Latent Reliability Defects in Automotive Chip Packages

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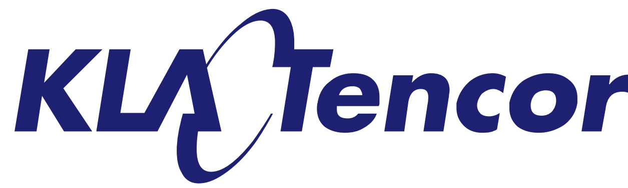

2018 Automotive Electronics Council Reliability Workshop

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In-vehicle technology continues to be most problematic: Audio/Communications/Entertainment/Navigation (ACEN) remains a troublesome category for vehicle owners, receiving the highest frequency of complaints.

New car owners encountering more technology problems

4,9 VEHIC WITH AD

PACKAGING, TEST & MATERIALS

How To Make Autonomous Vehicles Reliable

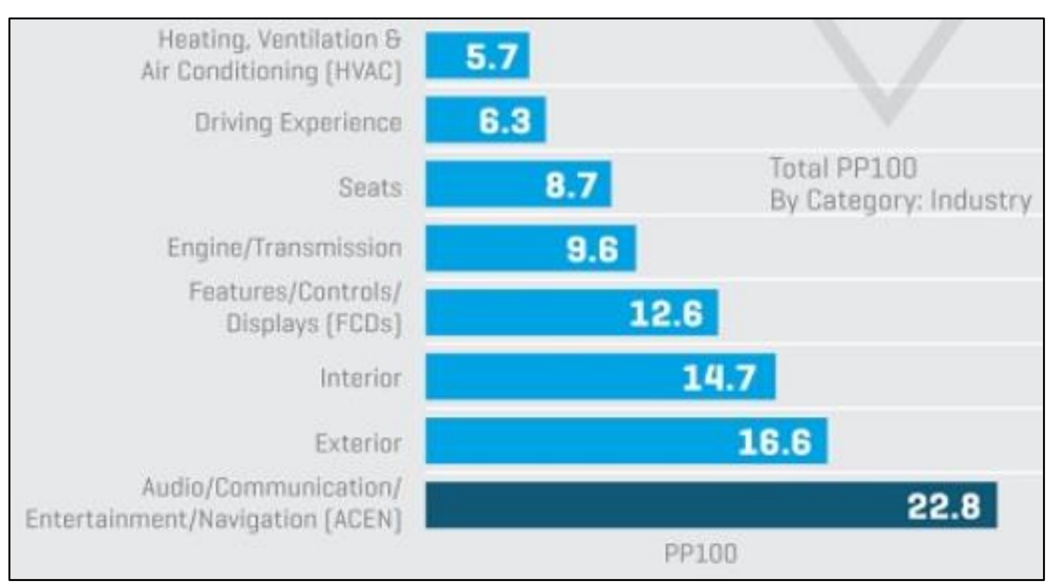
57

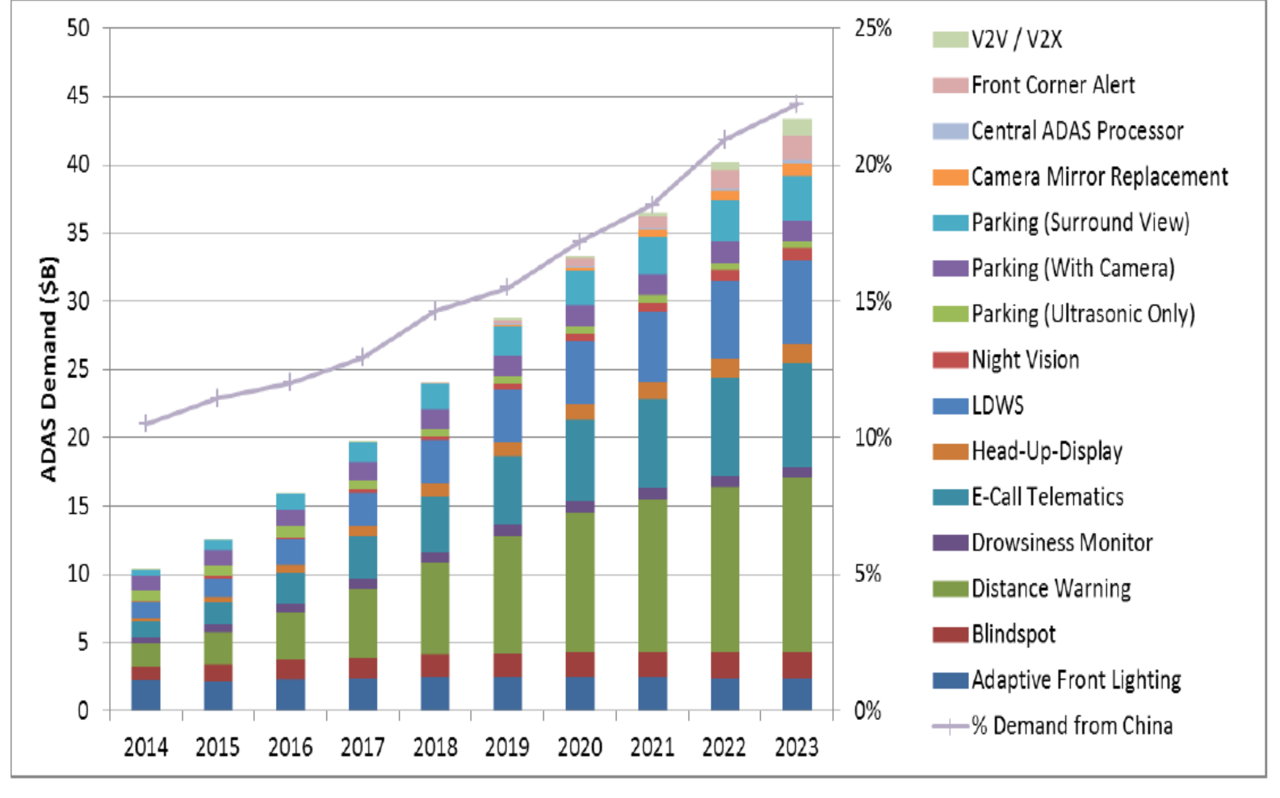
Making sure ADAS designs function correctly over time will be an enormous challenge.

SEPTEMBER 11TH, 2017 - BY: **ANN STEFFORA MUTSCHLER**

The number of unknowns in automotive chips, subsystems and entire vehicles is growing as higher levels of driver assistance are deployed, sparking new concerns and approaches about how to improve reliability of these systems.

Challenge: Overall Reliability Versus IC Growth in Cars





~8000 chips in each car for the luxury segment

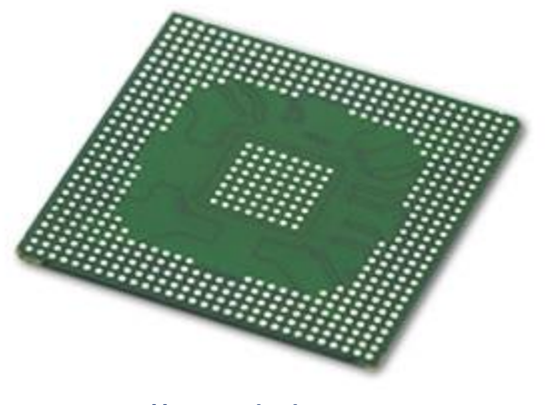
Challenge: Overall Reliability in Harsh Environments

- Expected long lifetime and reliability despite:
  - Large temperature variations and fast cycles
  - Vibration from driving on roads and engine rotations
  - Shocks from driving on roads (accidents not considered)
  - Humidity variations and related risk for condensation
  - Higher voltages driving electronics compared to the past
  - And multiple combinations of the above...

Trends – Automotive Industry

- Well proven (older) packaging solutions with **higher quality standards**
  - Require high end inspection & metrology
- Long product lifetimes
  - 10Y+ compared to short lifetime of consumer electronics
- Strong growth in amount of packages/car
  - Driven by autonomous vehicles, safety and carbon footprint reduction
- Much tighter inspection compared to mobile devices e.g. vehicle camera sensor + lens inspections

Leaded devices

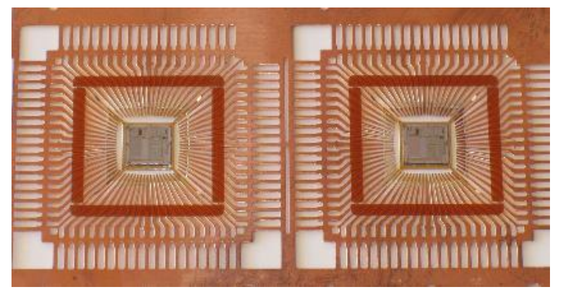
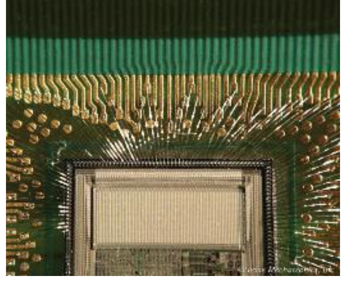
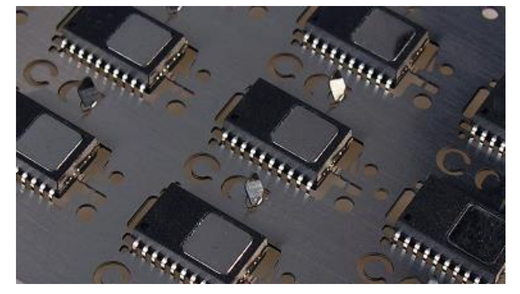
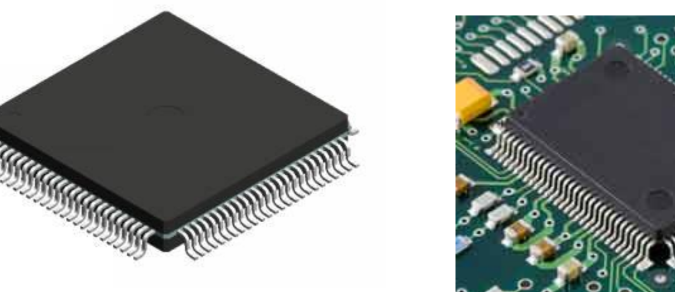


Ball Grid devices

Assemblies

Back End Inspections – Relation to Quality and Reliability

- After dies are cut from the wafer, many steps remain before die is assembled on a PCB

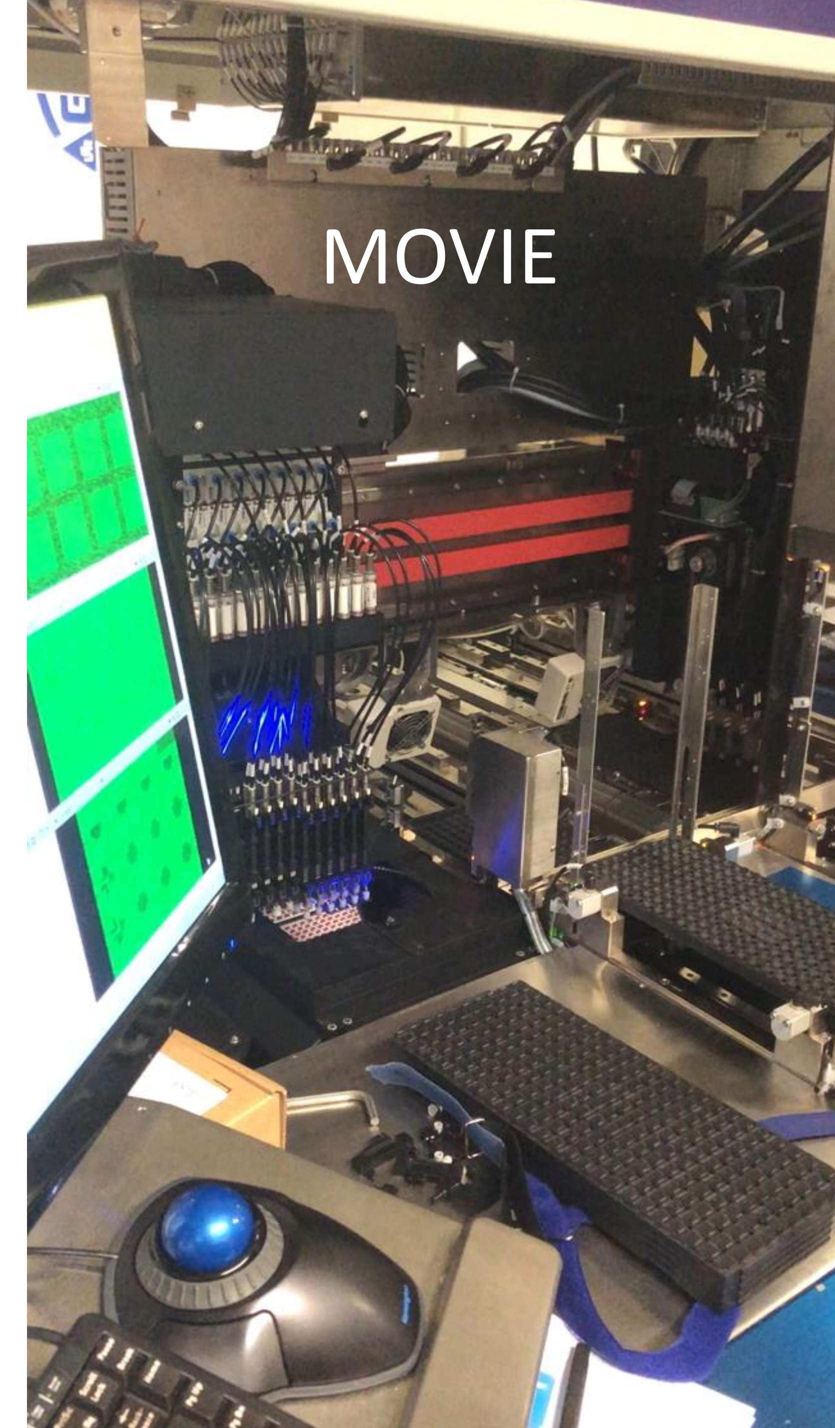





Die on Lead Frame | Wire Bonding | Molding & Singulation | **Package** | Module Assembly

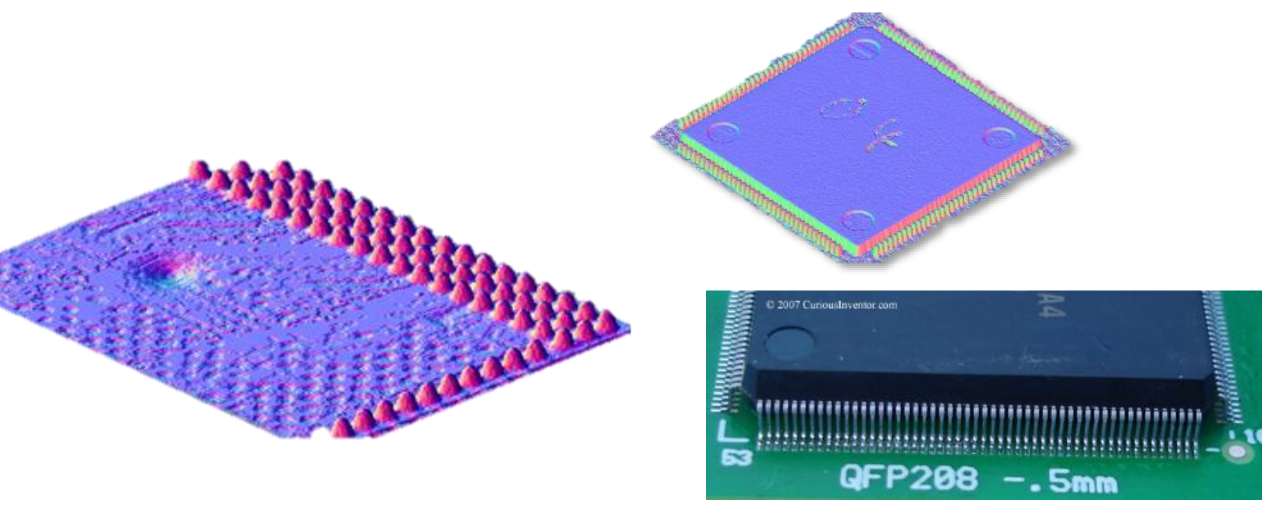
Back-End Quality Inspection
2D & 3D Metrology
Mold Crack
Burr Detection
Dirt-On-Lead
Foreign Materials

Vision Inspection is the Automation of a Manual Process

- How does it happen? -- taking pictures, many pictures
- With these 2D pictures, defects can be recognized and a 3D image can be created for metrology
  - 2D & 3D metrology
  - Mold crack
  - Burr detection
  - Dirt-On-Lead (DOL)
  - Foreign materials

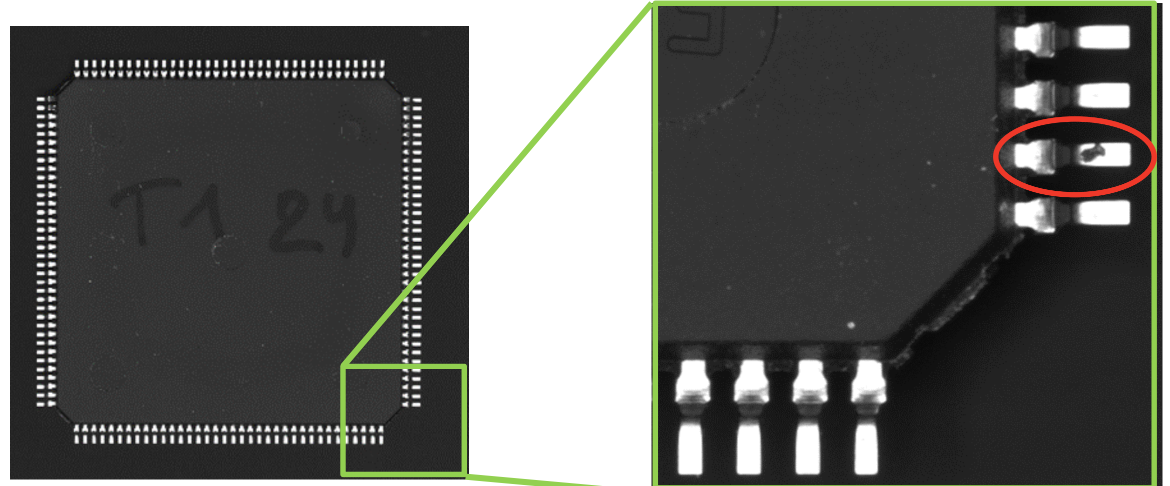


Typical Inspections for Automotive Packages

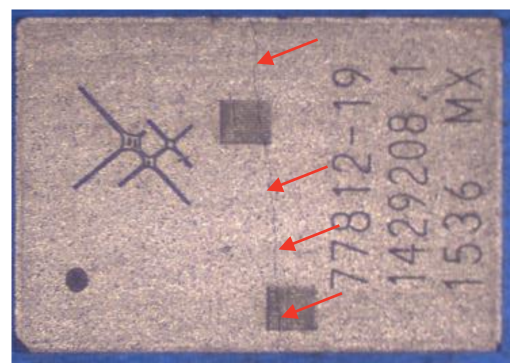


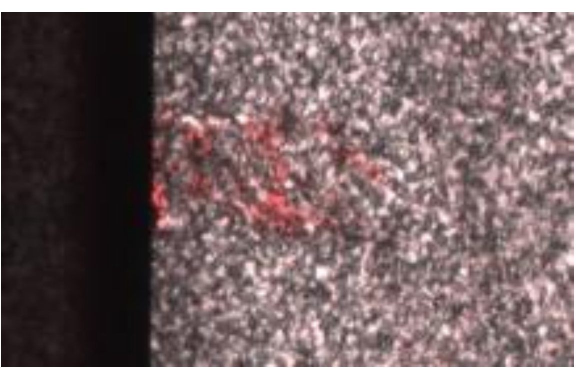
2D & 3D Metrology *(3σ at 5μm)*

Burr Detection *(down to 7μm defect size)*



Dirt-On-Lead *(down to 10μm defect size)*





Mold Cracks and Foreign Materials

(down to 0.1μm)

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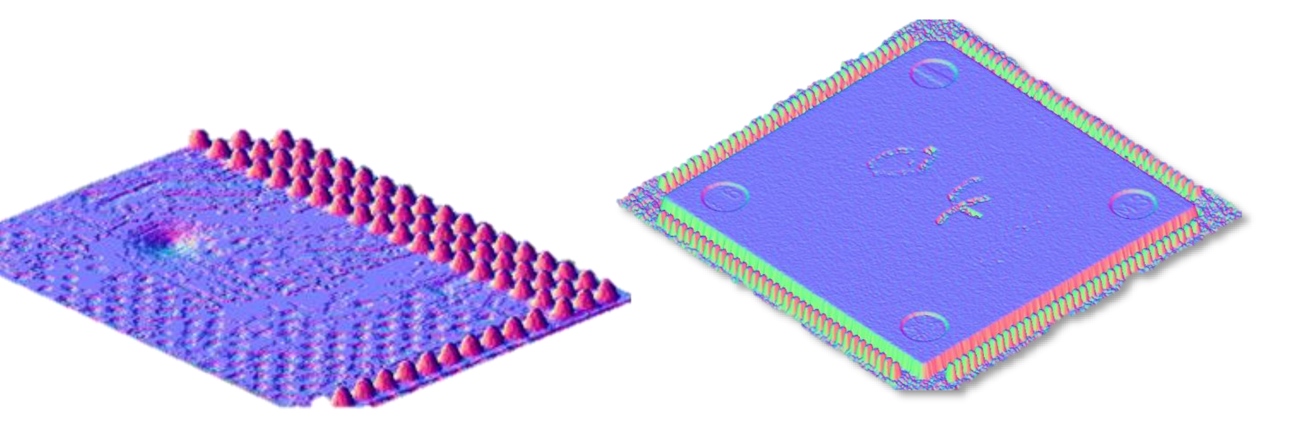

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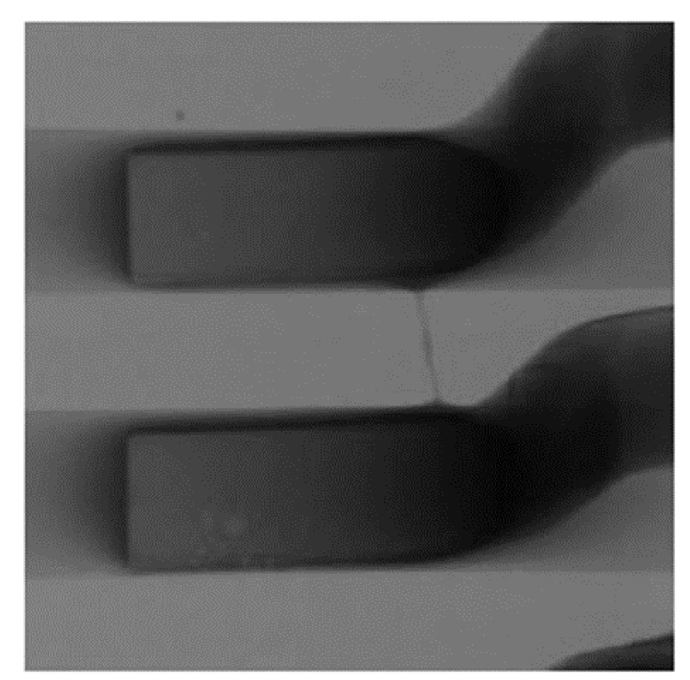

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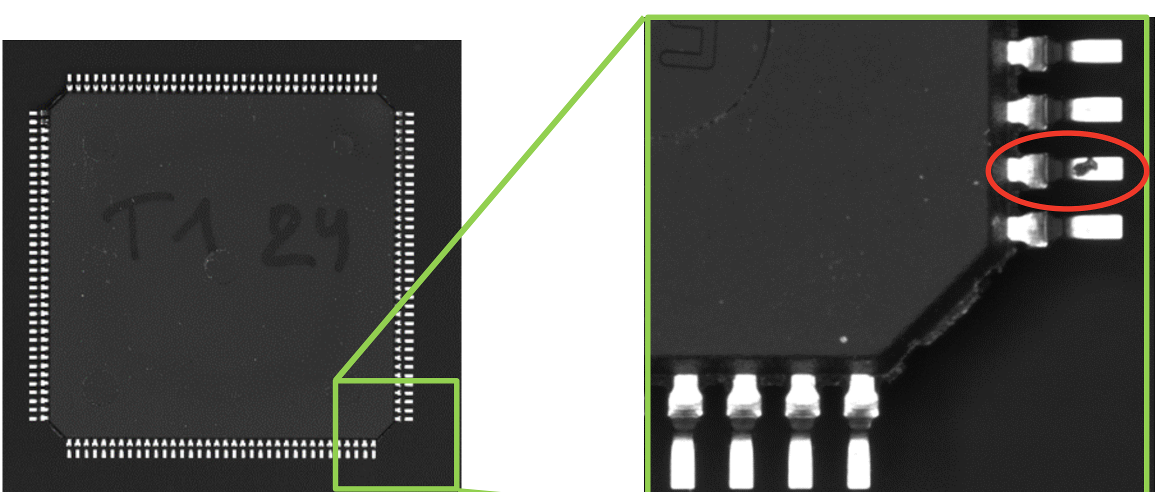

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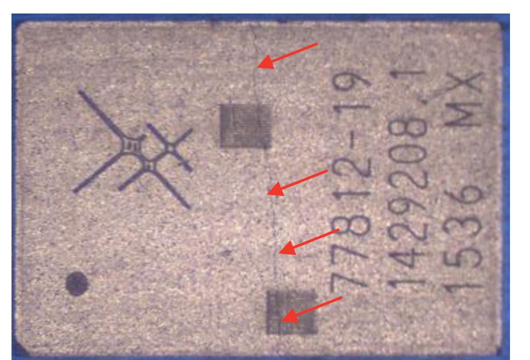

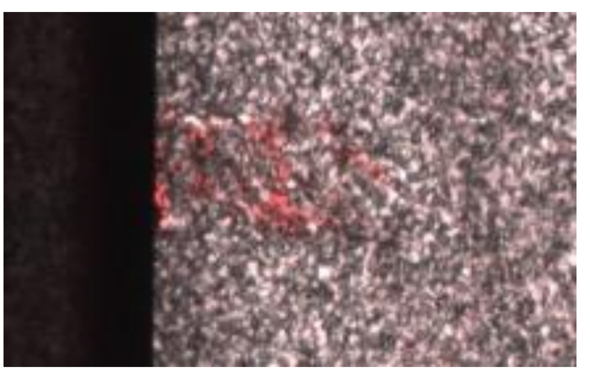

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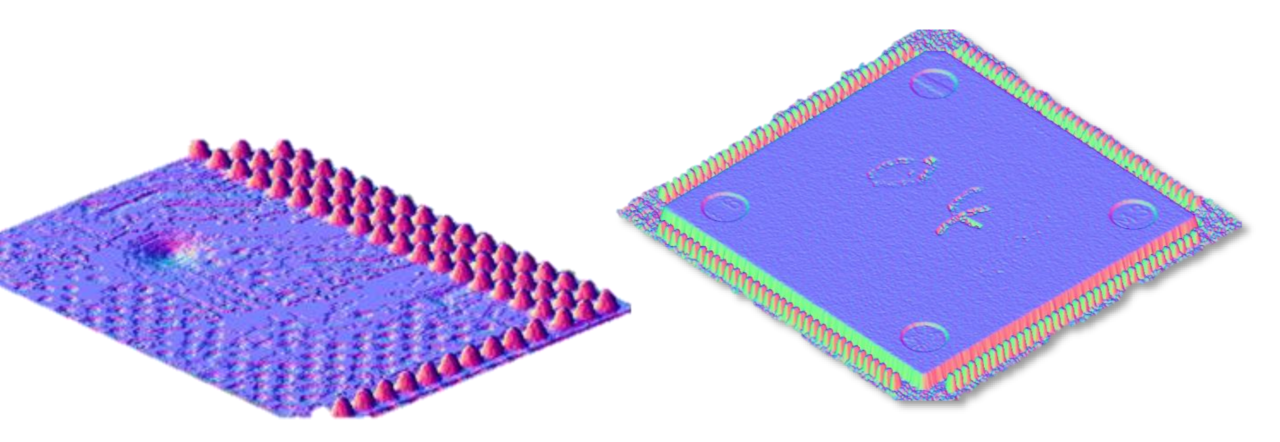

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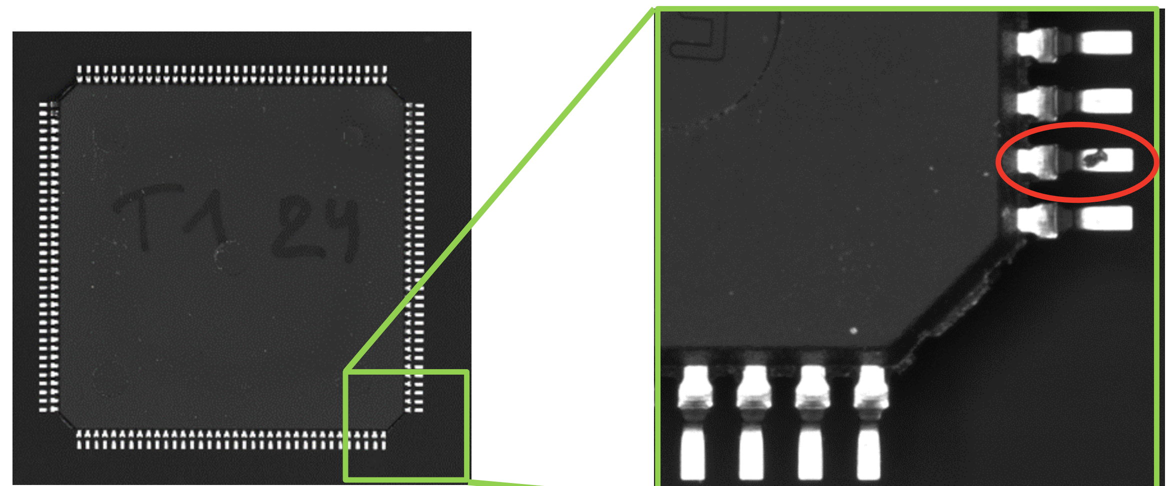

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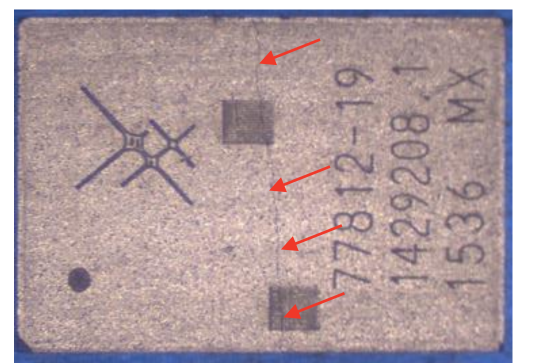

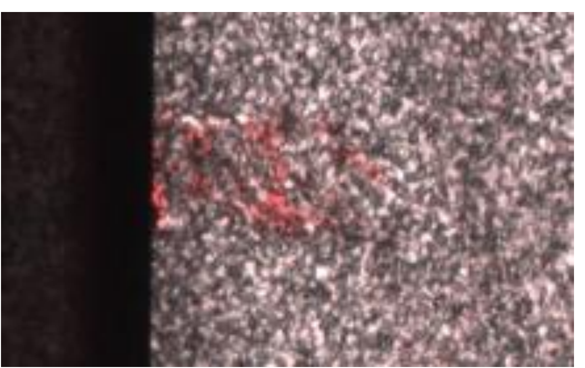

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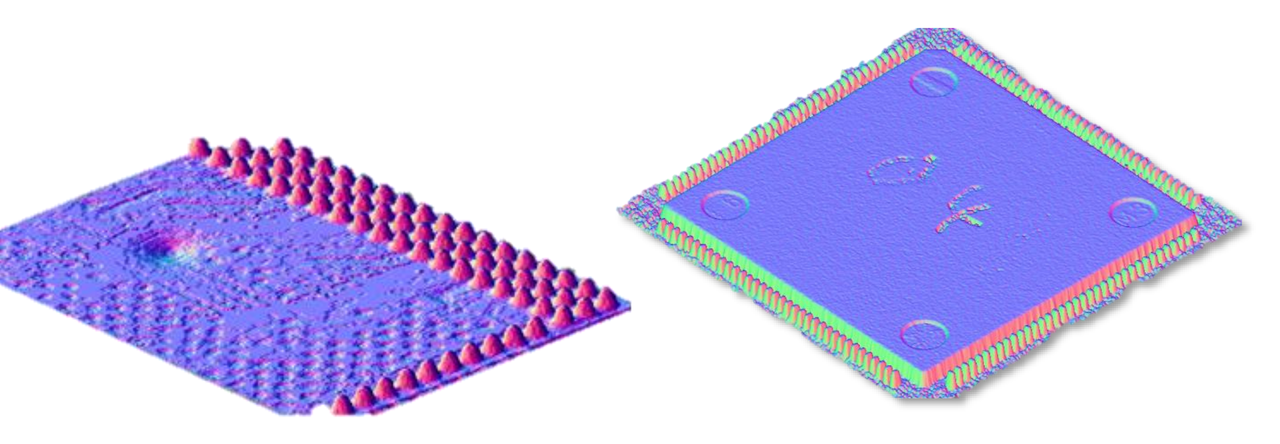

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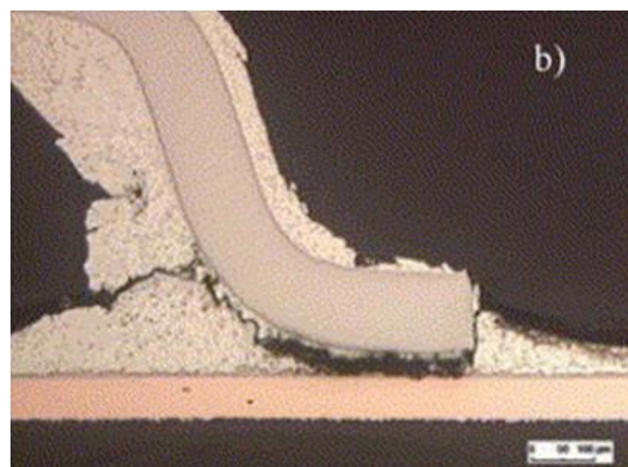

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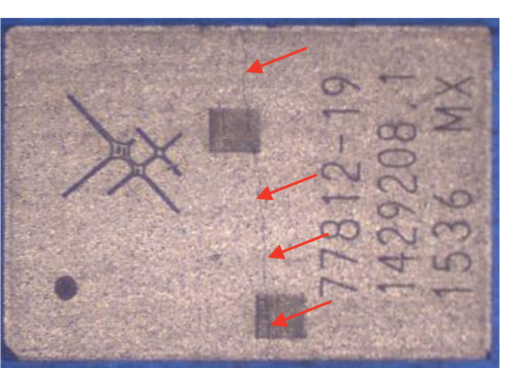

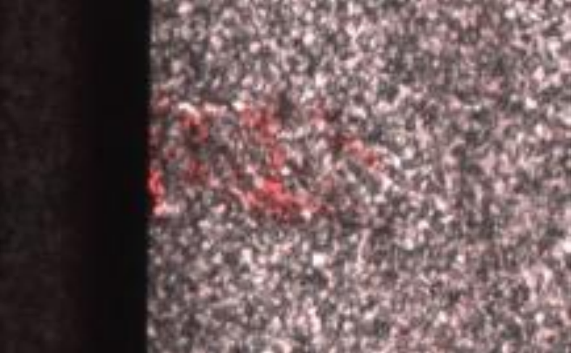

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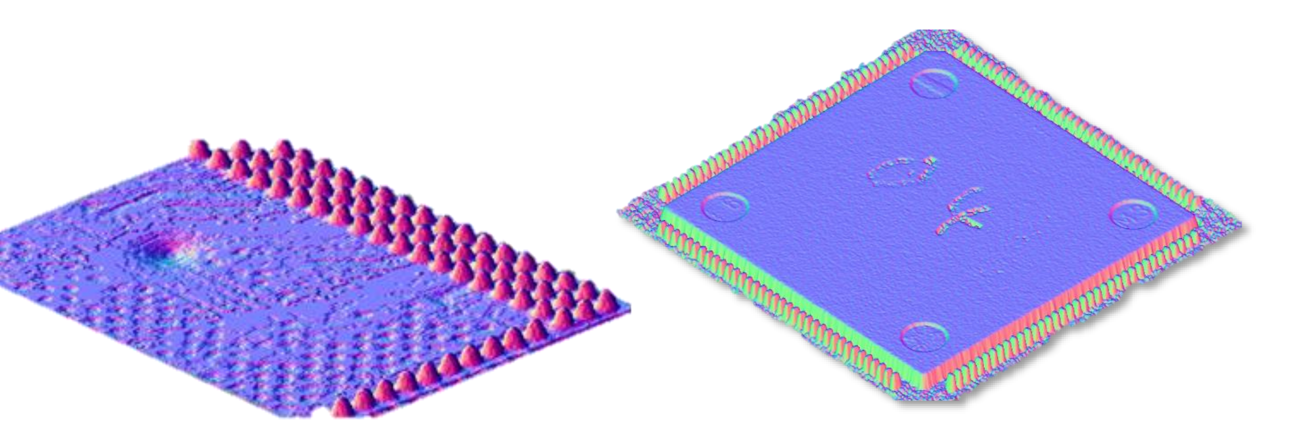

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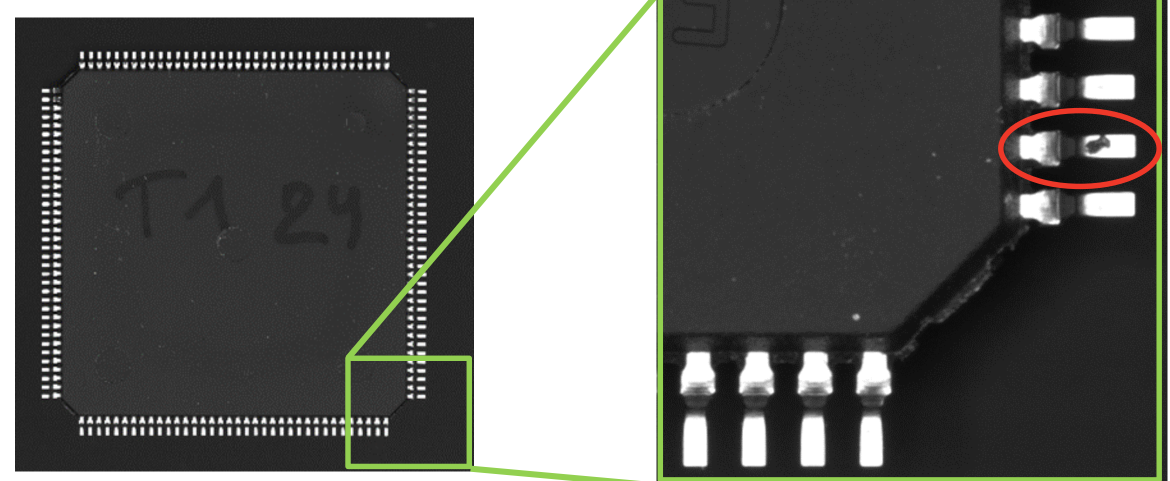

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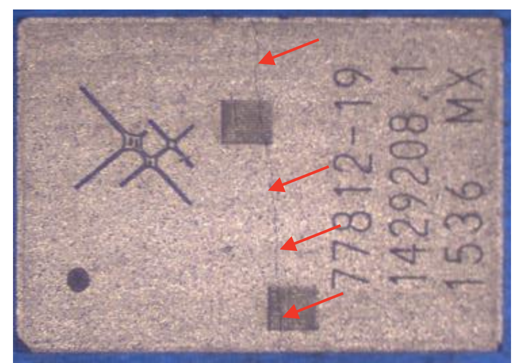

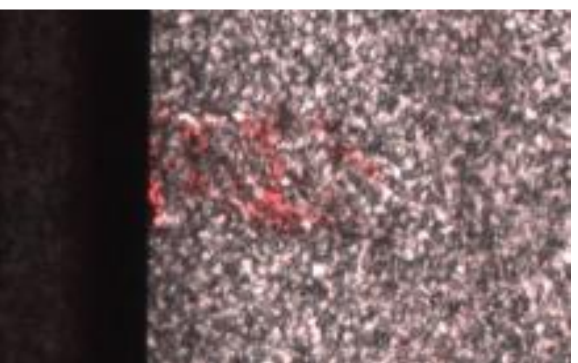

Mold Cracks and Foreign Materials
(down to 0.1µm)

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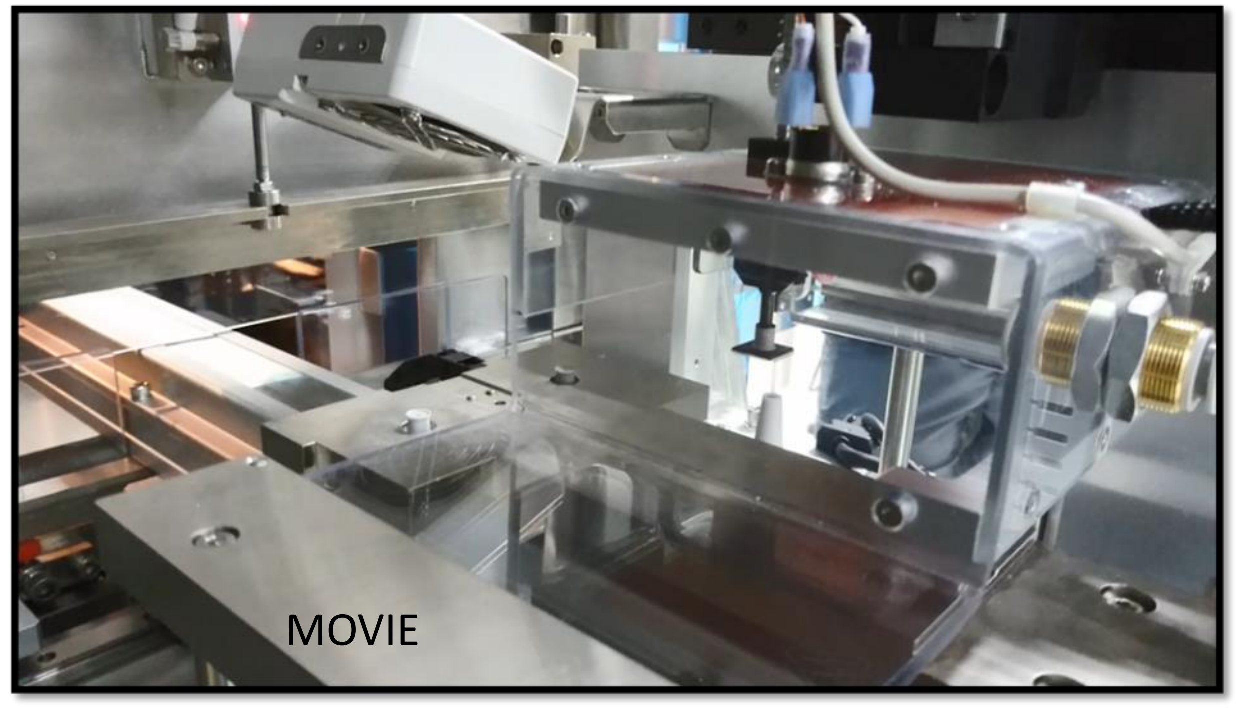
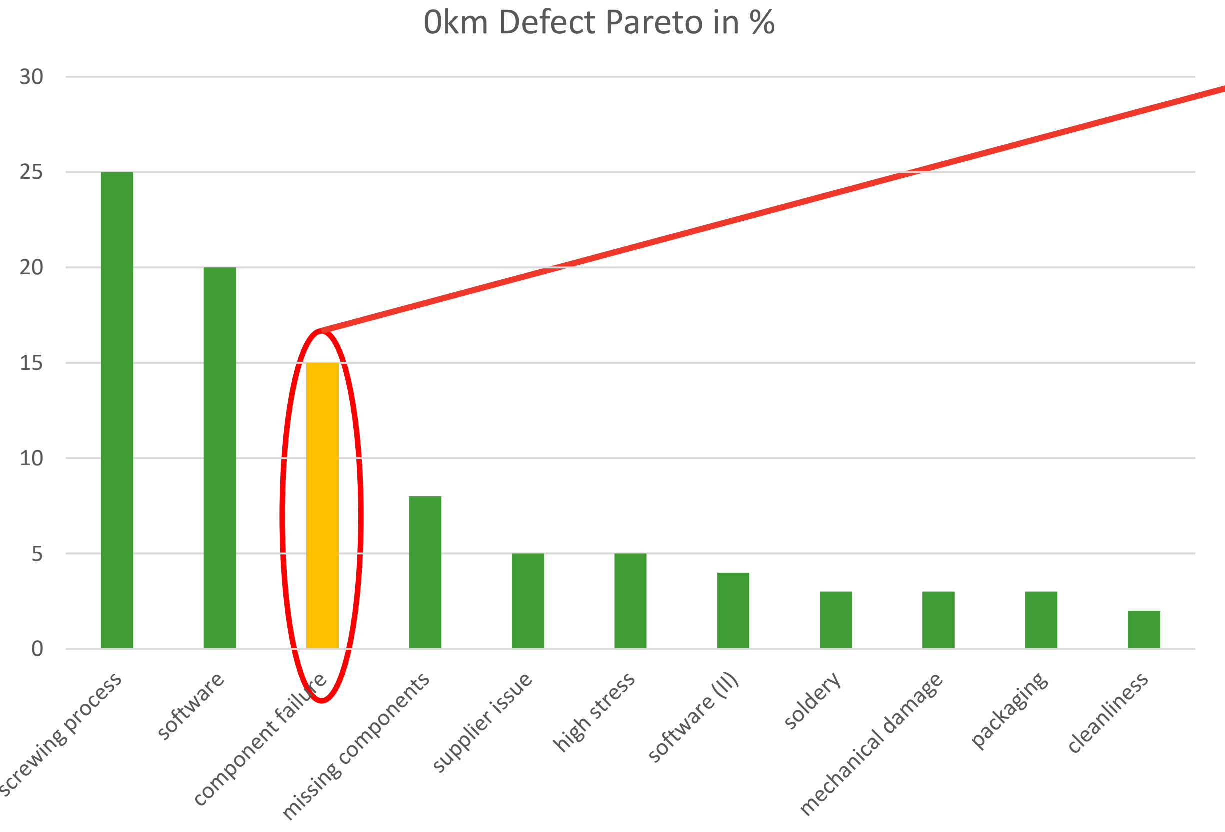
Process Steps Related to Inspection

- Detected defects can trigger an additional process step to increase yield without underkill
  - Example: Integration of CO_2 cleaning process step for removing small burrs and dirt particles found in inspection
  - Re-inspect the component for the final accept/reject sorting step



Package Inspection Prevents Defects from Arriving on the Assembly line: 0km Defect Pareto



- Component failures represent about 15% of all 0km failures
  - Growing concern for automotive OEMs
  - Higher voltages increase risk for latent defects to cause a defect over time
  - During use, this category is more dominant due to the exposure of these components to harsh environments

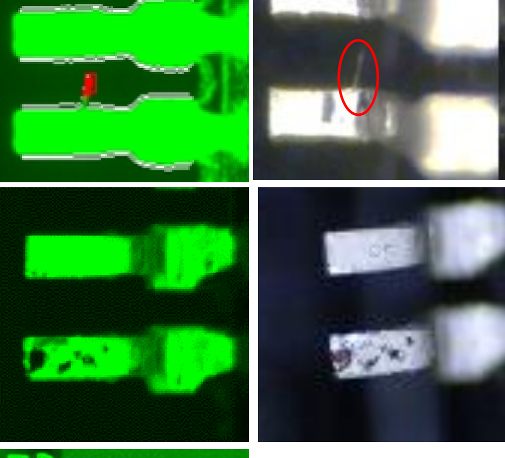
Use case: Resolution Decreases Underkill

- Inspection of single batch of components from QFP production chip using previous gen technology
  - 9 packages with defects

5 rejects based on burr defects

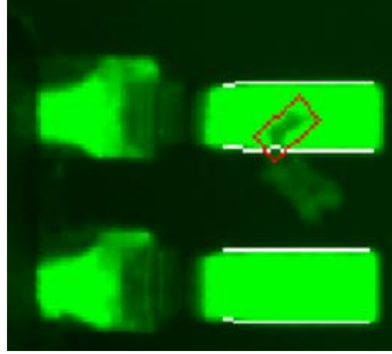
3 rejects based on DOL

1 rejects based on mold defect



- Inspection of same batch with the latest illumination and camera resolution:
  - 10 packages with defects

1 additional reject based on DOL



= 1 latent issue prevented

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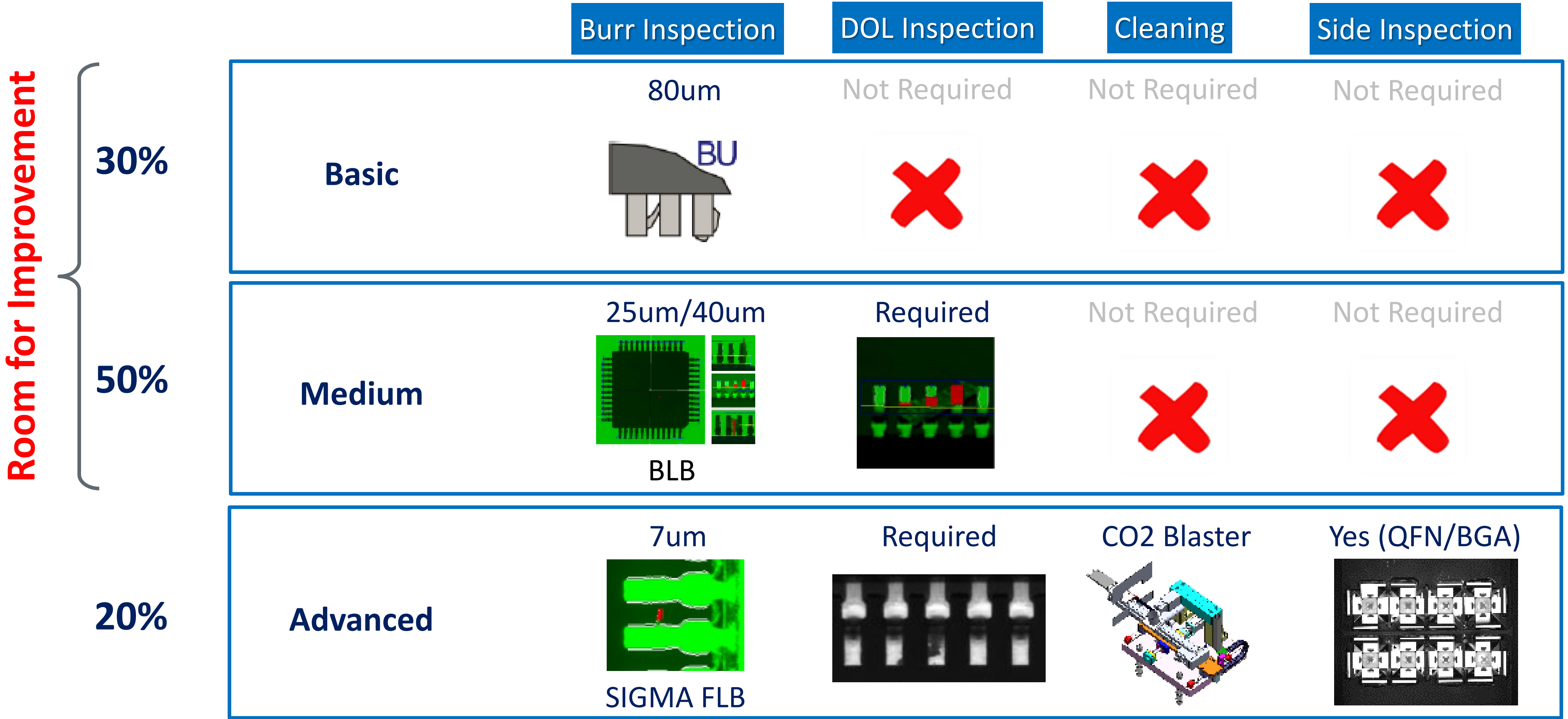
3 Levels of Automotive Package Inspection



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Use Case: Amount of Latent Defects Related to Inspection Level

Room for Improvement

		Burr Inspection	DOL Inspection	Cleaning	Side Inspection
NA	Basic	80um	Not Required	Not Required	Not Required
4-6	Medium	25um/40um BLB	Required	Not Required	Not Required
10	Advanced	7um SIGMA FLB	Required	CO2 Blaster	Yes (QFN/BGA)

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Conclusion

Metrology and inspection enables component sorting to prevent defective devices arriving at the assembly line and to keep track records of each device

- Metrology helps you verify:
  - Device dimensions are within tolerance to confirm the quality of assembly on the PCB
  - All (ball) contacts are present (BGA components)
- Inspection helps you verify:
  - Packaging and attributes like EMI shielding are well assembled before molding
  - Dirt particles and burrs are removed or allows the components are sorted towards the bin
- Inspection enables unique item level traceability and defect analysis

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