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Future Technologies and Applications of III-Nitride Materials and Devices

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III-nitride light-emitting diodes (LEDs) are now used almost everywhere, due to their energy-saving capability. In the near future, the vast majority of lighting sources will undoubtedly be based on LEDs. What future technologies and applications can we expect from III-nitride-based and particularly gallium nitride (GaN)-based, materials and devices?

The new generation of LED technology will be GaN-on-GaN lighting, with laser lighting following as the next opportunity. Ultraviolet A (UVA) light may play an important role in lighting, once it can be used to generate a high-quality white light source. In addition to lighting applications, ultraviolet C (UVC) light, light-based wireless communication (LiFi), laser communication, and electronic devices are the main applications of III-nitride materials and devices in the future.

GaN-on-GaN LEDs: The future of LED technology

The advantages of GaN-on-GaN LEDs include their low defect density, conductive substrate, low efficiency droop, semi-polar and non-polar substrates, high thermal conductivity, and low thermal droop. The facilitation rates of GaN substrates are much lower than those of GaN on sapphire. These advantages make the current density of GaN five times higher than that of sapphire, maintaining a much lower droop than found in conventional LEDs. GaN-on-GaN LEDs are good for directional lighting applications where high brightness and density are required, such as MR16 LED lamps. Cost is the biggest barrier for the development of GaN-on-GaN LEDs, due to the high cost of GaN substrates. To overcome this issue, the University of California, Santa Barbara (UCSB) research team has been demonstrating the use of ammono-thermal technology to grow GaN bulk crystals, a technology that would reduce substrate costs in future.

Laser lighting: The next opportunity in lighting

One limitation of LEDs is that their efficiency gradually decreases with the increase of input power. However, the input power for laser diodes can be increased dramatically while retaining very high efficiency. UCSB researchers have utilized a blue laser diode and yellow-emitting phosphor powder to generate a high-power white light with an intense, monochromatic, and directional laser beam. Laser lighting could have lighting applications in future.

Another application of laser diodes is intelligent lighting, such as mini projectors installed in smart phones that can be used to display imagery or data by projecting it onto nearby walls or floors.

UV LEDs: Covering a wide range of applications

As mentioned earlier, a blue LED can be used along with a yellow-emitting phosphor in order to generate a white LED. However, an alternative involves using a UVA LED or a laser diode, and a combination of red-, green-, and blue-emitting phosphors to generate a white LED. This LED has an emission spectrum from UVA to red, providing very high-quality illumination.

UVA LEDs can also be used for curing coatings, inks, and adhesives; they have medical and scientific applications as well, including photodynamic therapy. UVC LEDs hold promise for the medical sterilization and detection industries. The low efficiency of UVC is its main barrier to wide application.

LEDs will change communication

The use of LEDs in communication applications could be the next big thing. For example, LiFi is a new form of wireless communication that uses signals relying on LED light transmission, known to be more secure than traditional WiFi signals.

In summary, LEDs can help lighting become more intelligent and controllable. The future for GaN optoelectronics looks brighter than ever!

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