ACCEDE | ESCCON
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Revolutionizing PCB Soldering Verification with Computer Vision

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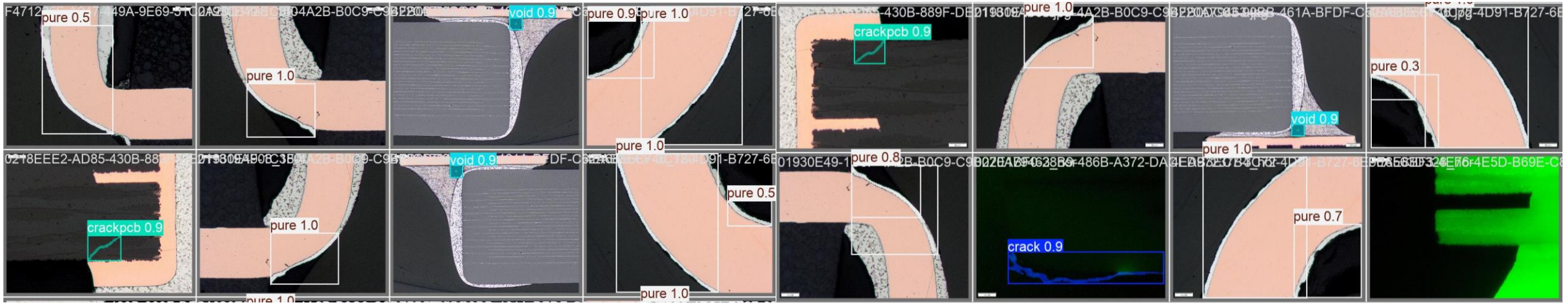


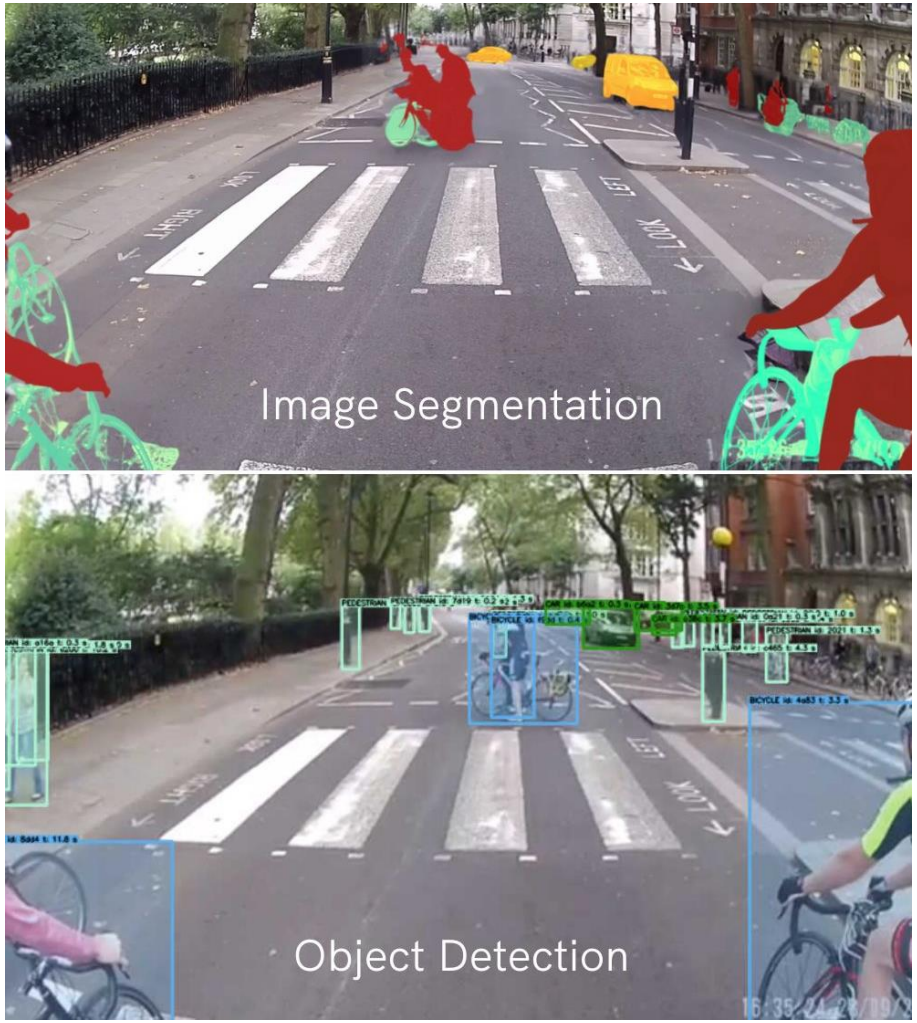
INTRODUCTION

Computer Vision

- Computer vision is **a field of artificial intelligence** that combines **machine learning** and **neural networks** to teach computers and systems to extract information from digital images, videos and other visual inputs,

- **Machine learning** uses algorithmic models that allow a computer to learn on its own about **the context of visual data.**

- A **convolutional neural networks** helps a machine learning or deep learning model ‘look’ by decomposing images into pixels that are assigned labels.



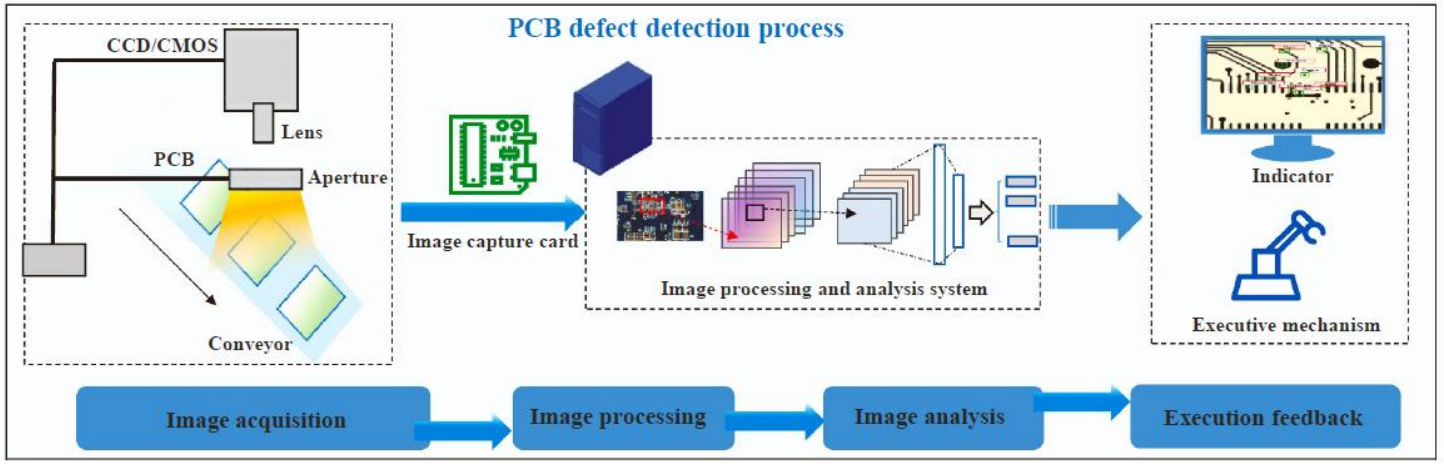
INTRODUCTION

Computer Vision in PCB industry

- Automatic Optical Inspection (AOI) during the PCB design, manufacturing or assembly is widely used by the industry since 1980 s.

- Main process monitoring by computer vision:
  - **Circuit printing**
  - **Component placement**
  - **Component soldering**

- Current automated inspections combine dedicated computer hardware and advanced cameras.

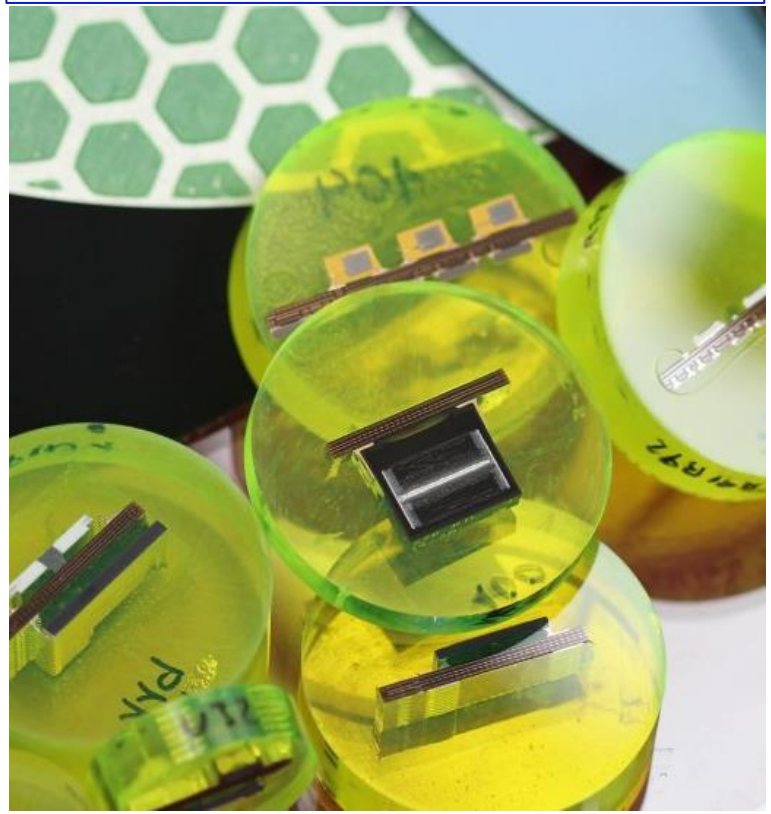


- How this algorithm works?
  - **Referential approach**: compare between pixels in the test image and in a template image.
  - **Non-referential approach**: work on geometry shapes and verify the design rules.
  - **Hibrid approach**

TY. Zhou, M. Yuan, J.Zhang, G.Ding, S.Qin. Journal of Manufacturing Systems 70 (2023) 557-578.
N.Petkov, M.Ivanova. Printed circuit board and printied circuit board assembly methods for testing and visual inspection: a review. Bulletin of electrical Engineering and Informatics, Vol 13, N4 (2024) 2566-2585

INTRODUCTION

Materials & Processes Laboratory



Accreditations

- **ESA recommended Microsectioning Laboratory** in accordance with ESA-TECMSP-MO-013165 memo.
- **ISO/IEC 17025:2017** accredited for PCB Testing in accordance with 345/LE2116 certificate.

Capabilities

- Qualification PCB
- Qualification assembled PCB
- Press-fit connector Qualification
- Wire crimping Evaluation
- Component microsectioning analysis

Technician expertise

- ESA **certified inspectors** for ECSS-Q-ST-70-08C, ECSS-Q-ST-70-38C & ECSS-Q-ST-70-26C
- IPC certified inspector IPC-600 & IPC-610

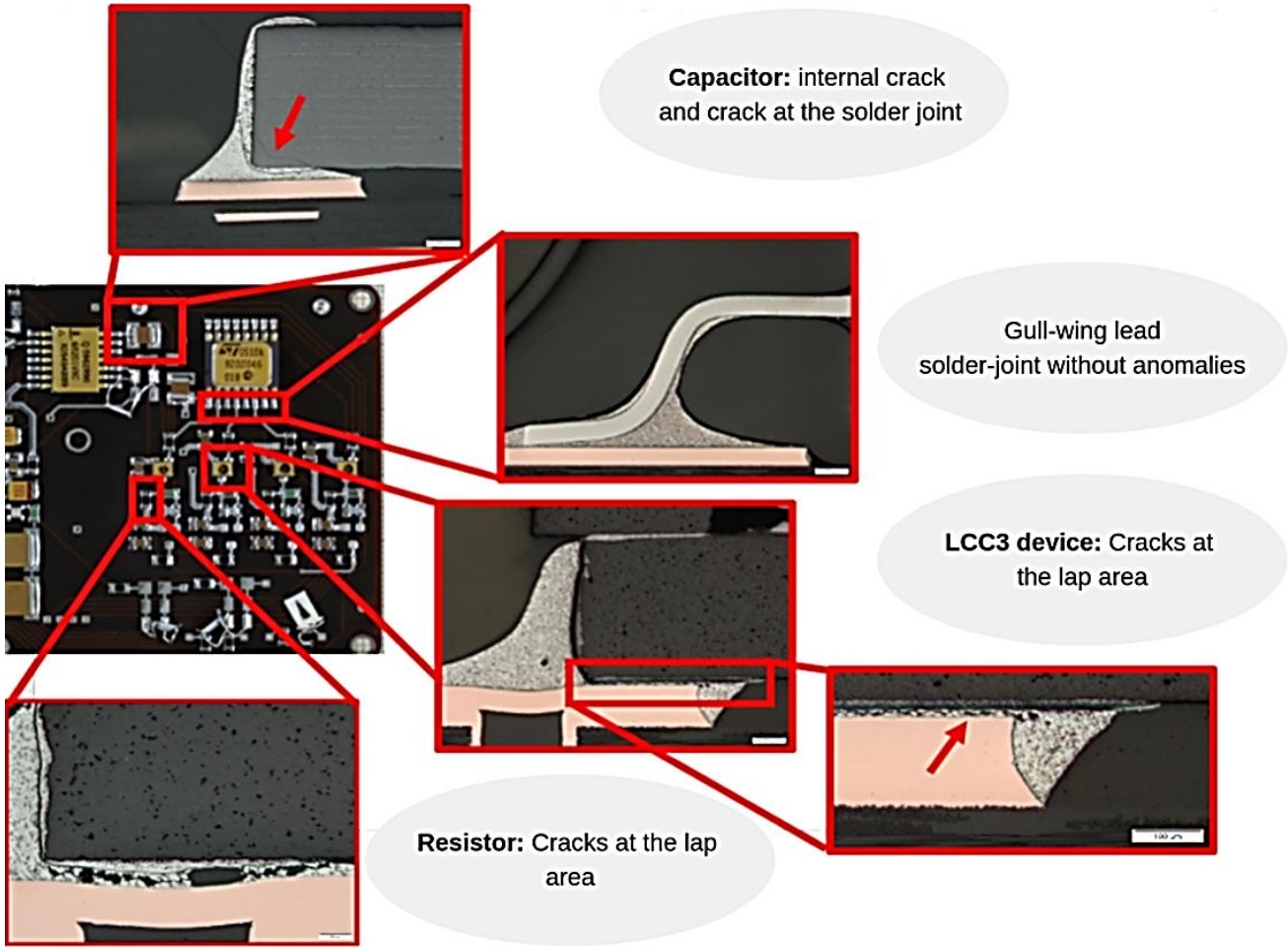
Certified IPC-A-600 Application Specialist

Certified IPC-A-610 Application Specialist

INTRODUCTION

Solder Microsection Anomalies

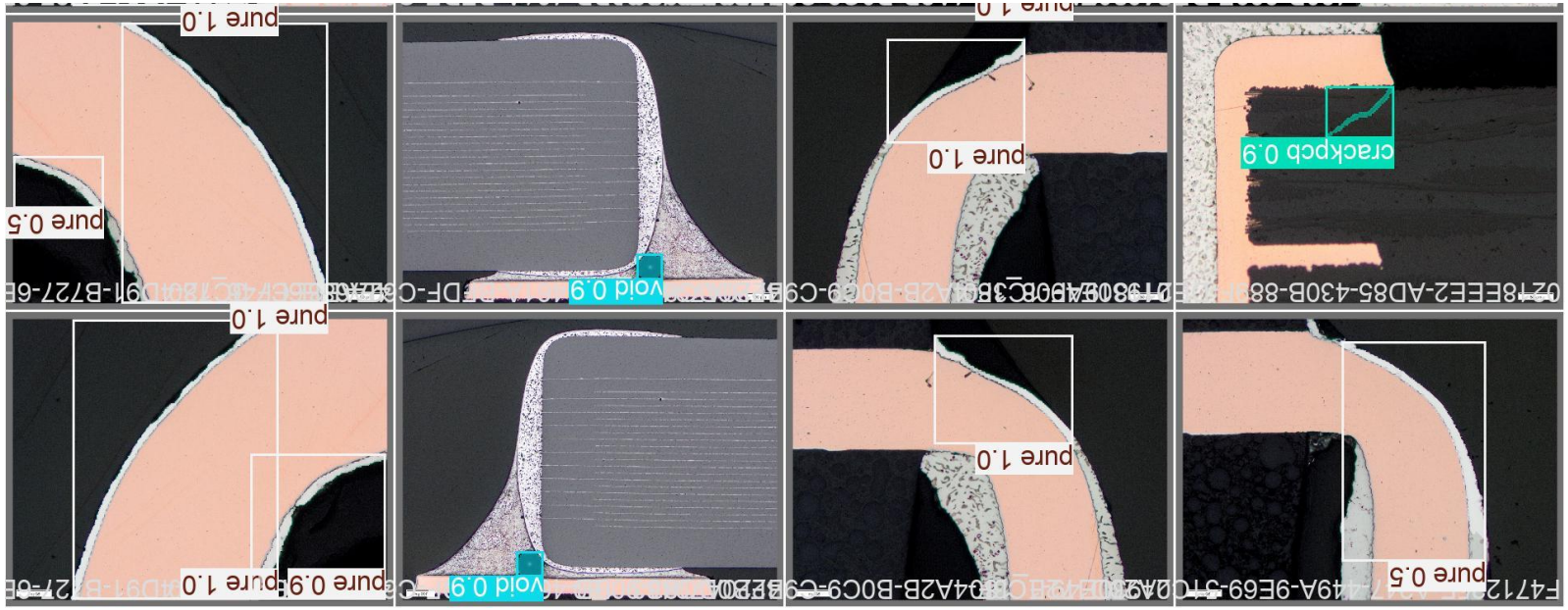
- **Microsection** evaluation of solder joint has become an essential practice for guaranteeing the durability and reliability of the final product.
- **Microsection** test is performed after thermal and mechanical stress helps to detect potential defects before they become critical issues in the field.



GOALS

The aim of this study is:

- To **develop a tool** that that will assist the inspector in analysing defects in the solder connection of PCB.
- **Design a training/test dataset** to give to the tool the enough experience to be able to work with different scenarios.
- **Harmonisation** of the criteria to evaluate anomalies in solder connections.
- To **optimize** the time dedicated to evaluating images of solder connections.



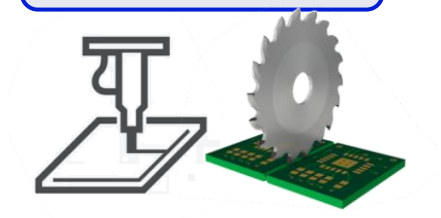
EXPERIMENTAL PROCEDURE

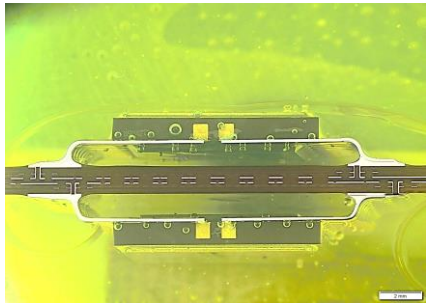
As **ESA recommended facilities** to perform microsection analysis as part of the qualification programme for assembled PCB, the laboratory of Materials and Processes has been analyzed more than **30.000** solder connections.

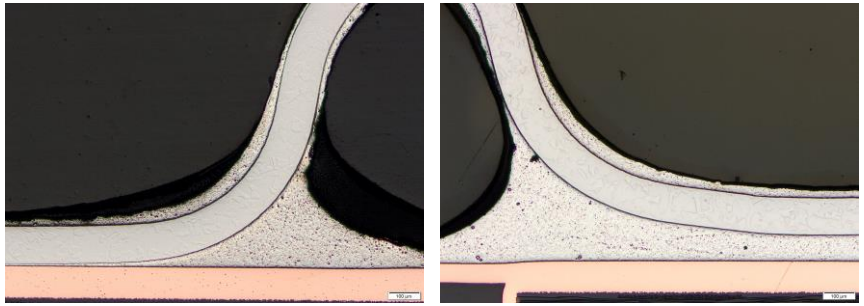
Sample preparation

Sample analysis

PCB cutting → Sample mounting → Grinding/Polish → Microscopy



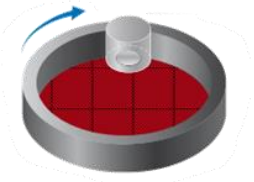




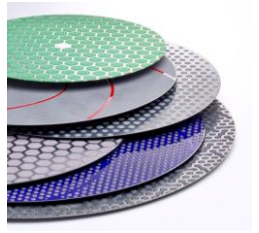
ALTER | TÜVIT

EXPERIMENTAL PROCEDURE

Grinding/Polish

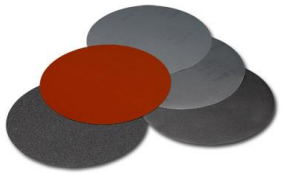


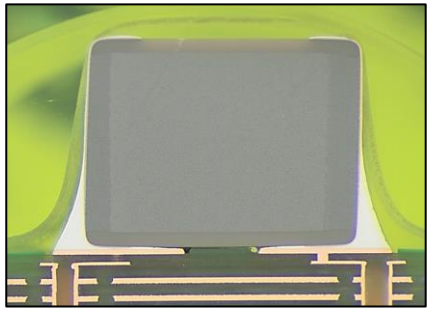
ALTER Technology has developed different **grinding protocols depending on the device** and based on the component materials of the device.

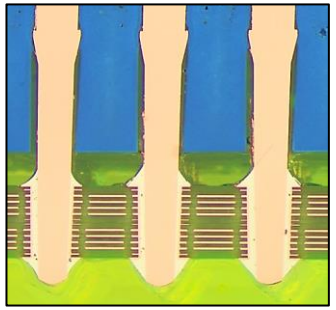


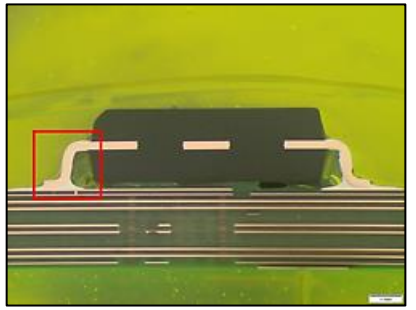
These methods define each **parameter** during the process, like:

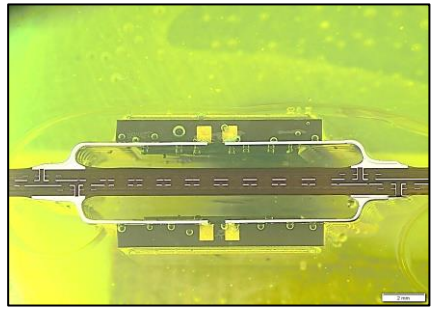
- Abrassive Surface
  - Diamond coated bases
  - SiC sandpapers
  - Polishing clothes
- Lubricant
- Rotation Speed
- Pressure
- Time
- Grit size







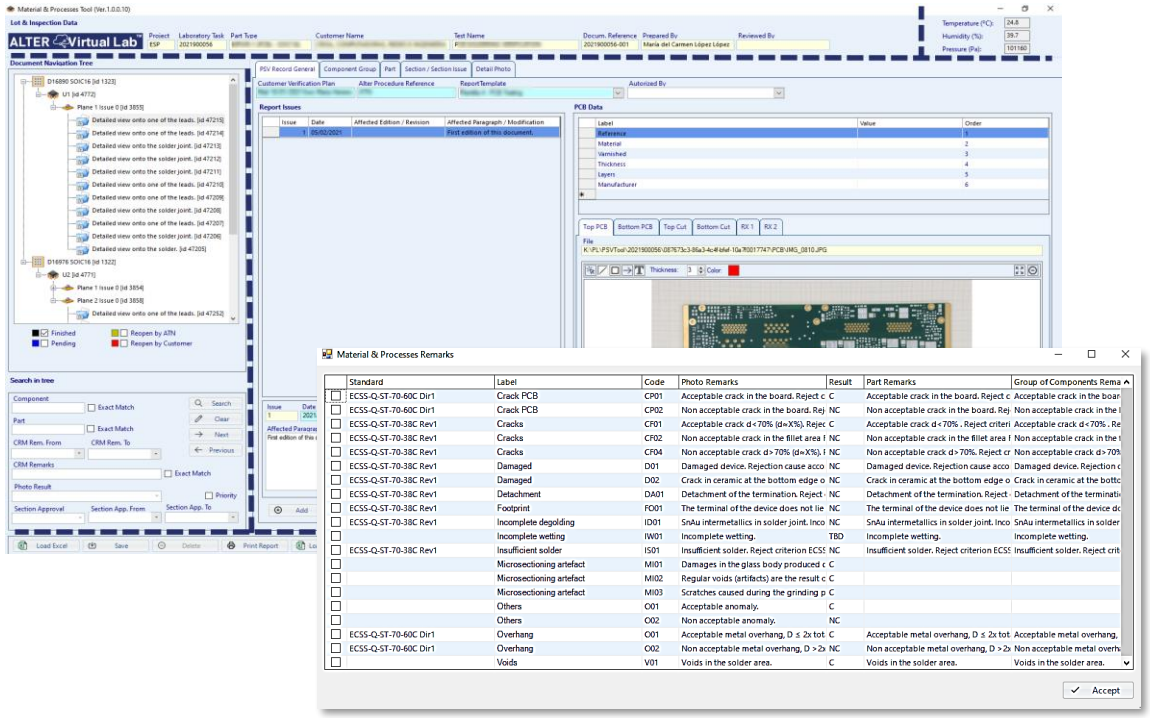




EXPERIMENTAL PROCEDURE

Sample analysis

- During the last 8 years, we have recorded more than 200,000 images.
- Our digitalization team developed a system to collect all the images and label them according to the anomaly that we detected on the solder connection.
  - Although our technicians are experts, reviewing and classifying images one by one is a time-consuming process and subject to human fatigue and error.
  - The problem is not only the quantity of images, but also the complexity of the defects: cracks, gaps, contaminants… all different and often subtle.
  - **May Computer Vision help us to be more productive?**



Certified IPC-A-600 Application Specialist

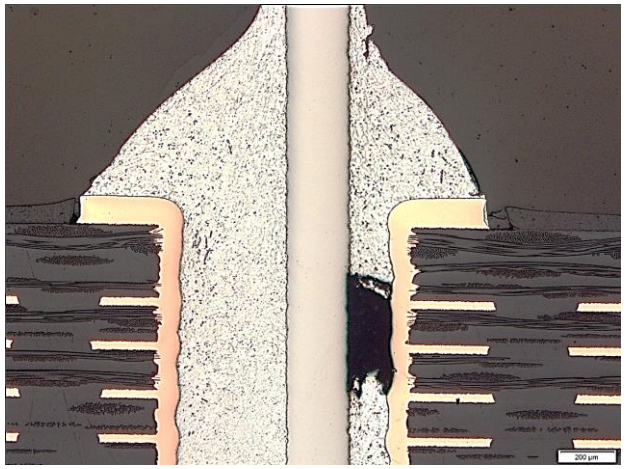
Certified IPC-A-610 Application Specialist

RESULTS

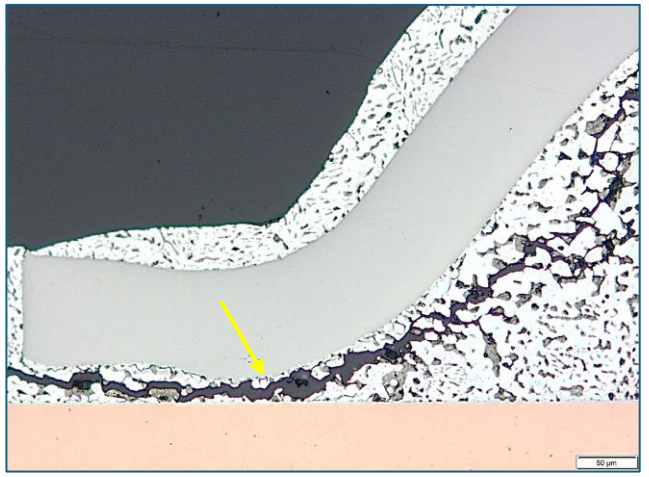
Anomalies under study

- Voids
- Crack in solder joint
- Cracks in PCB
- Poor degolding process
- Pure Tin

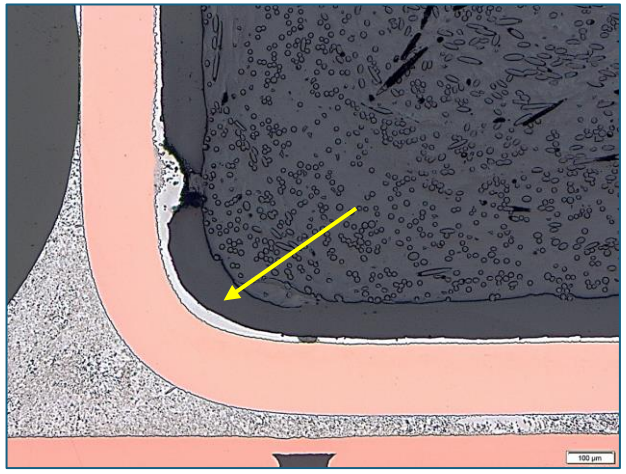
Voids



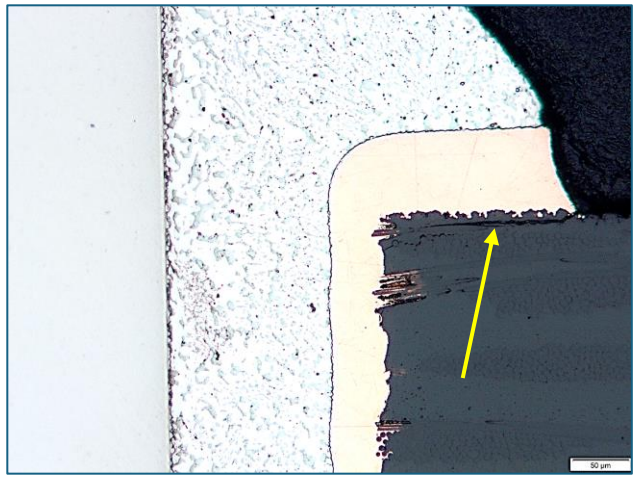
Crack in Solder joint



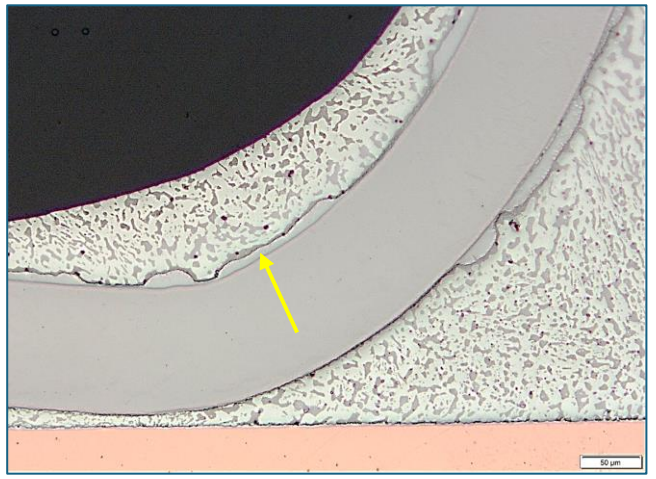
Pure tin



Crack in PCB



Poor degolding process

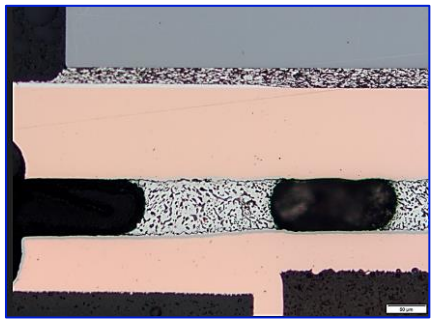
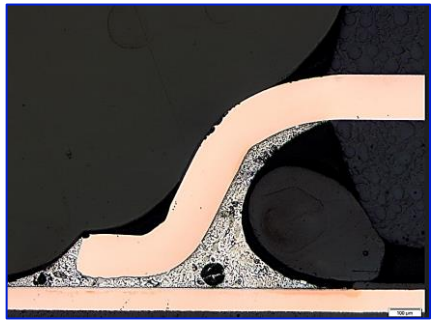
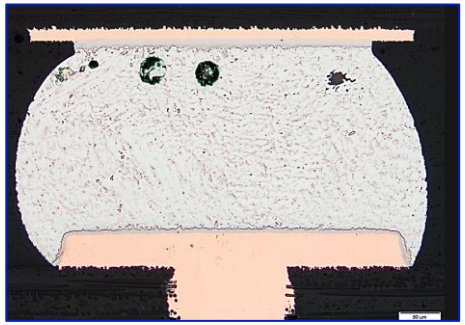


RESULTS

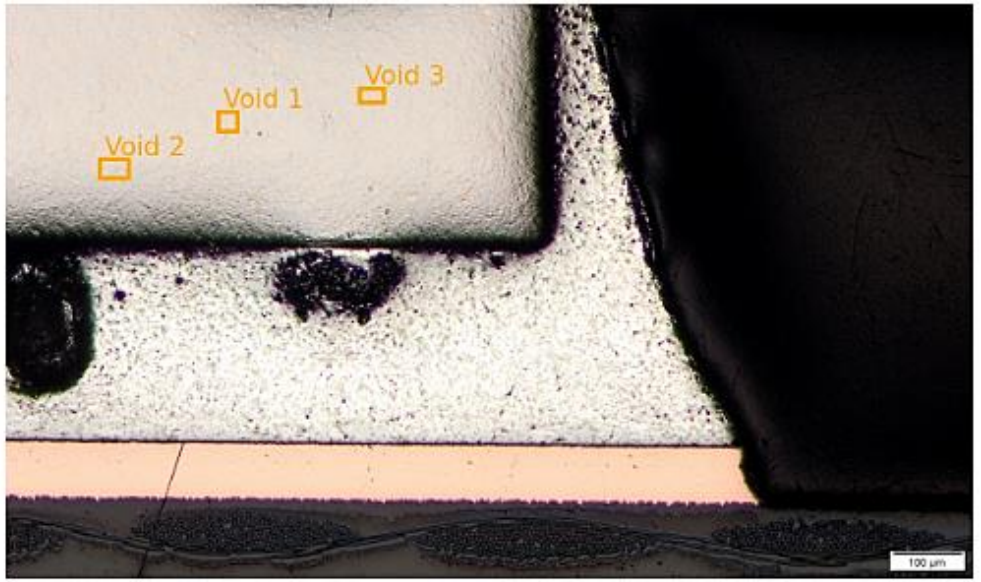
First Round

First round: Chat GPT

- Due to the complexity of the anomalies we can find in a solder joint, a simple defect was chosen to begin with: **Voids in solder joint**.

- The standard ChatGPT fails to identify the most evident anomalies in the picture.



- Although ChatGPT understands the acceptance criteria and the quality of the picture seems good enough, the results are totally unacceptable.

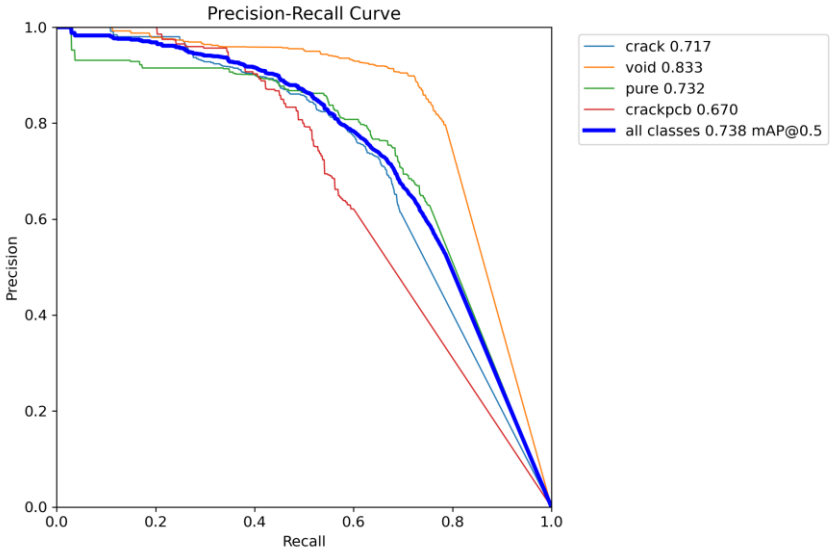
RESULTS

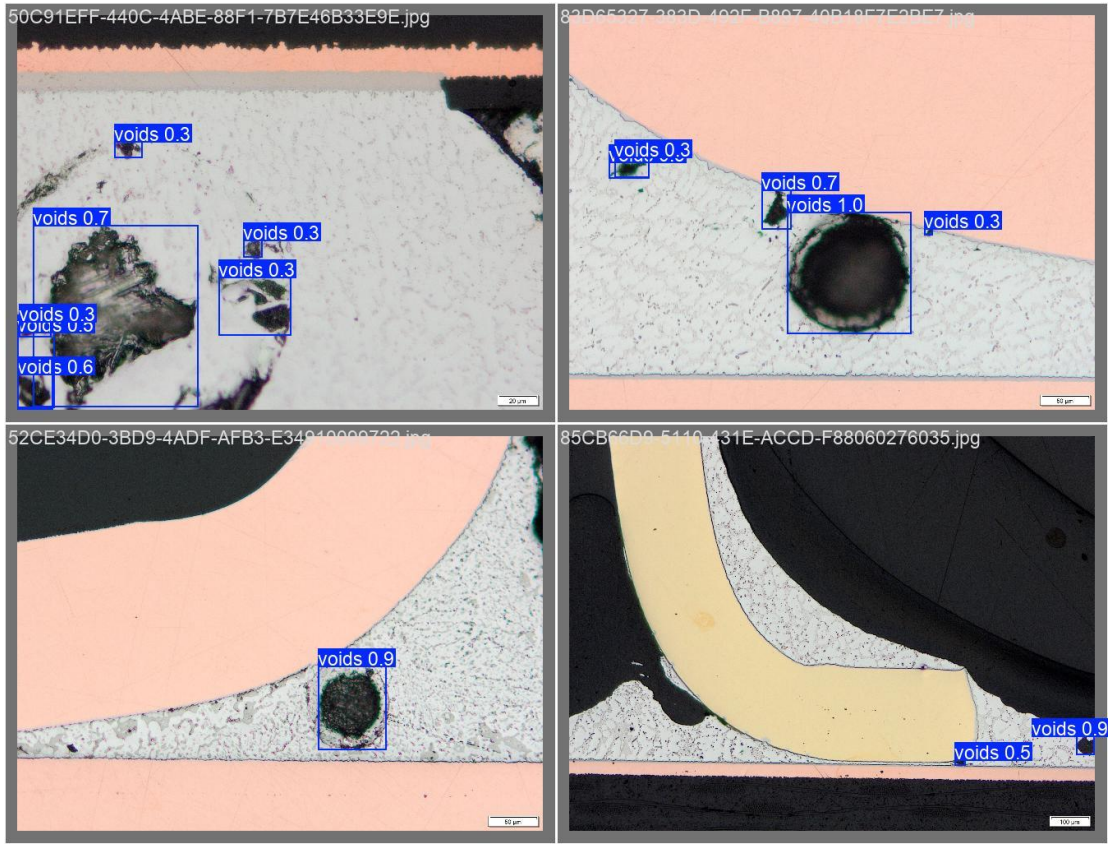
Second Round

Second Round: Single anomaly detection

- We have hundreds of images classified with the label **VOID**. These images are used to train the system to recognize a black hole in the SnPb solder like a void.

- Once we have classified hundred of pictures with one single anomaly, voids, it seems that **the model is able to identify** most of them and evaluate the degree of confidence that could be provided.





RESULTS

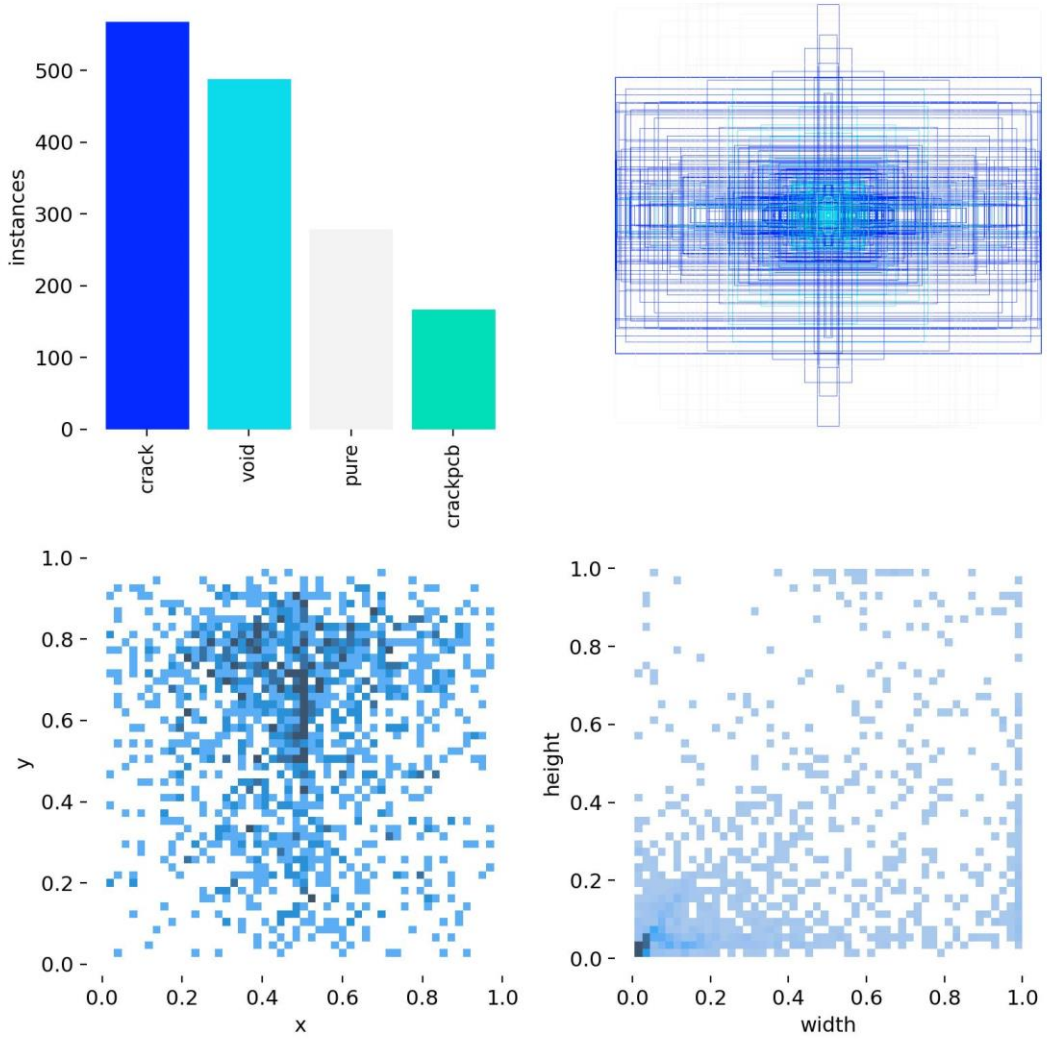
Data Review

Data Quality

The **conclusions** after analyzing the images obtained by the Materials and Processes Laboratory are the following:

- The **most** provable **anomaly** is the presence of **crack** in the solder connections.
- The extent of the **anomaly** is **small** compared to the size of the image.
- The **location** of the anomaly is typically **cented** in the image.

These data have to be read as the bias of our system.

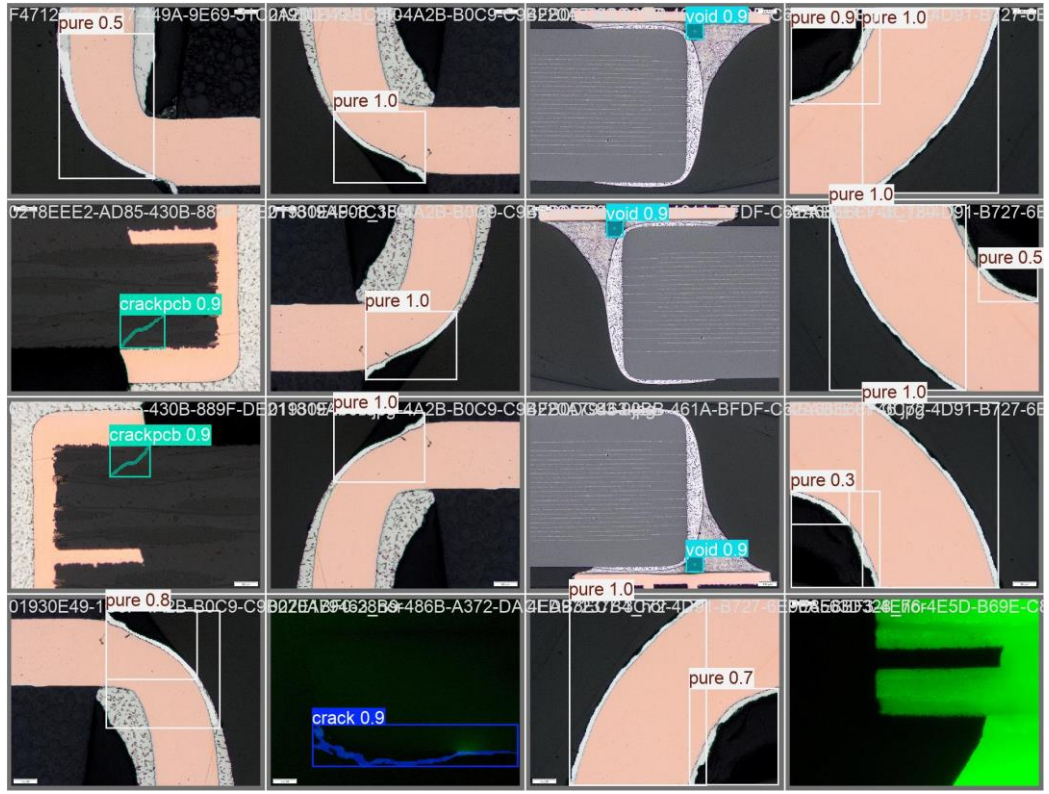


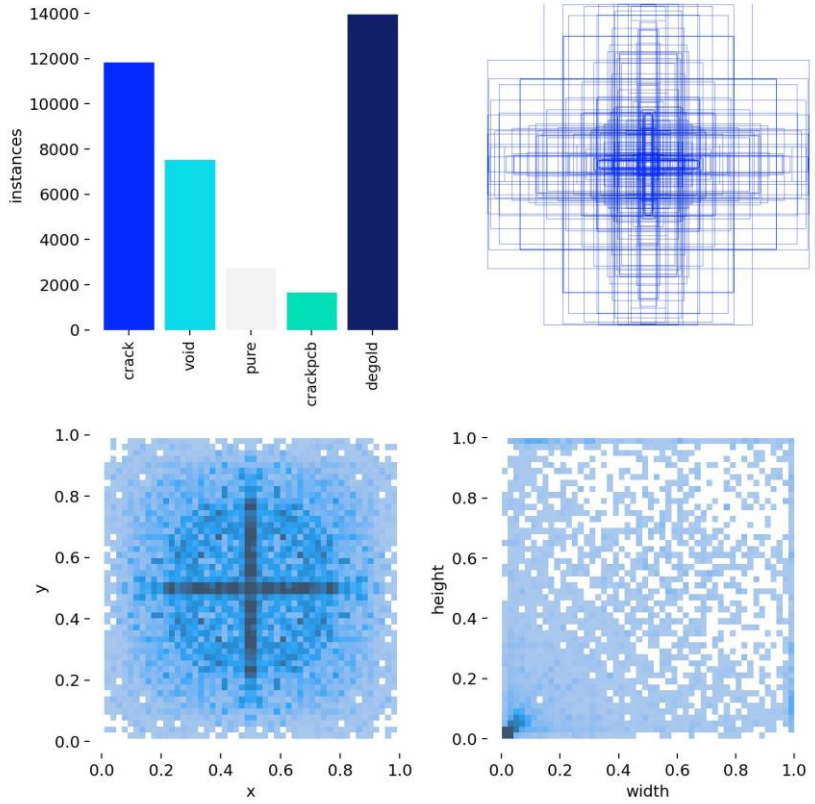
RESULTS

Third Round

Third Round: Everything at once

- For the **training stage**, synthetic data were generated. This type of data allow us to generate datasets based on **real-world events** that are more accurate representations of these events.
- Synthetic data allow to learn with greater accuracy and diversity.



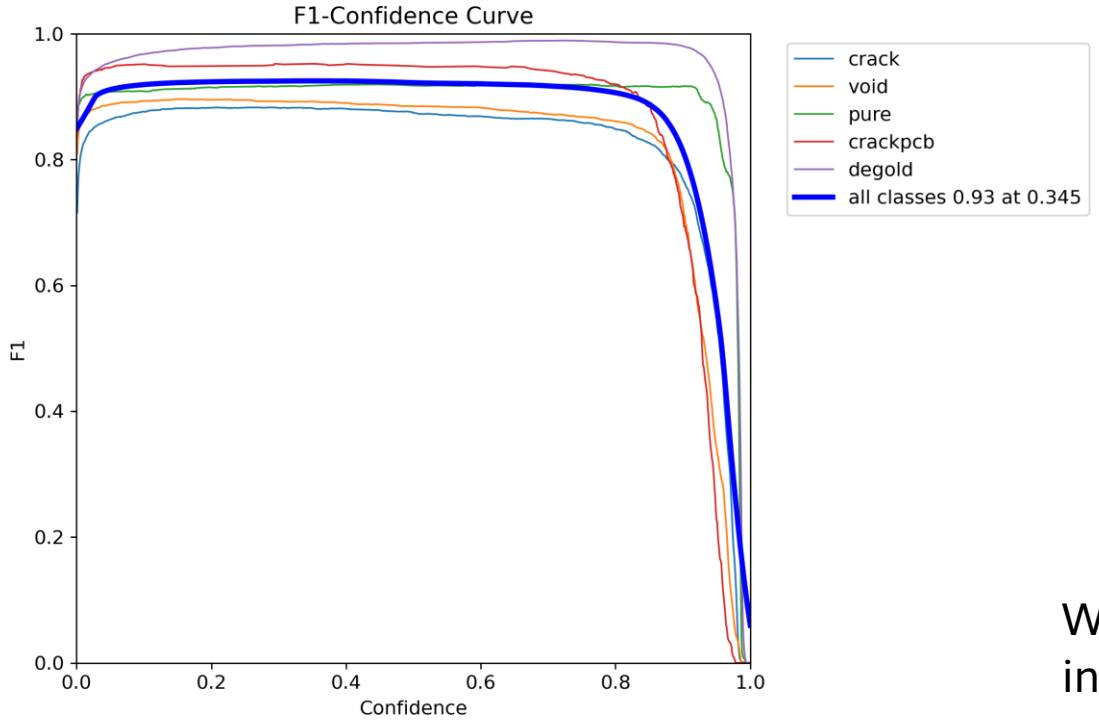


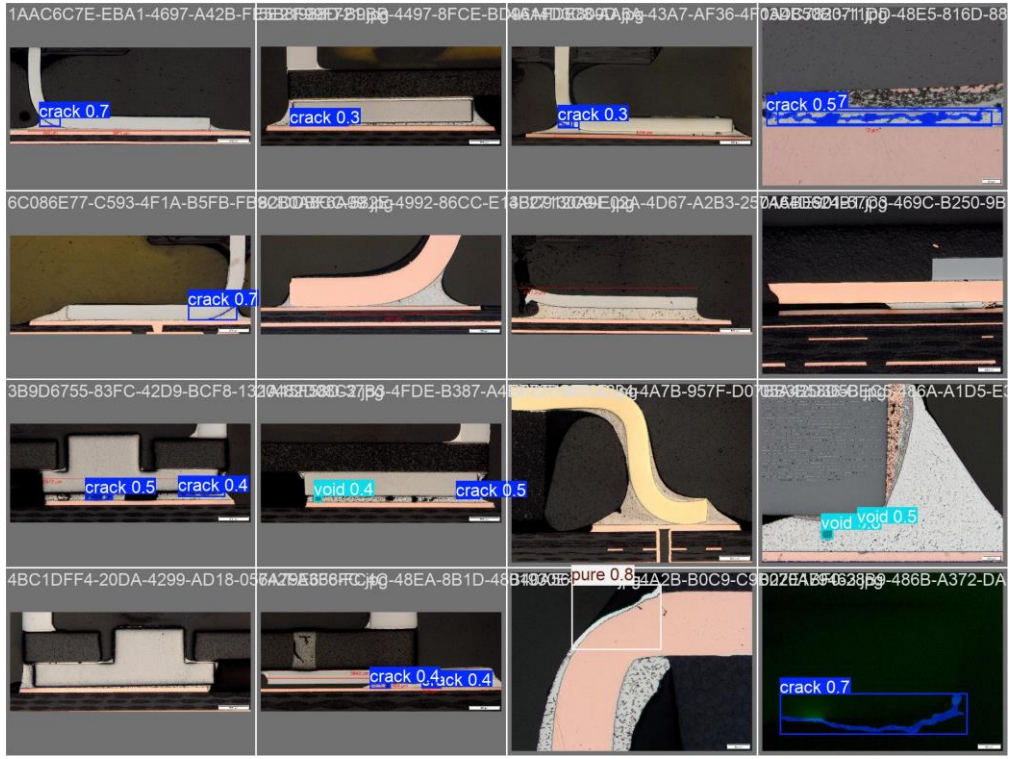
RESULTS

Third Round

Third Round: Everything at once

- This new training allows:
  - Improve the degree of **fulfillment** of the system.
  - Provide the **ability to predict** rare events.





With the **current results**, the **model** has not only met the initially defined standards but has **exceeded them!!**

CONCLUSIONS

- A tool base on **Computer Vision** models has been developed to analyse the potential anomalies of solder connections as a part of the daily work of the Laboratory of Materials and Processes.
- From a technical point of view, optimal preparation of the sample to be analysed is key to obtaining high quality images to be analysed with this new method.
- We have creating **training/testing sets** to lay the foundation of our Computer Vision tool .
- With the current results, the model has not only met the initially defined standards but has exceeded them in several key metrics. This indicates that **the model could be commercially viable** and capable of meeting expectations in real-world applications

Thank you for your attention.

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