Effect of adding oxygen to thin-film silicon-germanium micro-crystalline solar cells

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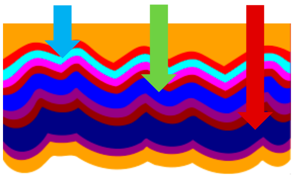
Introduction

To increase the efficiency of thin-film silicon solar cells, a larger portion of the spectrum has to be absorbed. Ideal device: a multi-junction solar cell, with amorphous silicon absorbing the blue part of the spectrum, microcrystalline silicon (μc-Si) for the rest of the visible spectrum and microcrystalline silicon-germanium (μc-Si_xGe_{1-x}) for the infrared.

The aim of this work is to optimise the μc-Si_xGe_{1-x} intrinsic layer to get a suitable bottom cell. So single junction p-i-n cells were deposited on textured zinc oxide.



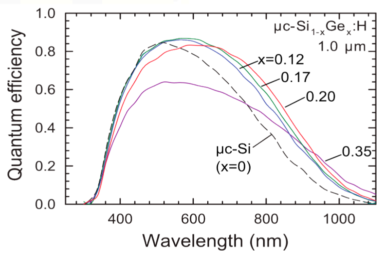
Effect of intrinsic layer composition and thickness

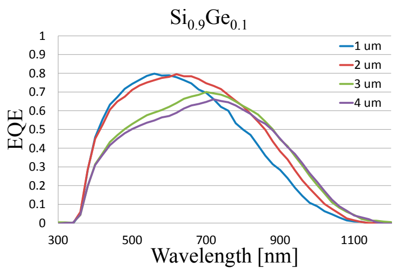
Effect of germanium content:

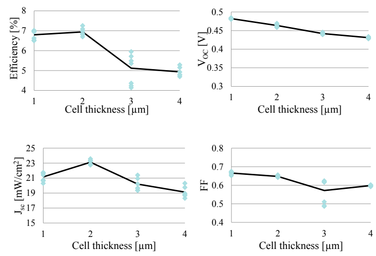
- Higher light absorption coefficient.
- Better IR absorption due to lower band-gap.
- If the Ge content is too high, the photo-generated carrier collection decreases.

Effect of i-layer thickness:

- Thicker layers have a higher IR absorption.
- If thicker than 2 μm, short circuit current decreases.
- The quantum efficiency in the blue region of the spectrum decreases in thick layers.







→ The IR absorption of μc-Si_xGe_{1-x} cells is limited because the germanium content and the i-layer thickness are limited. The photo-generated carrier collection has to be improved to turn these cells into valuable bottom cells.

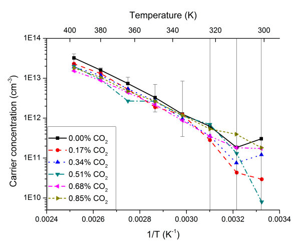
Effect of oxygen doping

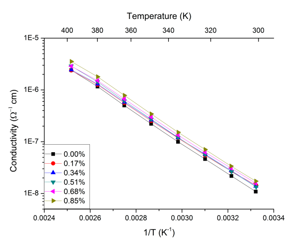
Oxygen is added to the intrinsic layer as a dopant:

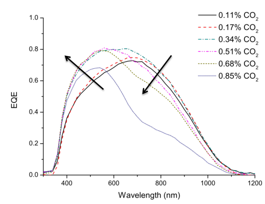
- The amount is too low to change the intrinsic character of the material.
- It does not have any effect on the film dark conductivity.

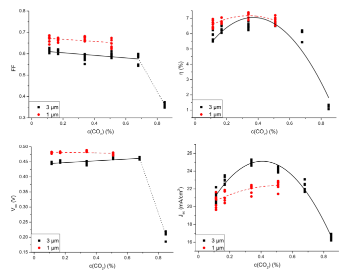
However, it has an impact on the cell performance:

- The blue response increases.
- There is an optimal concentration: when there is too much oxygen, the red response decreases.
- It has more impact on thicker cells.



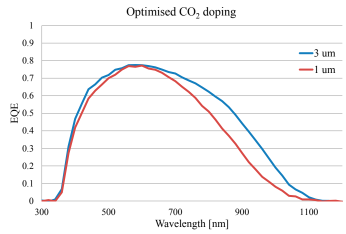






Conclusions

With the right amount of CO_2, a better photo-generated charge collection is achieved, especially near the p/i interface. This translates to a higher short-circuit current and efficiency. At the optimum doping level, the oxygen concentration in the intrinsic layer is around $1\cdot10^{19}$ - $2\cdot10^{19}$ cm^{-3}. For a 3 μm cell, the J_{sc} gain is 3.9 mA/cm^2.



References

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