52.7% CONVERSION EFFICIENCY OF SINGLE-JUNCTION GAAS SOLAR CELL FOR OPTICAL WIRELESS POWER TRANSMISSION USING LASER DIODE

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Optical wireless power transmission is expected to be smaller, higher-power, and longer distance transmission technology, comparing with conventional electromagnetic wireless power transmission. The highest efficiency have been reported to be 66.5% using GaAs multi-junction phototransducers, which value was obtained in a relative shorter distance within 20 mm by using fiber beam[1].

In this study, we investigated the power conversion efficiencies of single-junction III-V solar cells such as InGaP, GaAs, InGaAsP and InGaAs, with 20 cm longer distance transmission under irradiation of laser beam from laser diodes. These materials have bandgap energy (corresponding wavelength) of 1.9eV (656nm), 1.4eV (873nm), 1.1eV (1180nm) and 0.7eV (1675nm), respectively, which have been introduced into high efficiency 4-junction solar cell we have reported [2]. These 4 single-junction cells have the same size of 5mm x 5mm, and have the same shaded area of the grid fingers of 1%.

Conversion efficiencies were obtained by dividing the measured $P_{\text{max}} (= I_{\text{max}}V_{\text{max}})$ by the irradiated laser beam power with 638nm, 830nm, 980nm and 1550nm wavelength, respectively. In a result, efficiencies for these material solar cells were shown in Fig. 1. GaAs single solar cell showed the highest efficiency compared to other materials. Solar cells with lower bandgap such as InGaAsP and InGaAs exhibited lower efficiencies mainly due to lower open circuit voltage. On the other hand, InGaP solar cell also showed lower efficiency due to the lower short circuit current. Indeed this GaAs cell had a relative high efficiency of 25.9% under AM1.5G 1-sun, but it seemed that GaAs solar cell had the balanced bandgap to get a higher efficiency in this system.

In order to enhance an efficiency of GaAs cell, we varied the shaded area of the grid fingers from 1% to 5%. Because the efficiency of GaAs with 1% grid shadowing loss decreased at lower laser power as shown in Fig. 2. In a result, efficiency of GaAs solar cell was improved up to 52.7% at 0.4W/cm² and showed over 45% in the range of 4.0W/cm². By introducing the optimum grid finger structures and anti-reflecting coatings, efficiency of GaAs solar cell in this system is expected to be furthermore improved in the near future.

ACKNOWLEDGEMENTS

This project was supported in part by JSPS and CAS under the under Japan - China Scientific Cooperation Program.

REFERENCES