Current and future projection of edge-lit LED panel adoption in lighting

By Brett Shriver, Vice President, Sales & Marketing
Global Lighting Technologies, Inc., Brecksville, OH, USA

Abstract
Edge-lit lightguides utilizing high efficiency LEDs are becoming widely adopted within the lighting industry due to their ability to manipulate and efficiently distribute the light from LED light sources in the direction and distribution desired by the lighting engineer

Author Keywords
Edge-lit; Lightguide; Light Guide Panel (LGP); Light Guide Plate (LGP); backlight

1. Introduction

As lighting manufacturers continue to utilize the benefits of LED lighting within the construction of their fixtures, the designers must find ways to distribute this light in an efficient and esthetically pleasing method. One of the technologies being adopted in performing this function is the light guide plate (LGP) also referred to as a lightguide. LGPs have been used for over a decade in the illumination of liquid crystal displays (LCDs), and as a result are a very developed product in the market with a strong supply base. LCD suppliers utilize the ability of the LGP to uniformly and efficiently distribute the light from a limited number of LED sources over the back surface area of their product. Quality LGPs allow the end user to experience a uniform display illumination. In order to create this uniform and efficient light emission, the LGP suppliers must take into account the full path traveled by the light. This includes the emission pattern of the LED coupling to the LGP, the light extraction technology utilized to extract the light from the LGP, and any secondary films or optics utilized in the final assembly.

2. Coupling of LEDs to a lightguide

Design and implementation of a LGP begins with the light source coupling. As there are many LEDs with different distribution patters and lenses, it is important that the LGP designer takes into account the LED to lightguide interface. A well-engineered coupling surface with an appropriate LED can result in a coupling efficiency of 90% or greater. If the design requires lensing or other optical features to be implemented on the coupling edge of the LGP, this can result in significant increases in uniformity; however, this also results in decreases in efficiency. A poorly chosen LED device without proper coupling may result in efficiencies of 70% or less. In many systems this coupling loss alone may be the greatest inefficiency in the system. In most designs, the best practice is to utilize a non-lensed LED placed in intimate contact with a polished coupling surface, on an LGP of similar thickness to the LED.

3. Light Extraction Technology

Once the light from the LED is properly coupled to the LED, it is important to choose the proper light extraction technique for the end application. There are many options to be considered, including printed features, etched features, machined lenses, or scribed lenses. These features can be created either directly on the polymer LGP, or on a tool which is then injection molded or thermally embossed within the LGP.

The light extraction features utilized in the LGP will be the primary factor in determining the distribution of the light emitted from the panel, as well as the efficiency of the LGP. If the designer chooses to utilize etched or printed extraction features, there is little that can be done to modify the light emission pattern beyond what naturally occurs (non-controlled, diffused distribution), as shown in figure 3.1. If the designer chooses to utilize a lens-based light extraction feature, such as a scribed v-grove or a micro-optical lens, it will allow for greater control over the angular distribution of light from the LGP (specular reflection), as shown in figure 3.2.

4. Lightguide Position in lighting systems

As with any light emitting product, the design must consider the position of the LGP within the final system. This can include systems with lightguide being the outer most emitting surface of the product, exposed to the end user as part of the fixture, or a lightguide internal to the product with light management films and lenses covering it from the end user. As the technology used within the lightguide presents visual reflections of light, the designer of the LGP must have a clear understanding of where the product will be within the fixture. This will allow for the design of the LGP to match the desires of the final product.

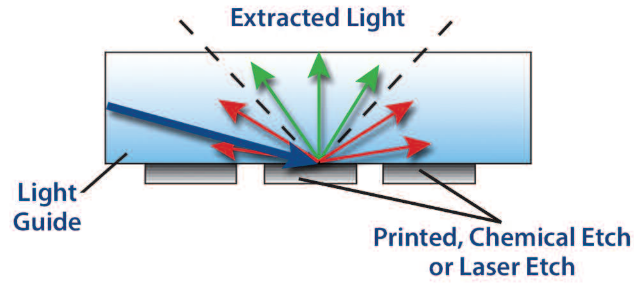

Figure 3.1 – Diffuse feature distribution pattern.

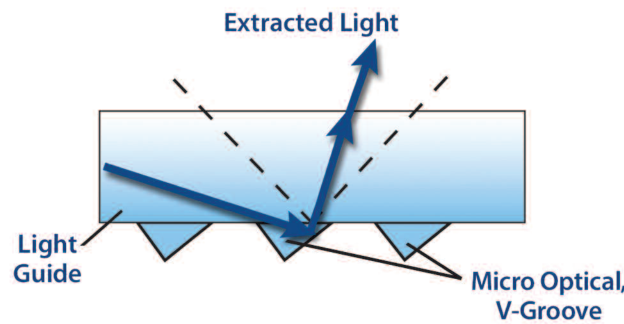

Figure 3.2 – Lens feature distribution pattern.

5. Distribution of light and emission patterns

Light fixture designers have chosen to utilize an edge illuminated LGP recently for many reasons; the primary is to deliver light from a point source (LED) to the end user in a controlled manner. The lightguide will capture the light from the LEDs and distribute it, or guide it, toward the desired distribution.

When utilizing an etched or non-specular light extraction feature, there is very little that can be done to modify the distribution of light emitted from the panel. The designer must either utilize the light as present from the LGP, or manipulate it using secondary optical films or by modifying and varying the position of the light sources. These are all viable production opportunities, and they have been utilized by manufactures to create products that have been accepted by the market.

When utilizing specular light extraction features, however, a designer is able to, within the limitations of the lens features, manipulate the angular distribution of the emitted light. By varying the angle of the specular reflector, it is possible to vary the angle at which the light will be emitted from the LGP. By doing this a designer can utilize a LGP to create a fixture with unique distribution patterns. These emission patterns can still be manipulated further by utilizing the same LED positioning and secondary film variables used with non-specular extraction features, however, it is usually more efficient to utilize the light extraction feature instead. By varying items such as the included angle of the lens, you are able to achieve light extraction patters as shown in figure 5.1

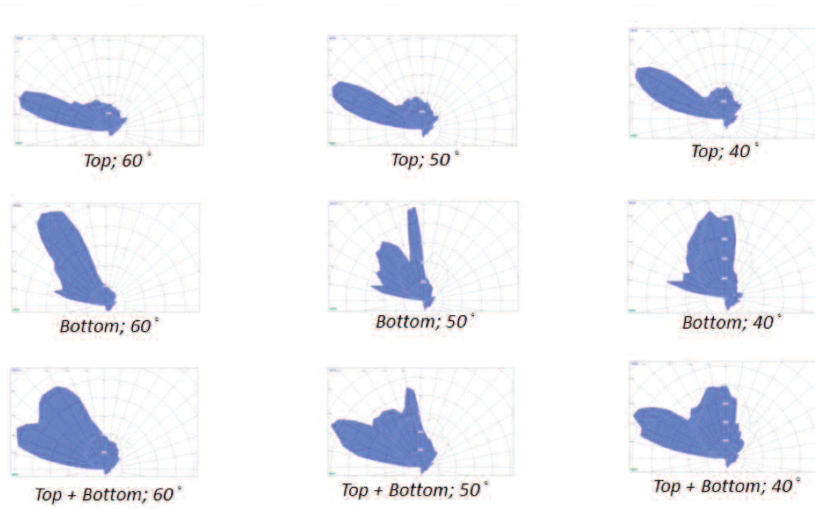

Figure 5.1 – Included Angle of Lens.

When using LGPs, it is also possible to utilize the light being directed from both the top and bottom surface of the lightguide in many applications (bi-directional). By varying the features used on the opposing sides of the product, it possible to achieve distinctly different distributions in opposing directions. This can be very beneficial in applications where a designer intends the final product to be utilized for both direct and indirect lighting of the space where the unit will be contained. One example of this emission pattern can be found in Figure 5.2. This example demonstrates a fixture with a directed downward light distribution, as well as a batwing distribution upward to be used for indirect lighting, all using a single LGP.

6. Current products in market

The first general lighting products using LGPs that were widely adopted into the industry were in applications such as exit signs and egress lighting sometime in the late 90's. Initially these LED backlights were utilized as a way to create thin and efficient lighting, while still allowing long battery life in the event of a power loss to the unit. Product has come a long way since these initial products.

In May of 2011, GE lighting announced and exhibited their recessed and suspended fixtures utilizing edge lighting and LGPs at Lightfair 2011 in Philadelphia [1]. The products they offered during this initial release included both recessed fixtures with a downward light

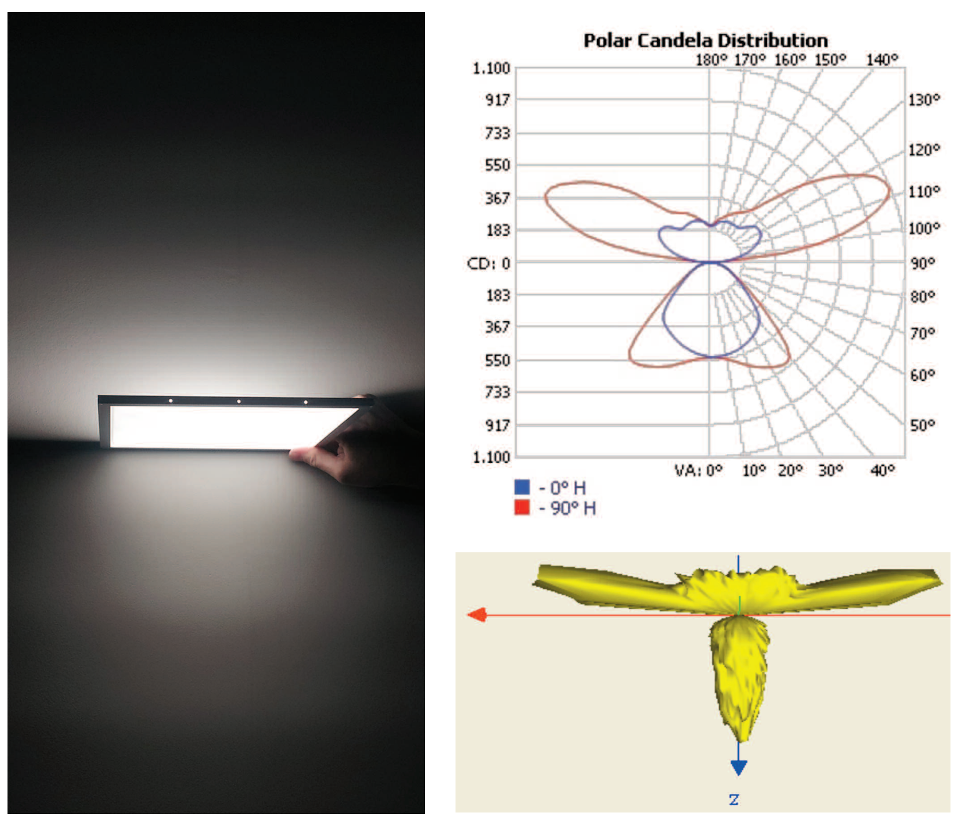

Figure 5.2 – Bidirectional distribution

emission pattern, as well as a suspended fixture. This was the first time that GE had announced fixturing using an edge-lit LGP technology.

The following year at Lightfair 2012 in Las Vegas, almost every major manufacturer of fixtures had begun working on and releasing fixtures utilizing LGPs. Cooper Lighting set up a portion of their booth that contained an invitation only viewing of the new product, including wall sconces, decorative room lights and pendants, as well as recessed lighting. Their invitation only event resulted in a line of visitors waiting to see the fixtures during most of the show, setting record numbers for visitors to the Cooper booth [2]. GE once again showed their edge-lit technology, and introduced new product which utilized the bi-directional aspect possible with LGPs, with the lightguides within these fixtures emitting light in both an upward and downward direction.

It seemed that by 2012, the general lighting industry had accepted LGPs as a standard component to be used within fixtures in order to help control the distribution of light from LEDs. This has continued since, with additional fixtures utilizing this technology being released at a steady pace.

7. Future Projection

With LGPs now being accepted by the general lighting industry as a near standard component to be used in fixtures, designers are now working to take advantage of the capabilities to an even greater degree. Moving away from using LGPs to only create even and uniformed down lighting, there is now a drive to create dramatically different fixtures in order to improve the aesthetic functions of a fixture.

One example of a new push within the LGP fixtures is to begin creating curves and three dimensional designs within the lightguide. As most fixtures currently on the market use flat, two-dimensional designs due to the lower complexity, it has required innovation in both design and manufacturing to achieve these complex structures.

Many fixture designers are also beginning to take advantage of the ability to create discrete distribution patterns from the LGP. This is being utilized in design of new fixtures to distribute the light from the fixture in very directed and controlled emission patterns. In some instances the lightguides are even designed to produce multiple emission patterns from a single light source, allowing the designers to have significant control over the light distributed from an LGP [3].

8. Conclusions

We have only recently begun to see lightguide technology utilized in the general lighting industry, and it may still be in its infancy. As more LGP manufacturers begin to work with the fixture manufacturers to assist in implementation, we will continue to realize new applications for the product. Although LGPs are not necessary in every LED fixture design, where appropriate they can create a much more desirable and efficient product. As LEDs continue to improve in brightness and efficiency, it will become even more important to utilize LGPs in order to spread this light and manipulate its distribution to match the designers' needs.

9. Acknowledgments

The author thanks Jonathan Doucet and Preston Yeh for technical assistance and creation of the light distributions models.

10. References

[1] GE Lighting (2011). GE Scientists Enable All-LED Rooms with New LED Edge Lighting Fixtures [Press release]. Retrieved from http://pressroom.gelighting.com/news/ge-scientists-enable-all-led-rooms-203524#.VRmUSrolgqY

[2] Cooper Industries (2012). One Cooper Spotlight May 2012 [Press release]. Retrieved from http://www.cooperindustries.com/content/dam/public/Corporate/Corporate%20MARCOM/NPI/2012PDFs/OneCooperSpotlight May5.25.12.pdf

[3] Global Lighting Technologies (2014). New LED Lightguides from GLT Emit Light From Top and Bottom Surface With Custom Distribution Profiles [Press release}. Retrieved from www.glthome.com/new-led-light-guides/