CBM

Compressed Baryonic Matter experiment at FAIR

Advanced optical quality assurance of the silicon microstrip sensors of the CBM Silicon Tracking System

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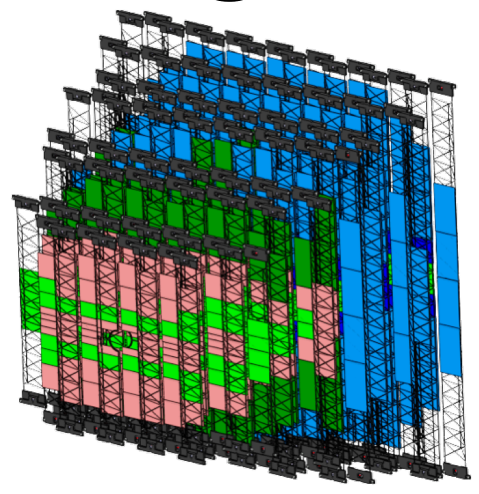
Optical quality assurance challenges

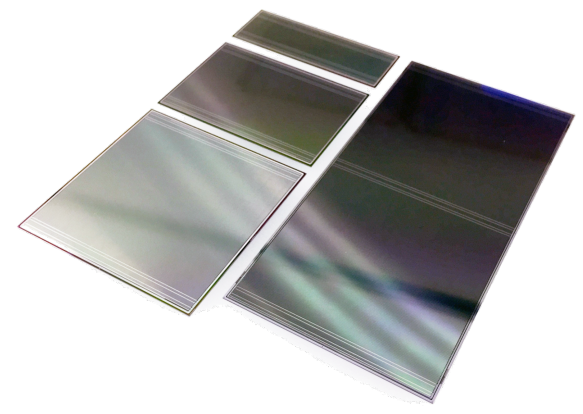
Efficient defect detection requires highly automated and efficient procedures

Challenges are:

- reliable defect recognition
- correct defects classification
- assessment of defect severity
- robust algorithms, general for different sensor types
- precise metrology



Silicon Tracking System

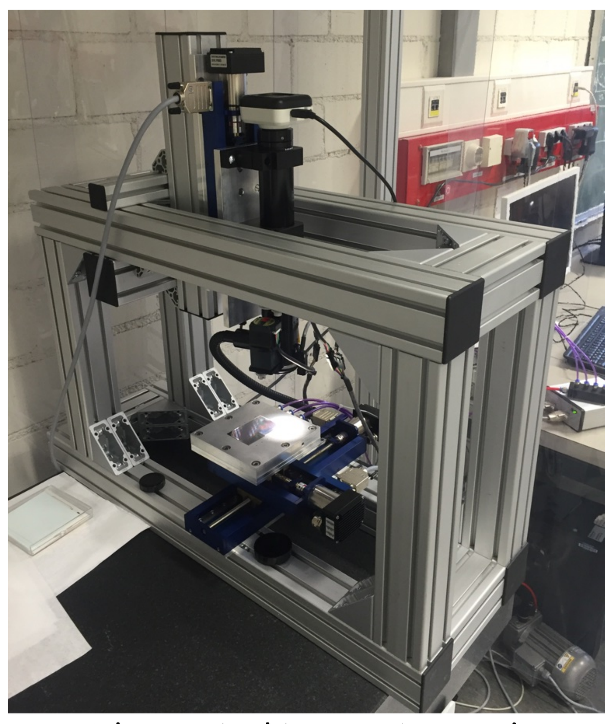


4 sizes of the STS sensors

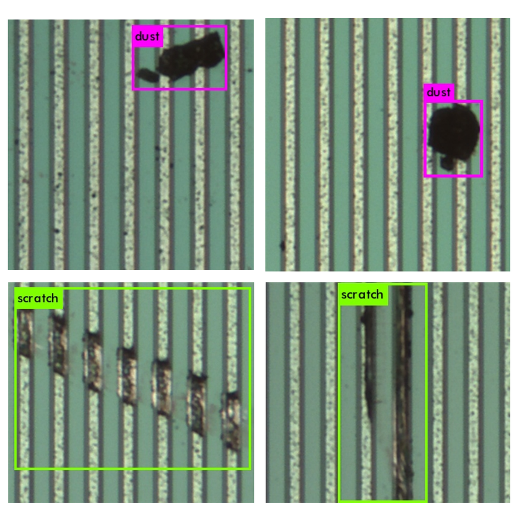
Surface quality inspection

Optical inspection setup:

- 5 MP digital microscope camera
- Motorized zoom and focus, optical axis on a Z motor stage
- XY linear stages with an object table
- 3-zone custom vacuum chuck with 150 mbar underpressure
- Modular software and hardware solution based on NI LabVIEW®
- Optical control and recognition by NI Vision® framework



The optical inspection and metrology setup in a clean area



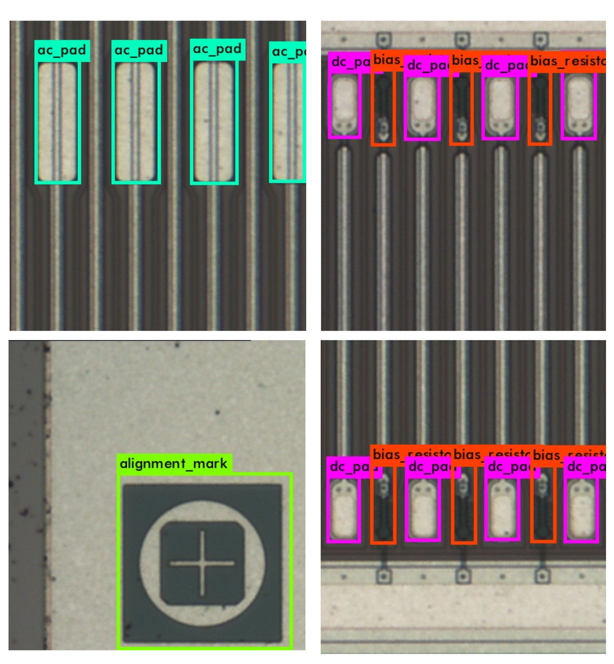
Dust and scratch defects detection

Sensor surface defects:

- Scratches (break the metal strips -> dead channel)
- Metal shorts (lower signal output)
- Metal breaks (dead channels)
- Implant shorts and breaks
- Electrical structuring elements defects
- Dust grains (might obscure more severe defects like scratches, metal breaks)

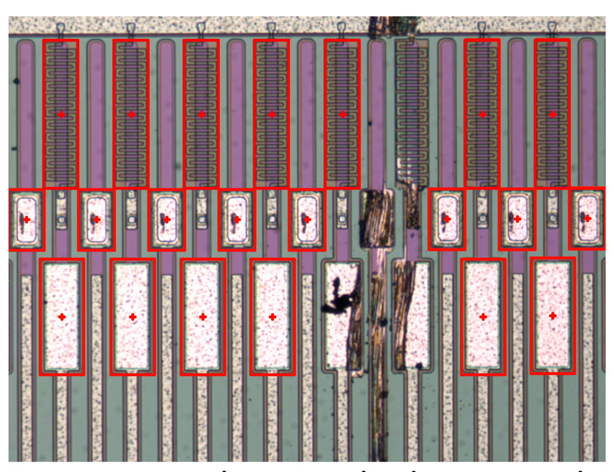
Defect context extraction:

- defines the severity of the defects:
  - Strips - read out channels
  - AC pads - cable bonding
  - DC pads - electrical strip tests
  - Bias resistors – electrical signal properties
  - Guard Ring – electrical field shaping



Neural network applied for defect context extraction

- Detection is done with machine vision algorithms:
  - edge detection
  - image filtering
  - pattern matching
  - texture matching
  - deep conv. neural networks



Pattern matching applied to control integrity of the elements

Metrology

Contactless high-precision height measurements:

- Makes use of the motorized focus or Z-stage
- Sharpness, and thus height is estimated by FFT
- Data fitted with Lorentzian distribution

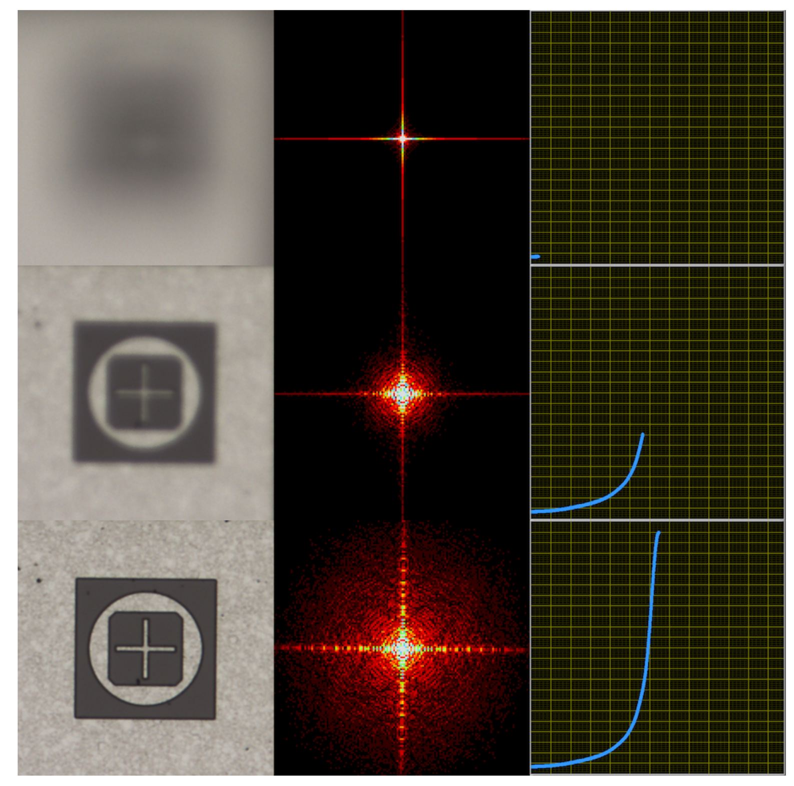
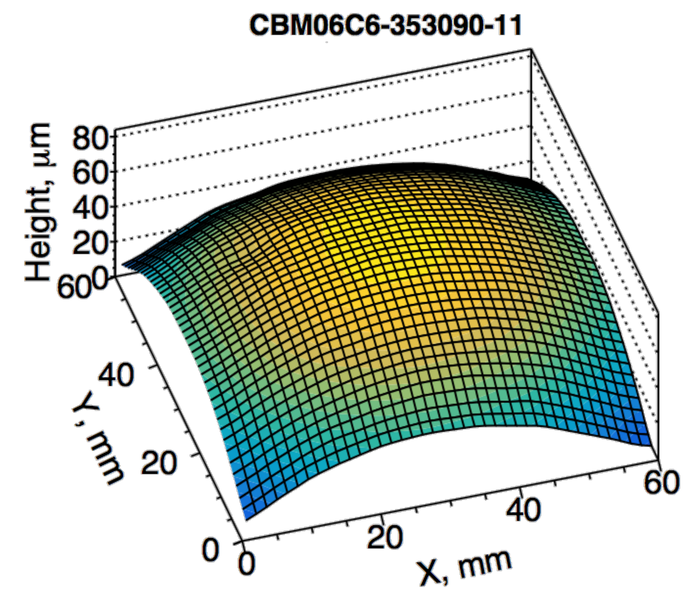


Figure: source image, FFT transformed complex image and Lorentzian distribution of the pixel sum vs motor position at different measurement stages



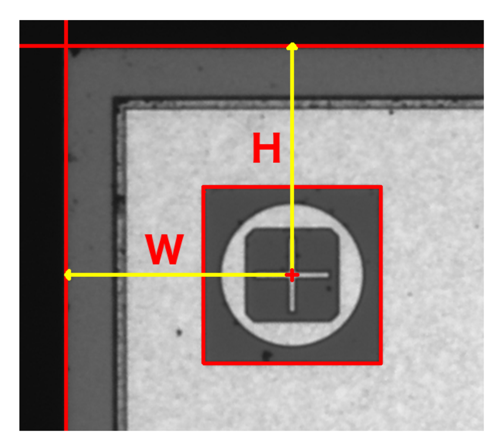
Sensor warp measured for a prototype sensor

Sensor warp:

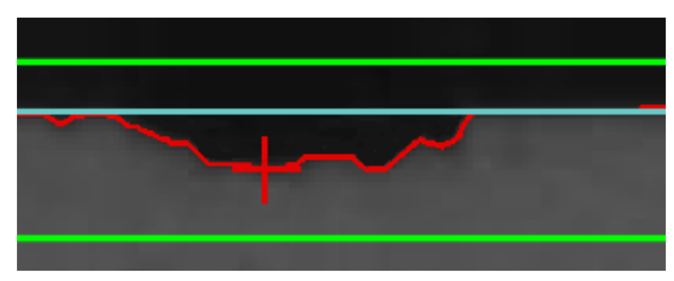
- Applying the height measurements over all sensor area allows to extract its height map (sensor warp).
- Knowing the sensor warp is important for detector precision assembly.

Sensor edge inspection:

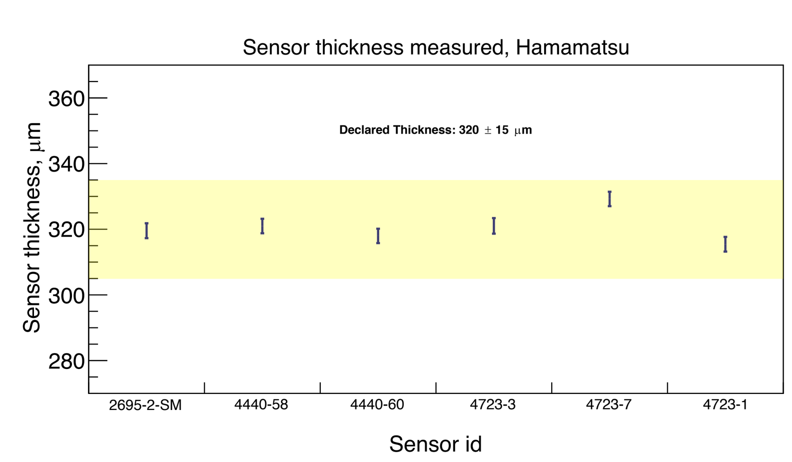
- Sensor edge defects occur due to cutting processes
- Ladder assembly relies on parallelism of the edges
- The straightness of edge cut, e.g. absence of big chips and bumps is essential
- Direct inspection of a sensor edge allow to measure the sensor thickness

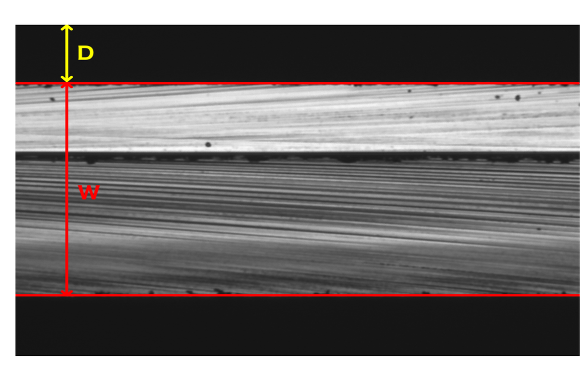


The sensor edge parallelism measurement principle



Sensor cutting edge quality measurement principle





Direct sensor thickness measurement principle

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