Reducing False Defects: Debris and Edge Excursions

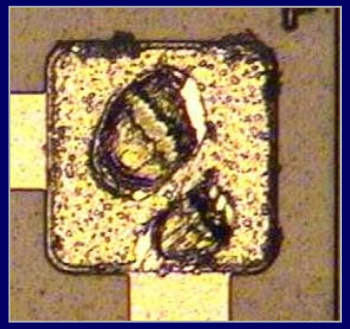
Rajiv Roy, August Technology

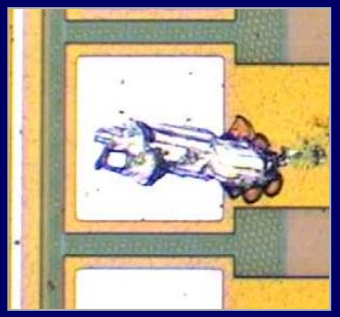
SW Test Workshop

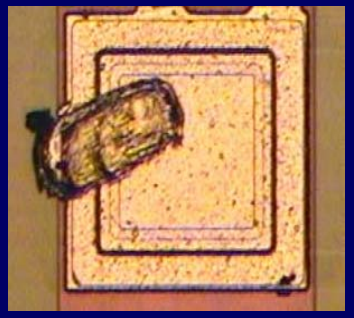
June 8, 2005

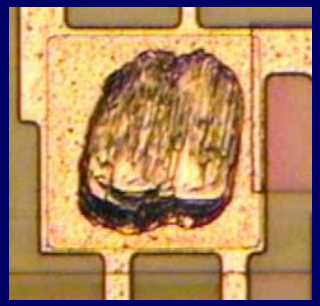
AUGUST TECHNOLOGY

Post-probe : Typical Process Defects Detected









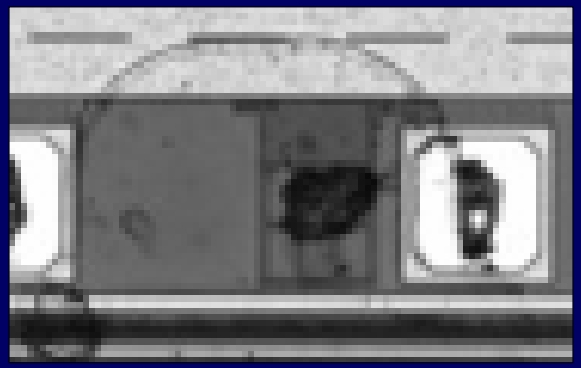
- Probe mark too big
- Probe mark too small
- Missing probe mark
- Pad discoloration
- Probe mark location
- Probe mark too close to edge

Probe Mark Inspection

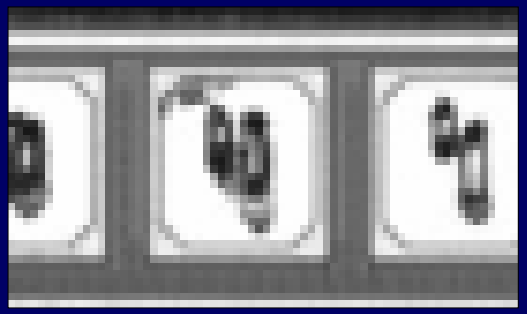
- Rectangular bond-pads
- Bond pad corrosion
- Probe mark area and location metrology
- Probe mark debris filter – size
- Probe mark debris filter – edge debris
- Real-time classification of probe mark defects
- Non-rectangular bond-pad
- Separate image save
- Auto-bond pad location

Why Automate Inspection?

System can find defects like these missed by operators:



Debris and stain



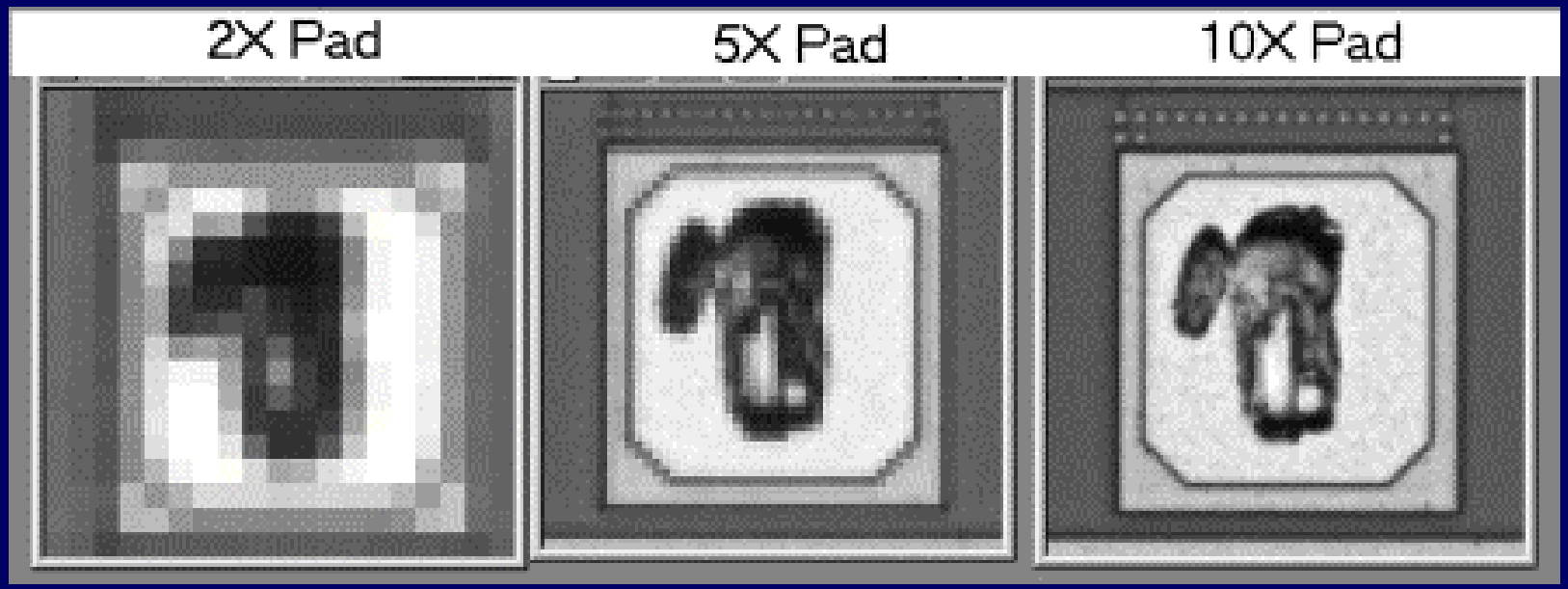
Passivation on pad

Excess metal
flake near pad

The Challenge of Automated Probe Mark Inspection

- To make inspection affordable
  - >15wph or higher throughput needed
  - Better than 1µm resolution needed for distinguishing true from false defects

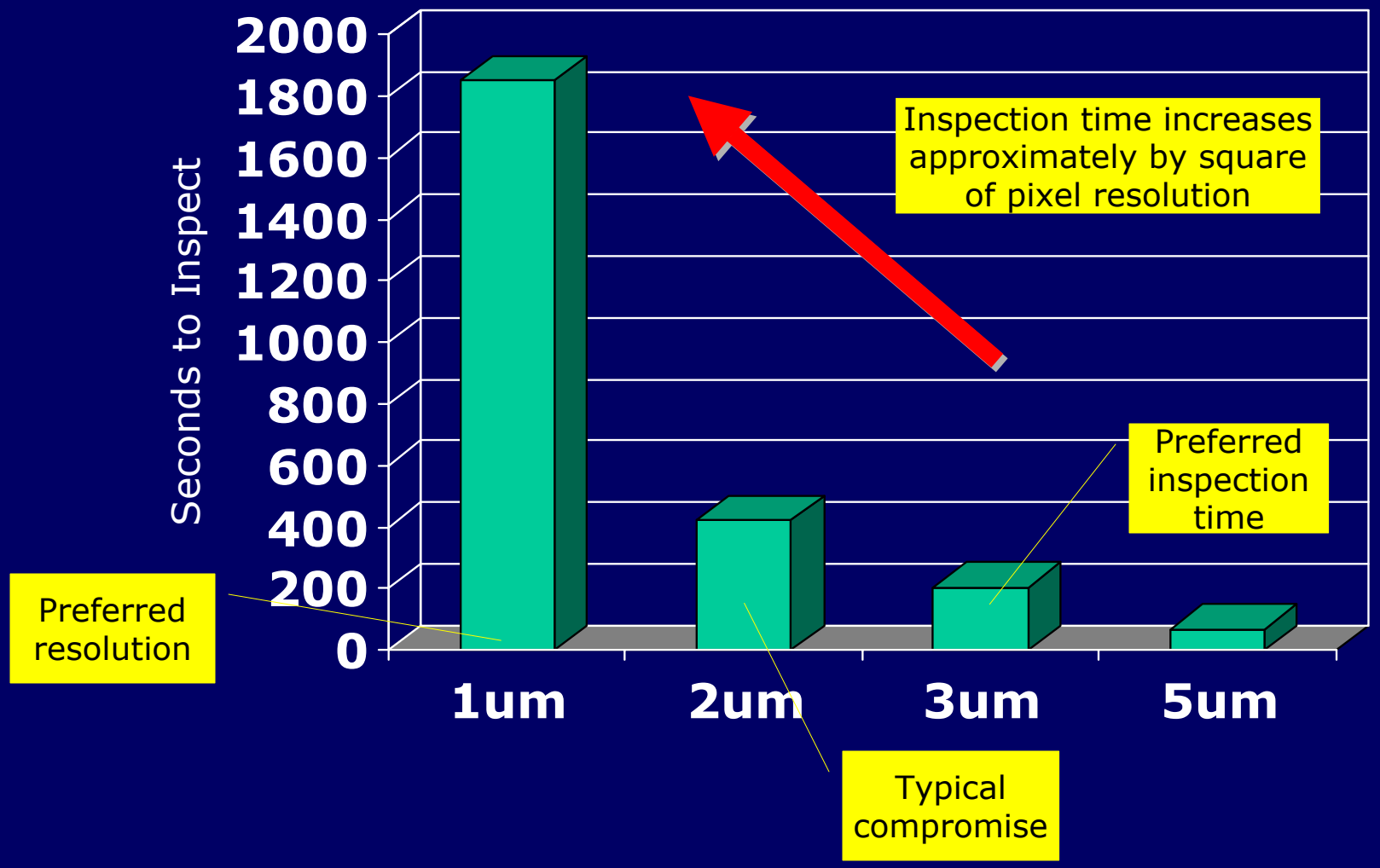
See More at Higher Resolutions



5µm 2µm 1µm

….but takes more inspection time

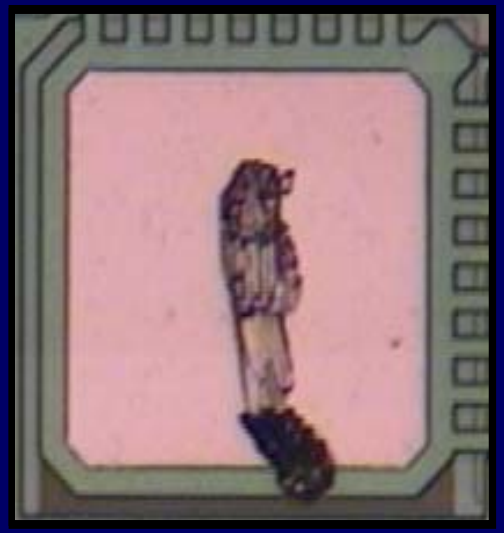
Throughput vs. Resolution



The Probe Mark Debris Challenge

- Debris is:
  - A natural by-product of the probing process
  - Considered non-critical to device functionality
- Automatic probe mark inspection systems have difficulty differentiating between defects and debris.

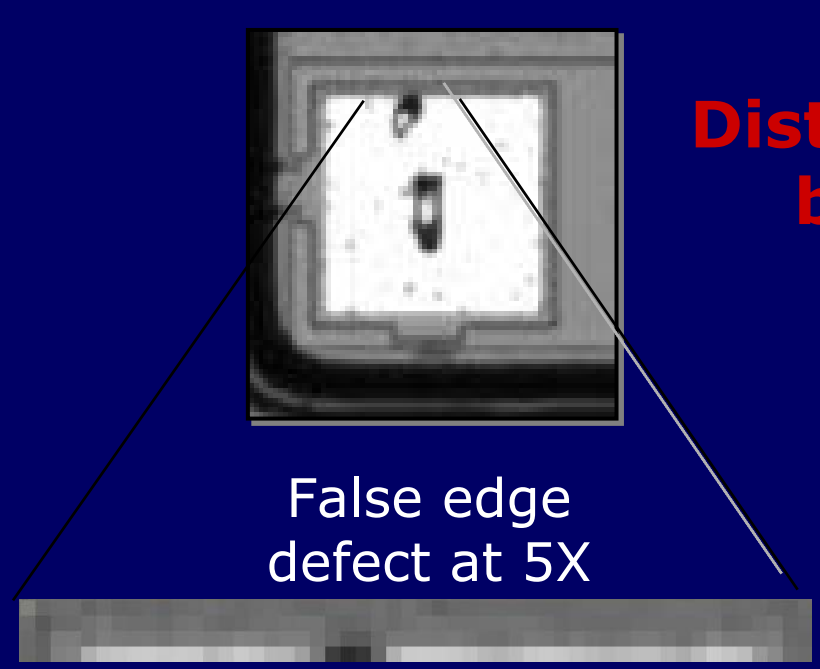
…… a source of false defects



Aluminum slag/debris – mistaken for probe mark too big

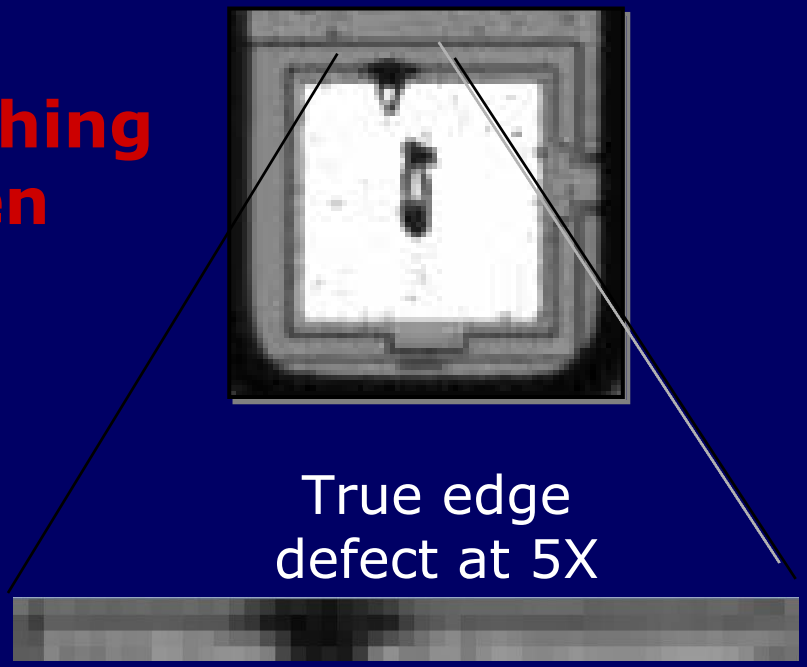
Edge debris – small/faint – mistaken for edge excursion

The Specific Challenge of Edge Excursions



False edge
defect at 5X

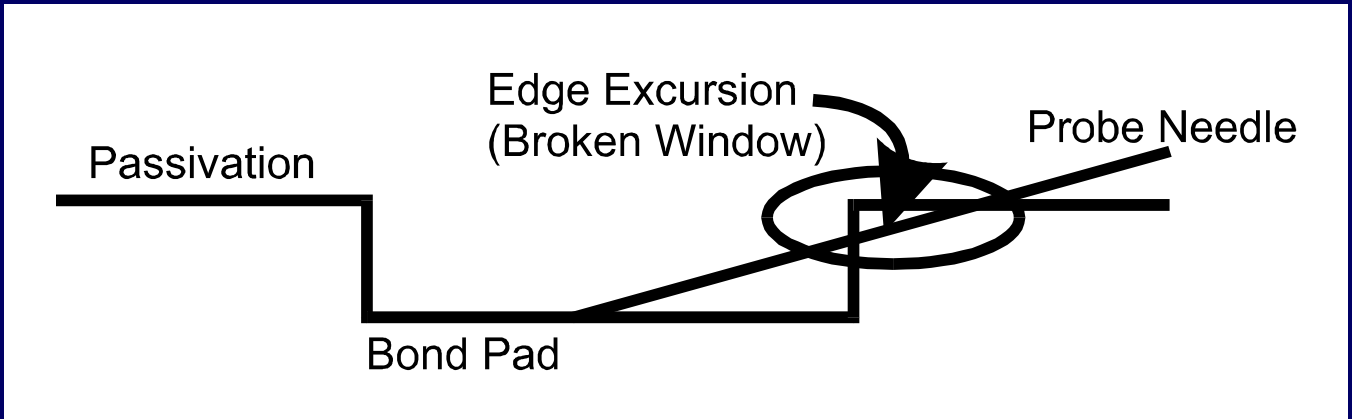
Distinguishing between



True edge
defect at 5X

Cause of Edge Excursion

- If probe needles and bond pad are not aligned properly, needles penetrate the edge of the passivation layers and cause a defect
- This defect is known as edge excursion or broken passivation



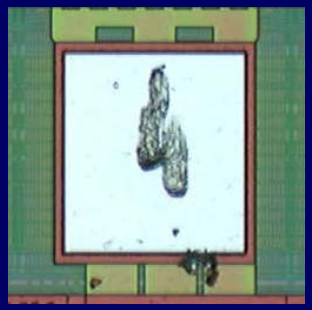
Rogues Gallery: Images of False vs. True Defects

- Real edge excursion – systems can detect



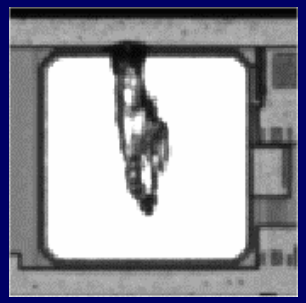
- Real edge excursion – systems struggle to detect



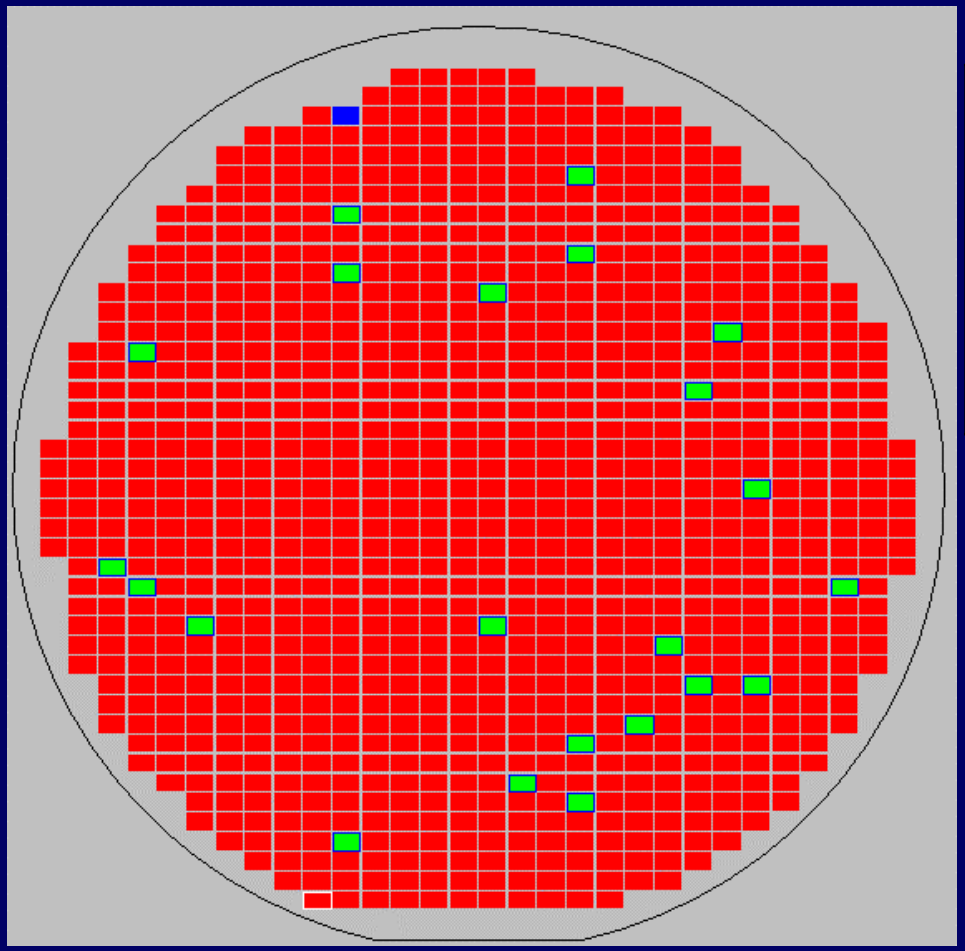


- Edge debris – systems detect but are false defects



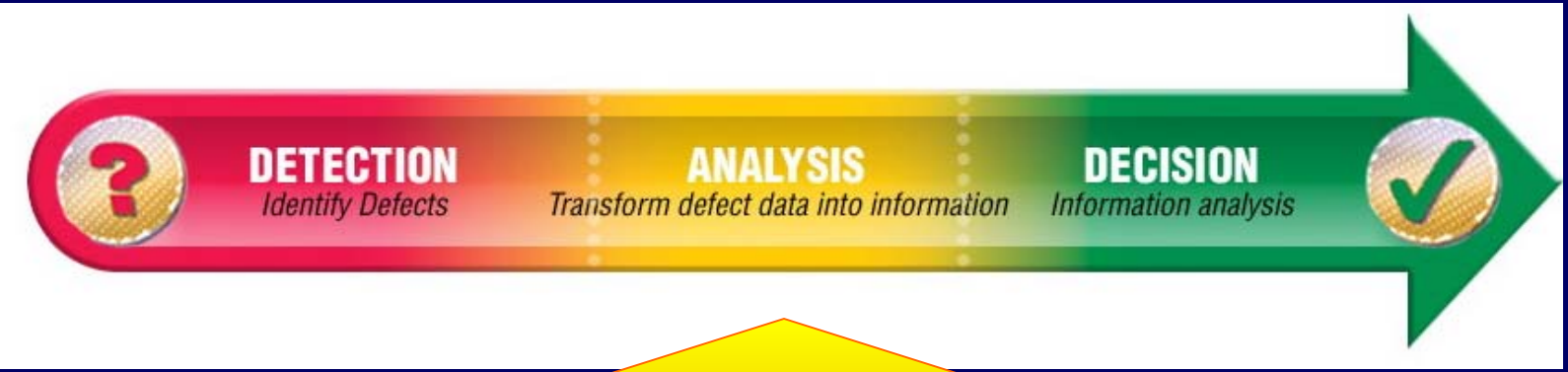
The Effect of Simply Detecting "Defects" (Anomalies)



Inspection Results: 5x	*Inspection Time:*	*5 minutes*
	Total number of defects:	*14400*
	Approximate Review Time:	*2 hours 20 minutes*

- Fast inspection
- Unacceptable review time

Detection to Decision for Probe Mark Inspection



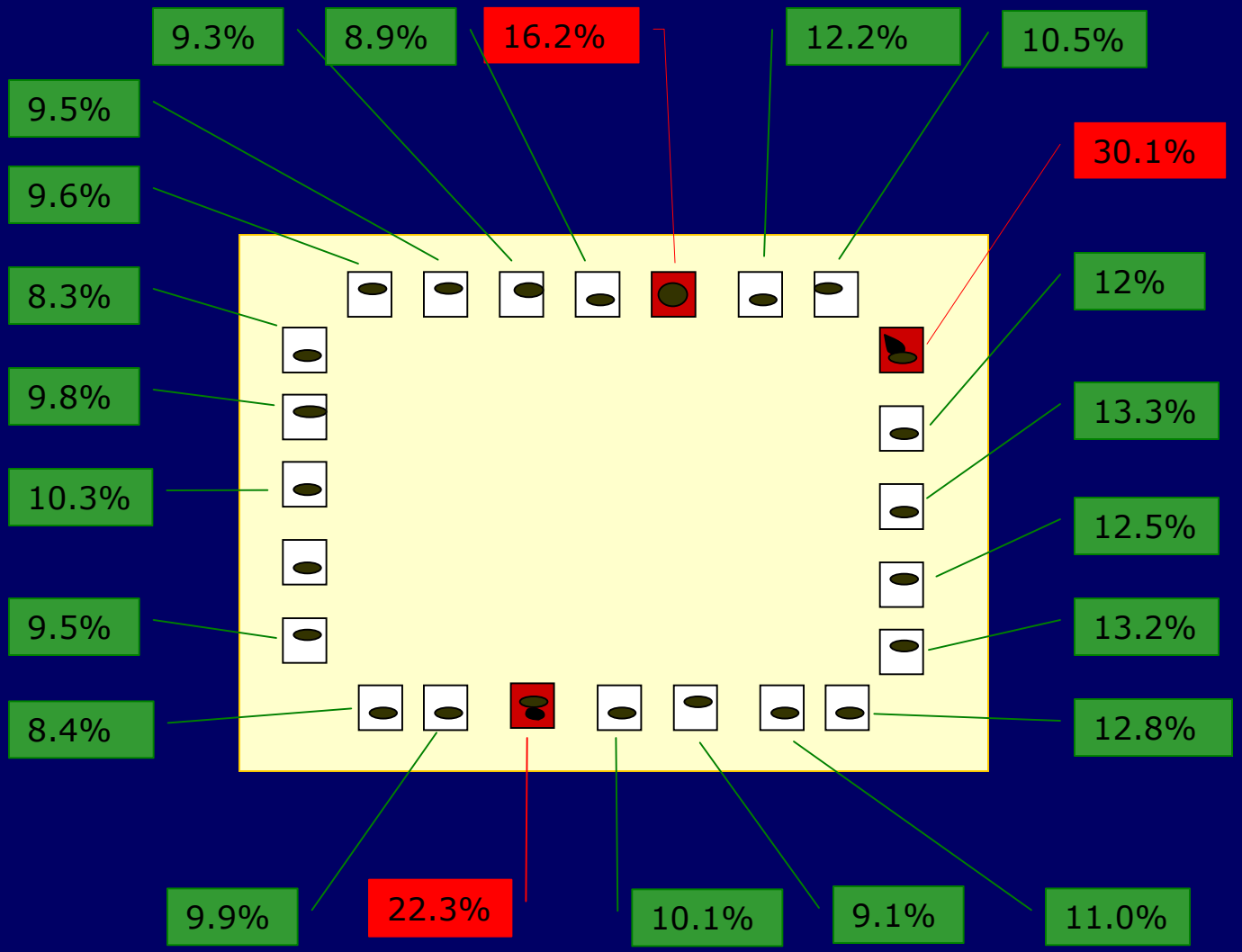
- Statistical Probe Mark Area Filter
- Debris Filter for Edge

Statistical Probe Mark Area Filter

Assumptions Made:

- All bond pads on one die have been subjected to the same number of touchdowns
- Actual probe damage area will not differ in a statistically significant manner within one die

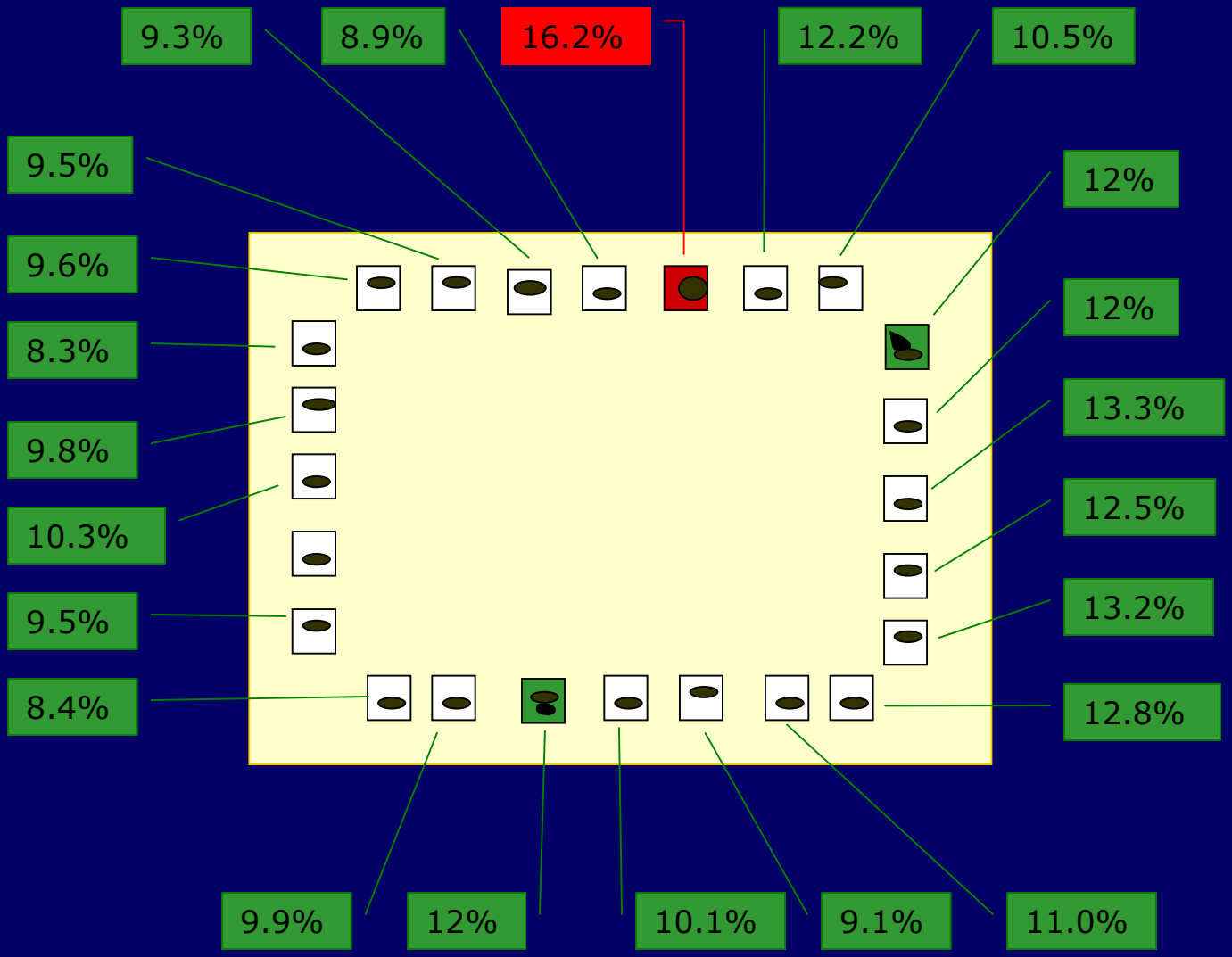
Probe Mark Area Inspection Without Filter



Max. area = 15%

Pad areas greater than max. area fail

Probe Mark Area Inspection With Area Filter



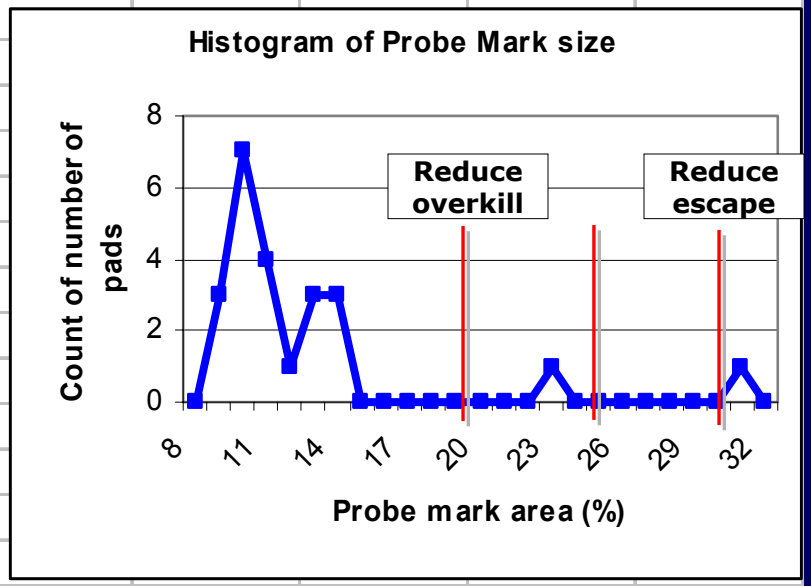
Max. area = 15%

Pad areas greater than max. area fail

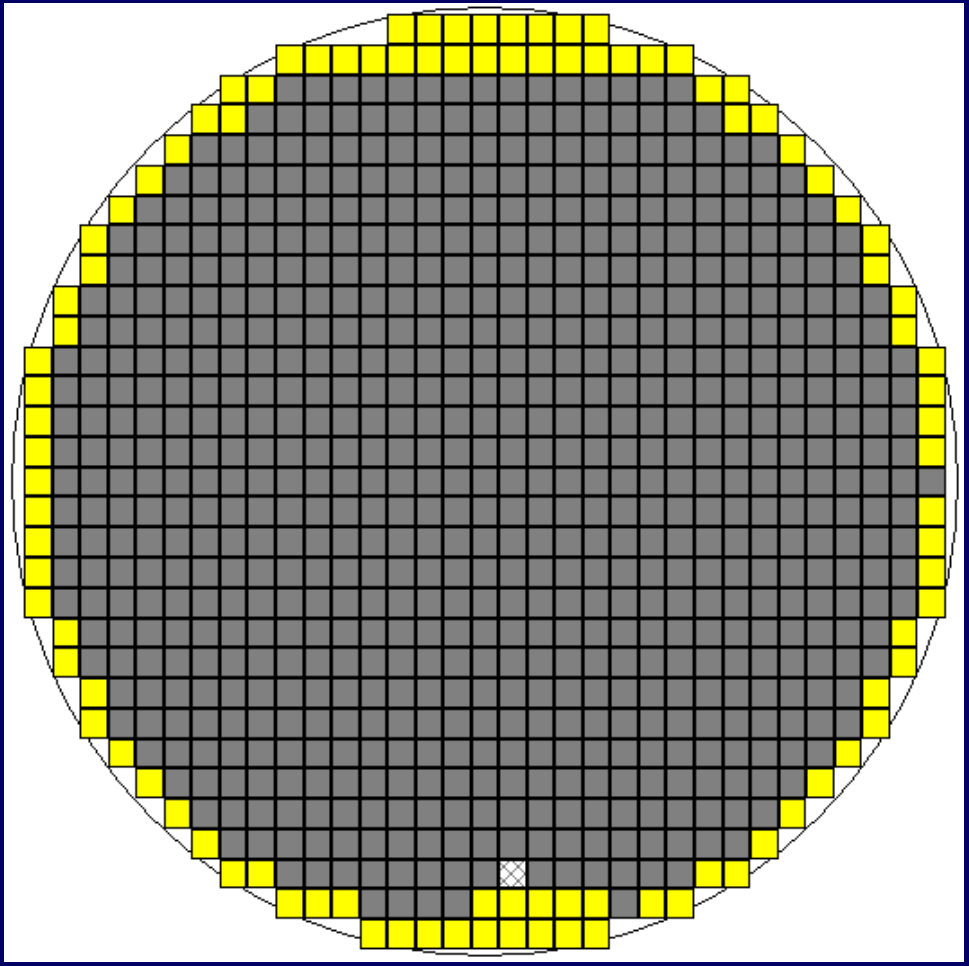
Standard Deviations vs. Performance

Bond Pad	No Filter	2σ Filter	3σ Filter	4σ Filter
1	9.60	9.60	9.60	9.60
2	9.50	9.50	9.50	9.50
3	9.30	9.30	9.30	9.30
4	8.90	8.90	8.90	8.90
5	16.20	16.20	16.20	16.20
6	12.20	12.20	12.20	12.20
7	10.50	10.50	10.50	10.50
8	30.10	11.99	11.99	30.10
9	12.00	12.00	12.00	12.00
10	13.30	13.30	13.30	13.30
11	12.50	12.50	12.50	12.50
12	13.20	13.20	13.20	13.20
13	12.80	12.80	12.80	12.80
14	11.00	11.00	11.00	11.00
15	9.10	9.10	9.10	9.10
16	10.10	10.10	10.10	10.10
17	22.30	11.99	22.30	22.30
18	9.90	9.90	9.90	9.90
19	8.40	8.40	8.40	8.40
20	9.50	9.50	9.50	9.50
21	10.30	10.30	10.30	10.30
22	9.80	9.80	9.80	9.80

Average PM Damage %	11.9913
Std Deviation of PM Damage %	4.900919
Debris Filter 2 Std Deviations	21.79314
Debris Filter 3 Std Deviations	26.69406
Debris Filter 4 Std Deviations	31.59498

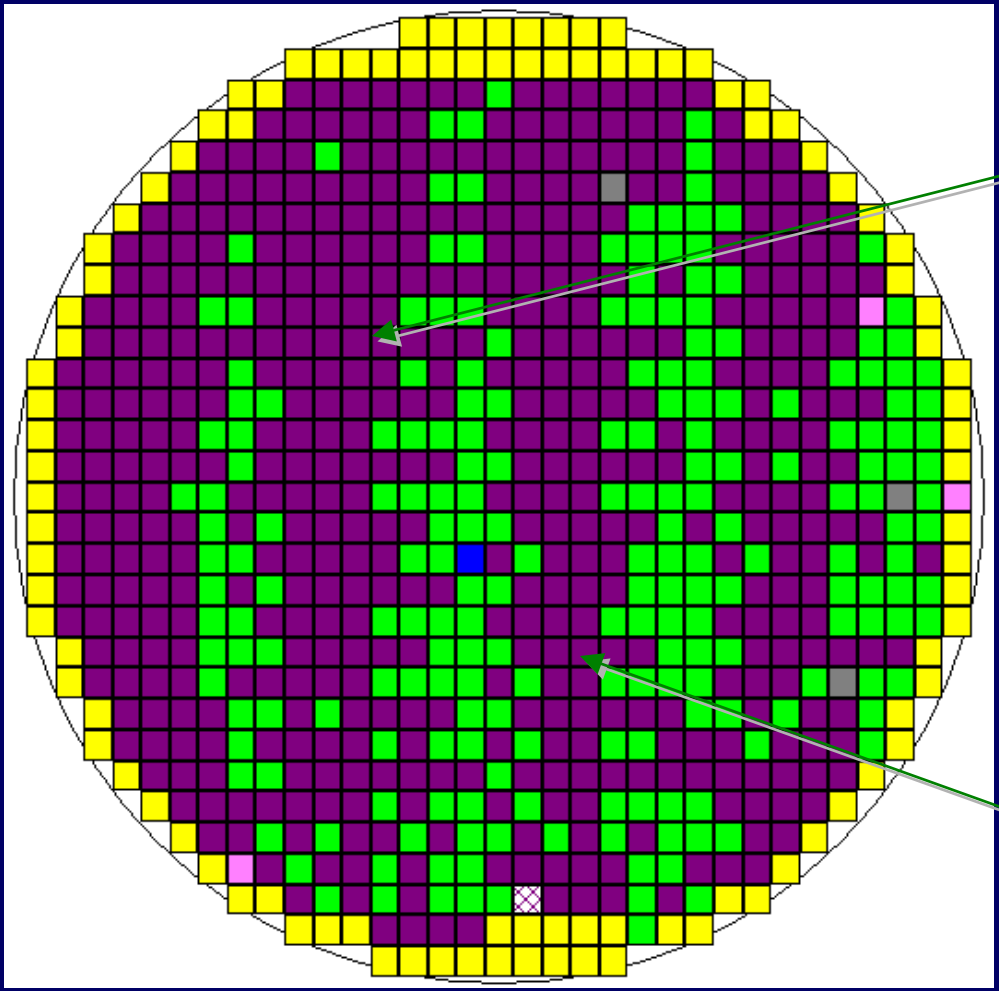


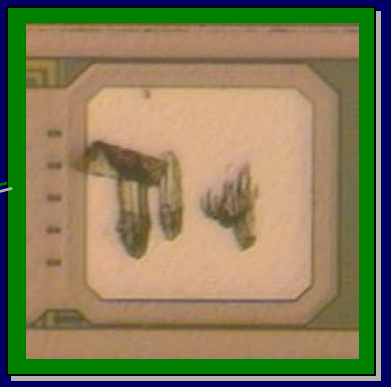
Parameters for Area Filter Test



Wafer size:	**8-inch**
Inspected die:	**713**
Die size:	**5897um x 6349um**
Pads/die:	**38**
Max. area:	**25%**
Std. Devs:	**1.1**

Defect Map Without Area Filter



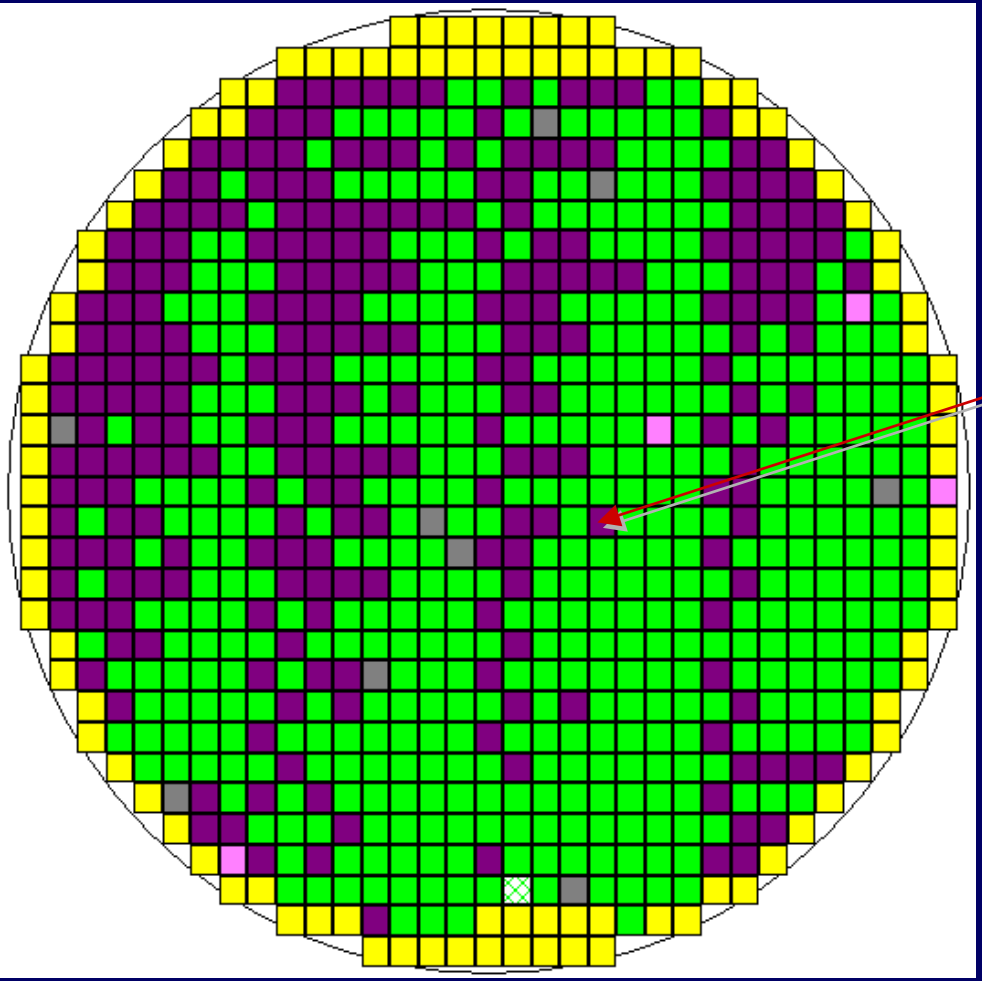


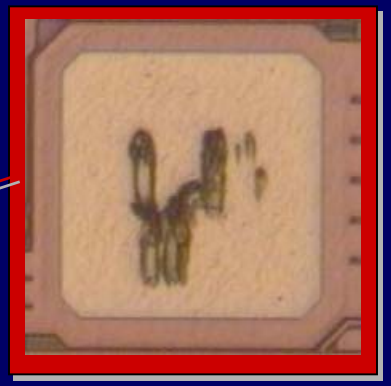
False "too big" defects from debris

Probe "Too Big"

Pass

Defect Map With Area Filter



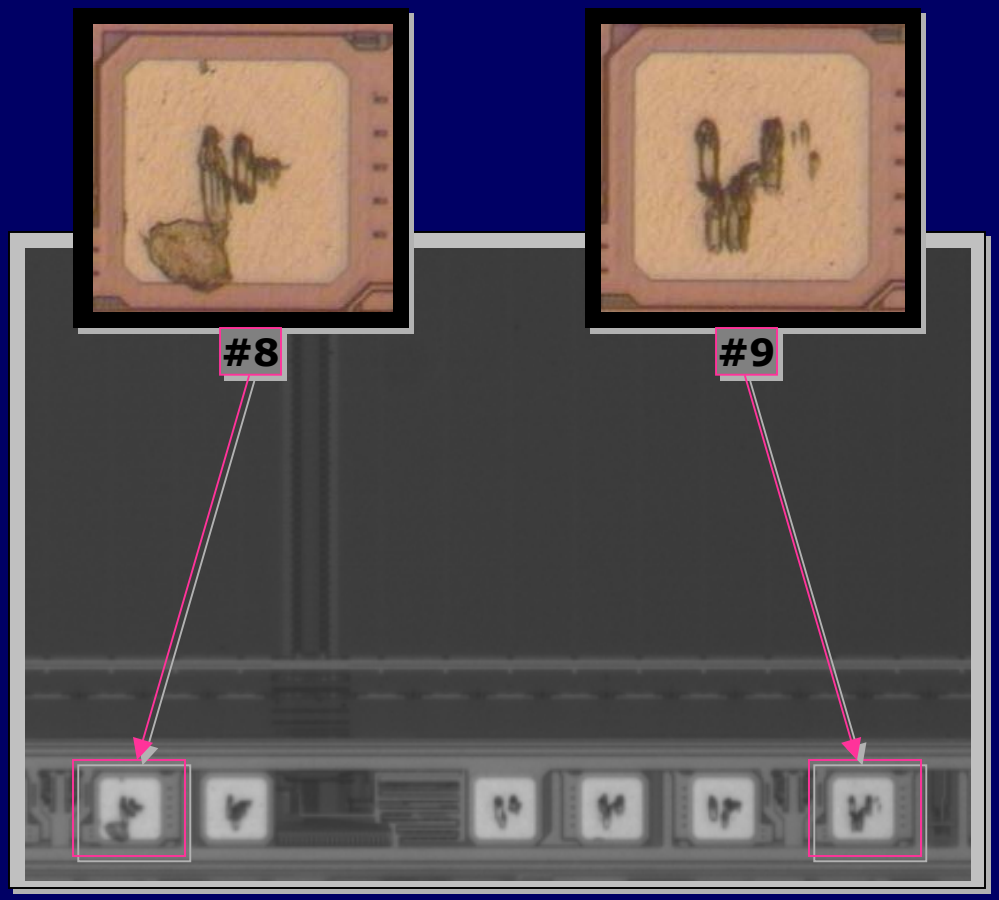


True "too big" defect

Probe "Too Big"

Pass

Pad Areas Before & After Filter



Before Filter:
Pad #8 Fails
Pad #9 Fails

Measurement	Die	Area %	Area um square
6	0	23.203909	1409.305542
7	0	21.484575	1314.597412
8	0	28.773952	1746.843262
9	0	25.316364	1537.989868

After Filter:
Pad #8 Passes
Pad #9 Fails

Measurement	Die	Area %	Area um square
6	0	23.203909	1409.305542
7	0	21.484575	1314.597412
8	0	21.993752	1746.843262
9	0	25.316364	1537.989868

Statistical Probe Mark Area Filter

Advantages

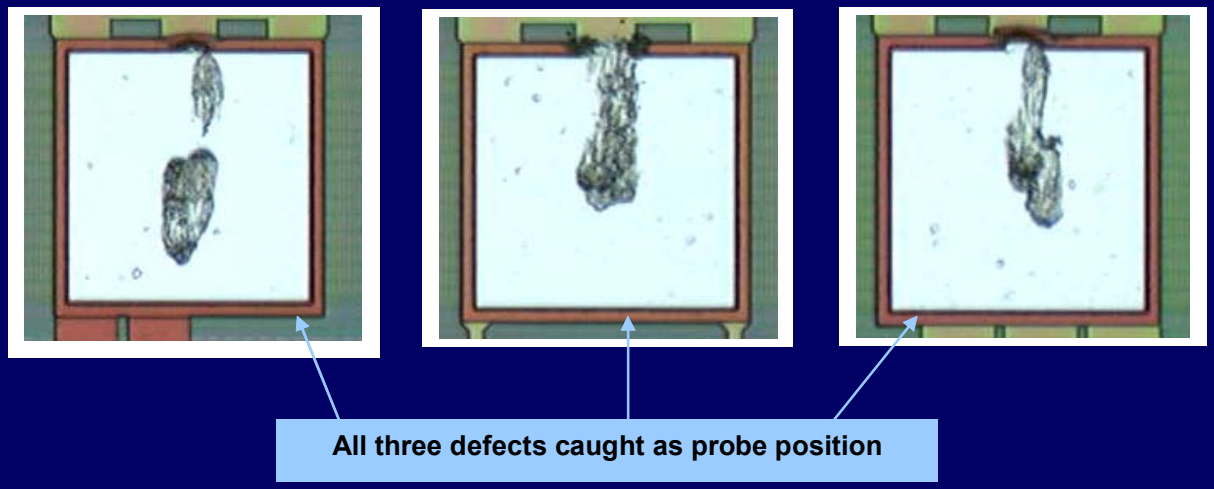
- Easy to use – user only specifies filter threshold level
- Fast – filter does not reduce machine throughput
- Effective – debris which significantly increases the perceived probe damage area is automatically cleared
- Automatically adjusts to variability of probing process. A well controlled process will have a lower standard deviation, resulting in a tighter debris filter threshold

Disadvantages

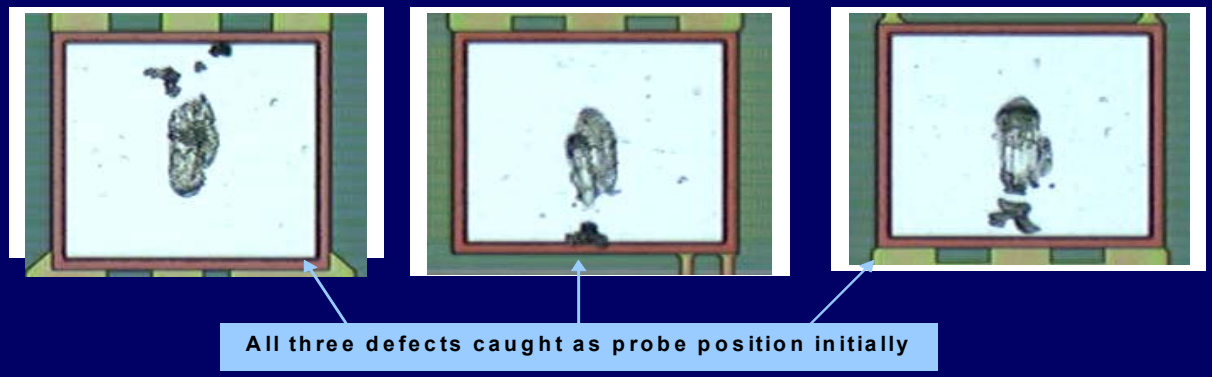
- Not effective for small debris which does not significantly increase the probe damage area but does occlude the bond pad edge is not cleared and may cause false rejects
- May cause escapes if one probe needle creates a significantly larger damage area than other probe needles

Probe Mark Debris Filter – Edge Debris

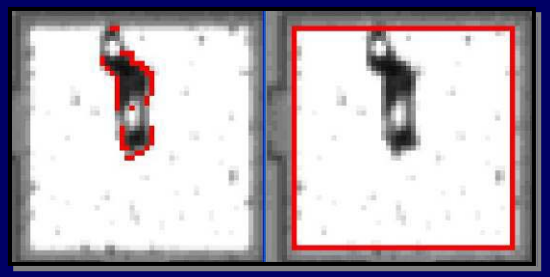
Sample defect images



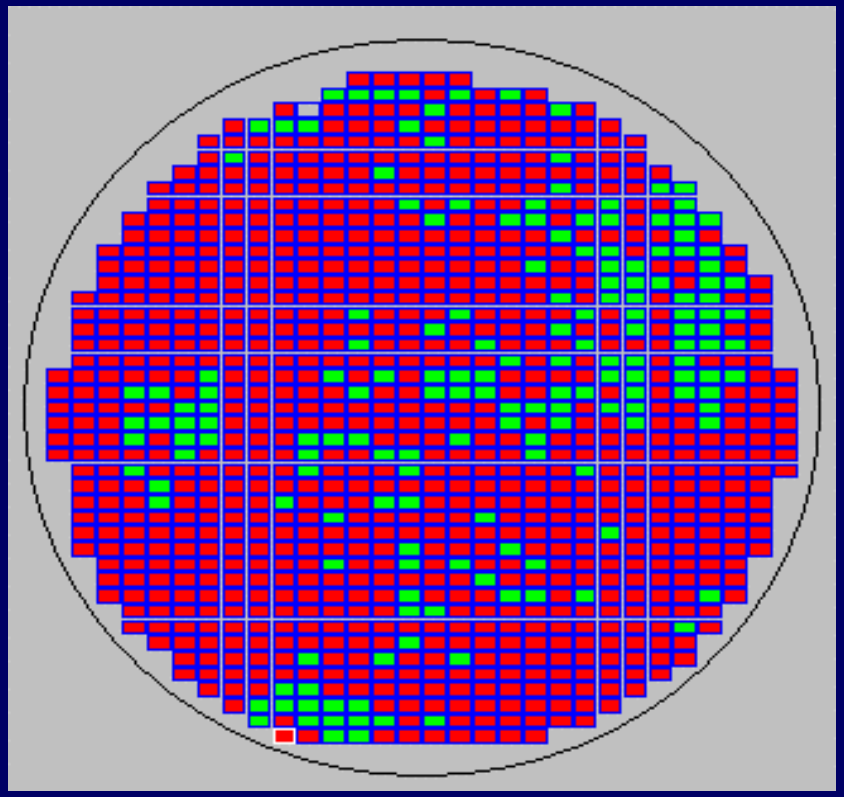
Sample defect images cleared with edge debris filter algorithm



Gradient analysis around the edge of the bond pad

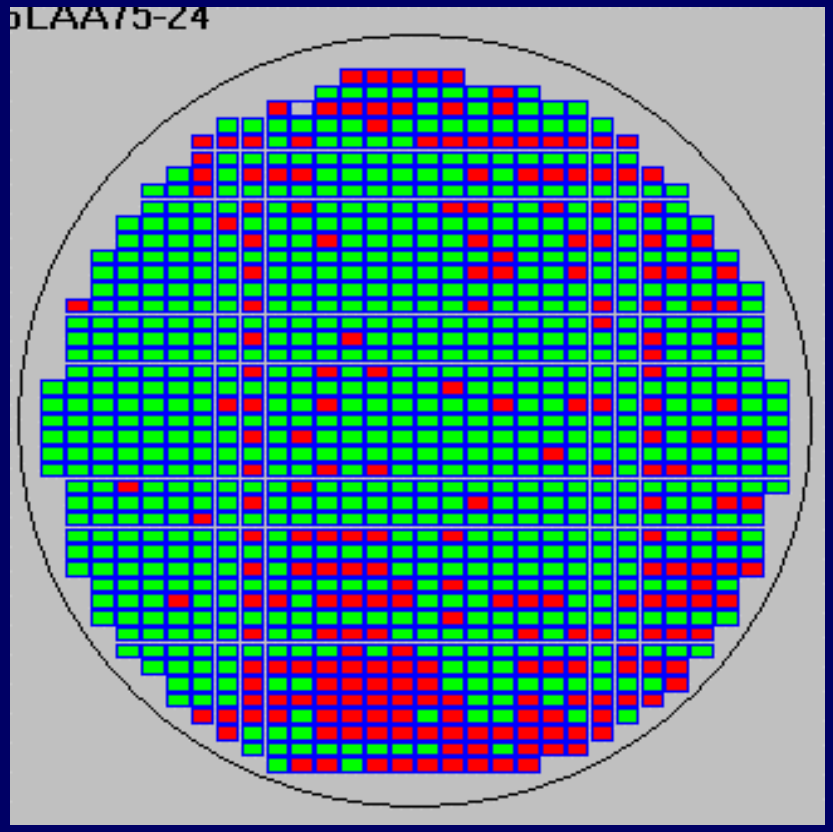


Method 1 – No Debris Filters



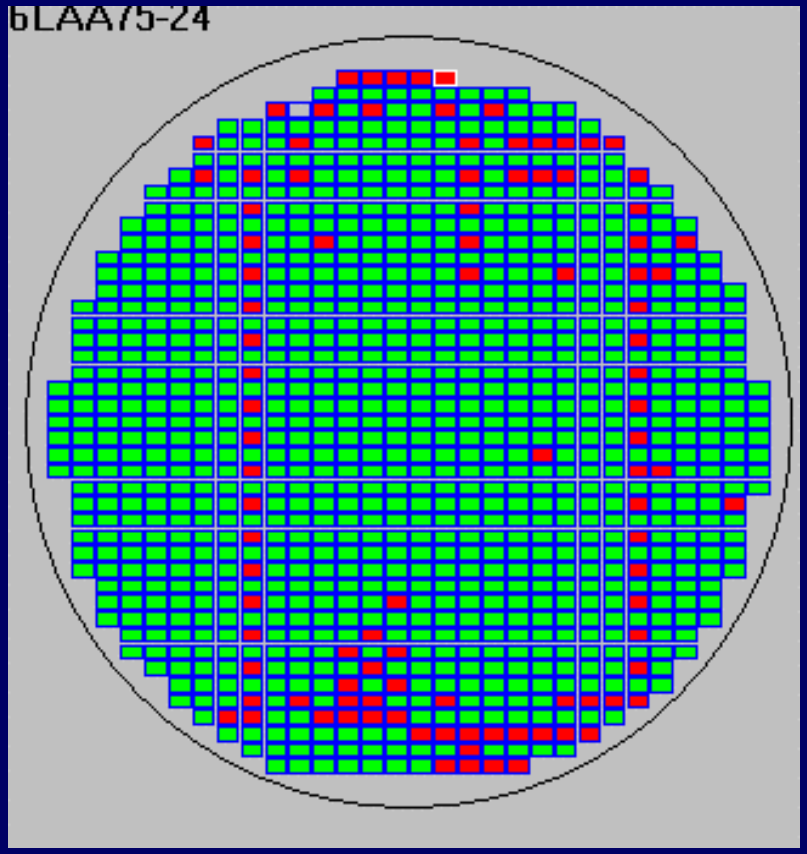
Inspection Results: 10x	***Inspection Time:***	***10 minutes 30 seconds***
	Total number of defects:	***7100***
	Approximate Review Time:	***1 hours 10 minutes***

Method 2 – With Edge Debris Filter



Inspection Results: 5x	*Inspection Time:*	*4 minutes 30 secs*
	Total number of defects:	*680*
	Approximate Review Time:	*7 minutes*
Number of defects caught as probe position		*279*
Number of defects caught as edge defects		*401*

Manual Review of Defects



Inspection Results:	***Total number of defects left:***	***300***

Edge Debris Filter

Advantages

- Fast – filter does not reduce system throughput
- Effective for small debris – debris which does not significantly increase the probe damage area, but does occlude the bond pad edge, is automatically cleared based on position variation
- Easy to setup – specify the width of edge analysis

Disadvantages

- Have not eliminated review – while the amount of review has been significantly reduced, a fair amount of review is still required

Summary of Debris Filter Usage

Type of Debris Filter	Cantiliver Probing	Vertical Probing/ Microspring
Size	Applicable	Not an issue
Edge Debris	Applicable	Not an issue

Acknowledgements

This data was generated by the following August Technology personnel:

- Woo Young Han
- Max Guest
- Steve Frankeberger

4900 West 78th Street
Bloomington, Minnesota 55435
Tel: (952) 820-0080

Rajiv.Roy@augusttech.com
www.augusttech.com

Thank You