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A Low Surface Recombination Velocity Realized on Textured c-Si by Cat-CVD SiN_x/P Cat-doped Layers

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A textured surface is essential in high-efficiency c-Si solar cells for lowering optical reflectance. High-quality passivation layers are required on textured c-Si surfaces for high-performance solar cells, particularly for back-junction solar cells. In previous study, we have reported that an extremely low surface recombination velocity (SRV) of 2 cm/s can be achieved when flat n-type (100) floating-zone (FZ) Si wafers firstly receives phosphorus (P) doping by exposing to P radicals generated by the catalytic cracking of PH_3 molecules (Cat-doping), and then are covered with a SiN_x film [1]. Both P Cat-doped layers and SiN_x films are prepared in a catalytic chemical vapor deposition (Cat-CVD) chamber. Cat-CVD is well known as less-damage process due to no energetic ion generation [2]. In order to demonstrate the applicability of the passivation structure in actual back-junction cells, in this study, we investigated the passivation quality of the SiN_x films and SiN_x/P Cat-doped layers on textured c-Si wafers.

Textured c-Si surfaces were prepared by immersing flat n-type FZ c-Si wafer into alkaline solution "Sun-X 600" diluted with H_2O at 70 °C for 50 min, followed by standard RCA cleaning processes [3]. Both sides of sample surface were then passivated with 100-nm-thick SiN_x films or SiN_x/P Cat-doped layers. Finally, the samples were annealed at 350 °C for 30 min in N_2 atmosphere for dangling bond termination by H atoms supplied from a SiN_x layer. SRV was calculated through effective minority carrier lifetime (τ_{eff}) measured by microwave photoconductivity decay (μ-PCD) method. The schematic of a sample structure for τ_{eff} measurement is shown in Fig. 1.

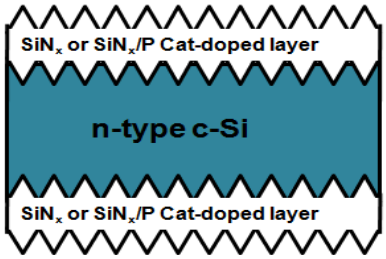

Fig. 1 Schematic of a sample structure for τ_{eff} measurement.

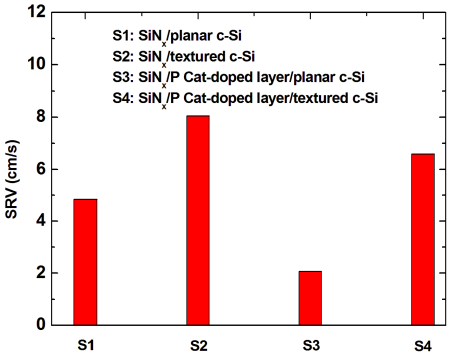

Fig. 2 SRV of the samples with flat and textured surfaces passivated with SiN_x films or SiN_x/P Cat-doped layers.

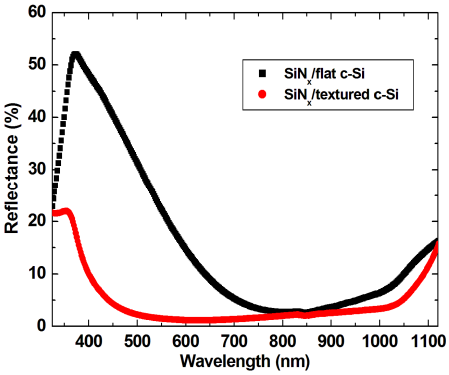

Fig. 3 Optical reflectance spectra of a SiN_x/c-Si and SiN_x/textured c-Si structures.

Fig. 2 shows SRV of the samples with flat and textured surfaces passivated with SiN_x films or SiN_x/P Cat-doped layers. The results show that P Cat-doping is effective in reducing SRV not only for flat c-Si but also for textured c-Si surface. By field effect passivation induced by a P Cat-doped layer and defect termination by H atoms in SiN_x films, a low SRV of 6.7 cm/s can be achieved on textured c-Si passivated with SiN_x/P Cat-doped layers. We have also confirmed a drastic reduction in optical reflectance for SiN_x/textured c-Si structure, compared to the SiN_x/flat c-Si structure, as shown in Fig. 3. The remarkable results indicate that Cat-CVD SiN_x/P Cat-doped layers with a low SRV of 6.7 cm/s and low optical reflectance are promising passivation layers for application to n-type back-junction solar cells.

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References

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