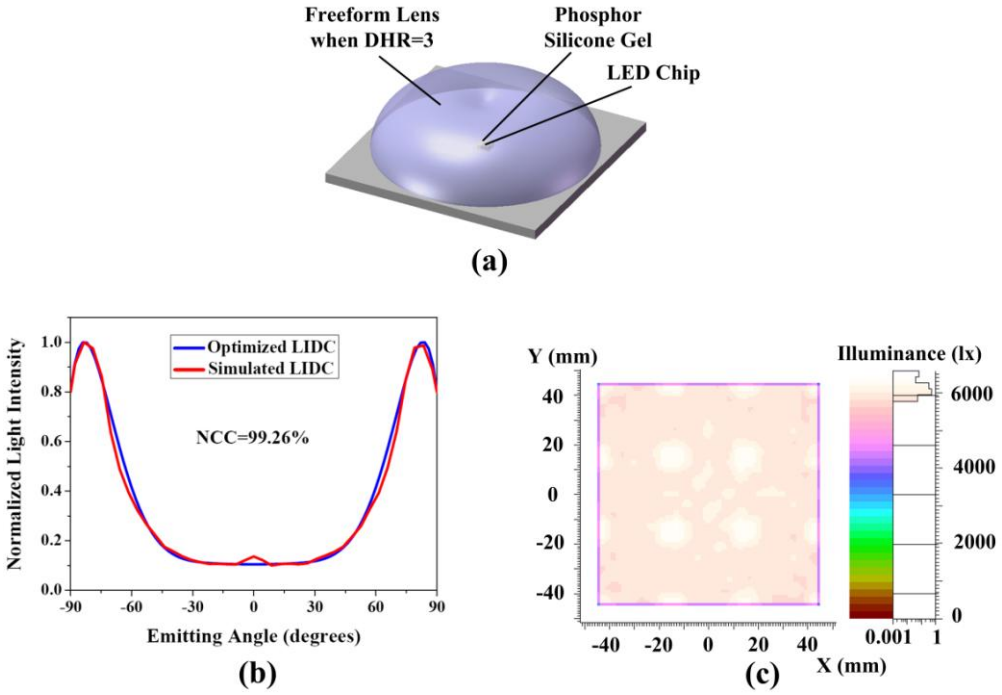


Fig. 9. (a) A new LED module integrated with a special silicone gel freeform lens for direct-lit backlighting when DHR = 3, (b) comparison of LIDCs between the simulated and the optimized results, and (c) lighting performance of these new LED modules array, $U$ = 0.887, CV(RMSE) = 0.0224.

## 5. Conclusions

In this study, a new reversing design method is proposed to solve the problem of optimizing LIDC and designing corresponding optical component to achieve LED uniform illumination when the DHR is given. This method includes design and optimization of LIDC to achieve high uniform illumination and a new algorithm of freeform lens to generate the required LIDC by LED light source. Slim direct-lit LED backlighting with thickness of 10mm is designed as an example. According to this new design method, two new LED backlighting modules integrated with freeform lenses are successfully designed generating optimized LIDCs to achieve uniform illumination. Uniformities of illuminance increase from 0.446 to 0.915 and from 0.155 to 0.887 when DHRs are 2 and 3 respectively. The range of DHR to achieve uniform illumination is much larger than the maximum range reported in previous reversing design. This reserving design method provides an effective way to dramatically decrease the number of LED modules when also able to achieve good lighting performance in slim direct-lit LED backlighting. Besides backlighting, this design method is also able to apply to other lighting applications, like LED interior lighting, commercial lighting, etc. Therefore, this new method provides a practical and simple way for the optical design of LED uniform illumination when DHR is much larger than 1.


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