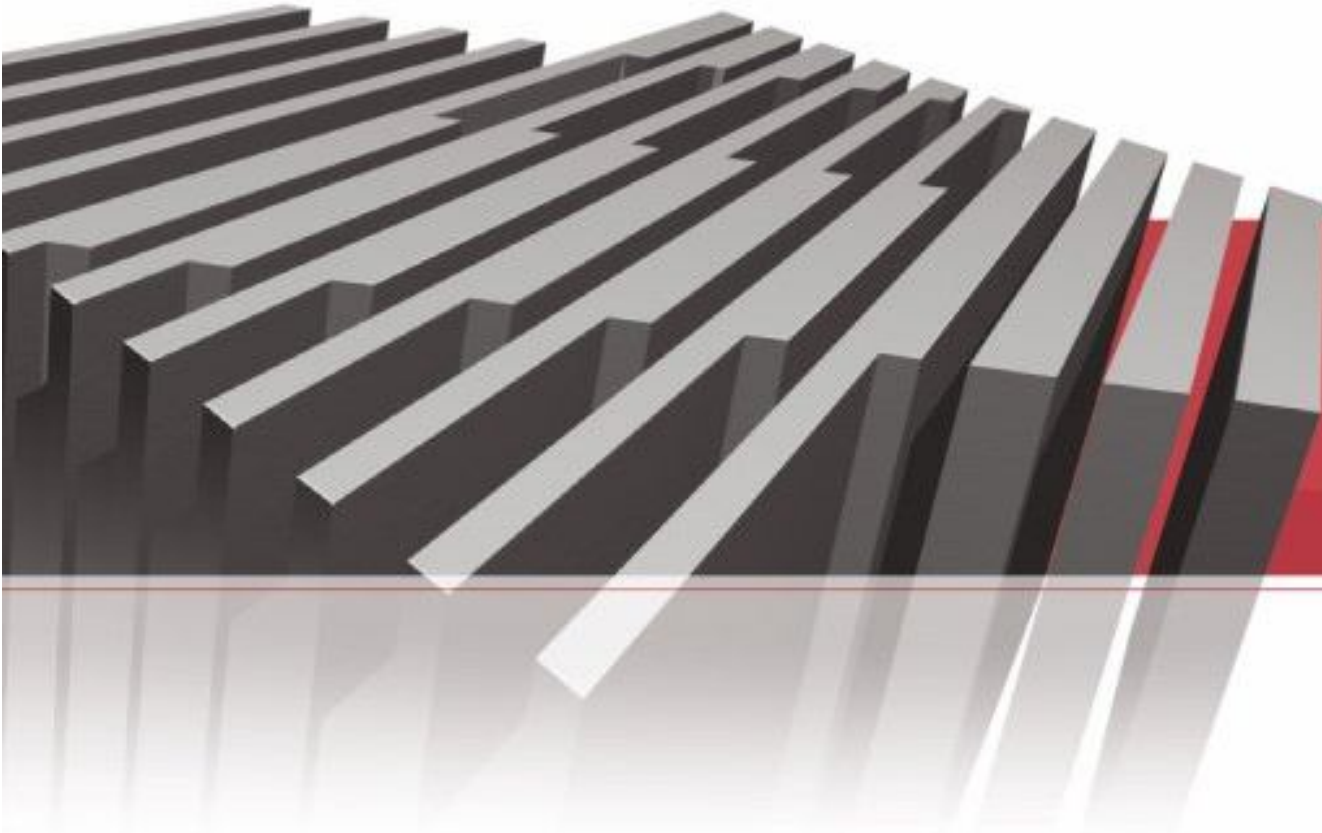


# Lens for Solutions for SSL Designs

Lighting Seminar 08'  
*"Lighting Your Knowledge"*

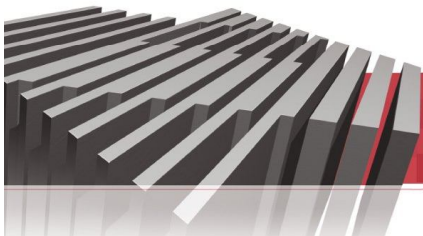


Eduardo Bobadilla  
Field Applications Engineer



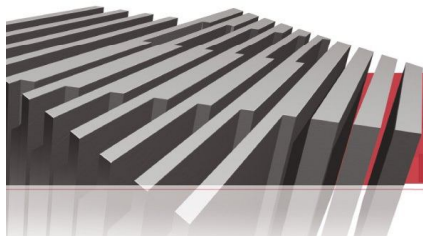
# Agenda

- Optics Basics
  - Snell and TIR
- Lens for LEDs Basics
  - Primary and Secondary Lens
  - Radiation Patterns
  - Optical materials & surfaces
  - Types
- Applications and considerations
  - Indoor and outdoor
  - Beam Considerations
- Lens use and maintenance
  - General aspects
- Avnet Lighting Group



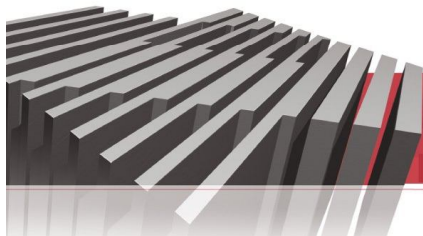
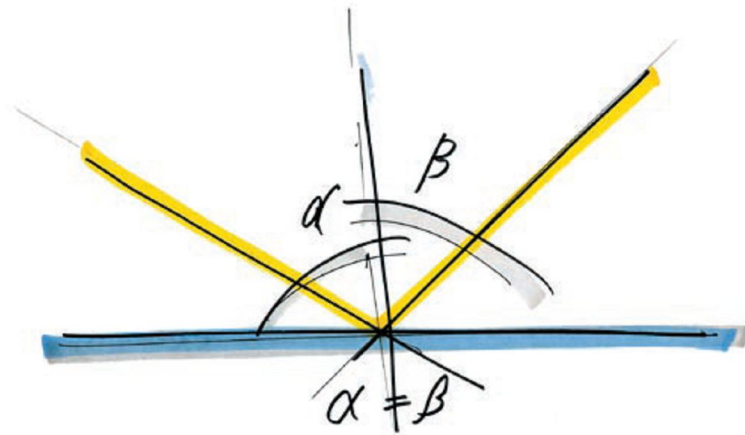


# Optics Basics



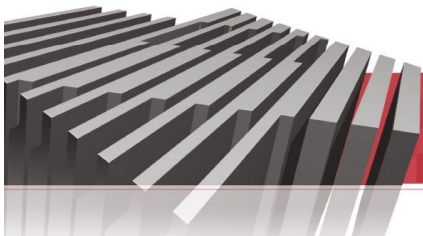
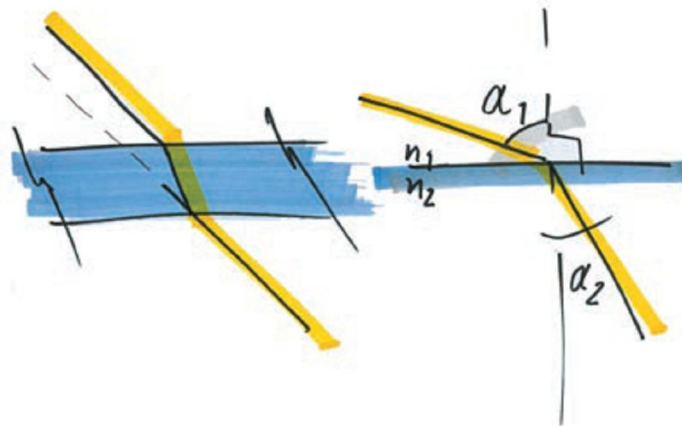
# Optics Basics

- **Reflection** occurs when a beam of light meets a surface. Light is reflected from the surface following the law of reflection: the angle between an incoming ray and a line normal to the surface is equal to the angle of the reflected ray and the normal one.
- Depending on the quality of the surface, reflection can be specular (polished surface), spread (rough surface) or diffuse (matte surface).



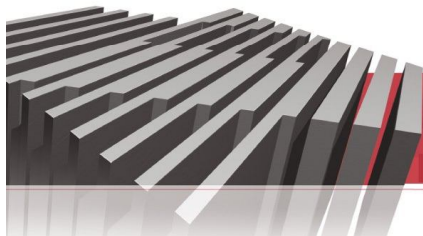
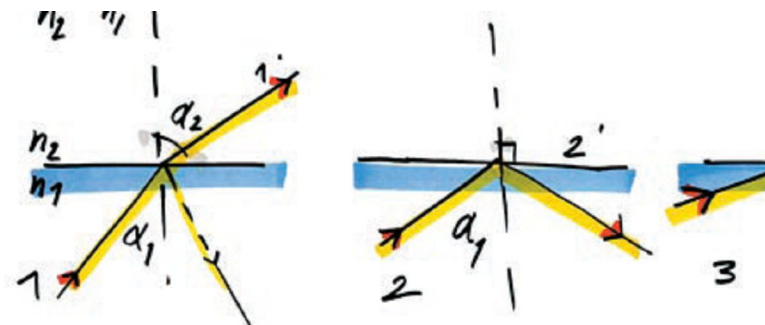
# Optics Basics

- When a beam of light coming from one material enters another material, it refracts, i.e., changes angle and velocity. **Refraction** depends on two factors: incoming angle of the light beam and refractive index of material. Refractive index is the ratio of the speed of light in a vacuum to the speed of the light in that material. The angle of the refracted ray can be determined with Snell's Law.
- E.g., the magnificent glittering of a diamond is caused by the high refractive index of diamond. Diamond is the most refractive optical material of all.



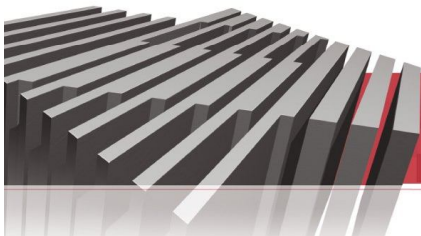
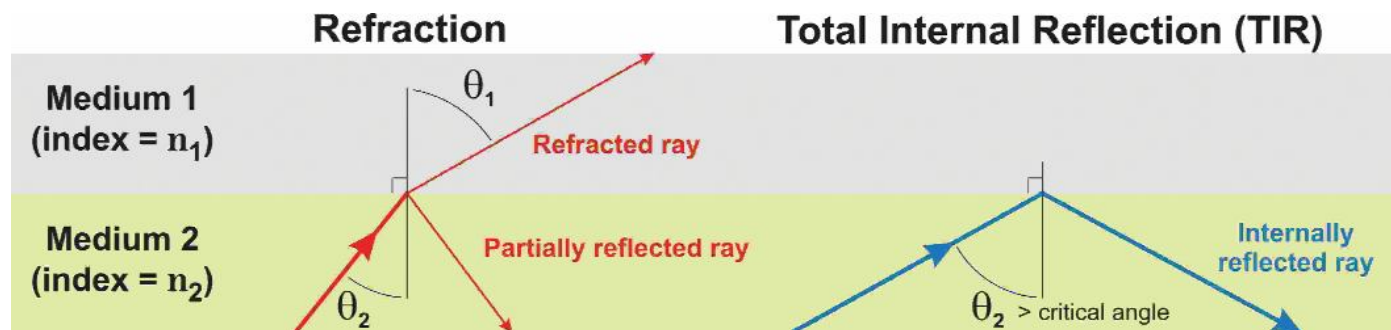
# Optics Basics

- When a beam of light comes from a material having a greater index of refraction to one with a lower index of refraction, it bends away from normal. When this angle increases, it reaches finally a point, from which forward all light is not anymore refracted but reflected. This phenomenon is used, e.g., in fiber optics and light guides where light has to be transported long ways; it's called **Total Internal Reflection**.



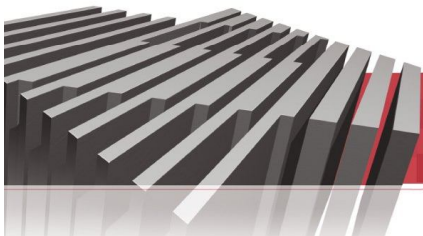
# Optics Basics

- As examples, the refractive index of acrylic is about 1.49, most glass is around 1.51, and air is slightly greater than 1. When light rays travel from one medium into another medium which has a different refractive index, they bend. This phenomenon, known as refraction, is illustrated on the left side of following figure:



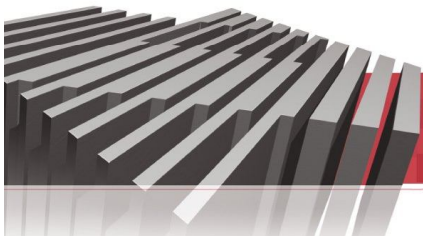
# Optics Basics

- Something really interesting happens if the incident ray strikes the interface at a large enough angle—the ray of light is reflected back into the medium. This is called total internal reflection (TIR), and the magic point at which TIR begins to occur is referred to as the critical angle. See last figure.



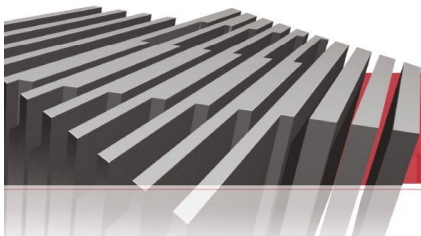
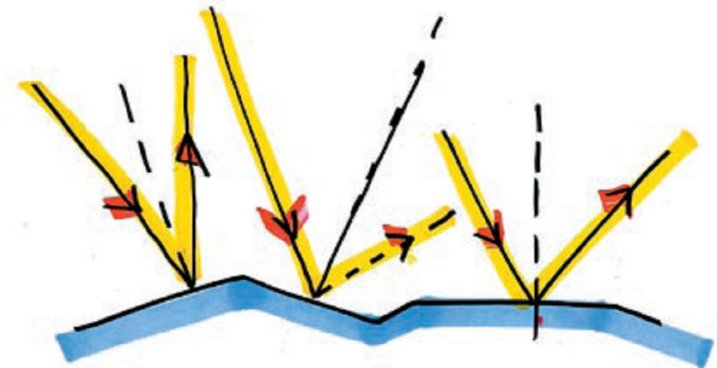
# Optics Basics

- When a beam of light goes through an object, it is called **transmission**. The phenomena that affect light transmission are reflection, refraction, absorption and diffusion. How much they affect is depending on the object's material properties and surface quality.



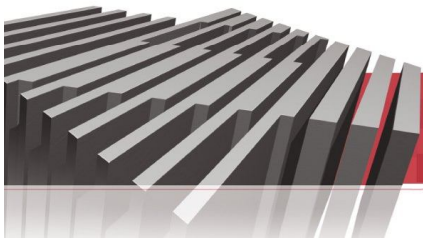
# Optics Basics

- Many materials selectively absorb more of certain areas of radiation. Normally absorbed radiation is converted into heat. Degree of absorption is defined by material thickness and concentration of the absorbing component.
- When a beam of light hits a rough surface, it is reflected or transmitted in many directions. This is called diffusion or scattering. The amount of diffusion depends on the difference in refractive index between the materials and the size and the geometry of the diffusing particles compared to the wavelength of the light.



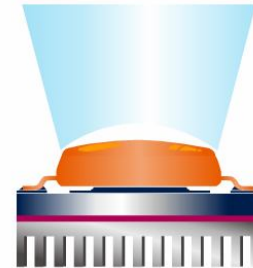


# Lens for LED Basics

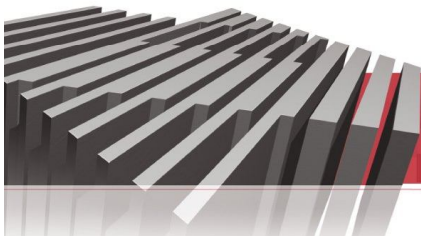


# Lens for LED Basics: Primary and Secondary Lens

- Primary Lens: The epoxy enclosure molded to an LED die to provide optical characteristics.

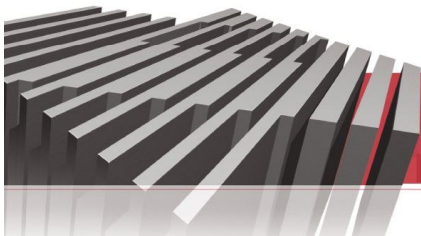
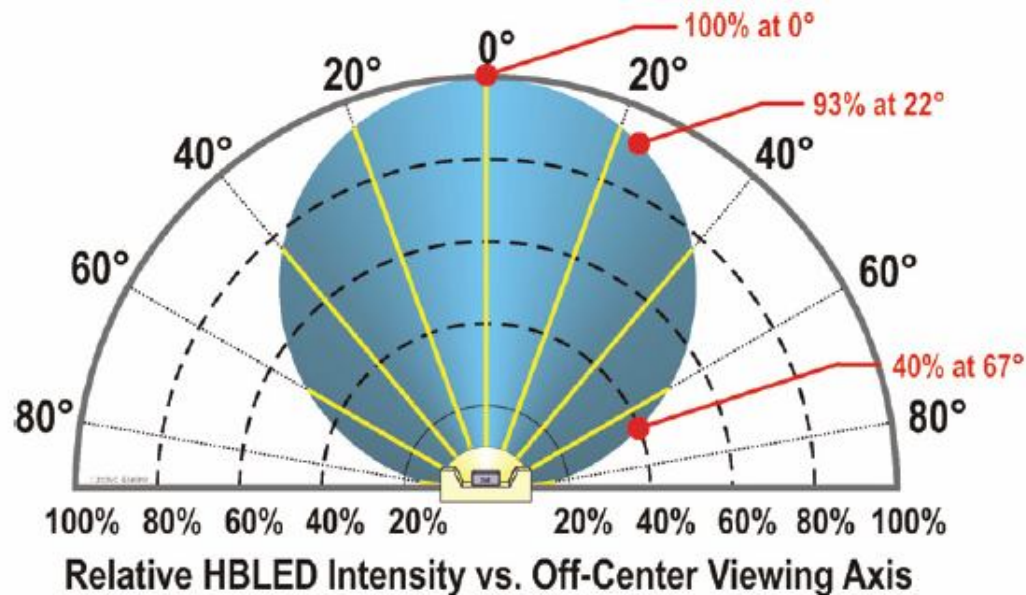


- Secondary Lens: Enclosure off-the-shelf material to provide optical characteristics, in order to get a specific footprint of the emitted light.



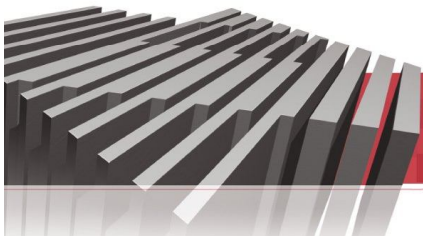
# Lens for LED Basics: Radiation Patterns

- One of those involves optics, beginning with the HBLED device itself. Physics, die size, the type of encapsulated and built-in lens all contribute to the shape of light that LEDs emit. A radiation pattern chart describes how light spreads outwards from the package. Most HBLEDs exhibit a Lambertian radiation pattern, as following figure:



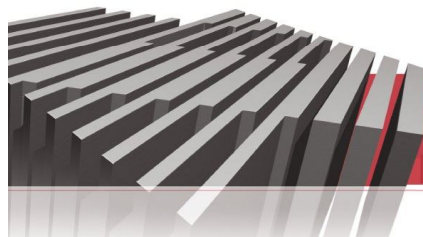
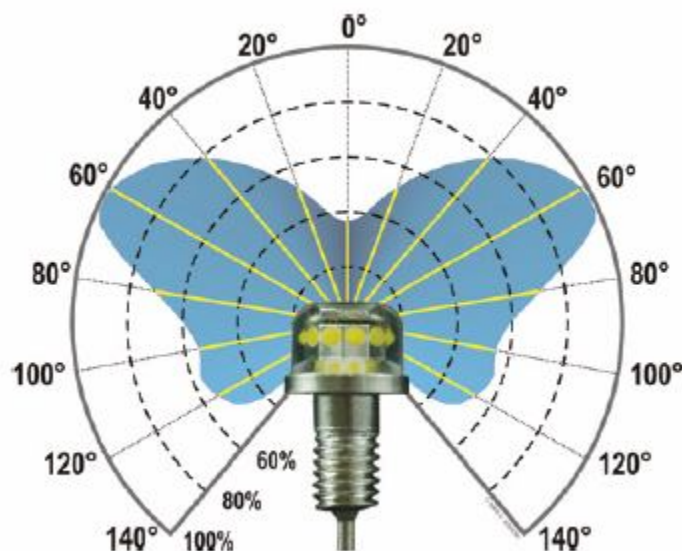
# Lens for LED Basics: Radiation Patterns

- In Lambertian source, the intensity from the perspective of the observer is directly proportional to the cosine of the angle between the observer and the surface normal, which is the LED die in our case. At a  $67^\circ$  angle from its axis, the light will only appear 40% as intense as it does when viewed down its centerline. Many off-the-shelf plastic lenses are available for Lambertian-type HBLEDs, making it easy to build spotlights, floodlights, oval-shaped lighting areas, etc.



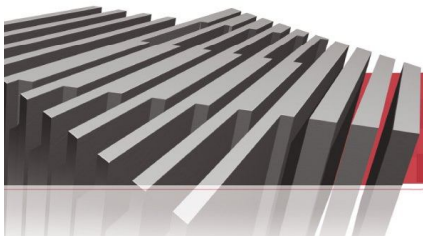
# Lens for LED Basics: Radiation Patterns

- As example, there are applications which need light to be emitted evenly on all sides, like a beacon or interior cabinet light. One interesting HBLED designed for this purpose has a radiation pattern resembling a butterfly wing.



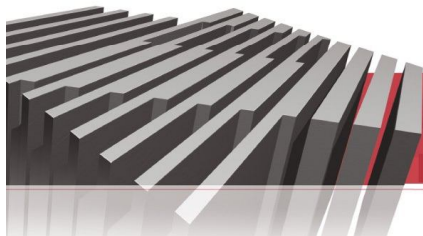
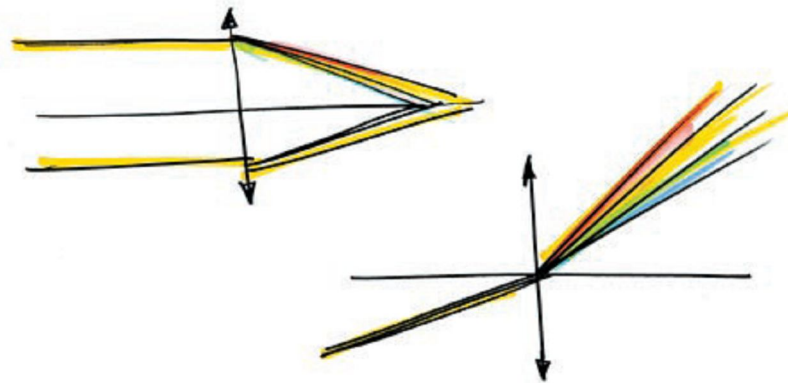
# Lens for LED Basics: Optical materials & surfaces

- The choice of the optical material normally depends on the optical, mechanical and environmental requirements set to the end-product, total costs and manufacturing possibilities. We use thermoplastics, coated or uncoated, in most of our products.



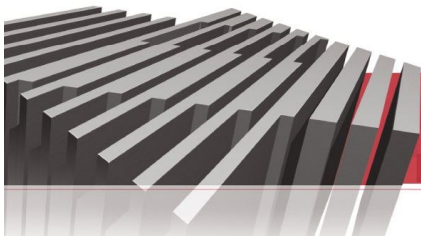
# Lens for LED Basics: Optical materials & surfaces

- **Optical materials:** The quality of a lens material is characterized by transmission and dispersion factor (so called Abbe factor). Glass is the best of lens materials, when it only comes to these figures. Plastic materials can be used, when developing a system with less requirements for optical precision, and when there is a need for good integration of the optical system to the rest of the mechanical structure.



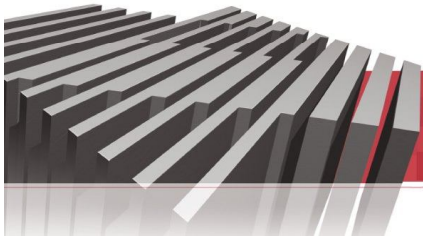
# Lens for LED Basics: Optical materials & surfaces

- **Optical Thermoplastics:** Suitable standard thermoplastics materials for lenses are, e.g., PMMA, PC, PS, SAN and PA12. When using thermoplastics, special attention must be paid to material specific properties, to material behavior in the molding process and to manufacturing & design of molds.
- Advantages of thermoplastics as optical material are
  - Mass production and low cost per piece
  - Geometrical degree of freedom
  - Light weight
  - Unbreakable
  - Easy integration
  - Quality in series
- Disadvantages in turn are
  - Sensitivity to heat
  - Shrinkage
  - Chemical resistance
  - Color unevenness
  - Flow lines



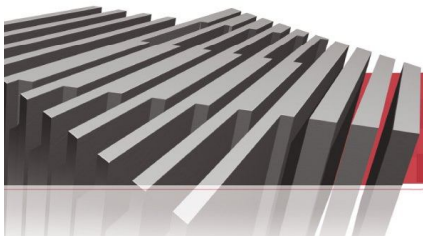
# Lens for LED Basics: Optical materials & surfaces

- Coatings establish reflective surfaces on thermoplastics. Paints in different forms make a diffusive optical surface. The percentage of light reflected is proportional to the color of the paint used and to the size and the geometry of the diffusing particles in it compared to the wavelength of the light.
- A mirror surface can be established on a diamond polished thermoplastics surface using different metallization techniques.



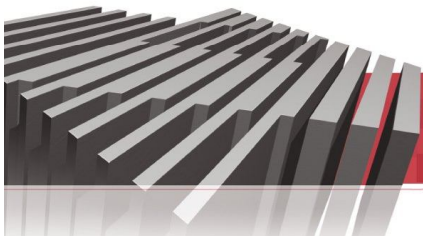
# Lens for LED Basics: Optical materials & surfaces

- The degree of reflection is based on material properties of the thermoplastics, mold surface quality and material flowing conditions inside the mold and coating material properties. The purer the material and the more homogeneous the flowing conditions inside the mold are the better is the mirror surface.



# Lens for LED Basics: Example of Types

- As a largest electronic components distributor, Avnet EM works with the most important Lens manufacturers around the globe. Two of the most important companies are:
  - KHATOD: [www.khatodusa.com](http://www.khatodusa.com)
  - LEDIL: [www.ledil.com](http://www.ledil.com)
- The type of lens is determined directly of the final application, and following requirements: collimation angle, beam and light foot print.



# Lens for LED Basics: Example of Types

- As an example of lenses, here is an KEPL199 Series brochure. We can check two main characteristics to do a lens selection: Beam and Angle.

**KHATOD®**  
LENSES FOR POWER LED

**OSRAM™**

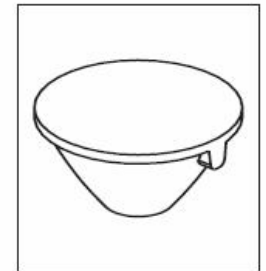
## Lenses for OSRAM® LEDs

## KEPL199 Series

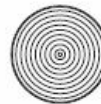


### KEPL199 Series

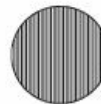
- Available in different beams
- High efficiency
- Collimator lenses are available in 9 colours options



Part Number	Type	LED type	Degree
PL 19906	Narrow Beam	Golden DRAGON®	10



Part Number	Type	LED type	Degree
PL 19925	Medium Beam	Golden DRAGON®	25



Part Number	Type	LED type	Degree
PL 19940	Elliptical Beam	Golden DRAGON®	15X90

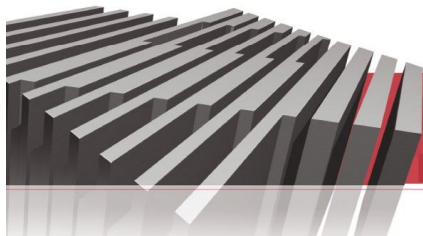


Part Number	Type	LED type	Degree
PL 19940W	Wide Beam	Golden DRAGON®	40



Part Number	Type	LED type	Degree
PL 1996D	Medium Beam	Golden DRAGON®	30

\* this lens is to be used without collimator



# Lens for LED Basics: Example of Types

- For outdoor lighting applications, some times the light foot print requirement is **elliptic**.

**KHATOD**  
LENSES FOR POWER LED

**OSRAM**<sup>™</sup>

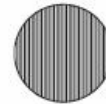
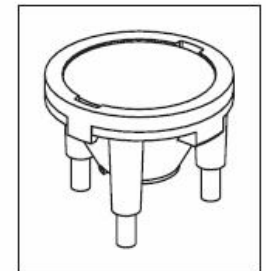
Lenses for OSRAM® LEDs

*KEPL24 elliptical Series*



**KEPL24 elliptical Series**

- Available in different beams
- High efficiency
- Free testing and technical support
- No mould charge on custom lenses



Part Number	Type	LED type	Degree
KEPL 24EL/H	Horizontal Beam	Golden DRAGON®	15x90



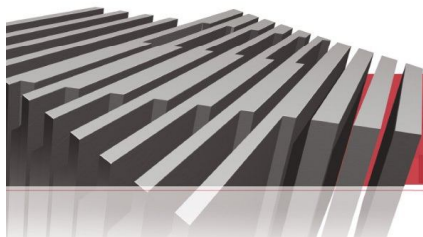
Part Number	Type	LED type	Degree
KEPL 24EL/V	Vertical Beam	Golden DRAGON®	90x15



KEPL 24EL/H

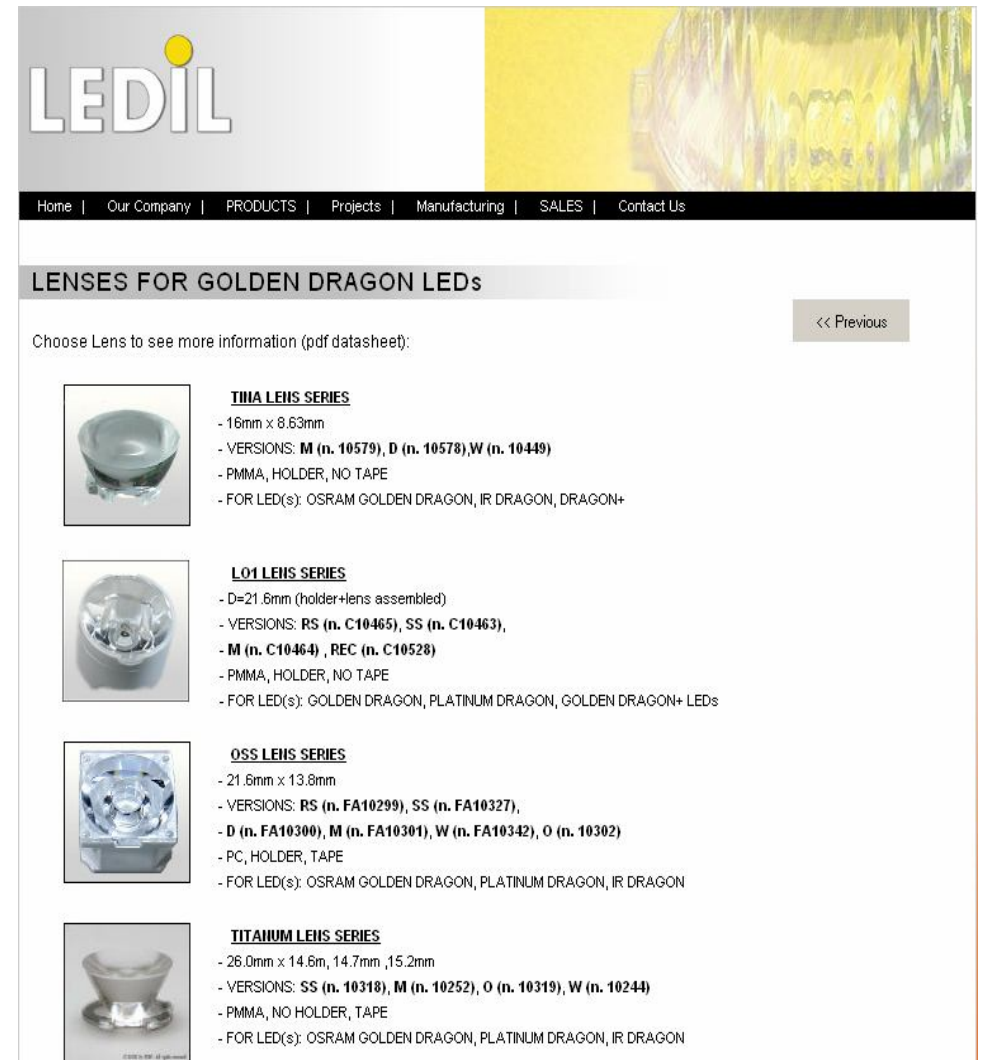


KEPL 24EL/V



# Lens for LED Basics: Example of Types

- As Avnet, we can offer lenses for each Osram HBLED either Dragon series or Ostar.



The screenshot displays the LEDIL website interface. At the top, the LEDIL logo is visible on the left, and a navigation menu includes links for Home, Our Company, PRODUCTS, Projects, Manufacturing, SALES, and Contact Us. The main content area is titled "LENSES FOR GOLDEN DRAGON LEDs" and features a navigation button labeled "<< Previous". Below this, there is a prompt: "Choose Lens to see more information (pdf datasheet):". Four product listings are shown, each with a small image of the lens and a list of specifications:

- T11A LENS SERIES**
  - 16mm x 8.63mm
  - VERSIONS: **M (n. 10579)**, **D (n. 10578)**, **W (n. 10449)**
  - PMMA, HOLDER, NO TAPE
  - FOR LED(s): OSRAM GOLDEN DRAGON, IR DRAGON, DRAGON+
- L01 LENS SERIES**
  - D=21.6mm (holder+lens assembled)
  - VERSIONS: **RS (n. C10465)**, **SS (n. C10463)**, **M (n. C10464)**, **REC (n. C10528)**
  - PMMA, HOLDER, NO TAPE
  - FOR LED(s): GOLDEN DRAGON, PLATINUM DRAGON, GOLDEN DRAGON+ LEDs
- OSS LENS SERIES**
  - 21.6mm x 13.8mm
  - VERSIONS: **RS (n. FA10299)**, **SS (n. FA10327)**, **D (n. FA10300)**, **M (n. FA10301)**, **W (n. FA10342)**, **O (n. 10302)**
  - PC, HOLDER, TAPE
  - FOR LED(s): OSRAM GOLDEN DRAGON, PLATINUM DRAGON, IR DRAGON
- TITANIUM LENS SERIES**
  - 26.0mm x 14.6mm, 14.7mm, 15.2mm
  - VERSIONS: **SS (n. 10318)**, **M (n. 10252)**, **O (n. 10319)**, **W (n. 10244)**
  - PMMA, NO HOLDER, TAPE
  - FOR LED(s): OSRAM GOLDEN DRAGON, PLATINUM DRAGON, IR DRAGON

# Lens for LED Basics: Example of Types

- Also, we can offer lenses especially suitable for Road Lighting solutions. At 8 meters' height fulfills the ESNA Class III requirements and its name is **CAT Lens Ostar**

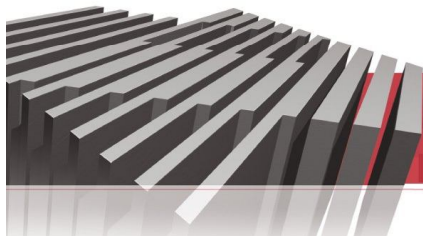


The screenshot shows the LEDIL website's product page for lenses. At the top, the LEDIL logo is displayed on the left, and a navigation menu includes Home, Our Company, PRODUCTS, Projects, Manufacturing, SALES, and Contact Us. On the right, there is a large image of a lens. Below the navigation, the page title is 'LENSES FOR OSTAR LIGHTING LEDs'. A 'Choose Lens to see more information (pdf datasheet):' section is followed by a list of products, each with a small image and a list of specifications. A '<< Previous' button is located on the right side of the product list.

Product Name	Dimensions	Material	Notes
<b>LEDIL STAR-L LENS SERIES</b>	- 35.0mm x 24.6mm	- PC	- NO HOLDER, NO TAPE - FOR LED(s): OSRAM OSTAR LIGHTING LEDs
<b>CAT LENS SERIES (n. 10410)</b>	- 31.5mm x 27.0mm x 23.0mm	- PMMA	- NO HOLDER, NO TAPE - FOR LED(s): OSTAR LIGHTING LEDs
<b>NATALIE LENS SERIES (n. 10267)</b>	- 35.6mm x 6.2mm	- PC	- NO HOLDER, NO TAPE - FOR LED(s): OSRAM GOLDEN DRAGON, PLATINUM DRAGON, IR DRAGON
<b>BOOMERANG REFLECTOR (n. 10437)</b>	- 19.79mm x 15.5mm	- metallized ABS	- FOR LED(s): OSTAR LIGHTING



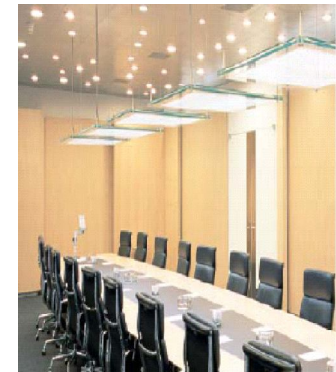
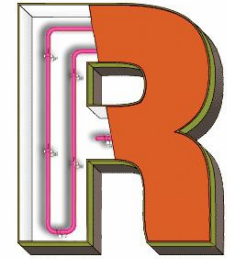
# Applications and considerations



# Applications and considerations: Indoor and outdoor

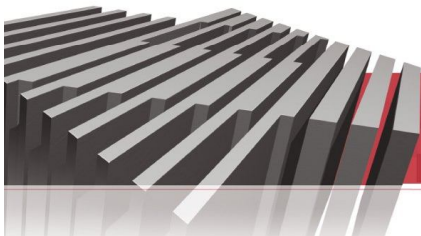
- General **Indoor** considerations:

- Color of Light
  - White: Warm, Neutral, Cold.
- Type of Building's Room
  - House, Office, Schools, Meeting Rooms.



- Light distribution
  - Indoor Photometric topics: Light footprint, Zonal Lumen Summary, etc.
  - Reflection and refraction of fixture protection

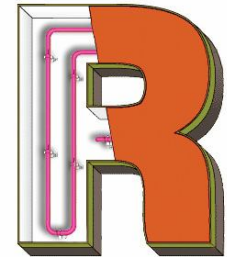
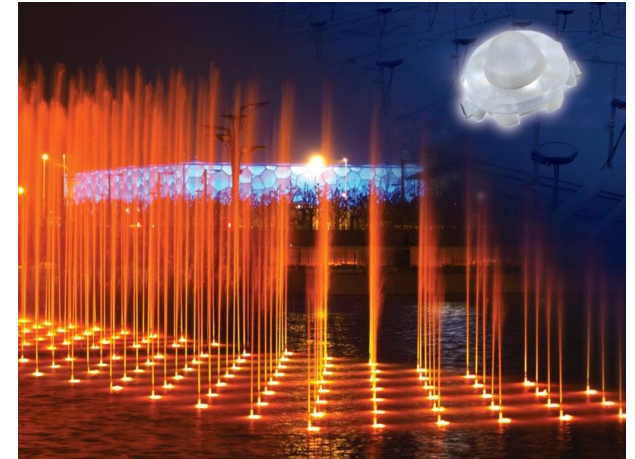
- Applications: Residential, Commercial, Medical, Scientific, Consumer, Automotive.



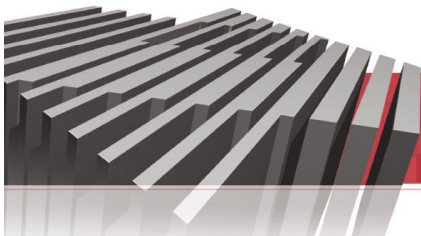
# Applications and considerations: Indoor and outdoor

- General **Outdoor** considerations:

- Color of Light.
  - Color: RGB for different applications.
- Type of Area.
- Lighting purpose.
- Power Management.
- Luminous intensity.
- Light distribution:
  - Indoor Photometric topics: Light footprint, Graphical representation, Fixture Classification, etc.
  - Reflection and refraction of fixture protection.
  - Secondary Lenses.

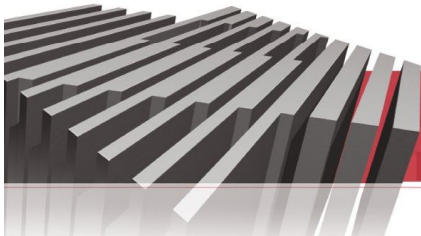


- Applications: Street lighting, Architectural, Commercial, Automotive, Signal, Ad Lighting, Video Displays, Gaming, Automotive.



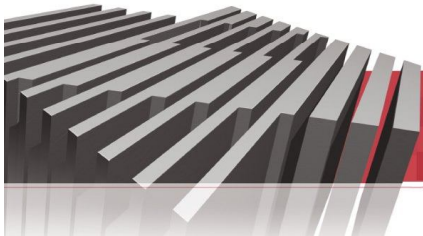


# Lens use and maintenance



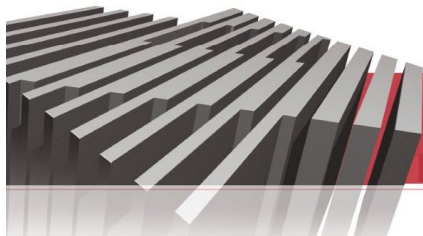
# Lens use and maintenance

- Do not handle or install lenses without wearing gloves, skin oils may damage lens or light transmission.
- Clean lenses with mild soap, water and soft cloth.
- Do not use any commercial cleaning solvent on lenses.





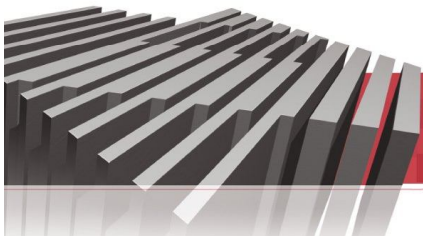
# Avnet EM Lighting Group



# Avnet Solid State Lighting Group

- **LightSpeed** offers our customers access to a national team of illumination-focused engineers we call Illumineers. Illumineers are experienced in LED technology, thermal management, power driver stage and secondary optics.

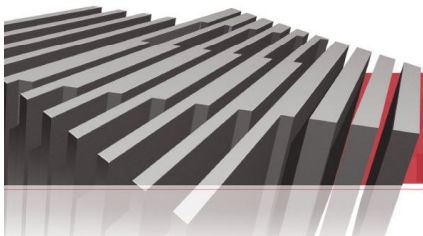
*LightSpeed*<sup>TM</sup>



# Avnet Solid State Lighting Group

- Whether you are considering a new application, or interested in re-visiting an existing design, a complete illumination solution integrates a number of carefully chosen elements. As a unit of Avnet Electronics Marketing, **LightSpeed** brings together the world's foremost LED, high-performance analog and optical/electromechanical manufacturers along with best-in-class technical expertise and supply chain management services.
- Working together, we can help you to bring your ideas to light.
- To learn more about designing an LED-based illumination system, go to:

[www.em.avnet.com/LightSpeed](http://www.em.avnet.com/LightSpeed)



# Questions or Comments?



# References

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