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CHEMICAL LY RESISTIVE AND HIGH QUALITY TRASPARENT SILICON NITRIDE PASSIVATION LAYERS FOR BACK-CONTACT CRYS TALLINE SILICON SOLAR CELLS

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The world top three records of efficiency of crystalline-silicon (c-Si) solar cells, 26.6%, 26.3% and 25.6% are all prepared by the amorphous-silicon (a-Si)/c-Si heterojunction back contact (HBC) structures [1, 2]. For further improvement of solar cell efficiency, transparent and high quality films are required as front passivation layers. In addition, for making fabrication process of back-contact electrodes easy, the front passivation films have to be tolerable in chemical etching process for making back-contact structures. Conventionally, silicon nitride (SiN$_x$)/a-Si stacked layers are considered as the best passivation structure for c-Si, because one can achieve a surface recombination velocity (SRV) of less than 0.2 cm/s [3, 4]. However, by using the a-Si layer light with wavelength less than 700 nm can be easily absorbed [5], which results in limitation of HBC solar cells’ efficiency. To avoid this, there are many works which report on inserting the SiO$_x$, Al$_2$O$_3$ or Si-rich-SiN$_x$ layer instead of using the a-Si [5, 6]. In this study, we present a novel and facile structure which is stoichiometric SiN$_x$/SiN$_x$ double layers for passivating surface of c-Si. The utilization of stoichiometric SiN$_x$ is to minimize the absorption of light. The SiN$_x$ layers in this work were fabricated by catalytic chemical vapor deposition (Cat-CVD) which is known as hot-wire CVD [7].

Figure 1 (a) shows structure of the sample for measuring effective carrier lifetime ($\tau_{\text{eff}}$). The 290-µm-thick n-type c-Si wafer with bulk carrier lifetime of about 9 ms was used. Before depositing the SiN$_x$ layers the c-Si was annealing at 350 °C. Then the SiN$_x$ first layer with thickness of about 15 nm was deposited at substrate temperature ($T_{\text{sub}}$) less than 150 °C, while the SiN$_x$ second layer with thickness of 80 nm was formed at $T_{\text{sub}}$ of 250 °C. The $\tau_{\text{eff}}$ of these samples as deposited and after annealing at 350 °C is shown in Fig. 1 (b). As can be seen from this figure, carrier lifetimes of n-c-Si increase to 6 ms when the SiN$_x$ first layers were fabricated at $T_{\text{sub}}$ below 100 °C. Comparing with Si-rich-SiN$_x$/SiN$_x$ stacked layers [5], the SiN$_x$ double layers exhibit better passivation quality, particularly $\tau_{\text{eff}}$ is improved for more than 1 ms. Figure 1 (c) also shows the etching rate of this SiN$_x$ double structure in hydrofluoric acid solution with concentration of 5% (5% HF). The etching rate is much smaller than that of plasma enhanced chemical vapor deposition (PECVD) SiN$_x$ and appears usable in fabrication process without any protecting films.

In summary, the stoichiometric SiN$_x$ double layers, prepared by Cat-CVD, with high optical transparency, good chemical resistivity and enough passivation quality are very promising structure to obtain high efficiency HBC solar cells.

References