Localisation of front side passivating contacts for direct metallisation of high-efficiency c-Si solar cells

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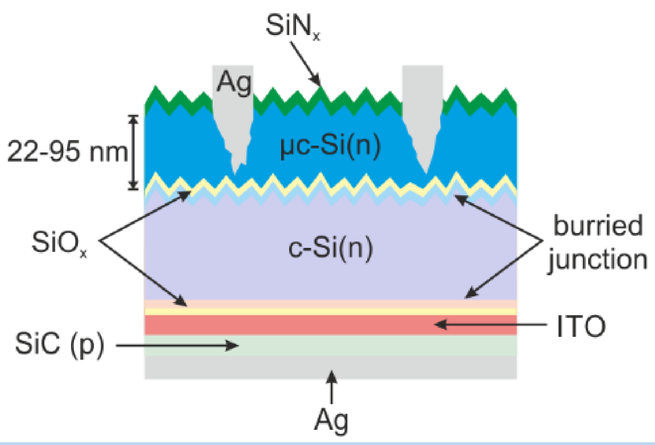
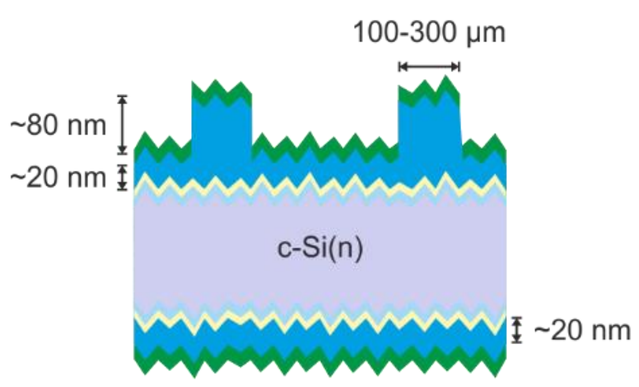
Firing Through Process: PVLAB strategies

Passivating contacts are keys to enable conversion efficiency ≥26%[1,2,3] and are compatible with firing through process. To ensure high V_{OC}, thick passivating contacts must be integrated at the front without compromising photo-generation of carriers.

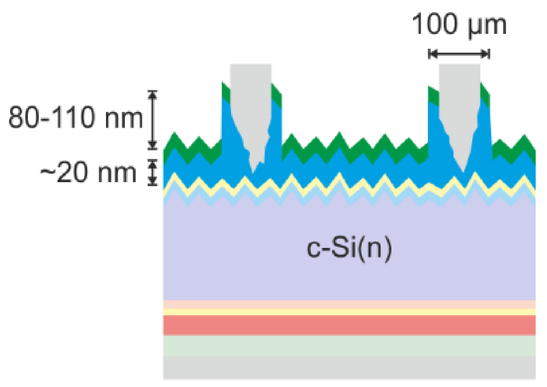
Non-patterned cells
Record efficiency of 19.4 %



Symmetrical structure to proof the localisation feasibility



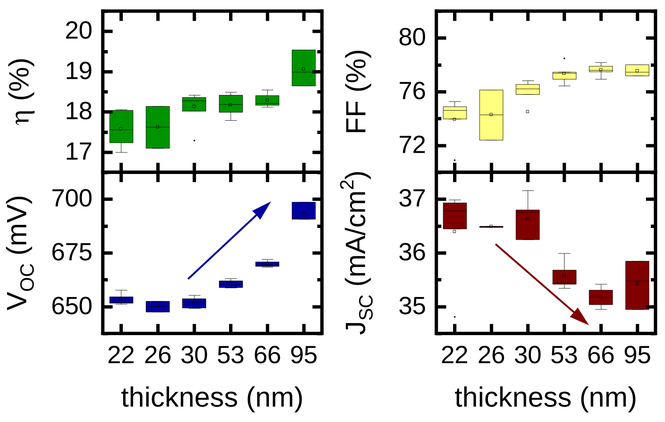
Patterned cells
Record efficiency of 21.72 %



Non-Patterned Solar Cells

Cell demonstrator:

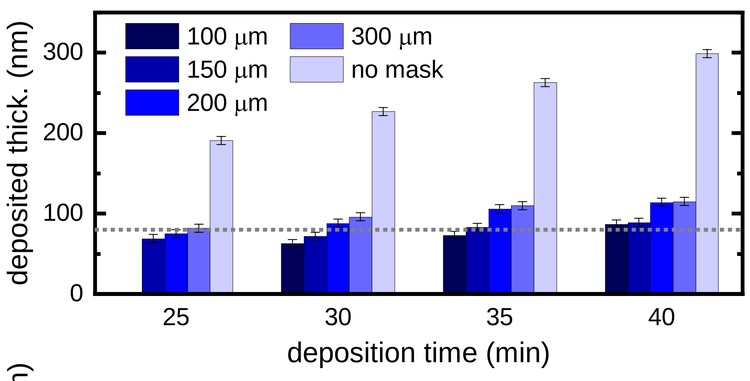
- PECVD deposition of various µc-Si(n) thickness (front) and SiC(p) (rear)
- Co-annealing at 850°C
- SiN_X deposition and Ag paste printing (front)
- Firing (hydrogenation and contacting of the Ag paste)
- metallization with sputtered ITO/Ag stack at the rear

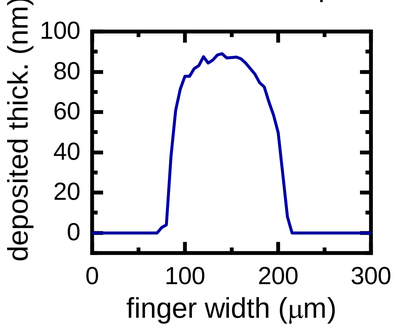


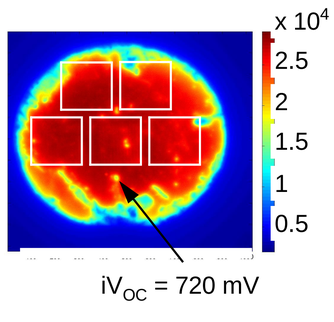
✓ Ag paste can be confined in the passivating contacts at 95 nm (V_{OC} up to 700 mV)

✗ Thick passivating contacts are responsible of large parasitic absorptions (low J_{SC})

Localization of Passivating Contacts







- Localised contacts deposited through hard mask during PECVD
- Localisation can reduce the parasitic absorptions
- Tested on symmetrical structure
- Profile made with Raman spectroscopy[4]

✓ Feasibility demonstrated up to 100 µm

✓ Low fingers tapering

✓ Homogeneous passivation

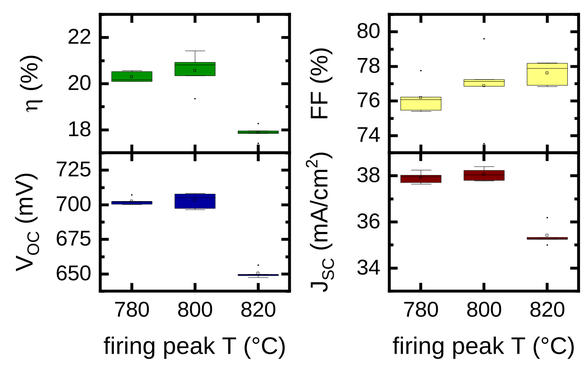
✗ Large increase of the deposition time

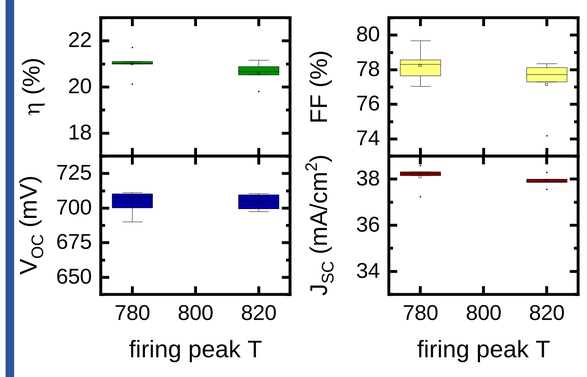
Solar Cells with Localized Front Passivating Contacts

Cell demonstrator:

- PECVD deposition of various localized µc-Si(n) thickness, addition of full-area thin µc-Si(n) (front) and SiC(p) (rear)
- Co-annealing at 850°C
- SiN_X deposition and Ag paste printing (front)
- Firing (hydrogenation and contacting of the Ag paste)
- metallization with sputtered ITO/Ag stack at the rear

Thick. (nm)	Eff. (%)	FF (%)	V_{OC} (mV)	J_{SC} (mA/cm²)
~100	19.06	79.5	658.6	36.40
~115	21.43	79.6	707.7	38.04
~130	21.72	79.7	711.2	38.32





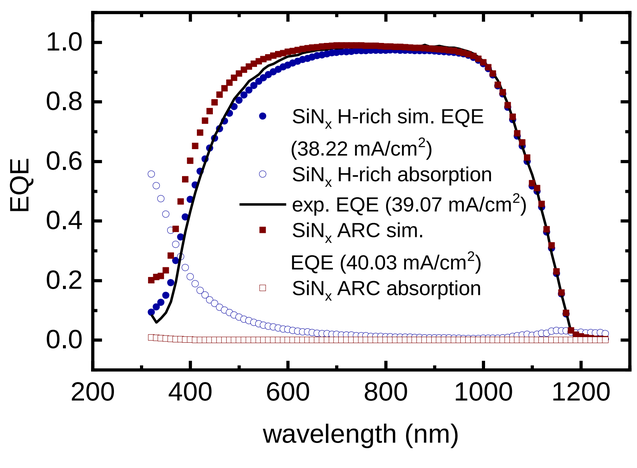
✓ Ag paste can be confined in the passivating contacts even at a firing peak T of 820°C

✓ V_{OC} up to 711 mV for the best cell

✓ High FF of almost 80 %

✗ Final cell efficiency mostly limited by the J_{SC}

- Simulated EQE are compiled with CROWM[5] to understand SiN_x impact on J_{SC}
- Simulation are in close agreement with reality within a minor error of 2% relative
- SiN_X optimized for hydrogenation induces large parasitic absorption
- More stoichiometric nitride optimized for ARC could push forward cell eff. over 22.3%



Conclusion

Non-Patterned Solar Cells

- Demonstration of thick blistering-free passivating contacts adapted for firing through process
- V_{OC} up to 700 mV
- Thick passivating contacts are responsible of large parasitic absorption → need of patterning for front side application

Localization of Passivating Contacts

- Demonstration of localization process through hard mask during PECVD
- Low finger tapering and homogenous passivation
- Increase drastically the deposition time → need a better solution to be integrated to industry process

Solar Cells with Localized Front Passivating Contacts

- Demonstration of high efficiency solar cells >21.7% with high V_{OC} >710 mV and high FF >79.5%
- Final cell efficiency limited by J_{SC} → can be easily improved by using a SiN_x optimized for ARC
- Long term objective: contact also the rear during firing through process

References

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