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CONTROL OF TEXTURIZED Si SUBSTRATES SURFACE PASSIVATION FOR a-Si:H/c-Si HETEROJUNCTION SOLAR CELLS

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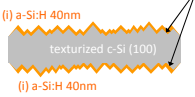
ABSTRACT:

☼In heterojunction solar cells applied R&D line, passivation tests by intrinsic a-Si:H on texturized and cleaned wafers to:

- Develop surface cleaning processes ➔ S and implied Voc by QSSPC, validation by HJ cell performance
  ➔ 2 targets: 1) best performance R&D recipe 2) Industrial cost effective and robust recipe
- Monitor production line ➔ correlation between S and Voc of control wafers and cell performance
  ➔ wet brick trouble shouting

EXPERIMENTAL:

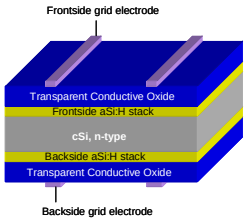
Passivation tests



Post texturization surface cleaning and HF last passivation

- QSSPC ➔Seff, implied Voc @ 1sun
- µPCD ➔mapping and effective lifetime
- VPD-DC-ICPMS ➔metallic surface contamination

HJ solar cells



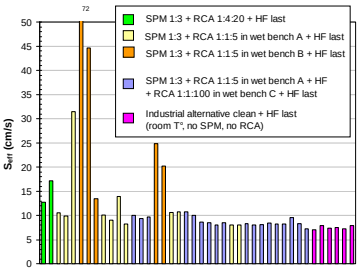
1. 125 PSQ N-type c-Si (100) 1-5 Ω·cm 180 µm wafers
2. Texturization KOH & IPA
3. Wet Cleaning
4. HF last passivation

} Wet brick

5. PECVD: (i) a-Si:H/ (p) a-Si:H and (i) a-Si:H/ (n) a-Si:H
6. ITO deposition front and back side
7. Front and back side metallization by screen printing
8. Edge isolation by laser
9. IV test at AM 1.5 conditions

RESULTS Cleaning process development:

Clean and HF last goals: remove surface defects (metals, salts, particles), smooth (111) facets, preserve the post textu optical confinement, insure stable and dense Si-H termination



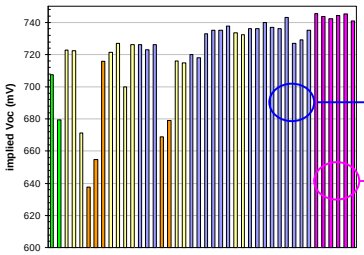


Figure 1: run to run passivation tests showing a-Si:H/c-Si interface quality improvement when introducing an intermediate HF deox and RCA redundancy or using an alternative cleaning recipe

Jsc mA/cm²	Voc mV	FF %	η %
35.6	700	77.6	19.3
35.6	698	77.3	19.2
35.7	699	77.2	19.3
35.5	704	78.0	19.5
35.3	704	78.1	19.4
35.2	704	78.1	19.4

Table 1: example of validation on HJ solar cells of the SPM-RCA-HF-RCA and alternative industrial clean

- Variability of single SPM-RCA clean: run to run variation of post texturization contamination level (table 2) and/or variation of baseline contamination of wet benches (fig. 2) ?
- Improvement of RCA –based clean: performance and robustness improved using HF deox, redundancy and industrial wet bench
- Alternative clean : slight improvement of surface passivation, but slight degradation of current density due to loss of reflectivity (-0.5% to -1% absolute on R_w 300-1200nm)

	Na	Mg	Al	K	Ca	Ti	Cr	Mn	Fe	Ni	Cu	Zn	Sum
as-texturized													
A	54	2900	370	220	1100	630	95	19	30080	10	11760	30	47 300
B	27	1300	26	630	64	200	300	3	4600	2	1200	21	8 400
C	65	1100	59	85	69	510	870	9	13000	8	8400	16	24 200
SPM													
A	< 1	18	44	15	73	< 0.6	< 0.1	1	6	< 0.1	9	3	169
B	4	40	44	10	280	< 0.6	1	8	15	< 0.1	8	38	448
SPM - RCA - HF - RCA - HF													
A	4.3	0.8	4.2	11	5.2	0	0.2	0.1	16	0.1	0	13	54.9
B	2	0.3	1	5	2	0.2	0.1	0.4	0.3	< 0.1	0.6	0.5	12.4

Table 2: typical surface metallic contamination (10^{10} at/cm²) on as-texturized and post cleaned 125 PSQ wafers

RESULTS HJ line monitoring:

Figure 2: long term run to run variability of S_{eff} for the SPM-RCA-HF-RCA-HF last sequence with multiple susbtrates types and suppliers

a) drift of performances attributed to equipments contamination baseline degradatio
b) hardclean corrective actions on wet equipment
c) variability on FZ wafers from supplier C mainly related to multiple ingots of various qualities

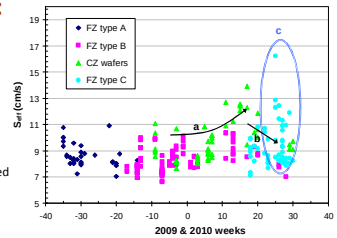
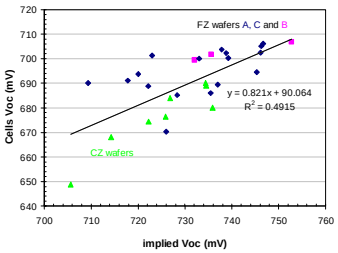


Figure 3: correlation between wet brick monitoring on control wafers and cell performance

Same wafer, same texturization run, same cleaning and passivation for cells and control wafers



CONCLUSIONS:

☼High performances and robust RCA &HF -based and alternative recipes
➔ implied Voc > 740mV, S_{eff} <8 cm/s for > 19% 148 cm² HJ solar cells (19.6% best cell)

☼Despite all HJ process steps show variability impacting cell performance, a correlation between the wet brick monitoring and global performance of HJ line is seen
➔ possible troubleshoot of the wet brick, contribution of the wafer quality

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