Paper

GaN-Substrate LEDs: Introduction nPola

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Abstract

Seoul Semiconductor's patented nPola technology increases brightness levels 5 times over existing LEDs. This technology took more than 10 years to develop and is set to revolutionise the LED lighting industry. nPola stands for Numerous polarities and is related to the substrate in which the LED is grown. nPola is grown on a GaN (Gallium nitride) substrate, whereas conventional LEDs use Sapphire or Silicone substrate in which most of the energy is converted to heat instead of light due to a defect caused by lattice mismatch. nPola, however, does not have the lattice mismatch issue like conventional LEDs because the GaN epitaxy has the same crystalline structure as the GaN growth substrate. Furthermore, nPola technology involves the utilization of the one of the nPola non-polar planes in the GaN crystal, either the a-plane or m-plane, whereas traditional LEDs currently utilize the polar c-plane GaN epitaxy on Sapphire or Silicon. nPola LEDs offer reduced electrical resistance, increased electrical efficiency, reduction in colour shift with varying operating current and smaller device size.

With nPola, Seoul Semiconductor has already improved the lumen density of LEDs by 5 times over the conventional LEDs based on equivalent die surface area and it expects to further improve this margin to 10 times in future.

Minimizing light source etendue by increasing the luminance of smaller size LED is essential to focus the light efficiently in smaller radiation angles allowing to realize smaller optical systems. Figure 1 shows the relation between chip size and luminance. With decreasing chip size, the luminance increases rapidly. We develop GaN-on-GaN LEDs called “nPola” to realize extremely high luminance at high current density with small size chip. Consequently, luminance of 200 Mcd/m at 3A were achieved. The nPola has low defect density less than 105 cm-2 while the GaN-on-Saphire LED has 108-109 cm-2. We obtained high reliability of 40K hours at temperature of 170 C and current density of 312 A/cm2 because of low defect density which is important for high power application. Efficiency degradation at high current density was remarkably improved in nPola LED by suppressing current crowding with thick conductive GaN substrate. In GaN-on-Saphire GaN LEDs with thin GaN, quantum efficiency decreases due to this current crowding with Joule heating. In thick GaN substrate in nPola LED, uniform current flow without current crowding is realized which leads to increase of quantum efficiency. Figure 2 shows the relation between operating current and optical power for n-Pola and GaN-on-Saphire LED. As a result, we obtained high optical power of 3.5 W at current of 2.8 A in nPola LED with size of 1mmX1mm(=3.5W/mm2), compared to that of 2.7 W in the GaN-on-Saphire LED with size of 1.1mmX1.1mm(=2.2W/mm2). Figure 3 shows the relation between operating current and degradation ratio of external quantum efficiency for n-Pola and GaN-on-sapphire LED. Smaller efficiency degradation of 27

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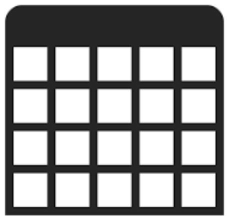

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Author’s CV

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Organisation

Seoul Semiconductor

Seoul Semiconductor develops and commercializes light emitting diodes (LEDs) for automotive, general illumination, specialty lighting, and backlighting markets. As the fourth-largest LED manufacturer globally, Seoul Semiconductor holds more than 12,000 patents, offers a wide range of technologies, and mass-produces innovative LED products such as Wicop – a simpler structured package-free LED which provides market leading color uniformity, cost savings at the fixture level with high lumen density and allows design flexibility; Acrich, the world’s first high-voltage AC-driven LED technology developed in 2005, includes all AC LED-related technologies from chip to module and circuit fabrication, as well as multi-junction technology (MJT); and nPola, a new LED product based on GaN-substrate technology that achieves over ten times the output of conventional LEDs.

CEO Statement: "Life is a drawing which cannot be erased and redrawn Thank you for your interest in Seoul Semiconductor. I believe a company should help the world, create value for its customers, let employees have pride and ensure the stability for its shareholders Seoul Semiconductor started in 1992 with around 30 employees in a small space of a commercial building in Bongchen-dong, Seoul. We have grown exponentially over the years creating many success stories With a dream that we would make our LEDs lit up even a space station, we built our company Logo and CI(Corporate Identity) in 1994 and have invested in R&D for the last two decades. Consequently, we also invented the world's first AC driven LED technology, "Acrich", 10 times brighter LED "nPola" and package-free LED technology "WICOP" With these technologies, not forgetting our original intention, we would like to build a clean, healthy and beautiful world! Moreover, we will do our best to meet stakeholders' expectations and requirements with our products and service and will abide by national and international standards. Lastly, I want to make a new history of light and wish to be a hope for young generation." CEO, Chung H. Lee

References

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