

Automating Defect Disposition in Fabs and Maskshops

Peter Fiekowsky (AVI)

S. Narukawa, T. Kawashima (DNP)

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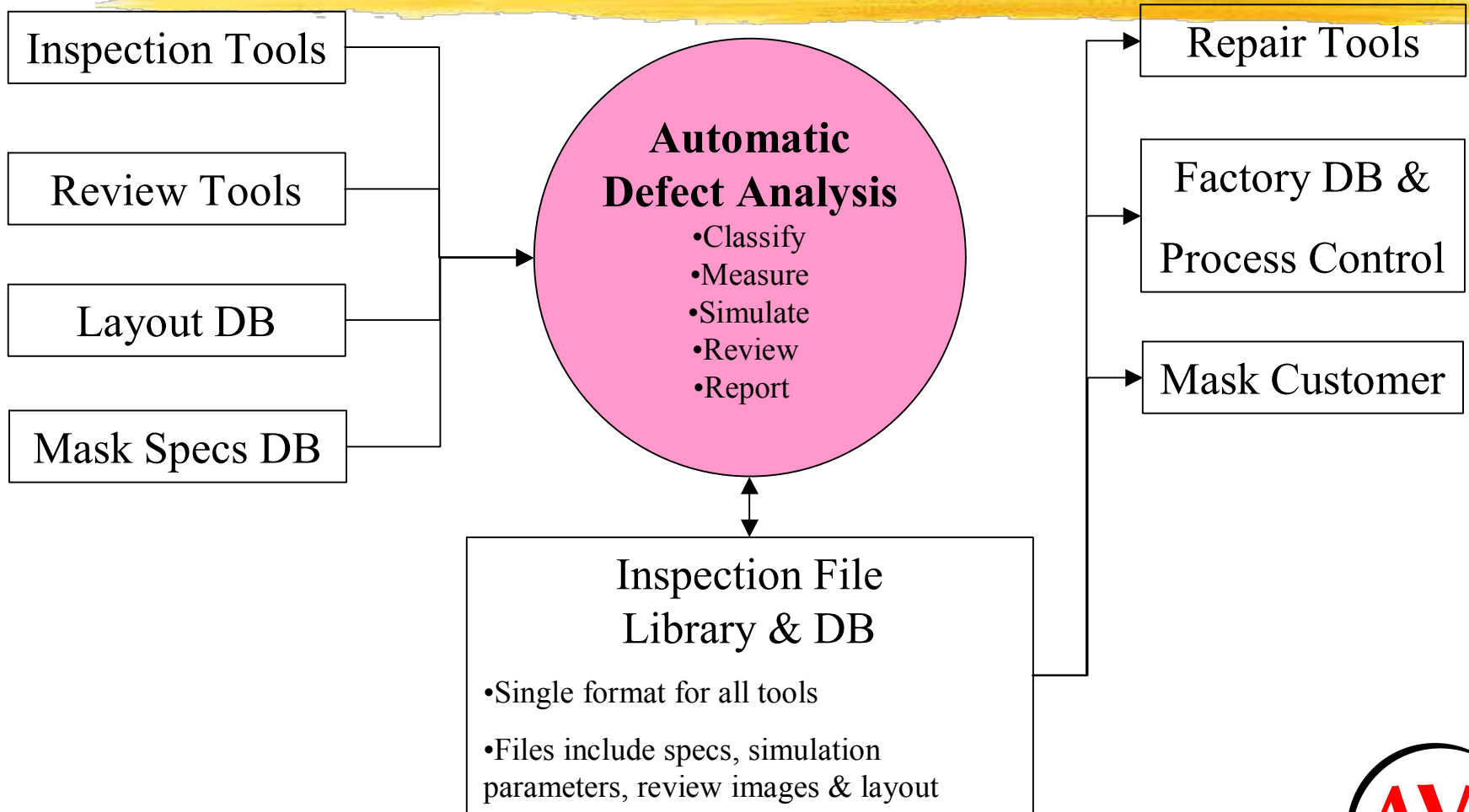
Abstract

ADAS (Automated Defect Analysis Software) is the first product to fully automate mask defect analysis for mask shops and fabs. ADAS classifies and dispositions photomask defects quickly and accurately. Disposition is based on defect size and printability measurements from simulation.

Full analysis of inspection reports with 100 defects requires 2 seconds. Printability measurements match AIMS within 6 percent at 3 sigma on 45 nm test masks. Repeatability is 5 percent at 3 sigma over multiple inspections. ADAS can reduce the need for production AIMS measurements by 90% and eliminate operator review errors and the re-pelliculizations they cause. ADAS increases overall inspection efficiency for mask shop first-inspection and final inspection. It can automate fab requalification inspections and eliminate the need for incoming inspection.



The Future of Disposition

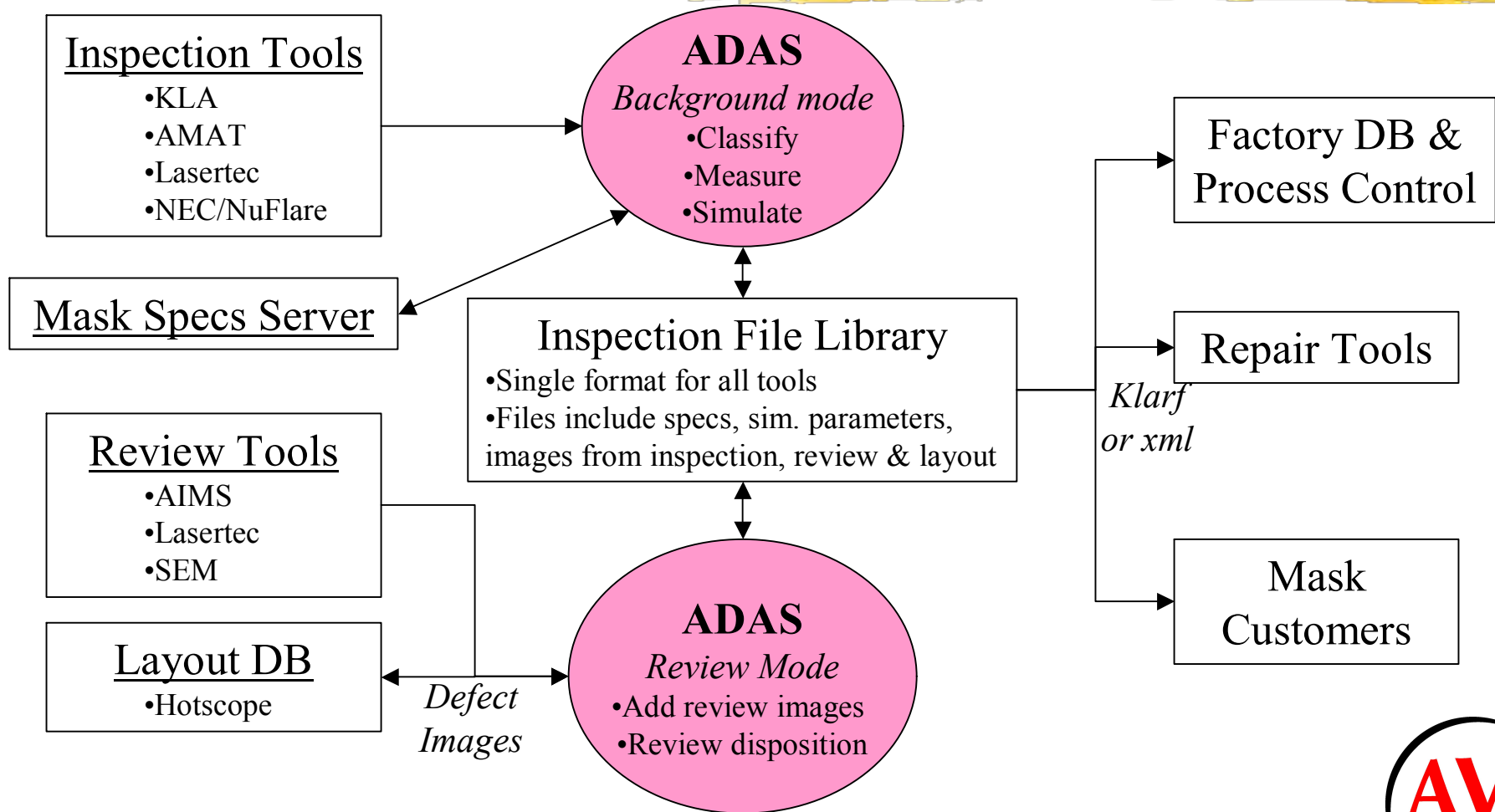


Opportunities & Benefits of Automated Defect Analysis

- **Save Money:**
 - Reduce labor, training, and operator errors
 - Reduce repairs and # of AIMS reviews
 - Increase inspection tool productivity
- **Accelerate Production & Development:**
 - Eliminate delays for inspection analysis
 - Mask maker & fab have the same data & analysis tool
 - Changing specs does not require re-training operators



ADAS in Fabs & Mask Shops



ADAS: Product Description



- Windows application software
- Developed with cooperation and support from DNP, Photronics, Toppan, Hoya, TSMC, Samsung, Hitachi, Qimonda, TI, Freescale, Micron, UMC, NEC, Lasertec, etc.
- Reads inspection reports over network
- Classifies and dispositions all defects automatically and accurately. Typically 5 seconds/inspection



ADAS Input / Output

- Inputs:
 - Inspection reports from mask inspection tools
 - 5xx, SLF, LM7000B, Aera-193, MATRICS (Q4 07)
 - Inspection modes: D2D , DDB, SL
 - Review tool images
 - AIMS, MRS, SEM
 - Layout DB -- through HotScope™
- Outputs:
 - Defect type, feature type, size & printability
 - Defect statistics for process & inspection tool control
 - Various file formats & export to Excel



ADAS Analyses

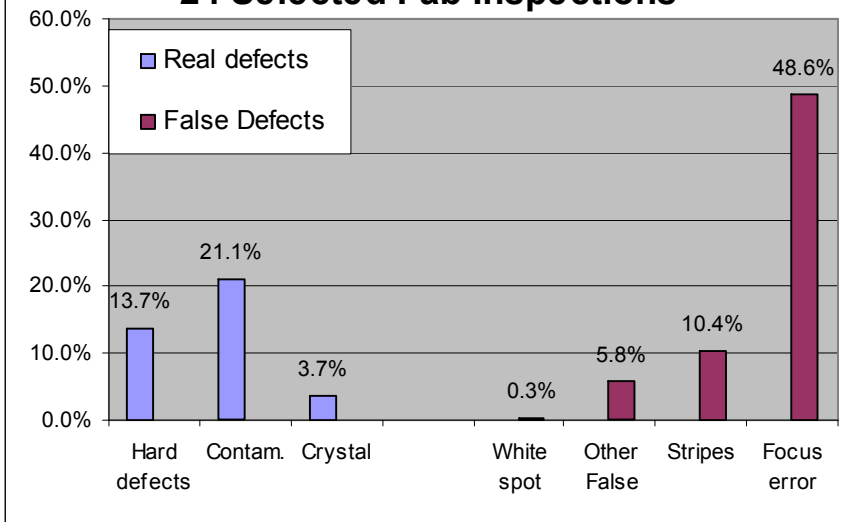


- False Defect Detection
- Feature type classification
 - Contact, line-end, corner, SRAF, border, etc.
- Defect type classification
- Defect size
- Simulation
 - CD error & isolated defect printability



ADAS Is Accurate: Classification Accuracy > 99%

**Selected Defect Types:
Percent of 8,445 defects from
24 Selected Fab Inspections**

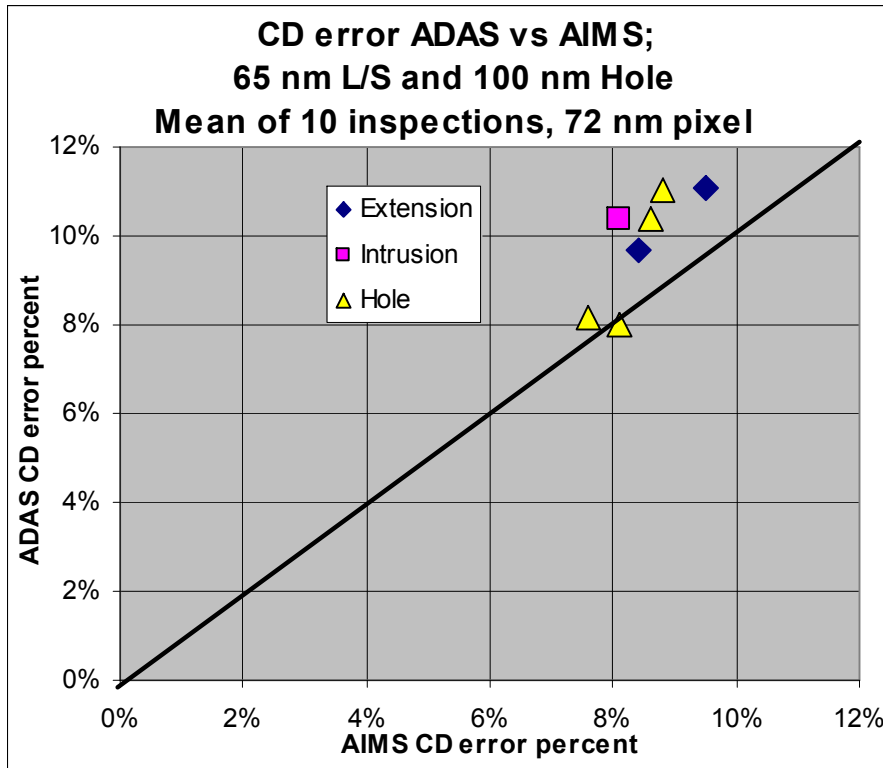


- Real defect detection: 99.95%
- False defect detection: 99%
- Accurate classification and statistics for
 - Crystal, White-spot, Focus, Stripes defects

Tools: KLA SLF, 5xx
Masks: 65-130 nm nodes
Binary and HT



Accuracy to AIMS, 45 nm node, hard defects



- ADAS-AIMS CD error
 - Mean diff. = 1.2%
 - 3 sigma = 2.7%
- Mean difference is smaller than repeatability
- Simulation conditions:
 - L/S: NA=.9 Sigma= .67/.97 annular
 - Hole: NA=.85 Sigma= .7 circular

Repeatability

3-sigma CD error repeatability
From 10 inspections of same defect
Defect sizes: 8-10% CD error *

- Noise sources:
 - Image noise
 - Defect position relative to pixel edges

	72 nm pixel	90 nm pixel
Edge 65 nm L/S	5.1%	Not detected*
Contact 100 nm	5.3%	3.8%

*Smallest L/S defect detected with 90 nm pixel was 75 nm, causing 16% CD error



ADAS Reduces Required AIMS Measurements

- 90% Reduction Expected
- Typically 1.4% of real defects cause CD errors between 2% and 15%.
 - Defects with ADAS CD error below 2% are assumed non-printing.
 - Defects with ADAS CD error above 15% are assumed to print.
 - Defects with ADAS CD error between 2% and 15% are measured on AIMS if repair is risky or more expensive than AIMS measurement.



ADAS Is Fast

- Analysis of a typical inspection: 5 seconds
 - 50 defects per second, including simulation
- Manual Review: 1-2 minutes per inspection

Complete inspection analysis time (typical)

<u>Mask node</u>	90 nm	65 nm
Defects/insp.		
100 defects	1.3 seconds	2.5 seconds
1000 defects	11 seconds	22 seconds
5000 defects	30 seconds	55 seconds



ADAS Is Ready For Production



- Map existing defect classes into objective ADAS classes (see next slide)
- Set CD error range for AIMS or test-print
 - CDerr > 10%: repair or clean
 - CDerr between 5% and 10%: AIMS or repair
 - Less than one defect per mask on average
 - Cderr < 5%: no repair required



Defect Classification

Typical class assignment

- 30 defect types detected
 - Each type is classified
 - Over-spec
 - Under-spec
- Class definitions can be specified for each customer

Defect type	Under-spec Class	Over-spec Class
Unprocessed	2D_Review	2D_Review
NoImage	2D_Review	2D_Review
Undefined	2D_Review	2D_Review
Multi	2D_Review	2D_Review
RepairSite	4B_Repaired_defect	4B_Repaired_defect
Crystal	4D_False /_nuisance	4A_Cont_on_clear
Stain	4D_False /_nuisance	4A_Cont_on_clear
ThinChrome	4D_False /_nuisance	2B_Intrusion
CtmClear	1D_In_spec	4A_Cont_on_clear
CtmEdge	1D_In_spec	4A_Cont_on_clear
CtmDark	4C_Cont_on_dark	4A_Cont_on_clear
CtmHT	4C_Cont_on_dark	4A_Cont_on_clear
Pinhole	1D_In_spec	2A_Pin_hole
Pindot	1D_In_spec	1A_Pin_dot
Intrusion	1D_In_spec	2B_Intrusion
Extension	1D_In_spec	1B_Extension
Contact	1D_In_spec	2B_Intrusion
Placement	1D_In_spec	2B_Intrusion
Linewidth	1D_In_spec	2B_Intrusion
LineEnd	1D_In_spec	2B_Intrusion
SRAF	1D_In_spec	2B_Intrusion
Corner	1D_In_spec	2B_Intrusion
Unprintable	4D_False /_nuisance	2D_Review
Nuisance	4D_False /_nuisance	2D_Review
RenderErr	4D_False /_nuisance	2D_Review
RefEdgeErr	4D_False /_nuisance	2D_Review
FocusErr	4D_False /_nuisance	2D_Review
WhiteSpot	4D_False /_nuisance	2D_Review
SLStripes	1C_Bright	1C_Bright
Bright	3A_Cr_on_atten	3A_Cr_on_atten
CrOnAtten	4D_False /_nuisance	2D_Review

Summary

ADAS reads inspection reports from all current mask inspection and review tools. It classifies false defects with accuracy above 99%. It classifies real defects with accuracy above 99.9%, compared with operator accuracy of about 97%. ADAS defect size measurement is highly repeatable because it uses accurate sub-pixel reference image alignment algorithms and quantitative measurement methods.

ADAS can reduce the number of defects requiring AIMS analysis by 90%. It uses an accurate simulation engine that has been verified on 45 nm process masks with simple and exotic illumination apertures. CD error measurement accuracy relative to AIMS is 6 percent at 3 sigma for 65 nm L/S patterns. Reproducibility error due to image variability from a KLA 5xx, 72 nm pixel inspection is 5 percent at 3 sigma.



Conclusion

ADAS fulfills the requirements for a productive automated defect disposition and analysis system. It implements consistent disposition rules for all inspection tools and operators.

In fabs ADAS can fully automate most inspection analysis while increasing the inspection and cleaning intervals. It does this with accurate printability simulation and by providing complete and accurate defect increase and growth statistics.

In mask shops ADAS will accelerate delivery and reduce costs by reducing repairs and AIMS analysis. It also allows fabs to move to printability specs because each defect is simulated. This will reduce un-needed repairs and waiver requests.

