PERFORMANCE OF OPTICAL WIRELESS POWER TRANSFER SYSTEM USING A VERTICAL CAVITY SURFACE EMITTING LASER ARRAY

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Wireless power transfer technology is recently used for a wide range of applications such as electric vehicles and consumer electronics. Most of the wireless power transfer systems are based on magnetic coupling, such as inductive coupling power transfer and magnetic resonant coupling power transfer. These techniques can be used for short-distance power transfer, however, it is difficult to apply for long-distance power transfer with a distance larger than a few meter. In addition, there is leakage electromagnetic fields which may influences electrical and electronic apparatus. Therefore, wireless power transfer systems which are not based on magnetic coupling are required for applications for long-distance power transfer without electromagnetic noise. Optical wireless power transfer is suitable for this kind of application.

Optical wireless power transfer is a wireless power transfer technique for long-distance power transfer. In this technique, power transfer is realized by using a optical emitter and an optical receiver. A laser device and a photovoltaic module is normally used for the optical emitter and optical receiver, respectively. In this system, power transfer efficiency is mainly influenced by electrical-to-optical conversion efficiency of the laser and optical-to-electrical conversion efficiency of the photovoltaic module. Although the most important problem of the optical wireless power transfer is the conversion efficiency, recent improvement of the both devices enables us to improve the power transfer efficiency. Therefore, we investigated optical power transfer using a vertical activity surface emitting laser (VCSEL) array and a silicon solar cell module.

The optical power transfer system used in this study consists of a VCSEL array with a wavelength of 973 nm (Princeton Optronics Inc. PCW-CA-1-40-W0975), Fresnel lens, and a silicon solar module. We used two different silicon solar modules for this experiment. One is a commercially available polycrystalline silicon solar module with a size of about 10 cm x 10 cm. The second module is a monocrystalline silicon heterojunction module with a size of about 9 cm x 9 cm. In our experiment, the distance from the VCSEL and the solar module is about 50 cm. The light emission from the VCSEL array (5 mm x 5 mm) was enlarged and projected to the solar module using the Fresnel lens.

By using the polycrystalline silicon module, optical-to-electrical conversion efficiency of 20.6% was obtained under the laser power of 18.7 W. The optical-to-electrical conversion efficiency was much improved by using the monocrystalline silicon heterojunction module, and the efficiency reached to 34.1% under the same laser power, corresponding to the power transfer of 6.38 W. This result clearly shows that this kind of simple system can be used for optical wireless transfer. However, the obtained optical-to-electrical conversion efficiency is significantly lower than the theoretical value (about 45%). The detailed analysis of the experimental results revealed that present efficiency limiting factor is non-uniform laser irradiation to the solar modules. Improving the uniformity of the laser irradiation or module design suitable for the distribution of the laser irradiation is significantly important for improving the optical-to-electrical conversion efficiency.

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