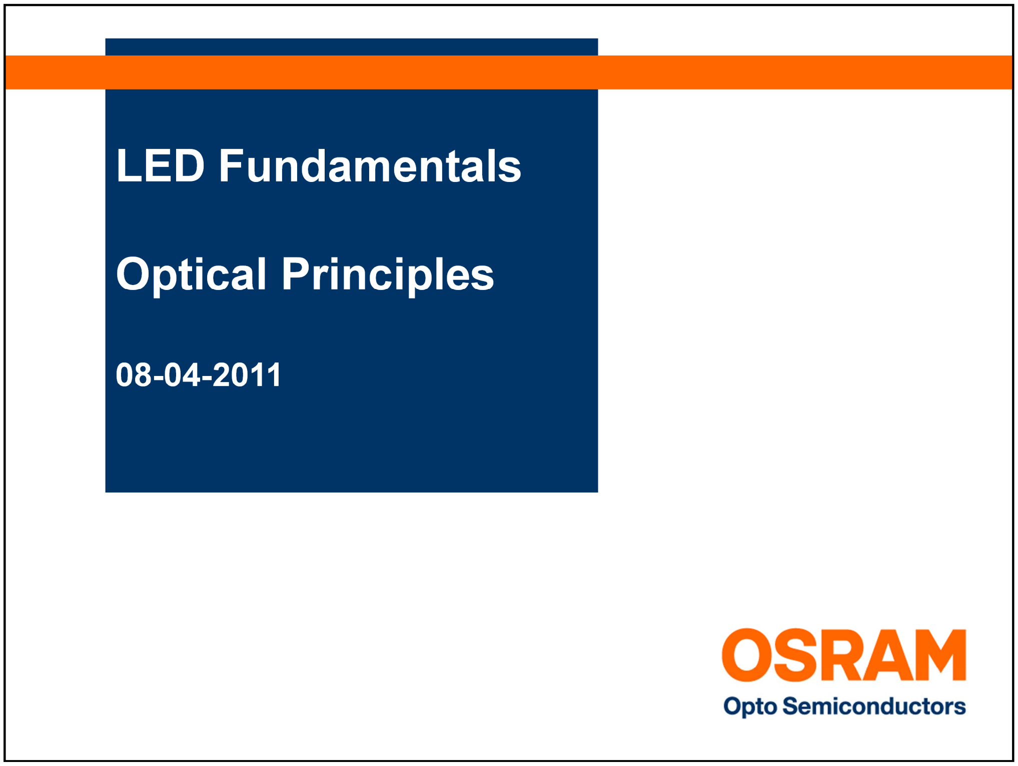
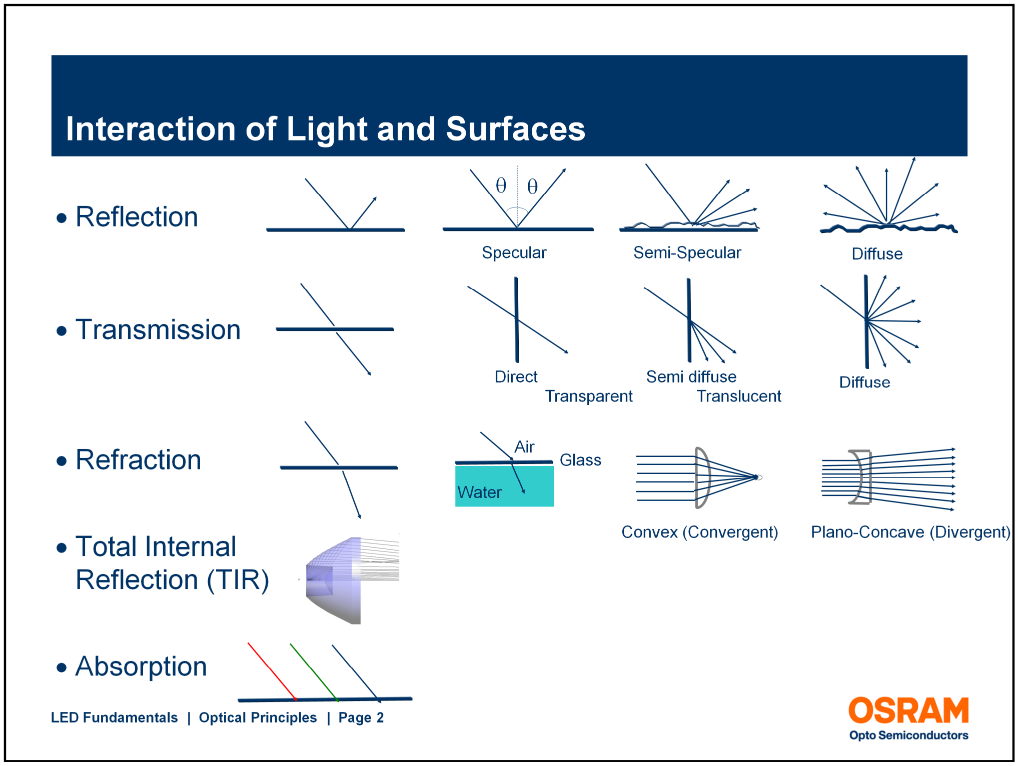
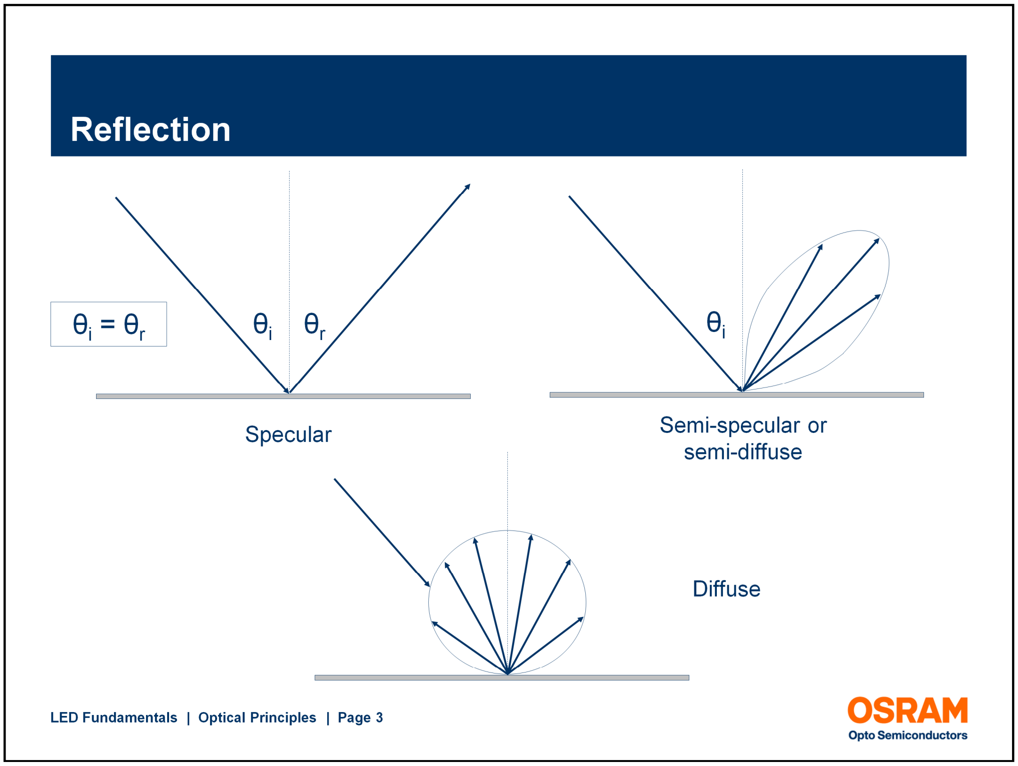


Welcome to this presentation on Optical Principals, part of OSRAM Opto Semiconductors‘ LED Fundamentals series.

In this presentation we will look at the basic optical laws that apply to solid state lighting.

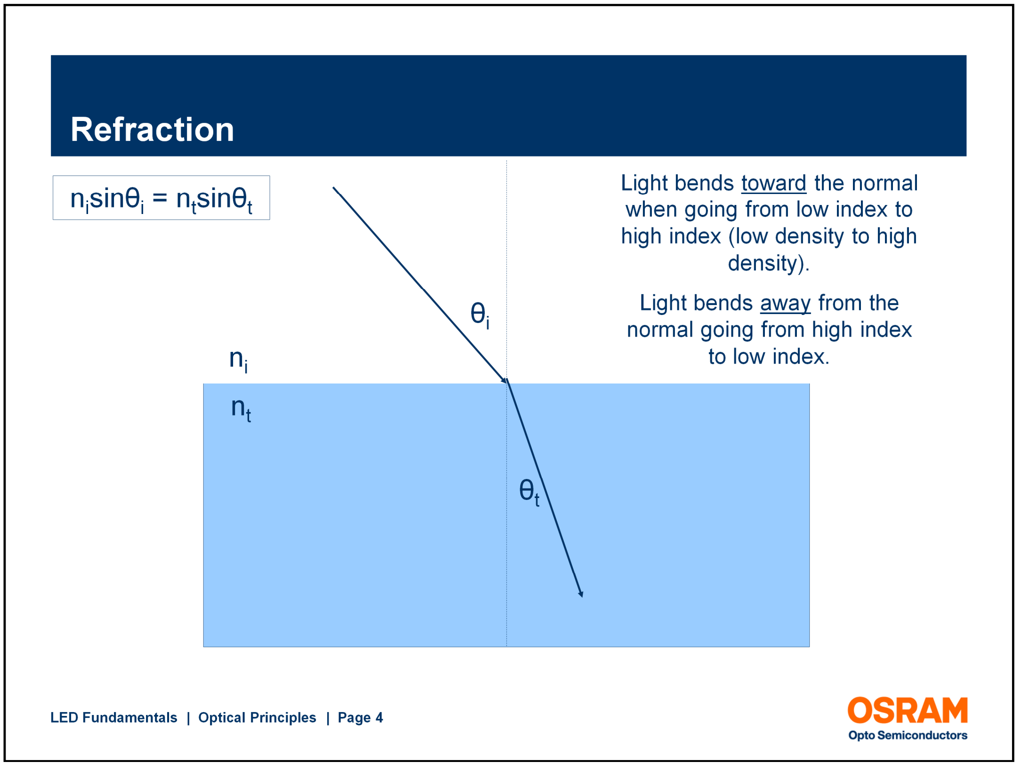


When light encounters a surface, or travels from one media to another, several interactions are possible. For general lighting, we are typically interested in reflection, transmission, refraction, total internal reflection (which is really a special case of refraction), and absorption.

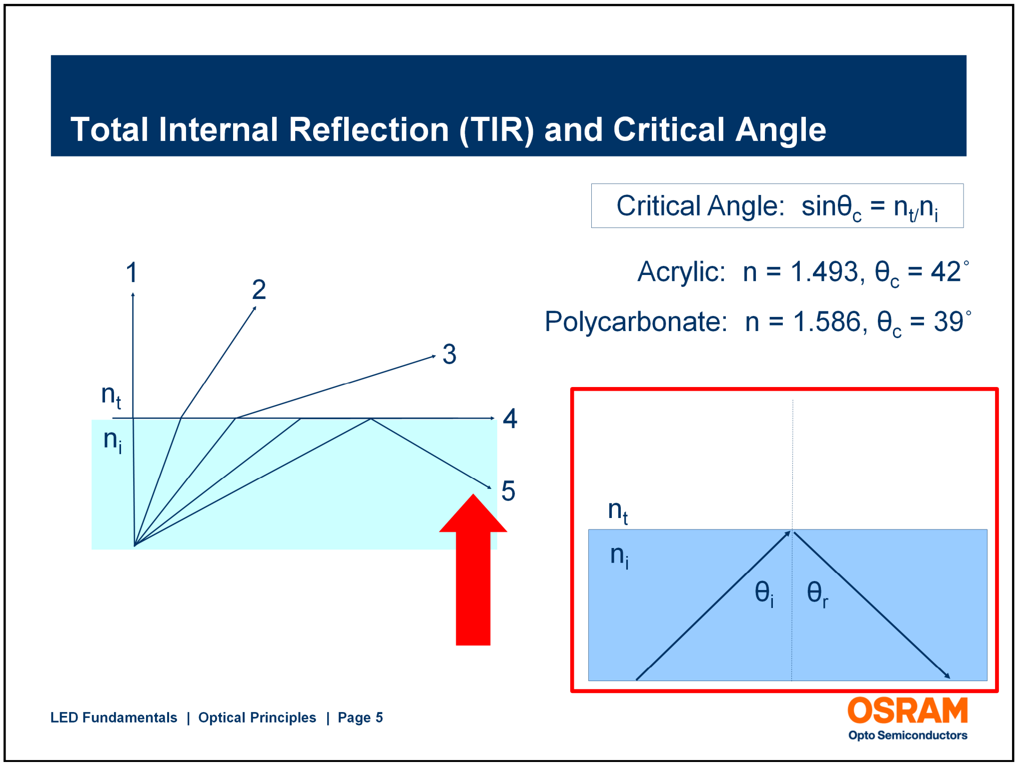


Consider a light ray striking a mirrored surface. The angle of the light ray with respect to the surface normal is theta I and is called the “angle of incidence”. The Law of Reflection states that the angle of incidence is equal to the angle of reflection. The is also the definition of a “specular” reflection. For a surface with some roughness, some of the light will reflect in the specular direction and some will be reflected in other directions. This can be called “semi-specular” or “semi-diffuse” reflection. A “diffuse” reflection sends light in all directions.

It should be noted that transmission works in a similar fashion.



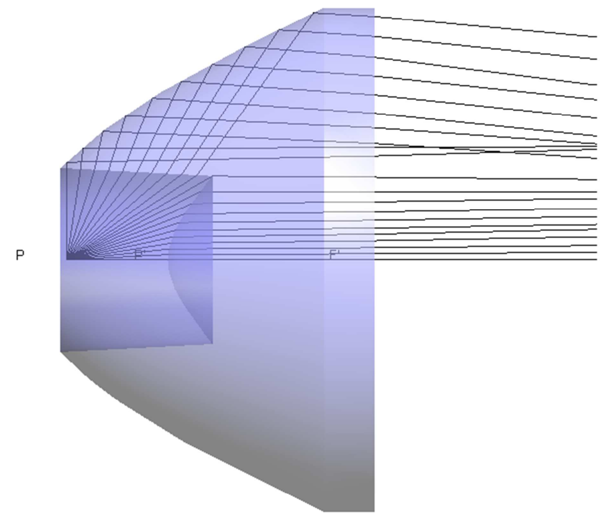
Refraction takes place when light passes from one media or material to another, say, from air to plastic. Light bends towards or away from the surface normal depending on the indicies of refraction of the materials and the angle of incidence. The equation which describes the relationship between the angle of incidence and the angle of transmission is known as “Snell’s Law”. In general, light bends toward the normal when going from a low index to high index, such as air to plastic. Light bends away from the normal when going from high to low index, for example plastic to air.



A special case of refraction is called total internal reflection, or TIR. This occurs when light is traveling from a high index material to a low index material. Referring to the figure on the left, as the angle of incidence increases from 1 to 2 to 3, the angle of transmission also increases. When the angle of incidence reaches the so-called “critical angle,” illustrated by ray 4, the light remains confined in the high index material. Beyond this angle, light reflects off the high index-low index boundary according to the Law of Reflection.

Total Internal Reflection (TIR) and Critical Angle

- Lightguides
- TIR optics



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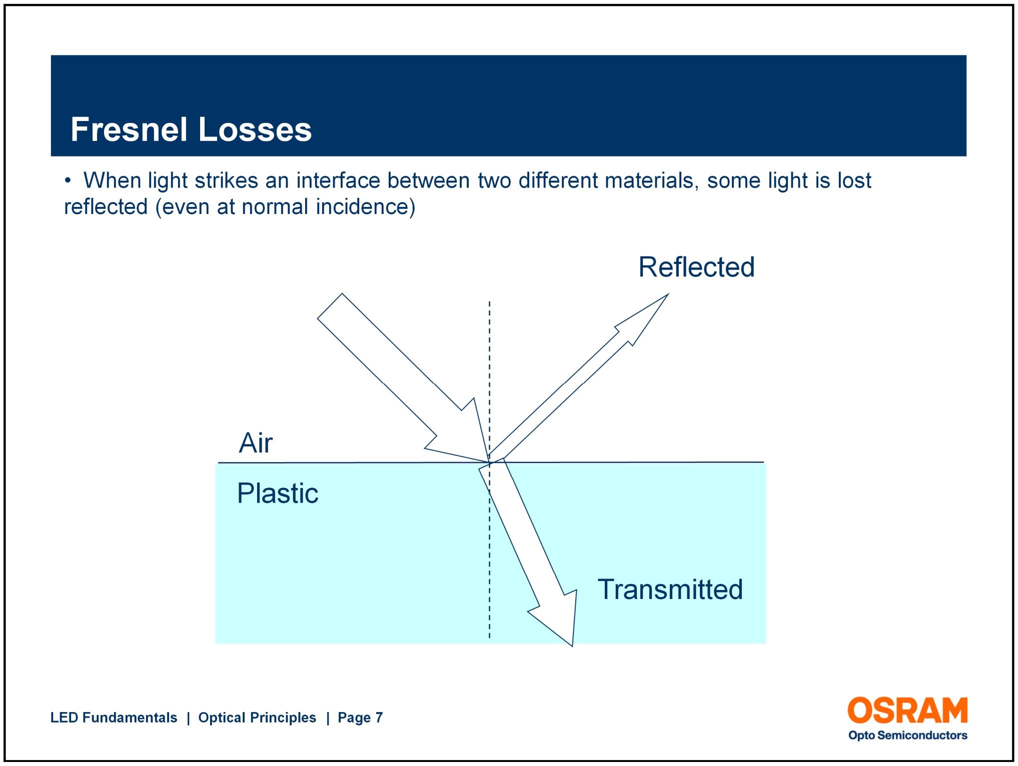
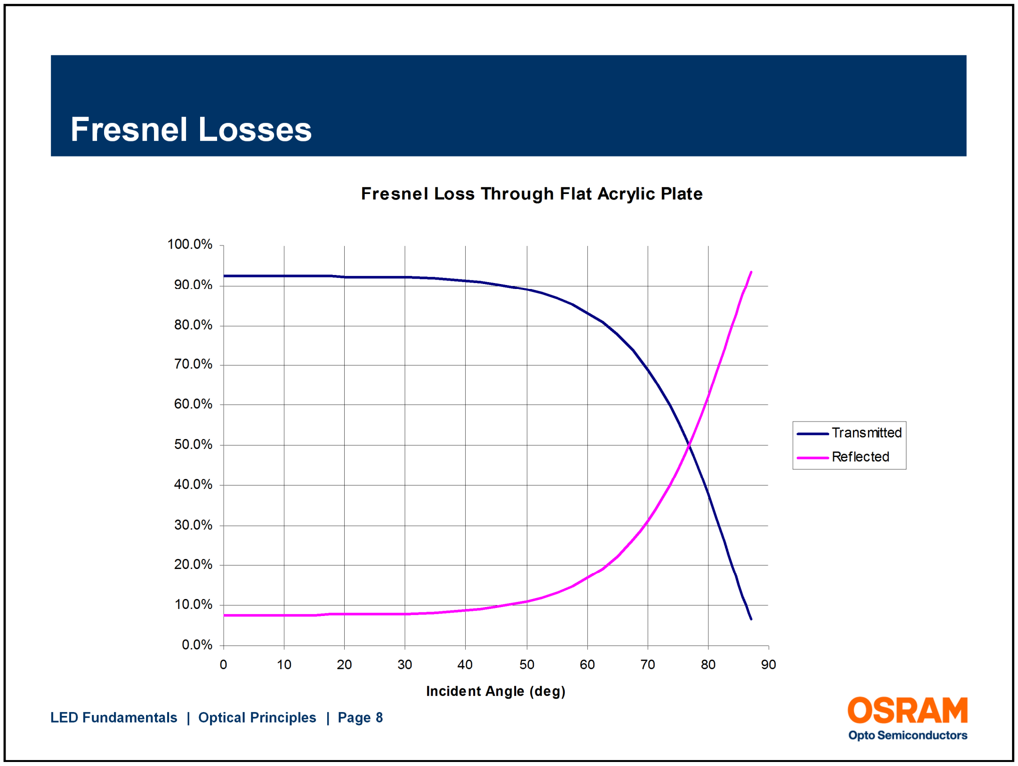
Since this is a lossless reflection, the principle of TIR can be used to design high efficiency optics. Lightguides, such as those found in LCD backlights, also take advantage of TIR.



An important consideration when light is passing through different material is Fresnel loss. When light is going from air to plastic or vice-versa, for example, part of the light is transmitted and part is reflected, even at normal incidence. The percentages of transmitted and reflected light depend primarily upon the angle of incidence and index of refraction. The polarization state can also be important, but for general lighting an average polarization is assumed when making calculations.



Here is a graph showing the percentages of transmitted and reflected light through an acrylic sheet surrounded by air. As you can see, significant transmission losses occur at angles of 60 degrees and beyond. Fresnel losses can significantly impact optical system efficiency if not considered.

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