Influence of Surface Defectivity on the Performances of Silicon Heterojunction Solar Cells
V Giglia, J. Veirman, R. Varache, E. Fourmond

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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 (\(\eta\)) losses

Approaches used to carry out the study

**Experimental approach**
- Creation of a controlled defectivity protocol
- Exp. Quantification of defectivity induced losses
- Validation of the modelled structure

**Simulation approach**
- 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**

**Physical mechanisms:**
- Minority charge carrier quasi fermi level \(\varepsilon_{F,K}\).
- Force applied on holes \(\nabla \varepsilon_{F,K}\).

**Validation of the modelled 2D structure (ATLAS Silvaco):**
- Same defectivity distribution as the actual cells.
- Parametrization based on SHJ cells characterization.
- Defect: locally maximized Dit.

→ Allows to trust the code to investigate the mechanisms behind \(\eta\) losses

**Quantification of defectivity-induced efficiency (\(\eta\)) losses**
- FF losses = 2/3 of efficiency losses.
- Good scratch-to-scratch repeatability.
- 0.2% surface scratched = -6%rel \(\eta\)!
- Good agreement experiments/simulation

**Carriers photogenerated within the affected region (pink) recombine in the depassivated region.**

\[1.4\% \text{ of carriers are lost } \Rightarrow J_{sc} \text{ losses } = 1.4\%_{\text{rel}}\]

The same analysis also holds for the other I(V) parameters losses (presented in the article).

The study of \(\varepsilon_{F,K}\) explains the mechanisms behind \(\eta\) losses.

**Conclusions:**
- Combined experimental-modelisation approach.
- Strong impact of surface defectivity mostly on FF according to [1].
- The depassivated 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 (\(\rho\), bulk lifetime).
- Study the influence of defectivity properties (spatial distribution, location (BS/FS), size ...).
- Suggest ways to mitigate losses.