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B-2-7 Analysis of Conversion Efficiency of Large Area a-Si:H Solar Cells

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Introduction

We have developed large area hydrogenated amorphous silicon (a-Si:H) solar cells with ITO/nip/SS structure as shown in Fig.1. The conversion efficiencies (η) of 6.47%, 5.2% and 4.2% were obtained for 1.2 cm^2, 49 cm^2 and 100 cm^2 cells under AM1 light, respectively.[1] Cell area dependence of η was investigated by comparing the characteristics of 1.2 cm^2 cell with that of 49 cm^2 cell. The incident power (Pin) dependence of the cell characteristics is also studied.

Experimental

The decrease of η with increasing cell area relates to the decrease of Jsc and FF as shown in Fig.2. The decrease can be caused from (1) areal inhomogeneity of a-Si:H layers, (2) series (Rs) and (3) shunt (Rsh) resistances existing in the cell. We prepared 25 small cells (1.2 cm^2) made on a 49 cm^2 substrate. Each 1.2 cm^2 cell was electrically isolated in order to compare its characteristics with 49 cm^2 cells. Figure 3 shows the J-V characteristics of cells. The solid lines represent the characteristics of 1.2 cm^2cells with the maximum and minimum η's among the 25 cells. The Jsc lies between 9.8 mA/cm^2 and 11.78 mA/cm^2, while Voc is almost constant. The dotted line was obtained when those twenty-five 1.2 cm^2 cells were parallel-connected. Jsc of the parallel-connected cell is 10.79 mA/cm^2 and is equal to the mean value of Jsc in small cells. This result indicate that areal inhomogeneity of the a-Si:H layer in the 49 cm^2 cell causes the area dependence of Jsc.

The effect of Rs was evaluated by calculating FF from the output power vs. current relation, which was derived by subtracting the calculated power loss in Rs (due to the ITO film and the grid electrodes) from the generated power. The output power of 1.2 cm^2 cell was taken as the generated power because the power loss was calculated to be less than 0.4% of the generated power and FF was measured as 0.659. FF of 49 cm^2 cell was calculated as 0.615, while the measured value was 0.576 as shown in Fig.2. About a half of the decrease in FF with increasing cell area can be attributed to the effect of Rs.

The Rsh of the 49 cm^2 cell having the η of 5.2% was measured as 145 Ω from the dark J-V characteristics. From the power loss by the Rsh, we calculated Voc and FF to be 0.875 V and 0.650 for the 49 cm^2 cell, respectively. These results indicate that about 10% of decrease in FF from 1.2 cm^2 to 49 cm^2 cells can be

attributed to the effect of Rsh.

The Pin dependence of η and FF of 1.2 cm^2 and 49 cm^2 cells were measured to estimate the effect of Rs on cell characteristics. Jsc and Voc of both cells increased with the increase in Pin. FF of 1.2 cm^2 cell is independent of Pin and that of 49 cm^2 cell decreases with increasing Pin due to the effects of Rs as shown in Fig.4. In 1.2 cm^2 cell, η increases with Pin due to the increase in Voc but that of 49 cm^2 cell slightly decreases, which is caused by the decrease in FF with increasing Pin.

Conclusion

Factors influencing the area dependence of the characteristics of a-Si:H solar cell have been studied. Analytical studies indicate that the Jsc lowering is entirely attributed to areal inhomogeneity of the a-Si:H layers, and the main factor for the FF lowering is the Rs which comes from the ITO film and the grid electrodes in the cell. The η of 49 cm^2 cell slightly decreases with increasing Pin due to this Rs. These results suggest that the cell characteristics of the large area a-Si:H solar cells can be further improved by an optimization of the grid electrode design and precise optimization of the a-Si:H film deposition conditions for uniformity.

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1) Y. Uchida et al, 15th IEEE Photovoltaic Specialist Conf. Florida(1981)

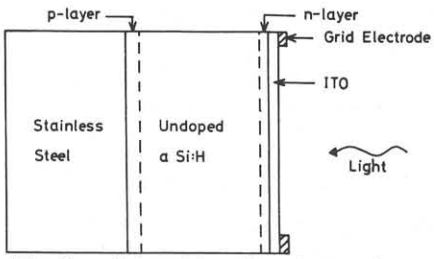

Fig.1 Schematic structure of a-Si:H solar cell

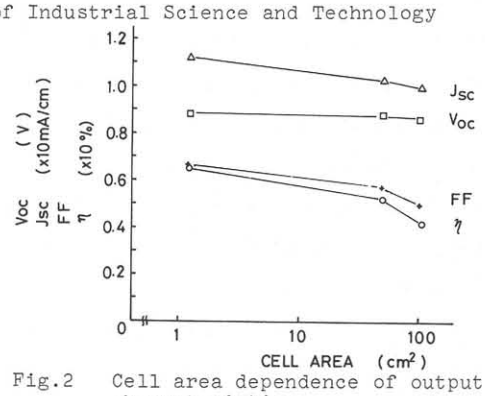

Fig.2 Cell area dependence of output characteristics

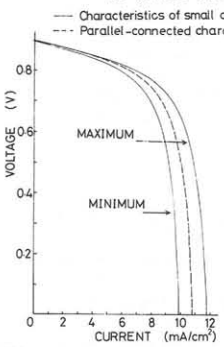

Fig.3 The output characteristics of 1.2 cm^2 cell

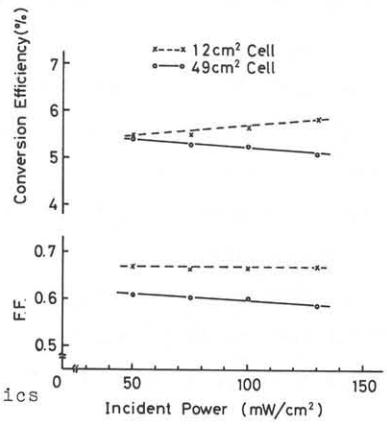

Fig.4 The Pin dependence of η and FF