n型バイフェシャルセル用エッチバックボロンエミッタの再結合解析
Recombination analysis of etch-back boron emitter for n-type bifacial solar cell

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Selective emitter structure reduces the Auger recombination and metal contact induced recombination in the contact region which are major efficiency limiting factors of screen printed solar cells. Selective emitter structures have been introduced to p-type silicon solar cells in recent years. A selective n^+ emitters in these solar cell are performed by a wet chemical etch-back method. A selective emitter is expected to obtain various benefits for n-type solar cell concepts as well. In our previous research, we had discussed the possibility of etching process without damaging the surface texture structures of the wafer and opportunity of controlling of sheet resistance by adjusting the etching time [1]. Within this study, a heavily doped boron emitter was etched with the same method as discussed in our previous study. Various etched-back emitters evaluated by measuring J_{0e} on symmetrical p^+np^+ structure with SiN_x/Al_2O_3 passivation stack.

Figure 1 shows corrected inverse effective lifetimes with investigated J_{0e} for symmetric p^+np^+ structures with various boron emitters passivated by SiN_x/Al_2O_3 stack on 180 μm thick high lifetime (>2.2 ms) n-type pseudo-square CZ-Si wafers. Al_2O_3 was deposited by thermal atomic layer deposition (ALD) at a temperature of 200℃, followed by a 70 nm SiN_x layer deposition at 450℃. The emitter saturation current density was measured by quasi-steady-state micro-photoconductance decay method (QSS-μPCD). The initial boron emitter of 49 Ω/□ was performed by BBr_3 thermal diffusion in an industrial furnace tube. The 49 Ω/□ emitter was obtained just after boron diffusion, and which was increased to 100, 160 Ω/□ after etching in chemical solution for corresponding etching time, respectively. From the measured effective lifetime the emitter saturation current density J_{0e} was extracted based on

$$\frac{1}{\tau_{eff}} = \frac{1}{\tau_{bulk}} + \frac{2}{W}\frac{J_{0e}(N_A+\Delta n)}{qn_i^2}$$

where τ_{eff} is the measured effective excess carrier lifetime, τ_{bulk} is bulk lifetime, N_A is the base doping level, Δn is the excess carrier density, W is the wafer thickness, q is the elementary charge, n_i is the intrinsic carrier concentration of silicon. The extracted J_{0e} decreases significantly from 56 fA/cm^2 to 23, 15 fA/cm^2, respectively, due to the reduced recombination on the etched shallow emitters of 100 Ω/□ and 160 Ω/□. At last, these n-type bifacial solar cells will be fabricated with etched-back emitters, which is expected to increase the cell conversion efficiency by increasing the short-circuit current density (J_{sc}) as a result of improving the blue response in the short wavelength. At the same time, an improvement in the open-circuit voltage with low J_{0e} is expected. The cell results with characterization about the recombination analysis will be discussed more in detail in the conference.

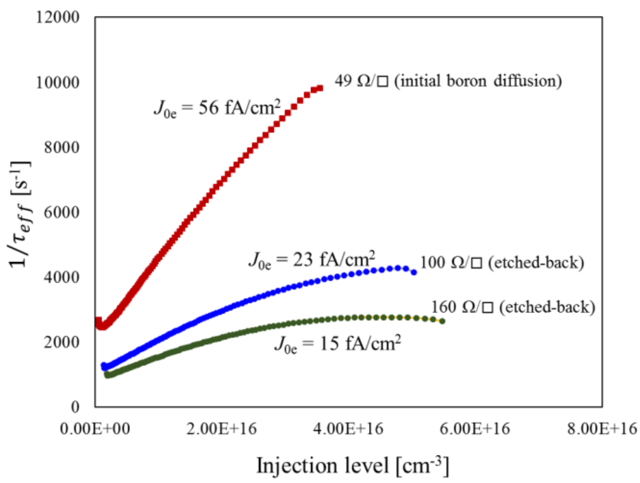

Figure 1: Measured effective lifetime as a function of injection level for J_{0e} samples with different sheet resistance.

References

[1] Shalamujiang Simayi, Yasuhiro Kida, Katsuhiko Shirasawa, and Hidetaka Takato, "Method of Removing Single-Side Doped Layer While Maintaining Pyramid Textured Surface of n-type Bifacial Solar Cells", accepted, not published yet.