



INTRODUCTION TO LIGHT PIPE TECHNOLOGY

Part 1 of 3 Part Series

Title

- *Introduction to Light Pipe Technology*

Purpose

- *Discuss product enhancement through use of LED light pipes*

Objective

- *What is a light pipe – definition, applications, attributes, alternative technologies*
- *How light pipes transport LED light*
- *Benefits of light pipe technology – design & cost advantages*

Content

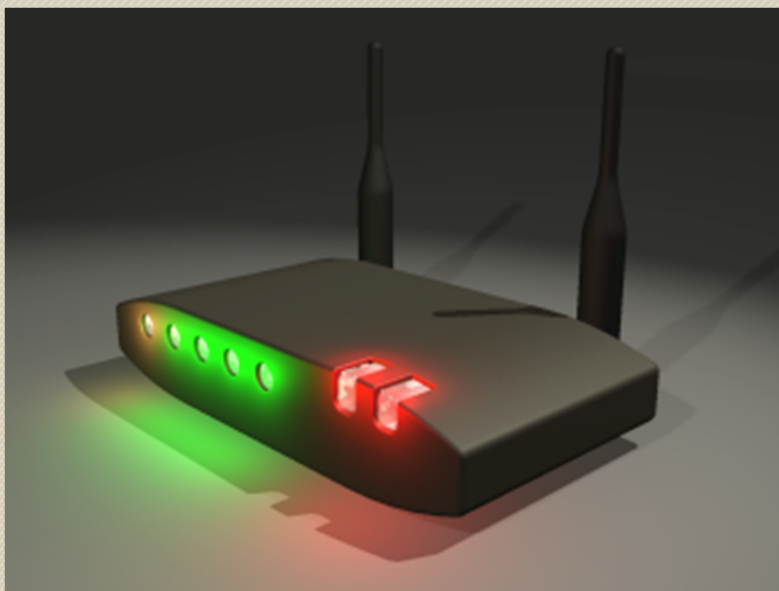
- *17 Pages*

Learning Time

- *5 Minutes*

Welcome to the Lumex TransBrite™ Light Pipe Technology training module. The objective of this training module is to discuss product enhancement through the use of LED light pipes. This module will present an overview of what a light pipe is, how light pipes can transport light from an LED and discuss design considerations and the cost advantages of Lumex's innovative light pipe prototyping and ray tracing software capabilities.

What is a LED Light Pipe?



An optical fiber or a solid transparent plastic rod for transmitting light lengthwise

Light pipes are a simple, practical solution for directing light from board-mounted LEDs to the exterior, or in some cases, a photo-detector. Light pipes can enhance display quality and add greater flexibility to light distribution. The integration of a LED Pipe is a cost-effective option to help eliminate many of the varied, complicated steps otherwise required to transport light from one place to another.

Light Pipe Applications



Medical Device



Security and Life
Safety



Small Space
Accent Lighting



Communications
Equipment



Industrial Control

Due to their cost effectiveness and diverse range of standard, semi-custom and custom formats, light pipes are widely used in a large variety of markets including medical, industrial control, security and life safety, communications equipment and small space accent lighting applications.

Attributes of a Light Pipe

- Made out of polycarbonate, glass or optical grade materials

- Custom shapes and variety of different lens caps

- Compatible for use with either surface-mount or through-hole LEDs

- Capable of being panel or PCB mounted

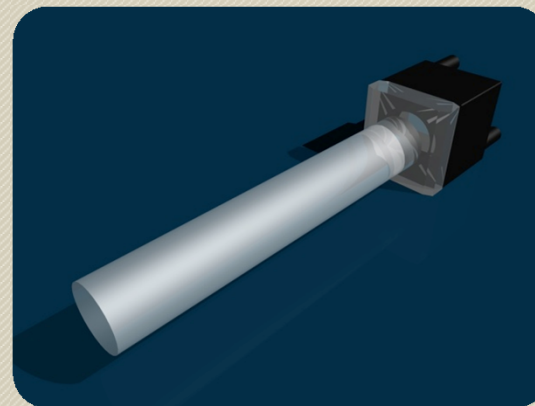
Although specific design considerations may vary, a standard Light Pipe construction is optically clear for visible and infrared wavelengths. Standard light pipes are made out of polycarbonate and are capable of being panel or PCB mounted. Light pipes can be designed to be compatible for use with any LED packaging, however typical light pipe construction is designed with surface mount LEDs. Lumex's TransBrite™ LED Light Pipes can be configured with a wide variety of shapes and sizes to meet specific application needs.

Types of Light Pipes

Flexible Light Pipe



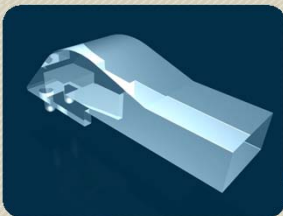
Rigid Light Pipe



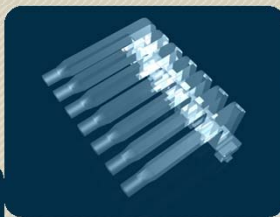
There are two basic styles of LED light pipes – rigid and flexible. A rigid light pipe is produced with a hard plastic material and will have either a vertical or a right-angle construction, capable of redirecting the LED's light output to the desired location with minimal loss of intensity. Rigid light pipes are ideal if the LED is mounted on a board immediately behind a front panel. Flexible light pipes are constructed with an optical grade plastic material that provides less rigidity allowing them to transport light from a board at custom, user-specified subtle angles ensuring easy integration around existing components. Both rigid and flexible light pipes can come in single or multi-unit configurations. A quality multi-unit light pipe will be designed to ensure there is no color bleed between adjacent light pipes.

Styles of Light Pipes

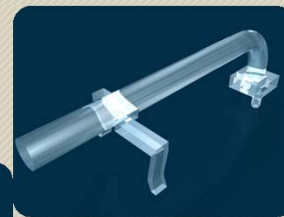
Rectangular



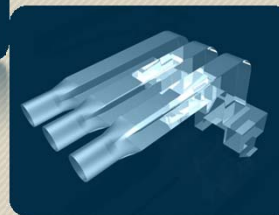
Right Angle



Single-Unit



Stacked



Multi-Unit



Vertical

There are two basic styles of light pipes: vertical and right angle. Within both styles, the light pipe can either be a single unit or multiple unit, and designed to a variety of shapes, including round or rectangular.

Advantages of Light Pipe Technology

Design

- Design flexibility
- Easy installation
- Multiple product format and packaging options
- High efficient optical design

Performance

- Uniform illumination over various lengths
- Reduced shadowing and glare

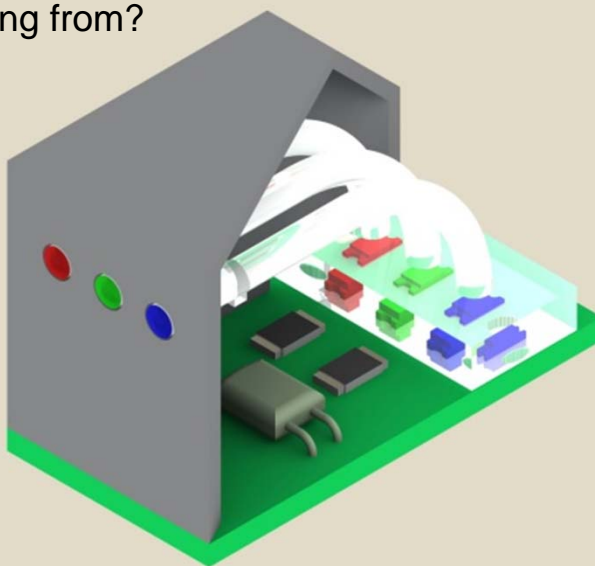
Cost

- Cost savings – up to 50% less expensive than alternative technologies

Light pipes provide considerable advantages over alternative technologies like fiber optics. Light pipes can cost as much as 50% less than fiber optic technology and often has simpler design processes when housing is not needed. Light pipes transmit up to 80% of emitted light with excellent visual performance, making them a viable option for a broad range of applications.

Design Considerations

- ✧ Where is the light source coming from?
- ✧ How far back is the LED from the emitting source?
- ✧ What LED are you considering for the design?
- ✧ How much brightness is required?
- ✧ What is the amount of real estate available to work with?

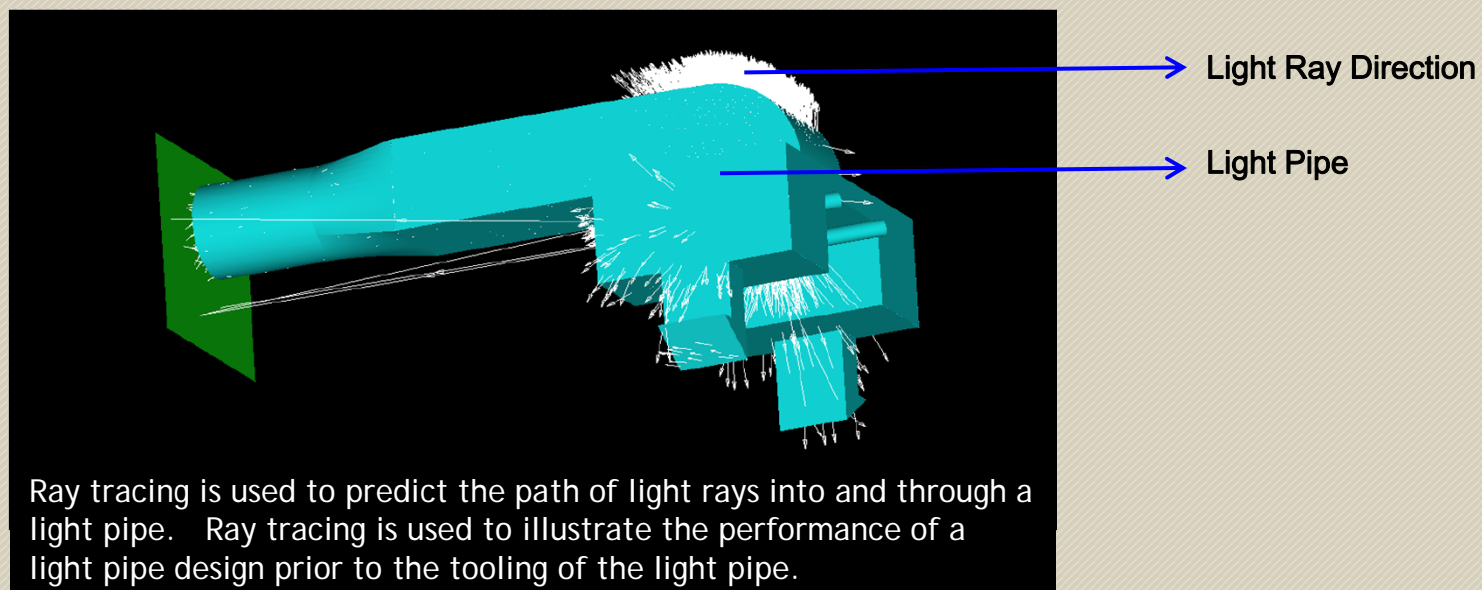


- ✧ Can the light be effectively routed in a right-angled application?
- ✧ What are the mounting considerations, i.e. friction or snap fit?
- ✧ What is in the path of the light transmission?
- ✧ Can the design provide uniform light performance?

There are several rules of thumb to keep in mind when integrating light pipes in product design. First, the light pipe has to be designed in such a way so that it captures the maximum possible amount of light from the LED (and minimizes the amount of light that is reflected away). Once the light has been correctly captured, design must focus on having the light leave the light pipe in the right location.

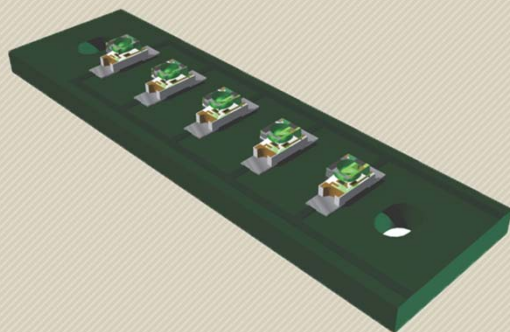
Light travels on a direct course within straight light pipes. More consideration needs to be given to effectively route light inside angled light pipes. There are a variety of options available for working around objects. Advanced ray tracing/prototyping of the design geometry to provide a high rate of light transmission through the exit surface with minimal loss is desirable. For more information on ray tracing/prototyping of light pipes, please see separate training module dedicated to this topic.

Ray Tracing



Ray Tracing is a method for calculating the path of light through a light pipe. Lumex uses state-of-the-art ray trace software with precise 3D CAD/CAM models to ensure proper design and optimal light transmittance, with minimal light loss. This advanced technology system helps to advance the design of the light directly from the LED into the light pipe to help eliminate many intermediate steps and ensure minimal light loss. Thanks to this technology, products can be brought to market up to 35% faster than traditional product development timelines at 40% cost savings! For additional information on ray tracing please see separate training module on this subject.

Matching Light Pipe to LED



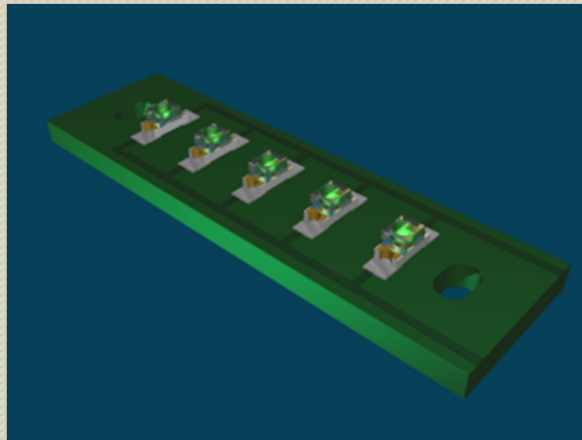
LEDs mounted on PCB board



Right angled LED light pipe

Generally speaking, the brightness emitted from a light pipe will be dependent upon the LED utilized, as well as the shape of the application. A properly matched light pipe will emit the same brightness as the individual LED, minimizing the amount of light lost. An LED must be effectively matched to the entrance of a light pipe in order to allow for proper light capture with minimal light loss. Effective light pipe and LED matching occur only when the LED radiation pattern angle matches the acceptance pattern angle of the light pipe.

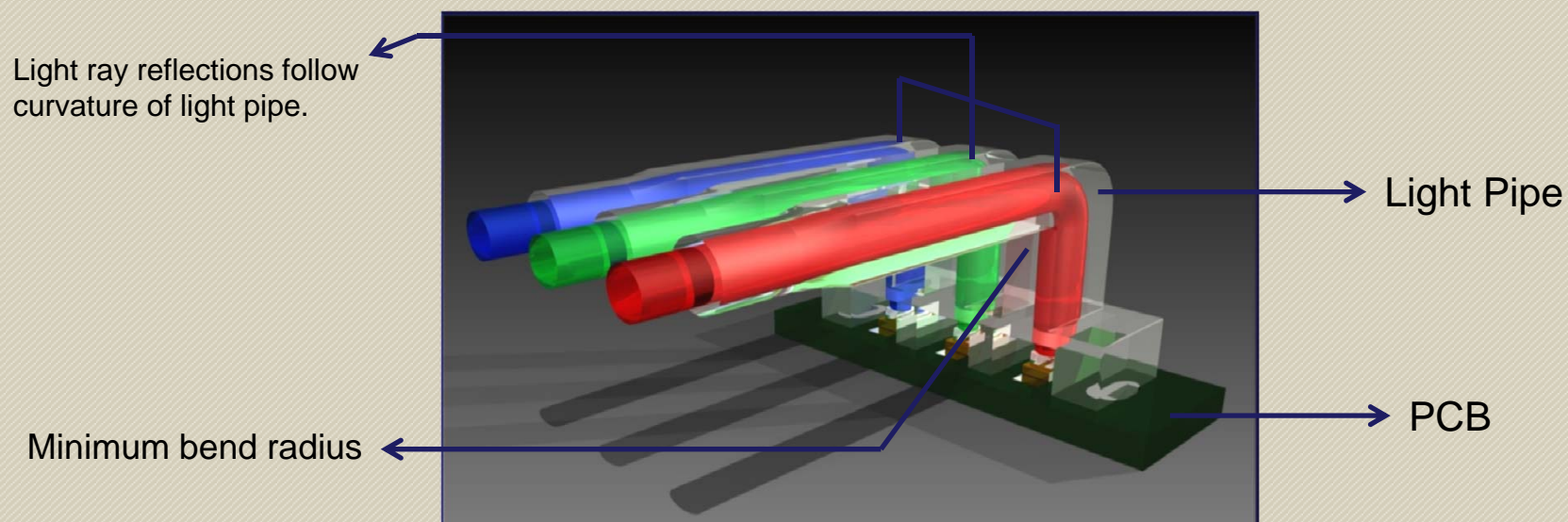
Matching Light Pipe to LED



A properly matched light pipe will emit the same brightness as the individual LED, minimizing the amount of light lost. The most effective light pipe and LED matching is to have the LED located inside the light pipe surface.

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How Light Pipes Capture & Transport Light



Light is transmitted through a light pipe by means of total internal reflection. One of the primary advantages of utilizing light pipes is that light pipes may be bent and skewed to fit inside the panel to create minimal light loss. In addition, designing the light pipe as close to the LED surface helps to capture and maximize light transmission.

Lumex Light Pipe Family

Standard

The Lumex TransBrite™ light pipe family consists of **over 70 standard light pipe technologies** in single or array, molded or flexible, single or multi-color formats with right angle, vertical or horizontal packaging for either panel or PCB mounting.

Custom

Light pipes are custom developed to contain anywhere from one to several individual pipes and many can be stacked to create almost any configuration.

Lumex TransBrite™ Light Pipes encompass a wide range of device styles that carry light away from a single LED to a front panel or viewing location that is up to 25 meters (80 feet) away. Cost-effective, high-performance custom light pipes are available thanks to cutting-edge 3D ray-tracing software used to create custom light pipe technology with reduced design and tolling costs and proven optical performance.

Lumex Integration Support

- Extensive integration assistance
 - LED matching, Ray Tracing, Technical Support.



- Extensive LED light pipe expertise
 - Flexible or rigid, rectangular, right angle, single-unit, multiple-unit, stacked or vertical, PCB or surface mounted, packaging options.

Lumex provides industry-leading customer technical support not only for large orders but also for small and mid-size projects. The Lumex Technical Design Team can provide engineers additional packaging options and design freedom. By allowing the LEDs to be mounted according to the dictates of the circuit board layout, the light itself can appear in the location, size, and/or shape that best suits the ergonomic design of the product. Best-in-class integration support ensures cost-effective, maximized performance for each unique application.

The Simple Solution



The Lumex Technical Design Team has a proven track record in successfully listening to customers, responding positively and effectively, and collaborating on a complete solution, rather than trying to pigeon hole a design with a standard product. With best-in-class support and the custom capabilities to support some of the most demanding applications, Lumex is a user-interface, total solution partner.