Press

Regensburg, April 2010

Bringing LED Efficiency to New Heights – OSRAM'S UX:3 Chip Technology

High power LED applications like automotive headlights, general lighting, or pocket projectors demand ever increasing brightness. High driving currents yield high brightness, but as the current rises, the efficiency of the LED declines. Hence high efficiency at high currents is the key to brighter high power LEDs. OSRAM Opto Semiconductors' new generation of high power chips features higher efficiency which is achieved by burying the n-type contact inside the chip. Moreover, the efficiency decline at high currents is overcome by reducing Auger recombination.

The two main aspects of LED efficiency are light creation – i.e. the production of photons in the chip's active region – and its extraction from the chip, called outcoupling. The term quantum efficiency describes the ratio between emitted photons versus injected electrons, while wall plug efficiency refers to the ratio between optical power output and electrical power input.

OSRAM's new and highly efficient UX:3 chips are based on the successful OSRAM ThinGaN technology which employs a metallic mirror below its active layer and a well defined scattering surface for optimized light extraction. This arrangement already yields an outcoupling of 75 – 80%.

Improved Outcoupling

One obstacle for light extraction is the metallic n-contact grid which injects the current on the chip surface. It absorbs light and reduces the active emitting area. These effects could be diminished by shrinking the metallic grid are, i.e. through wider grid spacing or narrower metallic line contacts. As a side effect, however, it would impair current spreading. Current Spreading poses already a major challenge for a high-power chip, caused by low lateral conductivity in the thin n-type GaN layer.

OSRAM takes a different approach by burying the entire grid inside the chip under the p-contact (Fig. 1). Vias, which penetrate the p-type material, connect it to the n-type layers. The p-contact comprises a highly reflective, silver-based layer. An insulation layer between n-contact and mirror prevents shorting of the two electrodes.

OSRAM GmbH
Corporate Communications
Media Relations
81536 München, Germany

OSRAM manufactures the new chip by bonding the grown epistructure onto a carrier and then removing the original substrate. Accurate design and control of mechanical carrier and interconnect provide the key for building a mechanically stable chip that features homogenous heat spreading. The new chips comply with all qualification requirements for automotive applications, including temperature cycles and stress tests at high temperature and humidity.

The buried n-contact yields higher quantum efficiencies in the new chips. Moreover, an improved epitaxial structure reduces the serial resistance and thus the ohmic losses. This in turn increases the wall plug efficiency. Thanks to the robust chip design the 1 mm x 1 mm chip can be operated at up to 3 A, depending on the package and thermal management.

Reduced Efficiency Loss at High Currents

High power LEDs suffer droop, a decline in efficiency, as the driving current increases. The cause of this effect is controversial, but OSRAM's research efforts lead to the conclusion that some form of Auger recombination is responsible for it. This is a non-radiative recombination between three or more carriers with at least one electron and one hole. These carriers are lost to possible photon production and the effect reduces the efficiency of light creation. Auger recombination cannot be eliminated from LEDs, but it can be reduced. Its occurrence is proportional to the cube of the carrier density; thus increasing the volume of the active region helps diminishing the effect. OSRAM's new UX:3 chip technology adopts this approach by minimizing the current density in the multi quantum well device.

Excellent Results

Measuring results verify the effectiveness of the new design. 1mm x 1mm chips emitting 440 nm show a peak external quantum efficiency of 68 %. They yield 640 mW optical power at 350 mA, and 3.2 W at 3 A. When phosphor-coated, these chips deliver white light with a peak efficacy of 136 lm/W and a maximum output of 830 lm at 3 A. Green LEDs using the new technology emit 523 nm and show a peak efficacy of over 200 lm/W. They produce 117 lm (100 lm/W) at 350 mA and 224 lm at 1 A. Those data make the LEDs a promising choice for high-performance projection systems based on green, blue and red emitters.

Even at high current densities, the emission pattern of UX:3 LEDs does not change with the drive current. Thus the design is ideal for use with external optics, such as automotive headlamp systems as well as projection and illumination applications. As the chips are surface emitters, their optical power is scalable. They can be combined to homogenously emitting, high-luminance multi-chip arrays.

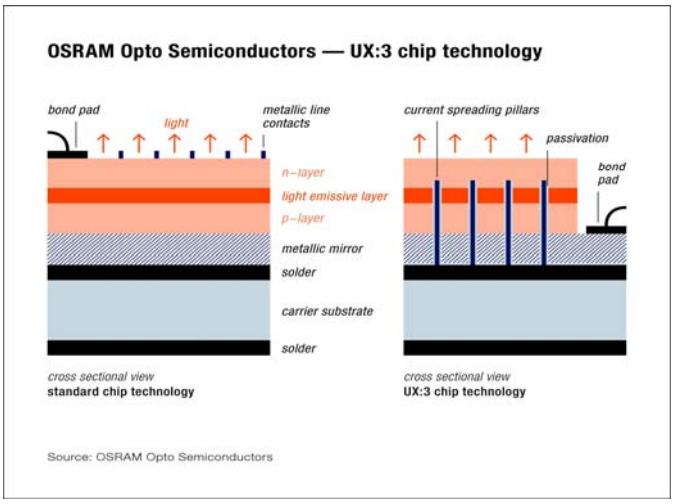

Figure 1: OSRAM's first generation of ThinGaN LED chips featured a metallic grid on the top of the device that reduced its active emission area and increased light absorption. The latest design remedies that deficiency by burying the n-type electrode in the epistructure.

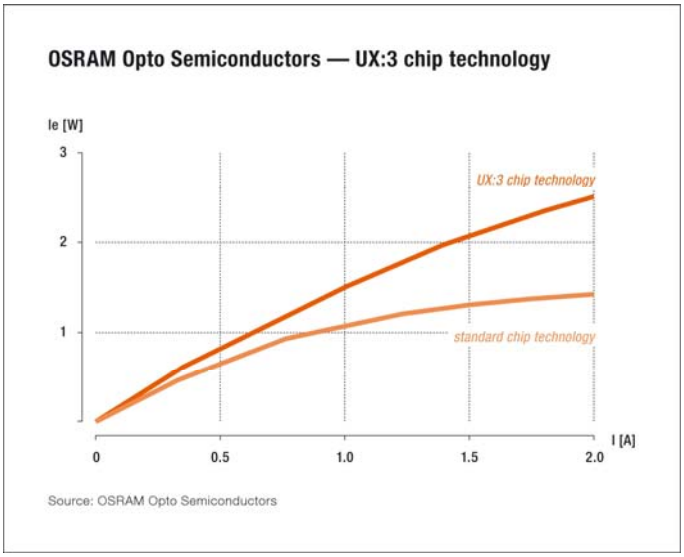

Figure 2: OSRAM has combated LED droop – normally seen as flattening of the Ie/I diagram towards higher currents – with a multiquantum well active region that has a very low carrier density. Auger recombination in the device is reduced.

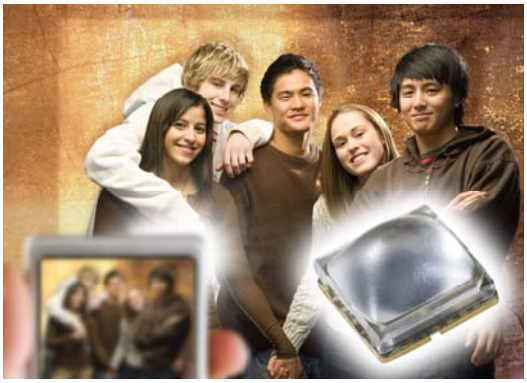

Figure 3: The new OSLUX LED– powered by UX:3 chiptechnology.

Photos: OSRAM
http://www.osram-os.com/press

PRESS CONTACT:
Marion Reichl
Tel. +49 941 850 1693
Fax +49 941 850 444 1693
e-mail: marion.reichl@osram-os.com