IEEE SW Test Workshop
Semiconductor Wafer Test Workshop

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VFPP-Very Fine Pitch 60µm Probe Card Technology Optimization

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June 8-11, 2008
San Diego, CA USA

AGENDA

- **INTRODUCTION**
- **DOE OVERVIEW**
  - DOE Variables / Data Sets
  - Lifetime Model Projections
  - Test Flow Configurations
- **PROBE STATISTICAL ANALYSIS**
  - Yield
  - Re-probe Rate
  - Mechanical
  - Electrical
  - Stepping-Off
- **RISK SUMMARY**
- **CONCLUSION**

INTRODUCTION

- Present VFPP (Very Fine Pitch Probe) Card Lifetimes currently ~ 525000 TDs; however, extending the lifetime would further reduce the overall cost of test.

- In addition, stepping-off the wafer would also significantly reduce the test time as compared to conventional vertical technology currently limited to stepping within the wafer.

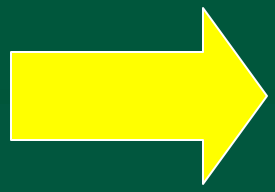
- As a result, a multi-legged DOE was designed to determine if the lifetime could be extended by optimizing the cleaning recipes and in-parallel, step-off the wafer without detrimentally affecting the probe card electrical and mechanical performance.

DOE VARIABLES

DOE was based in terms of the following Input /Output variables

INPUT VARIABLES:

- #PTds (probe touchdowns) between cleans ↑
- #CTds (cleaning touchdowns) ↓
- Stepping-On / Off Wafer
- 2 Probe Cards
- 2 VLCTs Test Cells



OUTPUT VARIABLES:

- CRes
- Yield
- Re-Probe Rate
- Planarity
- Alignment
- Tip Diameter
- TPT

DATA SETS: 2 Baseline and 3 DOE LEGS

- **Baseline Data Set**
  - BL 40_8 (40 Probe Td with 8 Clean Td)
    - Old baseline since initial release to production environment. Step within wafer.
  - BL 40_6 (40 Probe Td with 6 Clean Td)
    - New baseline release since Early November 2007 to ADT-TW. Step-On or within wafer.
- **DOE 3A, 3B, and 3C**
  - DOE3A
    - 40 Probe Td with 6 Clean Td and Step-Off Wafer
  - DOE3B
    - 45 Probe Td with 6 Clean Td and Step Off Wafer
  - DOE3C
    - 45 Probe Td with 4 Clean Td and Step Off Wafer

Lifetime Model-Calculation Chart

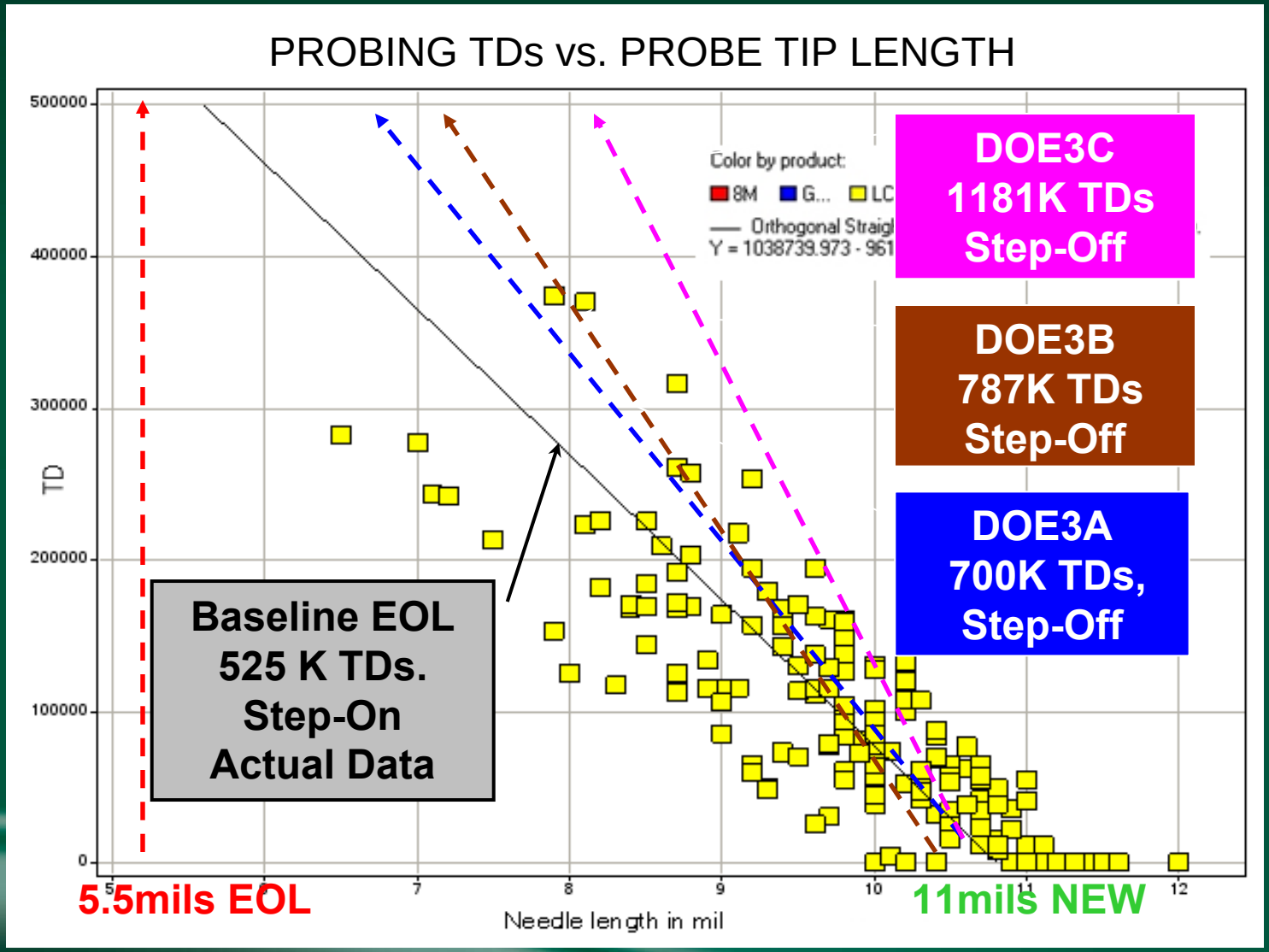
CTd	0.001330	Cleaning accounts for 99.9% of tip wear										
PTd	0.000001	Probing has insignificant impact on wear										
	BASELINE			DOE3A			DOE3B			DOE3C		
	PTd	CTd	TLR (um)	PTd	CTd	TLR (um)	PTd	CTd	TLR (um)	PTd	CTd	TLR (um)
	40	8	0.0107	40	6	0.0080	45	6	0.0080	45	4	0.0000
	80	16	0.0214	80	12	0.0160	90	12	0.0160	90	8	0.0001
	120	24	0.0320	120	18	0.0240	135	18	0.0241	135	12	0.0001
	:	:	:	:	:	:	:	:	:	:	:	:
Est EOL	525,000	105,000	140.1	700,000	105,000	140.3	787,500	105,000	140.35	1,181,250	105,000	140.70
Est Cycle		13,125			17,500			17,500			26,250	
DOE LEGS												

Probe T/d	Clean T/d	Step-Off Wafer	EOL t/d	Comment
40	8	No	525,000	Previous baseline
40	6	No	700,000	Current setup since Early Nov 2007
40	6	Yes	700,000	Stepping efficency increase
45	6	Yes	787,500	Min Objective
45	4	Yes	1,181,250	Target Objective

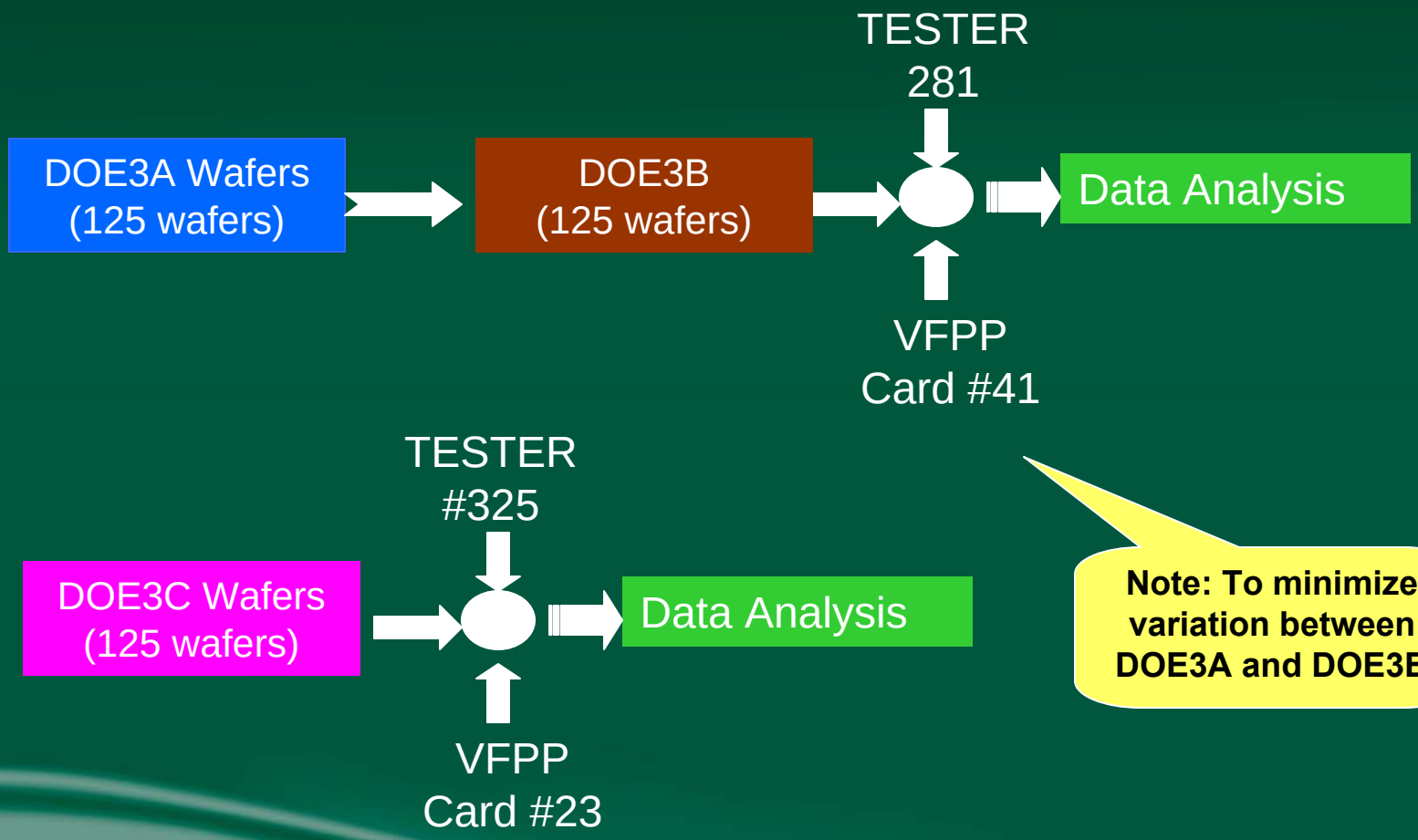
Cleaning accounts for 99.9 % of probe tip wear.

Probing on Al pads has basically no impact on probe tip wear.

Actual & Projected Lifetimes:



TEST FLOW CONFIGURATIONS



STATISTICAL ANALYSIS

Tukey-Kramer Method Used:

- In the Tukey-Kramer method, the minimum significant difference (MSD) is calculated for each pair of means. If the observed difference between a pair of means is greater than the MSD, the pair of means is significantly different.

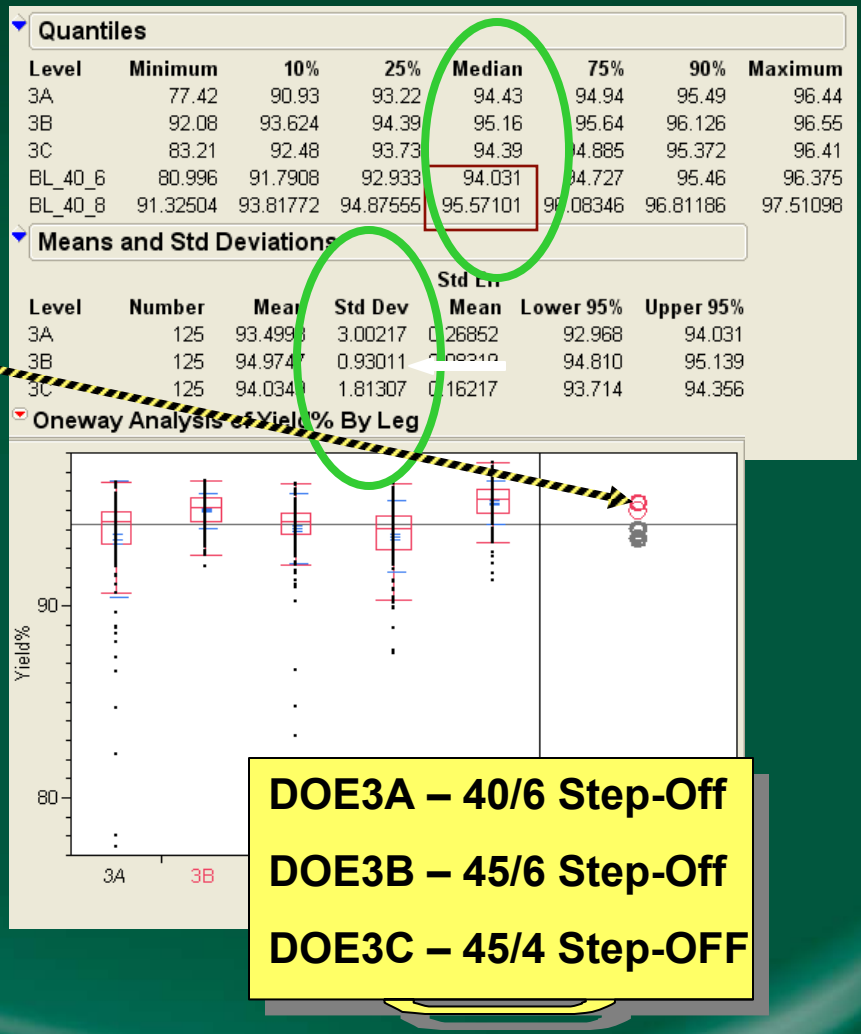
- The Tukey-Kramer technique is to find all the sets of groups whose means do not differ significantly from each other.

Reference:

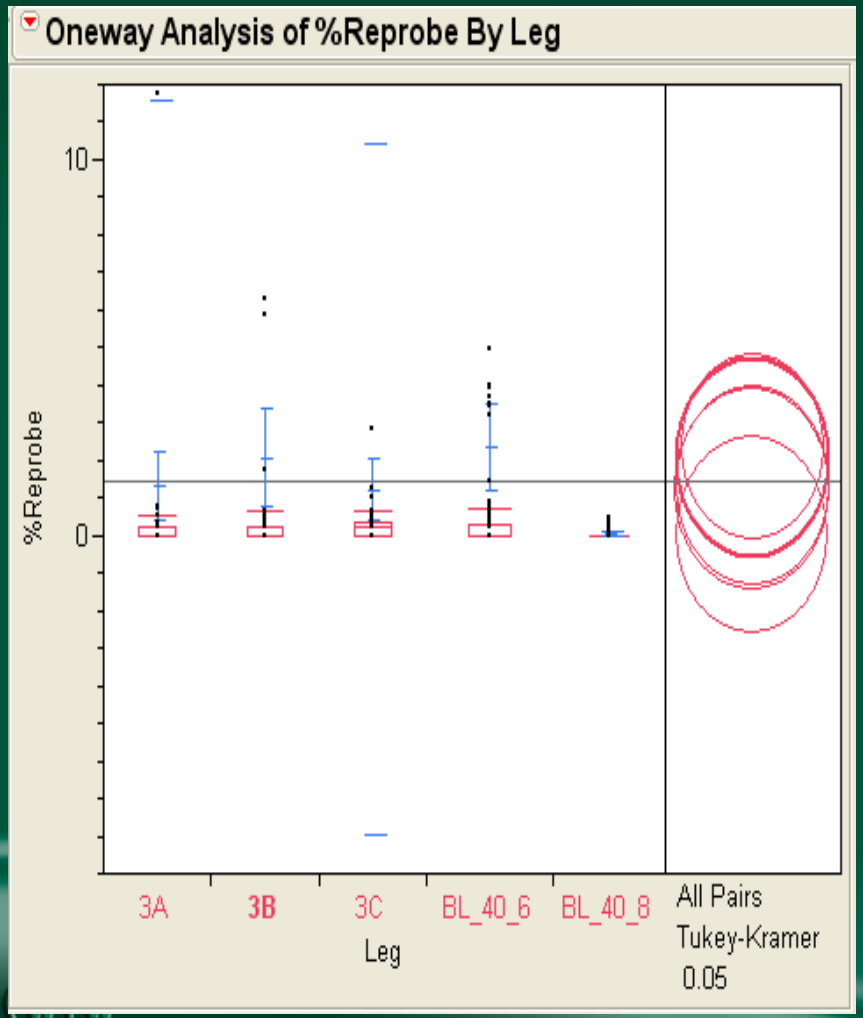
Handbook of Biological Statistics:
(http://udel.edu/~mcdonald/statanovaunplanned.html)

Yield Comparison For All Three DOE's

- Some wafers used in DOE3B were fab engr lots (EBxxx). ADT-TW were told not to use these wafers moving forward.
- **DOE3B shows identical average yield with BL_40_8 (BL=Baseline)**
- DOE3A and DOE3C shows statistically insignificant difference in average yield with BL_40_6
- All DOE Legs shows variation of median within 1.5% tolerance band (Baseline variation).
- **Stdev of yield variation is tightest from DOE3B (45/6 Step Off)**



Immediate Re-probe% Comparison



Immediate re-probe distribution shows that all Legs have statistically insignificant differences in distribution.

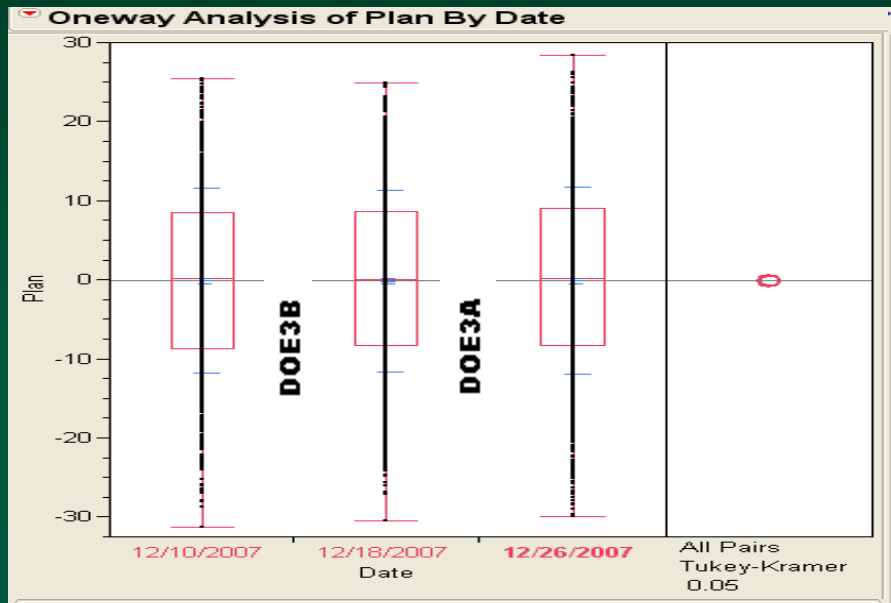
Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
3A	0	0	0	0	0.21	0.29	112.66
3B	0	0	0	0	0.25	0.446	128.08
3C	0	0	0	0.21	0.34	0.446	100
BL_40_6	0	0	0	0	0.29	0.84	100.58
BL_40_8	0	0	0	0	0	0.065886	0.439239

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
3A	125	1.31624	10.2881	0.9202	-0.5051	3.1376
3B	125	2.06176	14.4681	1.2941	-0.4996	4.6231
3C	125	1.22280	9.2045	0.8233	-0.4067	2.8523
BL_40_6	147	2.35830	14.0631	1.1599	0.0659	4.6507
BL_40_8	130	0.01886	0.0659	0.0058	0.0074	0.0303

Mechanical Planarity & Tip Diameter

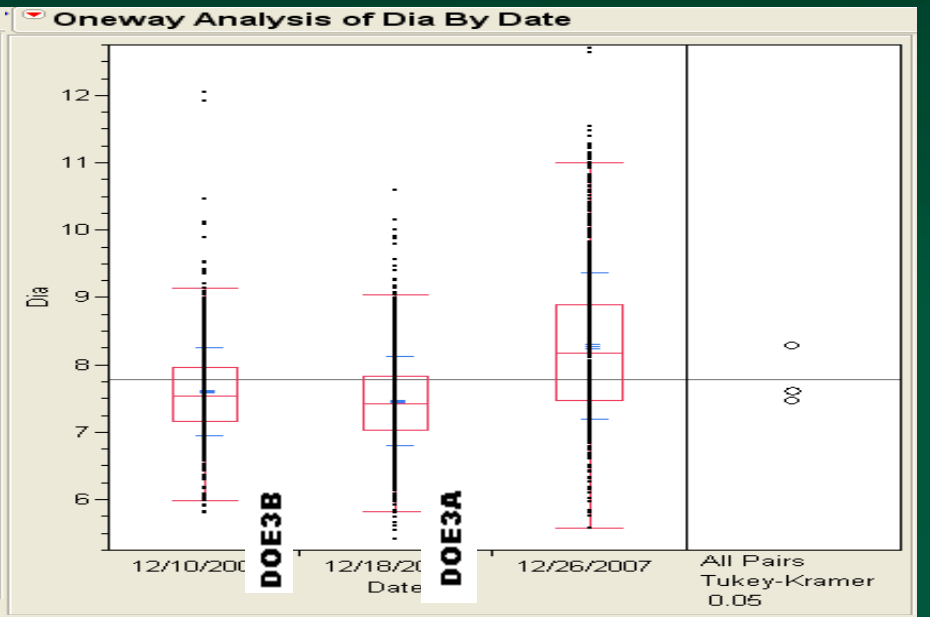


Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
12/10/2007	-31.2604	-16.6141	-8.665	0.1212	8.50465	14.945	25.4814
12/18/2007	-30.4444	-16.3642	-8.33065	0.0479	8.6697	14.57256	24.8476
12/26/2007	-29.9389	-16.6594	-8.3425	0.1527	9.0987	15.11121	28.4241

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
12/10/2007	1121	-0.12273	11.6847	0.34899	-0.8075	0.56202
12/18/2007	1125	-0.19982	11.5051	0.34302	-0.8728	0.47320
12/26/2007	1138	-0.13352	11.8516	0.35132	-0.8228	0.55579



Quantiles

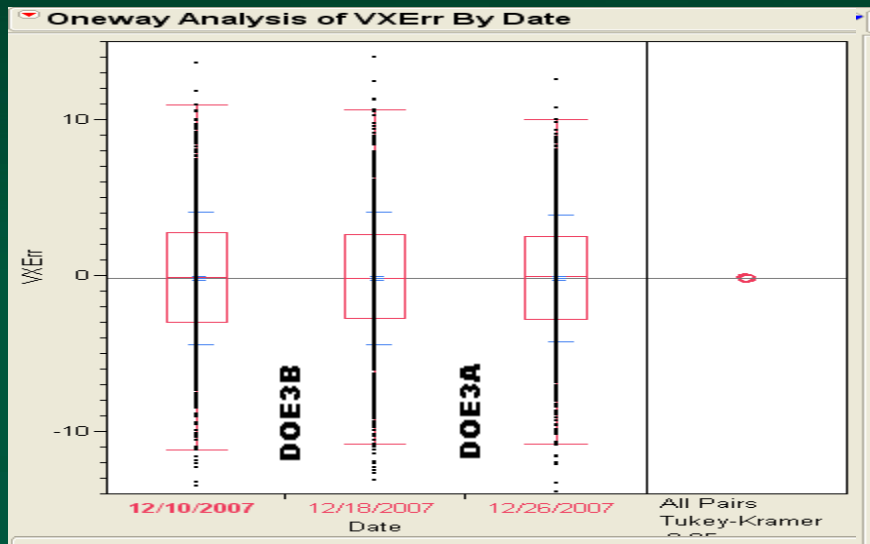
Level	Minimum	10%	25%	Median	75%	90%	Maximum
12/10/2007	5.8127	6.9098	7.1635	7.5432	7.9652	8.43222	12.0493
12/18/2007	5.4095	6.68848	7.03345	7.419	7.8372	8.3016	10.5867
12/26/2007	5.5761	7.02735	7.471875	8.1778	8.895475	9.7476	12.7022

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
12/10/2007	1121	7.60267	0.65301	0.01950	7.5644	7.6409
12/18/2007	1125	7.45999	0.66492	0.01982	7.4211	7.4989
12/26/2007	1138	8.27766	1.08254	0.03209	8.2147	8.3406

No statistical difference in planarity observed. Tip diameter well within specification.

Mechanical Alignment

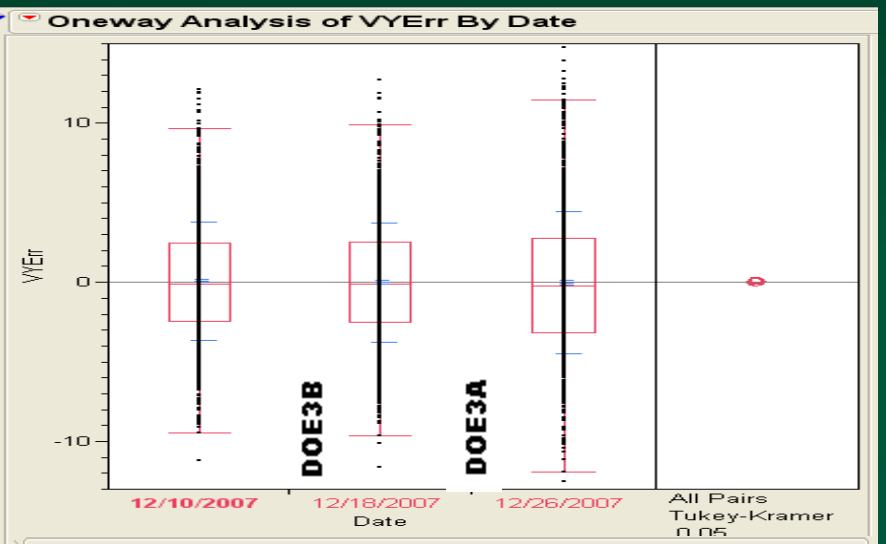


Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
12/10/2007	-13.4713	-5.93088	-2.98575	-0.0995	2.7571	5.25544	13.6209
12/18/2007	-13.135	-5.7814	-2.773	-0.2004	2.61105	5.16012	14.0015
12/26/2007	-13.8505	-5.595	-2.83743	-0.03345	2.5281	4.89677	12.5426

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
12/10/2007	1121	-0.19259	4.27584	0.12771	-0.4432	0.05798
12/18/2007	1125	-0.19945	4.23959	0.12640	-0.4475	0.04856
12/26/2007	1138	-0.17647	4.06899	0.12062	-0.4131	0.06019



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
12/10/2007	-11.1729	-4.59308	-2.44275	-0.1381	2.482	5.02124	12.1389
12/18/2007	-11.6287	-4.65598	-2.53215	-0.1299	2.50945	4.9964	12.7401
12/26/2007	-12.5199	-5.70856	-3.15795	-0.2107	2.7644	5.86182	14.7748

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
12/10/2007	1121	0.09501	3.71301	0.11090	-0.1226	0.31260
12/18/2007	1125	0.00359	3.75418	0.11193	-0.2160	0.22320
12/26/2007	1138	-0.02434	4.48147	0.13285	-0.2850	0.23632

No statistical difference in probe tip alignment.

Stepping-Off Wafer Efficiency*

step off wafer step count =	377	
average one wafer test time =	72.78515896	min
no step off wafer step count =	405	
average one wafer test time =	77.93346236	min
step gain % = (405-377)/405	6.913580247	
test time gain % = (77.9-72.70)/77.9	6.675224647	

*** Does Not Include Clean or Indexing Time**

Approximately a 7 % gain in TPT-test performance throughput is gained by stepping-off the wafer for this particular device.

Electrical Analysis Summary

	CPK					Control Limits (Ohms)	
Parameter	**BL_40_8**	**BL_40_6**	**DOE3A**	**DOE3B**	**DOE3C**	**USL**	**LSL**
Probe Card ID	All	All	41	41	23	NA	NA
Probe Td	40	40	40	45	45	NA	NA
Clean Td	8	6	6	6	4	NA	NA
Wafer Stepping	ON	ON	OFF	OFF	OFF	NA	NA
Calc EOL	**525k**	**700k**	**700k**	**787k**	**1,181k**	NA	NA
Yield (Stdev)	**1.15%**	**1.88%**	**3.00%**	**0.93%**	**1.81%**	NA	NA
Yield (Median)	**95.57%**	**94.03%**	**94.43%**	**95.16%**	**94.39%**	99.02%	92.12%
CresMax_1	**4.04**	**2.39**	**4.50**	**3.83**	**1.86**	0.00	15.00
CresMax_2	**1.61**	**3.11**	**2.63**	**3.27**	**2.75**	0.00	25.00
CresMax_3	**3.11**	**2.05**	**3.49**	**3.32**	**1.58**	0.00	15.00
CresMax_4	**3.43**	**2.62**	**1.57**	**4.43**	**2.29**	0.00	20.00
CresMax_5	**2.77**	**1.81**	**2.20**	**3.72**	**2.05**	0.00	15.00
CresLDO_A	**1.69**	**1.96**	**1.71**	**1.20**	**1.09**	0.00	10.00
CresLDO_APC	**3.05**	**8.19**	**4.92**	**2.91**	**4.78**	0.00	10.00
CresLDO_OSC	**1.11**	**0.93**	**0.94**	**1.00**	**1.00**	0.00	10.00
CresLDO_RF	**54.87**	**7.14**	**13.01**	**11.05**	**15.87**	0.00	10.00
CresLDO_X	**1.94**	**3.23**	**2.03**	**2.08**	**3.66**	0.00	10.00
% Cpk>1.33	**90%**	**90%**	**90%**	**80%**	**80%**		
% Cpk<1.33	**10%**	**10%**	**10%**	**20%**	**20%**		
Total# of param	10	10	10	10	10		

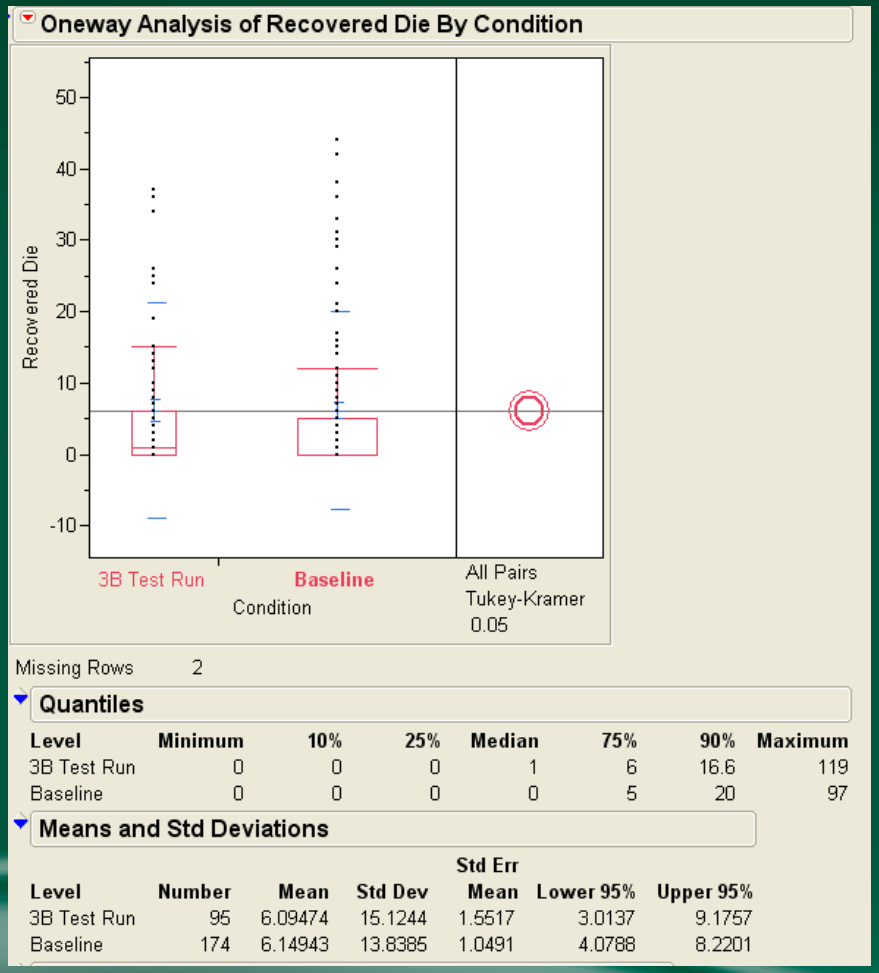
RISK SUMMARY

DOE Leg	Probe T/d	Clean T/d	StepOff wafer	EOL t/d	Comment	Status
Baseline	40	8	No	525,000	Previous baseline	Baseline
Baseline	40	6	No	700,000	Current setup since Early Nov 2007	Baseline
DOE 3A	40	6	Yes	700,000	Stepping efficency increase	DOE 3A
DOE 3B	45	6	Yes	787,500	Minimum Objective	DOE 3B
DOE 3C	45	4	Yes	1,181,250	Target Objective	DOE 3C

DOE 3B was considered pushing the envelope, only because of one marginal parameter (Cpk~1.20), thus risk considered acceptable to proceed to high volume production evaluation.

DOE 3C was not considered viable.

DOE3B Production Test High Volume Validation Run



Missing Rows 2

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
3B Test Run	0	0	0	1	6	16.6	119
Baseline	0	0	0	0	5	20	97

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
3B Test Run	95	6.09474	15.1244	1.5517	3.0137	9.1757
Baseline	174	6.14943	13.8385	1.0491	4.0788	8.2201

- The amount of immediate re-probe dies were statistically insignificant between the two populations
- The yield recovery from immediate re-probe werestatistically insignificant
- No other abnormality were observed during the 5 weeks of test run
- All characterized electrical parameters are not significantly different among the two populations.

DATA-DRIVEN CONCLUSION

DOE 3B recipe to deploy to all world wide TI internal and external test floors in a controlled manner (device per device) to ensure no device dependant anomalies occur due to the new cleaning protocols or from stepping-off the wafer.

ACKNOWLEDGEMENTS

- Al Wegleitner
- Dave Reed
- Pedro Cabezas
- Donny Stanton
- CK Hsu
- Frank Mui
- Mira Huang
- Gwen Gerard

AND

Micronics Japan Incorporated

Ardentec Test LLC