3 Dimensional Automotive Lamp using SMT LEDs on flex board with Aluminum

Application Note

Introduction

In the automotive sector, the design and implementation of three-dimensional lamps presents a challenge. It is relatively easy to produce a flat, two-dimensional circuit board populated with LED components in which the optics (reflector and glass) match the appearance of the automobile. However, the increased use of free-formed, curved geometry in the design of car bodies necessitates new construction methods for such lamps.

2D Lamp Units

Figure 1 shows the implementation of a 2D lamp unit with SMD (Surface Mounted Device) components. The populated board and corresponding optics are placed in the housing. The optics is exactly aligned to the LEDs by means of centering pins. The driver interface is mounted on the back side of the lamp housing. Finally, the pillow lenses are placed into position, and the driver circuitry is encased.

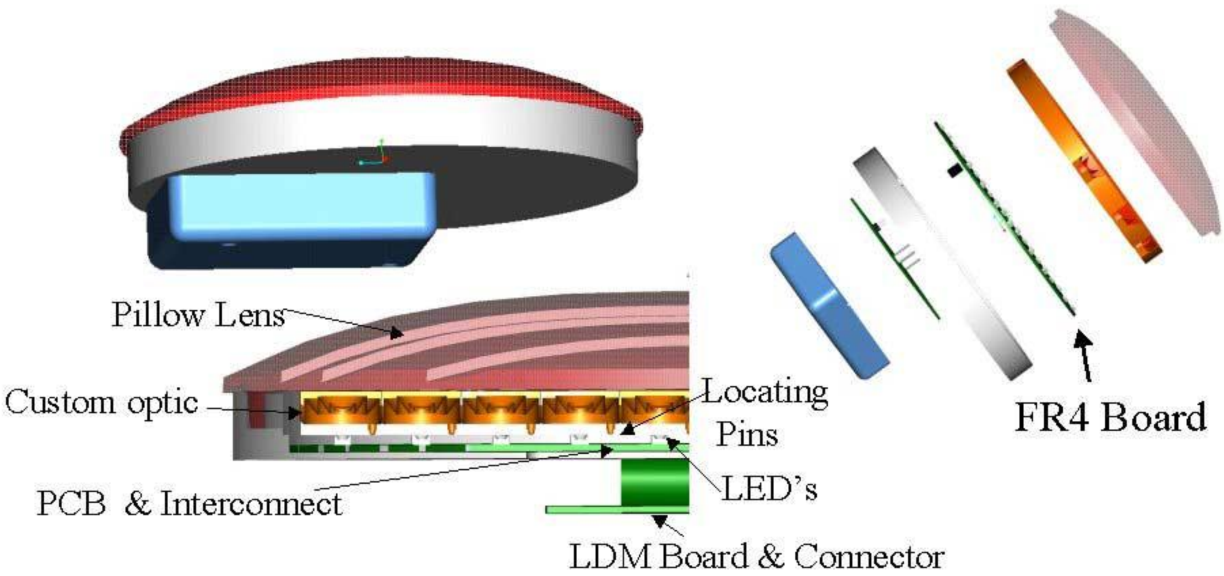

Figure 1: 2D lamp units with SMT components on FR4 printed circuit board material

3D Lamp Design Requirements

Design

In practice, the wishes and dreams of designers are often impractical to implement from a functional and economical standpoint. The complex, free-form geometry of the car body makes integration of the lamps difficult.

Legal Regulations

The color and brightness of emitted light are prescribed by underlying ECE and SAE regulations. The light must be emitted within a defined direction in space. For taillights, the direction is opposite of the direction of travel.

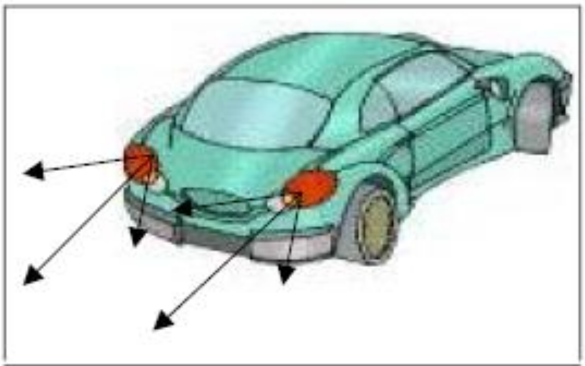

Figure 2: Emission direction of taillights

The design requirements on the one hand, and the legal regulations on the other, often do not permit the construction of a 2D lamp unit.

In practice, the designer has the challenge of designing a lamp with the given optics (Fig. 4 and 5) and the volume which is constrained by the back side of the unit (Fig. 6). This requires in most cases a stepped placement of the LEDs.

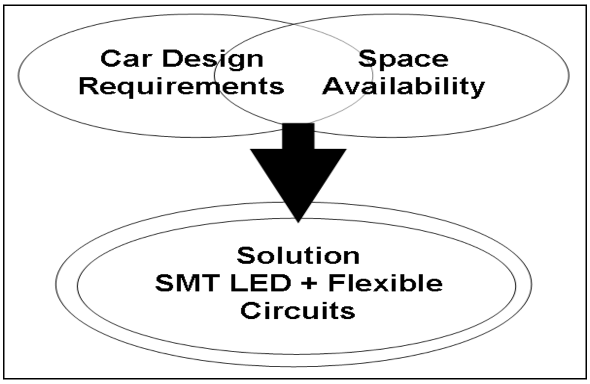

Figure 3: Decision making

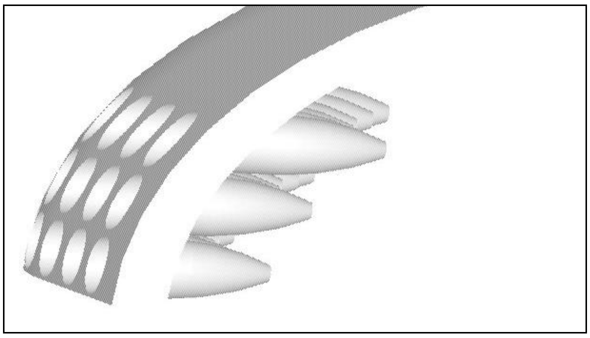

Figure 4: Optics, side view

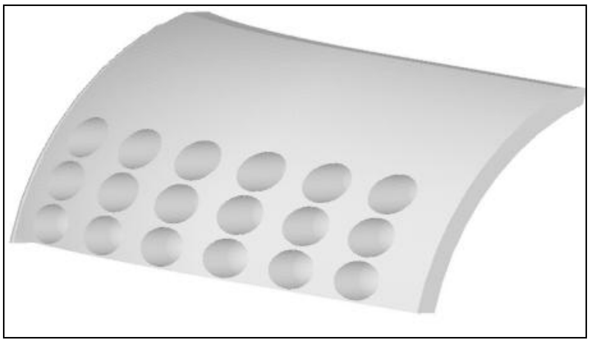

Figure 5: Optics, front view

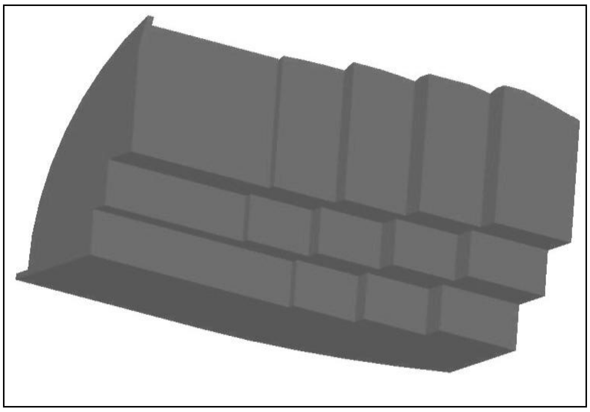

Figure 6: Back side of the lamp housing

What is Flex board on Aluminum?

Flex board is a flexible one- or two-sided circuit board material onto which one or more copper layers are added. This approx. 0.1 mm thick flex board is laminated to the aluminum surface using a PSA (Pressure Sensitive Adhesive). In this state, the flex board is stable, provides optimal thermal contact, and can be securely fastened. The circuit board material is ideally suited for use with SMD components (Surface Mounted Devices).

The following factors determine or influence the lamp design:

Available Space

At the present, most rear lights use incandescent bulbs. These are relatively deep, and penetrate far into the car body, due to the reflector optics. Through the use of LEDs, rear lights can be designed to be considerably thinner, so that a large recess is not required in the car body or trunk area, which in turn improves the stability and acoustics of the car body.

Position of the LEDs

The position of the LEDs is dependent on the size of the surface to be illuminated, the optics used, and the function of the lamp (rear lights, reverse lights, brake lights, turn signals, fog lights etc.).

Optics

The installation can include reflectors and beam or lens optics which can also be combined together.

Number of LEDs

The number of LEDs required is dependent on the LED type, the size of the area to be illuminated, the additional optics, and the function of the lamp (rear lights, reverse lights, brake lights, turn signals, fog lights etc.).

Specification, Appearance

The emission characteristics, brightness, color and size are given within the framework of the SAE and ECE specifications.

Advantages of Flex on Aluminum for the Implementation of Rear Lights

With the Flex on Aluminum concept, an aluminum panel is prepunched over approx. 70% of its surface (see Fig. 7). Due to the high stability, the flex board can be laminated to the surface (see Fig. 8), and SMD components can be exactly – see at tolerance description - positioned with standard high speed SMD mounting machines (see Fig. 9). Secure handling during production and transport are guaranteed. By means of sequential punching of the location holes for the layout of the LEDs, the production tolerances are kept to a minimum, which prevents an accumulation of tolerances between components. After the stamping process, the prepunched aluminum is placed together with the plastic carrier to form a secure and convenient assembly (see Figs. 10, 11 and 12). The individual LED modules are then fixed to the carrier (see Fig. 13) such that after assembly, the center of the optical axis of the LED coincides with the center of the reflector geometry (see Fig. 15). Thus, problems due to vibrations are eliminated. The plastic carrier centers the reflectors, resulting in an optimal arrangement of the lighting components. The finished lighting unit is then placed in the lamp housing (see Fig. 14).

Production Procedure

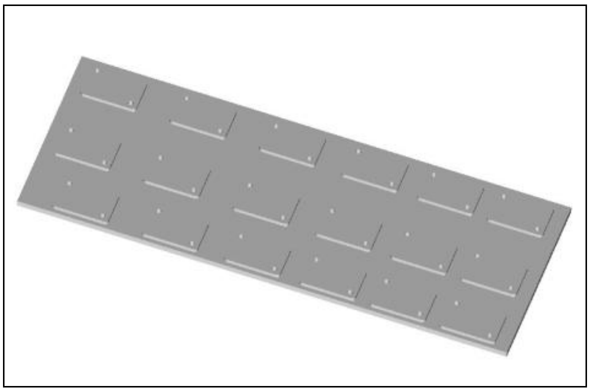

Figure 7: The prepunched aluminum panel

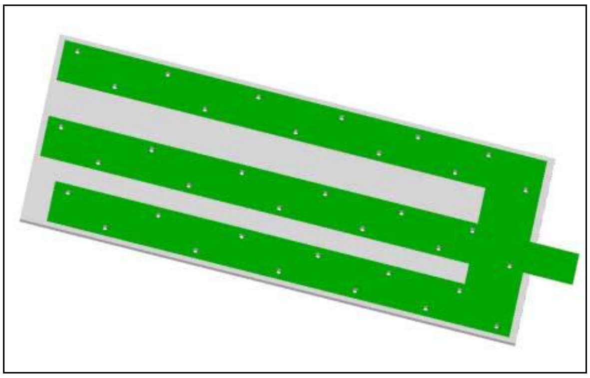

Figure 8: The flex board to be attached to the prepunched panel

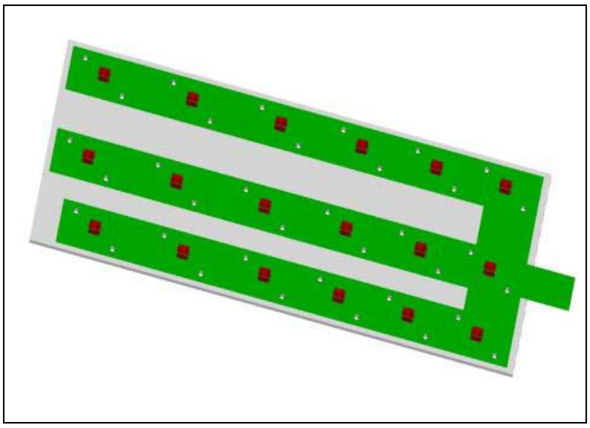

Figure 9: The SMD components are populated on the flex board

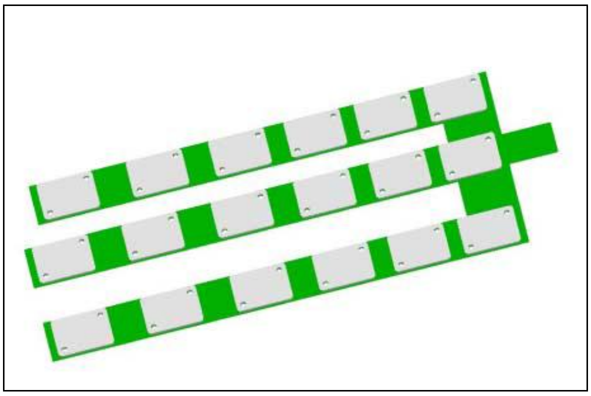

Figure 10: The backside of the punchedout flex board

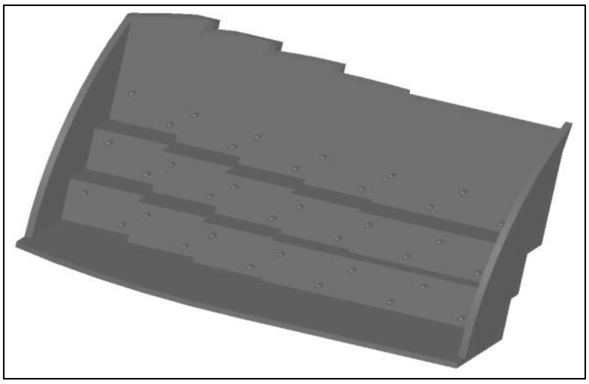

Figure 11: The plastic carrier with pins for alignment and caulking

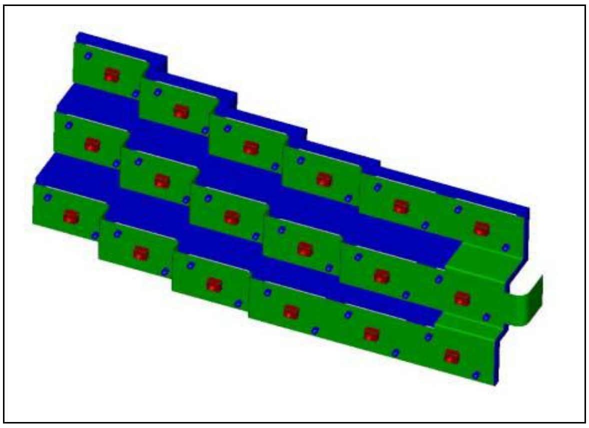

Figure 12: The assembly in which each LED segment is separately mounted on the alignment pins of the plastic carrier

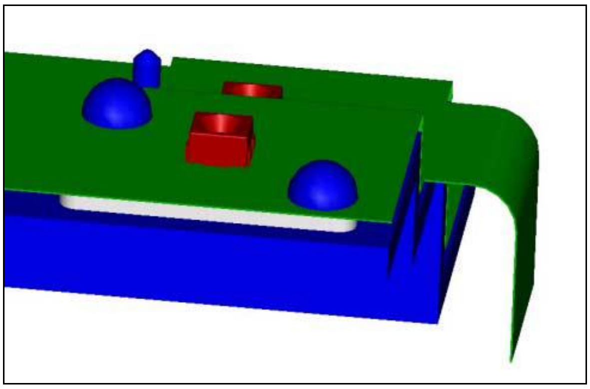

Figure 13: Two remodeled pins which hold the LED segment in place

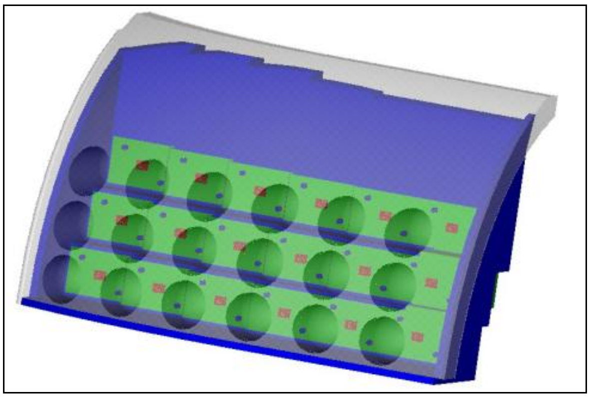

Figure 14: The completely assembled module

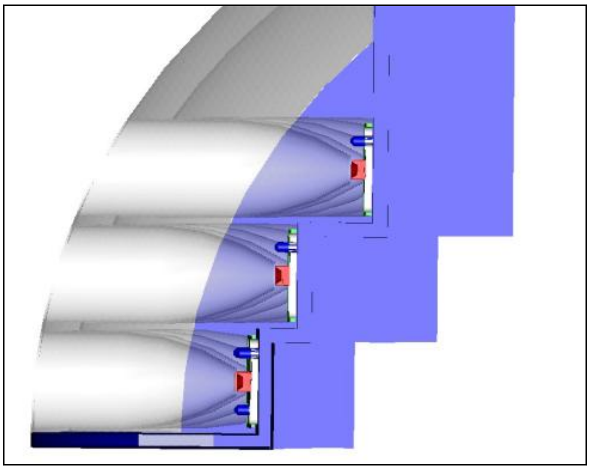

Figure 15: The position of the LED relative to the reflector

Tolerance Description

The target is to avoid a big summary of tolerances over the complete length of the module. The best way for realization is a sequential production of the alignments and assembly at each LED position.

Following components are base for the calculation of the tolerances.

Flex board manufacturing	0.05 mm
Flex - alu lamination	0.1 mm
LED assembly	0.1 mm
PCB assembly to support	0.1 mm
Total Tolerance Sum	0.38 mm

Statistical Tolerance Sum ± 0.18 mm

Assembly tolerances (worst case)

Statistic overall tolerance (+/-):

$$\Delta = \sqrt{0.1^2 + 0.05^2 + 0.1^2 + 0.1^2} = 0.18mm$$

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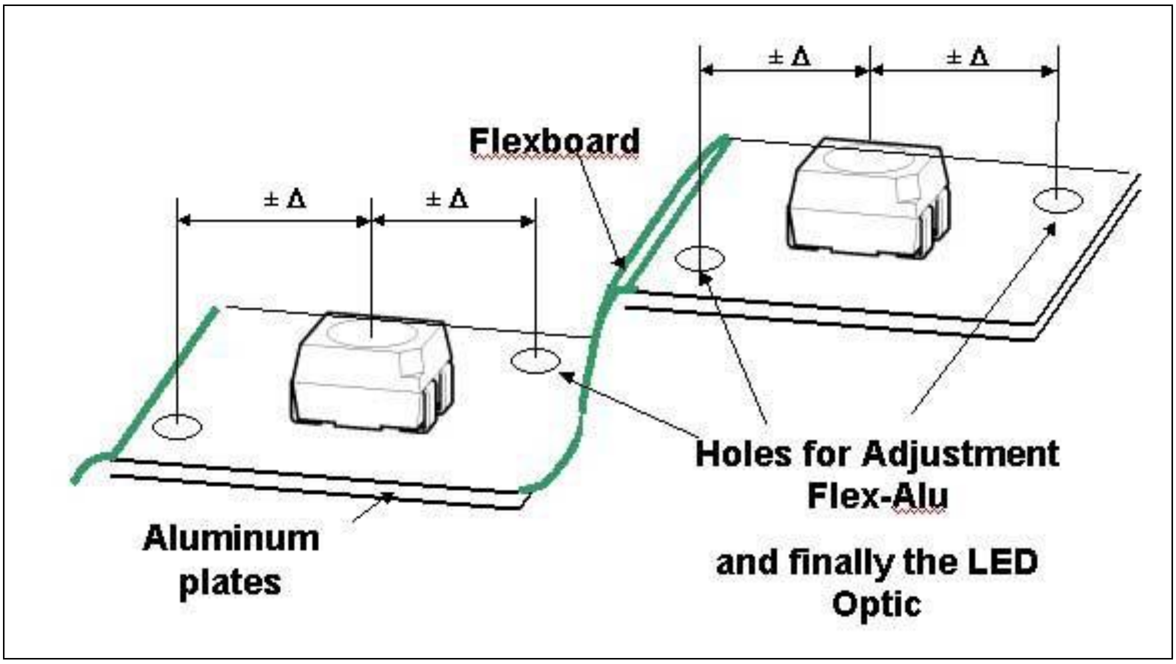

Figure 16: Schematic of tolerances

Tolerances X, Y(+/-):

LED assembly	0.1 mm
Flexboard hole stamping	0.05 mm
Flex-Alu lamination	0.1 mm
Plastic carrier assembly	0.1 mm

Tolerances Z (+/-):

LED assembly	0.1 mm
Flexboard:	0.02 mm
Flex-Alu lamination	0.05 mm
Plastic carrier assembly	0.1 mm

Statistic overall tolerance Z (+/-):

Δ_z = 0.18 mm

The tolerances of the plastic carrier are not considered in this calculation, since these are dependent on the production quality of the lamp manufacturer. The optics are then centered on the populated plastic carrier.

LEDs useable for RCLs (Rear Combination Lamps)

TOPLED (Lx Txxx)

Power-TOPLED (Lx Exxx)

Advanced Power-TOPLED (Lx Gxxx)

Golden Dragon (Lx Wxxx)

Detailed information about the LEDs can be obtained from the data sheets in the Internet at www.osram-os.com, or from the short form catalog.

Summary

Flexible circuit boards are ideal for use in three-dimensional designs because:

- Sequential production of the centering holes in the aluminum along with the layout of the flex board and the LEDs allows the tolerances for each LED position to be kept to a minimum.
- Additional SMD components such as SMD resistors can also be mounted on the flex board.
- The flexible connection between the laminated circuit board on the aluminum surface allows precise placement of the LEDs in contrast to a rigid punched or preformed metal frame.
- If layout changes are required, flex board is considerably cheaper to modify than punched metal grids.
- With flex boards laminated on aluminum, secure transport and handling are guaranteed.
- Standard technology methods are used in the manufacture of such modules.
- Caulking fixes the segments of the flex boards securely in order to prevent problems due to vibration.
- The aluminum surface under the flex board adds stability and provides the best possible thermal connection.

- Depending on the application, LED strings or matrix combinations could be employed. According to the layout, these can be integrated in the flex board or connected externally.

- This printed circuit board technology has been established in automobile production, e.g. in engine and transmission manufacturing, dashboard design and several rear combination lamps.

This concept illustrates the significant advantages in the design of rear lighting, unifying the requirements of design and technology. The high precision in positioning, the stable manufacturing process, the minimal space required by LEDs mounted on the flexible printed circuit board and high quality of OSRAM LEDs form the basis of the production process.

Appendix

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Don't forget: LED Light for you is your place to be whenever you are looking for information or worldwide partners for your LED Lighting project.

www.ledlightforyou.com

Author: Michael Sailer

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