



NOVELLUS

Innovative Technology. Trusted Productivity.

Fab Productivity

**Sensor Integration and Productivity Results
Novellus Observation**

Moving beyond Time Cleans



→ What EPD is not:

- An automatic detection of when the chamber is clean enough
 - Clean/Not Clean is not a black&white thing
- A particle counter
- A fix for particles that are not related to clean time.
- A fix for bad clean uniformity

→ What EPD is:

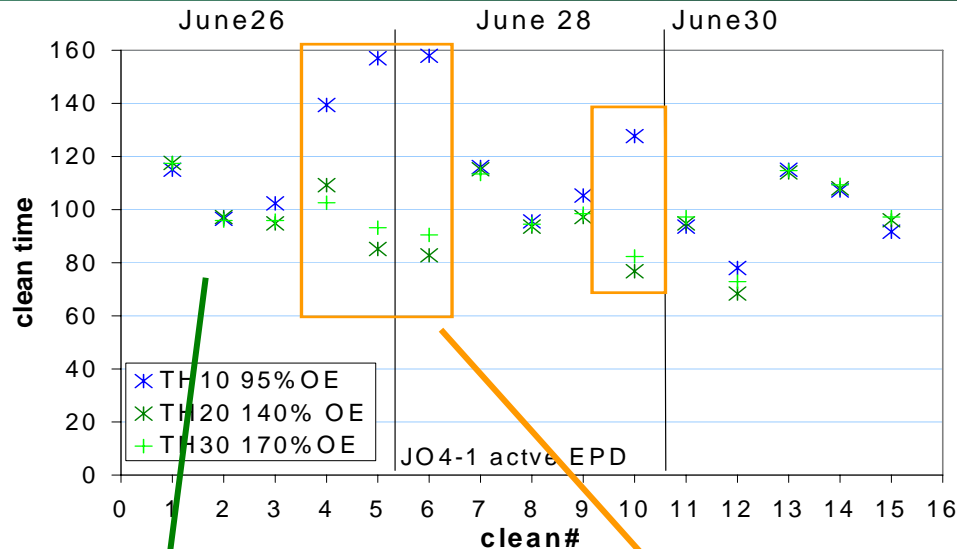
- A tool for the process engineer to track change in clean rate versus time
- Provides a marker for clean progress and assists in the development of clean algorithms

→ Potential Benefits

- Reduced Downtime
- Reduced Gas Consumption
- Improved Cleaning – Reduction in Particles
- Eliminates overetch due to poor signal intensity

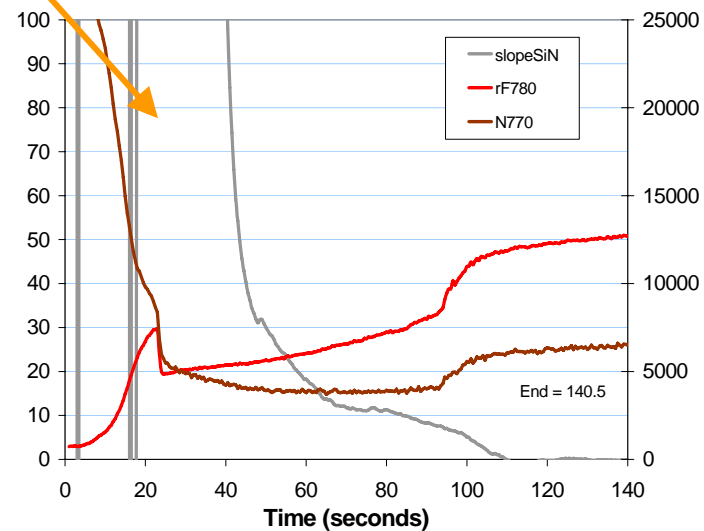
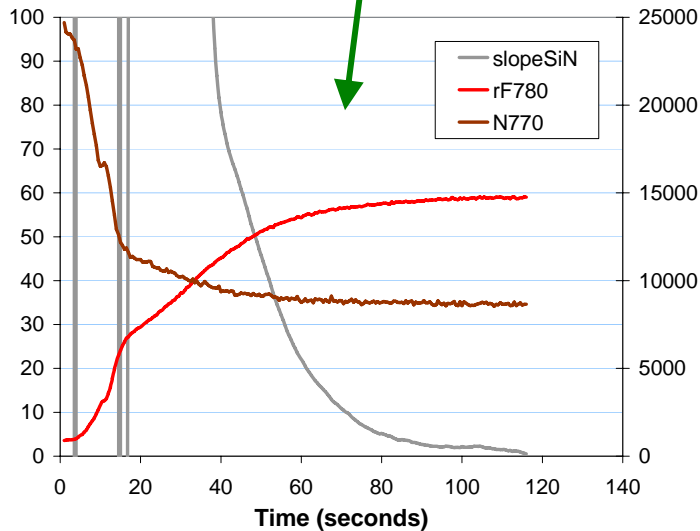
Effect of intensity drop

Longer clean times



If using Threshold=20, or 30 and adjusting %Over Etch, clean time is reduced

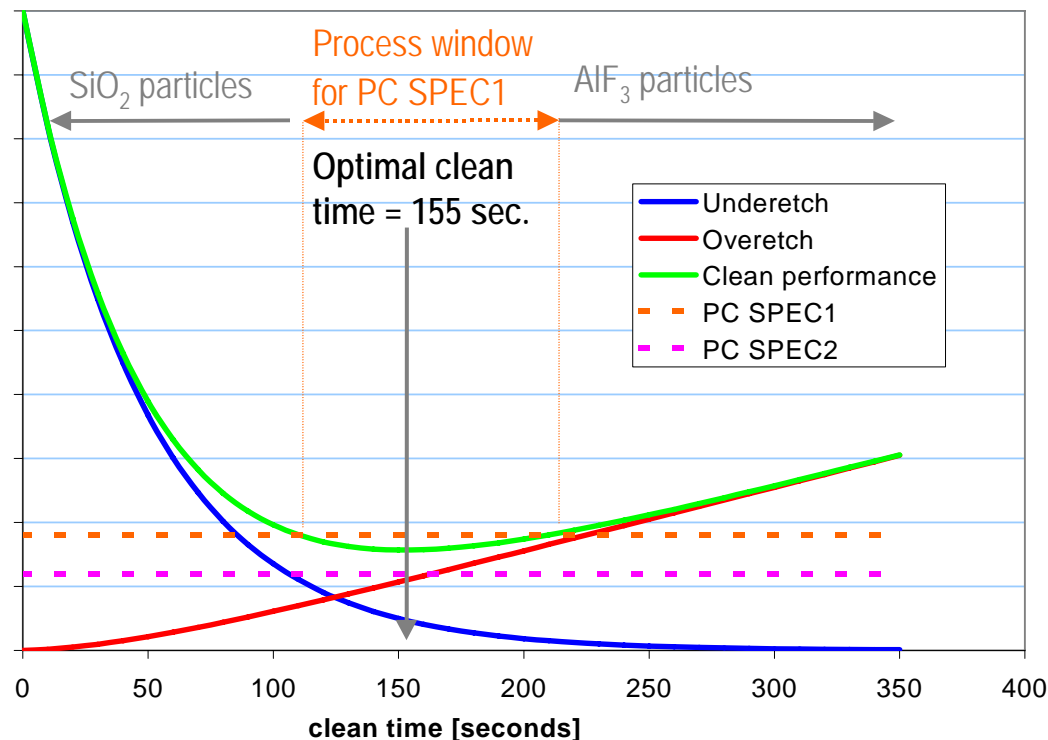
Effect of tail end of clean?



Particle Reduction Overetch vs. Underetch



- % Overetch is a compromise between two evils: under etch and overetch
- If particle spec is too low (SPEC2) or clean uniformity is bad, no process window exists
 - The optimized clean will have both AlF_3 and SiO_2 particles in excess of the SPEC



- Diagram shows relative contributions of under and overetch just before PM
- EPD only shows clean progress corresponding to the Green graph

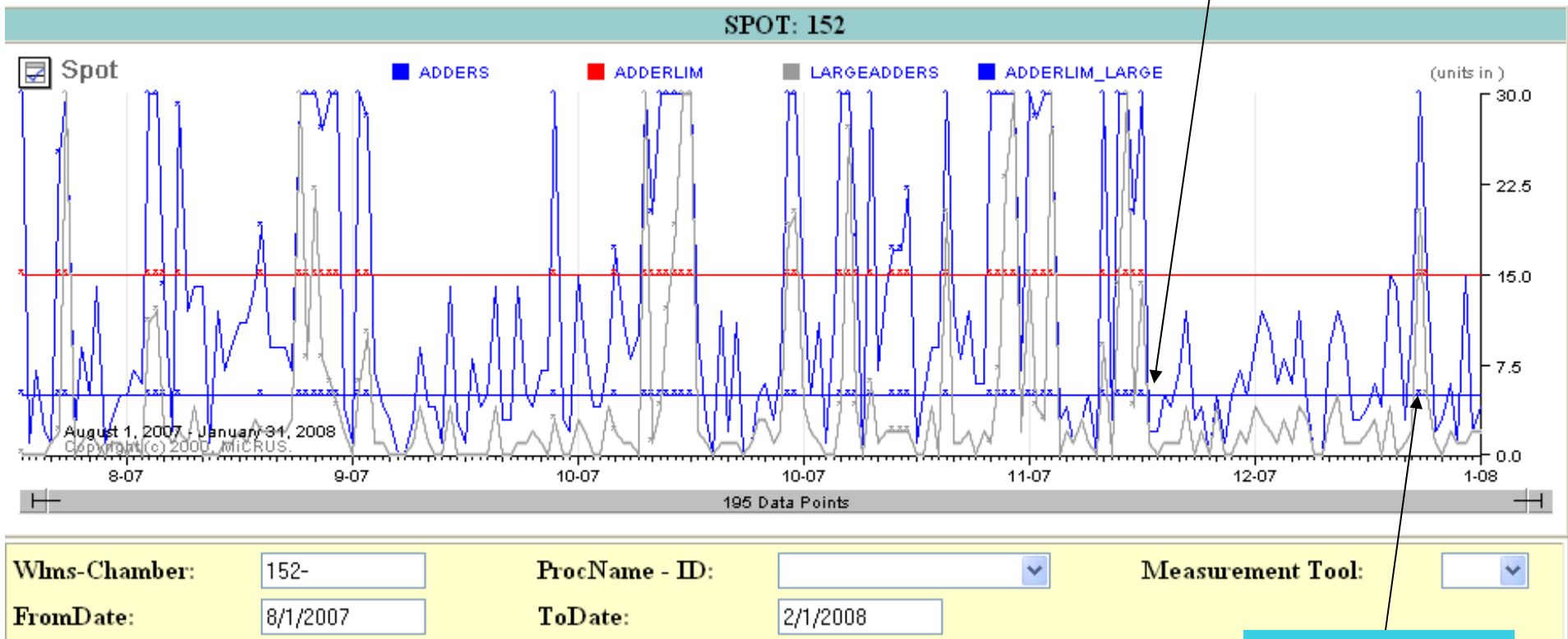
Optimal %OE can only be determined by feedback from particle performance

Justification



1. Particle Performance

Endpoint/ Toggle installed



Right after WC

Customer extended times between PM's due to improved Particles Performance

Customer Particle Statistics



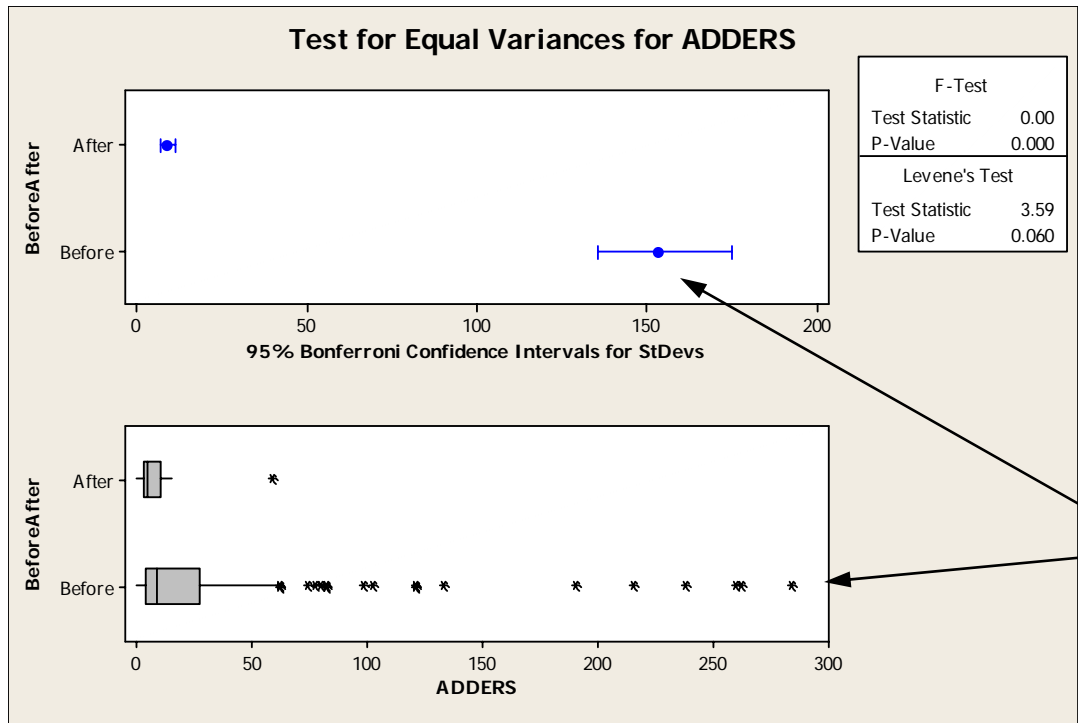
Mood Median Test: ADDERS Before versus After

Mood median test for ADDERS

Chi-Square = 6.23 DF = 1 P = 0.013

Before/After	N<=	N>	Median	Q3-Q1	Individual 95.0% CIs
After	31	15	5.00	7.25	(---*-----)
Before	72	83	9.00	23.00	(-----*-----)

5.0 7.5 10.0 12.5



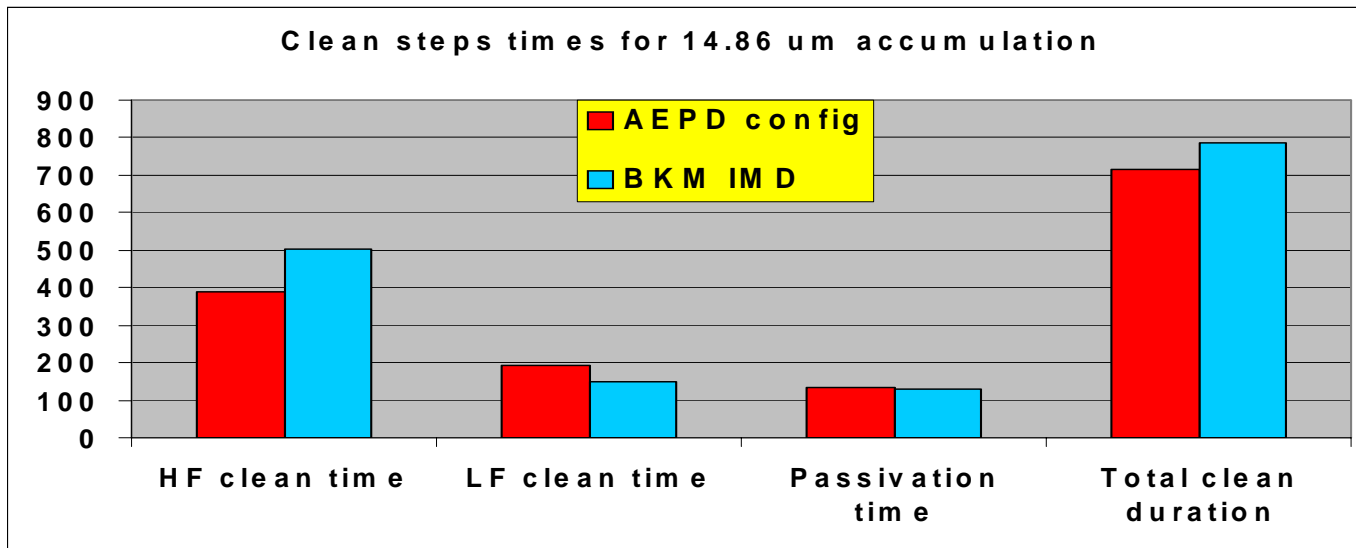
There is a statistically significant difference between "Before & After"

HDP production proven

Optimizing the clean allows to reduce NF3 consumption



→ **Based on HDP Best known Method deposition and clean recipes**



→ **Clean time 8% Shorter**

- Shorter HF clean
- Longer LF clean

→ **Benefits**

- 20 % NF3 saving



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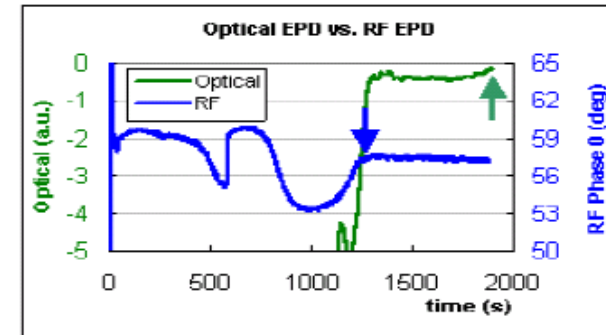
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A Gentler C_2F_6 Clean

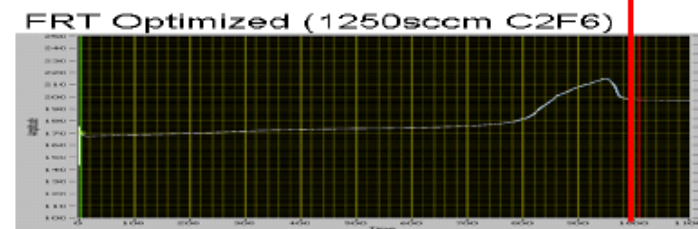
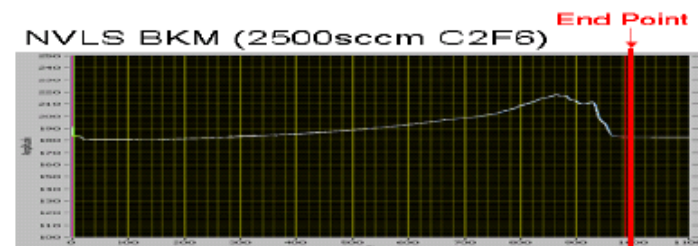
Optimizing C₂F₆ Cleans



High Pressure Clean		
Parameter	Standard High Pressure Clean	Optimized High Pressure Clean
O ₂ flow (sccm)	2000	1100
C ₂ F ₆ flow (sccm)	2500	1100
RF Power (watts)	3500	3500
Pressure (torr)	2.7	3
Low Pressure		
Parameter	Standard Low Pressure Clean	Optimized Low Pressure Clean
O ₂ flow (sccm)	2000	1000
C ₂ F ₆ flow (sccm)	2500	1250
RF Power (watts)	2500	2500
Pressure (torr)	0.7	0.7



Phase of the carrier frequency (13.56 MHz) during clean together with derivative of the NO/F ratio (derivative signal is shown for t>1100s only). Respective EP are marked with arrows.



Optimized Low Flow C₂F₆ / O₂ Chamber Clean



TEOS and SiN etch rates for reduced flow C₂F₆ / O₂ chamber clean show slight improvement to standard chamber clean

High Pressure Clean Process	Teos Etch Rate (7um accum)	SiN Etch Rate (15 um accum)
Standard 2.7 Torr 2500/2000 C2F6 / O2	6000 A/ min	5300
Optimized 3.0 Torr 1100/1100 C2F6 / O2	6300	6275

Potential increase in Wafer T-put due to improved etch rates

MMTCE Reduction using Optimized C_2F_6 / O_2



➤ Effluent measurements during chamber cleaning for TEOS process show >45% reduction in MMTCE for optimized C_2F_6 / O_2 process compared to standard

Process	Emissions (L*atm)			MMTCE x10E9
	CF_4	C_2F_6	C_3F_8	
Standard C_2F_6	1.93	8.34	-	131
Optimized C_2F_6 - Clean time reduction - Gas usage optimization	1.2	3.83	-	62
Optimized C_3F_8	1.78	-	3.14	62

Optimized Endpoint reduces the MMTCE produced by Novellus C1 Equipment

C₂F₆/O₂ Results



→ Potential Through put improvement

- Faster Etch can potentially improve Wafer T-put

→ Greener

- Effluent measurements show >45% reduction in MMTCE compared to standard C₂F₆/O₂ clean

→ Process Transparent

- 3 months of production data showed no impact of optimized C₂F₆/O₂ on process results for TEOS and SiN

→ Cost Effective

- MMTCE for optimized C₂F₆/O₂ chamber clean was found to be comparable to C₃F₈/O₂

→ RF Endpoint provides clear benefits –

- Cost
 - 20% decrease in NF_3 consumption
- Particle Reduction
 - 25% reduction in STI process particles
- Productivity
 - Faster Etch rates increase in batch size
- Environment
 - 50% reduction in MMTCE associated Gases

**The key to success for Novellus is developing technology partnerships
for our older equipment**