# Design of CMA to Improve Luminance of Aerial Image

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## 1. Introduction

We have been studying aerial imaging for aerial digital signage. Because the aerial signs have no physical hardware at the image positions, we can walk through the signs. Thus, these signs can be placed right in front of a walker's face. Signs for kids can be located below 1 m height or so. Advertisement at such lower heights pioneers a new world for digital signage. This system can show information in front of people.

Aerial image can be realized by use of dihedral corner reflectors [1]. We have designed and fabricated a crossed-mirror array (CMA) for LED lamps in order to realize aerial image of a large LED panel [2, 3]. CMA can converge any sort of wave that can be reflected by aperture wall of CMA, for example, infrared radiations and sound waves [4, 5]. It is important to determine design CMA in order to form aerial images with high luminance. CMA can form aerial image after double reflections on aperture-wall mirrors. Key design factors of CMA are aperture size and thickness for a designed image position.

The purpose of this study is to determine aperture size and thickness of CMA so that CMA converges radiations to a designed position effectively. We have simulated dependence of illuminance on incident angle on thickness of CMA.

## 2. Image formation by use of CMA

Aperture surface of CMA is a mirror. Ray-tracing of incident light to CMA is shown in Fig. 1. CMA is composed of comb-shaped mirrors. After double reflections, the incident rays are converging into the image position because each pair of reflection surfaces are placed perpendicularly and act as dihedral roof mirrors. Every light emitted from a light source converges to the position of the plane symmetry of the light source about the CMA plane.

## 3. Simulation to determine the best incident angle

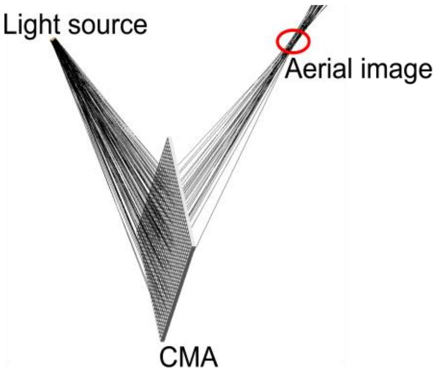


Fig. 1. Image forming by use of CMA.

Relationships between illuminance and light incident angle for CMA has been investigated with ray-tracing simulation software (Light Tools). Optical system for simulation is shown in Fig. 2. The CMA size is 142 mm × 142 mm. Its aperture size is 4 mm × 4 mm. We have simulated three thickness: 4 mm, 8 mm, and 12 mm. Distance of the light source from CMA is 300 mm.

Relationships between illuminance and incident angle are shown in Fig. 3. Peak angle is changed depending on the thickness of CMA. When CMA is thicker, peak angle gets smaller.

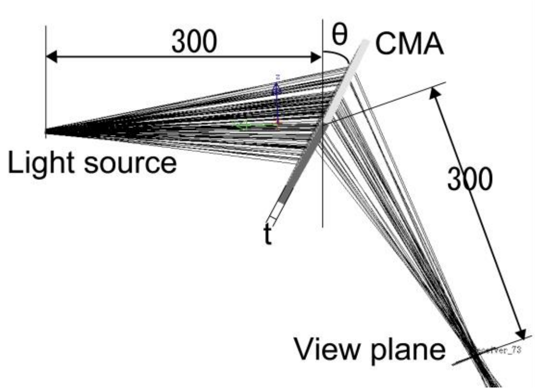


Fig. 2. Simulation setups. Using CMA aperture size of CMA is 4 mm × 4 mm. Thickness of CMA are 4 mm, 8 mm and 12 mm.

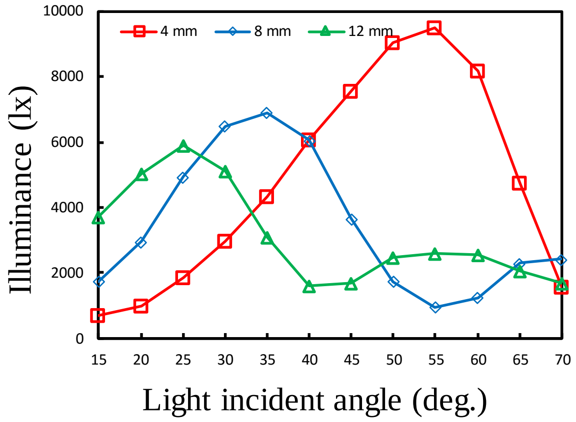


Fig .3 Relationships between illuminance and incident angle for different thickness of CMAs.

## 4. Conclusion

We have investigated relationships between illuminance and incident angle for CMA. The best incident angle that gives the peak illuminance changes with thickness of CMA, for example, 55 degrees is the best for our developed CMA that has 4 mm thickness and 4 mm × 4 mm apertures.

**Acknowledgements**

This work was partially supported by JSPS KAKENHI and JST CREST.

**References**

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