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Current State of the Art in High Brightness LEDs

GEORGE CRAFORD, Philips Lumileds Lighting Company

LED's have been commercially available since the 1960's. For many years they were used primarily for indicator applications. The remarkable increase in materials technology and efficiency that has been achieved since the early 1990's for AlInGaP red and amber LEDs, and InGaN green and blue LEDs, has enabled the penetration of markets such as outdoor display, signaling, and automotive brake light and turn signal applications. White LEDs, which are either blue LEDs combined with a phosphor, or a combination of red, green, and blue LEDs, are being used in emerging applications such as cell phone flash, television backlights, projection, and automotive headlights. In addition, to efficiency improvements these applications have required the development of higher power packages and, in some of these applications which are etendue limited, higher luminance devices. High power devices are commercially available which are capable of 140 lumens output and have an efficacy of around 70 lm/W for white emission. New package and chip technologies have been demonstrated which have a luminance of 38 mega nits (Mcd/m^2), approximately 50% more luminance than that of an automotive headlamp halogen bulb ($\sim$25 mega nits). The recent progress in materials technology, packaging, and chip technology makes it clear that LED's will become important for general illumination applications. The rate of LED penetration of this market will depend upon continued increases in performance and lower costs as well as better control of the white spectral emission. Efficiency, current density, and costs are closely linked because the cost in dollars/lumen is inversely proportional to how many lumens can be realized from each unit of device area for a given device type. Performance as high as 138 lm/W, and over 40% wall plug efficiency, has been reported for low power research devices and over 90 lm/W for high power research devices. It is clear that high power commercial products with performance in excess of 100 lm/W will become available soon, which is substantially more efficient than incandescents ($\sim$15 lm/W) and compact fluorescents ($\sim$60 lm/W) and equivalent to high performance fluorescent lighting. Performance in the range of 150 lm/W or even higher is plausible in the longer term. This talk will include an overview of the status and trends in LED technology and applications, and the challenges which must be met in order for LED's to become widely utilized in general illumination.