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Industrail technology of passivated emitter and rear cells with silicon oxynitride and silicon nitride as rear passivation for high efficiency BIPV modules

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Abstract

Solar cells using the passivated emitter and rear contact (PERC) structure have become very popular for high eifficiency BIPV modules in the past decade. In this paper, we discuss a method to increase the efficiency of p-type monocrystalline silicon solar cells with equipments suitable for mass production. Using this method,SiO_xN_y /SiN_x film stacks manufactured via PECVD are selected as rear passivation layer. Compared to conventional ALBSF cells, more than 0.6% efficiency gain was obtained. The rear contact pattern is also studied to increase the efficiency further. Most of the standard tools to produce conventional ALBSF solar cells can be utilized in this technology, which provides a cost efficient solution to mass-produce high efficiency BIPV modules.

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Keywords: BIPV, monocrystalline silicon solar cells, PERC, silicon oxynitride, silicon nitride

1. Introduction

In recent years, the BIPV energy system need more high efficiency crystalline silicon solar cells for development of low carbon cities [1-2]. Unfortunately, the potential for further development of conventional ALBSF crystalline silicon solar cells has been almost exhausted. Therefore, manufacturers are in urgent need of new technologies to further enhance the efficiency of crystalline silicon solar cells that can be easily integrated to the existing mass production lines. In this study, a technology of PERC,

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which became increasingly attractive recently [3], was developed for the production of monocrystalline silicon solar cells in an industrial scale. Compared to conventional ALBSF cells, this method provided substantial gains in efficiency at an acceptable cost. More importantly, the technology can be easily integrated to conventional ALBSF production lines. Factually, our study was done at an upgraded conventional production line in a factory. This is of particular significance to those manufacturers who entered the photovoltaic business at its peak time about five or six years ago and heavily invested in conventional production lines. Using our method, they could easily upgrade the production lines to adapt to the need of the development with only a small amount of additional investment. Subsequently, they can liquidize the assets to earn profit in the future.

2. EXPERIMENTAL

Our method used SiO_xN_y film stacks as rear passivation layer. SiO_xN_y layers contain a large number of hydrogen atoms which can be used to saturate the dangling bonds on wafer surface, which results in good passivation. Oxygen participation can form Si-O bond on surface prior to Si-H bond. This improves interface stability and reduces the density of unwanted interface states [4]. In addition, SiN_x film capping SiO_xN_y film could enhance the heat resistence of the film stacks [5]. The cell structure is shown in Fig. 1. The standard process flow of this technology involved 238.95 cm2 (156mm×156mm), commercial p-type monocrystalline silicon wafers which were sliced by conventional wire saw technique, with a thickness of about 190um and resistivity of 1-3 Ωcm. Initially, the as-cut wafers were polished by high concentration KOH solution to produce a smooth surface. This is important because rear passivation is strongly affected by the roughness of the rear surface. After polishing, SiO_xN_y /SiN_x film stacks were deposited on the rear surface using a PECVD tube. The wafers were then textured by alkaline process to produce straight upright pyramids. The textured wafers were then diffused using $POCl_3$ as the dopant source to produce the emitter with a sheet resistance of 70Ω/square. During the diffusion step, SiO_xN_y /SiN_x film stacks on rear surface also plays a role of hardmask. Therefore, edge isolation was not needed. The only leftover problem after diffusion was the removal of PSG via a wet process. After that, the rear dielectric film stacks were locally ablated by laser to form local openings for the rear metal contact. Thereafter, silicon nitride as anti-reflection coating was deposited via PECVD on the front side. The metallization was carried out in a conventional way. Silver and aluminium paste were screen printed on the front and rear surface of the wafers, which then created electric contact of solar cells following a fast firing process. Finally, the testing and sorting of solar cells was performed using a Berger testing system to improve the ouput power of the entire solar module.

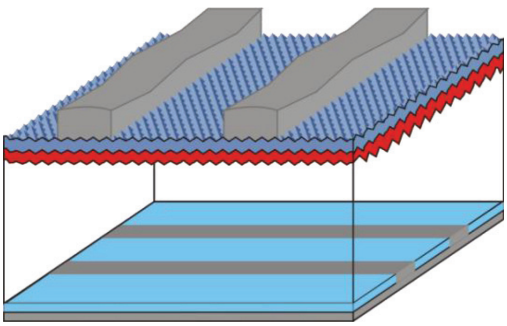

Fig.1. Schematic of cell structure