Automotive Illumination: Making the Shift to LEDs

By Mike Wills, Automotive Business Development Manager, Optek Technology

From dome lights, to dashboard backlighting, to taillights and side markers, automotive interior and exterior lighting is rapidly shifting to the use of LEDs. In fact, some predict that it's a matter of time when most lights within automobiles will be replaced by LEDs, moving incandescent bulbs even closer to obsolescence. As with any major shift in technology, lighting manufacturers face several challenges, including managing the heat output of LEDs, reducing cost and meeting the style and lens requirements of automotive manufacturers.

There are a significant number of areas within and around the automobile that require illumination, for both functional and design purposes. Previously illuminated by fluorescent and traditional incandescent bulbs, the shift to the implementation of LEDs began several years ago when their many benefits began to be realized. With the exception of dome lights, tail lights and head lights, almost all other vehicle lighting, both interior and exterior, have already been converted to LEDs due to their higher efficacy, package size, color consistency and color variations, to name just a few benefits.

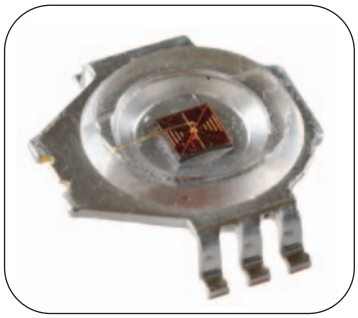

Figure 1. Optek Technology's 1 watt Optimal I package provides the light output, color variation and consistency required for many automotive applications

Dome lights and taillights are currently being converted to LEDs and the transition is expected to be complete in the next year or two. Headlights are still in progress, and the widespread implementation of LEDs in this application will not be completed until about the 2012/2013 timeframe. With all of the illumination changes being made, it's safe to say that incandescent bulbs will eventually become obsolete in automobiles.

On December 19, 2007, President Bush signed the Energy Independence and Security Act of 2007, part of which includes provisions to improve energy efficiency through lighting. According to the Lighting Controls Association, the bill details, among other things, a minimum color rendering index (CRI) for LEDs. Parallel with automotive, developments are being made in LED technology because of requirements such as those in the Energy Independence and Security Act. The automotive market will benefit from many of these developments, including higher light output, better color control and increased efficiency.

Although LEDs have higher efficacy, there are many other reasons OEMs are designing them into automobiles. Miniaturizing package size is instrumental in meeting design requirements for many applications. Automobile manufacturers have specific lens and style requirements for their brake lights, side markers and headlights. Because LEDs are so small, particularly when compared to halogen and incandescent, they can be placed close to the surface and don't need as much of a lens or depth behind the lens. Miniaturizing the package size affords designers of vehicles a tremendous amount of latitude with the design of lights within and around the vehicle.

This design flexibility plays a key role in the automobile's corporate brand image. The shape and size of specific elements of the car taillights, for example, are attributable to different automotive manufacturers. Without the size, positioning and overall flexibility of the LED, some design components may not be possible with the use of other lighting solutions. For example, incorporating turn signals into side mirrors, warning lights and blind spot radar system icons are so small that fluorescent and halogen lighting are typically not able to meet the design requirements in terms of size, color and power.

Figure 2. LEDs are being implemented into vehicles for turn signal and side marker illumination

The range of color options that an LED affords as compared to a fluorescent bulb is also an important element in a manufacturer's branding efforts. For example, one automotive manufacturer's signature color may be red while another's may be ice blue, regardless of the difference both colors are key components to each company's branding efforts. By replicating these colors within the vehicle either through backlighting, dashboard, switch and/or control lighting, the brand name is further reinforced. Specific color matching can be achieved through the use of LED components and arrays. With branding a key component to every automobile manufacturer's identity, LEDs play a significant role.

Lighting design engineers have encountered several challenges en route to replacing automotive lights with LED components and assemblies. In many applications, such as side markers, excess heat isn't an issue due to the power rating of the LED required. However, managing the heat output of some larger applications has proven to be a challenge. With exterior lighting, where the object of the LED is to illuminate rather than simply act as a marker, higher power LEDs are required, thus resulting in overheating concerns. While several thermal management solutions are available, most commonly used in automotive applications are aluminum based metal core boards.

Aluminum based metal core boards make it possible to mount LEDs directly to a heat spreader. The metal core material conducts heat to the chassis or heat sink that you attach the assembly, thereby improving thermal performance due to reduced thermal resistance.

The current through the LED determines how much heat is generated. High power LEDs require some assistance from a secondary heat dissipation system. It is common for the package to be mounted to some form of heat spreader, such as OptoTherm.

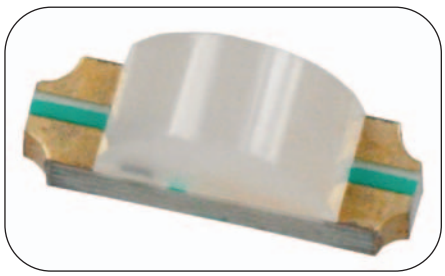

Figure 3. Optek's miniature surface mount RGB LED features top and side-view mounting options for dashboard and switch lighting

LEDs generate heat at an extremely high rate. The area of a chip that generates 1 watt of heat is about 1mm^2, making the heat generation rate 100 W/cm2. Although it is only 1 watt, the surface area that is available to conduct the heat away from the junction is also extremely small and is typically limited to the backside of the chip.

Over-temperature is the single greatest cause of LED failure. Most manufacturers of LED chips specify a maximum operating temperature for the junction region of about 130°C. This is an absolute maximum, and sustained operation near this value can cause reduced life. A more realistic design value to accommodate changes of ambient temperature is around 80°C, or a junction temperature 55°C hotter than 25°C ambient air.

In addition to heat management, keeping cost at a minimum is a concern with the shift to LEDs in automobiles, as it often is with many applications. While LEDs are more expensive than incandescent and fluorescent bulbs at the original purchase, their extended lifespan allows for significant cost savings over time. The LED will virtually never need to be changed throughout the lifespan of the vehicle. This eliminates not only bulb costs, but the cost to service the vehicle as well. LEDs are also more robust and therefore more capable of withstanding the vibration issues of a vehicle than incandescent and fluorescent bulbs. As LEDs increase in power and light output, many lighting designers are also reducing cost by reducing the number of LEDs used in each package, yet still meeting the power and brightness requirements.

Cost savings are further increased by lighting manufacturers who offer the complete LED subassembly, as opposed to just the component. Optek Technology, for example, designs and manufactures the entire light engine, consisting of the PC board, electronic circuitry, harnessing and optics, as well as thermal management materials when the application calls for it. OEMs save time and money by utilizing one supplier for all components of the lighting solution. Serving as a "one stop shop" for the customer allows the lighting designer to tailor the complete assembly to best meet the application requirements. Rather than adapting standard designs for each application, automotive manufacturers benefit most from lighting designers who are involved from initial design to end product and are capable of configuring a custom design for the complete lighting solution.

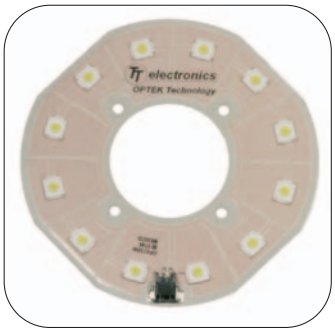

Figure 4. Optek's OptoTherm keeps LEDs below the maximum junction temperature, allowing LEDs to operate at the highest power required of the application

Although the current cost of an LED lighting solution is higher than that of an incandescent bulb and fixture, LEDs provide significantly longer life, meaning that LEDs will almost never need to be replaced, saving money in the long run. There are also advantages in miniaturization, performance and brand styling with LEDs, benefits not attributable to other lighting solutions. As LED technology evolves, LEDs will continue to be designed into more and more automobile applications.

Mike Wills joined Optek in 2005 as the Automotive Business Development Manager. Prior to Optek, Mike worked for CTS Corporation for 9 years in a variety of roles. He spent 4 years at Johnson Controls Inc. as a Project and Sales Engineer along with 4 years at NSK as a Manufacturing Engineer. Mike received his BSME from the University of Toledo. He can be reached at mwills@optekinc.com.