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Deposition of Cluster-free A-Si:H Films Using A Cluster-eliminating Filter
クラスター除去フィルタを用いた
クラスターフリー水素化アモルファスシリコンの製膜

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We have succeeded in deposition of highly stable a-Si:H films at a rate of 3 nm/s. To evaluate their performance as an I layer of PIN solar cells, Fill Factor (FF) of N-type c-Si/a-Si:H/Ni Schottky cells with cluster free a-Si:H films were measured. High quality stable a-Si:H films, were deposited with a multi-hollow discharge plasma CVD reactor together with a cluster-eliminating filter. Initial FF of the cell is 0.521, whereas stabilized FF is 0.495 that is 4.99% lower than the initial FF. Our multi-hollow discharge plasma CVD method is useful to fabricate highly stable a-Si:H solar cells.

1. Introduction

Hydrogenated amorphous Silicon (a-Si:H) suffers from the Staebler-Wronski effect, which results in the efficiency of devices utilizing amorphous silicon dropping as the cell is exposed to light. Recently, we have succeeded in deposition of highly stable a-Si:H films of $4.7\text{x}10^{15}$ cm^{-3} in stabilized defect density at a rate of 3 nm/s at T_s= 250°C by suppressing incorporation of amorphous silicon nanoparticles (clusters) below 10 nm in size into the films [1]. To evaluate their performance as an I layer of PIN solar cells, Fill Factor (FF) of N-type c-Si/a-Si:H/Ni Schottky cells with cluster free a-Si:H films was measured in this study.

2. Experimental

Cluster free a-Si:H films were deposited by a multi-hollow discharge plasma CVD method. For the method, clusters, which are generated in the discharge region, were driven toward the downstream region by gas flow, because the gas flow velocity of 330cm/s in the discharge region was much faster than the diffusion velocity of clusters. Therefore, cluster-free a-Si:H films were deposited on a N-type c-Si substrate of 20x20 mm^2 in the upstream region [2]. Gas of SiH_4 was supplied at a flow rate of 15 sccm. The total pressure was 0.5 Torr. Discharge frequency and power were 60 MHz and 20 W. Under these condition, a-Si:H films with 1μm thickness were deposited at T_s= 250°C.

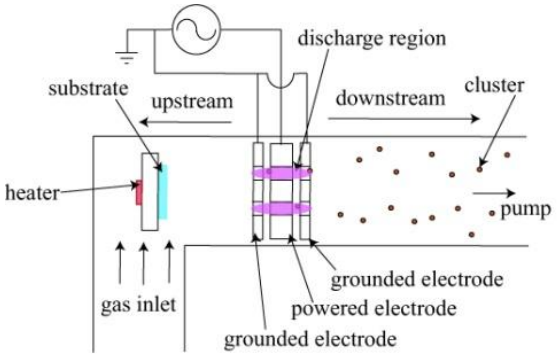

Fig. 1. Schematic of multi-hollow discharge plasma CVD reactor.

A cluster-eliminating filter was a device that removed clusters and through which SiH_3 radicals, which were the main precursor radicals of a-Si:H films of device quality, were passed. The filter reduced the contribution of the clusters to deposition of films using the difference between the sticking probability of the clusters and the surface reaction probability of the radicals. Cluster removal in the filter was realized by collision and attachment to the surface of the filter plates. The filter was composed of two stainless-steel plates of 0.1 mm in thickness with 8 or 9 slits of 1 mm in width. The slits of one plate were covered by the

other plate as shown in Fig. 2. The transmittance of these plates is 0.4. These plates were placed at a distance of 0.5 mm. The distance from Cluster-eliminating filter to electrode was 6.0mm. Cluster-eliminating filter was placed at distance of 5.0mm from discharge.

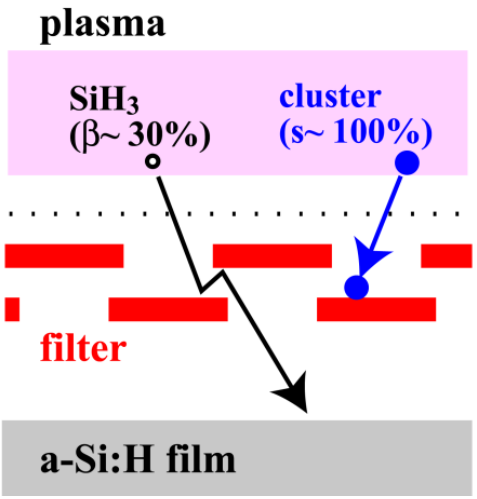

Fig. 2. Schematic of cluster-eliminating filter

3. Results

Figure 3 shows initial and stabilized J-V characteristics of the Schottky cell. Initial FF of the cell was 0.521. J_{SC} and V_{OC} were 2.70mA/cm^2 and 0.35V, respectively. Stabilized FF was 0.495 which was 4.99% lower than the initial FF. J_{SC} and V_{OC} were stabilized as 2.71mA/cm^2 and 0.35V, respectively. A-Si:H films of 7% degradation was also realized using a triode discharge system at low deposition rate of 0.018nm/s [4]. The deposition rate in this work was 0.065nm/s. These results show that our cluster free a-Si:H films at a higher deposition rate show better stability against light exposure. Our method is useful to fabricate highly stable a-Si:H solar cells.

4. Conclusions

We deposited a-Si:H films using SiH_4 multi-hollow discharge plasma CVD together with cluster-eliminating filter. Initial FF of the cell was 0.521. Stabilized FF was 0.495 which was 4.99% lower than the initial FF. Our method is useful to fabricate highly stable a-Si:H solar cells.

Acknowledgments

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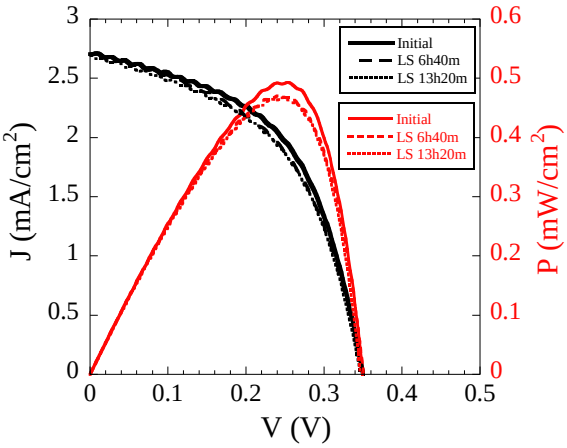

Fig. 3. Initial and stabilized J-V characteristics of Schottky cell.

Table I. Initial and stabilized characteristics of Schottky cell.

	Initial	Stabilized
FF	0.521	0.495
J_{sc} (mA/cm^2)	2.70	2.71
V_{oc} (V)	0.35	0.35
P_{max} (mW/cm^2)	0.493	0.471
R_{sh} (Ohm cm^2)	671	561
R_s (Ohm cm^2)	29	31