

Industrial Plasma-Less Dry Texturing Method for Diamond Wire Cut mc-Si Wafers - the universal ADE texturing process.

Laurent Clochard⁽¹⁾, Edward Duffy⁽¹⁾, Klaus Duncker⁽³⁾, Kai Petter⁽³⁾, Marc Hofmann⁽²⁾, Bishal Kafle⁽²⁾, J. Rentsch⁽²⁾, A. I. Ridoy⁽²⁾ and P. Saint-Cast⁽²⁾

1) Nines Photovoltaics, Synergy Centre, IT Tallaght, Dublin 24, Ireland

2) Fraunhofer ISE, Heidenhofstrasse 2, 79110 Freiburg, Germany

3) Hanwha Q CELLS GmbH, Sonnenallee 17 – 21; 06766 Bitterfeld-Wolfen OT Thalheim, Germany

T:+353 85 1130494 l.clochard@nines-pv.com

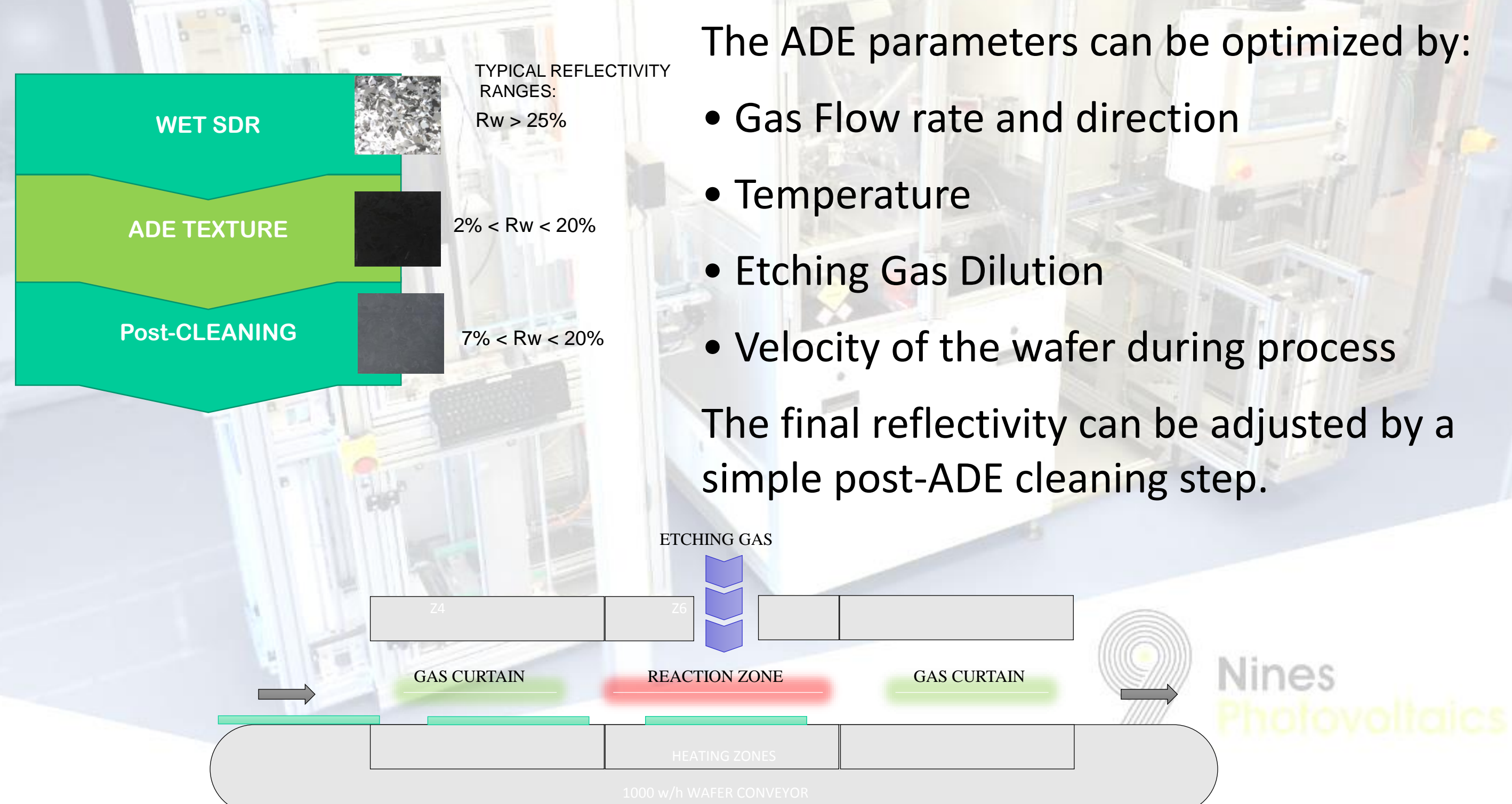
Motivation

The global adoption of diamond wire (DW) cut wafers by the mc-Si PV industry requires a reliable and future proof texturing solution. The incumbent wet etch process does not provide efficient texturing of DW mc-Si wafers. Other wet processes using metal catalyst have proven to be difficult to control and the impact of their waste products is questionable, with no clear management solution. Reactive Ion Etching is a well established technology providing a dry etching solutions but has never deeply penetrated the PV market due to its high cost.

- Atmospheric Dry Etching (ADE) has emerged in the last few years as a novel, universal dry etching industrial solution^(a).
- The ADE process has demonstrated efficiency improvements (+0.3% abs.) with slurry cut mc-Si and AISBF cell process and a cell efficiency at 18%^(b). The next step is to demonstrate its suitability for PERC and DW mc-Si wafers.

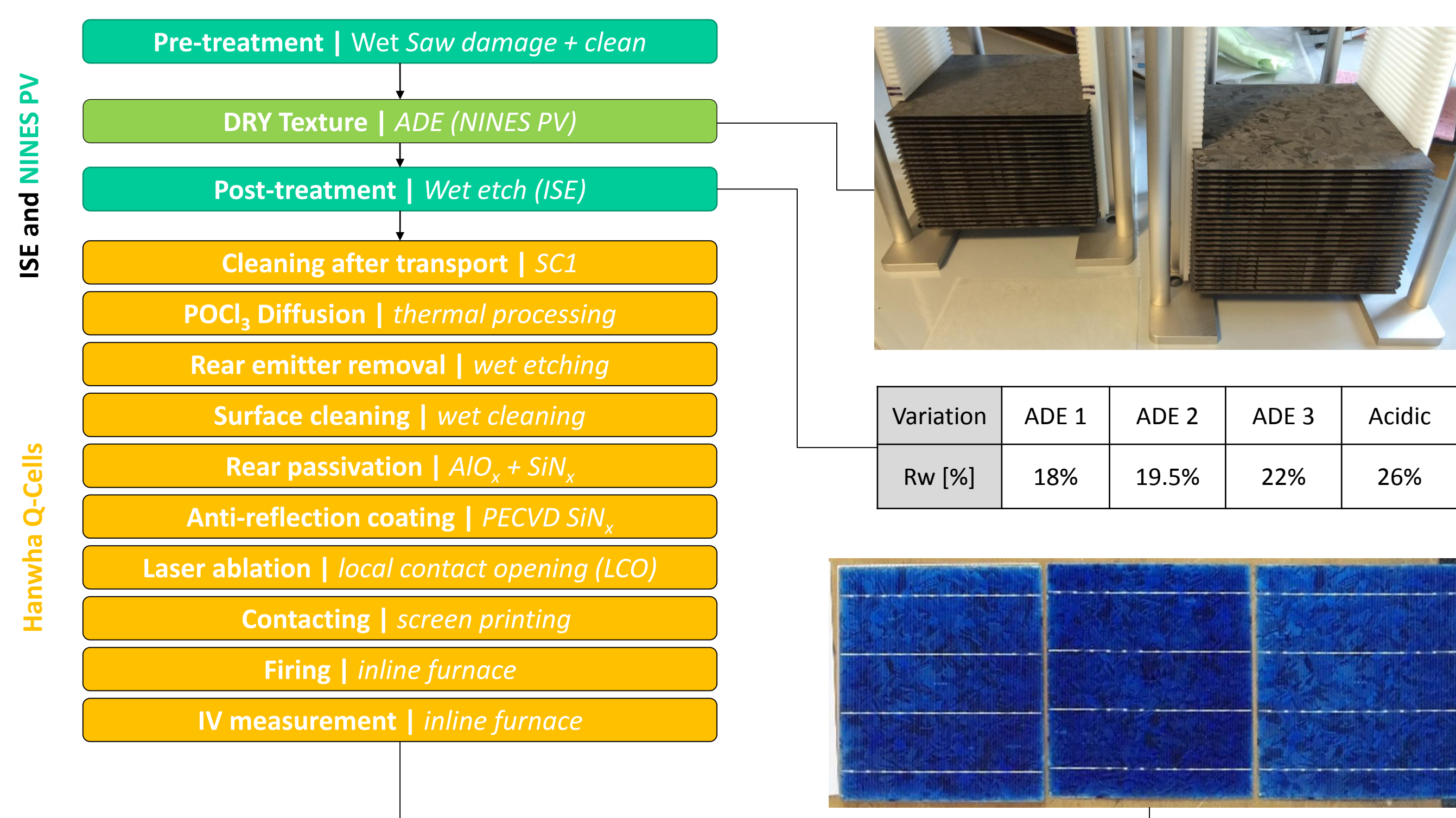
ADE texturing – an Atmospheric Dry Etching solution

The ADE process is a thermally activated chemical etch, carried out at atmospheric pressure. No plasma, no ions, no vacuum. Working at atmospheric pressure instead of vacuum results in much lower capex and opex, as well as a small footprint, a truly continuous inline process and high throughput.



First baseline for PERC process

- PERC process baseline using slurry cut p type mc-Si wafer, 1.8 $\Omega \cdot \text{cm}$.
- Process carried out at 3 different locations, shipping wafers in between
- 4 textures: 1 acidic reference + 3 ADE texture variations selected for easy integration
- No cell process variations or adaptations beyond texturing (standard cell process)

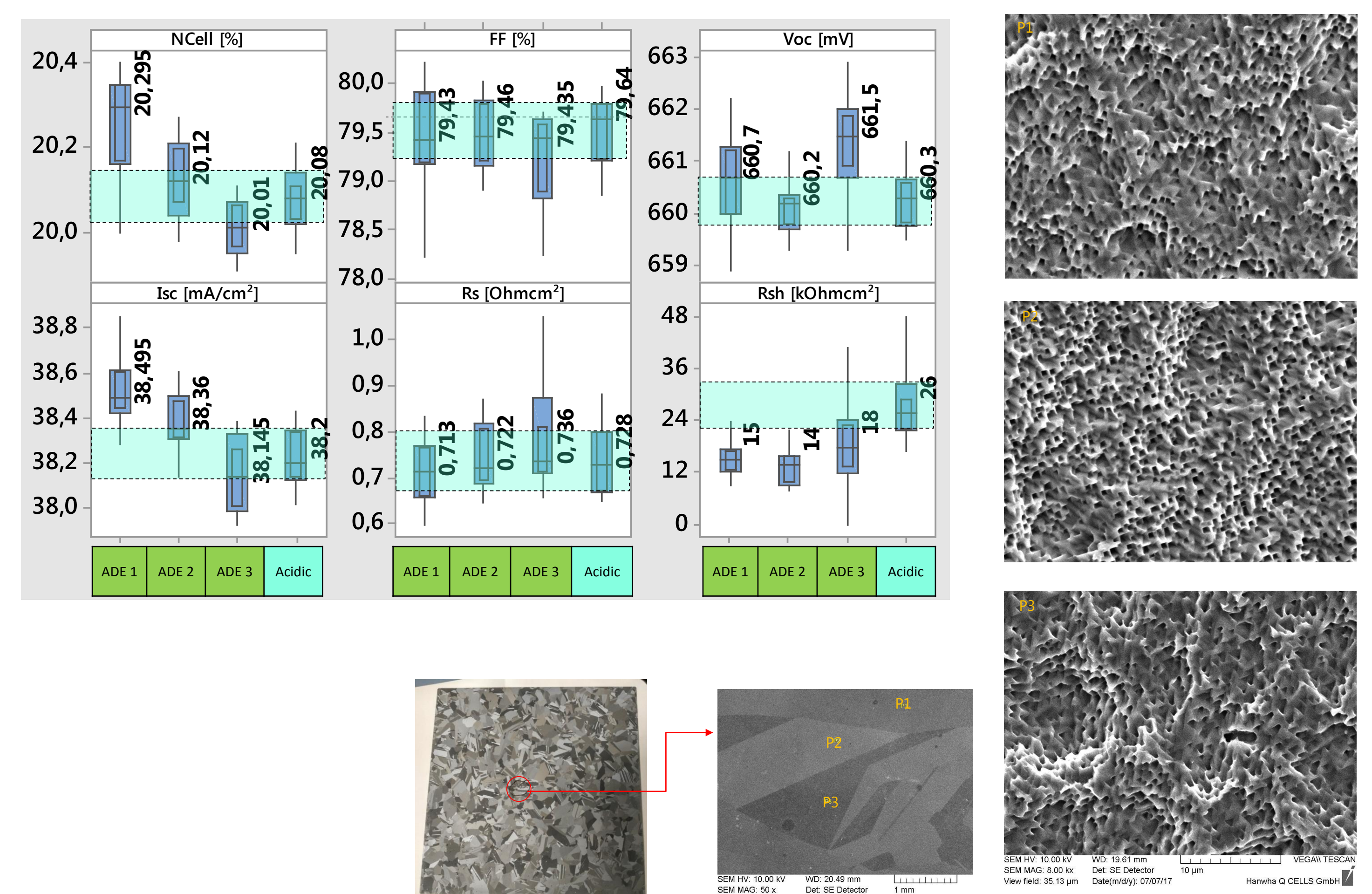


Conclusion

- First PERC batch without any adjustment of the cell process already show cell efficiency improvement: + 0.2 % abs and Jsc gain of ADE max. 0.3 mA/cm²:
- Voc of all groups on the same level, no loss induced by ADE
- Best ADE textured cell efficiency measured at 20.3%
- Uniformity / spotting issue due to imperfect cleaning and shipping
- Texturing/post-clean recipe to be adjusted to provide more anisotropic result
- Steps to be optimized: Emitter R and SiNx thickness
- Next step: run a PERC batch of ADE texture DW wafers

Results

- IV measurements were carried out and summarized below.
- SEM of 3 different grain orientations are also shown.



Texturing of DW mc-Si wafers

Initial ADE texturing tests of DW mc-Si wafers show:

- Similar results as slurry cut wafers – same texture can be achieved
- ADE Recipe used is identical as for slurry cut wafers
- ADE Texturing process slightly faster for DW wafers
- Very low reflectivity can be achieved after the ADE texturing (<5%)

