Area:III-V Compound Semiconductor and Concentrator and Space PV Technologies

IMPROVEMENT OF EFFICIENCY FOR 4-JUNCTION SOLAR CELL UNDER REAL SUNLIGHT

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Multi-junction solar cell is a promising technology to get a higher efficiency under concentrated sunlight. We have reported 42.0% efficiency of direct wafer bonded InGaP/GaAs/InGaAsP/InGaAs solar cell [1]. In this study, we measured the efficiency of 4-junction solar cell under real sunlight at summer and winter, and analyzed the I-V characteristics using estimated photocurrent of each subcell from EQE.

I-V performances of 4-junction solar cell under real concentrated sunlight without a lens and with a full-glass lens were investigated in summer and winter in Chiba Japan as shown in Fig. 1. A step-like I-V curve at summer was observed, which showed 27.7% efficiency at 1-sun condition. With increasing the concentrated sunlight, I-V curve became almost flat, which showed 38.3% at 38-suns. On the other hand, in winter, I-V curve without a step was observed, which showed 28.5% at 1-sun. With increasing the concentrated sunlight, I-V curve also became almost flat, which showed 40.3% at 64-suns.These concentrated efficiencies were estimated by using a concentrated number N which was defined by dividing $J^{(N)}_{sc}$ with a lens by $J^{(1)}_{sc}$ without a lens. We have analyzed the reason why 4-junction cell in summer exhibited a step-like I-V curve and showed lower efficiency compared to that of winter. It was found that these performances were due to the current mismatching for photocurrents of each subcell, as shown in Fig .2, which was caused by the difference of the real sunlight spectrum between summer and winter.

On the base of these results, then, we designed the optimum thickness of each subcell by the simulation using the software of PV-cell (STR-Group) in order to improve these current mismatching. The optimum thickness of GaAs base layer was estimated to be 1000nm as shown in Fig 3. Those of other materials such as InGaP, InGaAsP and InGaAs were also estimated to be 400nm, 1750nm and 3000nm. We found that the new optimum design could give another 2% advantage for an efficiency of 4-junction solar cell.

ACNOWLEDGEMENTS
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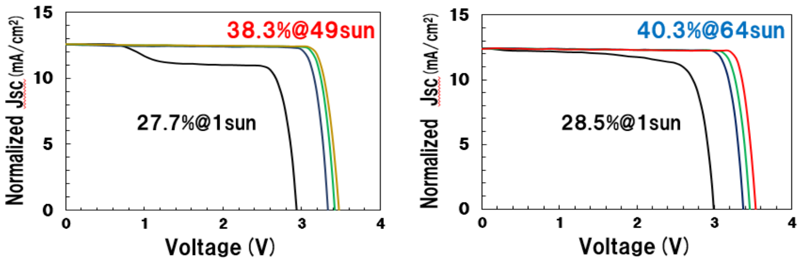

Fig. 1. I-V curves in summer (left) and winter (right) under real sunlight.

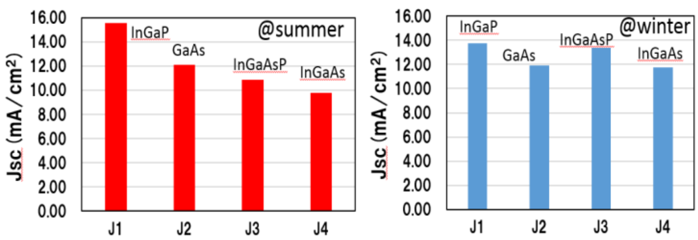

Fig. 2. Photo currents of each subcell at summer and winter

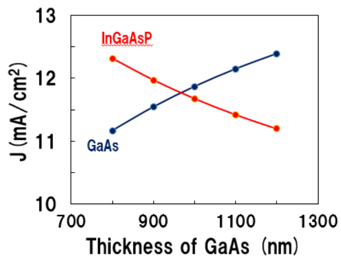

Fig. 3. Optimization of GaAs thickness

REFERENCES
[1] P. Dai, et al. Applied Physics Express, 9(1), 2015, 016501.