



MANZ AG

**Efficiency improvements and shorter return on invest
on Thin Film PV modules**

Th. Umschlag

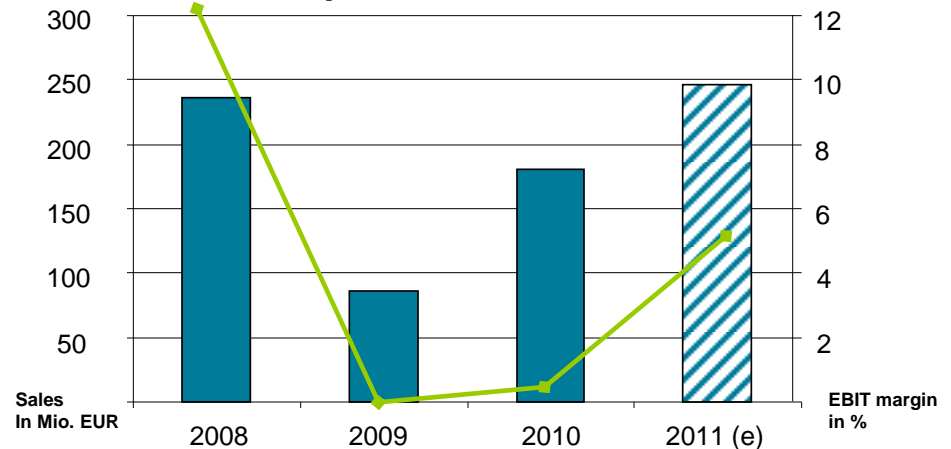
- Introduction Manz
- Efficiency improvements by inline quality control
- Laser processes in thin-film production lines
 - Laser scribing
 - “customized” laser scribing processes (BIPV)
 - Laser edge ablation
 - Laser drilling
- Conclusion

Manz AG is one of the world's leading technology providers for production systems in the photovoltaic industry, the FPD industry and for Li-Ion battery production.



- 1987** Established by Dieter Manz
- 1990** Developed first automation system to handle cSi solar cells in pilot production
- 1994** Supplied first LCD handling machines to Asia
- 2000** Supplied automation systems for the first fully-automated production line for cSi products
- 2005** Entered thin film solar market scribing machines
- 2006** Initial Public Offering (IPO)
- 2008** Manz became leading supplier of wet chemical processing machines by acquisition of Intech (Taiwan)
- 2009** Market entry into Lithium-Ion battery equipment
- 2010** Establishment of the Manz Coating GmbH. Manz acquires the exclusive rights of use to Würth Solar's CIGS production technology

Development of Sales & EBIT



automation / metrology / laser / vacuum coating / wet chemistry / metallization

Solar (35%)



System solutions for the production of silicon solar cells



System solutions for the production of thin-film solar modules – single equipment and totally integrated production line (CIGSfab)

FPD (40%)



System solutions for the production of FPD displays

New business (10%)



System solutions for the industrial-scale production of Li-Ion batteries



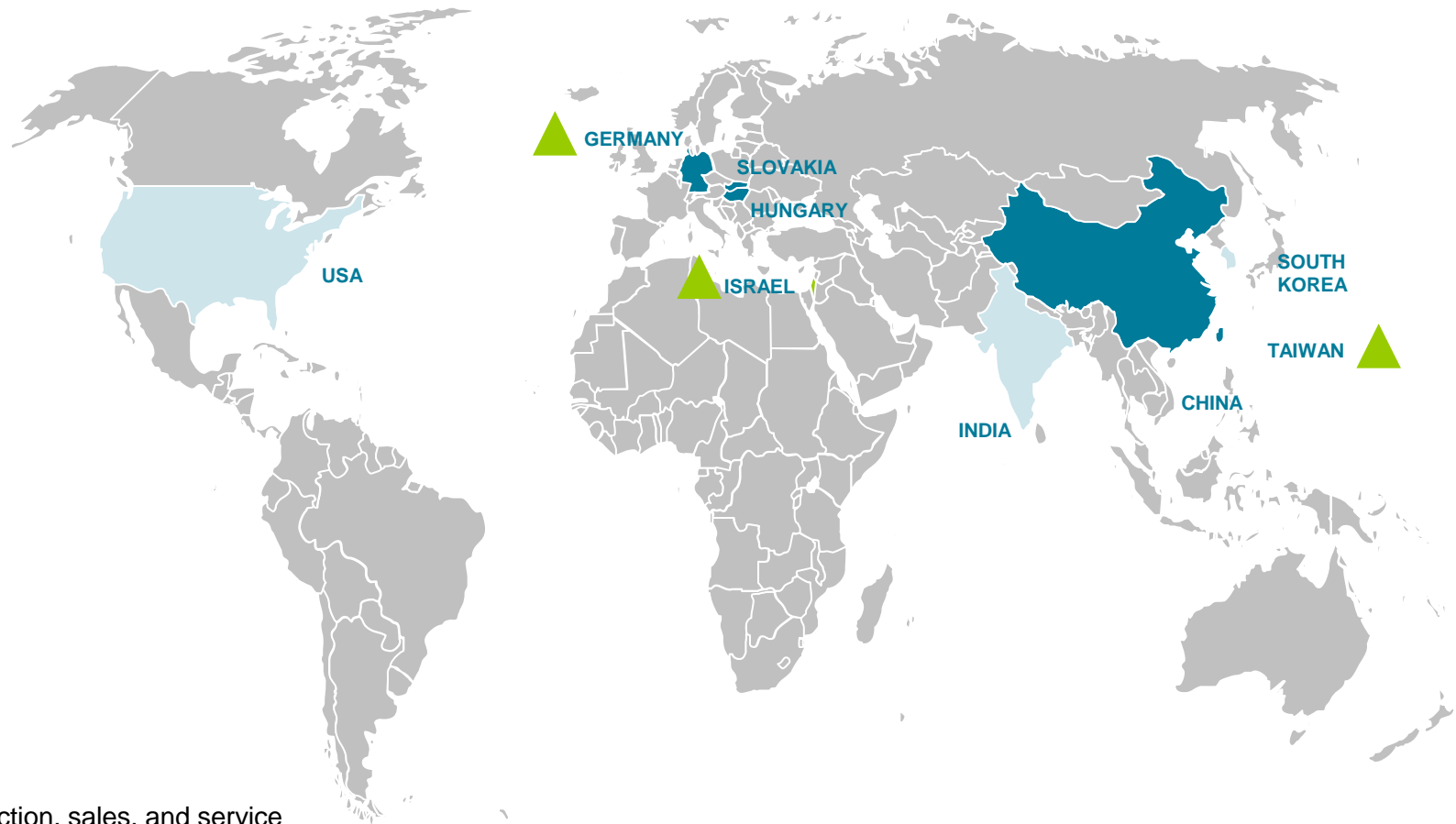
System solutions for the industrial-scale production of fuel cells




Others (15%)



System solutions for the production of
- packaging materials
- printed circuit boards (pcb)
Contract manufacturing of OEM systems

MANZ PRESENCE WORLDWIDE R&D, PRODUCTION, SALES & SERVICE



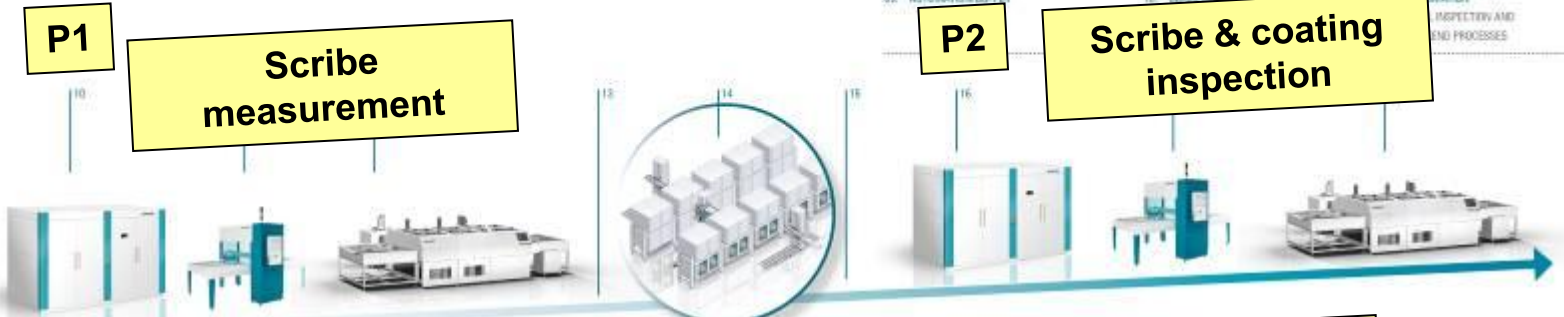
-  Production, sales, and service
-  Sales and service
-  R & D

**> 1950 employees worldwide,
600 in Germany, 900 in Asia**



THIN-FILM SOLAR MODULE PROCESS STAGES

- | | | |
|------------------------------|-----------------------------|---------------------------------|
| 01. AUTOMATION/GLASS LOADING | 10. LASER SCRIBING P1 | 19. AUTOMATION/BUFFER |
| 02. GLASS CLEANING | 11. SCRIBE MEASUREMENT | 20. COATING ELECTRICAL CONTACT |
| 03. AUTOMATION | 12. GLASS CLEANING | 21. AUTOMATION |
| 04. GLASS INSPECTION | 13. AUTOMATION/BUFFER | 22. SCRIBING P2 |
| 05. AUTOMATION/INFLU IDE | 14. COATING ADDRESSER LAITH | 23. SCRIBE MEASUREMENT |
| 06. COATING FRONT CONTACT | 15. AUTOMATION/BUFFER | 24. AUTOMATION/INFLU IDE |
| 07. AUTOMATION | 16. SCRIBING P2 | 25. LASER EDGE ABLATION |
| 08. TCO ETCHING | 17. SCRIBE MEASUREMENT | LASER GLASS CUTTING |
| 09. AUTOMATION/BUFFER | 18. GLASS CLEANING | AUTOMATION |
| | | INSPECTIVE AND
END PROCESSES |

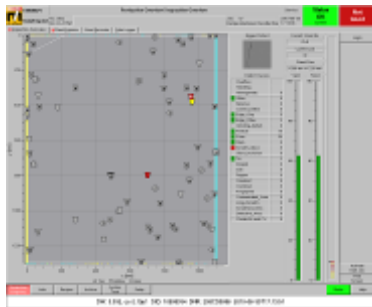


Metrology Solutions



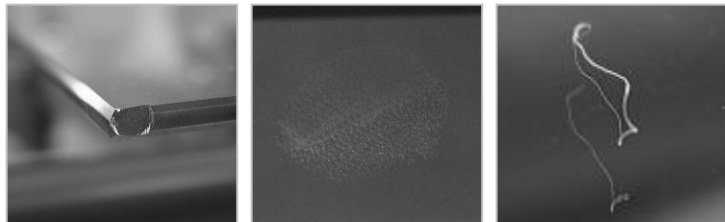
What it does

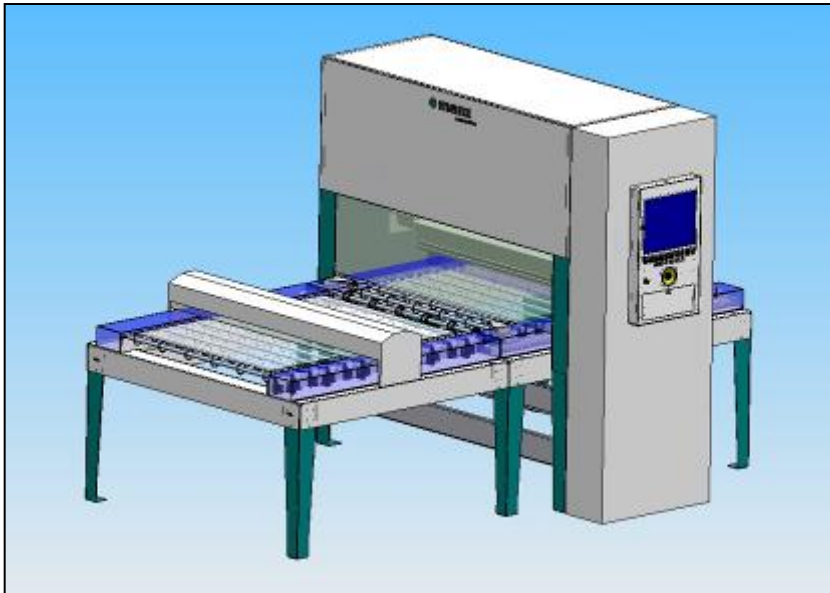
- Inspect: Detect features that deviate from a defined reference
- Measure: Record & evaluate known substrate properties
- Features
- Uses Dr. Schenk’s leading edge inspection technology
- 100 % defect & inhomogeneity inspection
- High precision measurement of panel properties
- Robust setup with industry proven components
- Very powerful and intuitive software



Applications

- Glass inspection → (edge) defects and contaminations
- Glass measurement → size, positions of glass features
- Coating inspection → layer defects, homogeneity monitoring
- Scribe inspection → discontinuities, under- & over scribes
- Edge deletion inspection → edge deletion residues
- Final inspection → encapsulation & lamination defects



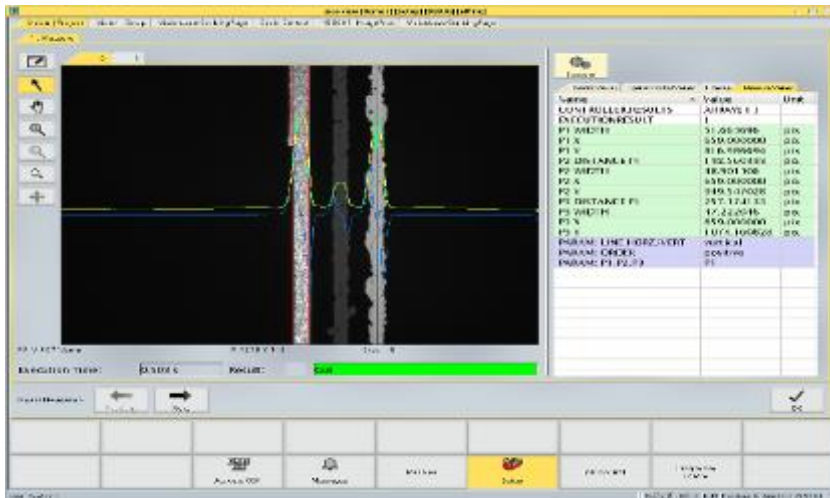


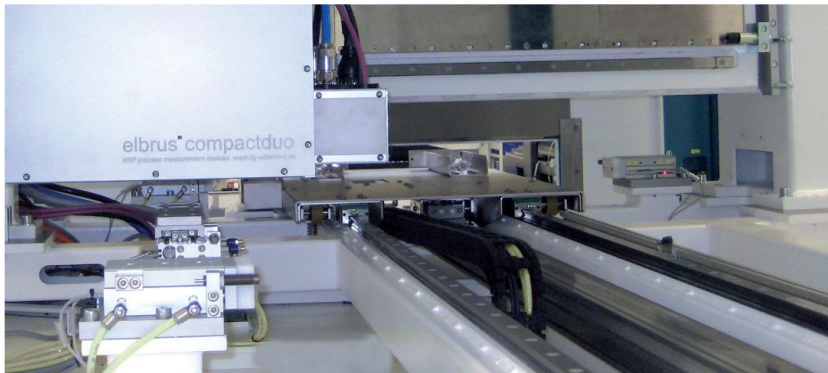
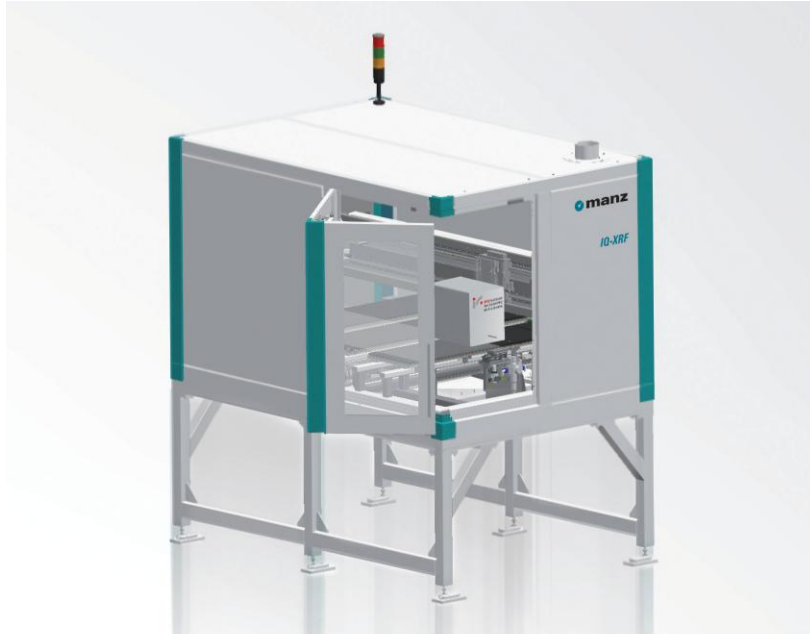
What it does

- Scribe inspection: Full area inspection of scribes
- High resolution measurement of all scribes
- Electrical insulation test for P1 (& P3)

Features

- Detection and assignment of scribing failures
 → down to 35 µm failure size
- Measurement of the average cell width
 → accuracy better than 100 µm
- High accuracy measurement of all P1-P2-P3 scribes
 → distance & width with µm resolution
- Electrical insulation test of all scribes (P1-P1)
 → unambiguous identification of shorts





What it does

- High precision measurement of element concentrations
- Determination of compositions and thickness
- Homogeneity mapping

Features

- Absolute accuracy
 - < 5% at a measurement time of 5 sec
 - Fast single measurements
 - 2 high-brightness X-Ray tubes
 - cooled fast Silicon Drift Detector
 - Robust Setup
 - industry proven components
 - Intensity monitoring with marker technology
- Discover systematic failures and process drifts on a short time scale
- Optimize device quality by monitoring the layer composition and thickness

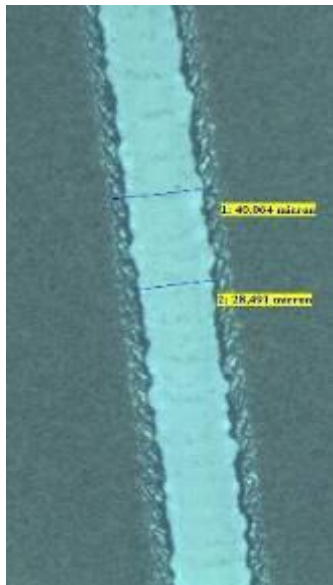
- 100% inline inspection capabilities
 - Inline screening of process parameters
 - better process control and optimization
 - Avoidance of unnecessary production costs and system downtime
 - Glass breakage in vacuum chamber → systems downtime of ~24 hrs can easily lead to loss of >300k€
 - Investment of inspection tool pays back almost immediately
- Highest flexibility and use of metrology tools
 - Designated inspection criteria
- Best use of process material



Laser Scribing Solutions

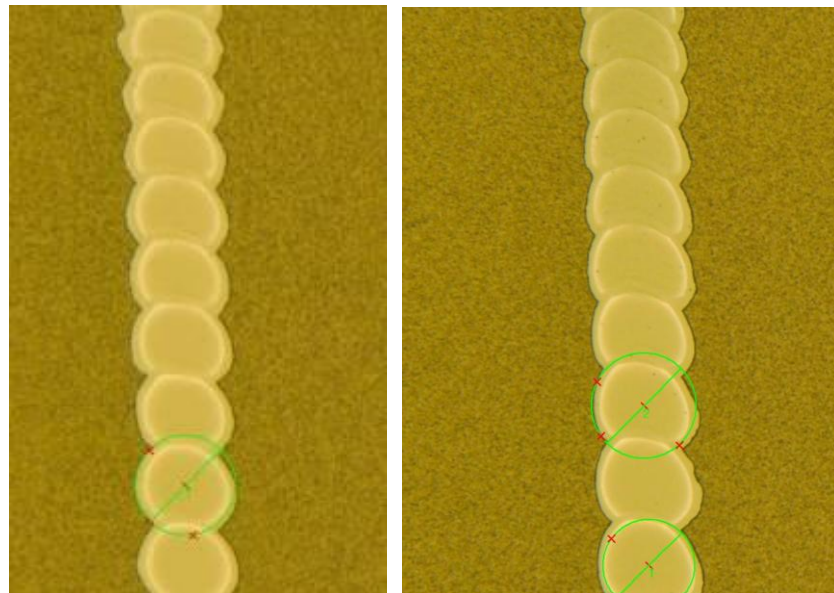
- Past: Manz focused on SnO, scribing with IR
- Now and Future: Manz will provide P1 with UV as well

P1 scribing with IR



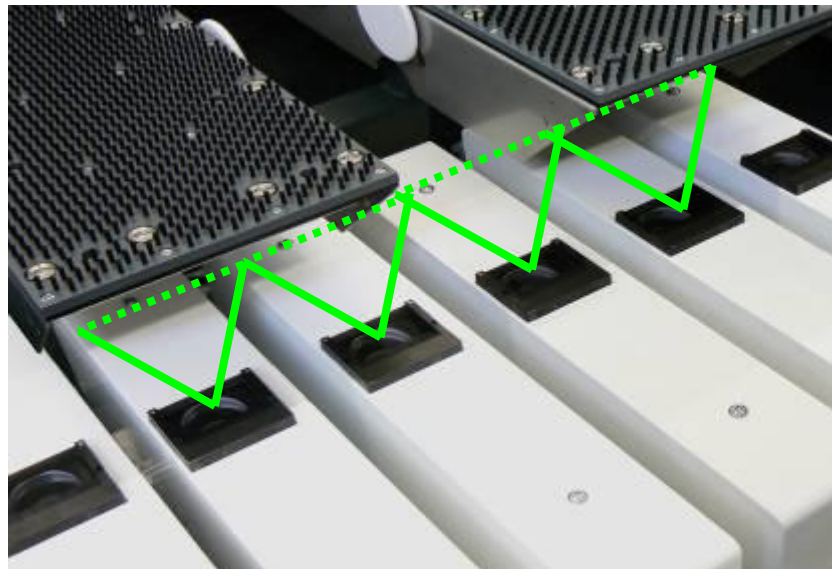
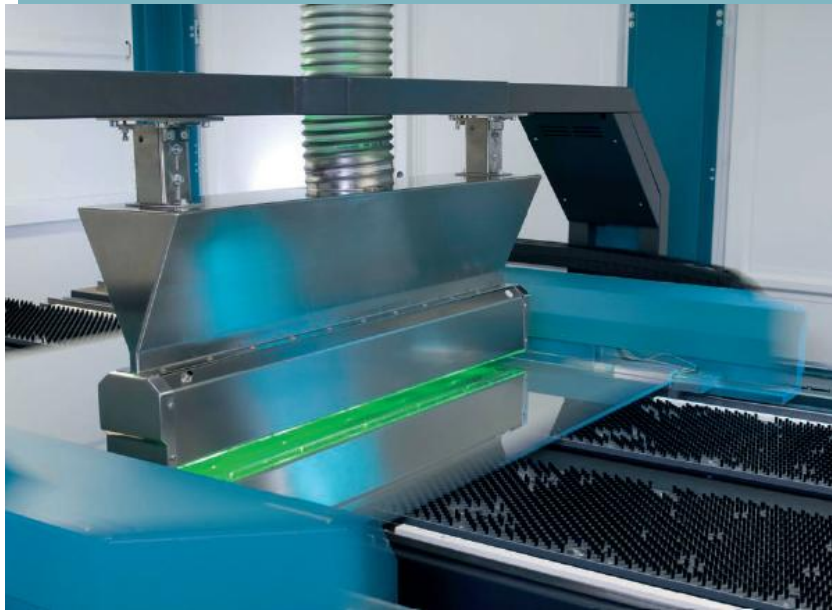
- Max scribe speed 600mm/s
→ limitation in process speed
- > 25M Ω insulation

P1 scribing with UV laser source



- No melt zone / no HAZ
- Proper ablation
- Clean spot ground / No substrate damage
- Wide range of scribing parameters
- No influence of Rep. Rate and Overlap

	IR scriber tool	UV scriber tool
Tool configuration	8 IR lasers	UV laser with 1:8 beam split
Scribing of SnO₂	✓	✓
Scribing of ZnO	Small process window Melting zone	✓ Large process window No melting zone
Process speed ZnO	☹ Max ~600mm/s to achieve good insulation	1400mm/s And faster



IPCS = Inline Precision Control System

Dead area ▼

- P2 & P3 are written with respect to P1
- parallel to within $\pm 10\mu\text{m}$ - every line!
- minimal dead area (down to $160\ \mu\text{m}$ possible)

Throughput ▲

- approx every 15 cm one laser module
- fast substrate input and output

Cost of Ownership ▼

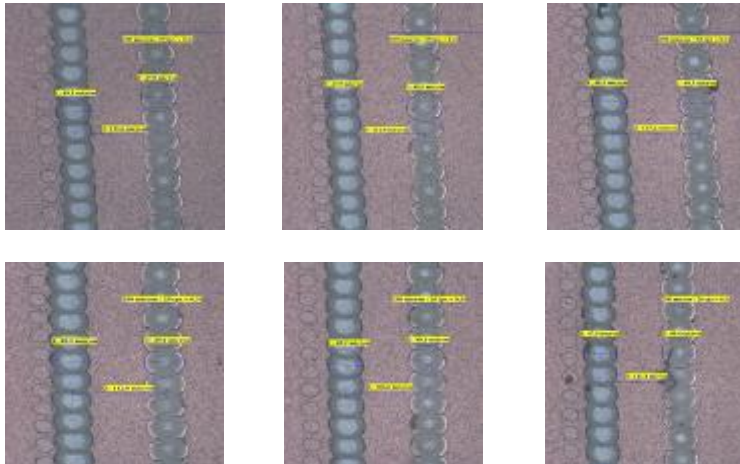
- high machine throughput & utilization
- tailored laser sources

Process robustness ▲

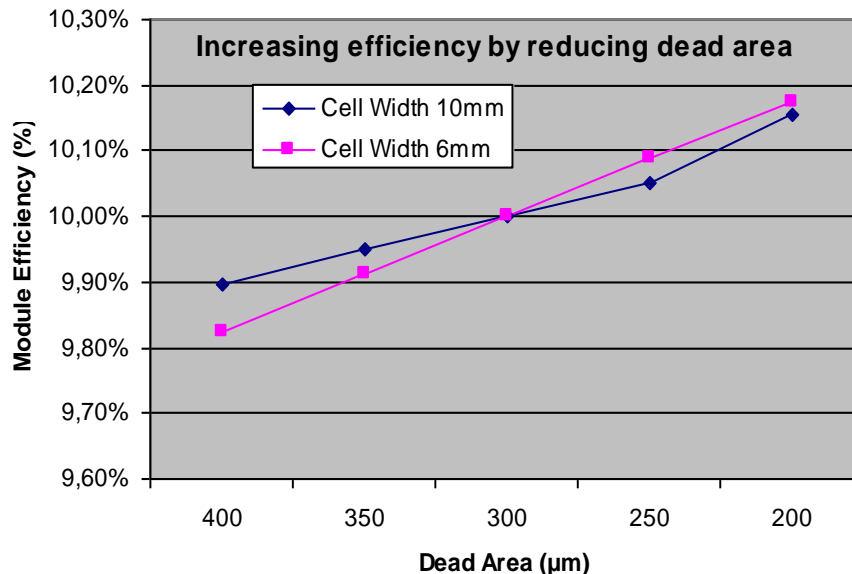
- process optimized laser sources with various power levels
- Also works for BIPV modules

- Highest scribe accuracy ($\pm 10\mu\text{m}$)
- Lowest dead area in the market (can be as small as $160\mu\text{m}$, depending on scribe widths)
- P2/3 scribing T-independent
 - referencing to scribes, no reference marks needed
 - minimized secondary time
 - no AC-unit required
 - reduced investment costs and CoO
- Customer friendly module exchange
 - minimized systems downtime
- Laser sources for all relevant layers available (different power level)
- IPCS can be used also for BIPV scribing
 - high throughput
 - customized spot size
 - various design pattern possible





P1 – P2 line variation <math><10\mu\text{m}</math> (center to center)



● Safe time! – minimize cycle time

- Fast load and unload of substrate
- No scribe alignment to reference marks needed
- Minimal secondary time and maintenance efforts → one block design of laser optic module (IPCS)
- Multiple laser sources for highest throughput (up to 8 lasers @ Gen 5 panels)

● Increase module efficiency and performance

- IPCS for active tracking of scribe lines
- Scribing accuracy becomes independent from temperature effects on substrate → no AC or T-stabilization required
- Each module has its own tracking function → highest scribe accuracy
- **With IPCS tracking customer was able to increase module power by 2W (average)**



Laser Edge Ablation

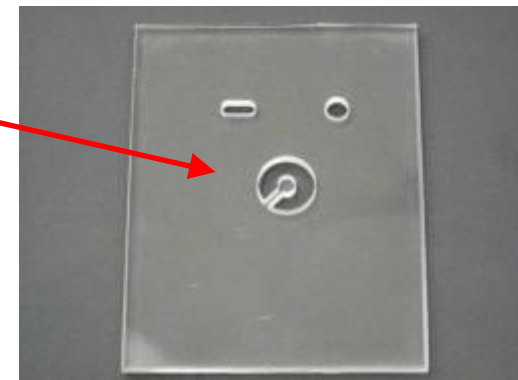
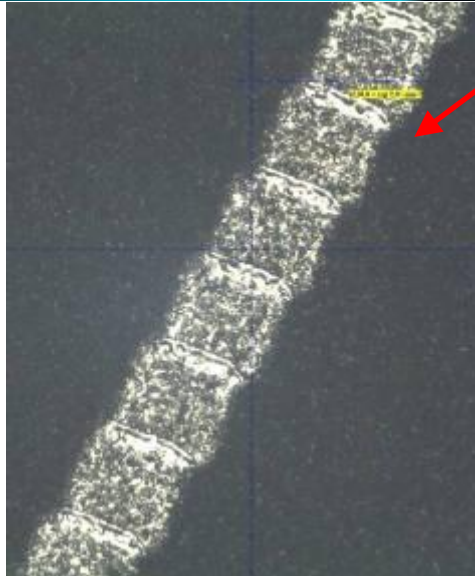
- No micro-cracks in glass
- Better process performance compared to conventional sandblasting or grinding
- Higher production yield
- Flexible usage of tool (BIPV, glass cutting) → shorter ROI
- Molybdenum exposure for CIGS

Further developments (CIGS application)

- Consequential step to further process optimization
- Laser based scribing of CIGS with highest scribing accuracy
 - smoothing CIGS layer
 - no melting zone
 - no micro cracking or flaking
 - No debris

● **Hole drilling for CIGS panels**

- in bare glass
- in Molybdenum coated
- CIGS coated substrates



- Efficiency improvements of TF-solar modules can be achieved with innovative product solutions at Manz
- Inline metrology tools will gain to higher production yield
- Manz offers innovative laser based process solutions which have a direct positive impact on module performance and efficiency
- Manz offers laser processing tools with all relevant wavelengths for any thin-film layer
- Manz Laser Patterning system with active scribe tracking (IPCS) combines higher throughput & smaller dead area at optimized system cost
- Combining multiple application into a single tool shortens return on invest

Thank you for your attention!

Visit us | Hall A1 | Booth B1

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