

STATUS AND FUTURE ROLE OF AUTOMATED OPTICAL INSPECTION

NEXT INDUSTRY CHALLENGE FOR
QUALITY IMPROVEMENTS

VITRONIC

THE MACHINE VISION PEOPLE

- Privately held company (founded 1984, owner managed)
- Total revenue in 2017: €150 million
- >900 employees
- R&D investment in 2016: €15 million
- Head office in Wiesbaden, Germany
- Subsidiaries on four continents
- Global network of service centers and partners
- Products for Photovoltaic, Automotive, Healthcare, Logistics, and Traffic industries
- > 2.000 PV systems for > 130 customers



AOI FOR EVERY STEP OF PV PRODUCTION



Raw wafer inspection



Coating inspection
Color inspection
Print inspection
Classification



Cell inspection
String inspection
Electroluminescence
inspection

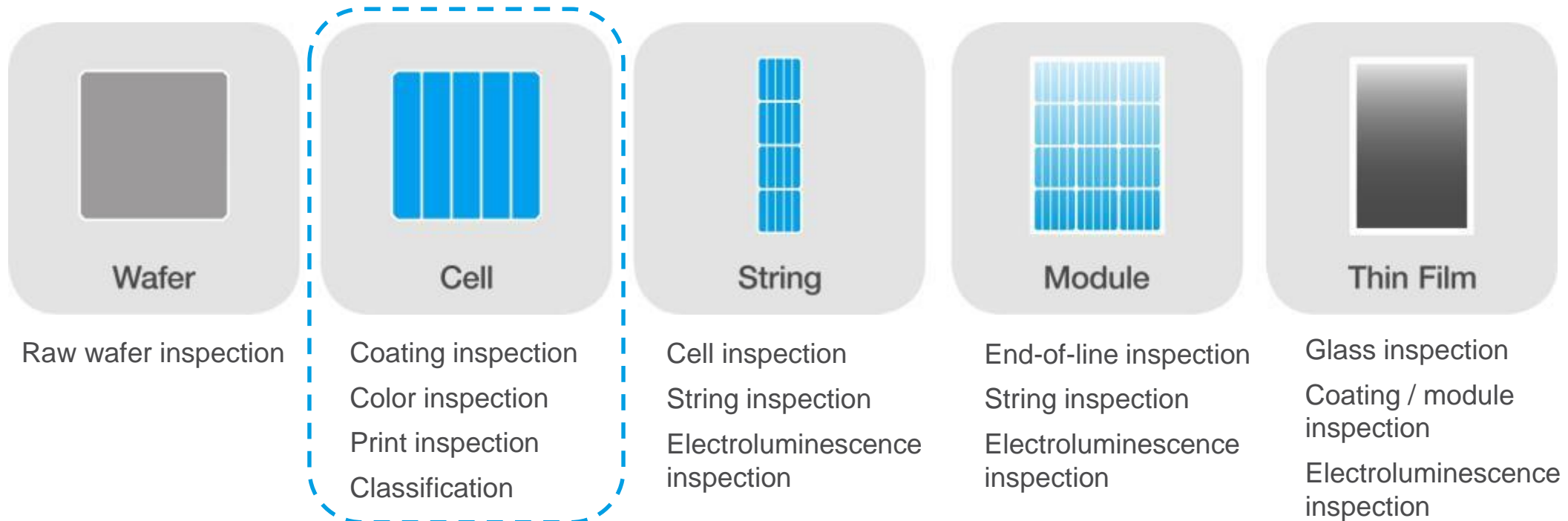


End-of-line inspection
String inspection
Electroluminescence
inspection



Glass inspection
Coating / module
inspection
Electroluminescence
inspection

AOI FOR EVERY STEP OF PV PRODUCTION



ALMOST STANDARD: AOI IN CELL TESTER / SORTER

- Sorting into color classes
- Sorting into optical qualities
- helps to reject cells that could cause later degradation e.g. bad firing, bad metallization, print interruptions, uneven coating, improper laser openings, missing rear side print, residues from chemicals,...
- Higher yield performance due to less over-rejects (overkill) and hardly any slippage (underkill)

Wafer
income
inspection



Texture
inspection



Coating
inspection



Print
inspection



Inspection
in cell
tester / sorter



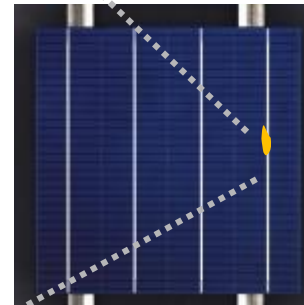
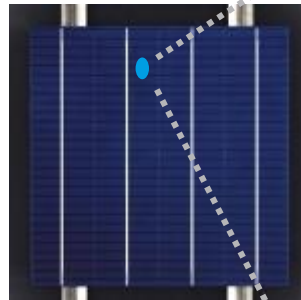
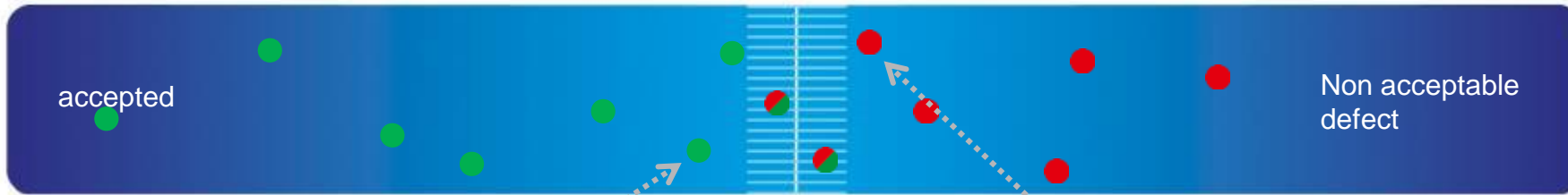
FEATURES OF HIGH PERFORMANCE AOI

- High throughput: 3.600, 4.500 cells/h and beyond
- Fast and guided system setup and calibration
- Future-proof for PERC, PERT, MWT, IBC, HJT, bifacial cells,....
- Central recipe management across all locations (identical quality, consistent data)
- Central performance and yield control
- Relevant data accessible throughout the fabs – big data – Industry 4.0

RELIABLE CLASSIFICATION THROUGH SMALL UNCERTAINTY RANGE

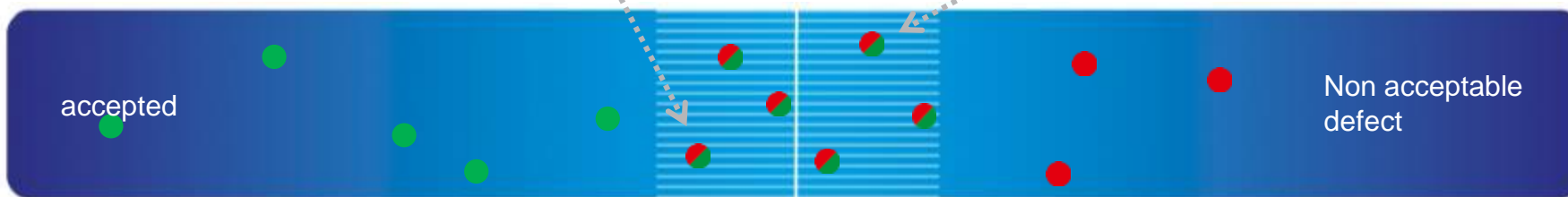
VITRONIC

Small uncertainty range



COMPETITORS

Wide uncertainty range



Risk for underkill and overkill

BEST YIELD PERFORMANCE PROOFED

	Production (no. of wafers)	Grade A (no. of wafers)	Overkill (A-class cells in B-class)	Underkill (B-class cells in A-class)
VITRONIC	100,000	90,000	less than 2 %	less than 0.3%
Competitor	100,000	80,000	more than 10%	less than 0.3%

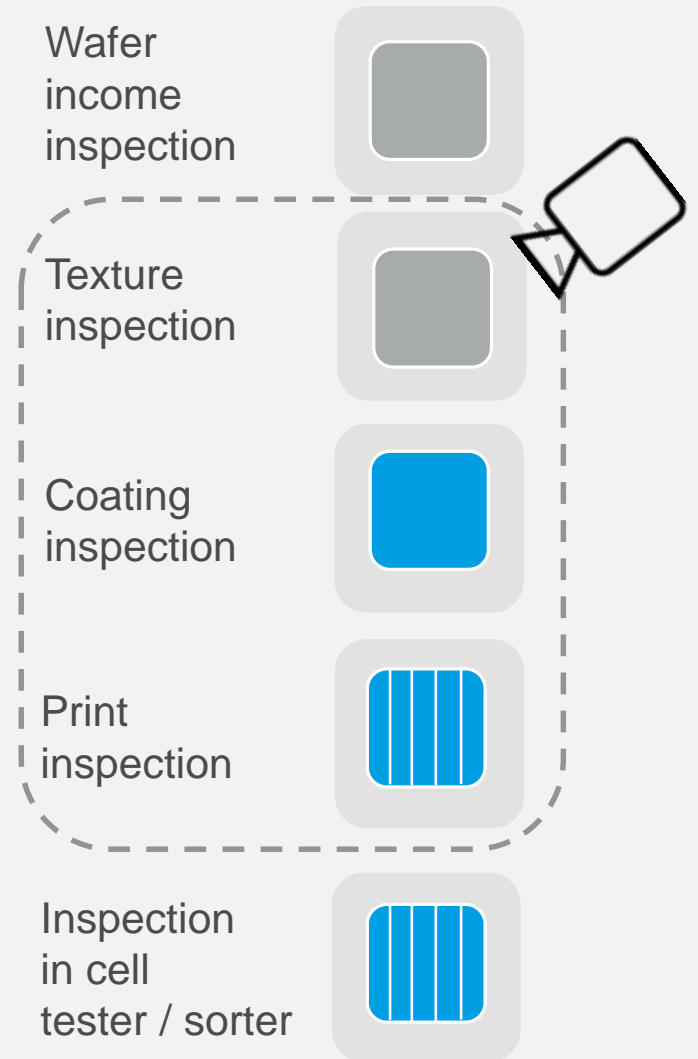
Benchmark test versus competitor (China 2017)

Direct comparison in same fab, same printers, manually resorted, figures rounded

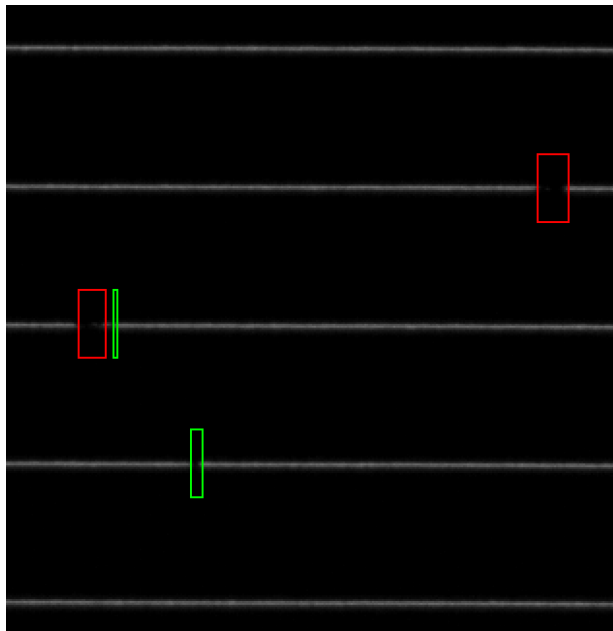
PROCESS OPTIMIZATION FOR INCREASING EFFICIENCY

Inline process control after every production step ensures

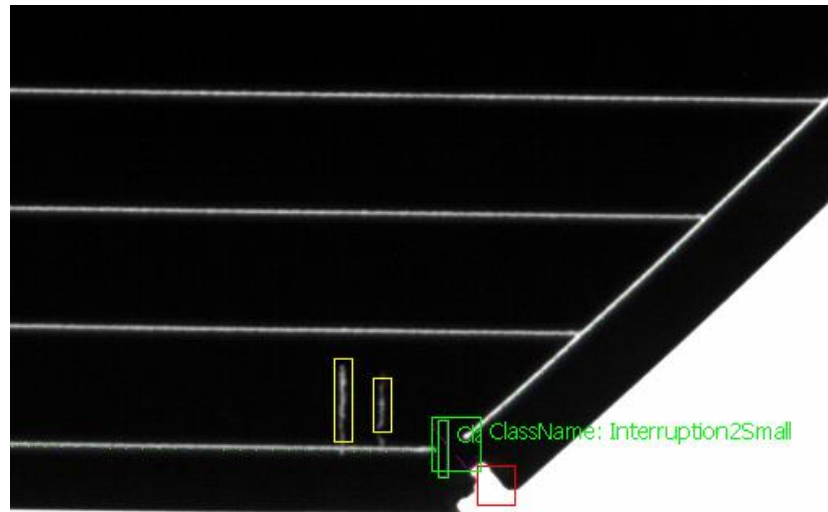
- reduction of scrap and reworking
- early detection of drifts of quality relevant parameters
- short feedback loop, that production parameters can be kept in a narrow tolerance range
- Leads to higher yield with higher quality!



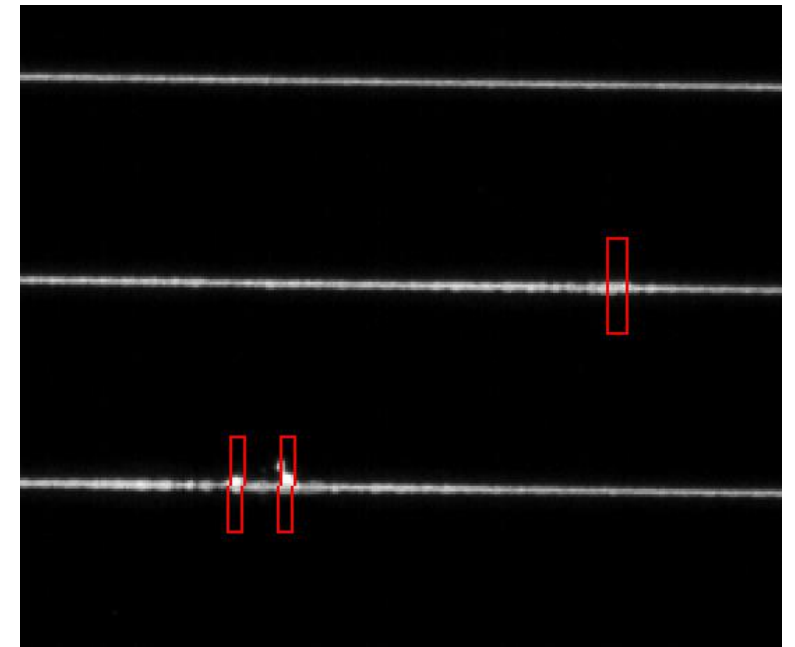
DEFECT SAMPLES FRONT PRINT



Large and small finger interruptions

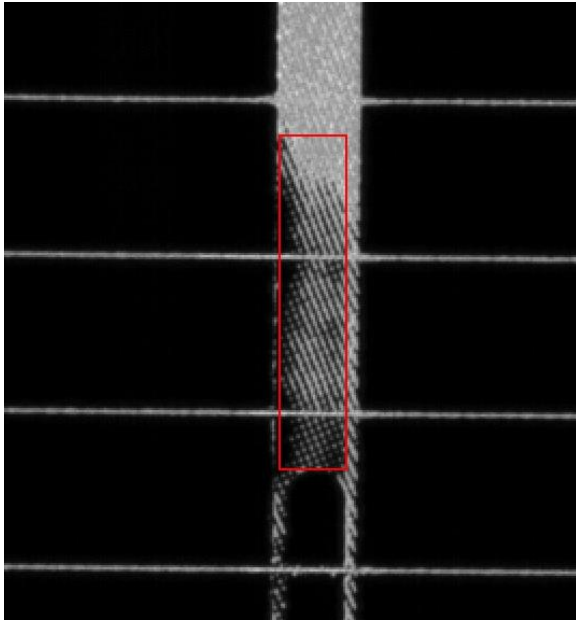


Paste stains, interruptions,
edge defects

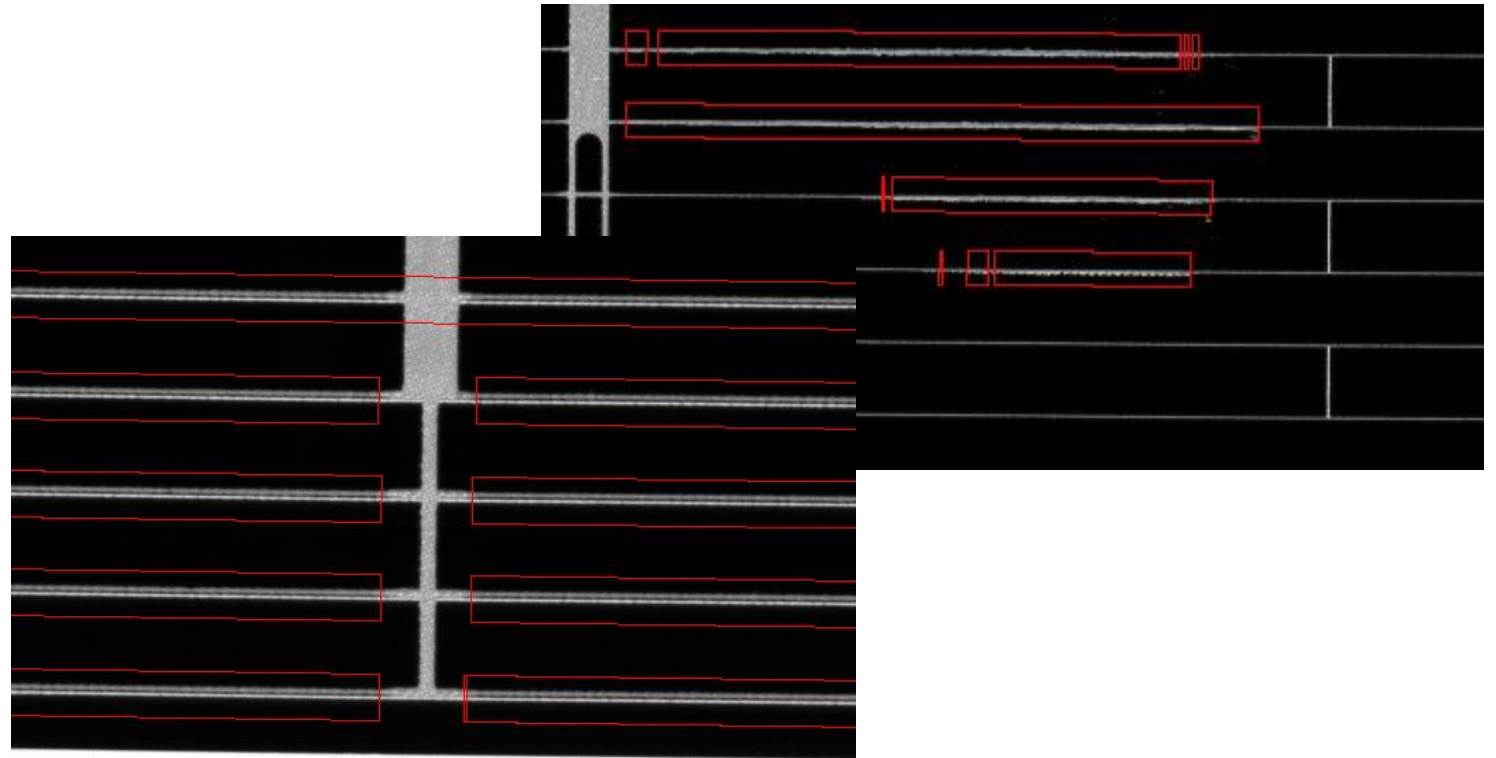


Finger bulges

DEFECT SAMPLES FRONT PRINT

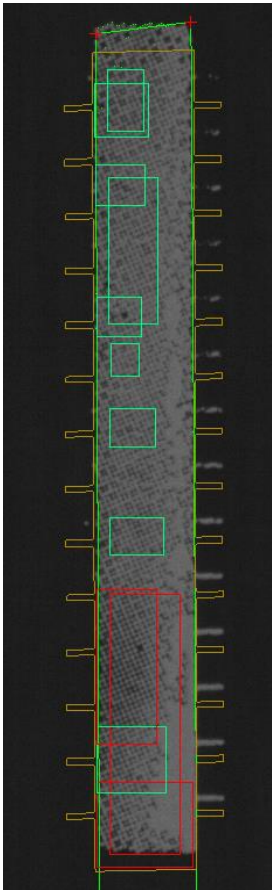


Busbar defects

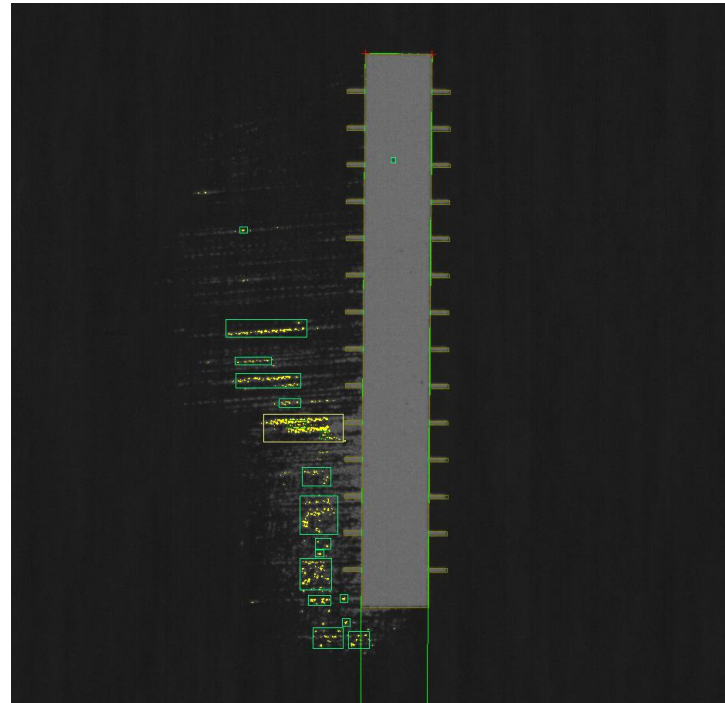
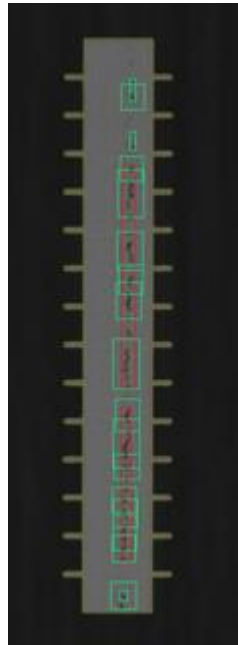


Misaligned double print and thick print

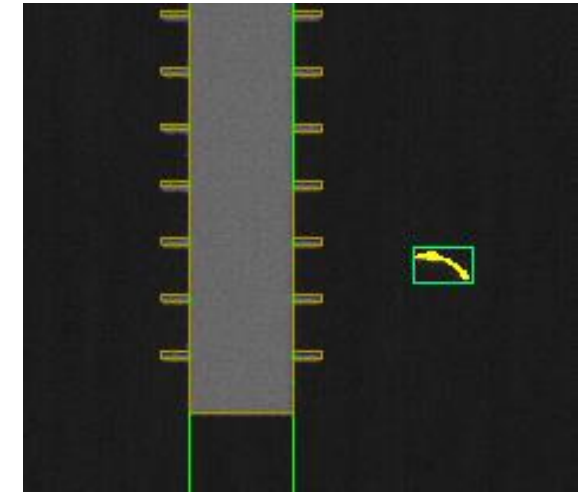
DEFECT SAMPLES REAR PRINT



Busbar Defects



Paste Smear

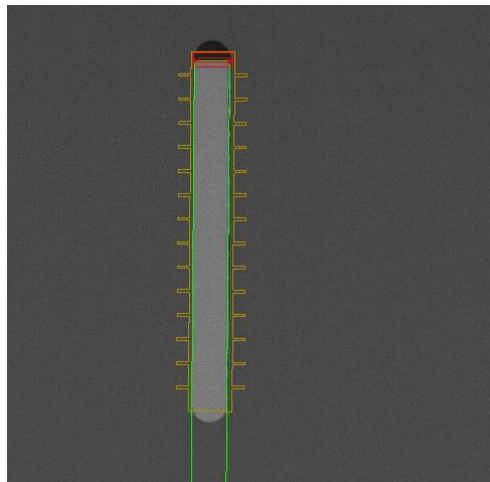


Paste Stains

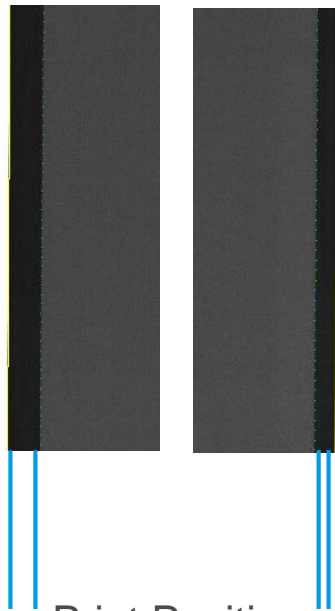


Edge Defects

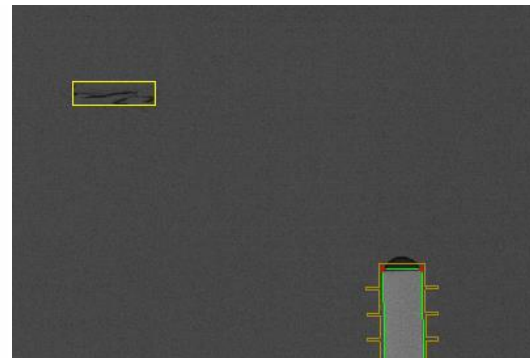
DEFECT SAMPLES REAR PRINT



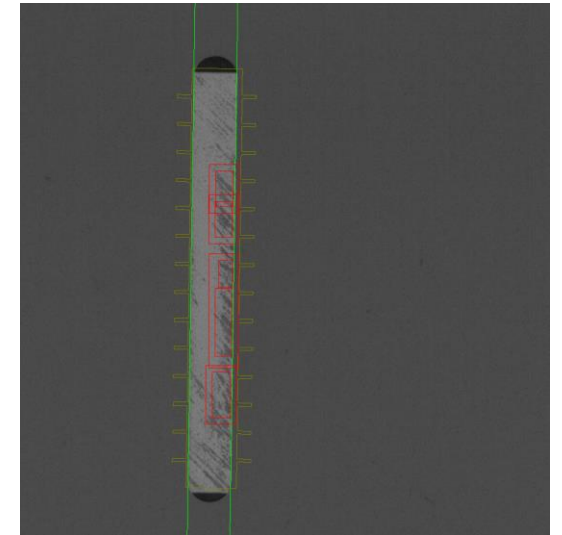
Print alignment



Print Position



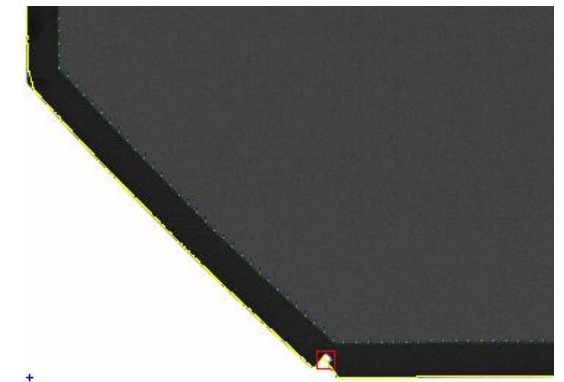
Scratch in Print



Busbar Defect



Missing Print



Edge Defect

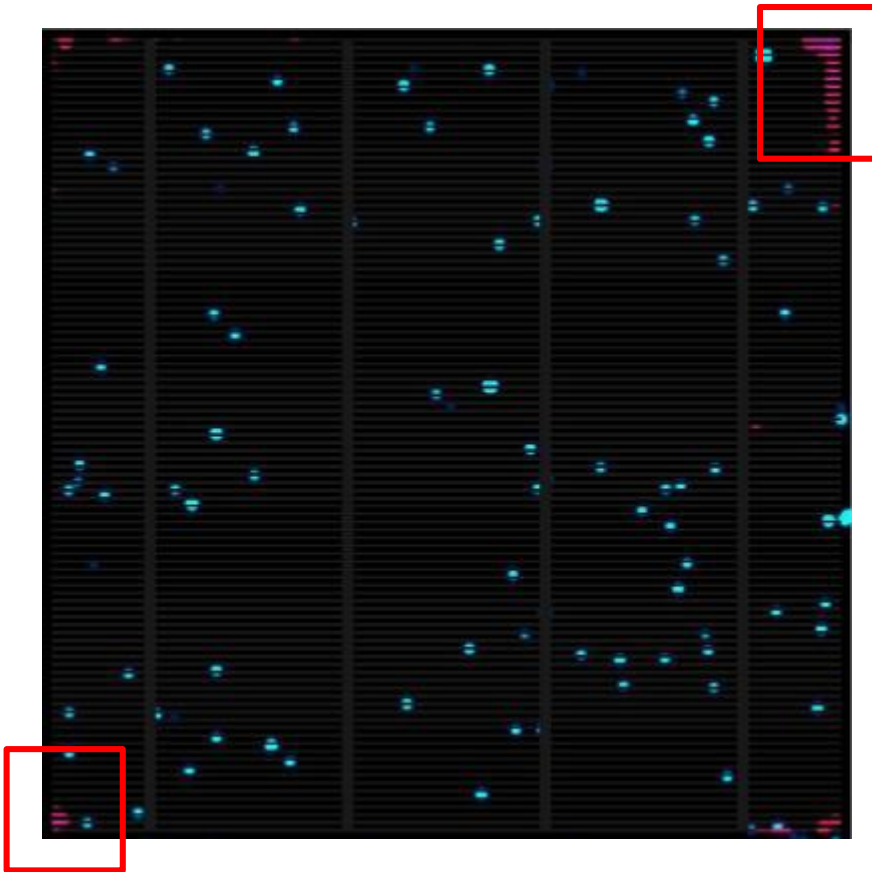
HEATMAP INDICATES DEVIATIONS AT AN EARLY STAGE



Ex.:

Early detection of wear of screen enables timely corrections

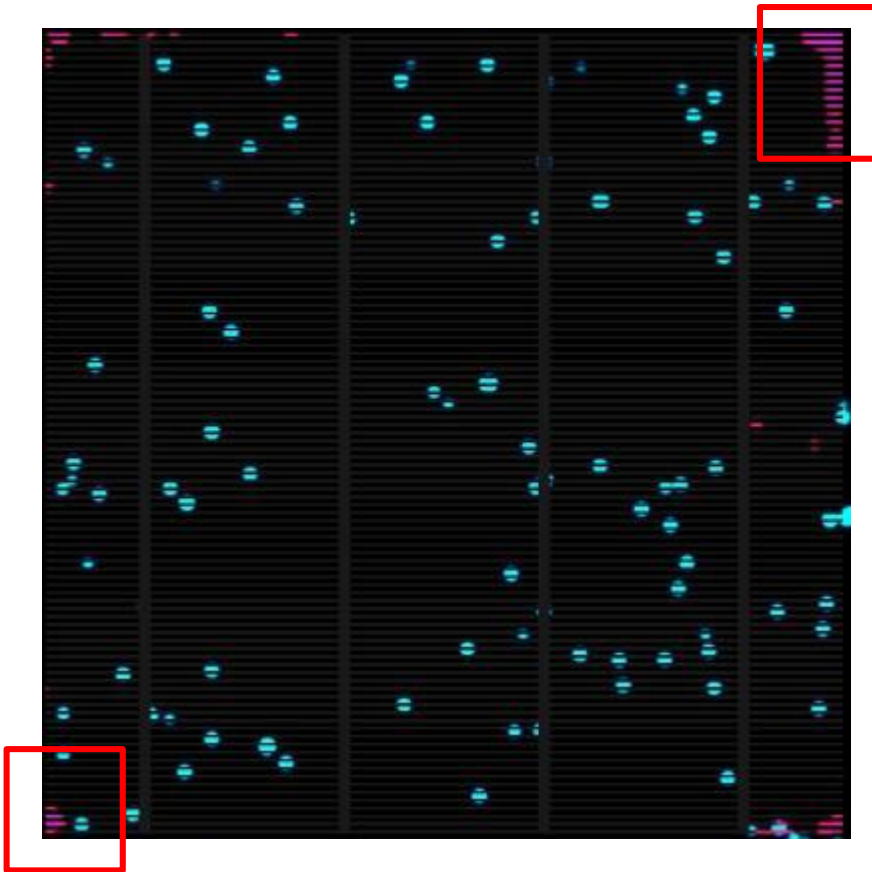
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Ex.:

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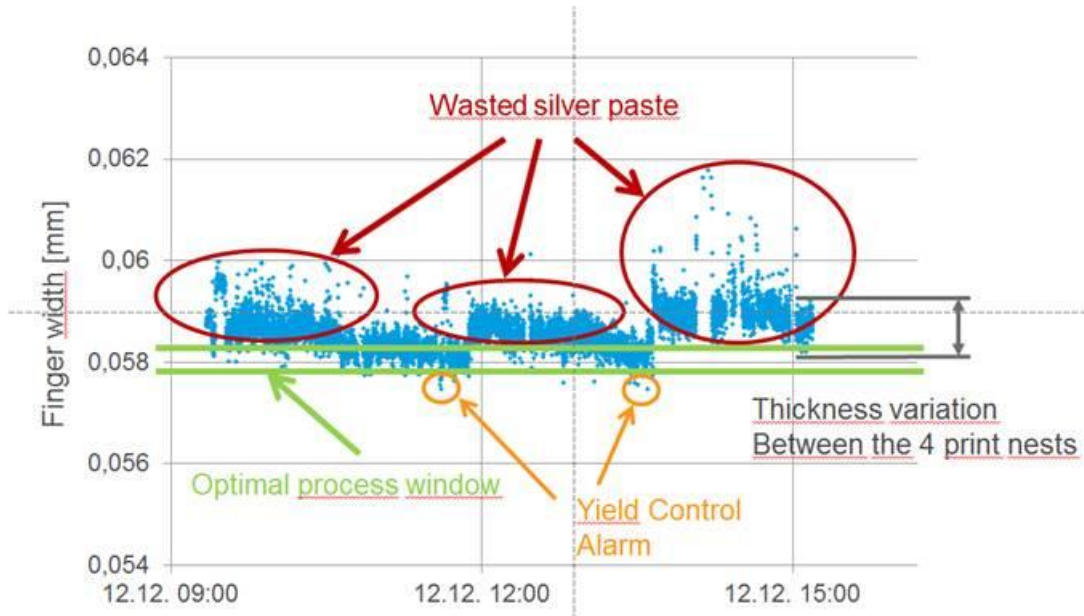
HEATMAP INDICATES DEVIATIONS AT AN EARLY STAGE



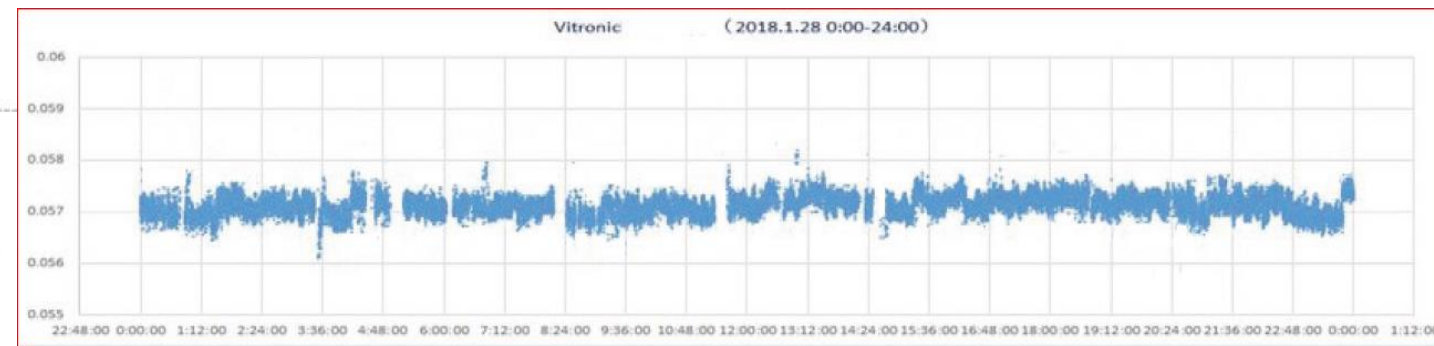
Ex.:

Early detection of wear of screen enables timely corrections

OPTIMIZATION OF PRINT QUALITY & SILVER CONSUMPTION



Smaller fingers with optimization:

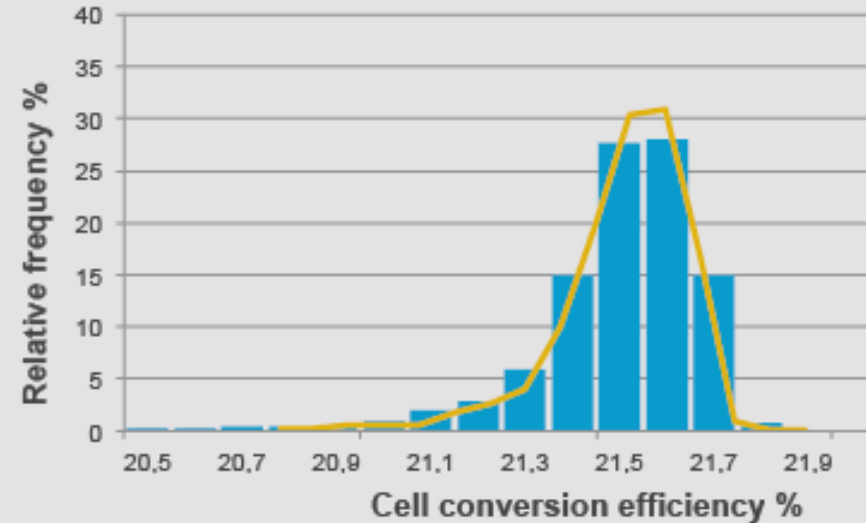
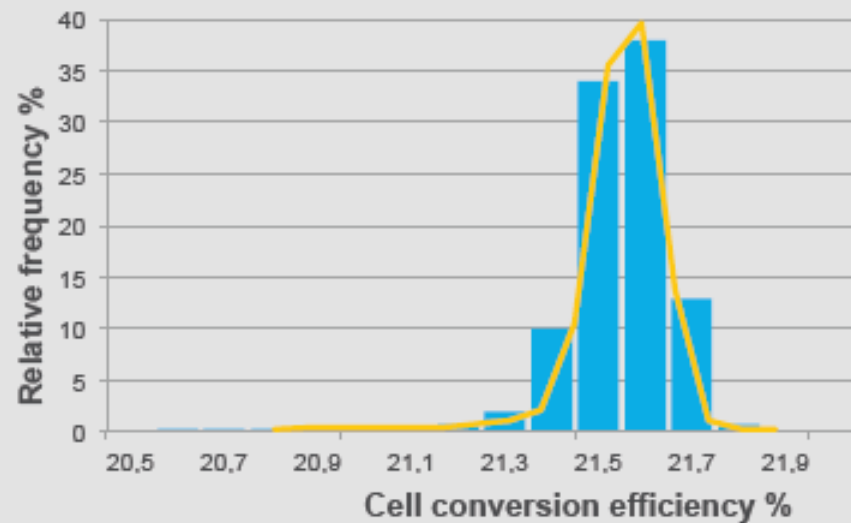


Feedback of finger width tracking leads to reduction of silver consumption

OPTIMIZATION OF CONVERSION EFFICIENCY

After process optimization

Normal efficiency distribution



Optimized coating process lead to optimized quality distribution

OPTIMIZATION OF PROCESS PARAMETERS

Benefits that pay off the invest for AOI within short:

- Elongation of screen lifetime (20-50 %) by optimizing process parameters, e.g. viscosity, screen position, pressure
- Reduction of silver consumption (1- 5 %) by minimizing finger width
- Reduction of downtime (10-30 %) by preventing printer stop
- Optimized quality distribution by keeping up optimal printer parameters
- Traceability and proof of produced quality – Industry 4.0

CONCLUSION & MISSION

Cell producers need to be pushed to

- integrate and consequently use high performance AOI and
- not just integrate low performance versions



WOULD YOU LIKE MORE INFORMATION?

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