AECAPC SYMPOSIUM 2000, Lake Tahoe

Supervision of Plasma-Etch-Processes at different Tool Types

Volker Tegeder

Infineon Technologies SC300

stop thinking Never

Supervision of Plasma Etch Processes at different Tool Types

- ➔ **European Project: APC300**
- ➔ **Sensor Integration**
  - different chamber types
  - B-field variations
- ➔ **Linking logistical Data**
  - spy for logistical data
  - innovative tool/sensor interface
- ➔ **Application Examples of SEERS in Production**
  - automatic Fault Detection
  - tool start-up / Tool release
  - chamber conditioning
  - influence of preprocesses

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European Project: APC300

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Supervision of Plasma Etch Process by SEERS

Assessment Site of Hercules/APC System

Infineon Technologies SC300 (Dresden)

Participants

AMD Saxony

ASI (Berlin)

Infineon Technologies (Regensburg)

ST Microelectronics (Rousset, France)

Start: 1st February 2000

Duration: 18 Month

European SEA IST-Project: APC300

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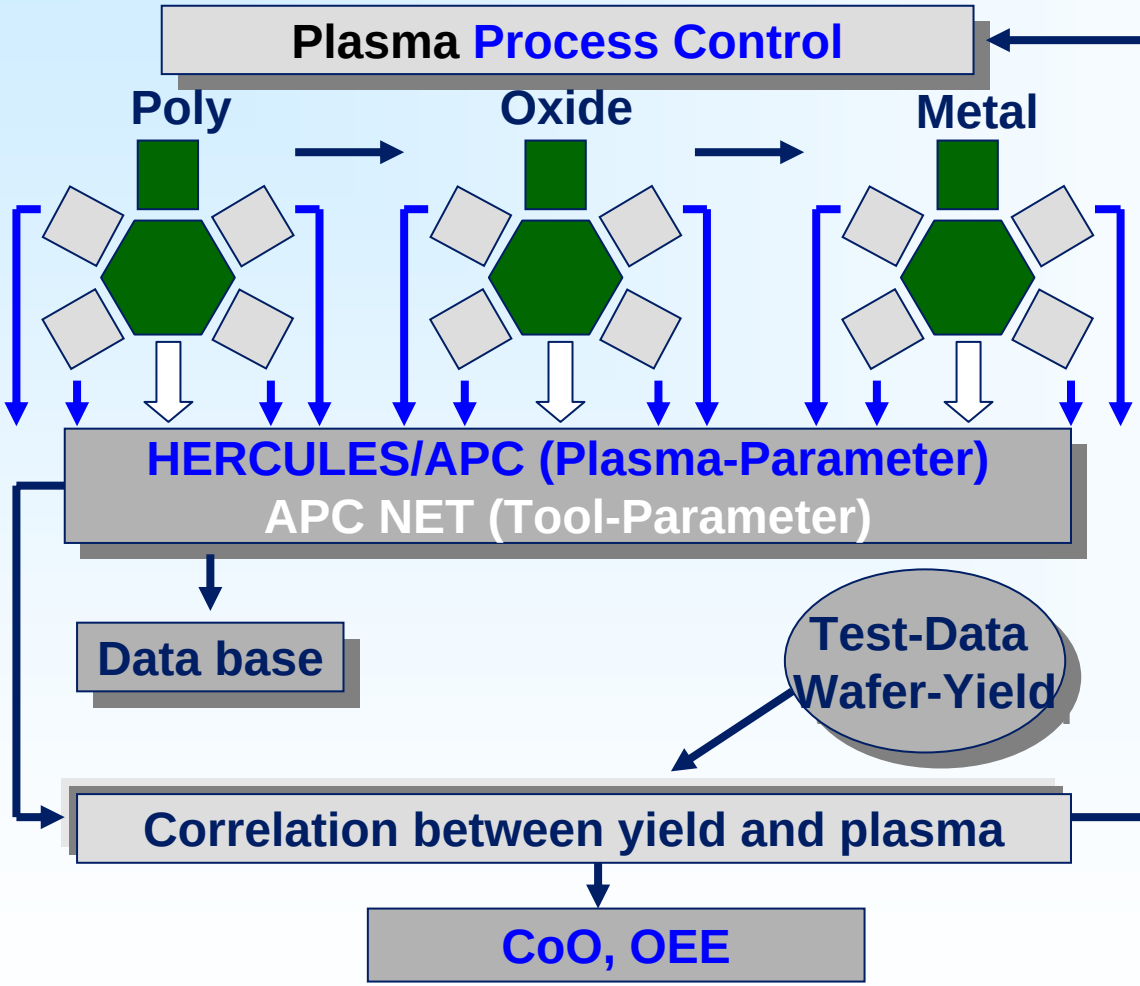
Control System Set Up



Evaluation site

focus on
- process control
- economical benefit

- 100% supervision on monitored etch processes
- up to 12 chambers
- approx. full POR
- link to logistical data
- different processes
  - poly / metal / oxide
- different chamber types
  - capacitive / ICP

Participants

- different applications at single tools
- mutual exchange of results

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Evaluation Site: Infineon Technologies SC300

Sensor Integration

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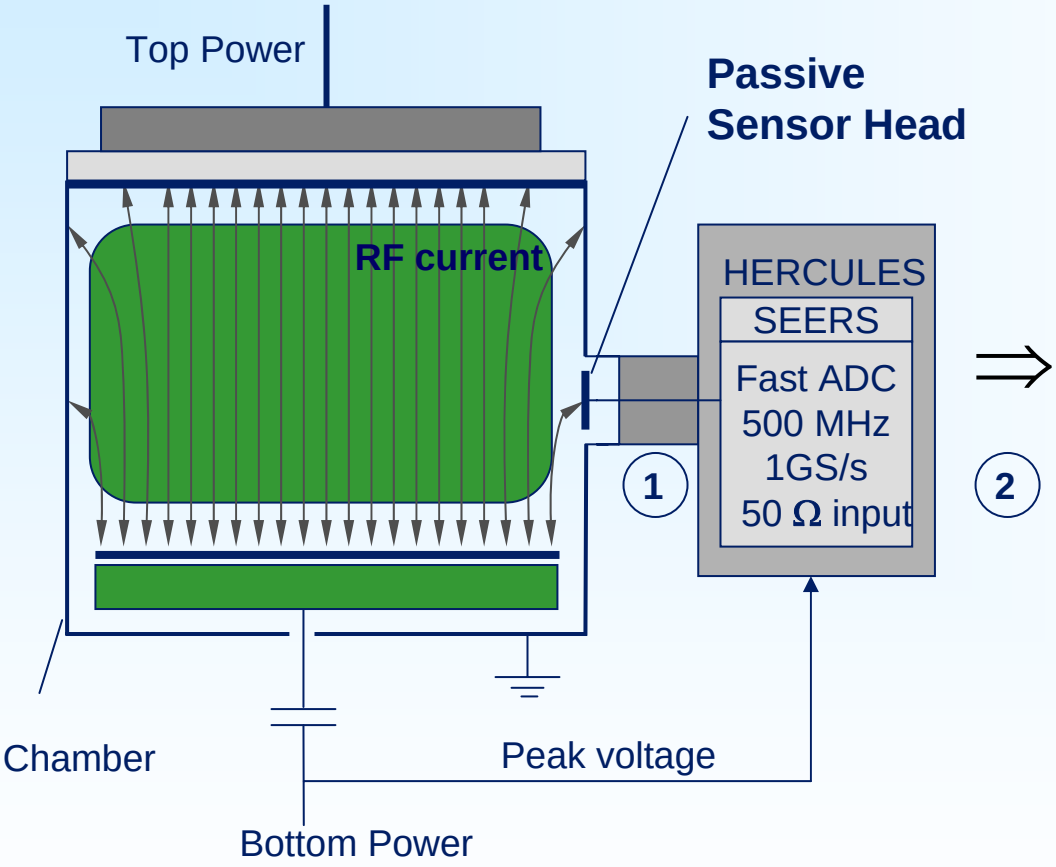
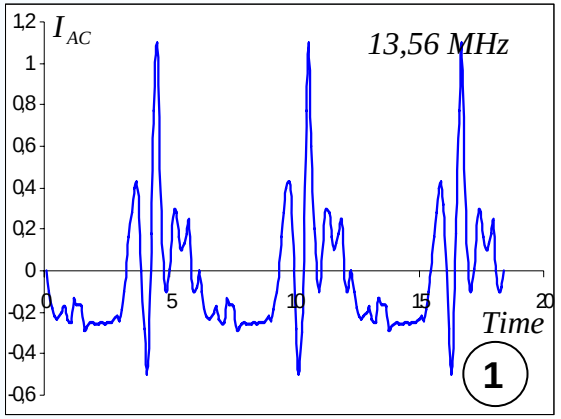
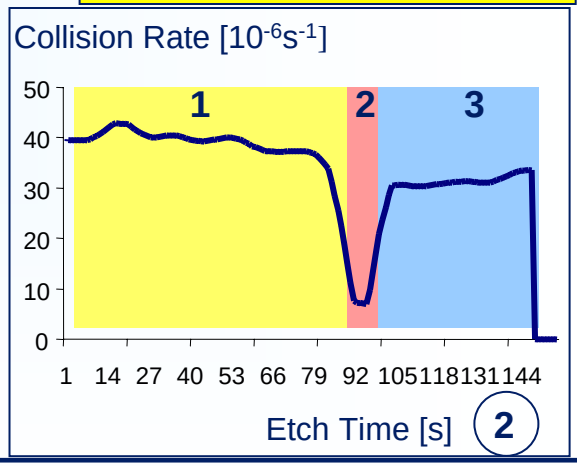
SEERS Measurement Principle



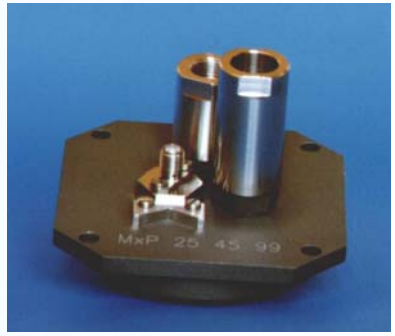


n: Electron density
ν: Collision Rate



Measurement of plasma-electron-density and collision rate

Adaptation to different chamber types



DPS

- peak voltage
- inductively coupled
- capacitive ≠ inductive coupled freqency

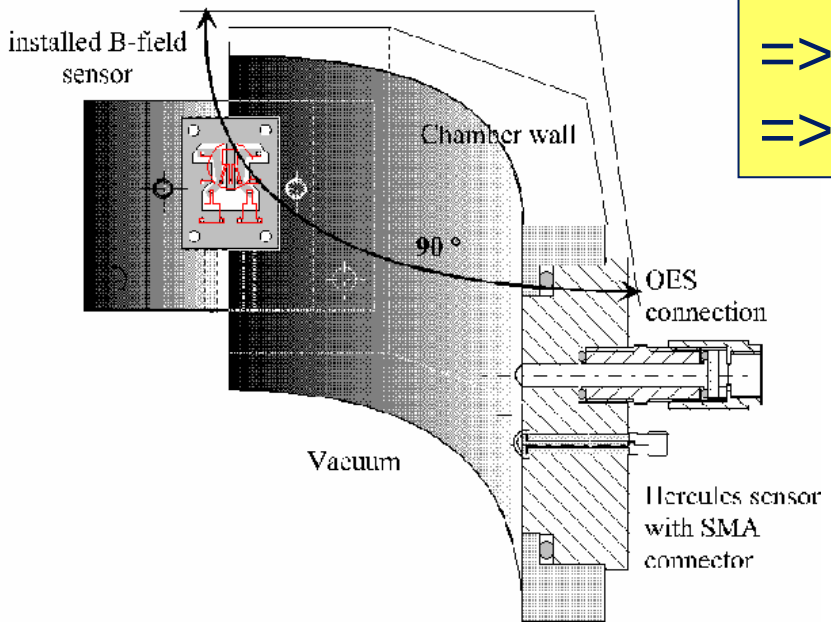
LAM 300

- peak voltage
- inductively coupled
- special software interface

eMxP+

- peak voltage
- rotating B-field
- optical access for OES

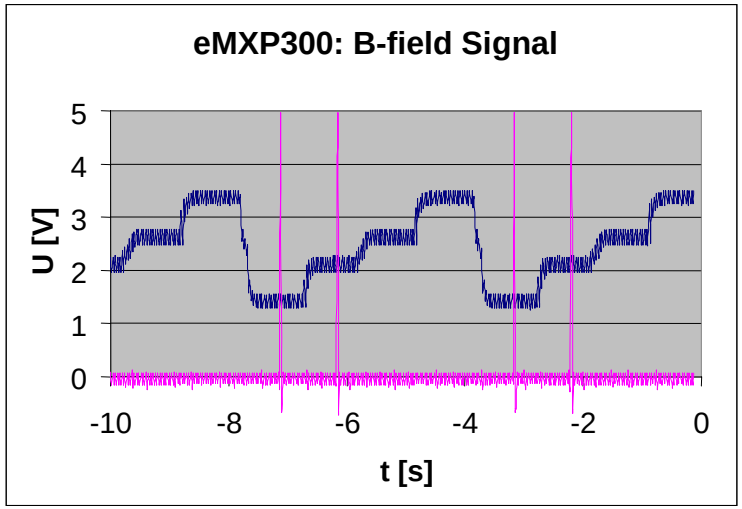
Synchronization to rotating B-Field



B-field sensor at chamber wall

B-field impacts plasma
=> varying SEERS signal
=> synchronization necessary

B-field and trigger signal



Varying magnetic field

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Linking Sensor Data to logistical Data

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Linking Sensor Data to logistical Data

Logistical data the missing link?!

Product #, lot #, recipe...important for any sensor:

- Data Analysis
  - correlation to in-line/electrical data
  - economical benefit
- Fault detection
  - depending on product
  - depending on recipe

Link I : Spy for logistical Data

Link II : Innovative tool sensor interface

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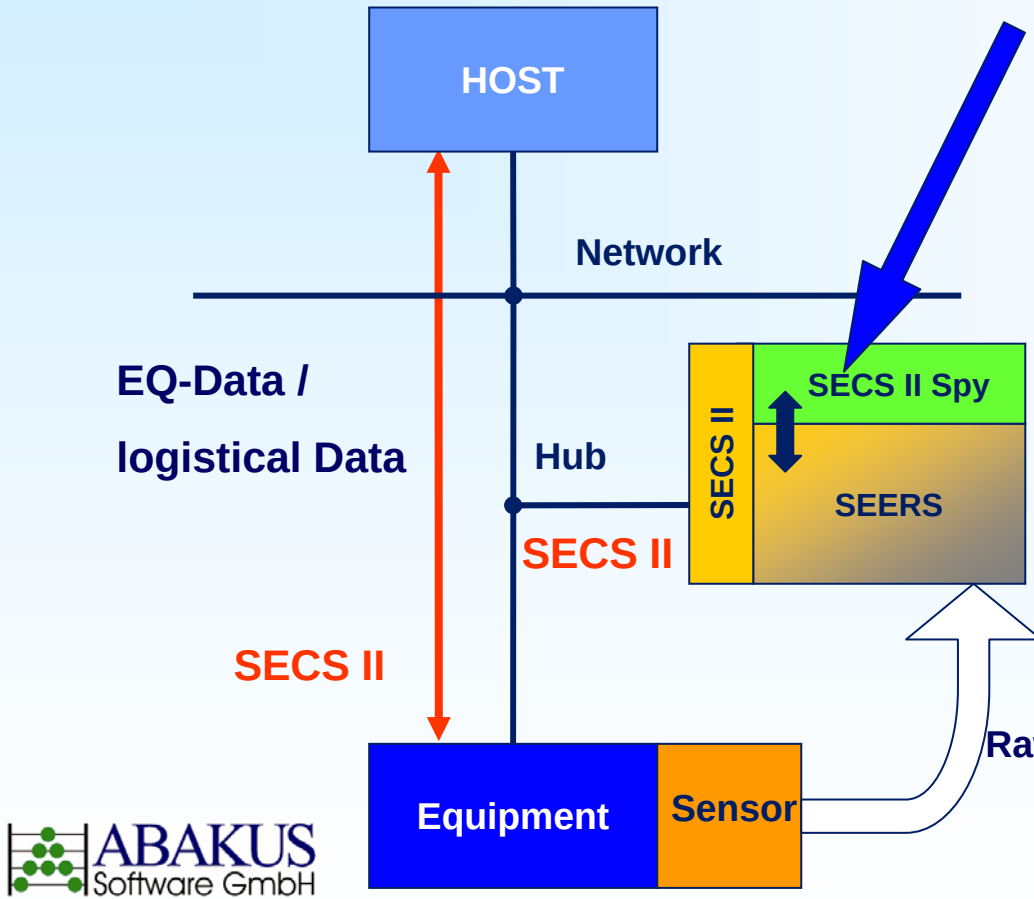
SPY for logistical Data



ABAKUS SECSII SPY

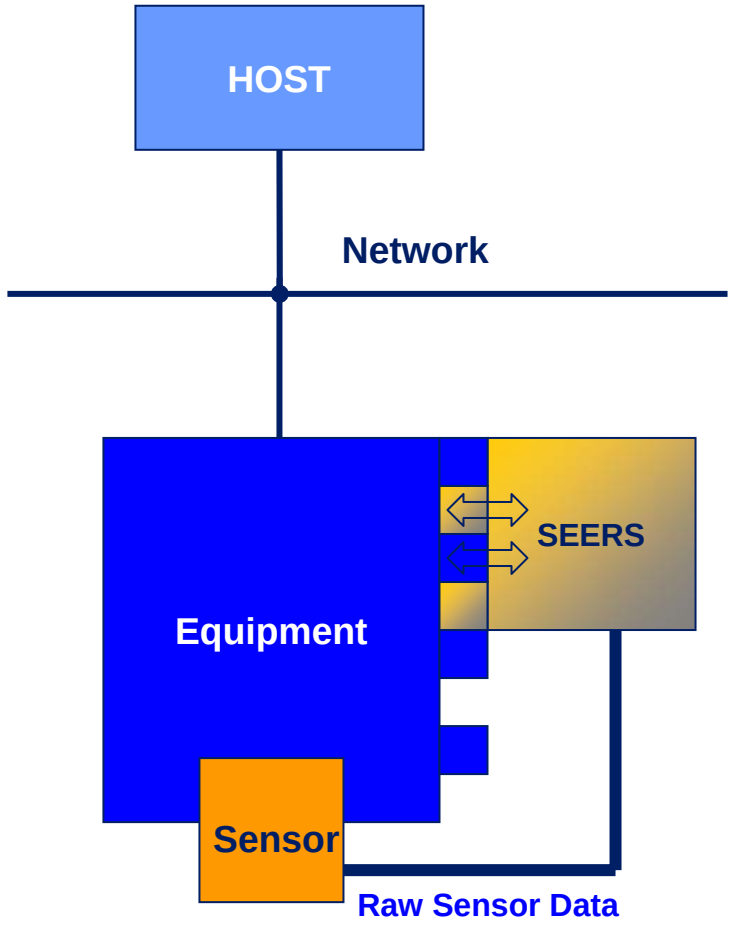
- full passive system
- configurable message filter
- communication to sensor via SECSII
- ethernet based

(patent pending)

Linking sensor data to logistical data

Innovative Tool / Sensor Interface

Example: SEERS



LAM Plug and Play Interface

- universal sensor data interface
- independent network ethernet based 10 Mbit
- access to logistical data
- merging tool and sensor data => the virtual tool

Application Examples of SEERS in Production

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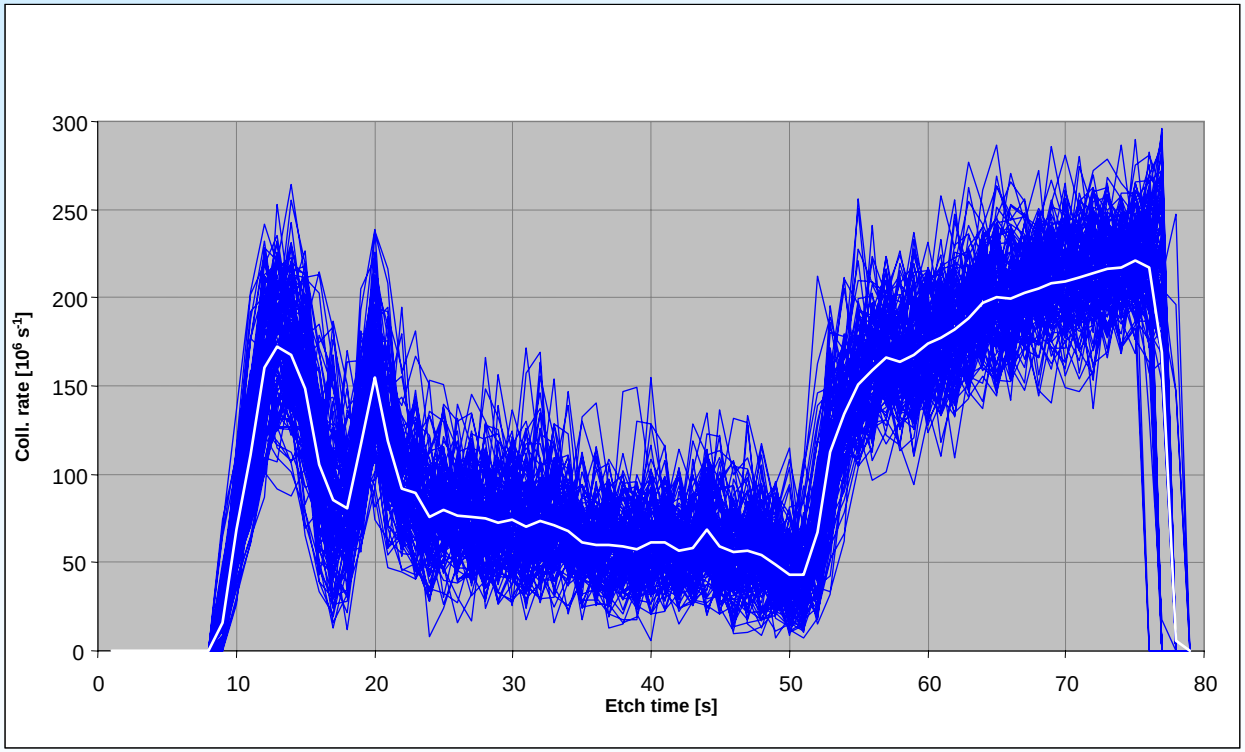
Automatic Fault Detection



SEERS sensitive to

- pressure
- magnetic field
- RF- power
- chemistry
- chamber condition
- pre-processes
- etched substrate
- arcing

Average curve from 80 individual M1 runs.

Different fault detection methods possible. First: average value of ν, n

SEERS Fingerprint

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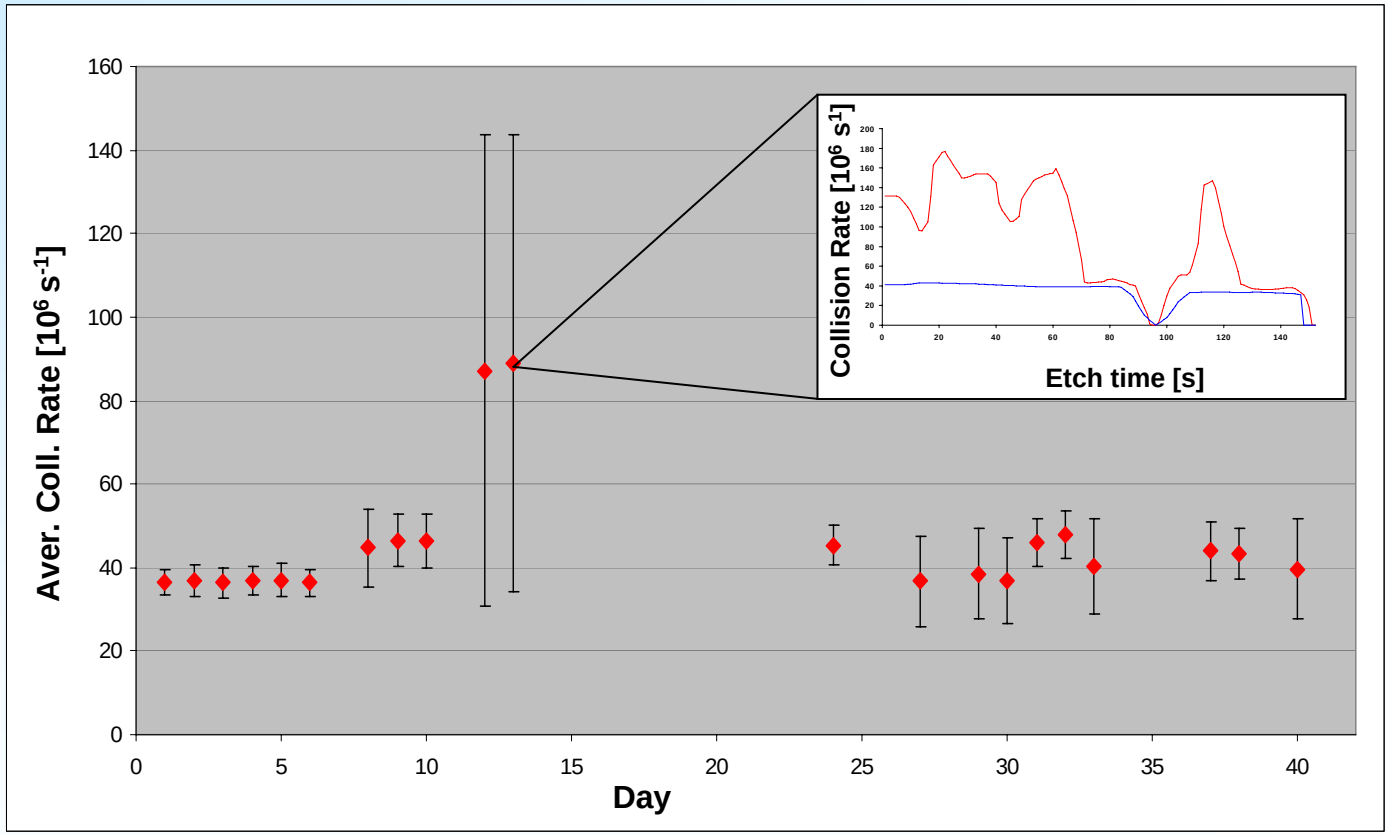
Automatic Fault Detection



Arcing Traces in Chamber ⇒ Exchange of E-Chuck and Ion Shield

Fault detected by lot-average of ν

Tool start up / Tool release

Checking Chamber Condition with SEERS

Define reference recipe

Determine process fingerprint

Perform Tests for

- HW change
- tool hook up

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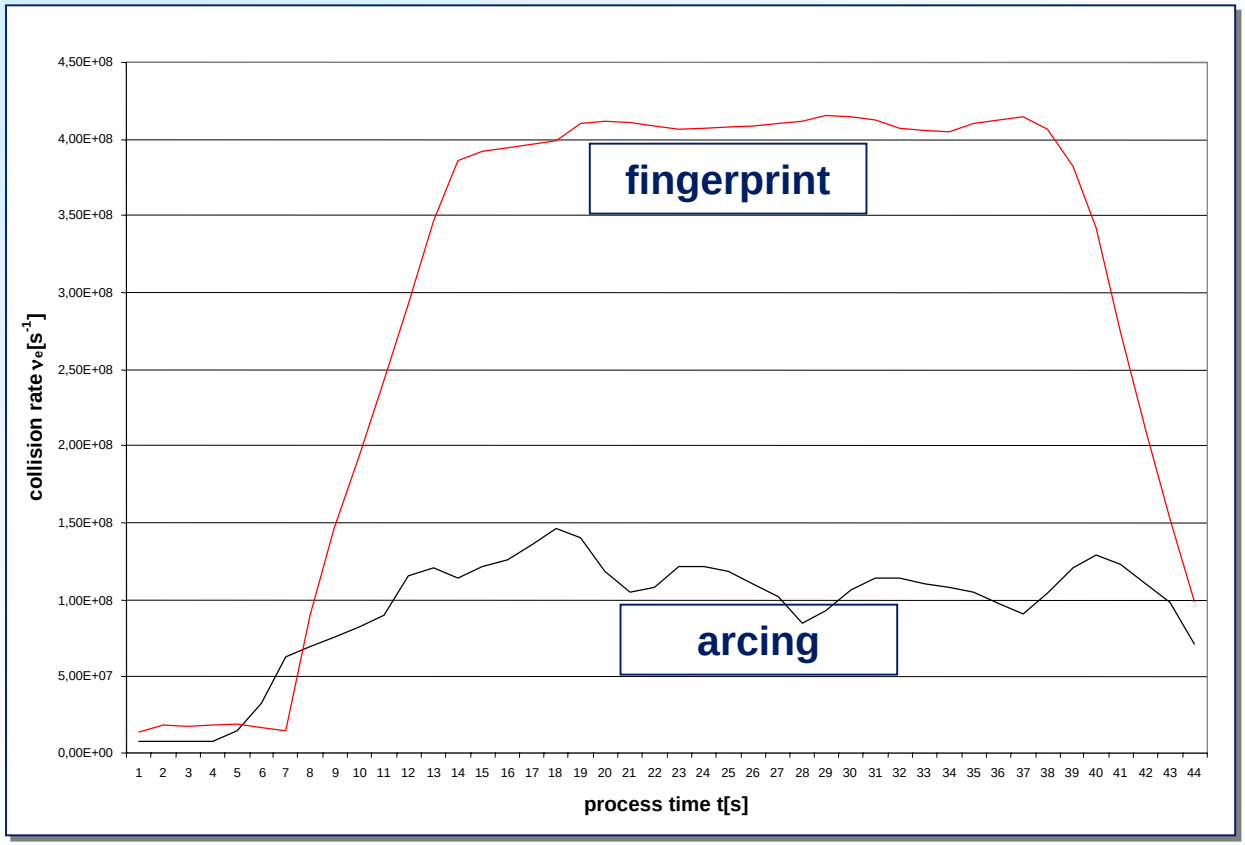
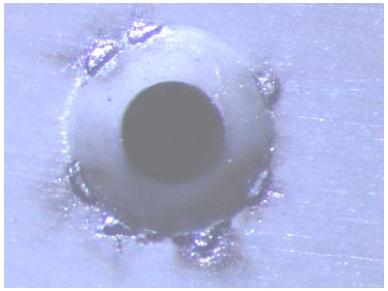
Tool start up / Tool release





Arcing traces at gas distribution

Recipe

Step 1

25mtorr /

215W / 30G/

50 sccm O2

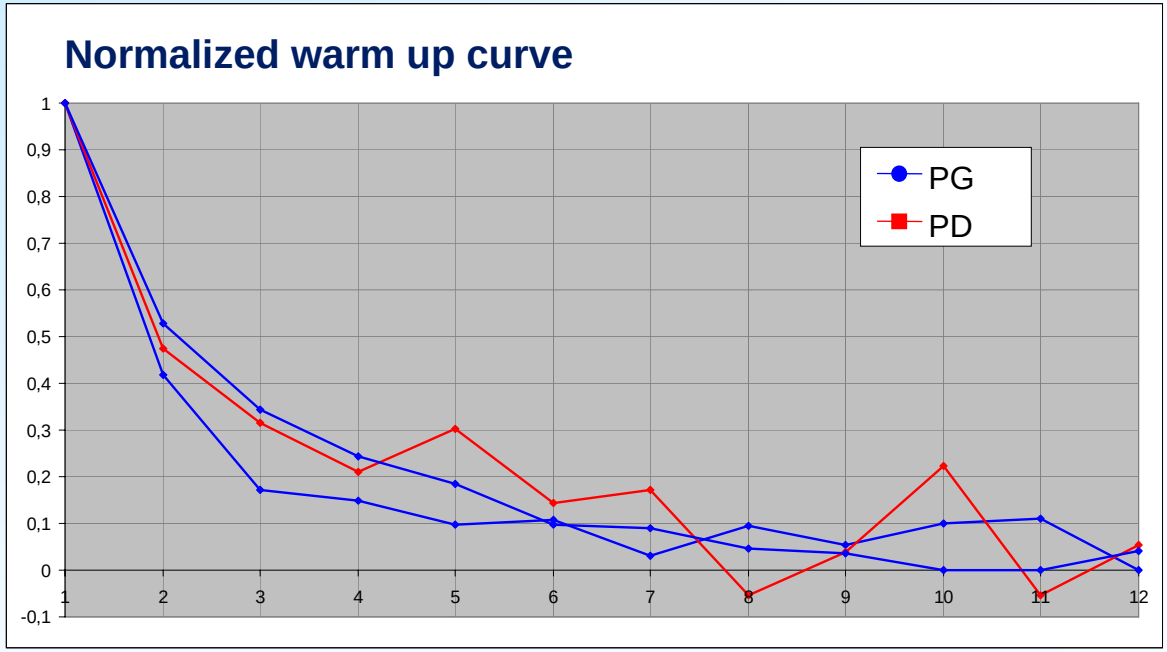
Step 2

25mtorr / 215W

0 G / 50sccm O2

Arcing detected at new tool

Chamber Conditioning
(after idle chamber)



First wafer effect

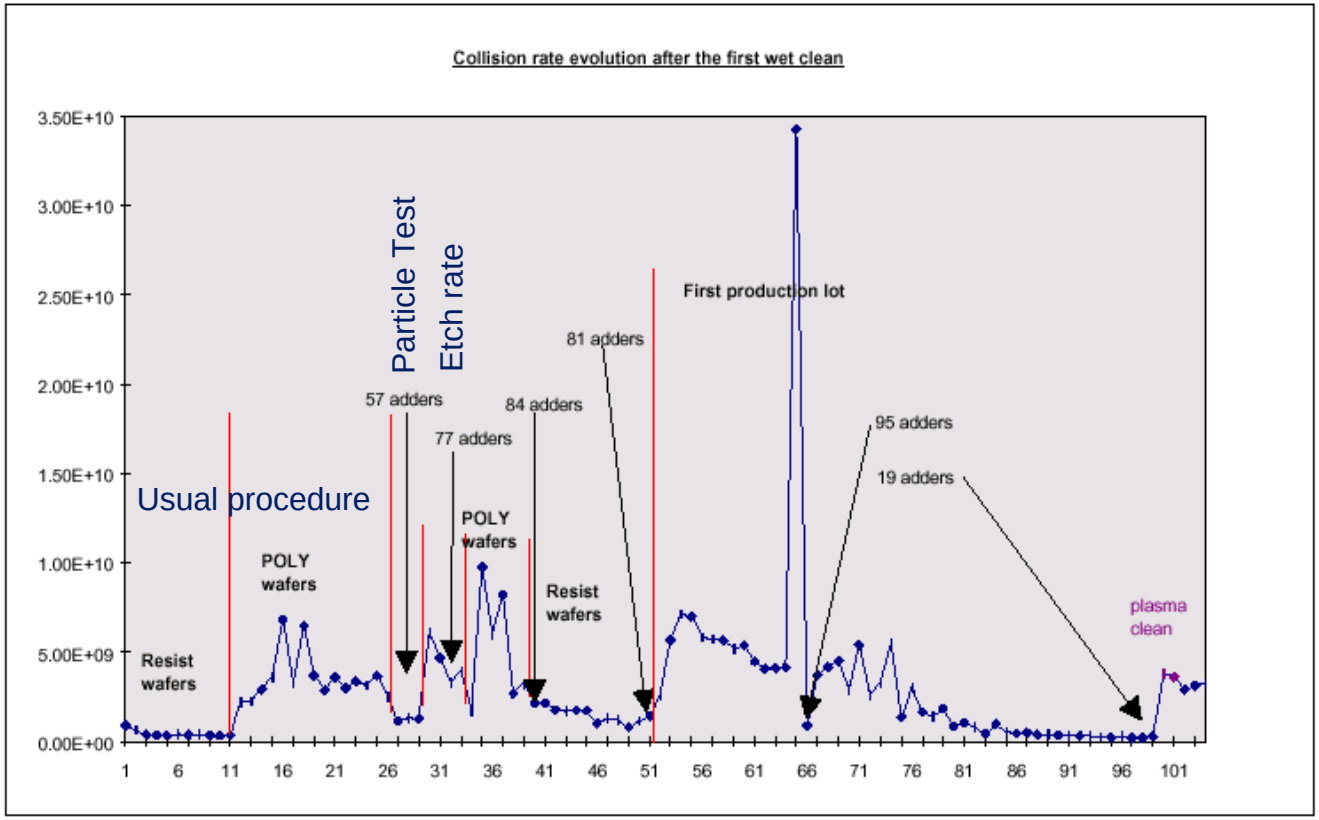
- same chamber
- approx. 1h idle
- different gasses
- $P_{G/D}$ proportion 1:2
- $t_{G/D}$ proportion 1:2,2
- $p_{G/D}$ proportion 1:2,5

similar warm up curve with strongly different recipes

=> thermic effect expected

Comparison with different recipes

Chamber Conditioning
(after wet clean)



Conditioning procedure I

- **resist wafers**
- **poly wafers**
- **particle test**
- **etch-rate test**

acceptable particle level after > 50 wafers

=> long and costly procedure

Lesson learned: minimal collision rate correlates with particle count

Usual procedure with resist and poly wafers

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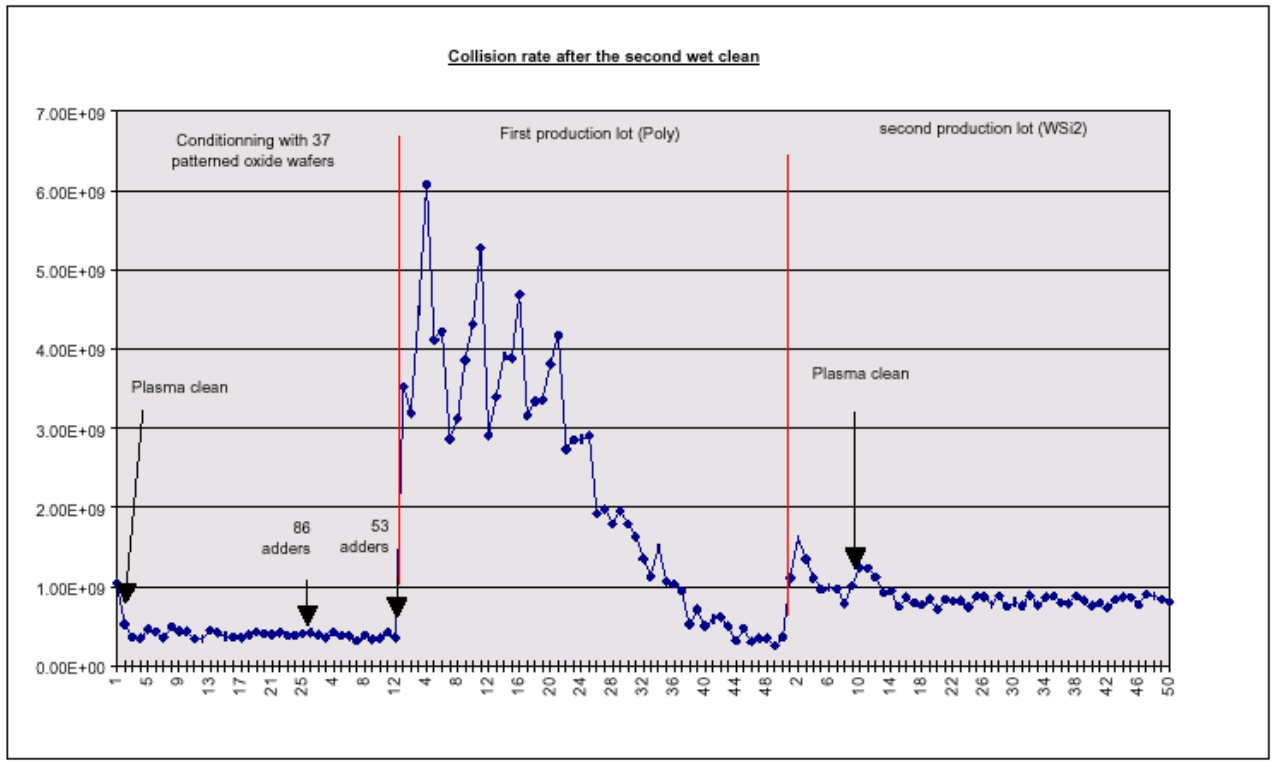
Chamber Conditioning
(after wet clean)



Conditioning procedure II

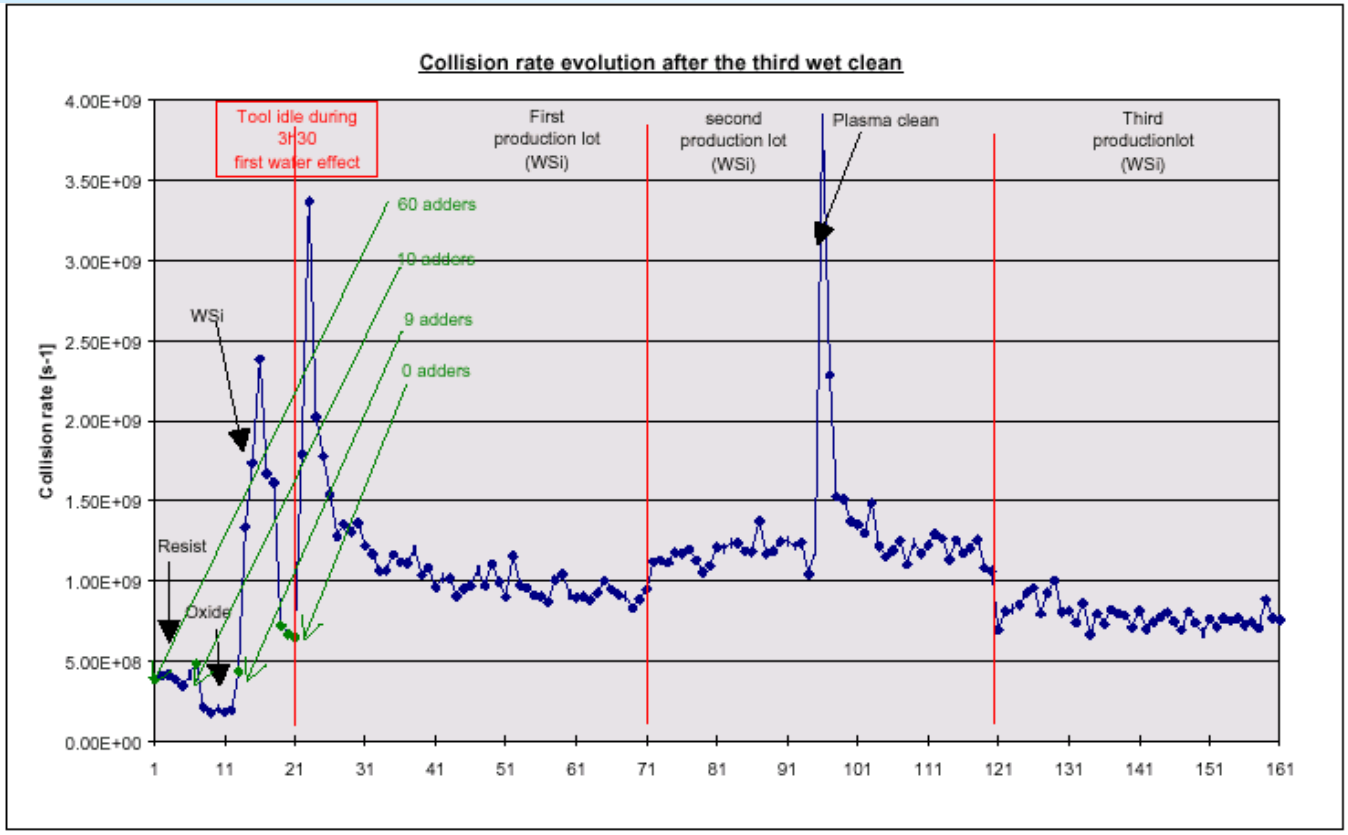
- **oxide wafer for low collision rate**
- **patterned wafers**
- **constant collision rate**
- **particle test**

Collision Rate rises as poly is etched

- still not perfect conditioning

Improved conditioning with patterned oxide wafers

Chamber Conditioning
(after wet clean)



Conditioning procedure III

- **resist wafers**
- **oxide wafers (unpatterned)**
- **particle test**

Only 10 wafers for conditioning compared to prior 50!

Optimized procedure with resist and oxide wafers

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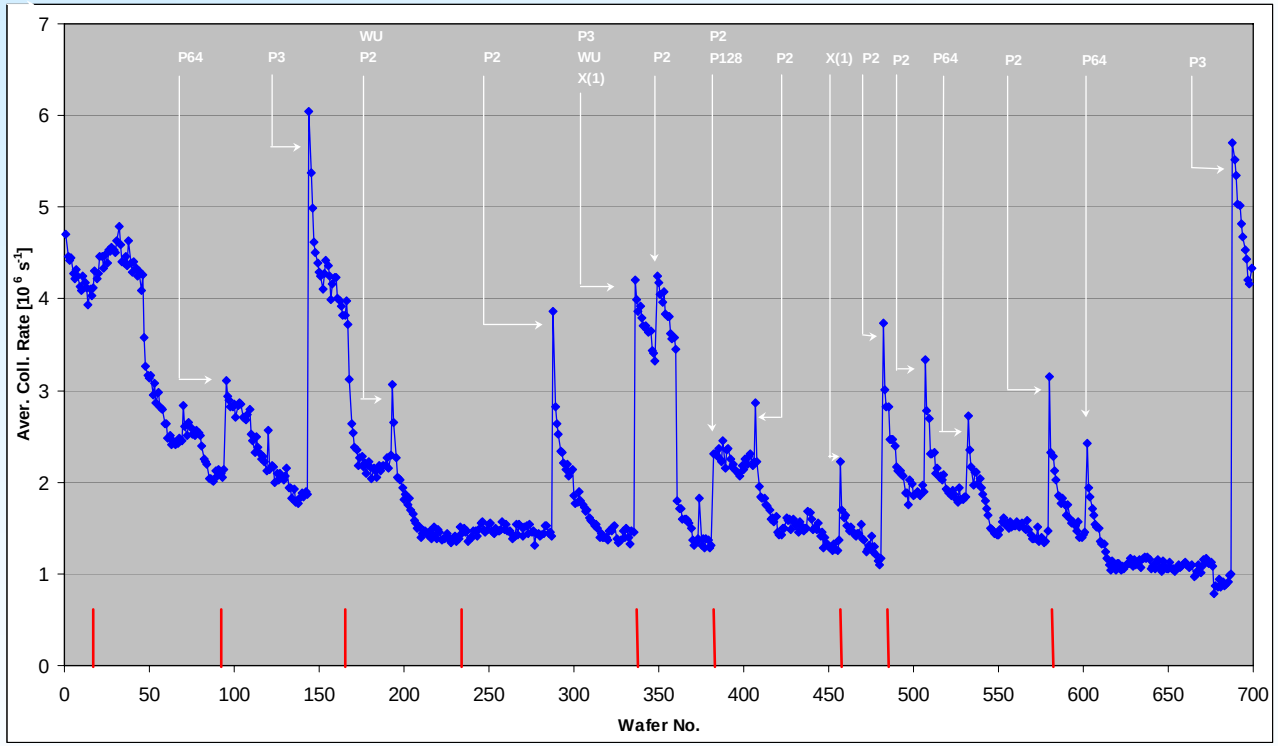
Influence of Pre-Processes



GC MO Process

- stable level for ν at $10^6 s^{-1}$
- P3 pre-process highest impact

Process mix at one chamber

Collision rate with different pre-processes

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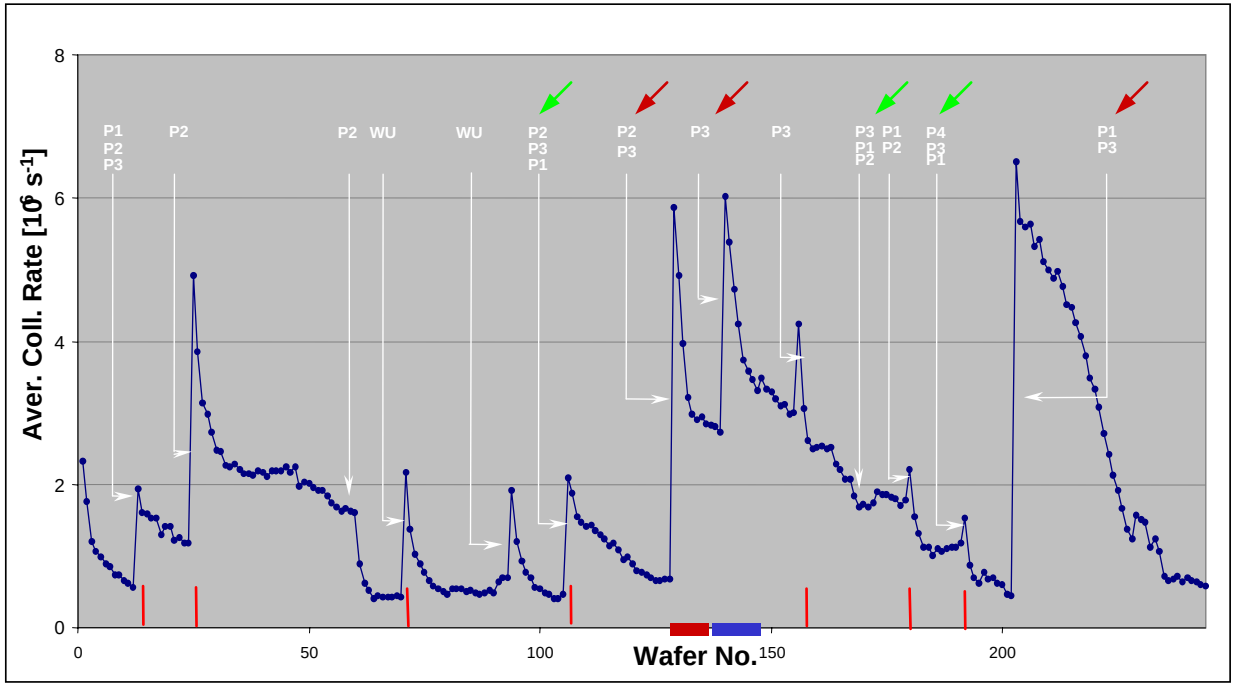
Influence of Pre-Processes



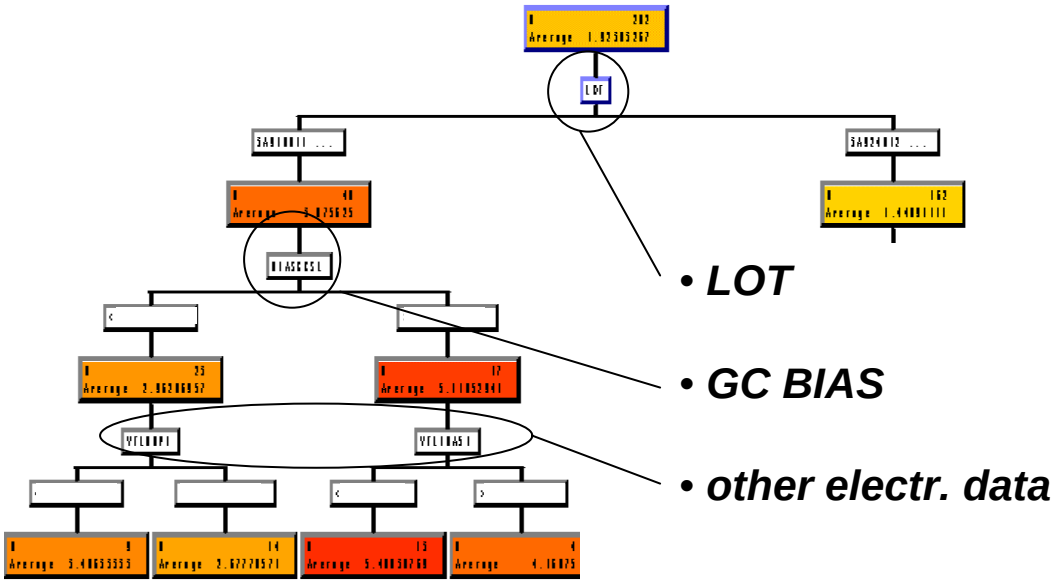
GC-Etch

- Multi-Process-Chamber
- Preprocess indicated
- P3 has highest impact
- P1 compensates P3 impact

P3: strongly polymerizing process
P1: strongly etching of polymers

Process mix impact on product

Influence of Pre-Processes



Data Mining:
Decision Tree

- based on statistics
- suitable for high data volume
- detects correlation

Target for decision tree: Plasma Collision Rate ν

$\Rightarrow$ Correlation: Collision Rate / GC BIAS for special Lots with high collision rate

Decision Tree for Electrical Data

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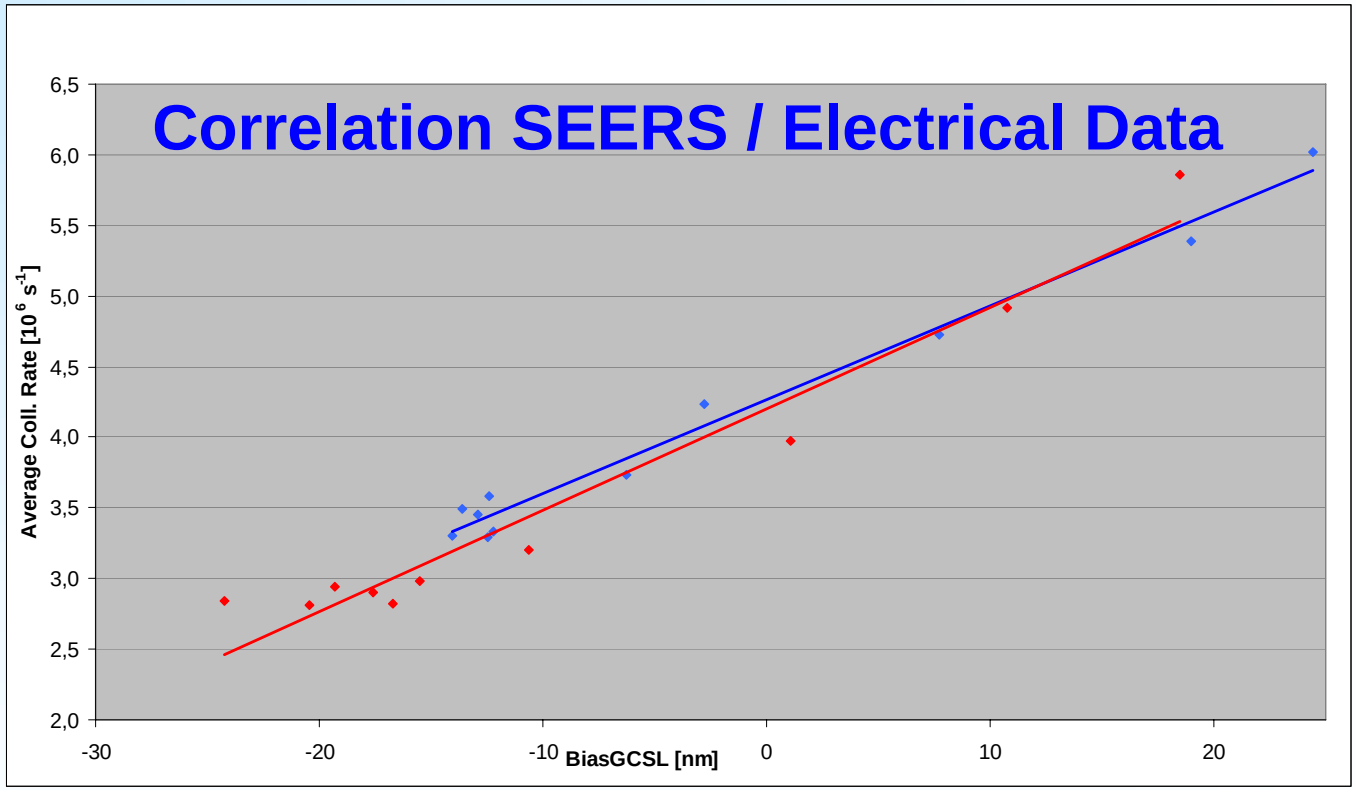
Influence of Pre-Processes



Strong correlation between collision rate and GC bias ($R^2 > 0,92$) for indicated lots with high collision rate

Plot of collision rate and GC bias

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