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Compatibility of copper plated cells with MWT module technology

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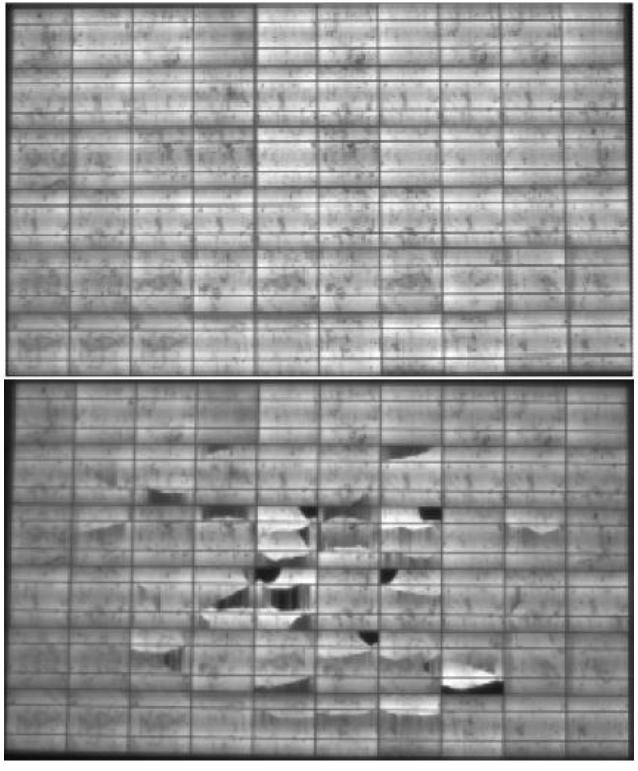
Why back-contact cells and modules?

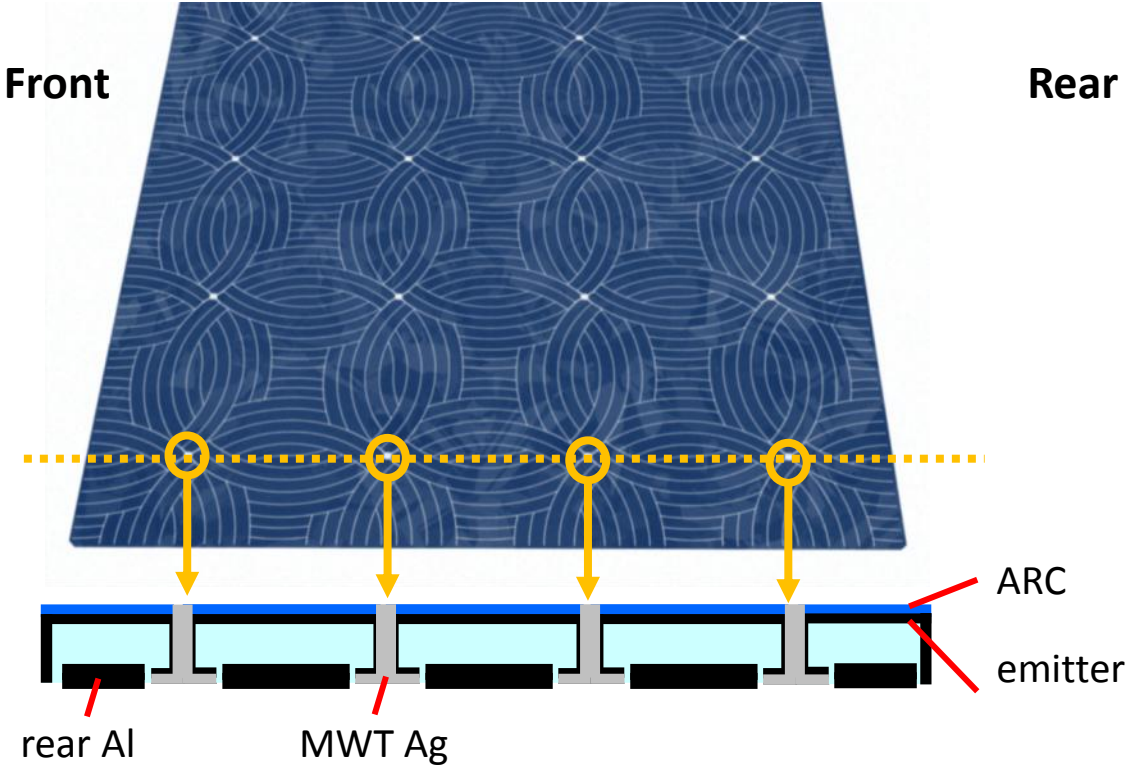
Limitations of H-pattern cells and modules:

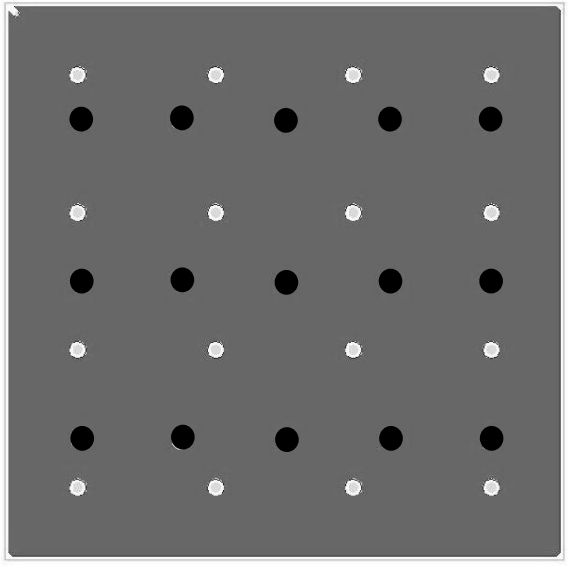
- Increased performance of cells requires thicker and/or wider tabs for interconnection
  - Wider tabs result in more shadowing
  - Thicker tabs result in a stiffer interconnection and so more thermomechanical damage during module manufacture and operation
- Thinner cells and higher performance metallisation pastes result in cracking during cell and module manufacture
- Stringing process requires a lot of cell handling which will have an effect on manufacturing yield



Zemen et al. 25th EUPVSEC, Valencia, 2010

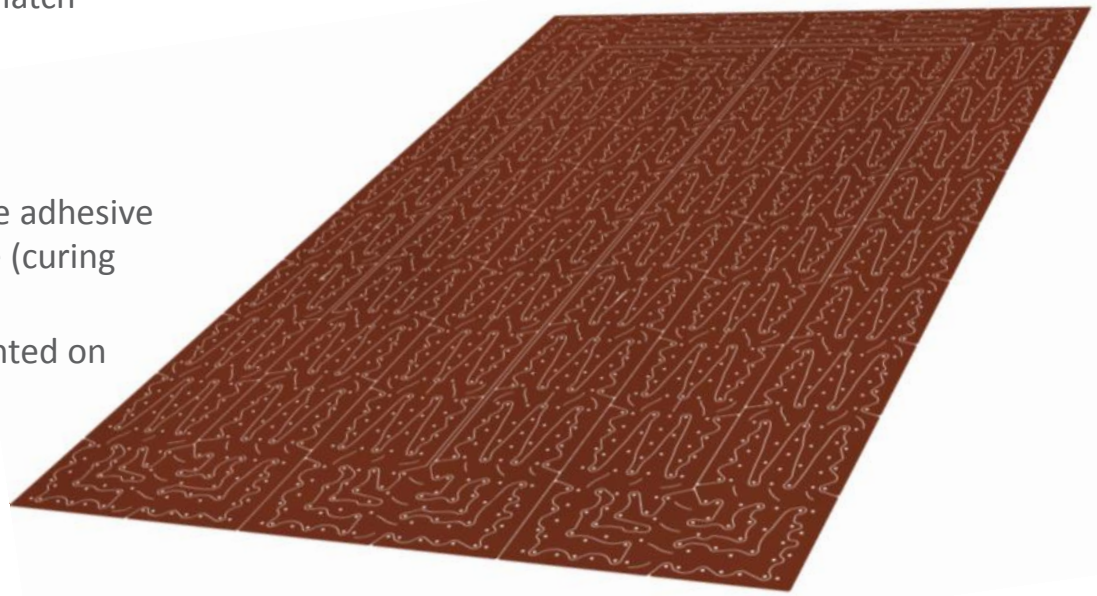
Metal Wrap-Through cell





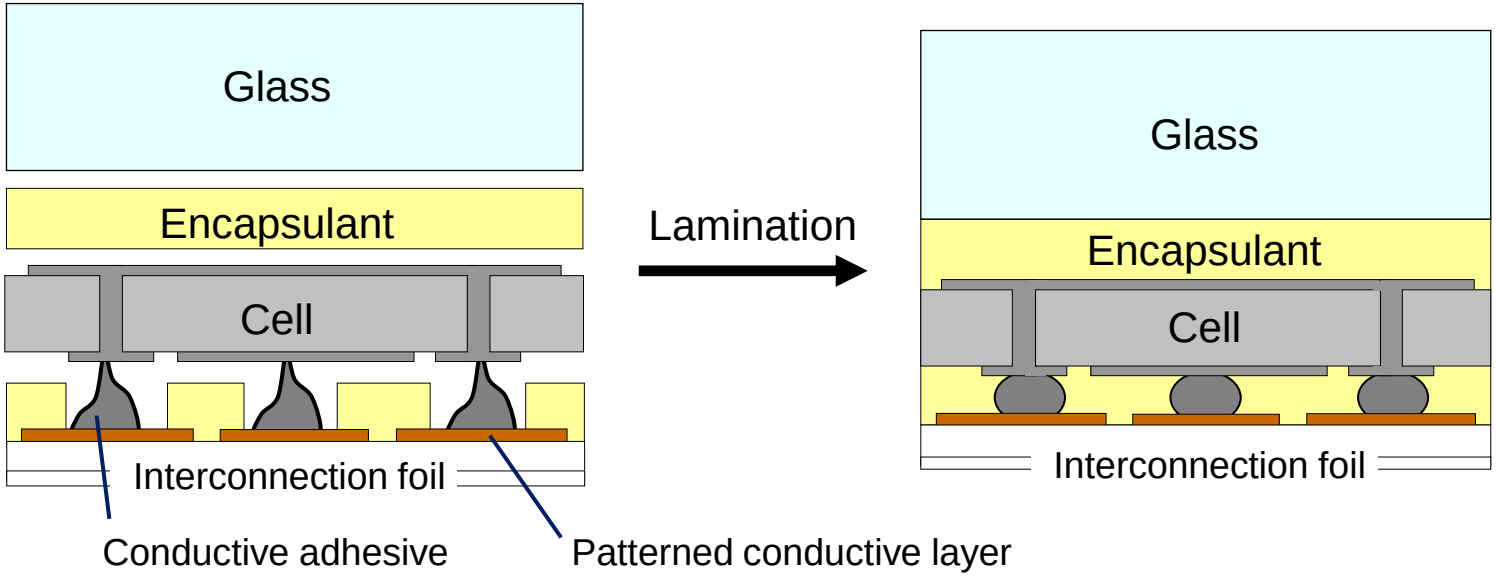
Interconnection with conductive back-sheet foil

- Conductive back-sheet
  - Laminate of standard back-sheet with conductive layer e.g. Cu-PET-PVF
  - Conductive layer patterned to match contact pattern on rear of cells
- Combined lamination and interconnection
  - Interconnection with conductive adhesive or other low-temperature paste (curing temperature ±150°C)
  - Conductive adhesive stencil printed on conductive back-sheet



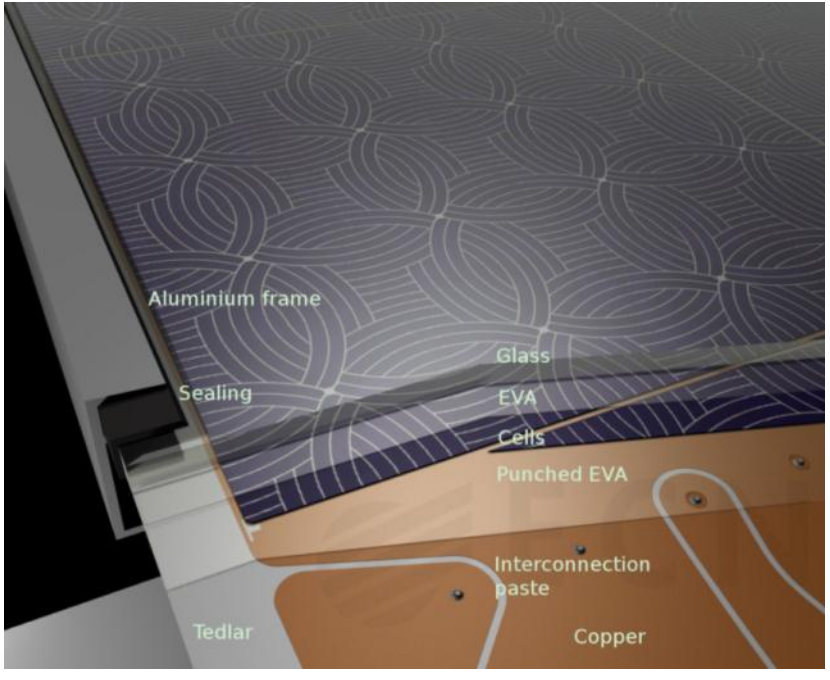
MWT module manufacturing

Combined lamination – interconnecting step



Advantages MWT module with conductive back-sheet

- Higher module efficiency
  - No shading (no tabs)
  - Lower resistance losses (FF +2-3%)
  - Smaller spacing between cells (<1.5 mm)
- Low stress manufacturing process
  - Single step assembly: cells only touched once
  - Flexible conductive adhesive interconnection
  - Suitable for very thin cells (<100 µm)



MWT module manufacturing

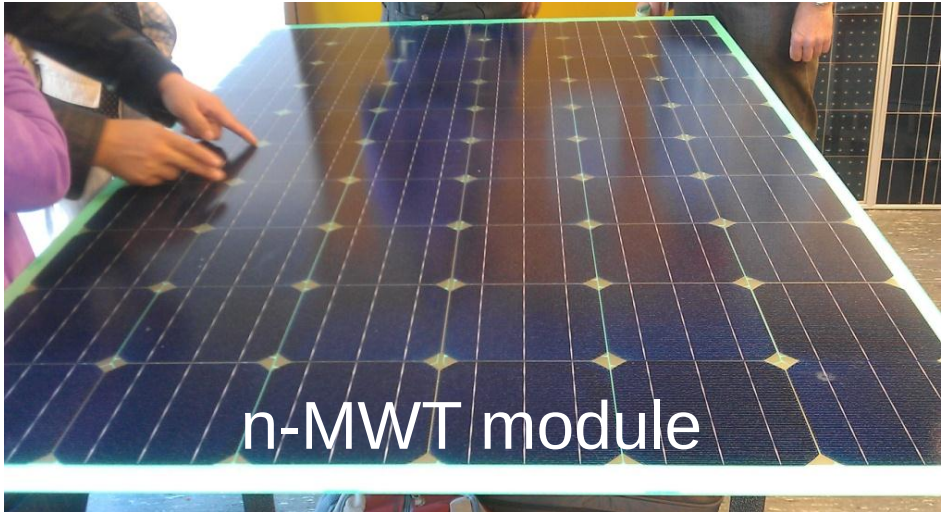
- Module manufacturing equipment fully developed
- Eurotron production tool
  - Partially or fully automated lines up to 180 Wp per line
  - Through-put: 1 module per 40 seconds
  - 4 to 8 times faster than stringer for H-pattern cells and modules

PV Module Performance

- N-type cells

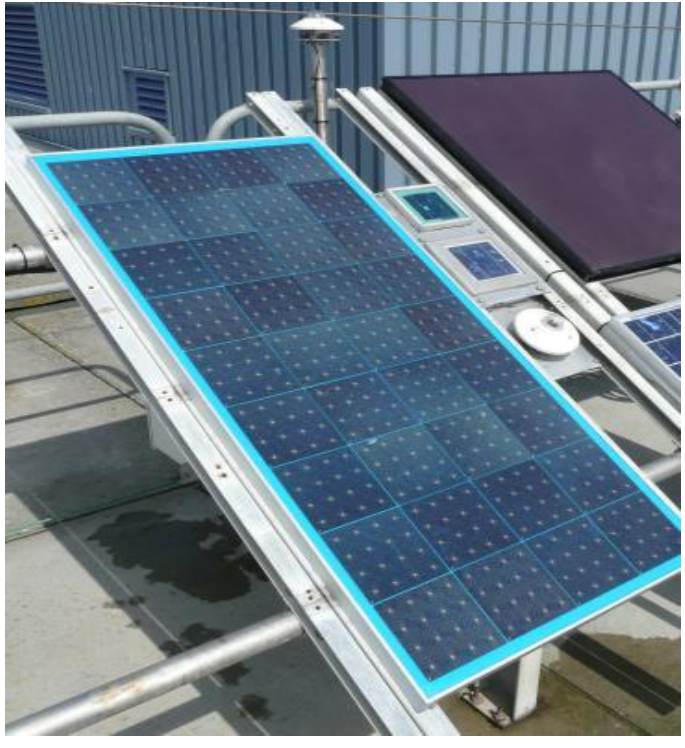
	P_{max} [W]	Cell-to-module FF loss
n-MWT	273	0.8%
n-PasHa	265	3%

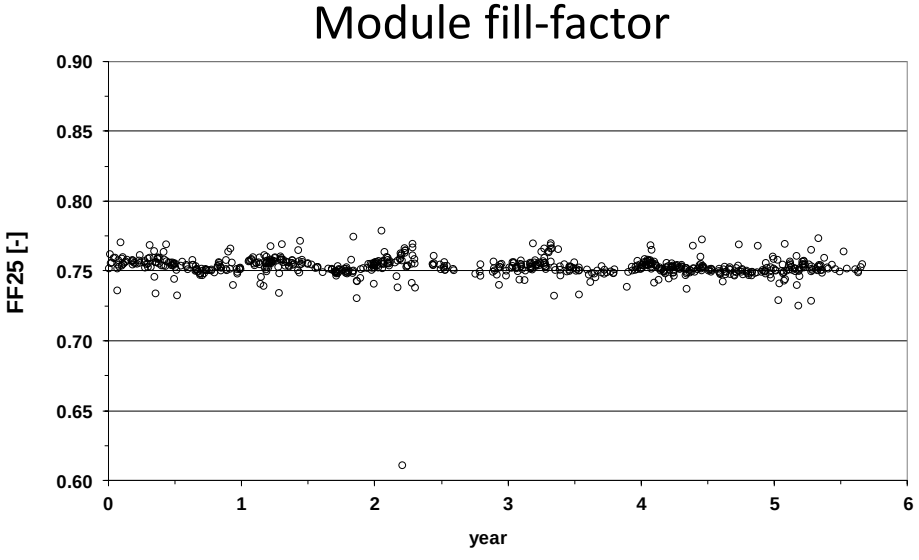
- With cell improvement:
  - Cell efficiency increased to
    - 19.3% for H-pattern
    - 19.6% for MWT
  - 60 cell module: **279 W**



N. Guillevin et al, 27th EUPVSEC, Frankfurt, 2012

Outdoor testing: 36-cell MWT module





- Testing since April 2007
- >5 years outdoors stable performance

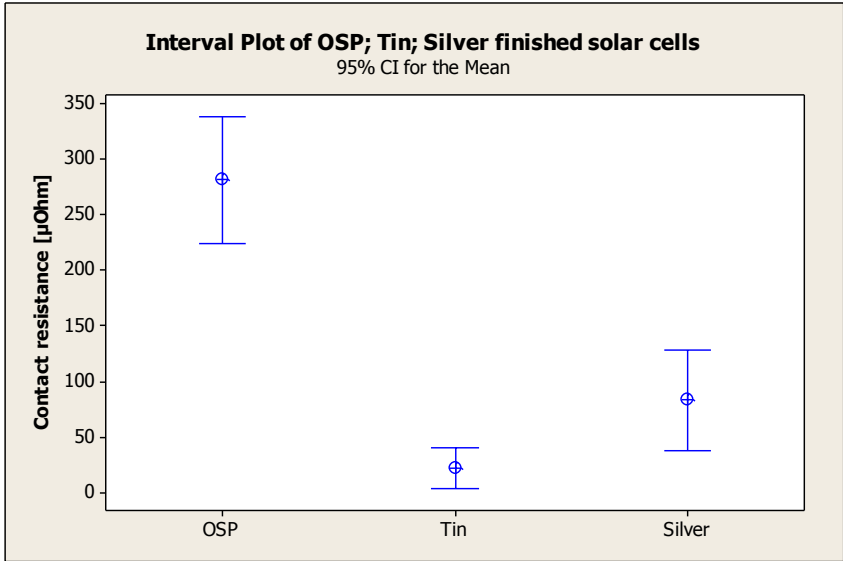
Compatibility MWT module technology with copper plating

- Aim
  - To confirm compatibility of copper plated cells with MWT module technology
- Compatibility conductive adhesive with copper plated cells
  - Contact resistance
  - Adhesive strength
  - Reliability in modules in damp-heat and thermal cycling
- Copper plated cells
  - H-pattern p- and n-type cells
  - Screen printed silver, plated with copper

Contact resistance and peel strength

- 4-point measurement
  - Tab attached to copper metallisation with conductive adhesive
  - EVA spacer
  - Cured in standard lamination cycle as for MWT module
  - Copper with tin, silver and OSP finish
  - Comparison with contact resistance on fired silver metallisation
- Peel test
  - 90 and 180°
  - Comparison with peel strength on fired silver metallisation

Results contact resistance and peel strength



Material finishing	90° (peel)	180° (shear)
OSP	0,5-1 N	30-40 N
Tin	0,3-1 N	21-33 N
Silver	0,3-1 N	9-24 N

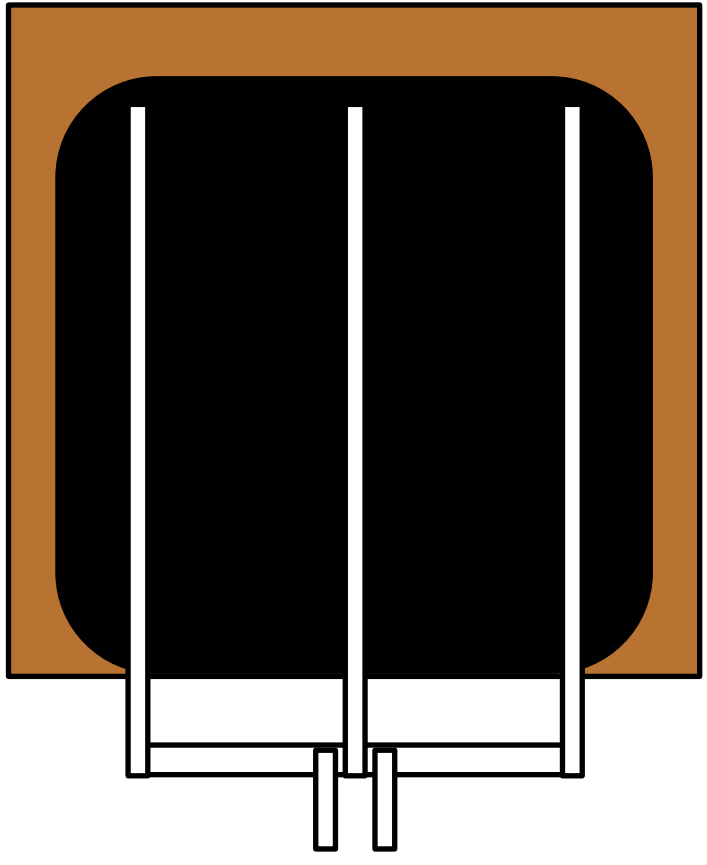
- Contact resistance lowest on tin coating, highest on OSP
  - Compare well with results on fired silver metallisation
  - Lower than contact resistance to copper back-sheet foils with OSP (approx. 500 µΩ)
- Peel test highest on OSP
  - Comparable with peel test on fired silver metallisation (1-2 N typical for 90° test)
  - Failure between tab and conductive adhesive

Manufacture single cell modules

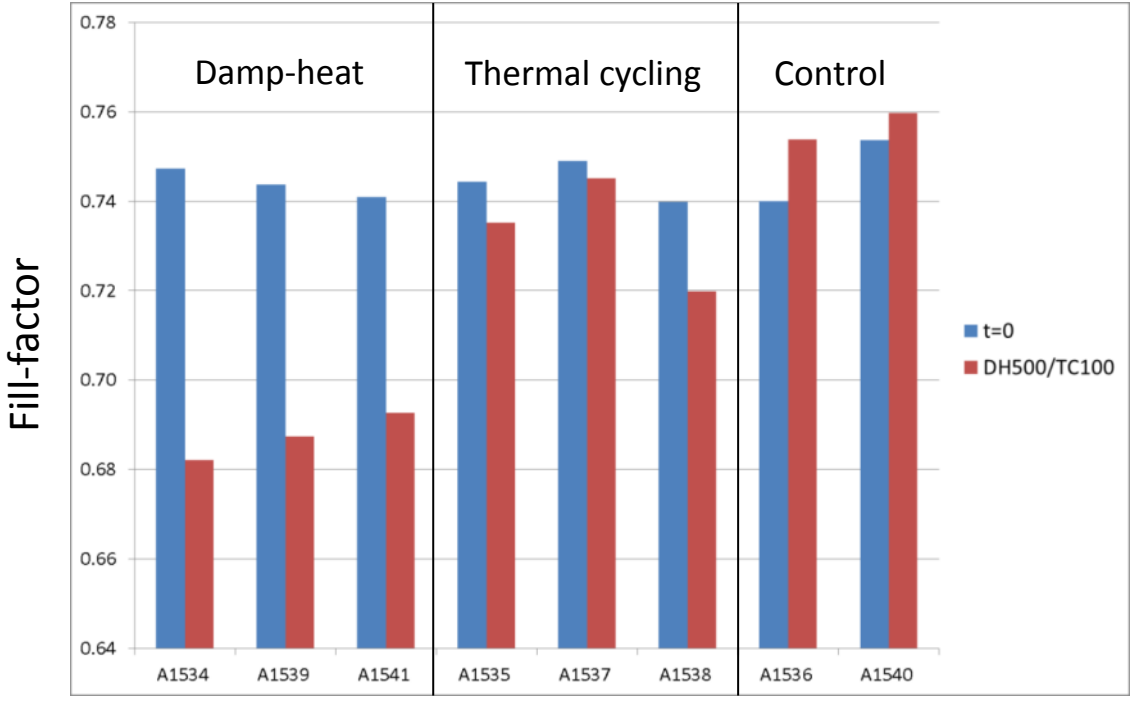
- Front-side contacts soldered with standard tabbing
- Rear-side contacts with conductive adhesive to simulate MWT module
  - Same adhesive and during profile used
  - Adhesive dot size same as in MWT module
  - Copper sheet used, no pattern
- Characterisation by IV, EL, DLIT and visual inspection
- Climate chamber testing in damp-heat and thermal cycling

Single cell modules

- Front-side contacts soldered as for H-pattern
- Rear-side contacted to copper foil with conductive adhesive as for MWT module

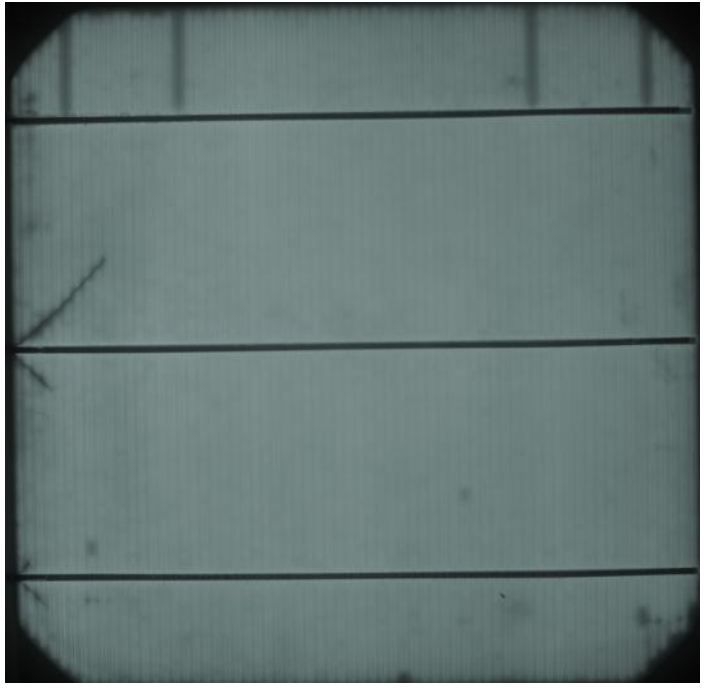


Results climate chamber testing single cell modules



- Thermal cycling: -40/85°C
- Damp-heat: 85%RH/85°C

EL images modules after damp-heat



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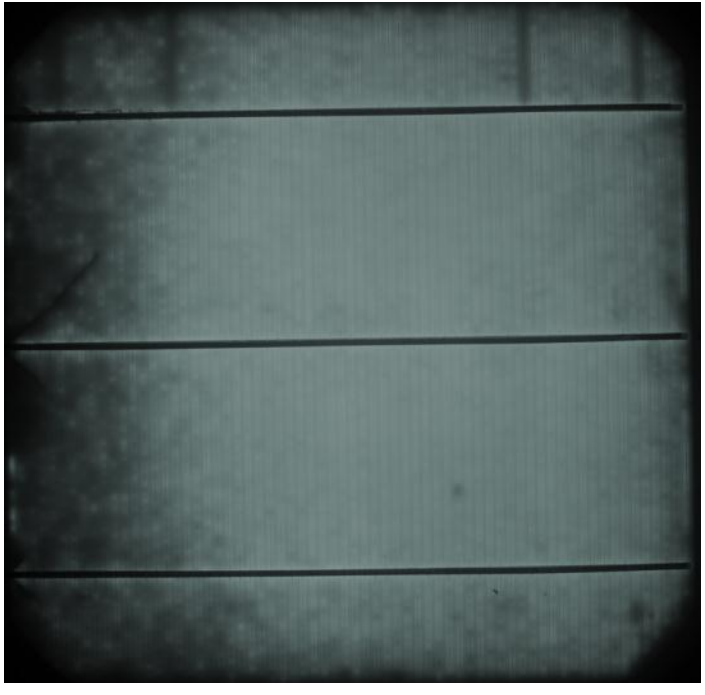
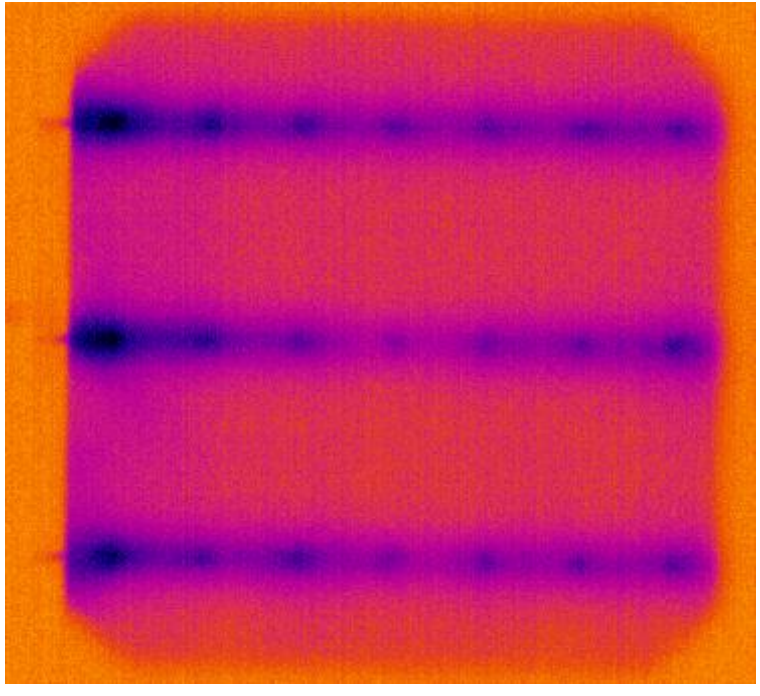


500 hours DH

DLIT images modules after damp-heat



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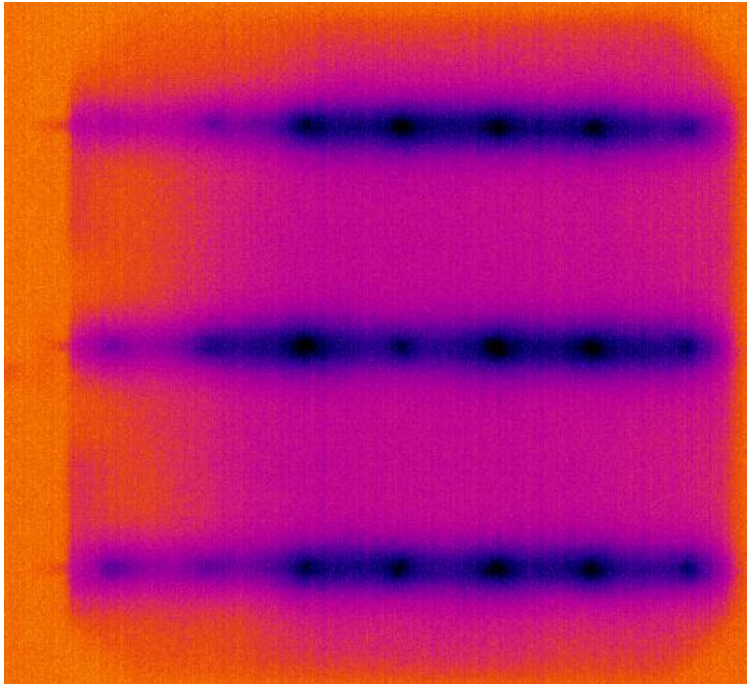
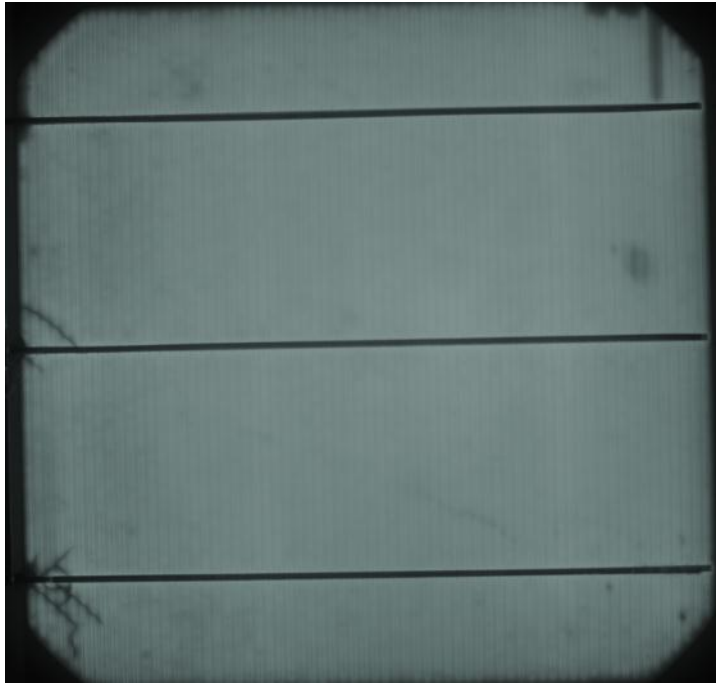


500 hours DH

EL images modules after thermal cycling



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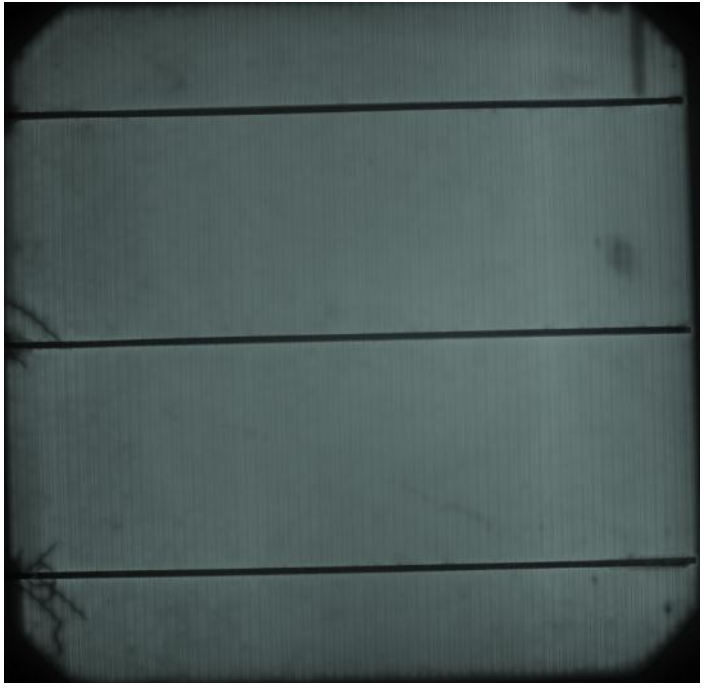
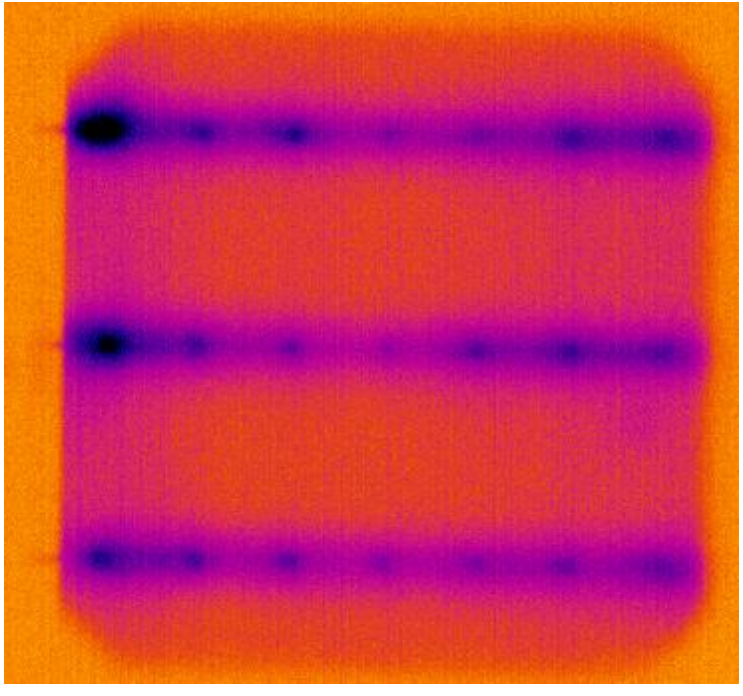


100 thermal cycles

DLIT images modules after thermal cycling



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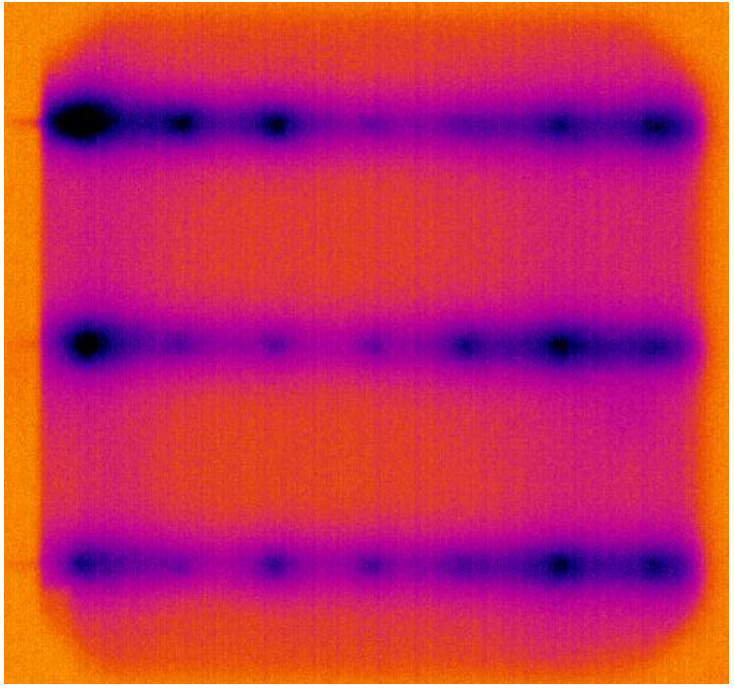

100 thermal cycles

Conclusions

- Contact resistance and peel strength comparable with conductive adhesive on fired silver contact
- Good performance in thermal cycling
- Decrease in FF in damp-heat due to poor adhesion between silver print and silicon on front side of cell after damp-heat
  - Degradation not related to interaction between adhesive and copper plating

- Copper plated cells are to be compatible with MWT module technology
  - Further climate chamber tests followed by post-test analysis are being performed to confirm this

Thank you for your attention

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