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Influence of Surface Defectivity on the Performances of Silicon Heterojunction Solar Cells

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UNDERSTANDING OF THE INFLUENCE OF THE SURFACE DEFECTIVITY ON SILICON HETEROJUNCTION CELL PERFORMANCE.

Context of the study

Commercially available bulk lifetimes ↑
Production tools throughputs ↑

Defectivity importance likely to increase



Necessary to quantify and understand the defectivity-induced efficiency (η) losses

Approaches used to carry out the study

Experimental approach

Simulation approach

Creation of a controlled defectivity protocol

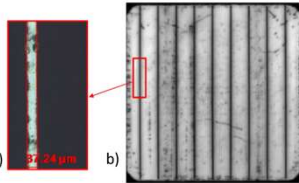
Exp. Quantification of defectivity induced losses

Validation of the modelled structure

Identification of physical mechanisms

Presentation of the study

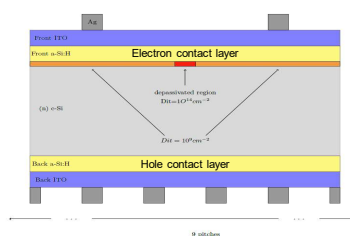
Controlled defectivity on busbarless cells:



- A scratch every 9 pitches (total c-Si surface depassivation).
- Choice of Busbarless metal scheme → easy scratch creation and facilitated simulation.
- On 10 cells : I(V) measurements after each scratch.

Protocol for the creation of a well-defined defectivity

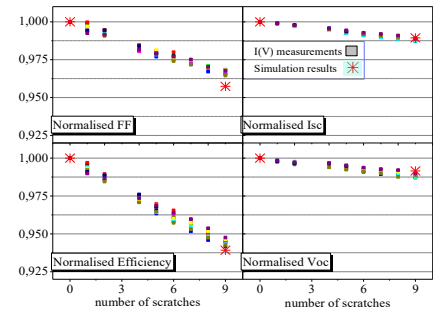
Validation of the modelled 2D structure (ATLAS Silvaco)



- Same defectivity distribution as the actual cells.
- Parametrization based on SHJ cells characterization.
- Defect: locally maximized D_{it} .

➔ Allows to trust the code to investigate the mechanisms behind η losses

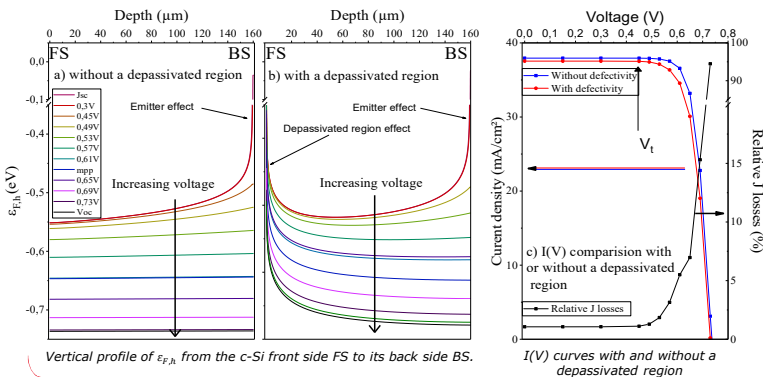
Quantification of defectivity-induced efficiency (η) losses



- FF losses = 2/3 of efficiency losses.
- Good scratch-to-scratch repeatability.
- 0.2% surface scratched = -6%_{rel} η !
- Good agreement experiments/simulation

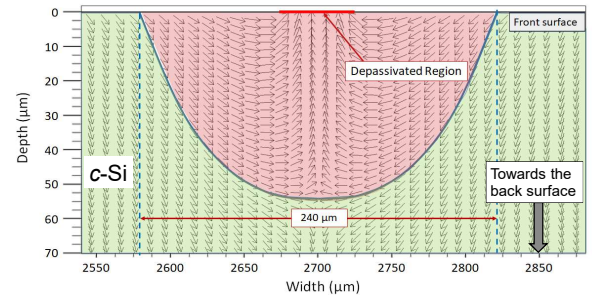
Physical mechanisms:

- Minority charge carrier quasi fermi level $\epsilon_{F,h}$.
- Force applied on holes $\approx \bar{v} \epsilon_{F,h}$



Force towards the defect increasing with the voltage

$\bar{v} \epsilon_{F,h}$ profile in the c-Si at the short circuit working point (J_{sc}):



- Carriers photogenerated within the affected region (pink) recombine in the de-passivated region.
- 1,4% of carriers are lost → J_{sc} losses = 1,4%_{rel}.
- The same analysis also holds for the other I(V) parameters losses (presented in the article).

The study of $\epsilon_{F,h}$ explains the mechanisms behind the η losses.

Conclusions: ➤ Combined experimental-modellisation approach.

- Strong impact of surface defectivity mostly on FF according to [1].
- The de-passivated region high recombination rate induces a force increasing with the voltage towards itself leading to important FF losses.

Perspectives: ➤ Predict the influence of cell parameters on the performance losses (ρ , bulk lifetime).

- Study the influence of defectivity properties (spatial distribution, location (BS/FS), size ...).
- Suggest ways to mitigate losses.