HIGHLY EFFICIENT LOW CARBON FOOTPRINT SOLAR CELLS: IMPACT OF HIGH TEMPERATURE PROCESSING ON EPITAXIALLY GROWN P-TYPE SILICON WAFERS

C. Rittmann¹, P. Messmer¹, E. Supik¹, F. D. Heinz¹, Y. P. Botchak Mouafi², M. Drießen¹, C. Weiss¹, F. Schindler¹

¹ Fraunhofer Institute for Solar Energy Systems ISE, Freiburg im Breisgau, Germany
² University of Konstanz, Konstanz, Germany

clara.rittmann@ise.fraunhofer.de +49 761 4588 5102
florian.schindler@ise.fraunhofer.de +49 761 4588 5918

Introduction

- Epitaxially grown wafers, EpiWafers, with a low carbon-footprint and low costs are suited for highly efficient solar cells
- Cell efficiencies above 25% predicted for TOPCoRE solar cells on p-type Si EpiWafers
- Remaining quality limitation of EpiWafers are structural defects

We investigate the influence of high temperature treatment during TOPCoRE solar cell fabrication on the material quality of EpiWafers focusing on structural defects.

Material quality of EpiWafers after high temperature treatment

- EpiWafers
  - Epitaxially deposited in an APCVD batch reactor of microelectronic standard
  - 3 cm p-type Si, 5x5 cm², 135 µm thick, KOH etched, Al₂O₃ passivated

High temperature treatment representing TOPCoRE cell fabrication²

- Oxidation at 1050°C for 1h (+3 min KOH etching)
- POCl3-Gettering at 840°C for 1h (+5 min KOH etching)

Material quality accessed by

- Photoluminescence imaging with lifetime calibration by modulated photoluminescence (modulum at Fraunhofer ISE)
- Efficiency limiting bulk recombination analysis (ELBA)
- µPL-mapping with a high resolution of ~20 µm

Structural defects in initial EpiWafer

- Dislocations detected as etch pits (EP)
  - Appear randomly distributed at the front side
  - Arrange in lines along <110> and form pairs at the back side

Quality of EpiWafer after KOH etching

- Testing the effect of solely KOH etching in comparison to high temperature treatment and KOH etching

Quality of EpiWafers after high temperature treatment and KOH etching

KOH etching removes structural defects at the back side and hence improves material quality significantly

The positive effect observed for the oxidation may mostly be due to the KOH etching

Gettering has a positive influence on the material quality in direct comparison to KOH etching

Results

- EpiWafers are well suited for high temperature treatment during high-efficiency solar cell fabrication
- In the initial EpiWafer, quality limiting structural defects are mainly located on the backside
- Structural defects at the backside can be removed by KOH etching
- POCl3-gettering has an extremely positive effect on the material quality with predicted solar cell efficiencies exceeding 24%