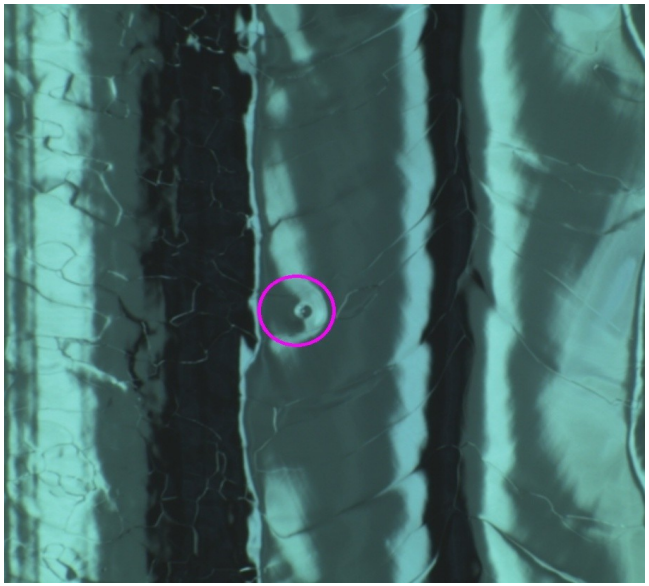
Cavity Surfaces Defect Detection

How to teach a machine to recognize images?

Summer Student Program Report

- Introduction
- Eigenfaces
- Segmentation
- Viola-Jones method
- Summary



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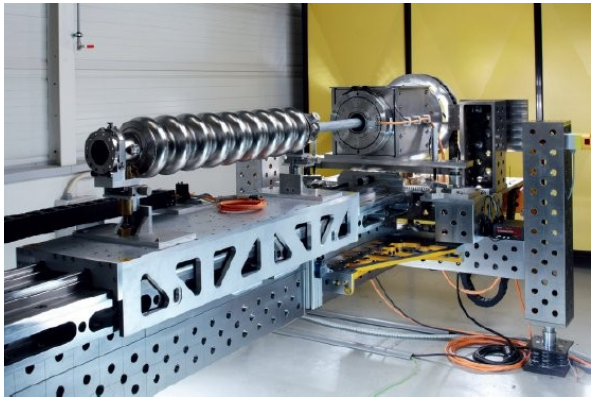
Summer Student Presentation
DESY, 29 August 2013

HELMHOLTZ ASSOCIATION

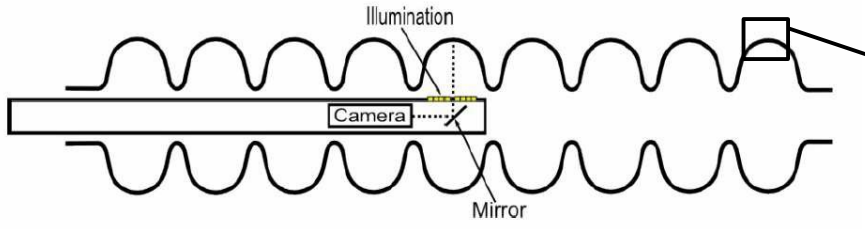
DESY

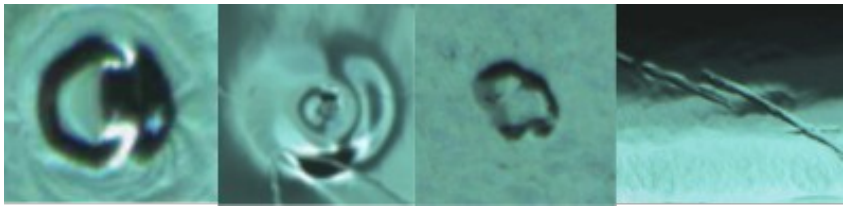
OBACHT

- **O**ptical **b**ench for **a**utomated **c**avity inspection with **h**igh resolution and short **t**imescales



- Fully automated optical inspection: camera position, illumination, image taking and image storing
- Pixelsize of 3.5 µm x 3.5 µm
- 2790 images per cavity





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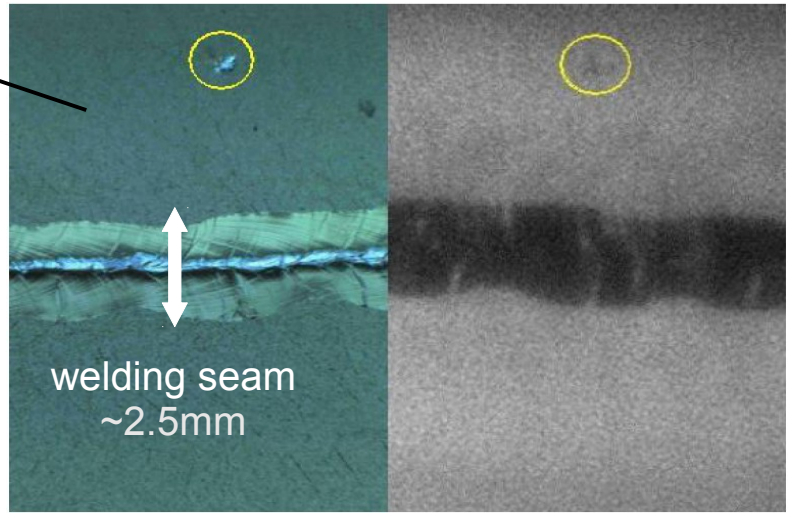
Boroscope



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Introduction

Given

$(\{x_1, y_1\}, \{x_1, y_1\}, \ldots \{x_N, y_N\})$ - training set

$x \in X$ - image set

$y \in Y$ - image classes

f.e. $Y = \{-1, +1\}$

Find

$f = f(x)$ - classificator

$x \in X$

$f : x \longrightarrow y$

$$\text{True positive rate} = \frac{\#\text{true positives}}{\#\text{true positives} + \#\text{false negatives}}$$

$$\text{False positive rate} = \frac{\#\text{false positives}}{\#\text{false positives} + \#\text{true negatives}}$$

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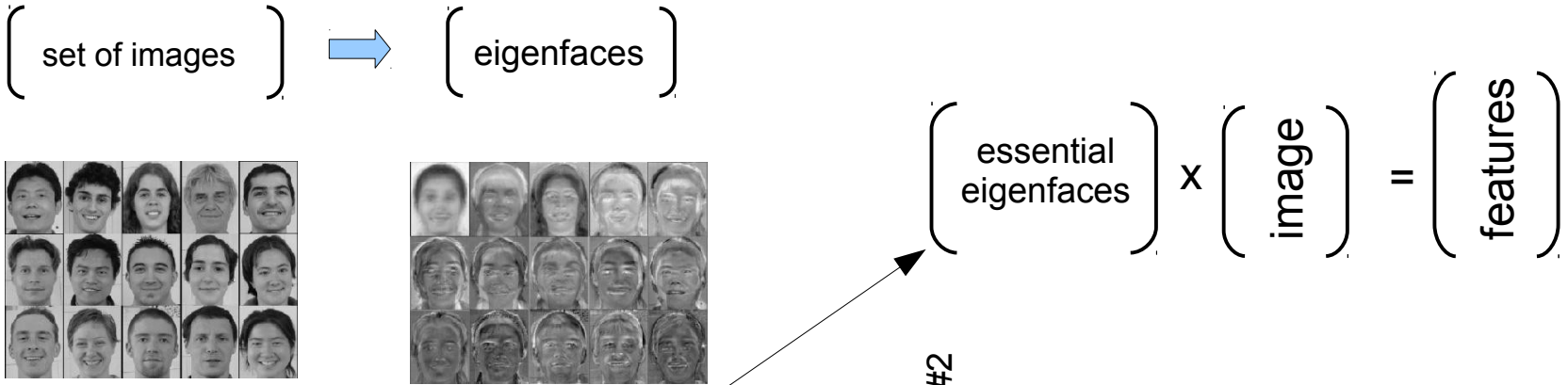
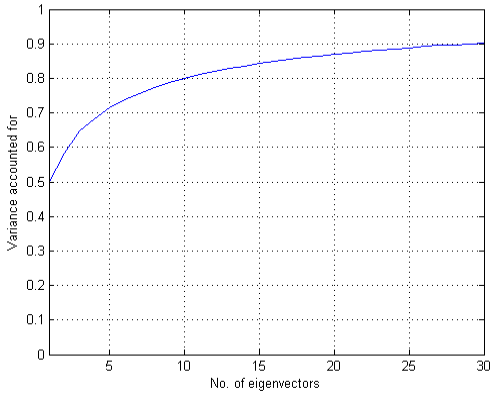
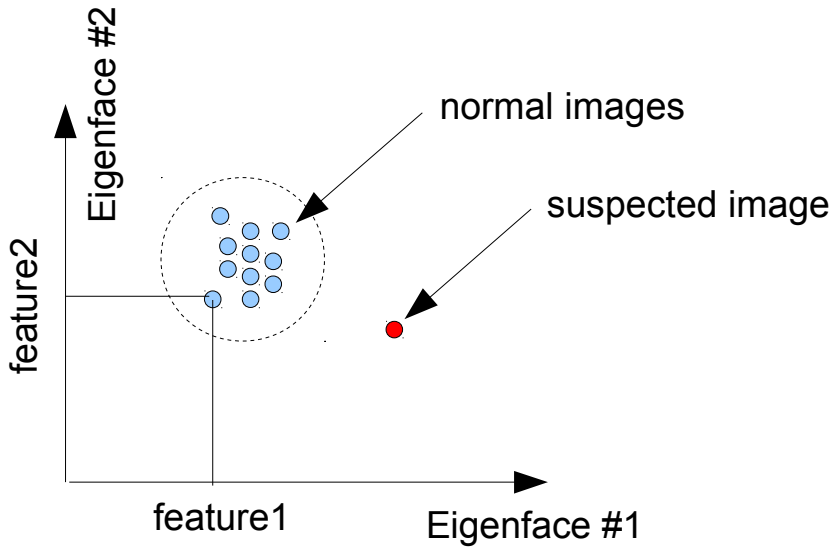
Eigenfaces

- Eigenfaces are principal components of images

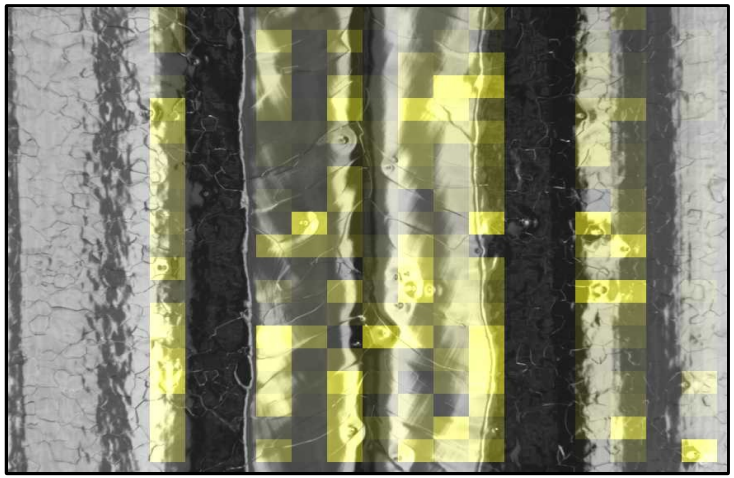


- We don't need all the eigenfaces

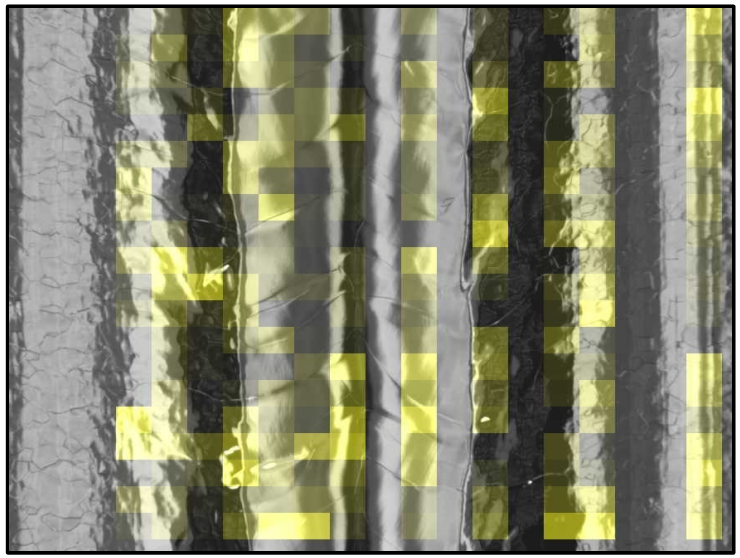




Eigenfaces



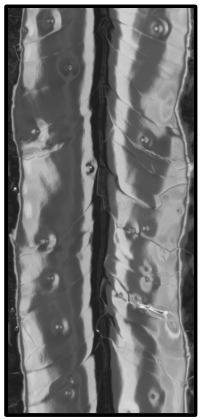
- 5-7 pure images for training inside an equator
- Vertical stripes with irregularities are marked
- The higher irregularity the brighter tile



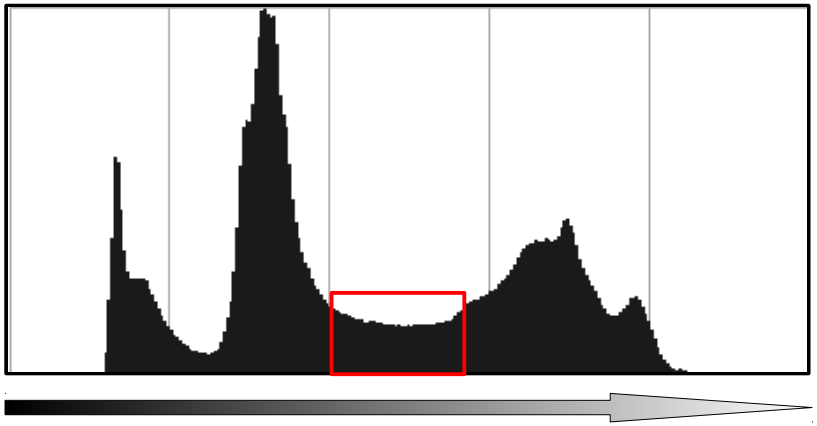
- The structure of the surface is irregular itself
- High false alarm rate

Segmentation

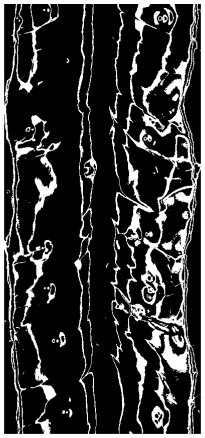
source image



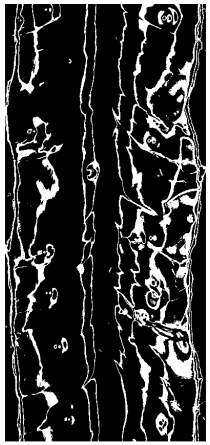
source image histogram



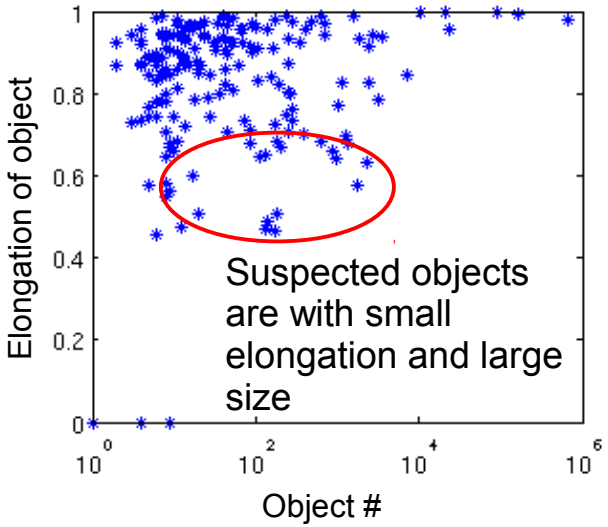
binary image

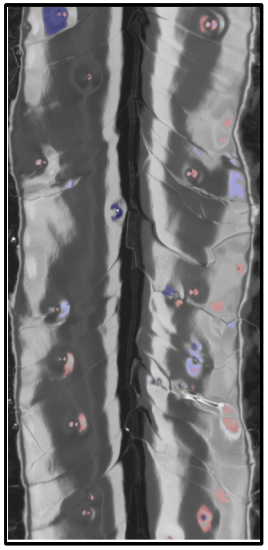


binary image

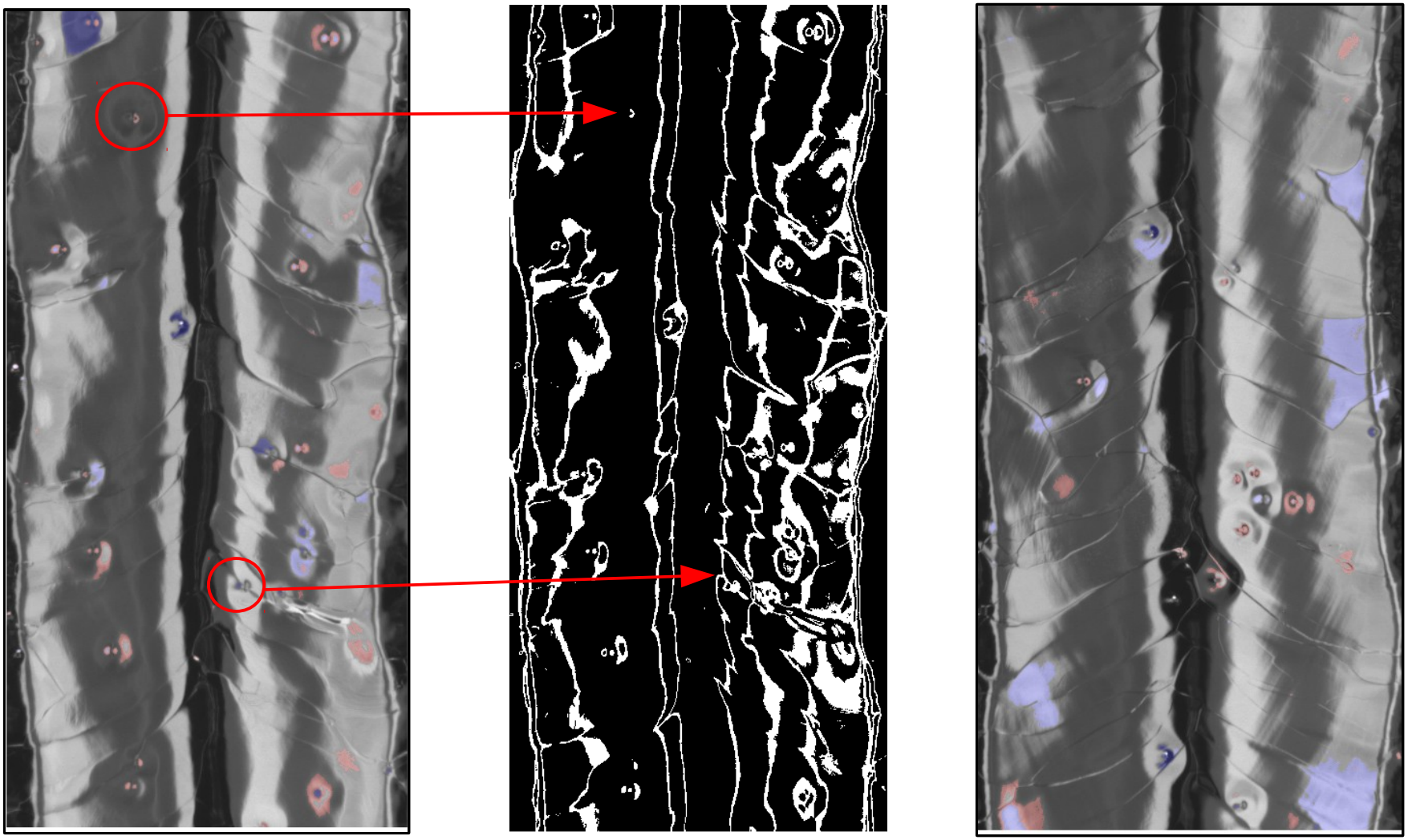


defect selection





Segmentation



Viola-Jones method

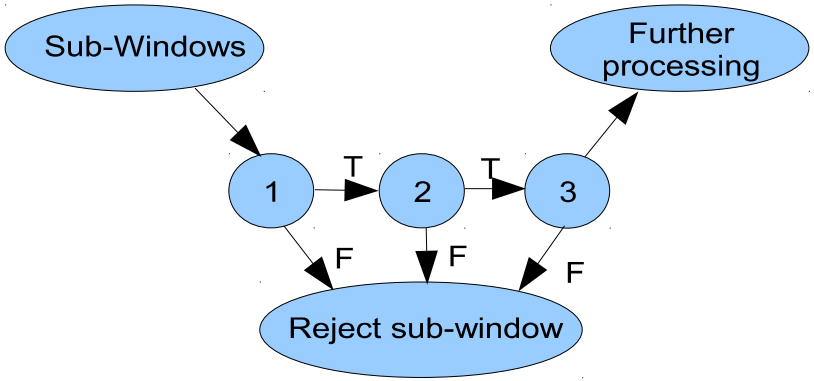
Weak classifier – very rough guess

WC_1 → *WC_2* → … *WC_K* – a strong classifier

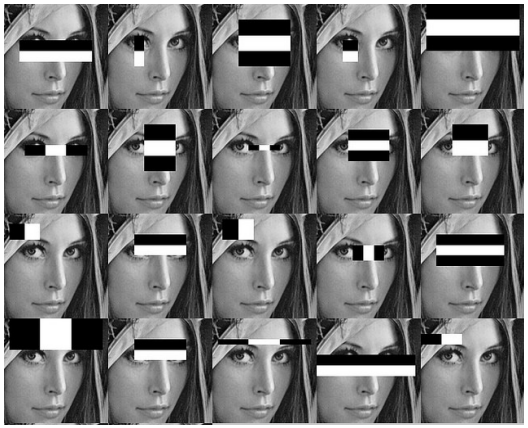
Strong classifier – precise guess

SC_1 → *SC_2* → … *SC_N* – a cascade with extremely low false alarm

Profit!

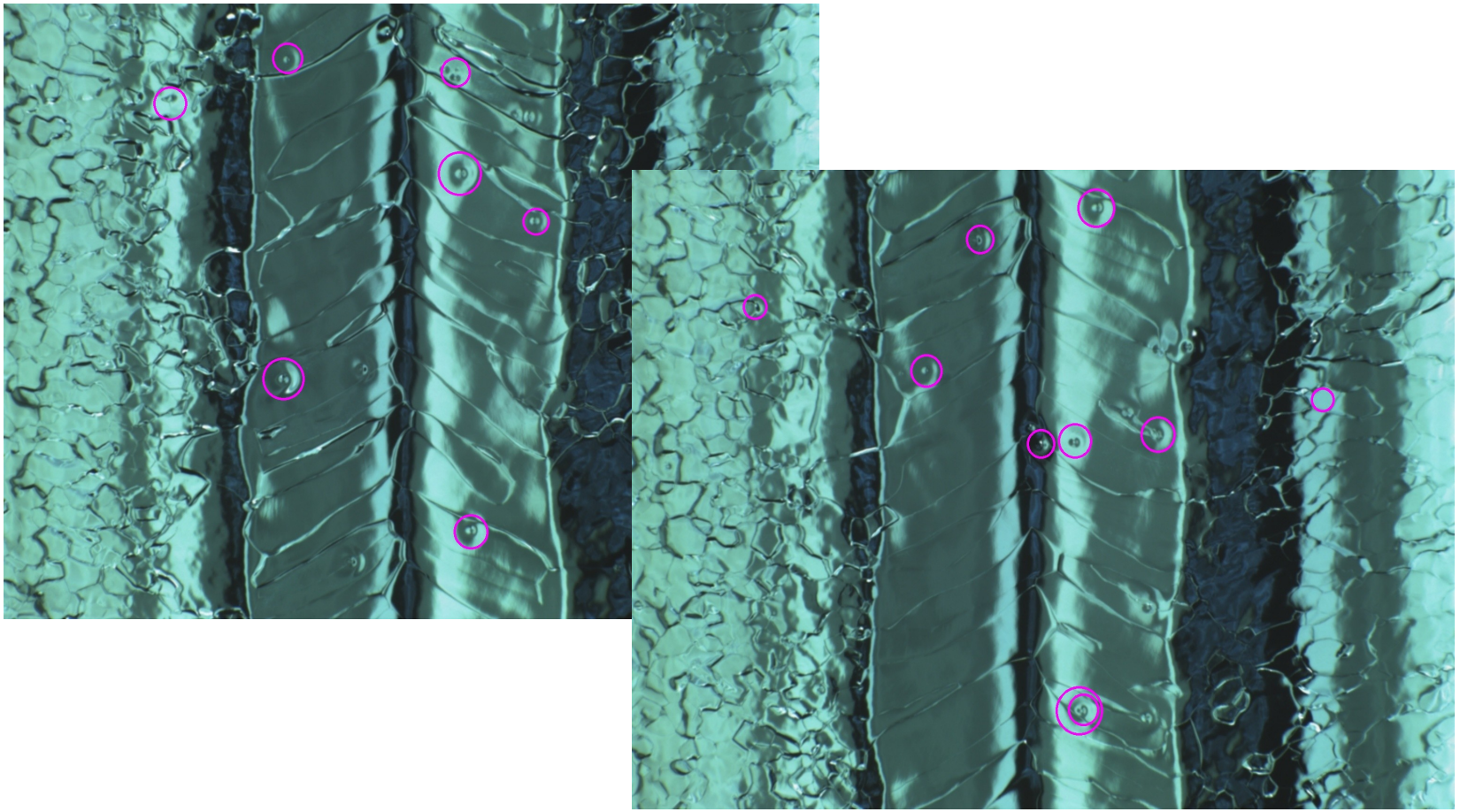


V-J uses Haar features to check an image



Viola-Jones method

Training: 1000 samples of defects and 1500 pure images



Summary

- Three methods of defect detection were studied
- Viola-Jones method showed the most promising results

Method	False alarm	Detection rate	Training	Testing
Eigenfaces	high	low	fast	< 1 second
Segmentation	medium	medium	-	> 1 second
Viola-Jones	low	high	3 days	< 1 second

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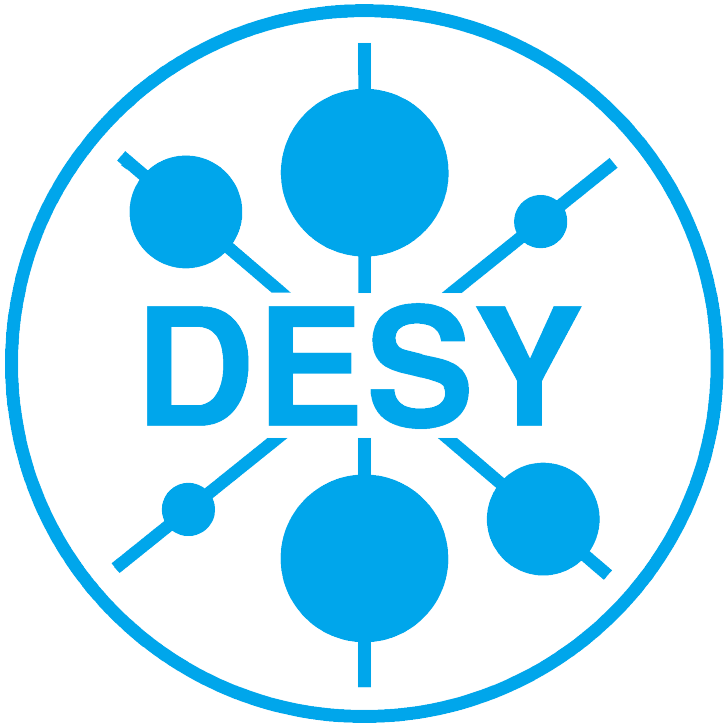
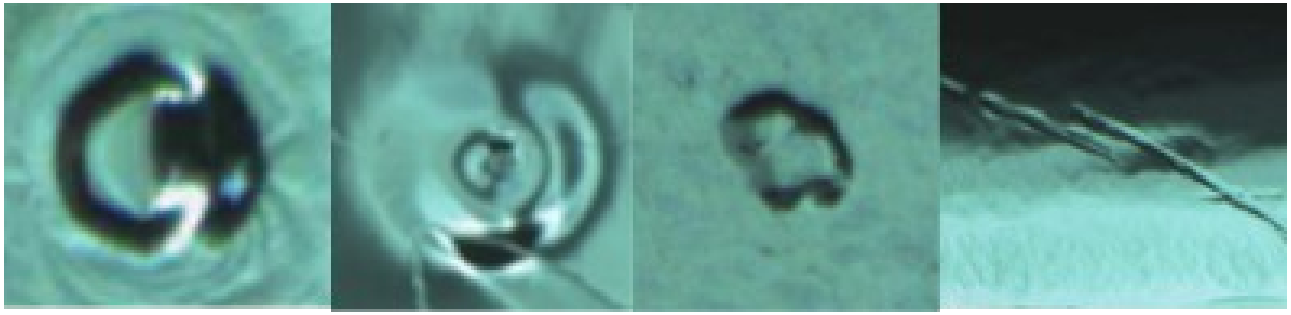
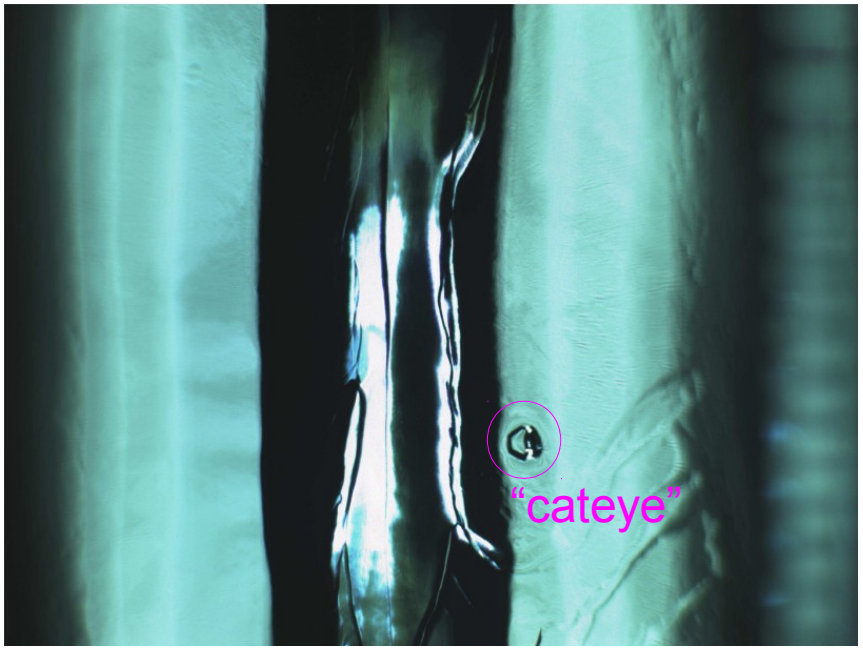
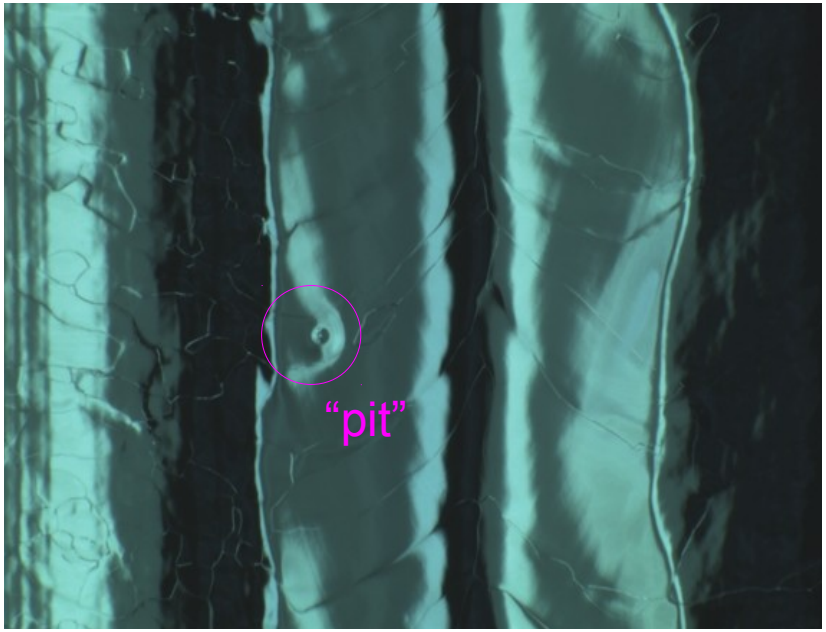
Backup



How defects look like

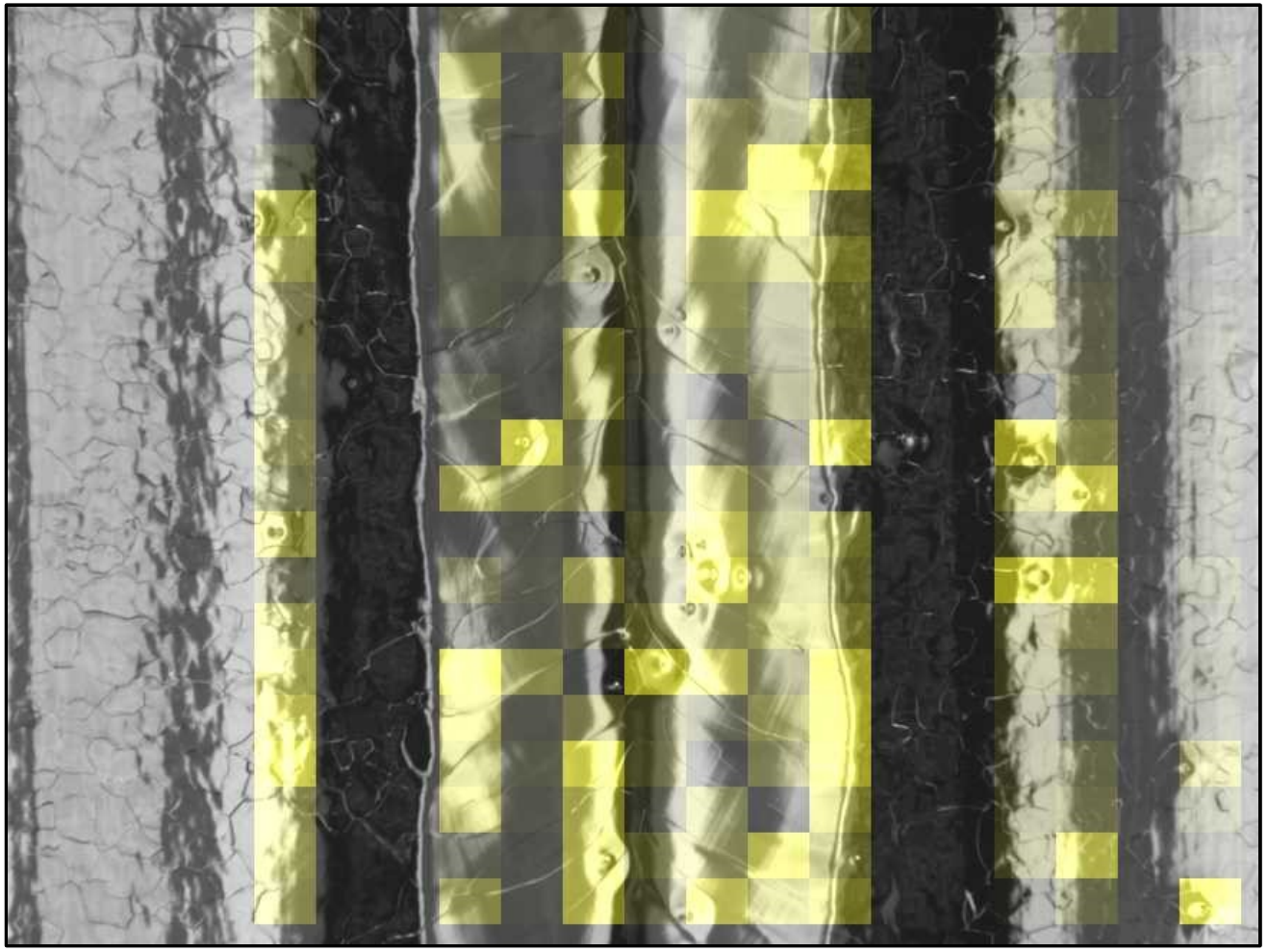






Eigenfaces

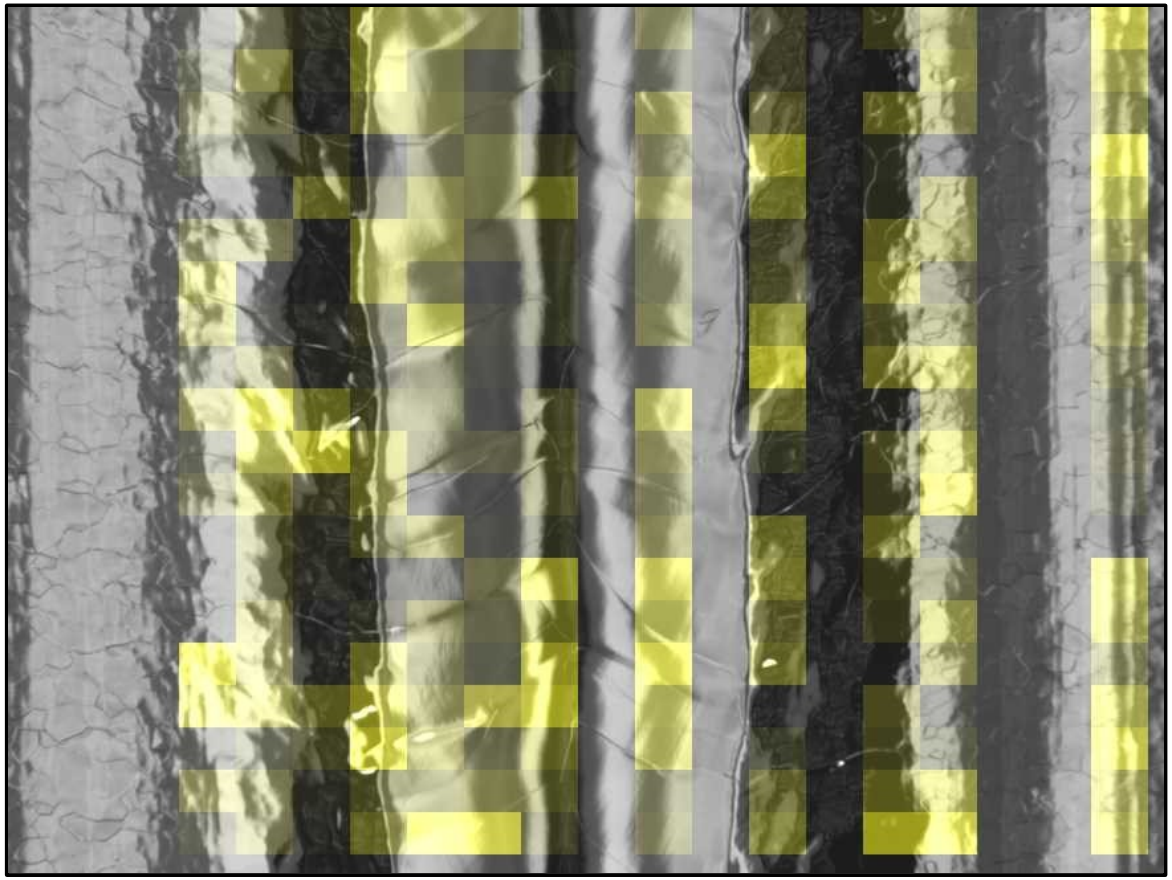
- Results



Eigenfaces

> Results

- The structure of the surface is irregular itself → High false positive rate



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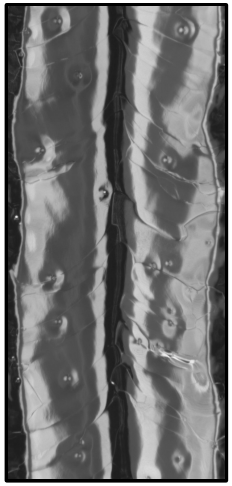
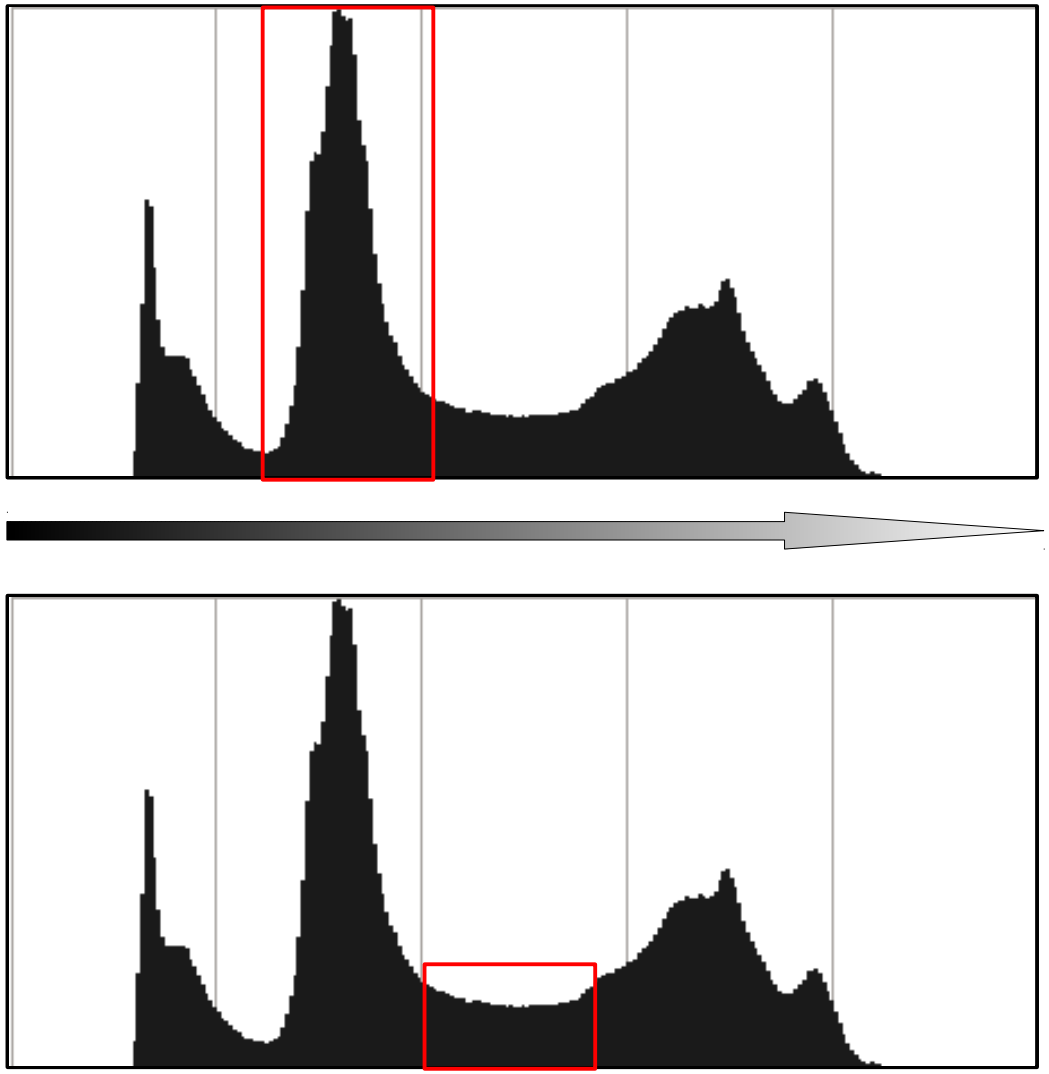
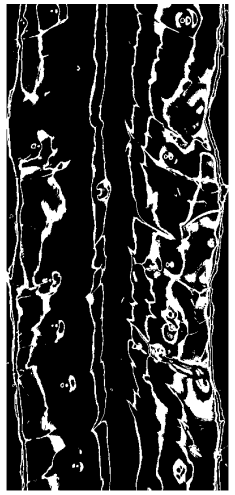
Segmentation

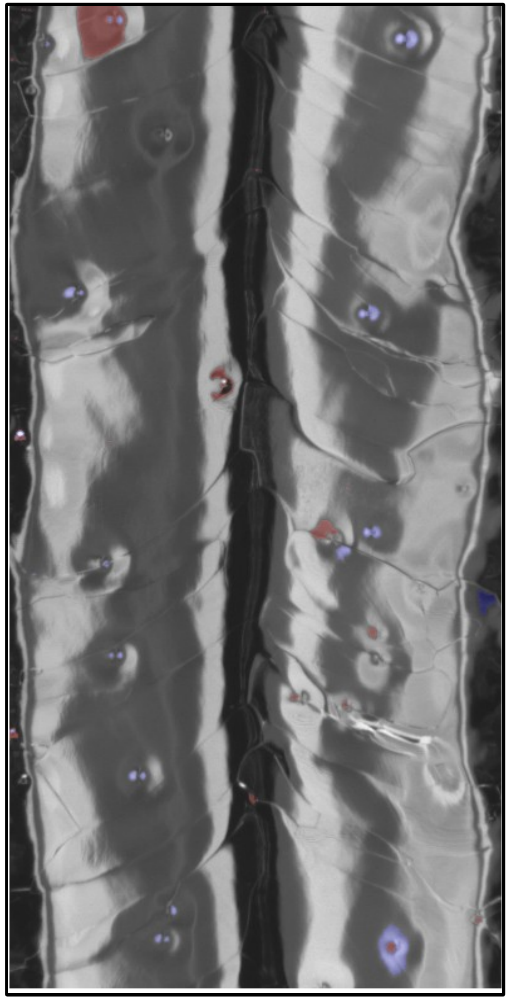


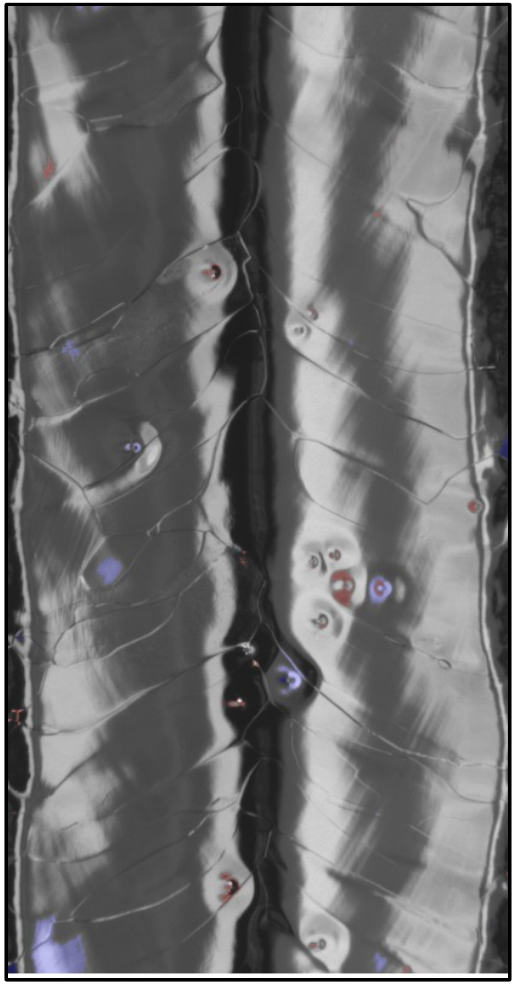




Segmentation

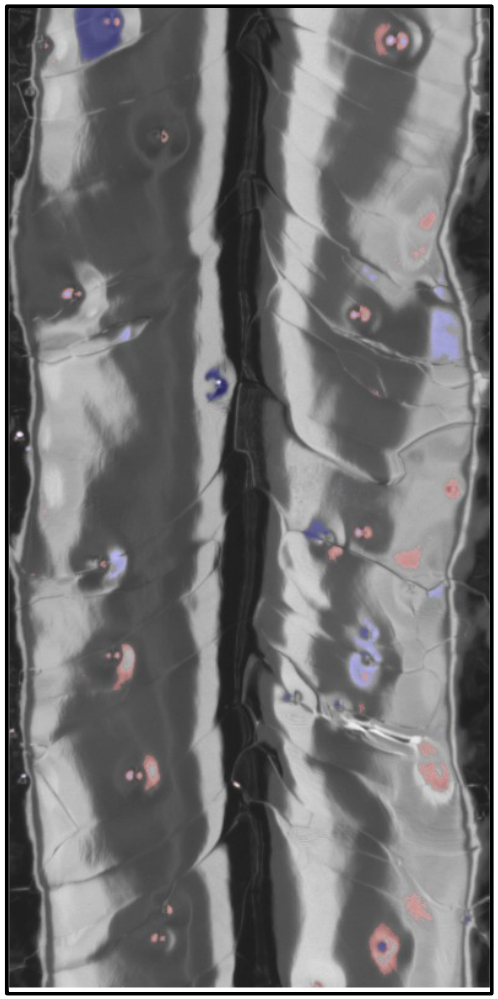
Low tones

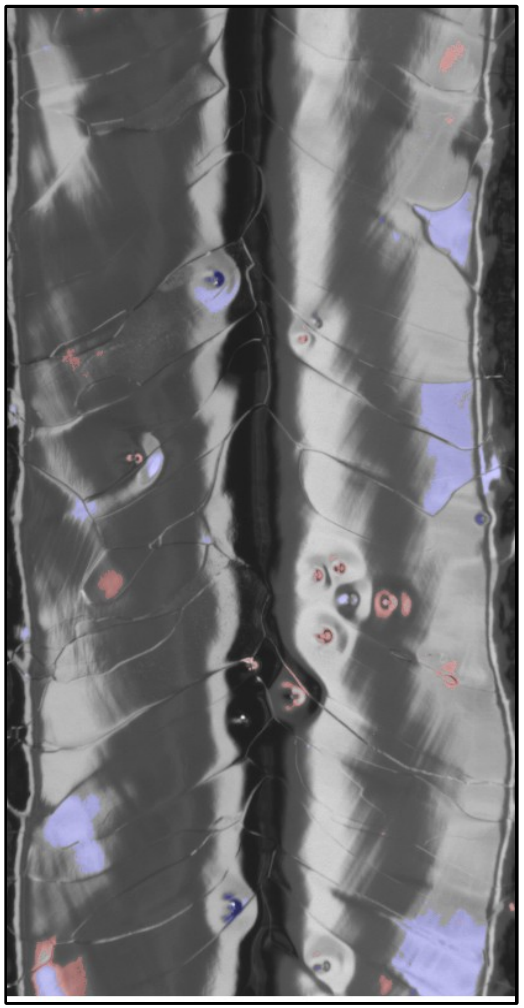




Segmentation

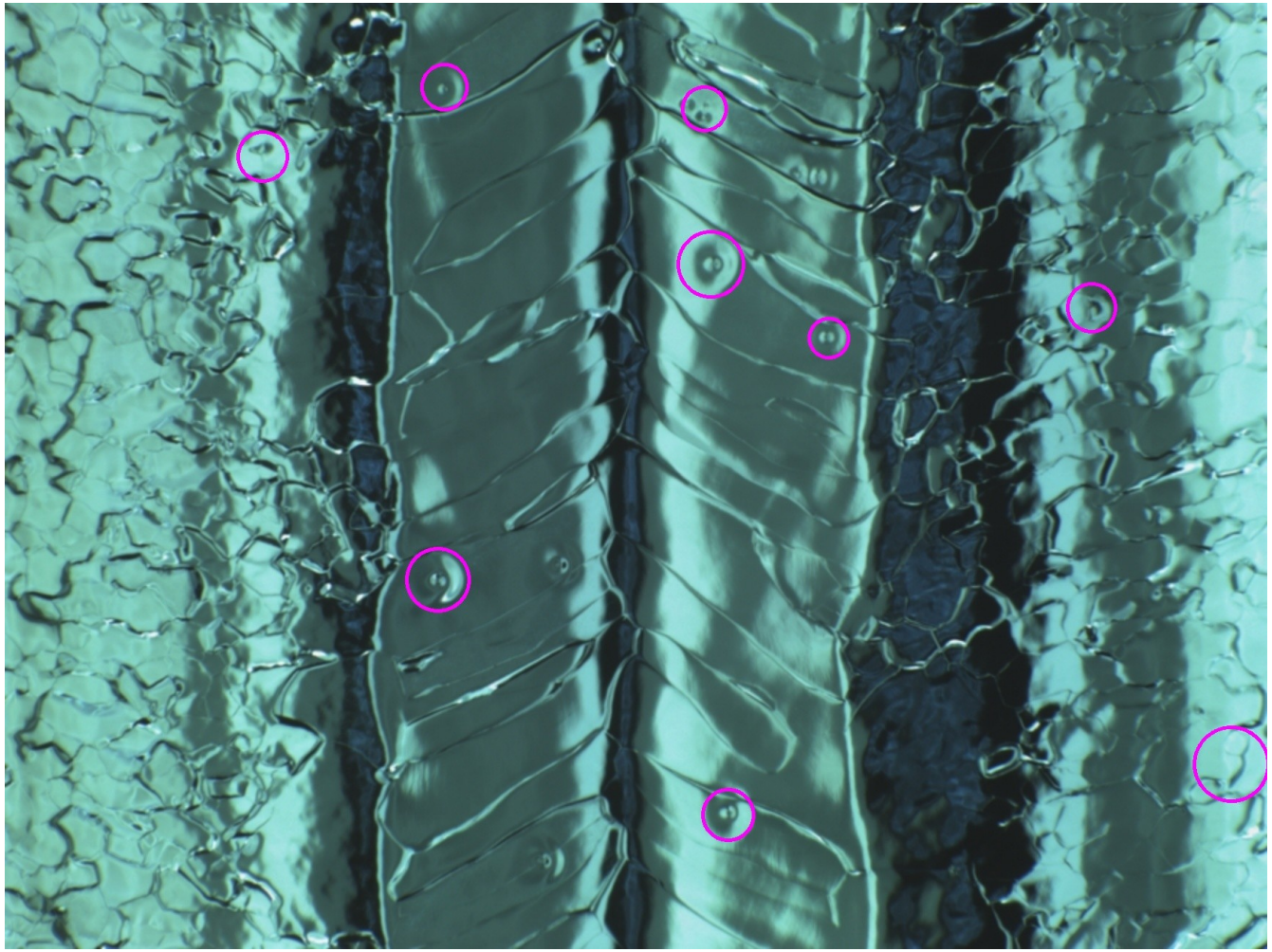
Middle tones





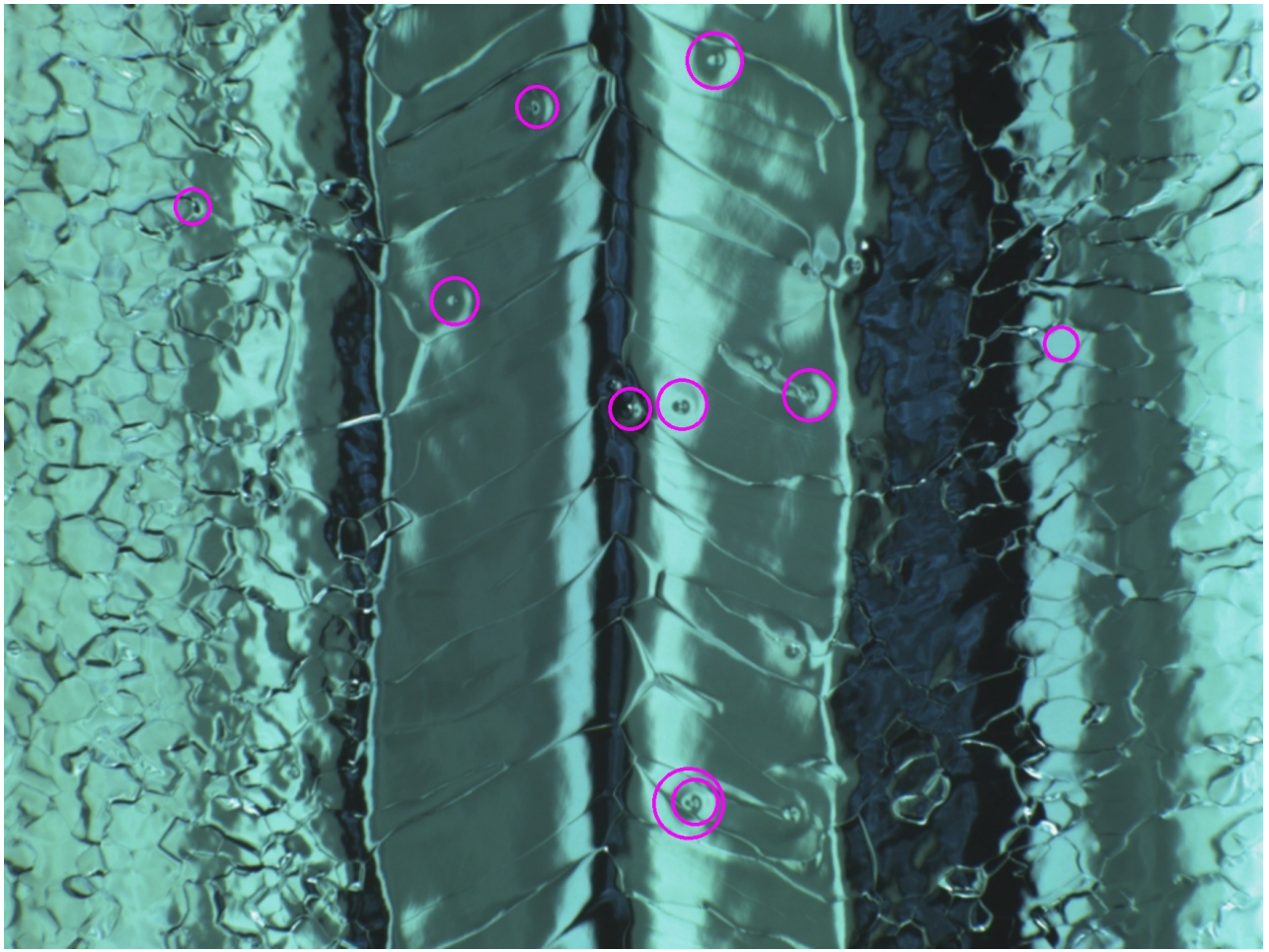
Viola-Jones method

- Results



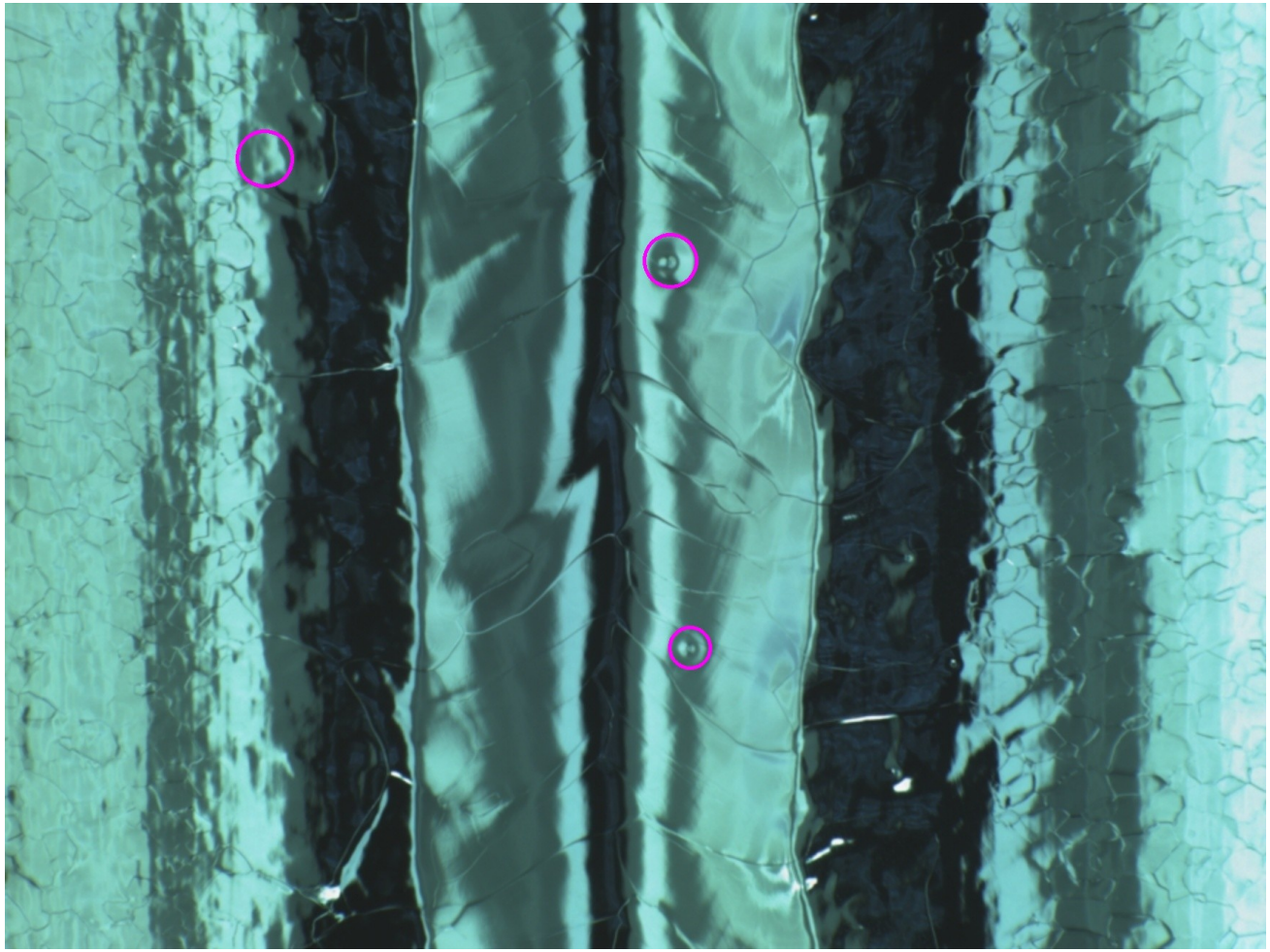
Viola-Jones method

- Results



Viola-Jones method

- Results



Viola-Jones method

- Results