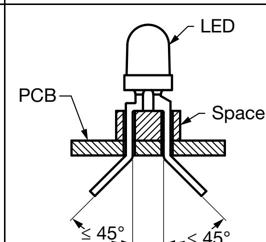
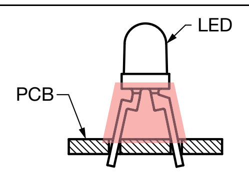
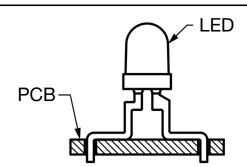
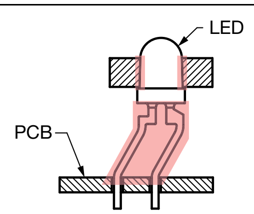
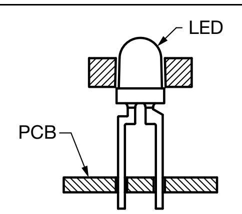
a)		
b)		
c)		
d)		

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1. During cutting and lead forming, mechanical force must not be applied to the epoxy case. Suitable measures for strain relief have to be taken (Table 1, a):
   - Do not stress the LED case during lead forming. Use a bending tool, which securely holds the leads at their upper position without touching the epoxy case, so that no force will be transmitted to the epoxy case
   - Minimum 2 mm clearance between the epoxy case and bending point
   - Lead forming has to be done prior to soldering
   - Do not bend the leads more than twice at the same point
2. Generally, do not apply excessive force to the LEDs and allow cooling down of the LED below 50 °C before applying any force from outside
3. The distance between the lower epoxy rim and the closest solder point should be > 2 mm
4. A direct touch down of the epoxy case to the PCB should be avoided
5. The LED pins must be inserted mechanically tension-free into the solder holes (Table 1, a to d)
6. The mounting hole pitch must match the lead pitch of the LED. A proper lead forming according to item “1.” may be done to meet this requirement (Table 1, c)
7. Pressure from the top or sides must not be applied to the LED during the whole soldering process, including the cooling-down phase
8. Holders must not create a stiff connection between the epoxy case and PCB, nor apply any spring force to the LED. Component covers or holders must leave some clearance to the epoxy case to avoid stress on the LED (Table 1, b)
9. Crimping should be avoided, or if it is really mandatory, the LED should still have a little clearance so that it could be slightly moved after crimping. The crimping angle should not exceed 45° (Table 1, b)

For further instructions, soldering methods, temperature profiles, and maximum ratings, please refer to individual datasheets and assembly instructions: www.vishay.com/doc?80092

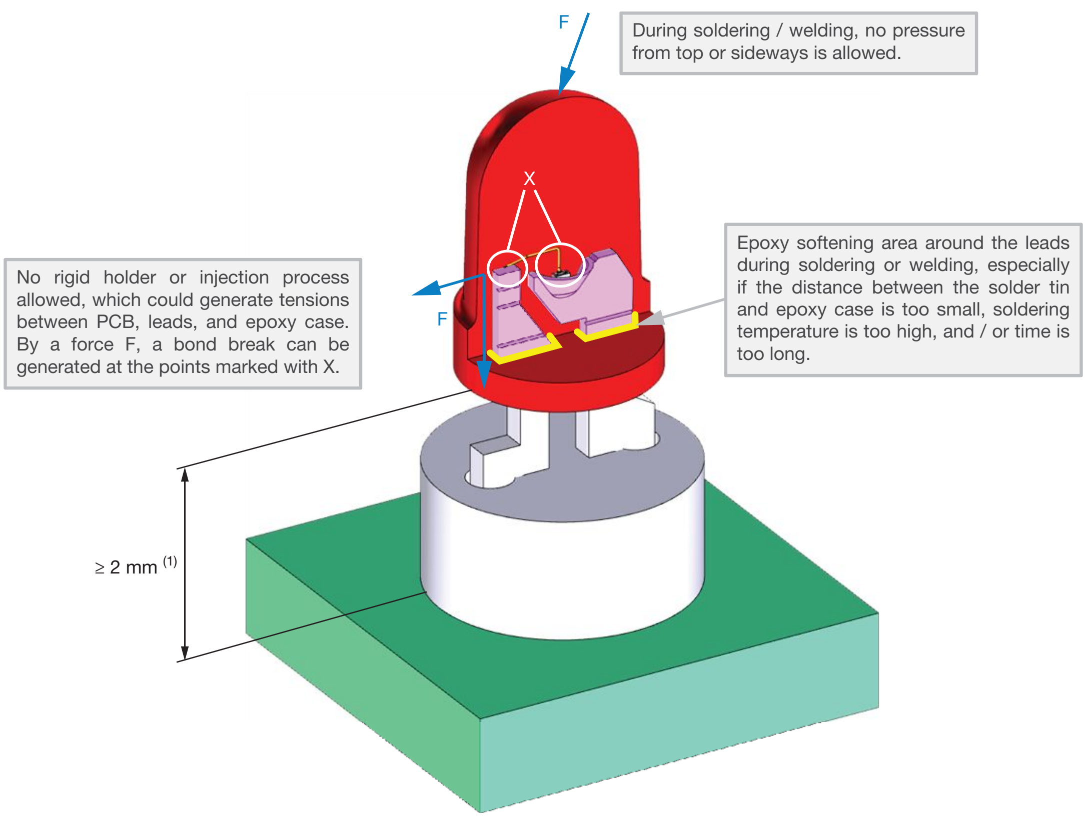

Fig. 6 - Basic Illustration of the Effects

Note

(1) If soldering distance is < 2 mm there is an increased risk to melt / delaminate the castingresin around the connections. Especially in theareas X, the bond connection can be impaired