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Passivation Quality of A SiN_x Single Passivation Layer on Crystalline-Si Prepared by Cat-CVD

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Passivation films on crystalline Si (c-Si) surfaces contribute greatly to reducing surface recombination velocity (SRV) of minority carriers as well as acting as anti-reflection coatings. It has been known that SiN_x/a-Si stacked passivation layers on c-Si realize extremely low SRV around 1.5 cm/s [1]. However, since a-Si film absorbs sun-light, more transparent passivation layer is desired.

Catalytic chemical vapor deposition (Cat-CVD) is a successful method to prepare passivation layers on c-Si without plasma-damages. In addition, if the films are deposited at low substrate temperatures, the films can contain a large amount of hydrogen (H), which can eliminate defects on the surface of c-Si. Here, we investigate the passivation quality of a single SiN_x layer (refractive index is around 2.0) prepared by Cat-CVD. In particular, we investigated the effect of substrate temperatures (T_s), gas pressures (P) during SiN_x deposition and annealing on passivation quality of films.

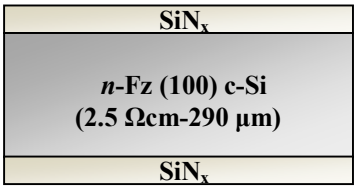

Figure 1. The schematic cross-sectional view of a c-Si wafer passivated by SiN_x films.

SiN_x films were deposited using SiH_4 and NH_3. The schematic cross-sectional view of a c-Si wafer passivated by SiN_x films is shown in Figure 1. Samples were then annealed at 350 °C for 30 minutes in N_2 atmosphere. The passivation quality of films was evaluated through effective minority carrier lifetime (τ_{eff}) measured by microwave photoconductance decay (μ-PCD) method. We also investigated the effect of H content and fixed charge density on passivation quality. The H content was estimated through Fourier-transform infrared spectra and the fixed charge density was calculated using the capacitance voltage method.

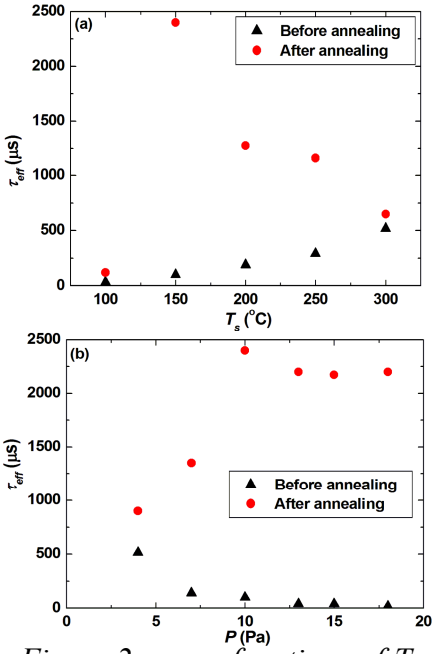

Figure 2. τ_{eff} as functions of T_s and P before and after annealing process.

Figure 2 shows τ_{eff} as functions of T_s and P before and after annealing. τ_{eff} increases with increase in T_s, while decreases with increase in P. However, τ_{eff} is improved significantly after annealing. Samples prepared at lower T_s show more significant improvement in τ_{eff} by annealing, probably due to higher H content. Highest τ_{eff} obtained for the sample deposited at T_s of 150 °C and P of 10 Pa is about 2.4 ms, corresponding to SRV of 6.0 cm/s.

It is concluded that SRV as low as 6.0 cm/s can be achieved even if a SiN_x single layer is used for passivation when it is deposited at low temperatures by Cat-CVD and successive annealing.

[1] K. Koyama, K. Ohdaira, and H, Matsumura, Appl. Phys. Lett. **97**, 082108 (2010)