Sensing is life.

Automated Data Analyses in Production

An Algorithm Toolkit

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Agenda

Automated Data Analyses in Production: An Algorithm Toolkit

Company presentation

Automated data analyses in production

Data structure

Toolkit demonstration

Company presentation

Key focus technologies

	Emitters	Optical components & micro-modules	Detectors	Integrated circuits & algorithms
Key solution components	• LEDs • µLED (Micro LED) • EEL/VCSELs • Lamps	• Optical elements: Lenses, light guides, DOEs • Micro-optical packaging • Optical modules	• Light sensors • Bio-sensors • Image sensors	• Emitter driver ICs • Sensor interfaces • Sensor processors (incl. algorithms)

Micro-Optical Solutions & Lamps

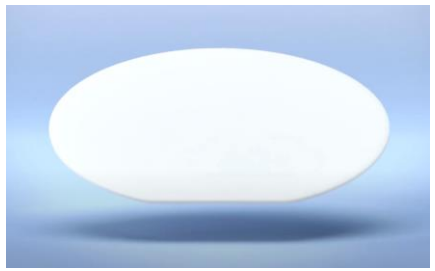
Sensing

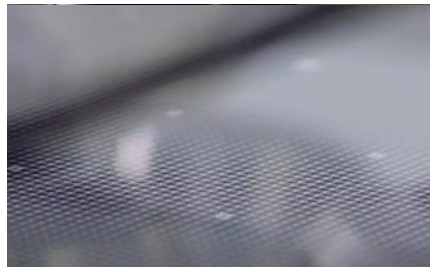
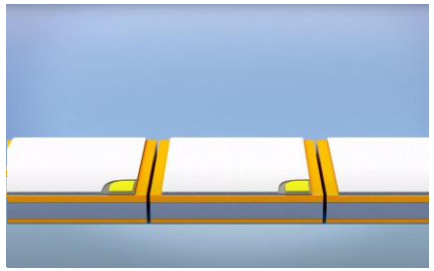
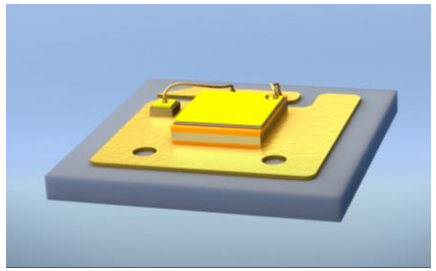
Illumination

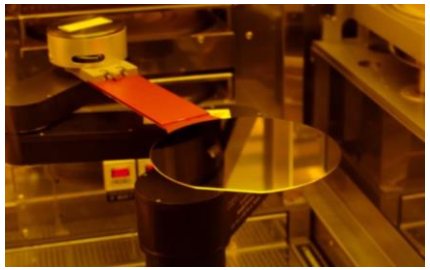
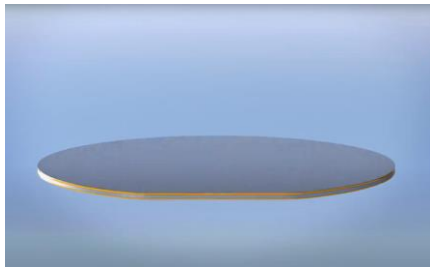
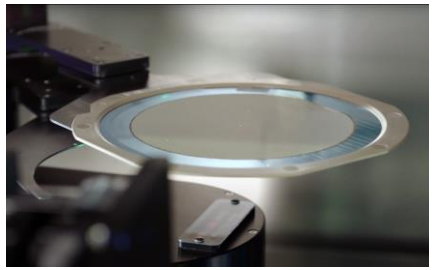
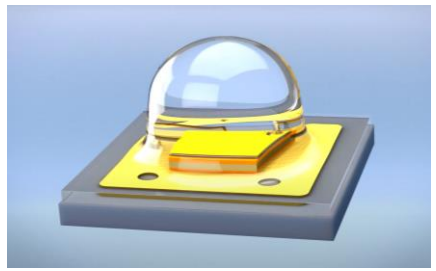
Visualization

Company presentation

Production of LEDs – Overview



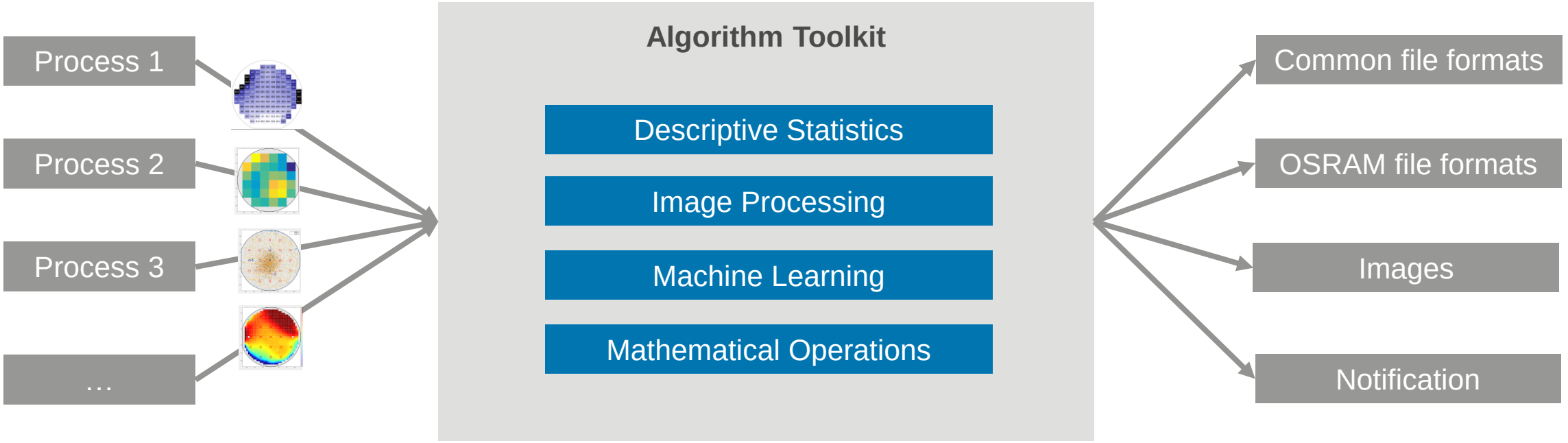




Epitaxy | Metallization | Structuring | Separation | Mounting

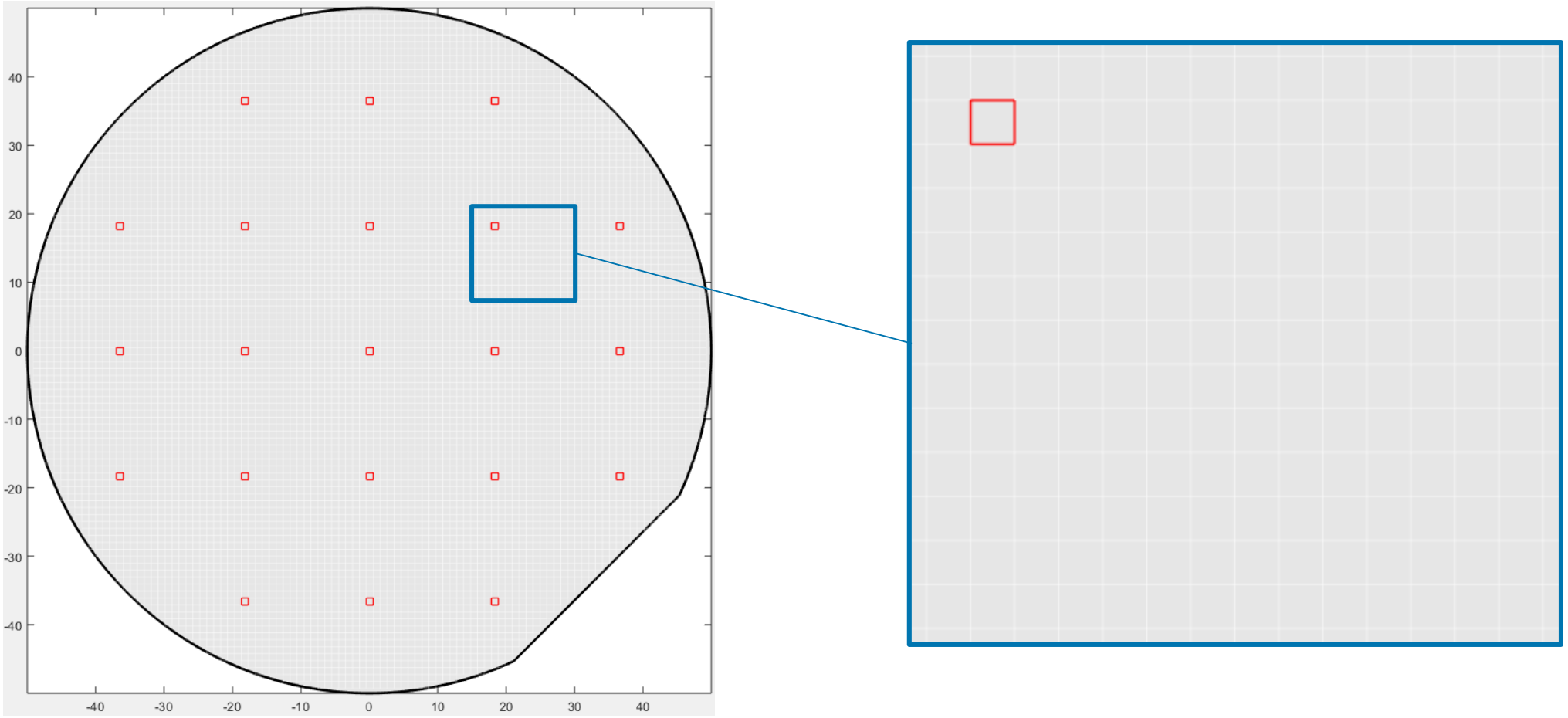
Automated data analyses in production

Overview



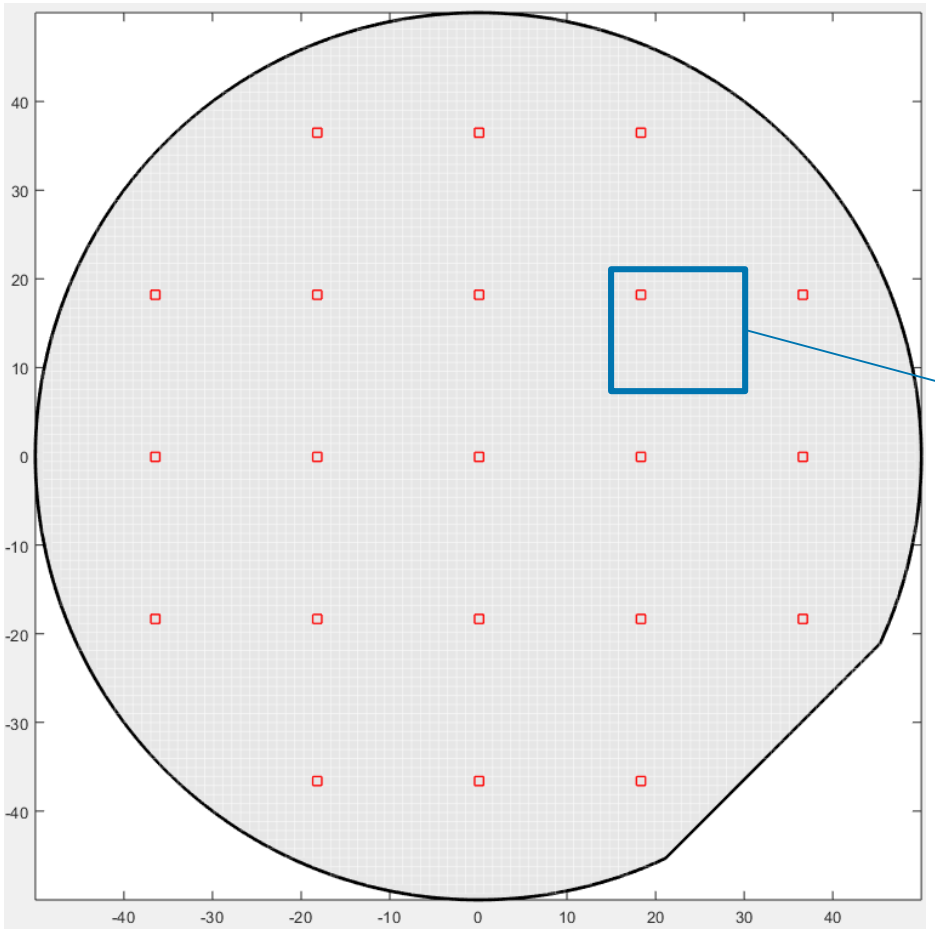
Data structure

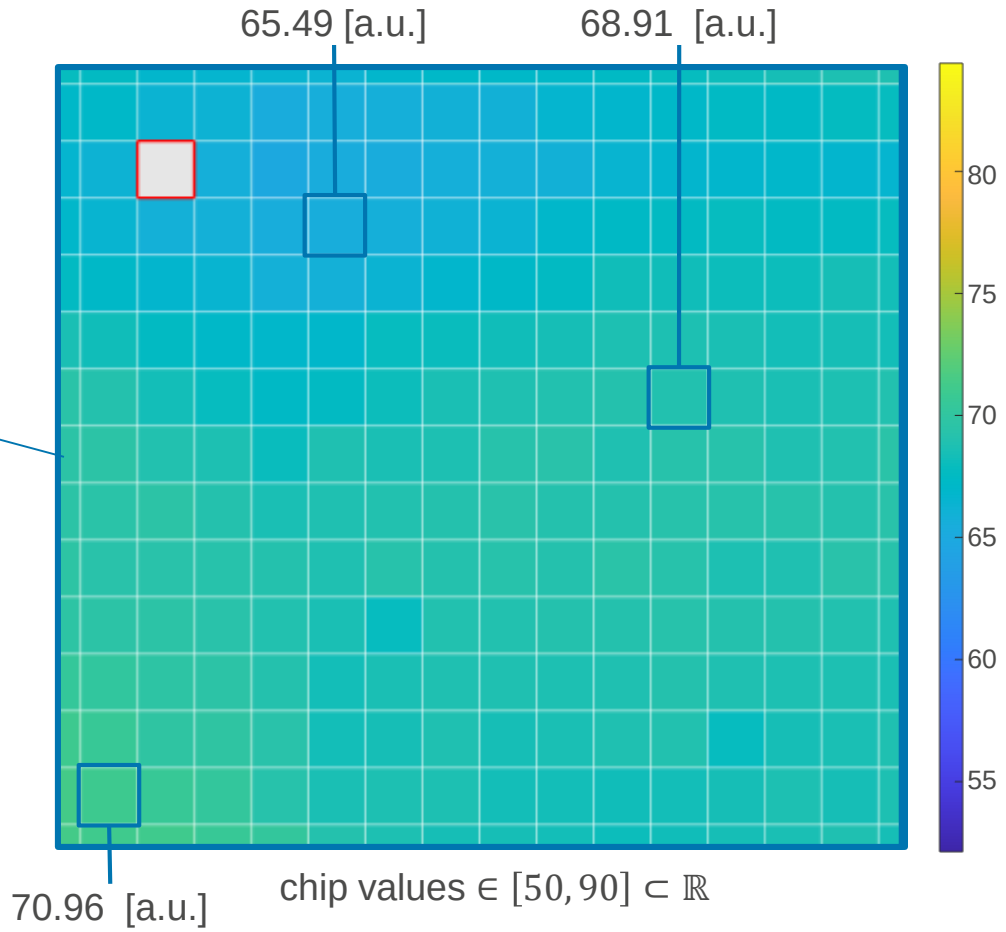
The grid



Data structure

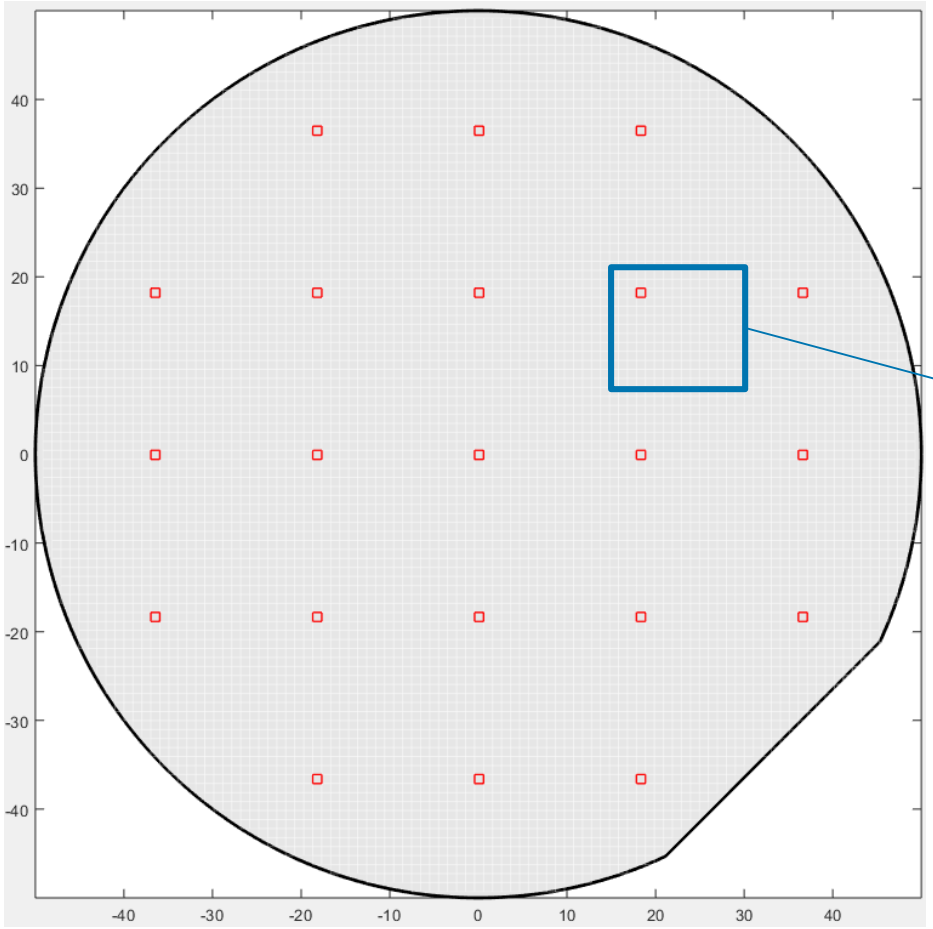
Real numbers

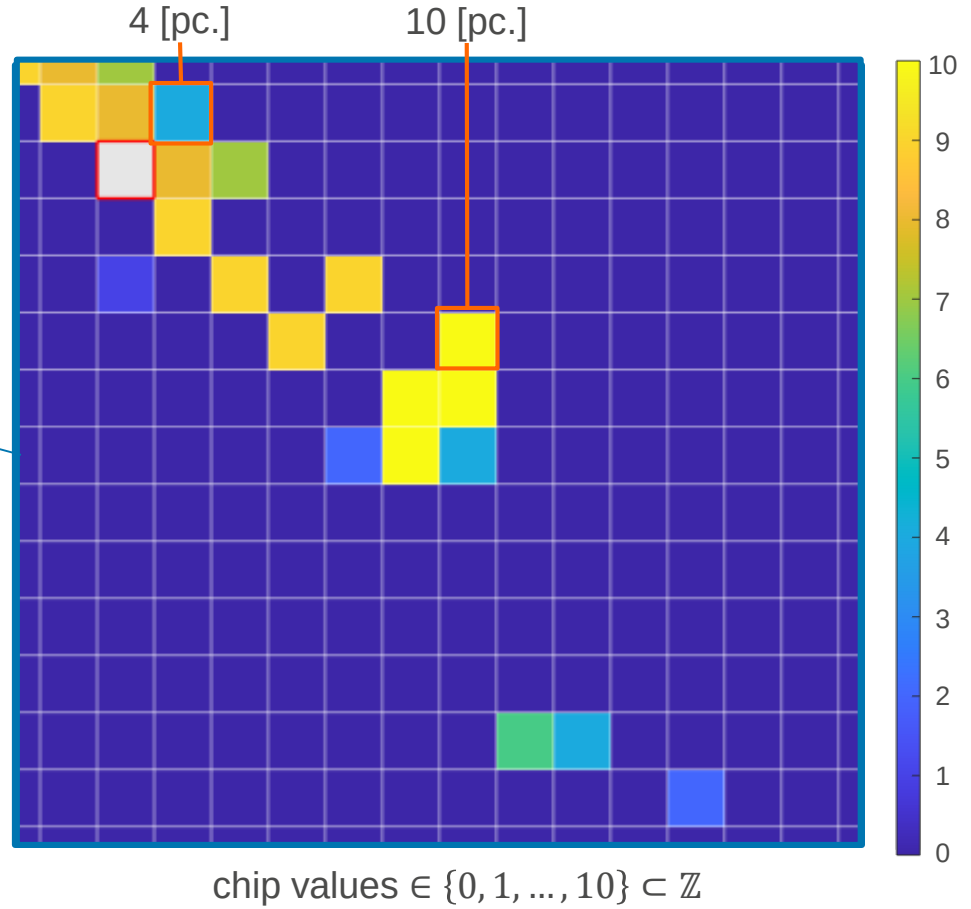




Data structure

Integer values

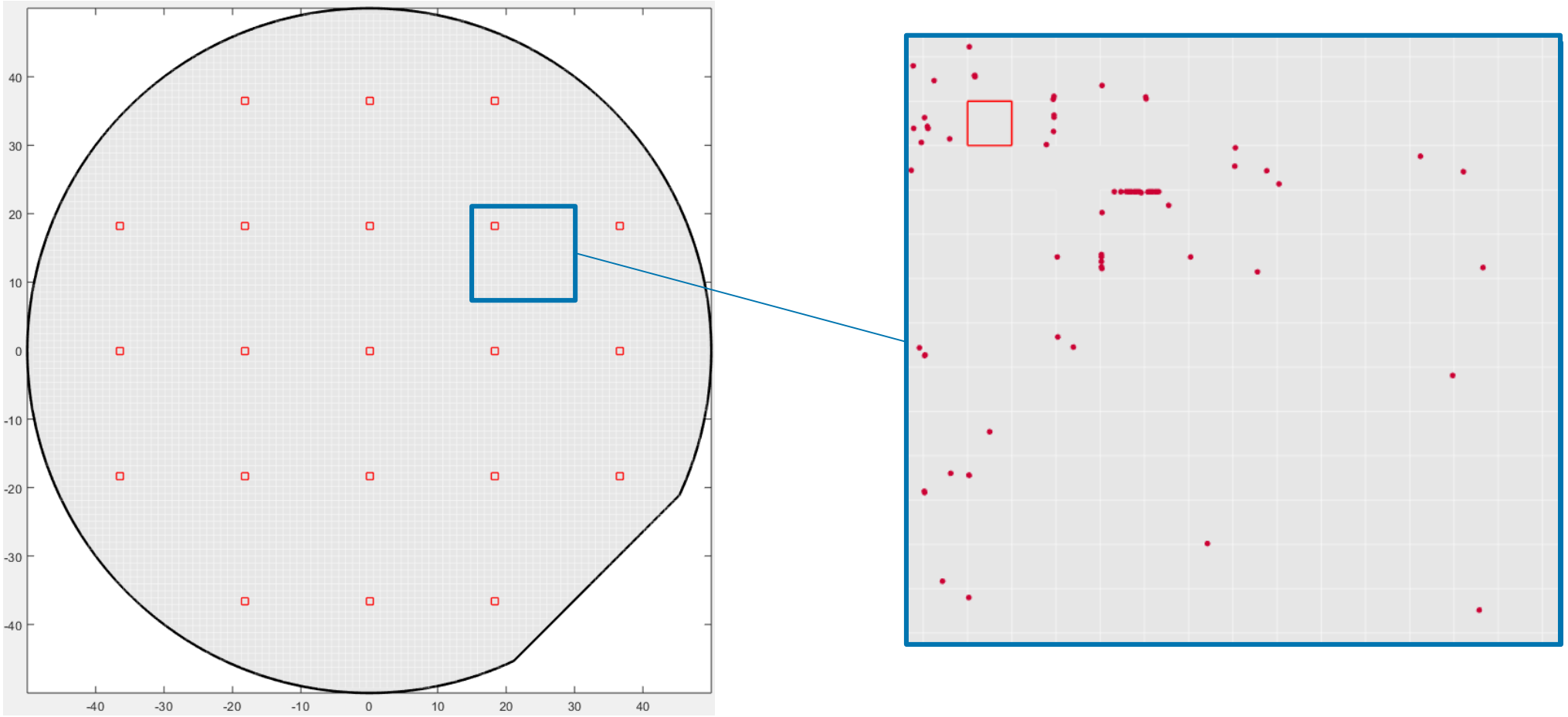




chip values $\in \{0, 1, \ldots, 10\} \subset \mathbb{Z}$

Data structure

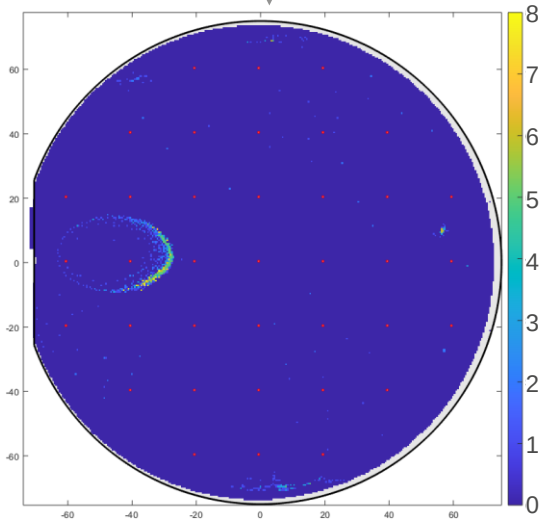
Defects



Toolkit demonstration

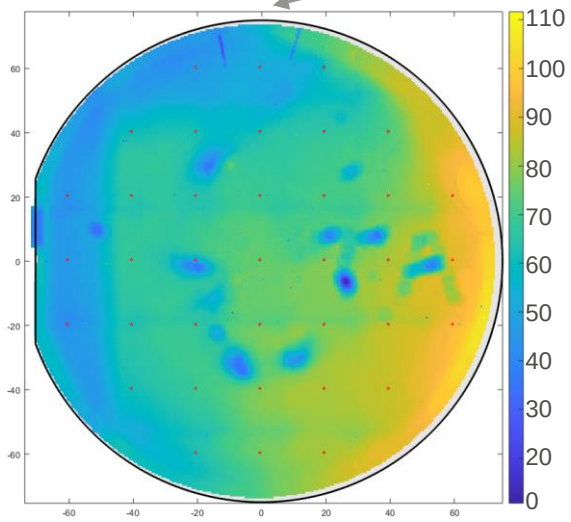
Example wafer – artificially created data

Process 1

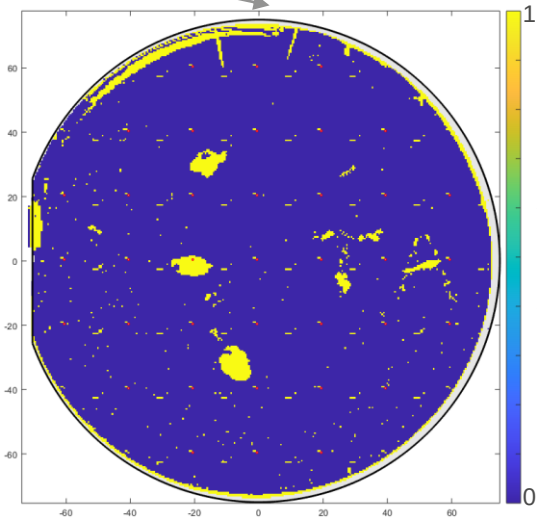


Measurement A
Chip values $\in \{0, 1, \ldots, 8\} \subset \mathbb{Z}$

Process 2

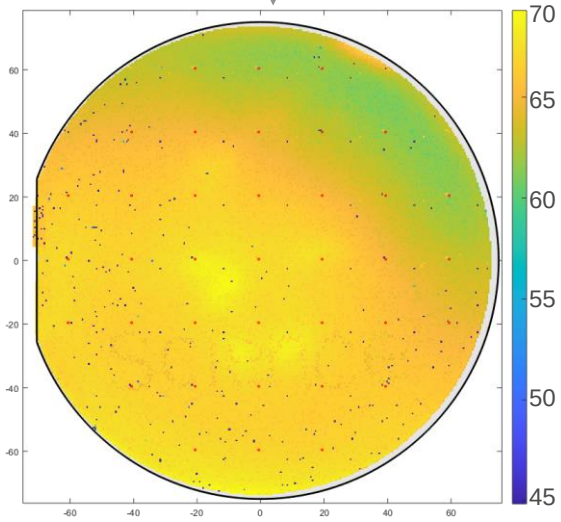


Measurement B
Chip values $\in [0,\ 110] \subset \mathbb{R}$



Measurement C
Chip values $\in \{0,\ 1\} \subset \mathbb{Z}$

Process 3



Measurement D
Chip values $\in [45, 70] \subset \mathbb{R}$

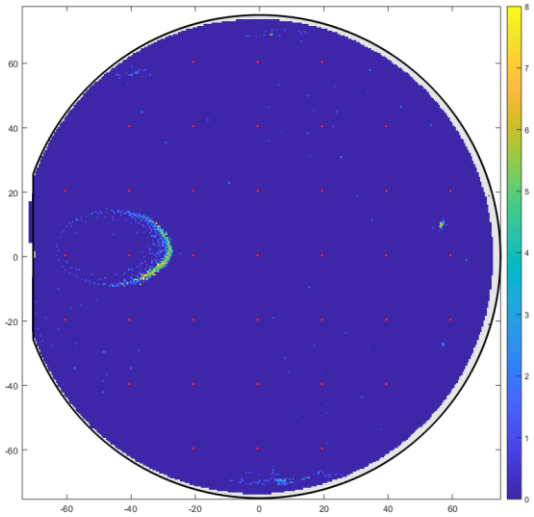
Sequence 1: Image Processing

Input maps and target

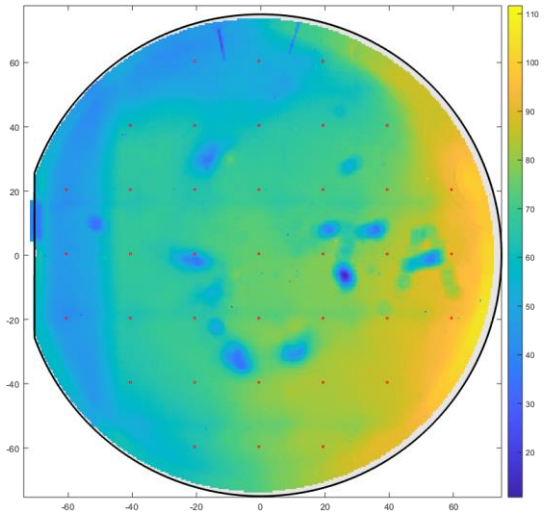
Target

Detect that part of the ellipse in measurement A for which values in measurement B are greater than a threshold

Input Maps



Measurement A
Chip values $\in \{0, 1, \ldots, 8\} \subset \mathbb{Z}$
Imprint on the wafer

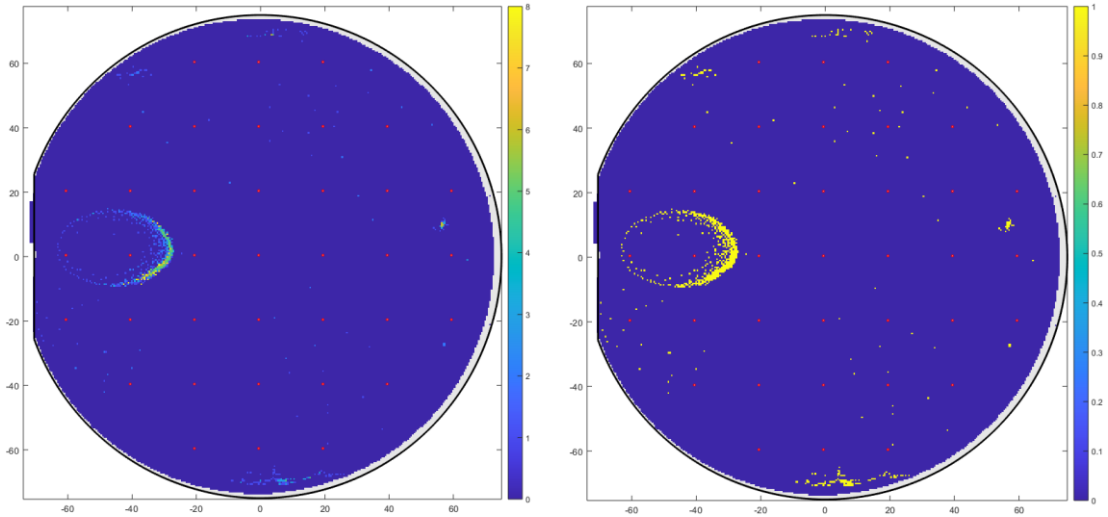


Measurement B
Chip values $\in [0,\ 110] \subset \mathbb{R}$

Sequence 1: Image Processing

Detection and filling of the ellipse

Thresholding

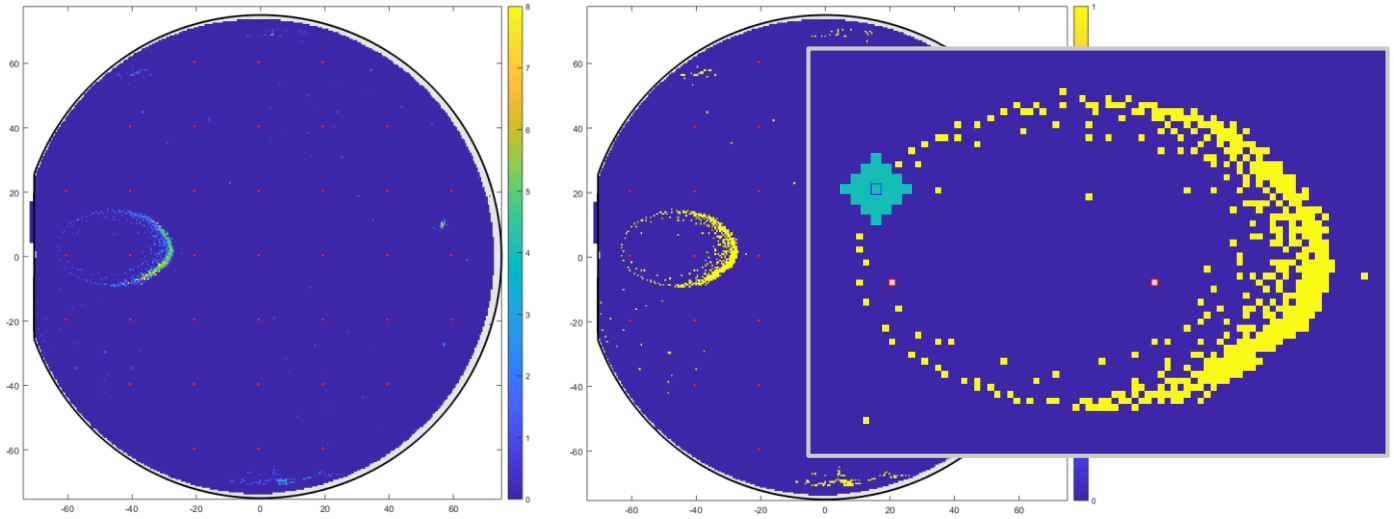


Sequence 1: Image Processing

Detection and filling of the ellipse

Thresholding

Filling

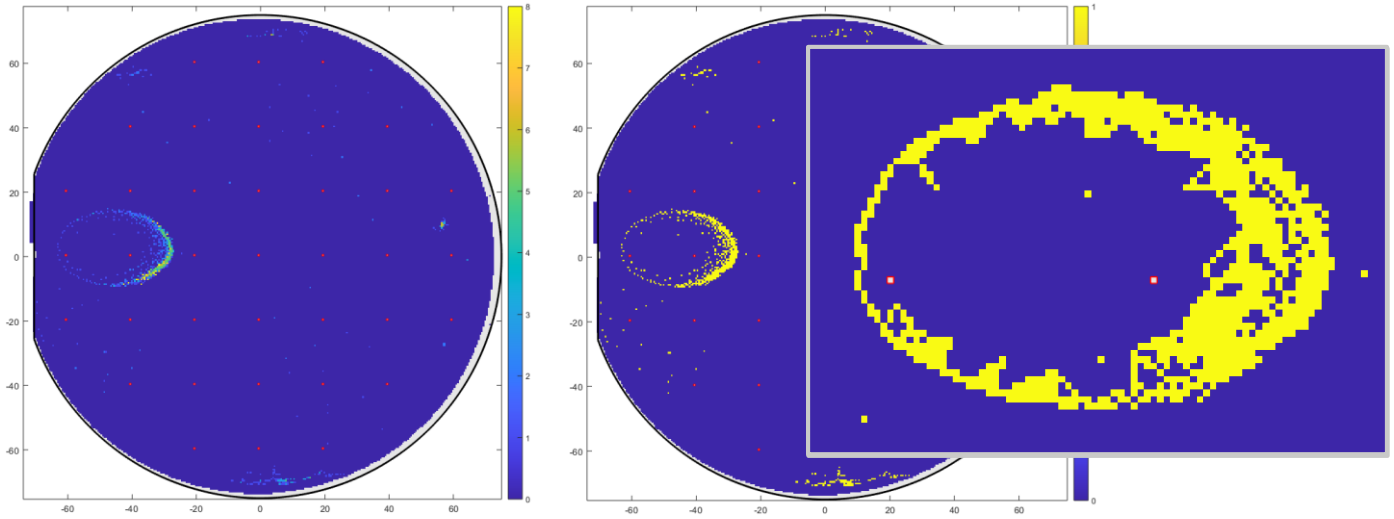


Sequence 1: Image Processing

Detection and filling of the ellipse

Thresholding

Filling

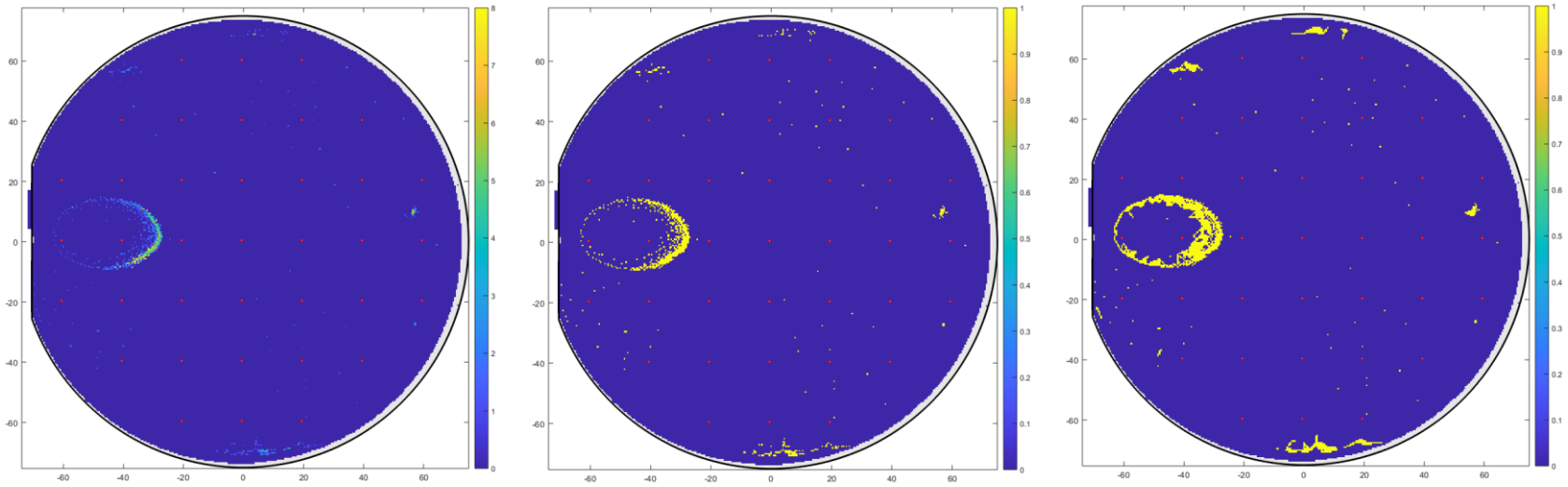


Sequence 1: Image Processing

Detection and filling of the ellipse

Thresholding

Filling



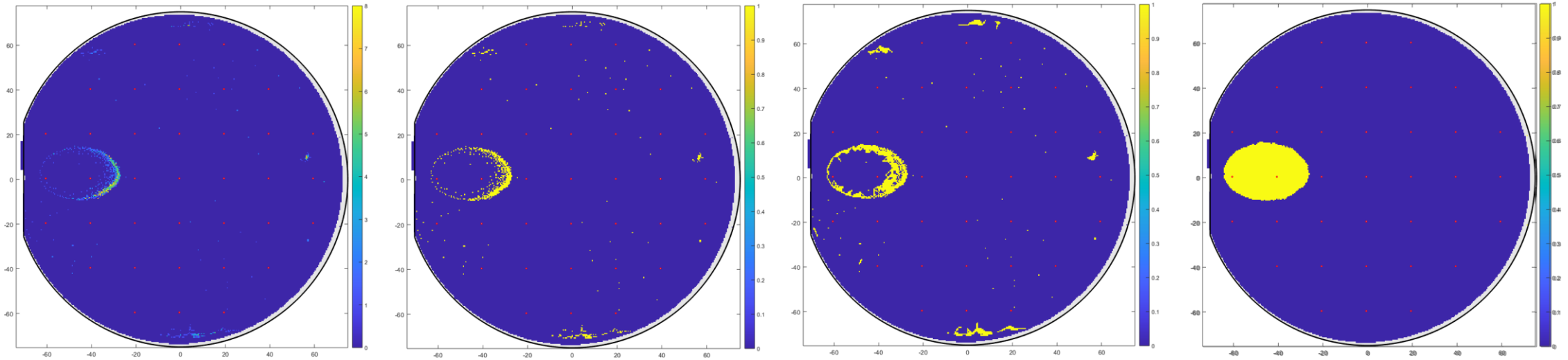
Sequence 1: Image Processing

Detection and filling of the ellipse

Thresholding

Filling

Pattern Recognition
Filling & Dilation

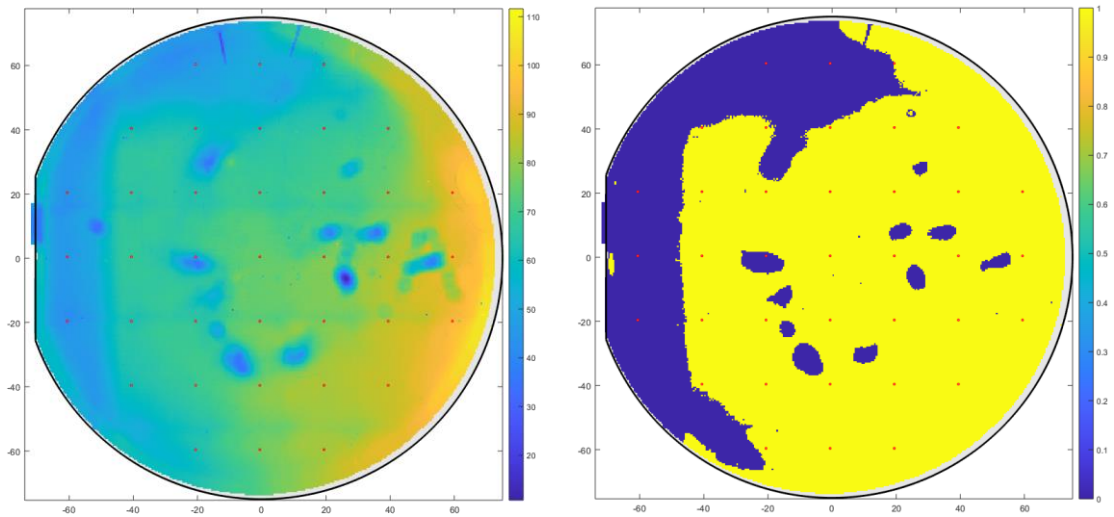


Interim result

Sequence 1: Image Processing

Combining the ellipse with the second measurement

Thresholding

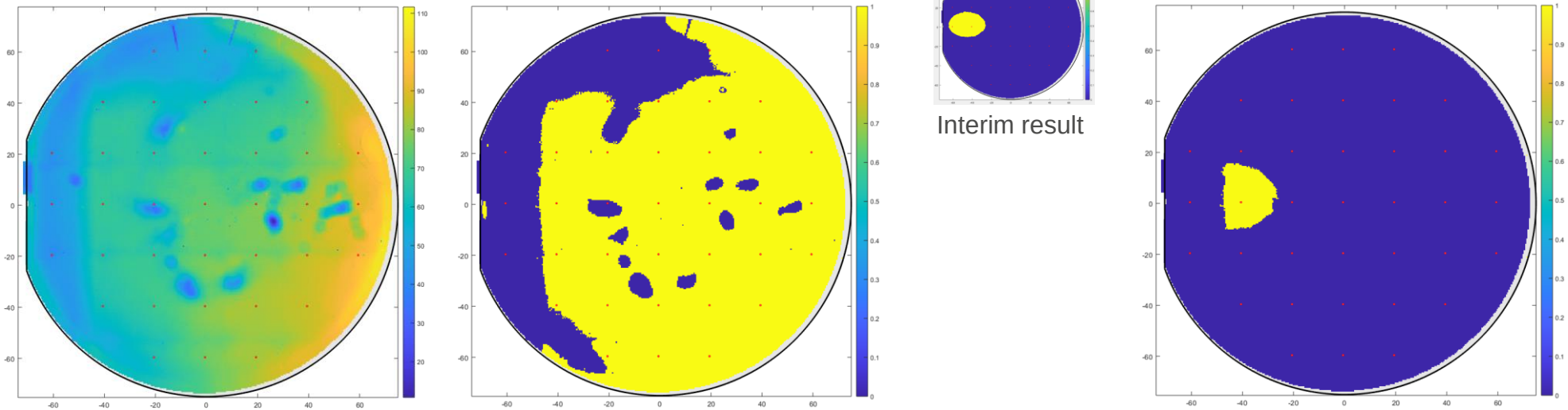


Sequence 1: Image Processing

Combining the ellipse with the second measurement

Thresholding

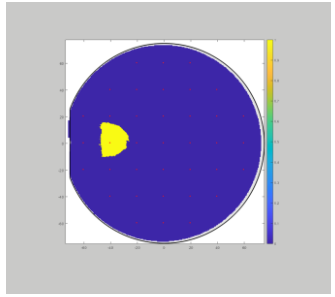
Logical AND



Interim result

Sequence 1: Image Processing

Combining the ellipse with the second measurement



Thresholding

Logical AND

Interim result

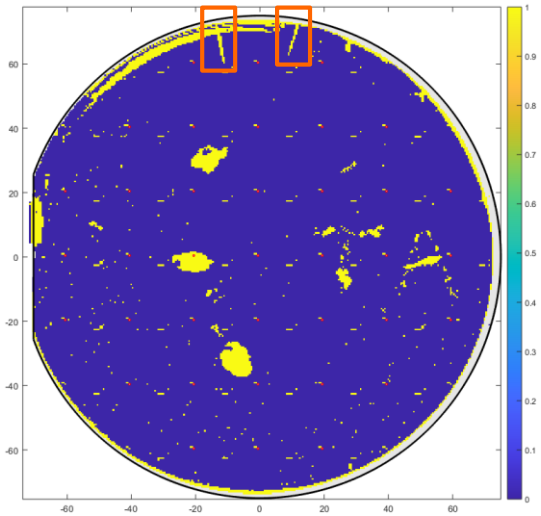
Sequence 2: Image Processing

Input maps and target

Target

Detect and extend the two lines at the top of the wafer

Input map

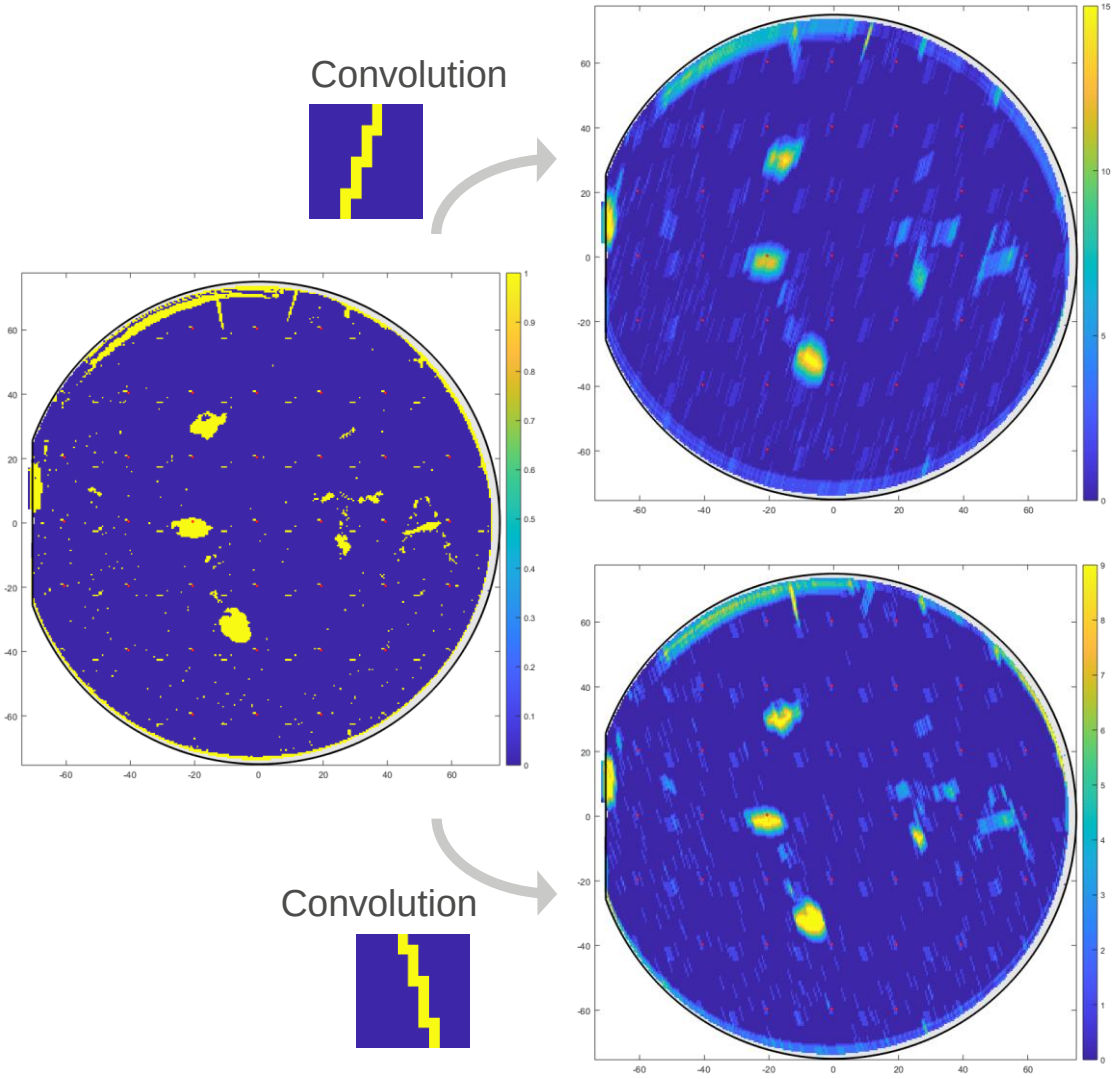


Measurement C

Chip values $\in \{0,\ 1\} \subset \mathbb{Z}$

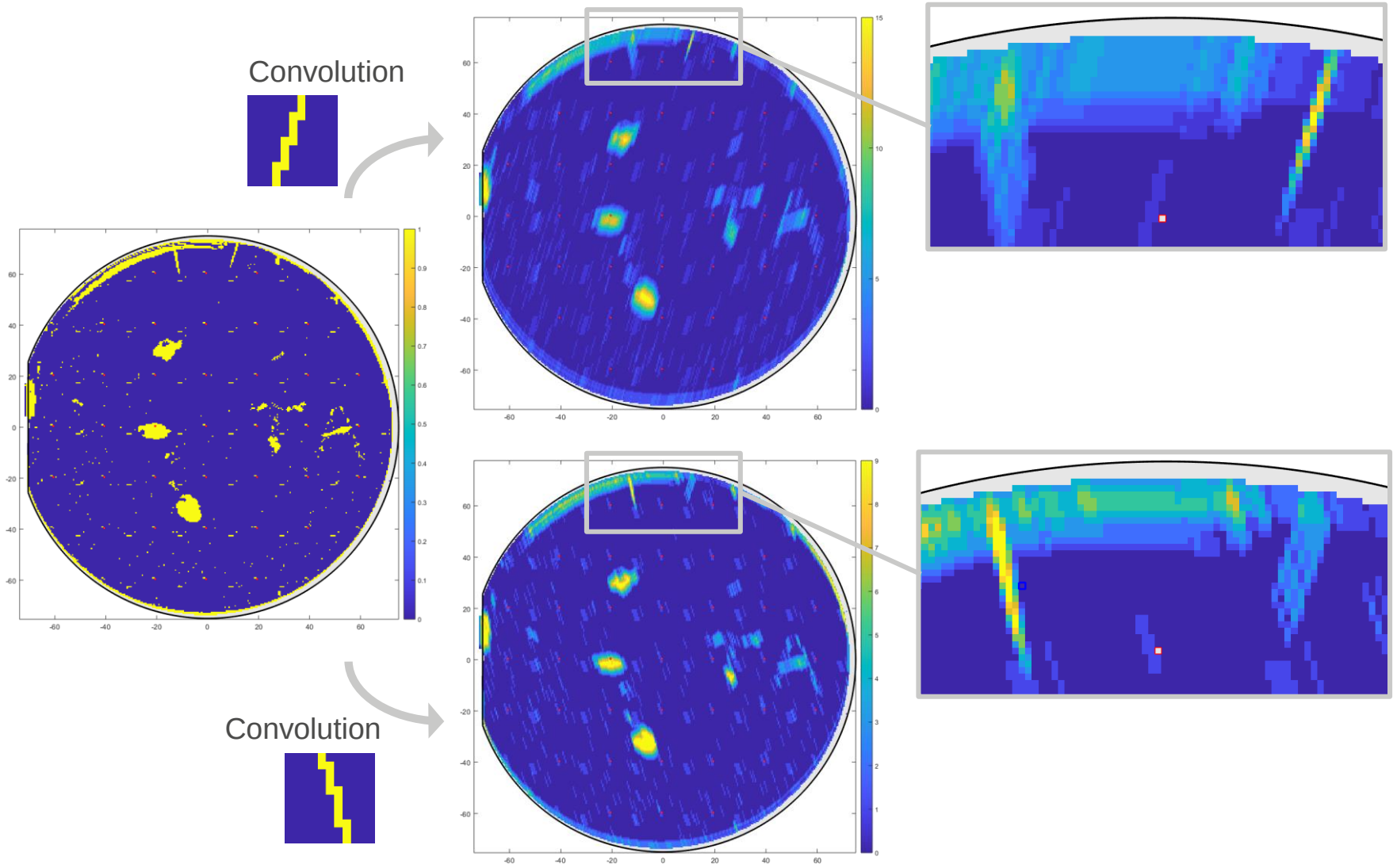
Sequence 2: Image Processing

Detection and extension



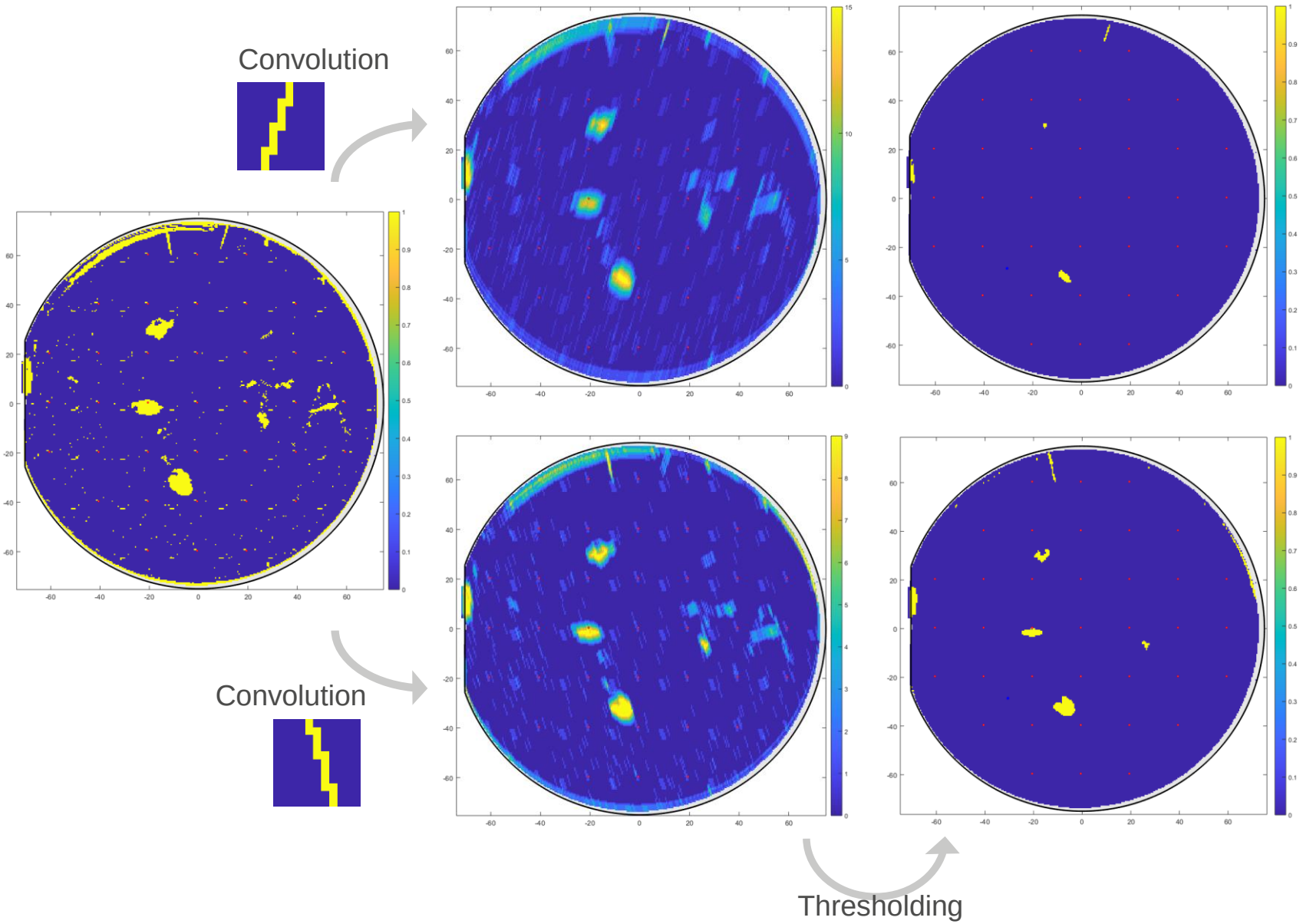
Sequence 2: Image Processing

Detection and extension



Sequence 2: Image Processing

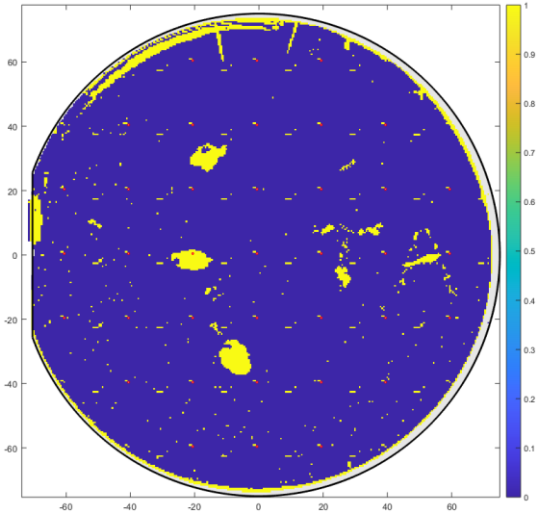
Detection and extension



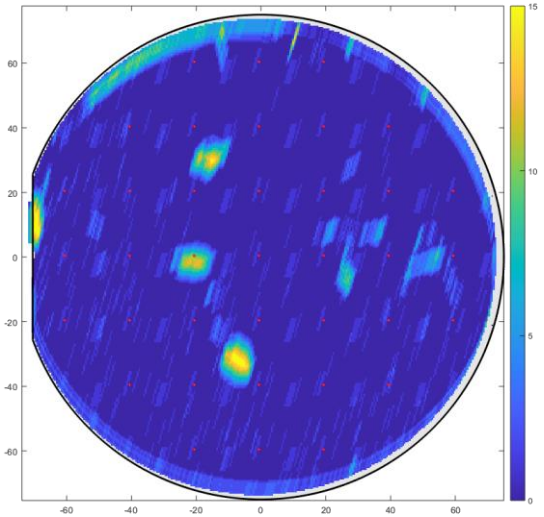
Sequence 2: Image Processing

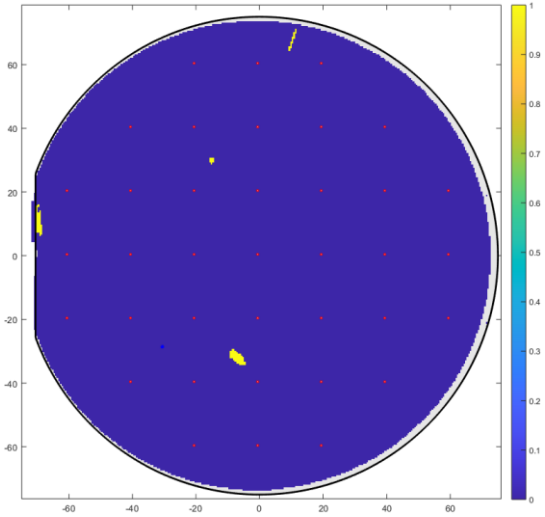
Detection and extension

Convolution

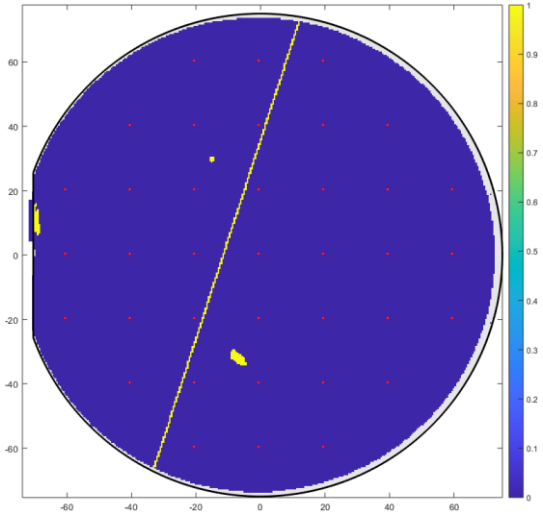


Thresholding

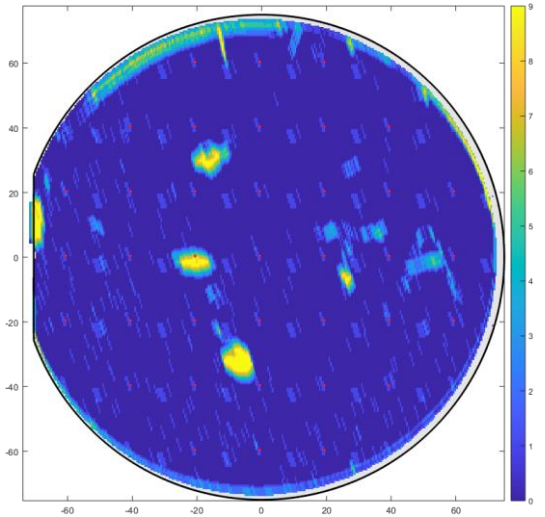




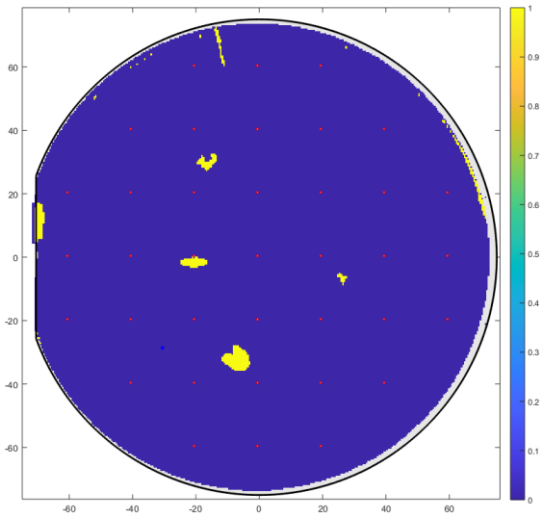
Extension



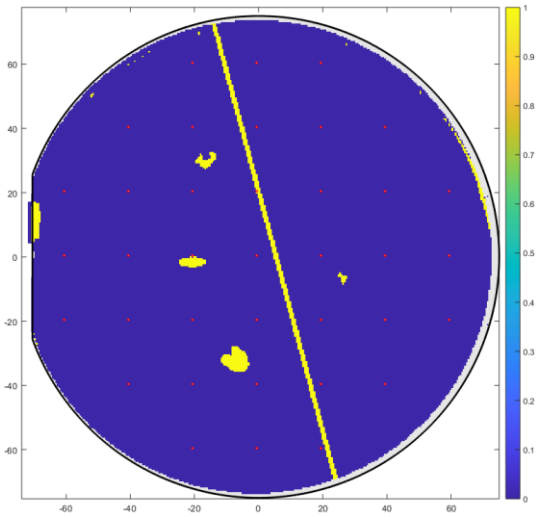
Convolution



Thresholding

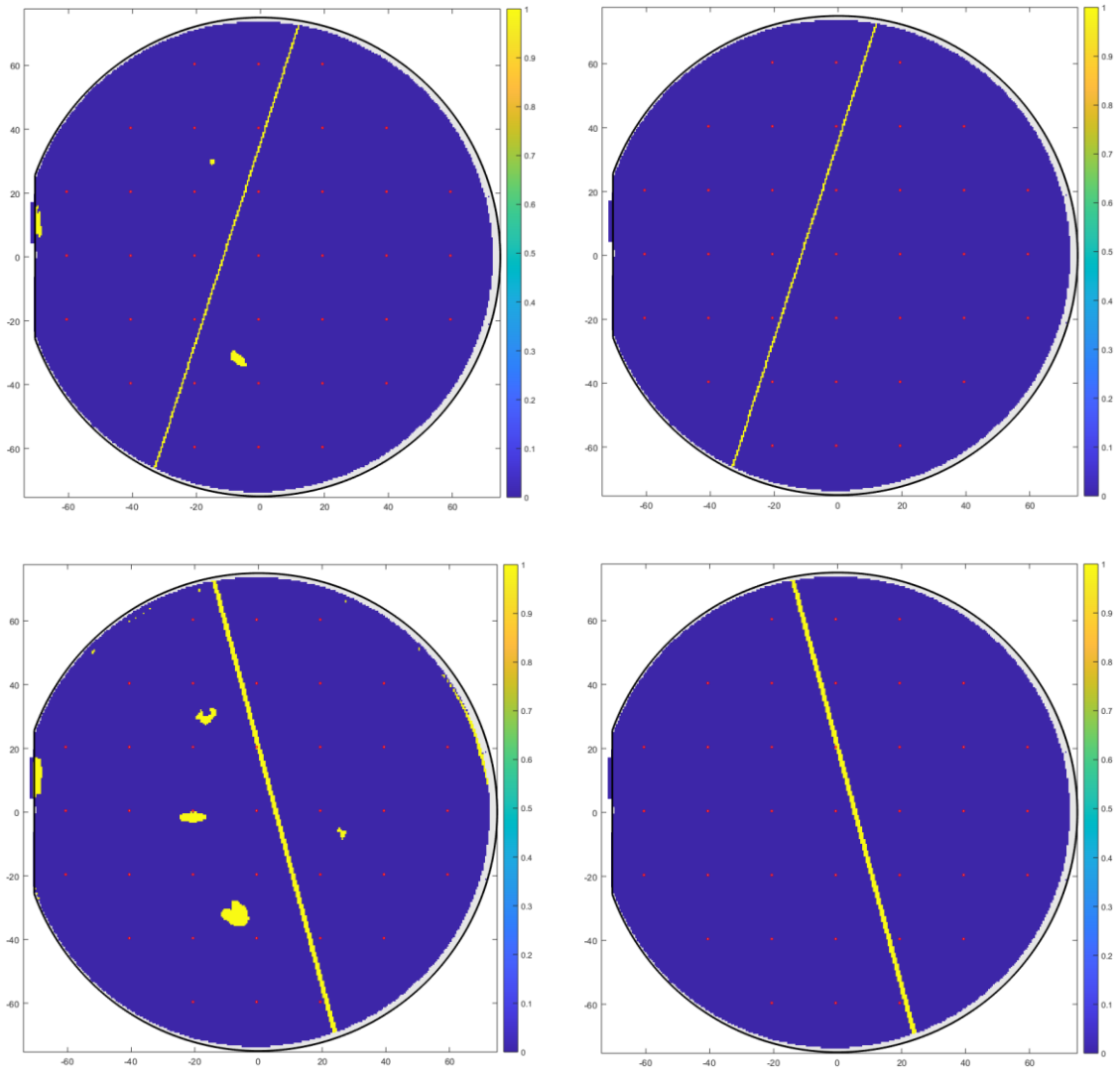


Extension



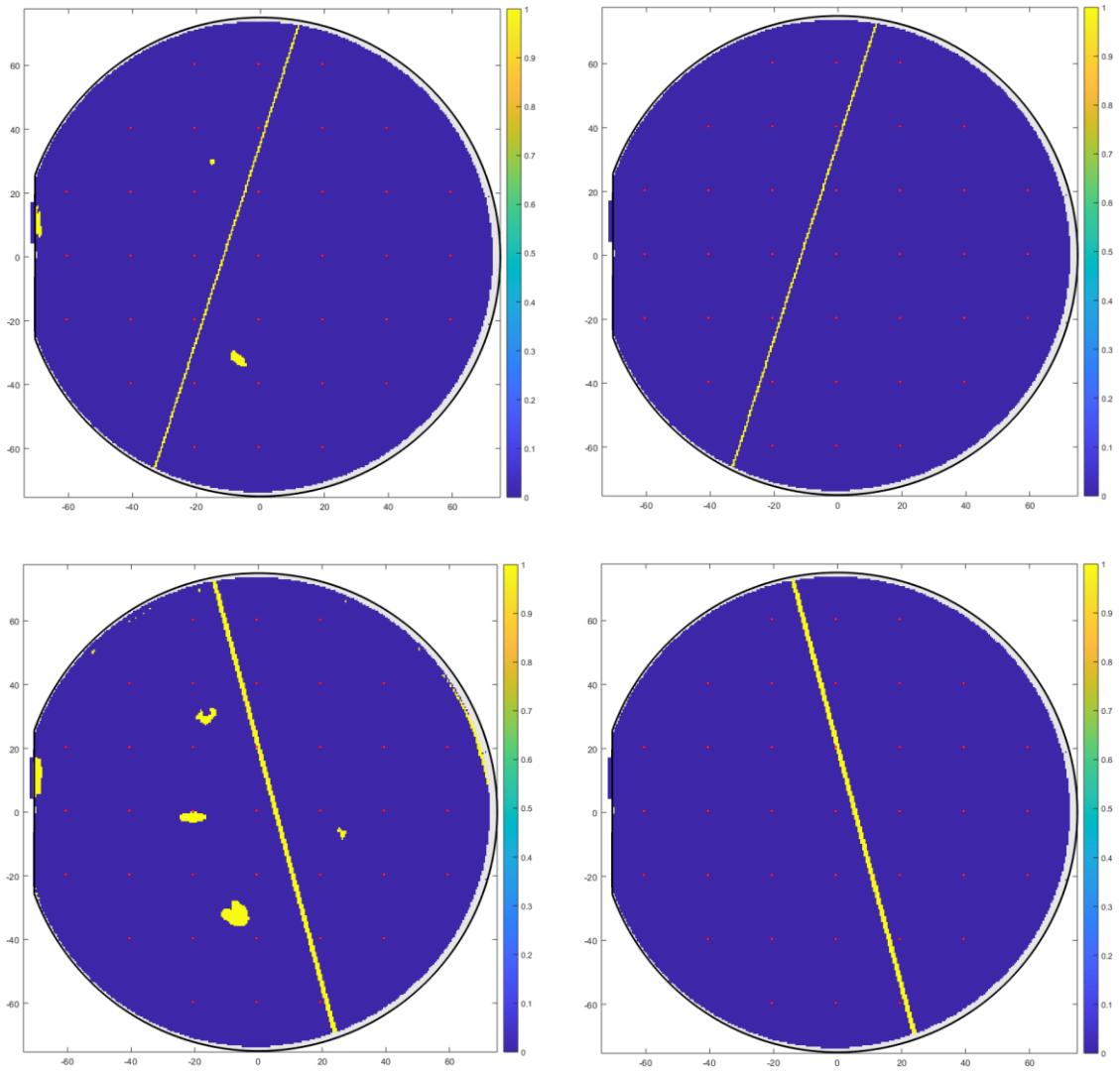
Sequence 2: Image Processing

Detection and extension



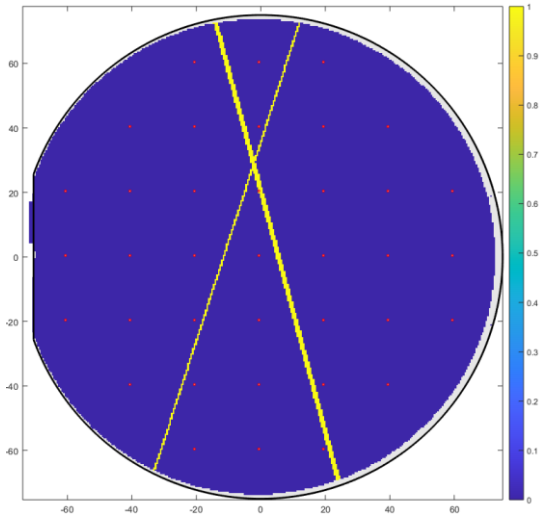
Sequence 2: Image Processing

Detection and extension



Filtering

Logical OR

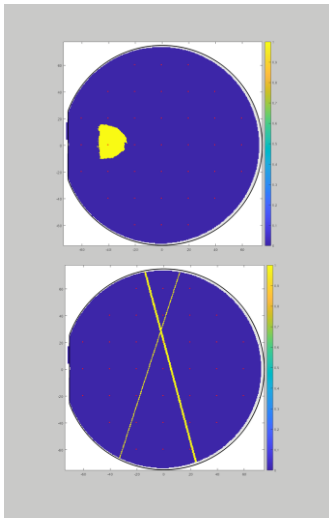


Filtering

Sequence 2: Image Processing

Detection and extension

Logical OR

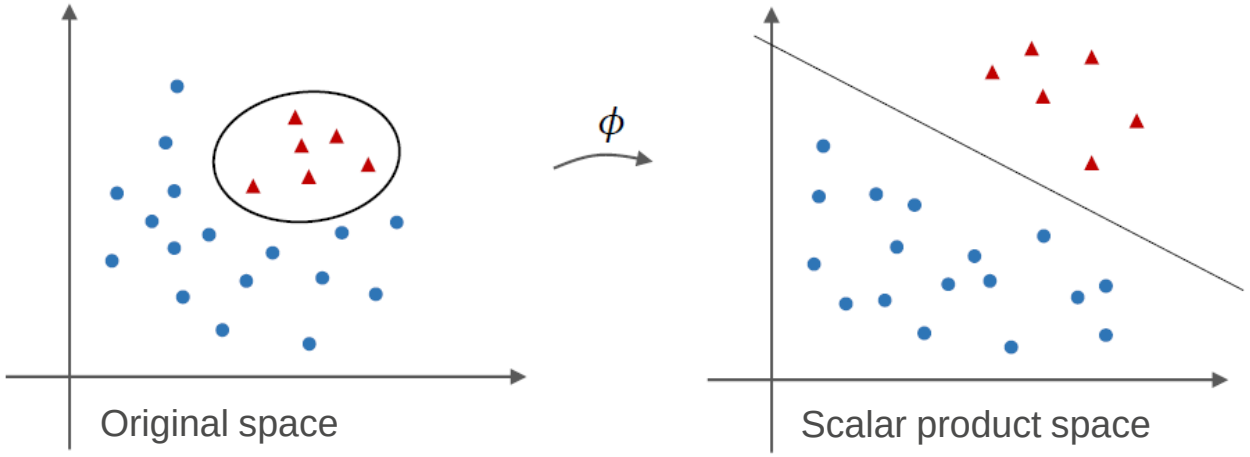


Sequence 3: Machine Learning

Input maps and target

Target
Use a support vector machine which was trained to predict the chip quality (pass/fail)

Support Vector Machines shortly explained
- Separating point clouds into different groups → classification
- Classification for training set necessary → supervised learning
- Functional principle: transform the observations into a higher dimensional space where a separating hyperplane can be found easier than in the original space



Sequence 3: Machine Learning

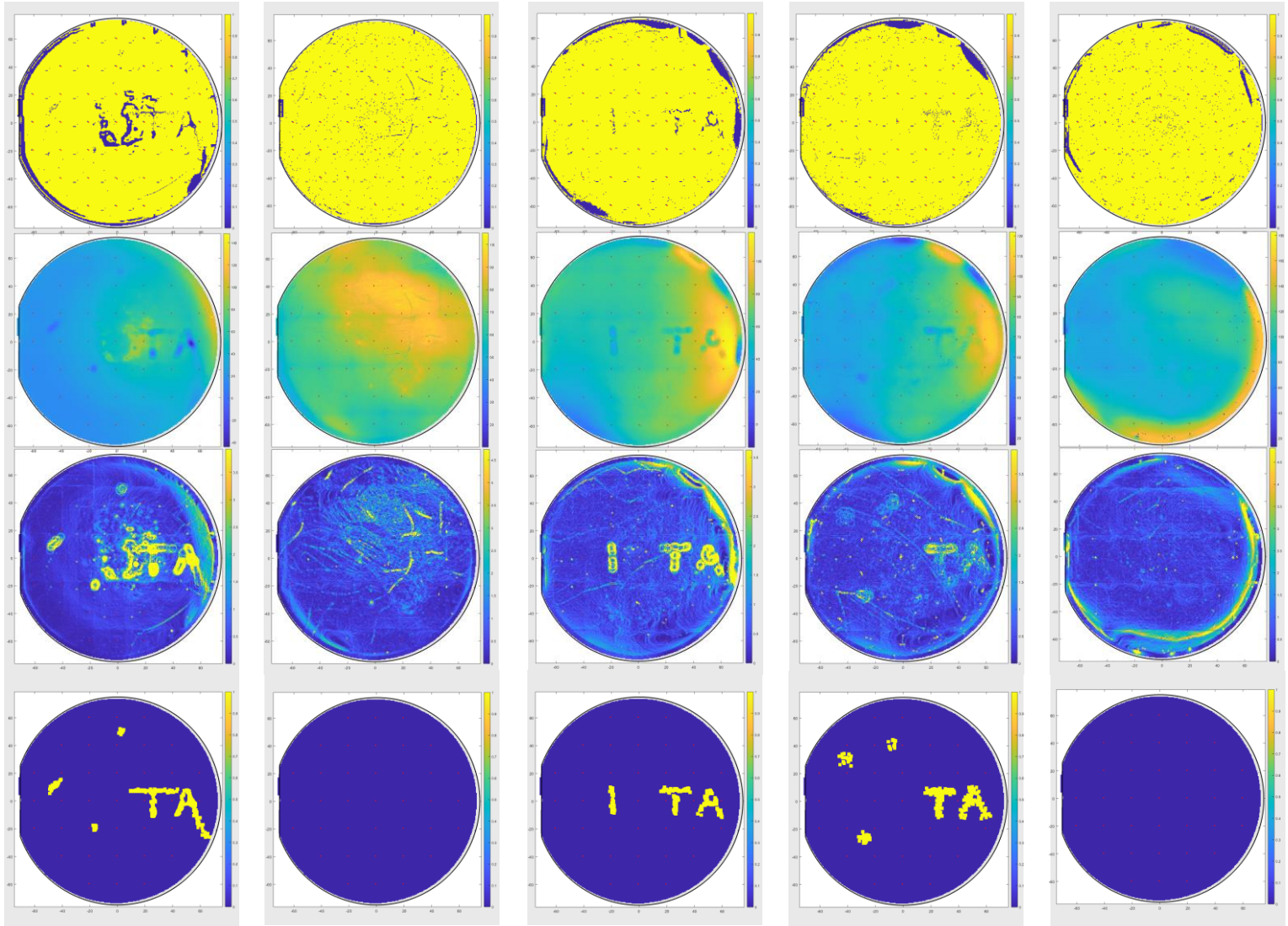
Training the Support Vector Machine

Measurement C

Measurement B

Gradient of measurement B

Classification: pass/fail



Sequence 3: Machine Learning

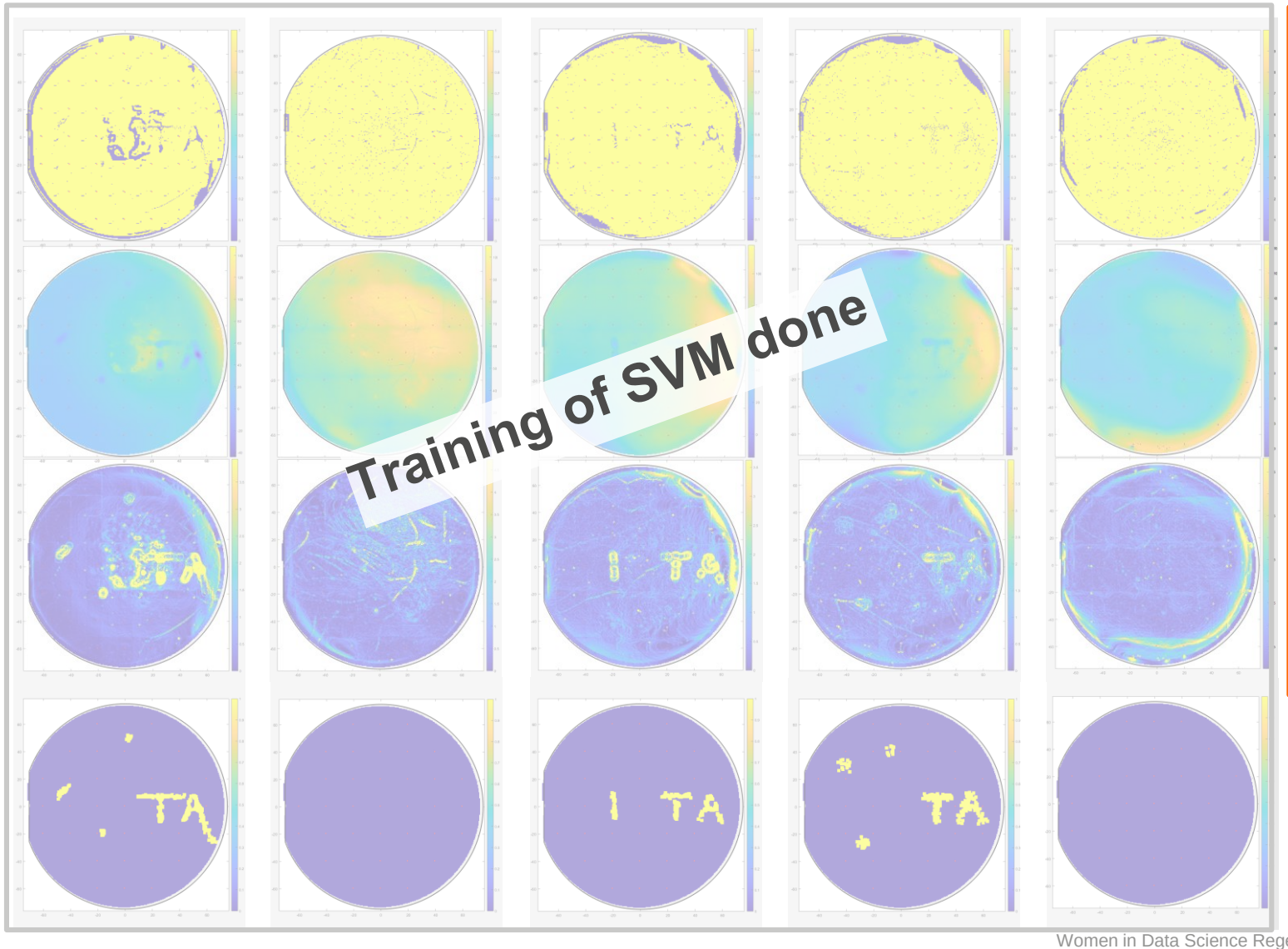
Prediction by the trained Support Vector Machine

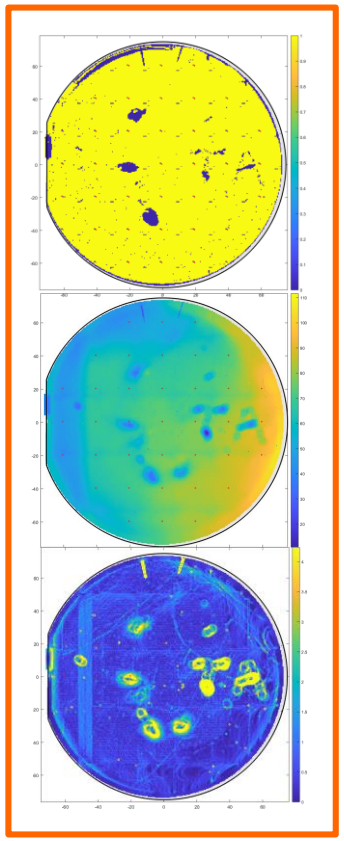
Measurement C

Measurement B

Gradient of measurement B

Classification: pass/fail



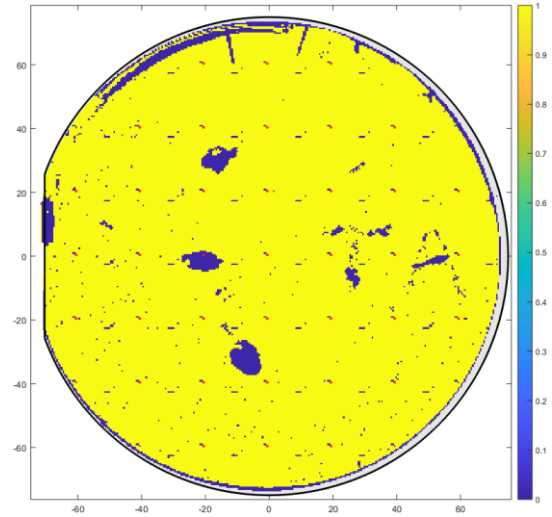


Wanted: Prediction

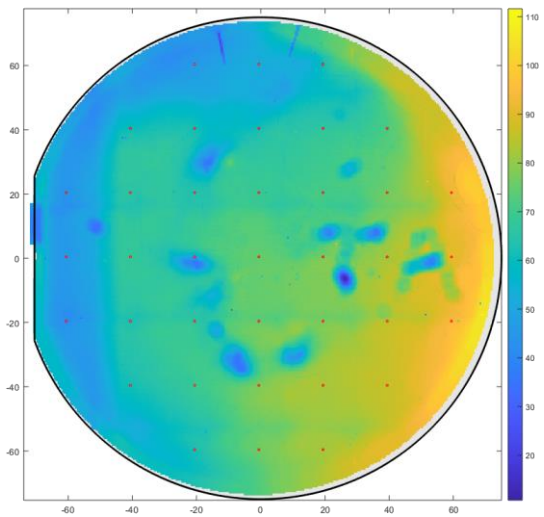
Sequence 3: Machine Learning

Prediction by the trained Support Vector Machine

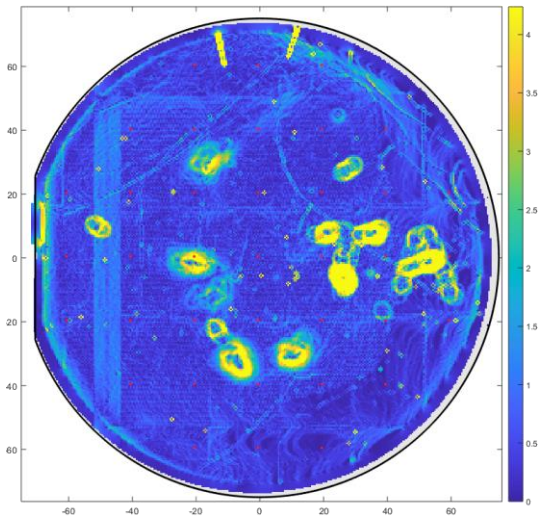
Prediction by trained SVM



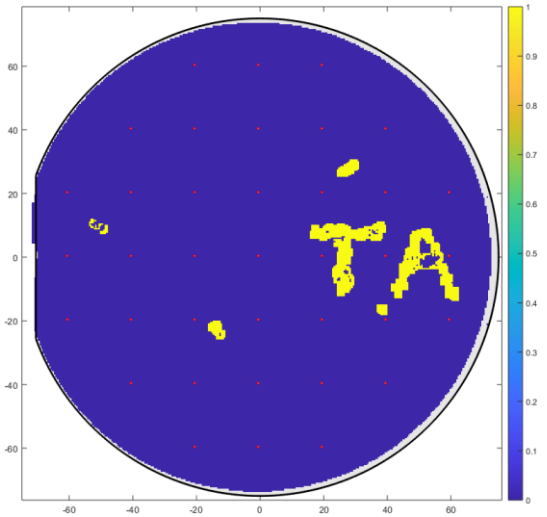
Measurement C



Measurement B



Gradient of measurement B



Sequence 3: Machine Learning

Prediction by the trained Support Vector Machine

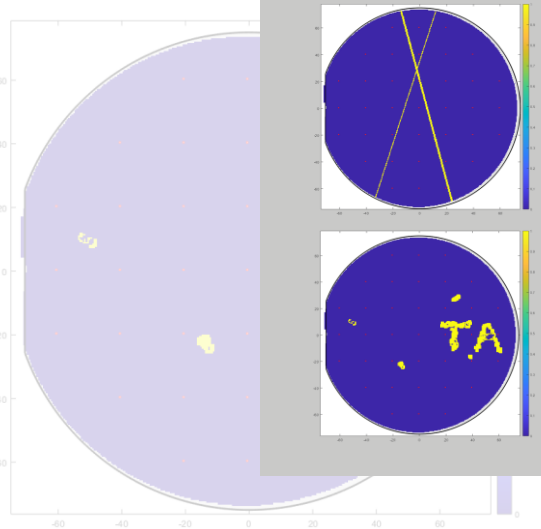
Input variables for the SVM

Prediction by trained SVM

Measurement C (inverted)
Pass/Fail information of measurement
Chip values $\in \{0,1\}$

Measurement B
Chip values $\in [0,\ 110]$

Gradient of measurement B



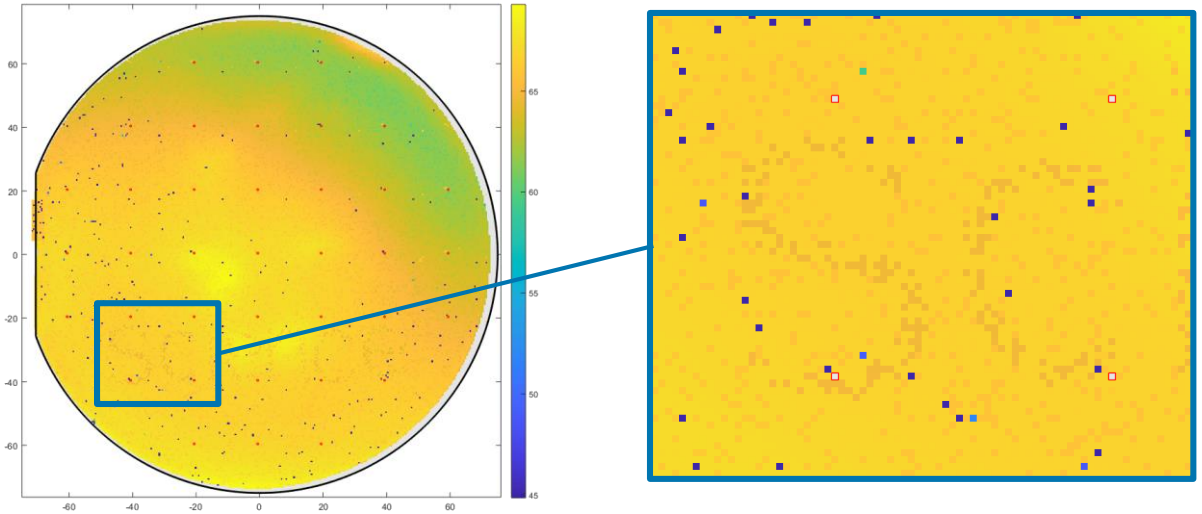
Sequence 4: Descriptive Statistics

Input map and target

Target

Detect chips whose values deviate slightly from their local neighbourhood using statistical functions

Input map

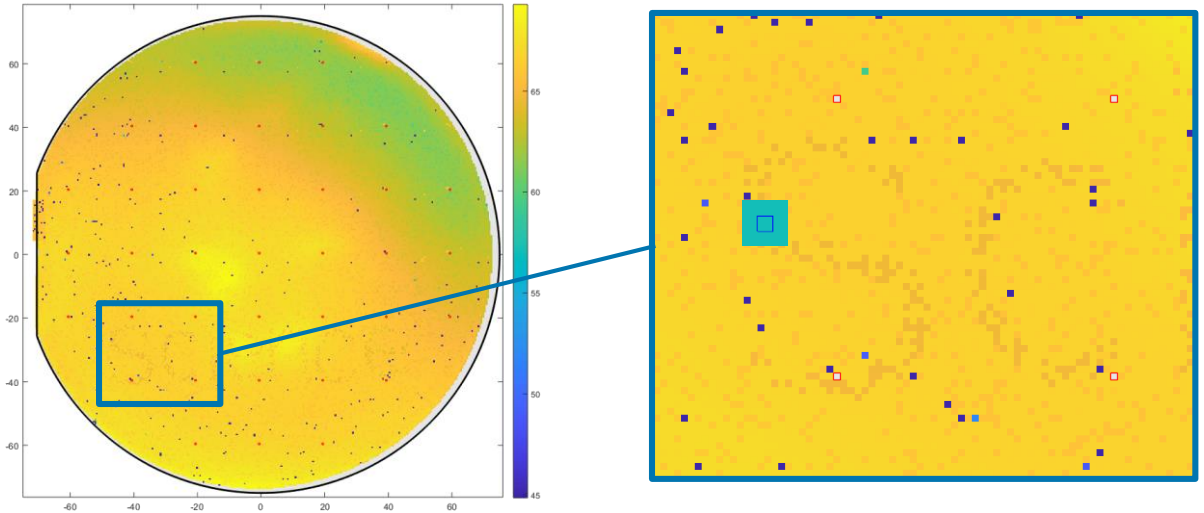


Measurement D

Chip values $\in [45, 70] \subset \mathbb{R}$

Sequence 4: Descriptive Statistics

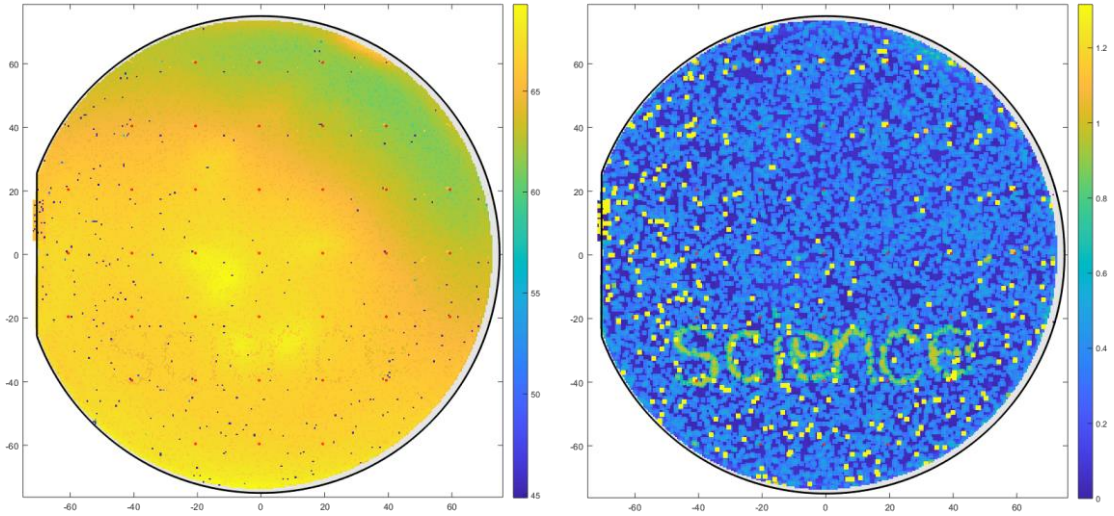
Outlier detection



Sequence 4: Descriptive Statistics

Outlier detection

Standard Deviation
in local neighbourhood

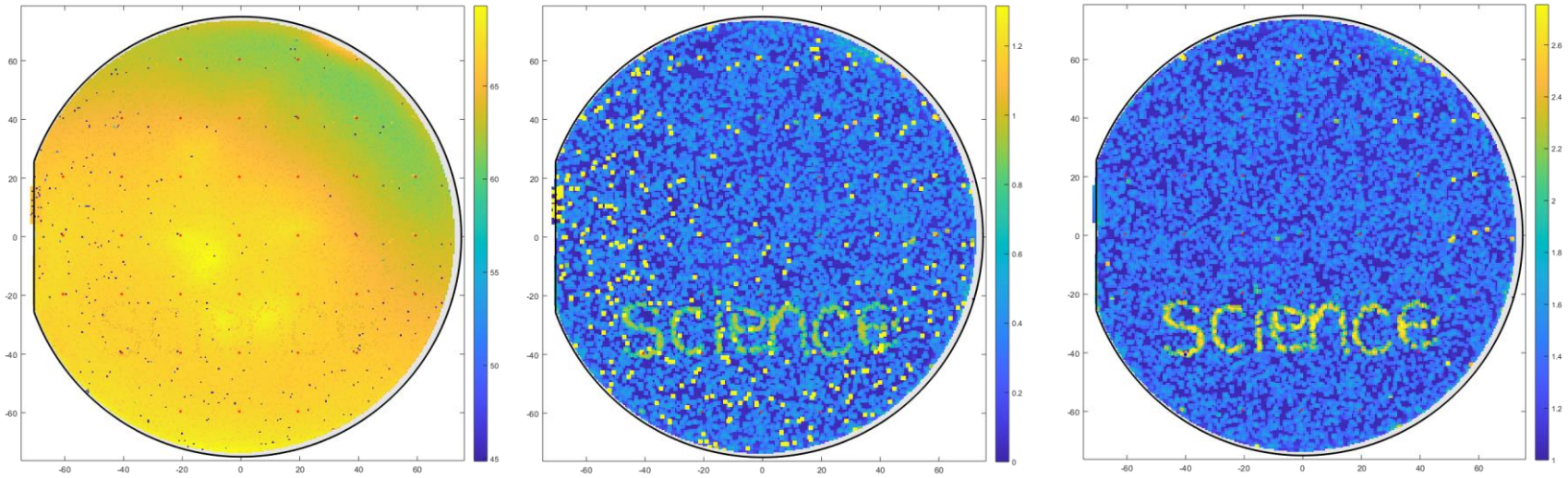


Sequence 4: Descriptive Statistics

Outlier detection

Standard Deviation
in local neighbourhood

Replacing high values
Interpolation



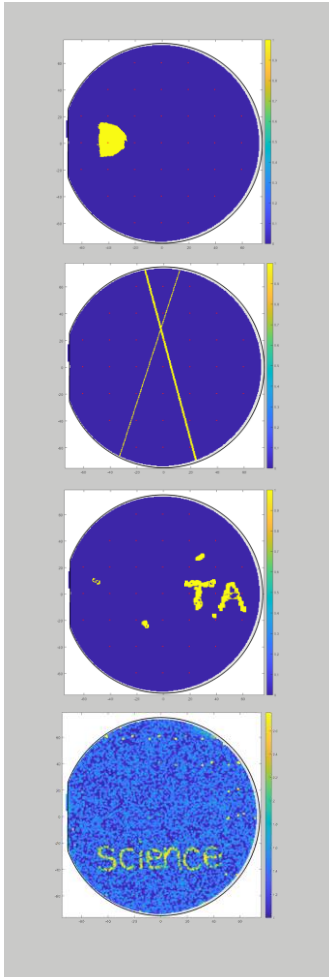
Sequence 4: Descriptive Statistics

Outlier detection

Standard Deviation
in local neighbourhood

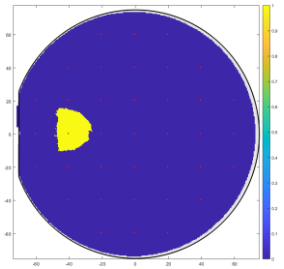
Replacing high values
Interpolation

Measurement D
Chip values $\in [45, 70]$

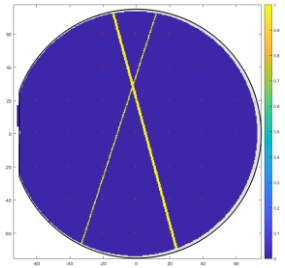


Sequence 1-4: Combination

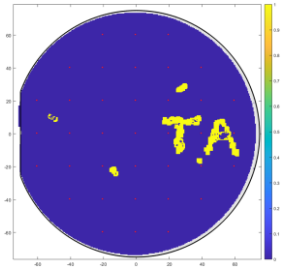
Sequence 1



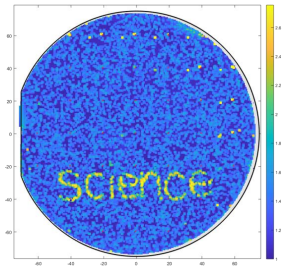
Sequence 2



Sequence 3



Sequence 4



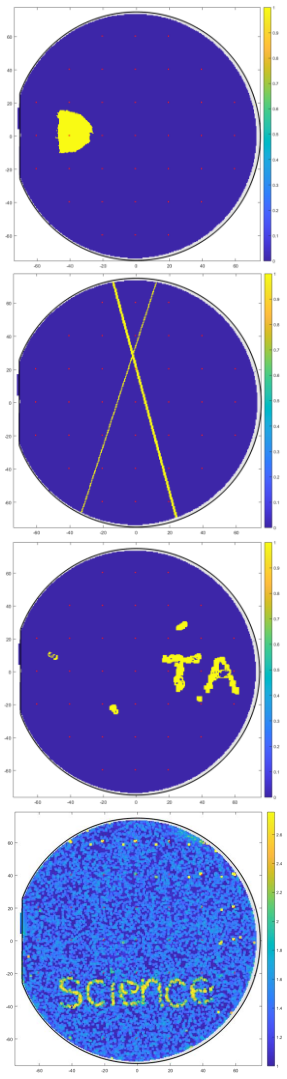
Sequence 1-4: Combination

Sequence 1

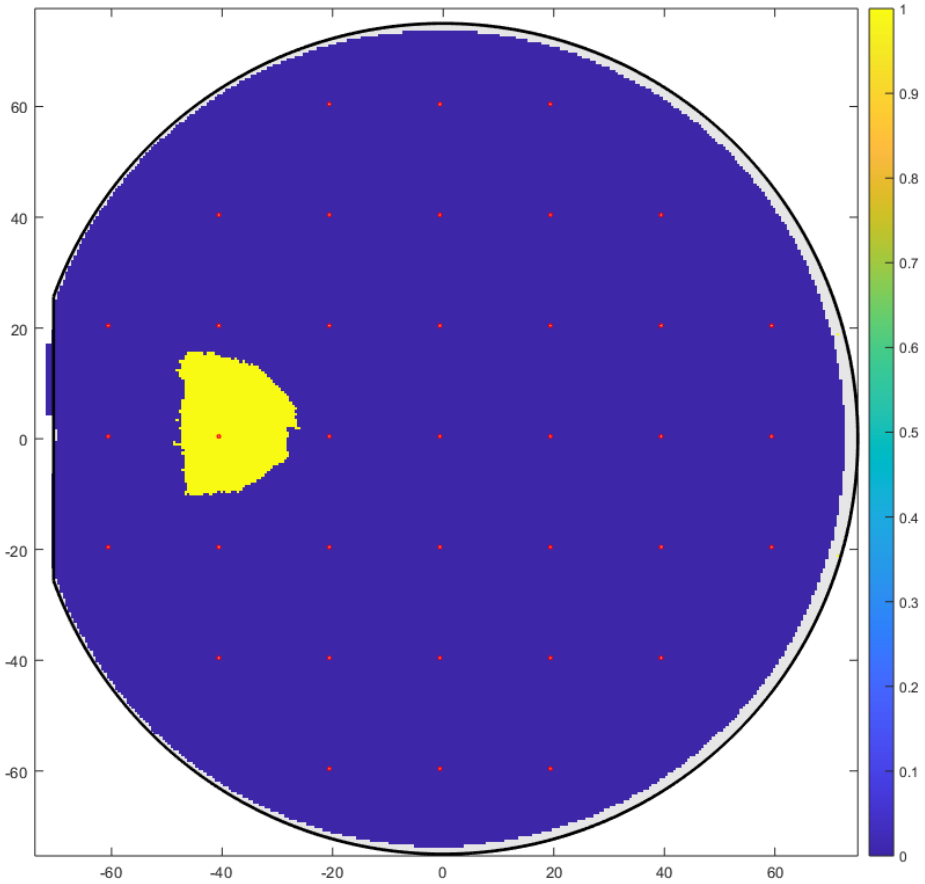
Sequence 2

Sequence 3

Sequence 4



Combination



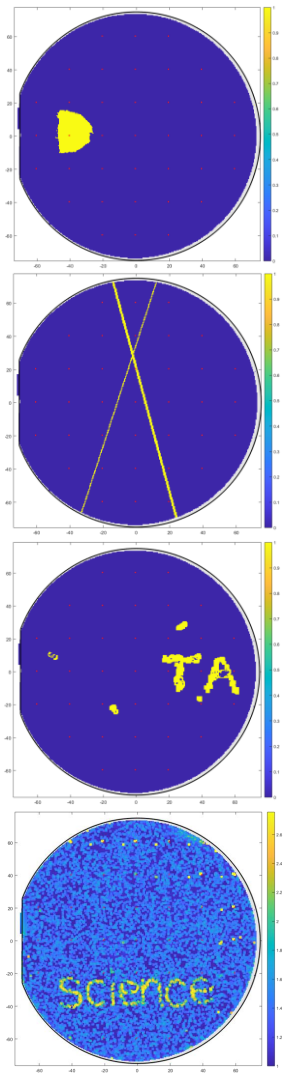
Sequence 1-4: Combination

Sequence 1

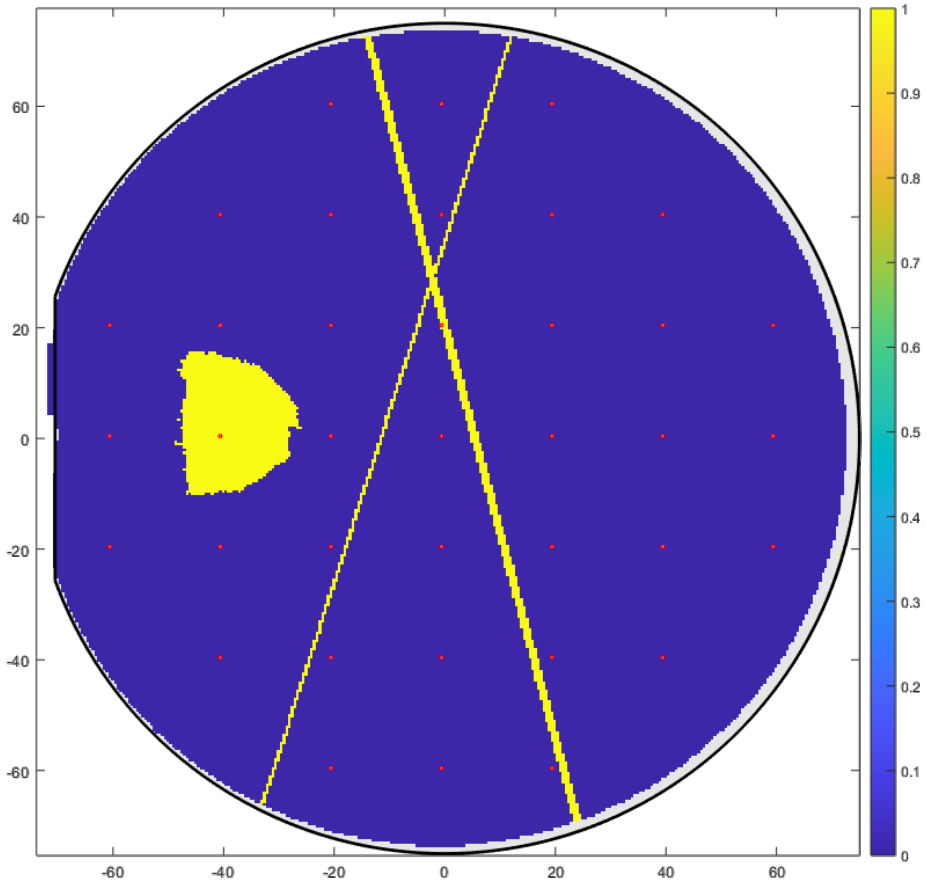
Sequence 2

Sequence 3

Sequence 4



Combination



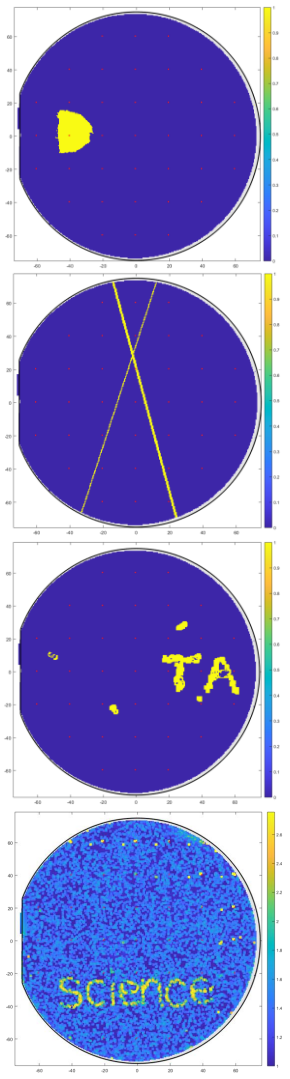
Sequence 1-4: Combination

Sequence 1

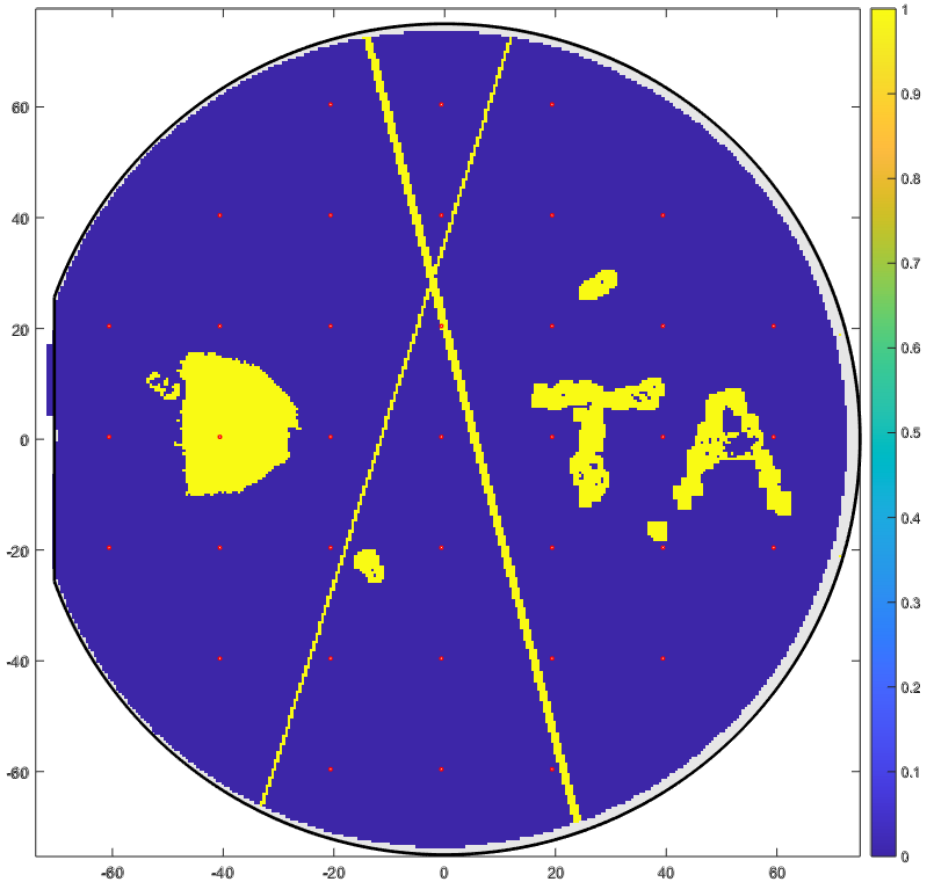
Sequence 2

Sequence 3

Sequence 4



Combination



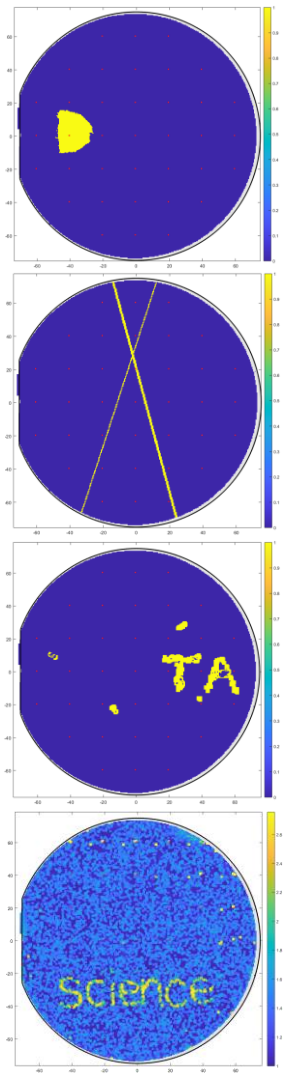
Sequence 1-4: Combination

Sequence 1

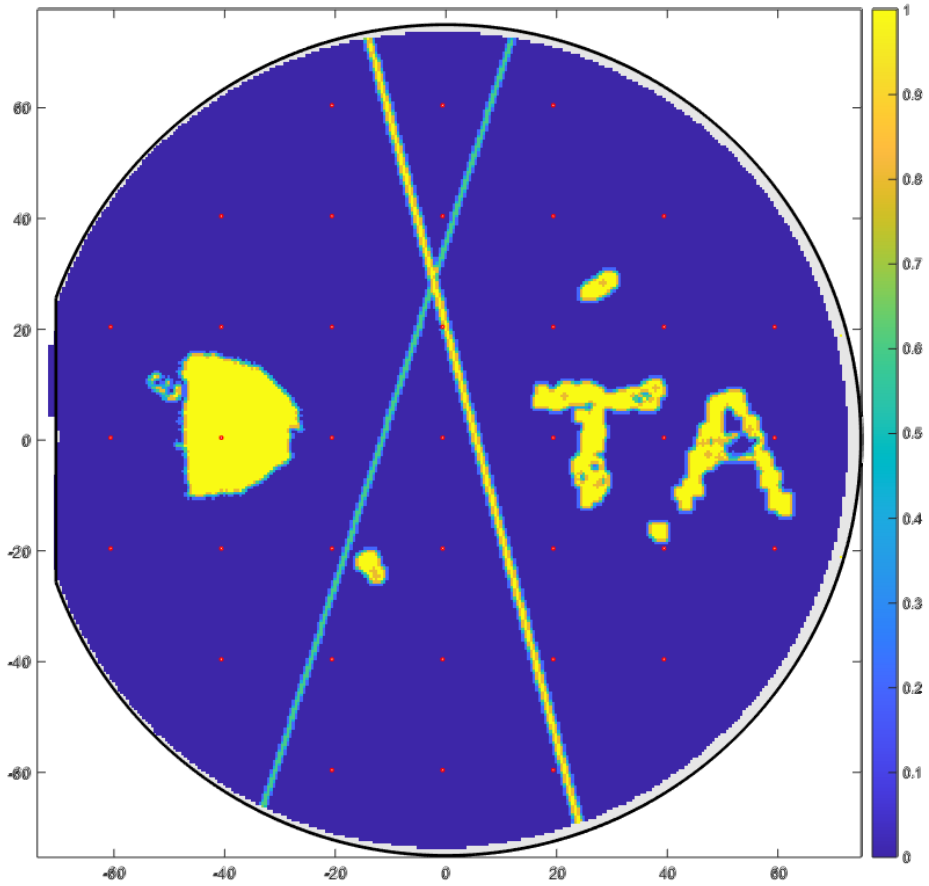
Sequence 2

Sequence 3

Sequence 4



Combination



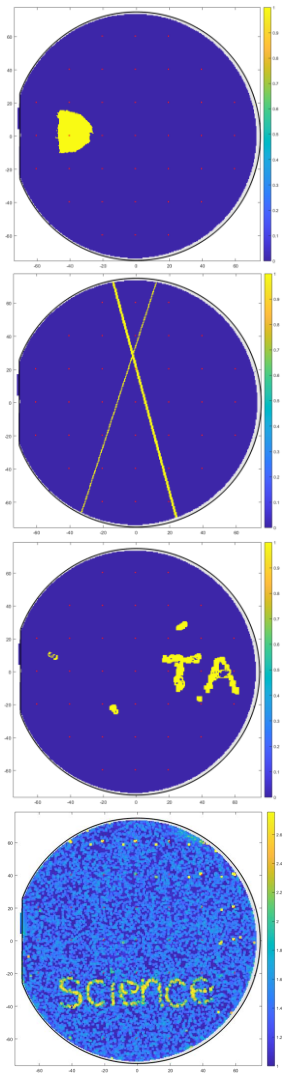
Sequence 1-4: Combination

Sequence 1

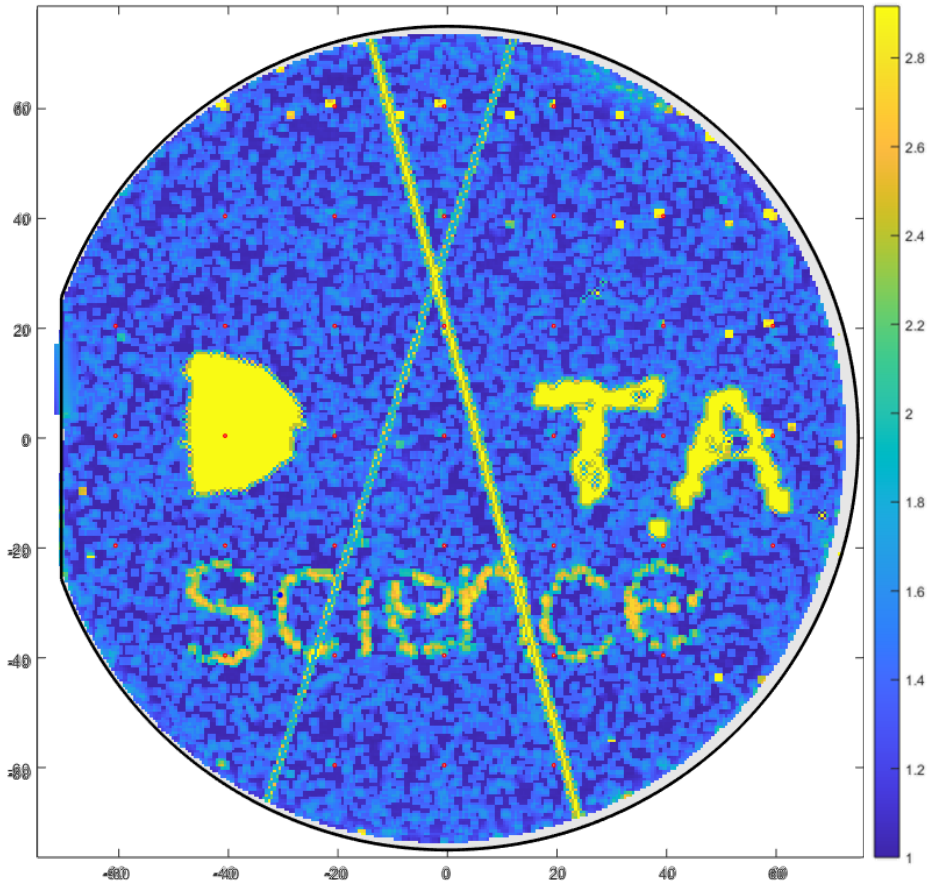
Sequence 2

Sequence 3

Sequence 4



Combination



Sensing is life.

Veronika Völkl

Data Scientist
OSRAM Opto Semiconductors GmbH

13/04/2021

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