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Deployment of Plasma Parameters for FDC in Etch

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Advanced Process Control

Micronas

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Why using APC in a 0.45µ-Fab ?

- Automotive products incl. Zero ppm Program
- No Zero ppm w/o APC !
- Yield < 100%

- Identification / understanding of tool and process problems is fundamental
- Fixed % limits in tool software for control not sufficient
- Most parameters are not controlled at all (valve / match...)

- Realtime control of tool including additional external sensors necessary

Goals of APC Implementation

- Improvement of process and product performance, quality and productivity (process, product, tools, maintenance,...)
- Transition from preventive to predictive maintenance
- Optimization of costs (e.g. faster qualification of products and equipment / reduction of testwafers / ...)
- Improvement of in-line yield by avoiding excursions / disasters
- Reduction of engineering time for processing non conforming lots

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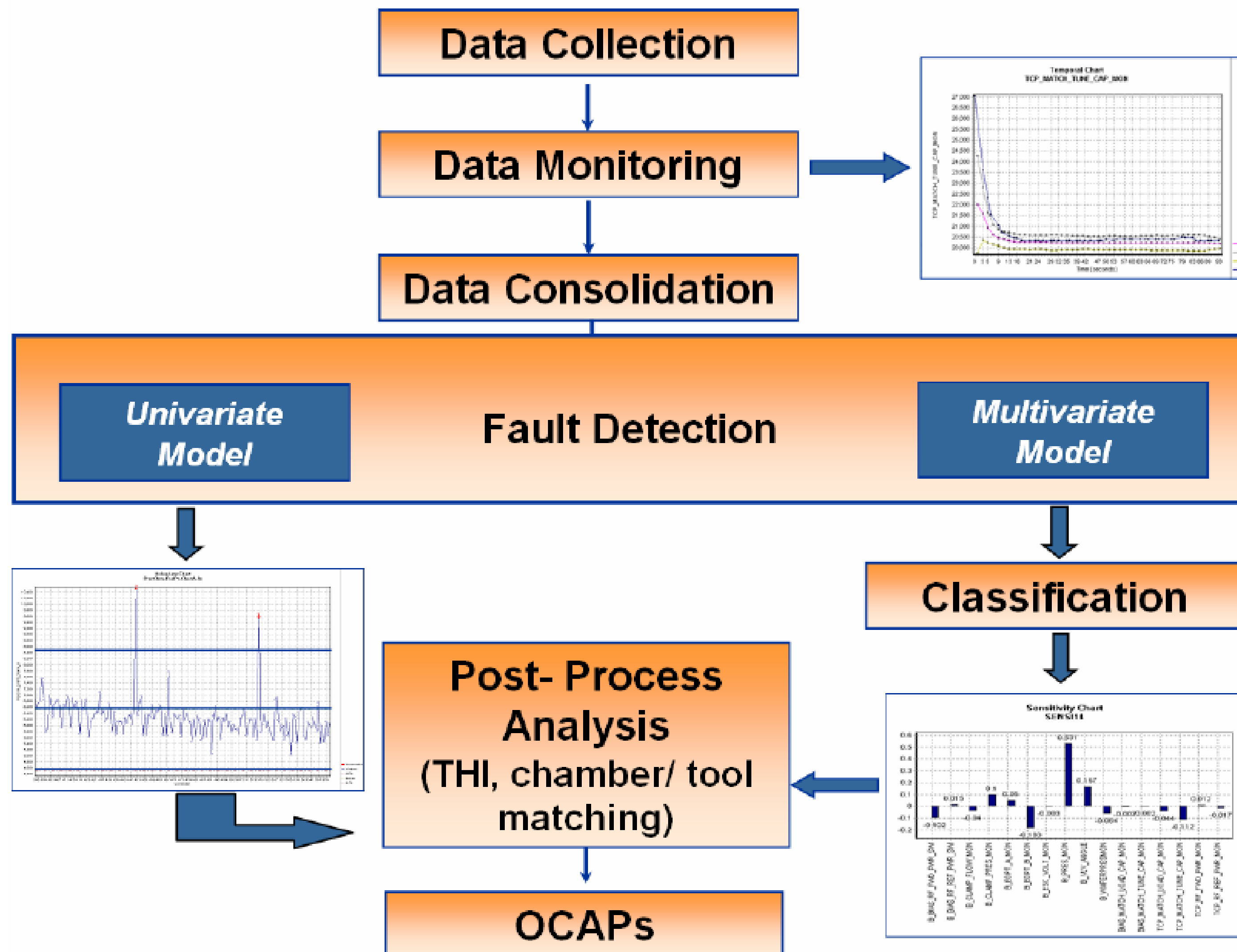
FDC-Software *Maestria* (PDF Solutions / Si Automation)



Maestria Deployment Status @ Micronas

- Etch : Lam Alliance + Lam Rainbow + FSI Mercury + Mattson Aspen II
- Diffusion : ASM 400
- Implant : Varian EHP 500
- Litho : Canon I5+ Stepper
- Thinfilm : AMAT Endura

- 32 Tools incl. 65 modules / chambers
- 850 strategies active, 130 with OCAPs, 420 with limits
- PCA (Process Control Analyzer) training for process & maintenance (30 engineers)
- PCA implemented in daily work

- but : sometimes internal tool data is not enough, additional sensors are necessary...

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Why are Plasma Parameters ideal for FDC in Etch ?

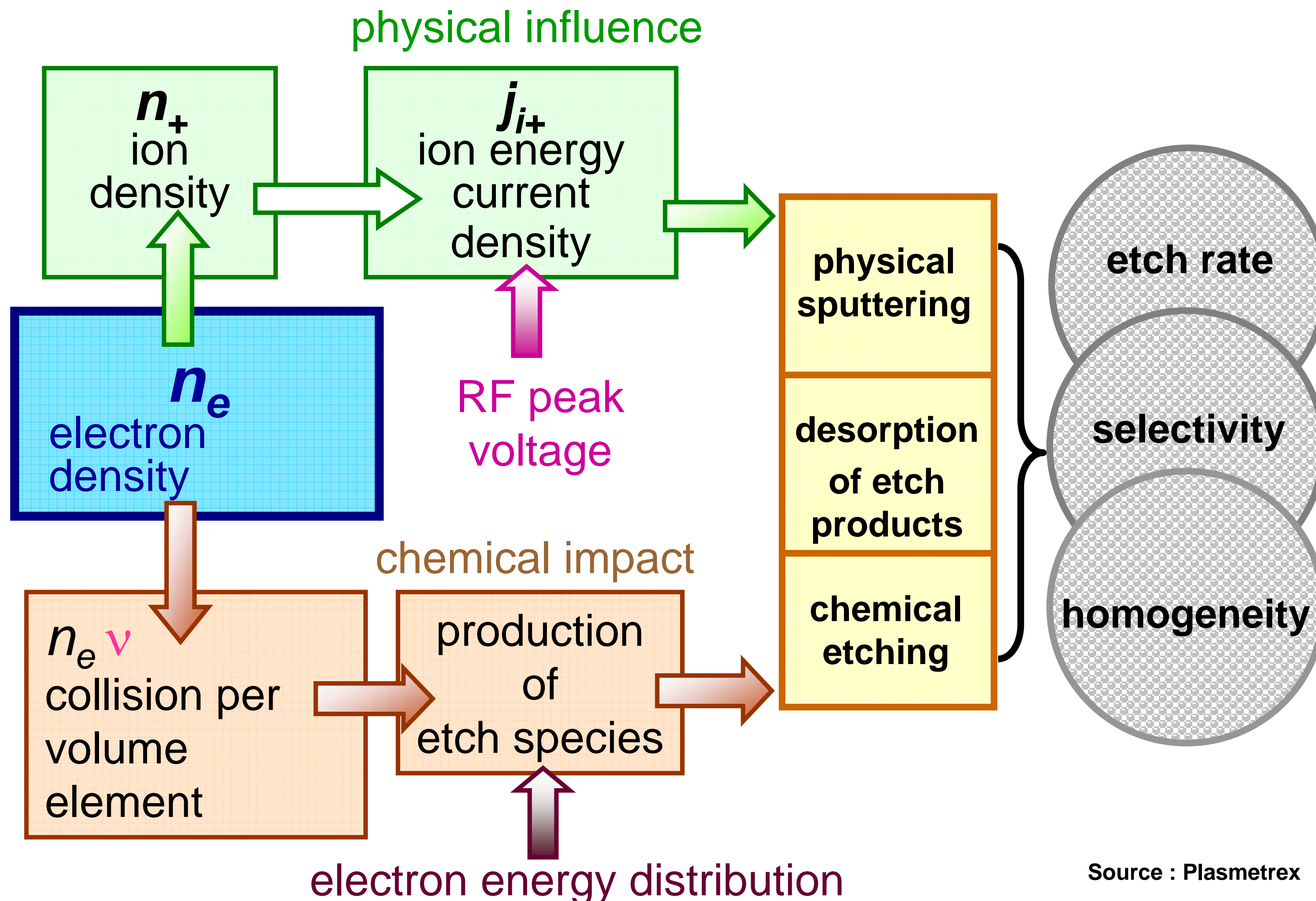
Electron Density and **Collision Rate** are sensitive to

- Process parameters (e.g. gas flow, pressure, power)
- Process / chamber drift (conditioning, clean, WAC)
- Product differences (e.g. open area)
- Tool failure (e.g. baratron, rf, MFC)

Plasma Parameters provided by HERCULES® help to

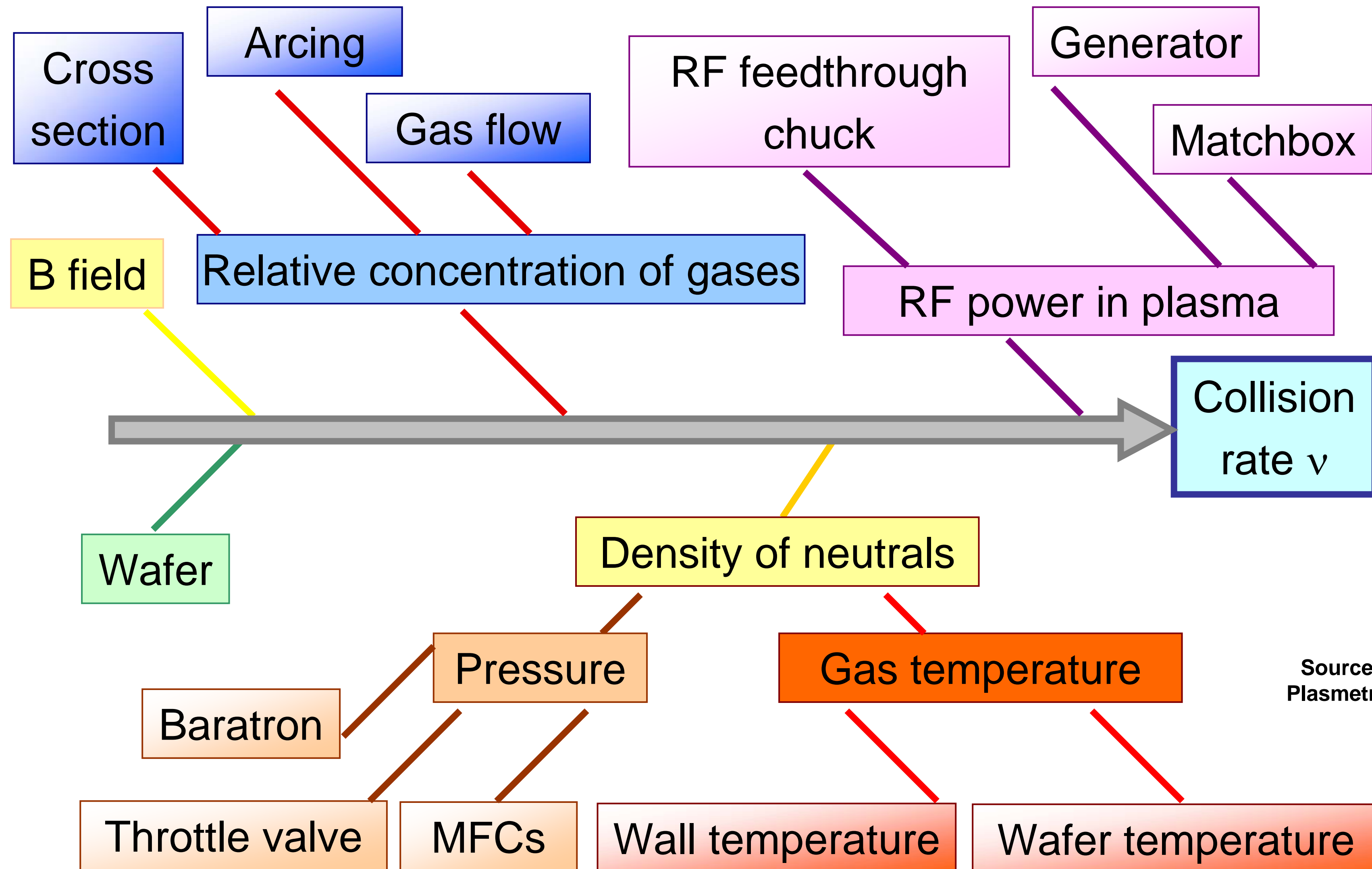
- optimize conditioning, WAC, MTBC, cleaning procedures
- understand process / tool issues

Influence of Electron Density on Etch Process



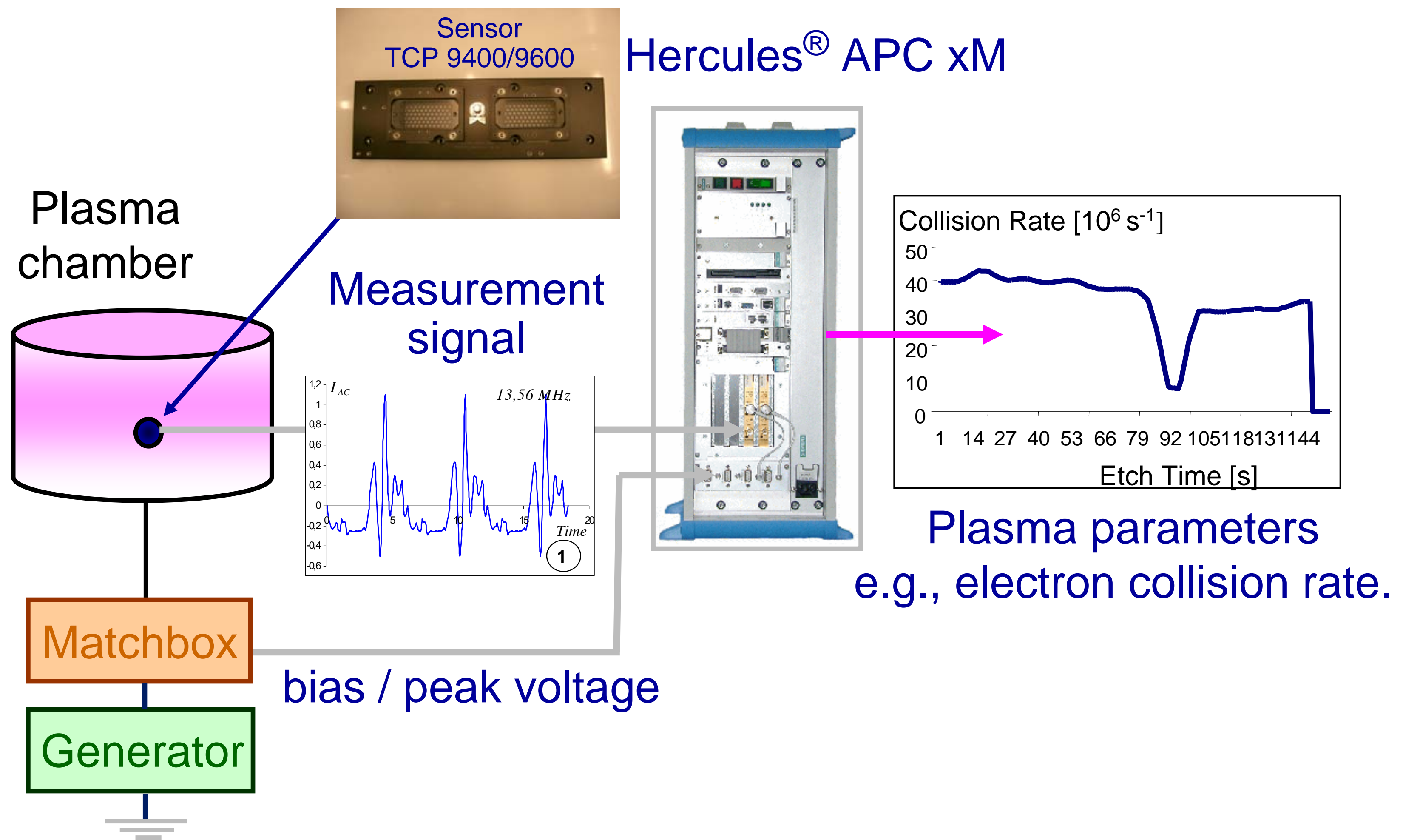
Source : Plasmetrex

Influence of Tool / Process Parameters on Collision Rate



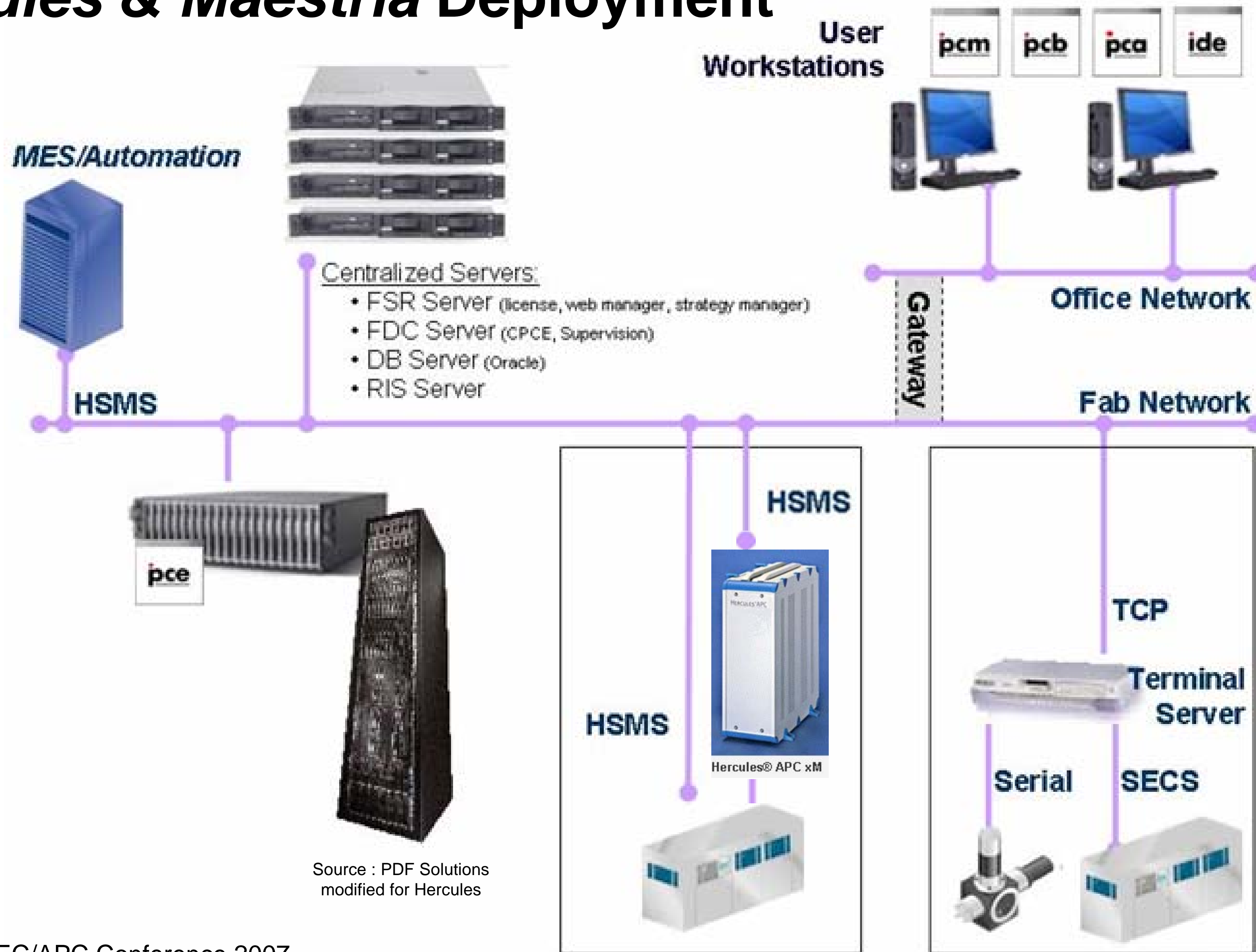
Source : Plasmetrex

Basic Setup of *Hercules*®

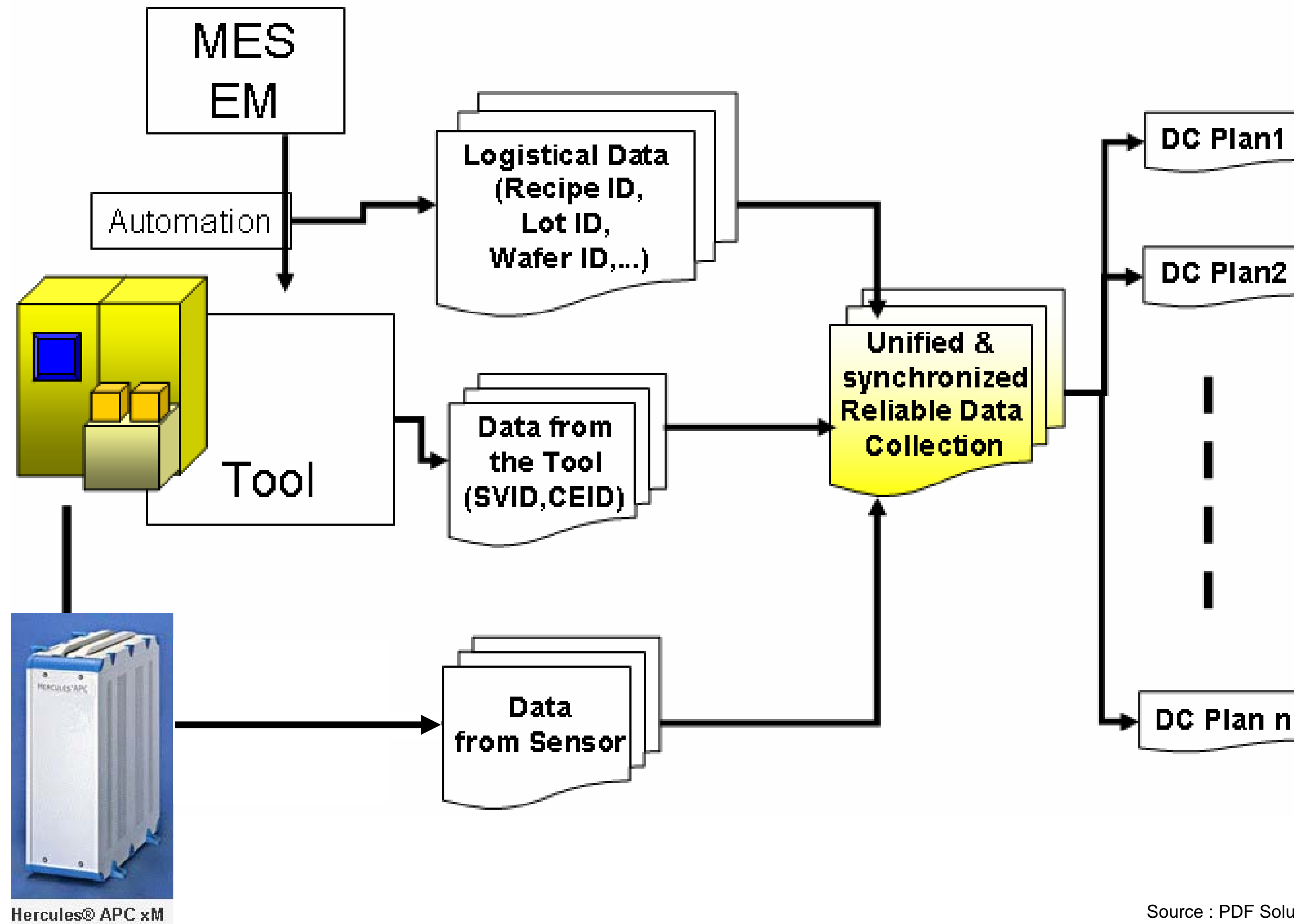


Source : Plasmetrex

Hercules & *Maestria* Deployment



Source : PDF Solutions
modified for Hercules



Source : PDF Solutions
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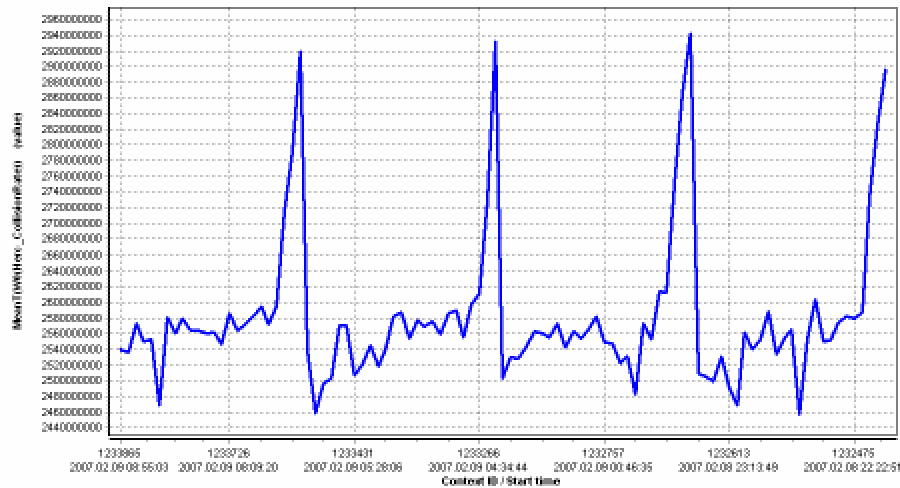
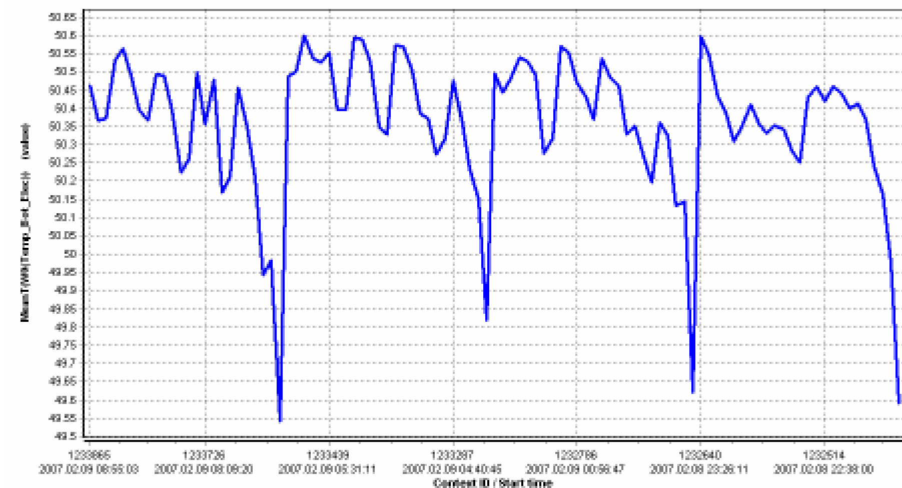
Easy Correlation of Tool & Sensor Data



Collision Rate



Bottom-Temp

Implementation of external sensors into *Maestria* allows easy comparison / correlation of tool and sensor data !

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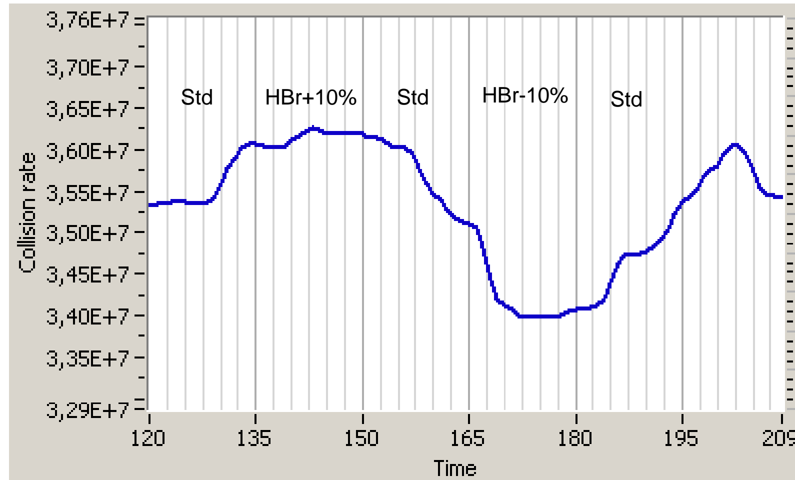
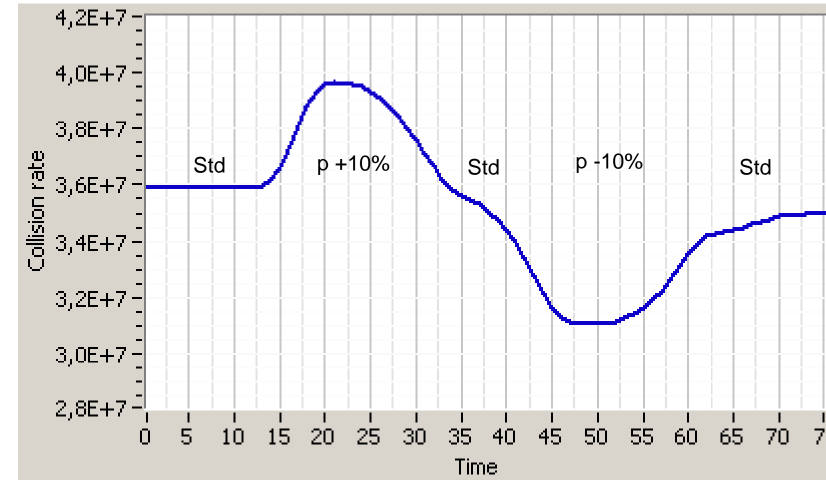
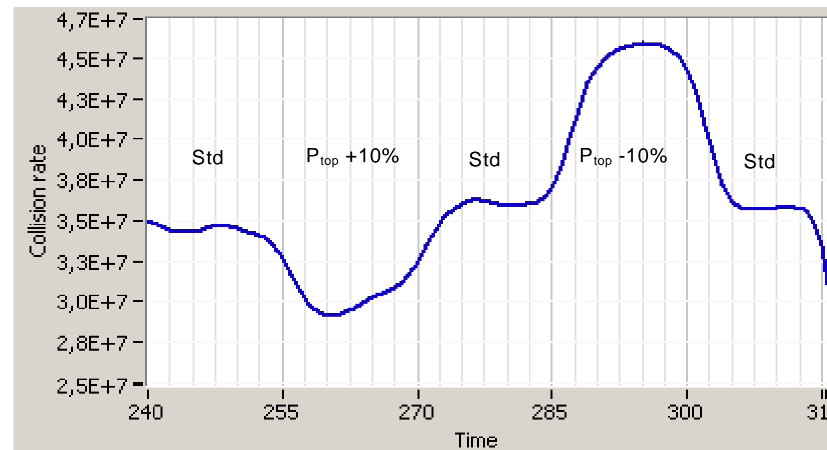
Influence of Poly TCP Process Parameters on Collision Rate

±10% HBr = ca. ±3% change in collision-rate



±10% pressure = ca. ±11% change in collision-rate





±10% TCP-Power = ca. 15-25% change in collision-rate

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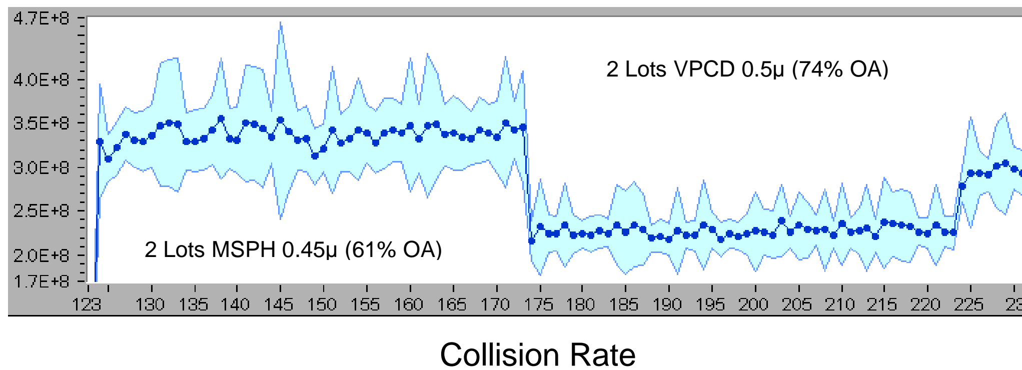
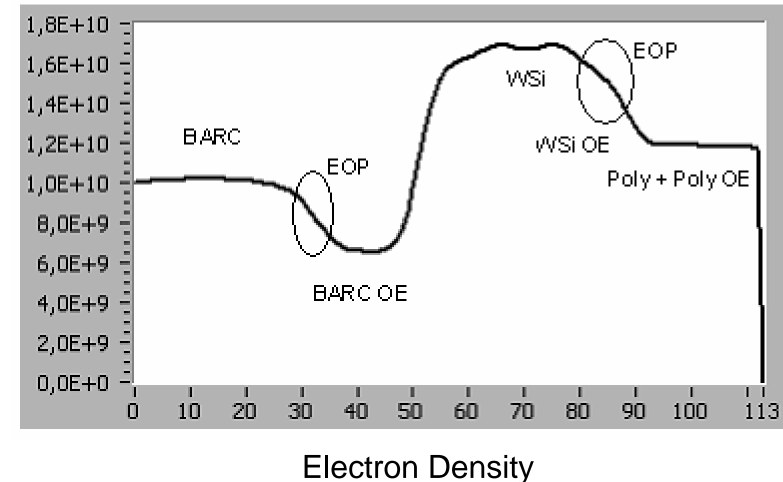
Collision Rate vs. Open Area & Endpoint Sensitivity

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



Collision Rate



Electron Density

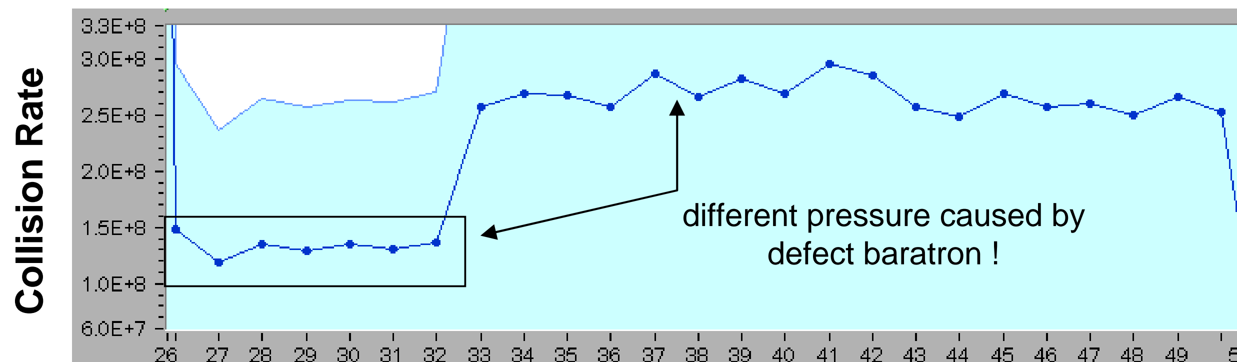
Plasma parameters are very sensitive

to the etched open area (OA)

Possibility of EOP detection.

FDC Example : Defect Baratron (1)

Because of sensitivity to process / tool parameters, collision rate and electron density are ideal for detecting tool failures resulting in process parameter drifts. In this example a baratron had a defect causing a shift in real pressure. The process was **not** aborted by the tool. Control of additional parameters like collision rate is needed for FDC.



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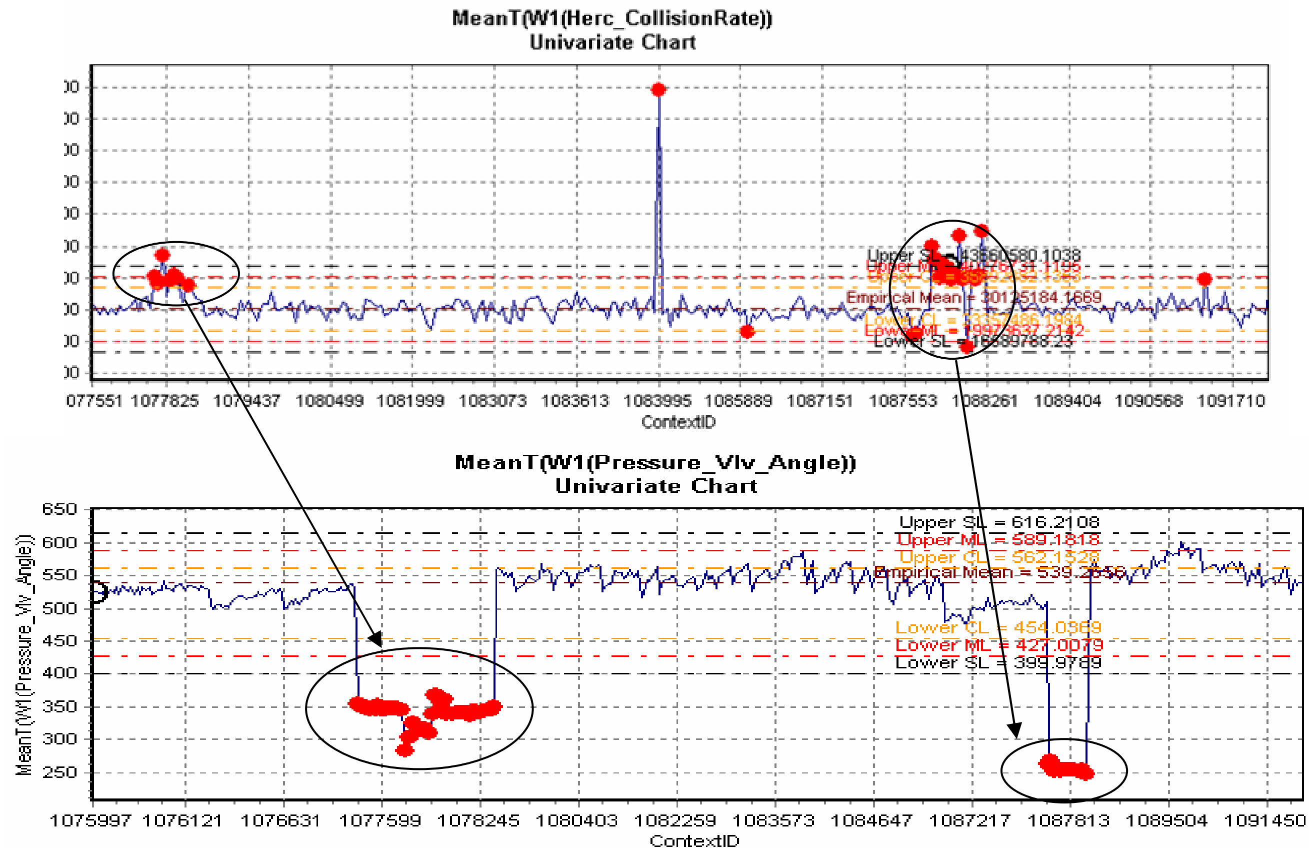
FDC Example : Defect Baratron (2)



Defect is indicated only by collision rate & VATvalve angle. Collision rate is a convenient in situ parameter for the real process status inside the chamber !

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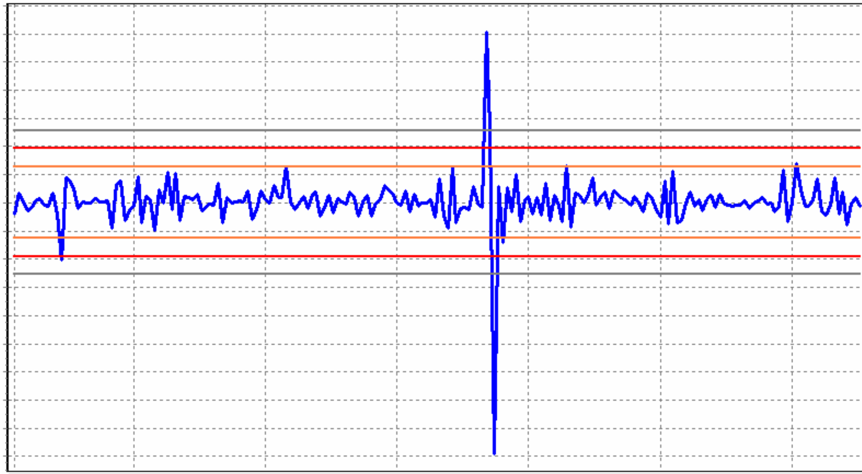
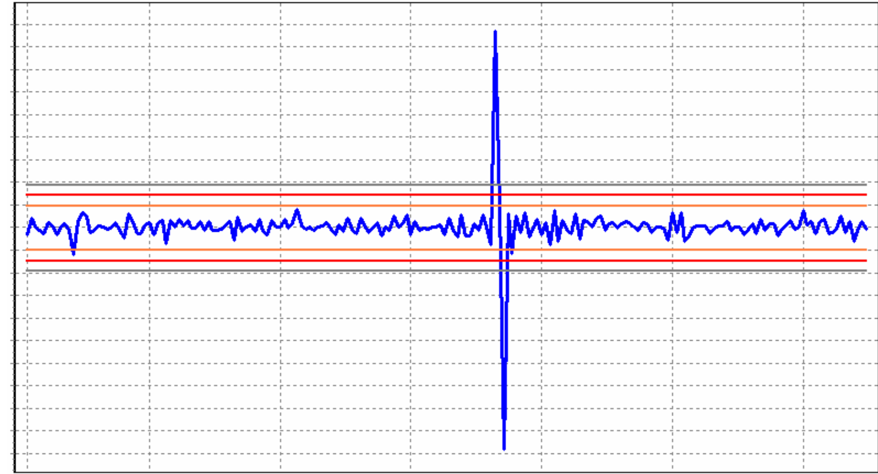
Process Control by Wafer-to-Wafer-Difference



Collision Rate



Electron Density

Wafer-to-wafer-difference of plasma parameters is
an easy recipe independent process/tool control ;
easy identification of excursions, tool & process problems !

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