Electrically Conductive Adhesive-Free Interconnection of Shingle Solar Cells

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Session VI: ECA Based Interconnections Technologies
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Introduction

Interconnection of Shingle Solar Cells by an Electrically Conductive Adhesive (ECA)

State of research

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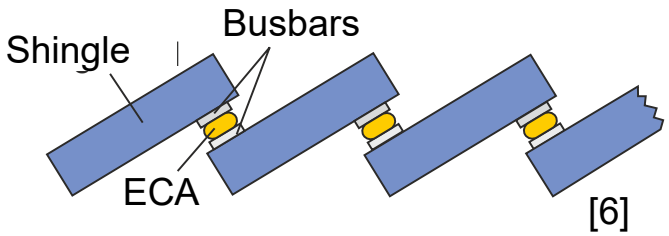
- Typically, ECA is applied as dots or dashes instead of a continuous line
- Consensus that extreme ECA reduction will compromise module output power



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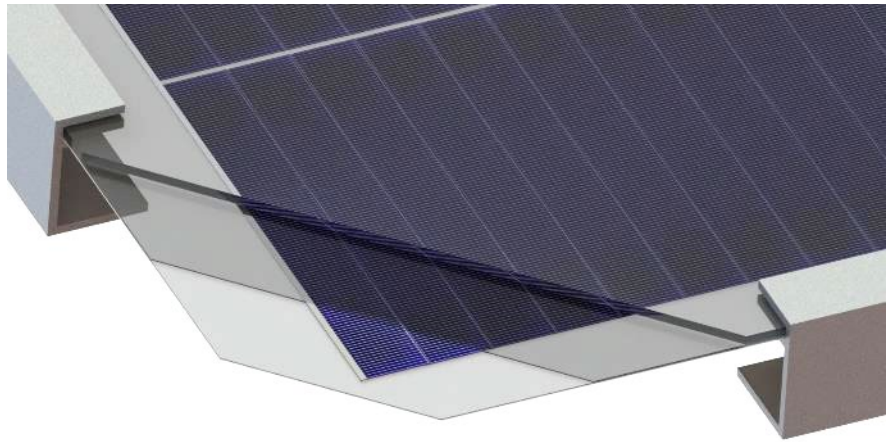

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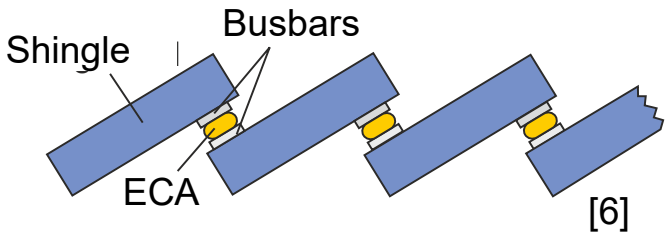

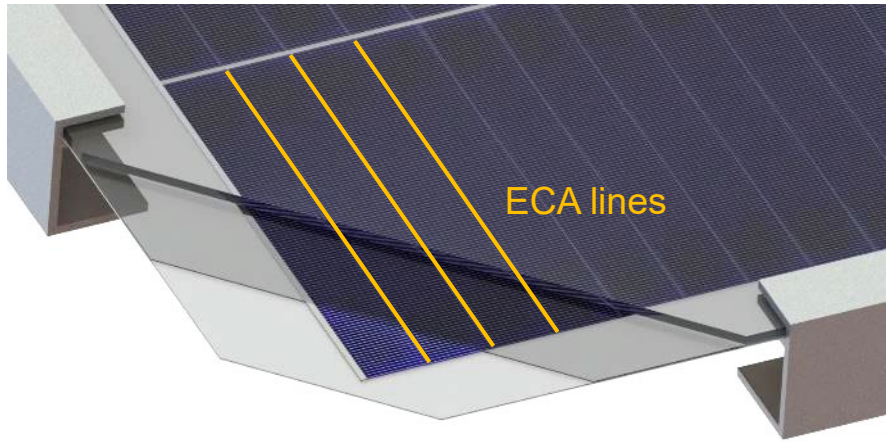

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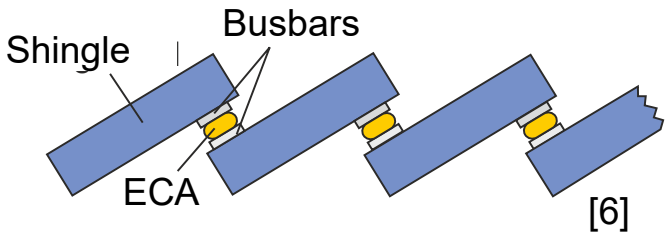

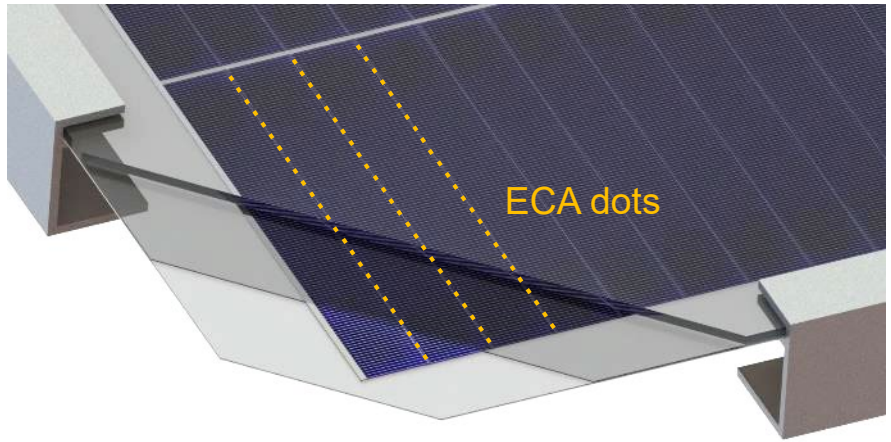

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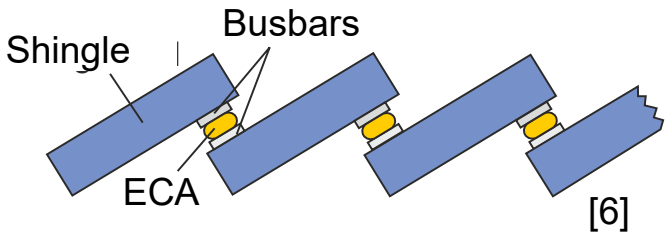

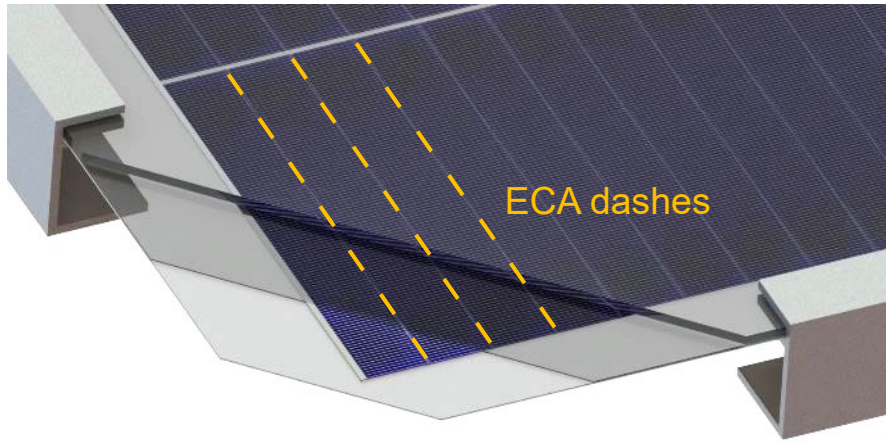

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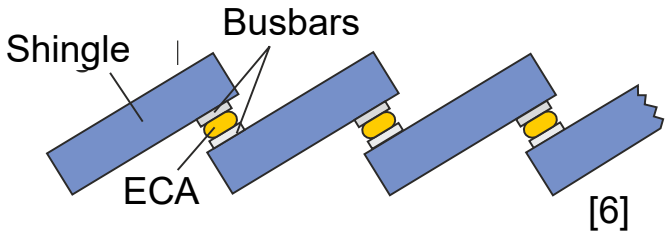

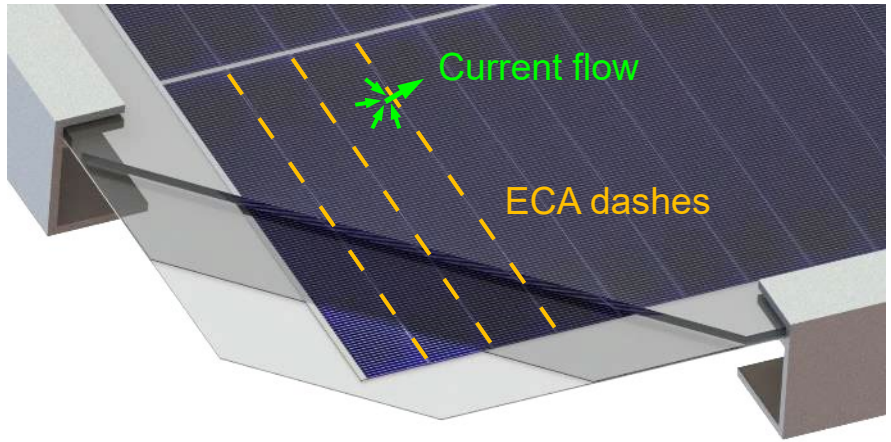

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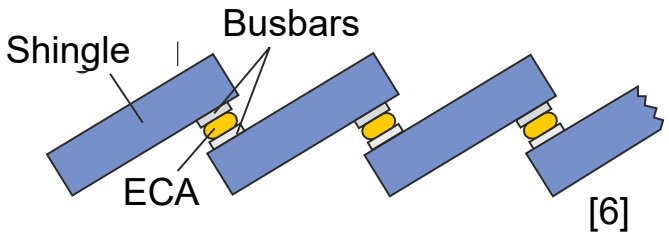

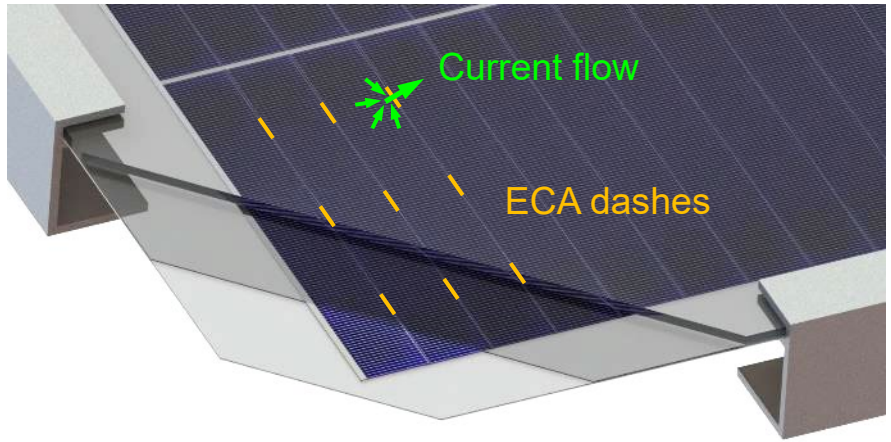

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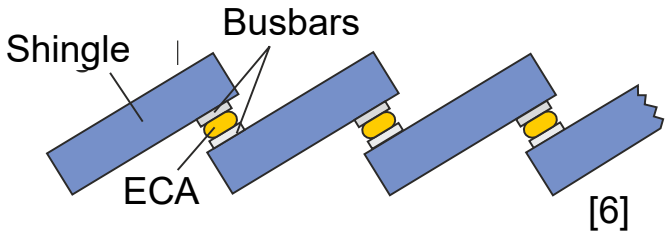

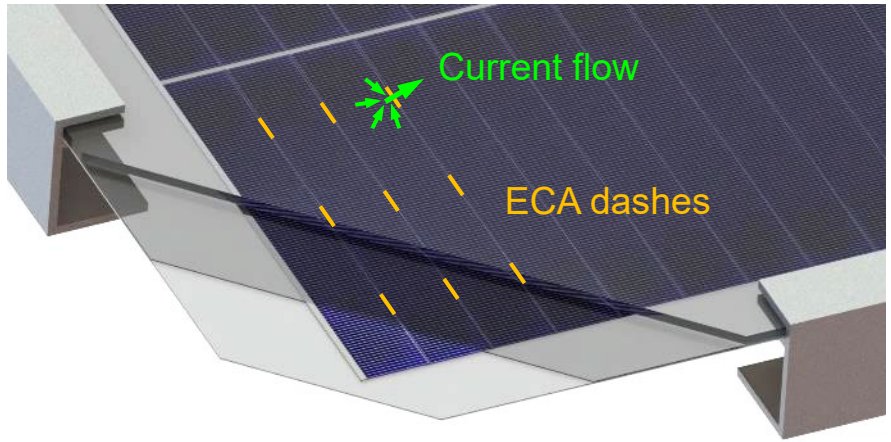

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Even without ECA, decent interconnection can be formed. How is that possible?

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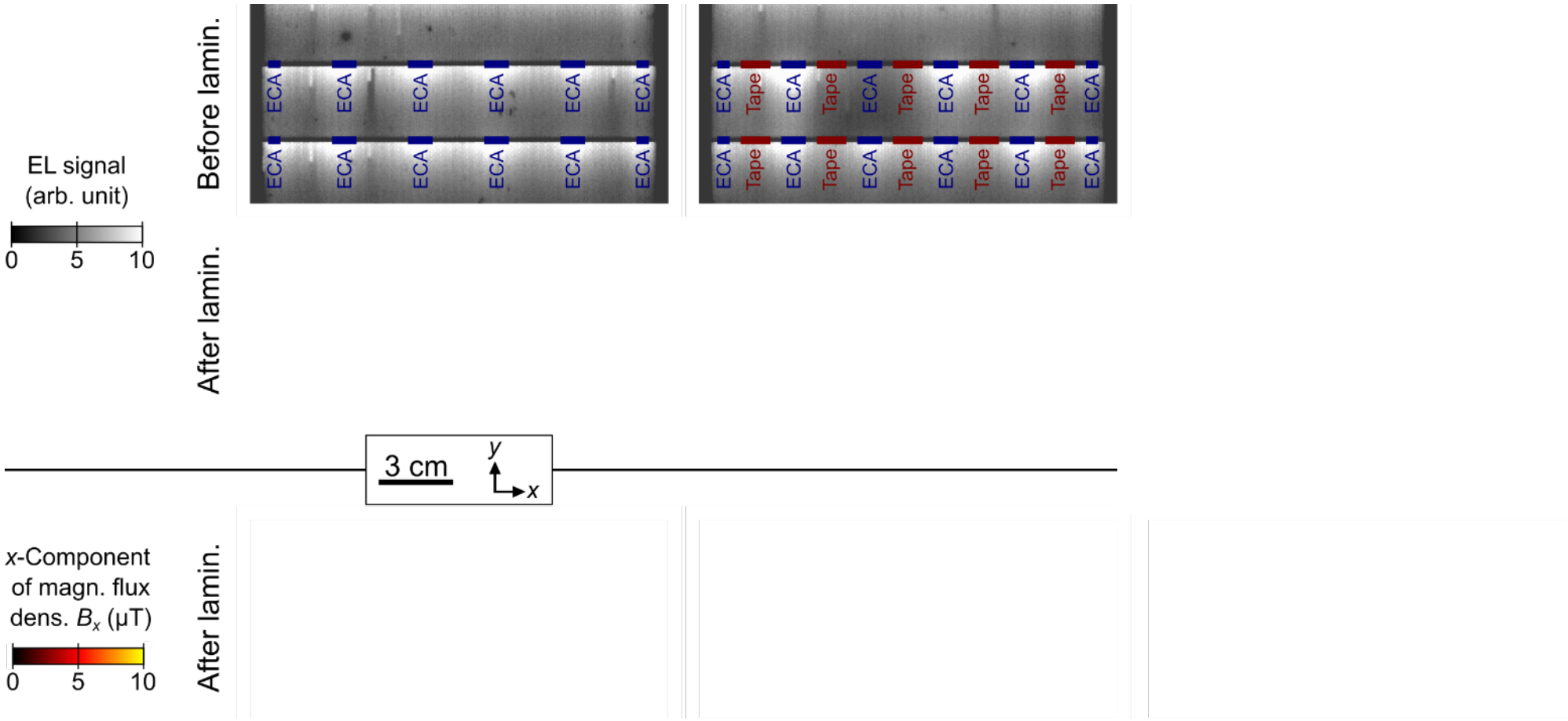
Effect of ECA Reduction on the Interconnection Quality

Electroluminescence (EL) and Magnetic Field Imaging (MFI) Measurements



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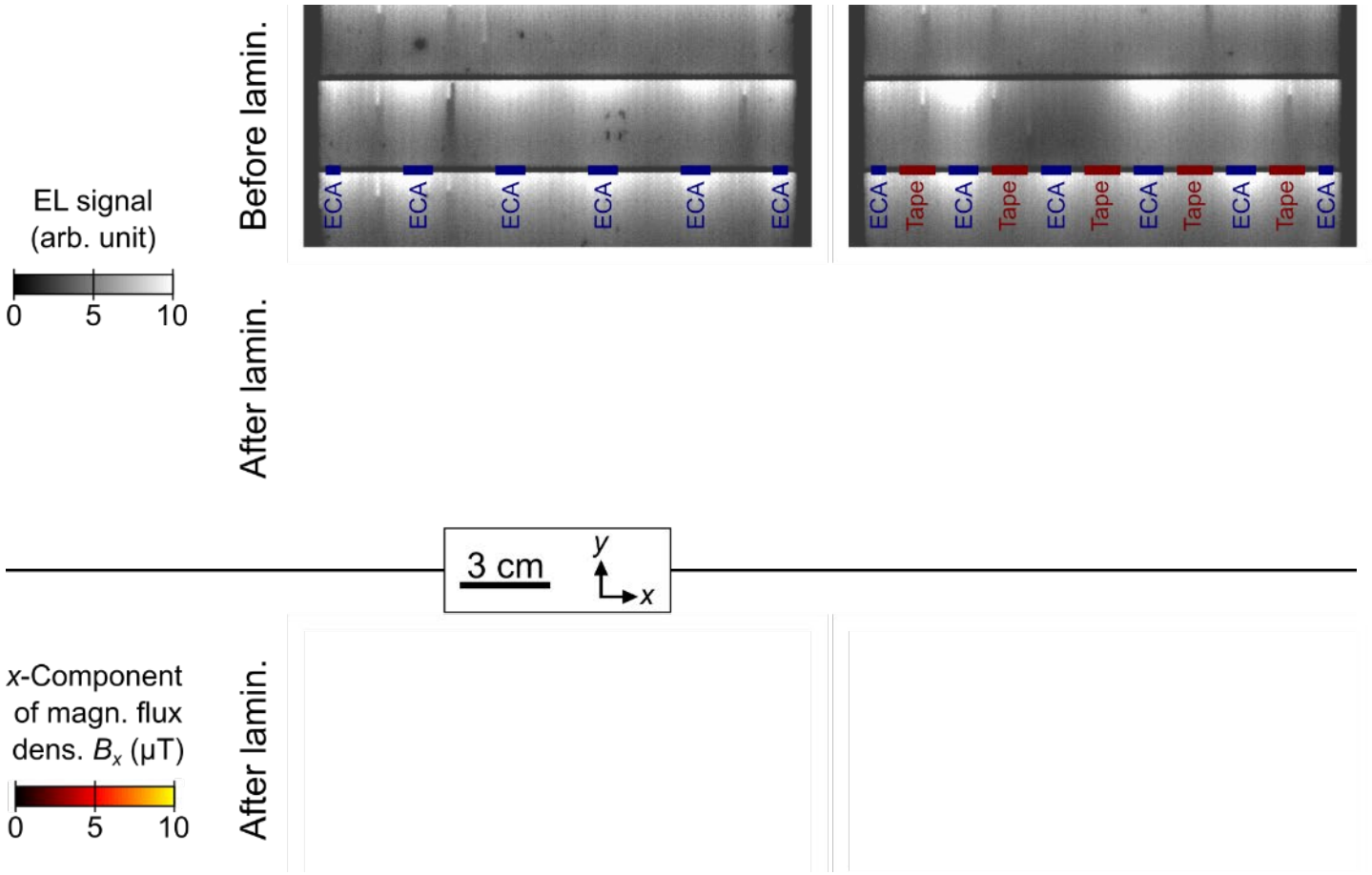

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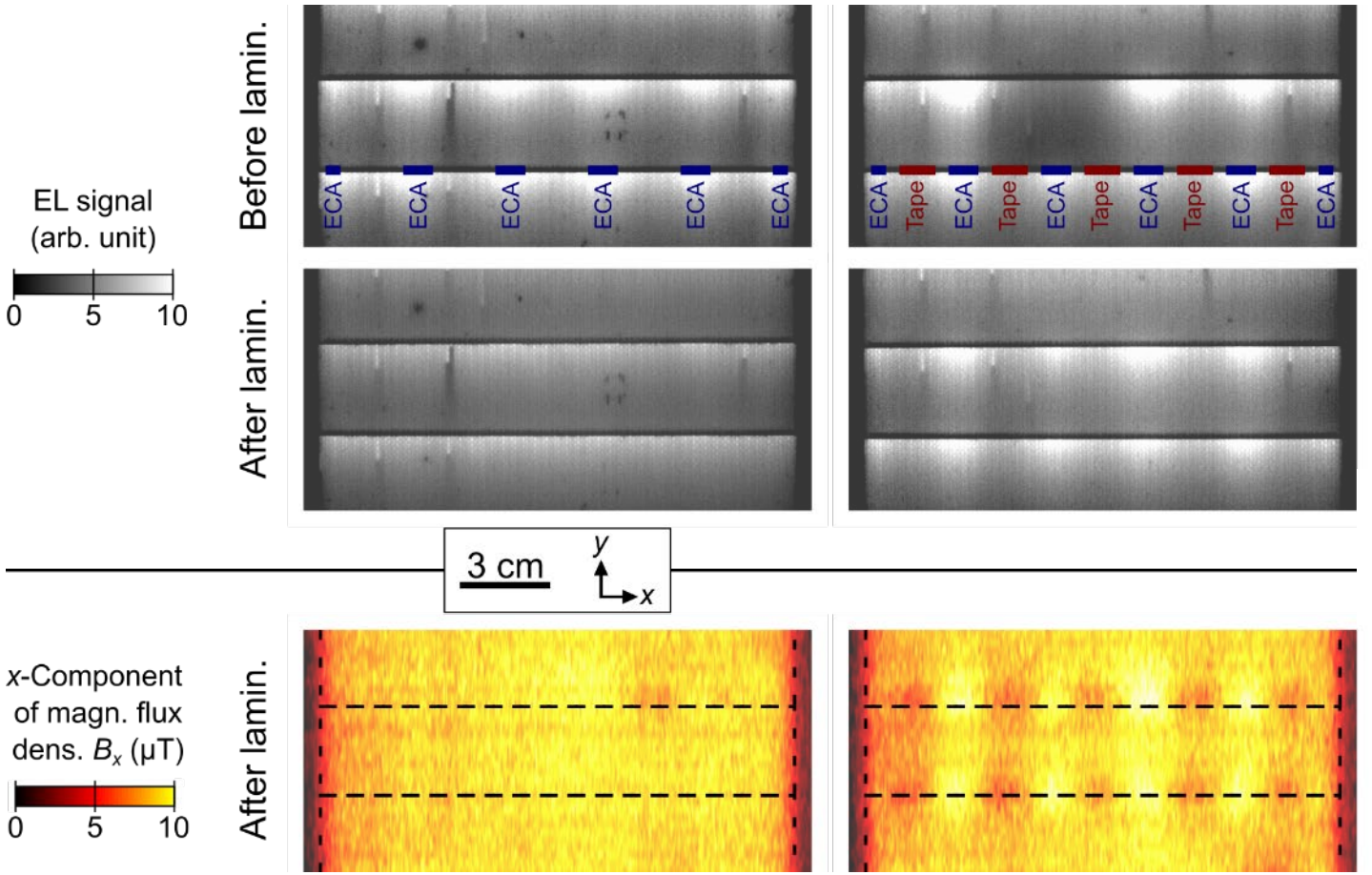

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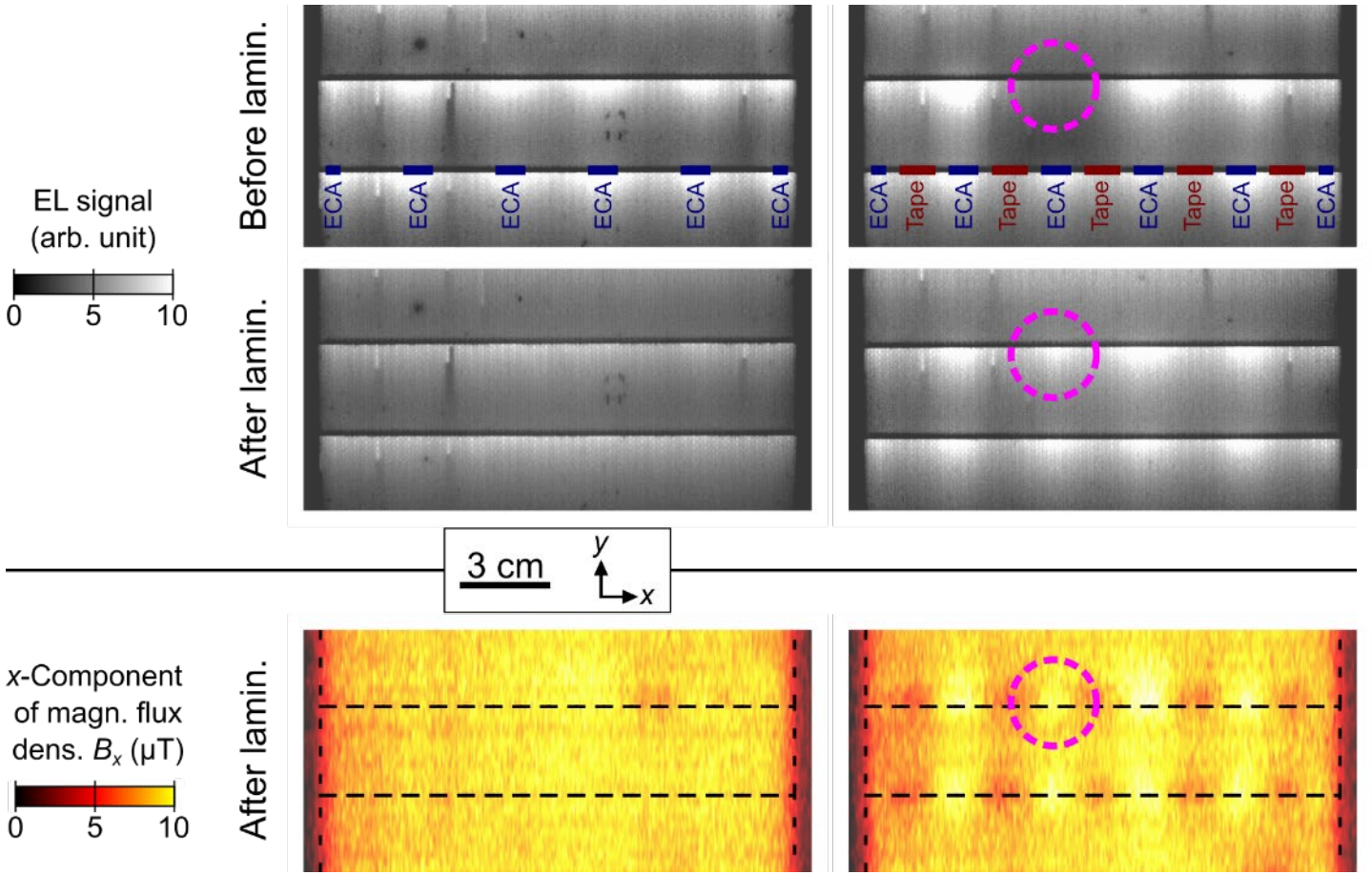

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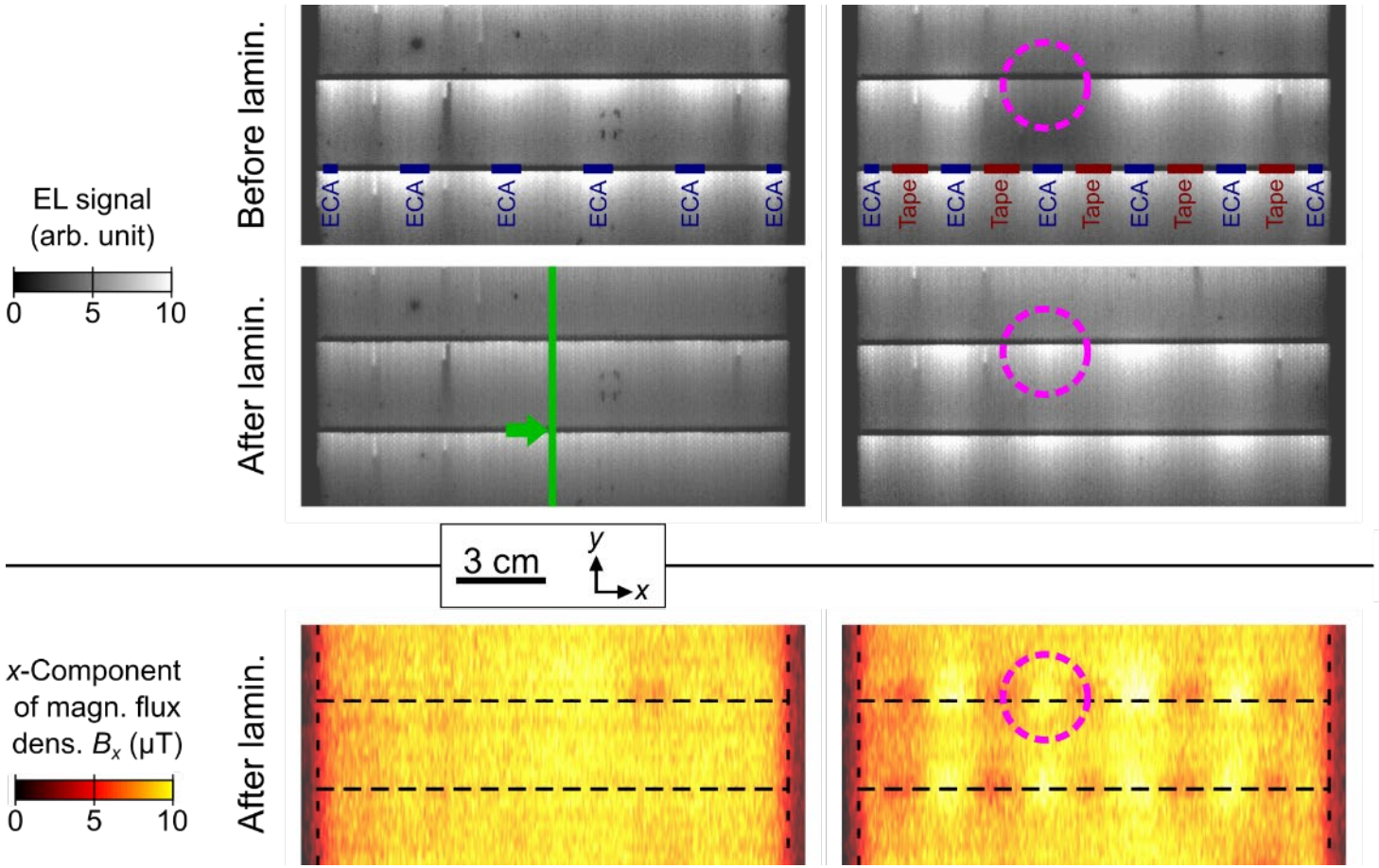

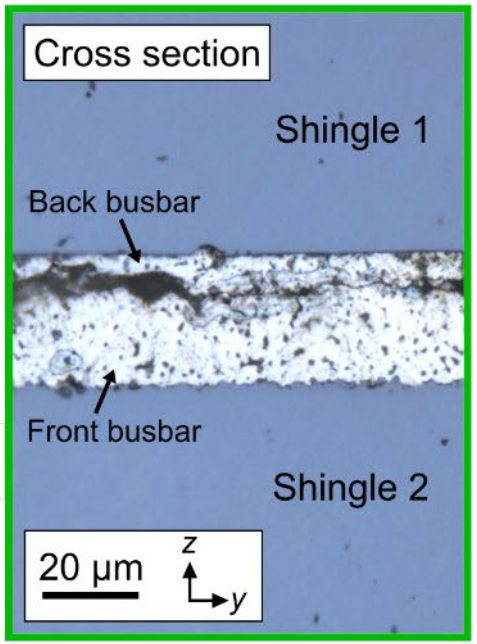

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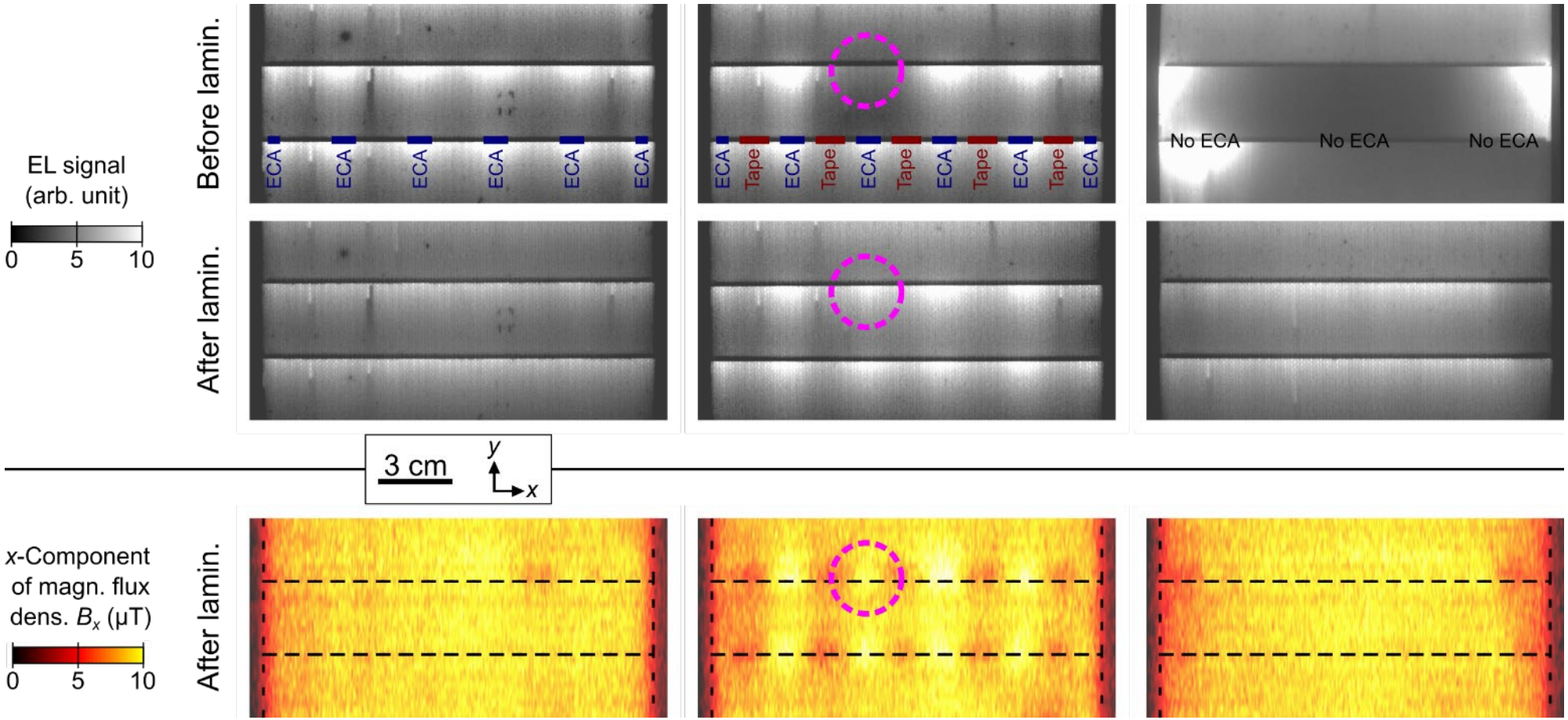


Effect of ECA Reduction on the Interconnection Quality

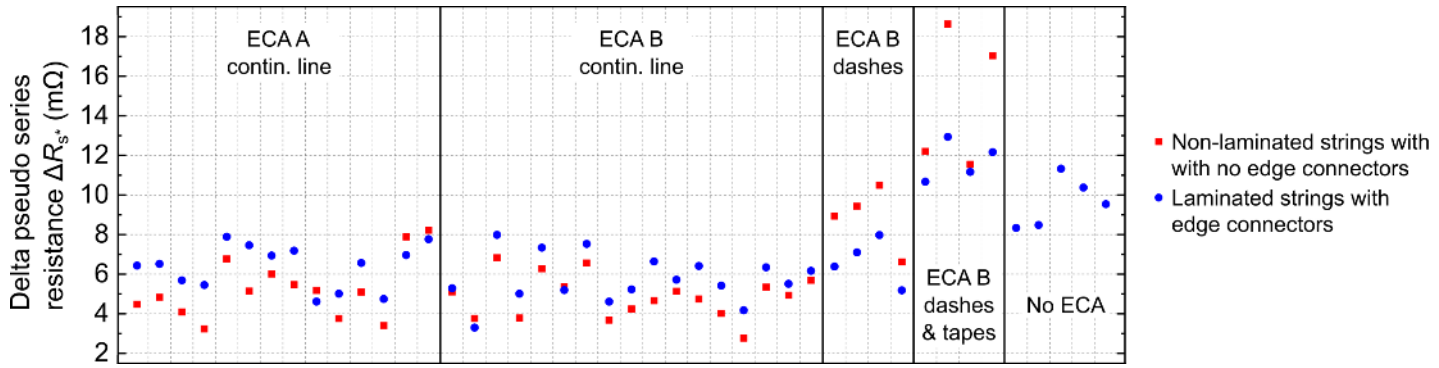
Summary

Presented findings

- At an ECA dash, lamination can turn poor into decent shingle interconnection
- At gaps between ECA-dashes and inside shingle joints with no ECA at all, lamination can form a busbar-to-busbar contact

Further findings in the proceedings paper

- For shingle joints with a continuous ECA line, lamination can enhance interconnection quality
- Laminated strings without ECA, with continuous ECA lines, or ECA dashes feature similar interconnection quality



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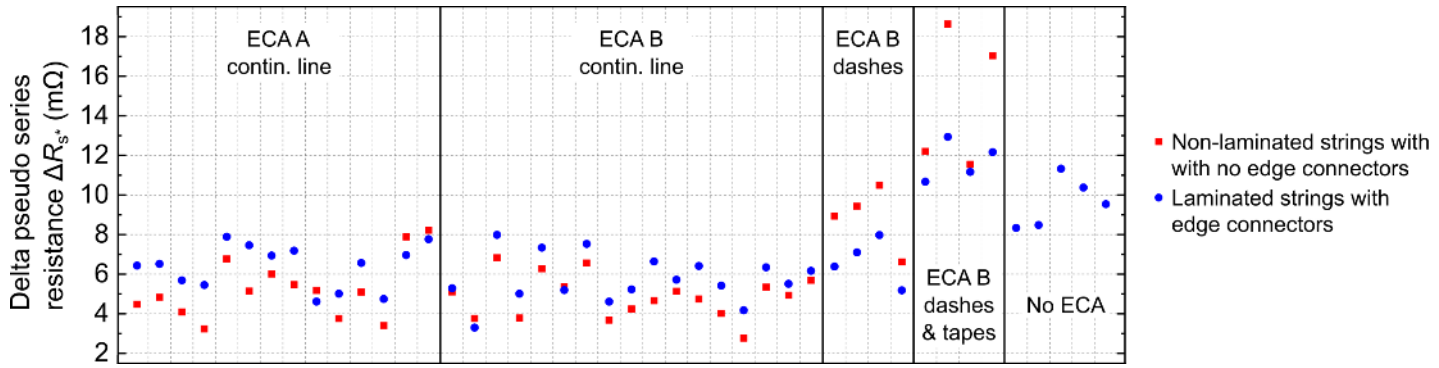


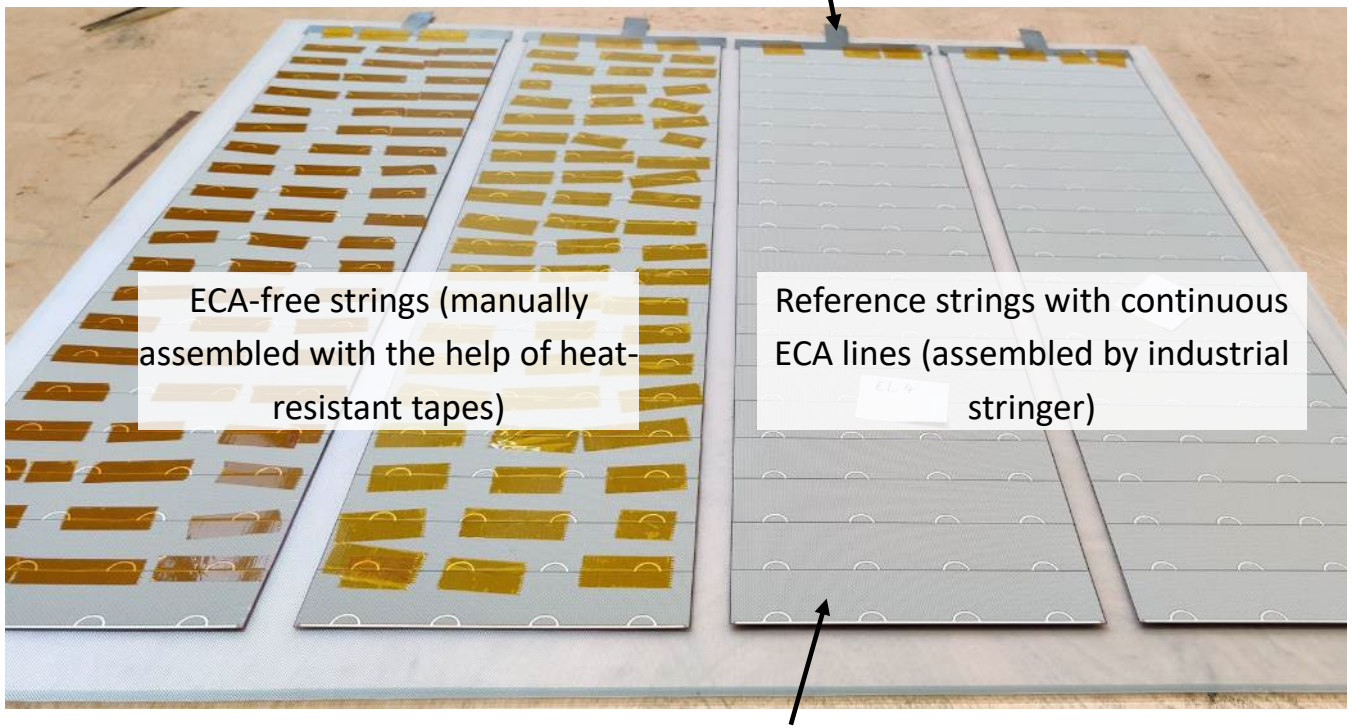
Can omitting the usage of ECA be an alternative approach for shingle interconnection?

Aging of ECA-Free Shingle Strings

Methodology

Bill of materials for lamination

- Front glass (3 mm · 725 mm · 700 mm)
- Ethylene-vinyl-acetat (EVA) encapsulation foil
- Polyethylene-terephthalate (PET) back sheet



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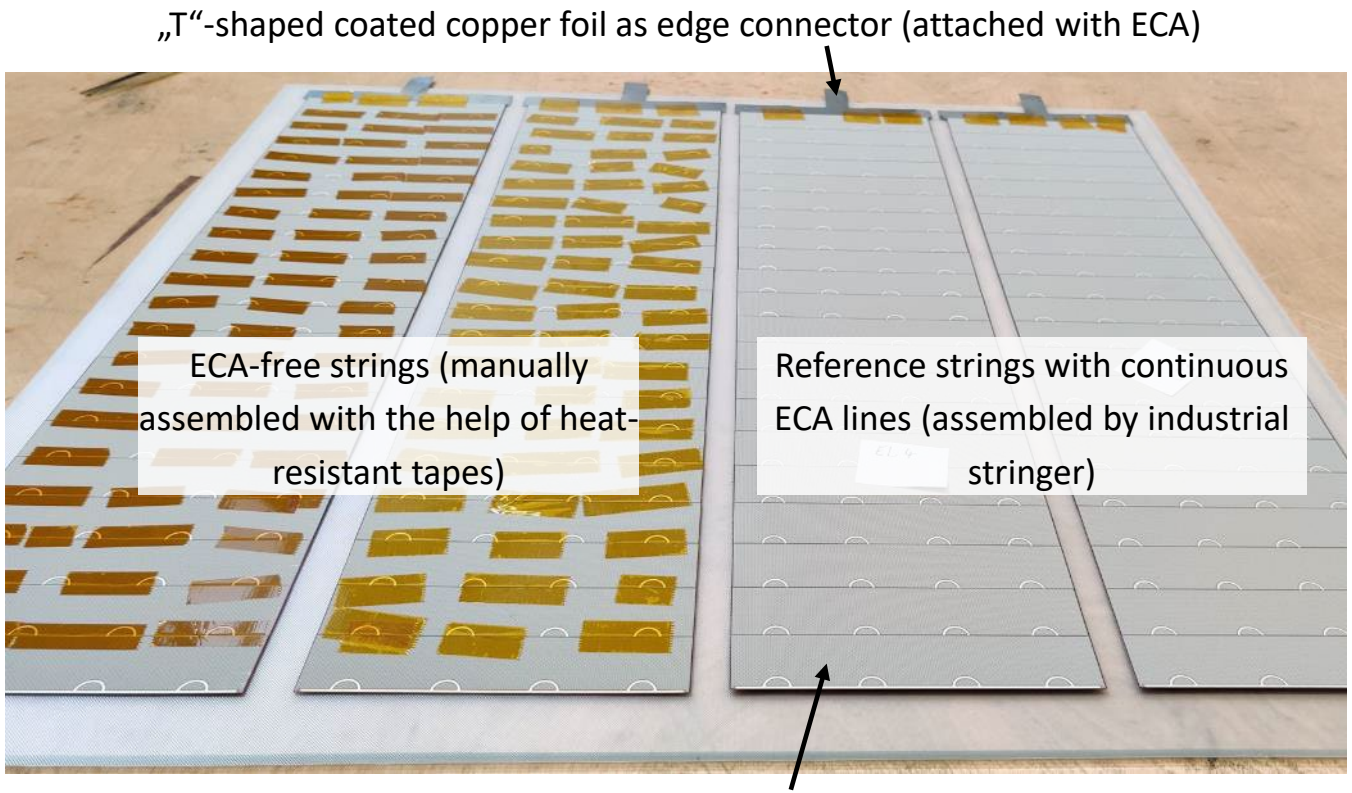
Aging tests*

- 200 temperature cycles (TC200)
- 1000 h of damp heat (DH1000)
- Dynamic mechanical load (DML)



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Aging tests*

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Characterization before and after aging

- *I–V* measurements (standard testing conditions)
- EL measurements
- MFI measurements

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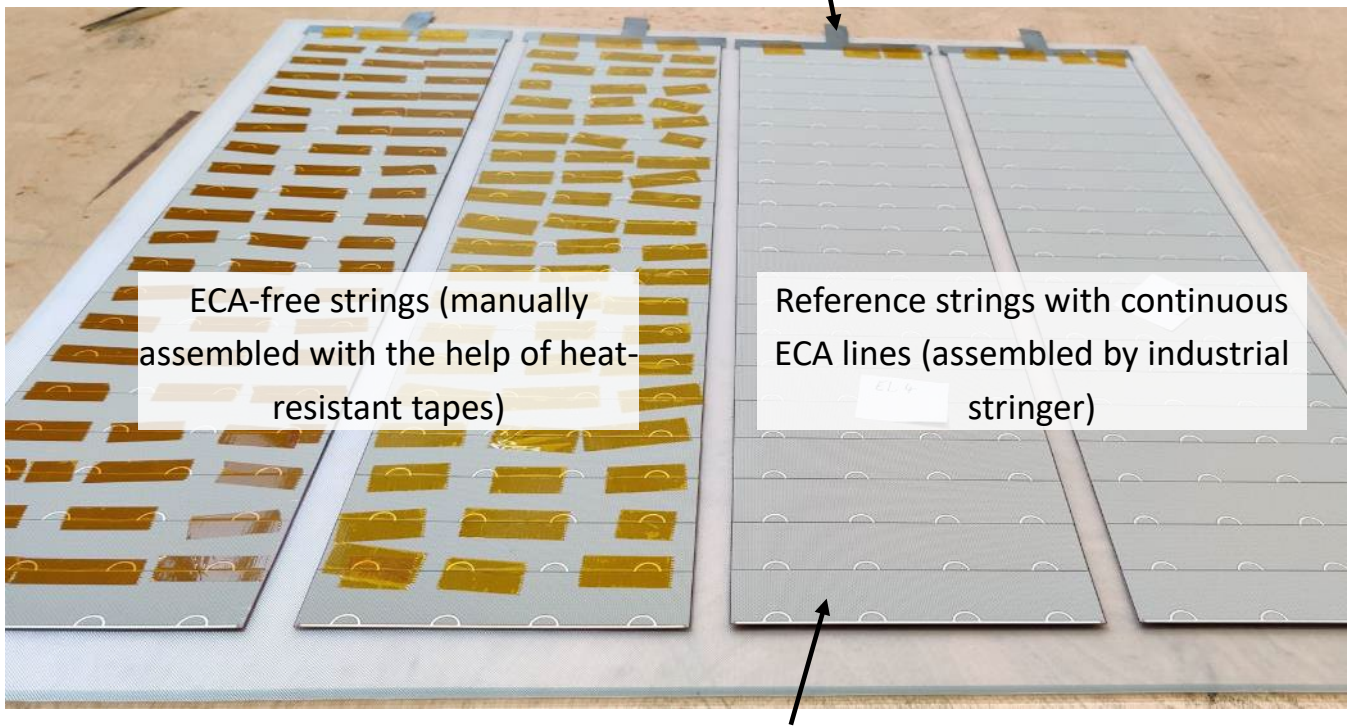
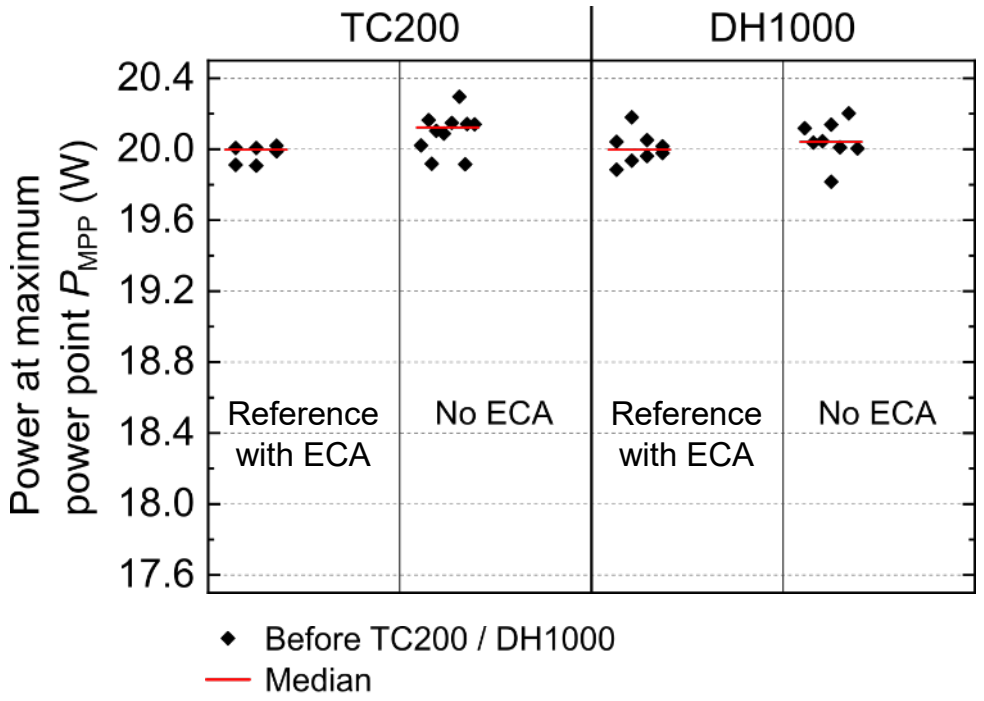


Aging of ECA-Free Shingle Strings

200 Temperature Cycles (TC200) & 1000 h of Damp Heat (DH1000)

Results

- Before aging, no significant difference between ECA-containing reference strings and ECA-free strings in terms of P_{MPP}*



* Power at maximum power point P_{MPP} is not an ideal quantity to assess the interconnection quality [1]

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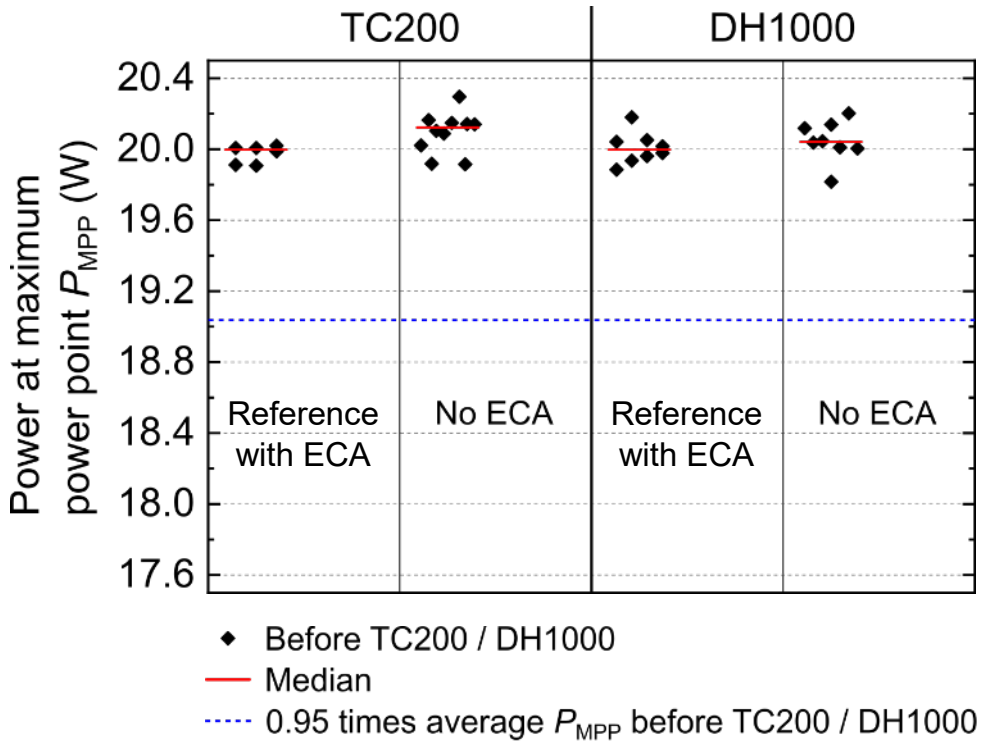

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200 Temperature Cycles (TC200) & 1000 h of Damp Heat (DH1000)

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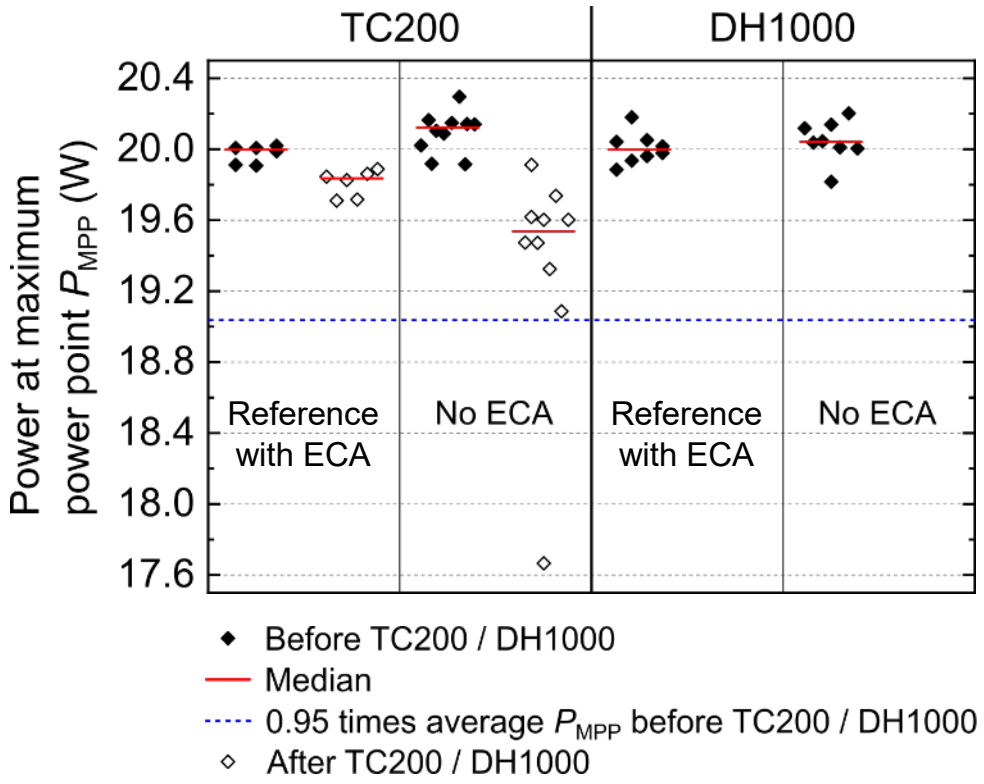
- Before aging, no significant difference between ECA-containing reference strings and ECA-free strings in terms of P_{MPP}*
- Significant power loss due to TC200 for the ECA-free strings (interconnection quality fluctuates strongly among strings)



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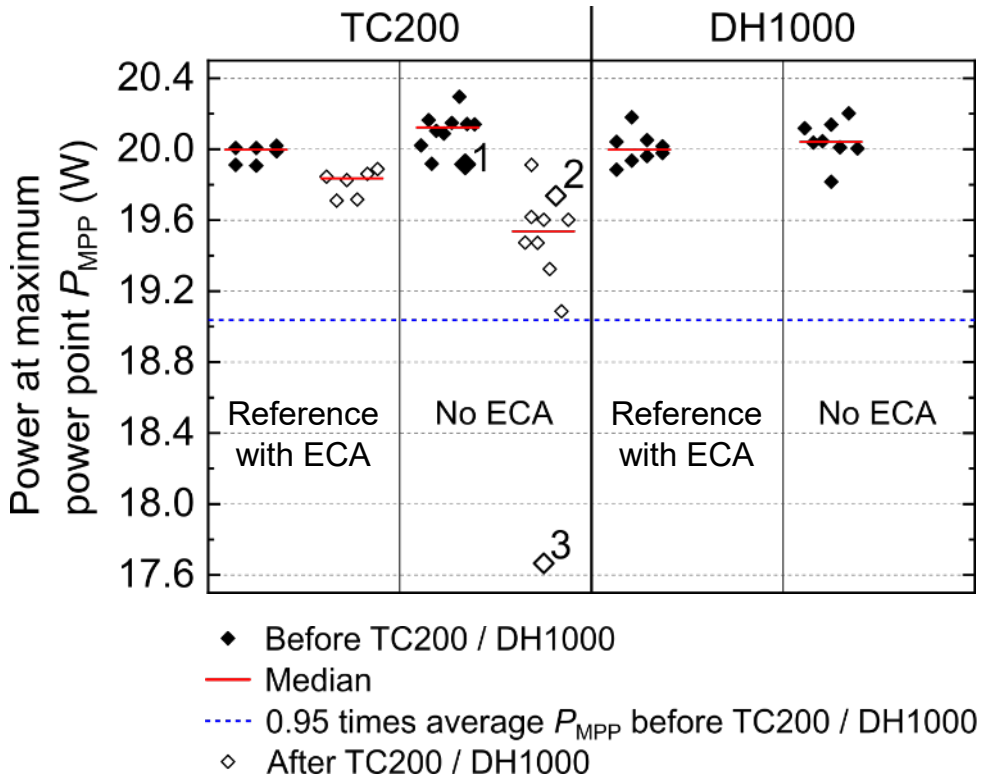

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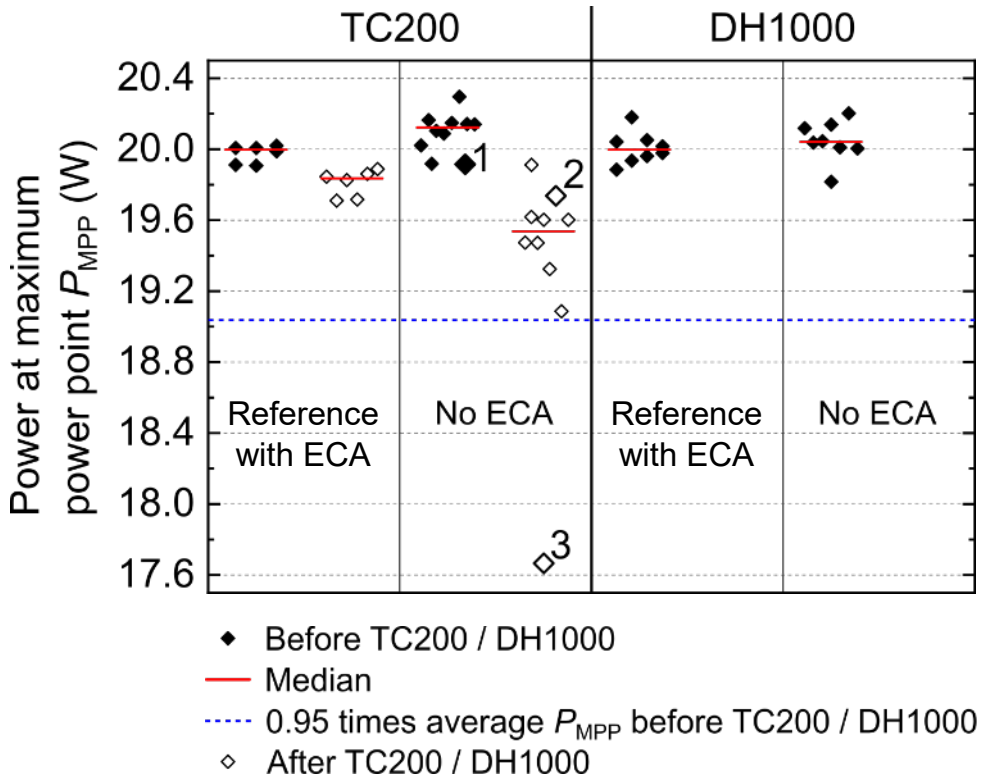

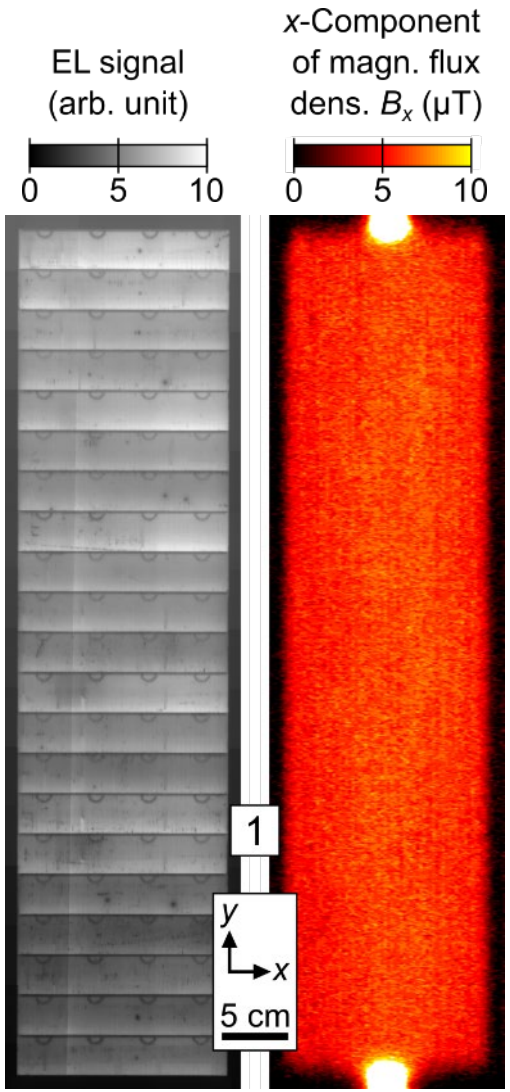

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Aging of ECA-Free Shingle Strings

200 Temperature Cycles (TC200) & 1000 h of Damp Heat (DH1000)

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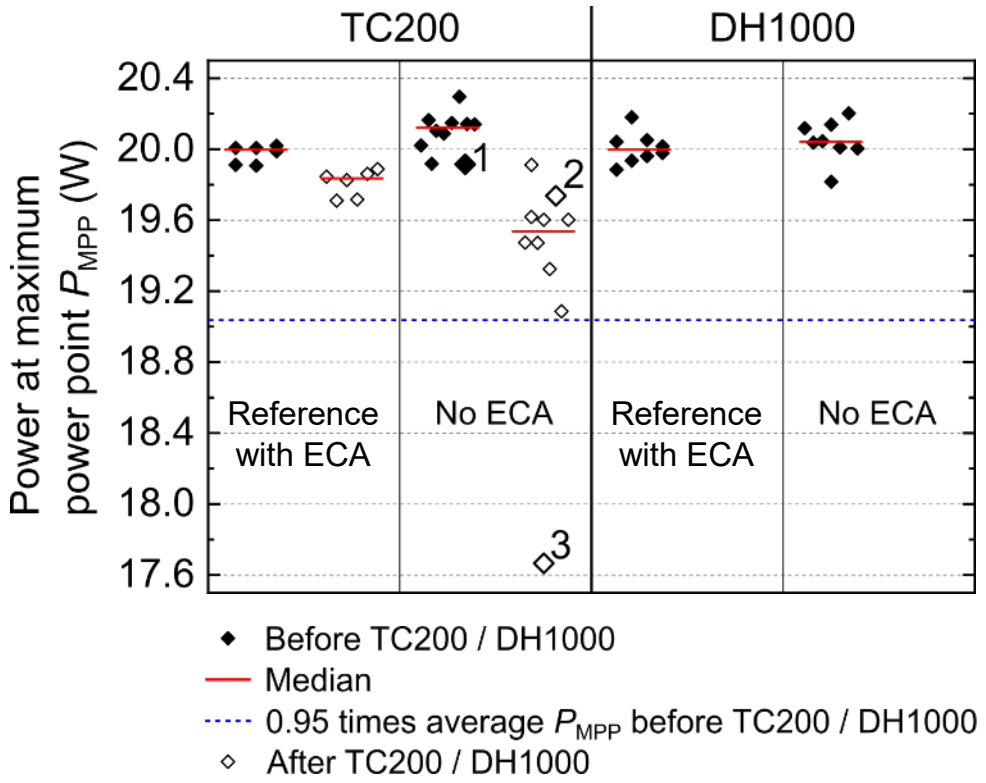

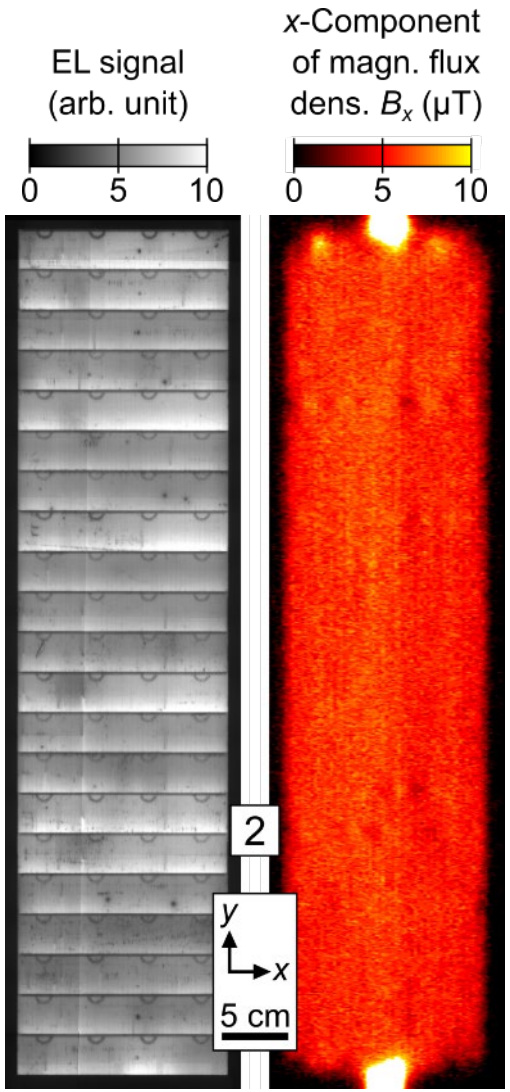

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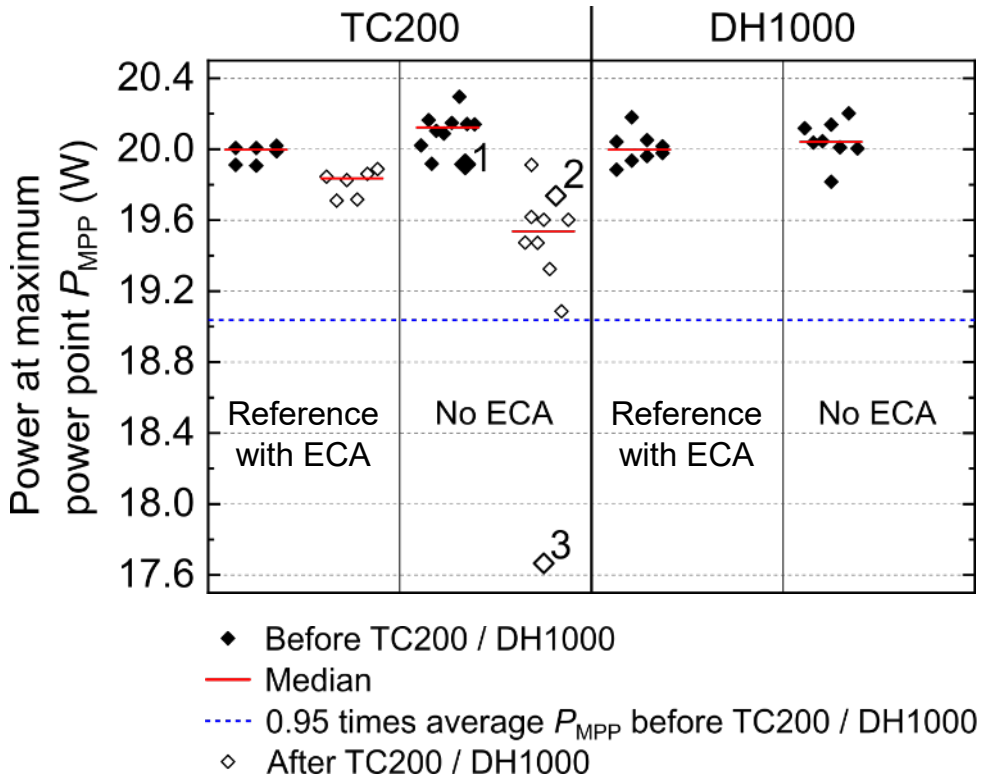

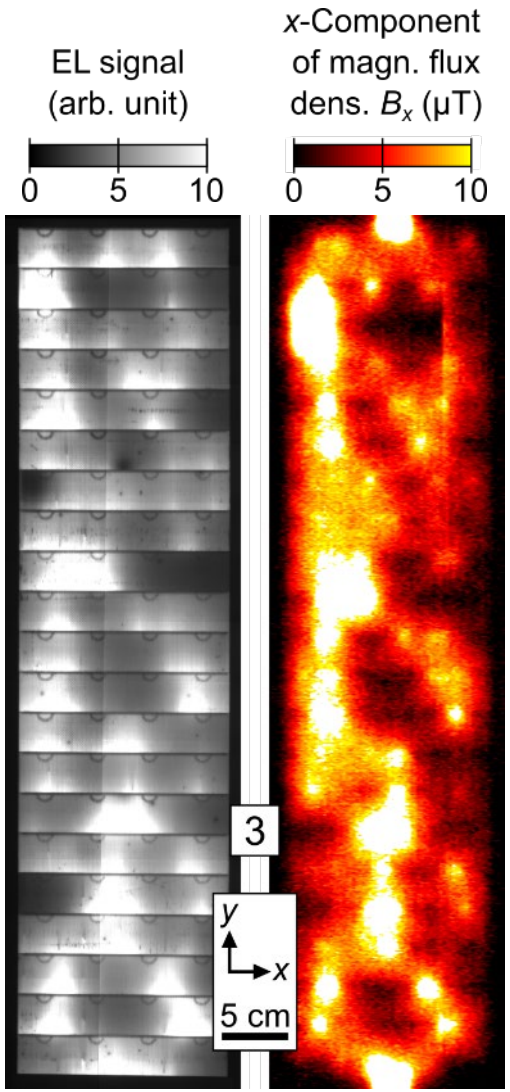

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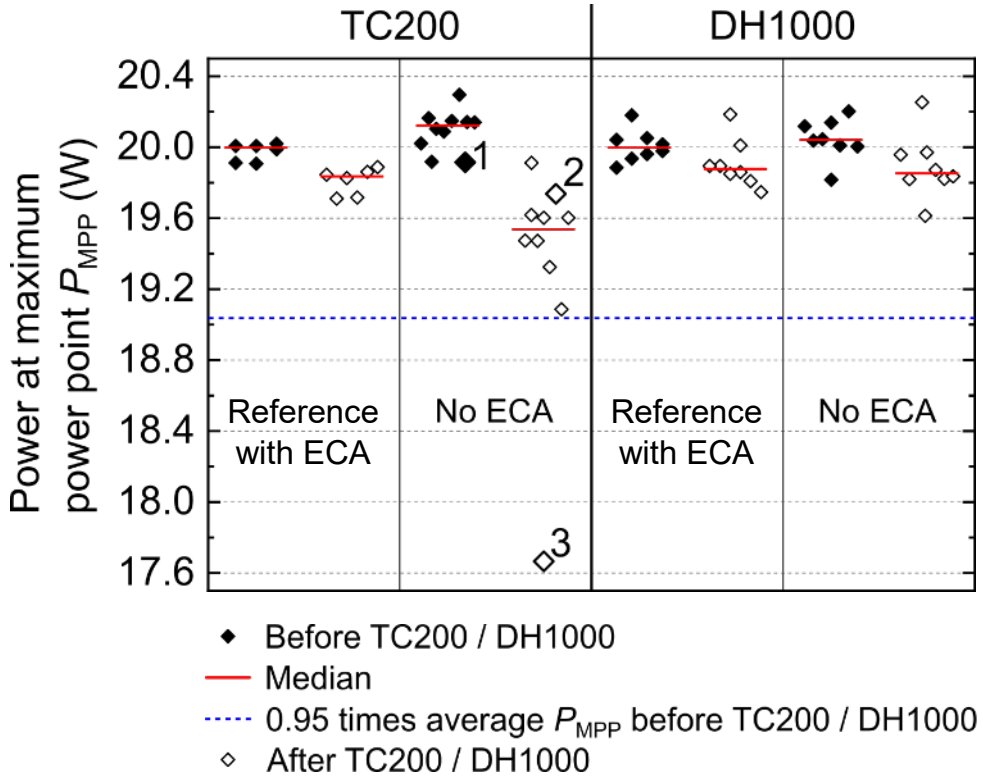

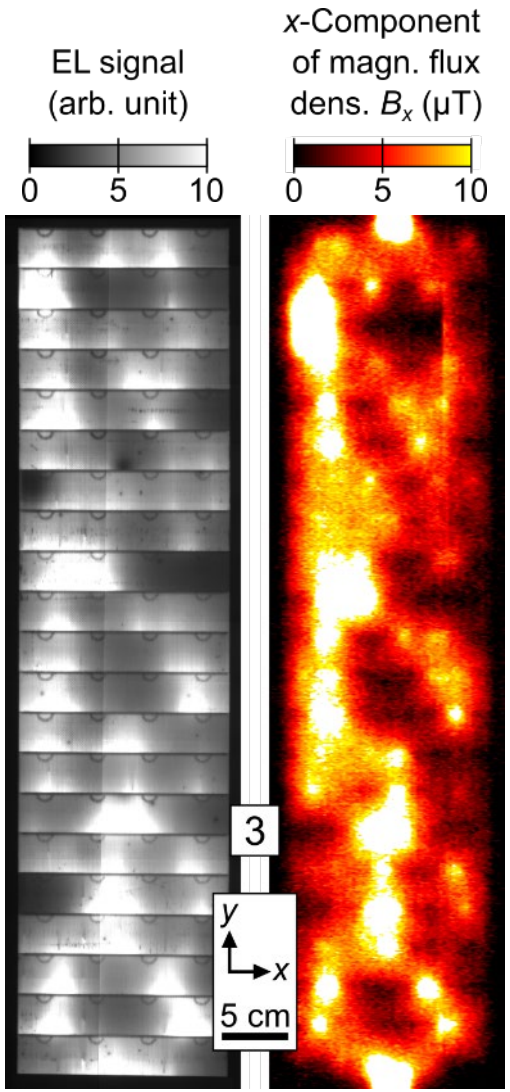

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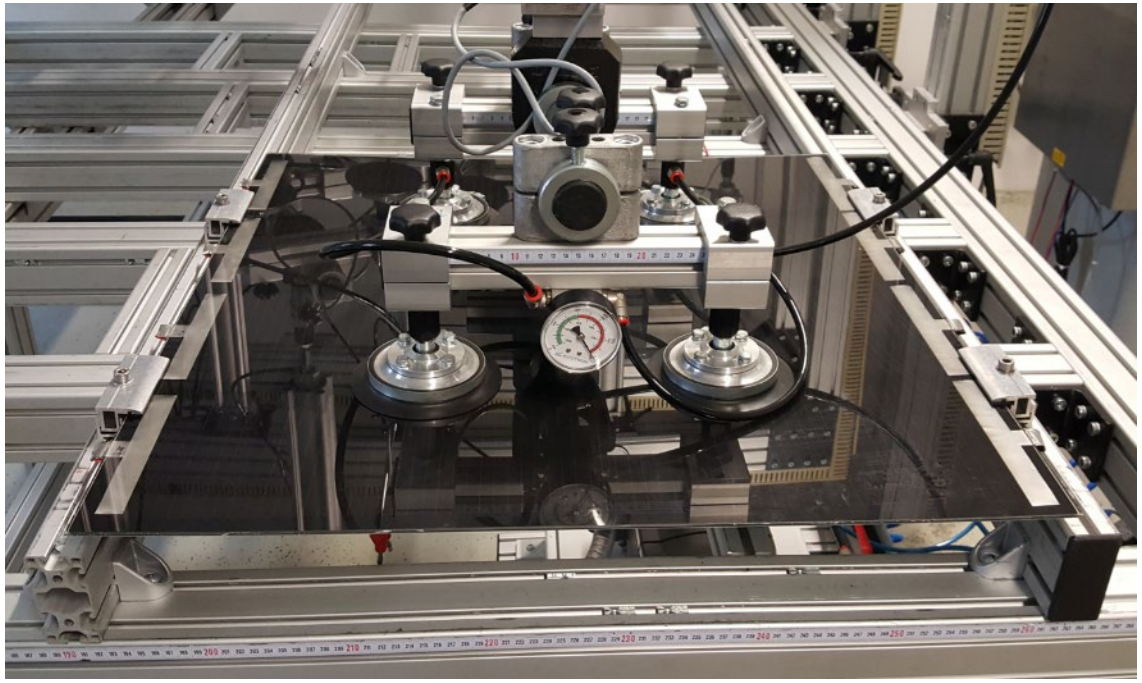
Dynamic Mechanical Load (DML)

Methodology

- Laminate with 2 ECA-containing and 2 ECA-free strings (already subjected to DH1000) mounted at two edges
- 4 vacuum cups connected to a pneumatic cylinder placed on laminate surface
- 1000 push-pull cylces conducted with pressure of ±1 kPa (resulting in ±17 mm deflection)



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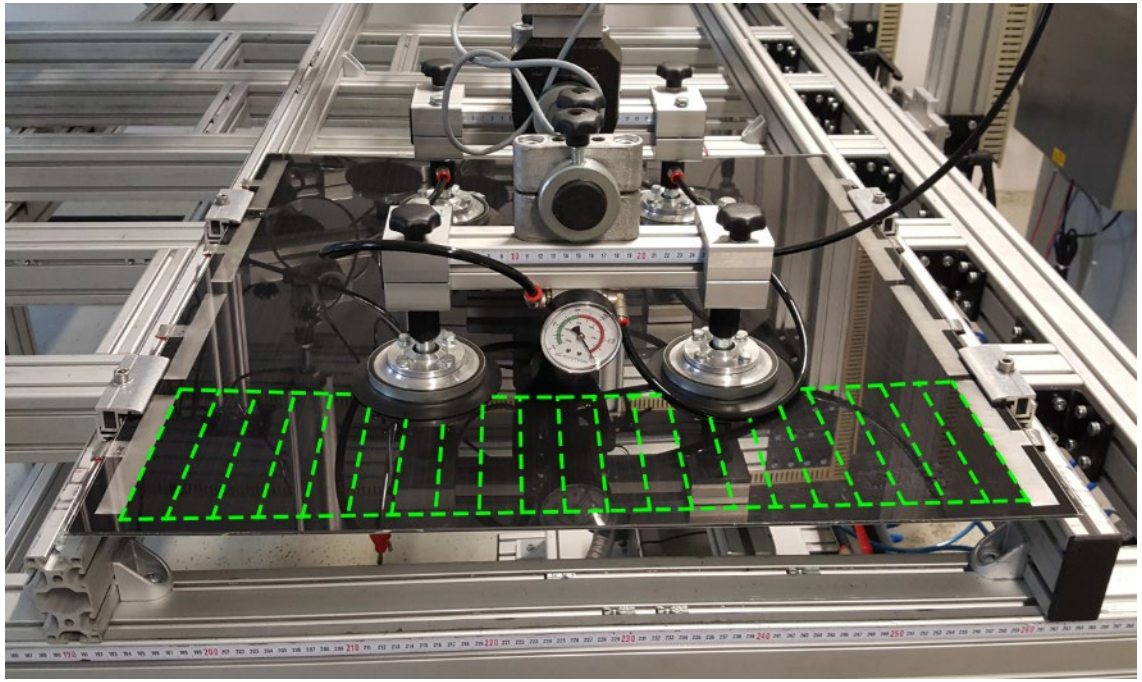

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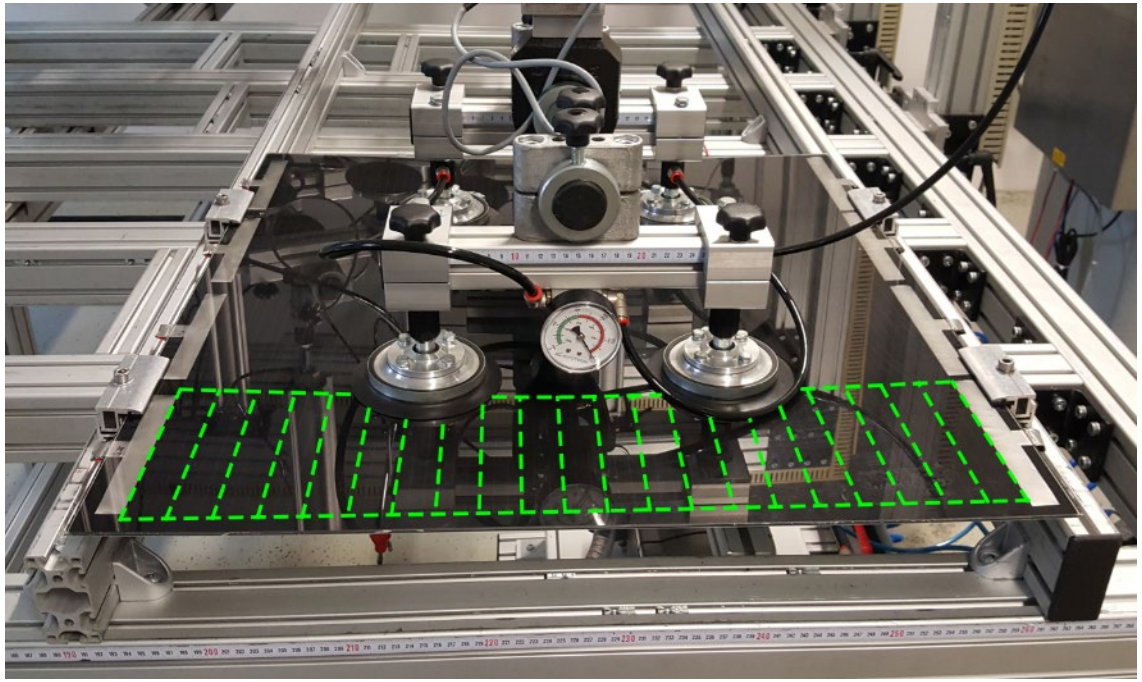

Results*

- Interconnection qualitiy unaffected by DML according to
  - Dark *I*–*V* measurmeents
  - EL measurements
  - MFI measurements

* Details are given in the proceedings paper

Summary and Outlook

- New insights into shingle joint properties
  - Lamination can enhance interconnection quality at ECA lines or ECA dashes
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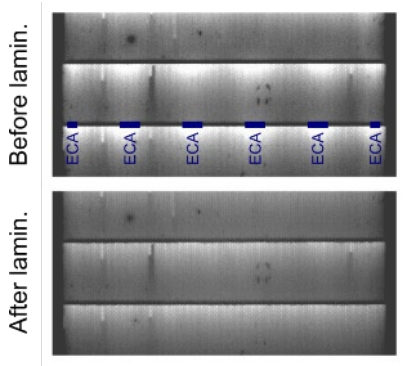

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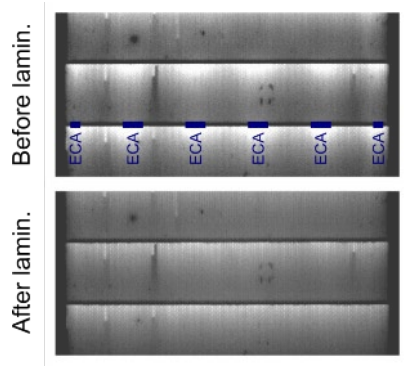

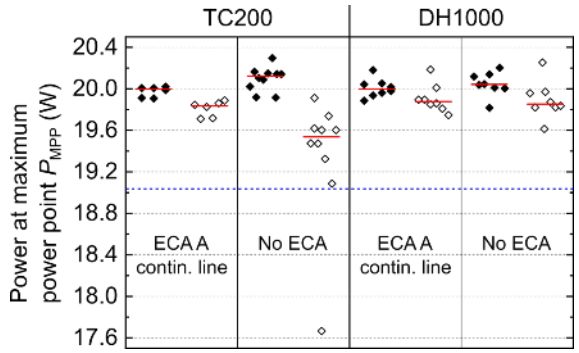

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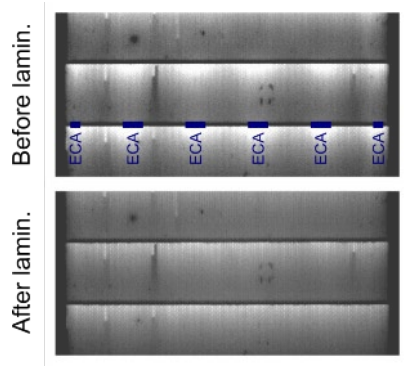

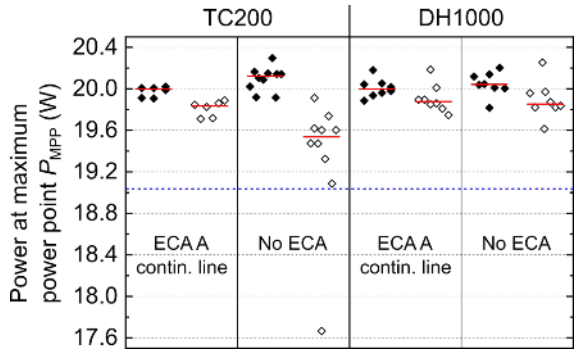

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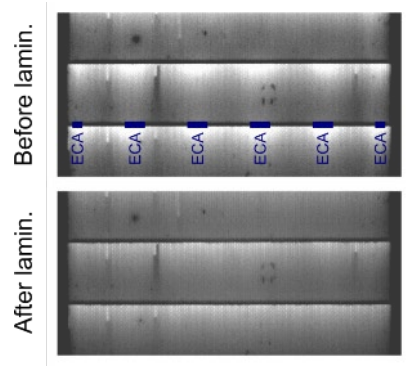

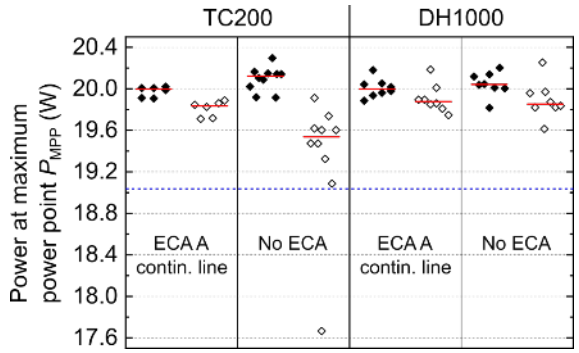

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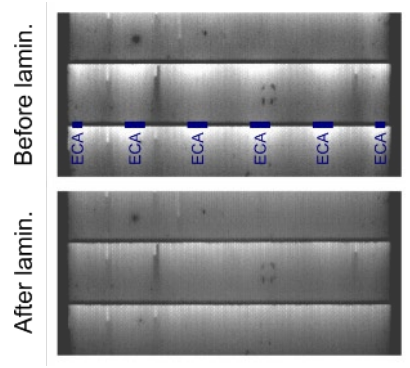
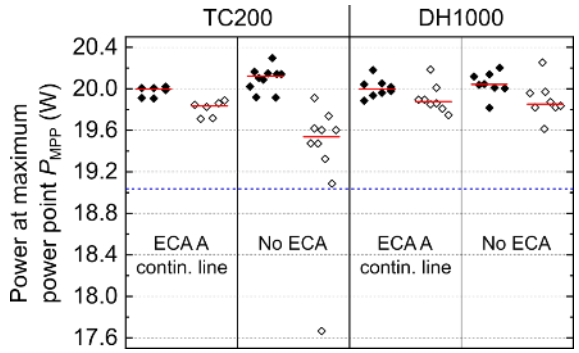
    - Enhancement of TC-stability





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Thank you for your attention!

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