Goldeneye Inc

Goldeneye™
High Brightness LED Light Sources

Summary

Goldeneye Inc., an intellectual property development company headquartered in Carlsbad, CA, has developed high-brightness, solid-state light sources utilizing current state-of-the-art LEDs. The first application for this light source is in projection displays including audio-visual projectors, home theatre projectors and large rear projection televisions. The company has applied for multiple US patents that provide broad and comprehensive coverage for the high-brightness sources. The initial patent has issued, US Patent No. 6,869,206.

The Goldeneye™ LED-based light sources utilize light-recycling cavities that can provide 2 to 5 times the brightness of existing state-of-the-art LEDs. The use of light-recycling cavities solves the crucial problem of how to effectively achieve a small light-source area while incorporating a sufficient number of LEDs to illuminate a large area display.

The Goldeneye™ LED-based light sources can potentially replace arc lamps currently used in projection displays that incorporate DLP, LCD or LCOS micro-displays. Arc lamps can produce on the order of 10 optical watts of optical power in an area of a few square millimeters. However, arc lamps have many undesirable properties, including short lifetimes, slow startup, lack of color control, high bulb pressures and the use of mercury. LED light sources can eliminate these problems while increasing color saturation and doing away with replacement bulb expense.

Detailed Explanation of the Technology

Projection televisions that use DLP, LCD or LCOS micro-displays currently utilize arc lamps as light sources. A light source with a small emitting area is very important for projection displays. Micro-displays have small active areas and require restricted angular inputs, both of which result in small values of an optical quantity known as etendue. In order to replace an arc lamp with an LED-based light source, the LED light source must produce the appropriate amount of light within the etendue value required by the micro-display. The etendue of the micro-display, expressed in units of square-millimeters-steradians, is defined as:

Etendue (in mm2-sr) = (area of micro-display)*(p)*(sin2[half-angle])

In the above equation, the area of the micro-display is expressed in square millimeters (mm2). The half-angle in degrees is one-half of the full angular extent of the light that can be utilized by the micro-display. The etendue of a typical micro-display ranges from about 13 mm2-sr to about 60 mm2-sr. A commonly used Texas Instruments HD2-DLP micro-display has a diagonal measure of 0.8 inches, an aspect ratio of 16:9, an area of 172 mm2 and an input half-angle of 12□. The etendue of the HD2-DLP is 23 mm2-sr. This etendue value will be used as an example output etendue for the light recycling cavities described below.

Although LEDs are highly desirable replacements for arc lamp sources in projection display systems, present LEDs do not have sufficient light output in a small enough area to meet the etendue requirements for large (e.g. 40-inch diagonal or larger) displays. For example, state-of-the-art GaN blue LEDs can produce as much as 0.2 watts of optical power at 465 nm in an area of 1 mm2. The LEDs have approximately a Lambertian (± 90□) output distribution. Applying the above etendue equation to the LED source, each LED has an etendue of p or 3.14. If the LEDs are arranged in a planar configuration as illustrated in Figure 1, only seven or eight LEDs can be used in order to keep the etendue less than or equal to about 23 mm2-sr. Eight such LEDs will produce only 1.6 watts of blue optical output. This is insufficient for a typical large-area display. Green and red LEDs have even less output power per square millimeter, resulting in substantially less optical power within an etendue of 23 mm2-sr.

Figure 1- Typical Flat LED Array

Goldeneye Inc. has developed the innovative and patented concept of a light-recycling cavity to address the etendue problem. A light-recycling cavity contains several LEDs and has a small output aperture with an etendue that matches the etendue of the micro-display. An example of a light-recycling cavity is shown in Figure 2.

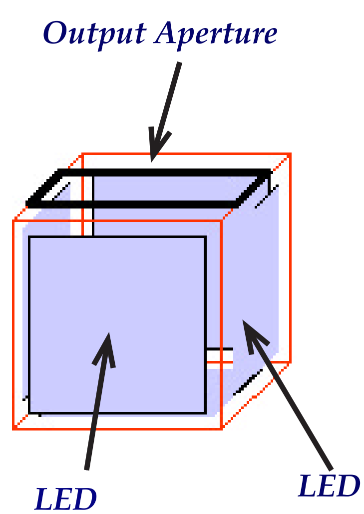

Figure 2- Goldeneye™ Light Recycling Cavity

In this example, the light-recycling cavity is in the shape of a cube. The inside surfaces of five sides of the cube are partially covered by LEDs that emit light directed toward the center of the cube. The sixth side of the cube is constructed from a highly reflective material that has an output aperture. The inside surfaces of the cube that are not covered by the LEDs are also covered by a highly reflective material. Light only exits the cavity through the output aperture.

The LEDs inside the light-recycling cavity must also be reflective so that a significant fraction of the generated light can exit the cavity without being absorbed. By configuring the LEDs in this light recycling cavity, the output flux from all the LEDs is combined and reflected until it exits the output aperture of the cavity. The output aperture can be the same size as a single LED with a higher luminance than any one of the LEDs within the cavity. Since the output from the output aperture of the cavity is lambertian, the desired etendue is achieved with a higher luminance than any of the LEDs within the cavity.