Advanced Laser Cutting Equipment for n-Type Cells

HighLite

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Overview

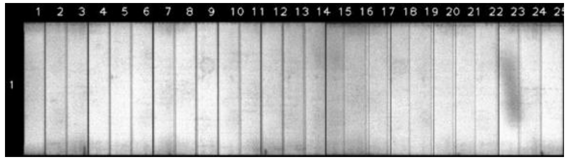
- H2020 HighLite project
- 3D-Micromac at a glance
- TLS-Dicing
- microCELL MCS
- Cell edge passivation on TLS diced SHJ solar cells
- Cell edge passivation on TLS diced IBC solar cells
- Summary

Approach in H2020 HighLite project

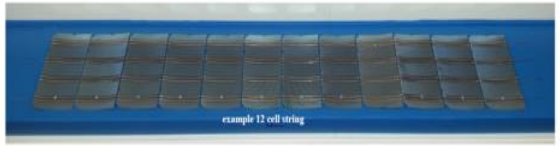
2) Develop novel equipment and processes for premium modules tailored for various applications (BAPV, BIPV, VIPV)

Novel cutting + edge re-passivation:

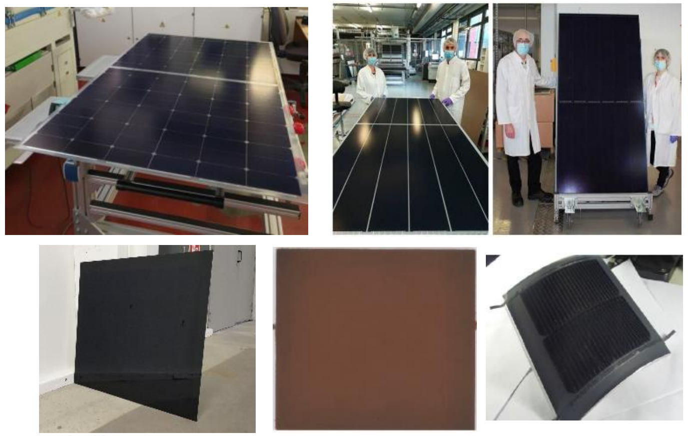
Shingling assembly:

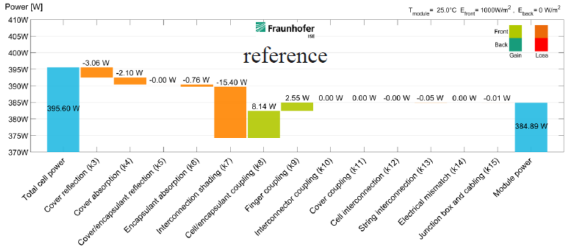


IBC cut-cell assembly:



Development of tailored modules designs
(materials, CTM losses, reliability, etc.)

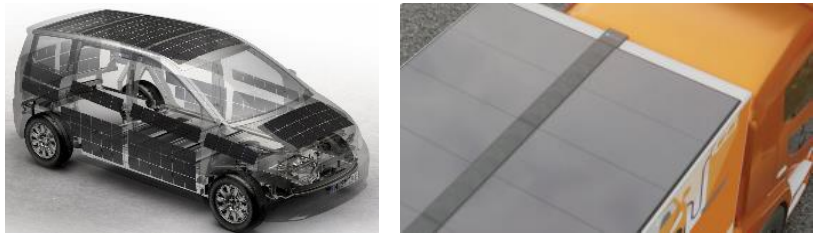




Building-applied PV (BAPV)

Building-integrated PV (BIPV)

Vehicle-integrated PV (VIPV)



https://www.highlite-h2020.eu/

HighLite

3D-Micromac – Micromachining Excellence

We are the leading specialist in laser micromachining.

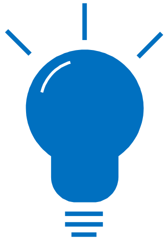
Our mission:

- Development and production of unique process and machine solutions for various high-tech markets
- Customer support from product development to high-volume production
- Enabling laser micromachining techniques for new devices
- Superior production efficiency and reliable process stability

"Our international customers place great value on future-oriented and user-friendly processes. Our solutions help them increase production efficiency and lower cost".
Uwe Wagner, CEO

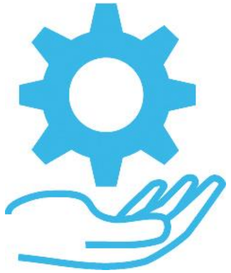
3D-Micromac – The Specialist in Laser Micromachining

Key Facts



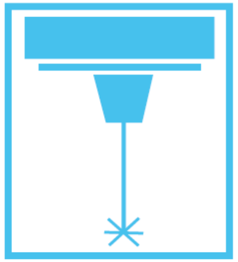
- » Founded in 2002
- » 190 employees
- » Based in Chemnitz, Germany
- » Branch offices in US, Taiwan, China

Services



- » Feasibility studies & process development in house
- » Production of limited lots and ramp up production
- » Worldwide sales & service network

Machine Base

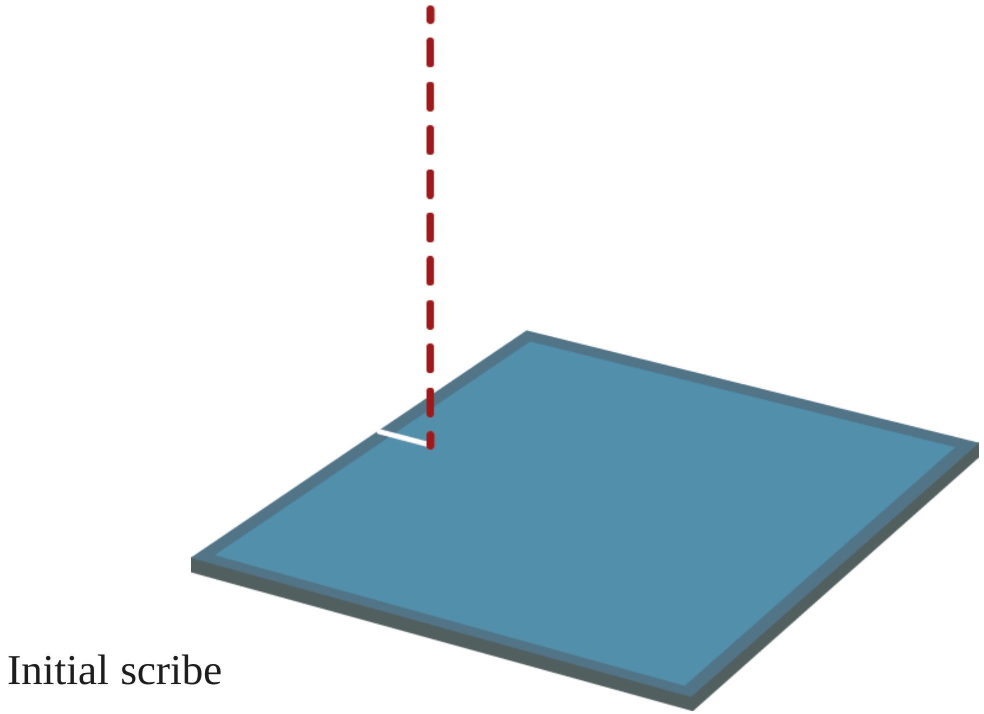


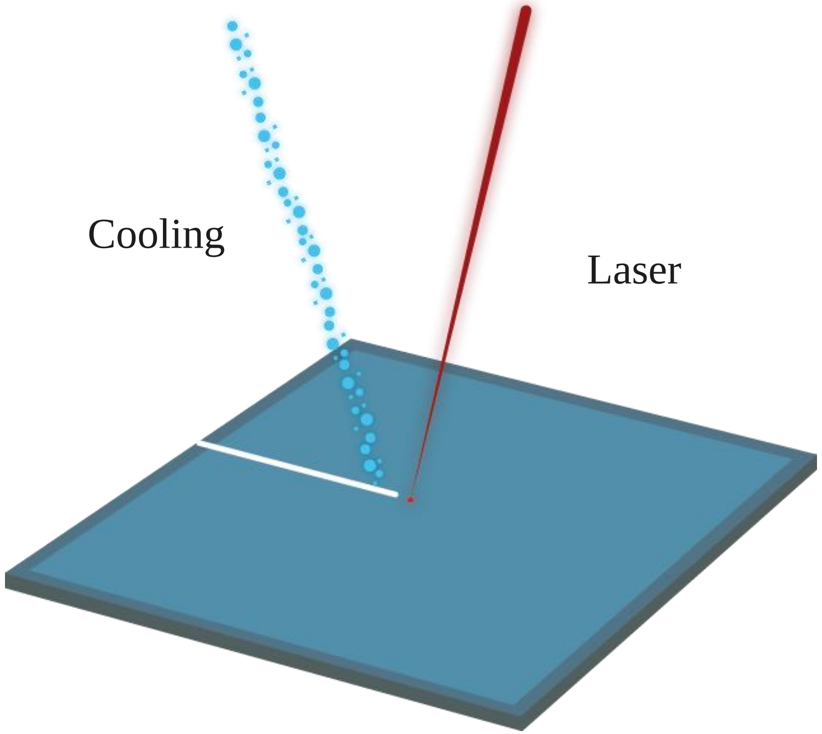
- » > 600 installations worldwide
- » > 100 systems in PV industry

3D-Micromacs Cutting Solution: Thermal Laser Separation (TLS-Dicing®)

- Starting point defined by initial scribe

- TLS is a cleaving process, initiated by heat and immediate cooling





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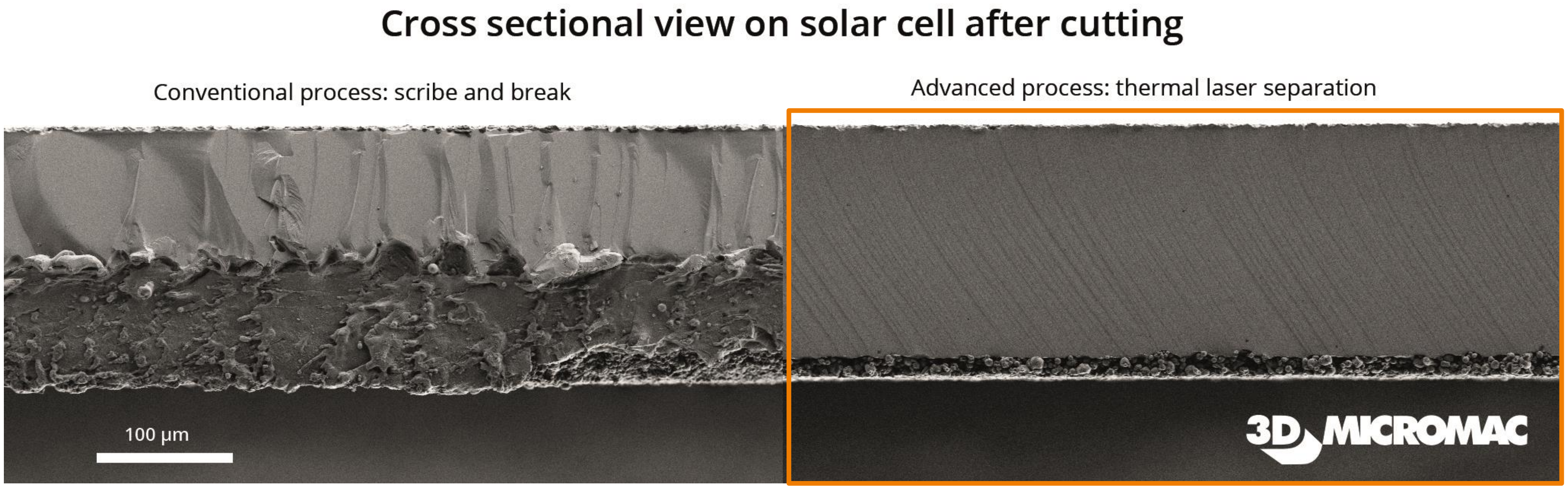
TLS-Dicing™ vs. Scribe and Break – Results Breaking Edge



→ Extensive chipping
→ Very rough structure

→ Very smooth structure
→ No chipping visible
→ perfect surface for re-passivation approaches

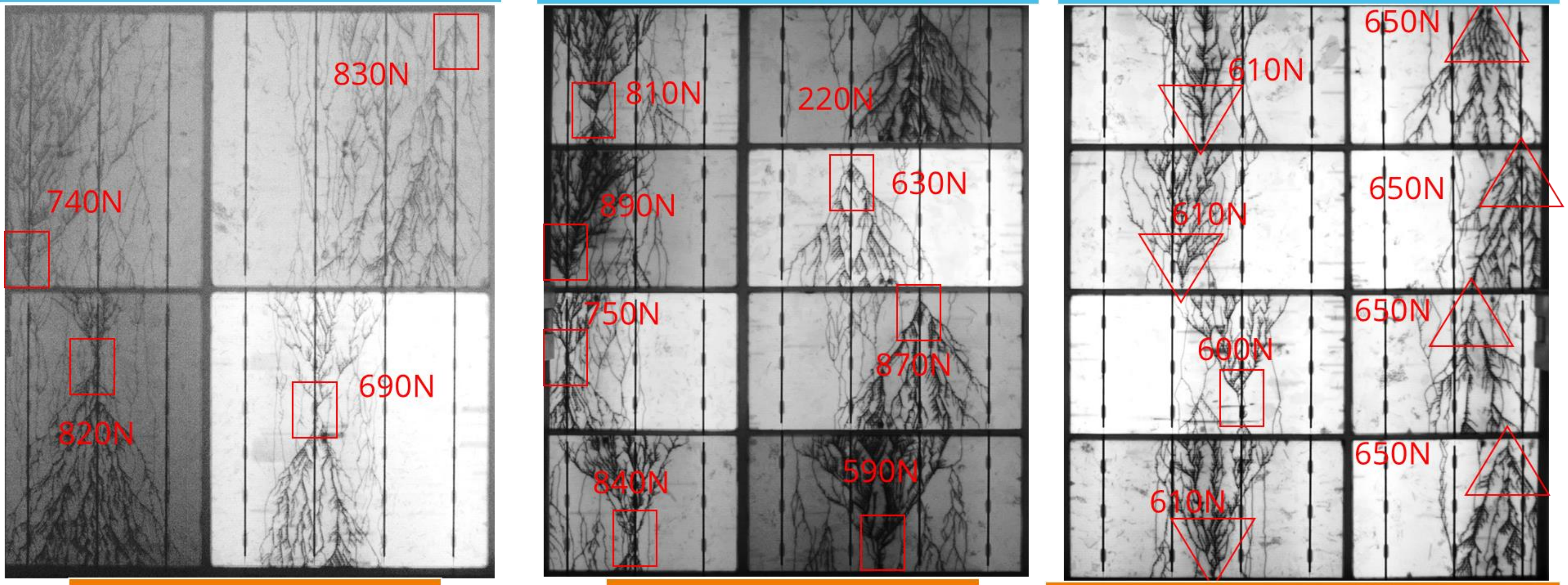
TLS-Dicing™ vs. Scribe and Break

Comparison of Fracture Origin

EL images from module laminate test	Fracture Origin: □ Surface ▽ Edge

EL pictures after testing | brightness and contrast adjusted

Full Cells (reference)	Thermal Laser Separation (**TLS**)	Laser Scribe and Cleaving (**LSC**)



surface defects → pads	surface defects → pads	mostly edge defects → cutting process

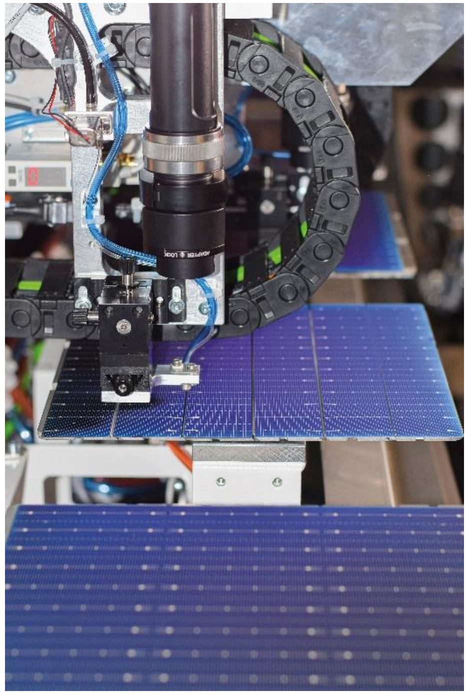
→ Courtesy Fraunhofer CSP

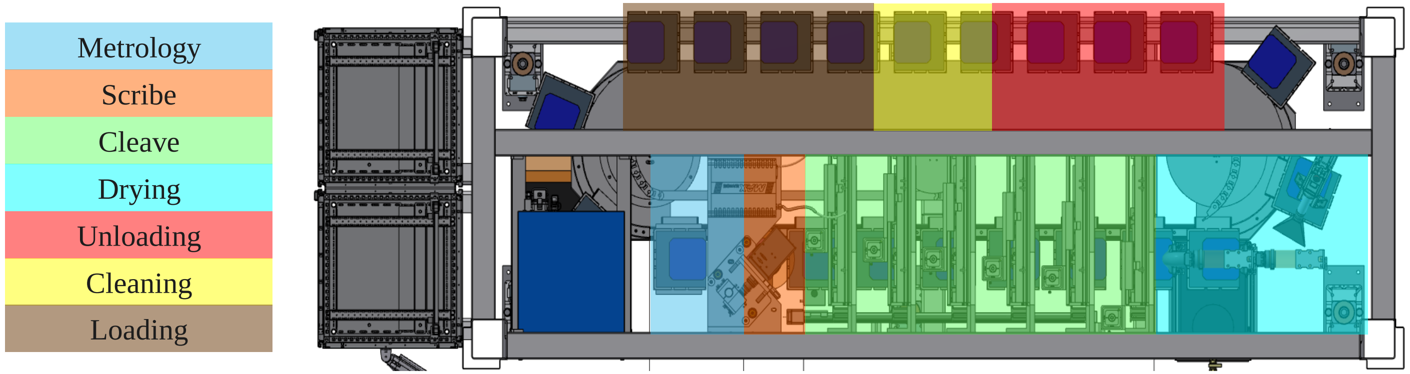
microCELL MCS

3D-Micromac’s HighThroughput Shingling Tool

- Circulating chuck system with 22 carriers
- 4.6m x 1.4m x 2.0m (length x width x height)
- Format and pattern adjustments via flexible chuck design
- up to five process positions: exchangeable, retrofitable, expandable
  -> fully flexible from ½ cells to 1/6 cell stripes
- Wafer sizes up to M12
- Wafer recognition by camera
- Scanner-based initial scribe
- Cleave: adjustable on motorizes stages
- v_{max} = 500 mm / s
- TPT_{max} = 6.400 wph

- available for demonstration and applications





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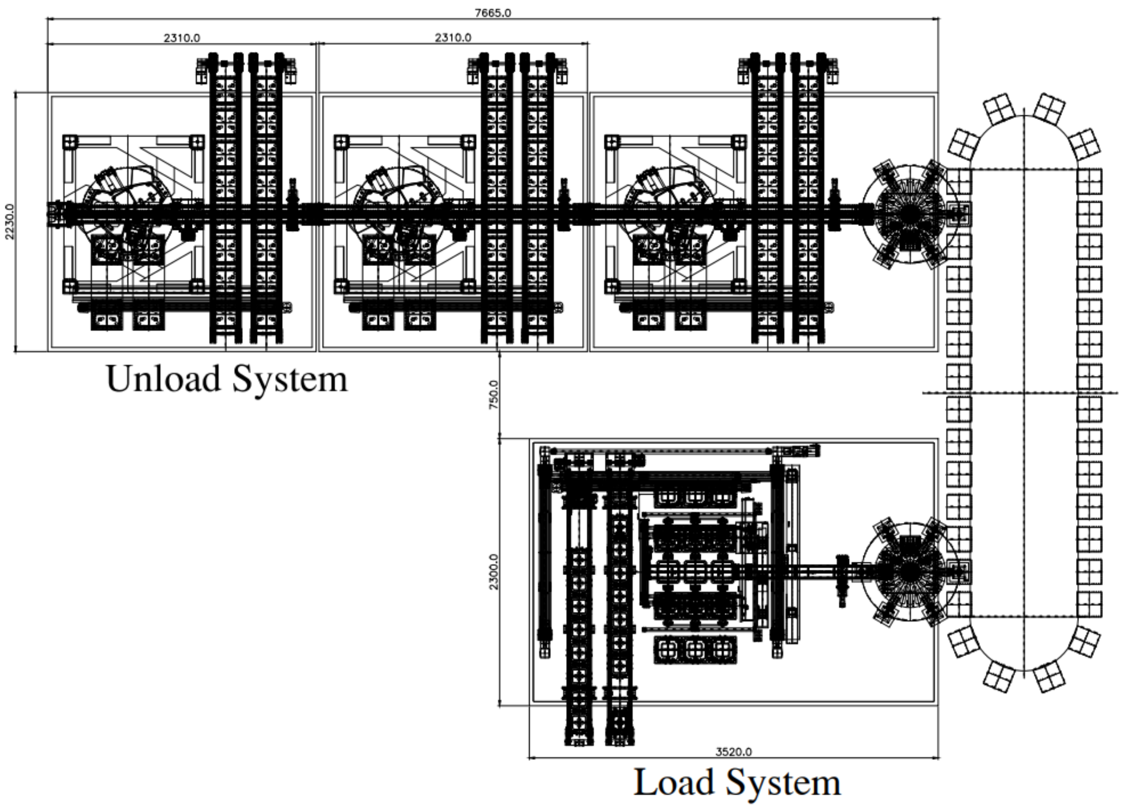
microCELL MCS

3D-Micromac’s HighThroughput Shingling Tool



Load System

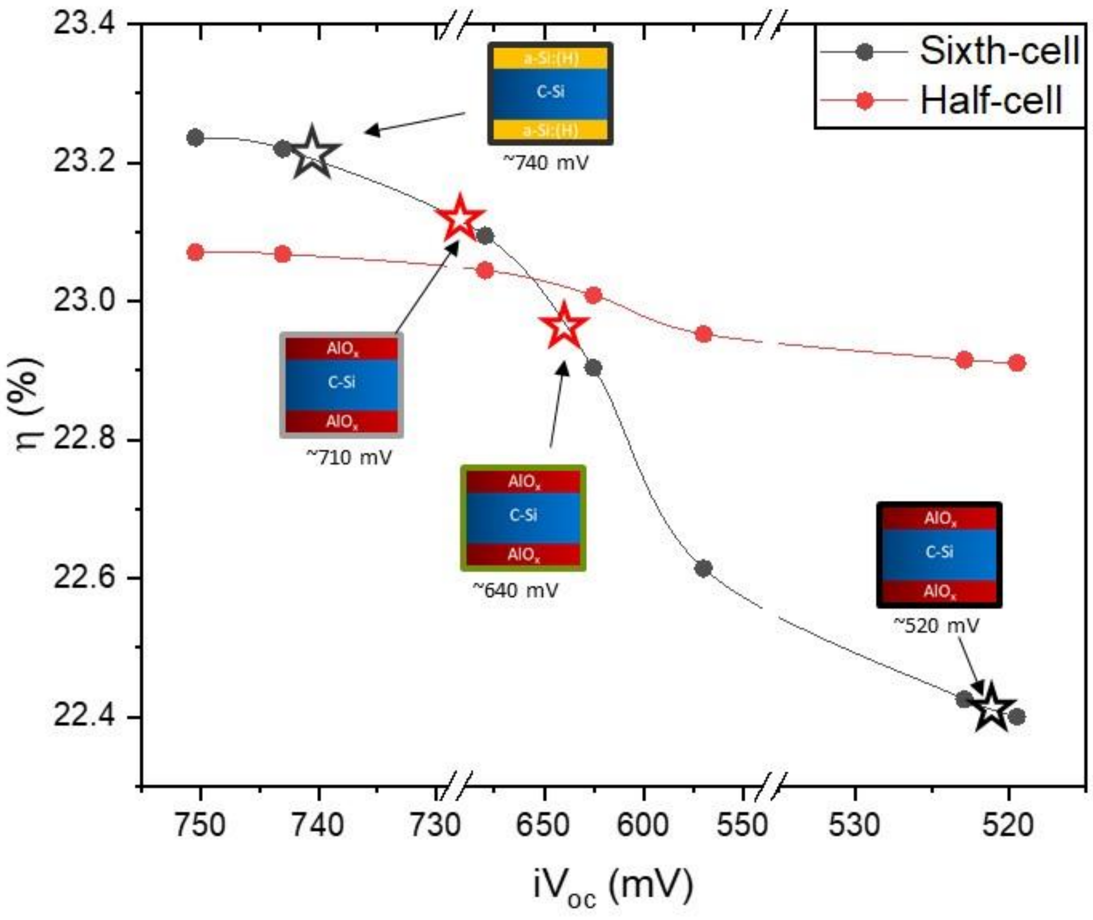
- rotary pick-and-place out of boxes
- buffer with 10 full cell boxes, fully automatic box change and transfer
- Wafer size up to M12

Unload System

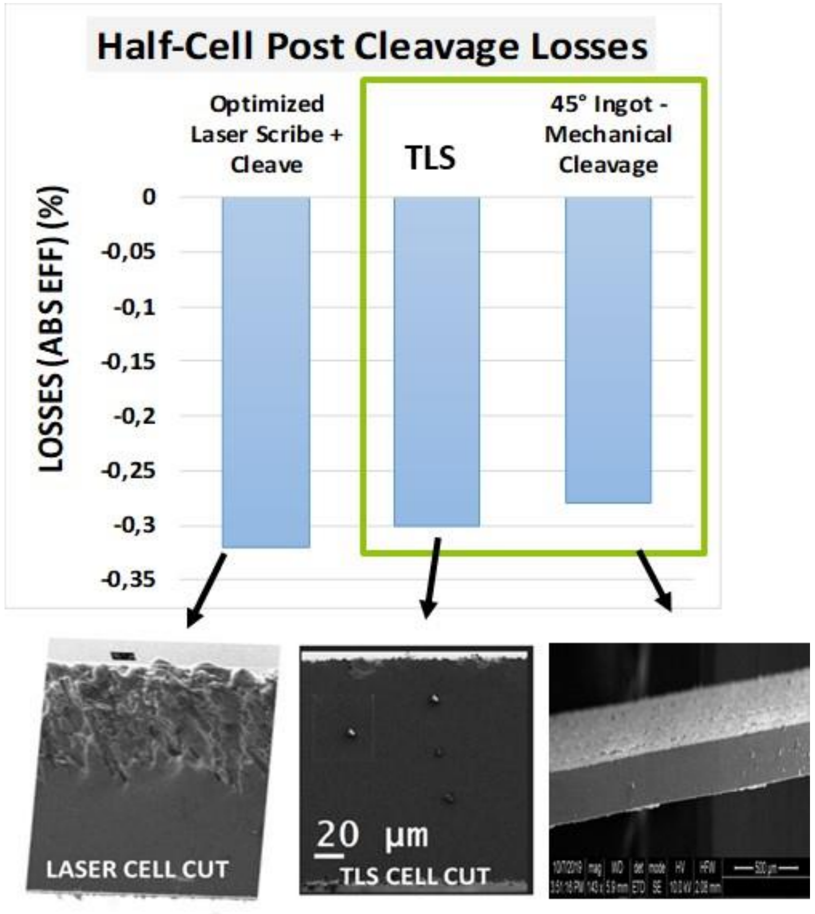
- Modular system
- Upgrade unloading modules possible depending on the number of strips
- Buffer with 10 boxes, fully automatic box change and transfer, pick-and-place via Spider robots
- Wafer size up to M12

Cell edge requirements for SHJ & edge passivation

✓ High recovery potential achievable, but requires high-post-cut edge morphology quality

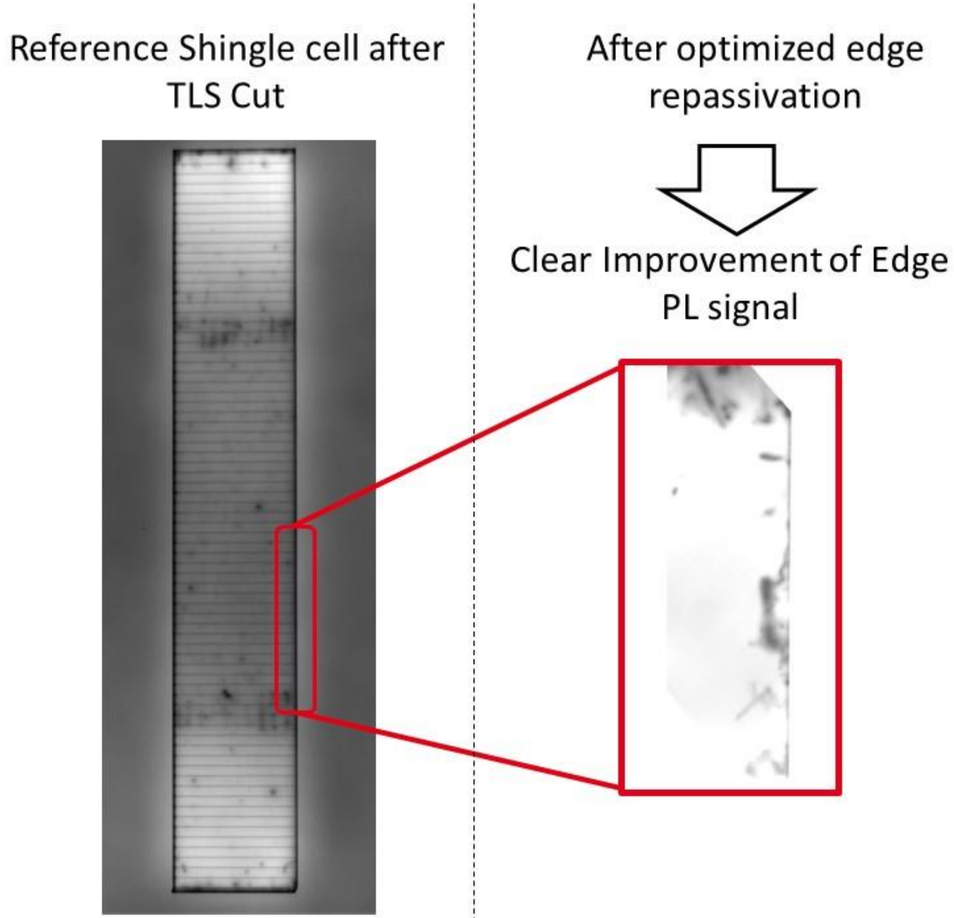


✓ Equally good morphological & electrical results obtained for TLS & Mechanical cleavage

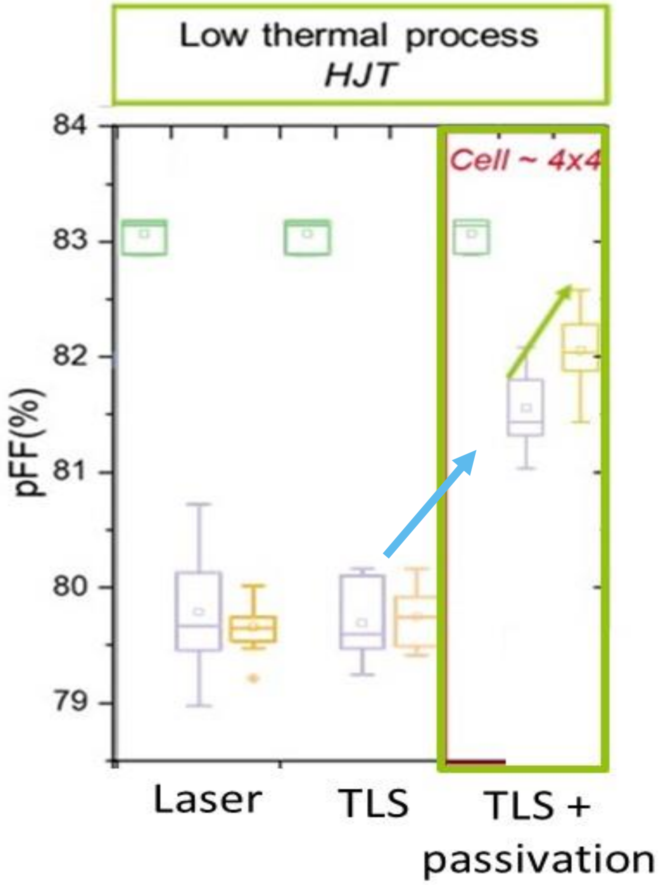


Promising Combination of TLS & Edge repassivation for Shingle cells

✓ PL confirmation of TLS good compatibility with proper post-cut edge passivation



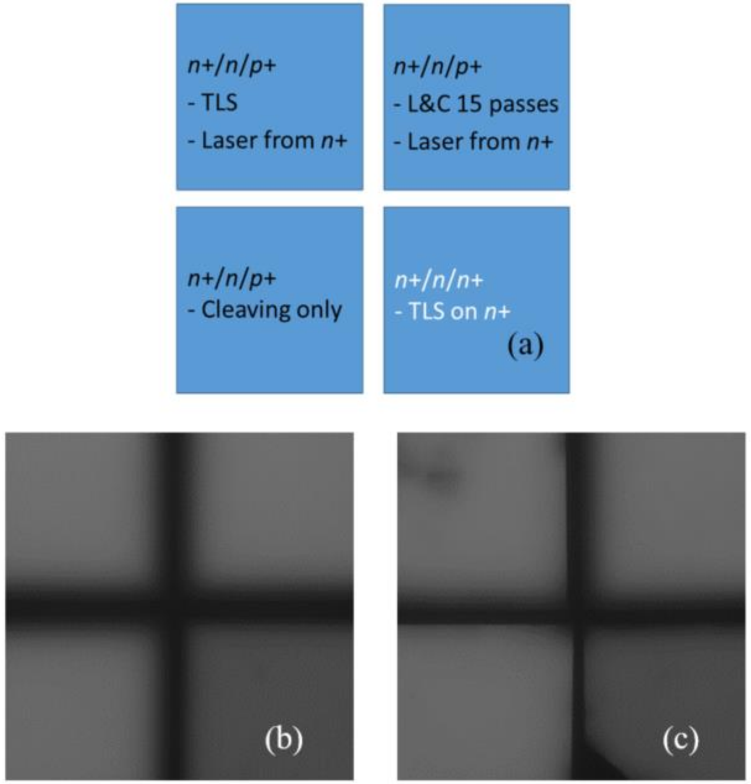
✓ Electrical outputs: partial recovery of cell performances obtained for TLS cut & edge passivation combination



Repassivation of IBC Solar cells

On cell level

- Using high-resolution PL for characterization edge passivation
- Evaluated different cut techniques: TLS, L&C, and cleaving
- Equally good repassivation on TLS and cleaved samples, however, not stable yet



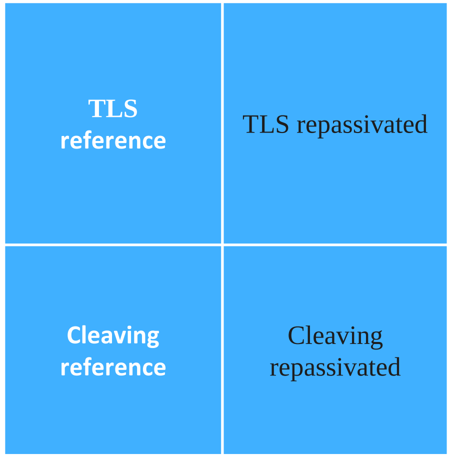
Repassivation samples locations (a), before repassivation (b) and after repassivation (c)

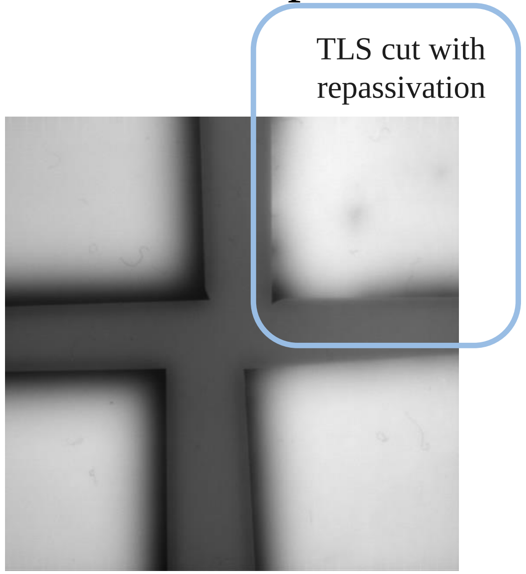
Reference: N. Chen, D. D. Tune, F. Buchholz et al., "Impact of Cut Edge Recombination in High Efficiency Solar Cells – Measurement and Mitigation Strategies." 38th EU PVSEC, 2021.

Repassivation of IBC Solar cells

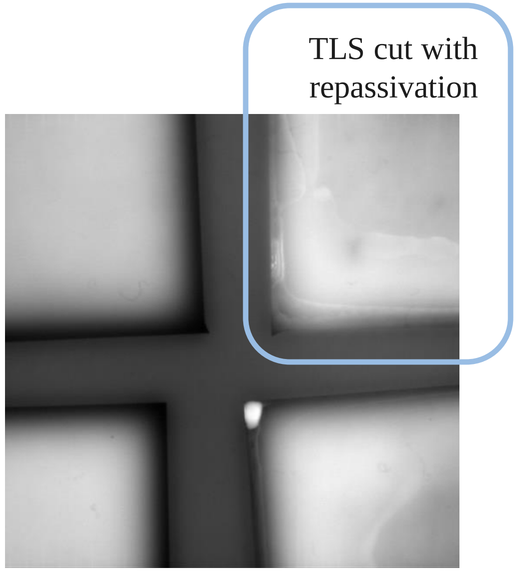
on module level

- n+/n/p+ samples, with TLS or cleaving cut
- with Glass/backsheet and EVA encapsulation, the samples were immediately encapsulated after repassivation
- Repassivation is still good after Damp Heat 1000 hours

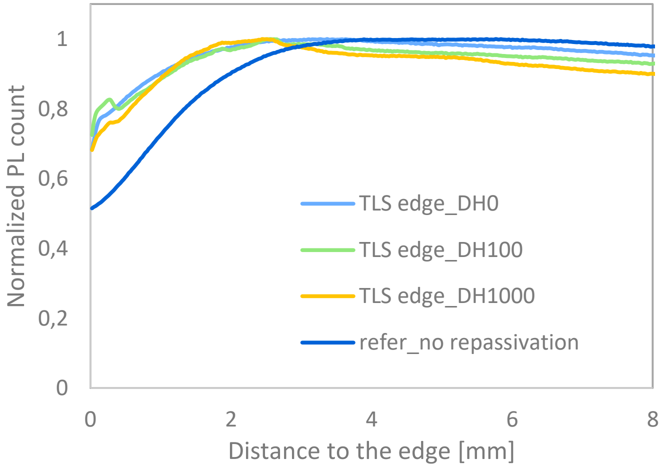




After repassivation



DH1000

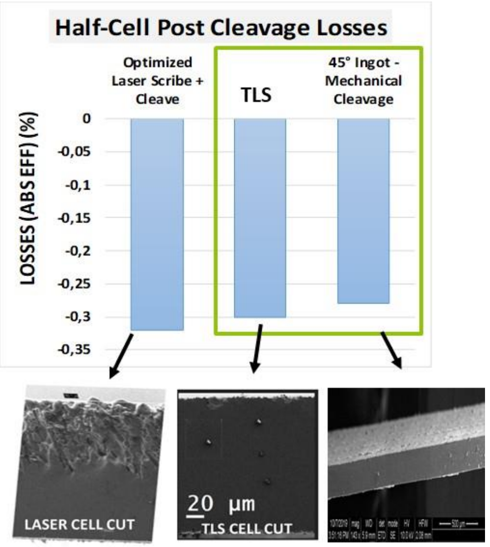


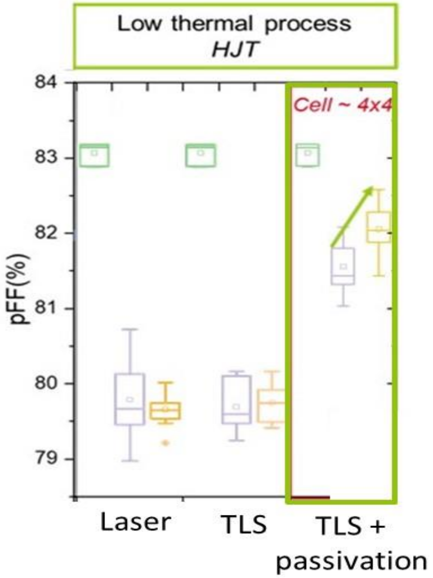
Reference: N. Chen, D. D. Tune, F. Buchholz et al., to publish

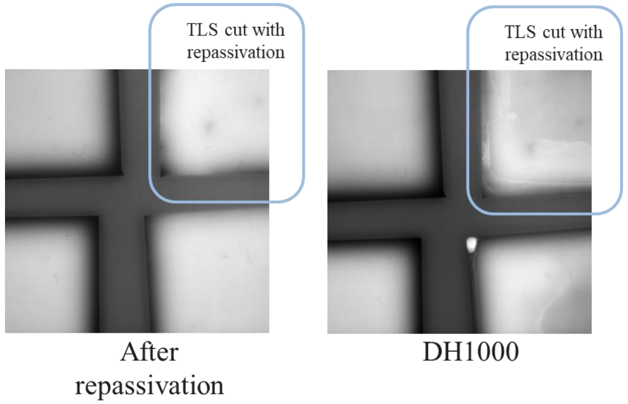
Summary

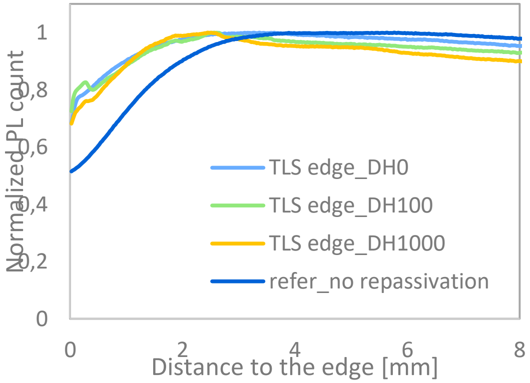
- High throughput tool with TLS process to cut cells in ½, 1/3 cells and shingles is available
- Flexible chuck design accept wafers up to M12

- excellent egde quality of TLS-Dicing is the key for efficient repassivation approaches
- Demonstrated for SHJ and IBC solar cells and modules









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