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Abstract
For backlight modules with RGB LEDs, this research provides techniques to design color mixing zone and light scattering microstructures for optimal optical performances. The result can produce the edge-lit backlight module, for large display-based applications, with wider color gamut and less energy loss. Taguchi’s method was used to configure the design analysis. For the design of color mixing zone, the set of considered parameters includes allocations of the reflector and LEDs, light emitting angles of LEDs, optical performance of the reflector, and length of color mixing zone. For the design of light guide plate, the set of considered parameters includes shape of the microstructure, angle of the microstructure, size of the microstructure, and backlight type. The considered four parameters are controlling factors in the terminology of Taguchi’s orthogonal arrays. Three levels of variations with respect to each controlling factor were used to sort out the factor which has the maximum impact on the resultant effect in an effort to find the best combination of these design parameters.
According to the results from color mixing design research, the controlling factors on the effect of color mixing were compared. In the descending order, the sequence of the influence was found to be: length of color mixing zone, allocations of the reflector and LEDs, optical performance of the reflector, and light emitting angles of LEDs. Regarding the optical efficiency, the influence sequence in the descending order were found to be: allocations of the reflector and LEDs, optical performance of the reflector, length of color mixing zone, and light emitting angles of LEDs. In searching for optimal design parameters for color mixing, the design is targeted to solve the problem of energy efficiency that is less than 80% in general. On the basis of analysis of variance procedure, the found optimal design consists of a long U-shape, mirror-like reflector arranged with a row LED in front and a column of LEDs in the back, LEDs with Side + Lam light emitting angles, and a 40mm color-mixing zone. By the use of Lumileds design as a reference, our design is compared in terms of color-mixing effect and efficiency performance. To attain the same level of color mixing effect, our color-mixing zone is 40 mm which is 35 mm shorter than the 75 mm color-mixing zone in the reference design. This shorter zone also cuts the energy loss to 6 %.
According to the results from microstructure research, the controlling factors on the effect of luminance distribution were compared. In the descending order, the sequence of the impact was found to be: angle of the microstructure, shape of the microstructure, backlight type and size of the

microstructure. The best optical performance comes from the configuration that the microstructure is set for the shape of prism, the angle of 44o, the size of 0.2mm and combined with a wedged-type backlight with a 0.3o of wedged-angle. The normal-direction luminance produced by the backlight design based on this research was compared with that of the backlight with light-scattering dots based on the traditional etching process. In the comparison of luminance under the condition where the brightness enhancement films (BEFs) are not present, our design is capable to produce the luminance that is three times the level of what can be produced from the tradition design due to the fact that the microstructure is able to collimate the light in the direction normal to the light emitting surface. With this collimating function, the cost of the developed backlight can be reduced, since only one BEF instead of two is needed for building the module.
By analyzing a 40”backlight module composed of eight similar backlight units from our design, we found that brightness of the module was up to 10000 Nit, luminance uniformity was more than 85 %, color difference was well below 0.01. These results show that designed backlights are not only satisfactory to provide better color gamut for general applications of LCD panels, but also meet the requirements of high intensity, high luminance and better color uniformity for large display-based applications.
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