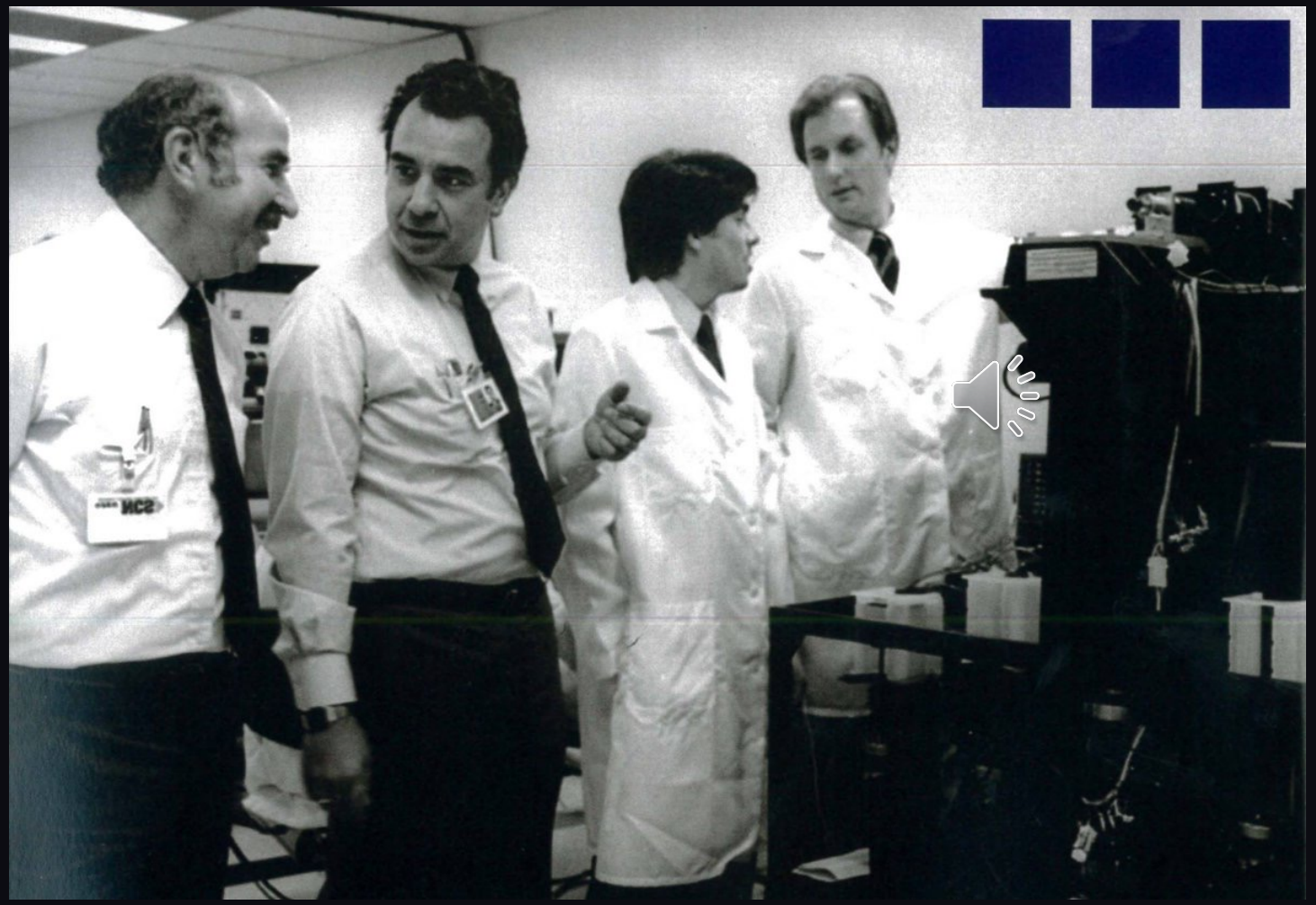
AI Models in the FAB

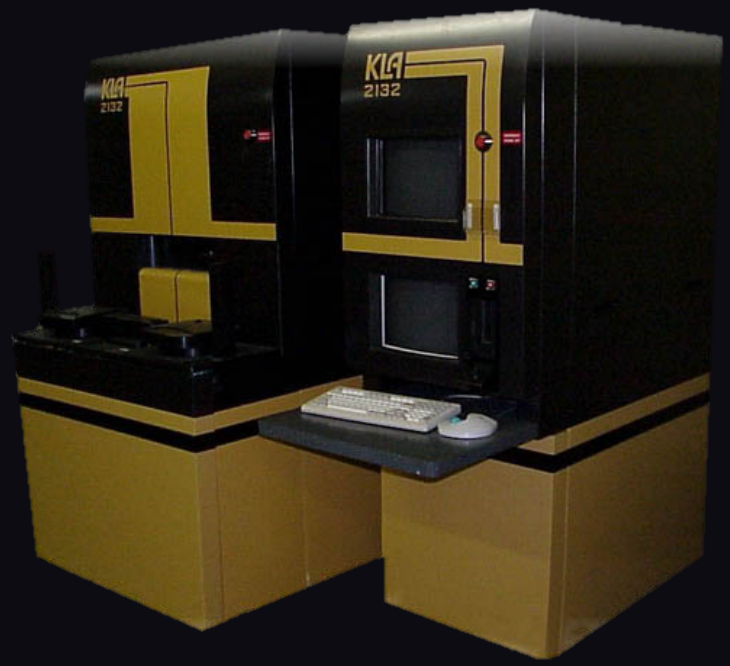
Steve Esbenshade

9/29/2021

In the beginning …
KLA and Tencor were physics-based hardware companies

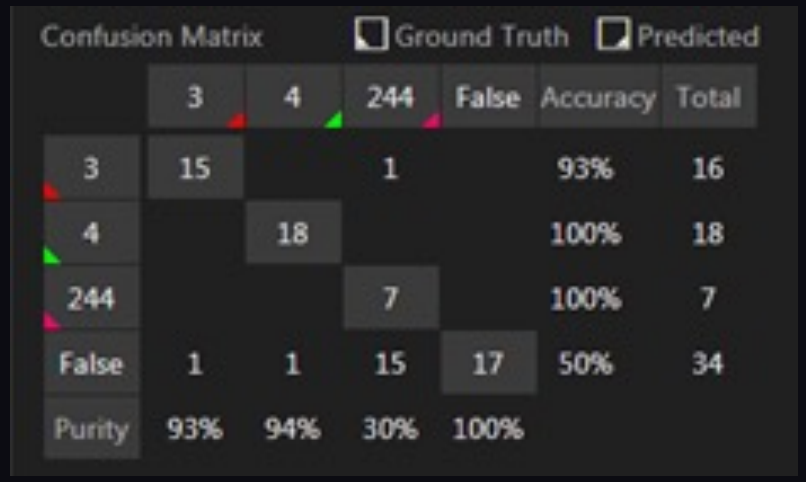


We built hardware to find defects …



We discovered software was quite useful too!

We discovered labels …

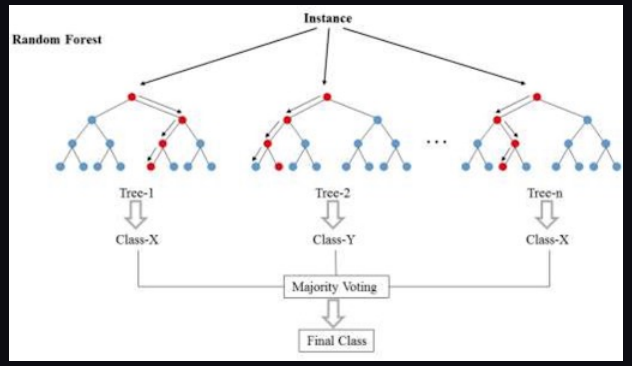


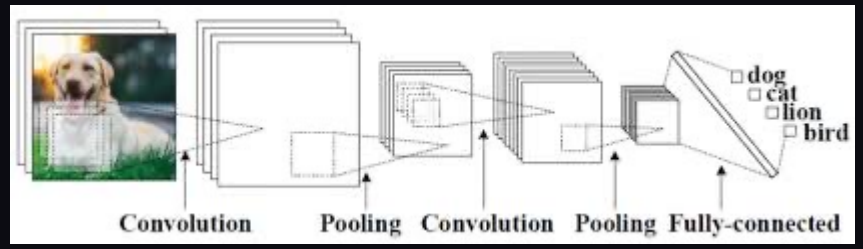
	3	4	244	False	Accuracy	Total
3	15		1		93%	16
4		18			100%	18
244			7		100%	7
False	1	1	15	17	50%	34
Purity	93%	94%	30%	100%		

KLA and Tencor merged

KLA-Tencor India was founded

We pioneered AI in semiconductor manufacturing …





And we found our +

A Physics based AI Company

Agenda

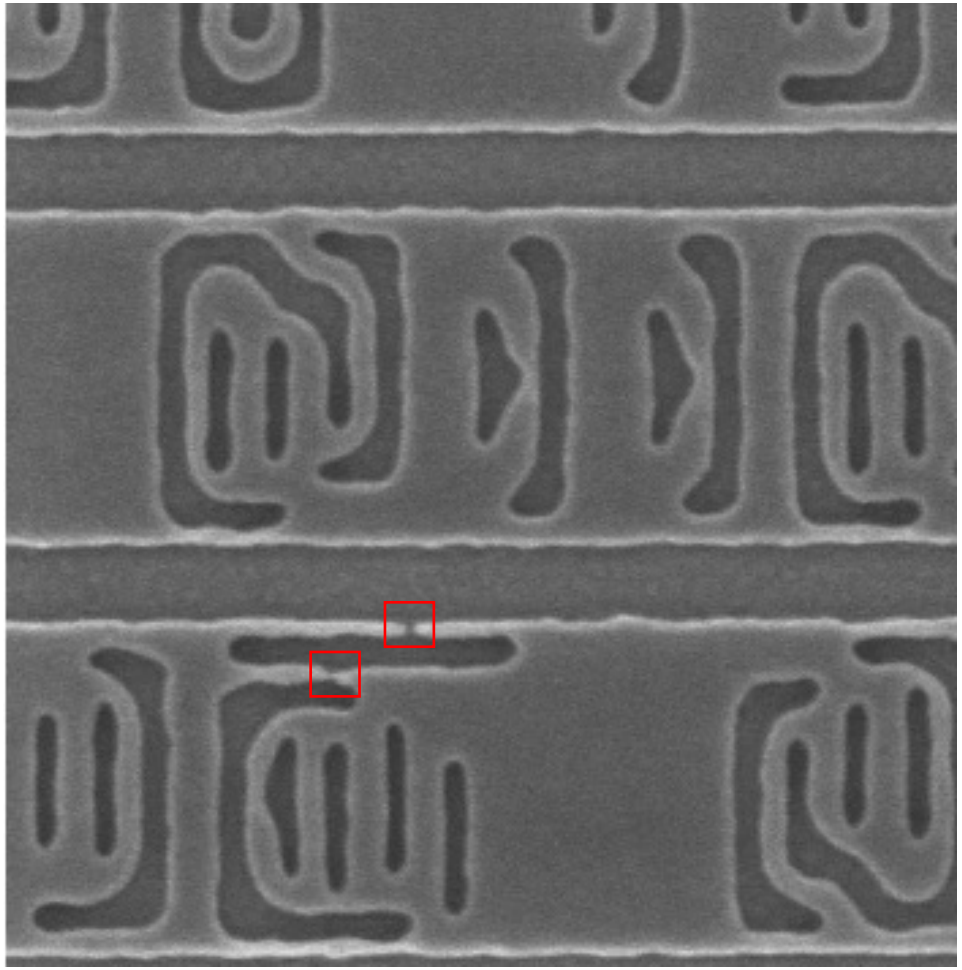
- In the semiconductor fab environment
- All you need is Tensorflow?
- Perhaps

Why is our AI Challenge Unique?

Air Gapped Fab Environment – Very IP Protective

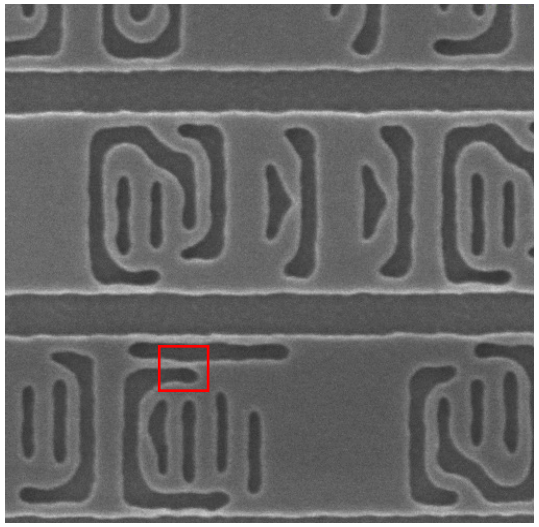
Human Error Rates are Considerably High

Can you spot the defect?



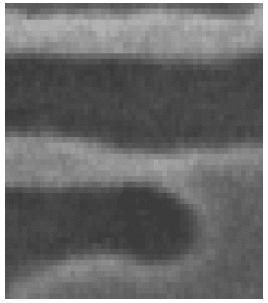
eSL10™: AI algorithms vs traditional

Defective Images



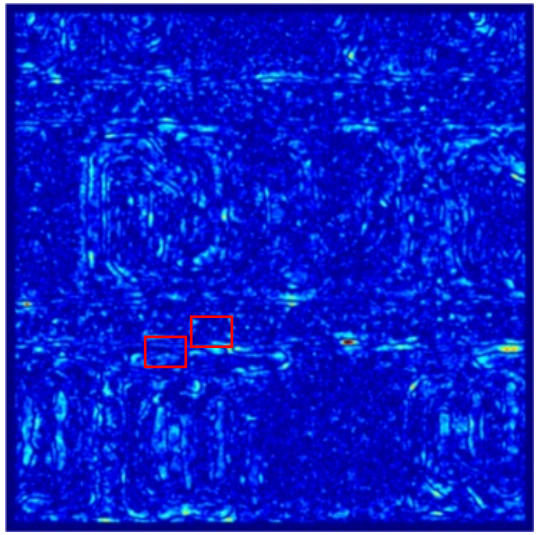
A – B blinking

Defective Images zoomed

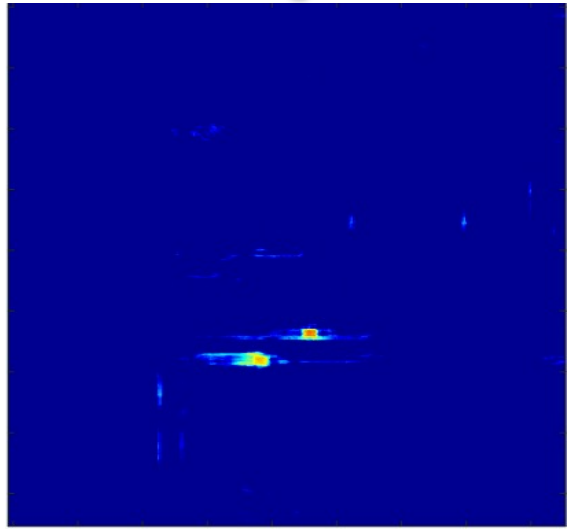


A – B blinking

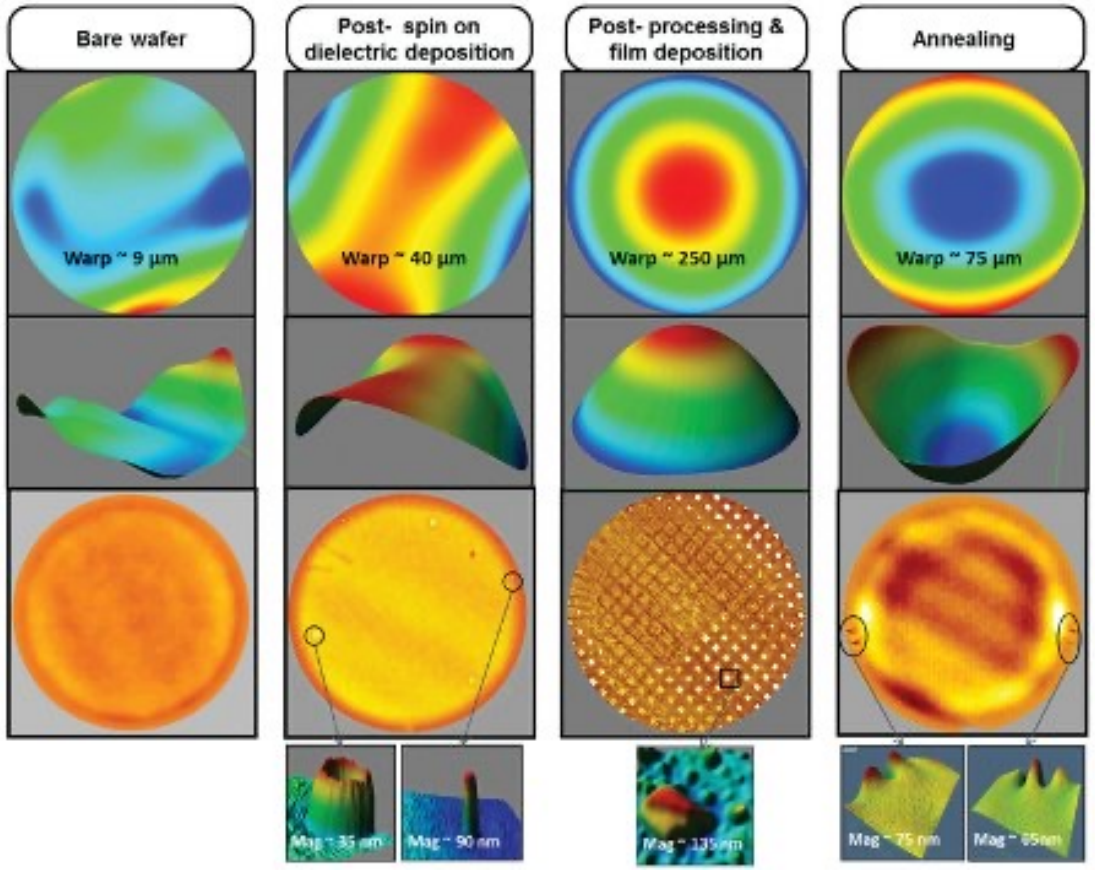
Traditional Algorithms

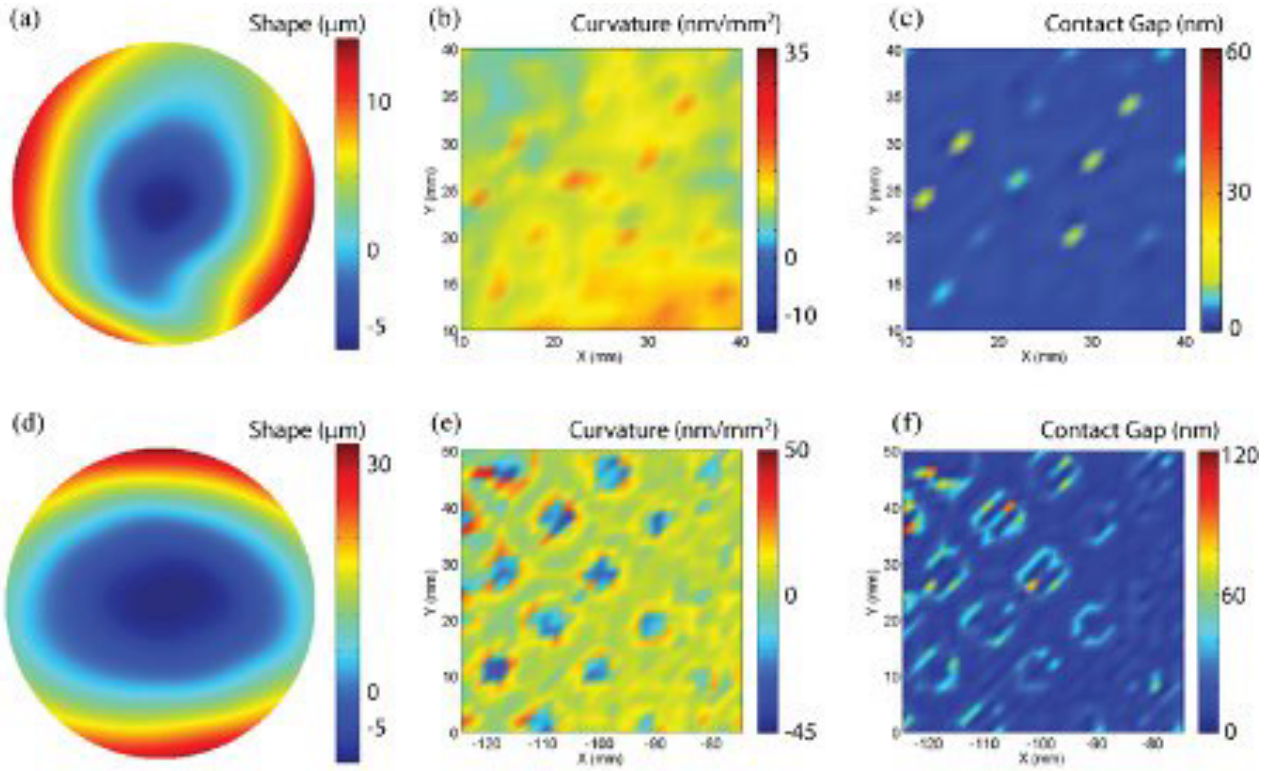


AI Algorithms



Process and Tool Variations





Examples of changes in wafer geometry that occur as a result of wafer processing. The top two rows show wafer shape while the bottom rows show geometry maps that have been filtered to remove long wavelength (>10 mm) variations.

Source https://siliconsemiconductor.net/article/95474/Role_of_process-induced_wafer_geometry_changes_in_advanced_semiconductor_manufacturing/feature

Time and Cost Pressures

Why is our AI Challenge Unique?

- Air Gapped Fab Environment
- Process and Tool Variations
  - Export Model Training to the Fab/Customer – Build Models in the “wild”
- Human Error Rates are Considerably High
  - UI Tools to Visualize and Resolve issues
- Time and Cost Pressures
  - Shared Model Training Infrastructure with GPUs

SMARTs™

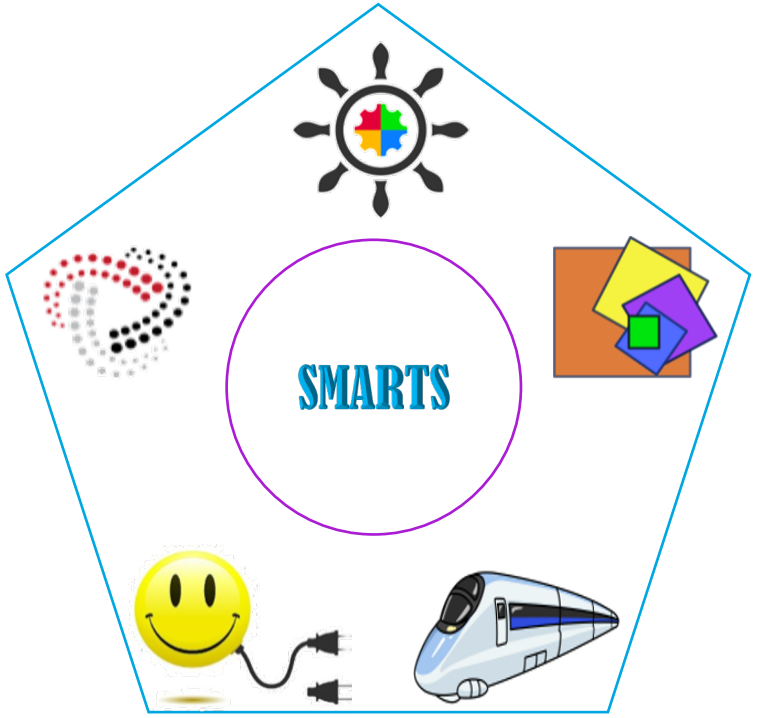
SMARTs

Deep Learning based engine

on

eSL10™ e-beam inspection tool

for defect detection and classification



DefectWise® for Kronos™ 1190

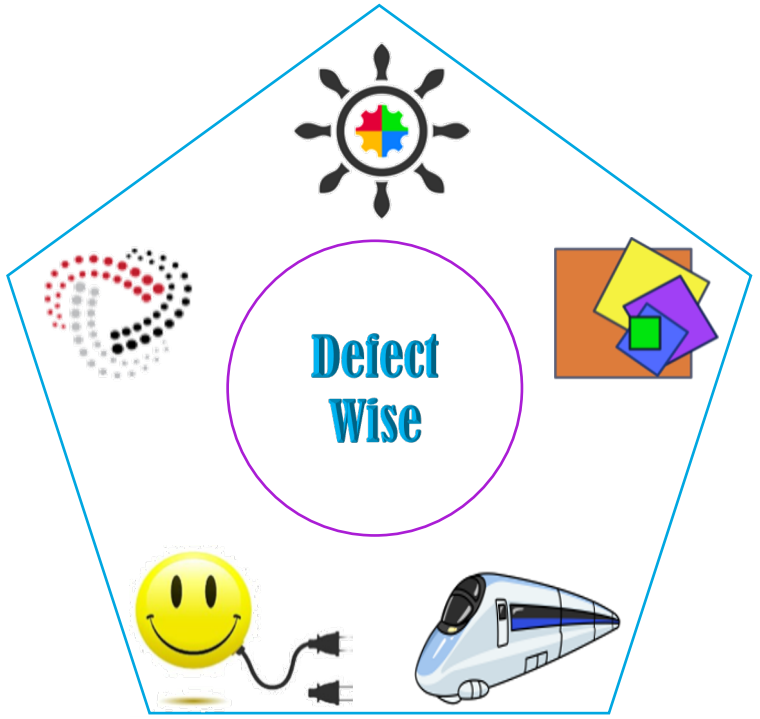
DefectWise

Deep Learning based engine

on

Kronos 1190 optical inspection tool

for defect classification



Animation

What happens when training data is not good?

Training using insufficient training data

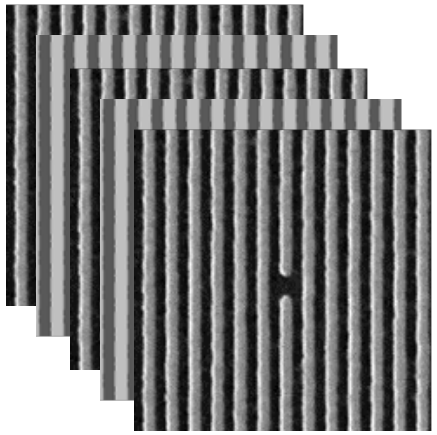
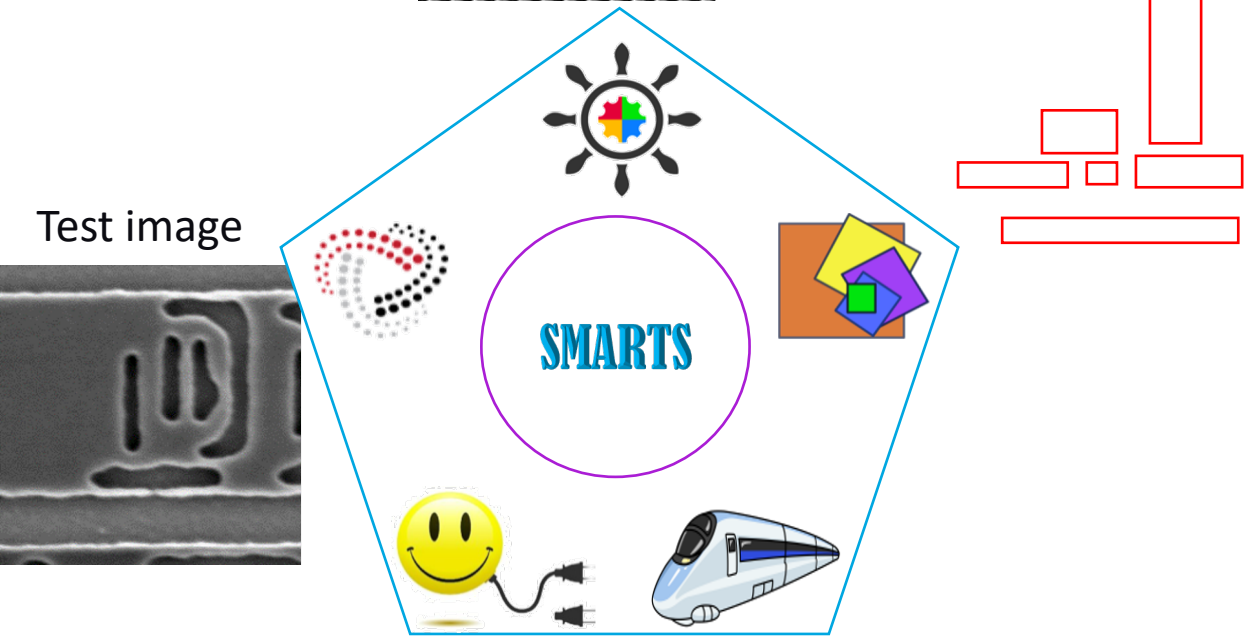


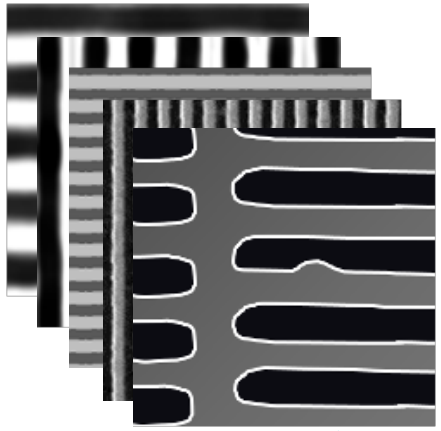
Image Sources:
SPIE Photomask Technology, 104510L
Xiong, "Broadband Optical Inspection Technology for Emerging Process Inflections," FCMN, April 2019
SPIE Advanced Lithography, 1161128, 2021

Training

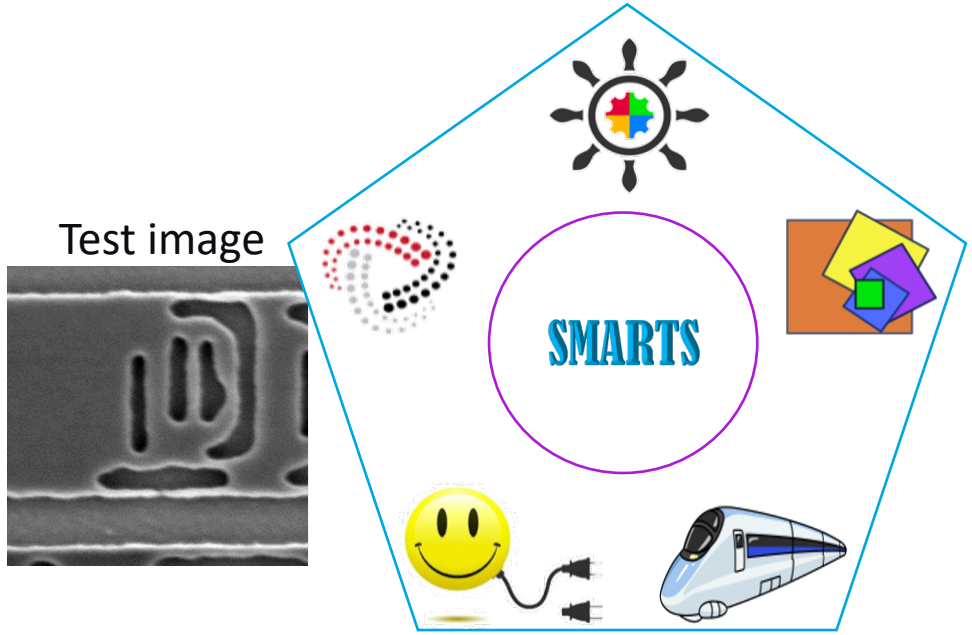


Test image

Training using diverse training data



Training



Test image

SMARTs™ Training Services


SEA

The SMARTs Easy Annotation is the Smarts UI. Web Browser based to run anywhere, for labeling ground truth, visualizing model results, and gap closure drill down.


SDS

The SMARTs Data Service stores all images, design, meta data, GT labels, trained models and results. Supports versioning of GT and trained models with results. Workspaces connect recipe, data, models and results for ease of use.


STA

The SMARTs Training Algorithm provides the deep learning algorithms built on TensorFlow combined with traditional physics-based algorithms.


STS

The SMARTs Training Service is the web server front end to the training algorithm, GPU server resource manager and user interface for advanced user diagnostics.

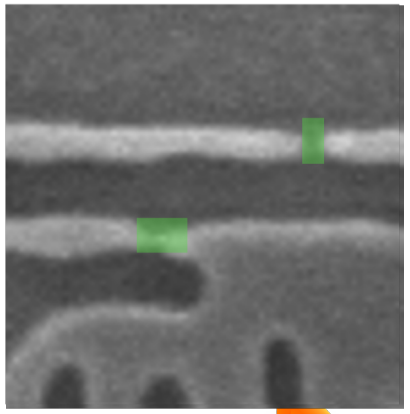

SOTS

The SMARTs On Tool Service is the data exchange interface to the legacy tool software. Manages the setup training flow and connection to trained models and results.

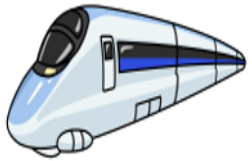
SMARTs™ Training Services Technology Stack

- Tomcat
- Spring
- Angular
- Jersey
- JOOQ
- Flask
- HTTP/JSON
- Web Sockets
- Typescript
- Javascript
- HTML
- Java
- Python
- Tensorflow
- Cython
- C/C++
- PostgreSQL
- SQLite

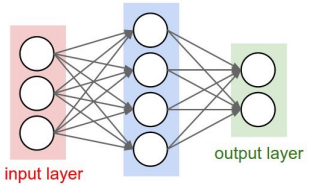
Sample Data Flow



SEA



STS



STA

SOTS

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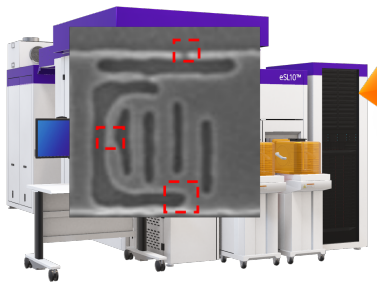

eSL10™

Thank you