Development of Double-sided TOPCon Solar Cells on Textured Silicon Wafer using ALD-SiO_x

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Double-sided, front and rear, thin oxide passivated contact (TOPCon) solar cells are developed on textured silicon wafers. The double-sided TOPCon structure is composed of (p) poly-Si/SiO_x/(n) c-Si/SiO_x/(n) poly-Si, where the ultrathin oxide (SiO_x), about 0.6 ± 0.1 nm, is deposited by ALD. A photoconversion efficiency (PCE) of 18.8 % is obtained with the short-circuit current measured above 39 mA/cm^2 for a front Ag grid structure. The performances are successfully improved by controlling the boron and hydrogen diffusion profiles near the p-side SiO_x/c-Si.

Floating zone Si wafers (n-type, phosphorus-doped, 1-5 Ωcm, 280 µm-thick, oriented ⟨100⟩) are textured by KOH chemical etching and cleaned with our standard cleaning process [1]. The ALD process to deposit the SiO_x and the subsequent PECVD for p-type a-Si:H at the front and n-type a-Si:H at the rear are detailed in [2]. The annealing temperature is set at 820 ºC for 1h to change the a-Si:H into poly-Si films, confirmed by TEM images [2]. Then, a hydrogen plasma treatment is performed at 300 ºC for 1min to incorporate H into the SiO_x/c-Si interfaces and to terminate the dangling bonds [3]. The boron diffusion into the c-Si is controlled by the B_2H_6 flow during the (p/i) a-Si:H stack deposition. Figure 1 presents the open-circuit voltage (V_{oc}), short-circuit current (J_{sc}), fill factor (FF), and the PCE as a function of the B_2H_6 flow. An optimized flow at 50 sccm is underlined. The boron profile measured by SIMS is 1.3×10^{20} at/cm^3 at the SiO_x/c-Si interface with a junction depth about 100 nm. The hydrogen concentration is measured at 2×10^{21} at/cm^3 accumulated at the SiO_x/c-Si interface. To improve the FF, a DHF chemical step prior to the ITO deposition is performed.

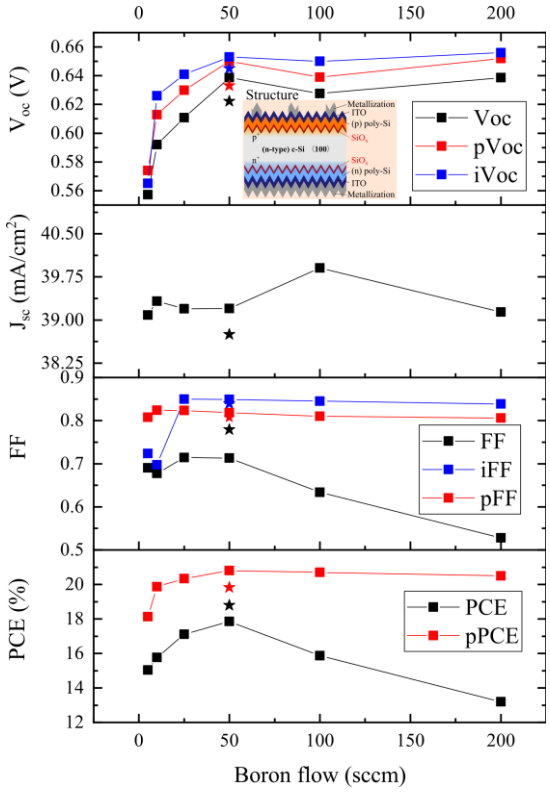

Figure 1: Solar cell characteristics as a function of the B_2H_6 flow for the (p) poly-Si (22±1 nm)/SiO_x/c-Si/SiO_x/(n) poly-Si (22±1nm) [2]

References: [1] S.N. Granata et al., *Energy Procedia* **27** (2012) 412-418 ; [2] M. Lozac'h et al., *SOLMAT* **207** (2020) 110357 ; [3] M. Lozac'h et al., *JJAP* **58** (2019) 050915.