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Simplified Cleaning for a-Si:H passivation of wafers bonded to glass

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Introduction

Silicon photovoltaic (PV) roadmaps indicate the reduction of wafer thicknesses and the need for innovation in wafering method and cell processing. Within this framework, Imec proposes the i^2-module device [1], i.e. an heterojunction interdigitated back-contact (HJ i-BC) solar module [2] processed on 40-μm thick epitaxial wafers bonded to carriers by means of silicone. In the i^2-module concept, the Rear Side (RS) of the solar cell is passivated while the wafer is bonded to the module glass and the influence of the silicone on the passivation process is reduced by an O_2 plasma realized in an Reactive Ion Etching (RIE) chamber [3]. In this contribution, the effect of different post-bonding cleaning sequences on the passivation of wafers/silicone/glass stacks treated with an O_2 plasma is investigated and a simplified post-bonding cleaning sequence leading to state-of-the-art passivation is proposed.

Experimental

The wafers used are 200μm-thick, polished <100> Float Zones (FZ) with a resistivity (ρ) of 400Ωcm. The adhesive used for bonding is a 2-part silicone Dow Corning® PV-6100 designed for encapsulation of PV modules. The glasses used are commercially available borosilicate glasses. First, the wafers and glasses are cleaned with H_2SO_4:H_2O_2 4:1 and H_F:H_2O 1:20. Wafers are loaded into the PECVD reactor and Front Side (FS) passivation is performed using an a-Si:H(i/n$^+$) layer that leads to emitter saturation current densities (J_0) of 3±1 cm/s at an injection level of $1x10^{16}cm^{-3}$. 50 μm-thick layers of silicone are screen printed on glasses and cured at 100°C for 15 minutes in vacuum. The wafer is manually bonded to the glass and a second curing is performed at 200°C for 1h. After bonding, some of the samples undergo an O_2 plasma in a RIE reactor with the parameters reported in [3]. Different post-bonding cleaning sequences are tested, combining TMAH-based (TMAH:H_2O 1:25, 40˚C, 5minutes), HF-based (HF:H_2O 2:100, 25˚C, 1minute), SC1 (NH_4OH:H_2O_2:H_2O 1:1:5, 25 ˚C, 10minutes) and SC2 (H_2O_2:HCl:H_2O 1:1:6 25 ˚C, 10minutes) solutions. A last HF dip (HF:H_2O 2:100, 25˚C, 20seconds) is performed immediately before rear side (RS) passivation. The RS of the wafer is passivated by a-Si:H(i) deposited at 160˚C to avoid silicone outgassing [4]. A scheme of the wafer/adhesive/glass sample is reported in Fig. 1. The minority carrier effective lifetime (τ_{eff}) of the samples is measured by QSSPC [5] and pseudo-J_0 at an injection level of $1x10^{16}cm^{-3}$ for the RS a-Si:H(i)/c-Si pseudo-junction is calculated. J_{0s} at high level of injection (HLI) are independent of the bulk lifetime of the wafer and hence, this figure helps evaluate the quality of the surface passivation according to the different cleaning sequences.

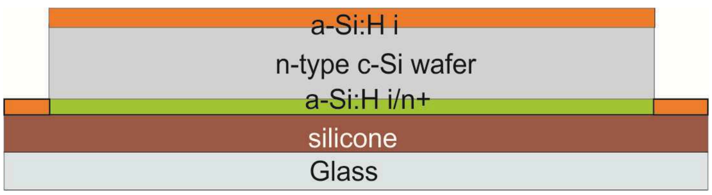

Figure 1: Scheme of the wafer/adhesive/glass stack used for passivation.

Results and Discussion

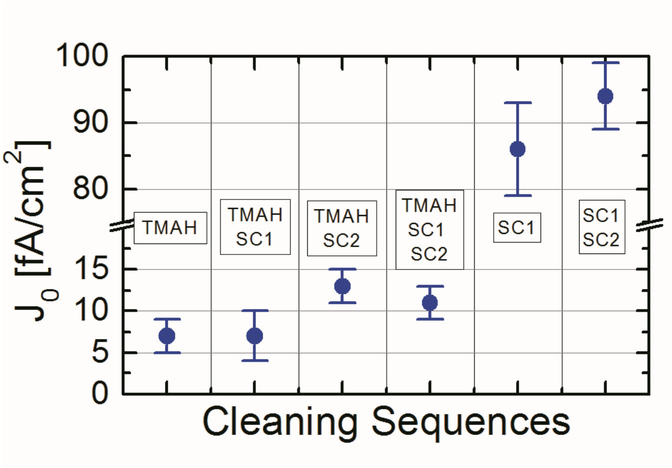

Fig.2: J_0 measured at $1x10^{16}cm^{-3}$on wafers/adhesive/glass stack as a function of the different post-bonding cleaning sequences. Two HF dips are also performed respectively before and after the sequence indicated in the legend.

Fig. 2 reports the J_0 extracted at $1x10^{16}cm^{-3}$ on the wafers/adhesive/glass stack cleaned with the different cleaning sequences, As such, three results can be withdrawn: first, a TMAH-based step is necessary to significantly improve the surface passivation and this may be related to the removal of wafer damage induced by the Ion bombardment during the O_2 plasma step [6]. Second, an additional oxidation step such as SC1 and SC2 is not necessary to further improve the J_0, i.e. a simple HF/TMAH/HF sequence can be used to achieved excellent surface passivation of wafers/adhesive/glass stacks.

Conclusion

Excellent J_0 in the order of $10fA/cm^2$ can be obtained on wafer/adhesive/glass stacks treated with an O_2-plasma performed in an RIE reactor and cleaned with a simple post-bonding cleaning sequence consisting of HF / TMAH / HF. This sequence is able to remove possible contamination generated by the presence of silicone during processing and the wafer damage induced by the O_2-plasma.

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