LaserSKI: Object Detection for Defect Detection in Semiconductors

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DILAS

INNOLUME

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About dida

- Software company, 30+ scientists, mathematicians & physicists
- Specialized in algorithmic problem solving & machine learning (ML)
- Best paper award **ICML '21**

Research

Conference contributions

NEURAL INFORMATION PROCESSING SYSTEMS

ICML International Conference On Machine Learning

Research partners

DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center

Fraunhofer

TUM TECHNISCHE UNIVERSITÄT MÜNCHEN

Industry

Mid-to-large enterprises

STRÖER

idealo

klöckner & co

Public institutions

esa

DAKOSY

Deutscher Wetterdienst Wetter und Klima aus einer Hand DWD

we help to bridge

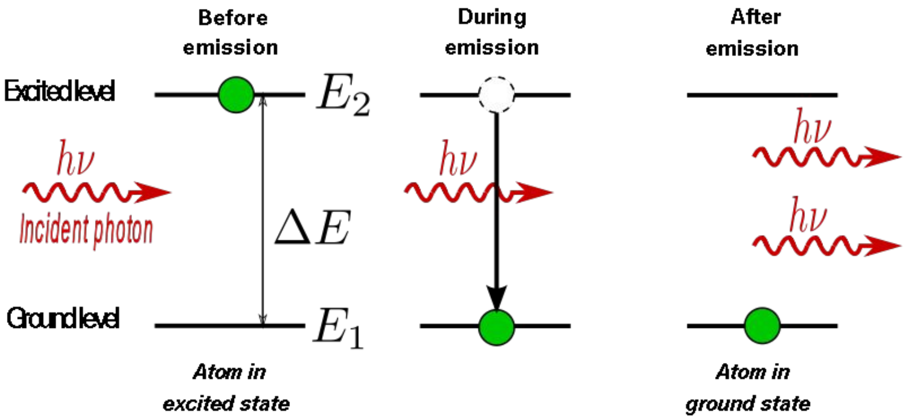
- **ML research/application gap**
- **ML PoC trap**

Agenda

- Intro to Diode Lasers
- Problem formulation and example data
- FasterRCNN Model
- Example results
- Possible extensions

Lasers

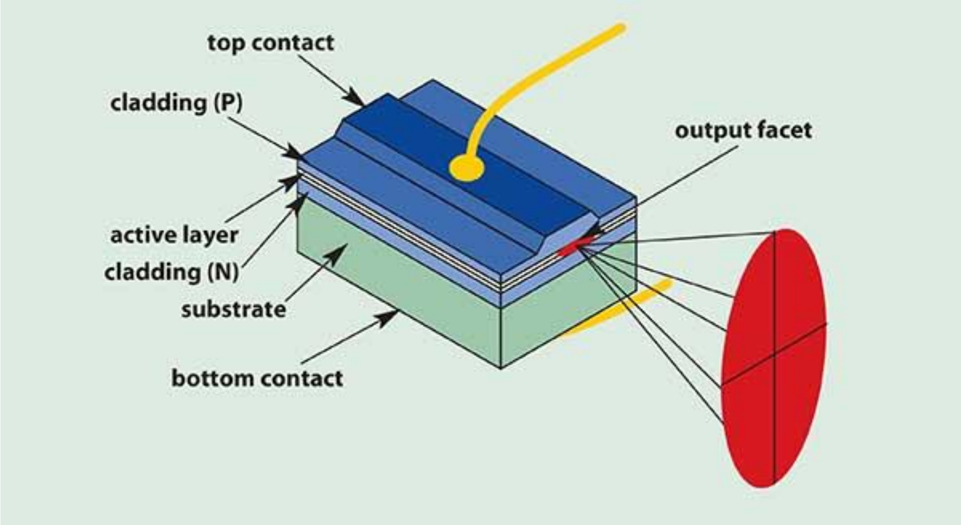
- In a laser light is amplified by stimulated emission from a system that can exist in two states with different energies.
- In a diode laser this is achieved by using a junction between p and n type semiconductors.



$$E_2 - E_1 = \Delta E = h\nu$$

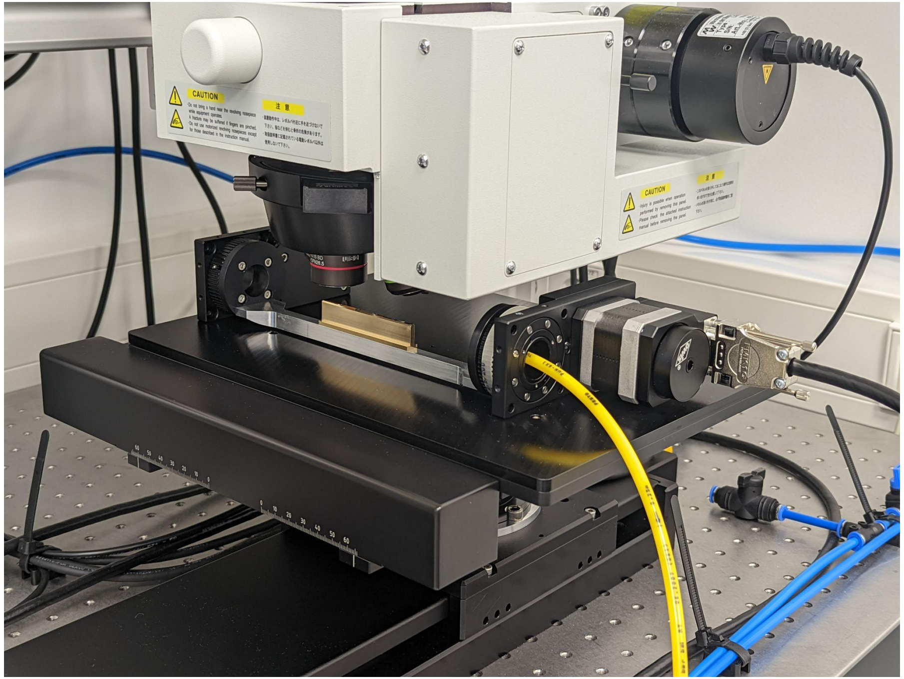
Diode Lasers

- In a P type semiconductor charge is conducted by “holes” with missing electrons
- In an N type semiconductor it is conducted by extra electrons
- A PN junction normally only lets charge through in one direction (this is a diode).
- When a voltage is applied in the “wrong” direction a photon can move an electron across and act as a laser



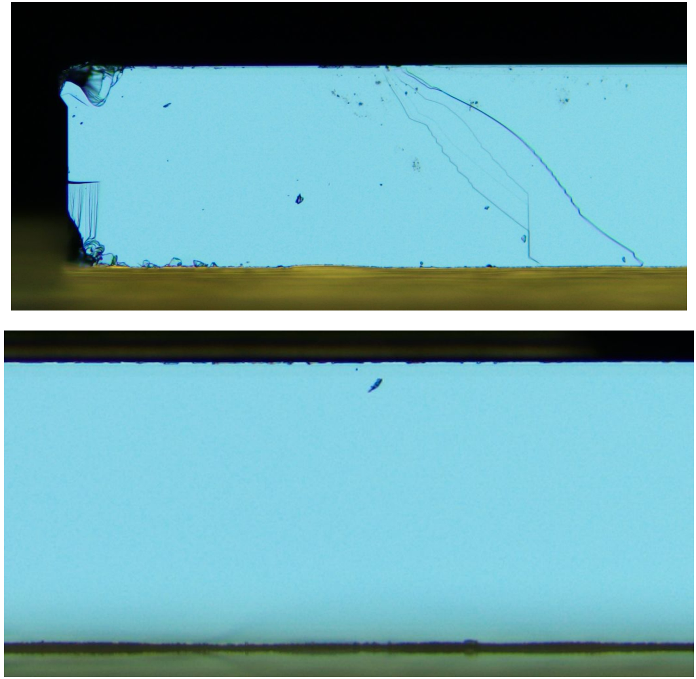
Problem formulation

- We want to find defects on both the “top” (p-side) and the front and back “edges” (facet)
- Images are taken using a microscope with a rotating assembly to allow access to all three axes.

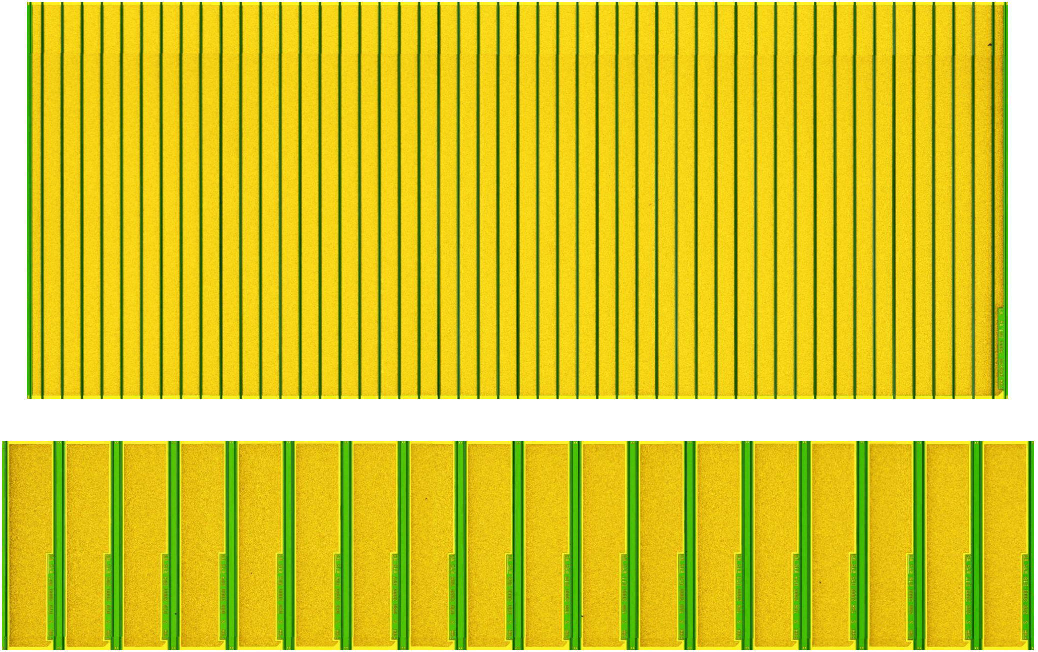


Data

(Front / Back) Facet

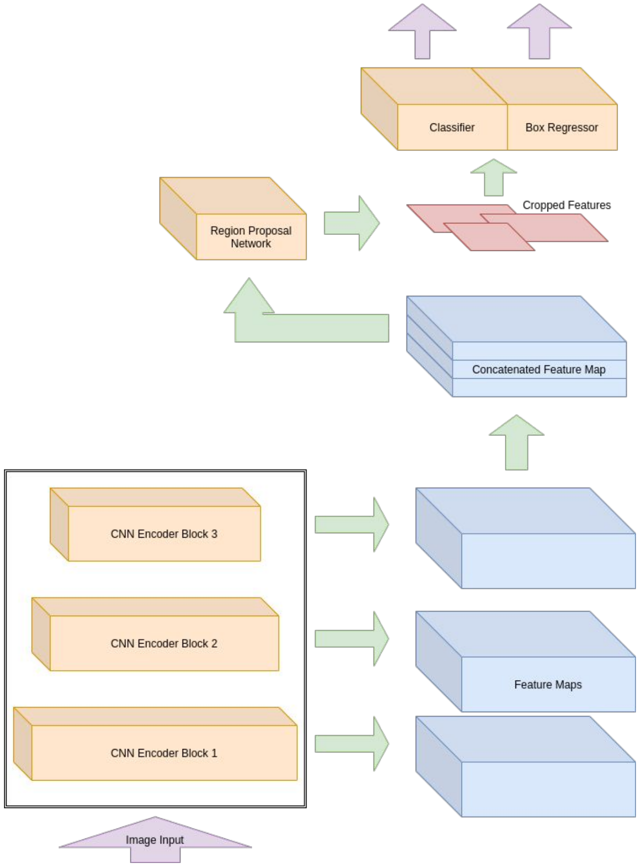


P-Side



Faster RCNN

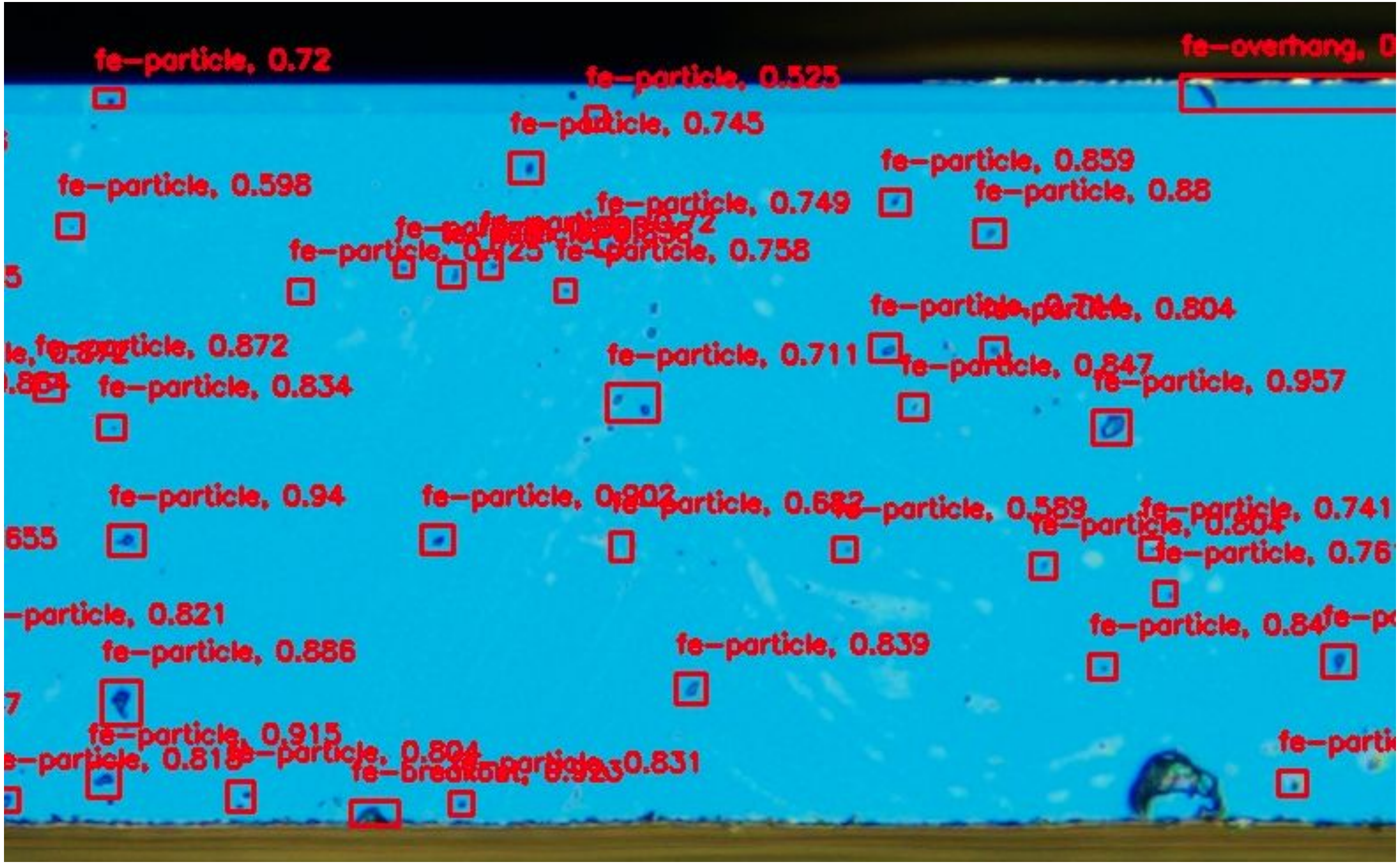
- Multi Scale feature maps are extracted from a CNN encoder.
- These are concatenated and fed into a CNN region proposal network to predict candidate regions.
- Classifier and bounding box regression networks are used to predict bounding boxes and classes.
- The network can use a pretrained encoder and be fine tuned end to end.



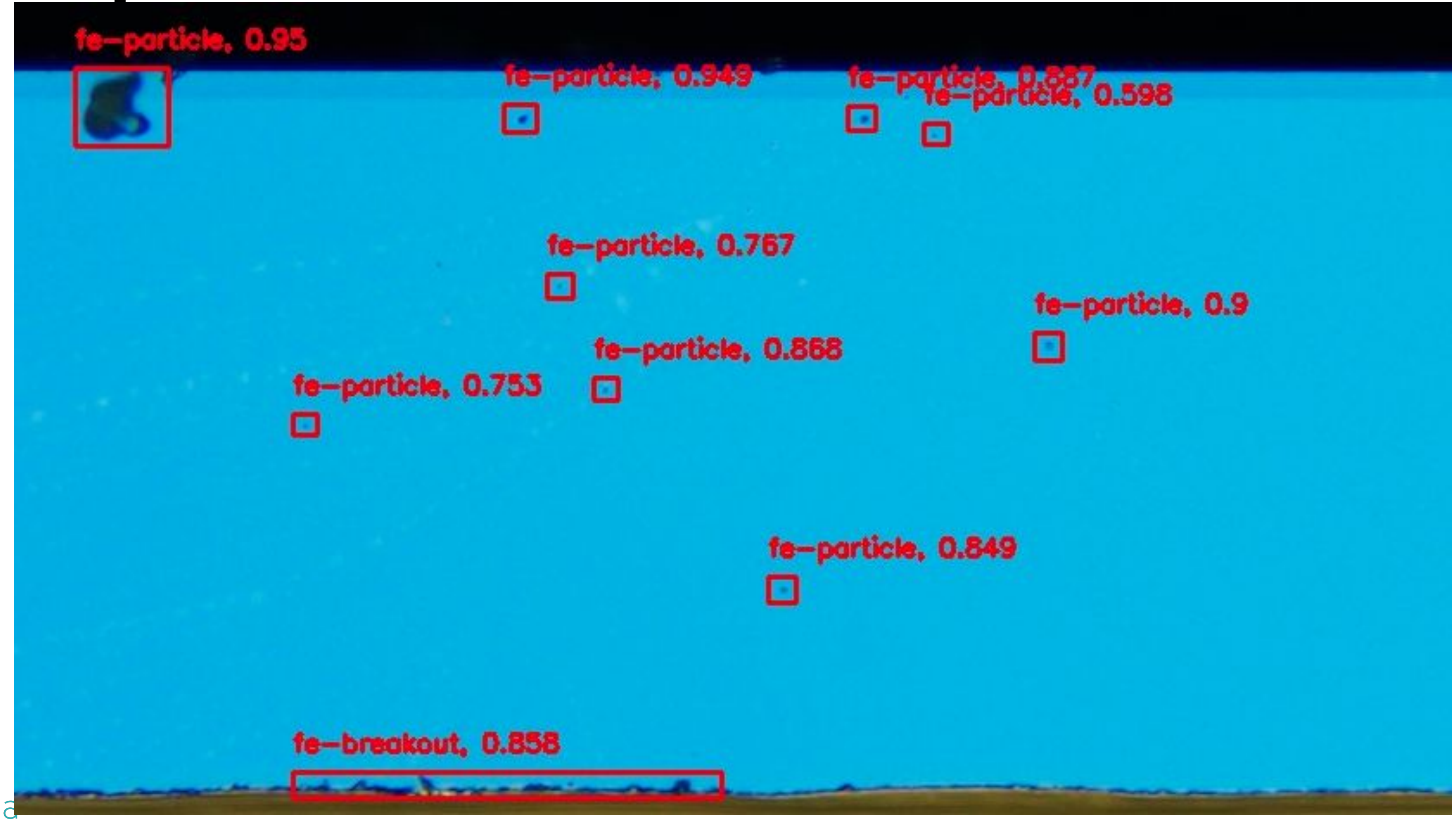
Implementation details

- Implemented in Pytorch Lightning
- Large dataset labeled by FBH 256
- Trained on 800x800 pixel chunks
- Metrics used were:
    - F1 50|50 (objectness threshold | intersection threshold)
    - mAP (Mean average precision at different thresholds)
- Boxes predicted across multiple chunks are sewn together

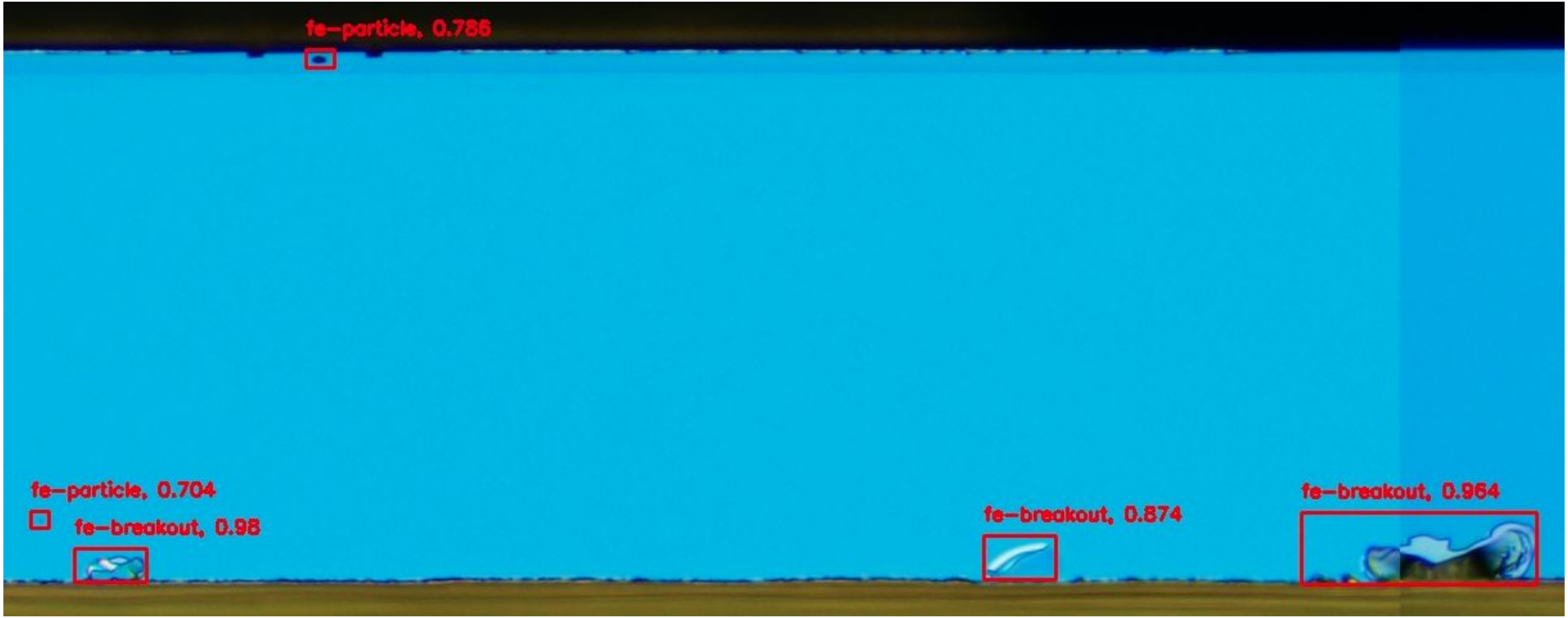
Example Results: Facet



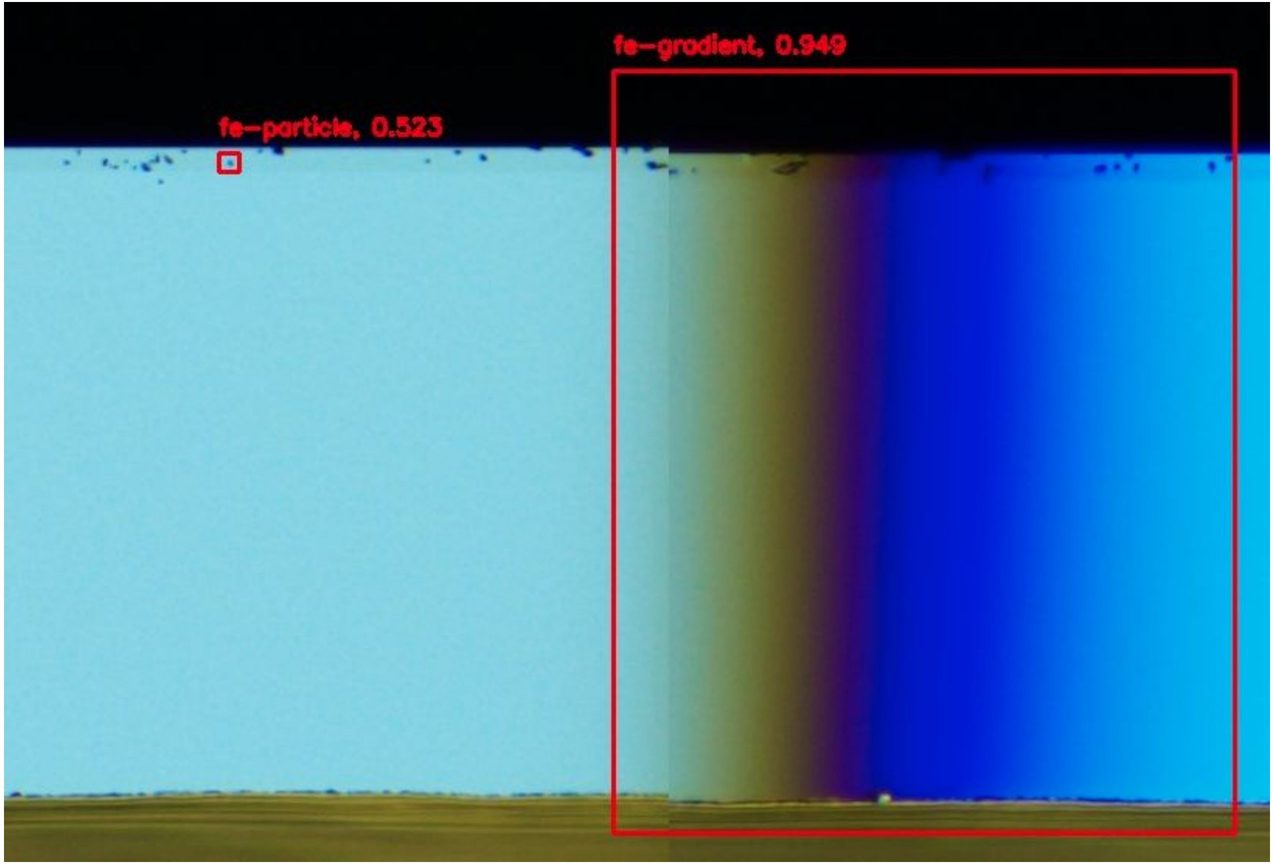
Example Results: Facet



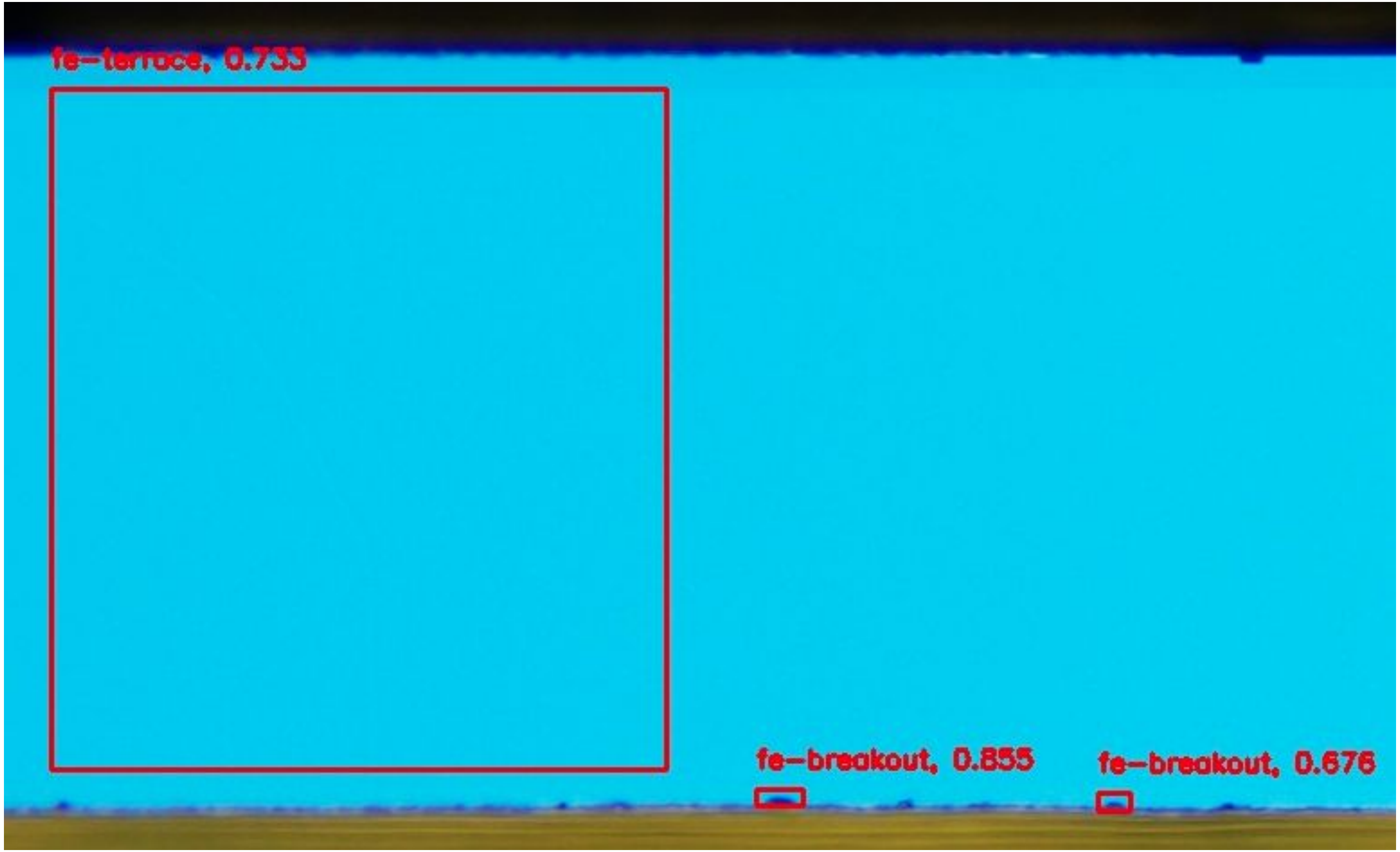
Example Results: Facet



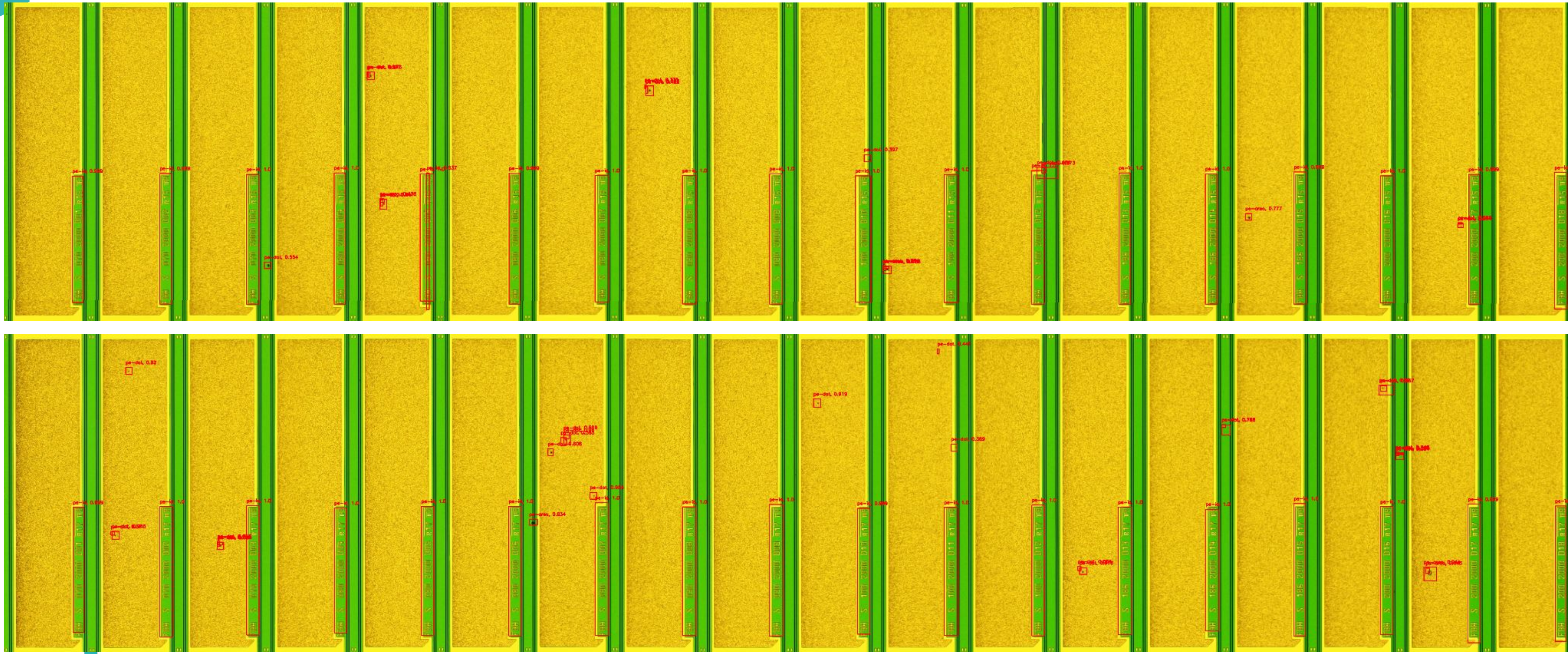
Example Results: Facet



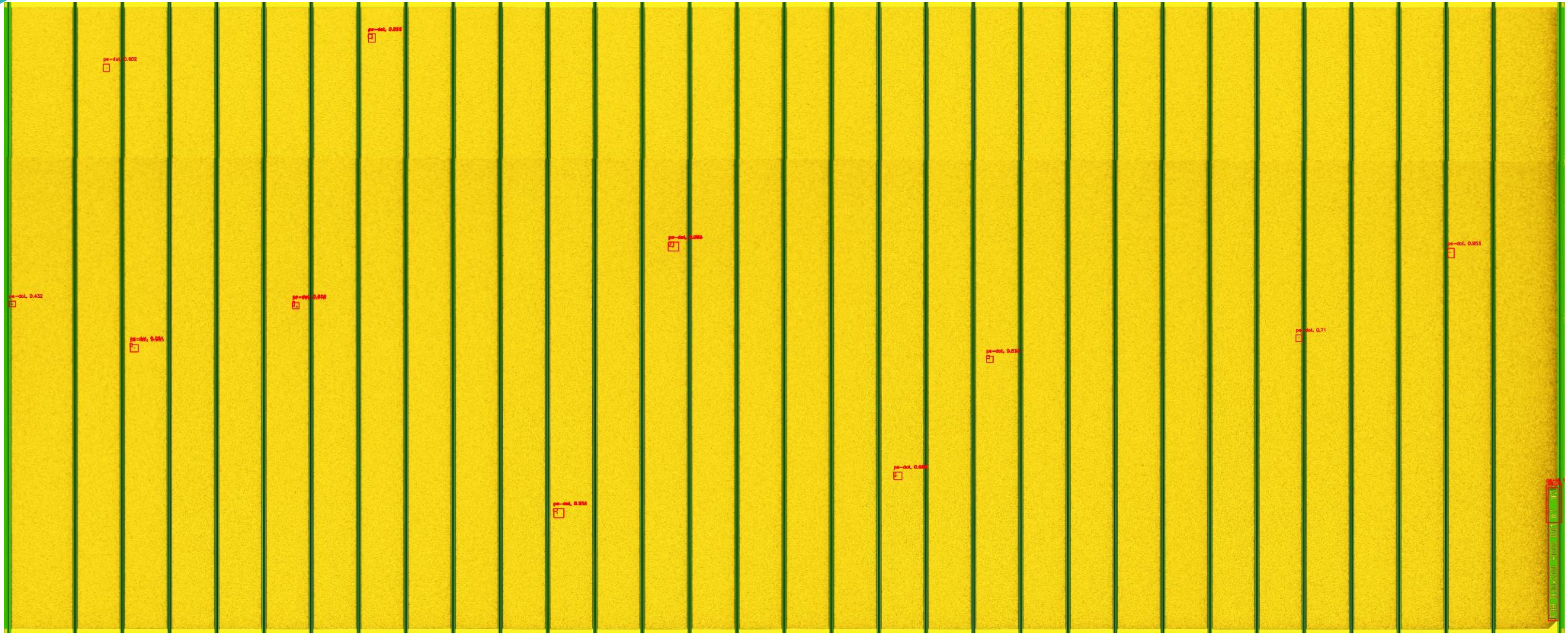
Example Results: Facet



Example Results: P-side



Example Results: P-side



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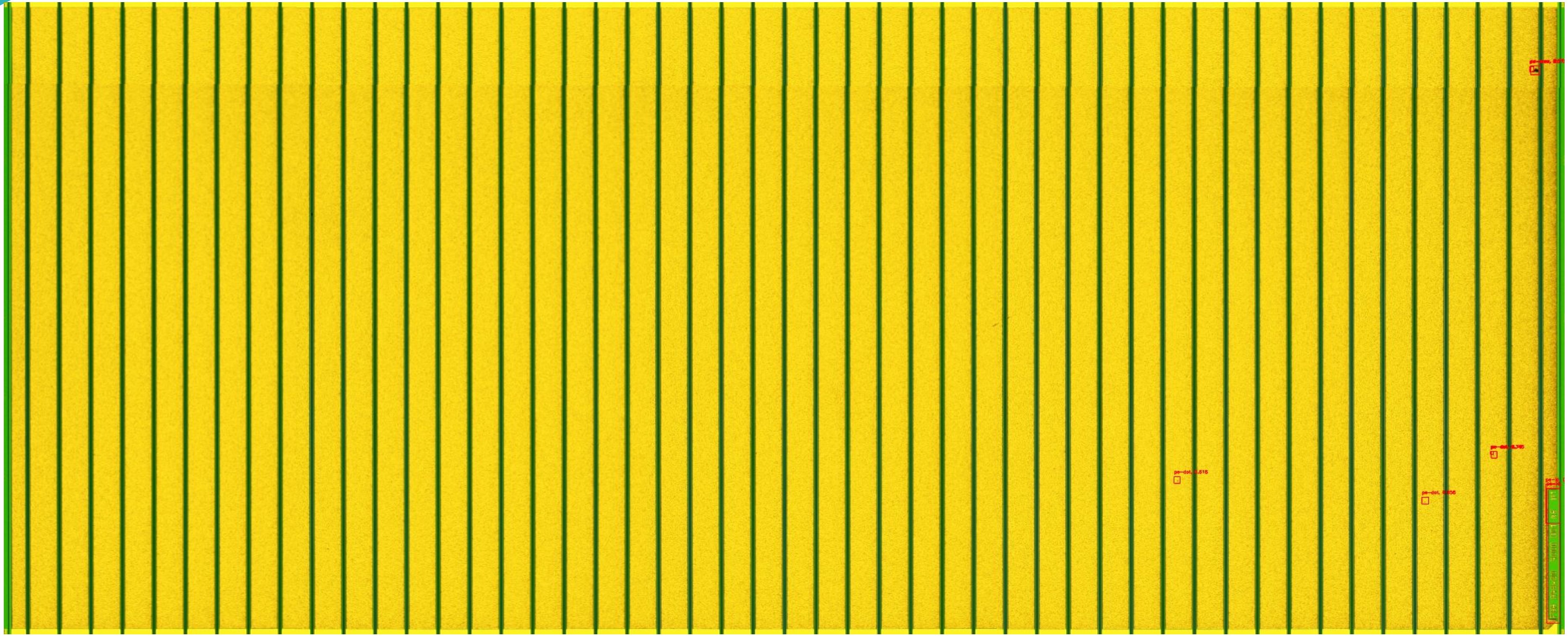

Takeaways

- Object detection models are well suited for defect detection in semiconductors.
- The most common failure cases are:
  - Crowded regions
  - Multiple detections

Possible Extensions

- Move to segmentation:
  - Advantages
    - Easier to train
    - More precise information on defects
  - Disadvantages
    - More time consuming labelling
- Wrap the model in an active learning environment.