

Surface Mount LEDs - Applications

Application Note

Introduction

SMT Replaces Through Hole Technology

The use of SMT-TOPLED varies greatly from the use of traditional through hole LEDs. Historically through hole LEDs have been incorporated directly into front panels using the leads as a stand off (Figure 1). Due to the automated nature of SMT assembly, and the size constraints of SMT component and assemblies, SMT-TOPLED applications are different from through hole applications. For SMT applications the LED is often 10 mm or more from the front panel (Figure 2). Employing light guides can create the optimum display to the final viewer. Because of the size and radiation pattern of the Osram Opto Semiconductor SMT-TOPLED the final light emitting surfaces can be created in almost any shape. Lenses can also be combined with SMT-TOPLED. Because of the uniform repeatable radiation pattern, the lens design can be matched to the exact customer requirements. Additional applications include backlighting of symbols and liquid crystal displays.

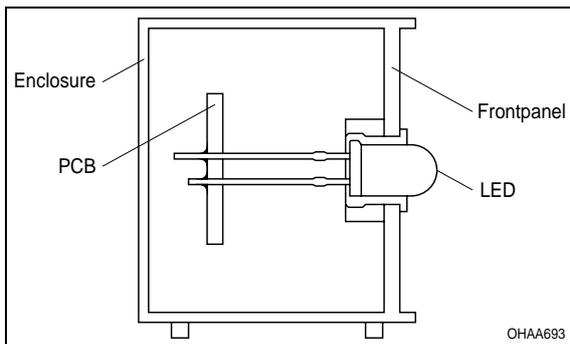


Figure 1. - Typical through hole LED mounting

Applications

Of course the simplest way of using SMT-TOPLED is in a direct view application.

Efficient optical design ensures that further optics are not required. Direct view applications include simple displays and moving message boards. Figure 3 and Figure 4 show these examples.

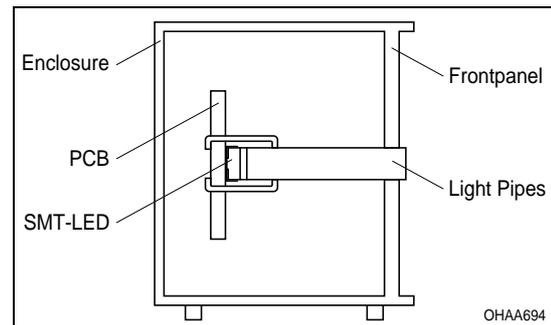


Figure 2. - SMT-TOPLED with light guide to frontpanel

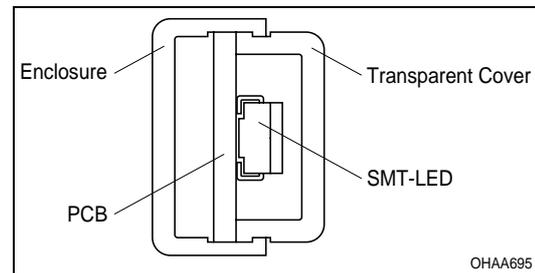


Figure 3. - Direct view application of SMT-TOPLED

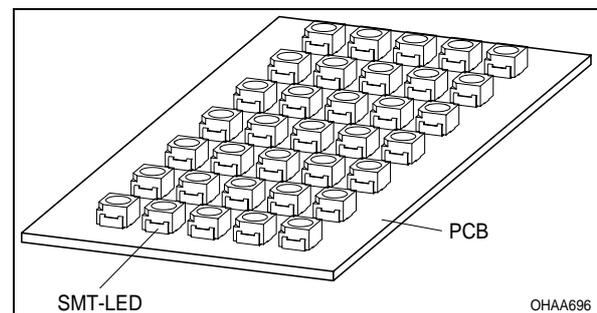


Figure 4. - Moving message board with SMT-TOPLED

In direct view applications, the following features are of particular advantage:

- Defined, rounded light emitting area
- Uniform illumination
- Large, uniform radiation pattern
- Due to the package design, the performance of the package is very robust
- Misplacement and tilting will not adversely affect the optical performance.

All these applications are addressed with the same SMT-TOPLED design. For the user this means simplified design and standardised assembly. This improved optical design freedom is an additional benefit of SMT-TOPLED.

Light Guides

A major application of SMT-TOPLED will be with light guides. Figure 5 shows some possible designs. By using light guides, the distances between boards and front panels can be bridged and almost any luminous area or picture can be produced. The light emitted from a light guide does not need to be directly above the SMT-TOPLED. By making use of the critical angle of an optical system, (based on total internal reflection), or with mirrored reflectors, the light can be deflected to any angle with only minimal losses. Figure 6 illustrates one example.

Multi Color Light Guides

By coupling LEDs of different wavelengths (colors) into the same light guide it is possible to have either multicolor capability, or new colors formed by the combination of the existing colors (Figure 7). Bridging the distance between PC boards and front panels by an electrically non conducting light guide automatically produces protection for electronics against ESD.

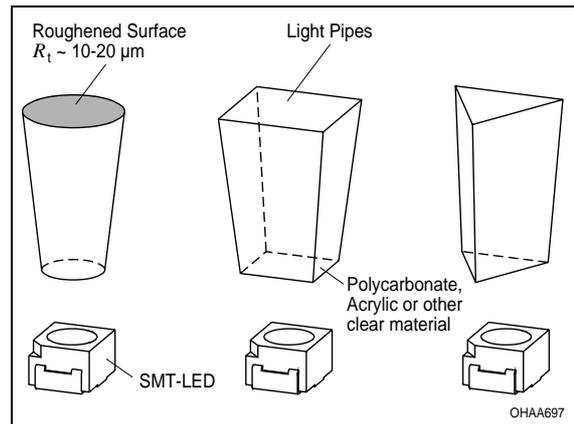


Figure 5. - Light guides used in conjunction with SMT-TOPLED

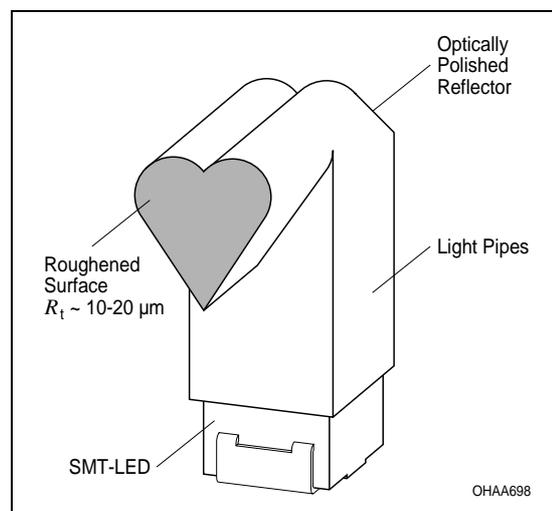


Figure 6. - Right angle light guide

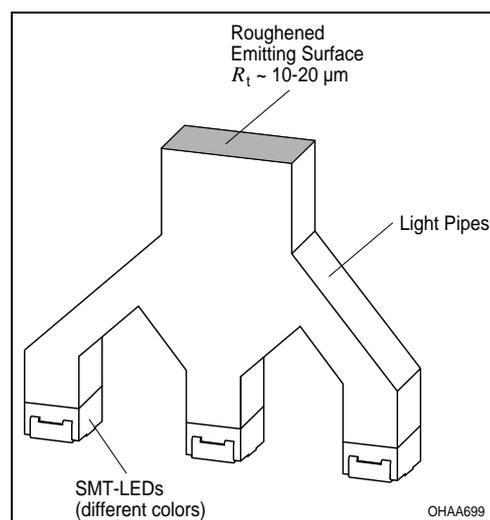


Figure 7. - Light guide used to form a multicolor indicator

Backlighting

Backlighting of legends and LCDs is a major application possibility for SMT-TOPLEDs. There are three ways of getting the light from the LED to the backlighting area.

- Direct use of SMT-TOPLED
- Incorporating reflectors
- Incorporating large area light guides

Direct use is appropriate for low total height applications such as membrane keyboards. Because of the uniform, wide emission angle, surfaces with heights of 2 to 3 mm can be illuminated uniformly without any additional measures (Figure 8).

If more height is available or required and larger surfaces are to be illuminated, such as car dashboards, the SMT-TOPLED

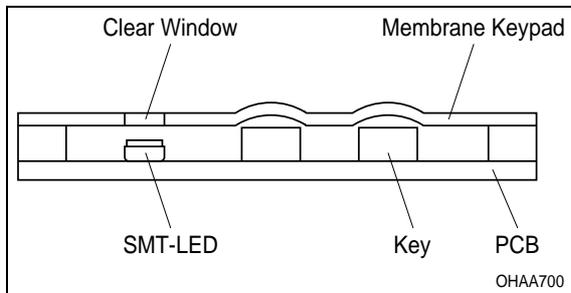


Figure 8. - LED behind membrane keypad

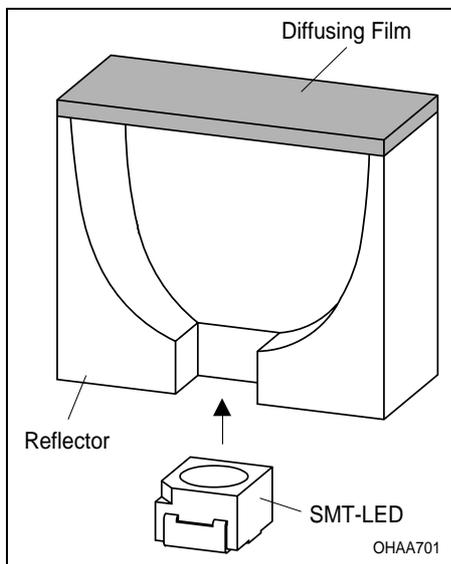


Figure 9. - SMT-TOPLED TM illuminating a reflecting cavity

can be combined with external reflectors. In this way both single leg-ends (Figure 9) and surfaces of any size can be backlit brightly and uniformly (Figure 10). A reflector/SMT-TOPLED combination is advantageous for backlighting positive and negative LCDs as sufficient brightness is produced with only a few LEDs. If the assembly does not leave space for an external reflector, legends and LCDs can be backlit with flat light guides. In this way it is possible to produce backlit units of only a few mm height. Figure 11 illustrates backlighting for a LCD display where the LCD is at a right angle to the LED board.

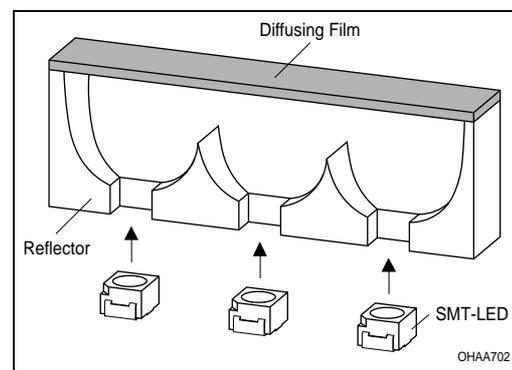


Figure 10. - SMT-TOPLED illuminating a large area

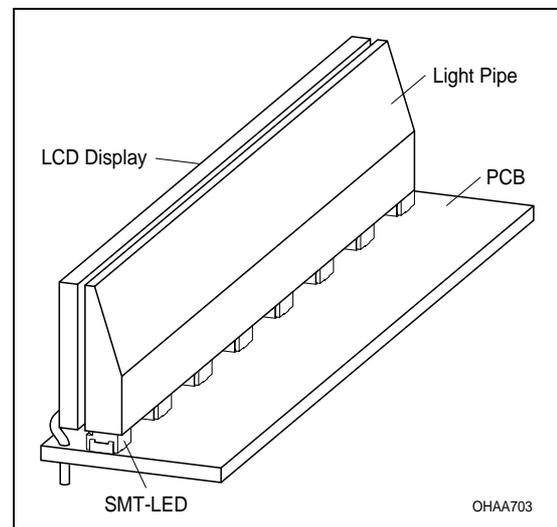


Figure 11. - LEDs backlighting an LCD display with a right angle light guide

Figure 12 and Figure 13 outline locations in which the LCD is parallel to the LEDs. In

Figure 13 the light couples into the light guide on both sides to increase brightness or illuminate a large area.

Lenses

The common through hole LED standards of 3 mm and 5 mm diameter emit light through a lens integrated into the package. Different radiation patterns are produced depending on the die and lens spacing and the shape of the lens. With straight forward design lenses can be produced to couple with the SMT-TOPLED to emit light at any required angle or pattern (Figure 14). Using an external lens can change both the on axis intensity and the viewing angle. For example, it is possible to change the typical light output from an Iv of 6 mcd and a viewing angle to 120 degrees to an Iv of 18 mcd and a viewing angle of 60 degrees, or even to an Iv of 40 mcd with a viewing angle of 30 degrees (Figure 15 and Figure 16). Exercise proper care in the design of the light guides for optimum coupling of the light emitted by the SMT-TOPLED to the final viewer. Tests have shown that with proper design and care more than 90% of the light can be transmitted by the light guide.

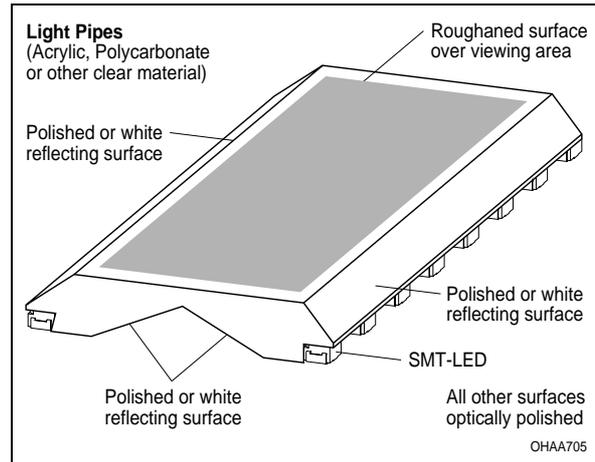


Figure 13. - Improved brightness for LCD backlighting

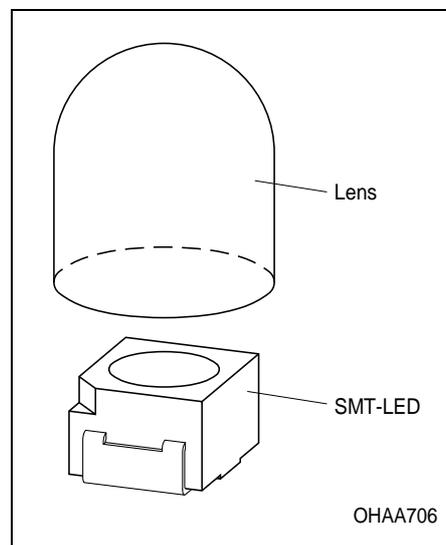


Figure 14. - LED with lens

The design guidelines for light guides are covered in a seperate application notes, "Light Guides" from Osram Opto Semiconductors. Furthermore Osram Opto Semiconductors is designing and producing lights guides on customer request. Clarification of the optical and electrical needs for each application are the first step in the support process.

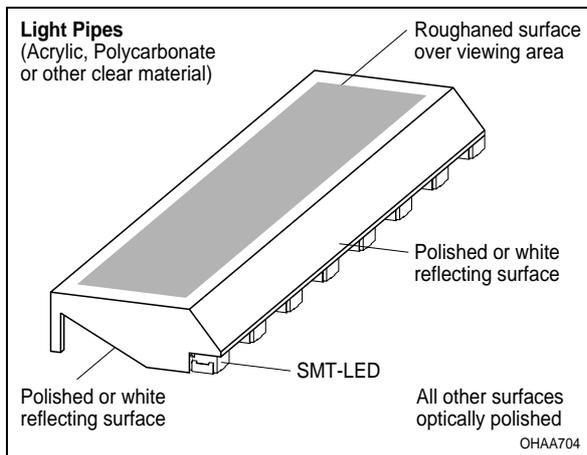


Figure 12. - LCD backlighting configuration

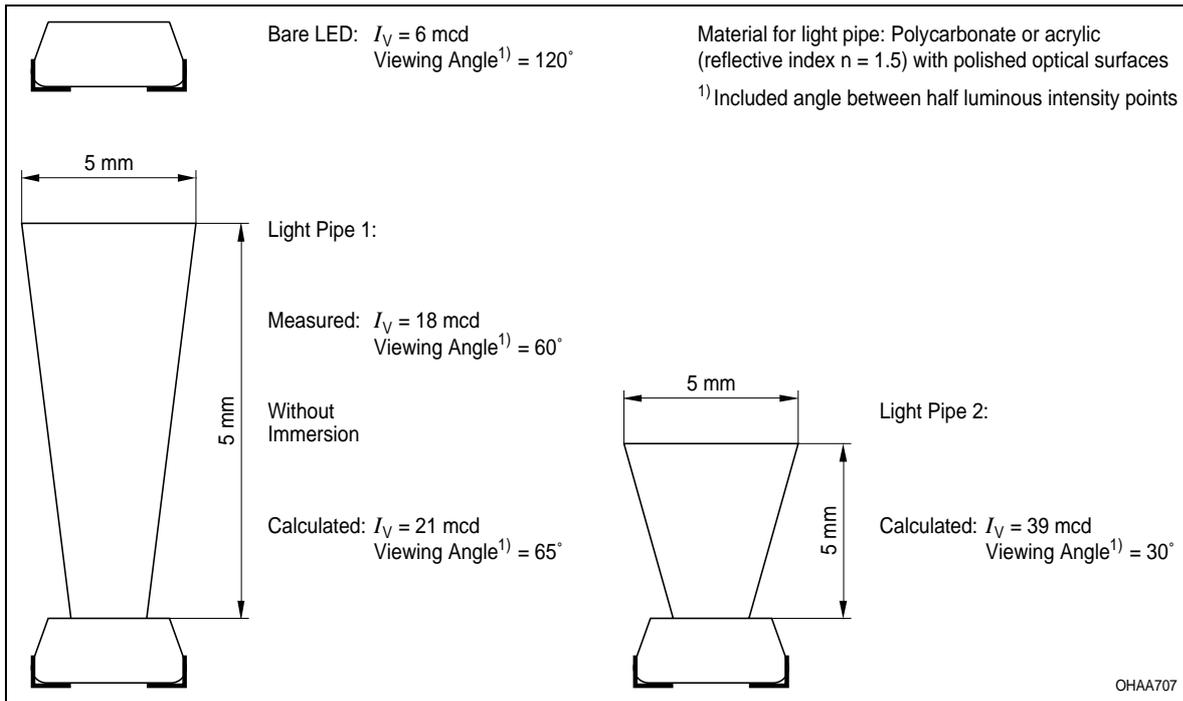


Figure 15. - Different light guide configurations

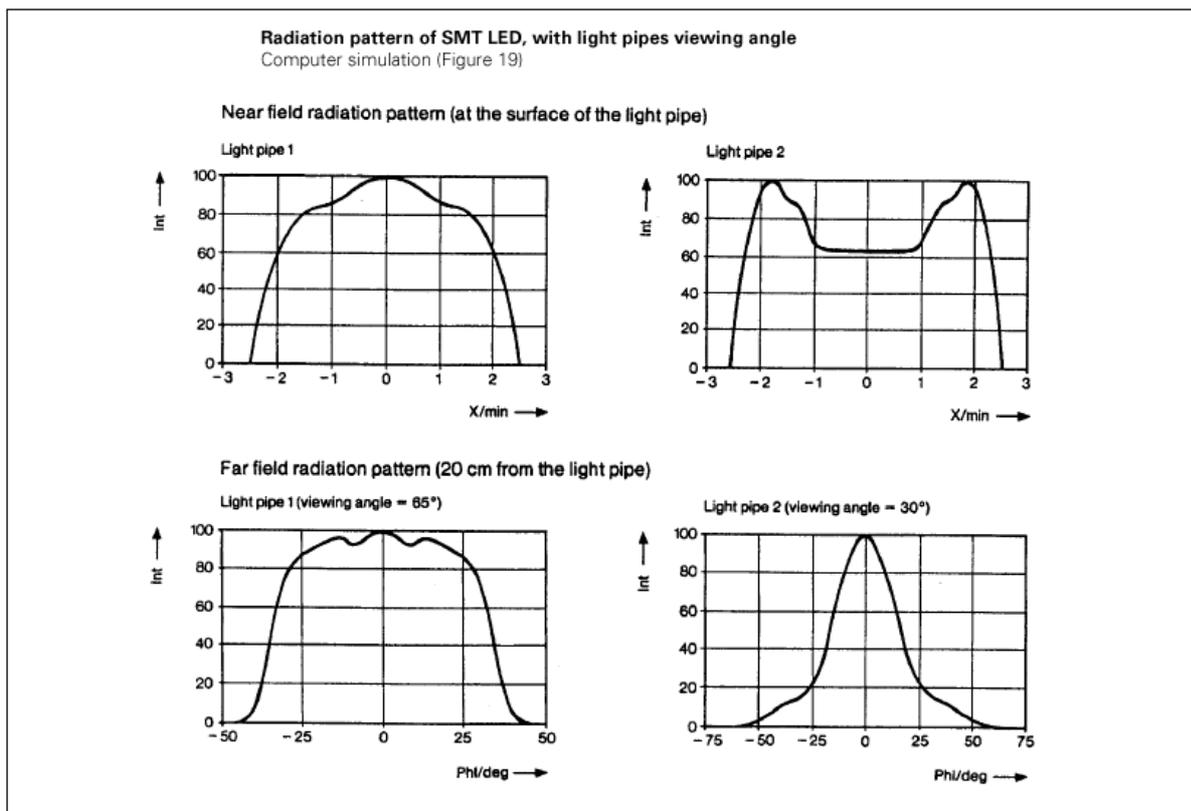


Figure 16. - Computer simulation of radiation patterns of SMT-TOPLED TM with light guides

Designing with Surface Mount LEDs

The evolution from through hole technology to SMT demands surface mount optoelectronic components. Osram Opto Semiconductors has addressed this need by creating a SMT standard for LEDs. The advantages to the user of using SMT-TOPLED are many:

- Lower PC board costs: reduced area, less drilling, fewer plated through holes
- Quality, time and cost improvement through automatic placement
- Components packaged in standard tape and reel
- Standard package allows for ease of landing pad design
- Low component height compared to through hole
- Uniformly placed components
- Uniform soldering techniques
- Improvement in reliability
- More flexibility during assembly
- Assembly processes compatible with active and passive components

SMT LED Design

Figure 17 shows a cross sectional view of the SMT-TOPLED. High temperature thermoplastic is insert molded around a continuously stamped lead frame. Selection criteria for the plastic material included mechanical and thermal characteristics, and its high value of diffuse reflectance (90% efficient). Optical characteristics were achieved by reflector cavity geometry and the material features. A semiconductor die is placed in the prefabricated lead-frame/molding assembly. An epoxy resin is used to improve the light output coupling, and seals the reflector cavity for environmental protection. The resin and the package materials were carefully matched to minimize mechanical and thermal stresses during soldering.

SMT Compatibility

Due to the specific and standardized assembly techniques that evolved in SMT, the following list of requirements are essential for a true SMT-TOPLED.

Pick and Place

- Flat surfaces on LED package
- Tight package tolerances
- Standard dimensions for automation
- Standard tape and reel sizes
- Standard lead bends and finishes

Traditional through hole LEDs lack many if not all of these features. Careful engineering and cooperation with standard setting organizations assures that all of these requirements are met.

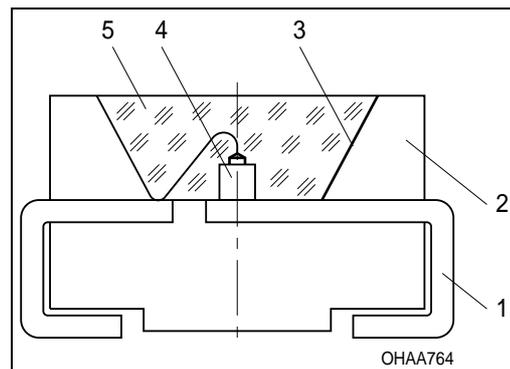


Figure 17. - SMT-TOPLED cross section

Soldering

- Infrared Reflow (IR)
- Vapor Phase Reflow (VP)
- Through the Wave Soldering
- (TTW) Solder finished leads for soldering processes
- Standard Landing Pads

Characterization of these processes insured an LED designed to withstand the specific mechanical, thermal, and chemical extremes of each.

Cleaning

- Ethyl Alcohol
- Isopropyl Alcohol
- Aqueous Cleaning solutions
- Solvent Cleaning solutions

Aqueous and organic solvents containing alcohol are suitable for cleaning soldered components to remove the remaining soldering flux. Due to environmental concerns and possible negative effects on the LED package do not use chlorinated hydrocarbons, fluoridated hydrocarbons, and ketones.

Optics

- Rounded emitting area
- High on axis intensity
- Wide viewing angle
- Compatible with external optical systems
- Compatible with light guides
- Suitable for backlighting: legends or LCDs

Osram Opto Semiconductors is producing for more than ten years SMT LEDs. All experience up to now have shown, that SMT LEDs allows designs with lower costs at higher quality.

Reliability

Incoming inspection of SMT-TOPLED supplied in tape and reel format is difficult for the user. This means that high quality must be assured at incoming inspection in the low parts per million (PPM) defective range. To ensure this the quality departments of the user and the supplier must have effective communication to monitor quality levels and concerns.

Osram Opto Semiconductor SMT-TOPLED Solution

Figure 18 shows the design of SMT-TOPLED in a form that matches the dimension of Tantalum B molded capacitor. This is from the IEC publication 286 part 3, and from EIA standard IS28.

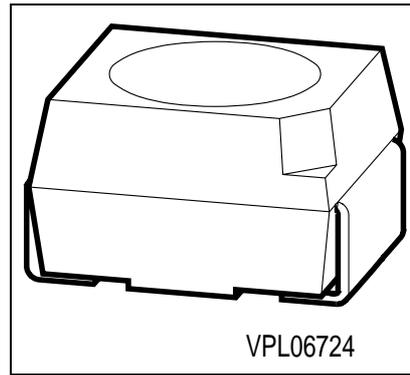


Figure 18. Package drawing of SMT-TOPLED

Features

- EIA and IEC Standard Package
- Standard Lead Bend and Footprint
- Cathode Identification
- Flat top and sides for Pick and Place Compatibility
- High Temperature Thermoplastic Housing for SMT soldering
- Nonimaging Optical Design for High Intensity Light

SMT-TOPLED Manufacturing

A stable, controlled manufacturing line helps to assure quality (Figure 19). The SMT-TOPLED manufacturing line incorporates the latest semiconductor assembly equipment in a "hands off" environment for process quality and repeatability. Decisions which affect quality are made based on statistical data and process capability data. The use of extensive automation eliminates the possibility of random uncontrolled failures in the process. From lead-frame manufacturing to final bagging, the SMT-TOPLED is never handled by human hands.

Quality and Reliability

With SMT comes a heightened need for quality and reliability. Cost and complexity of boards demand high yields in SMT assembly. To meet these yields effectively,

the components must exhibit outstanding initial quality and long term reliability.

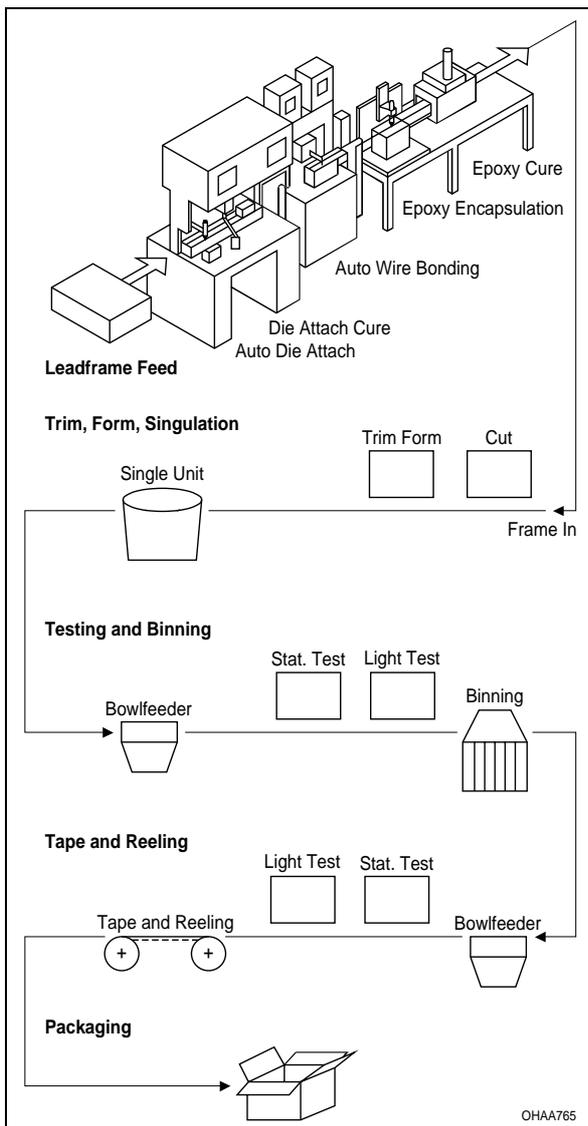


Figure 19. Manufacturing process flow

Performing stringent qualification testing by the component manufacturer ensures adherence to customers' strict requirements. Reliability qualification of the SMT-TOPLED includes preconditioning of the LEDs before testing. This consists of screen printing adhesive to the test boards, pick and placing the LEDs, and soldering the board through the intended soldering process. On completing preconditioning, the boards' reliability testing may begin. Figure 20

illustrates the qualification tests done on the SMT-TOPLED.

These tests simulate and accelerate actual user environments. Demanding qualification criteria used in testing assures LED users a guarantee for a product that will function after soldering and long into the future in the field.

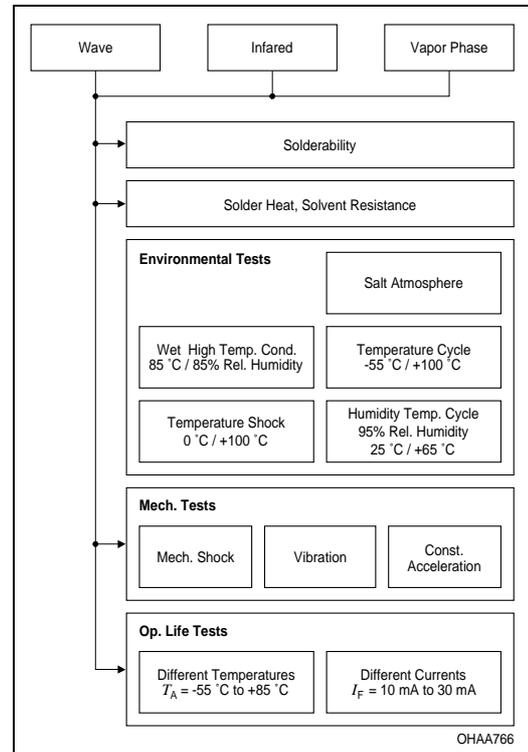


Figure 20. SMT-TOPLED qualification tests

Conclusion

Since the introduction of TOPLED SMT-LEDs, several package variations based on the described technology have been developed, to get the most valid product for a specific application.

Package families are:

- TOPLED
- MiniTOPLED
- SIDELED
- Power TOPLED
- Golden Dragon

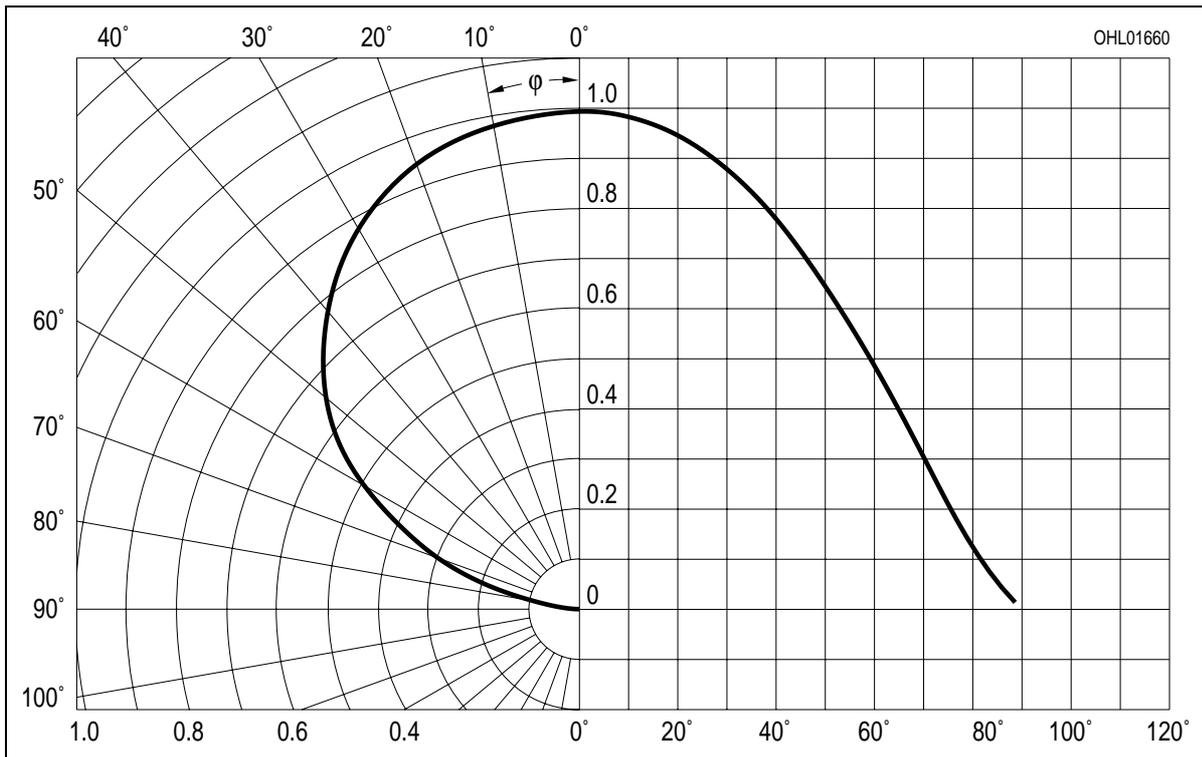


Figure 21. SMT-TOPLED TM radiation patterns

About Osram Opto Semiconductors

Osram Opto Semiconductors GmbH, Regensburg, is a wholly owned subsidiary of Osram, one of the world's three largest lamp manufacturers, and offers its customers a range of solutions based on semiconductor technology for lighting, sensor and visualisation applications. The company operates facilities in Regensburg (Germany), San José (USA) and Penang (Malaysia). Further information is available at www.osram-os.com.

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