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Process Stability Analysis on a Lam TCP 9400 PTX by HERCULES® (SEERS)

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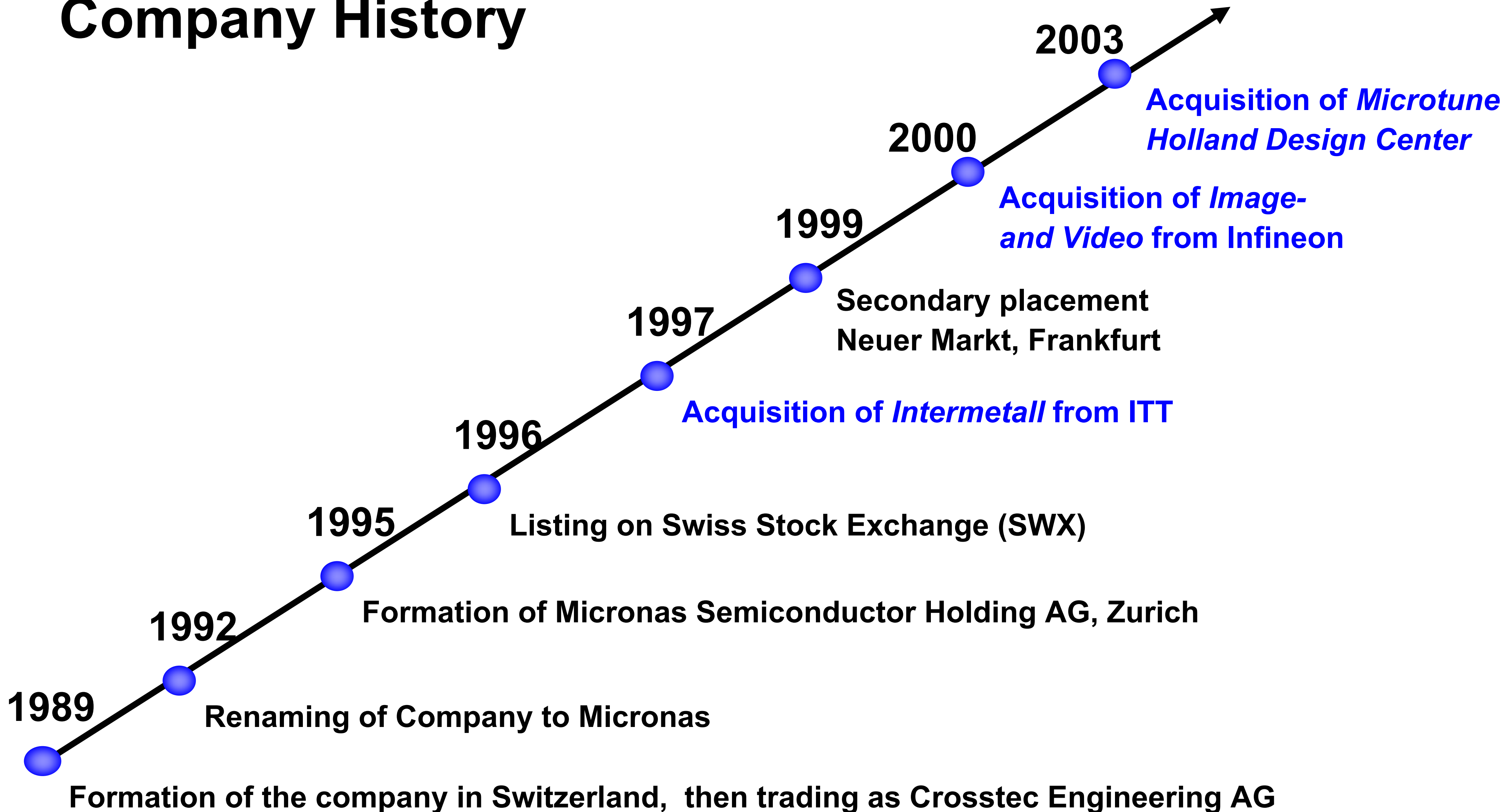
"Silicon for the Senses"

A leading independent supplier of innovative application-specific semiconductor solutions for consumer and automotive electronics

Company History



Product Portfolio

Consumer

- Mixed signal audio, video and data IC's for use in TV's, LCD TV's/Monitors , STB's and multimedia products
  - Multi-sound processors
  - Video processors and Scanrate converters
  - Receivers/Decoders for digital TV
  - Scalers & Picture Processors for LCD TV
  - Picture-in-picture processors
  - Controllers for teletext and data services
  - Compressed audio processors (MP3)
  - USB Connectivity

Automotive

- Dashboard controllers
- Hall sensors

Manufacturing Strategy

- Own wafer manufacturing on mature processes
  - 6”/8” wafer line for 0.45µ high performance mixed signal processes
  - Backup qualified at wafer foundries
- Foundry manufacturing on leading edge technology
  - Currently UMC, TSMC, and Infineon as partners

HERCULES® Evaluation Lam TCP 9400 PTX

Problems and Points of Interest

- complex and costly wet clean procedure + conditioning
- no dedicated tools (nitride, poly, product mix)
- no conditioning between poly and nitride implemented
- process / chamber stability / WAC
- tool failure / fault detection

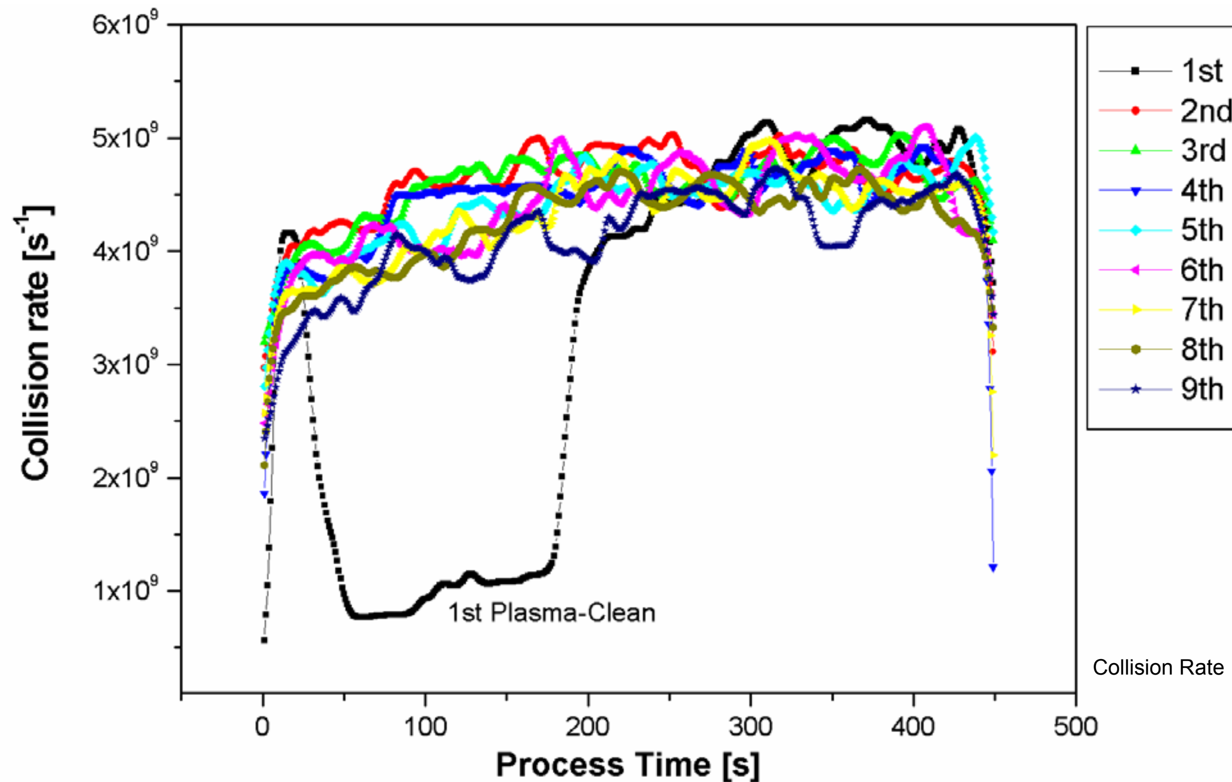
Wet Clean Procedure + Conditioning

- before opening and cleaning the chamber a plasma clean cycle is run
- 9x [SF_6 / O_2 plasma-on + SF_6 / O_2 plasma-off], duration 2 hrs.
- followed by pump-purge
- directly after the wet clean an O_2 process is run to reduce leak rate
- followed by conditioning the chamber with 20 wafers

Questions

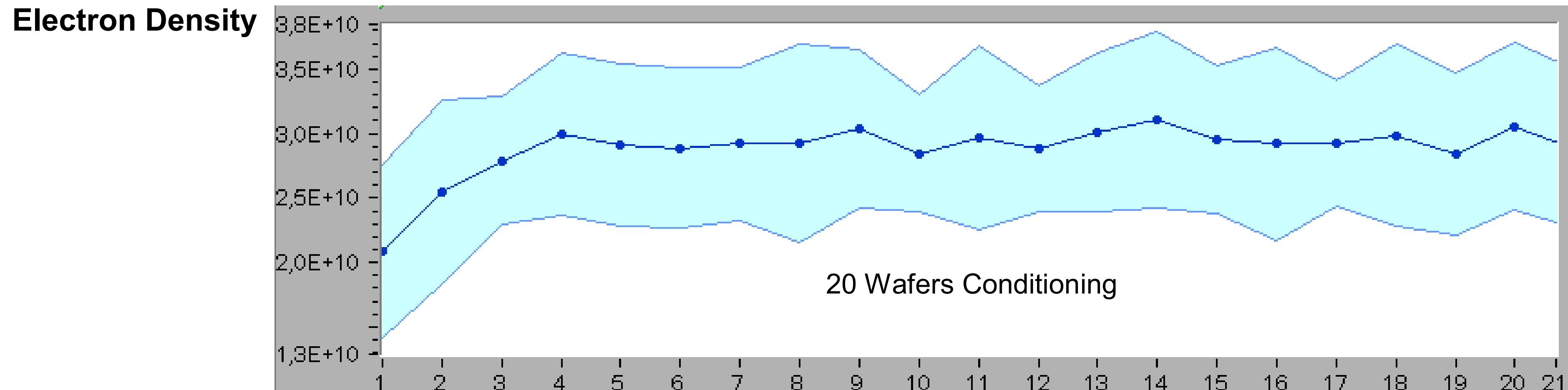
- are 9 plasma clean cycles necessary before opening the chamber ?
- are 20 wafers necessary for conditioning ?

Plasma Clean Cycles before Wet Clean



Large change inside chamber during 1st cycle only. 3-5 cycles are sufficient for stable chamber before chamber opening. Already implemented in production without any negative impact on cleaning efficiency. (time saving : 1 hr.)

Conditioning after Wet Clean



Chamber stable after only 5 wafers. Reduction to 13 wafers already implemented without any problems. Further reduction planned and easily possible.

Etching Poly and Nitride

- we have to etch poly and nitride layers on the same tool
- no dedicated tool for nitride or poly possible (for backup reasons)
- no conditioning between poly and nitride implemented
- no work instruction for order of poly / nitride lots
- same waferless auto clean (WAC) for nitride and poly processes

Questions

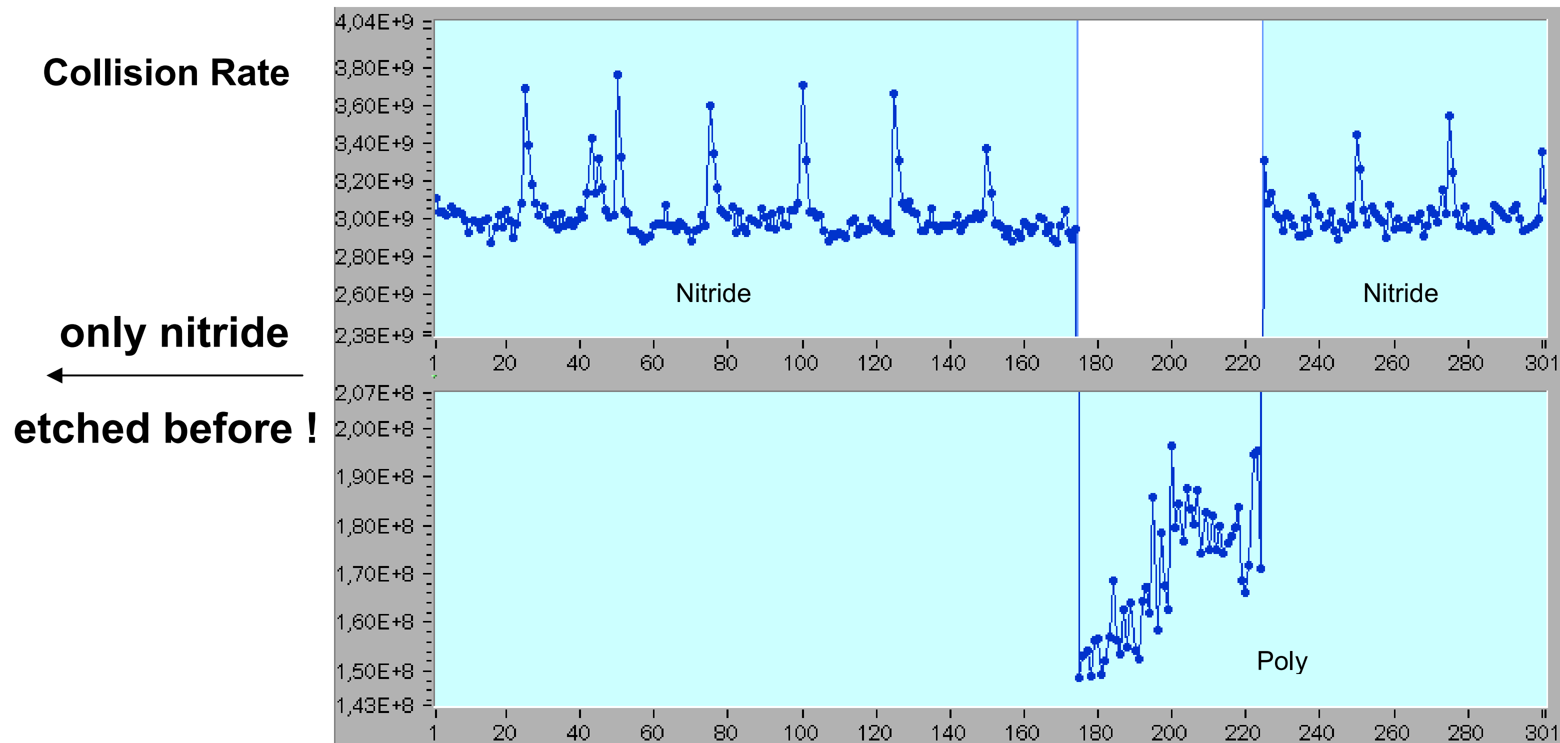
- are the processes stable after switching from poly to nitride and vice versa ?
- is conditioning necessary ?
- is the WAC stable and optimal ?

Nitride → Poly Switch w/o Conditioning

Collision Rate

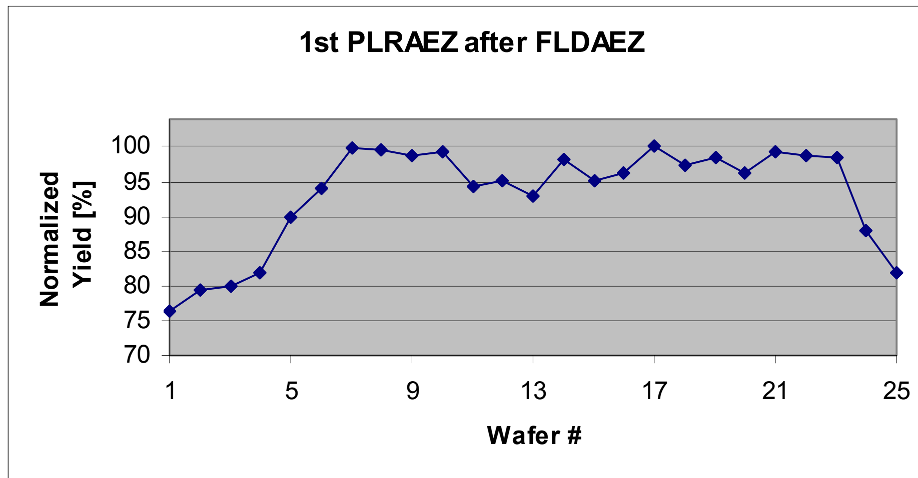
only nitride

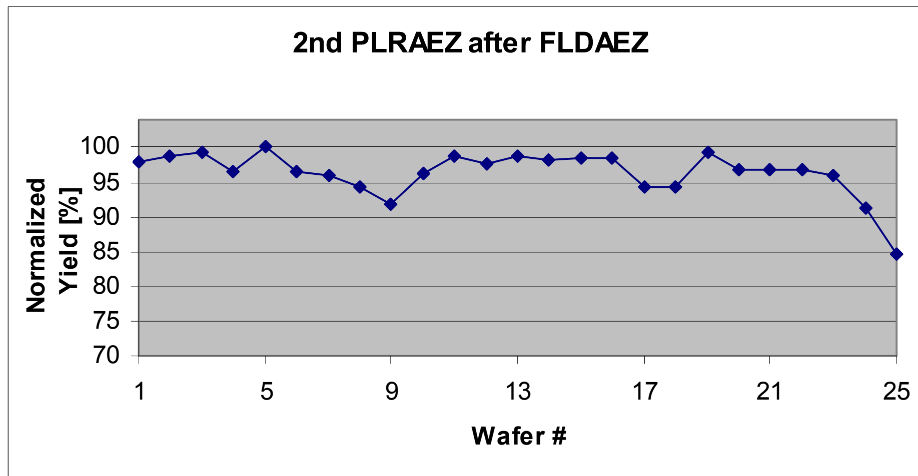
etched before !

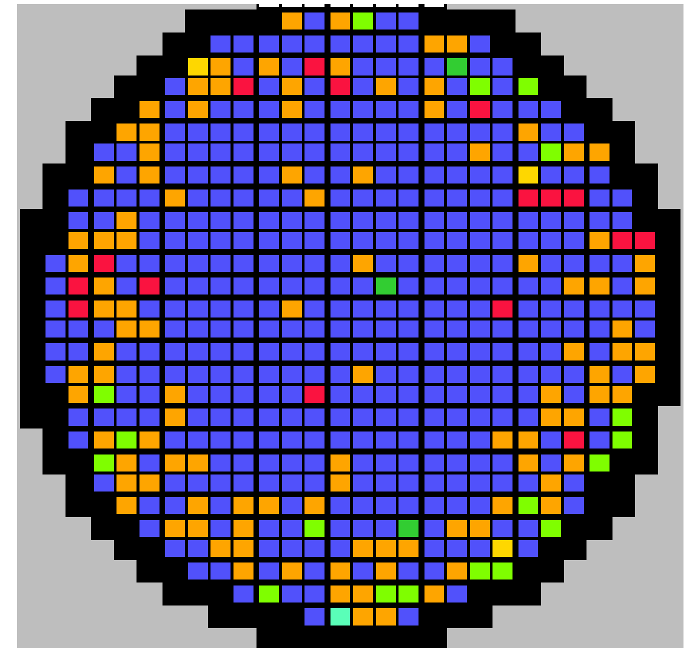


We can observe 1st wafer effect for 2-3 nitride wafers, but the lot itself is stable. Poly lots processed among nitride lots are drifting !

Effect of Nitride to Poly Switch w/o Seasoning

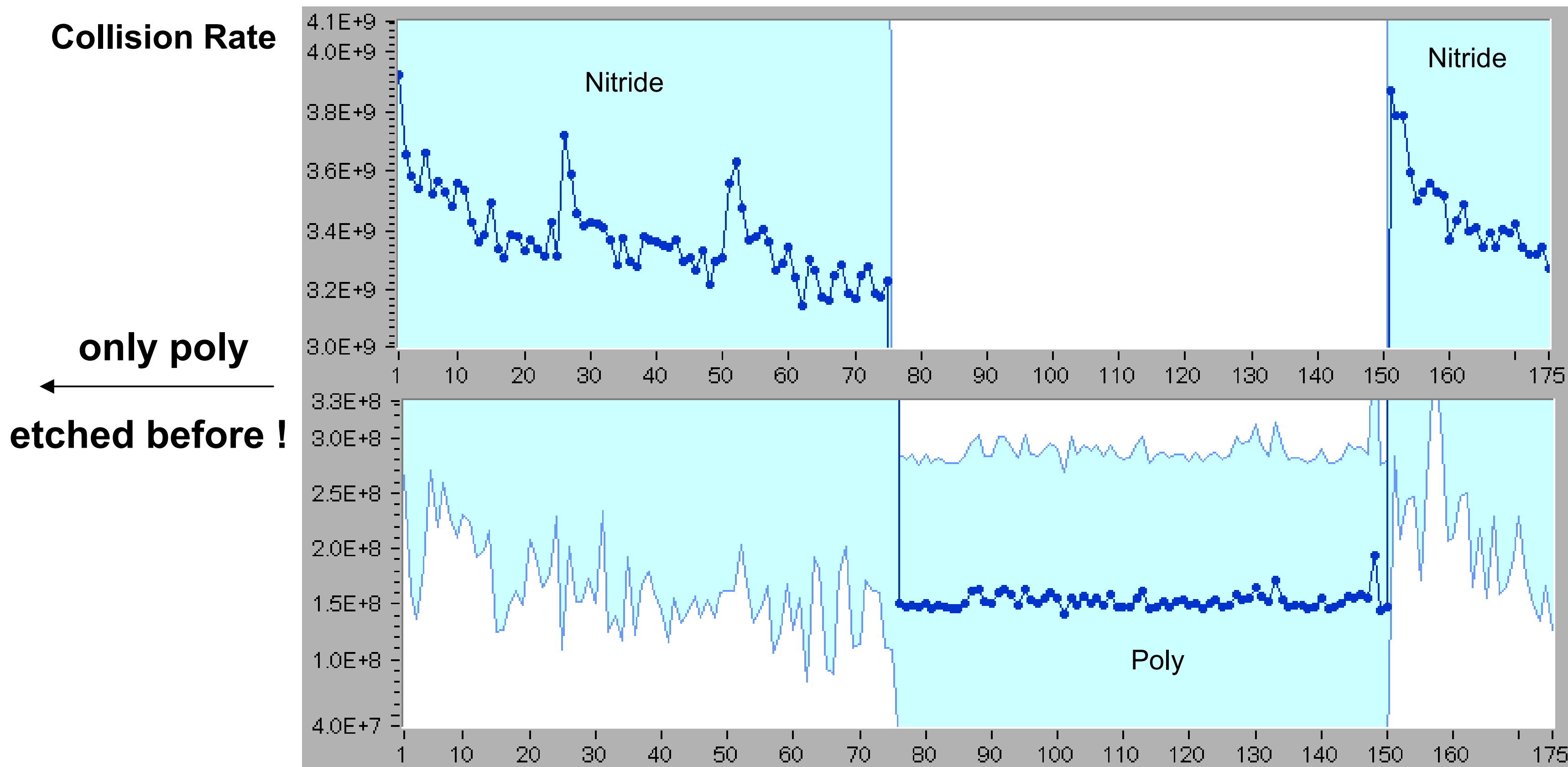






Switching between fluorine-based chemistry and chlorine-based chemistry could cause yield loss due to particles falling from top plate !

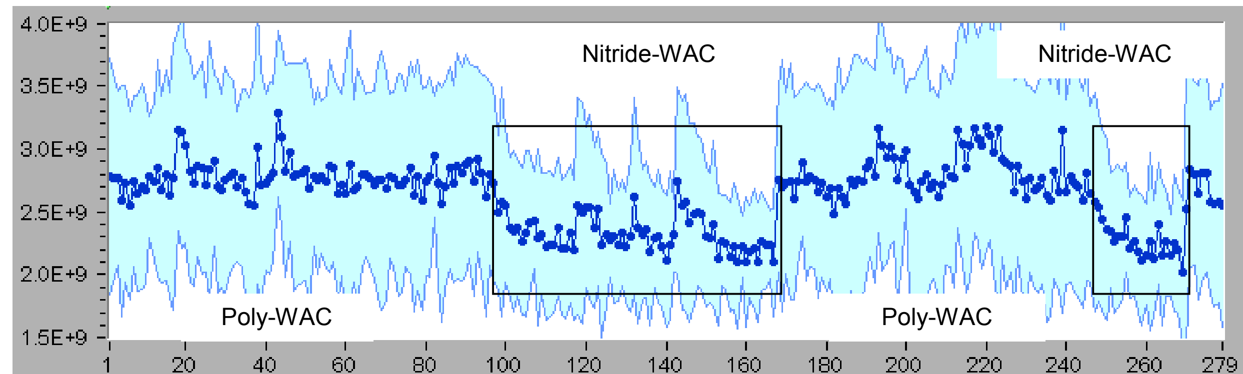
Poly → Nitride Switch



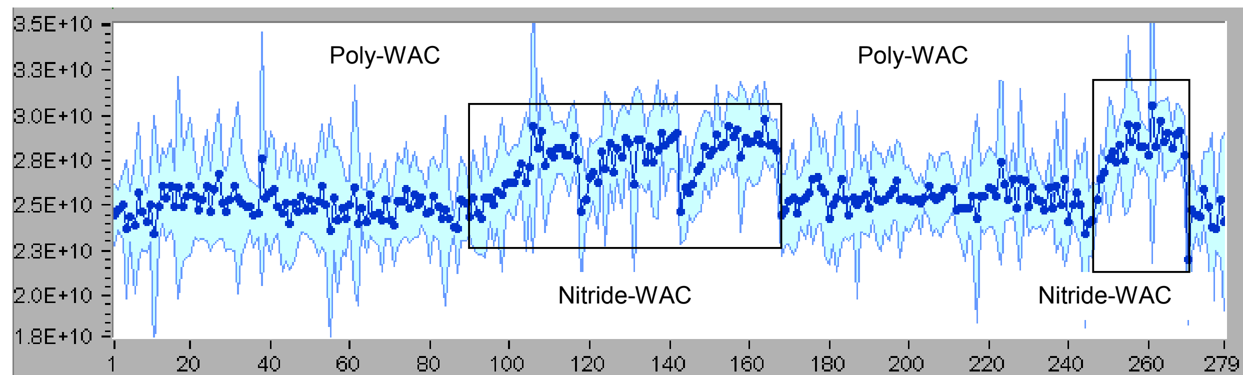
Same effect as switching from nitride to poly : after etching only one layer for a longer period (poly) switching to an other layer (nitride) results in process drifts !

Poly → Nitride Switch (WAC)

Collision rate



Electron density



The WAC for nitride and poly is identical, but nevertheless the WAC processes between each wafer also show a drift like the etch processes !

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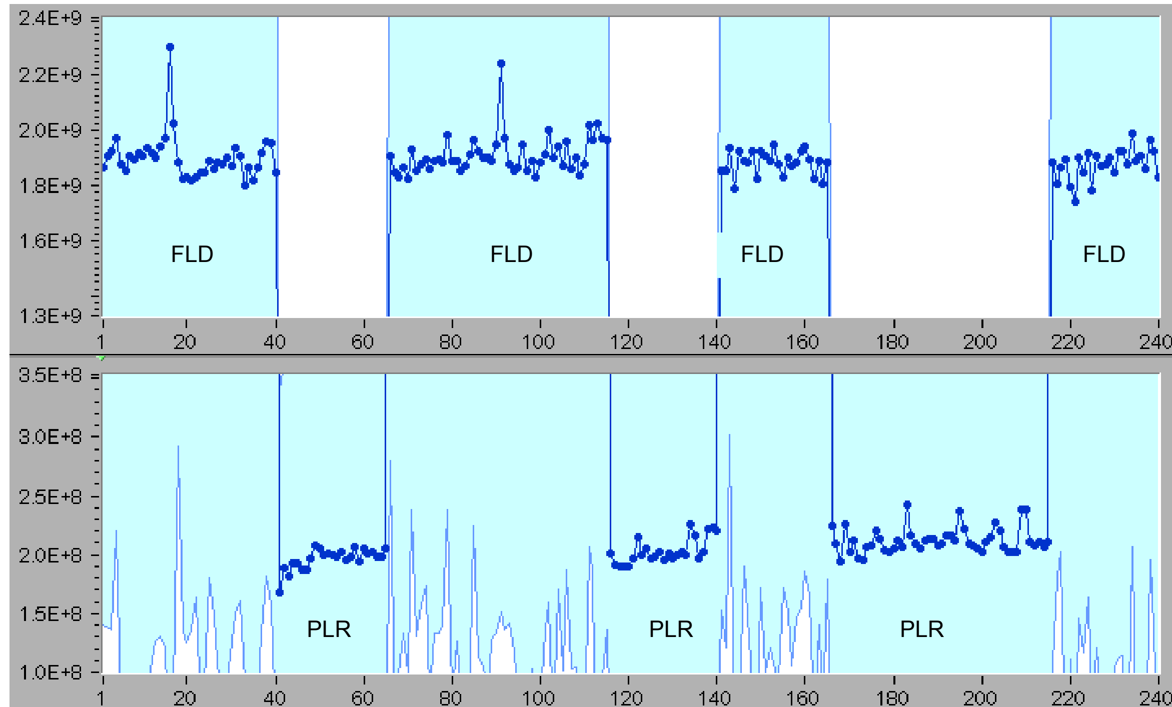
Continuous Switch Nitride → Poly → Nitride

Collision Rate



Switching continuously between etching nitride and poly layer stabilises the processes w/o additional conditioning ! MTBC improvement could be possible !

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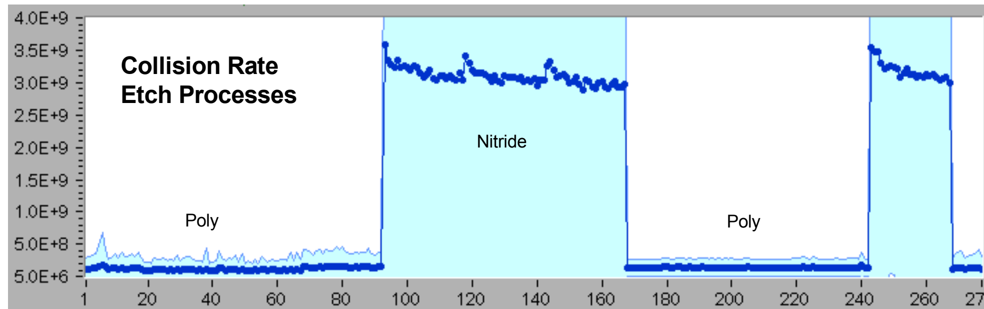
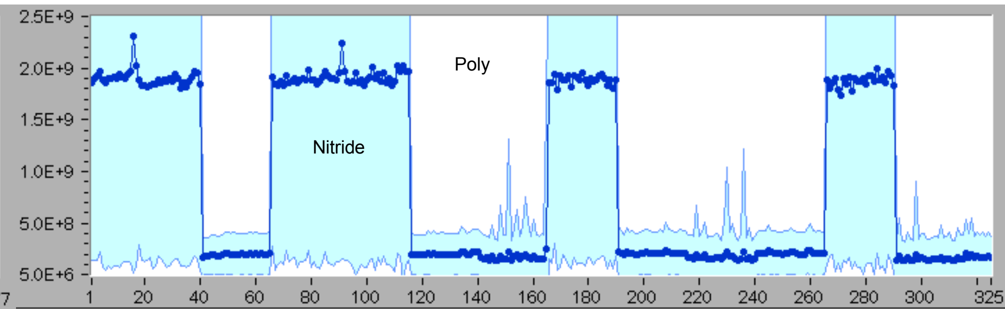
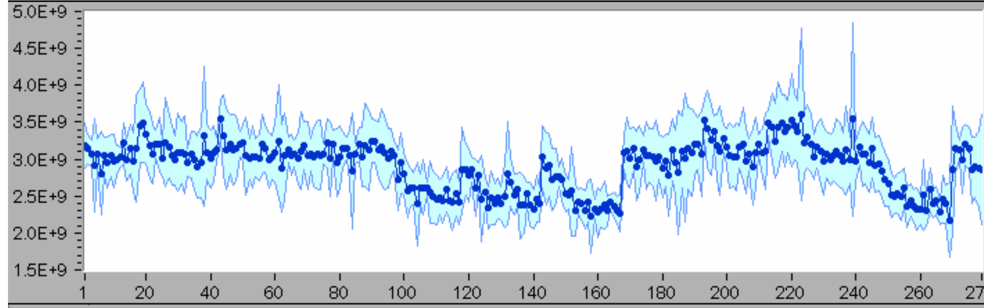
Comparison Continuous / Random Switch

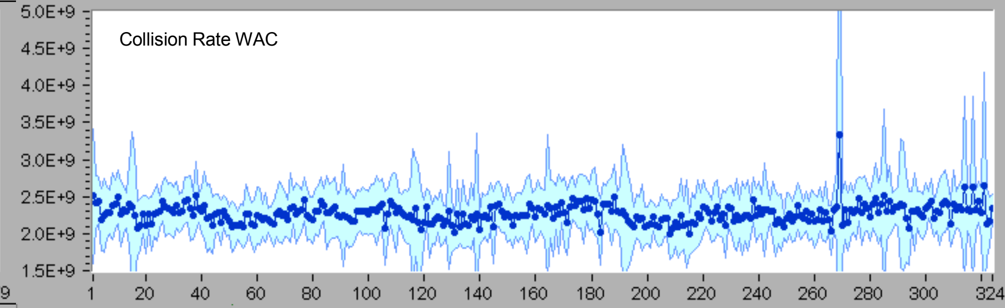
random switch

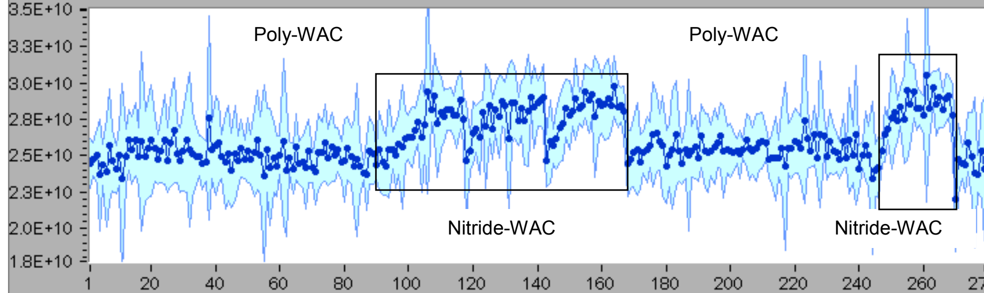
continuous switch

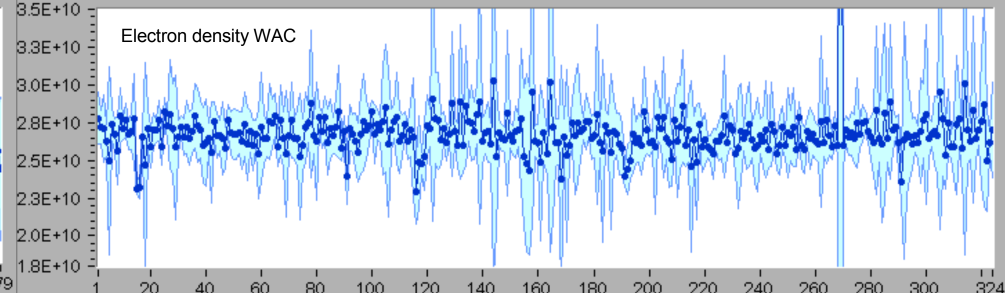






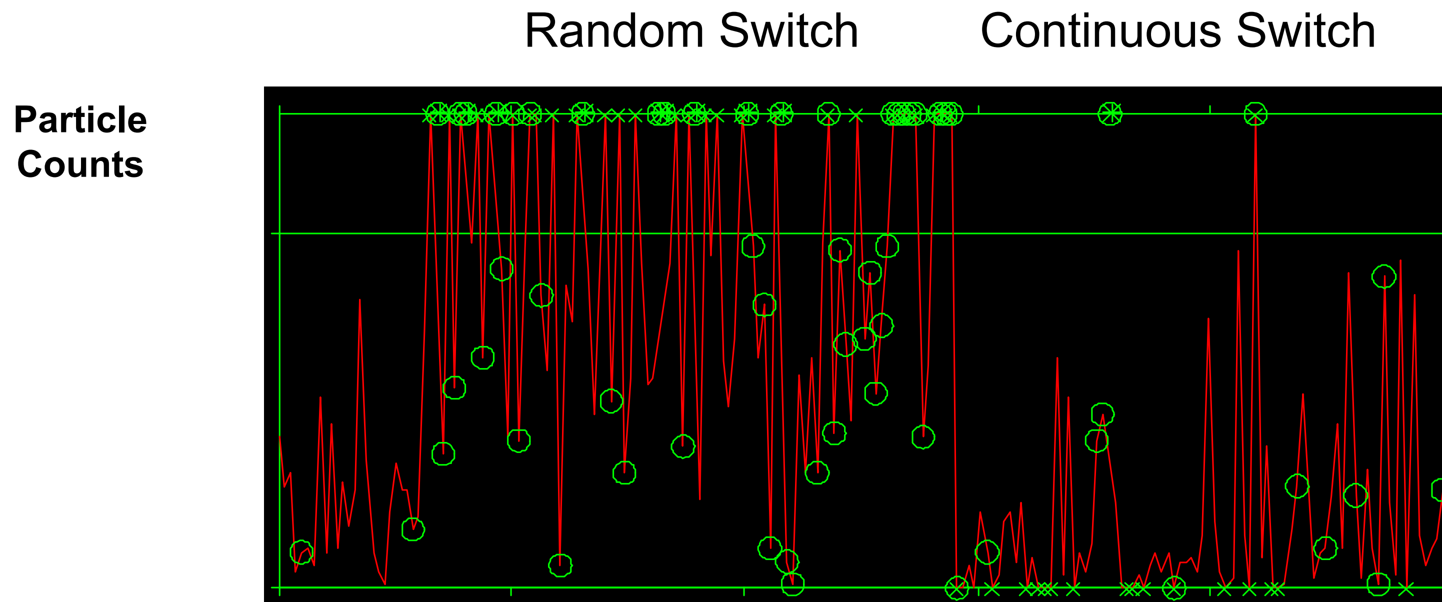






Experience with Continuous Switch Nitride → Poly

Improving MTBC and particle performance by continuously switching between poly and nitride is not really new to us. Several years ago a similar problem appeared on an old Lam Autoetch in terms of particle counts and has been solved by continuous switching.



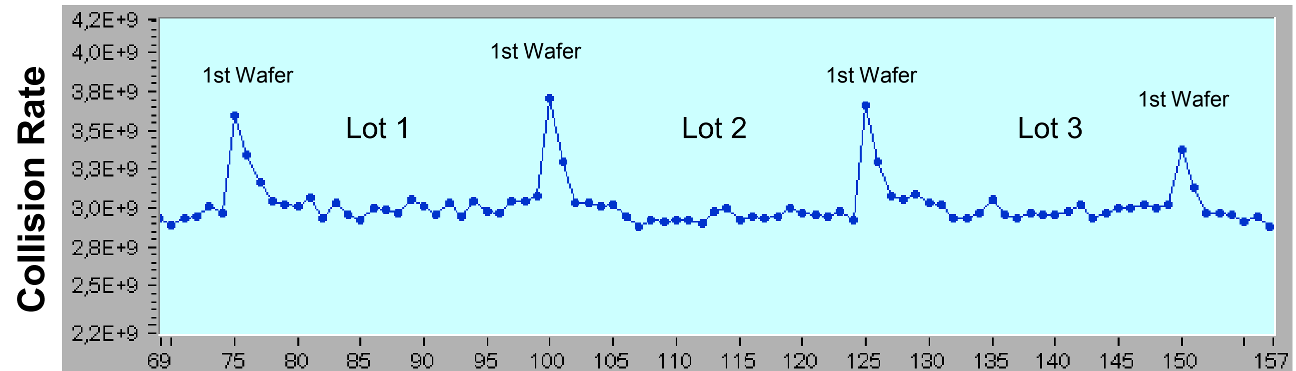
Recommendations for Switching Nitride → Poly

- continuous switch between poly and nitride could help to increase process stability w/o conditioning
- increased MTBC seems to be possible using continuous switch based on former experiences
- dedicated tools for nitride and poly best choice for process stability
- WAC has to be optimized

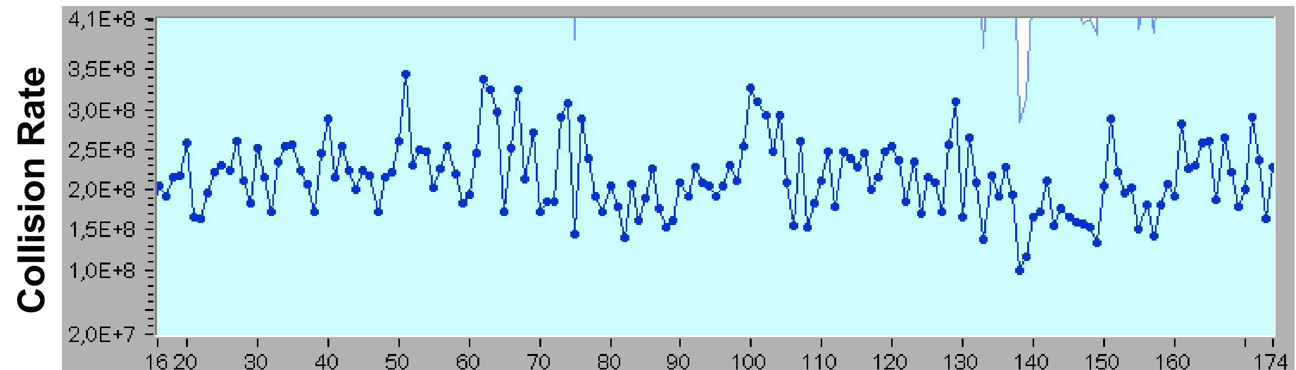
1st Wafer Effect

Nitride

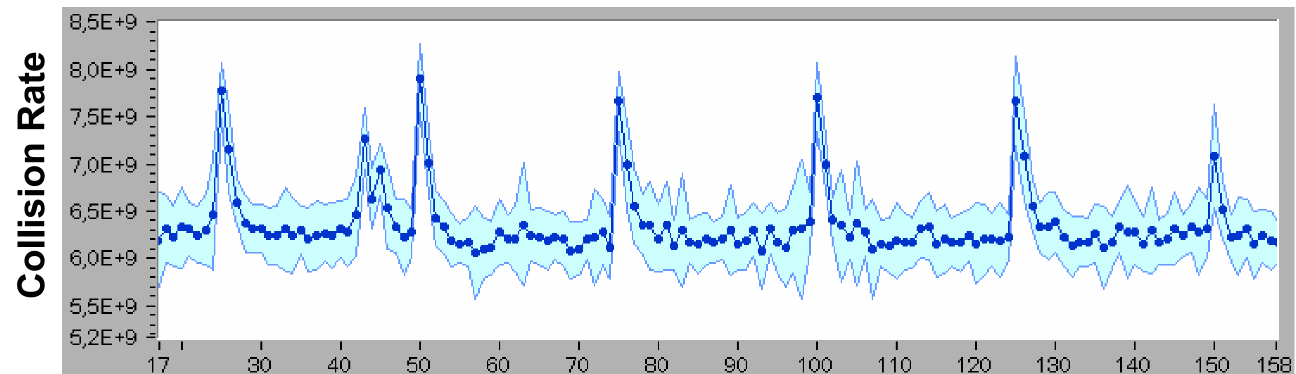
Step 1+2+3



Step 1+2 (HBr, CF_4, SF_6)

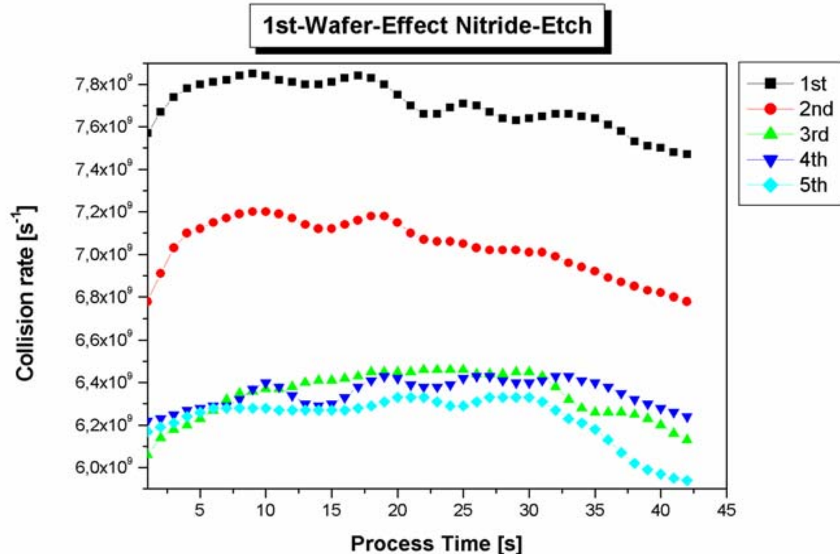


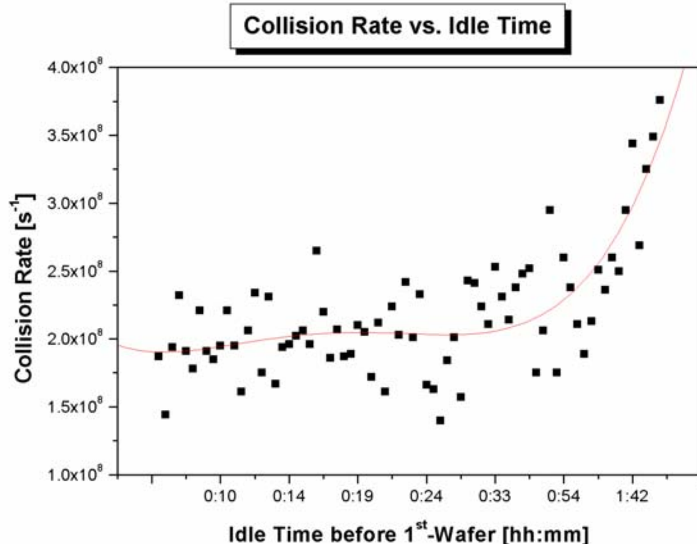
Step 3 (HBr, SF_6, O_2)



1st wafer effect is seen only in overetch step !

1st Wafer Effect Nitride





No easy explanation for 1st wafer effect:

- no pure temperature effect because of 2 steps run before !
- no pure temperature effect caused by idle time !
- only change from CF_4 to O_2 in overetch step could be possible reason, but why are only 2-3 wafers affected ? And why does this effect not decrease from lot to lot ? Combination of temperature and chemistry change ?

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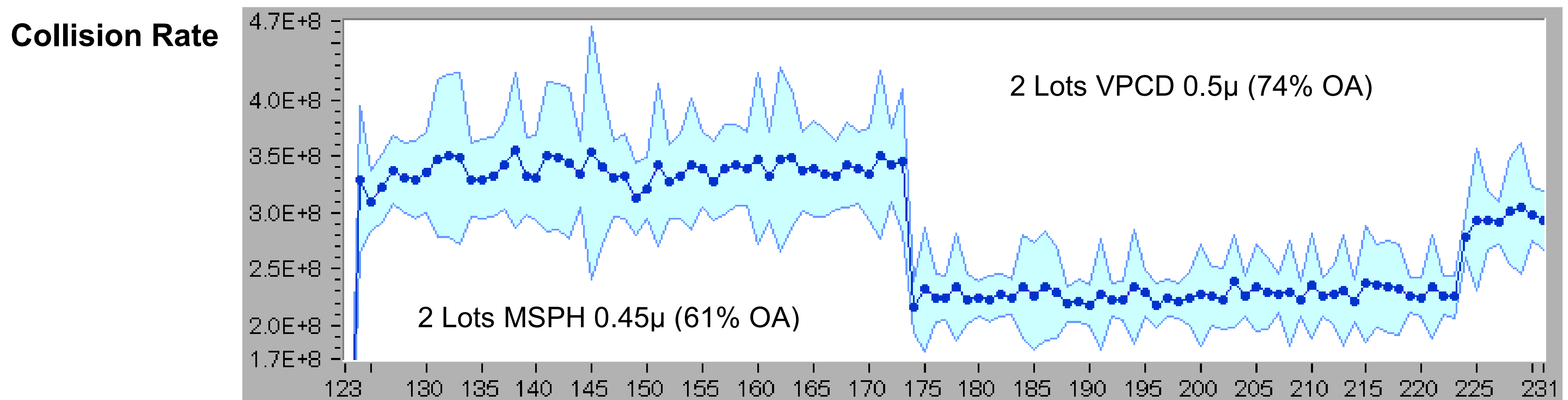
Product Dependence

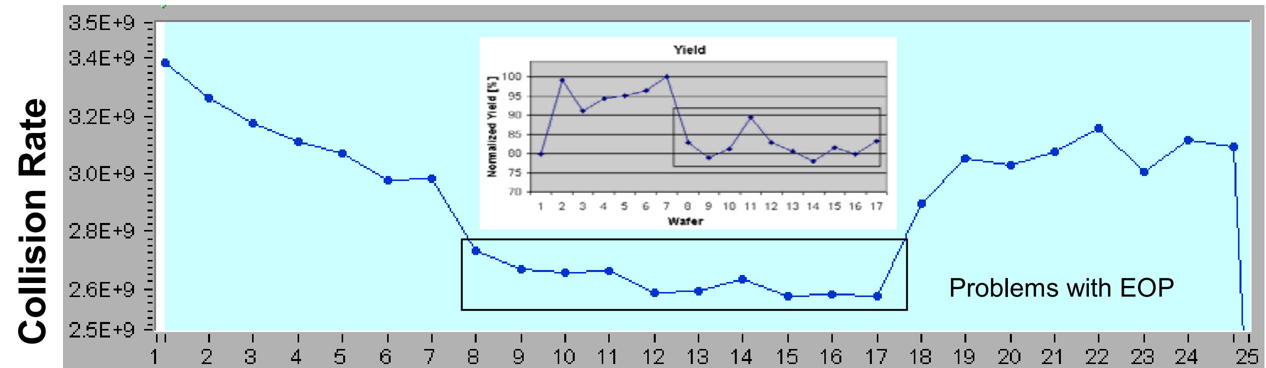
Gate-Poly MSPH 0.45µ - VPCD 0.5µ (Poly-OE-Step)



Collision rate is very sensitive to the etched open area (OA).

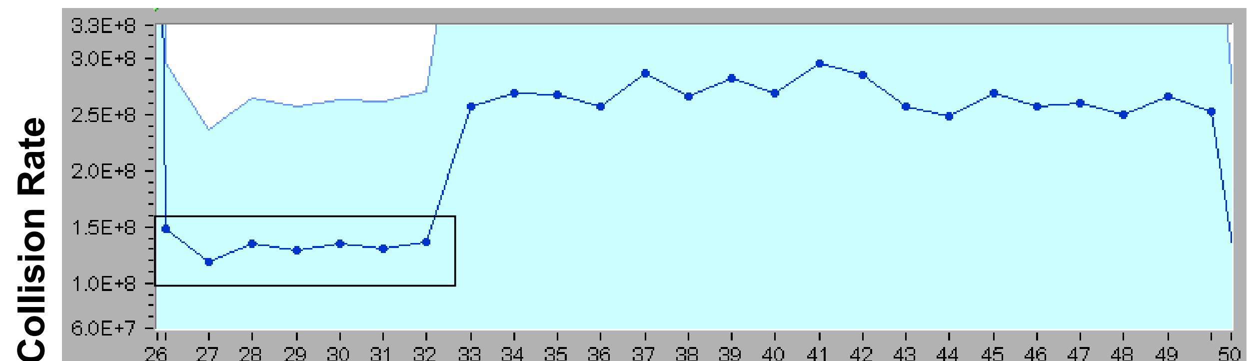
Tool Failure – Baratron Shift

Nitride-Etch



Because of sensitivity to process / tool parameters, collision rate and electron density are capable of detecting tool failures resulting in process parameter drifts. In this case a baratron had a defect causing a shift in pressure. The nitride lot had endpoint problems for wafers 8-17 ! Poly process not aborted !

Poly-Etch



Conclusion

Electron Density and **Collision Rate** are sensitive to

- Process parameters (e.g. gas flow, pressure, power)
- Process / chamber drift (conditioning, clean)
- Product differences
- Tool failure

HERCULES® will help to

- optimize conditioning, WAC, MTBC, cleaning procedures
- understand process / tool issues

Outlook / Next Steps

- Qualification of 2nd source parts using SEERS
- Lam TCP 9600 (WAC implementation, etc.)

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