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Ultrahigh quality amorphous silicon film deposition for solar cells employing novel plasma enhanced CVD[1]

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Hydrogenated amorphous silicon (a-Si:H) is most widely employed as a top cell material in thin film Si tandem solar cells. The a-Si:H solar cells have three important problems to be solved: 1) a low stabilized efficiency below 10%. 2) light induced decrease in efficiency around -20% of the initial one. 3) a low deposition rate of 0.5 nm/s. In SiH_4 discharges employed for a-Si:H deposition, there coexist three deposition precursors; SiH_3 radicals, HOS radicals, and amorphous clusters [1]. SiH_3 radicals are the main deposition precursor for "good" quality films. Incorporation of clusters into a-Si:H films has been pointed out to cause the light induced degradation, whereas that of HOS radicals has not. To study effects of clusters on the light induced degradation and to control their deposition into films, we have employed a multi-hollow plasma CVD method to deposit films in which the incorporation of clusters is reduced in the upstream region with the gas flow that drive clusters toward the downstream region of the reactor [2, 3]. Films deposited in the upstream region tend to be more stable than those deposited in the downstream region; and the films deposited far from the discharges in the upstream region shows high stability, which indicates that the incorporation of clusters degrades the stability of a-Si:H films against light exposure. Our a-Si:H films deposited at 2.3 nm/s show a remarkably low stabilized defect density of $4x10^{15}$ cm^{-3}.

[1] M. Shiratani, et al., Thin Solid Films 427 (2003) 1.
[2] W. M. Nakamura, et al., J. Phys.: Conference Series 100 (2008) 082018.
[3] W. M. Nakamura, et al., IEEE Trans. Plasma Sci. 36 (2008) 888.

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