Advanced Techniques for Post-CMP Inspection: An Evolutionary Approach

> K. Greissinger CMP Users Group September 4, 2002



# Agenda

- Hamamatsu/Inspex Corporate Profile
- Wafer Inspection System Overview/Technology
- Defect Gallery
- Process Defect Management (AEC)
- Case Study CMP Microscratches
- Discussion



# Hamamatsu/Inspex Profile

- Hamamatsu Photonics K.K.- Parent Company
  - \$500M Revenue (Traded TSE)
  - World Leader Photonics (PMT, Cameras, Sensors, Medical Equipment, FA Tools)
- Inspex

CORPORATE

- Founded 1973 by Hamamatsu
- Product History
  - 1980- Bare Wafer Inspection
  - 1985- Patterned Wafer Inspection
  - 1988- Microscope Review Station
  - 1993/1994- Data Management System (DMS-I) Introduced
  - 1999- Eagle WIS and DMSVision Introduced
- Large Company stability with a proven track record of global support.

Semiconductor Defect Detection/Analysis/ Reduction

INSPEX

**A Hamamatsu Company** 

25+ Years of









## **Platform Details**

- Technology Advantages
  - Darkfield imaging with CCD Camera (4096 Gray Levels)
  - CMI<sup>TM</sup> Continuous Motion Imaging with TDI
  - Excellent stage accuracy
  - Five Bar Fourier Mask: Memory or Logic / Memory
  - Dual Laser Beams with Independent Programmable Angles and Polarization
  - <u>Patented Automated Pixel-Level</u> <u>Thresholding</u>





## **DF Inspection Camera Images**







## **Fourier Mask Application**

#### Fourier Pattern

#### Laser Image

#### Before Fourier Mask





#### After Fourier Mask







# **Process Optimization - Optics**

• Illumination and Collection Optics

WIS Technology

- *Independent variable laser angles and polarization* illuminate target defects and particles in trenches, contacts, etc.
- Dual approach angles increase sensitivity by increasing preferential scatter
- Optimization for any process
  - Ideal for post-CMP, post-ETCH and POLY applications.





WIS Technology

## **Pixel-Level Thresholding**

Raw image contains features of different intensities. Without multiple thresholds, a global threshold higher than the brightest feature is used.



Raw image

Lowest  $\blacktriangleleft$ 

Regional Masks, developed by Inspex and still in use by the competition, can miss critical defects - especially in logic or high-topology areas.



Conventional Regional Masking

► Highest

Threshold Value -

Patented –Automated Pixel-Level Thresholding

allows the Eagle to capture more defects and smaller defects by providing the highest threshold resolution.



Pixel-Level Thresholding



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- Patented Automated Pixel-Level Thresholding
- Reliable and easy to use

Sensitivity with True Production Throughput and Ease of Use!





#### Metal 1 Post-Cu CMP







#### Metal 2 Post-Cu CMP



# **Process Defect Management Features**

- Built-in On-System Review
  - Precision microscope with Autofocus.
  - Image capture ability.
  - Ability to compare defect with adjacent die for verification
- Built-in Data Analysis
  - On-board DMSVision<sup>TM</sup> software
  - Delta, Compare, Overlay, Classification, Partitioning and Trend Analysis.
- Advanced Automatic Event Characterization Package





# **Real Time Binning (RTB)**

- Provides a coarse qualitative analysis of defects.
  - Bins out nuisance defects (grains, bumps, hillocks)
  - Bins yield relevant defects

RTB

- Done in parallel process with inspection (on the fly)
- Improve quality of reviewed defects
- Maximize utilization of review tools

Focus Your Resources on Defects of Interest!



# Case Study: Real Time Binning of CMP Microscratches





# Background

- Customer monitoring CMP process with four daily BPSG monitor wafers
- Brightfield inspection used to detect microscratches





# **Monitoring Issues**

- Low throughput of brightfield inspection
  - allowed only 25% inspection of wafers
- Poor data for SPC decision making
  - Low capture rates
  - Forced to interpolate "total" microscratches





# **Monitoring Replacement**

- Eagle darkfield inspection system installed in customer fab
- 100% inspection of all monitor wafers
- Throughput of 50 WPH
- RTB attributes at the time not were not sufficient to accurately bin microscratches







**Case Study** 



Small



# **Monitoring Solution**

#### • New Linearity attribute added to attribute set

**Case Study** 

RTB	Chatter	Small	Total	Purity
Chatter	122	0	122	100%
Small	5	35	40	86%
Other	9	*	-	-
Total	136	-	-	-
Accuracy	90%	_	_	

90% Accuracy, 100% Purity!



# Discussion

