How to boost SEM Metrology and Inspection?

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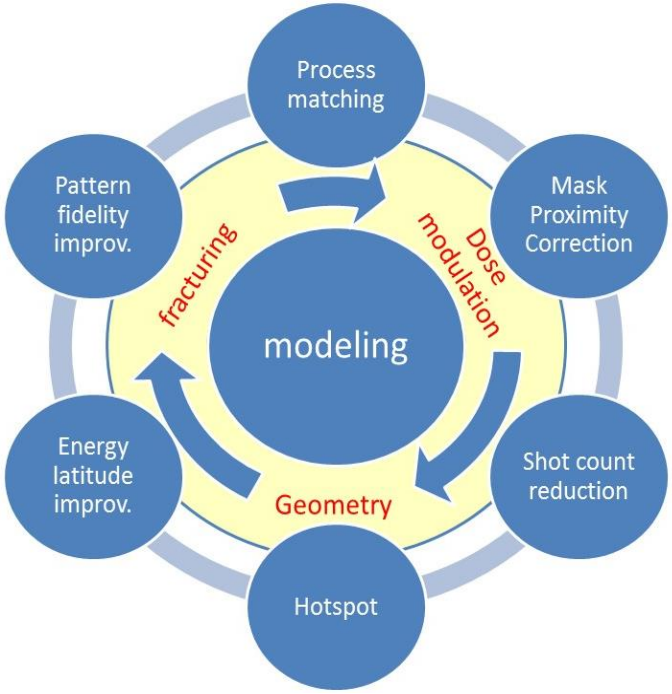
Agenda

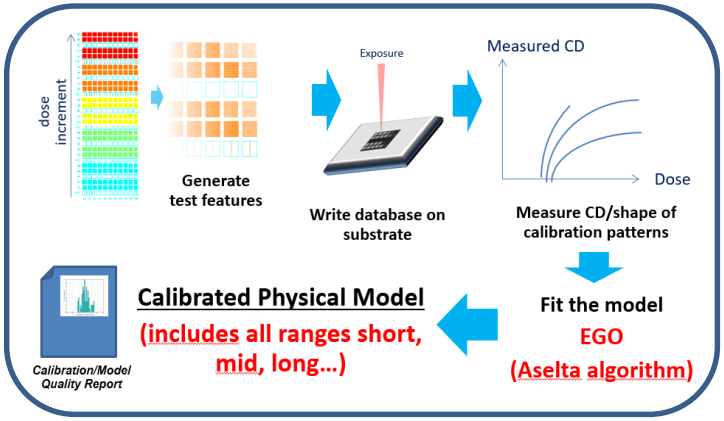
- Company Overview
- Inspection & Metrology technology
  - Synthetic SEM Image Generation
  - Offline & online Contour Extraction
- Conclusion

Aselta Nanographics - Overview

- R&D started at CEA-Leti in 2008
  - Spun-off for commercialize e-beam mask dataprep flow (Inscale software)
- Customers using First Aselta's Inscale software since 2010
- Expertise in e-beam physics and mathematics
  - 35% of employees with PhD degree
- R&D capacity augmented by strong partnership with **CEA-Leti**, Fraunhofer Institut and LTM
- Located in Europe, Japan and USA

Modeling is the core of Aselta technology

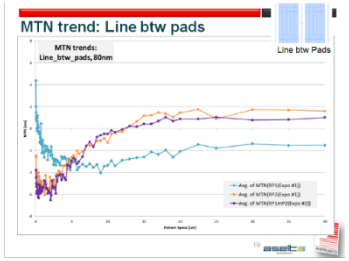




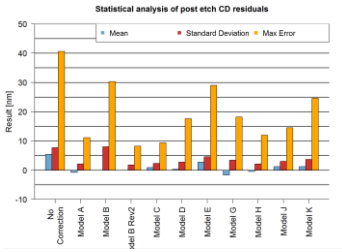
E-beam Model (including MB)

Process Model

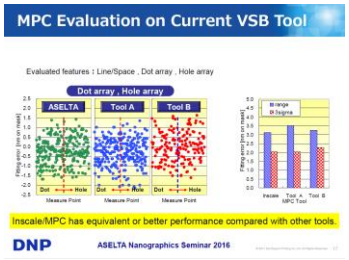
Aselta ranked 1st place in several industry benchmarks :



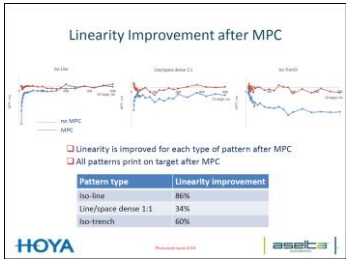
Photronics
(Process Matching)



AMTC
(EUV MPC)



DNP
(VSB and MB MPC)



HOYA
(VSB MPC)

Moving towards SEM modeling

- Current process model accuracy is of the order of metrology variability
- … so we started **modeling the SEM** to **improve metrology**

Aselta is extending its modeling expertise to electron imaging applications (metrology/inspection; CD-SEM, MB-SEM)

Current strategy :

- Model-based approach for e-beam imaging and contour extraction
- Compact models for inspection and CD-SEM => speed
- Contour extraction as a key differentiator

Aselta Technology Ecosystem

- Industrial partners:
  - Working on leading edge technology for both inspection and metrology use cases
  - Images on mask and wafer at the most varied types of stacks (including EUV), from all major SEM tool suppliers
  - Strategic projects and partnerships with Inspection tool suppliers

- Aselta benefits from an unique R&D environment to develop its technology
  - Strong research capabilities to propose algorithms
  - Access to 300mm cleanroom
  - Printing the patterns on different substrates and pattern materials
  - Imaging by different SEMs (AMAT, Hitachi, …)
  - Verified by different tools: AFM, TEM, …

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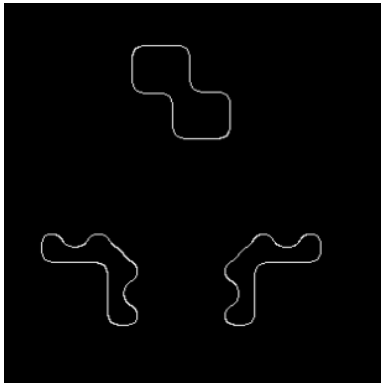
Synthetic SEM Image Generation

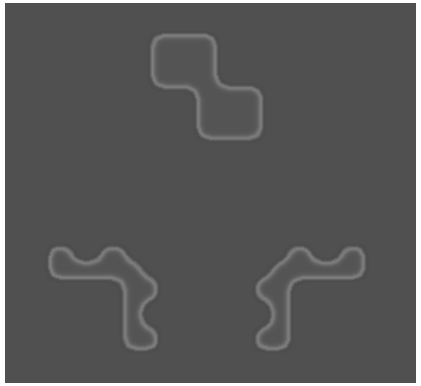
- Standard flow

CAD layout

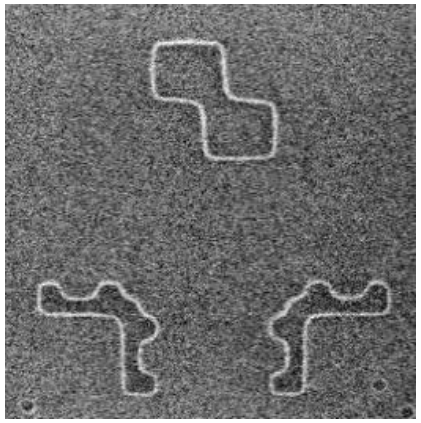
Aselta Inscale process modeling



Reference/synthetic image generation



Comparison to real image



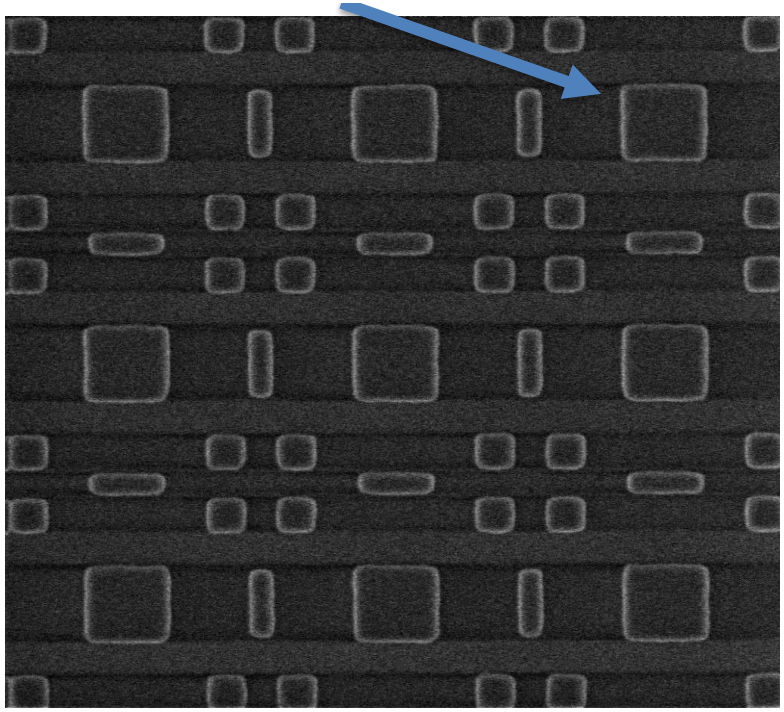
- Modeling of the process effects as well as of the imaging effects

- Compact models does not require full stack information

Compact model can include charging

- Emulates the observed signature of the charging effect

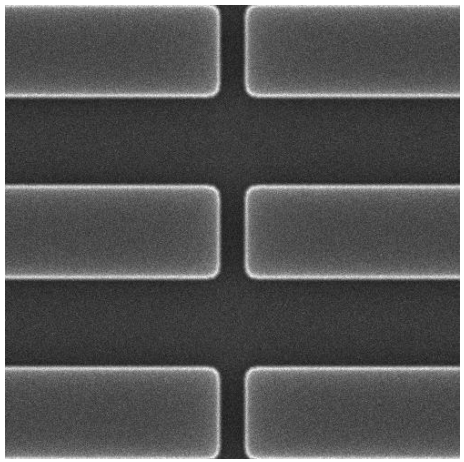
Charging dependent on geometry & density



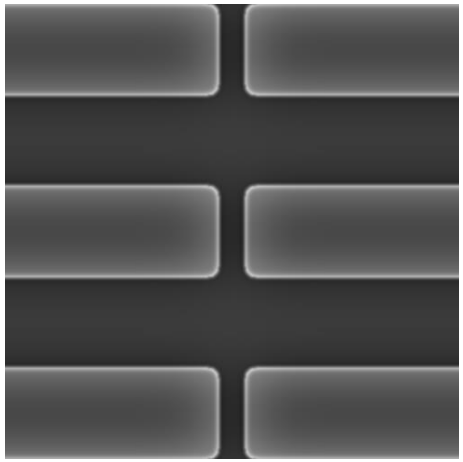
Generated image

Charging effects calibration required as well

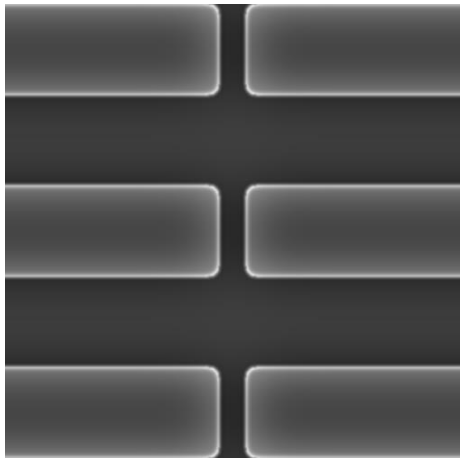
Synthetic SEM Image Generation



Monte Carlo simulation



Model 1

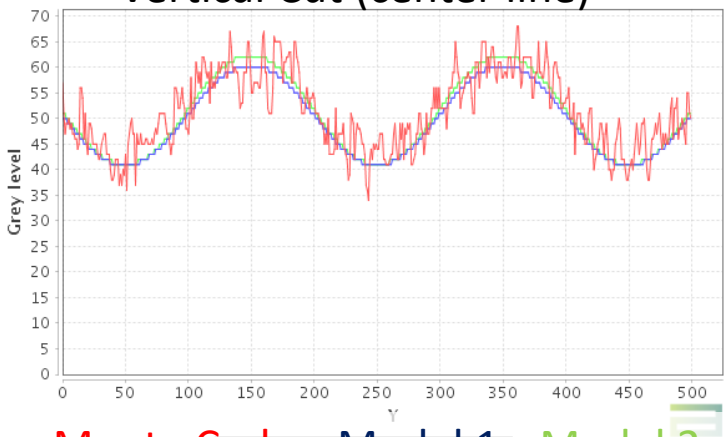


Model 2

Horizontal Cut (center line)

Monte Carlo Model 1 Model 2

Vertical Cut (center line)



Monte Carlo Model 1 Model 2

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Contour Extraction

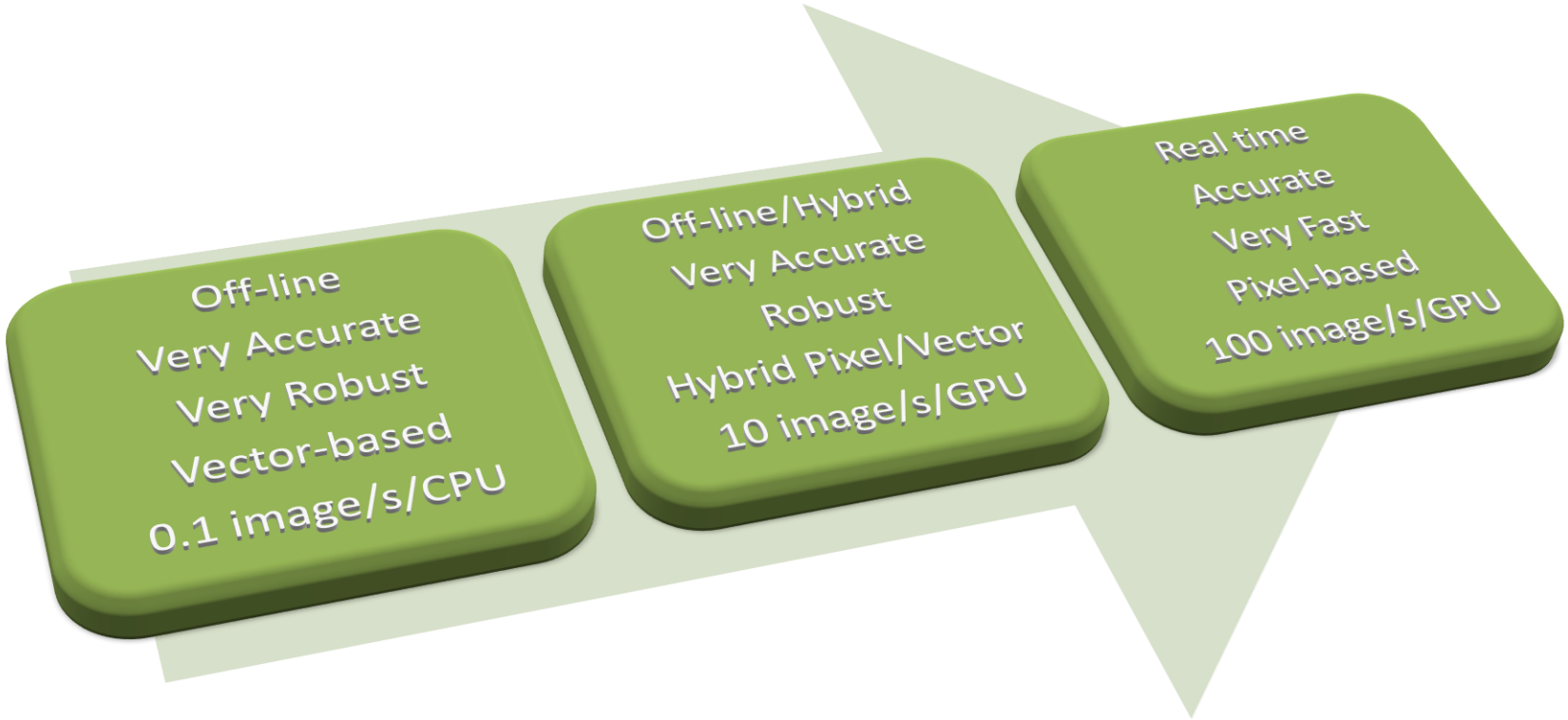
- Model-based Contour extraction algorithms

- Excellent robustness to noise
  - Contour can be extracted despite much larger amount of noise than with standard algorithms
  - Faster acquisition; lower resist damage, …

- Significantly robustness to charging
  - extraction does not get trapped by charging
  - improved robustness to fading of contrast due to charging on long lines

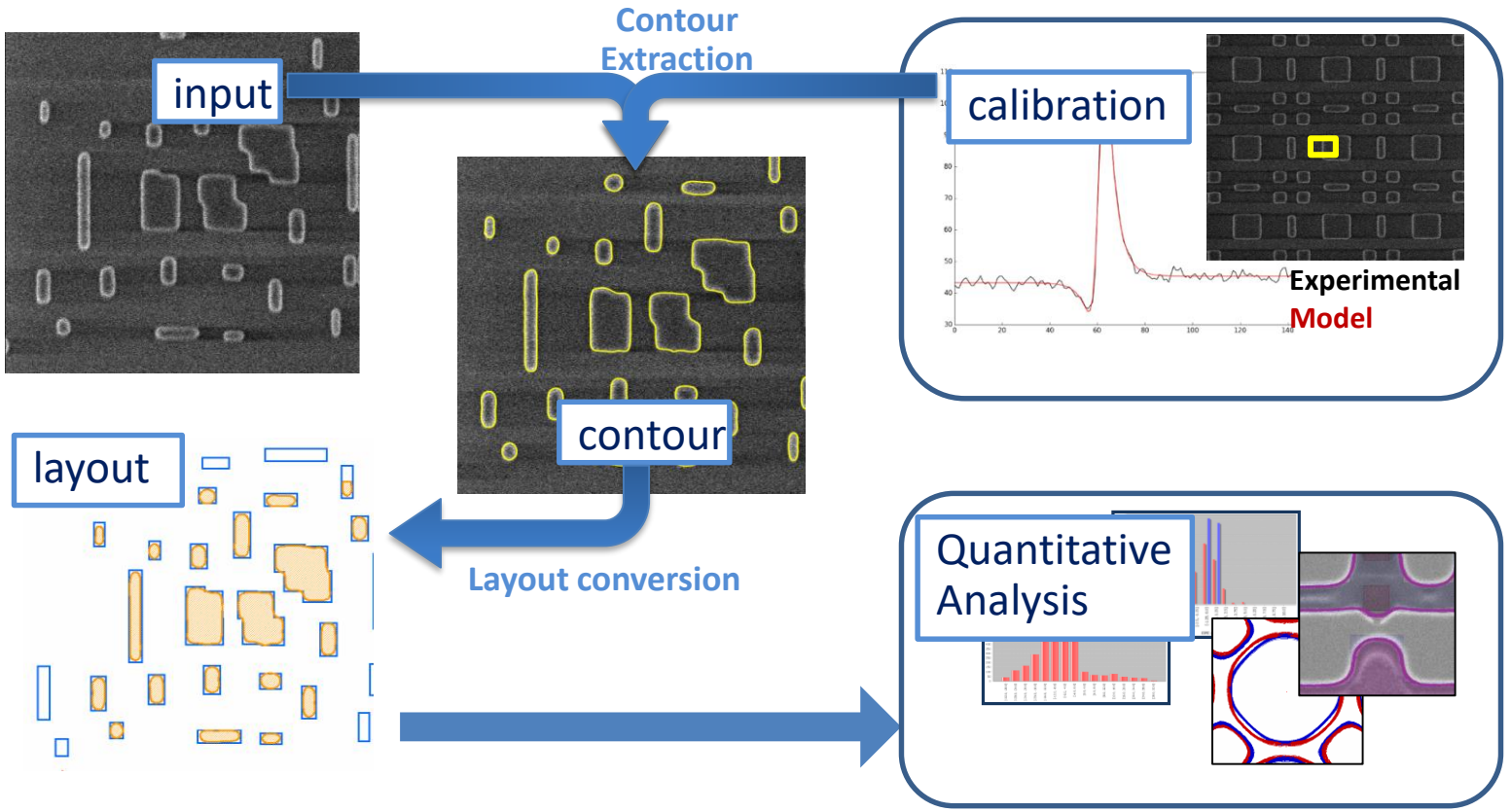
Contour Extraction Algorithm Integration

- Aselta's contour extraction algorithms may be adjusted to different usages: from off-line to real time



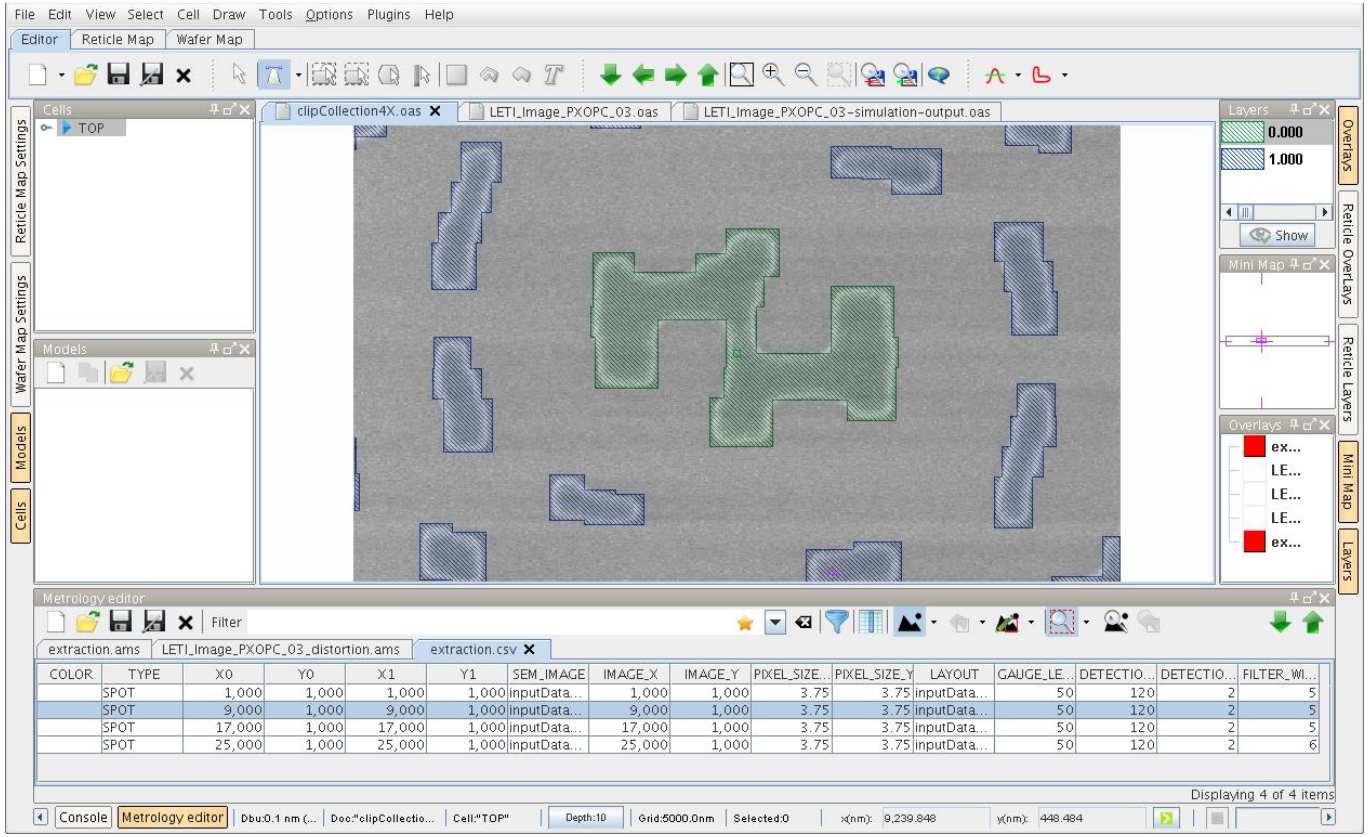
Contour Extraction : SIMPL Analysis toolbox

Aselta's SIMPL is a SEM metrology toolbox supported by a Model Based approach for e-beam images (SEM metrology).
It provides a robust and accurate Contour Extraction as well as a powerful contour analysis capability

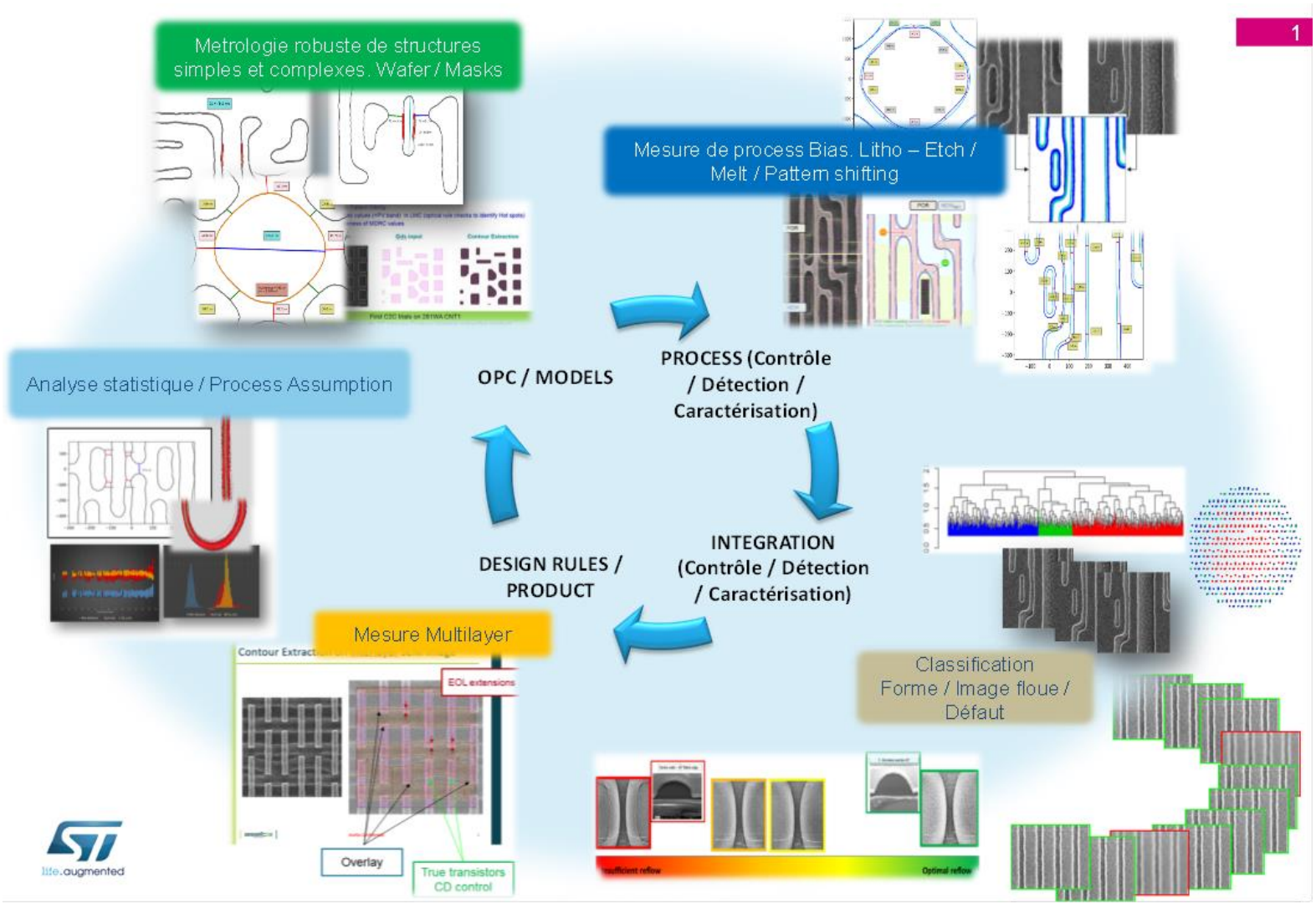


Graphical Interface

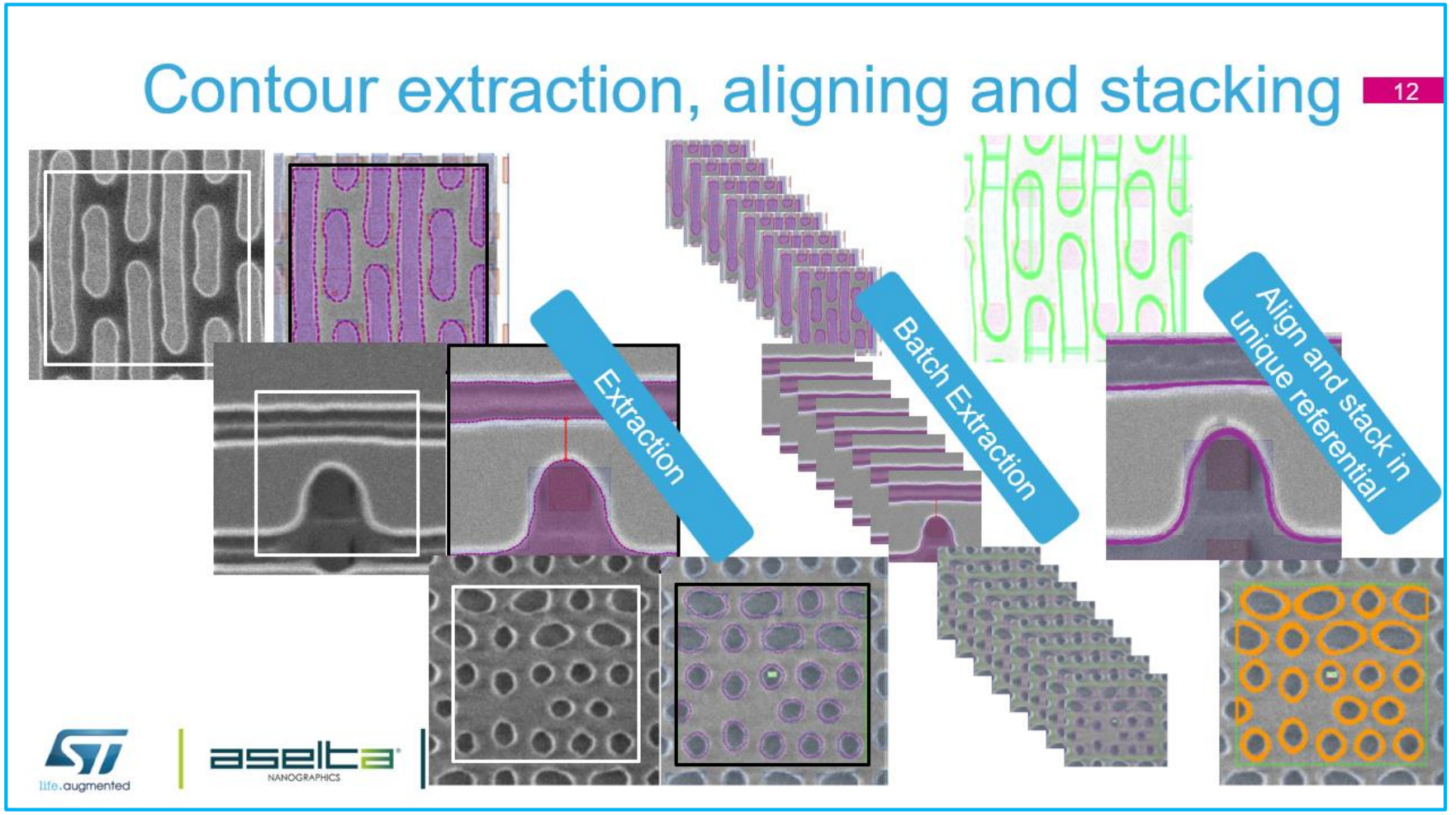
- Inscale GUI has been enhanced to understand and edit files with image/ROI information:
  - Meta-data used for automatic image positioning



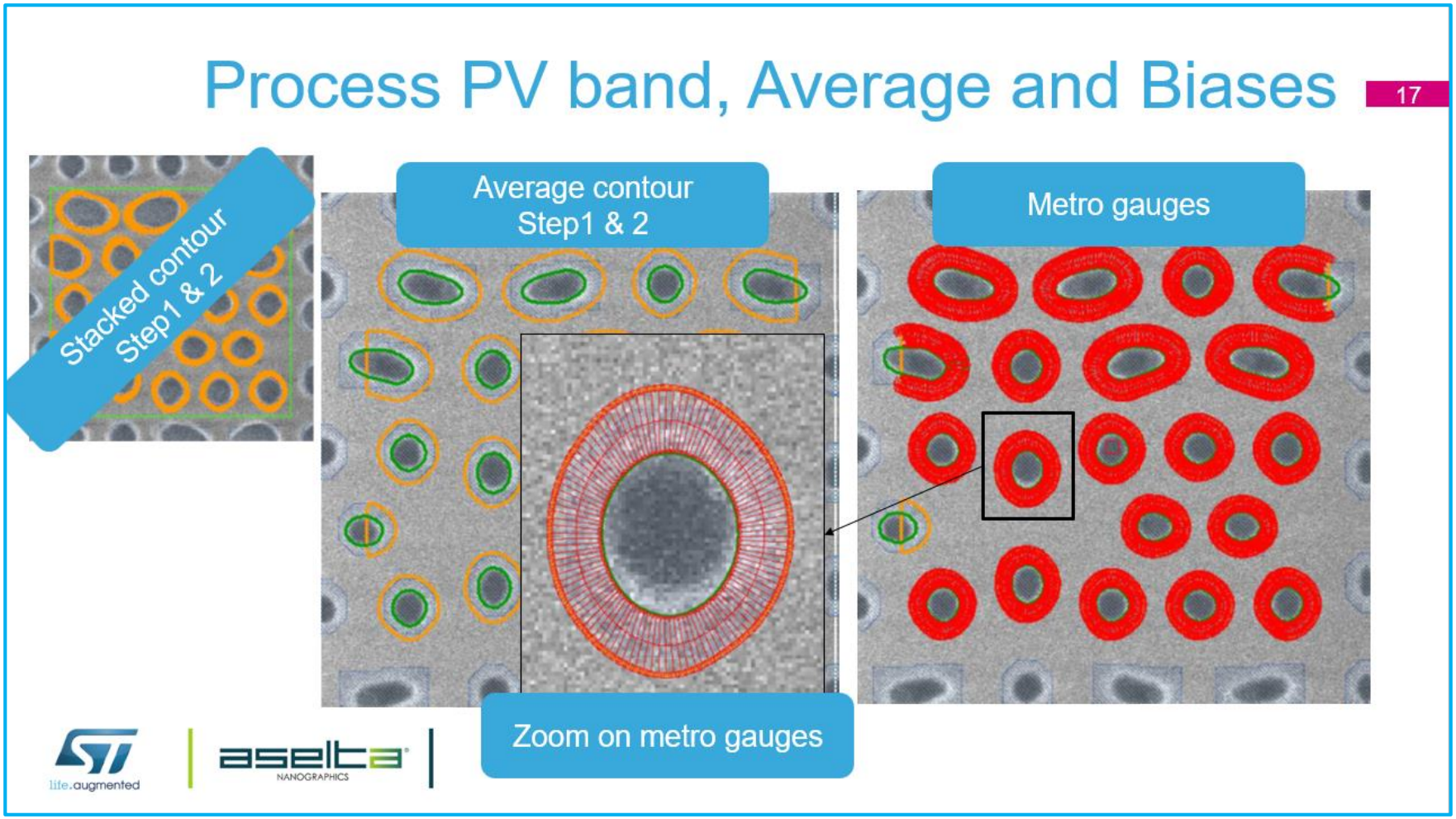
Using the contours in different applications



Using the contours in different applications



Using the contours in different applications



Using the contours in different applications

Multilayer contour extraction

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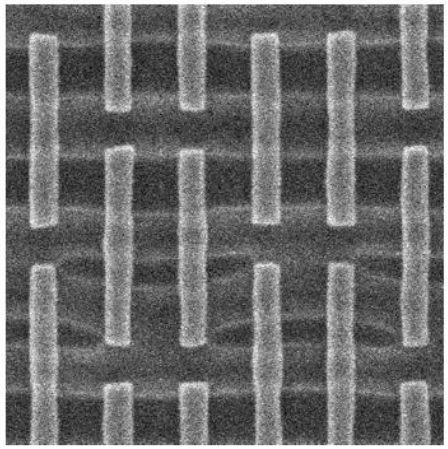
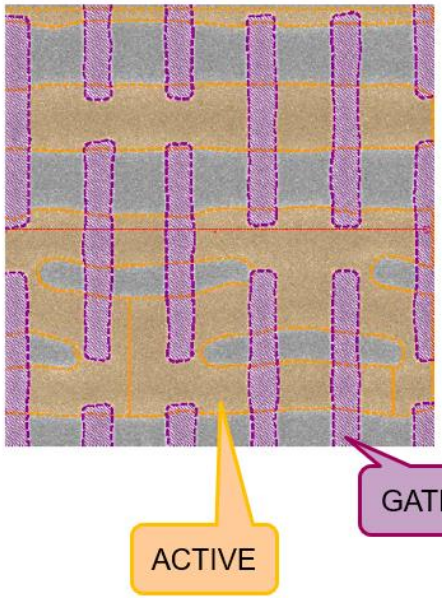
- In case the SEM picture shows multiple layer it is also possible to extract multiple contour and attribute each contours to the right layer





GDS assisted contour extraction

Inter layer metrology
- OVL
- Line end Extension
- Transistor area's (intersection GATE : ACTIVE)
- …

Using the contours in different applications

Pattern shift metrology – Contour based

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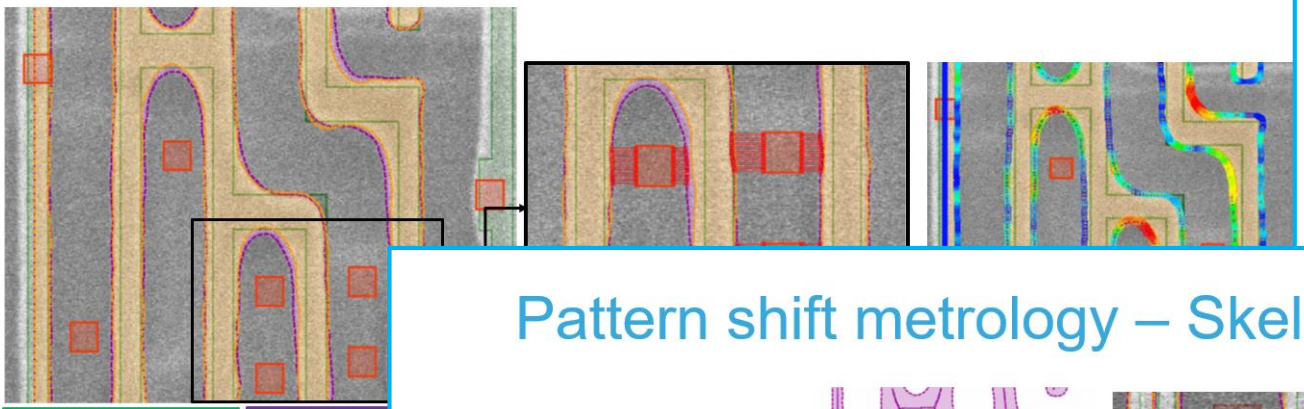

Pattern shift metrology – Skeleton based

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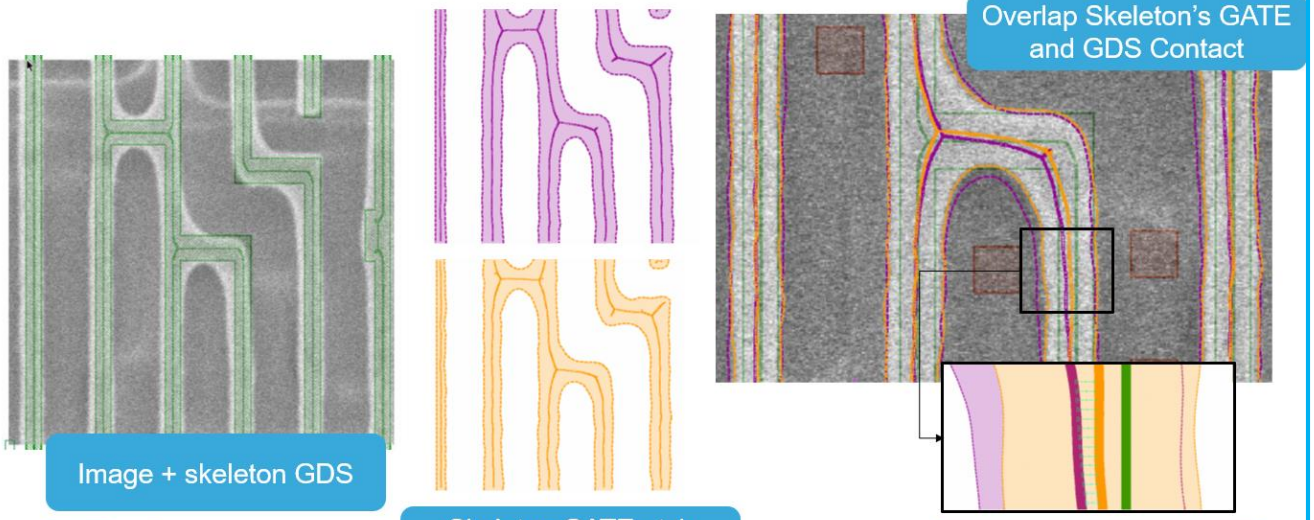

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Conclusion

- Aselta Nanographics solutions are able to explore in depth the information available in SEM images
  - Thanks to the model-based strategies

- The expertise in e-beam modeling enable strong solutions for metrology and inspection
  - Algorithms for both Synthetic SEM images and contour extraction are on real time
  - Extracted contours present both high robustness to noise and to charging
  - High accuracy / high precision
  - SIMPL tool enables obtaining quantitative and qualitative information from contours

Conclusion

- Aselta flexible solution and strong research and development capabilities enable many differentiated use cases

- Special thanks to **CEA-Leti** for assisting Aselta in <u>both</u> technologies presented today
  - Common lab + first experimental data

How to boost SEM Metrology and Inspection ?

- It is **SIMPL** !
- Just contact:

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