Homogenous monochromatic irradiance fields generated by microlens arrays

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Microlens array homogenizers are an attractive choice in the field of radiometry and photometry to generate highly uniform beams with high efficiency. In the present paper a microlens array homogenizer used to determine the spectral responsivity of large size, partially filtered photometer is presented. The effect of non-uniformity of the field is shown to be smaller than 0.2% in the whole visible spectrum.

INTRODUCTION

Homogenous monochromatic irradiance fields are essential for various applications in the field of photometry and radiometry. The calibration of the irradiance responsivity of radiometers (including UV-meters) requires a highly uniform illumination beam. Another example of application is the determination of the relative spectral responsivity of large sized, partially filtered (mosaic type) photometers.

Homogenous irradiance fields are typically generated using the output radiation of an integrating sphere or a transmitting diffuser. However a large amount of the energy gets lost due to the large scattering of these elements. In practice, integrating spheres have to be combined with expensive tuneable laser sources to generate homogenous monochromatic field of irradiance over large sizes. Homogenizers based on microlens arrays are an interesting alternative. They are commonly used in the field of photolithography [1], laser beam shaping [2] and LED illumination systems [3]. Thanks to technological progresses over the past few years, homogenizer based on high quality microlens array are becoming an attractive choice in the field of photometry and radiometry.

MICROLENS ARRAY HOMOGENIZER

Figure 1 illustrates an imaging type homogenizer system consisting of two microlens arrays LA_1 and LA_1 and a field lens FL. The homogenization plane FP is located at one focal length distance f_{FL} behind the spherical lens FL. The dimension of the irradiance field in homogenized plane D_{FT} is given by

$$D_{FT} = \frac{P_{LA1} \cdot f_{FL}}{f_{LA1} \cdot f_{LA2}} \left[f_{LA1} \cdot f_{LA2} - a_{12} \right], \qquad (1)$$

where P_{LAX} is the pitch and f_{LAX} the focal length of the microlens arrays LA_X, and a_{12} the spacing between the two microlens arrays. Two crossed arrays of cylindrical microlenses are usually used to generate a squared flat top.

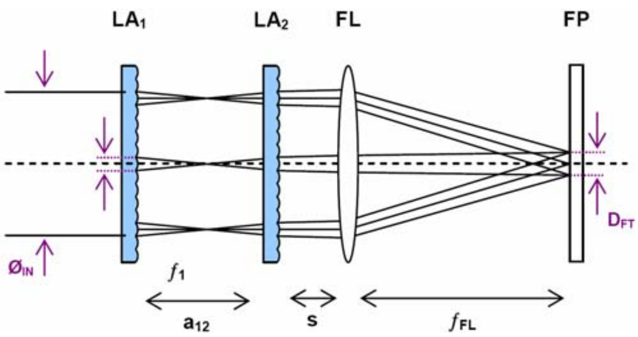

Figure 1. Imaging microlens array homogenizer

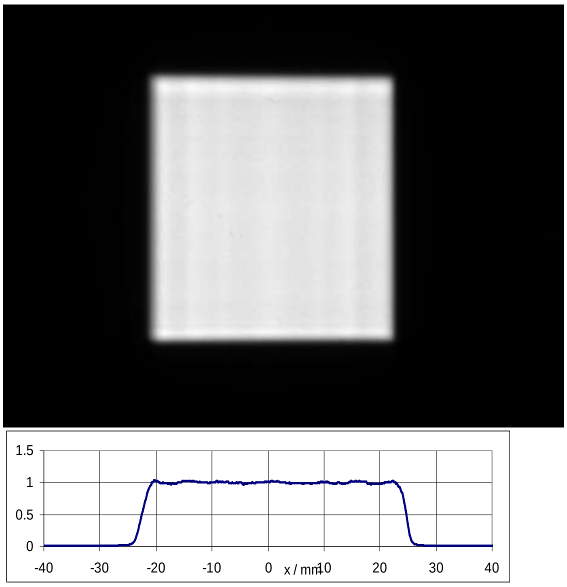

Figure 2. Irradiance field generated through imaging

microlens array homogenizer.

MEASUREMET SYSTEM FOR SPECTRAL IRRADIANCE RESPONSIVITY

At METAS the set-up used to calibrate the spectral responsivity of radiometers in the visible region consists of a monochromator ($f_{\#}$/5.4, f = 640 mm, spectral bandwidth = 2.4 nm), a set of order sorting filters and a current stabilised 45W tungsten halogen lamp. A high quality microlens array homogenizer (P_{LAX} = 250 µm, f_{LAX} =1.6 mm and f_{FL} =300 mm, fused silica) generates a homogenized irradiance square field of the size of about 45 mm x 45 mm. Figure 2 shows the irradiance distribution of the field generated at 500 nm. The mean irradiance is in the order of 0.4µW/cm^2. The uniformity measured with a detector of 100 µm diameter is in the order of 1%. In radiometry the irradiance field is usually averaged over a few millimetres. Figure 3 shows the change in average irradiance while displacing a detector having a 8 mm diameter aperture. By taking into account the repositioning error of an automatic detector translation system of 100 µm, the error due to the non-uniformity of the field falls well below 0.1%.

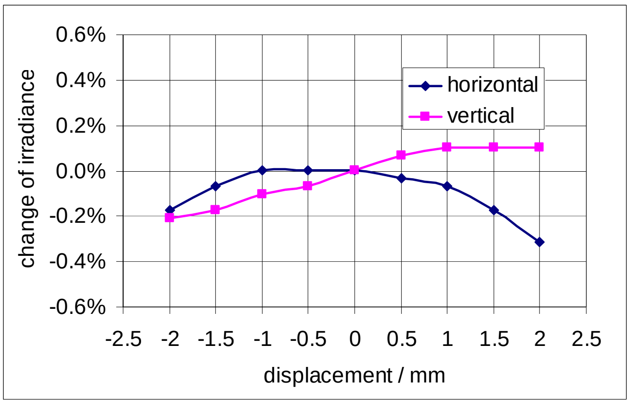

Figure 3. Change of the average irradiance while displacing a detector having 8 mm diameter aperture.

SPECTRAL RESPONSIVITY OF LARGE-SIZED PARTIAL FILTERED PHOTOMETERS

An important field of application of homogenous monochromatic fields is the determination of the relative spectral responsivity of photometers. High precision photometers consist of large sized and partially filtered sensors. In principle, the spectral responsivity of these devices could be determined by scanning locally an aperture-under-filling beam. However the method of scanning the aperture at each wavelength is very time consuming and may introduced some systematic errors. The privilege way of determining the responsivity is to illuminate the detector by an over-filled beam of high uniformity. In this case it is important that the ratio between the irradiance averaged over the size of the reference detector and the irradiance averaged over the size of the photometer remains constant for the whole spectral range. Figure 4 shows this ratio for a photometer of 30 mm diameter aperture and a reference detector of 8 mm diameter aperture. The ratio was determined by measuring the spatial irradiance distribution for different wavelengths and by calculating the averaged irradiance for both aperture diameters. The ratio variation is smaller than 0.2% in the most sensitive wavelength range of the photometer.

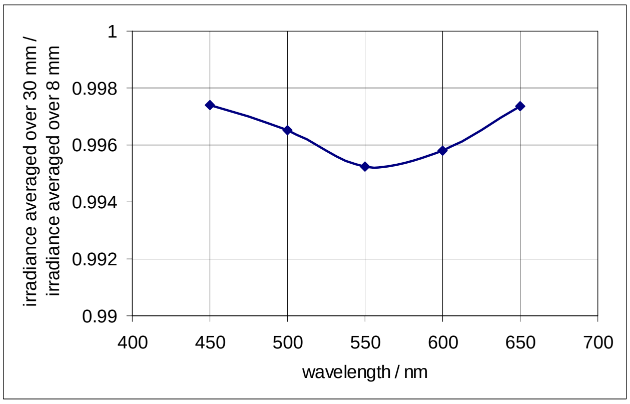

Figure 4. Ratio of irradiance averaged over two apertures diameter versus wavelength.

CONCLUSIONS

Thanks to technological progresses over the past few years, high quality microlens array homogenizers are becoming an attractive choice in the field of photometry and radiometry for the generation of highly uniform light fields. In this paper a microlens homogenizer system was used to determine the relative spectral responsivity of large sized partially filtered photometers. The effect of non-uniformity of the field is shown to be smaller than 0.2% in the whole visible wavelength region.

REFERENCES

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