Optimizing Test Cell Performance

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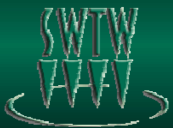
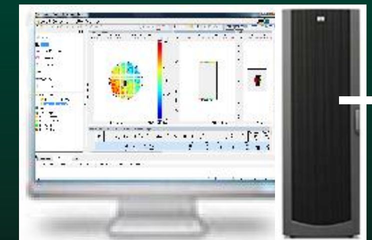


Problem Statement

- **How are we going to optimize Test Cell performance?**
  - Investigate Prober performance
  - Investigate Probe Card performance
  - Investigate Probe Card Analyzer correlation to Test Cell

Design Of Experiment

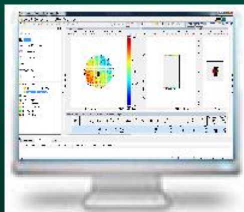
- **Pass1**
  - Measure/Adjust probe card on PrecisionPoint® VX3
  - Probe wafers
  - Inspect probe marks with NSX® after probing
  - Measure Probing Process performance with WaferWoRx® on NSX
  - Compute VX3 correlation to scrub marks



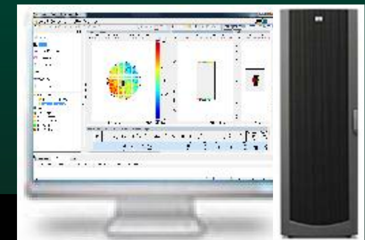
PMI data

Design Of Experiment

- **Pass2**
  - Adjust Probe Card on PrecisionWoRx® VX4 using *"Predictive Scrub"*
  - Probe wafers
  - Inspect probe marks with NSX after probing
  - Measure Probing Process performance improvements with WaferWoRx on NSX



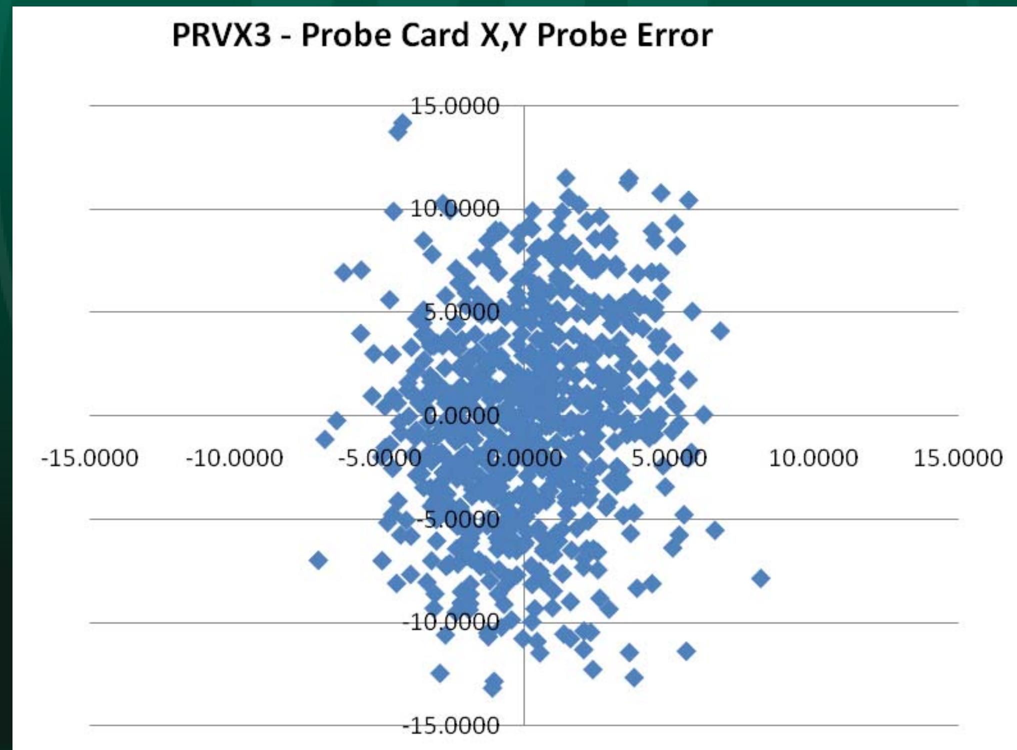
Pass1 WWX info



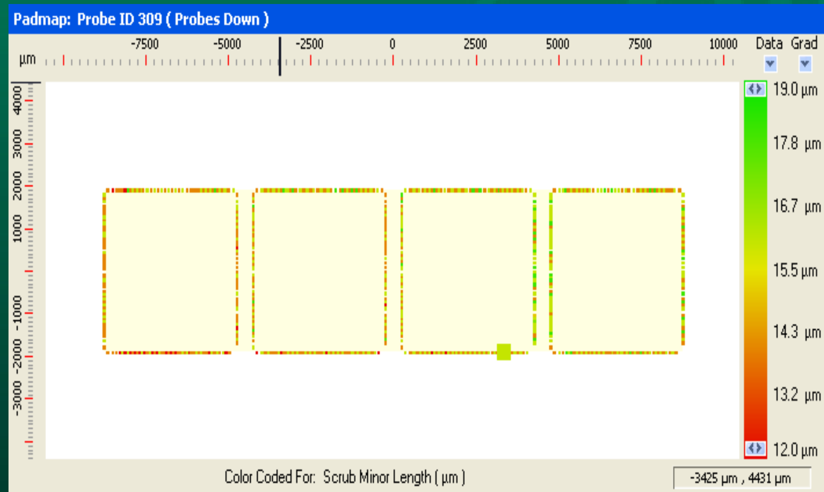
PMI data

Pass1: Measure/Adjust probe card on VX3

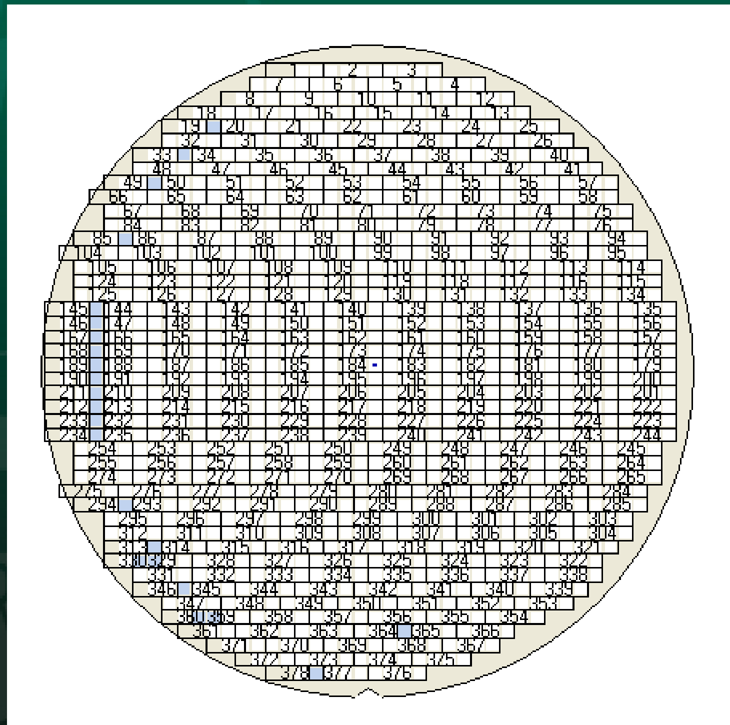
- VX3 data shows probe's center of scrub is within spec and nominally centered on the pad



Pass1: Probe Wafers



- 200mm wafer
- 378 Touchdowns



- Cantilever probe card (4 X 1)
- 700+ probes
- Two tiers (different tip lengths)[1]

Strom, "Multi-tier Probe Cards and Contact Resistance, SWTW 1998[1]
Strom, A Study of Probing Process Analysis, SWTW 1999[1]

Pass1: PMI Results

Results Table

Group By: None — Asc / Des

	Index	Die Column	Die Row	Die ID	Pad ID	Scrub ID	Probe ID	DUT ID	Scrub X Size (µm)	Scrub Y Size (µm)	Scrub X Pos (µm)	Scrub Y Pos (µm)	Scrub Minor Length (µm)	Scrub Major Length (µm)	Scrub Angle (°)	Scrub Align (µm)	Edge Distance (µm)	Left Distance (µm)	Right Distance (µm)	Top Distance (µm)	Bottom Distance (µm)
1																					
2																					
3																					
4								Not Found	3	3	3	3	3	3	3	3	3	3	3	3	3
5								Min	6.563	3.926	-19.316	-19.086	8.024	12.036	0.000	0.014	0.000	-4.946	-7.021	-6.004	-8.028
6								Max	55.874	53.032	16.205	19.285	48.156	61.597	135.000	20.637	21.042	30.172	40.091	34.896	39.748
7								Average	19.697	20.394	-3.353	0.134	15.516	27.189	51.222	9.108	6.168	14.205	20.910	17.050	17.318
8								Std Deviation	7.197	6.786	5.948	7.259	2.502	4.478	46.628	4.047	4.859	6.539	7.530	7.872	8.272
9	1	0	-1	1	1	1	1	1	12.741	28.631	0.132	8.892	14.042	30.105	90.000	8.893	2.884	22.848	22.585	2.884	20.667
10	2	0	-1	1	2	1	2	1	14.825	26.834	4.052	0.199	16.048	28.098	90.000	4.057	11.472	25.726	17.623	11.472	11.870
11	3	0	-1	1	3	1	3	1	14.562	28.896	-1.080	1.235	16.048	30.105	90.000	1.641	8.401	20.726	22.887	8.401	10.872
12	4	0	-1	1	4	1	4	1	14.222	26.920	-1.819	2.113	16.048	28.098	90.000	2.788	9.514	19.154	22.792	9.514	13.741
13	5	0	-1	1	5	1	5	1	12.569	28.494	3.990	3.932	16.048	30.105	90.000	5.601	9.920	23.783	15.804	9.920	17.783
14	6	0	-1	1	6	1	6	1	15.006	26.433	-0.999	4.049	16.048	28.098	90.000	4.170	10.833	17.577	19.574	10.833	18.931
15	7	0	-1	1	7	1	7	1	13.045	39.419	4.143	4.375	22.072	40.315	45.000	6.025	5.017	22.695	14.410	5.017	13.768
16	8	0	-1	1	8	1	8	1	15.147	24.644	1.984	4.100	16.052	26.127	135.000	4.555	12.680	19.486	15.518	12.680	20.880
17	9	0	-1	1	9	1	9	1	12.859	26.906	-2.059	-0.022	16.048	28.098	90.000	2.059	15.626	17.590	21.707	15.671	15.626
18	10	0	-1	1	10	1	10	1	15.133	27.264	-3.784	15.298	16.048	28.098	90.000	15.759	0.000	16.734	24.301	-2.839	27.757
19	11	0	-1	1	11	1	11	1	21.194	26.709	6.115	1.850	21.870	30.383	45.000	6.389	11.890	24.605	12.375	11.890	15.591
20	12	0	-1	1	12	1	12	1	16.730	27.258	0.874	0.091	18.054	28.098	90.000	0.879	13.375	20.594	18.845	13.375	13.557
21	13	0	-1	1	13	1	13	1	15.158	27.138	-3.872	3.116	16.048	28.098	90.000	4.970	9.406	16.633	24.377	9.406	15.639
22	14	0	-1	1	14	1	14	1	14.986	26.845	-0.733	10.052	16.048	28.098	90.000	10.079	2.617	19.858	21.325	2.617	22.721
23	15	0	-1	1	15	1	15	1	12.907	26.767	-2.715	-1.046	14.042	28.098	90.000	2.910	12.666	18.915	24.346	14.757	12.666
24	16	0	-1	1	16	1	16	1	15.141	24.730	-1.907	6.016	16.048	24.084	90.000	6.311	7.710	18.606	22.421	7.710	19.742
25	17	0	-1	1	17	1	17	1	12.982	31.624	2.073	2.251	14.042	32.112	90.000	3.061	8.028	23.667	19.520	8.028	12.530
26	18	0	-1	1	18	1	18	1	13.019	30.330	1.092	0.134	14.042	32.112	90.000	1.100	11.796	22.667	20.482	11.796	12.063
27	19	0	-1	1	19	1	19	1	12.604	29.175	-0.088	1.025	14.042	30.105	90.000	1.028	12.486	21.694	21.870	12.486	14.535
28	20	0	-1	1	20	1	20	1	14.723	28.875	1.141	5.927	16.048	30.105	90.000	6.035	7.735	22.867	20.584	7.735	19.588
29	21	0	-1	1	21	1	21	1	12.640	33.595	4.218	9.294	14.042	34.120	90.000	10.206	0.000	25.982	17.546	1.003	19.591
30	22	0	-1	1	22	1	22	1	14.941	24.594	-1.824	4.226	16.048	26.091	90.000	4.603	10.572	18.789	22.437	10.572	19.024
31	23	0	-1	1	23	1	23	1	15.037	32.685	-3.132	8.134	16.048	28.098	90.000	8.716	3.622	17.434	23.698	3.622	19.890
32	24	0	-1	1	24	1	24	1	15.358	22.561	0.026	1.982	16.052	24.708	45.000	1.982	14.836	19.428	19.376	14.836	18.799
33	25	0	-1	1	25	1	25	1	12.845	26.919	-4.832	2.059	14.042	28.098	90.000	5.252	12.580	14.824	24.487	12.580	16.697
34	26	0	-1	1	26	1	26	1	16.490	26.679	0.505	10.076	18.054	28.098	90.000	10.088	6.690	20.344	19.335	6.690	26.841
35	27	0	-1	1	27	1	27	1	13.252	28.779	5.066	1.056	14.042	30.105	90.000	5.175	12.653	24.519	14.386	12.653	14.764
36	28	0	-1	1	28	1	28	1	15.200	20.735	-0.108	2.024	16.048	22.077	90.000	2.027	15.707	19.373	19.590	15.707	19.755
37	29	0	-1	1	29	1	29	1	12.962	30.741	-0.094	3.886	16.048	32.112	90.000	3.887	9.845	19.503	19.691	9.845	17.617
38	30	0	-1	1	30	1	30	1	16.431	23.084	-1.866	13.065	18.059	24.708	45.000	13.198	4.495	18.003	21.735	4.495	30.625
39	31	0	-1	1	31	1	31	1	11.675	28.602	-0.027	2.822	14.042	30.105	90.000	2.822	11.979	22.220	22.274	11.979	17.623
40	32	0	-1	1	32	1	32	1	15.004	24.703	-4.164	4.323	16.048	26.091	90.000	6.003	11.424	14.412	22.741	11.424	20.070
41	33	0	-1	1	33	1	33	1	13.593	35.345	-0.907	10.426	26.085	38.896	45.000	10.465	0.000	19.378	21.192	-0.000	20.852
42	34	0	-1	1	34	1	34	1	15.613	28.921	-3.994	11.100	24.708	37.477	45.000	11.796	2.538	17.286	25.275	2.538	24.737

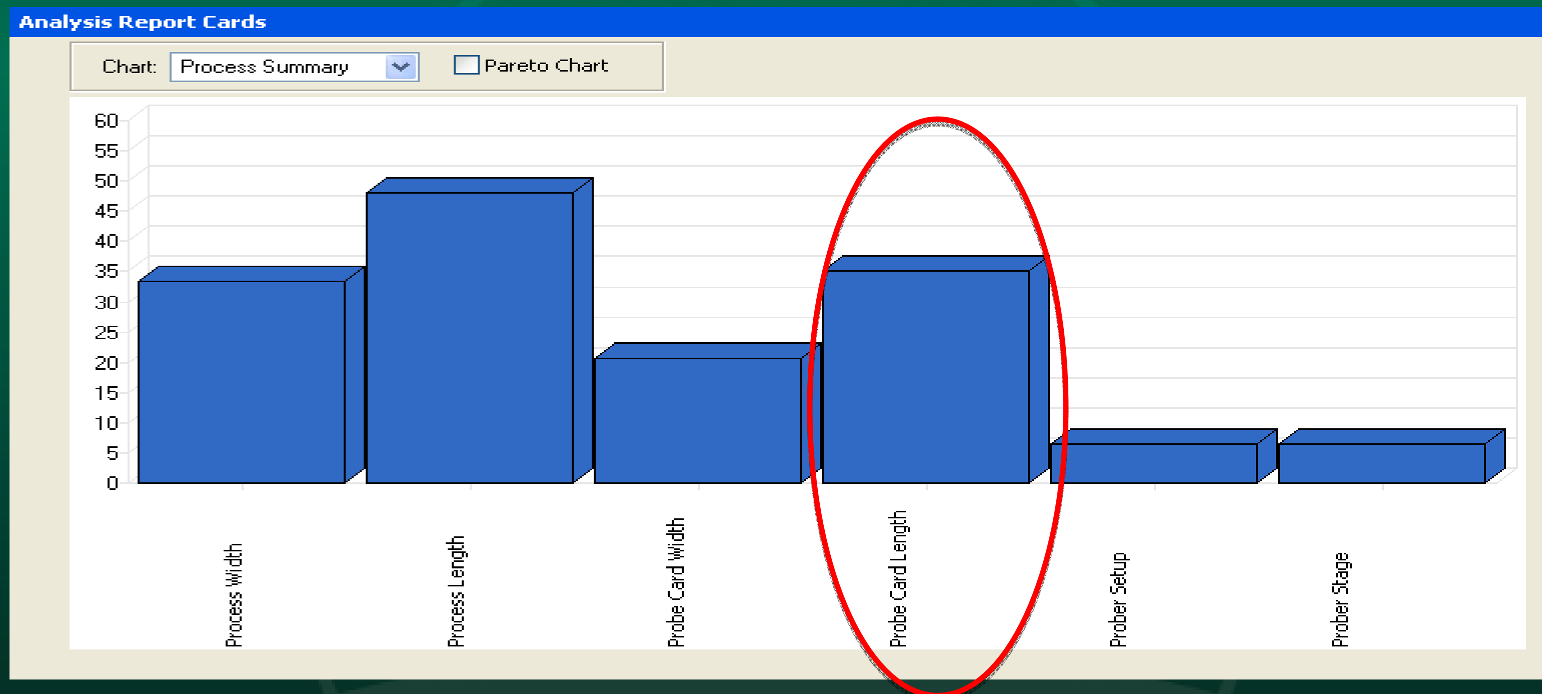
Pass1: Probing Process Analysis Overview

- PMI raw scrub mark data is input
- Prober, Probe to Pad Alignment (PTPA) and Probe Card performance is calculated
- Process performance is determined from combined Prober and Probe Card performance

Raw Scrub Data → Prober and PTPA Performance → Probing Process Performance

Raw Scrub Data → Probe Card Performance → Probing Process Performance

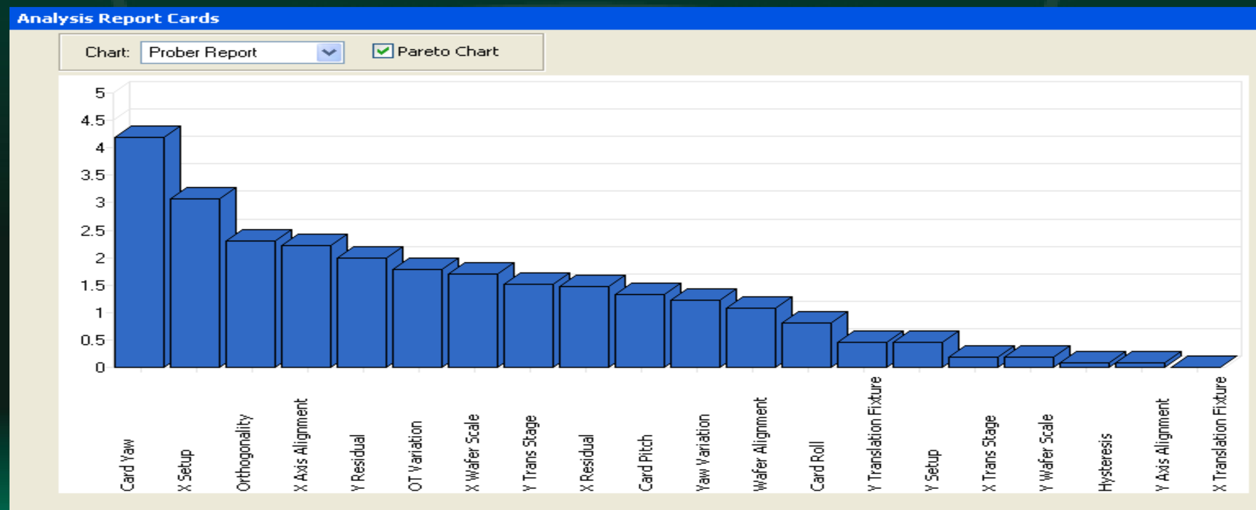
Pass1: Probing Process Performance Summary



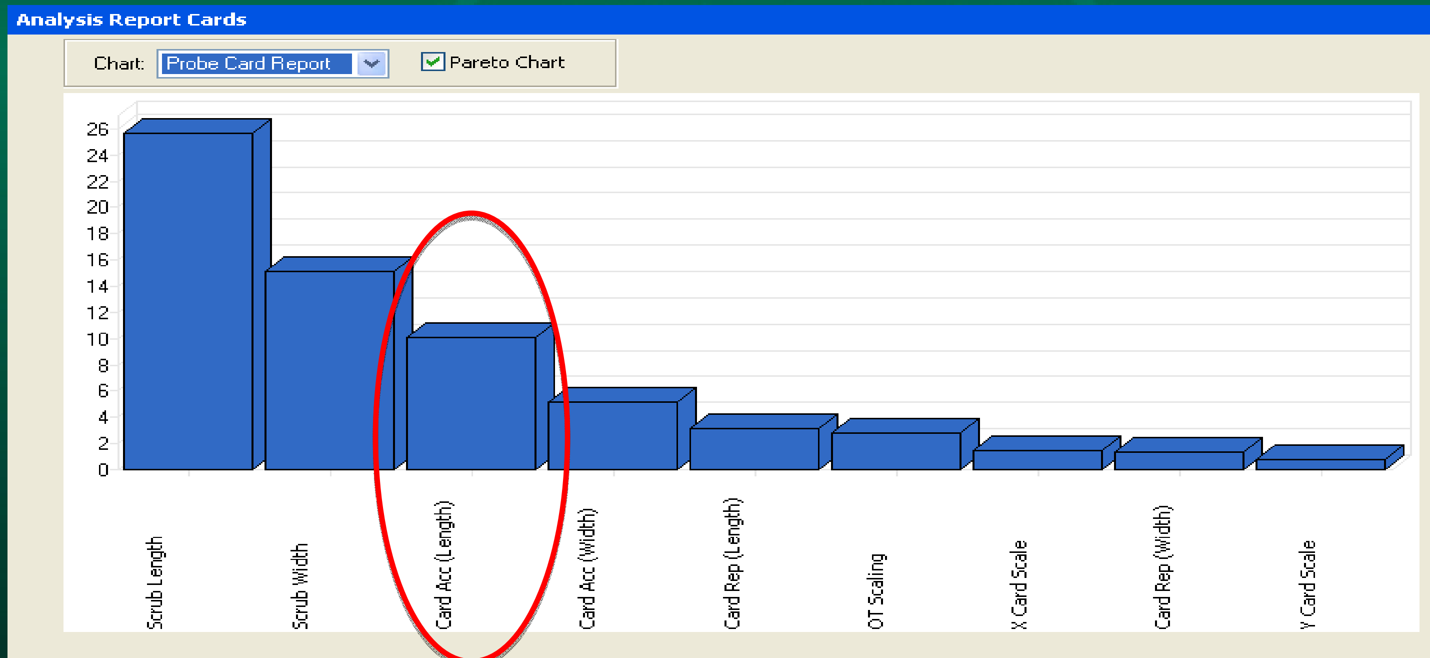
- Process Length issues
  - Pad Size = 60 microns and the Process Length = 48 microns
  - Single Wafer CPK ~ 1.25
- Probe Card is the major error source
- Prober error contribution relatively small compared to Probe Card error

Pass1: Prober Performance Summary

- Overall prober error ~= 12 microns
- Probe to Pad Alignment larger than normal (~5 microns)
- Deflection/Translation under load relatively large for just 800 pins – may be problematic with higher load probe cards
- Small Orthogonality and Scaling errors in stage motion



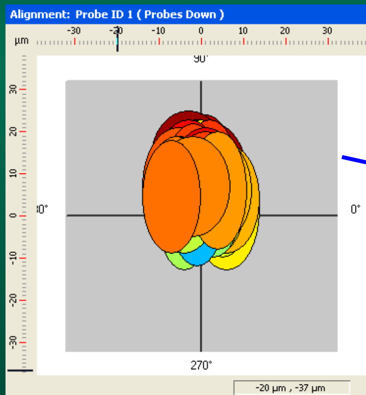
Pass1: Probe Card Performance



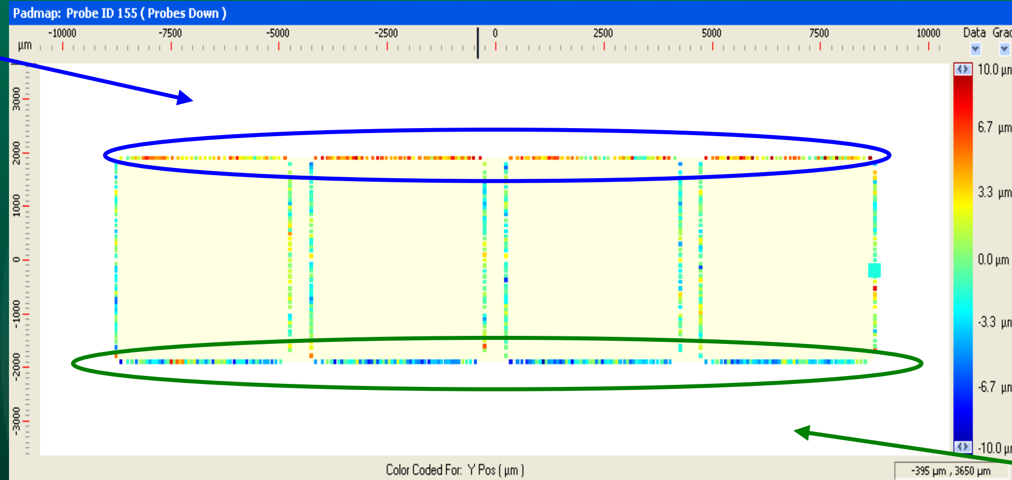
- No XY scaling errors
- Good repeatability
- Scrub Length and Width typical for a cantilever probe card

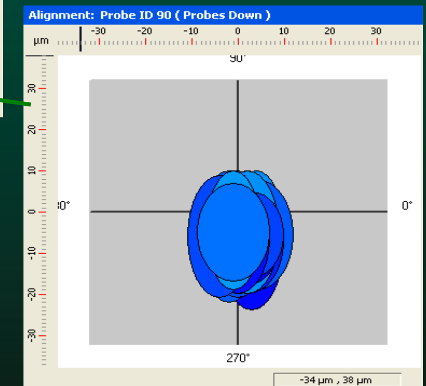
- Probe Card Length Accuracy is the major error source (10 microns)

Pass1: Probe Card SuperPad View



Top row only





Bottom row only

- Probes are scrubbing short of pad center
- Different tiers have different offsets

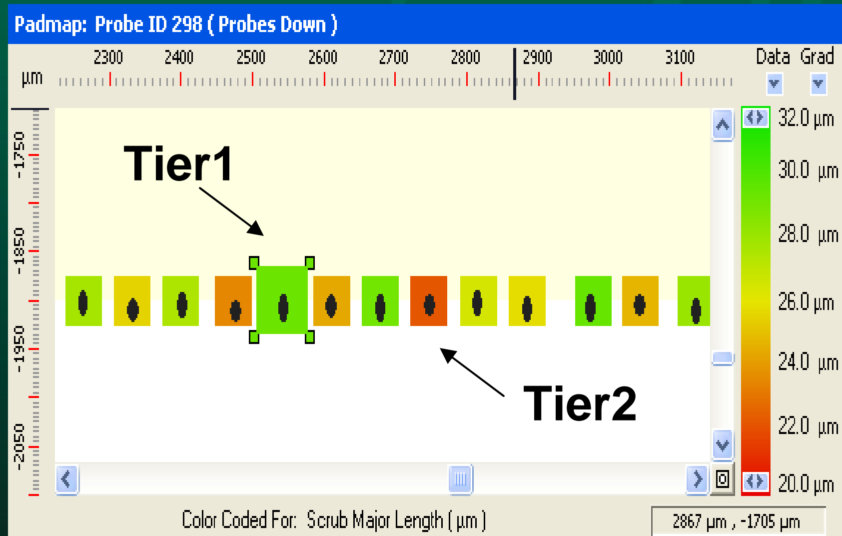
Pass1: Probe Card Vector View Of Alignment Errors

- Probes scrubbing short of the center of the pad
- Tiers have different errors / scrub characteristics

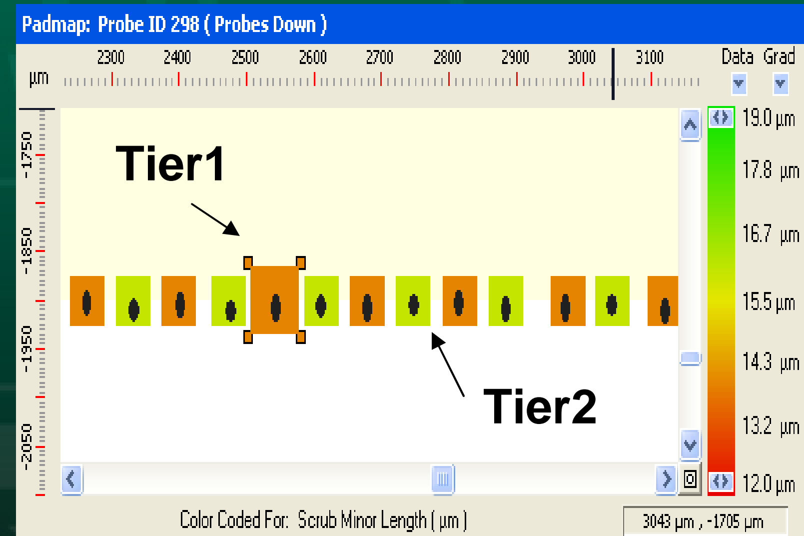
Vector pointing to the right = scrub center is to the right of pad center.

Pass1: Probe Card Scrub Length and Scrub Width

Color Coded for Scrub Length



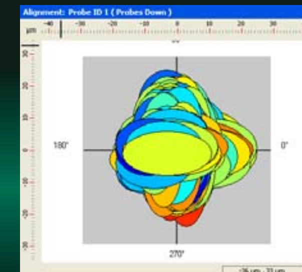
Color Coded for Scrub Width



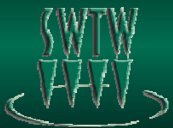
- Interleaved tiers have different scrub characteristics
  - Tier1: Shorter tip lengths = long and thin scrubs
  - Tier2: Longer tip lengths = short and wide scrubs

Pass1: Probe Card Performance Summary

- Pros
  - Probe positions show no XY scaling error
  - Probes positions (scrub marks) are repeatable
- Cons
  - Probes are scrubbing short of the pad center
  - Multiple tiers/tip lengths each have different scrub characteristics
    - Long Tip Length: Short wider scrub
    - Short Tip Length: Long thin scrub
      - Can not resolve by simply changing overtravel
- Probe card performance problems consume major part of pad

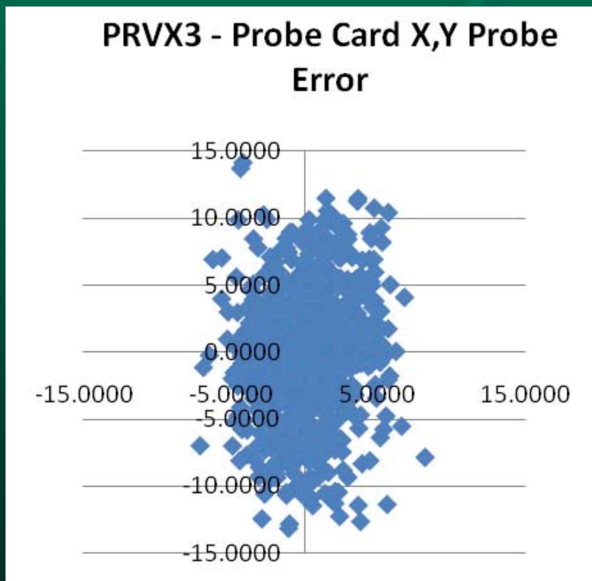


Probe Card Analyzer to Test Cell Correlation Analysis

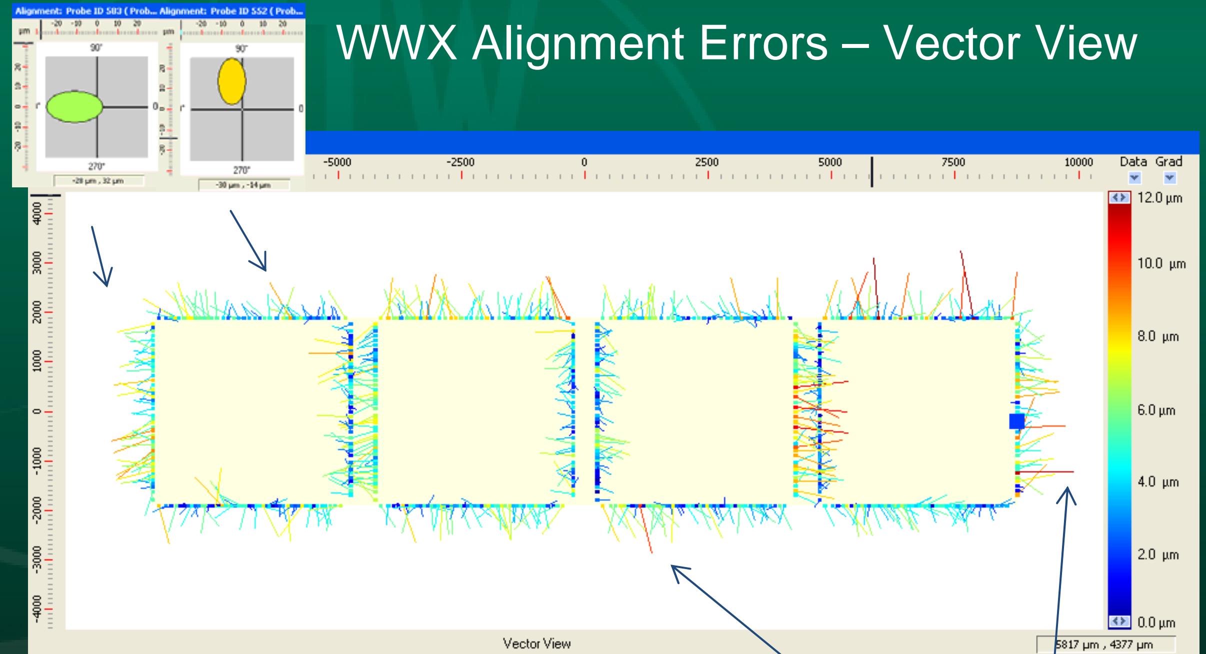


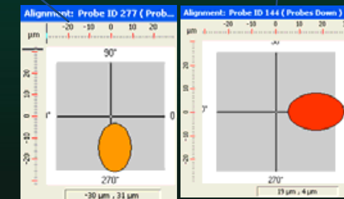
Pass1: Test Cell vs. VX3 Probe Card Correlation

VX3



WWX Alignment Errors – Vector View



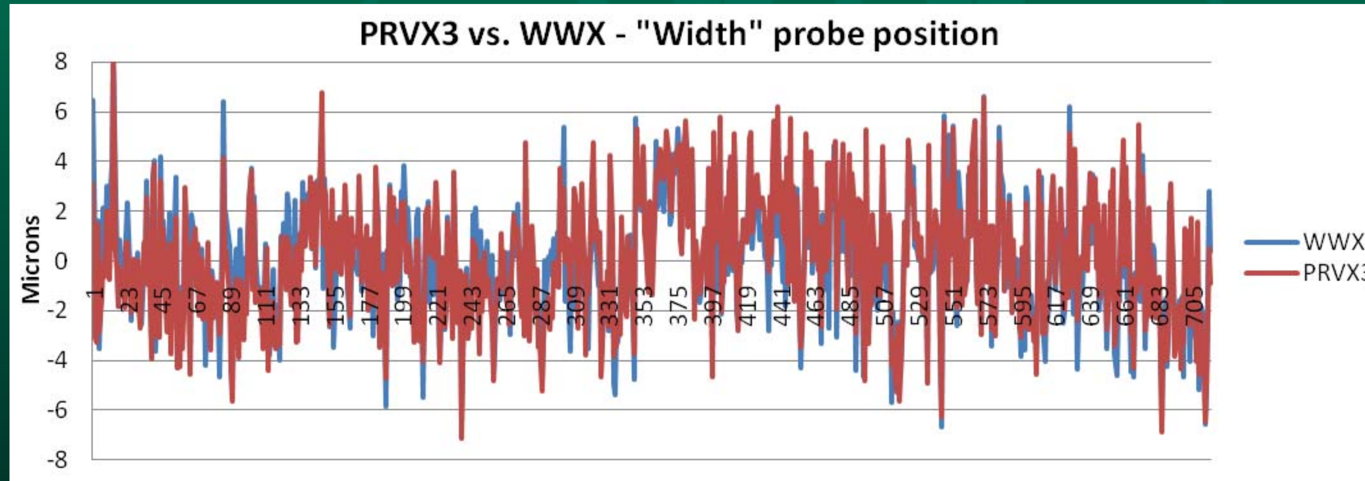


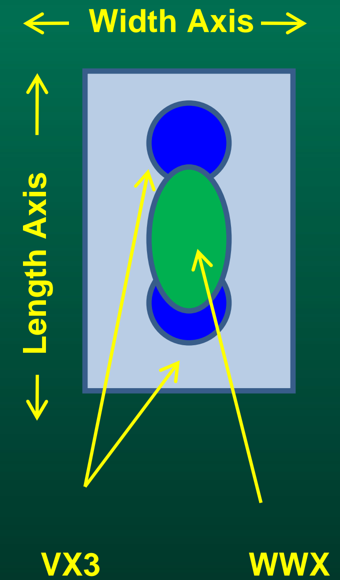
- VX3 measures probe center of scrub ~= center of pad
- WaferWoRx shows probes scrubbing short of pad center

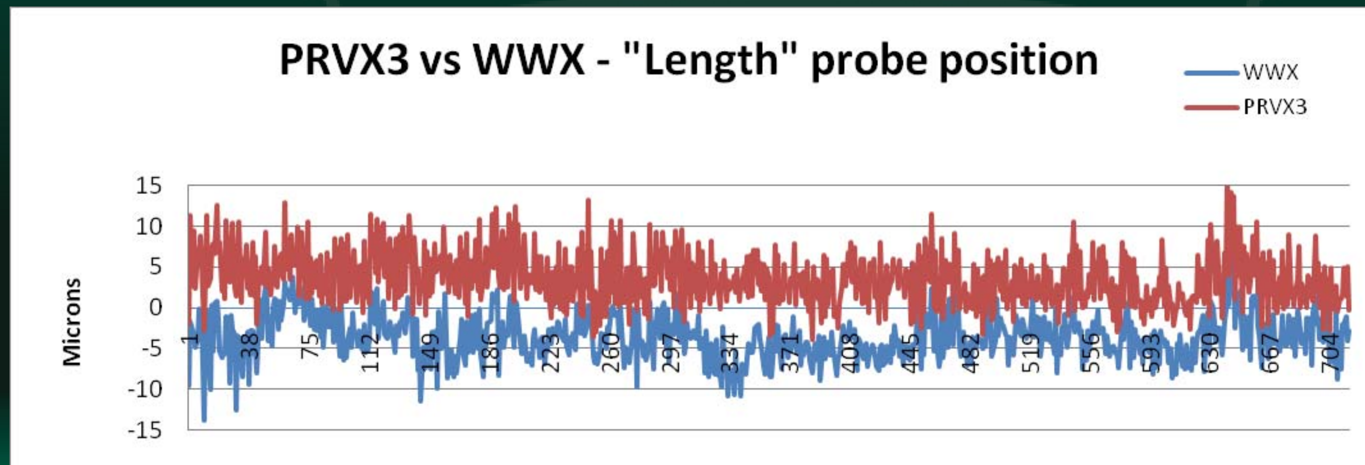
Vector pointing to the right = scrub center is to the right of pad center

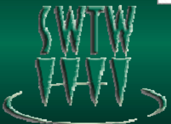
Pass1: Test Cell vs. VX3 Probe Position – Absolute

Probe Relative analysis

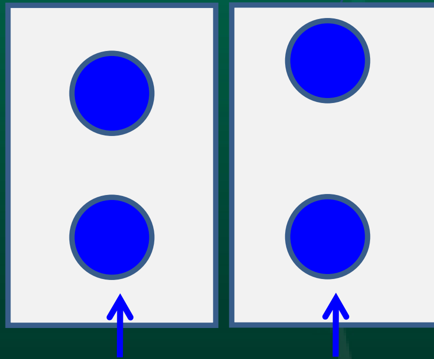


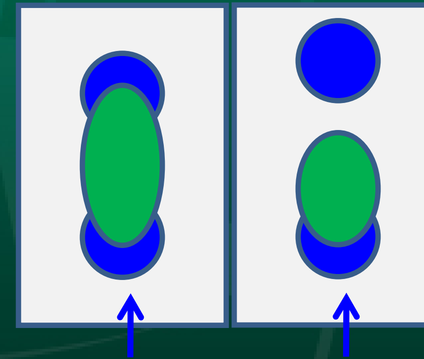






Review Cantilever Probe Scrub Properties on PCA Measurement Window vs. on Bond Pad





PCA Window – Low Friction

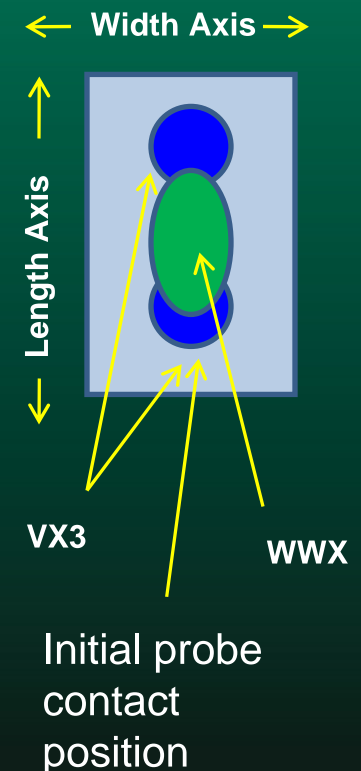
- Minimal probe tip deflection because friction is low
- Scrub length increases with tip length

Aluminum Bond Pad – High Friction

- Significant probe tip deflection because friction is high
- Longer tip lengths scrub shorter due to higher deflection
- Shorter tip lengths scrub longer due to lower deflection

Pass1: Test Cell to VX3 Correlation - Summary

- Good correlation in “Width” axis between VX3 and WaferWoRx data
  - VX3 is accurately representing the initial contact position of the probe
- Correlation issue in the “Length” axis
  - Losing ~ 10 microns of scrub position due to cantilever probe scrub characteristic differences on hard surface vs. aluminized pad



Process Improvement Opportunities

Prober Improvement

- Probe to Pad Alignment Improvements (Yaw and X Offset)
    - Process improvement available ~5 microns

Probe Card Improvement

- Use VX4 “Predictive Scrub” during card adjustment
    - Process improvement available ~10 microns

"Predictive Scrub"

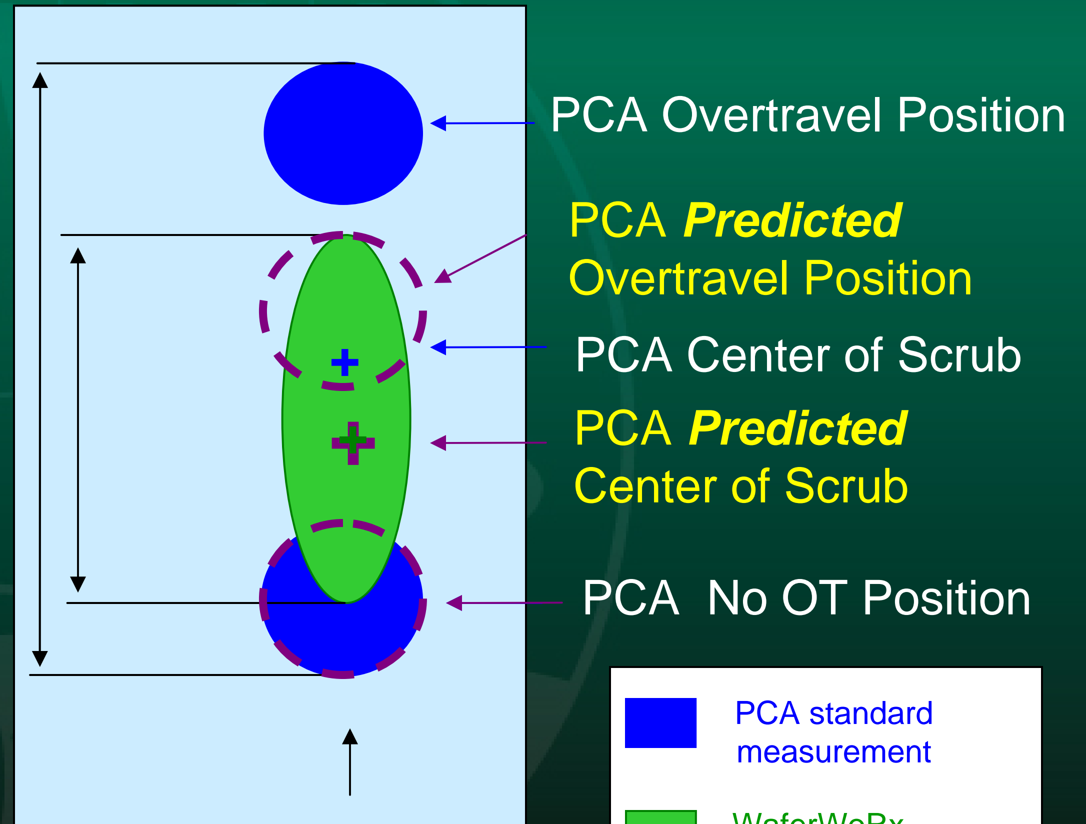
Predictive Scrub

1) PCA measurement

2) WaferWoRx Probe Card measurement from PMI data

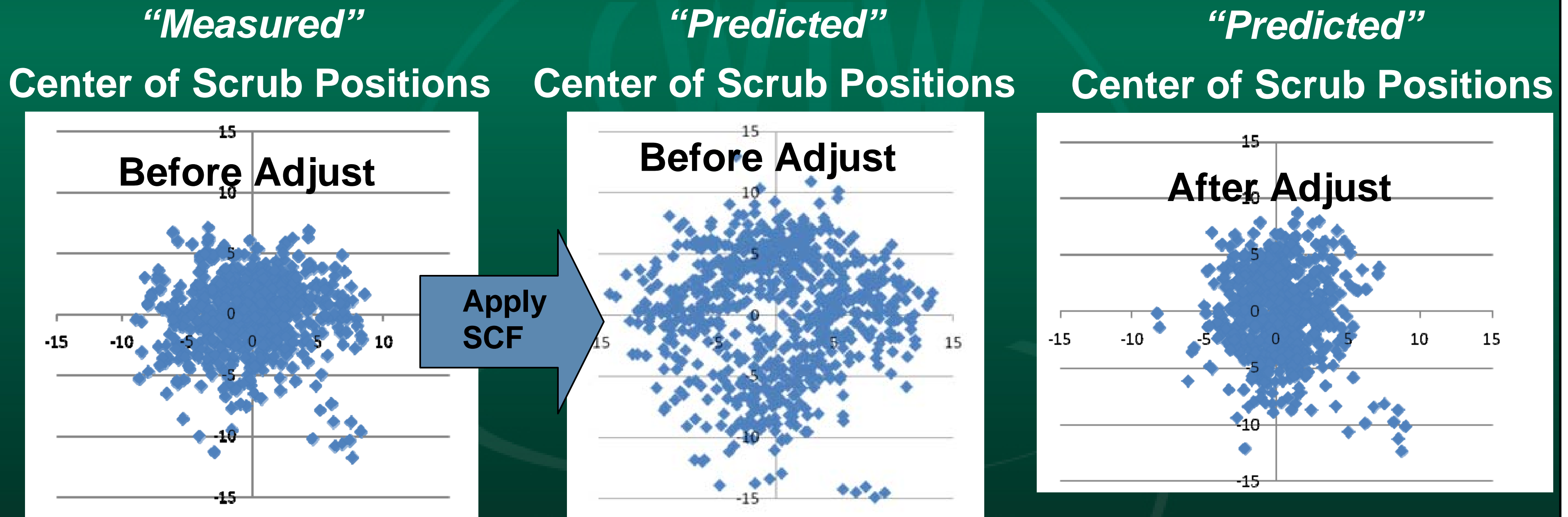
3) Quantify differences between PCA and Test Cell

4) Measure ***Predictive Scrub*** with VX4



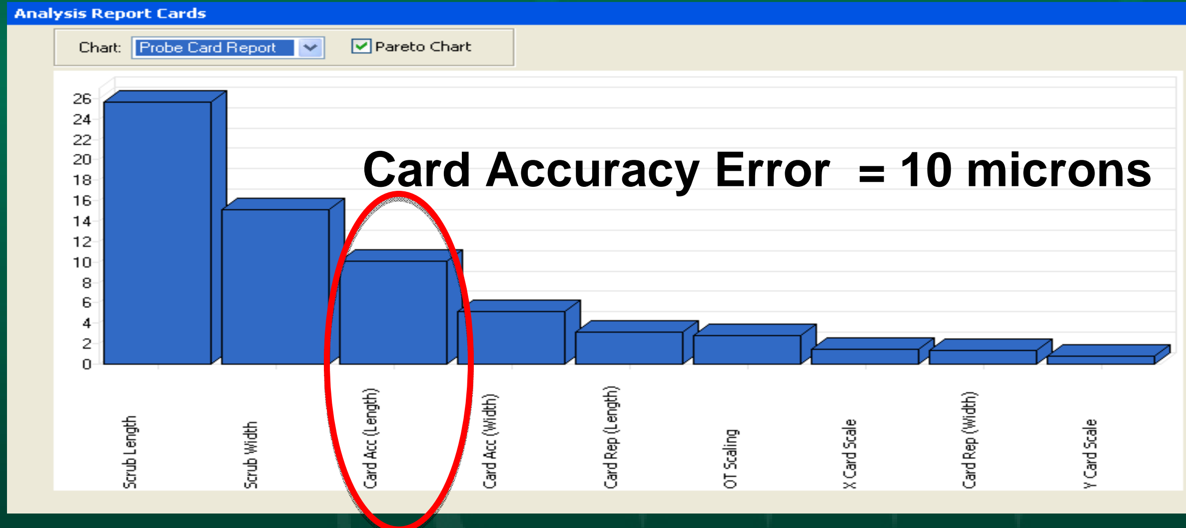
	Probe ID	Channel Label	User Defined Label 1	User Defined Label 2	X Reference (µm)	Y Reference (µm)	Major Diameter (µm)	Minor Diameter (µm)	Tier	Probe Scrub Correlation
1	1	1015	472	0_001	-1894.000	8647.660	20.000	20.000	1	0.80
2	2	MC2	329	0_002	-1894.000	8497.580	20.000	20.000	2	0.60
3	3	354	200	0_003	-1894.000	8397.340	20.000	20.000	1	0.80
4	4	351	201	0_006	-1894.000	8315.860	20.000	20.000	2	0.60
5	5	489	344	0_007	-1894.000	8235.500	20.000	20.000	1	0.80
6	6	459	330	0_008	-1894.000	8159.060	20.000	20.000	2	0.60
7	7	1018	456	0_009	-1894.000	8083.180	20.000	20.000	1	0.80
8	8	490	328	0_010	-1894.000	8011.220	20.000	20.000	2	0.60
9	9	551	198	0_011	-1894.000	7938.700	20.000	20.000	1	0.80
10	10	458	346	0_012	-1894.000	7868.700	20.000	20.000	2	0.60

Pass 2: Measure Probe Card on VX4 Before and After Adjust

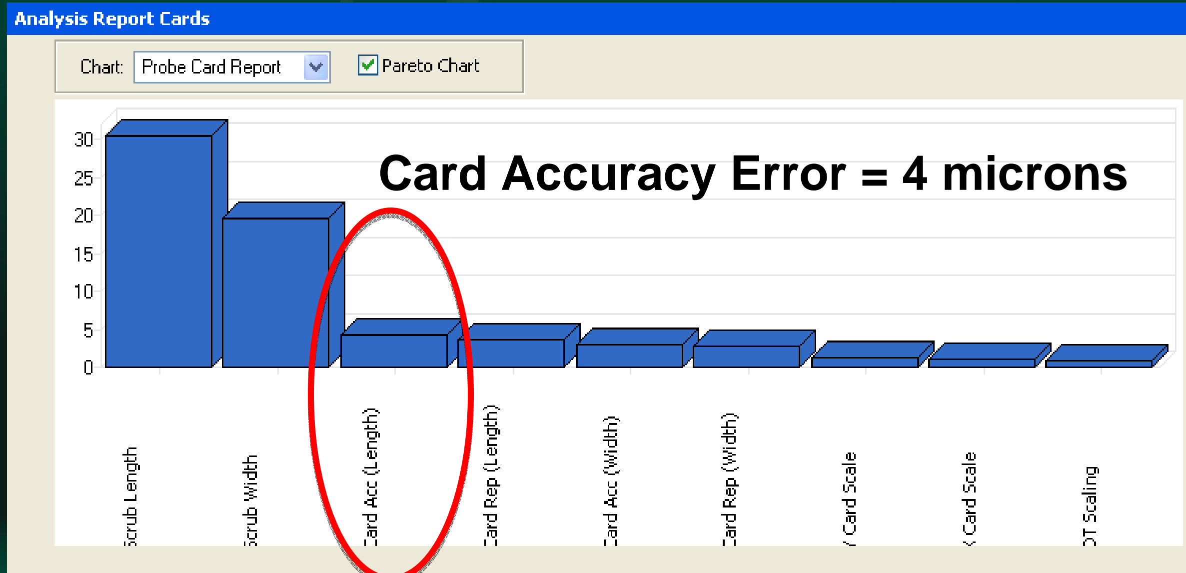


- VX4 Results ***BEFORE*** adjusting probe positions
  - ***Measured positions*** are well centered
  - ***Predicted positions*** have a donut hole of probes scrubbing short of center
- VX4 Results ***AFTER*** adjusting probe positions based on Predicted Positions
  - ***Predicted positions*** are now well centered

Pass 2: Measure Process Improvements

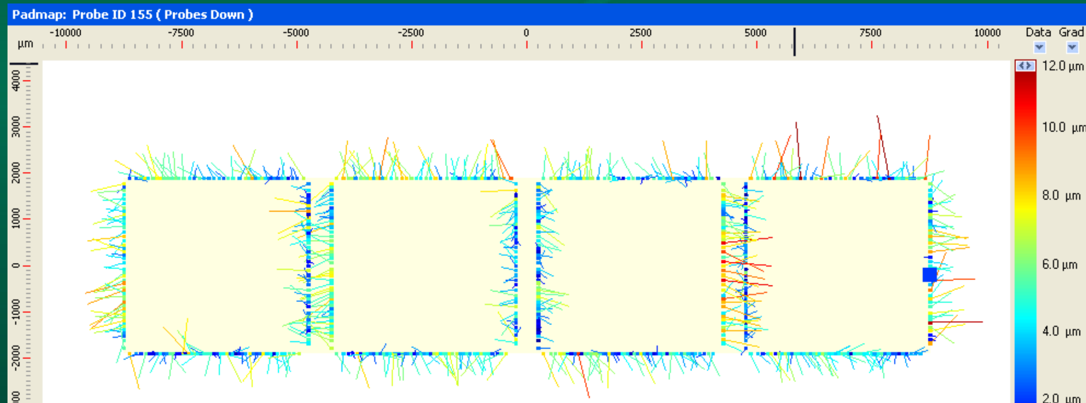


Pass1 Results

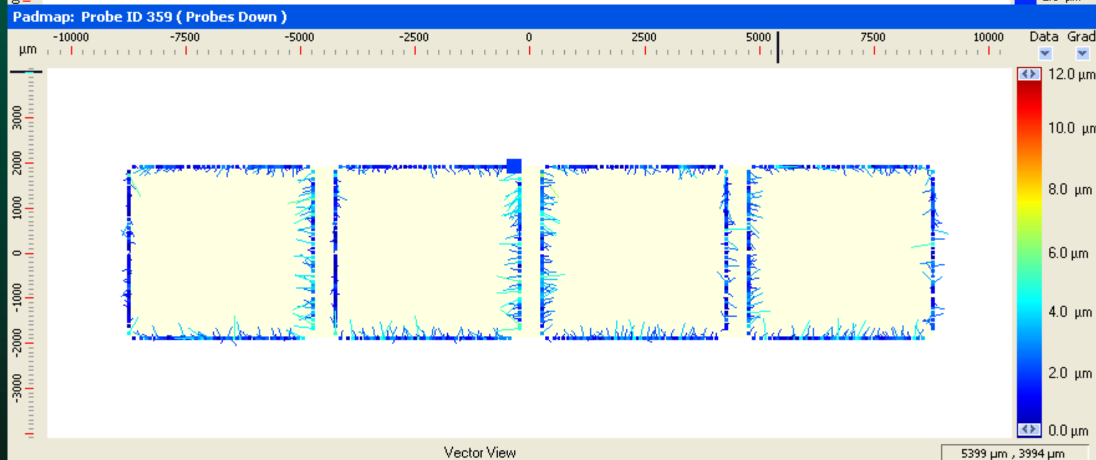


Pass2 Results

Pass 2: Probe Card Performance Details



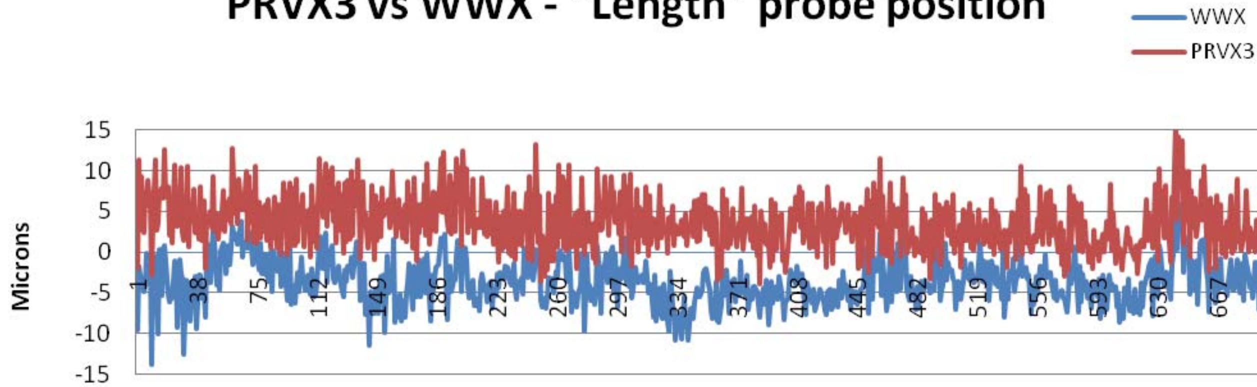
Pass1 WaferWoRx Results



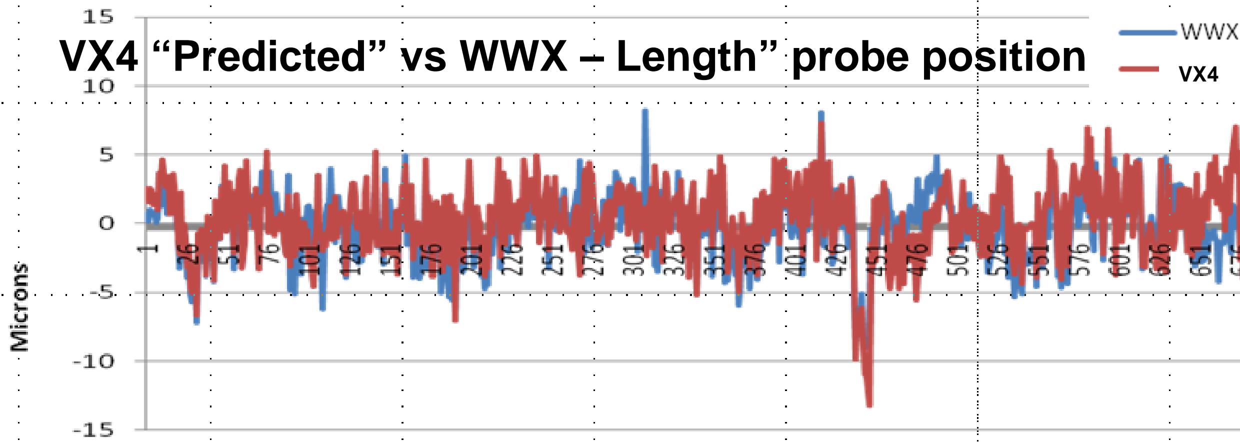
Pass2 WaferWoRx Results

- Probes scrubbing short of pad center for Pass1 data
- Probes are well centered for Pass2 data
  - Probe Card was adjusted using VX4 ***"Predictive Scrub"***

Pass 2: VX4 *"Predictive Scrub"* Correlation to Test Cell



Pass1 Correlation



Pass2 Correlation

Summary

- **We were able to improve Test Cell performance!**
- **CPK improvements**
  - Pass1 CPK = 1.25, Process Length = 48 microns
  - Pass2 CPK = 1.45, Process Length = 41.3 microns
- **Probe Card Performance improvements by adjusting probe positions based on VX4 "Predictive Scrub"**
  - Pass1 Length Accuracy Error = 10 microns
  - Pass2 Length Accuracy Error = 4 microns
- **Improved Probe Card Analyzer correlation to Test Cell using VX4 *"Predictive Scrub"***
- **Identified Prober Stage and PTPA Errors with WaferWoRx on NSX Probing Process Analysis**
  - Additional performance improvement available to pursue

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