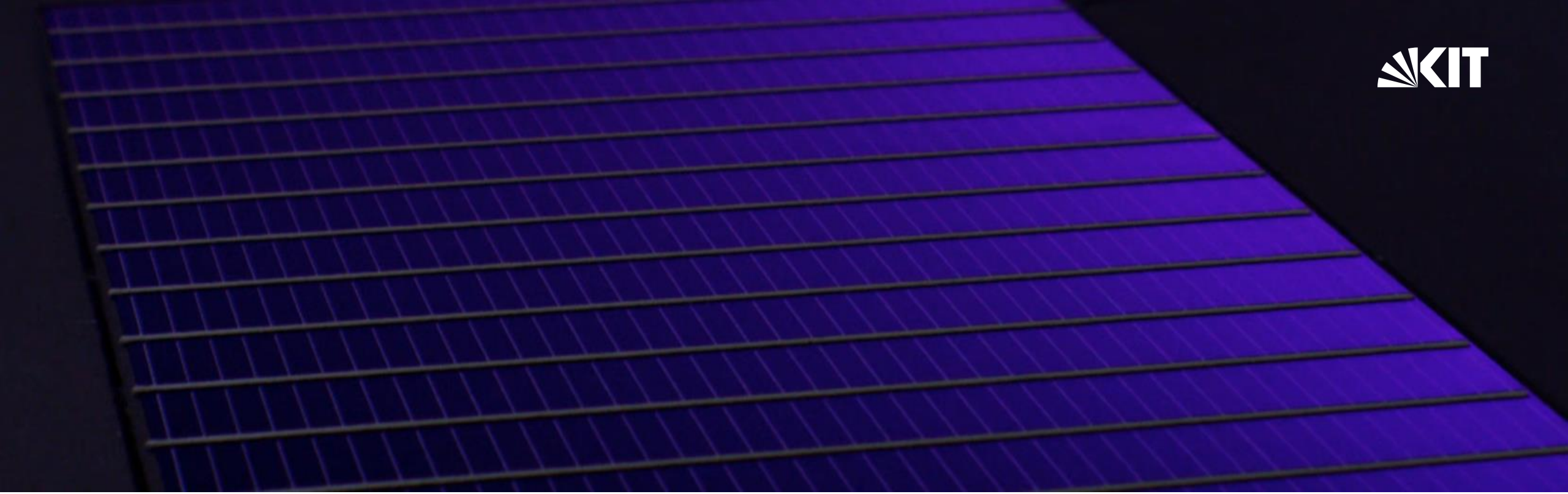

T-ECA – Thermoplastic Adhesives for Solar Cell Interconnection

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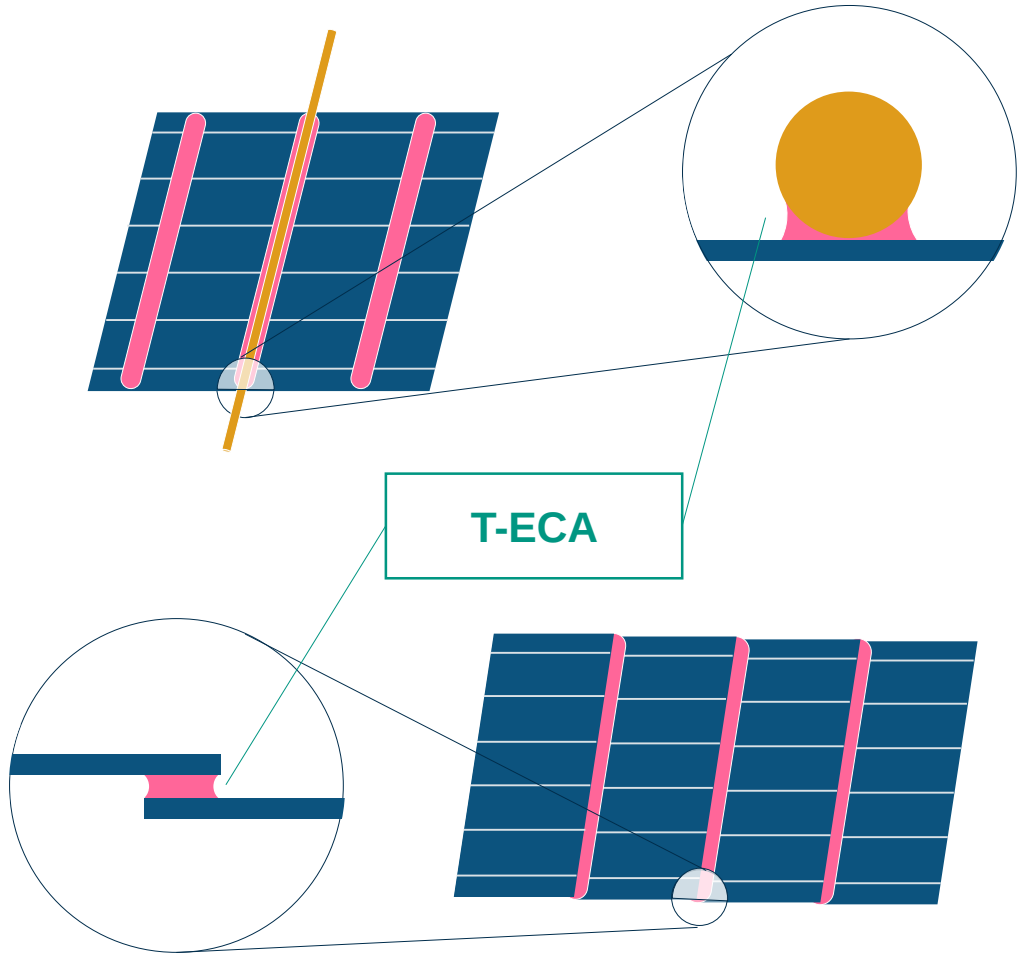
Motivation:
Resource Efficient Low Temperature Interconnection

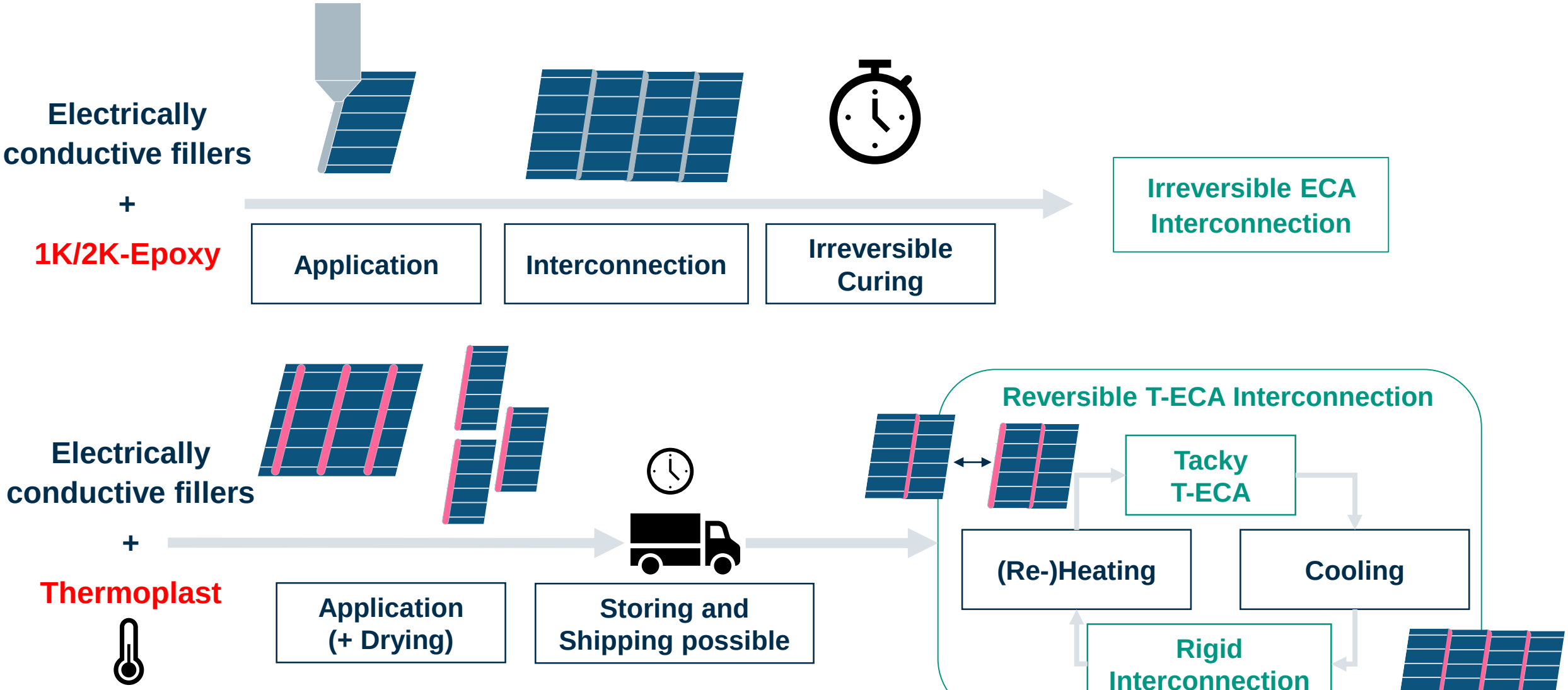
- **Challenges**
  - **Low Temperature** Interconnection
  - Sustainable and **cost effective** use of precious materials
  - Application in **known processes**
  - Easier **Repair and Recycling**

- **Our Experience** with electrically conductive materials
  - Electrically conductive 3D printing filaments
  - Polymer rheology
  - Solar Cell Metallization
  - Conventional ECAs

→ **Thermoplastics enable innovative processes for interconnecting low temperature solar cells**

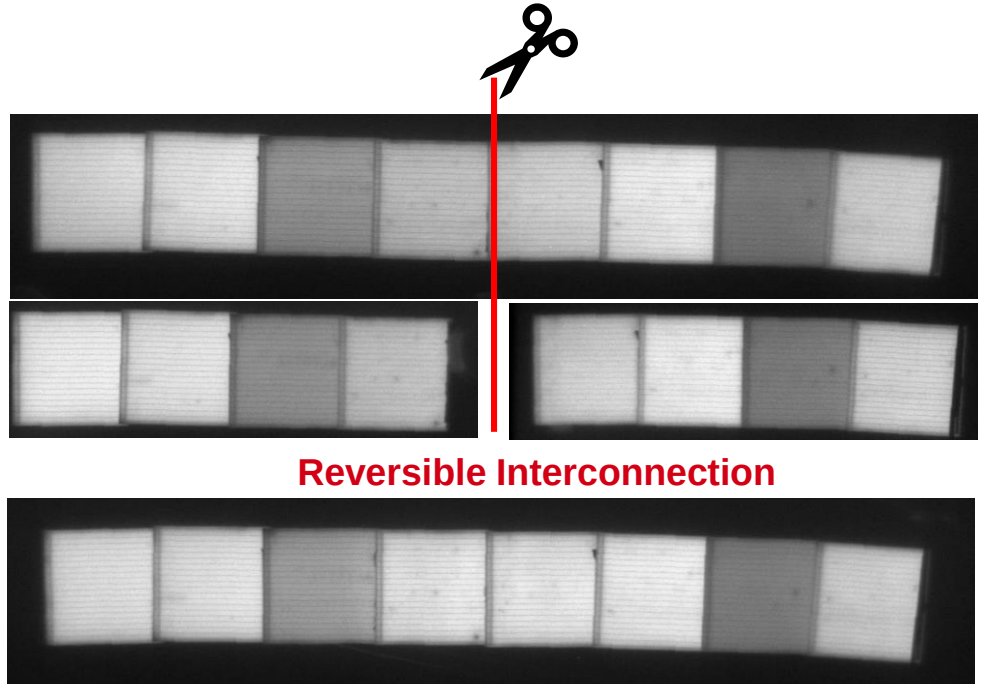


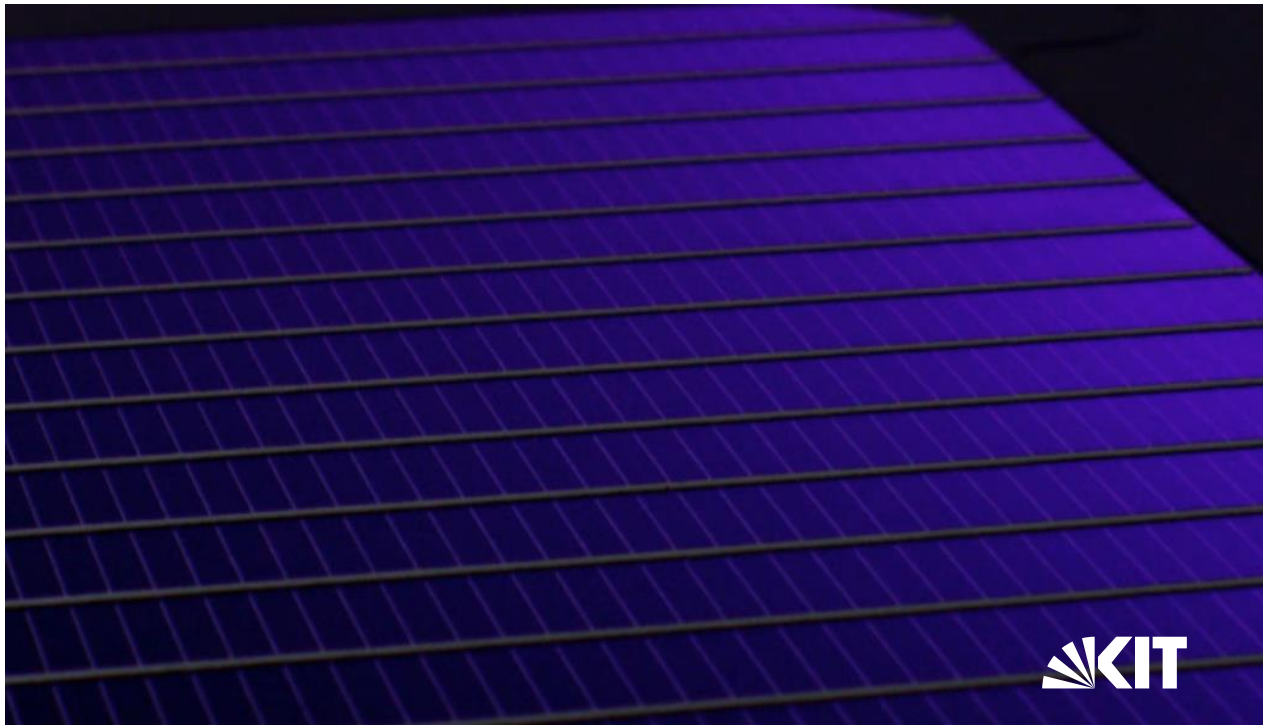
T-ECA enables simplification of cell interconnection



T-ECAs offer more than conventional ECAs

- → Reversible Interconnection
- → Infinite „Pot-Time“
- → Tailored choice of conductive particles and polymer
- → Suitable for shingling and stringing

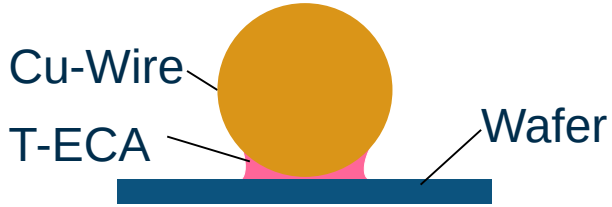




Thermoplastic Busbar Concept

Thermoplastic Busbars

- **What is a thermoplastic busbar?**
  - Screen-printed, thermoplastic, electrically conductive adhesive (T-ECA) for current collection on the front side of solar cells



Thermoplastic Busbar Connection

- **Working principle:**

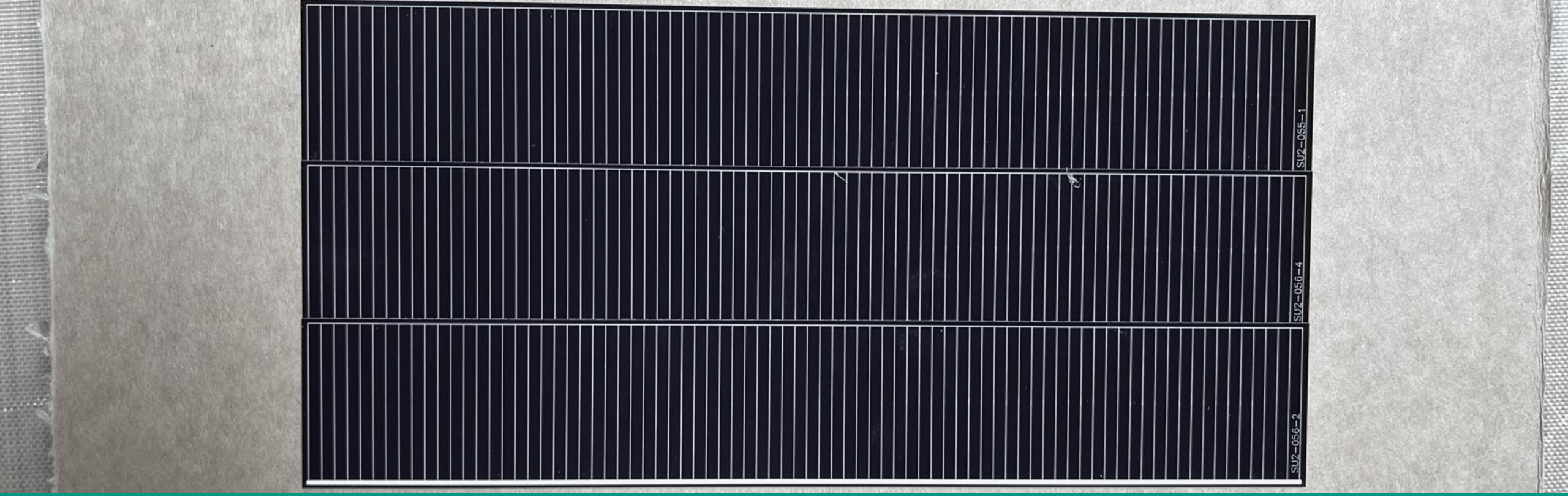
Paste Formulation → **Screen Printing** → **Drying** → **Printed Busbars - ready for transport and interconnection**

- **Benefits**
  - Low Temperature interconnection
  - Silver savings: Low-Silver or Silver-free + No solder pads needed
  - Applicable in established processes
  - Applicable to all cell types
  - Flexible workflow for cell interconnection

J. Marten, K. Abdel Aal, T. Finger, N. Willenbacher, *„Zellverschaltung von Hoch- sowie Niedertemperatur-Solarzellen mittels direktem Verkleben von Runddrähten und thermoplastischen Busbars“* ***German Patent Application 22.11.2024 Nr. 10 2024 134 365.6***

Preliminary Results for Thermoplastic Busbars

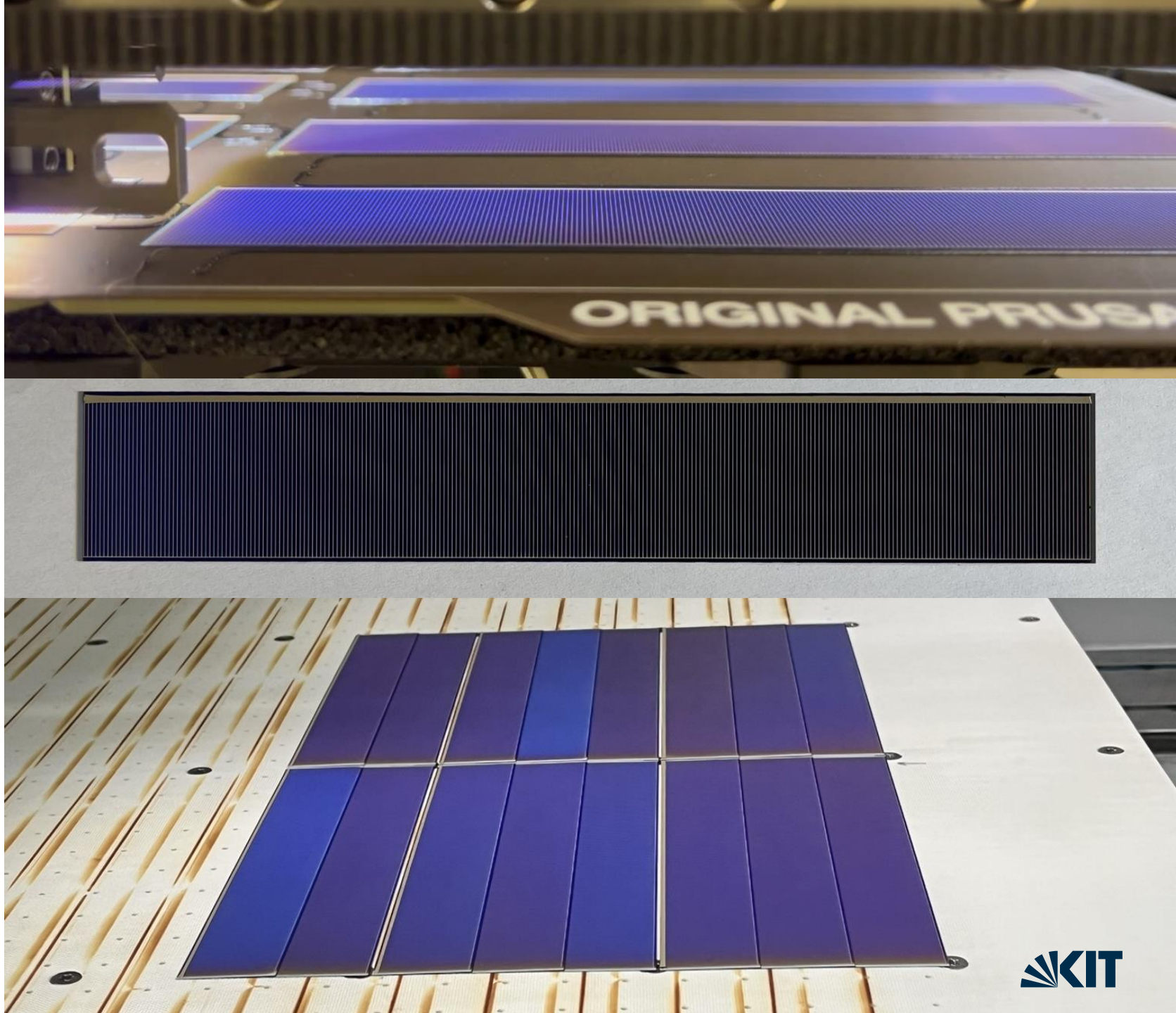
- **T-ECA Properties:**
  - Φ_{Ag} = 10 vol.%
  - κ = 71 S/cm
  - T_g = 120 °C
- **90% silver savings** compared to conventional busbars
- **More results next year!**



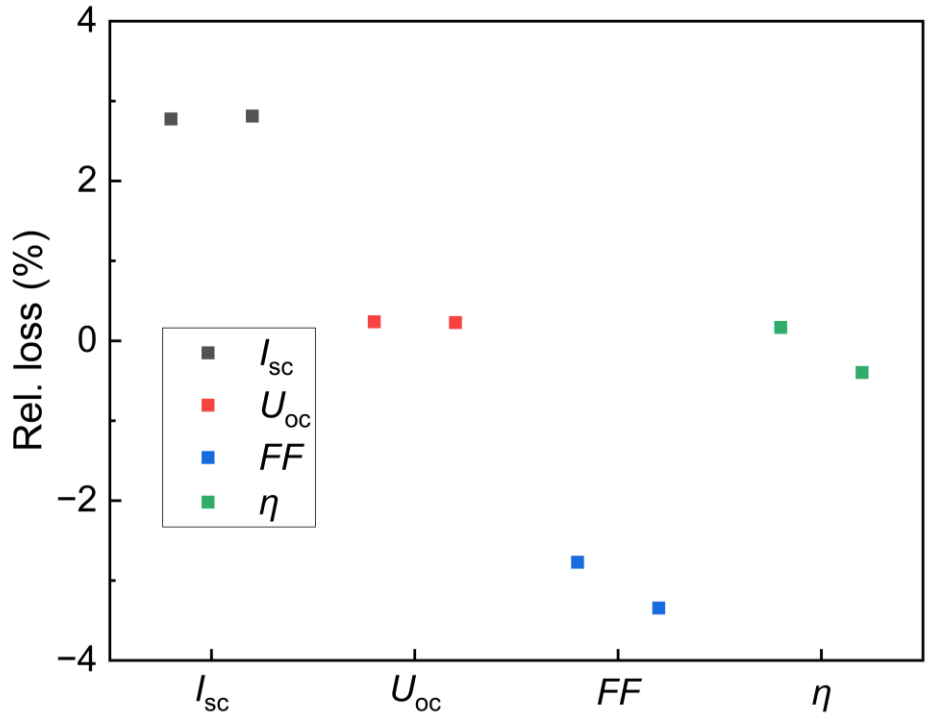
Proof of Concept: Shingeled Solar Cell Interconnection with T-ECA

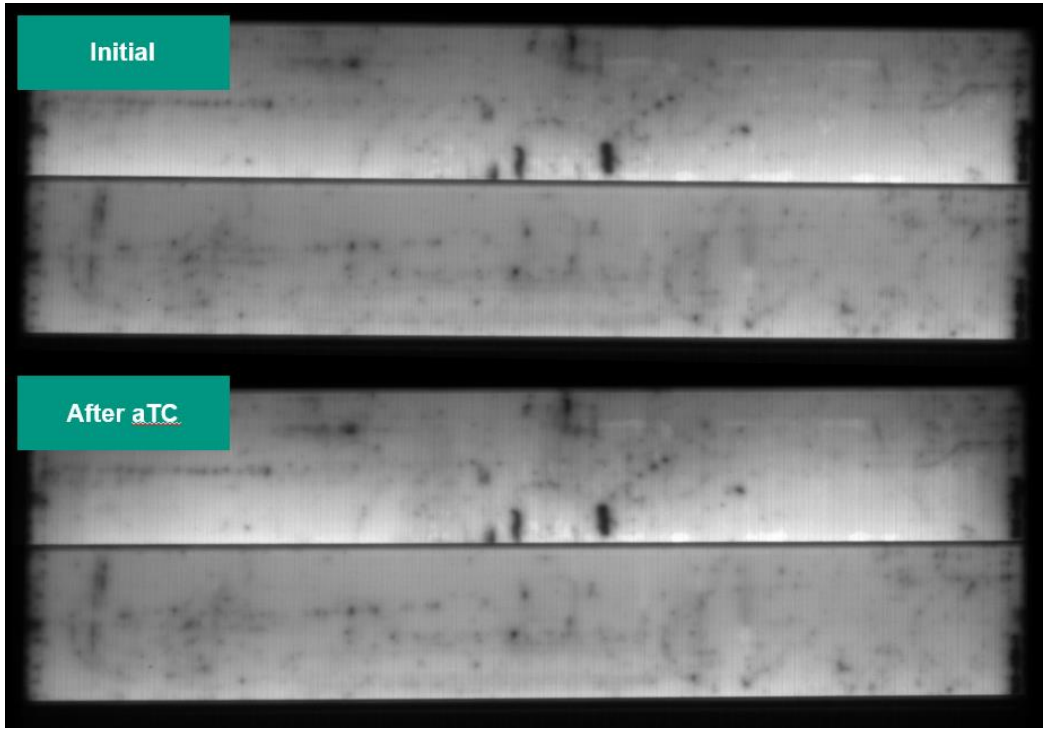
T-ECA 3D-Printed onto Solar Cells

- **Electrically conductive filament** for FFF 3D-printing
- Filament is **melted** and extruded onto the cell, where it cools and hardens
- The cells are then **shipped** to the stringing facility, where the T-ECA can be **reheated** for interconnection
- 3-cell **mini-modules** were shingled and encapsulated



Mini Module Characterization: aTC





Initial IV Characterization

- Efficiency: 20.3 ± 0.1 %
- FF: 75.6 ± 0.4 %

Modules tested using aTC200

- Efficency unchanged
- Low losses in FF

Conclusion

- Thermoplastic busbars offer **new degrees of freedom** in cell interconnection **without loss in cell performance**
- Works for **all cell types**: PERC, TopCon, HJT, Perovskite (Tandem)
- Substantial **savings** of **precious resources** using **thermoplastic busbars**
  - Preliminary results: **90 % less silver** compared to conventional silver busbars
- **Proof of concept**: Shingled **HJT mini-modules**

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