overview activities APC 300 @ AMD Dresden

APC 300 Plasma Monitoring @ AMD

Goals at AMD

- improving tool startup with plasma monitoring

- improving and control of chamber matching

- connecting logistical data to plasma data with step wise recipe resolution

- process development with PL Monitoring as helpful tool

Improving Tool-Startup with PL-Monitoring

the idea:

- using a simple recipe with gases available at each chamber
- results of measuring should be reproducible and comparable at each chamber with the same performance
  - first step:
    - check the recipe and the results at released chambers
  - second step:
    - recipe run at new chambers before any other plasma is ignited
    - compare the data between those chambers
    - compare of fingerprints between released and new chambers
  - third step:
    - normal startup procedure with O2-recipe from time to time, e.g. before and after etch rate kit

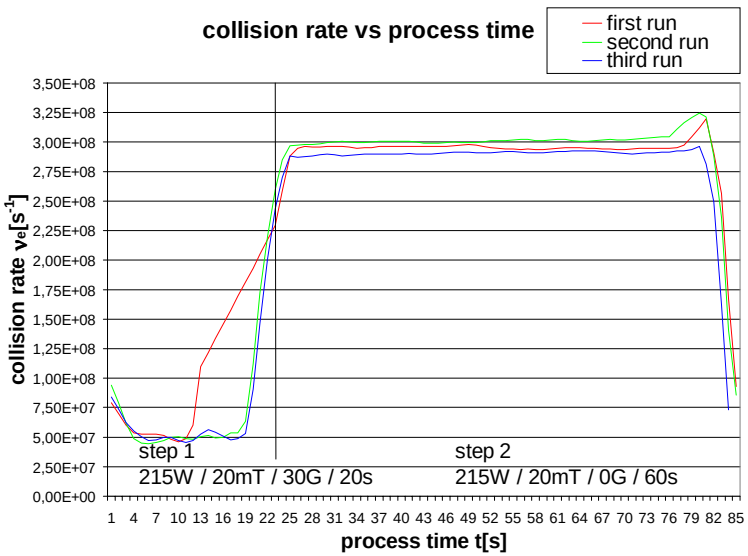
  and chamber-conditioning

Improving Tool-Startup with PL-Monitoring

first step / O2-recipe check

- using a O2-recipe with following parameters
  - step1 20s / 20mT / 215W / 30G / 50sccm O2
  - step 2 60s / 20mT / 215W / 0G / 50sccm O2

- high magnetic field for hardware check while first step
- non magnetic field at second step for higher collision rate
- low pressure for high dc bias voltage
- low power consumption



results at process chambers with production

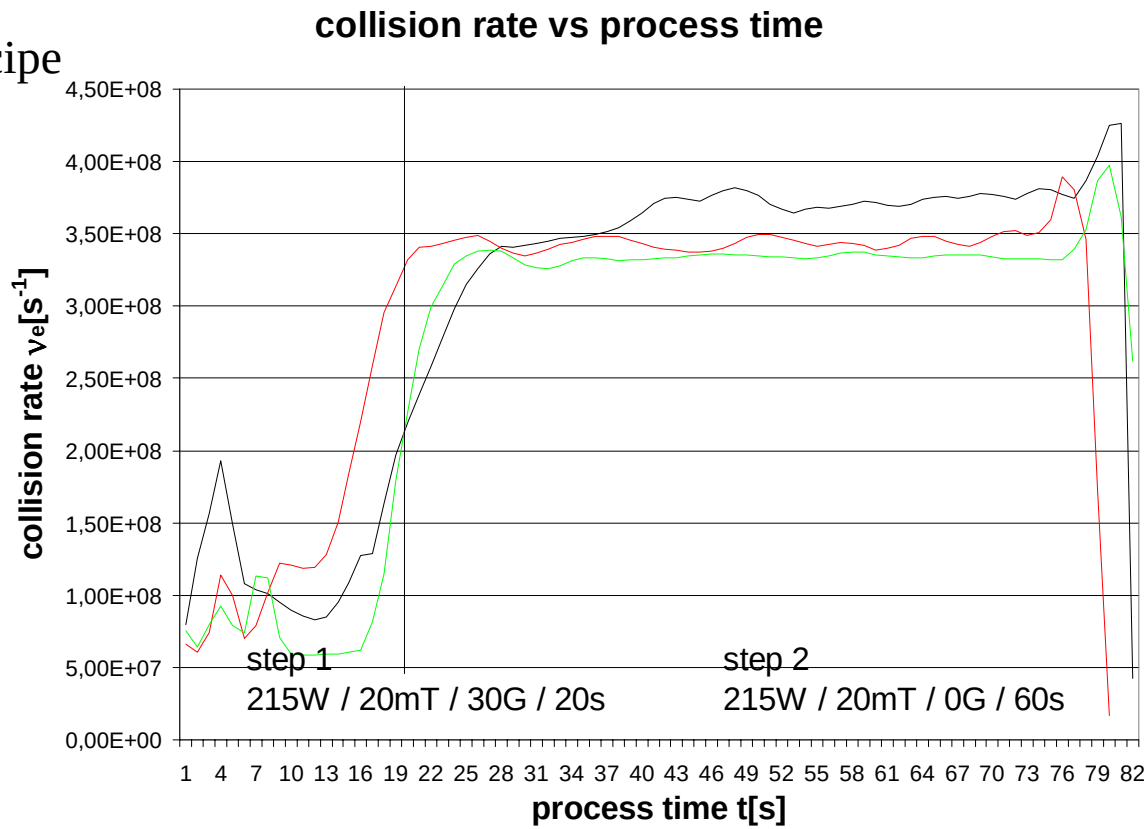
- first wafer effect
- smooth wave-form for all runs → stable process

Improving Tool-Startup with PL-Monitoring

second step / O2-recipe run at new chambers

- results from O2-recipe:
  3 wafer runs with same recipe

results at process chambers
with no issues

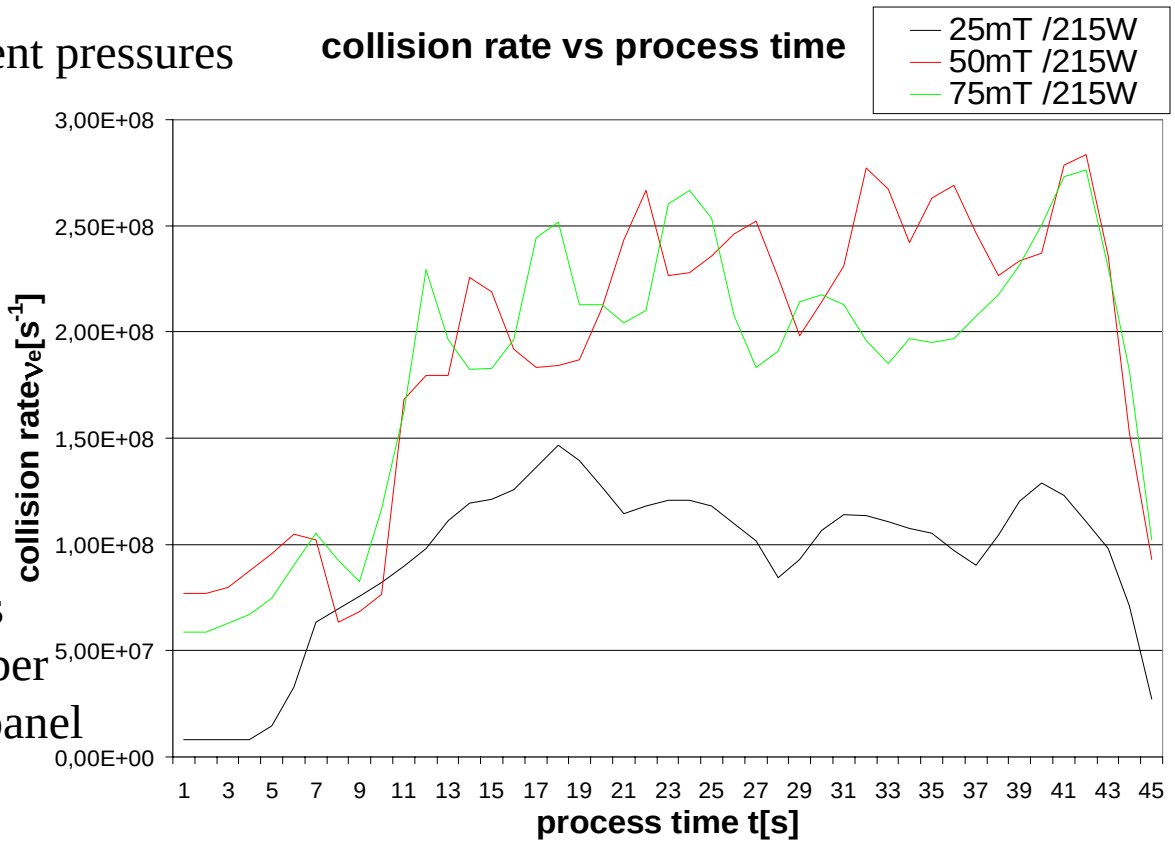


Improving Tool-Startup with PL-Monitoring

second step / O2-recipe run at new chambers

- results from O2-recipe:

3 wafer runs with different pressures



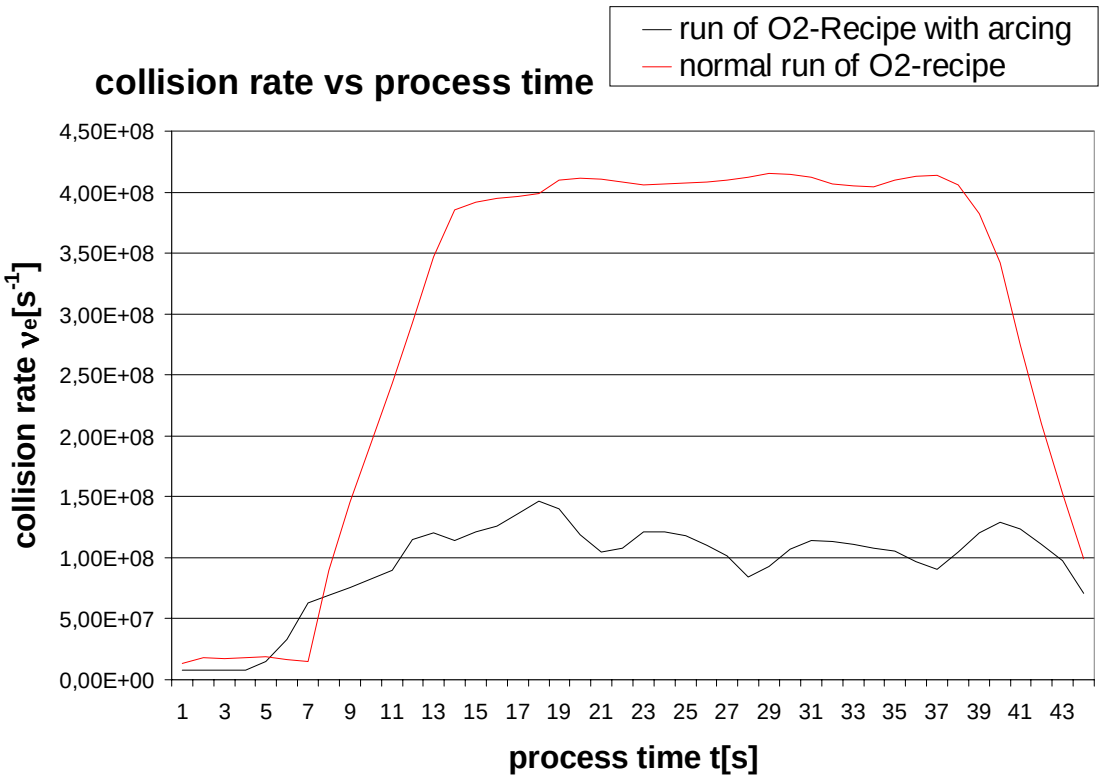
results at process chambers with arcing issues at chamber body and gas distribution panel

Improving Tool-Startup with PL-Monitoring

second step / O2-recipe run at new chambers

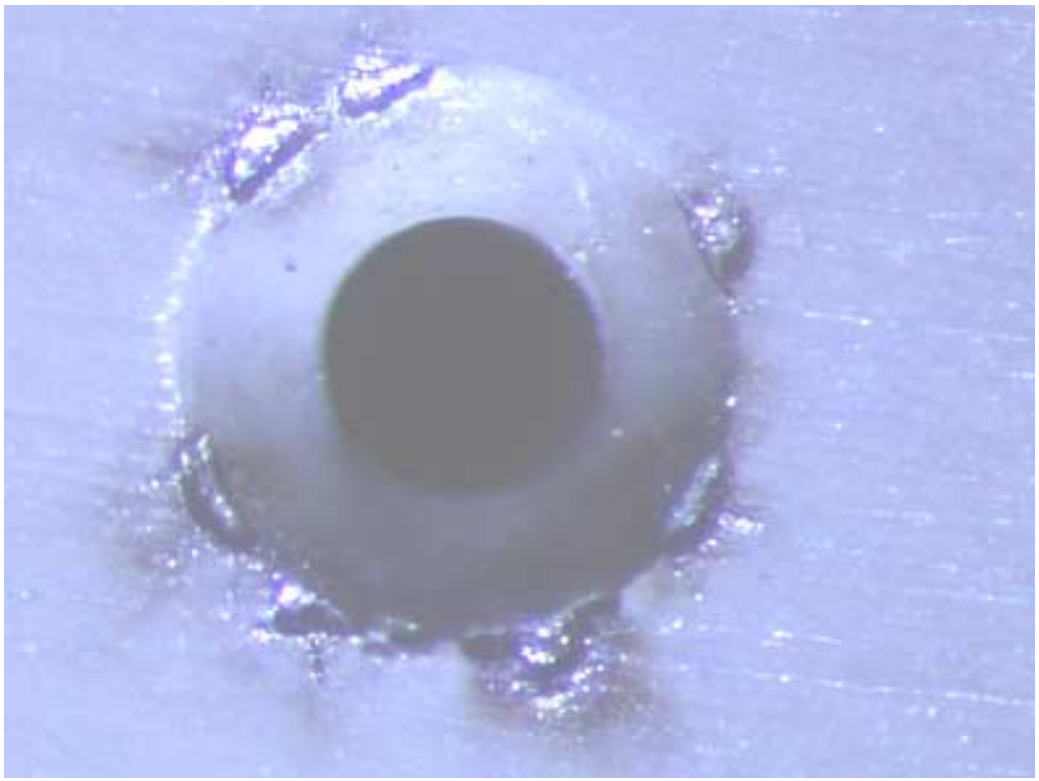
- in case of arcing the collision rate is match smaller than for normal process
- and the wave-form is not
  - as smooth as the
  - baseline

Comparison between standard run and wafer run with arcing



Improving Tool-Startup with PL-Monitoring

- Arcing at the Gas Distribution Panel at Applied Material MxP Chamber as result of wrong hoses for Fluorinert (shorted the electrode with the mainframe)

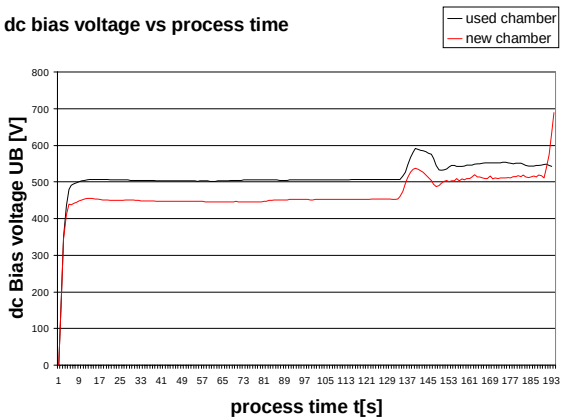


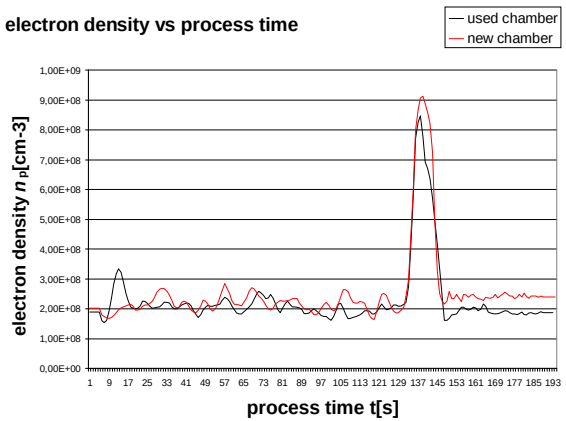
Improving Tool-Startup with PL-Monitoring

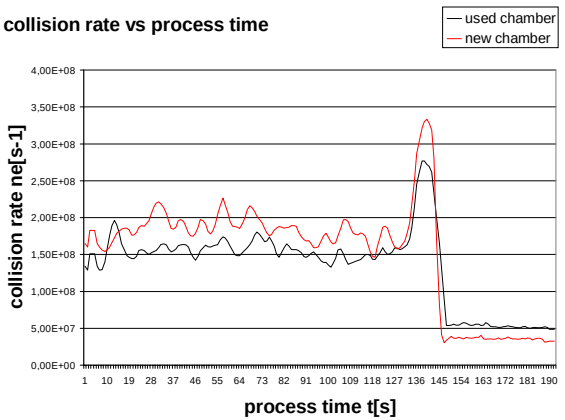
second step / fingerprint comparison between released and new chambers

- fingerprint from all processes at the production chambers where taken (e.g. conditioning, etch rat wafer and TOPO wafer)
- check for comparability from run to run to save test wafer and time
- fingerprints for

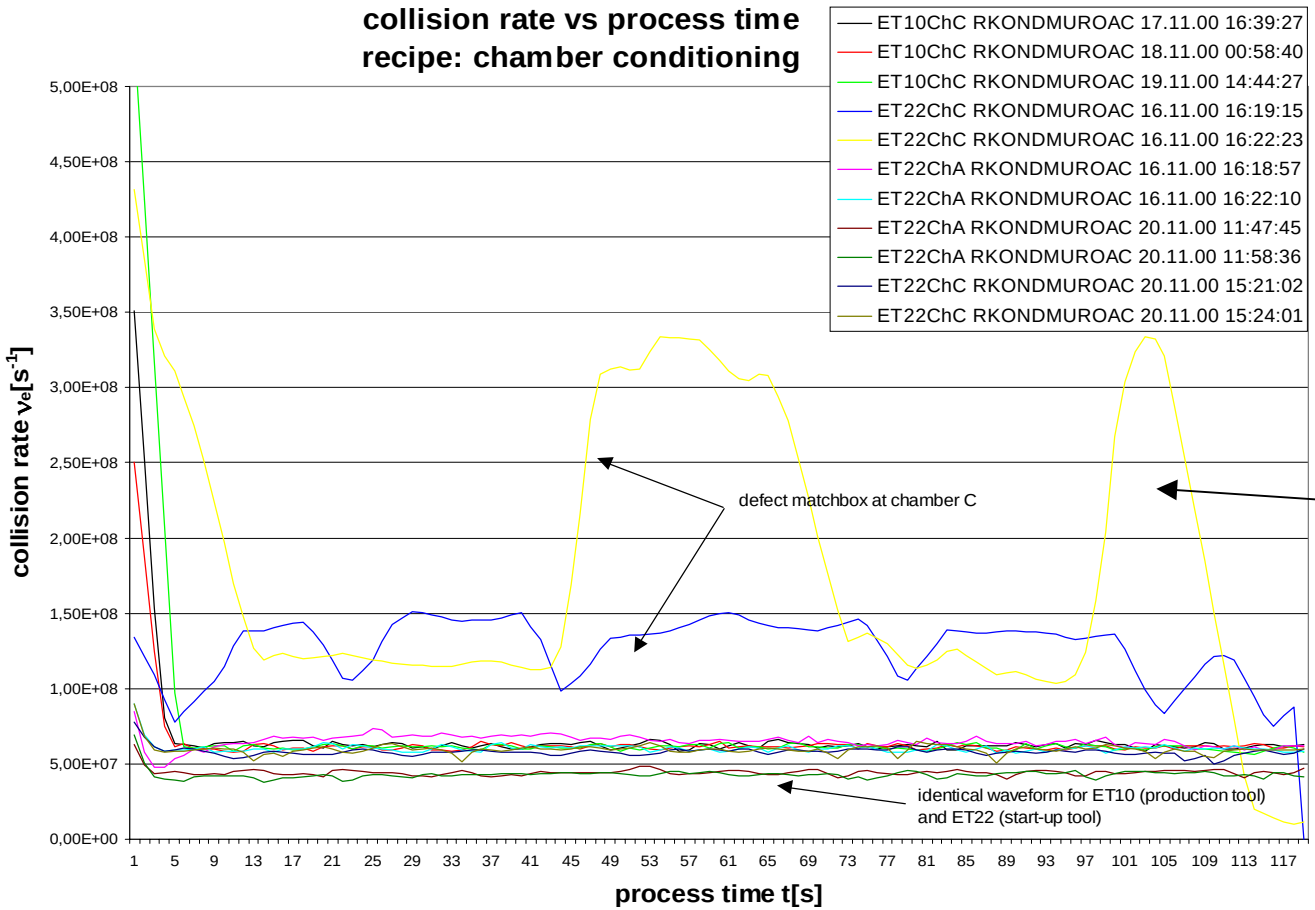
  collision rate, dcBias voltage and electron density







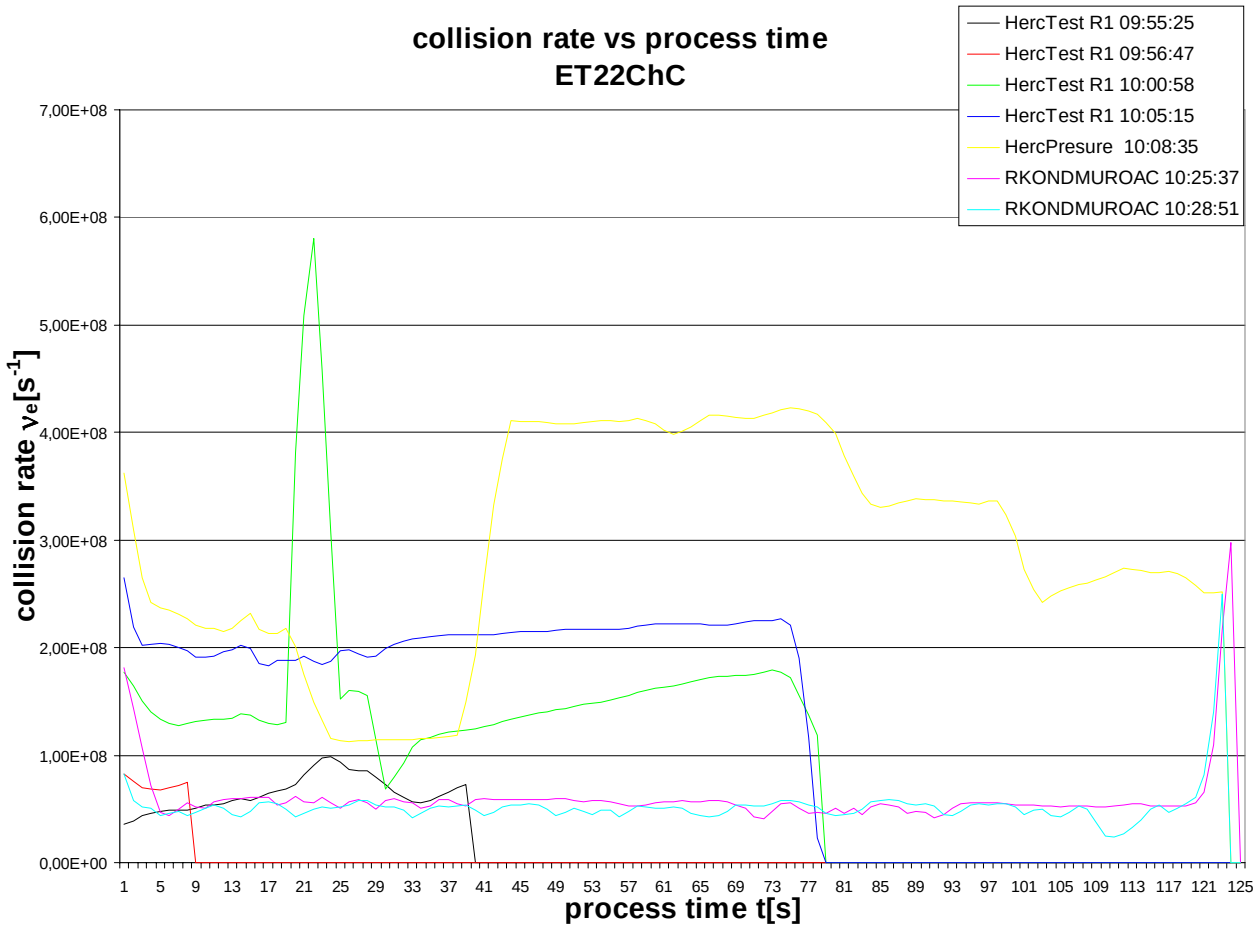
Improving Tool-Startup with PL-Monitoring



- strongly unstable collision rate for conditioning of the chamber

- two runs at chamber with defect matchbox (or defect magnetic field sensor? = hardly to separate)

Improving Tool-Startup with PL-Monitoring



- chamber with in-correct working matchbox

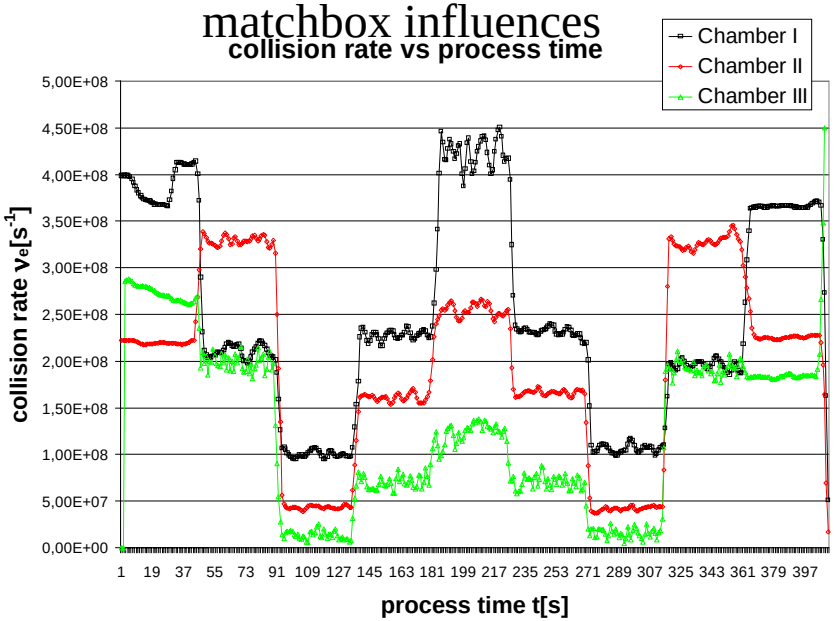
- process stop while wafer run

- high peak in collision rate (reflected power high)

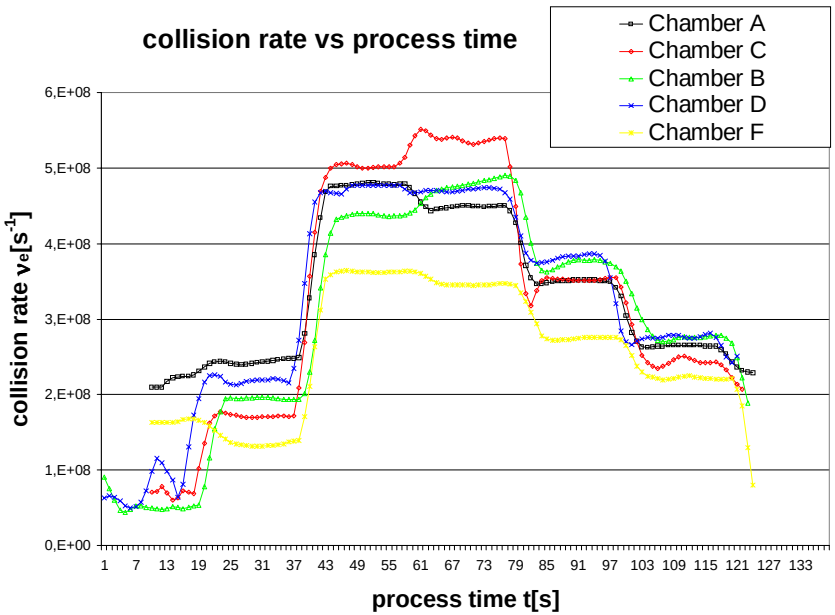
- unstable collision for process with magnetic field

Chamber Matching with PL-Monitoring

- O2-recipe for different pressure and different magnetic field strength
- the behavior for each chamber looks like the other
- differences trough different chamber conditions, e.g. RF-hours and matchbox influences



- different magnetic field strength
  0G to 40G to 0G, Step 10G



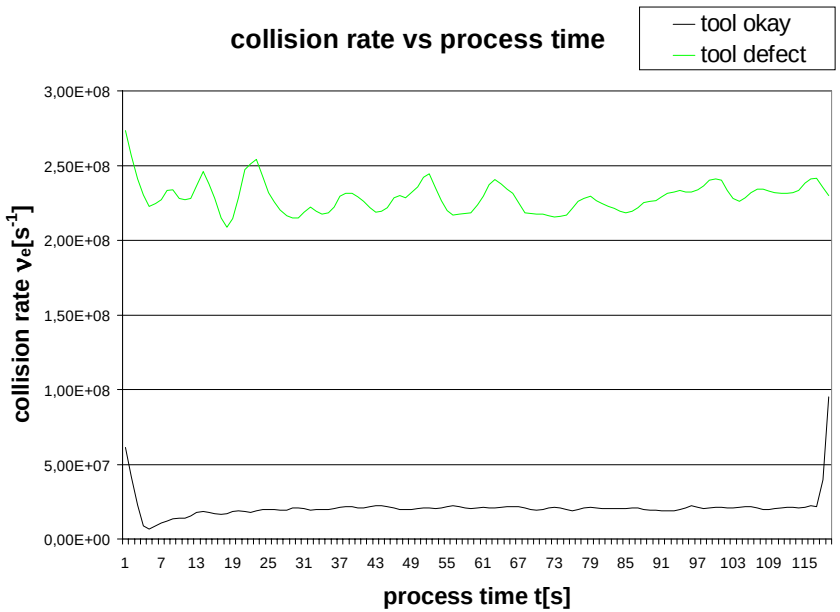
- different pressure
  20mT/30G, then 20mT to 100mT/0G , Step 20mT

Chamber Matching / Fault Detection with PL-Monitoring

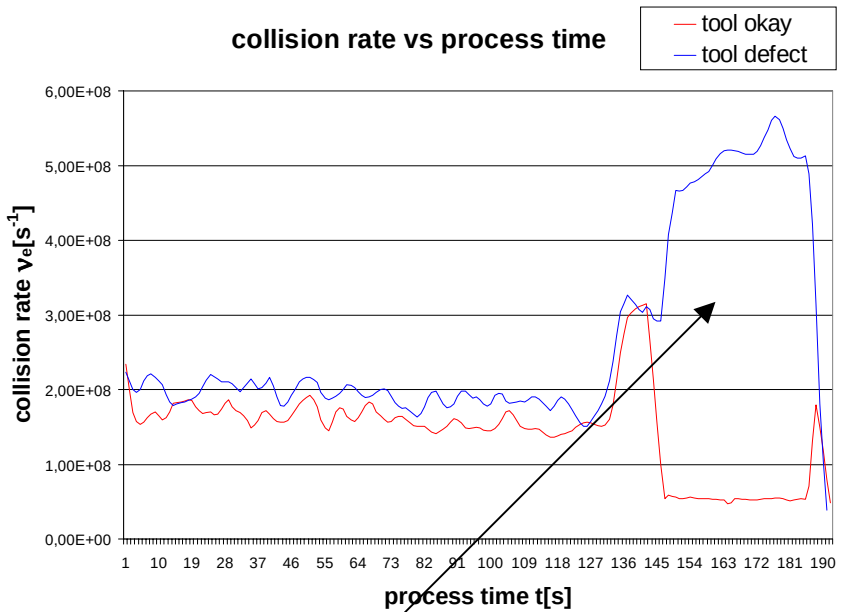
- typically fingerprints for each process can be used for fault detection

→ trough baseline and online process data correlation (average and standard deviation)

→ e.g. magnetic field failure (magnetic field switched off) increases the collision rate while processing



- magnetic field hole time off, normally on!



- magnetic field at step 3 off, normally on!

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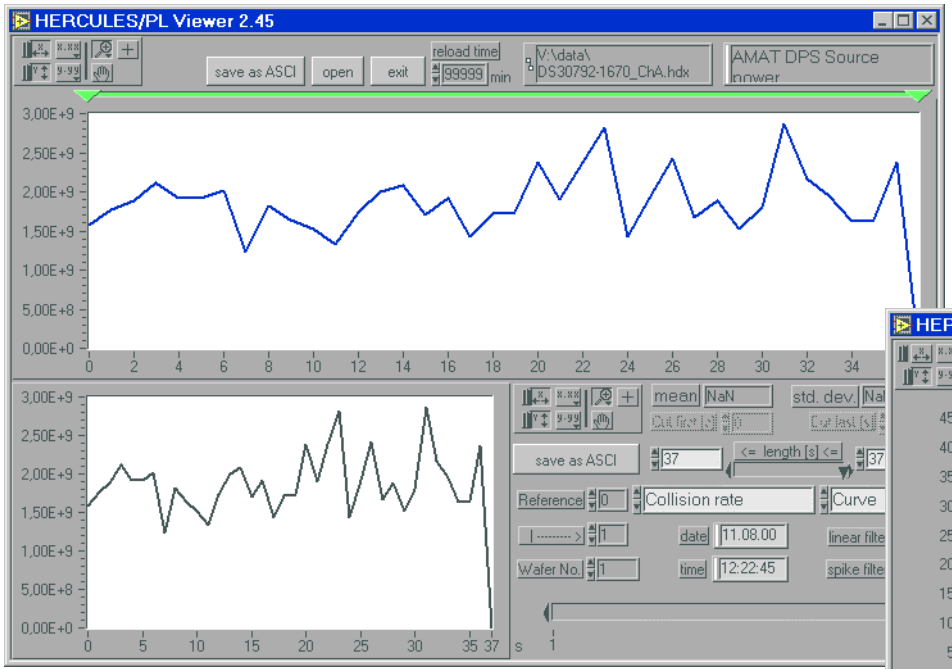
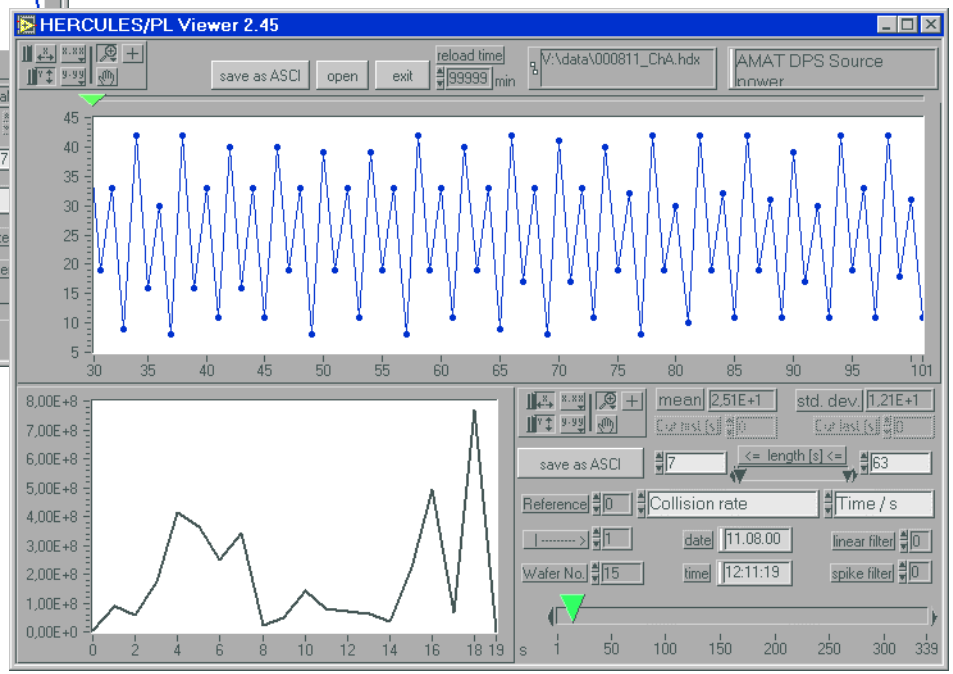
Data Collection:



One lot processed with a recipe with more different step with same and different length.

The first plasma step is saved in a file with correct name, e.g. Lot-ID- Chamber.

DS30792-1670_ChA.*



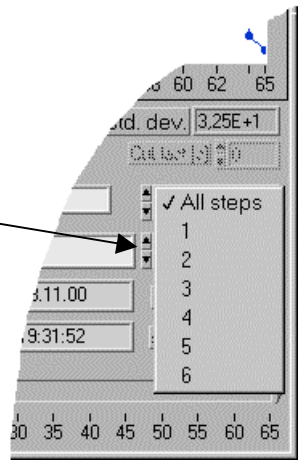
The remaining steps are saved in an other file it almost impossible to separate each step for data analyzes.

Data Collection:

Status:

- implementation of step wise data resolution into EI-Software and into Hercules PM Software
- the communication between [Hercules ←→ Etcher] works, but still problems

Step information is available!



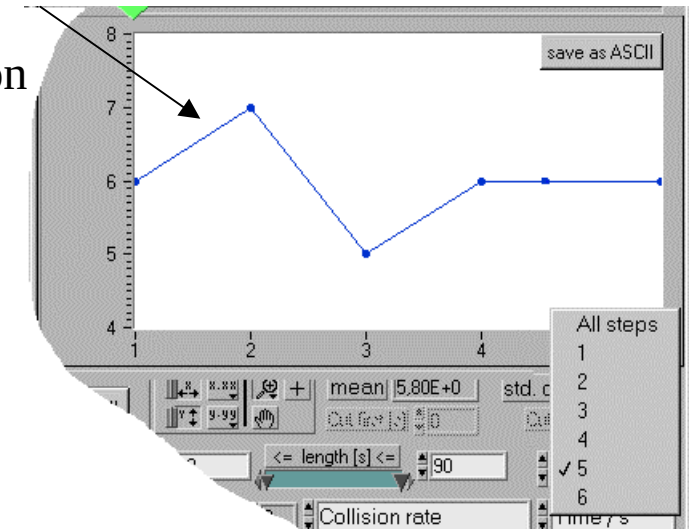
But.....

Data Collection:

Problem:

- information about step change with to big delay from tool to PM via EI
- wrong assignment from plasma data to step information

- some recipes without the necessary information
- different recipes and sequences are tested



"Plasma data" from recipe with no RF-power in step 5!

Solution:

- trouble ticket for Applied Materials / software request!

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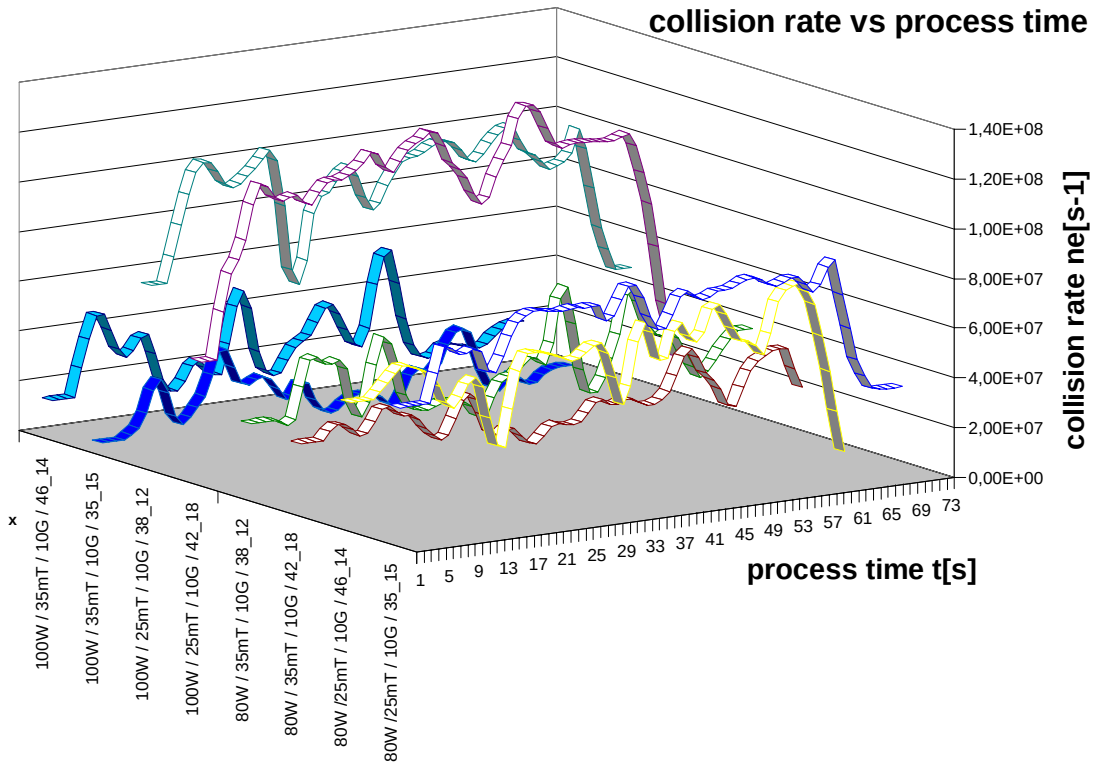
Process development at AMD

- over the hole process development the Hercules data were storaged and could used for checking the chamber matching and to see the influence of magnetic field

- spacer etch process development
  the results of spacer width measuring apparently shows different spacer widths at same plasma data from chamber to chamber

  influence of conditioning of the chamber is very important
  etch rates in qualification kits are different and depending at chamber conditioning more as expected

DOE for process development



- DOE of etch rate with different parameters with magnetic field at MxP-chamber

- Chart shows unstable collision rate for this experiment

- results of etching gives a reference
- the uniformity across the wafer is bad, more than 15%

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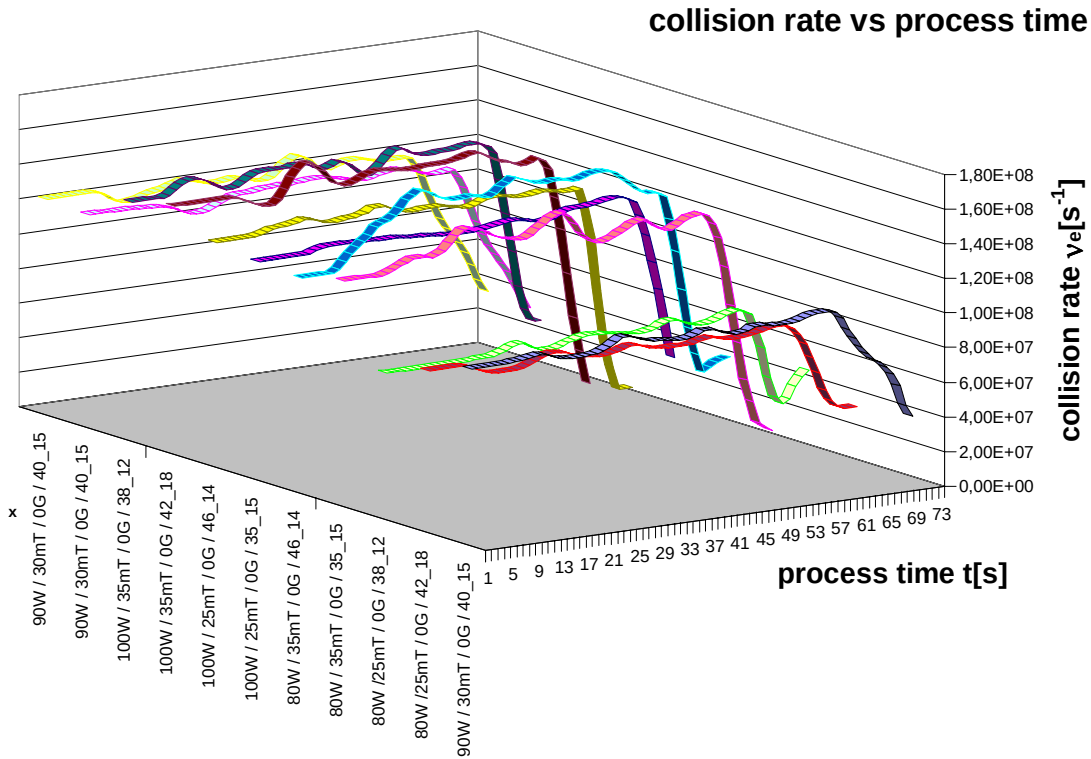
DOE for process development



- DOE of etch rate with different parameters with magnetic field at MxP-chamber

- Chart shows stable collision rate for this experiment

- results of etching gives a reference
- the uniformity across the wafer is better than 5%

Results from this experiment

- a good process window was found through the etchrate date and the Hercules data
- further test and a DOE with a higher resolution have shown a good way to improve the process

- but the behavior is different between test- and production wafer so we had to change the hole process to an other recipe with different chemical, wall temperatures and more steps
- therefore we have seen many difficult problems, e.g.
  comparison of the data between newer and older Hercules tools
  → this check is still in progress
  → try to get data at one long process step by switching the tool while the plasma is ignited

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Summary

- Plasma Monitoring is a helpful tool for not only Tool Startup

there is a possibility to save a lot of time while Tool Startup

simple usable to test the chamber matching, e.g. influence from different matchboxes to etch rate