Renewable Energy Research Center

Removal of single side doped layer with maintaining the pyramid textured surfaces of n-PERT solar cell

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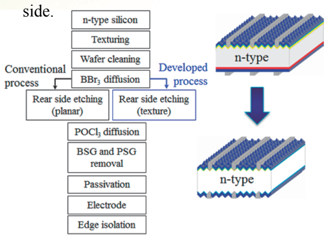
研究の目的

BBr_3 and $POCl_3$ thermal diffusion is one of the widely used technique for the p-type and n-type emitter formation in bifacial solar cell fabrication. However both are gas and the diffusions are performed at high temperature, so it causes both side diffusion. Thus one side doped layer removal step is necessary. Consisting of HF and HNO_3 was studied by using a transport roller technique [1,2, 3] or as a new method the spin etching technique [4] was applied. However in both cases, one side planar solar cell become planar, the optical losses due to the planer surface effect the bifaciality of the PERT solar cells through lowering the short-circuit current.

In this work, we have demonstrated to develop a new procedure to maintain the pyramid textures on the doped layer removed side.



n-PERT solar cell fabrication process

実験

A spin etching technique was used to remove the doped layer.

Chemical solution: HF + HNO_3

Chemical solution was developed by Nippon Kasei Chemical Co.,Ltd

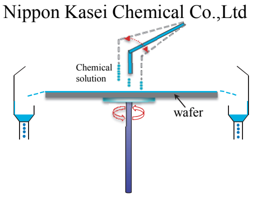
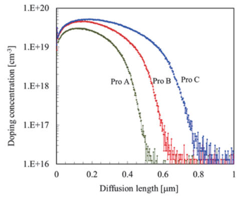
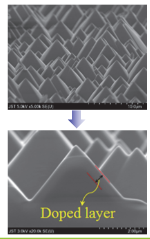


Illustration of spin etching diagram.

wafer	n-type Cz-Si wafer
Wafer size	156 mm x 156 mm
Wafer thickness	200 µm



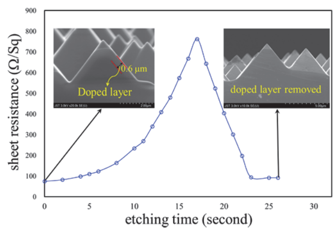
SIMS profiles of boron diffusion for doped layer removal experiment.



結果

[i] Solution characterization

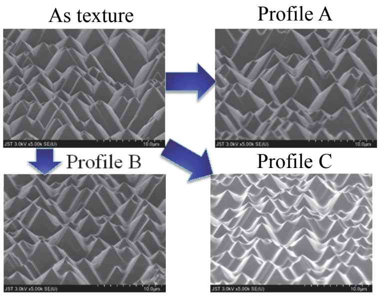
Below figure shows the corresponding etching time of 0.6 µm boron diffused layer. Removal of doped layer was examined by emitter sheet resistance and SEM images. The silicon base resistivity $\rho = \rho_{sheet}/d_{(wafer\ thickness)}$ implies the removal of doped layer.



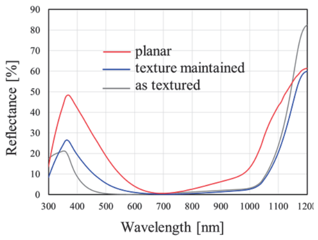
Sheet resistance Vs etching time. Inputs show the SEM images with doping layer and doped layer removal.

[ii] Effect of doping layer removal on the wafer surface

(1) texture pyramids maintained on the surfaces even in deep doping. (2) the edges of texture pyramids become wider (3) small texture pyramids still can be seen on the surface (4) the reflection decreased compare to the planar surface.



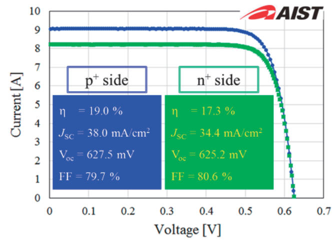
SEM images of (a) as texture wafer (b) 0.4 µm (c) 0.6 µm (d) 0.8 µm doped layer removed surfaces.



Reflectance of planar, maintain texture, and as texture wafers with the passivation of SiN_x.

[ⅳ] Applying on PERT solar cell

In order to investigate the impact of the developed process, n-PERT solar cell has been fabricated on 156×156 mm² n-type 180 µm thickness CZ-Si wafers, with a resistivity around 2.2 Ω cm. For the p^+ emitter formation SIMS profile B was employed.



One sun illumination (standard 1 kW/m² AM 1·5 global spectrum at 25° C)

考察

The measured front and rear side I-V parameters of the rear maintained texture and rear planar reference n-PERT cells are illustrated in Table 1. Shifting from a rear planar n-PERT cell to rear texture maintained n-PERT cell we observe an increase from 87 % to 91 % in the bifaciality of the cell. From Table 1 we notice that the increase in the bifaciality of the rear maintained texture n-PERT cell mainly due to the increase of rear side J_{SC}.

Table 1. Front and rear side one sun parameters of rear side flattened and rear side texture n-PERT solar cell (AM1.5G, 100 mV/cm², 25℃).

		J_{sc} [mA/cm²]	V_{oc} [mV]	FF [%]	η [%]	Bifaciality
Doped layer flattened cell	Front	38.2	626.5	78.7	18.8	87 %
	Rear	32.9	624.0	79.2	16.3	
Doped layer Texture maintained cell	Front	38.0	627.5	79.7	19.0	91 %
	Rear	34.4	625.2	80.6	17.3	

To investigate the increase in the J_{SC} of texture maintained cell, EQE measurement was performed.

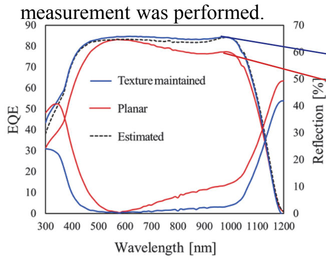


Figure: n⁺ side EQE and reflection of rear side flattened and rear side texture maintained n-PERT solar cell.

Short circuit current from spectral response:

$$J_{SC} = q \times (1 - n_{electrode}) \times \int (\Phi_{AM1.5}(\lambda) \times EQE(\lambda)\, d\lambda$$

$J_{SC} = 34.2$ mA/cm²

$J_{SC} = 32.1$ mA/cm²

By assuming that the planar surface shows same reflection senerio with the maintained surface reflection

$$EQE_{flattened} = \frac{EQE_{flattened}}{(1 - Ref(flattened))} \times (1 - Ref(tex\ maintained))$$

$J_{SC} = 33.9$ mA/cm²

結論

- We have investigated the removal of doping layer with maintaining the texture pyramids on the surface by applying spin etching technique.
- The effect of the doped layer removal with maintaining the pyramid textures was examined by SEM images
- SEM images show a planar spaces between the texture pyramids, optical losses due to the planar space was investigated by reflection measurements.
- In order to investigate the potential of this new procedure an n-PERT cell was fabricated, and I-V parameters are compared with the rear planar n-PERT cell.
- By applying the developed procedure on the n-PERT cell fabrication, the bifaciality was increased by 4%.

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