MICRONAS

Process Stability Improvement on a Dual Frequency Etch Tool by Means of Plasma Parameters

Micronas at a Glance

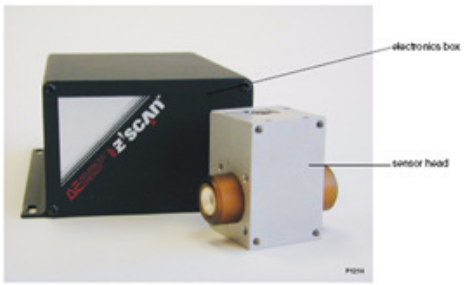
Known and recognized in the **automotive** and **industrial** business as a reliable global partner for **intelligent, sensor-based system solutions**

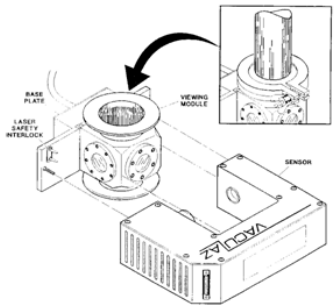
- About 900 employees worldwide
- Leading supplier of hall sensors for the automotive industry
- Full in-house production with own waferfab and backend operations including testing and packaging
- zero ppm quality to ensure customer satisfaction
- Commitment to environmental protection

APC & Sensors

- all tool parameters are ok, but the product not ?
- tool data show that tool has no problem, but you experience problems like arcing ? strange process aborts ?

- **additional sensors and in situ measurement tools are necessary !**
- **V/I probe, OES, SEERS Hercules, ISPM, measurement wafers (temperature, plasma voltage, shock, etc.)**





Plasma Sensor (Hercules) History @ Micronas

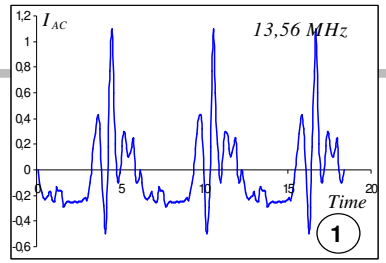
- 2003 : Lam TCP 9400 (Poly / Nitride)
- 2005 : Lam TCP 9600 (Metal, Al, W)
- 2011 : Lam Exelan (Dielectric)
- 2013 : Applied P5000 (Sputter Etch)

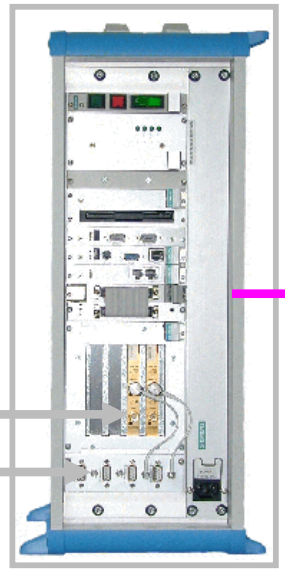
Basic Setup of HERCULES®

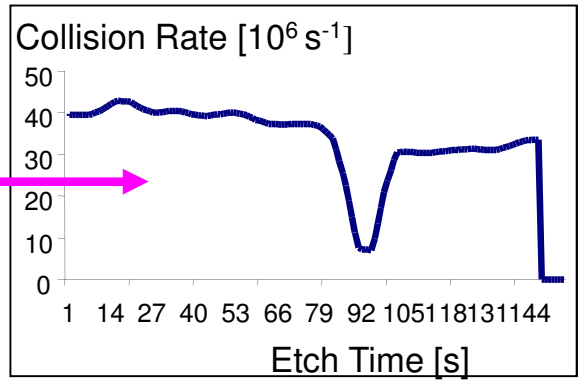
Hercules® APC xM

Plasma chamber

Measurement signal







Plasma parameters
e.g., electron collision rate.

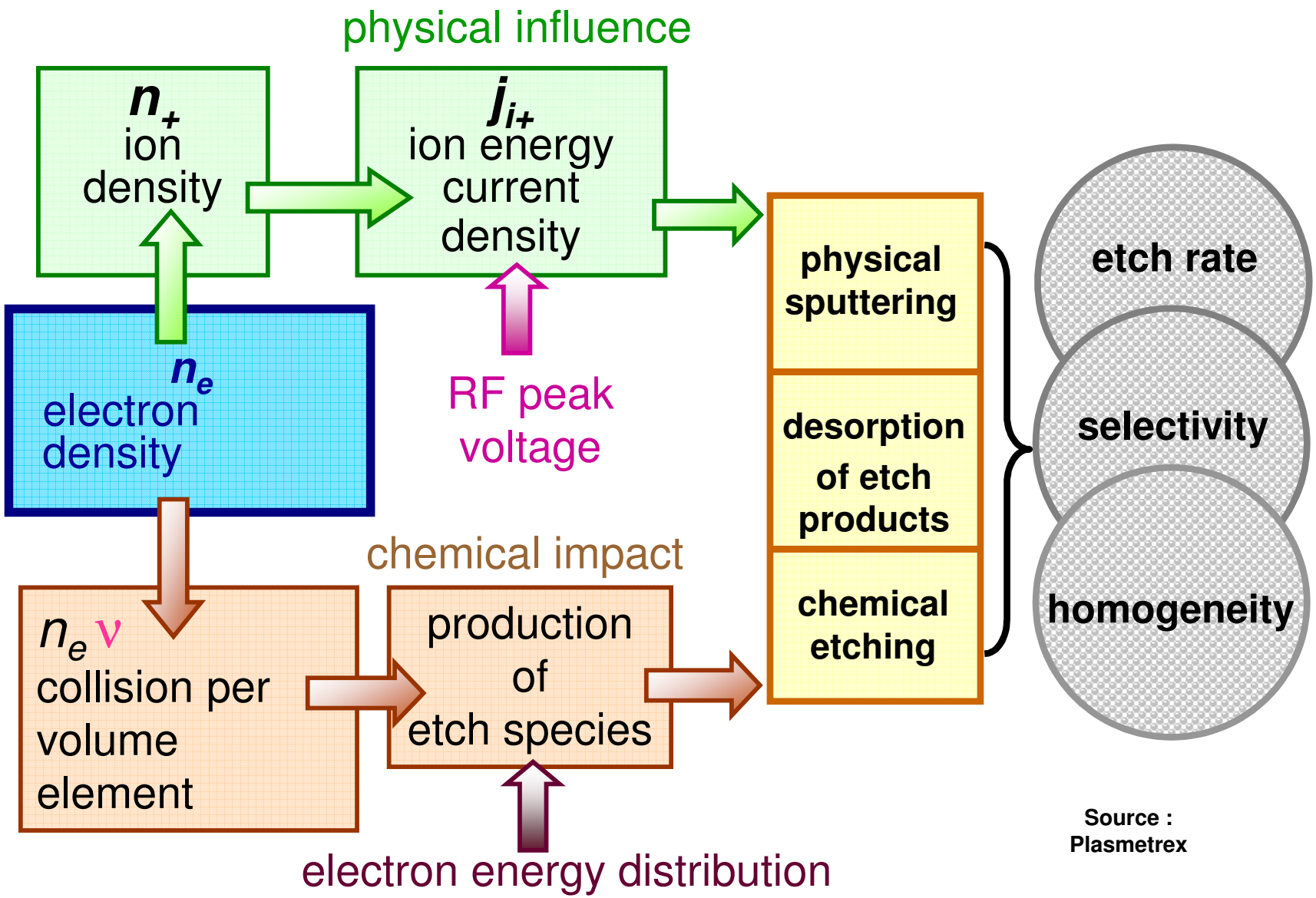
Matchbox

bias / peak voltage

Generator

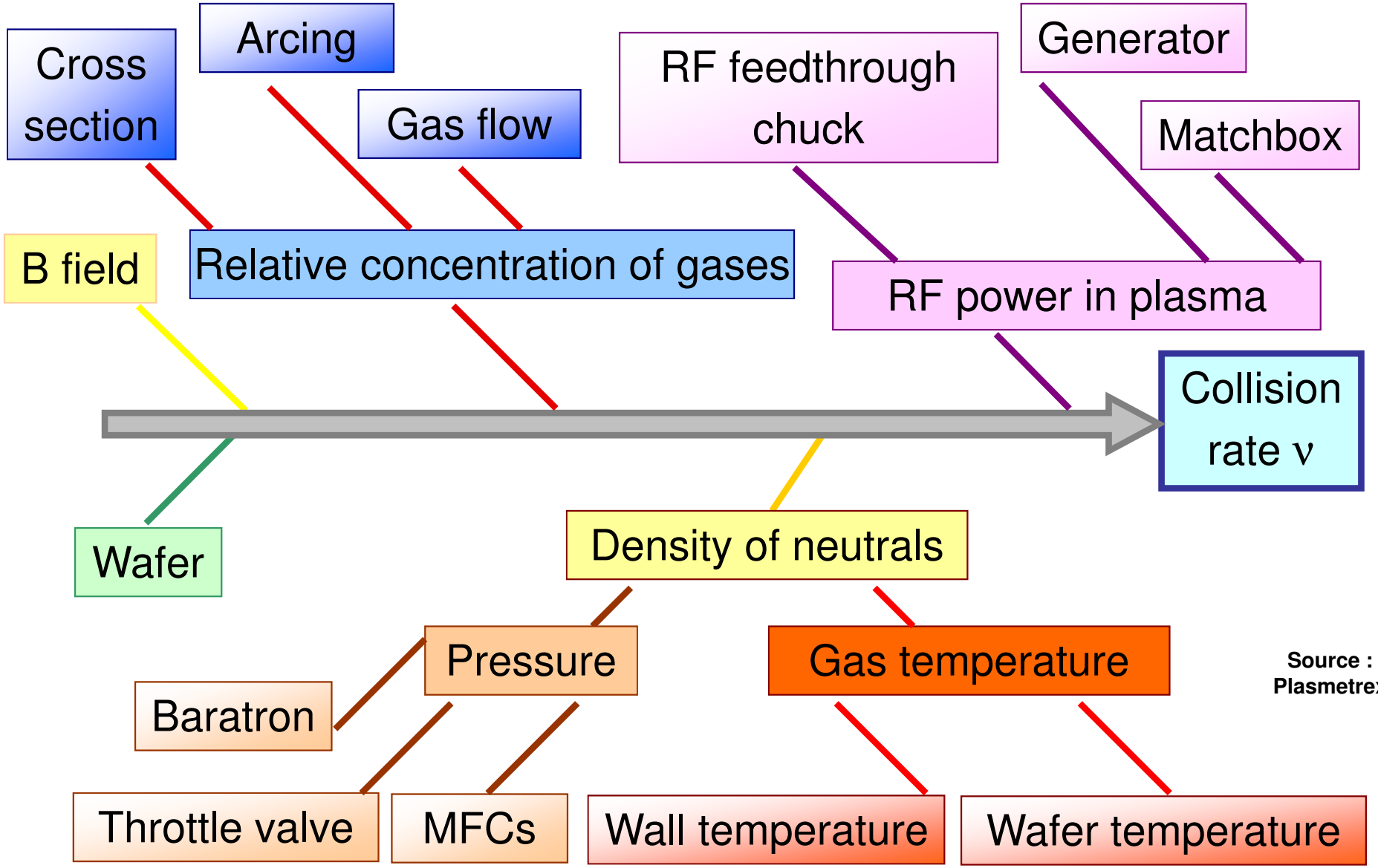
Source : Plasmetrex

Influence of Electron Density on Etch Process



Source : Plasmetrex

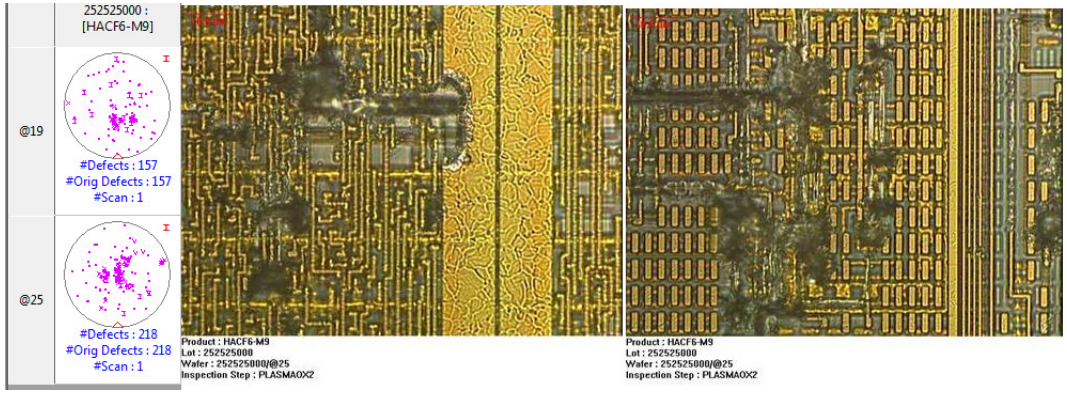
Influence of Tool / Process Parameters on Collision Rate

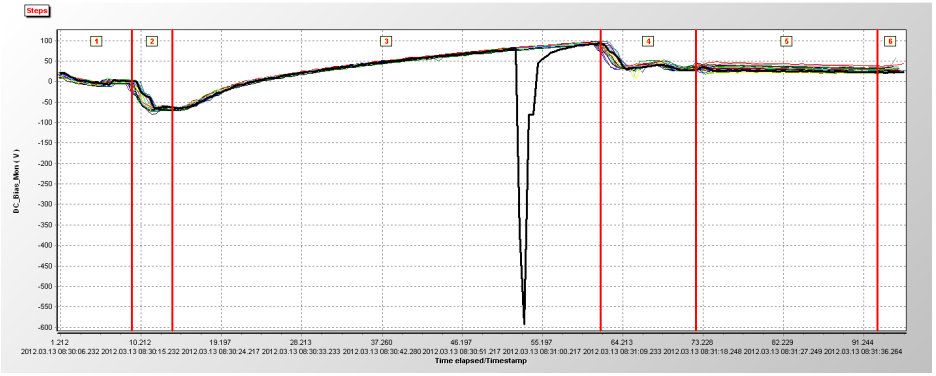


Source : Plasmetrex

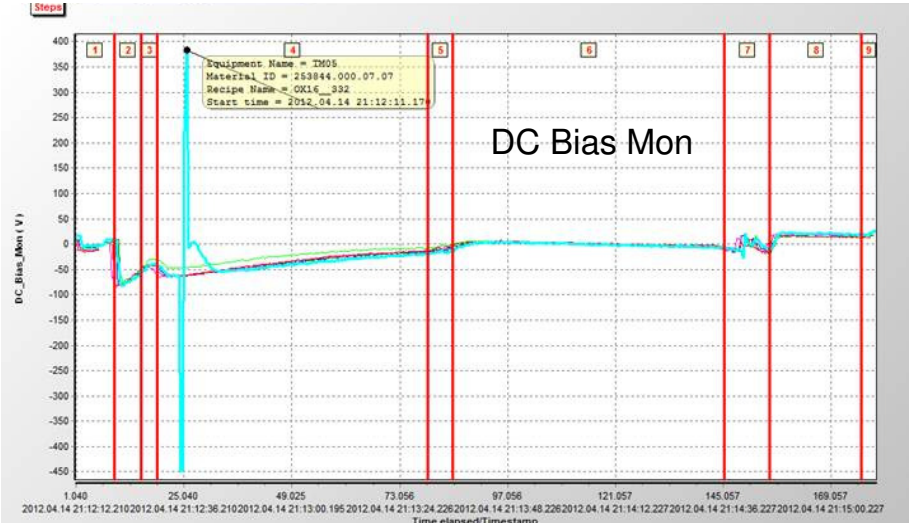
Plasma Instabilities

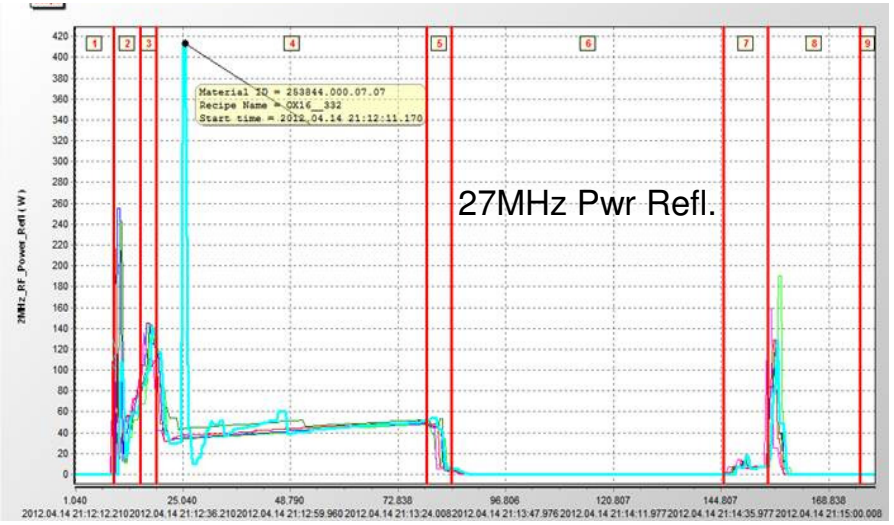
For years we are experiencing different types of plasma instabilities on a dielectric dual frequency etch tool (27/2 MHz). Sometimes the plasma is recovering, the tool is not aborting but the wafer shows arcing damage. Sometimes the plasma is just dropping out...

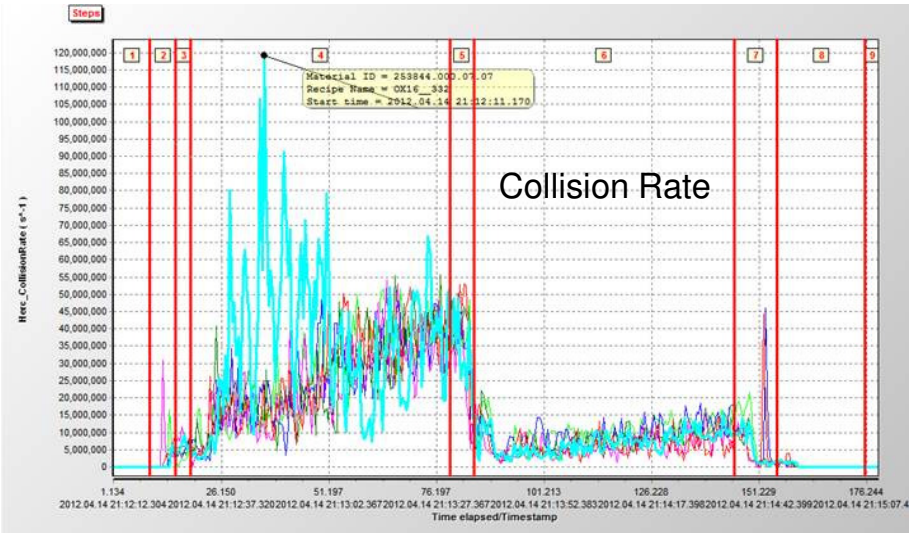




Plasma Instabilities

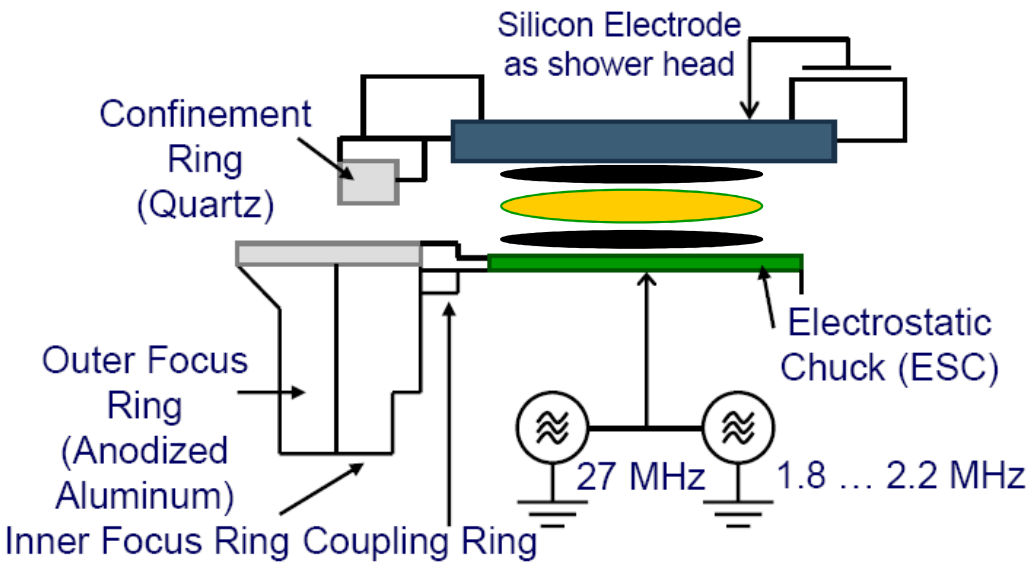






Plasma instabilities sometimes result in plasma dropout, sometimes it´s recovering like in this case...but plasma parameters like collision rate show a remaining medium-term plasma instability and the product often is damaged without any tool alarm.

Dual Frequency : Plasma Generation & Boundaries



- 27 MHz is responsible for plasma generation
- 2 MHz is controlling the sheath and is influencing the ion acceleration (DC Bias)
- 2 MHz nearly no influence on plasma generation (➲ 27 MHz)
- the higher the 2 MHz power the smaller the plasma bulk, sheath is filling mostly the gap
- the smaller the pressure, the smaller the bulk
- the smaller the gap, the smaller the bulk

- choosing the 2MHz power too high, the 27 MHz power is too small to generate an adequate plasma bulk for a stable plasma sustainment
- situation is getting worse with smaller gap, e.g. caused by new parts inside the chamber

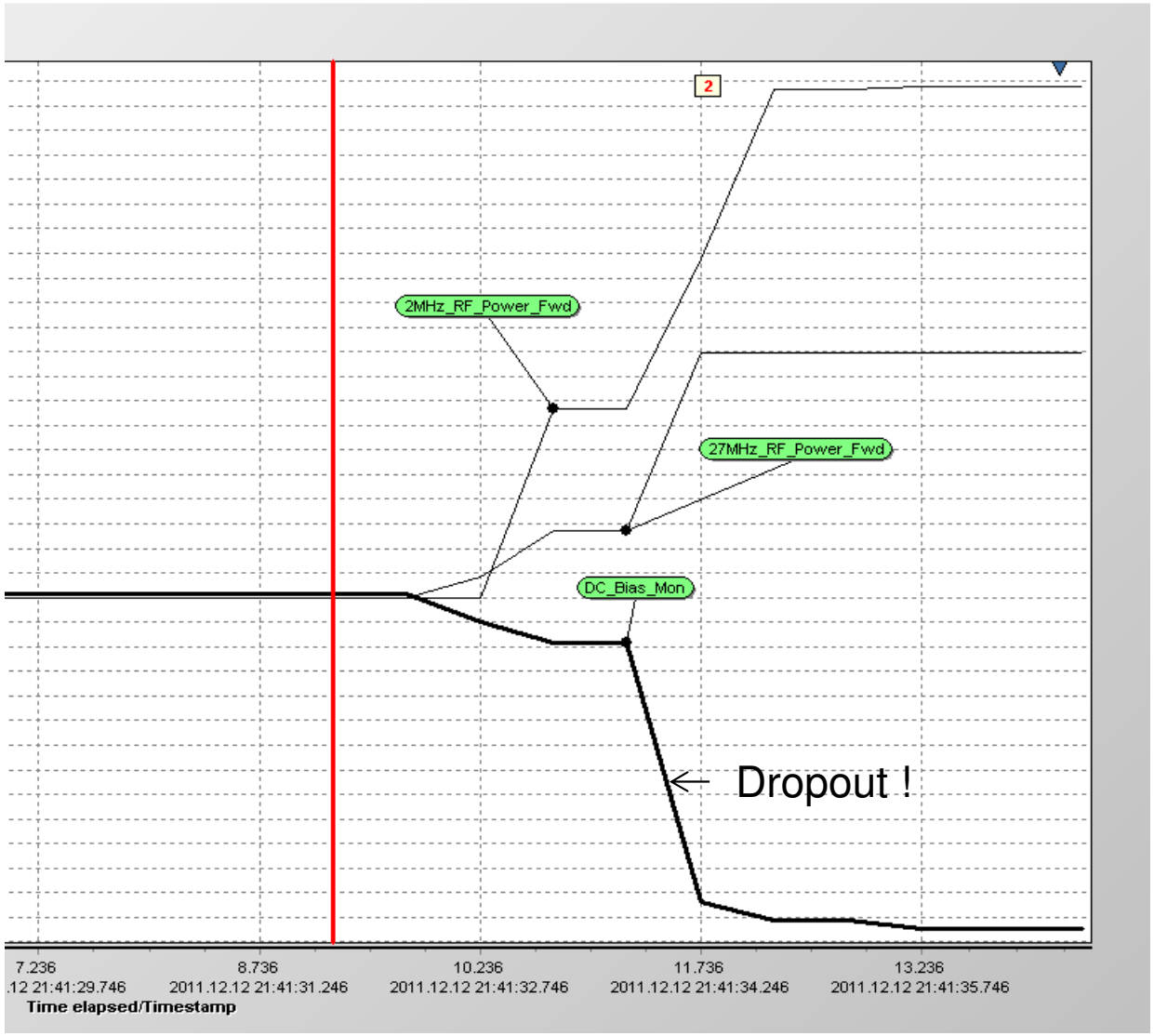
➲ process gets instable and small influences can cause plasma dropout

RF Ramping during Plasma Ignition

- process was setup by supplier / according to BKM
- strange : the 2MHz is ramped to max value before the 27MHz power
- most aborts are happening in step 2 during this ramp
  - 27MHz power is not able to provide stable plasma conditions as fast as needed
  - 2MHz starts to pull ions out of the bulk and is increasing the sheath
  - bulk is collapsing, plasma dropout

	1	2	3	4
27 MHz RF Power (w)	0,0	750,0	750,0	1000,0
27 MHz RF Refl Max (w)	50,0	250,0	250,0	100,0
27 MHz RF Ramp Time (s)	0	2	0	2
2 MHz RF Power (w)	0,0	1000,0	1000,0	1000,0
2 MHz RF Refl Max (w)	50,0	300,0	300,0	300,0
2 MHz RF Ramp Time (s)	0	2	2	2

RF Ramping during Plasma Ignition



RF Ramping during Plasma Ignition

	1	2	3	4
27 MHz RF Power (w)	0,0	750,0	750,0	1000,0
27 MHz RF Refl Max (w)	50,0	250,0	250,0	100,0
27 MHz RF Ramp Time (s)	0	2	0	2
2 MHz RF Power (w)	0,0	1000,0	1000,0	1000,0
2 MHz RF Refl Max (w)	50,0	300,0	300,0	300,0
2 MHz RF Ramp Time (s)	0	2	2	2

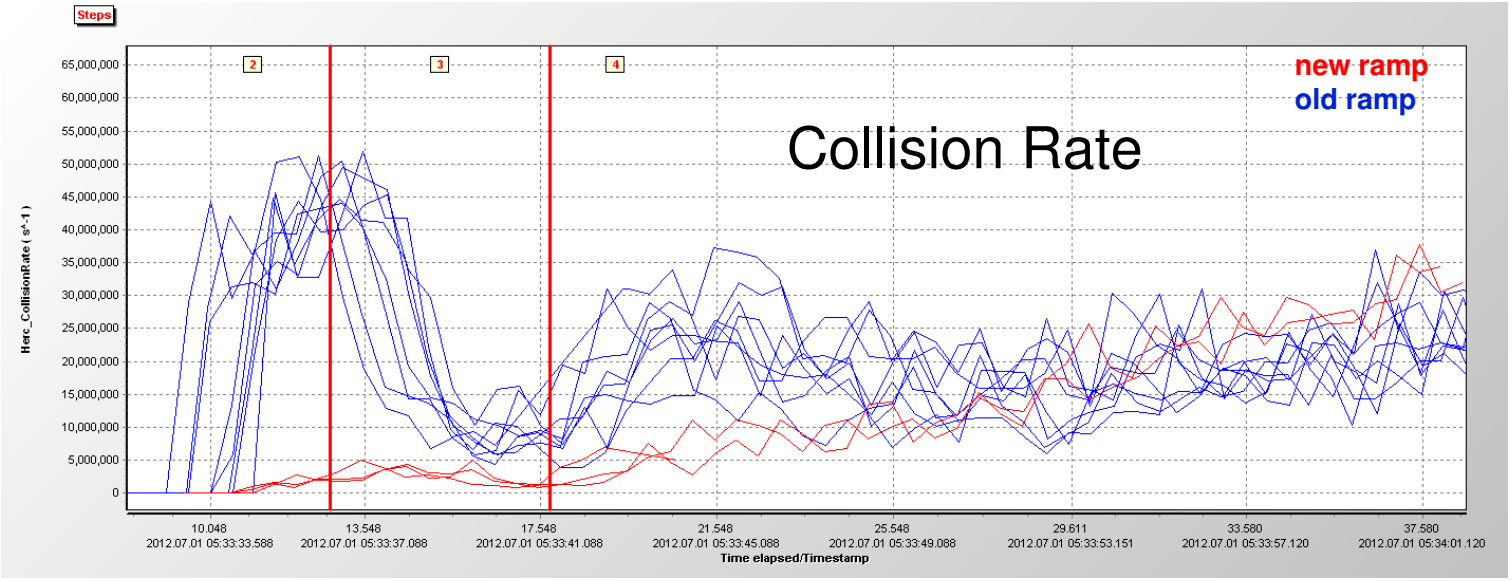
old ramp

- a must : ramp 27MHz first & faster then 2 MHz power
- done by decrease in and delayed ramp of 2MHz power

	1	2	3	4
27 MHz RF Power (w)	0,0	750,0	750,0	1000,0
27 MHz RF Refl Max (w)	50,0	250,0	250,0	100,0
27 MHz RF Ramp Time (s)	0	2	0	1
2 MHz RF Power (w)	0,0	500,0	500,0	1000,0
2 MHz RF Refl Max (w)	50,0	300,0	300,0	300,0
2 MHz RF Ramp Time (s)	0	2	2	3

new ramp

RF Ramping Evaluation by Plasma Parameters



new ramp is

- more stable during ignition
- showing more medium-term stability
- showing no aborts in the last months

Conclusion

- after years of problems it was possible to identify the plasma ignition and ramping as the main reason for short- & medium-term plasma instabilities
- thanks to the plasma monitoring system (Hercules) it was possible to visualize these instabilities
- thanks to the plasma monitoring system it was possible to try several modifications of plasma ramping and to check them in real time without the need of waiting weeks or months to see a change in plasma stability