

Phosphor-converted Light Emitting Diodes  
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The main idea behind color conversion of primary emission from Light Emitting Diodes (LEDs) was and is the generation of white light in an easier way than mixing the emission of several LEDs. The mixing concept being still attractive as it promises maximum efficiency needs feedback color control to achieve stable output.

“Plain white”, generated by exciting the yellow broad band luminescence of YAG:Ce by blue LED light is now in wide spread use; this kind of white LEDs now differentiated mainly by light output, operational stability and efficiency. R&D efforts have been devoted to improvements of the quality of the white light and illumination-grade warm white light LEDs have been introduced during the last year. However, the quality reflected in extremely high color rendering index values has to be paid by a decrease in efficiency. Being already significantly higher than the efficiency of incandescent lamps the next step will be to compete favorably with tungsten-halogen and compact fluorescent lamps

Several concepts have been tried by many groups: blue pumped 2 phosphors, blue pumped 3 phosphors, UV pumped 3 or more phosphors. Comparative advantages have been claimed for each concept. The efficiency of the pump LED naturally having a dominant role. Trying to eliminate this factor one should define in a meaningful manner ‘conversion efficiency’ as the specific feature in the respective concept. The talk will present results obtained with experimental makes of all different concepts and outline some general conclusions. Emphasis will be on interaction between phosphors modifying spectra far beyond simple superposition and on losses to package components, limiting conversion efficiency even for the highest quantum efficiencies of the involved color converters. The role of quantum dots as color converters without some of the limits of classic phosphor materials will be discussed.

Color conversion of blue or UV pump light into monochromatic or narrow band emission of different color – true color conversion - will be touched upon, as this concept could gain importance for applications, in which certain LED properties are non-optimum.