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Future Solid State Lighting Based on Light Emitting Laser Diodes

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Abstract— Solid state lighting (SSL) based on LEDs is today the most efficient light source for generation of high quality white light. Diode lasers, however, have the potential of being more efficient than LEDs for the generation of white light. A major advantage using diode lasers for solid state lighting is that the high efficiency can be obtained at high light lumen levels in a single element emitter and therefore less light sources are required to achieve a desired light level. Furthermore, the high directionality of the generated light from laser diodes increases the energy savings in many applications.

Within the coming years, it is expected that the efficiency of blue laser diodes will approach the efficiency of infrared diode lasers. This will enable high efficiency white light generation with very high lumen per watt values.

SSL today is mainly based on phosphor converted blue light emitting diodes (LEDs). Blue emitting 445–460 nm LED chips with conversion in phosphorescent materials have undergone tremendous development in the last decade with ultra high efficiencies. However, the technology suffers from a decrease in efficiency at high input current densities, known as the “efficiency droop” [1]. This efficiency droop limits operation to relatively low output lumen levels for single element emitters. The cause of the efficiency droop is still not completely clear and thus a solution is not easily found. In the literature it has been suggested that carrier overflow in the quantum wells and non-radiative recombination could be the causes. Recently, Auger recombination was proposed as the dominant mechanism for efficiency droop [2].

In the talk, we discuss the mechanisms of the efficiency droop in LEDs and we show how this problem can be eliminated in laser diodes. With the introduction of diode laser based lighting, high luminous flux levels and high efficiency can be available at the same time. Laser diodes operate in a fundamentally different regime using stimulated emission for light generation as opposed to spontaneous emission in LEDs

The recent progress in solid state lighting based on diode lasers will be reviewed and we will present a new diode laser architecture that emits as high as 2100 lumen green light with an efficiency of 70 lm/W.

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