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System of crossed-mirror array to converge illumination light for culturing chlorella

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1. Introduction

Recently, plant factory is promising for stable growth of high-quality agricultural products. However plant factory have a problem whose production cost is very high. In older to reduce that cost, we propose aerial light converging system of LED illuminators for improving illumination efficiency. In our system, crossed-mirror array (CMA) is used for three-dimensional in older to control light distribution. CMA is mirror optical device to form aerial LED image [1, 2]. CMA is composed of hollow apertures and each aperture performs dihedral roof mirrors. After double reflections, the incident rays are converging into the real-image position. By using this device for conversing light, lighting position will be easily designed suitable to each agricultural product.

In this paper, in order to confirm the possibility of CMA device for aerial light converging system, we have investigated luminance distributions and observed culturing chlorella by this LED lighting system.

2. Luminance distribution of LED Illuminator

Luminance distributions were investigated at distance and lateral direction, when light was converging to real-image position by CMA. Figure 1 shows experimental setup for investigating luminance distribution. Light source was one LED. Thicknesses of our using CMA are 4 mm and 8 mm. The distance between the light source and the CMA was set to 300 mm.

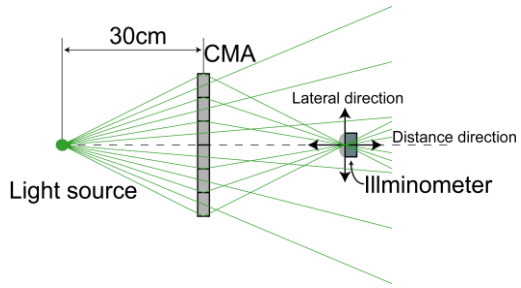

Fig.1. Experimental setup for measuring luminance distributions.

Luminance distribution of real-image of LED light by CMA is shown in Fig. 2. Luminance distribution has the maximum peak at the center of 0 mm. This peak is the result of converging light after double reflections by CMA. One time reflected lights have crossed-shaped distribution. Light is converging enough as CMA is thicker.

3. Culture of chlorella

We cultivated chlorophyte of chlorella by using our LED lighting system of CMA. This chlorella was kept by National Institute for Environmental Studies. We used nutrient agar for culture medium. Light source is red LED. That LED is integrated lens. Optical path is shorted by lens.

Figure 3 shows microscope images of chlorella before and after 24 hours illumination by LED real-image. Non-converging position means 2cm away from a light converging position. Before starting illumination, chlorella did not grow at all position. At light converging point, green particles grow after 24 hours. At non-converging position, green particles are hardly observed. This means chlorella is grown at only light conversing point.

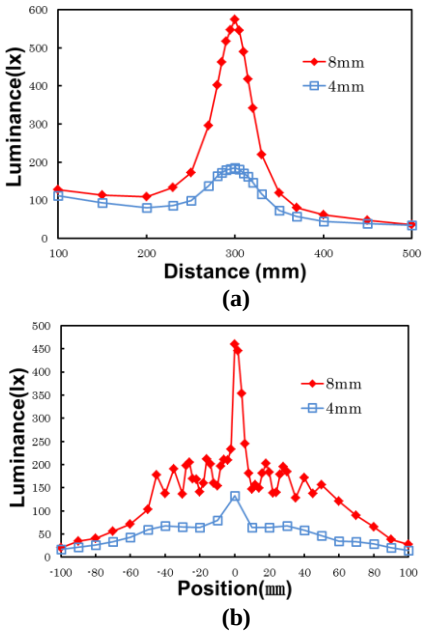

Fig.2. Luminance distributions with CMA in (a) distance and (b) lateral direction. Thicknesses of using CMA are 4 mm and 8 mm.

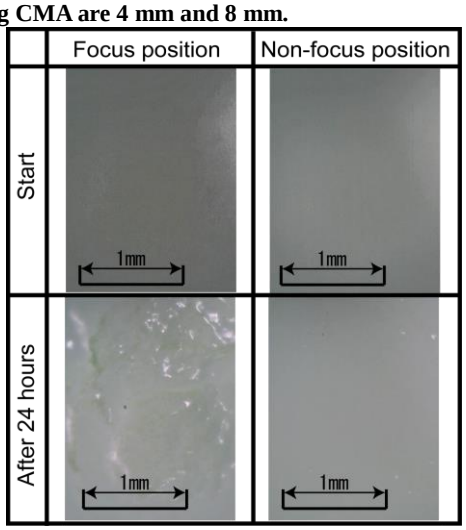

Fig. 3. Microscope observations of chlorella that was cultured with the proposed LED illuminator.

Thus, CMA is useful to cultivate chlorophyte.

4. Conclusion

Aerial light conversing system by using CMA for plant factory has been proposed.

Luminance distributions has a maximum peak and cultivating chlorella at converging position. As aerial light converging system can illuminate only need point. Chlorella is grown at light converging position. Our proposed system by using CMA is useful to cultivate agricultural products.

References

[1] H. Bando et al., Proc. IDW'11, 935-938 (2011).
[2] H. Yamamoto et al., Proc. SPIE, 8288 (2012).