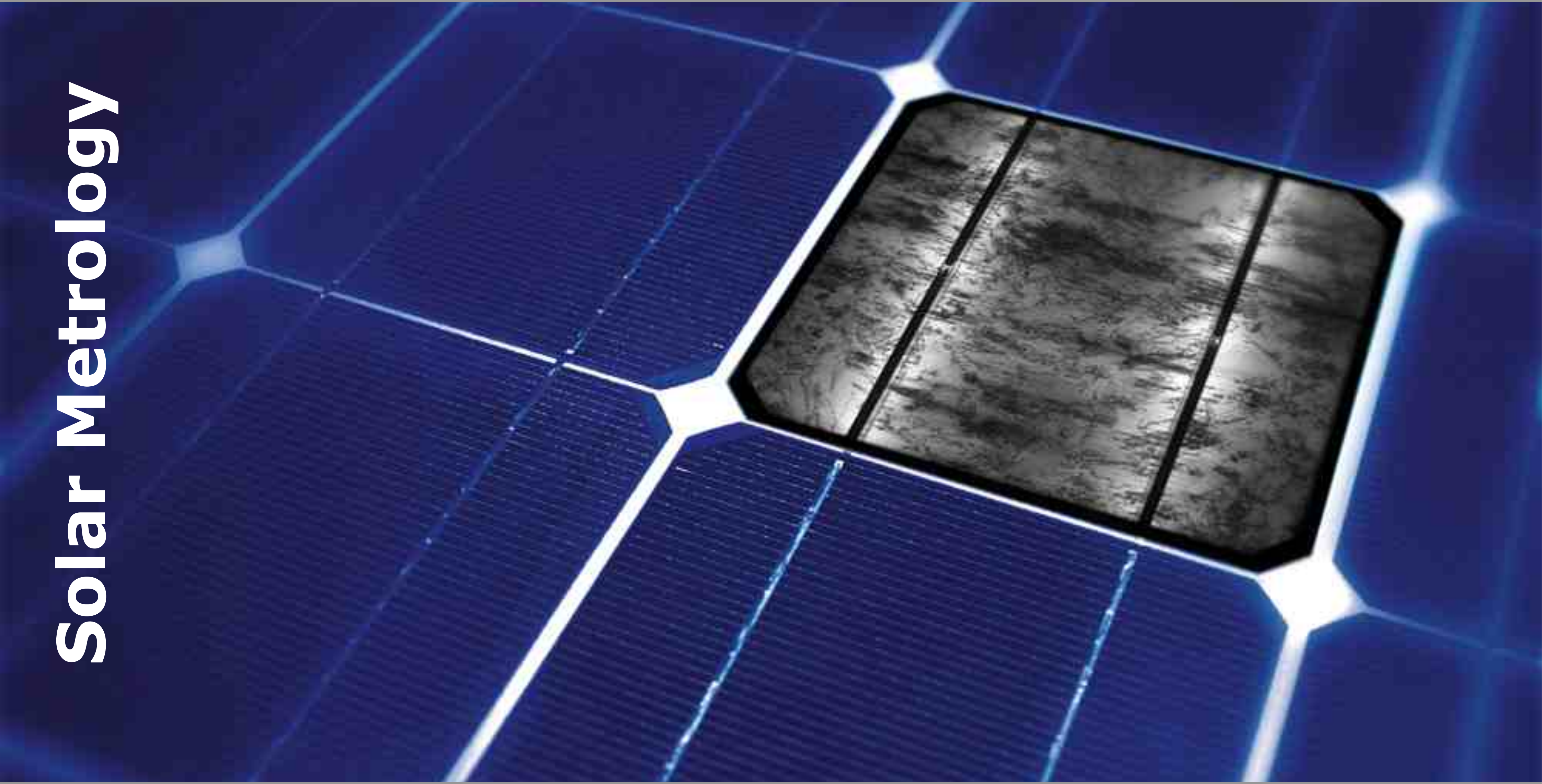
Solar Metrology



Metrology solutions for the complete value chain of solar cell and module production

Op-tection

In the next minutes you will:

- Get an introduction of the company Op-tection GmbH
- Get introduced to a selection of the metrology systems we built
- Discover the capabilities these systems provide you

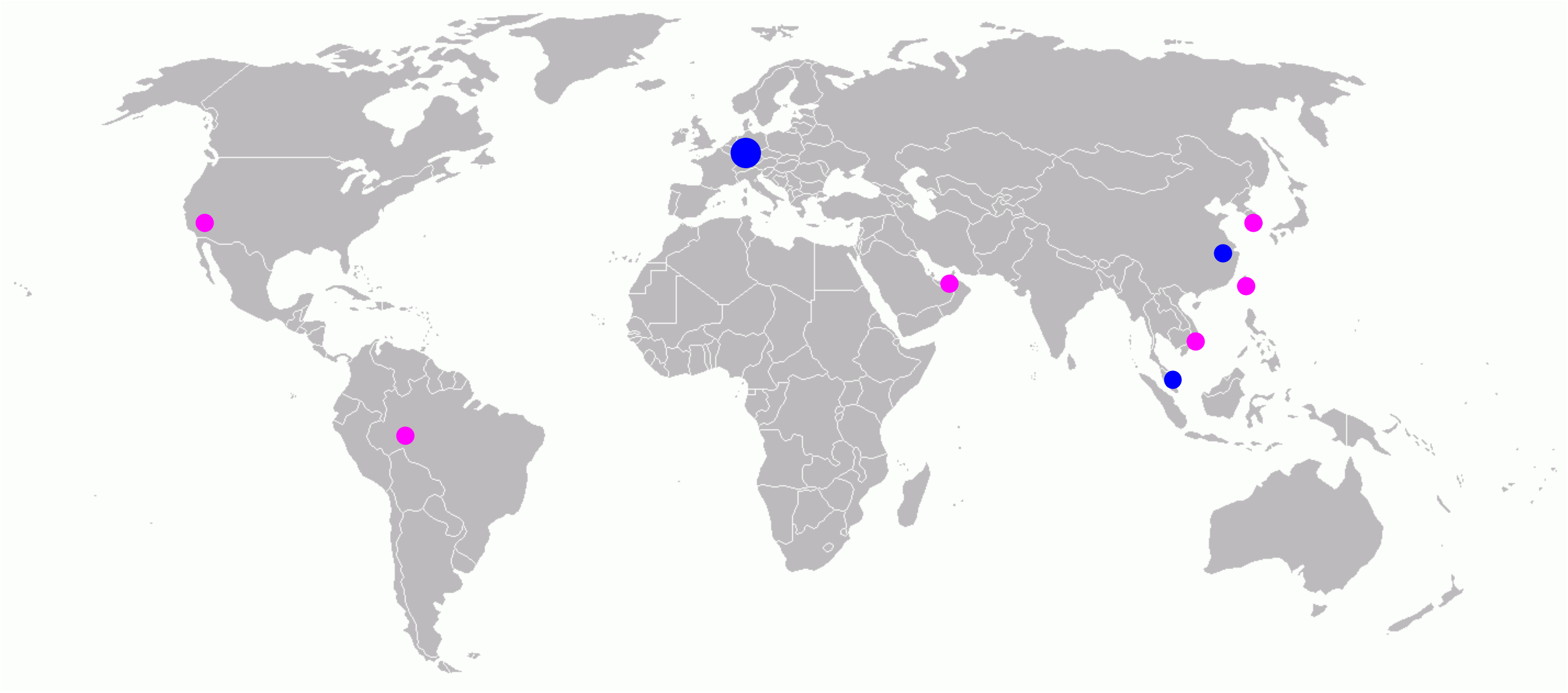
Op-tection GmbH...

Op-tection GmbH…

- was founded in 2005
- is located in Heinsberg, Germany
- **is specialized in optics, spectroscopy and image processing**
- benefits from a strong background in high-tech industries
- **successfully established its metrology solutions for the PV industry**
- helps it customers to create competitive advantages using advanced QC solutions

Present around the globe

- Headquarters in Germany
- North America
- South America
- China
- Taiwan
- Singapore
- Vietnam
- South Korea
- United Arab Emirates



Install Base

● Installation Sites

Isn’t it a great feeling to have everything under control?

Now you can!

Our metrology solutions for <u>all critical process steps</u> enable you to:

- Ensure using the **best raw materials**
- Produce solar cells and modules with **consistent high quality**
- Lower cost and create **attractive pricing** for your customers
- Create **ultimate trust** in you product using comprehensive QC solutions

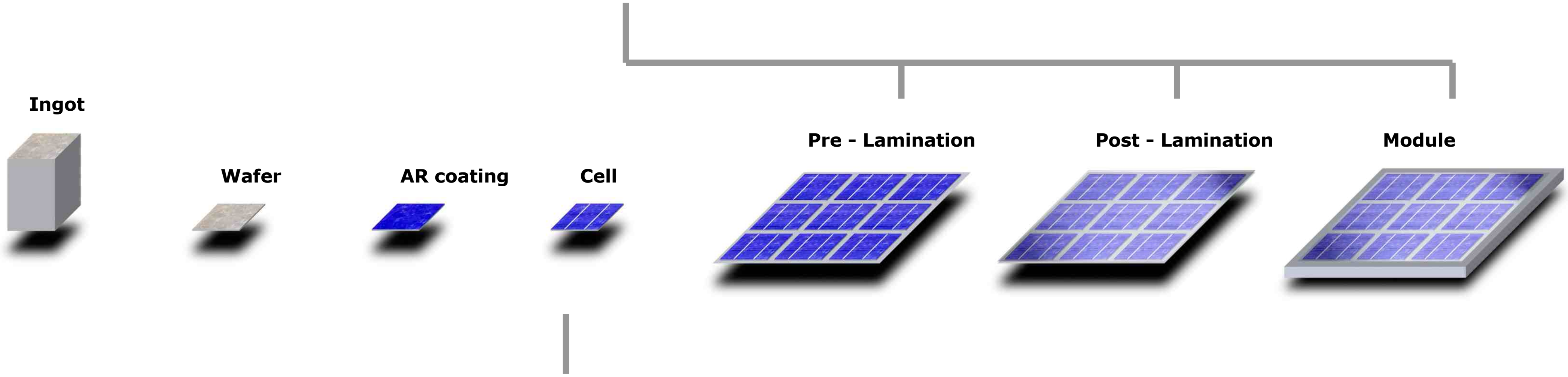
We provide dedicated metrology solutions for following processes:

- Inline SiNx Thickness and Refractive Index
- Stand-Alone SiNx Thickness and Refractive Index

- Inline Micro-crack
- Inline Wafer Reflectivity
- Inline Wafer Thickness
- Inline Dopant Weight

We provide dedicated metrology solutions for following processes:

- Inline & Stand-Alone String & Module EL before lamination
- Inline & Stand-Alone Module EL after lamination



- Inline Cell Electro Luminescence
- Stand-Alone Cell Electro Luminescence

OSIS Wafer

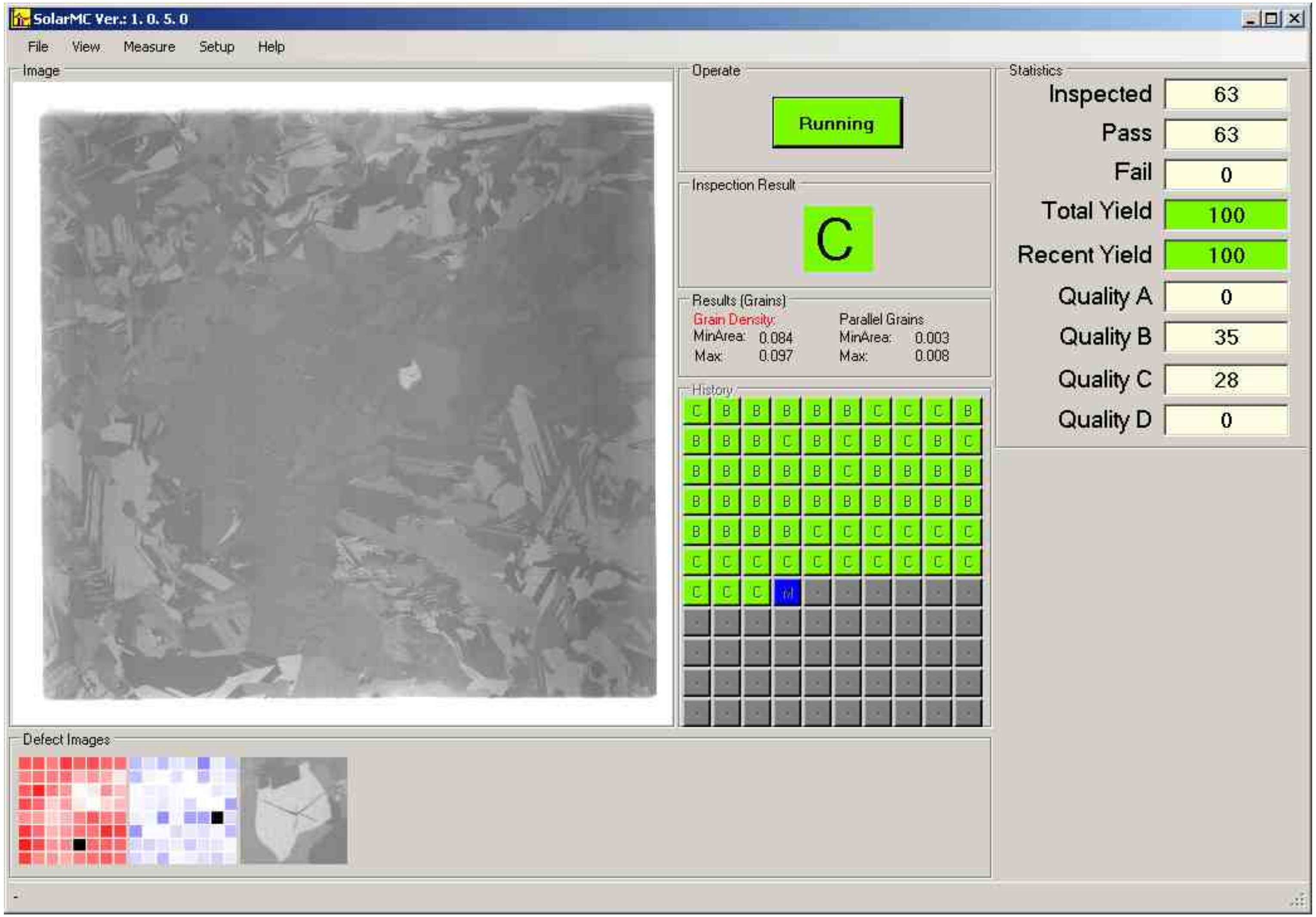
Inspection Items:

- Micro & macro cracks
- Inclusions & Holes
- Grain density & Geometry

Features and Capabilities:

- **High resolution** camera >> *4096 pixel / 40μm defect detection*
- On-the-fly scan >> ***No** downstream **interruptions** for measurement*
- Transmission NIR setup >> ***Bulk defect** and crack **detection***
- Full frame image >> *Wafer inspected to the edge; no cropping*
- Durable LED light source >> *No consumables; low maintenance cost*
- Full user access to images >> ***Better defect cause analysis***

OSIS Wafer: Presentation example



Results (Grains)

Grain Density		Parallel Grains	
MinArea:	0.084	MinArea:	0.003
Max:	0.097	Max:	0.008

History

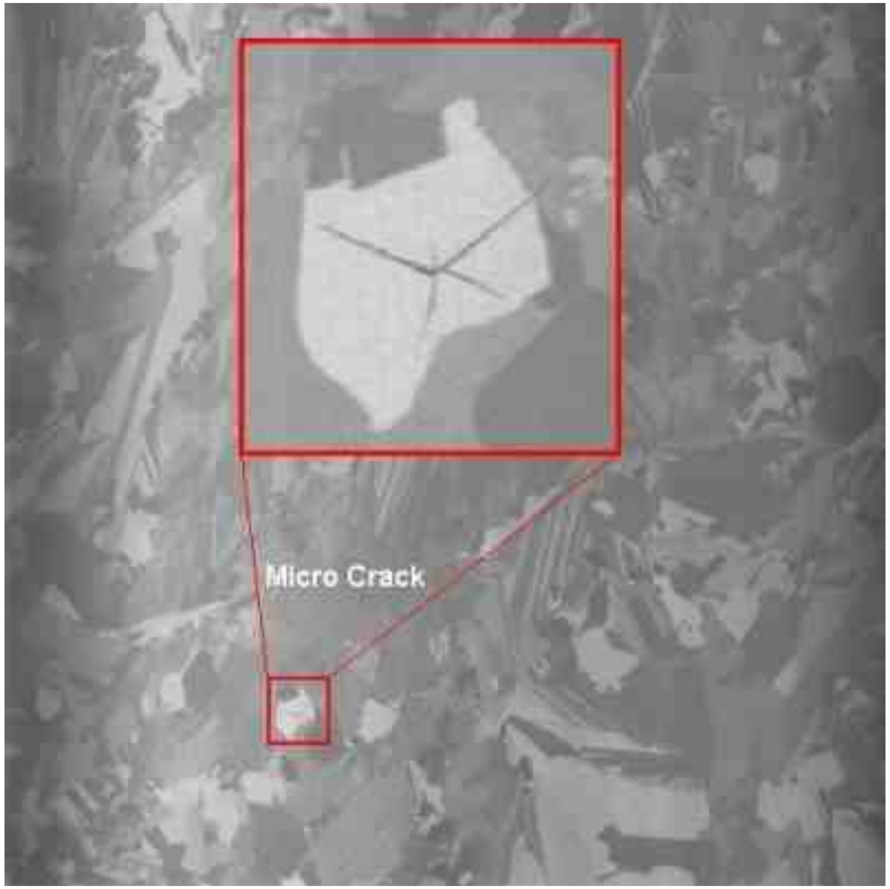
C	B	B	B	B	B	C	C	C	B
B	B	B	C	B	C	B	C	B	C
B	B	B	B	B	C	B	B	B	B
B	B	B	B	B	B	B	B	B	B
B	B	B	B	C	C	C	C	C	C
C	C	C	C	C	C	C	C	C	C
C	C	C	M	·	·	·	·	·	·
·	·	·	·	·	·	·	·	·	·
·	·	·	·	·	·	·	·	·	·
·	·	·	·	·	·	·	·	·	·
·	·	·	·	·	·	·	·	·	·

Statistics

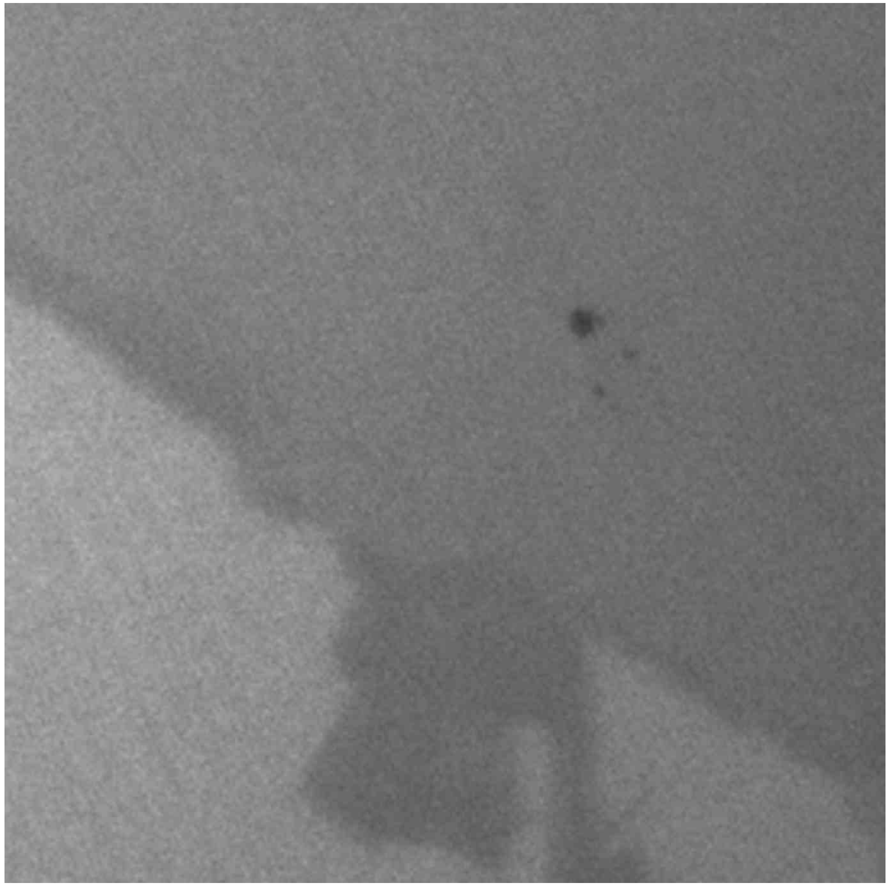
Inspected	63
Pass	63
Fail	0
Total Yield	100
Recent Yield	100
Quality A	0
Quality B	35
Quality C	28
Quality D	0

- Image
- Result
- Defects
- Statistics

OSIS Wafer: Scan example

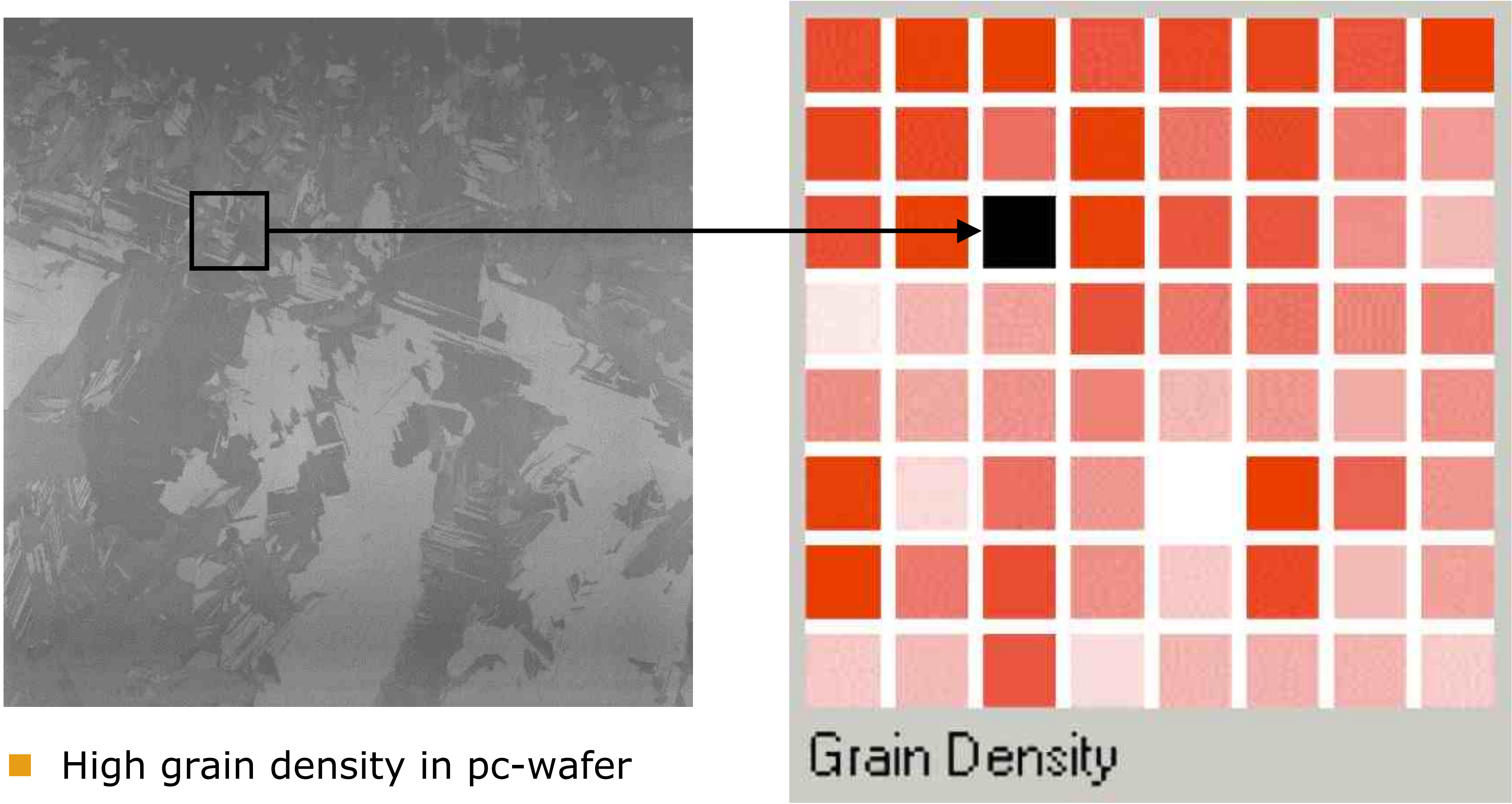


- Micro crack in pc-wafer



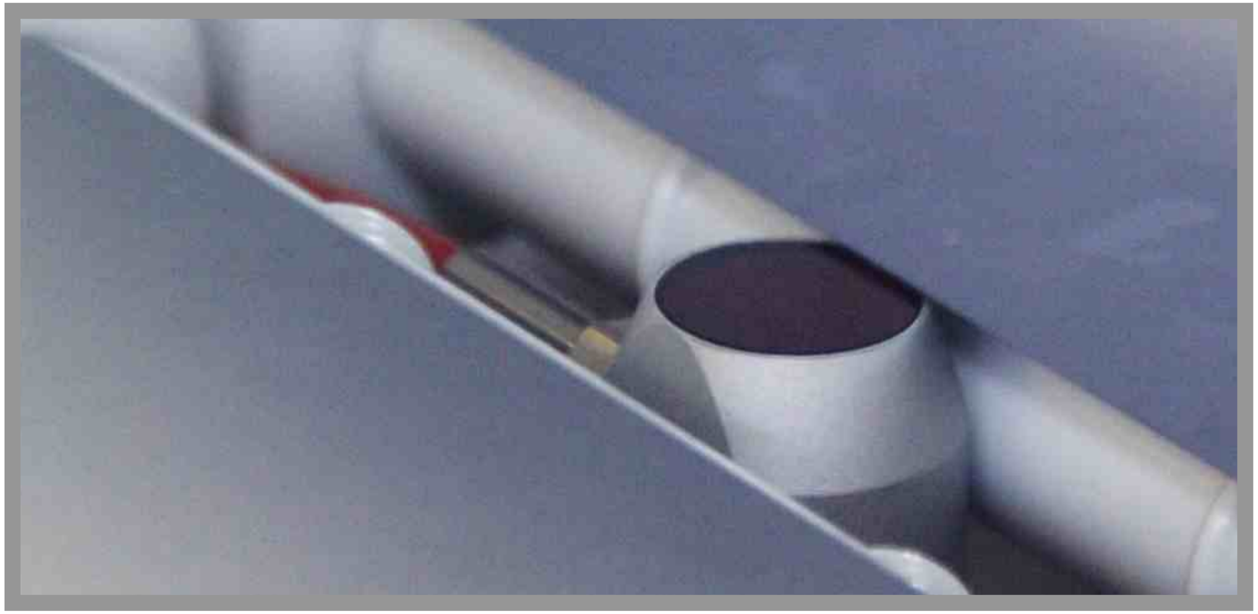
- Inclusion in pc-wafer

OSIS Wafer: Grain geometry and properties



- High grain density in pc-wafer

OSIS Texture



Inspection Items:

- **Wafer reflectivity**
- Reflectivity trend

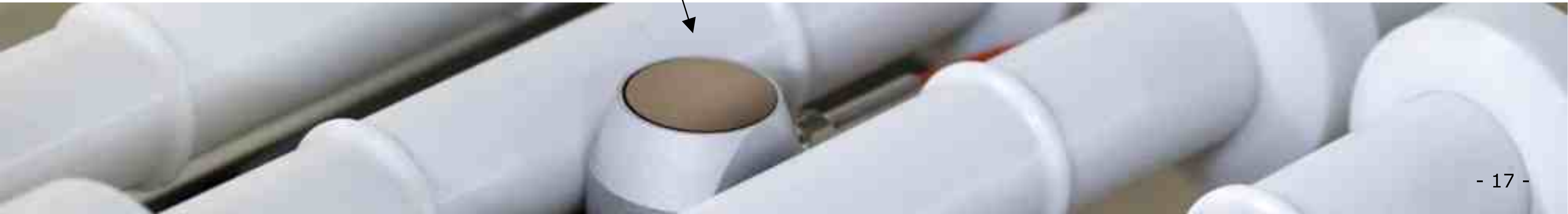
Features and Capabilities:

- Inline measurement >> *Significantly **less labor** than manual weighing*
- each wafer is measured >> ***Direct process feedback** (bath monitoring)*
- On-the-fly scan >> *No downstream interruptions for measurement*
- Wafer reflectance >> *Measure the target parameter directly*
- Self-referencing >> *Accurate and long-term stable*

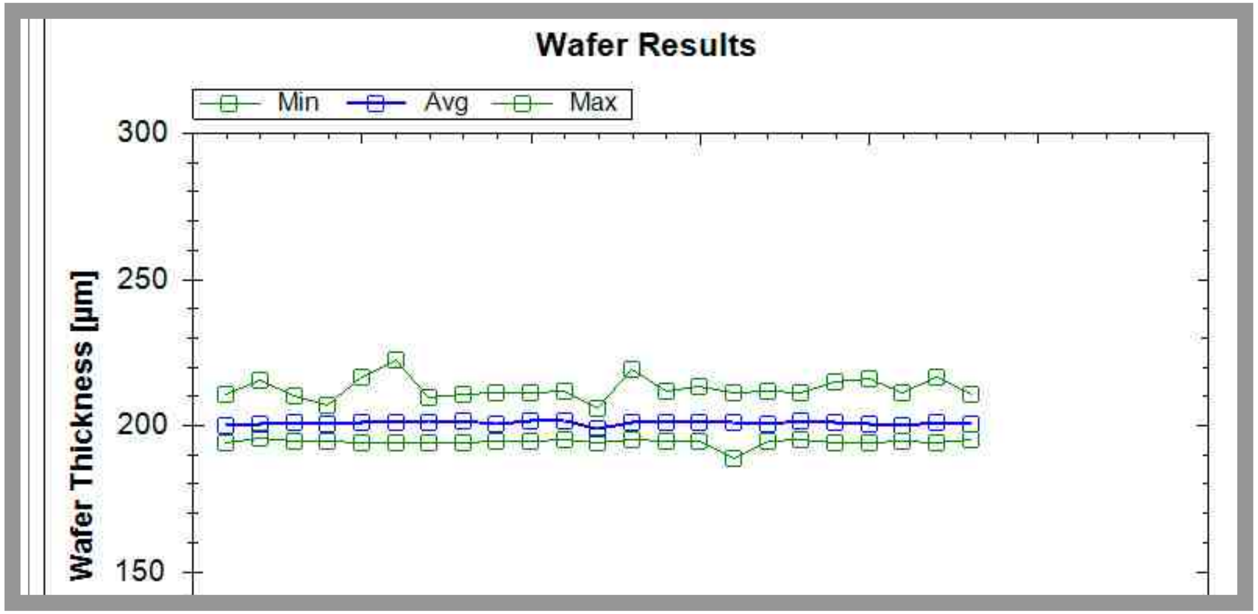
OSIS Texture

OSIS Texture

- Average reflectance per wafer
- Reflectance map of one wafer
- Reflectance trend of batch
- Small probe between tracks



OSIS Wafer Thickness



Inspection Items:

- Wafer Thickness

Features and Capabilities:

- Optical measurement >> ***Non-contact**, hence wafer is not touched*
- Fast inline measurement >> *No process bottle neck*
- For textured wafers >> *Measure the actual produced wafers directly*
- Thickness measurement >> ***Direct measurement of etch removal rate***
  (comparing before and after texturing)

OSIS Dopant

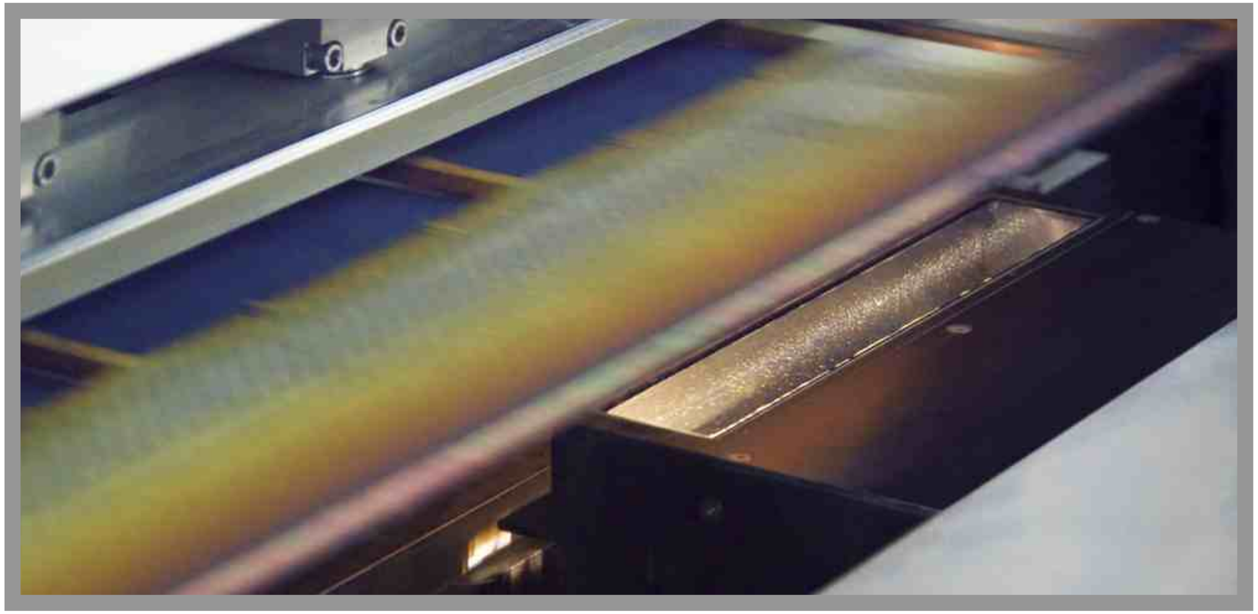
Inspection Items:

- H3PO4 Dopant Weight

Features and Capabilities:

- Optical measurement >> *Non-contact, hence wafer is not touched*
- Fast inline measurement >> *Quick process feedback*
- Weight trend >> ***No offline weighing** needed*

OSIS Coating



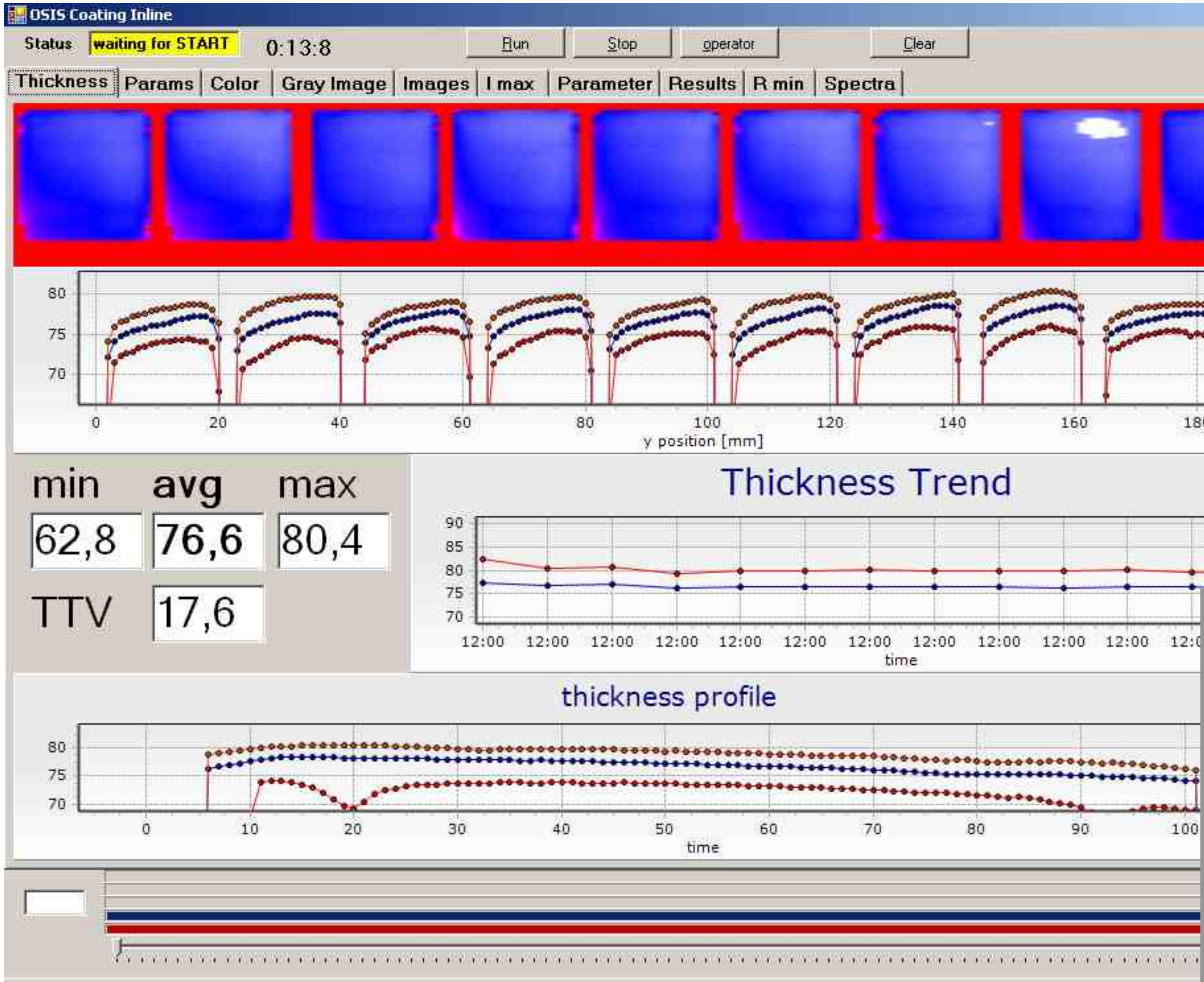
Inspection Items:

- SiN thickness
- SiN refractive index
- **Coating distribution**

Features and Capabilities:

Measure production wafers	>>	***Directly on the textured*** *mc- and pc-wafers*
Fast **inline measurement**	>>	*20x20 points in less than 0.5s*
Dense offline measurement	>>	*100x100 points in less than 15s*
Very accurate	>>	*directly comparable to conventional methods*
Inline version	>>	*direct process feedback,* ***faster ramp-up***

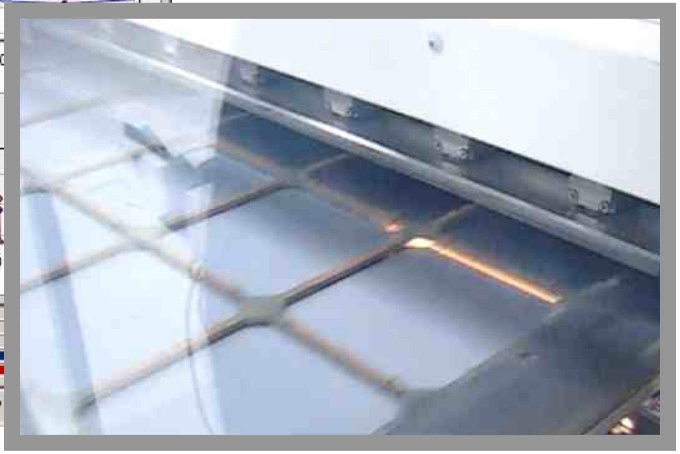
OSIS Coating Inline: Presentation example



Status waiting for START 0:13:8

min	avg	max
62,8	76,6	80,4

TTV 17,6



- Inline
- Real-Time
- On Wafer
- Over Carrier

OSIS Coating Inline: Presentation example

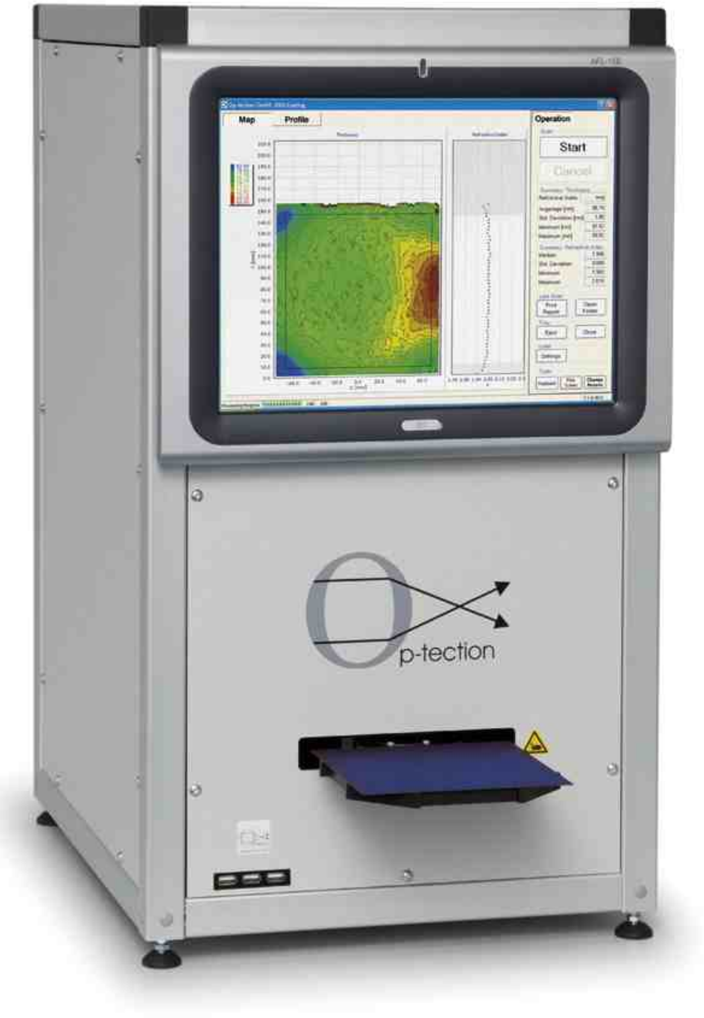
R.I. 2.141

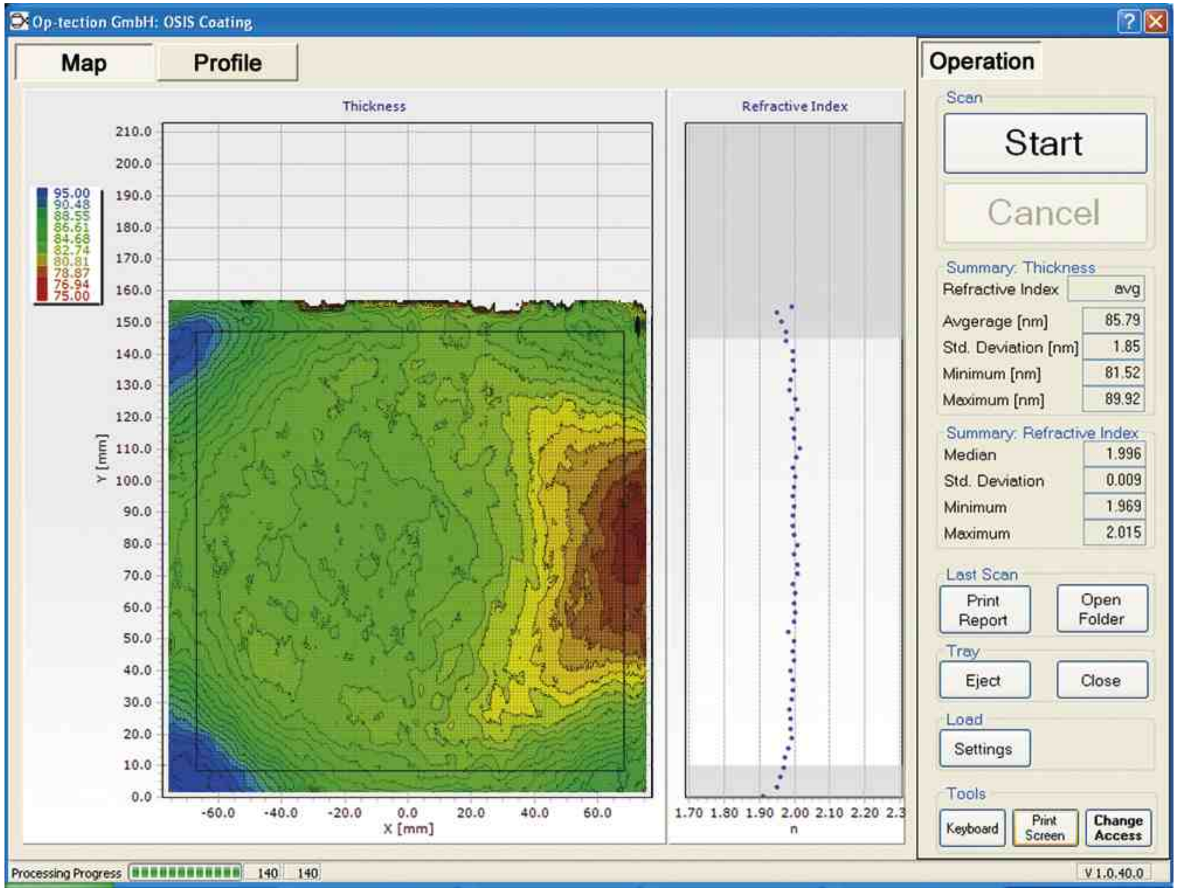
Th [nm] 85.44

2.0 %

- Inline
- Real-Time
- On Wafer
- Over Carrier

OSIS Coating: High-speed stand-alone system





Summary: Thickness
Refractive Index: avg
Avgerage [nm]: 85.79
Std. Deviation [nm]: 1.85
Minimum [nm]: 81.52
Maximum [nm]: 89.92

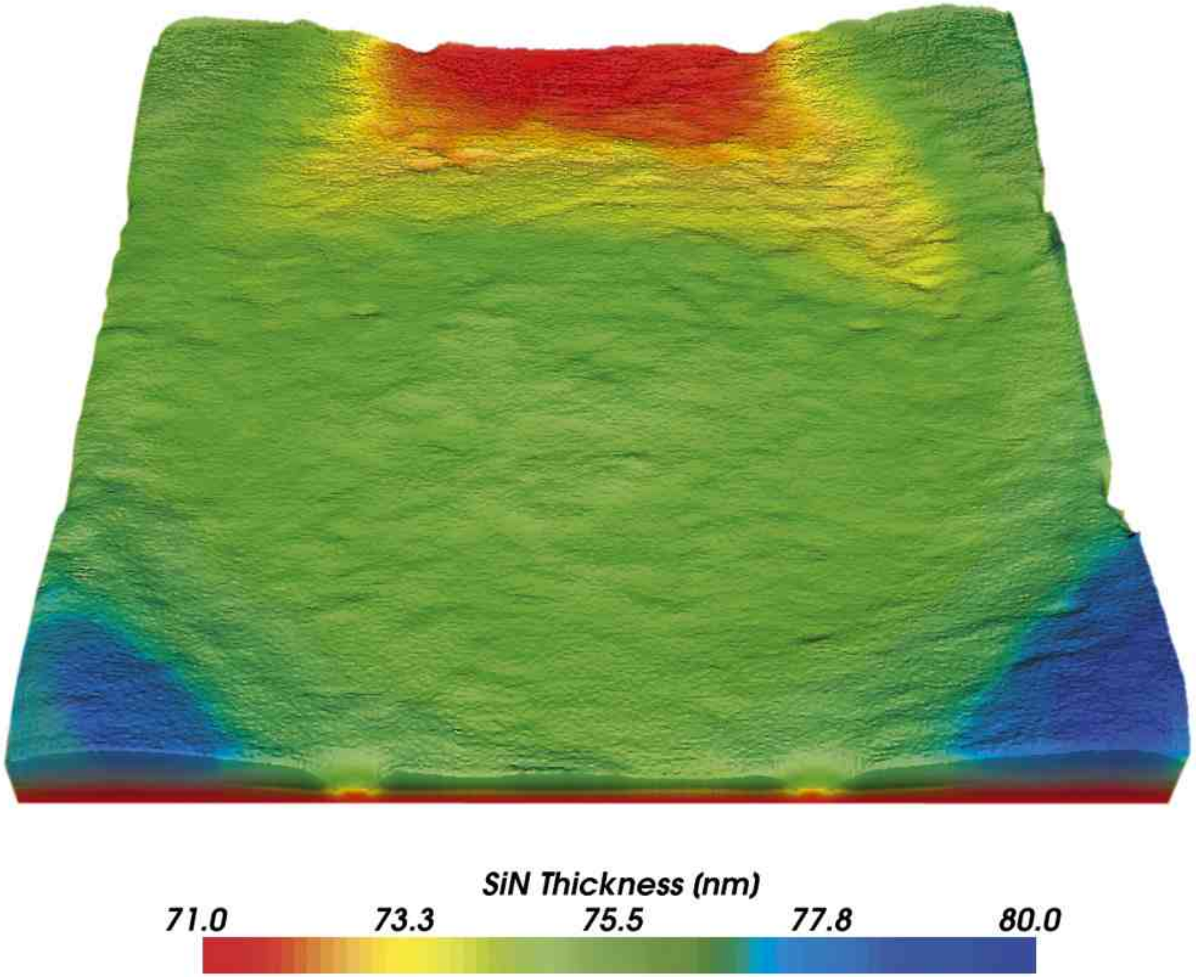
Summary: Refractive Index
Median: 1.996
Std. Deviation: 0.009
Minimum: 1.969
Maximum: 2.015

Processing Progress: 140 140

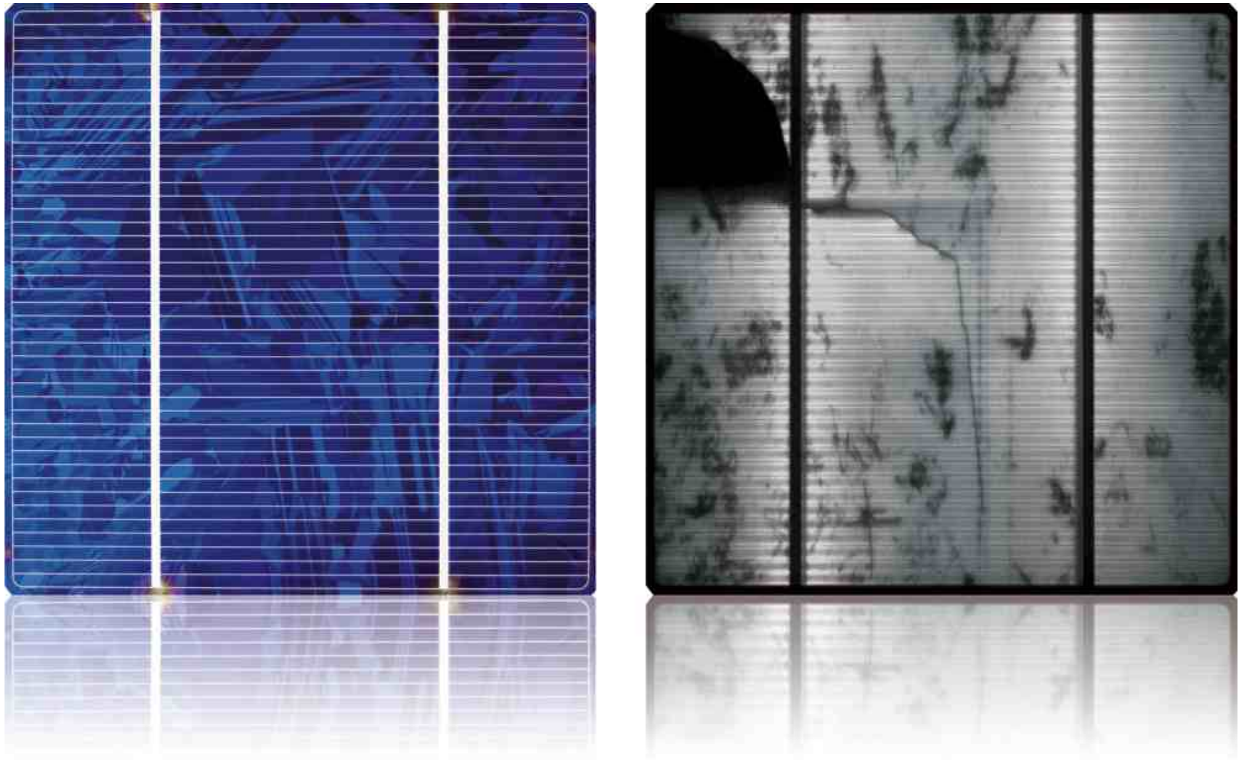
V 1.0.40.0

OSIS Coating: High-speed stand-alone system

- Dense distribution maps
- Distribution profiles
- Touchscreen operation
- Reporting functions
- USB, LAN, WLAN



OSIS Cell



<u>Inspection Items:</u>

- Cracks
- Dislocations
- Dark areas
- Shunts

<u>Features and Capabilities:</u>

- Defect detection by software >> ***Fast and consistent sorting***
- Adjustable quality limits >> *Convenient sorting*
- **Flexible platform** >> *Automatic + sorter / automatic / manual*
- Make the invisible visible >> *Find and diagnose process errors*

OSIS Cell: System versions

- Manual

- Automatic

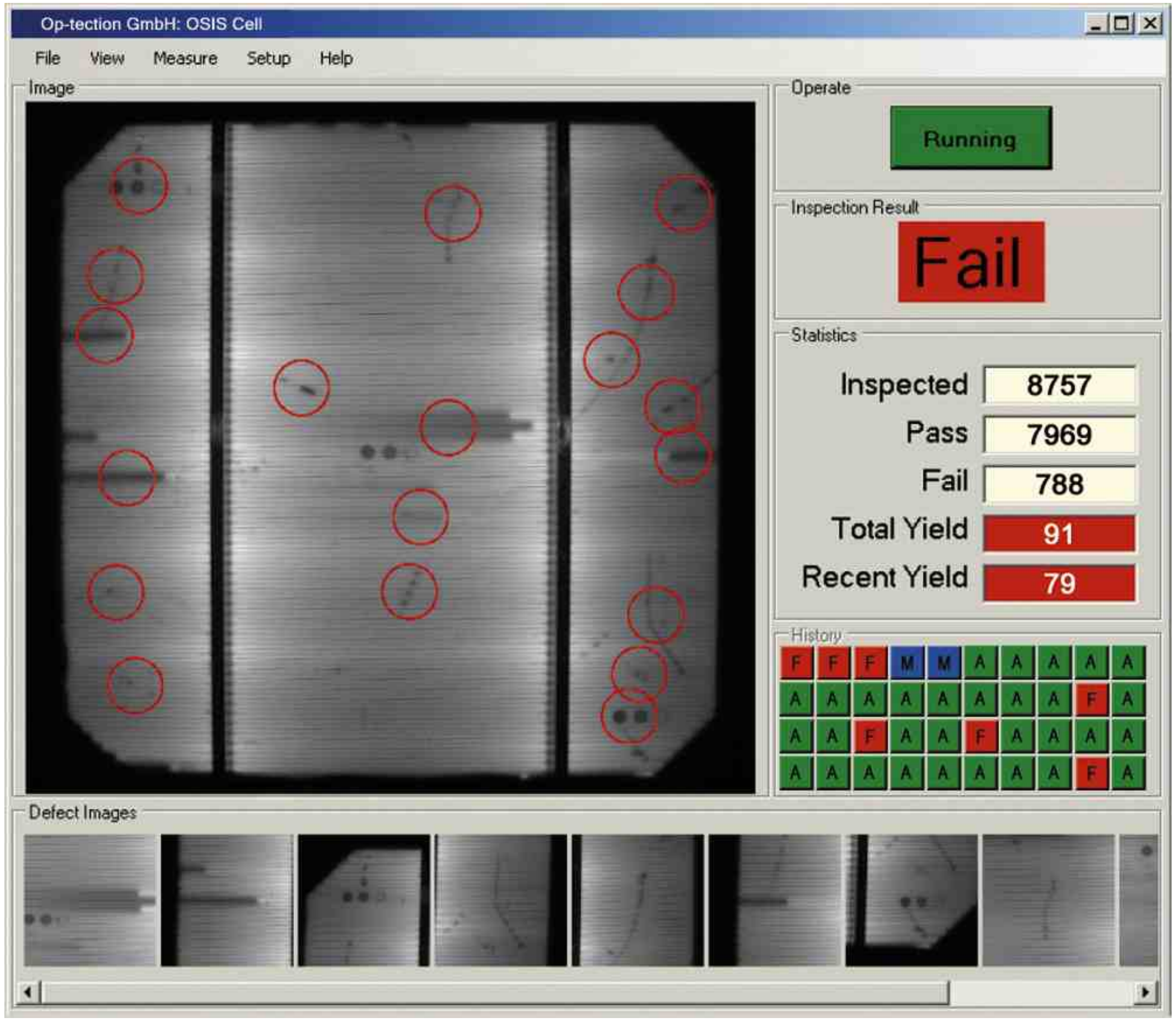
OSIS Cell: System versions

OSIS Cell: Cell Sorting

Highlights:

- 4 Input boxes
- 5 Sorting boxes/classes
- 1800 cells/hour
- automatic sorting
- gentle cell handling
- optional IV-tester
- optional AOI

OSIS Cell: Presentation example

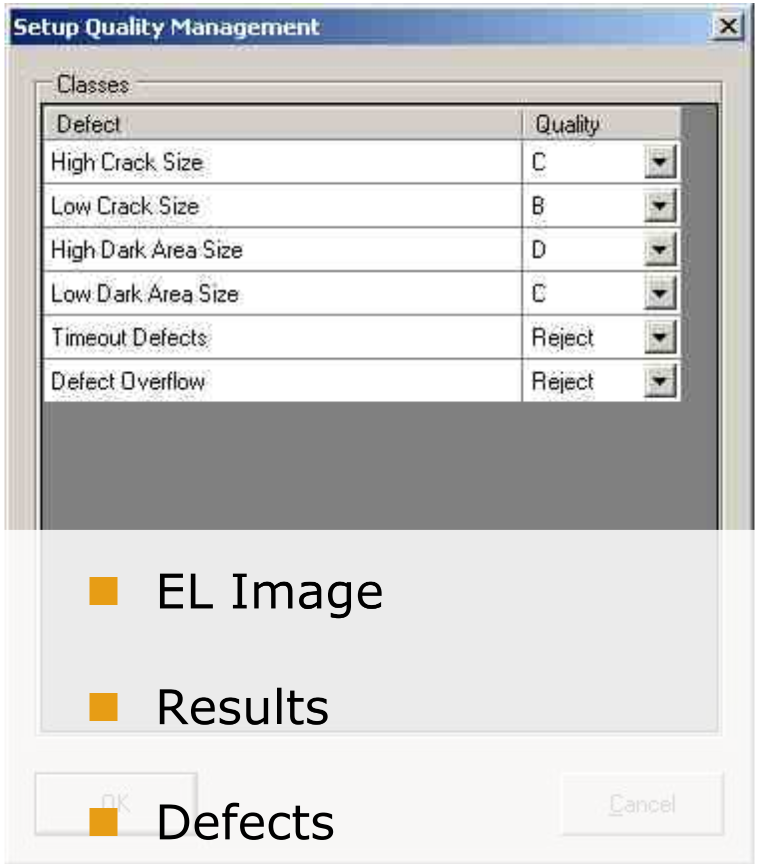


Inspection Result: **Fail**

Inspected	8757
Pass	7969
Fail	788
Total Yield	91
Recent Yield	79

History

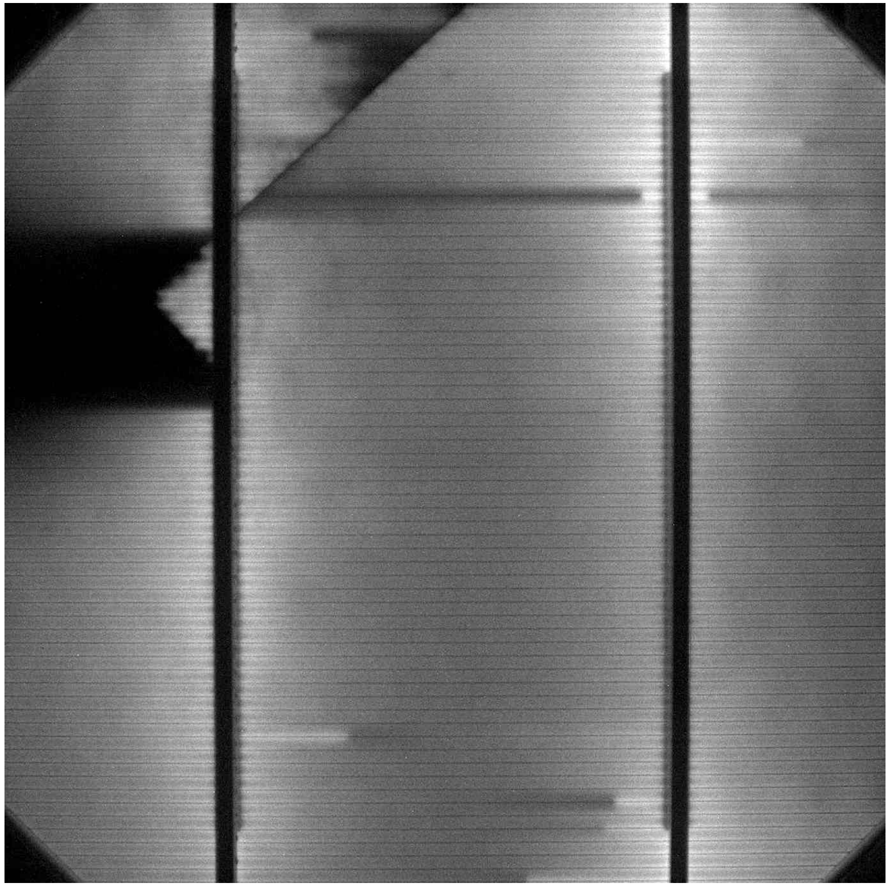
F	F	F	M	M	A	A	A	A	A
A	A	A	A	A	A	A	A	F	A
A	A	F	A	A	F	A	A	A	A
A	A	A	A	A	A	A	A	F	A

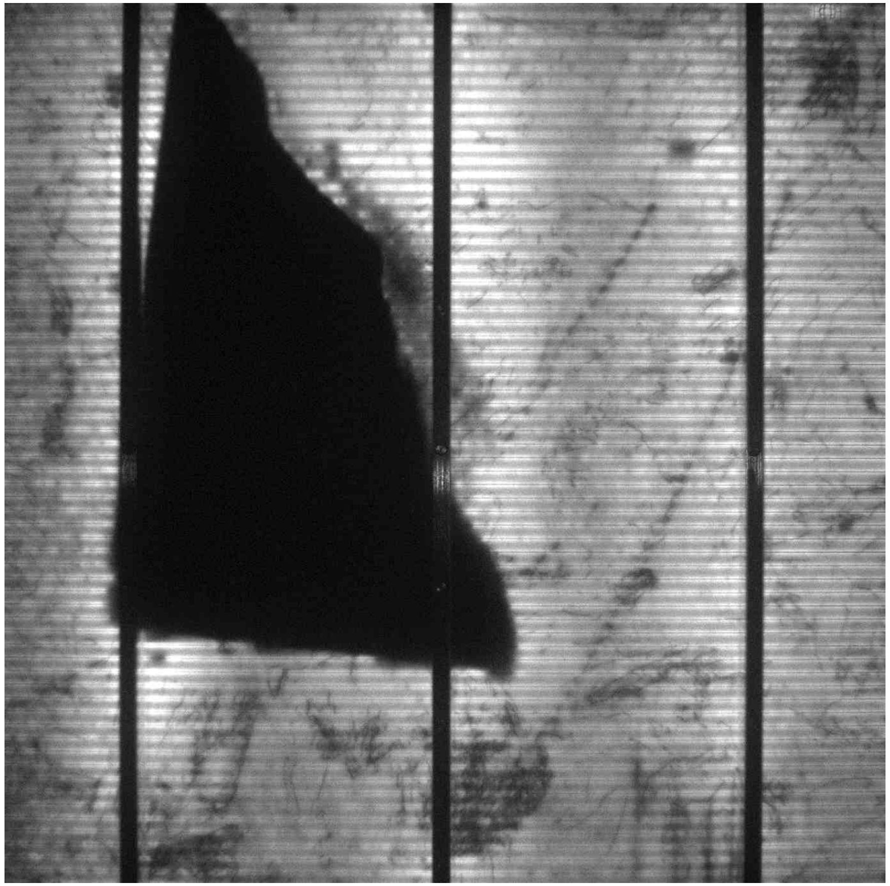


Defect	Quality
High Crack Size	C
Low Crack Size	B
High Dark Area Size	D
Low Dark Area Size	C
Timeout Defects	Reject
Defect Overflow	Reject

- EL Image
- Results
- Defects
- Statistics

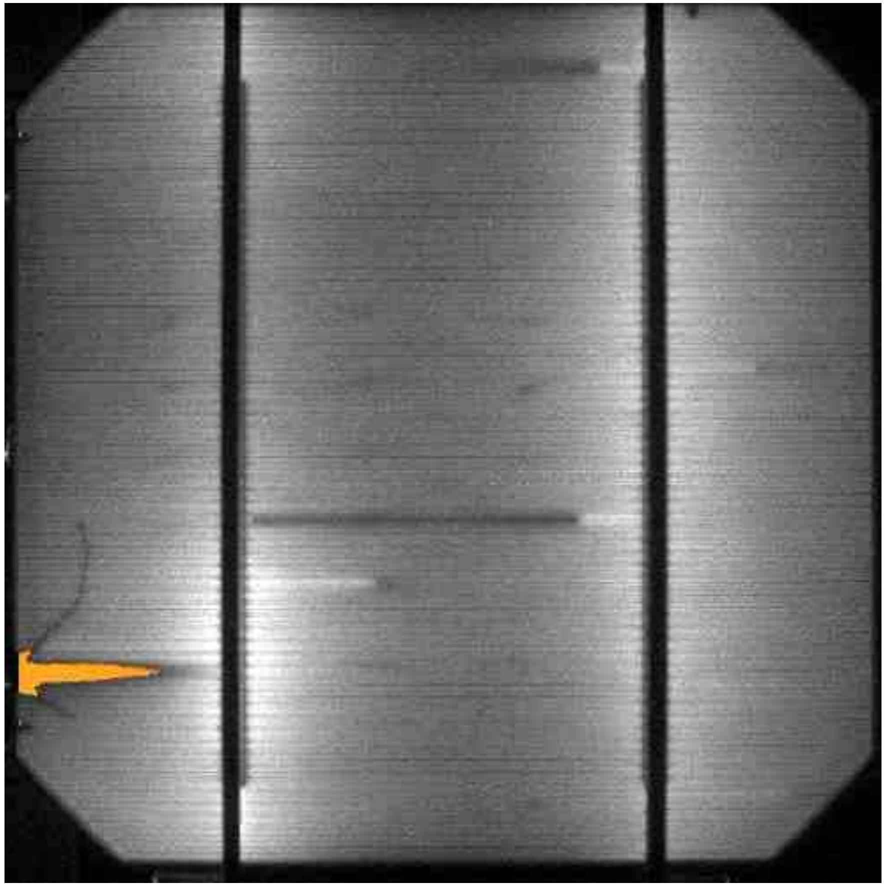
OSIS Cell: Measurement example



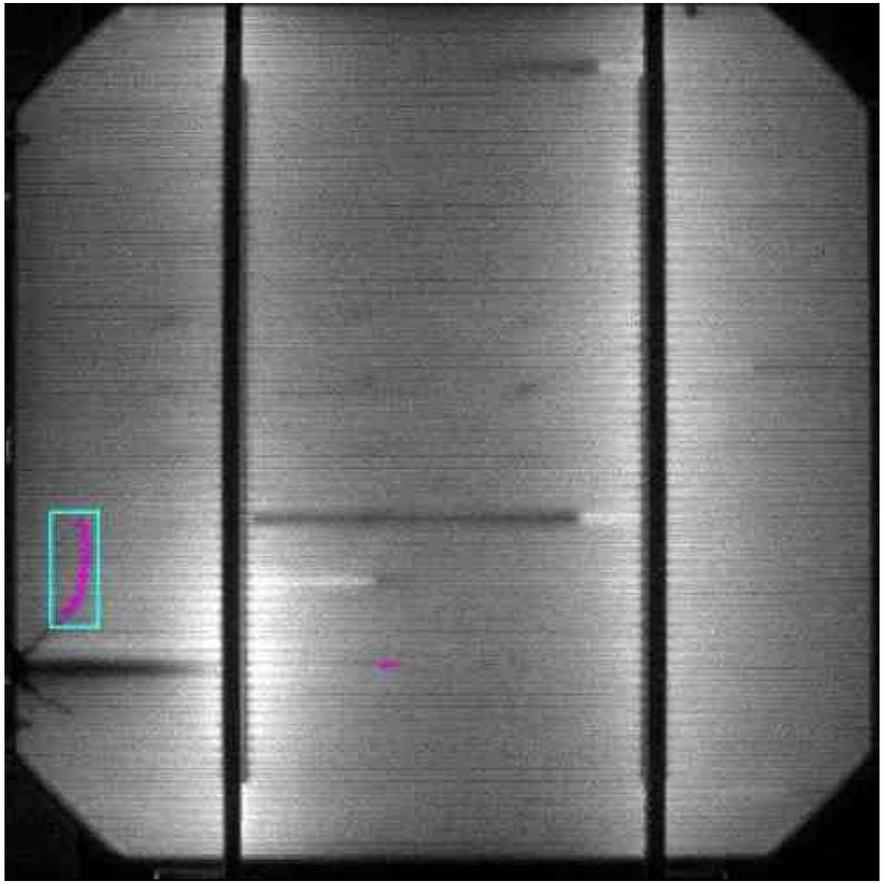


- mc-Cell with Crack & Shunt
- pc-Cell with missing pn-Junction

OSIS Cell: Measurement example

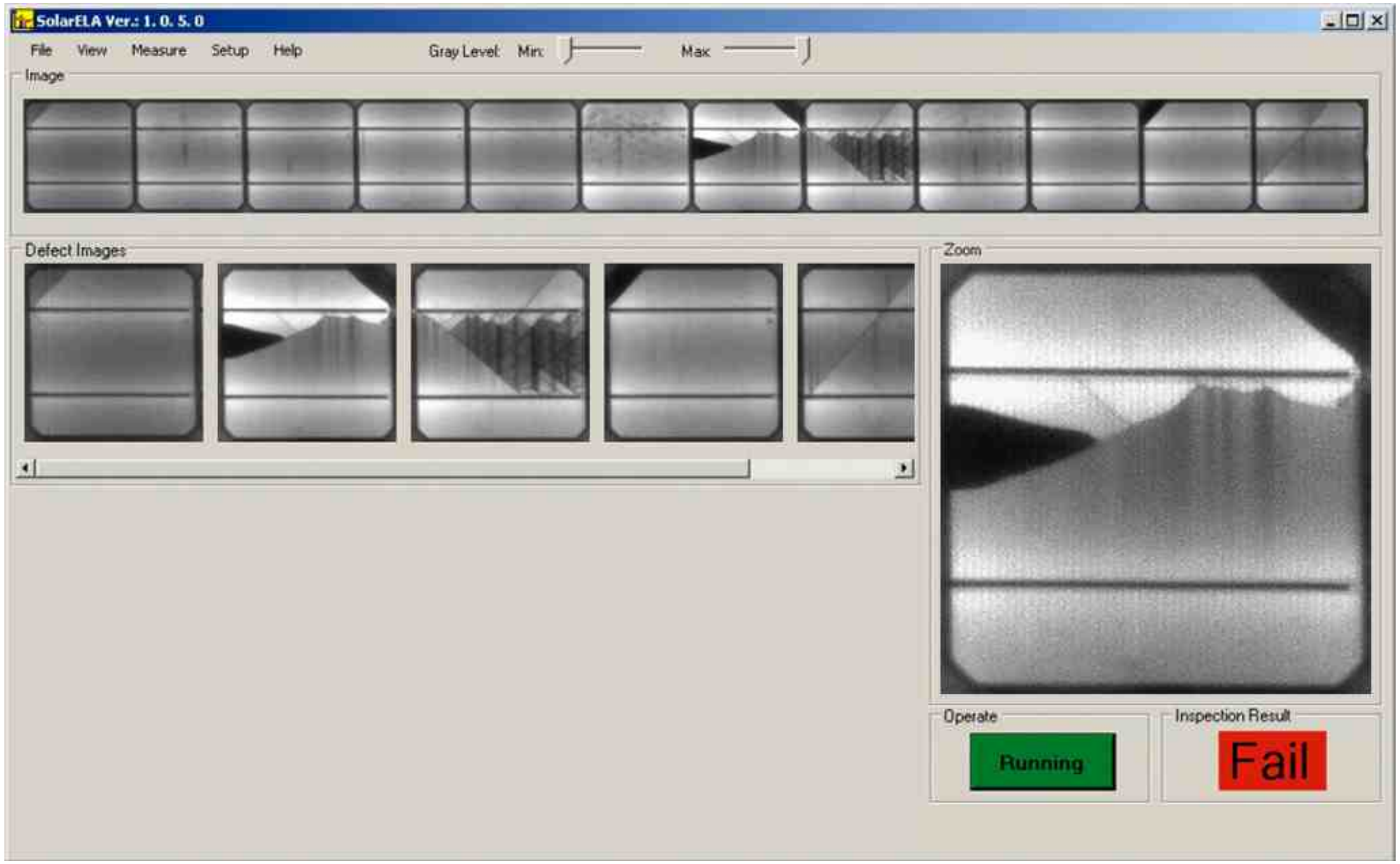


- Dark area (edge isolation)



- Crack

OSIS String: Measurement example



Operate: Running

Inspection Result: Fail

- Defects in a string

OSIS Module

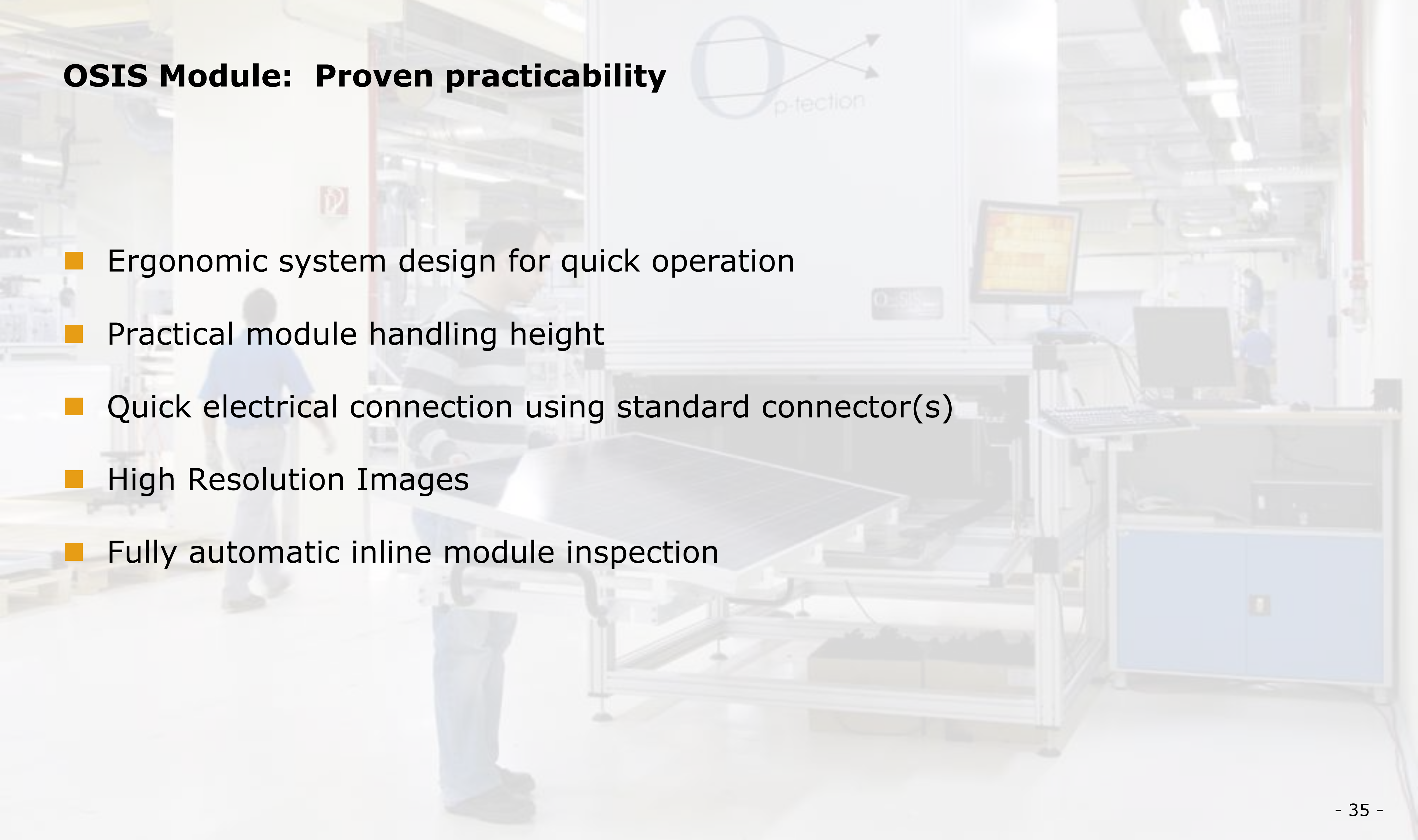
Inspection Items:

- Cracks
- Dislocations
- Dark areas
- Dead cells / strings

Features and Capabilities:

- Single or multiple cameras >> *Crisp **high-resolution** images*
- Flexible platform >> *For pre- and post-laminated module inspection*
- **Easy handling** >> *Module handling at practical working height*
- **Inline version** available >> *1m pass-line height sunny-side down inspection*

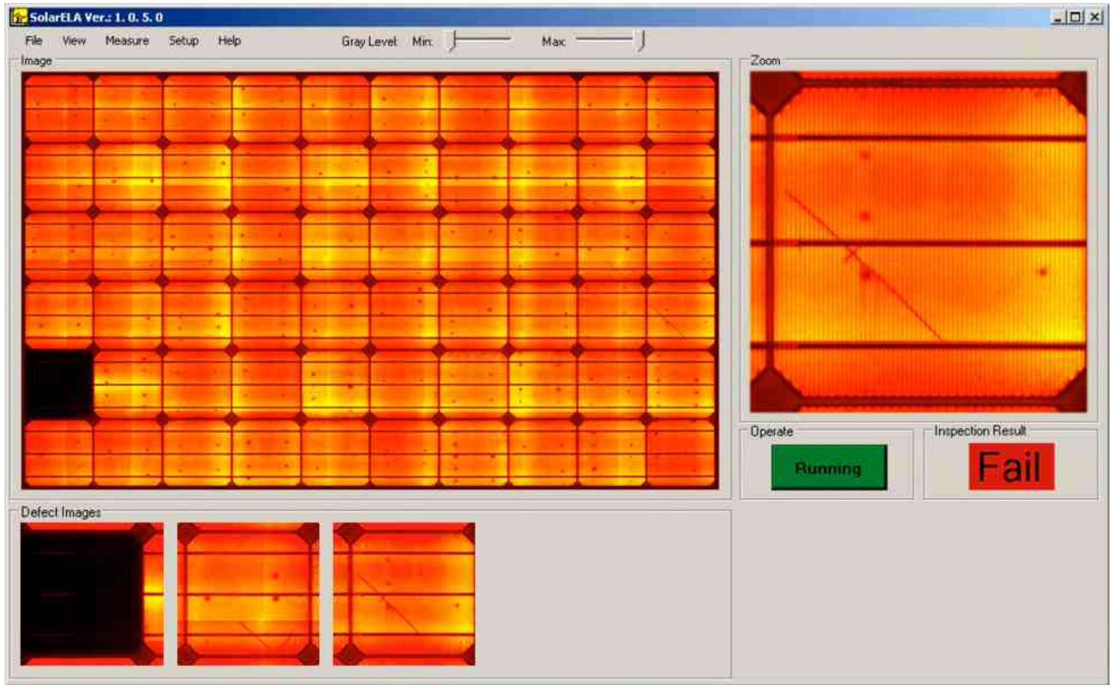
OSIS Module: Proven practicability



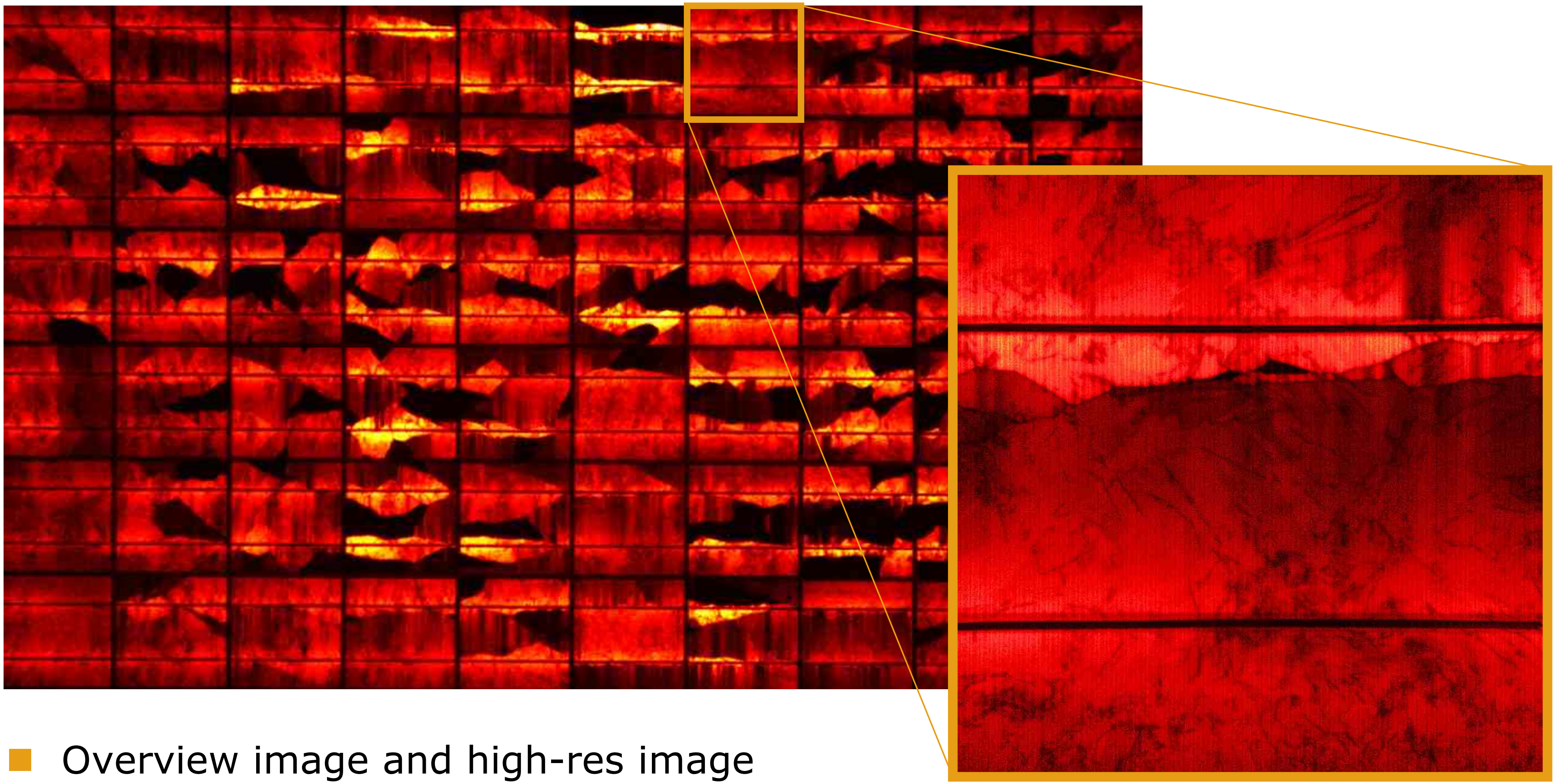
OSIS Module: Proven practicability

- Ergonomic system design for quick operation
- Practical module handling height
- Quick electrical connection using standard connector(s)
- High Resolution Images
- Fully automatic inline module inspection

OSIS Module-I: Inline Module Inspection

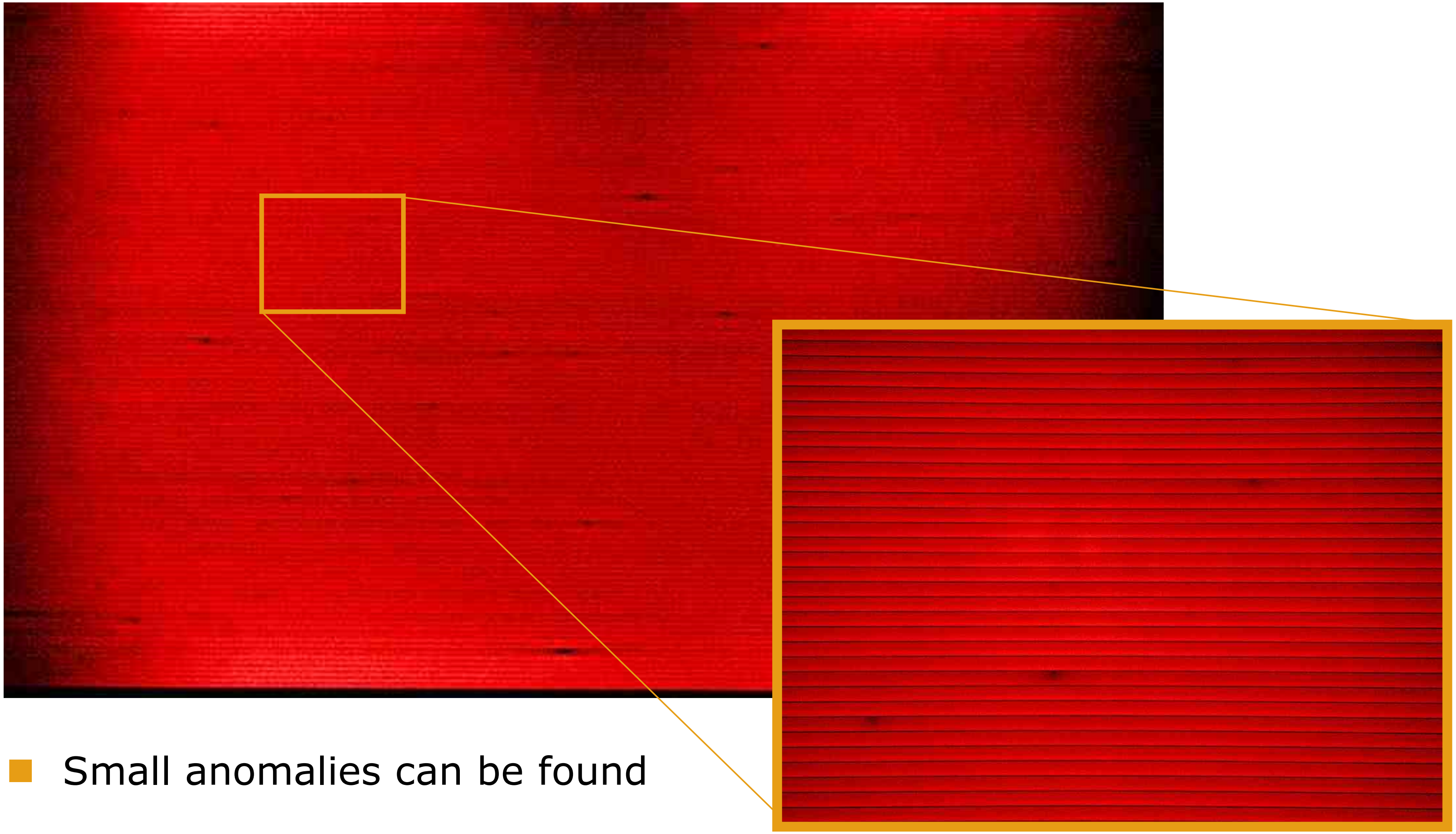


OSIS Module: pc-module measured with OSIS Module



- Overview image and high-res image

OSIS Module: CIGS panel measured with OSIS Module



- Small anomalies can be found

METROLOGY meets MES:
The Quantum Leap in PV Yield, Efficiency and Quality

Combining OSIS Metrology tools with cmNavigo MES

Value for solar panel producers:

- Direct insight in correlation of process steps and parameters
- Excellent accessibility of production data
- 100% traceability from raw material to end-product
- Competitive advantage while ensuring product lifetime

Now, what can we do for you?

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