

# *PROBE-TO-PAD POSITIONING PROCESS*

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*IEEE Southwest Test Workshop - '97*

# *TOPIC AREAS*

## *Pad Opening/Scrub Capability*

- *Scrub Window Model*
- *Scrub Window Measurement*
- *Scrub Window Simulation*
- *Derived Process Factors Signatures*

# *SCRUB WINDOW MODEL*

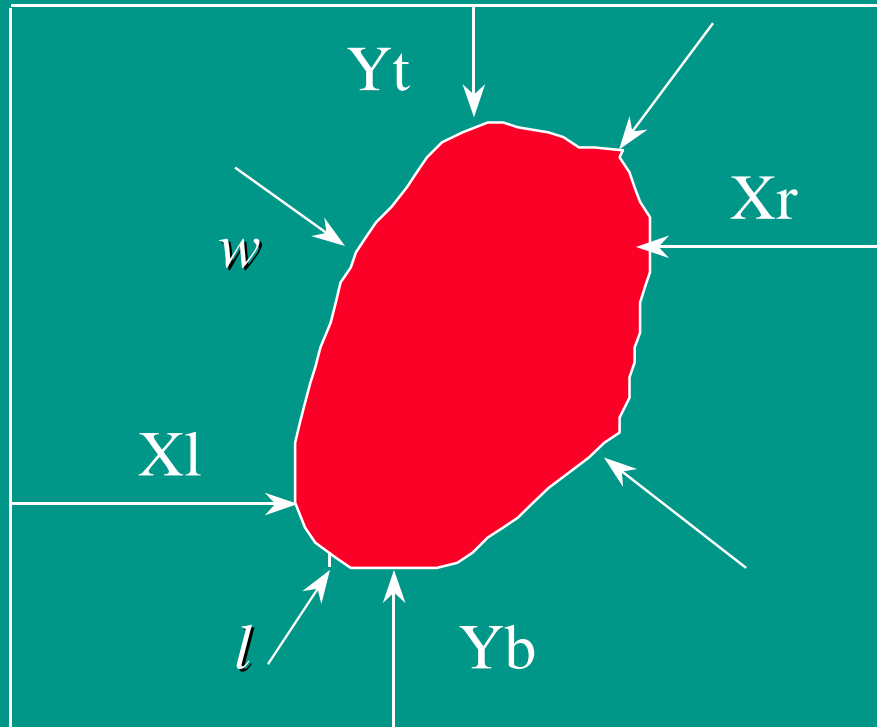
- *Process Factors:*
- *Card, System, Set-up, Wafer*
- *Best Fit Probe to Pad*
- *XY Alignment*
- *Z Planarity, Lateral Scrub Profile  
(length, width, angle)*
- *Window = Composite of all Scrub Boxes*

# *Scrub Window Measurement Parameters*

- *Setup and Print Sample*
- *Measure Gap Passivation Edge to Scrub Box*
- *Maximize the Gap Minimize the Variation*
- *Determine the Best Fit*



# *Scrub Window Measurement*



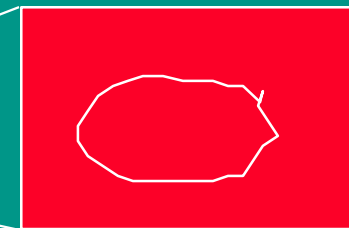
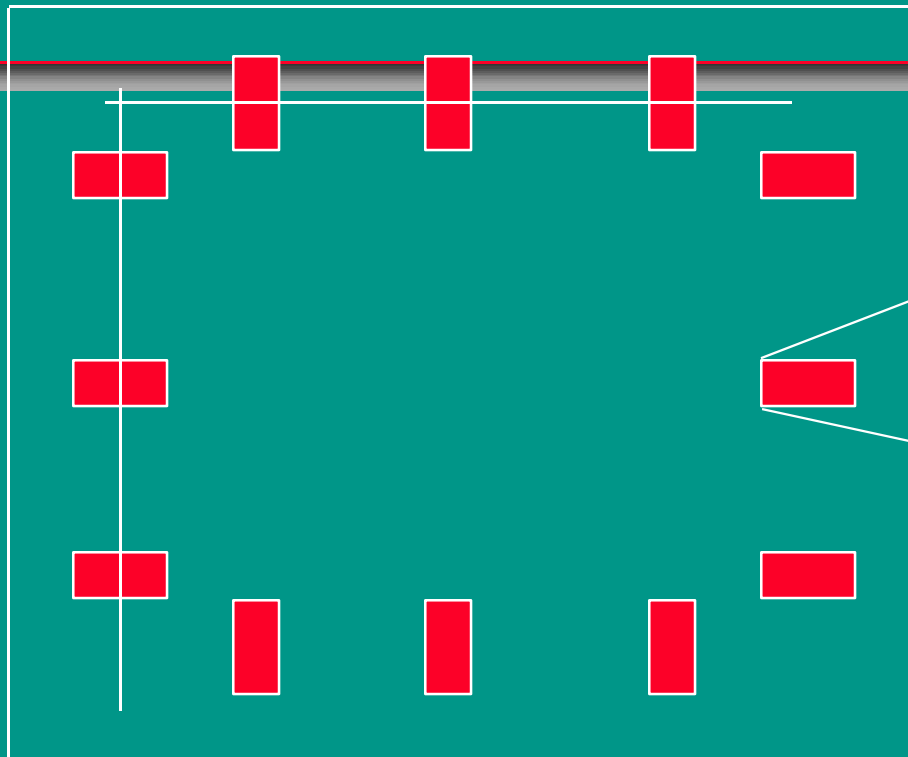
$$Pad\_Opening = Gaps\_Dist + Scrub\_Box\_Composite$$

# *SCRUB WINDOW MEASUREMENT CASES*

- *Pad Bounded (Die, Wafer) all factors*
- *Unbounded (Metal Wafer) card, system factors*

*Note: probe tip toe overhang will not be detected, except against passivation edge*

## Pad Bounded Scrub



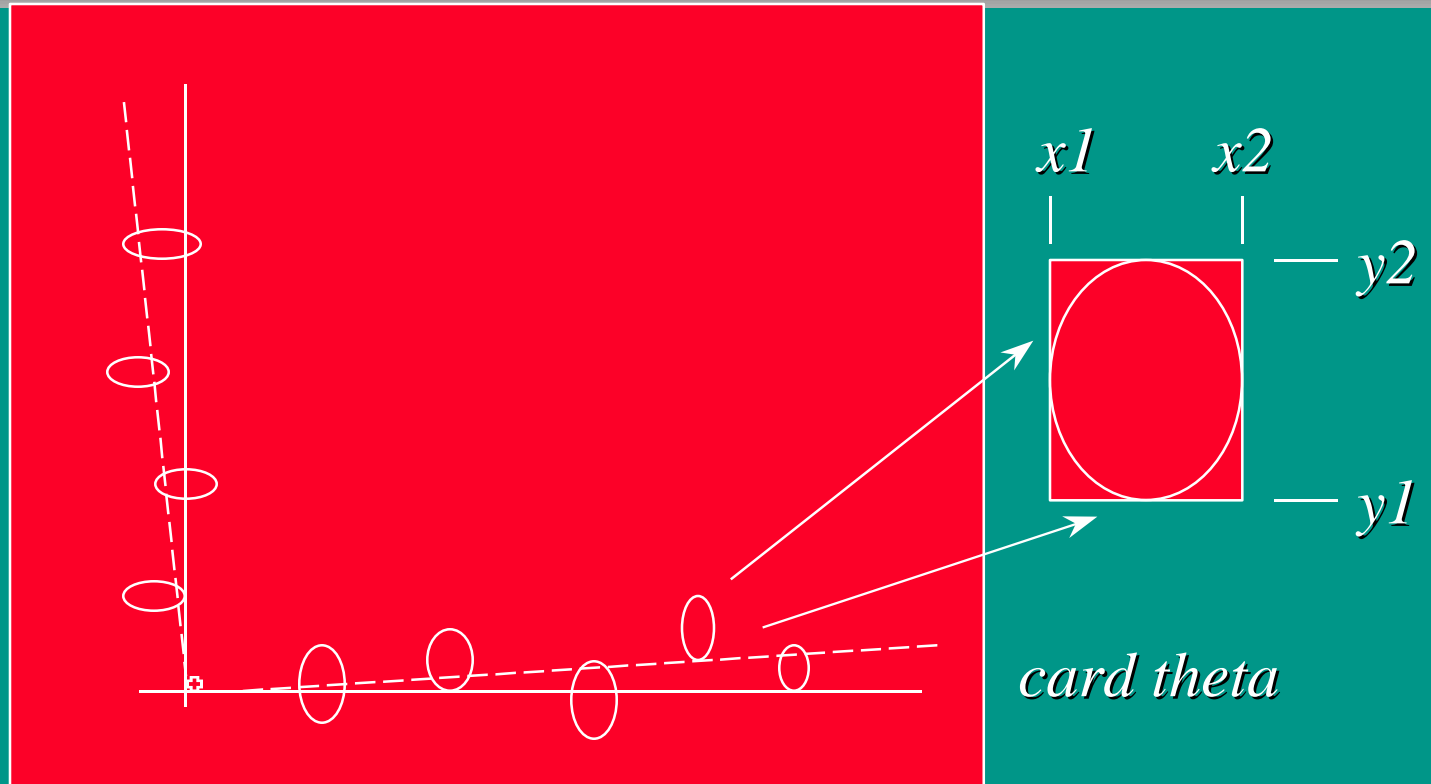
*Scrub*

**Gaps Measurement Method**

**Centroids Measurement Method**

**Best Fit Plane (x,y)**

# Unbounded Scrub - Metal Wafer



**Select a Scrub Centroid Reference o**  
**Best Fit Scrub Locations to Pad Ring**



# *SCRUB WINDOW SIMULATION*

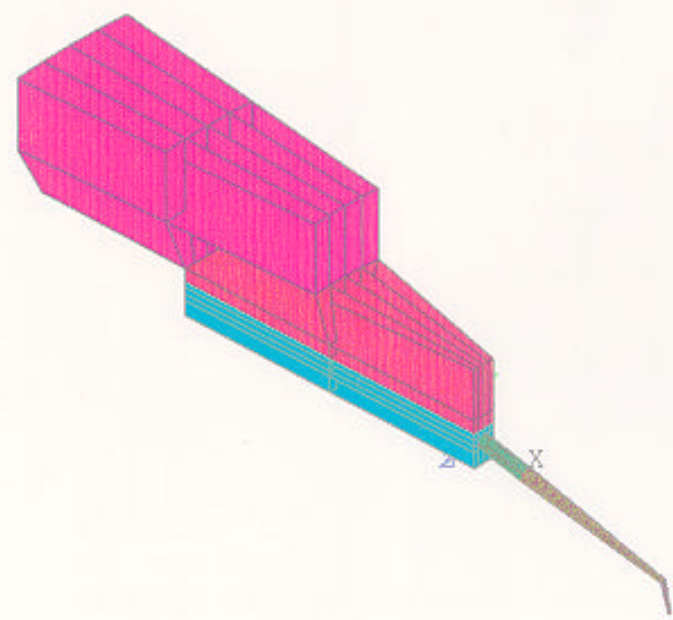
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- *Relationship of Probe Mechanics to Pad Scrub*
- *Identification of parameters which affect the end-result profile*

1

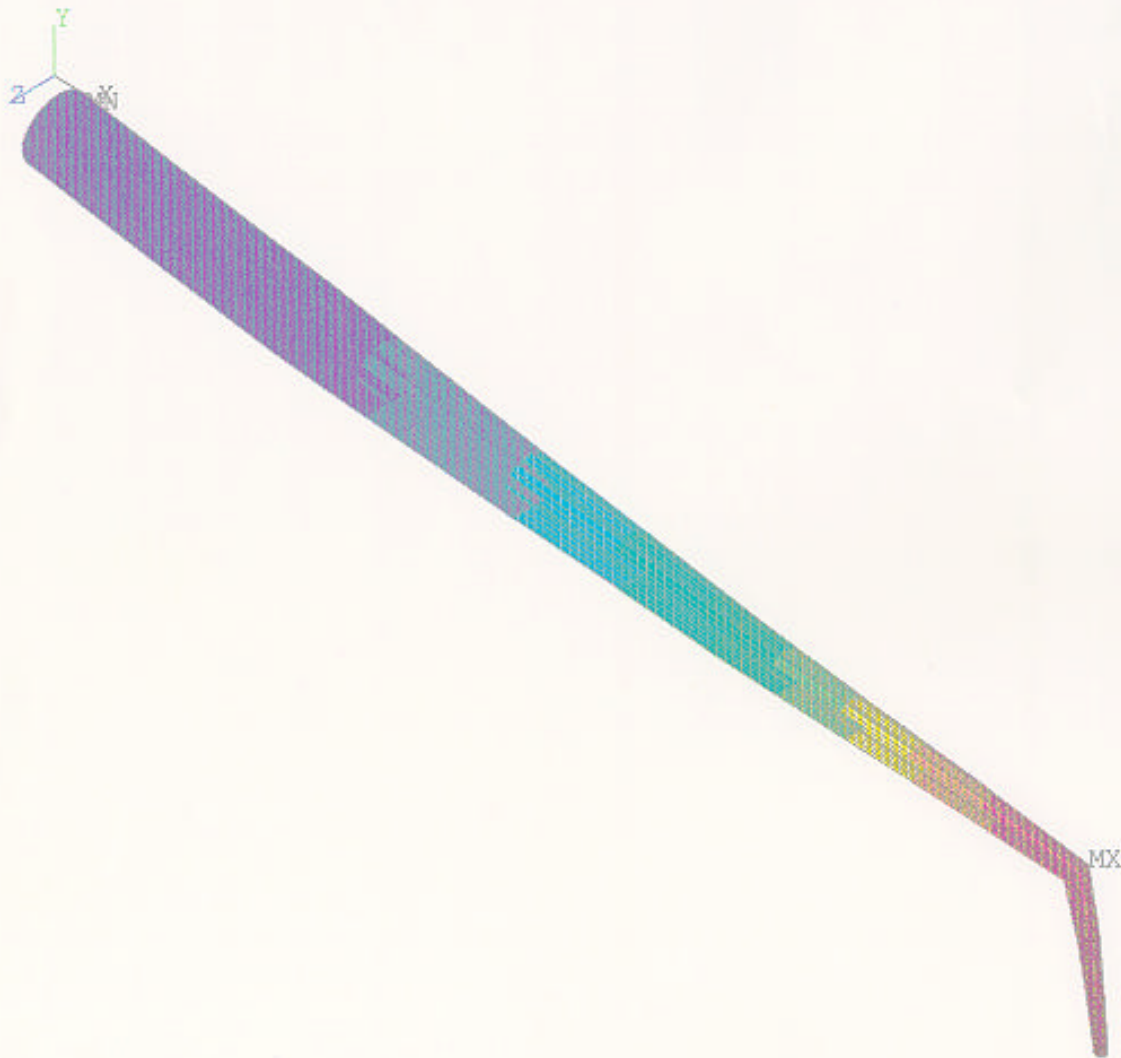
ANSYS 4.4A  
JAN 30 1991  
10:28:45  
PLOT NO. 1  
PREP7 ELEMENTS  
TYPE NUM

XV =1  
YV =1  
ZV =1  
DIST=0.396164  
XF =-0.290707  
YF =0.035432



SYSTEM MODEL, Probe, Epoxy Composite, Anodized Alum, FR4 Elements

1



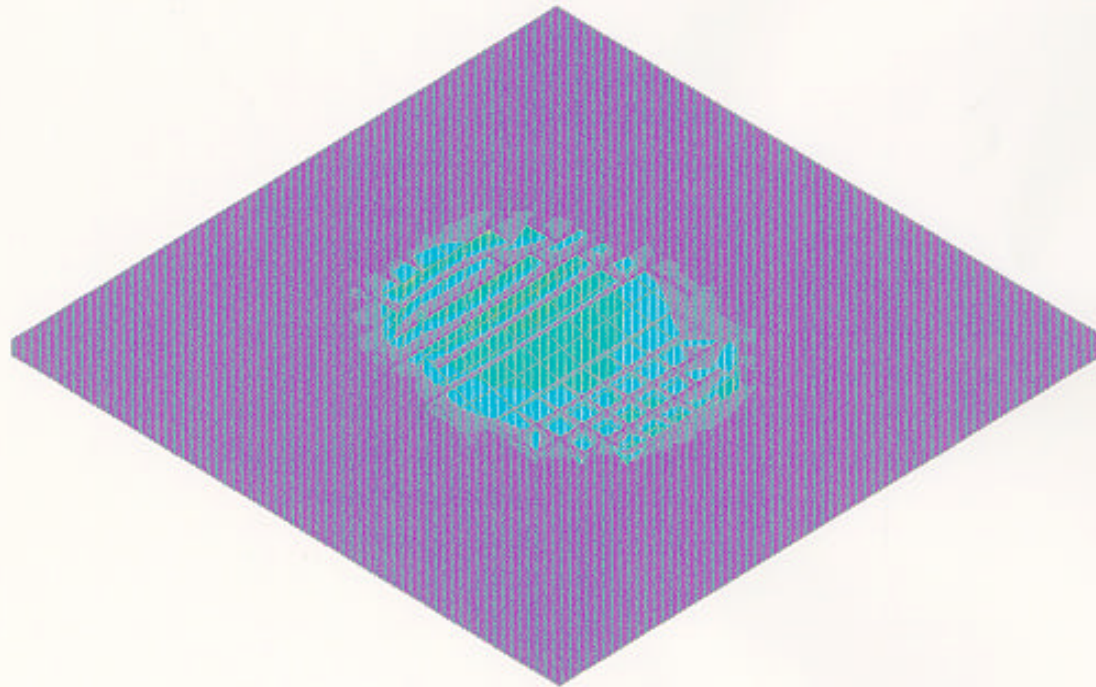
ANSYS 4.4A  
JUL 30 1991  
13:12:05  
PLOT NO. 1  
POST1 STRESS  
STEP=1  
ITER=1  
UY  
D GLOBAL  
DMX =0.002  
SMN =-0.002  
SMX =0.894E-04

XV =1  
YV =1  
ZV =1  
DIST=0.070206  
XF =0.084391  
YF =-0.023252  
-0.002  
-0.001768  
-0.001536  
-0.001304  
-0.001071  
-0.839E-03  
-0.607E-03  
-0.375E-03  
-0.143E-03  
0.894E-04

Probe Depth Displ, Bond Pad Presence, Radiused Tip, 2 mil O-D

1

ANSYS 4.4A  
JUL 25 1991  
10:02:48  
PLOT NO. 1  
POST1 STRESS  
STEP=1  
ITER=1  
UX  
D GLOBAL  
DMX =0.616E-05  
SMN =-0.149E-06  
SMX =0.206E-05



XV =1  
YV =1  
ZV =1  
DIST=0.0028  
XF =0.16785  
YF =-0.051385  
-0.149E-06  
0.970E-07  
0.343E-06  
0.589E-06  
0.835E-06  
0.108E-05  
0.133E-05  
0.157E-05  
0.182E-05  
0.206E-05

Al-1%Cu Lateral Scrub (Probe Wipe Dir), 2 mil Over-Drive Condition

1



```
ANSYS 4.4A
JUL 30 1991
13:38:39
PLOT NO. 1
POST1 STRESS
STEP=1
ITER=1
UX
D GLOBAL
DMX =0.636E-05
SMN =-0.150E-06
SMX =0.222E-05

ZV =1
DIST=0.00198
XF =0.16785
YF =-0.051378
-0.150E-06
0.113E-06
0.376E-06
0.639E-06
0.903E-06
0.117E-05
0.143E-05
0.169E-05
0.196E-05
0.222E-05
```

Al-1%Cu Lateral Scrub (Probe Wire Dir), Radiused Tip, 2 mil O-D

# *DERIVED PROCESS FACTOR VALUES*

- *Comparative and Quantitative*
- *Analyses per Factor*
- *Capability = Spec/Actual*
- *= pad\_op/scrub\_wind\_composite*
- *= pad\_op/(pad\_op - 2xgap\_mean*  
*+ 3xproc\_sigma)*
- *proc\_sigma = sqrt (sum sqrs factorsig)*

*EXAMPLE:*

$$\text{Proc\_sig} = \pm \sqrt{\text{card\_sig}^2 + \text{prbr\_sig}^2 + \text{opr\_sig}^2}$$

$$\text{Proc\_sig} = \pm \sqrt{4^2 + 2.1^2 + 3.3^2}$$

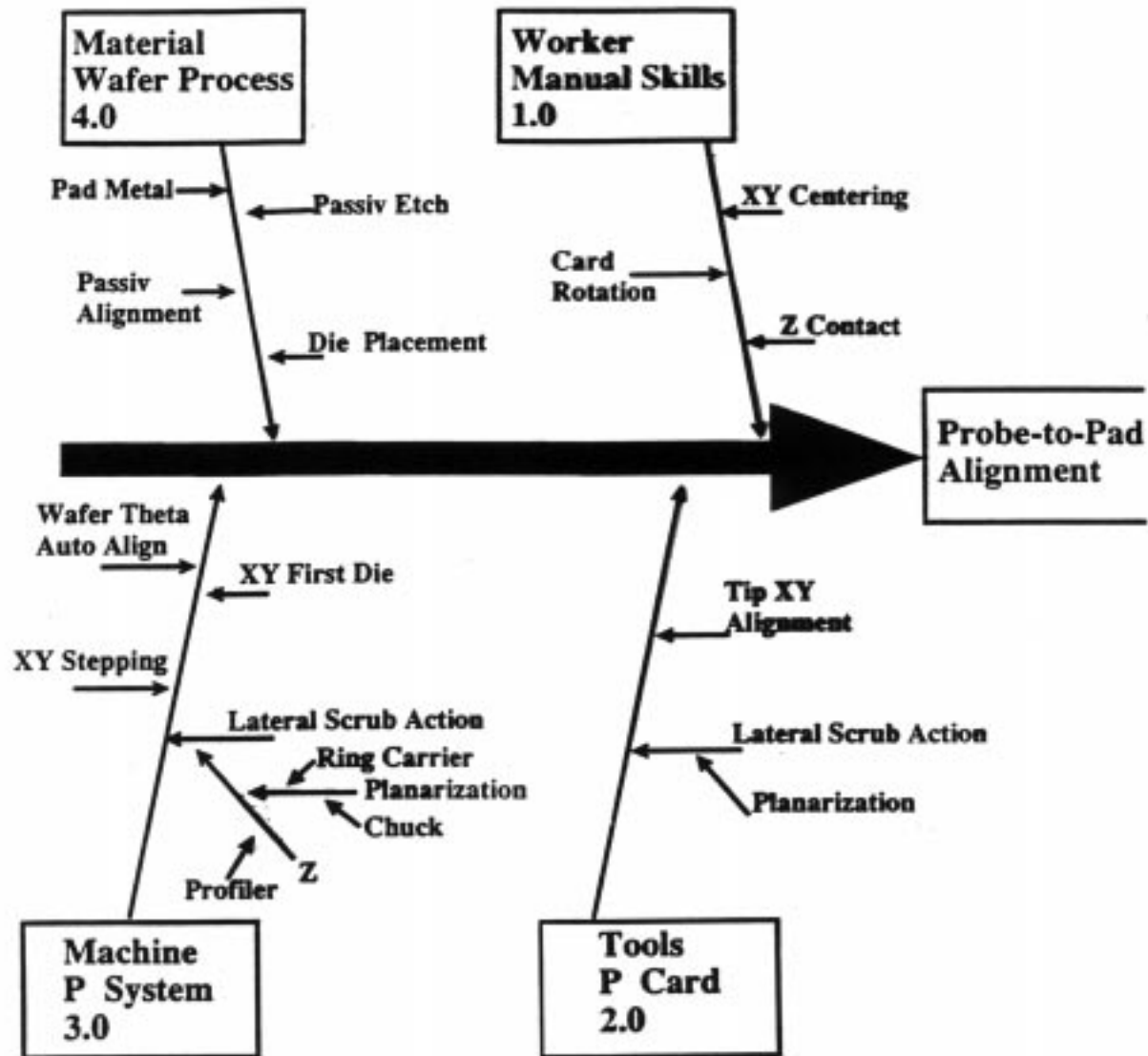
$$\text{Proc\_sig} = 5.6, \quad 3 \text{ proc\_sigma} = 16.8 \text{ microns}$$

$$\text{Gap\_mean} = 10 \text{ microns}$$

$$\text{Capability} = 67 / (67 - (2 \times 10) + 16.8) = 1.05$$

*For 80 micron pad pitch - 13 micron pass\_space*

# Fishbone Alignment







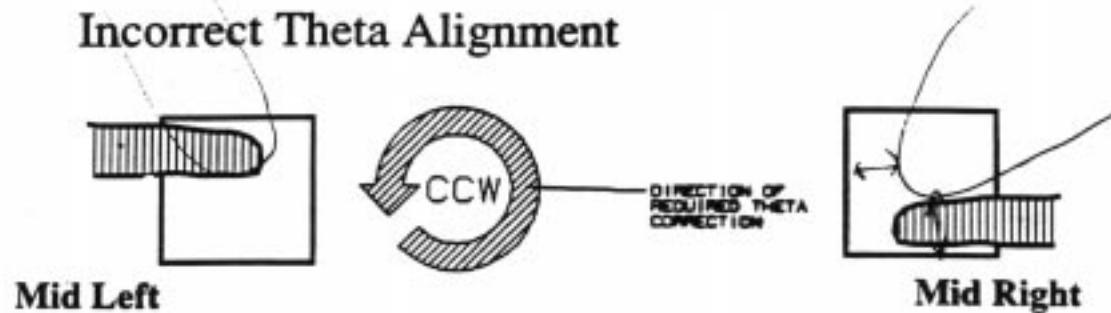
## Manual Set Up Factors

| Factor   | Process Tolerance               | Measurement Method  | Symptom    | Corrective Action       |
|--|---------------------------------|---|------------|-------------------------|
| 1.1 Theta Alignment,<br>Card Rotation to<br>match die<br>orientation | < 0.50mil,<br>12 um<br>< 30mdeg | 2 = LC/RC, TC/BC<br>Ytop, Xleft Gap<br><del>delta-Delta</del> Angle<br>1 = UL/UR Ytop<br>pad edge gap | >1/8th pad | Adjust<br>*Use<br>Zoom* |
| 1.2 XY Centering,<br>Probe Tip-to-Pad                                | < 0.50mil, 12um                 | Xleft, Xright, Ytop,<br>Ybot Gap delta  | >1/8th pad | Adjust<br>*Use<br>Zoom* |

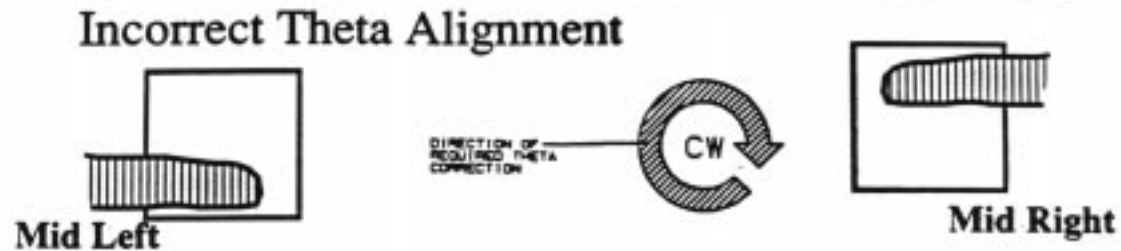


## Manual Set Up - Card Theta 1.1

### Incorrect Theta Alignment



### Incorrect Theta Alignment



### Correct XY Centering and Theta Alignment

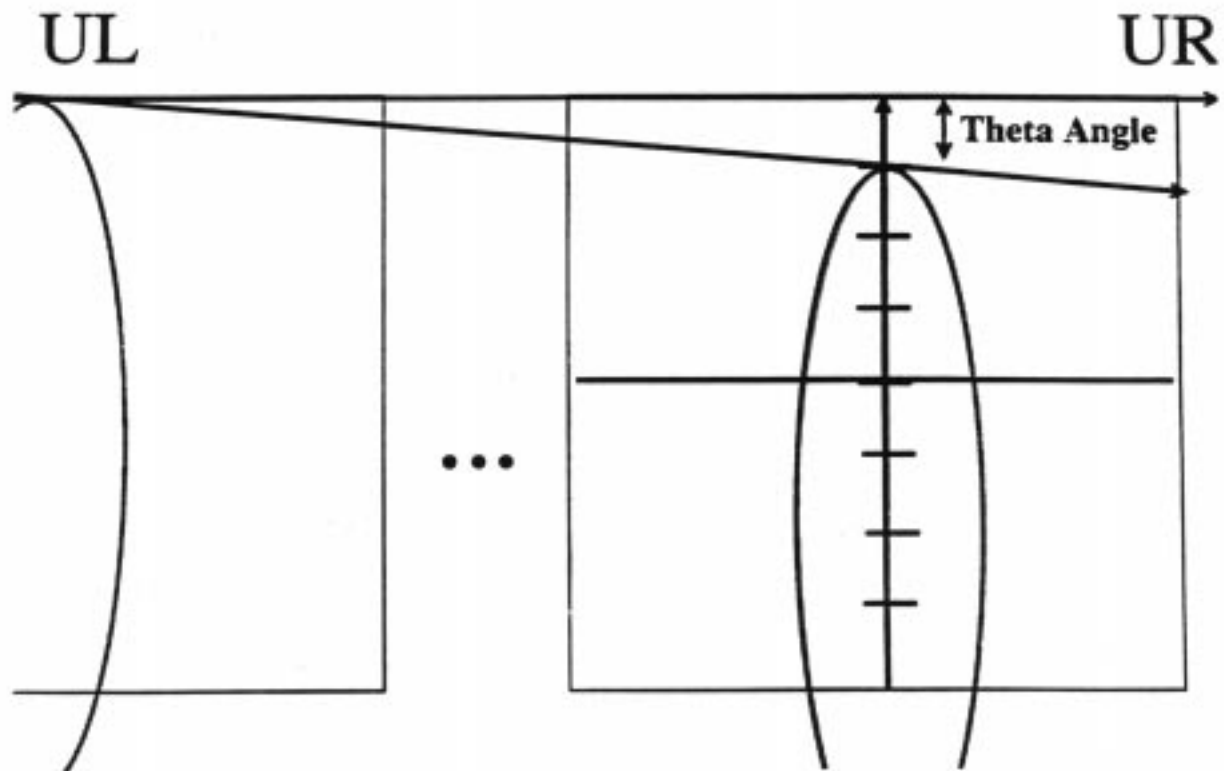


5/21/93

Probe-to-Pad Alignment Process



# Manual Set Up 1/8th Theta Misalign





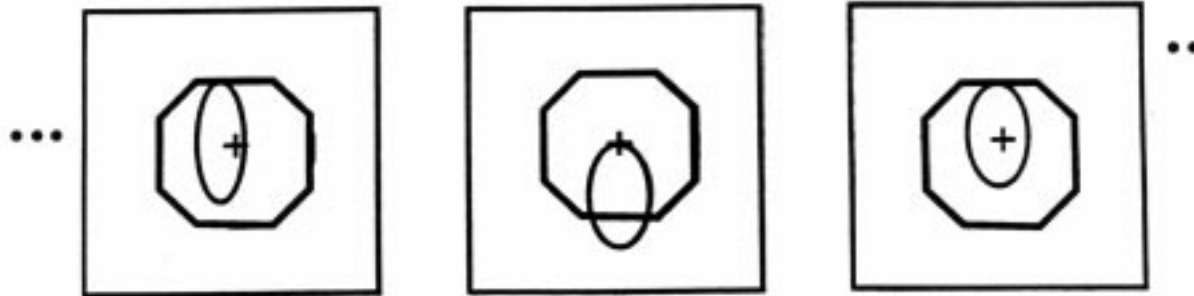
## 2.0 Probe Card Factors

| Factor                   | Process Tolerance      | Measurement Method                                   | Symptom                                 | Corrective Action   |
|--------------------------|------------------------|--|---|---------------------|
| 2.1 XY Alignments        |                        |  |   |                     |
| 2.1.1 Tip-Target         | +/- 1.0 mil<br>810.019 | Target W/ Scrub<br>Checkpoint                        | Few tips out                            | Reposition<br>Tips  |
| 2.1.2 Array Registration | +/- 0.25 mil           | Min-Max XY<br>Micrometers                            | Many tips out<br>Pattern per<br>side    | Vendor re-<br>build |
| 2.2 Tip Planarization    | +/- 0.5 mil<br>810.019 | Pacer, Checkpoint,<br>Min-Max Z focus<br>Micrometers | 1,few,random<br>light/missing<br>scrubs | Replanarize         |
| 2.3 Probe Mount          | Epoxy bond             | Visual inspect, manual<br>tweak, BCF measure         | Intermittent<br>scrub, High<br>CF...    | Rebond              |
| 2.4 Tip Flat             | PTC photos             |  |   |                     |
| 2.4.1 Cleanliness        |                        | Min-Max microscope                                   | High CF,<br>contaminated,               | Swab/sand           |
| 2.4.2 Smoothness         |                        |  | rough/burr                              | Sand                |
| 2.4.3 Circle Complete    |                        |  | Broken                                  | Replace Tip         |
| 2.5 Scrub Action         | 810.019                |  |   |                     |
| 2.5.1 Tip Length         |                        | Min-Max Z micrometer                                 | Short                                   | Replace tip         |
| 2.5.2 Tip Angle          |                        | Min-Max XYZ Meas                                     | > 4 deg                                 | Reposition          |
| 2.5.3 Beam Length        |                        |  |   |                     |
| 2.5.4 Beam Angle         |                        |  | > 4 deg                                 | Reposition          |



# Probe Card XY Alignment

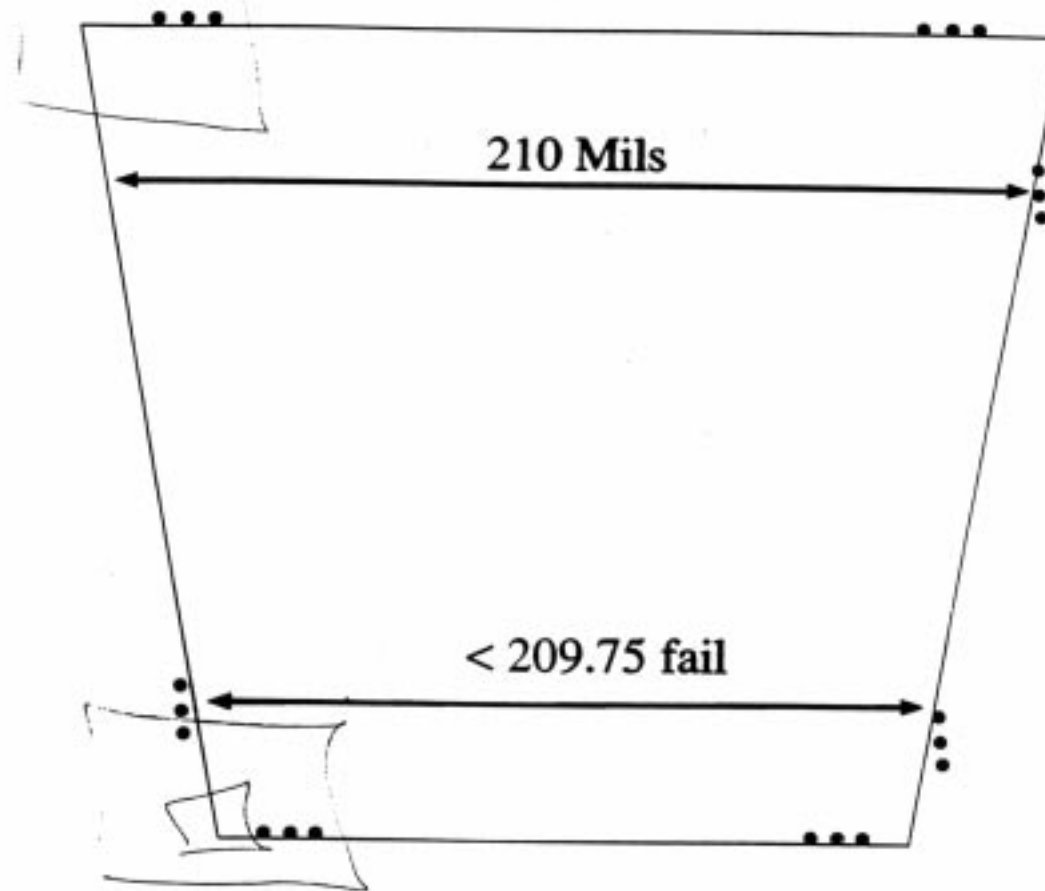
Tip-to-Pad Alignment  
Tip-to-Tip 2.1





# Probe Card XY Alignment

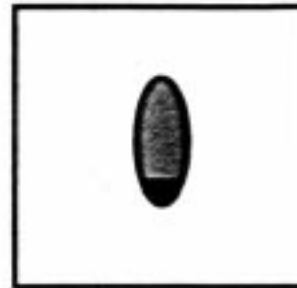
Tip Array Registration 2.1.2



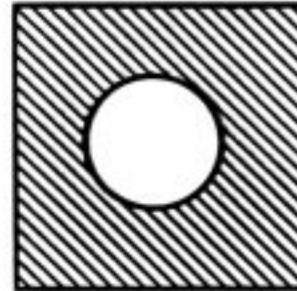


## Tip Characteristics

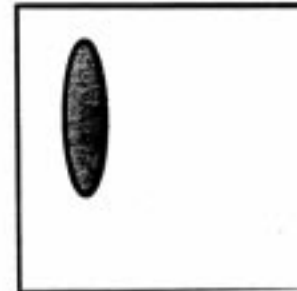
**2.5.0 Ideal**  
"Heel-in Scrub"



**2.5.1 Tip Length**  
"Short"



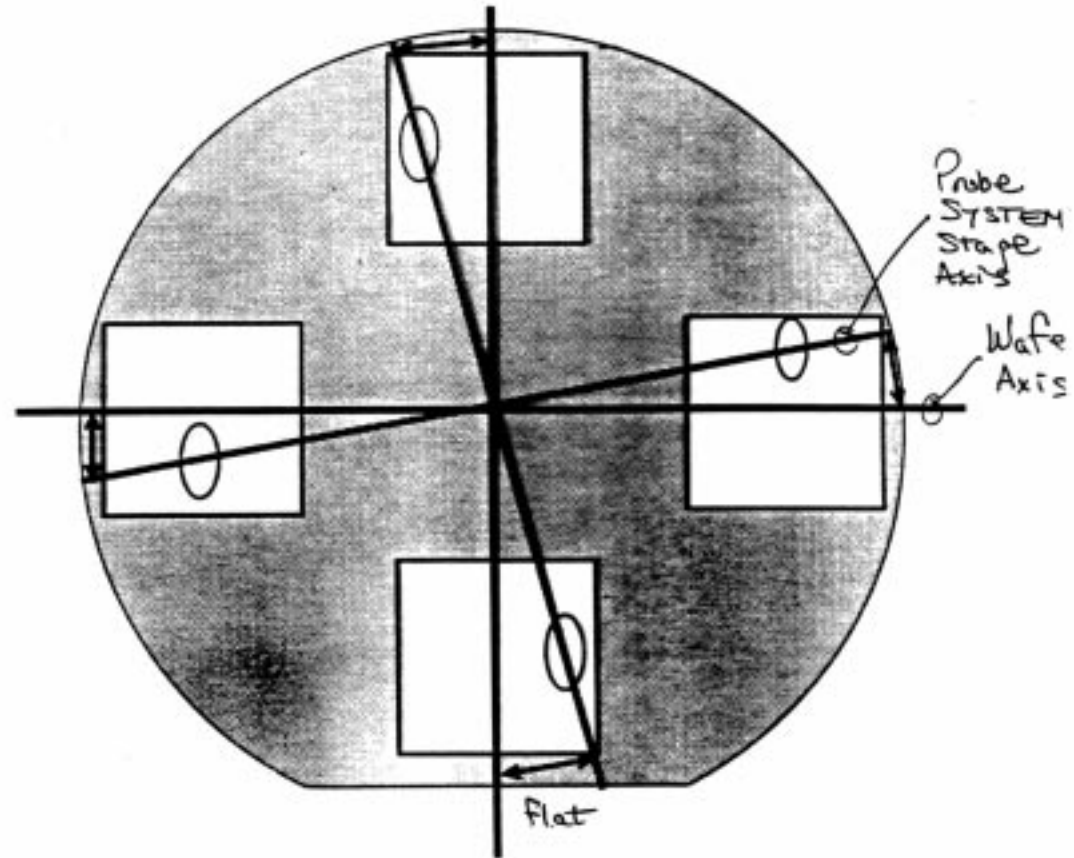
**2.5.2 Tip Angle**  
"Lateral Tilt"





# Probe System Factors

## 3.1 Wafer Theta - Auto Align

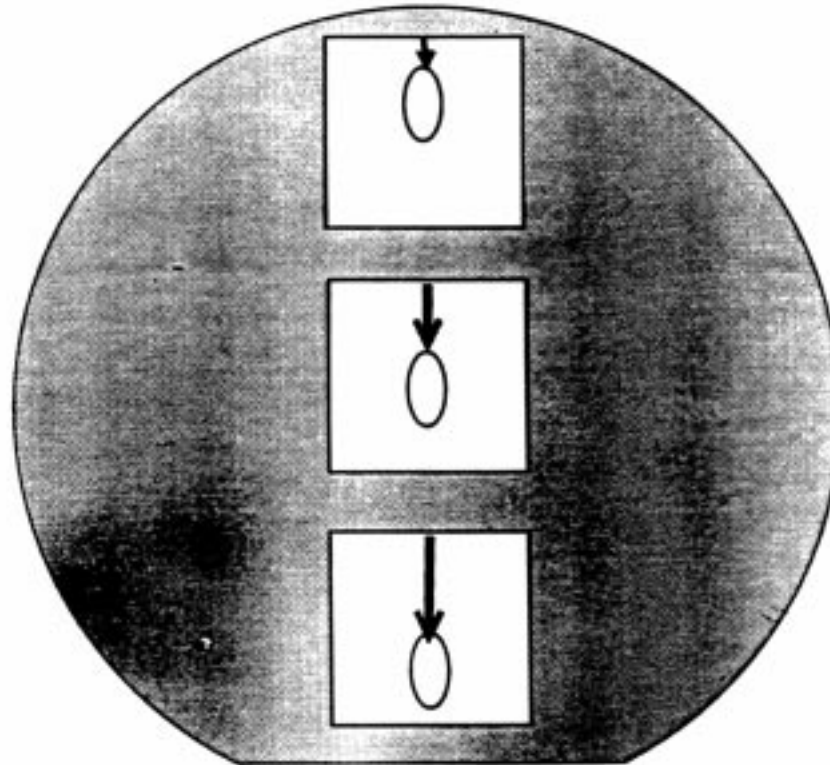






# Probe System Factors

## 3.2 XY Shift

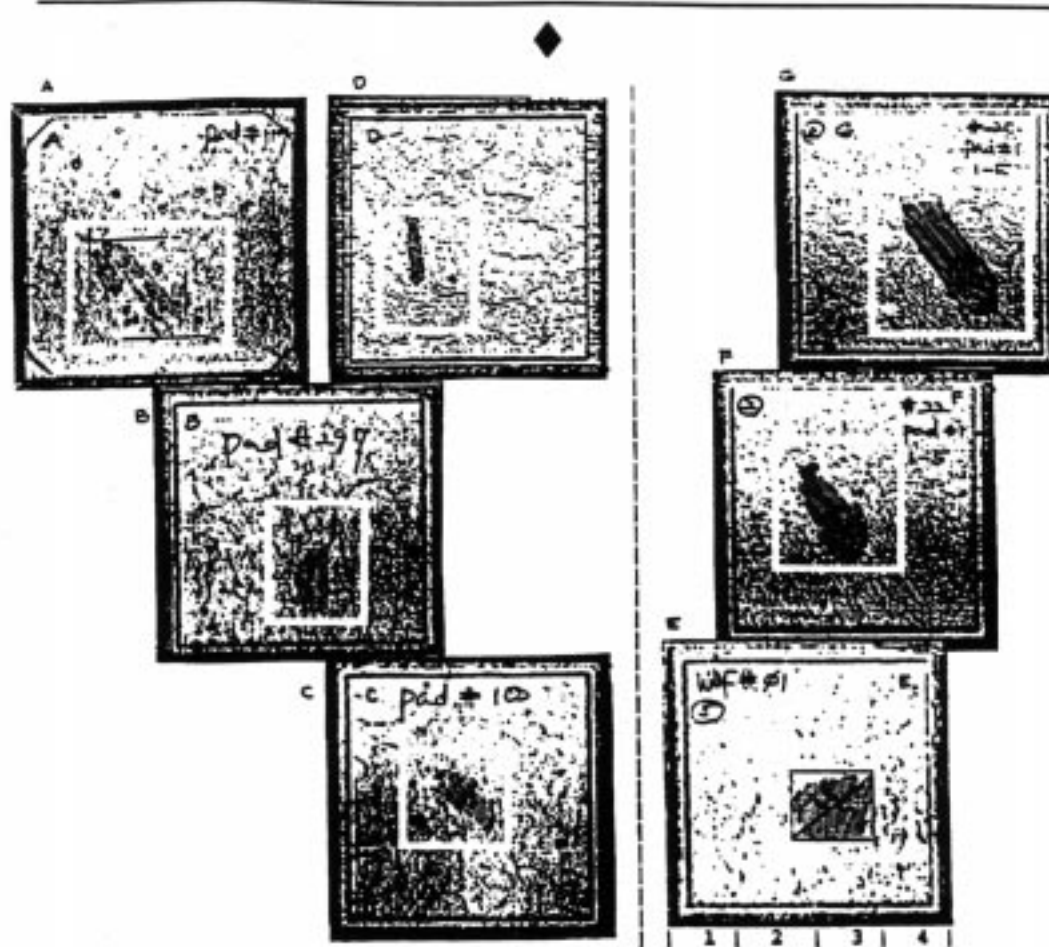


FLAT



## Probe System Factors

| Factor                                    | Process Tolerance                    | Measurement Method  | Symptom                             | Corrective Action                               |
|---|--------------------------------------|---|-------------------------------------|---|
| 3.0 TIR<br><i>total indicated reading</i> | +/- .05 mil, or<br>12 microns        | Same/ fixed/ or<br>matched pad<br>Start-of-Scrub X, Y<br>Gap Delta                                    | Scrub<br>offsets                    | As below  |
| 3.1 Auto Align<br>Wafer<br>Theta          | < 0.5 mil, 12 um<br>< +/- 0.005 deg. | Same/ fixed/ or<br>matched pad<br>Start-of-Scrub Y<br>Gap Delta across<br>wafer row or X Gap<br>Delta | Scrub<br>offsets<br>both X and<br>Y | Retrain target<br>re-cal camera<br>re-cal light |
| 3.2 XY Shift                              | < +/- 0.5 mil,<br>12 um              | Start-of-Scrub Gap<br>Uniformity Down<br>wafer Col.   | X Shift<br>Y Shift                  | Offset XY setup<br>PM EG                        |



### Scrub Mark Symptom

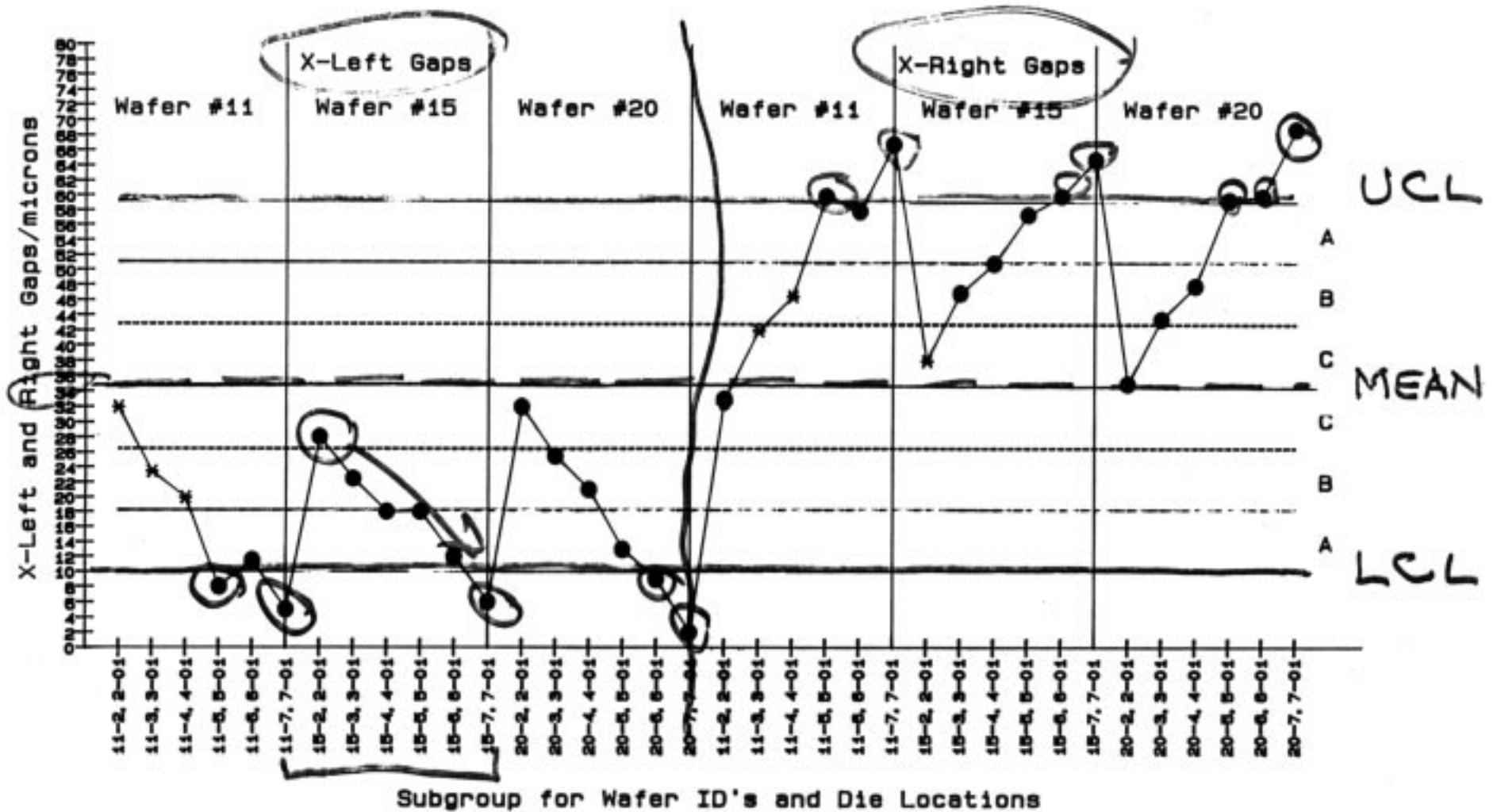
Defect: Figures a,b,c,d

- o Scrub length less than 1/4 pad width as in figures B, C
- o Scrub width less than 1/4 nominal pass width as in figure D
- o Scrub depth particle peak skimming as in figure A

Normal: Figures e,f,g

- o Scrub length equal or greater than 1/4 pad width
- o Scrub width nominal as illustrated
- o Scrub depth nominal with streak-in to pad metal as illustrated

TM18 Prober Diagonal Dice X-Left and Right Gaps Measurements  
 from Lot #J003-38-11, 15, 20 (3 wafers 18 upper left pad)



Out of Control Subgroups (RULE) 4 (-1) 5 (-2) 6 (-1) 7 (-5) 8 (-3) 9 (-3) 10 (-2)  
 11 (-2) 12 (-1) 13 (-5) 14 (-3) 15 (-3) 16 (-3) 17 (-1) 18 (-1) 19 (-5) 22 (1) 23 (2)  
 24 (1) 26 (3) 27 (3) 28 (3) 29 (1) 30 (1) 31 (5) 32 (3) 33 (3) 34 (1) 35 (1) 36 (1)