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**Non-Confidential Description - PSU No. 4514**

**“High Light Extraction Efficiency Light Emitting Diode (LED)”**

**Keywords:**

Light emitting diode, LED, high light extraction efficiency, LEE

**Inventors:**

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**Background**

The light emitting diode (LED) market is expected to reach over \$30 billion USD in 2016, and is anticipated to grow to \$45 billion by 2020. These lower energy light sources have uses in almost every field where lighting is needed. One of the key measures of LED devices is the light extraction efficiency (LEE). LED materials have a high refractive index and a portion of the emitted light remains trapped in the active area which lowers the LEE. A method for allowing this trapped light to escape can greatly improve the efficiency of the LED, with no increase in power consumption. Current methods include the creation of micro and nanostructures on the exit surface and/or substrate of the LED. However, although the efficiency is improved, there is still a significant amount of trapped light. A further improvement in LEE is needed and can be achieved by harnessing new micro and nanostructures.

**Invention Description**

This new method employs the creation of a novel asymmetric obtuse angle micro-structures on the substrate and/or exit surface. This novel structure has the following unique features: first, with the same high-to-base aspect ratio the asymmetric obtuse angle micro-structured substrate has a larger surface area than that of a symmetric micro-structured substrate; second, the deflection angle of asymmetric obtuse angle micro-structure is a function of location, which can increase the LEE. This new design can result in an LEE as high as 70.4%, which is over a 10% increase over current methods.

**Advantages**

- **Efficiency** – LEE is increased up to 10% over current designs.
- **Simple Design**– the approach of patterning of the substrate allows for standard design and processing methods.
- **Brighter and Lower Cost LEDs** – The output of the LED is increased with no increase in energy usage.

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