How Do We Apply Cat-doping to Improve Passivation Quality of SiN_x Single Layer Prepared by Cat-CVD on Crystalline Silicon?

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We study on properties of silicon-nitride (SiN_x) prepared by catalytic chemical vapor deposition (Cat-CVD) for surface passivation of crystalline-silicon (c-Si). It has been reported that an extremely low surface recombination velocity (SRV) < 0.2 cm/s for amorphous-silicon (a-Si)/SiN_x stacked layers on n-type c-Si is obtained [1, 2]. However, it is not easy to achieve low SRVs in the case of SiN_x single layer which has a good optical transparency compared with a-Si/SiN_x stacked layers. *Cham et al.* have reported that by introducing a phosphorous (P) Cat-doping before depositing SiN_x the SRVs can be easily decreased [3]. This is due to the effect of Cat-doping in controlling surface potential of c-Si. However, the study is limited to investigate the application of Cat-doping for SiN_x prepared at particular conditions. And so that, such SiN_x films do not have chemical resistance, which is required to make fabrication process of back contact solar cells easier. Thus, in the present study, we will fabricate the SiN_x films with different conditions and study how does Cat-doping affect on passivation quality of the SiN_x.

Intrinsic (i-) a-Si/SiN_x stacked layers are deposited on the back side of n-type c-Si by Cat-CVD in order to obtain a good surface passivation. The i-a-Si and SiN_x films are deposited at substrate temperature (T_{sub}) of 90 °C and 350 °C, respectively. P atoms are Cat-doped on the front side of the c-Si at T_{sub} = 80 °C for 5 min. Then the Cat-CVD SiN_x single layer is deposited at various T_{sub} and catalyzer temperatures (T_{cat}). Figure 1 shows SRV as a function of T_{sub} for depositing SiN_x for samples with and without P Cat-doping after post annealing at 350 °C. From the figure, we can confirm that P Cat-doping has a positive effect in reducing SRV, especially for the SiN_x deposited at T_{sub} below 250 °C and T_{cat} = 1800 °C. However, the effect of Cat-doping also appears to be dependent on the preparation conditions of SiN_x films.

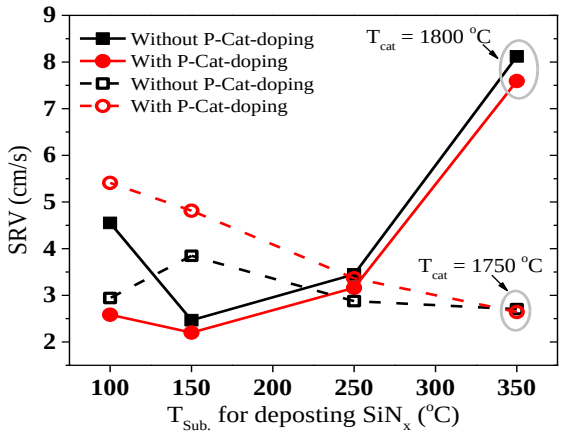

Figure 1: Dependence of SRV on T_{sub} for depositing SiN_x

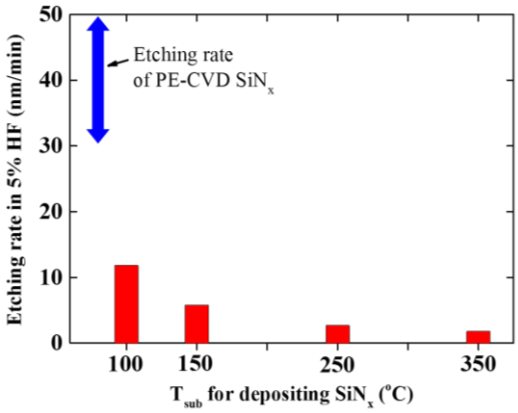

Figure 2: Etching rate of SiN_x fabricated by Cat-CVD as a function of T_{sub} for depositing SiN_x.

Figure 2 shows the etching rates of such SiN_x passivation film in 5% HF solution which is used in forming back contact patterns. The figure shows the etching rate is lower than 5 nm/min, much smaller than PECVD SiN_x films, and acceptable for solar cell fabrication.

It is concluded that 1) SiN_x single passivation on c-Si is possible when c-Si surface is Cat-doped, and 2) such SiN_x films can be chemically resistive, which makes fabrication process of solar cells easier.

[1] *Koyama et al., Thin Solid Films,* ***519,*** *4473 (2011).*
[2] *Nguyen et al., Proc. 43rd IEEE PVSC 2016.*
[3] *Cham et al., J. Appl. Phys.* ***116****, 044510 (2014).*