Experimental analysis of focus effect on power generation characteristics of optical wireless power transmission when obliquely irradiated

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1. Introduction

Optical wireless power transmission (OWPT) has characteristics of long-distance power transmission and no leakage of electromagnetic waves compared to existing wireless power transmission [1]. From a numerical analysis of an OWPT system with a simple light source, the energy transmission efficiency begins to decrease rapidly due to beam deformation when obliquely irradiated the solar cell module in the case of focusing on solar cell [2]. In previous research when the beam was perpendicularly irradiated on solar cell, optimum focused condition was effective for wide transmission distance of OWPT system, because of transmission distance dependence of lens magnification under fixed lens position and variable focal length of liquid lens [3].

In this research, we investigated the influence of focusing condition on the power generation efficiency when the beam is obliquely irradiated on solar cell by experiment.

2. Configuration of experiment

As shown in Fig. 1, 1.5mm square VCSEL array chip (λ=808 nm) as light source, liquid lens and 10cm square Silicon solar cell were used in this experiment. The distance between VCSEL and solar cell is fixed at 4.5 m, and the input power of VCSEL are fixed at 3.325W and light output power of 0.672W. The distance between VCSEL and liquid lens is a_0, a_1, a_2, (a_0<a_1<a_2) respectively, and the focal length of liquid lens are variable. By controlling of the lens position and focal length, transmission (imaging) distance and lens magnification are controlled independently. The tilted angle φ of the solar cell is 0°, 40°, 60° respectively. When $\varphi = 0$, a_1 and $f = 66.7\,mm$ are imaging condition with appropriate lens magnification. The output of solar cell is used to evaluate the power generation efficiency of OWPT system. At the $\varphi = 0$ condition, the output of solar cell was as low as 80mW due to light leakage caused by small aperture of liquid lens.

3. Results of experiment

The results are shown in Fig. 2. When $\varphi = 40°$, the output power of solar cell maximized when focused at $f = 66.7\,mm$ and a_1 position. This is the same as optimum condition of $\varphi = 0$. When $\varphi = 60°$, the output power of solar cell maximized when unfocused, which means the beam deformation by out of focus compensated the beam deformation by oblique irradiation. Since extension of length of one side of beam shape causes large loss, light beam with smaller beam size and unfocused shape improved the light usage efficiency.

4. Summary

We confirmed that imaging (focusing) is not always essential for OWPT system when the beam is obliquely irradiated on solar cell. In the future, appropriate focus condition for maximum power generation efficiency needs to be discussed further.

Acknowledgements

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References

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[2] J. Tang, K. Matsunaga, T. Miyamoto, OWPT2019, P-20.
[3] Y. Toyama, T. Miyamoto, OWPT2019, P-10.

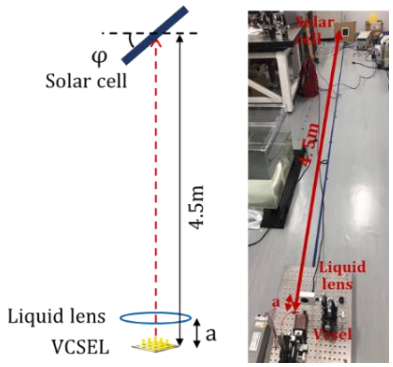

Fig. 1 Configuration of experiment for oblique irradiation.

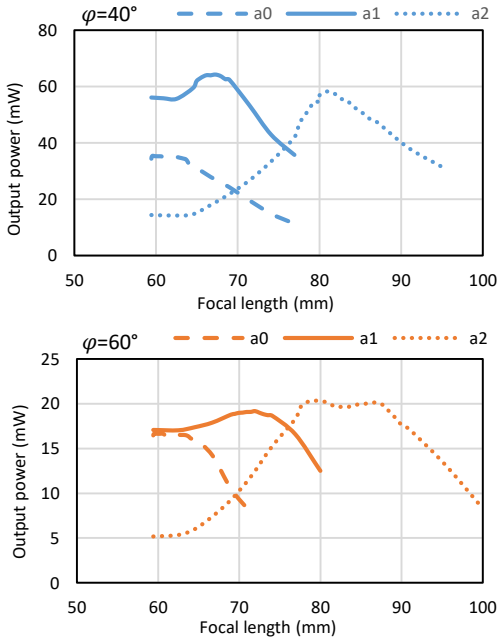

Fig. 2 Experimental results for oblique irradiation.