ML-assisted approaches for digital image analysis to perform reliable failure analysis in microelectronic components

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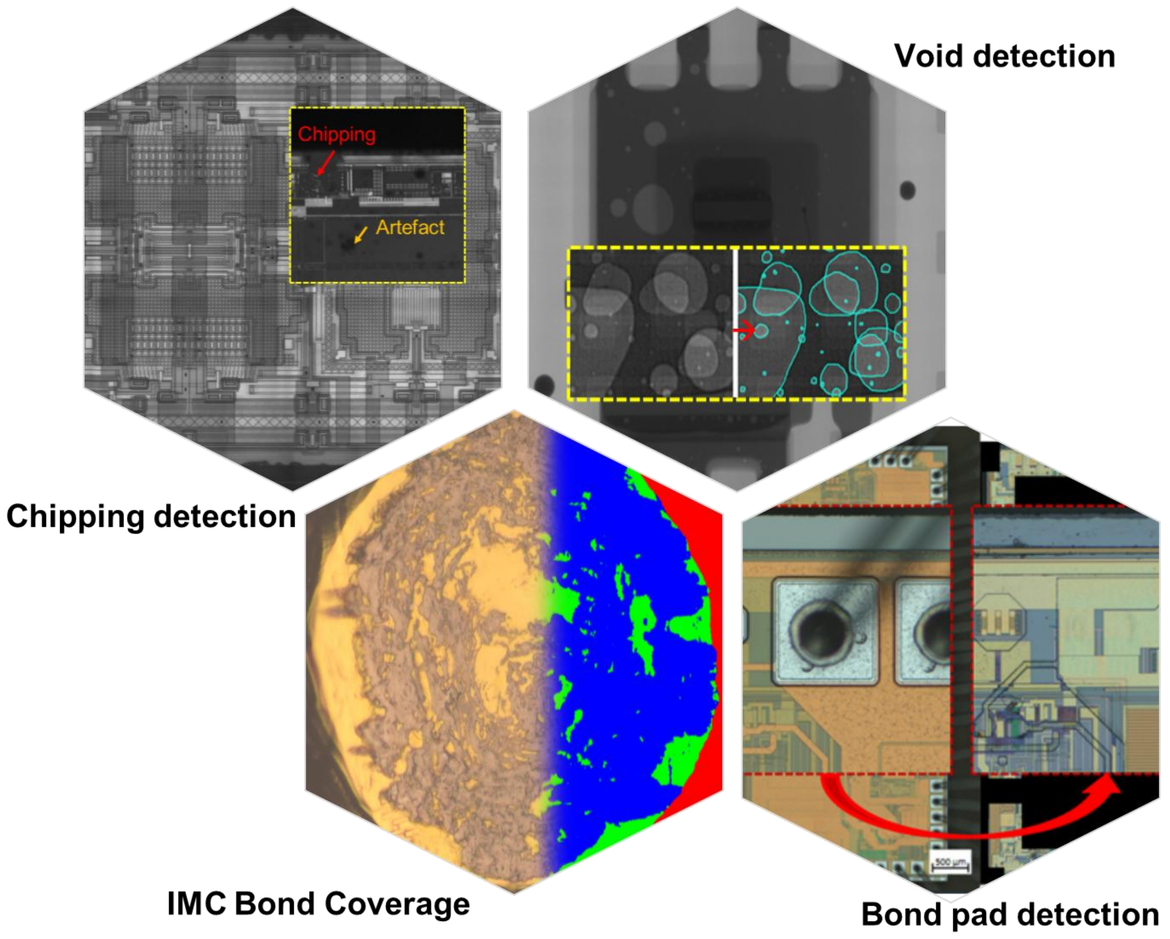
Motivation and use-cases

- Digitalization and automation of industries require reliable electronic systems (ECS), making effective failure analysis is crucial for detecting material-level defects from microscopy image data
- Manual image analysis is slow, highly subjective, and prone to fatigue errors when contrast difference between regions of interest is poor
- ML techniques for image analysis, aided by materials science, improve microscopic characterization

Experiments and model architecture

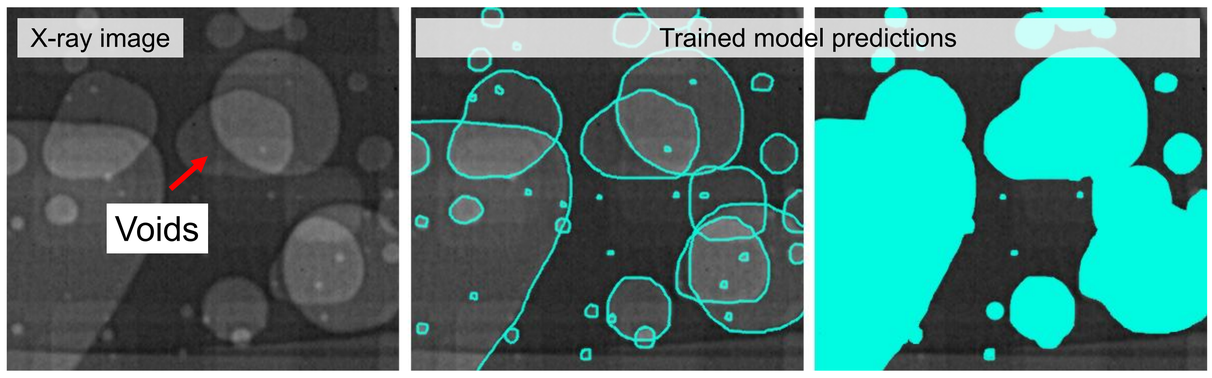
- Supervised learning approach combined with transfer learning techniques
- Data augmentation: flip, rotation, zoom, blur, noise, CLAHE, perspective and motion blur

Use-case	Data source	Model Architecture	Training Dataset
Void detection	X-ray	Mask-RCNN & U-net	72 images (1000 x 1000 px)
IMC Bond Coverage	Light microscopy	U-net	75 images (2584 x 1936 px)
Chipping detection	Infra-red microscopy	FPN	801 images (512 x 512 px)
Bond pad detection	Light microscopy	U-net	52 images (1024 x 1024 px)

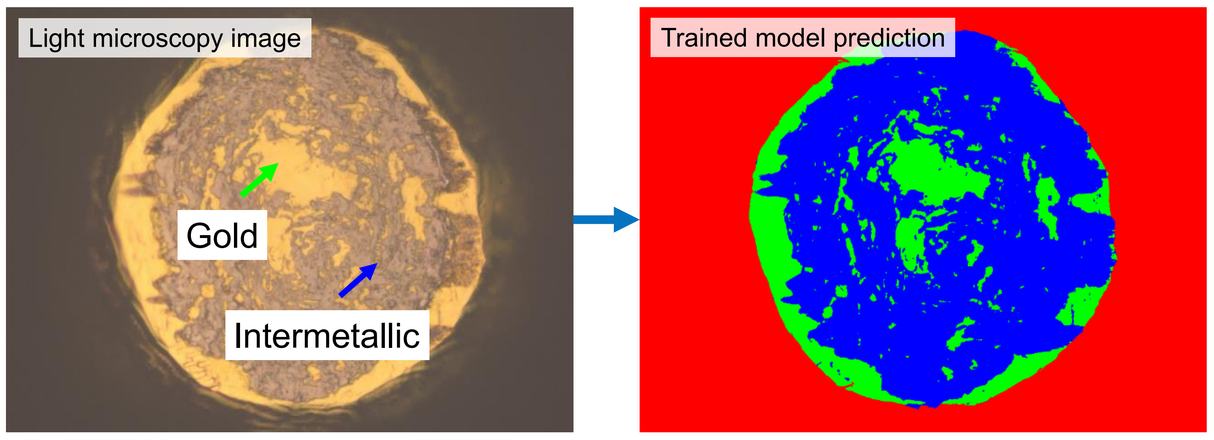


Results from trained ML model for different use-cases

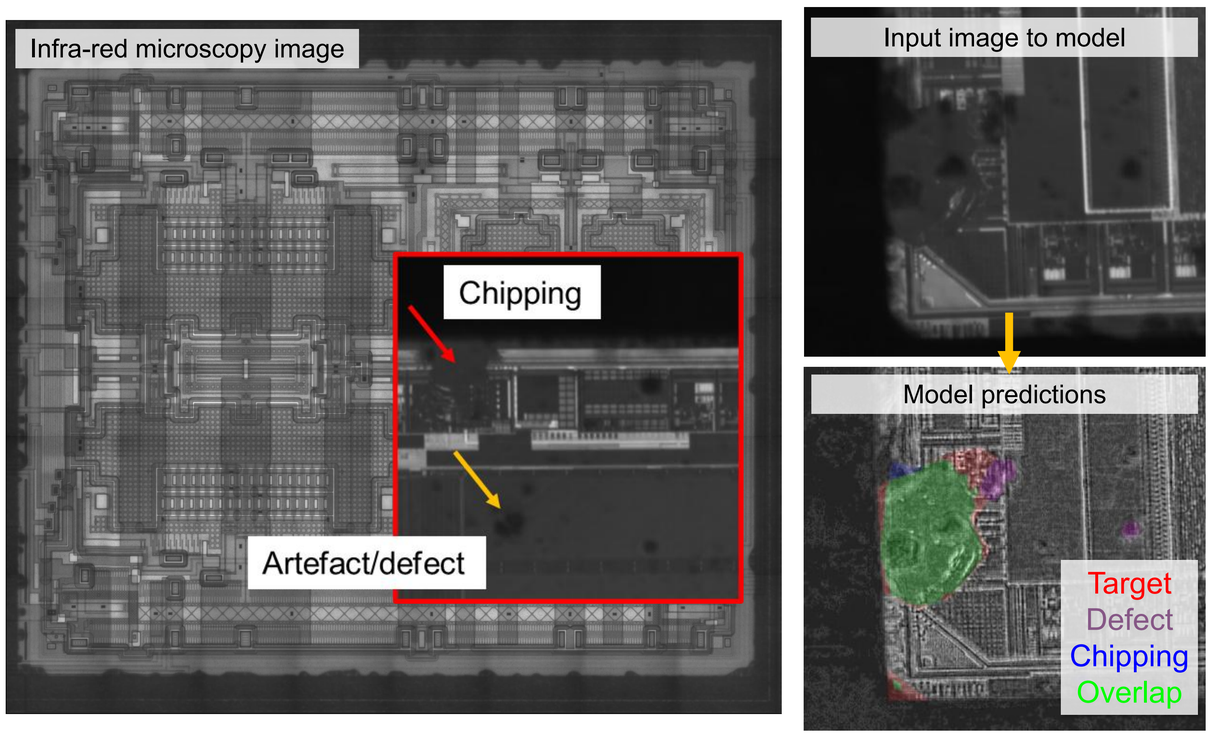
Void detection with 91% accuracy; overlapping voids at 71% accuracy



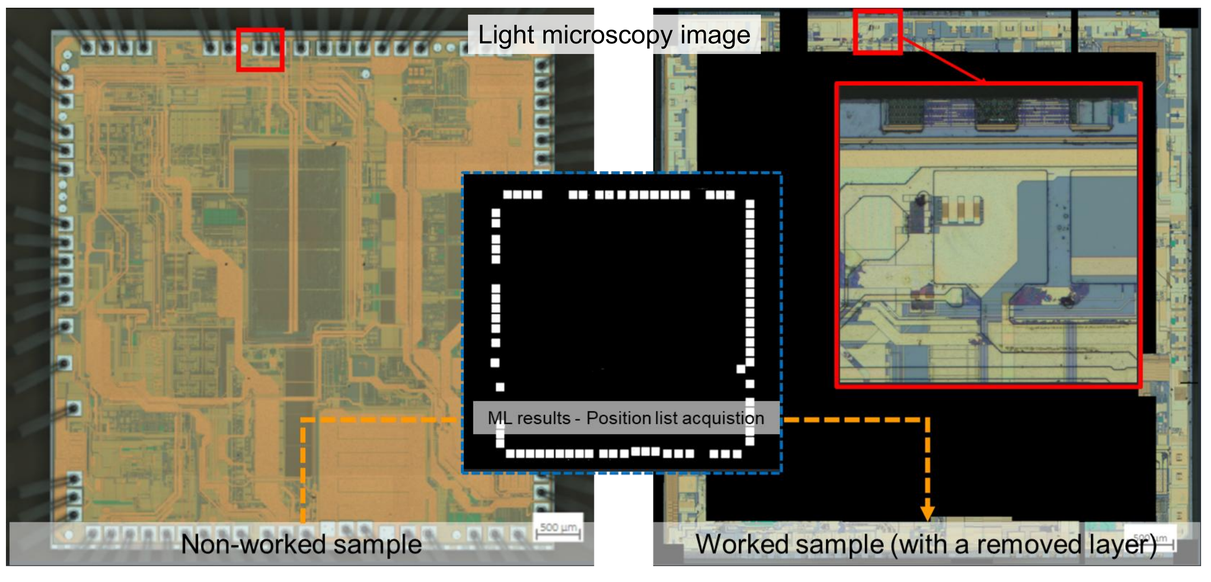
Phase detection in intermetallic compound (Gold); 30x faster and 95% accuracy



Chipping detection with 95% success rate; 5% over detection; 20x faster analysis



Automated pipeline for bond pad detection in non-worked samples and position transfer for defect detection in worked samples; 20x faster analysis



Conclusions

- ML-based approaches speeds up the quality and failure analysis process ***(20x - 30x faster than manual process)***
- The developed models for defect and phase detection have good accuracy that can reduce the risk of overlooking critical failures ***(> 90 % accuracy)***
- With integrated ML automation with materials microscopy, the overall cost of analysis can be reduced due to the human capacity saving and lower analysis time

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