TECC-Wire: A new Low-Temperature Technology for the Interconnection of Solar Cells

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Solyco Technology GmbH

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- Techniques for the interconnection of solar cells with TCO
- ***TECC-Wire*** Technology
- Status of R&D
- Outlook
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Experience of the Team

- 1996 – 1999 PV module manufacturing startup “SolarWerk GmbH”
- 1999 – 2014 Part of SOLON´s technology division (for PV module manufacturing and PV products R&D)
- 2007 – 2011 Strategic partner of a manufacturer of flexible CIGS solar cells and modules
- 2015 - 2016 Part of First Solar´s „Tetrasun“ devision (developed the first commercial n-TOPCon cell and module)
- since 2017 Technology consulting firm and PV products R&D
  Strategic partner of PI-Berlin for module QA projects

The legal entity was established in 2007 as a SOLON R&D company which had been spun off by an MBO in 2012.

Techniques for the interconnection of solar cells with TCO

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SHJ solar cells

- Low-temperature multi-wire soldering based on 9-12 wires which are coated with a low-temp alloy (→ Risen)
- *"SmartWire"* by MeyerBurger – a low-temperature In- or Bi-based soldering with 18-22 wires (→ REC; MB; HEVEL)
- Conductive adhesive paste-based interconnection (→ 3SUN; HEVEL)
- Conductive tape-based interconnection (→ Panasonic)

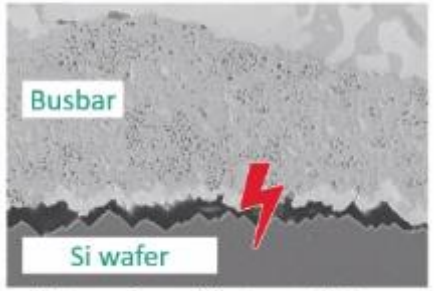
other

- Flexible CIGS solar cells: ECA paste (→ GlobalSolar)
- c-Si/pero tandem solar cells (in development): *SmartWire*, ECA paste

Jochen Rentsch on “PV HeterojunctionTech 2021”:

Challenges for the Interconnection of HJT cells

- Temperature sensitivity of hetero layers [1-3]
- Lacking adhesion of metallization
- SmartWire Connection Technology (SWCT) is protected by Meyer Burger



Busbar ablation after soldering on HJT paste

- Two routes for interconnection

Conventional soldering with ribbons or wires

Electrically conductive adhesives (ECA)

[1] B. A. Korevaar *et al.*, Influence of annealing on the performance for hetero-junction *a*-Si/*c*-Si devices, 23rd EU PVSEC, pp. 1859-1862, 2008
[2] S. De Wolf *et al.*, Nature of doped *a*-Si:H/*c*-Si interface recombination, Journal of Applied Physics, vol. 105, no. 10, 2009
[3] J. Haschke *et al.*, Annealing of Silicon Heterojunction Solar Cells: Interplay of Solar Cell and Indium Tin Oxide Properties, IEEE Journal of Photovoltaics, pp. 1-6, 2019

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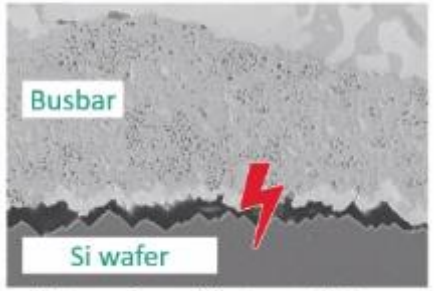

Busbar ablation after soldering on HJT paste

- Three ~~Two~~ routes for interconnection

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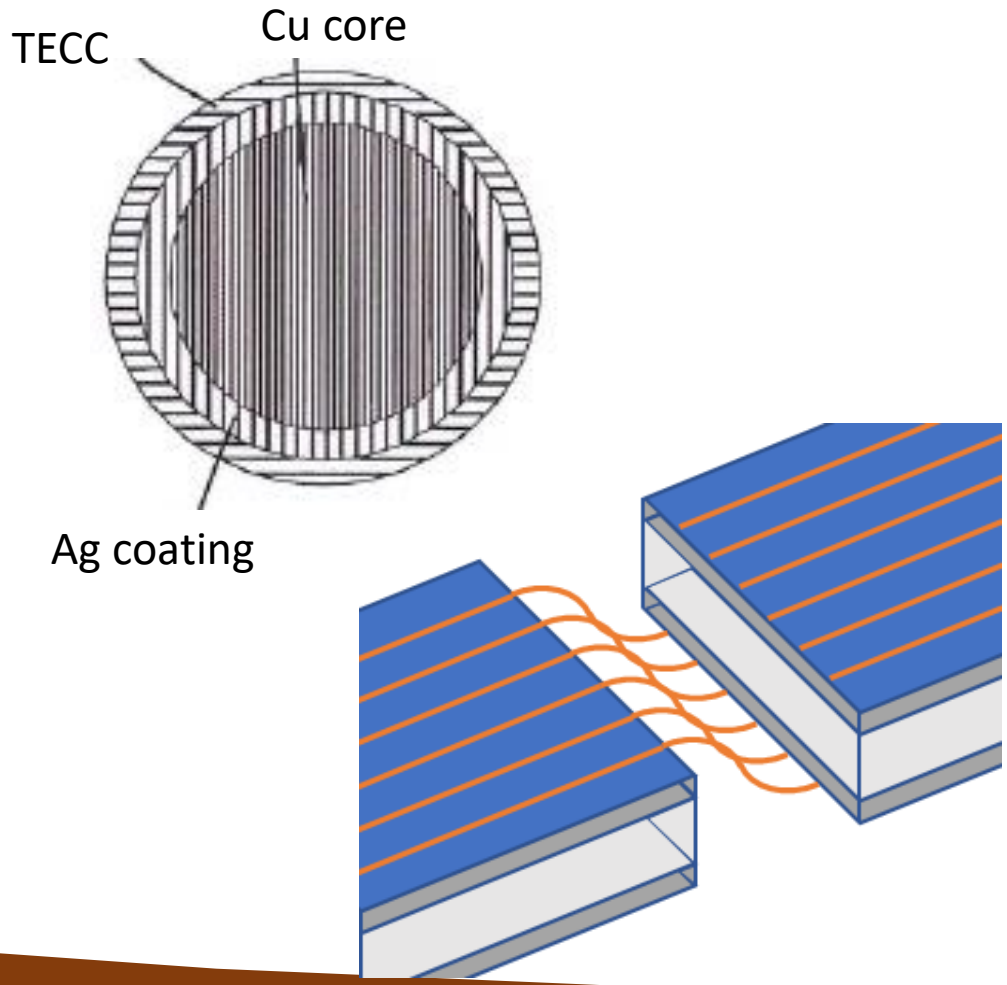
New: TECC-Wire *by Solyco*

TECC-Wire Technology

TECC = Thermoplastically and **E**lectrically **C**onductive **C**oating

- Very similar to multi-wire approach
- Wires are coated with an electrically conductive thermoplastic (instead of a solder alloy)

TECC-Wire Technology



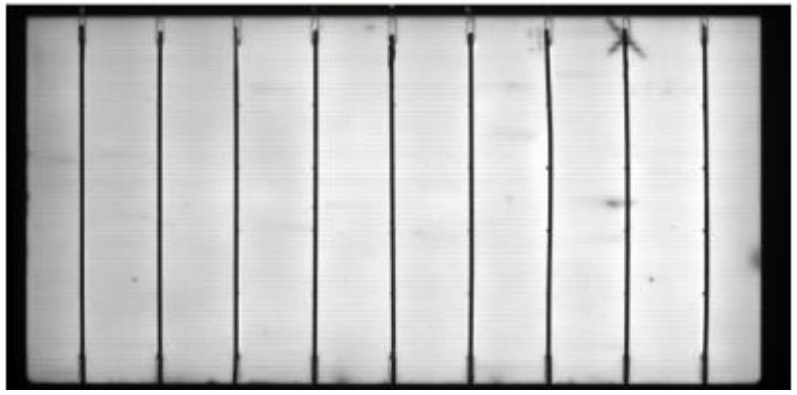
- The wire has a core of Cu with a typical thickness of 280 µm
- Then there is a thin coating of Ag in order to prevent from oxidation of the Cu
- The outer layer of the wire is an electrically conductive thermoplastic material
- Melting temperature can be adjusted between 130°C – 200°C

Status of R&D

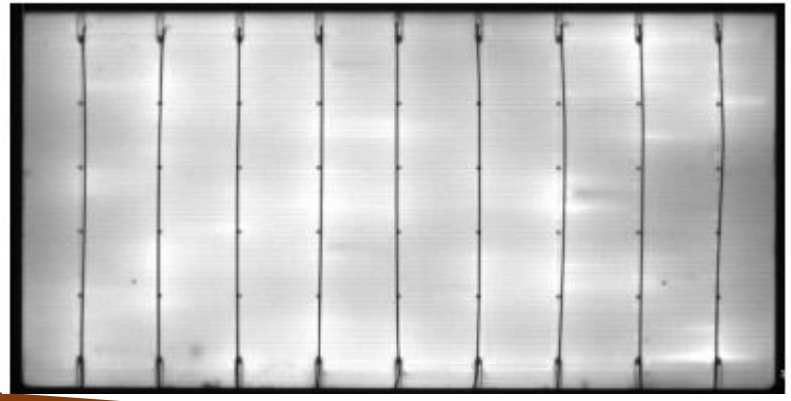
1. **STC power and EL imaging analysis of *TECC-Wire* compared to other means of electrical connection**
   - 9BB n-TOPCon solar cells
   - Busbarless SHJ solar cells with Ag-printed grid fingers
2. **Reliability testing**
   - HF10
   - TC400
3. **Industrial manufacturing with automated stringing machine**

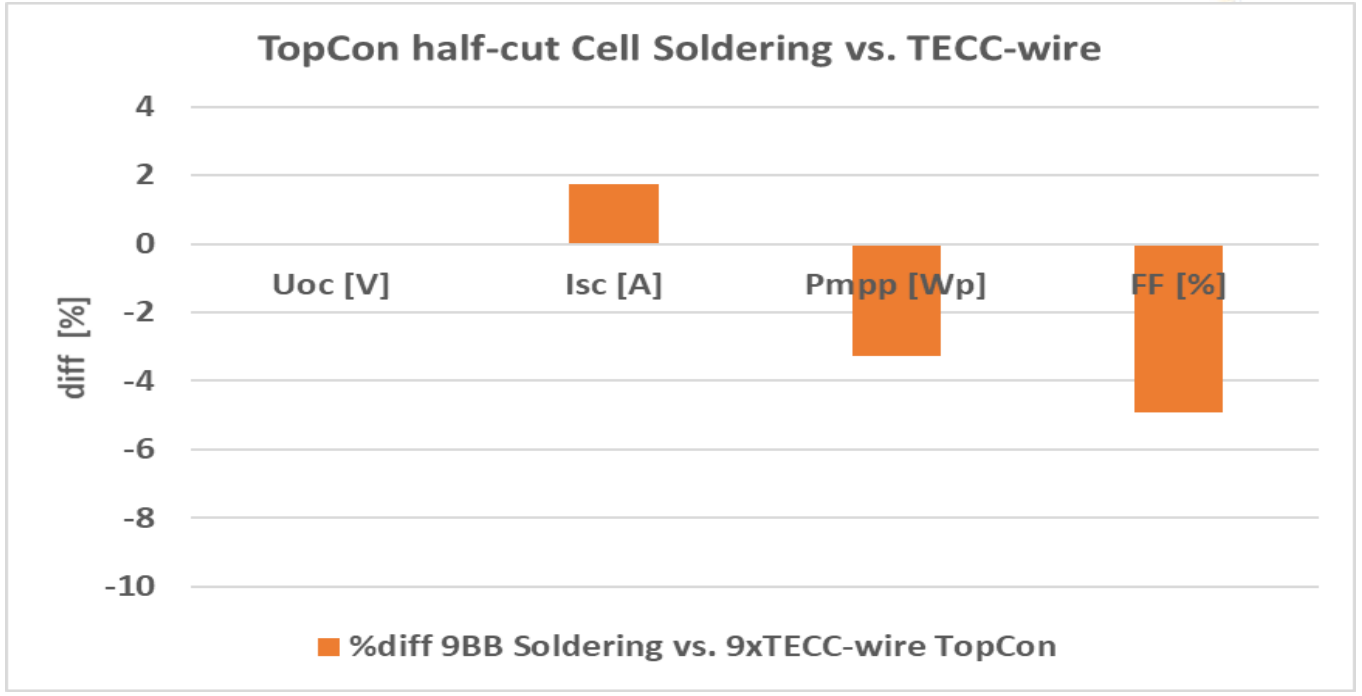
Status of R&D – STC Power

9BB ½ cut n-TOPCon cell: soldered (ref.)



9BB ½ cut n-TOPCon cell: NIC TECC wire



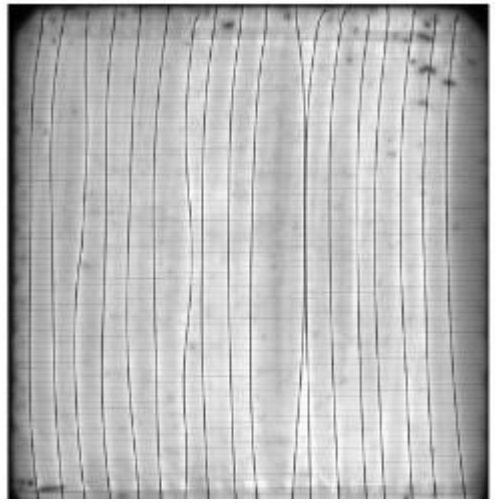


For 9BB design we see some reduction in FF and power. This can be attributed to not perfect contacts in some areas (manual application of the wires).

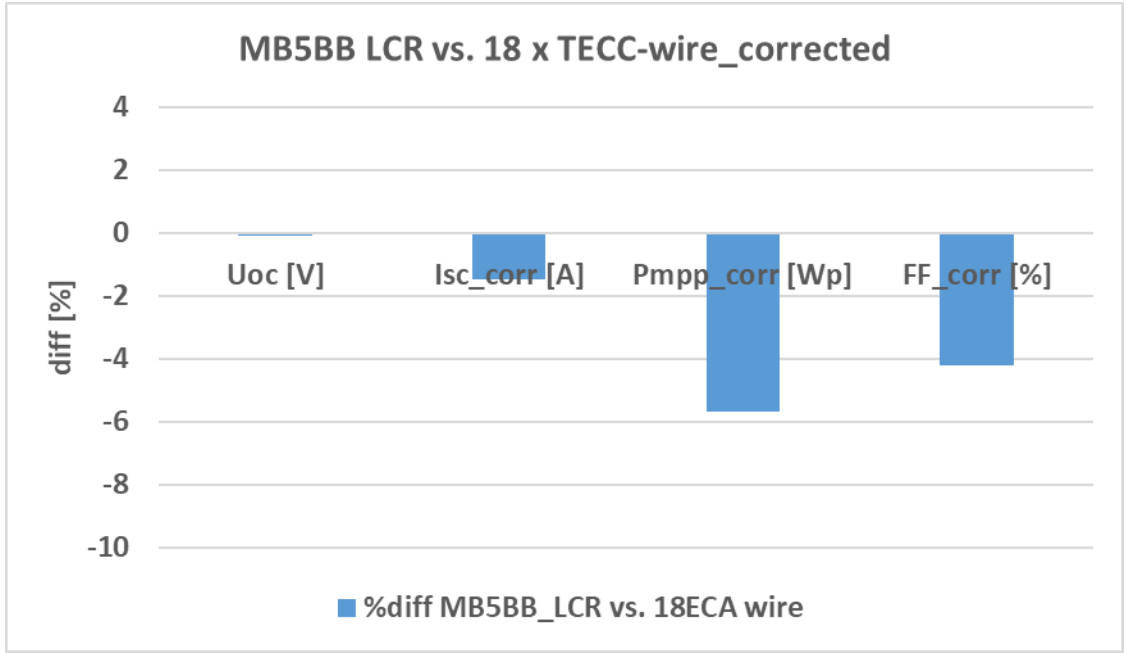
Status of R&D – STC Power

SHJ Solar Cells

ECA paste with 5BB LCR



18x *TECC* wires



For busbar-less SHJ cells we see a slight loss in FF. This also can be attributed to non-perfect contact in the left area which is due to manual application of the wires. Conceptually we get a good contact (electrical and mechanical) to TCO.

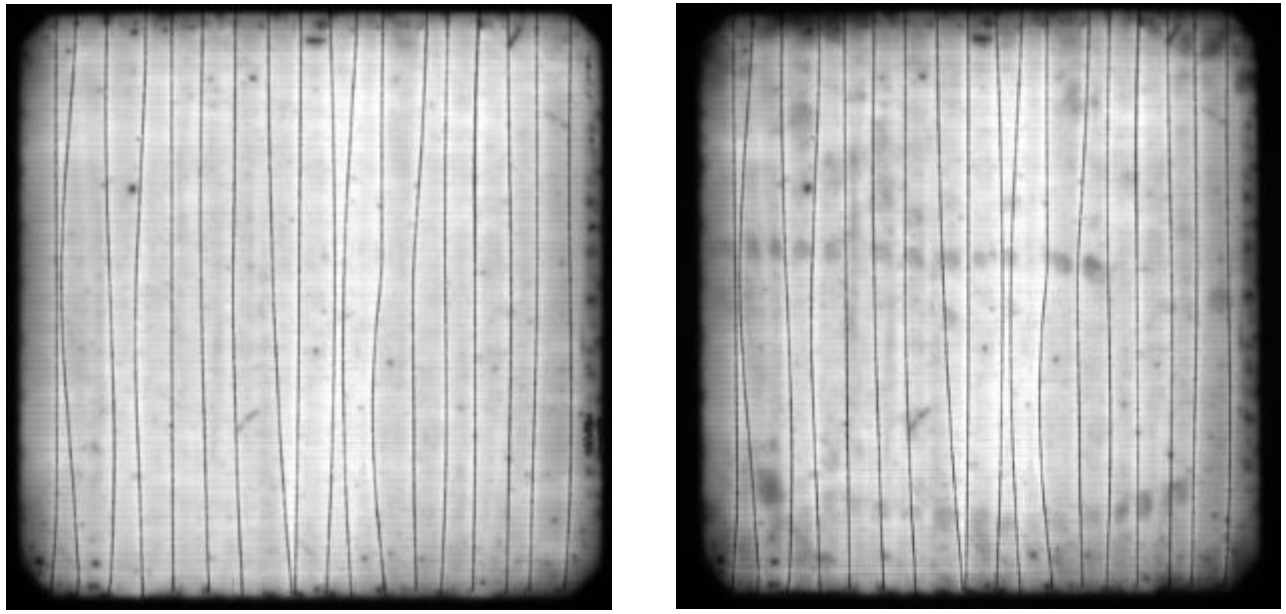
Status of R&D – HF10

STC results initially and after HF10 (10 cycles humidity-freeze)

BB-less SHJ cell	Voc [V]	Isc [A]	Pmpp [Wp]	FF [%]	Vmpp [V]	Impp [A]
Initial	0.728	8.77	4.85	76.04	0.570	8.52
After HF10	0.725	8.70	4.59	72.76	0.557	8.24
%diff	-0.41	-0.80	-5.36	-3.28	-2.28	-3.29

The degradation is most likely related to the solar cell itself because it was a glass / back-sheet module (see EL image next slide)

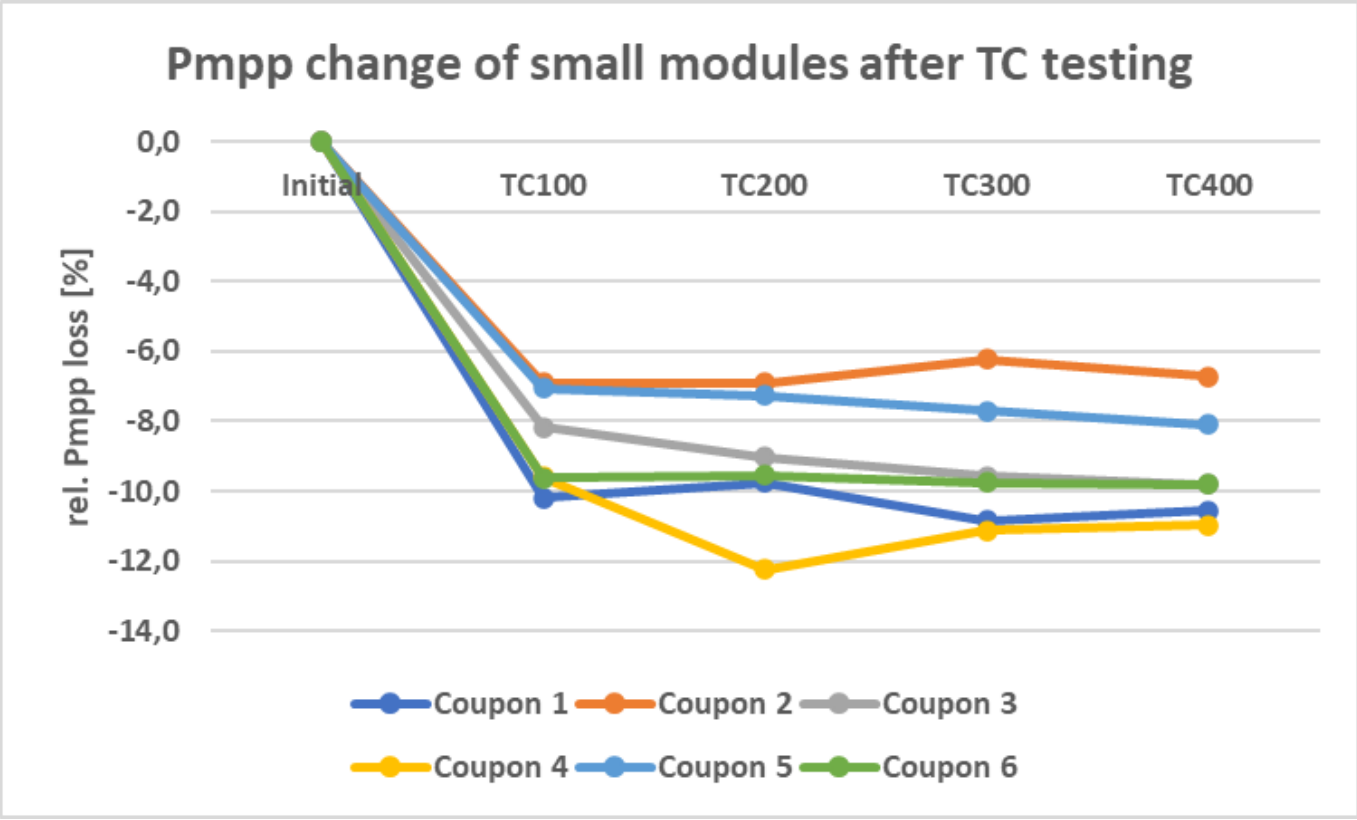
Status of R&D – HF10



EL images of a *TECC*-wire contacted 1-cell coupon with a busbarless SHJ solar cell before (left) and after HF10 (right). It seems that degradation is starting from the outer edges.

The losses which results in the darker areas in the EL image after HF10, are most likely related to the solar cell itself rather than to the interconnection connection.

Status of R&D – TC400

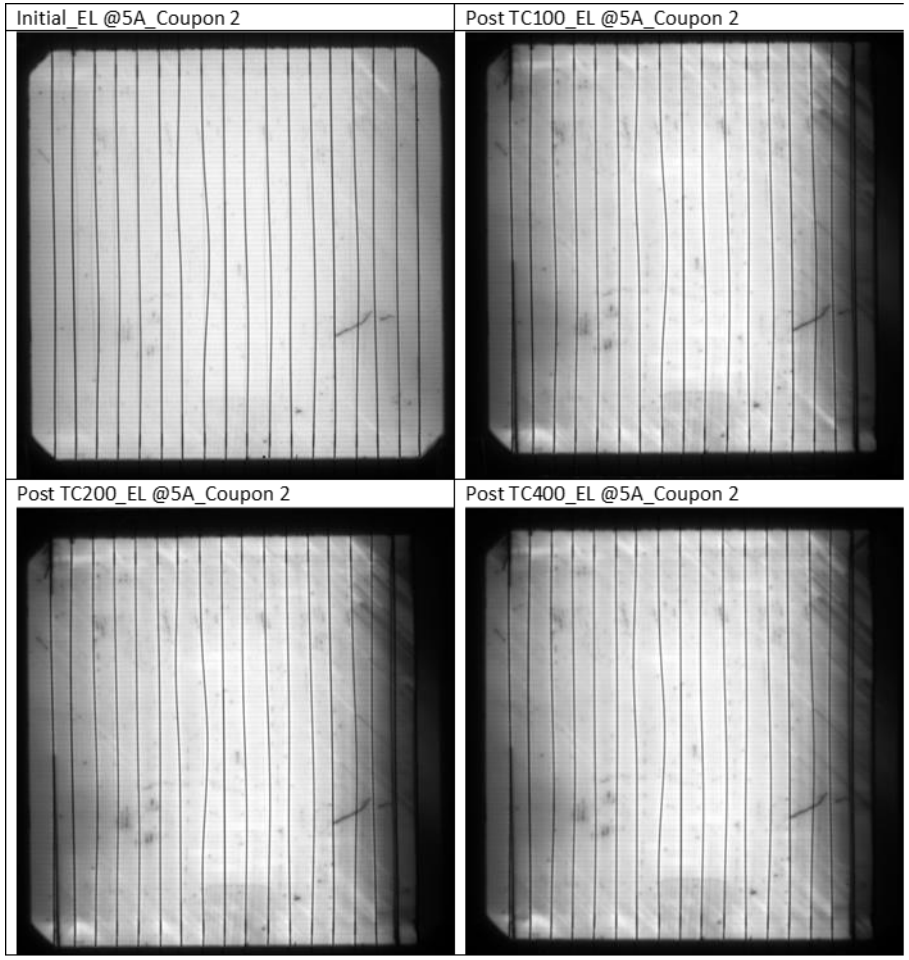


- BB-less SHJ solar cells
- 1-cell coupons; 18 wires
- 6 different samples. Variation parameter is the pressure for *TECC* wire application

- All samples show a degradation of 6 – 12% after TC100
- Afterwards stable up to TC400 (test continuing)

- nothing is yet optimized

Status of R&D – TC400



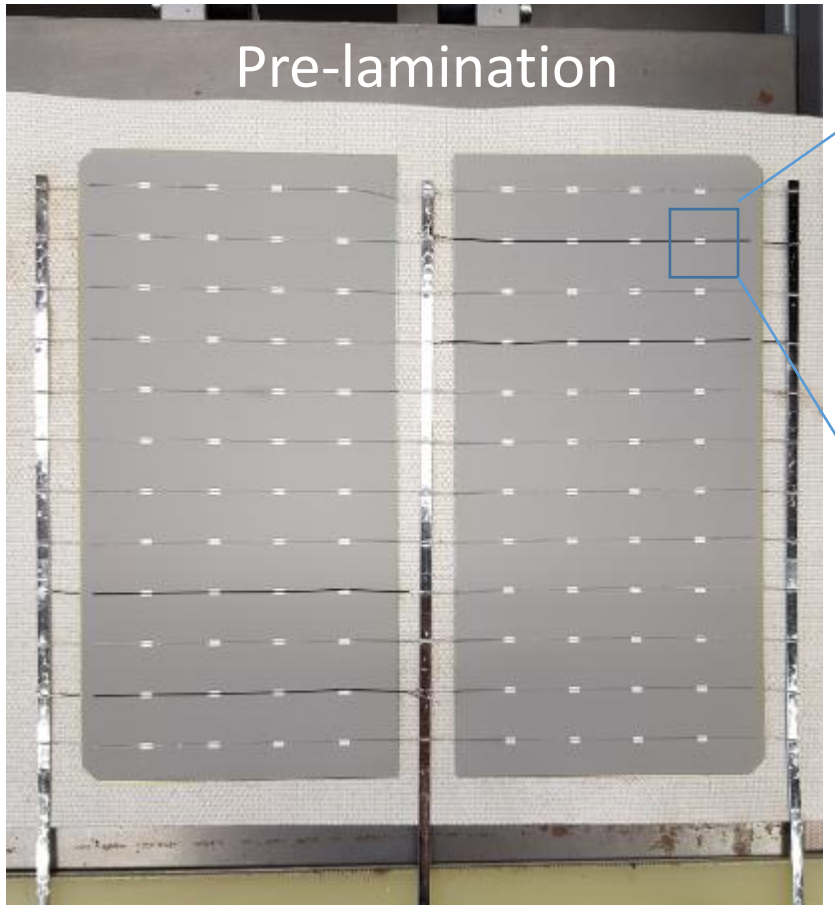
- BB-less SHJ solar cells
- 1-cell coupons; 18 wires
- 6 different samples. Variation parameter is the pressure for *TECC* wire application

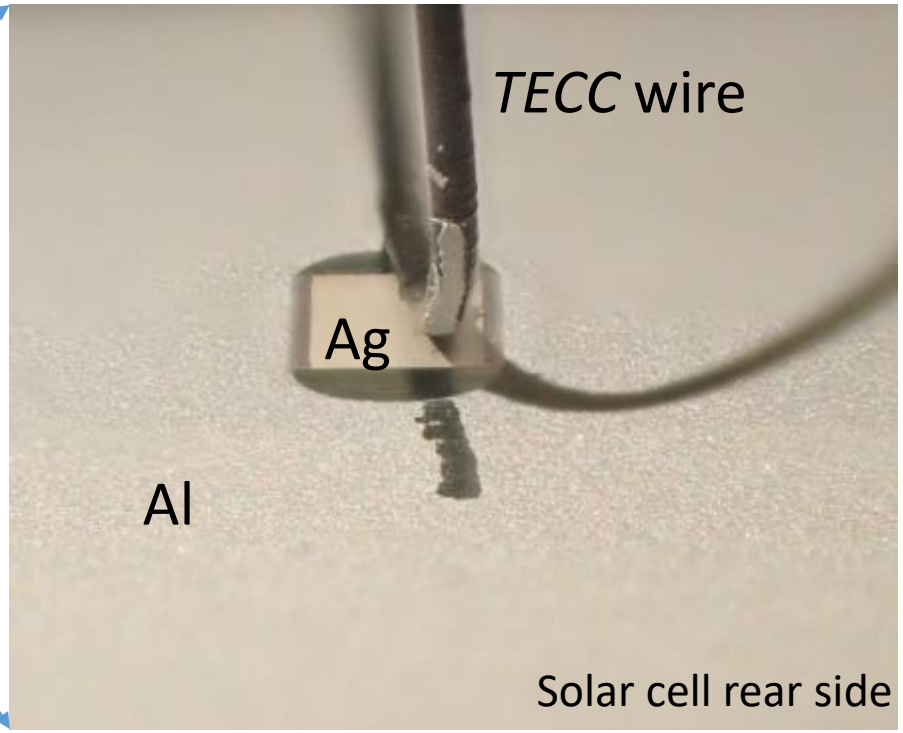
- All samples show issues along the outer edges → might not be related to the interconnection technology

Status of R&D – Industrial Stringing

- trials on a commercial XN CHn40 stringer – side-by side with Bi-based solder wire
- *TECC* wire applied on BB #2 and #4
- SnBiAg wire applied on remaining 10 BB
- Process temperature < 150 °C

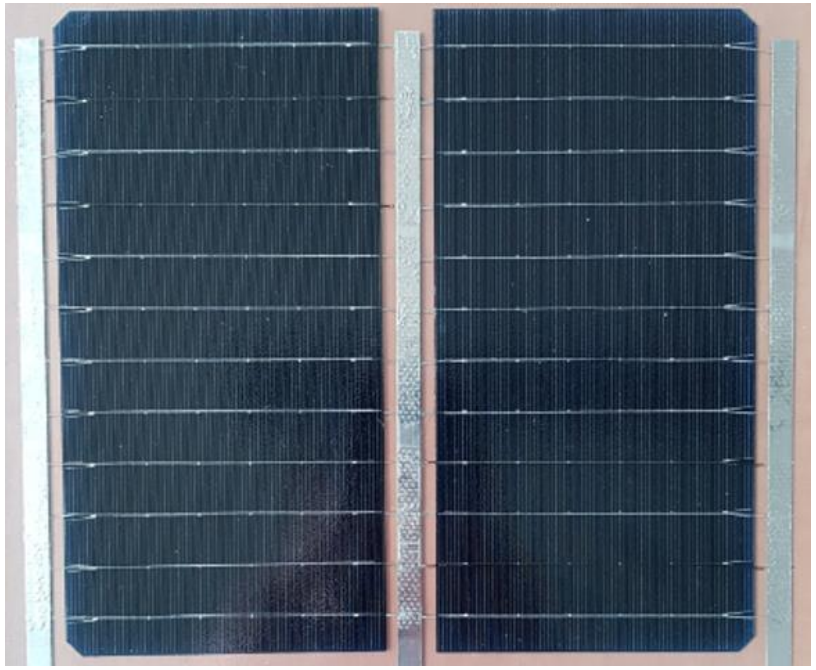
Status of R&D – Industrial Stringing

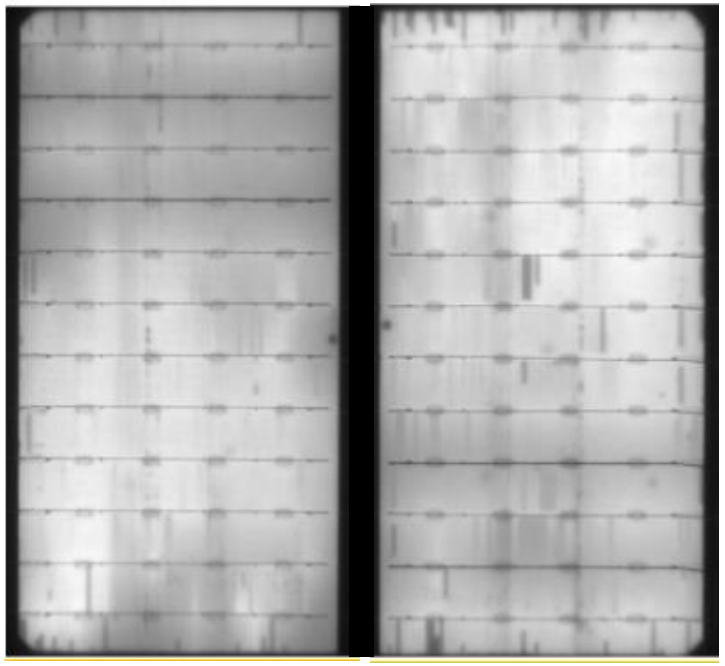




- *TECC* wires stick strongly to the solar cell
- Even pulling Al off the cell during peel testing

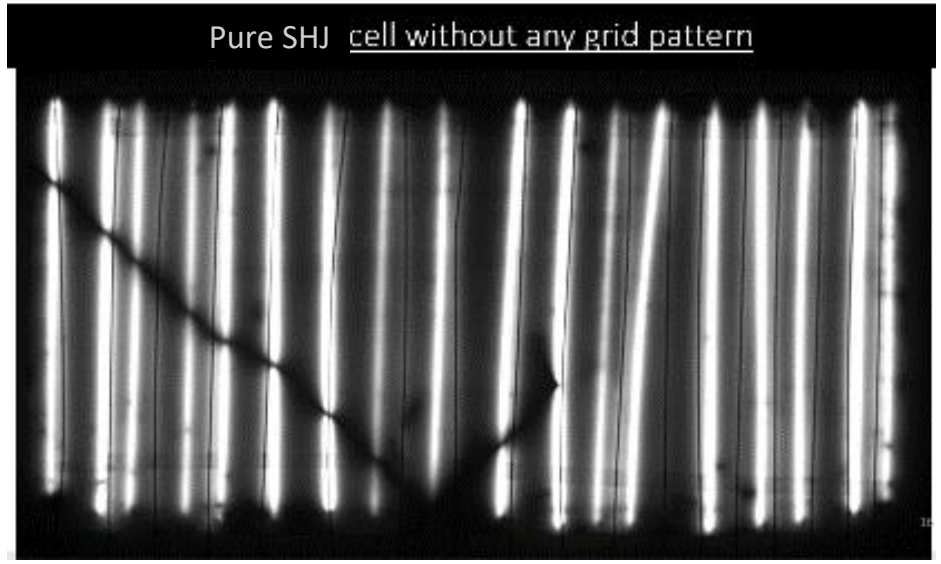
Status of R&D – Industrial Stringing





Front side of the 2 x ½ cut cell module after lamination (left) and the respective EL image (right).
There is not much difference between *TECC* wires and low-T soldering.

Outlook: Ag-free PV Industry



Half-cut metallization-free SHJ solar cell

Result of ½ -cut cell (TCO only)	Voc [V]	Isc [A]	Pmpp [Wp]	FF [%]	Vmpp [V]	Impp [A]
18x *TECC*-wires	0.73	3.95	1.19	41.46	0.47	2.53

For a metallization-free SHJ ½-cut cell the EL image shows a very good electrical contact along the wires. This also demonstrates the good electrical (and mechanical) contact to TCO. The very low FF results from the poor lateral conductivity of the TCO layer.

Summary

- *TECC-Wire* is a low-temperature (< 200°C) non-soldering solar cell inter-connection technology. Basically, a multi-wire approach with very special wires.

- We see a very good electrical and mechanical contact both to SiN and TCO. The observed losses can be attributed to the fully manual application of the wires.

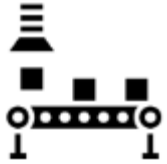
- We could demonstrate that also pure TCO surfaces can get contacted. This enables the long-term vision of an Ag-free PV industry.

Summary

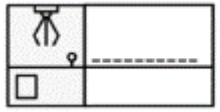
Solution for temperature-sensitive solar cells such as SHJ or c-Si/pero tandems

Enables the vision of an Ag-free PV industry

Unique IP position – enables a globally proprietary stringing technology basis



compatible to any other solar module manufacturing steps (e.g. lamination)



established solar cell stringing equipment can be used with limited modification

different aesthetical options should be possible (black; shiny)

combinable with other stringing tech-nologies like “zero-gap”, “paving” etc

Call for Collaboration

We are looking for PV producers who are interested in a commercialization.

We are open for any routes into commercialization such as:

- Collaborative R&D work
- Licensing
- Transfer of IP

Thank you for your attention !

Solyco Technology GmbH

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