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Development of Heterojunction Back Contact Si Solar Cells

Junichi Nakamura

Energy System Solutions Division, SHARP Corporation, 282-1 Hajikami, Katsuragi-shi, Nara Prefecture 639-2198, Japan
Phone: +81-745-27-3681 E-mail: nakamura.junichi@sharp.co.jp

Abstract

A energy conversion efficiency of 25.1% was achieved in the Heterojunction Back Contact (HBC) structure Si solar cell utilizing Back Contact (BC) technology and an amorphous silicon thin film solar cell production technology. Short circuit current density (J_{sc}) and open circuit voltage (V_{oc}) were 41.7 mA/cm^2 and 736 mV, respectively. The high J_{sc} as well as the high V_{oc} indicates that the strength of HBC structure cell concept was realized. Besides, fill factor (F.F.) was a high value of 0.819, which shows that HBC structure cell doesn't have fundamental critical losses because of distinct structure.

1. Introduction

In order to achieve so-called 'grid parity', it is necessary to lower the cost of a solar power system including cell and module costs. Actually, the module cost isn't necessarily the largest part of the total cost of an electrical power generation system. Therefore, it is important to enhance energy conversion efficiency in order to decrease a total power generation cost containing the costs of power conditioning subsystems (PCS), balance of systems (BOS) and so on.

The HBC structure is one of the most promising candidates for higher performance in the crystalline Si based solar cells. It has the advantages of both BC structure and the heterojunction structure between a crystalline silicon (c-Si) and a hydrogenated amorphous silicon (a-Si:H). The former has a high short circuit current density (J_{sc}) since there is no shading effect caused by the presence of front side electrodes [1]. The latter brings a high open circuit voltage (V_{oc}) because of the high quality passivation [2].

In this study, the HBC structure cells were developed by utilizing the Back Contact (BC) technology and the a-Si:H thin film solar cell technology, which had been strengthened in the history of Sharp's solar business.

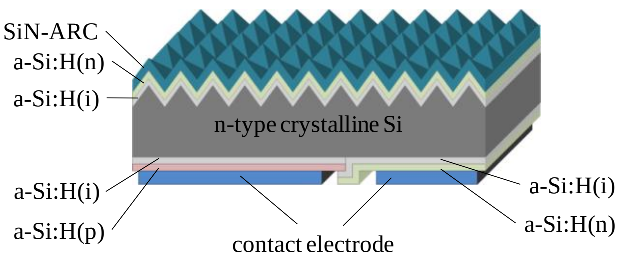

Fig. 1. Structure of HBC cell.

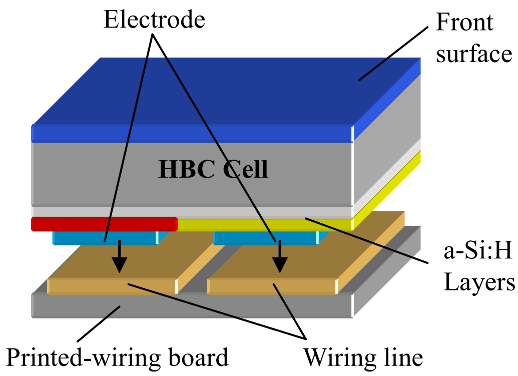

Fig. 2. Schematic configuration of SMT concept.

2. Development

The important issues for the development of the HBC structure cells were the passivation quality of the heterojunction, the structure and dimensional design of BC, the fabrication processes of the BC structure including heterojunction, and so on. In particular, the development of a-Si:H patterning process for the forming of the BC design was thought to be a key issue. This is because the quality of the patterning process affects not only a realization of accurate BC design with the heterostructure but also the passivation quality of the c-Si/a-Si:H interface. After the studies of various patterning processes, the best one was chosen, and the detail process conditions were carefully adjusted.

3. Experiments

Figure 1 shows the HBC structure cell. The Cz-grown, n-type <100> oriented c-Si substrates were used for the development of HBC cells. The substrate was chemically etched so as not to leave the surface defects caused by the slicing process. And one of the surfaces of the substrate was textured by a normal alkaline wet treatment method. After a cleaning process, a-Si:H layers were deposited by the Plasma Enhanced Chemical Vapor Deposition (PECVD) on each surface. The back side a-Si:H layers were formed into an interdigitated layout. There, the suitably selected and adjusted patterning processes were employed. On the front a-Si:H layers, the Anti-Reflective Coating (ARC) layer was deposited. Then, contact electrodes were formed on the rear a-Si:H layers and patterned in the interdigitated layout.

4. Results and discussion

Figure 3 shows the IV characteristics of the HBC structure cell. High cell efficiency of 25.1% was achieved.

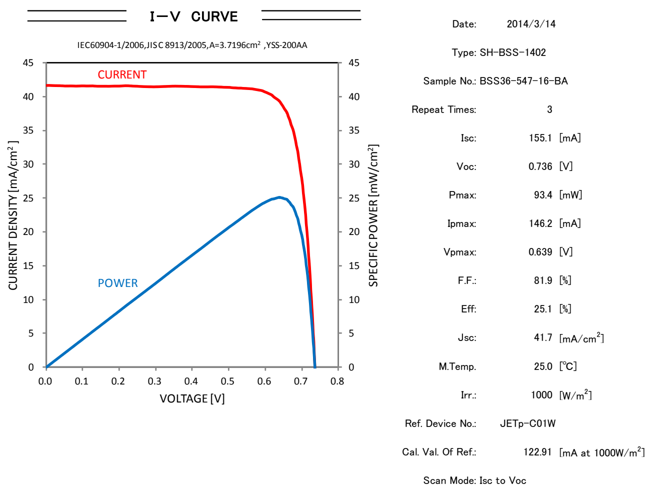

Fig. 3. IV curve of the HBC structure cell. Aperture area: 19.3mm x 19.3mm (3.713cm2). Measured at AM1.5, 1000W/m2, 25ºC by JET

Each parameter of the IV characteristics was a J_{sc} of 41.7 mA/cm^2, a V_{oc} of 736 mV, and an F.F. of 0.819. The high J_{sc} and V_{oc} indicate that the advantages of both BC structure and the heterojunction were realized in the HBC structure cell simultaneously. Besides, the high values of IV characteristics demonstrate that the degradation of cell properties was well suppressed during the fabrication process including a-Si:H patterning. Also, as shown in figure 4, respective layers of rear i/n, i/p, and electrodes were fabricated with clear and straight edges.

As for the HBC design, we concerned about the degradation of its performances due to an increase of series resistance and/or a decrease of shunt resistance caused by the unique cell structure. But actually, a high F.F. was attained, which shows that fabricated HBC cell cleared the issue and that the HBC cell design concept has no fundamental problem regarding F.F. Also, there is still room to enhance cell efficiency; the HBC design is considered to have a potential to achieve a higher energy conversion efficiency.

Figure 5 shows a progress of our HBC cell efficiency. The development started about 3 and a half years ago. We

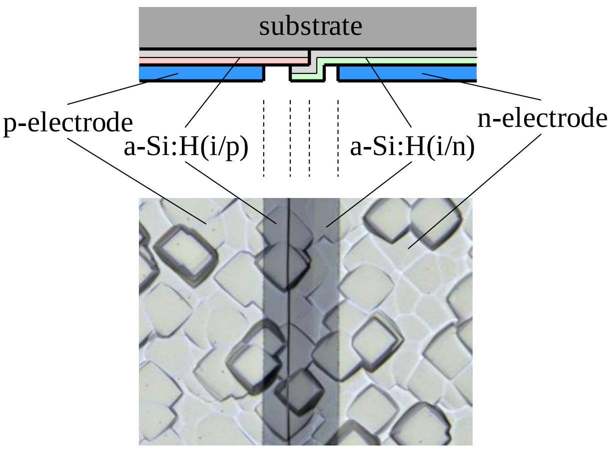

Fig. 4. View of the rear side of the HBC cell.

attained high conversion efficiency of over 25% in short period. It shows that the HBC cell concept has high potential and Sharp's technologies were utilized effectively.

4. Conclusions

The HBC structure crystalline silicon solar cells were successfully produced utilizing Sharp's accumulated technologies. And by the excellent a-Si:H patterning process, the negative impact through the fabrication process was adequately suppressed. As a result, the high conversion efficiency of 25.1% was achieved showing the high potential of this cell design concept. Each parameter of the IV characteristics was J_{sc} = 41.7 mA/cm^2, V_{oc} = 736 mV and F.F. = 0.819. The high V_{oc} and J_{sc} indicate that the strengths of both BC structure and heterojunction were realized in the HBC structure cells simultaneously, avoiding the degradation by the fabrication process of BC structure with

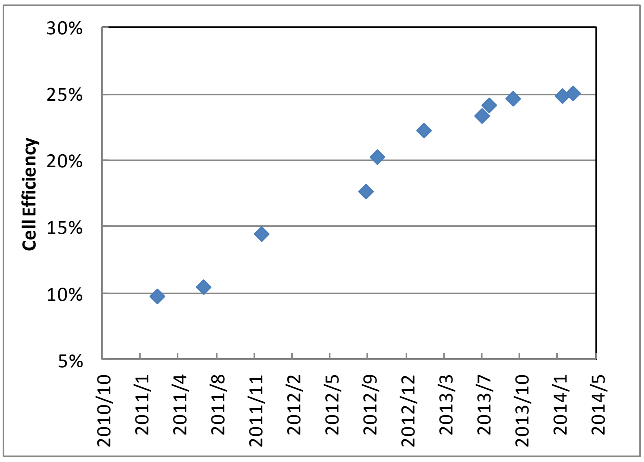

Fig. 5 Progress of HBC cell efficiency.

heterojunction and fundamental worsening of F.F. caused by distinct structure of HBC. Meanwhile, we have observed room to enhance the efficiency. Therefore, we believe that the HBC cell concept has potential to achieve higher conversion efficiency.

Acknowledgements

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