

Advanced Tungsten CMP with No Pad Conditioning

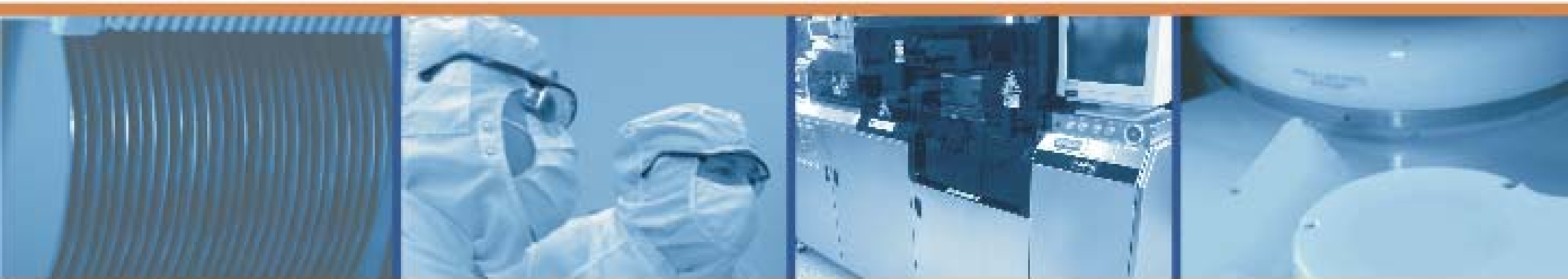
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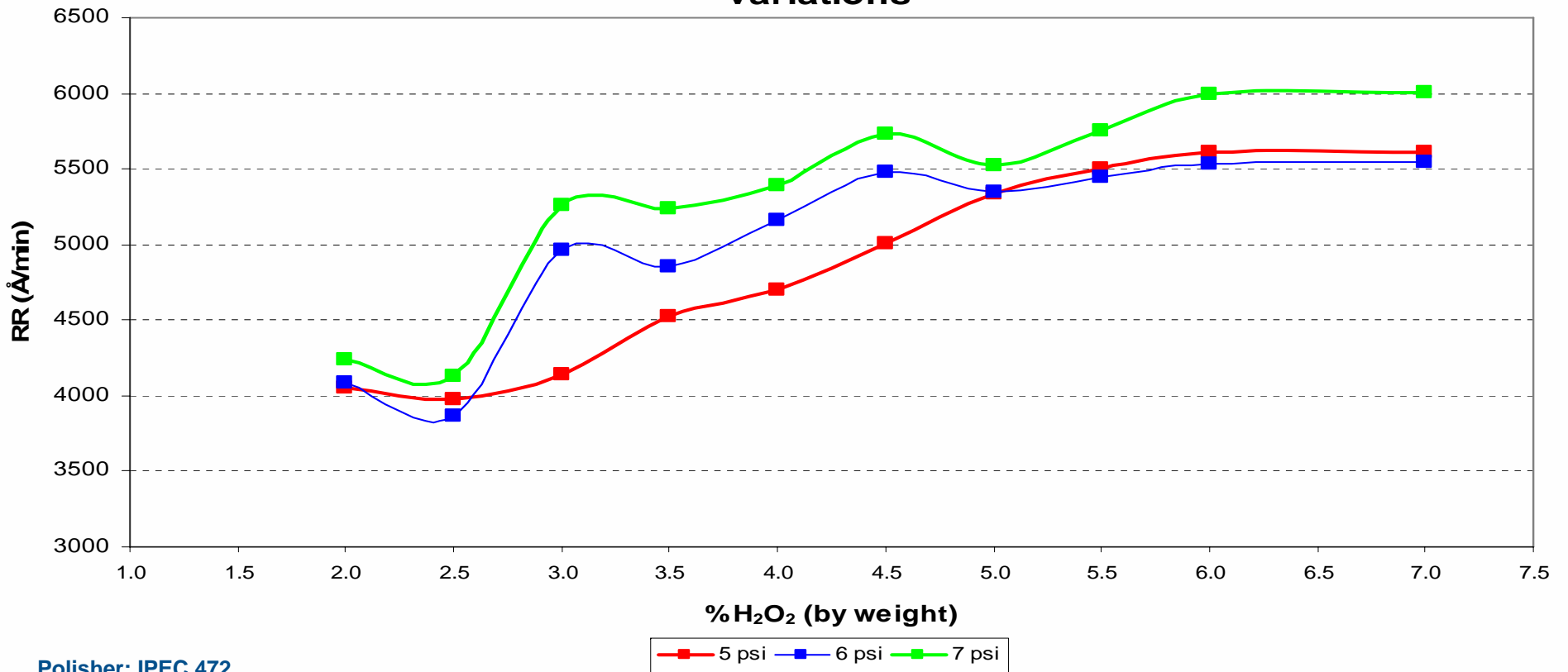


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- **Background Information**
- **Process Data Using ASP-W3525 Pads**
- **Process Qualification and Production Results**
 - **Extended run**
 - **Contamination data**
 - **Lot-to-lot consistency**
- **Contact info**

- **Entrepix provides professional outsource CMP for everything from prototypes and development work through volume outsource production.**
- **Desired properties for a tungsten CMP production process:**
 - **Excellent pad-to-pad and lot-to-lot consistency**
 - **Reasonable removal rate and very low uniformity**
 - **Low defectivity**
 - **Minimal conditioning (zero if possible)**
 - **Long pad life**
- **Multiple pads screened and best performance achieved with the psiloQuest ASP-W3525 pad.**

RR Study comparing Down-Force @ % H2O2 concentration variations

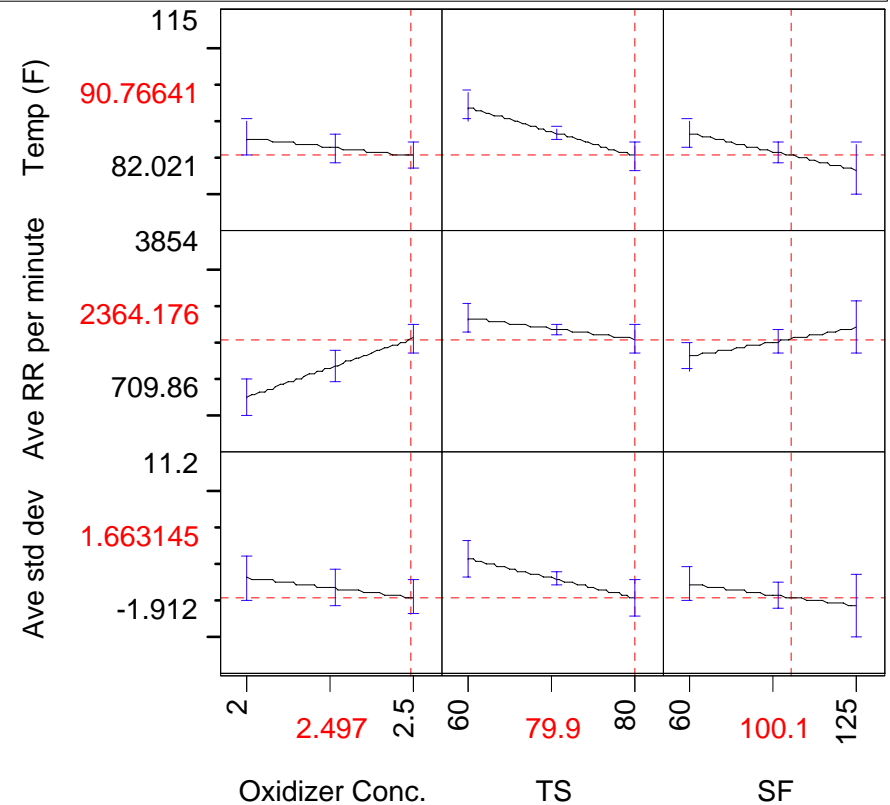


Polisher: IPEC 472
Slurry: Cabot SSW-2000

- Simplified DOE shows strongest response to oxidizer concentration
- Negative slope for removal rate vs table speed is likely an artifact of simplified design

Least Squares Fit

Prediction Profiler



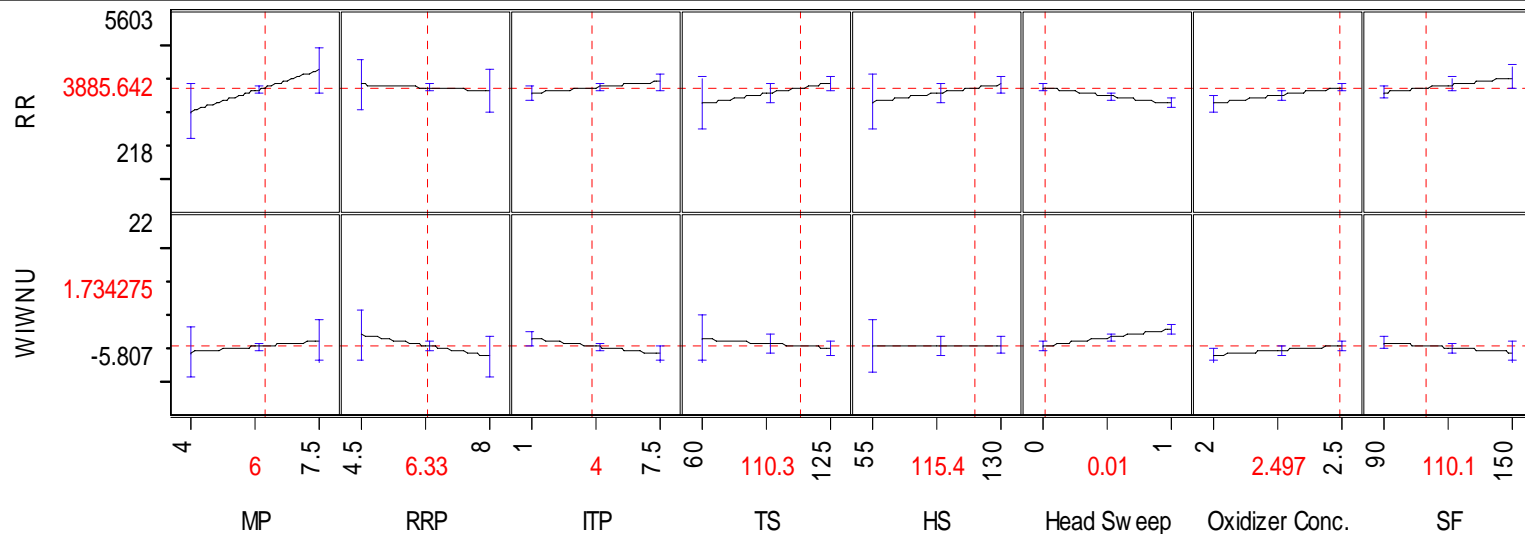
- Membrane pressure (downforce) is largest predictor coefficient
- Wide process margin on all other variables tested
- Consistent with trends observed in IPEC 472 data

Least Squares Fit

Response RR

Response WIWNU

Response Surface Effects on AMAT MIRRA MESA using 1:1 SSW2000:DIW



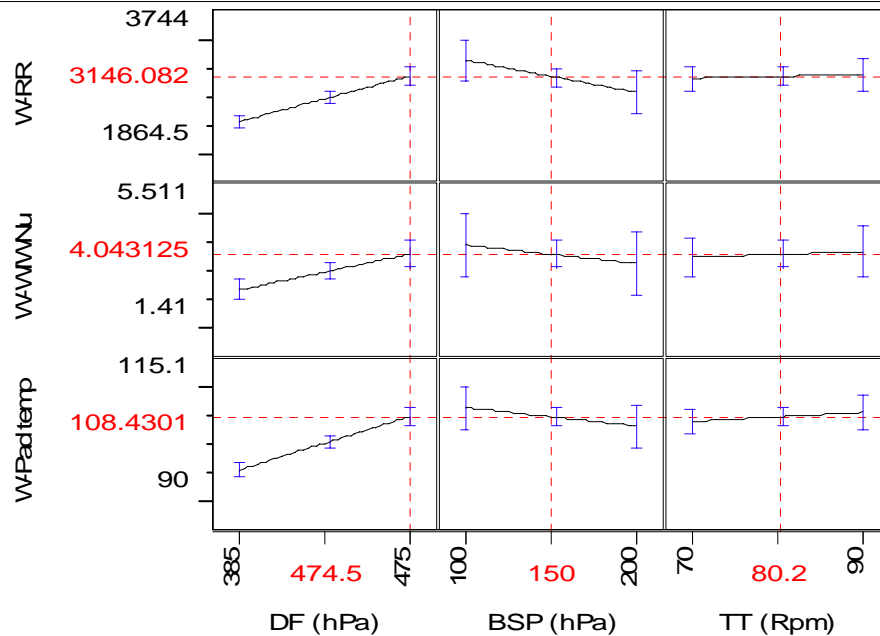
Least Squares Fit

Response W-RR

Response W-WIWNu

Response W-Pad temp

ASP-W3525 Response Surface Effect on Ebara F-Rex200 using 1:1 SSW2000:DIW at 2% H_2O_2



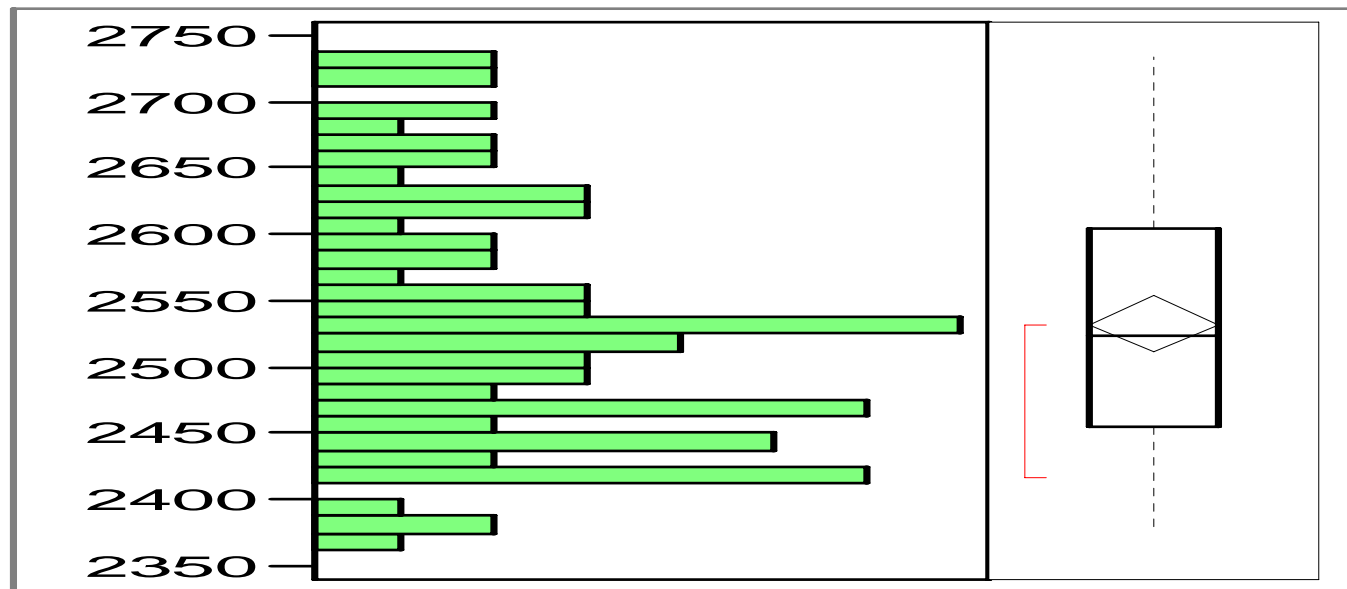
Recent data taken on Ebara EPO222 polisher

- Downforce (DF) has the biggest effect on measured response parameters
- TurnTable (Table Speed) has very minimal effect on the response parameters.
- As expected, tungsten RR (W-RR) increases as Downforce (DF) increases.
- BSP has mild inverse effect on W_RR, W-WIWNu and W- Pad Temperature

- **Polishing data taken across multiple pads**
 - Total of 20 ASP-W3525 pads
 - Includes 5 different raw material lots
- **Rate and uniformity data taken on 3 monitor wafers per pad**
 - All polishing performed on IPEC 472 polisher at psiloQuest apps lab
 - Data compiled into single dataset for comparison
- **Demonstrates excellent pad-to-pad consistency across multiple lots**

Distributions

P-RR (MIN)

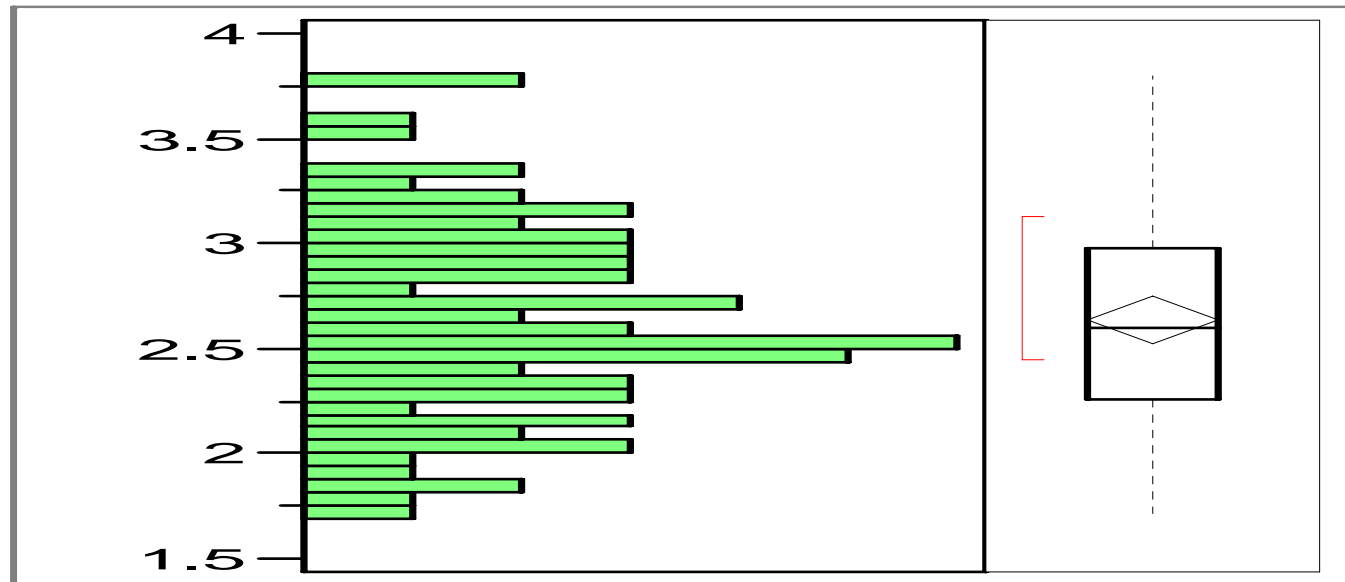


Moments

Mean	2532.7365
Std Dev	94.865909
Std Err Mean	11.027938
upper 95% Mean	2554.7151
lower 95% Mean	2510.7578
N	74

Distributions

P-Stdev

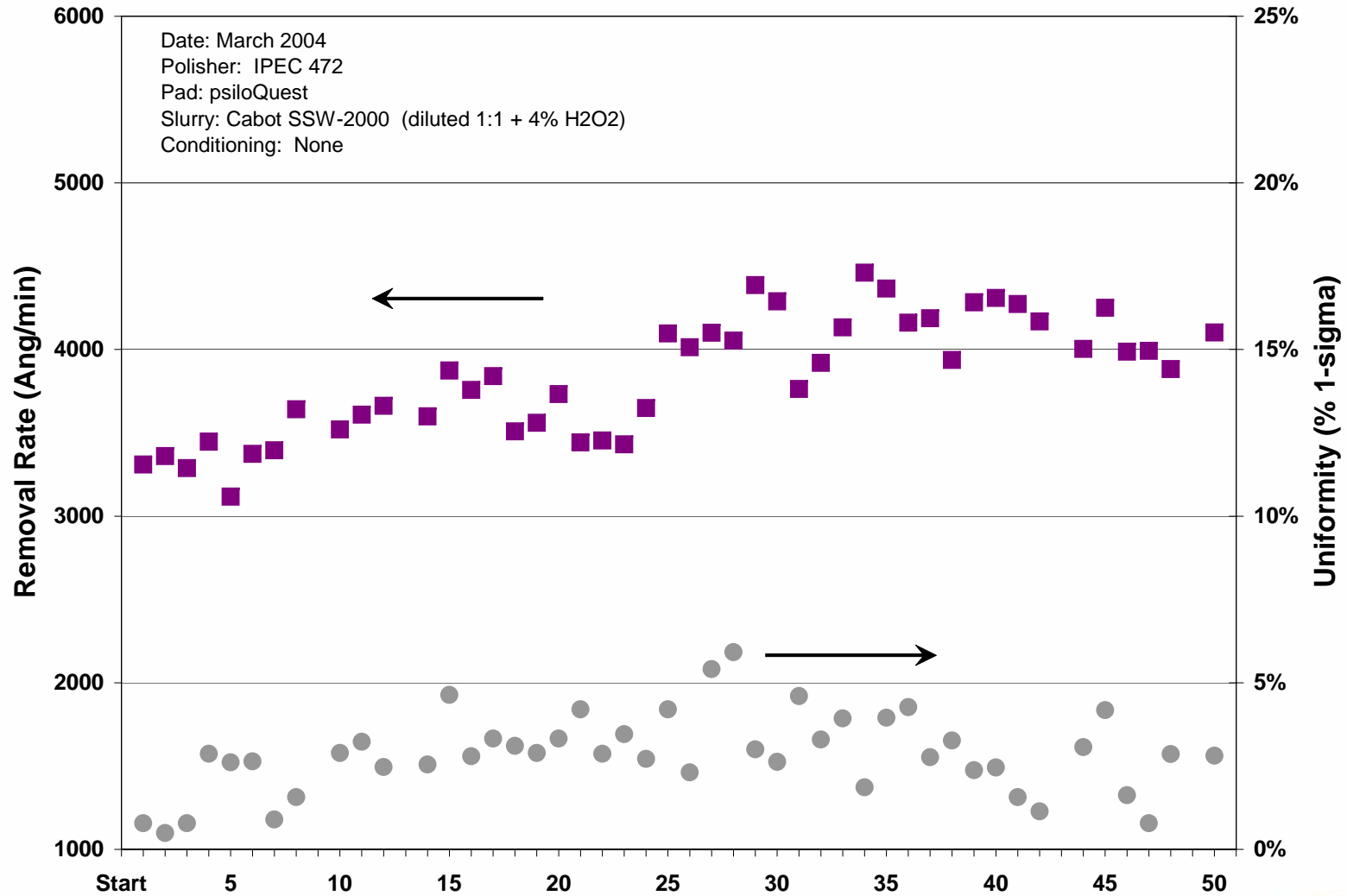


Moments

Mean	2.638
Std Dev	0.4834226
Std Err Mean	0.05778
upper 95% Mean	2.753268
lower 95% Mean	2.522732
N	70

- **Elements of Rapid Qual Plan**
 - 50-wafer baseline run for blanket film rate and uniformity
 - SIMS/TXRF data showing residual contamination levels
 - Defectivity
 - Device yield on multiple split lots
- **Results**
 - All qualification runs completed in very short timeframe
 - Comparison to in-fab process showed equal or better performance on all critical metrics

First attempt 50-wafer baseline run

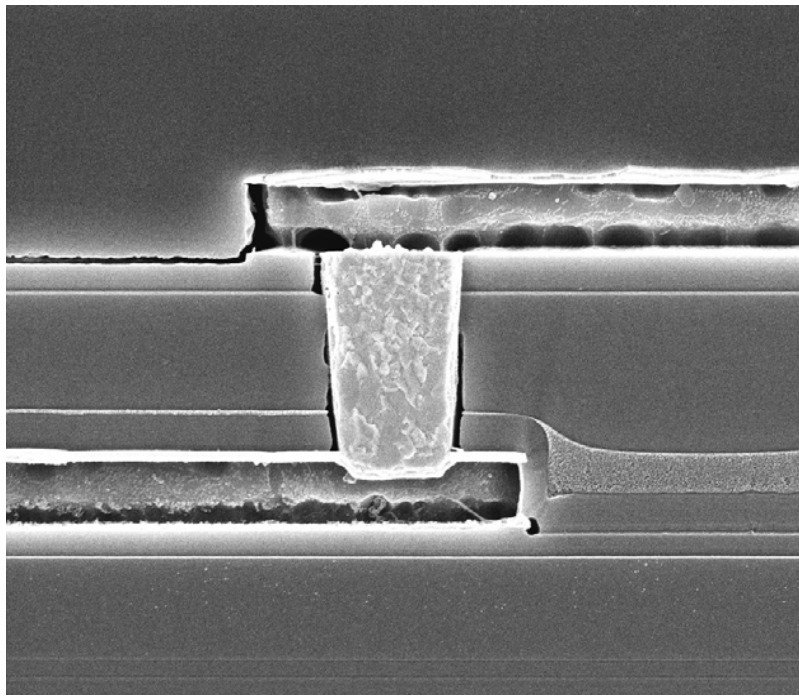


Key Points

- **Comparison to IC1000 shows equal or better performance**
- **All values from Entrepix lab are less than or equal to fab reference**

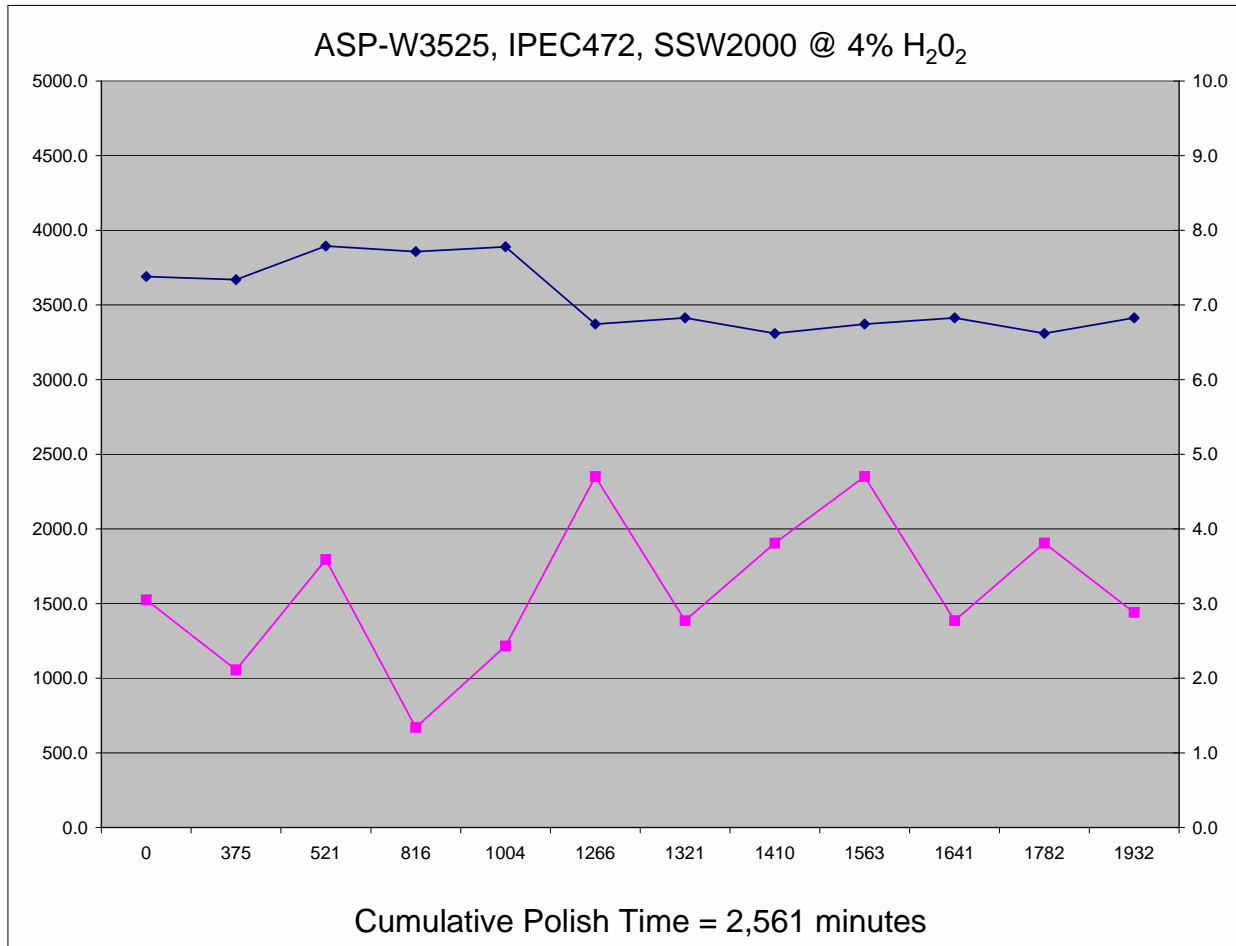
#	Element	PF1 Reference	IC1000 Process on 472's at PSI	pQ Pad on 472 at PSI	pQ Pad on 372M at PSI	Scrubber Qual	Second Scrubber Qual
1	P	108.07	81.91	96.28	76.24	80.32	84.78
2	S	478.7	402.44	368.09	389.6	383.63	384.49
3	Cl	79.84	80.31	80.98	66.78	77.42	72.85
4	K	0	0	0	0	0	0
5	Ca	5.18	14.97	7.74	39.96	5.75	3.62
6	Sc	0	0	0	0	0	0
7	Ti	0.65	1	0	0	0	0
8	V	0	0	0	0	0	0
9	Cr	0	0	0	0	0	0
10	Mn	0	0.09	0	0.13	0	0
11	Fe	179.11	114.37	95.44	95.03	0.94	0.45
12	Co	0	0	0	0	0	0
13	Ni	0	1.11	0.21	0.08	0.25	0
14	Cu	0.1	2.53	0.74	3.93	0	0
15	Zn	0.05	11.37	3.38	15.39	0.85	0
16	W	0	0	0	0	0	0

Cross section of completed via



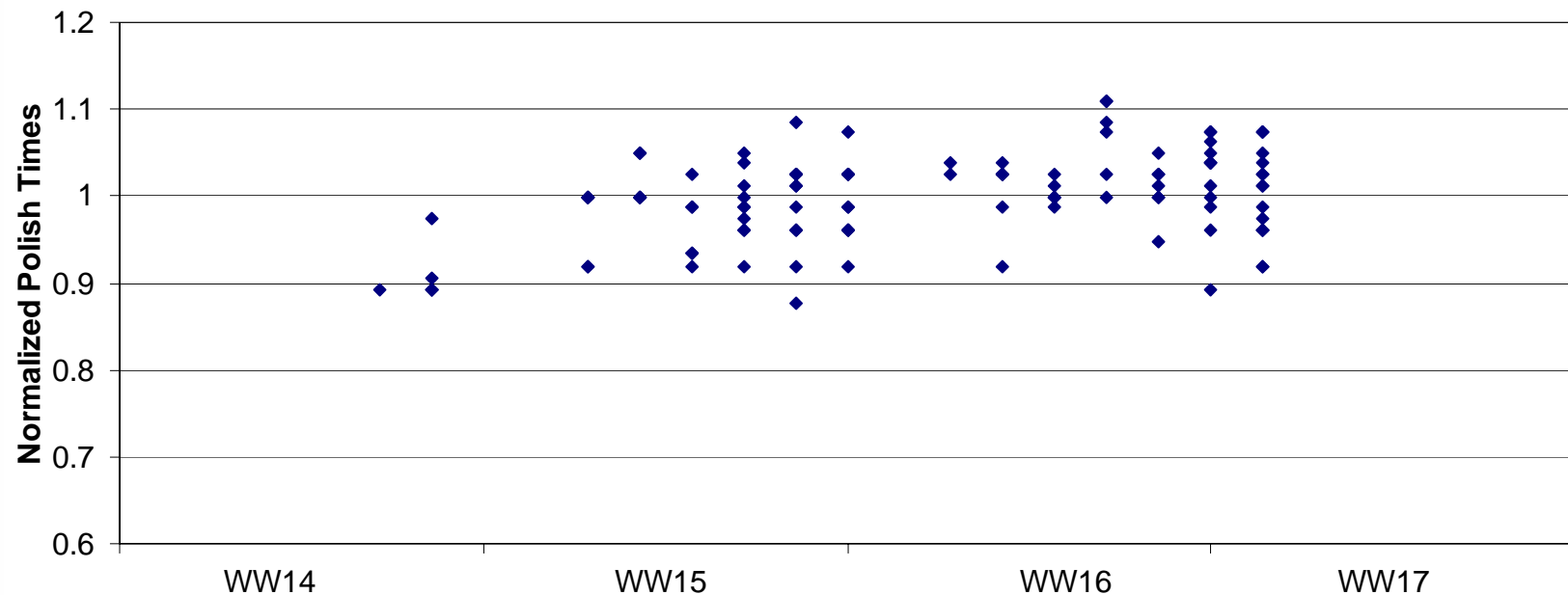
- **Excellent plug planarity and controlled recess.**
- **End-of-line device yield equivalent between outsourced CMP and existing qualified fab process.**

Blanket Film Qual Data through Pad Life



Normalized Production Lot Polish Time

Daily Production Data
(103 wafer lots - Random mix of contact, via1 & via2)



Over 100 production lots across multiple pads showing very repeatable polishing performance

- **The psiloQuest ASP-W3525 tungsten CMP pad provides:**
 - Excellent pad-to-pad and lot-to-lot consistency
 - Reasonable removal rate and very low uniformity
 - Zero conditioning required
 - Low defectivity
 - Long pad life
- **Through Entrepix, the end customer has achieved:**
 - Immediate capacity with no capital outlay
 - Product yield equivalent to current fab in-house production

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