Status update on ACF interconnect tests at UniGE

CLICdp vertex & tracking WG meeting 21/06/2019

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Remainder

Anisotropic Conductive Film (ACF)

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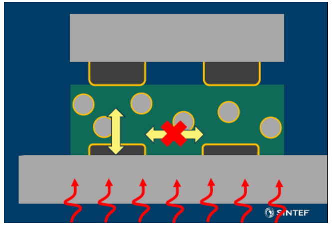
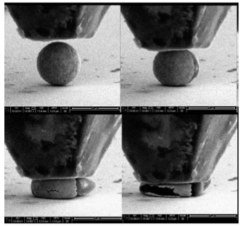
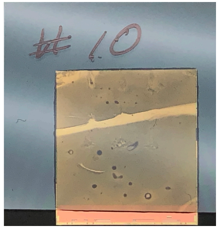
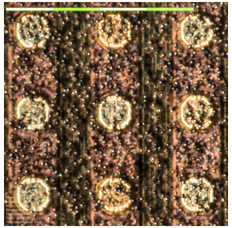
- **18 µm** adhesive film filled with **3 µm** conductive micro-particles
  - Curing starts at ~ 100 ℃
  - Recomended bonding temperature = 150-180 ℃
    - ACF-63: Ni/polymer – Film with high density of particles
    - ACF-64: Au/Ni/polymer – Film with lower particle density
  - Pre-bonding: 10 kg at 80 ℃ during 10 seconds
  - Bonding with **100 kg** force
    - Film flow at 80 ℃ T_{flow} seconds and final film curing at 150 ℃ for 18 s

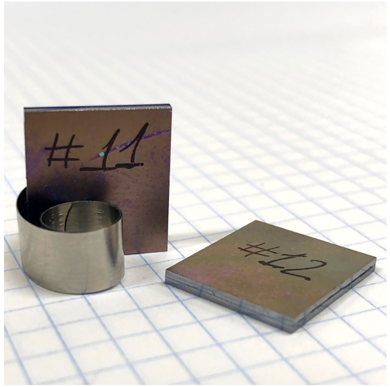


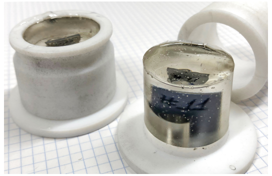






- S10: Timepix-Glass, ACF-63 + T_{flow}= 100s
- S16: Timepix-Glass, ACF-64 + T_{flow} = 500s (New)
- S11: Timepix-Timepix, ACF-63, T_{flow} = 100s
- S12: Timepix-Timepix, ACF-64, T_{flow} = 100s





First look

Sample 10 – ACF 63 – Flow for 100s

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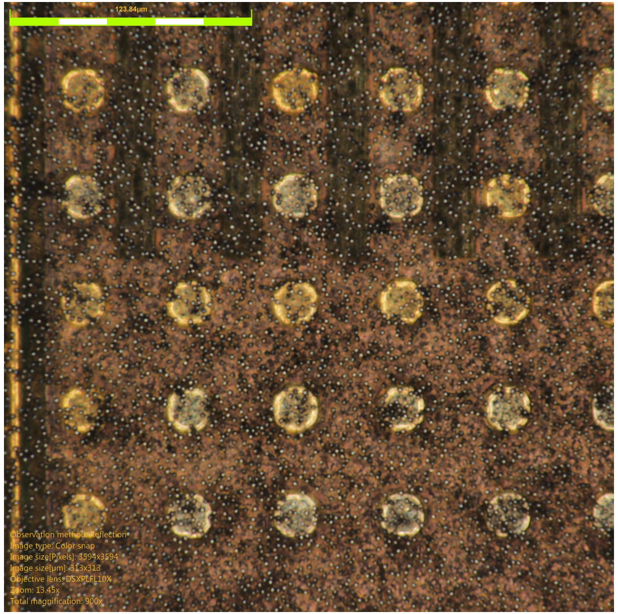
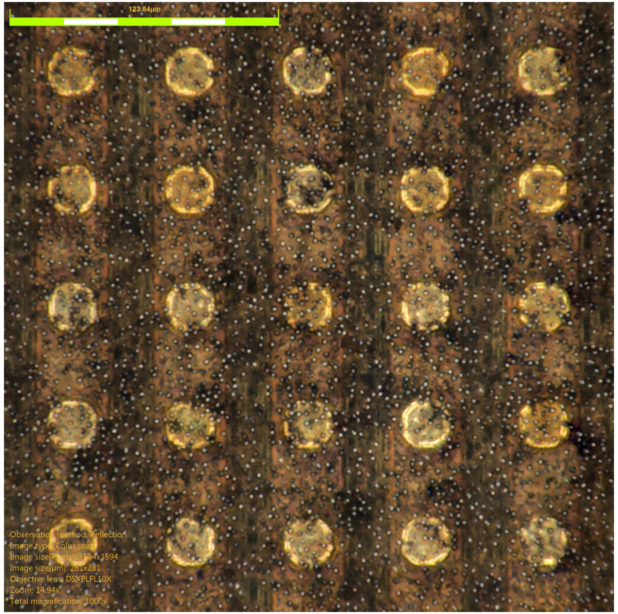
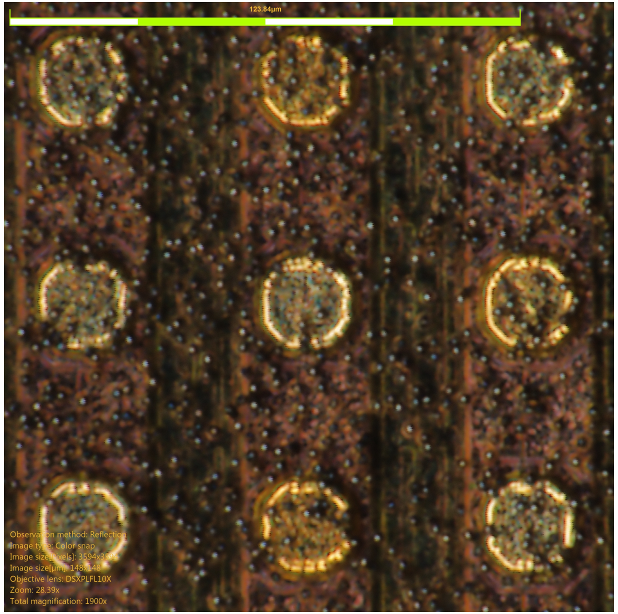
- Initial (human) visual inspection shows about ~ 10 particles per pixel pad







First look

Sample 16 – ACF 64 – Flow for 500s

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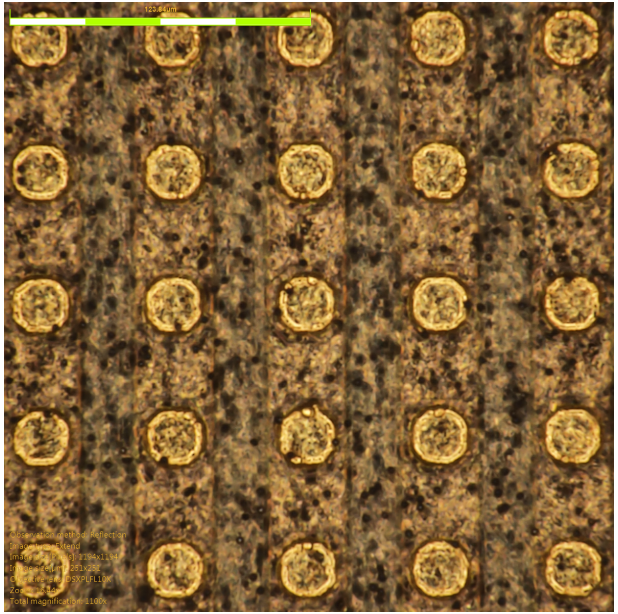
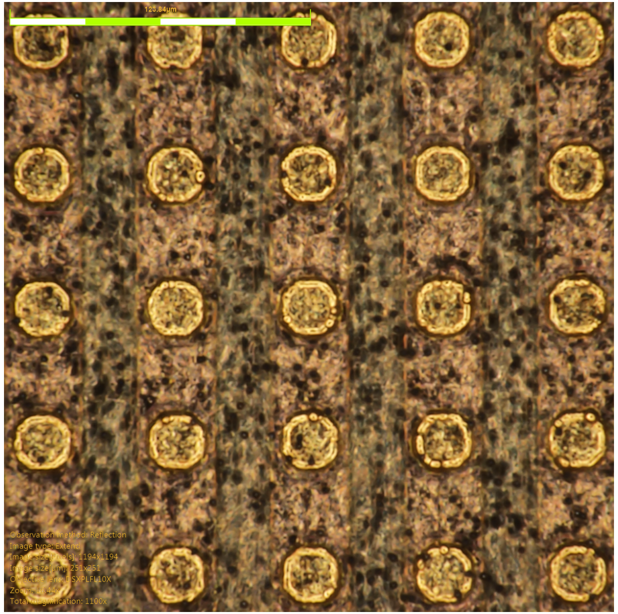
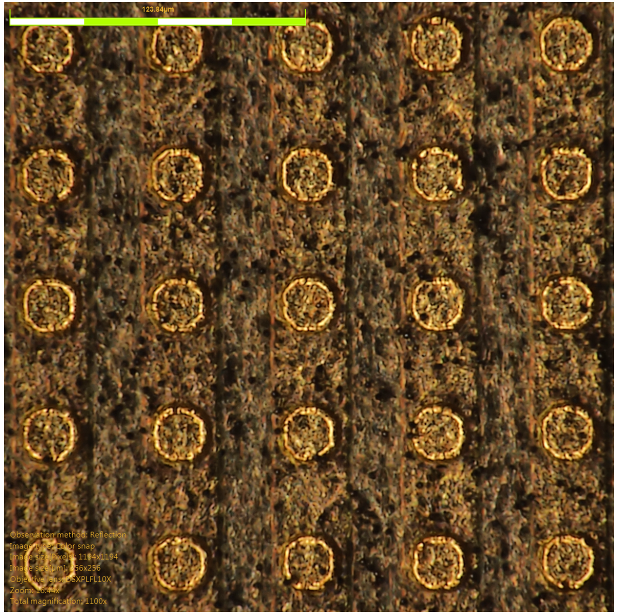
- Capture rate for the lower density film drops to about 1-3 particles







Particle counting

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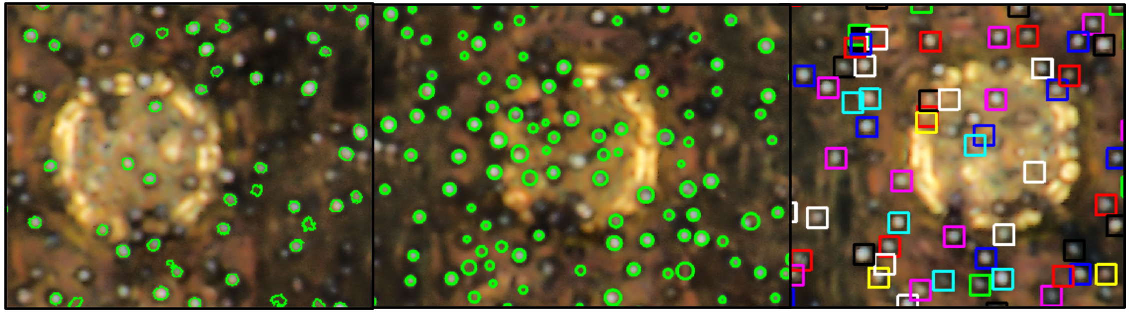
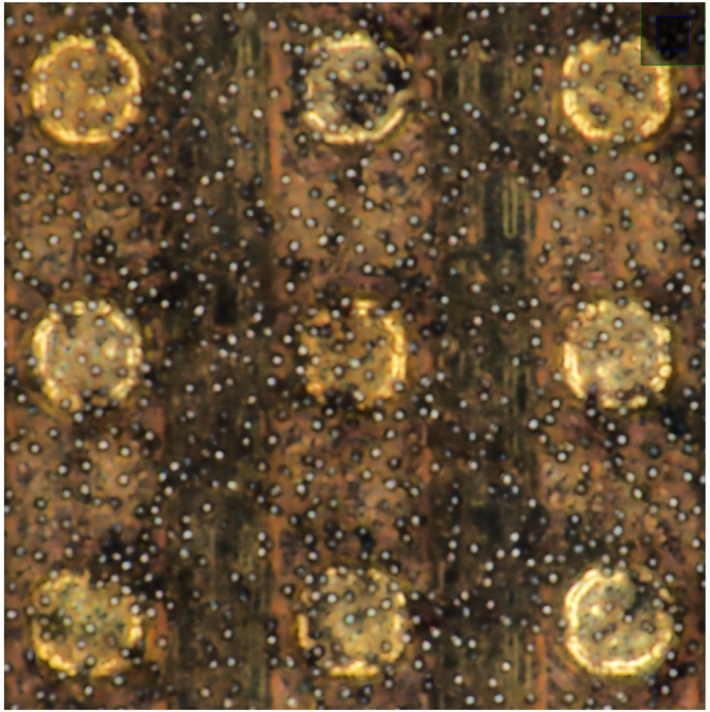
- Counting the conductive particles with computer vision using OpenCV
  - Finding contours
  - Blob detection
    - RGB to HSL color space conversion
  - Pattern matching
    - Averaged result + blob detection
    - Pattern matching ^2
  - Deep Neural Networks (new dnn OpenCV module)





Particle counting

Finding contours

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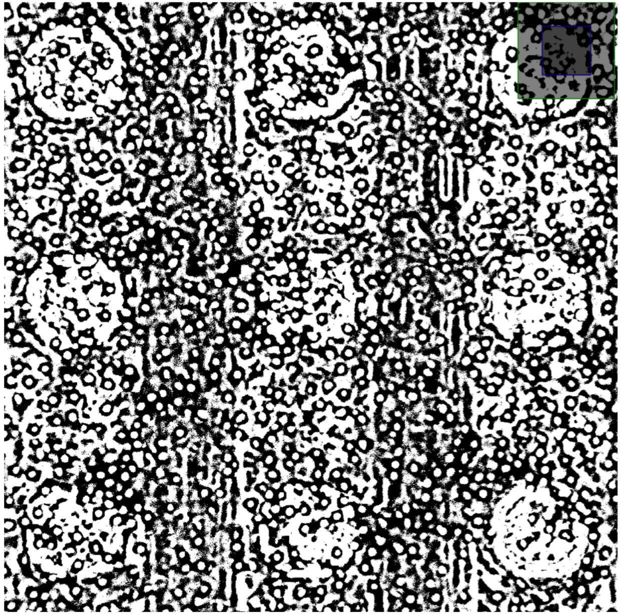
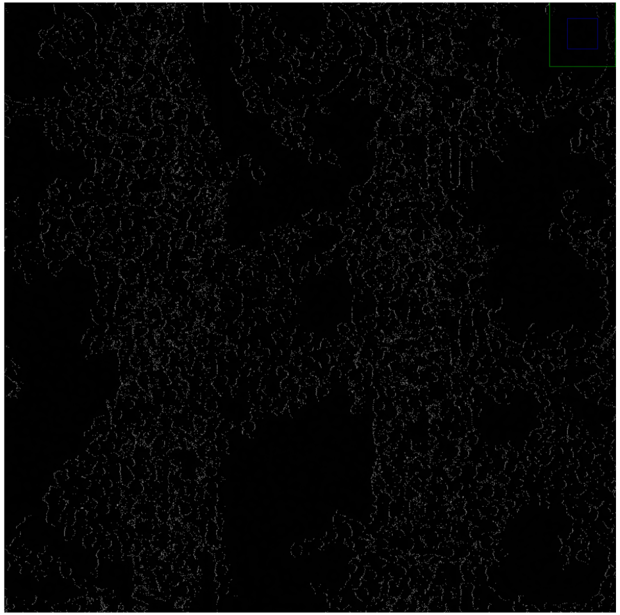
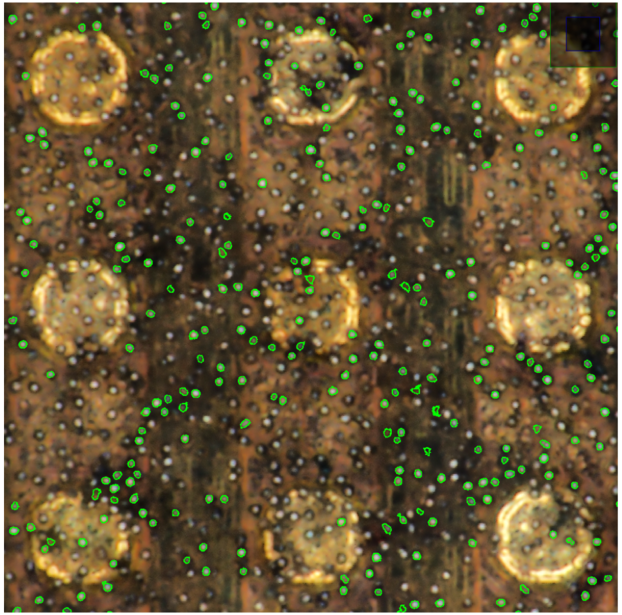
- Many methods starts with converting the image into a binary image by applying diferente thresholds
- Contours are any 2 subsequent points (x1,y1) and (x2,y2) having same color or intensity







Particle counting

Finding contours

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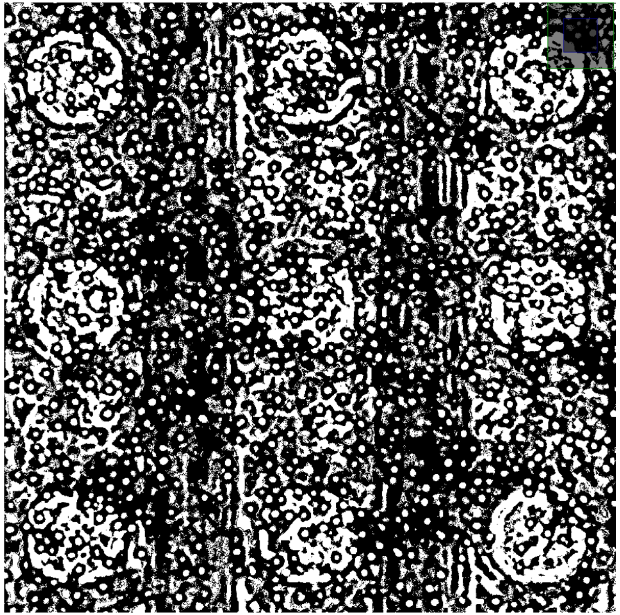
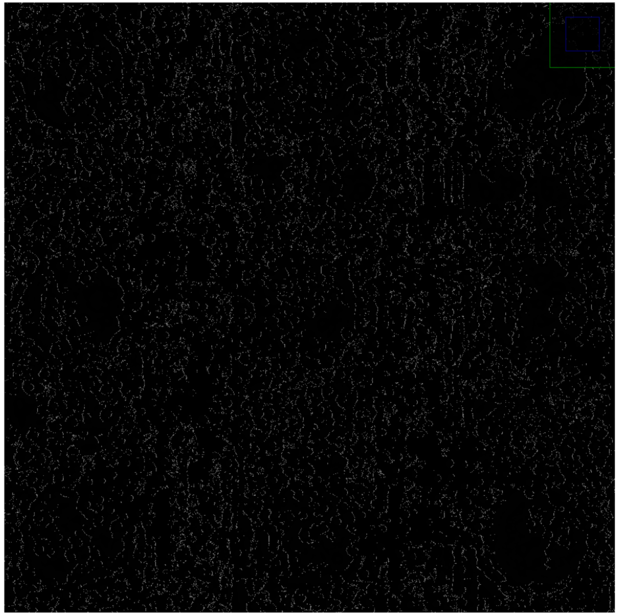
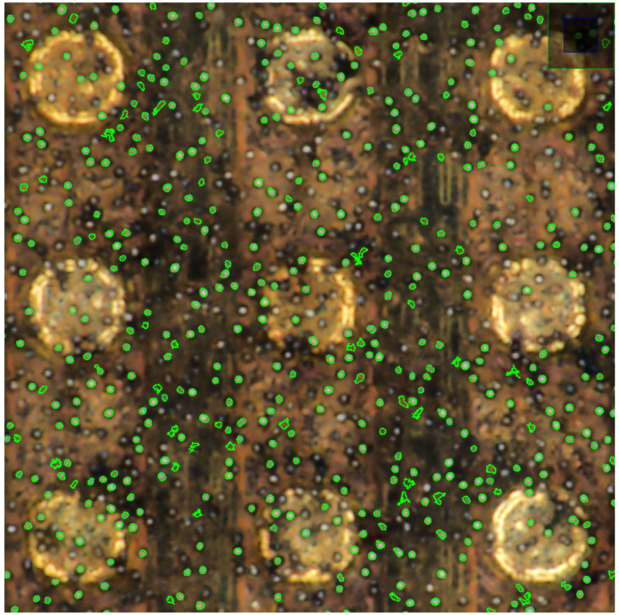
- Methods can profit from post-processing in the microscope pictures, such as contrast and brightness adjustment
- Contours detected ~ 70k; Filtered out (by area, convexity, and etc) particle contours ~ 1000







Particle counting

Blob detection

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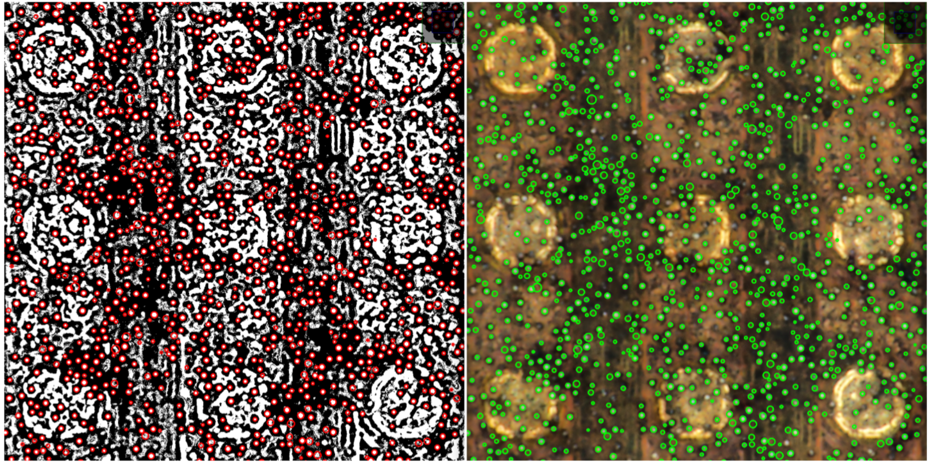
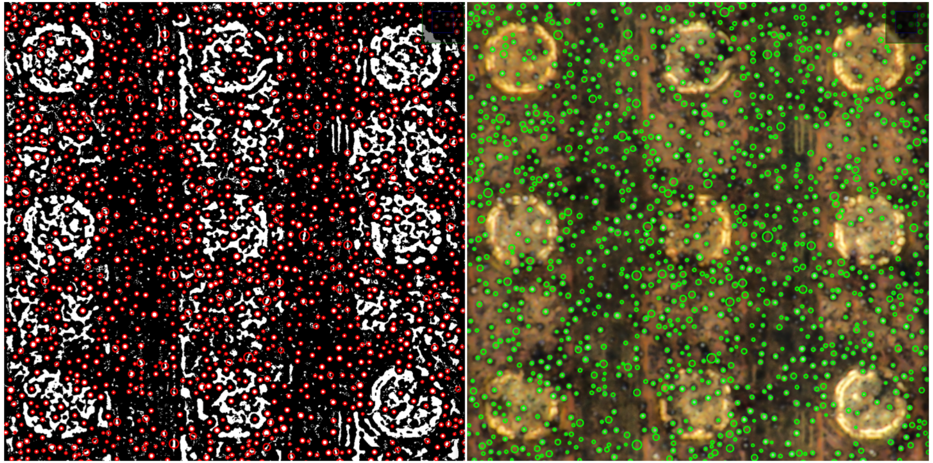
- A blob is a group of connected pixels in an image that share some common property, as the grayscale value
- As with the contour detection, it is also possible to filter out detected blobs
- Number of real and fake particles detected changes a lot with threshold and filter settings



Default contrast and brightness



Higher contrast and lower brightness

Particle counting

Blob detection in HSL

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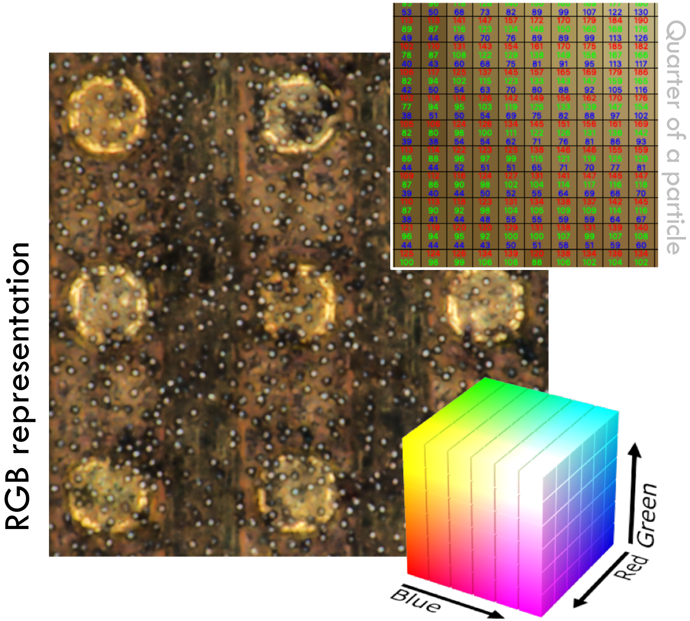
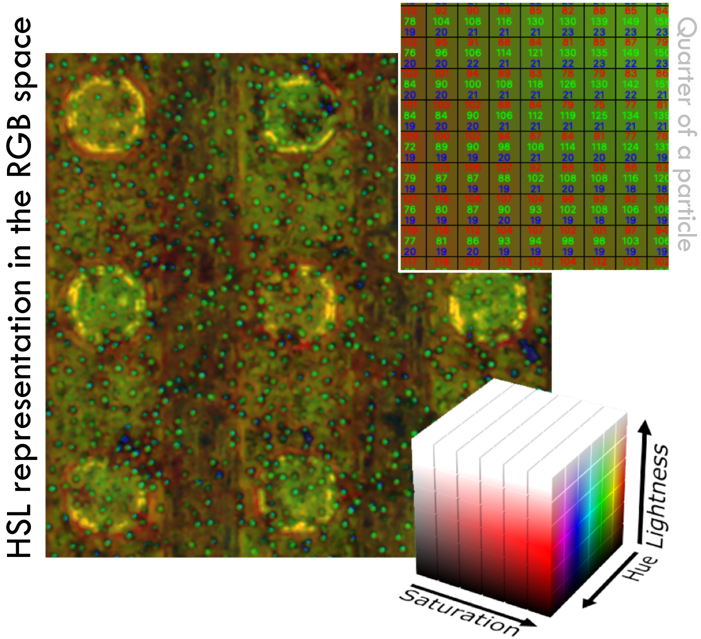
- Changing the color space from **R**ed **G**reen and **B**lue to **H**ue **S**aturation and **L**ightness might help to highlight the particles
- Pixels outside HSL cut range are masked out





Particle counting

Blob detection in HSL

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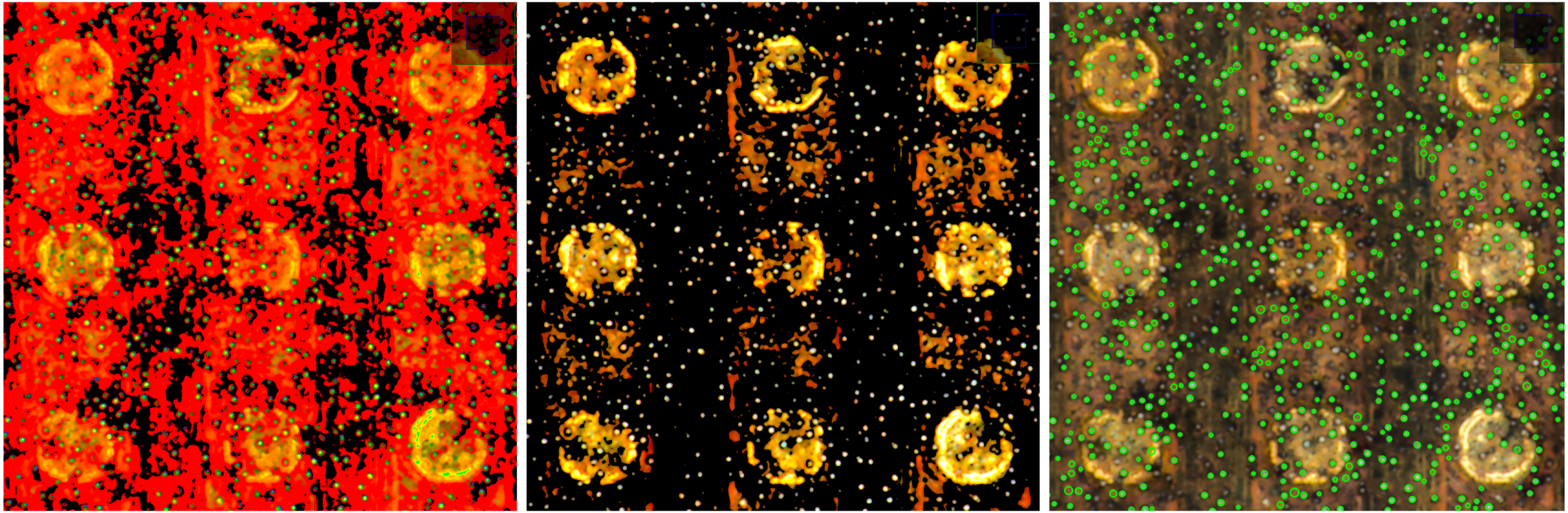
- Post-processing contrast and brightness also helps to highlight the particles
- Still, particles are lost on the cut and residual brackground yields fake detection



Particle counting

Problem looking for particles

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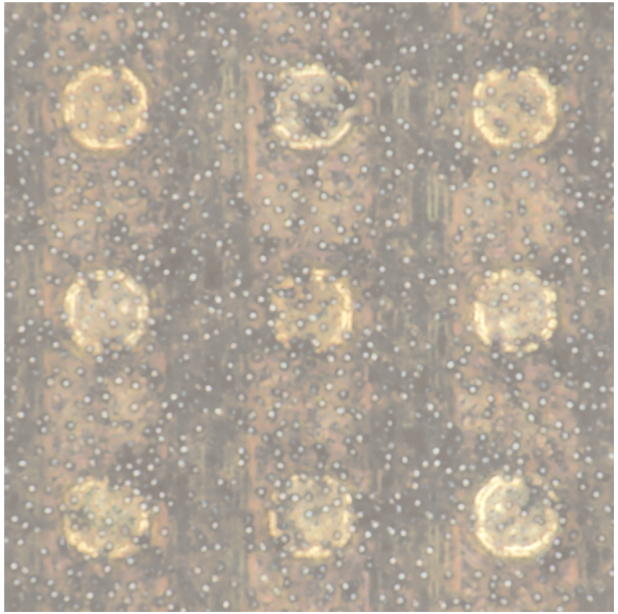
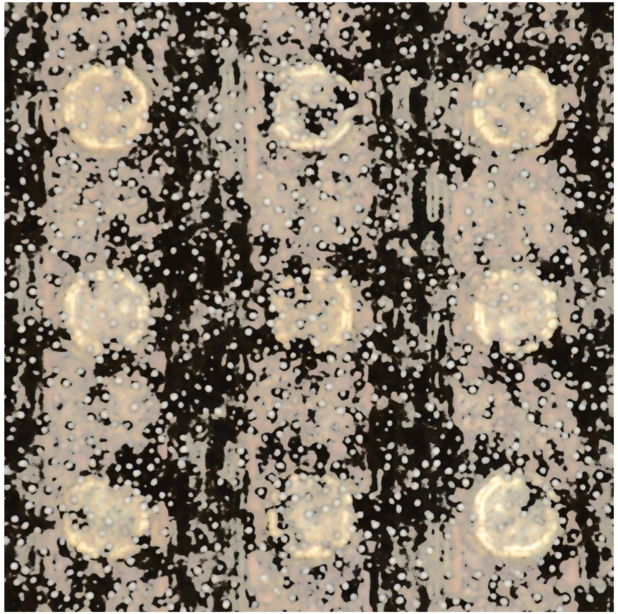
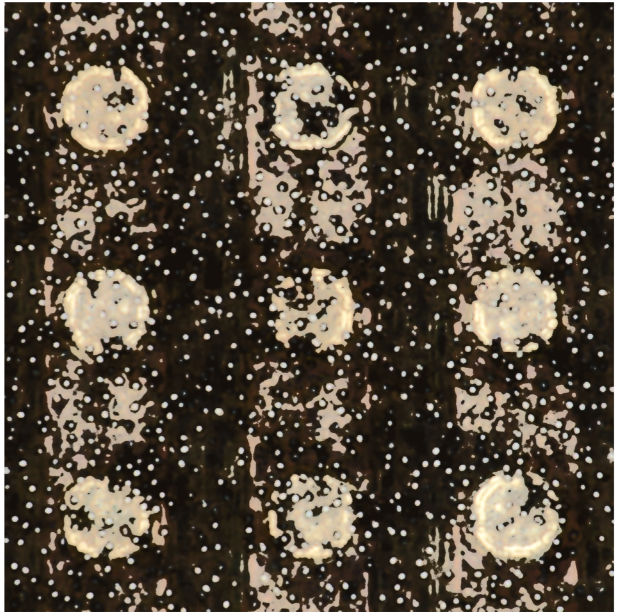
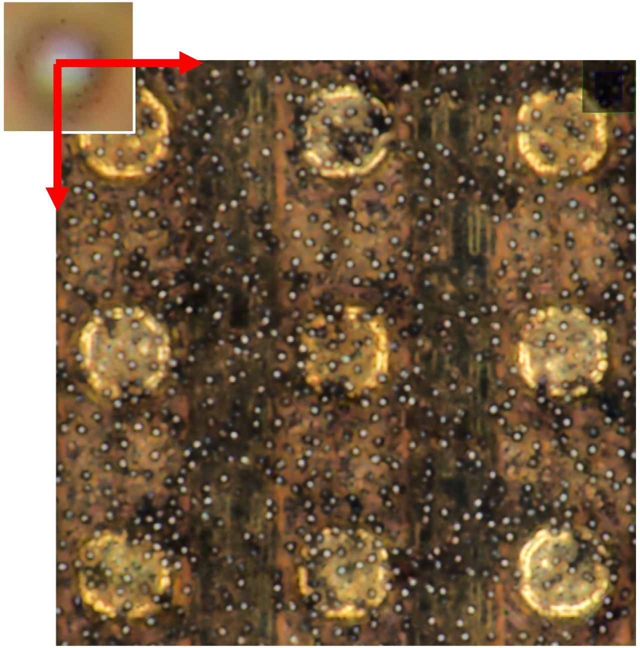
- As different thresholds and filters are applied to the pictures, the non-uniformity (in shape and color) of different parts of the chip pictures creates false particle detections

Particle counting

Pattern matching

- At each location, a metric is calculated representing how "good" or "bad" the match at that location is
- Pattern matching is limited to scale and rotation transformations



Pixel values goes from 0 to 1, where 1 is the perfect match

Particle counting

Pattern matching

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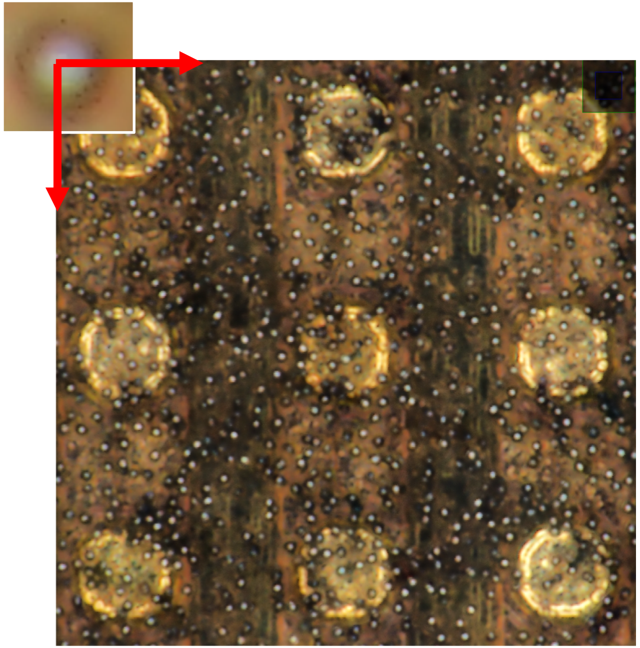
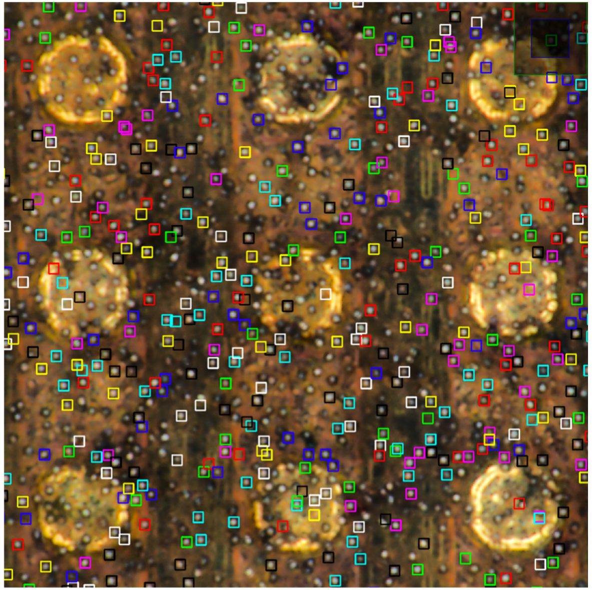
- At each location, a metric is calculated representing how “good” or “bad” the match at that location is
- Pattern matching is limited to scale and rotation transformations



Good… less fake detections… still many particles missing



Particle counting

Pattern matching - Averaging the result matrix

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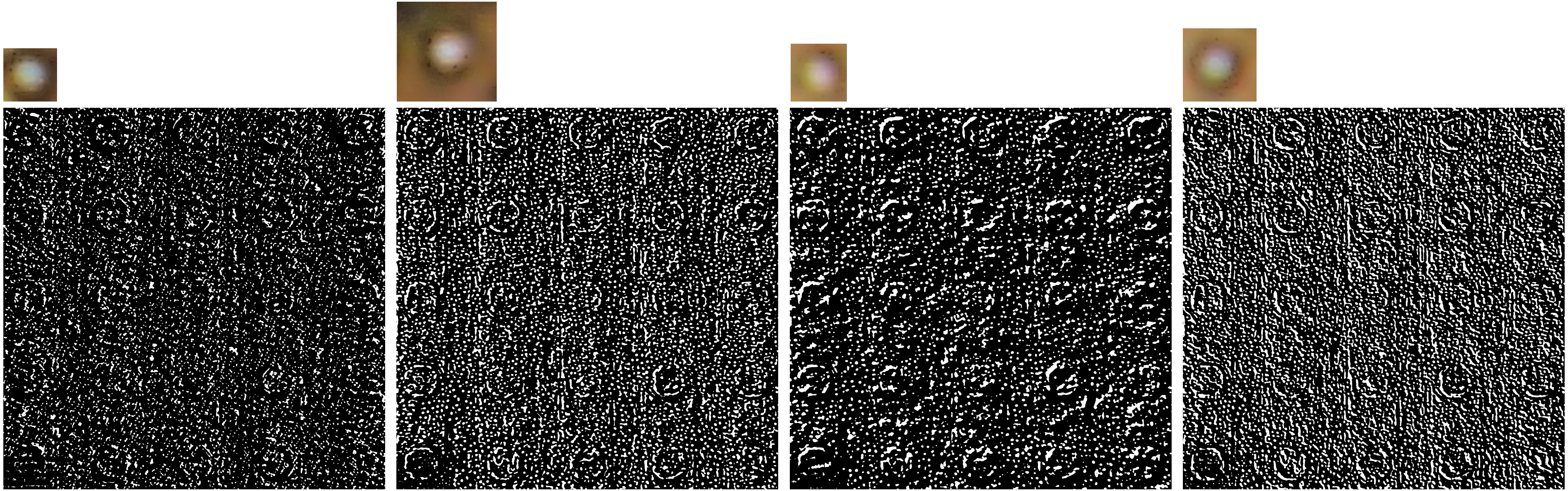
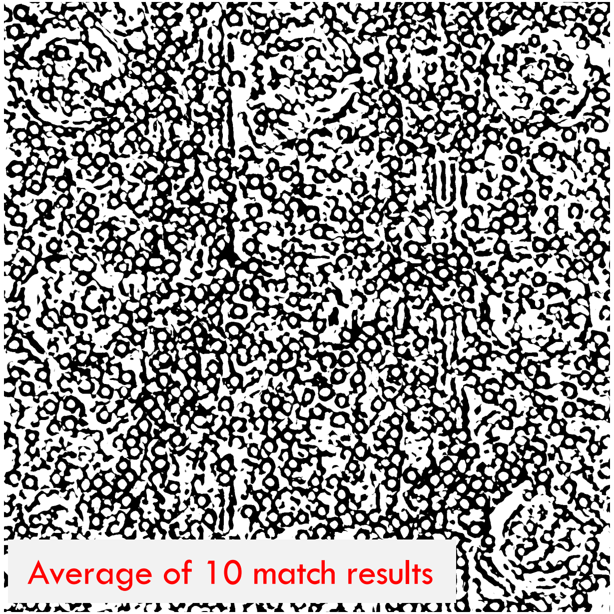
- Each pattern will result in a different matching result matrix
- With the particles always in the same position, the "contamination" can be averaged out, leaving the particle **blobs**

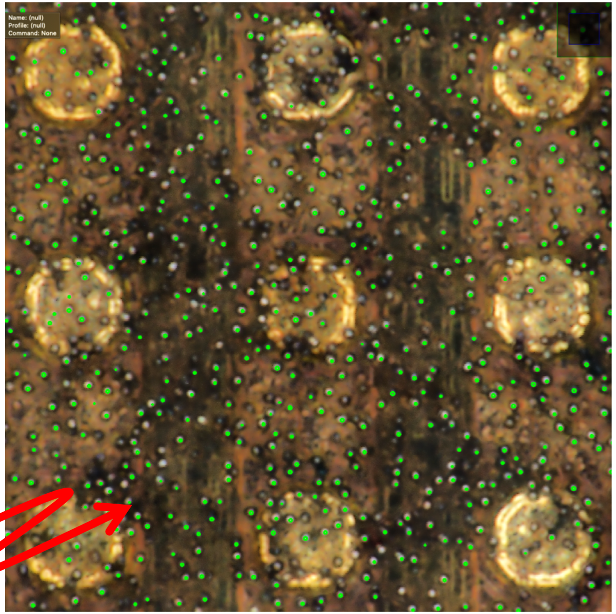


Particle counting

Pattern matching - Averaging the result matrix

- Many particles are lost in the process
- No fake particle detection





Particle counting

Pattern matching on the pattern match result

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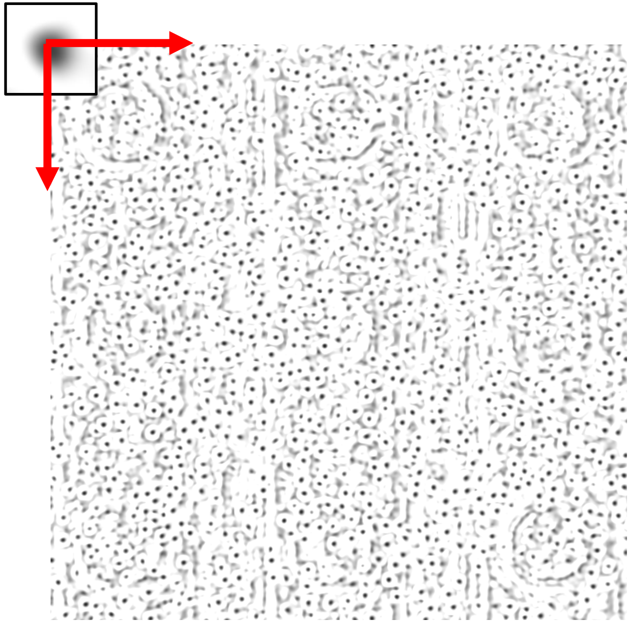
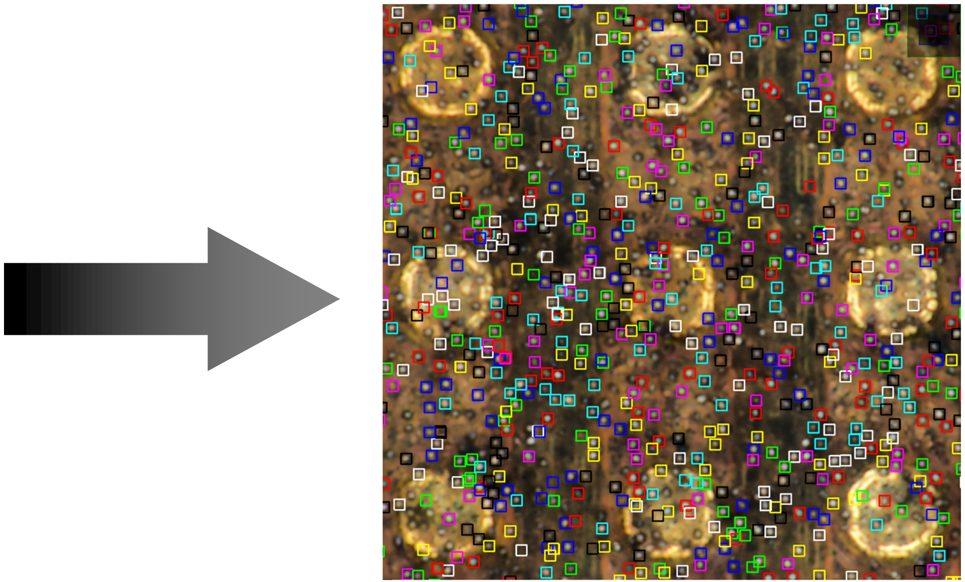
- Match result shows particle blobs very isolated from each other
- Running a pattern match a second time helps to discover many more particles with almost no fake detection





Particle counting

Deep Neural Networks and OpenCV

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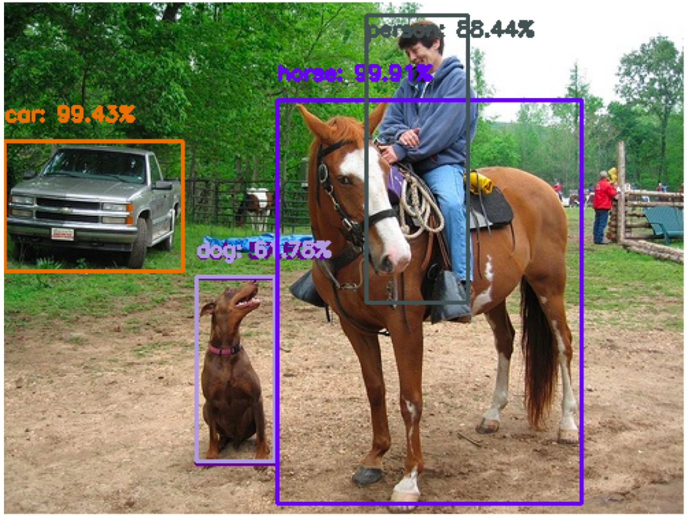
- New OpenCV module offers easy access to several **dnn** frameworks and layer types
- Running tutorials using the Caffe framework with an model trained on the COCO dataset (Common Objects in Context)
  - Capable of detect 20 objects in images, among: airplanes, bicycles, birds, boats, cars, cats, chairs, horses, motorbikes, people, potted plants, etc…



Particle counting

Deep Neural Networks and OpenCV

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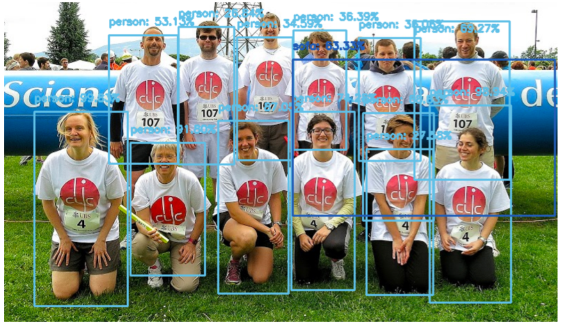
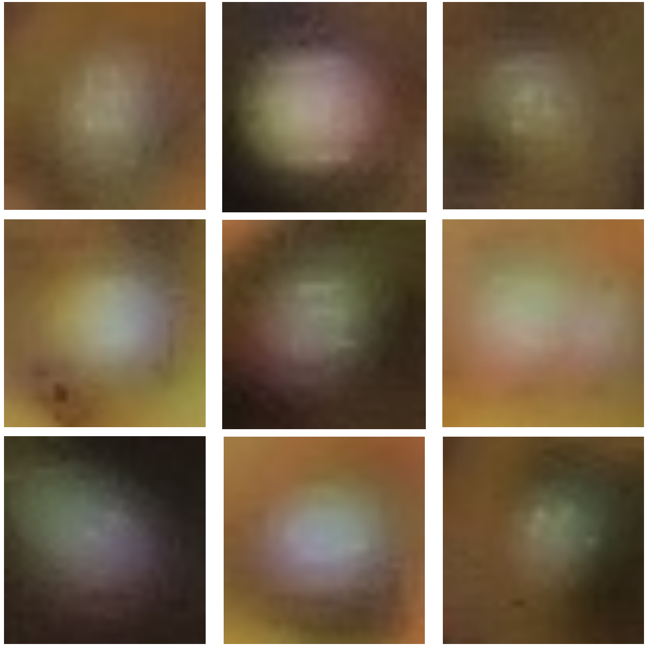
- Next step is to train a model with the patterns matched using the previous methods

Testing with custom pictures



Particles templates for dnn training



Cross-section measurements

Timepix-to-Timepix assemblies

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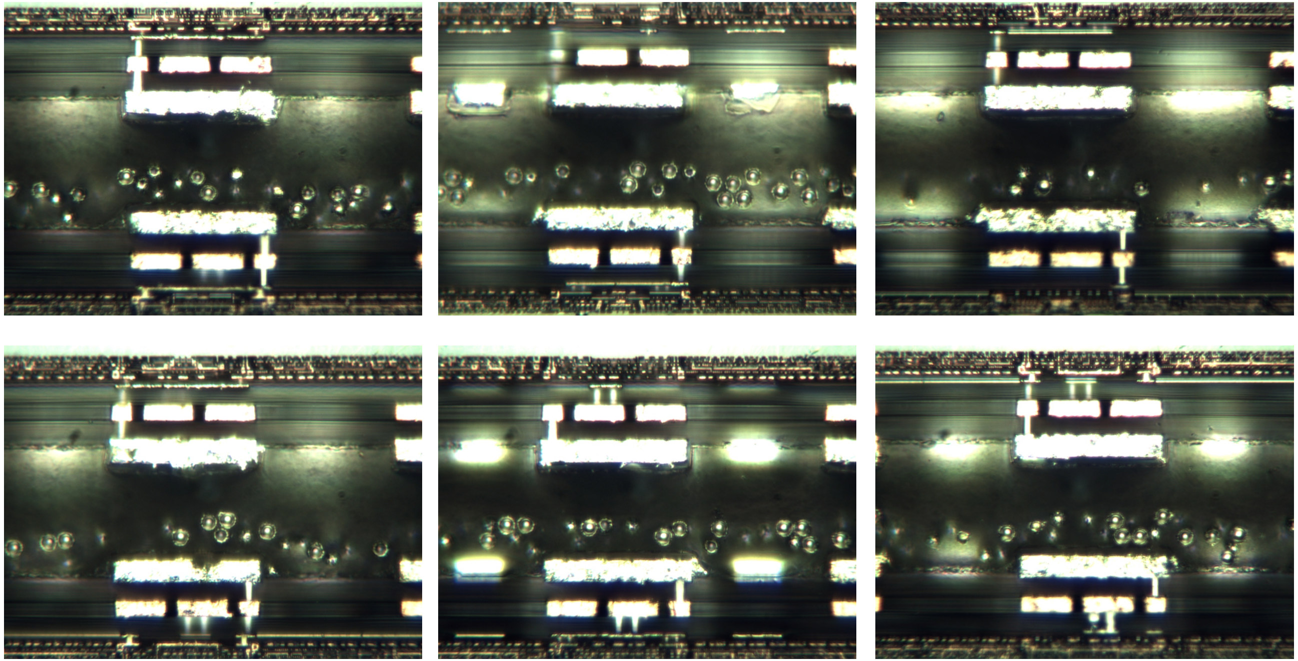
- **S11,** high density film
- Good capture rate per pad
- Pictures shows no particle being crushed
- Pixel pad gap ~ **18 µm**
  - Good agreement with film thickness
  - Thinner film needed for next assemblies;



Cross-section measurements

Timepix-to-Timepix assemblies

- **S12,** low density film
- Low particle capture rate
  - Confirming surface pictures
- No crushed particles
- Smaller pixel gap ~ **6 μm**