

Comparison of Applied Materials DPS chambers used for Poly – Si etch processes by plasma parameters

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**Project
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Outline

- ❑ **Motivation - Target of the measurements**
- ❑ **Chamber comparison by plasma parameter measurement**
 - **Measurements at Poly - Si etch step 1**
 - **Measurements at Poly - Si etch step 2**
 - **Measurements at Poly - Si etch step 3**
- ❑ **Summary and conclusions**

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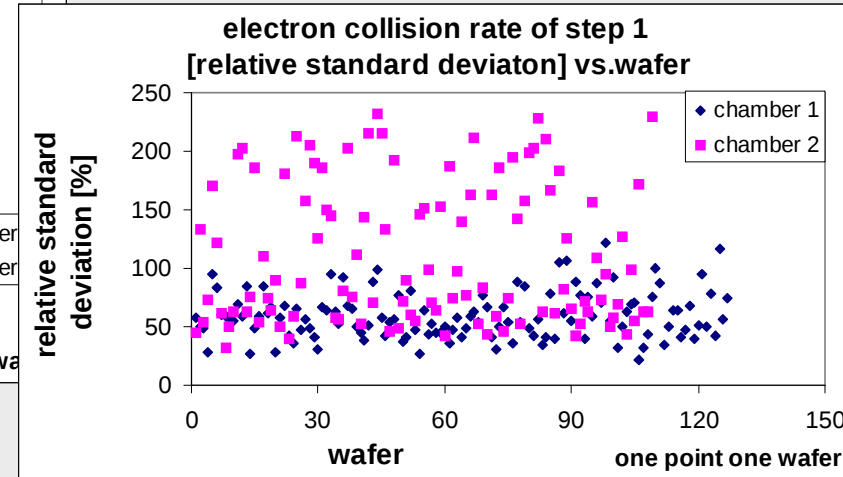
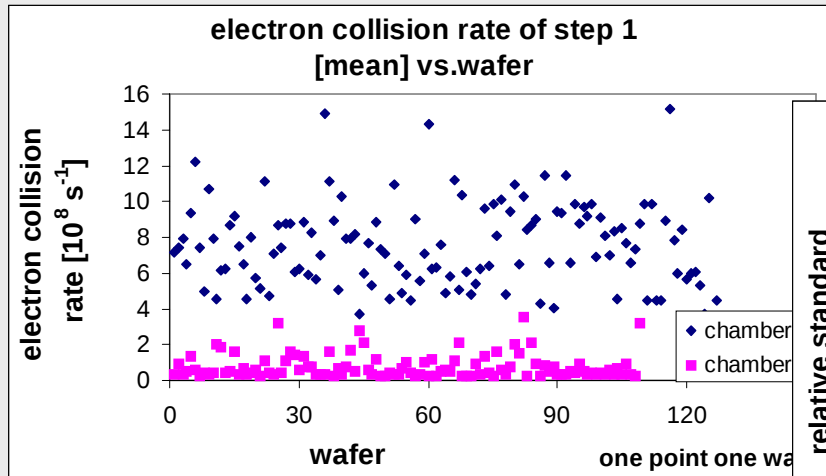
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Motivation - Target of the measurements

- ❑ At start up of new tools all chambers have to fit the same specifications.
- ❑ Plasma parameters are helpful to characterize new chambers, because:
 - They are sensitive to hardware and wafer impacts
 - We get the measurement results in real time
 - We can measure on test wafers and on product wafers.
- ❑ Target of these measurements:
 - No process problem, baseline measurement at two DPS chambers
 - Base line results can be used later in case of possible tool- or process problems to identify the reason easier
- ❑ Chamber comparison by measurement on product wafers:
 - Poly - Si etch process
 - 10 split lots, all lots were split, 50 % of each lot on both chamber

Poly-Si etch step 1:

Chamber comparison by use of electron collision rate

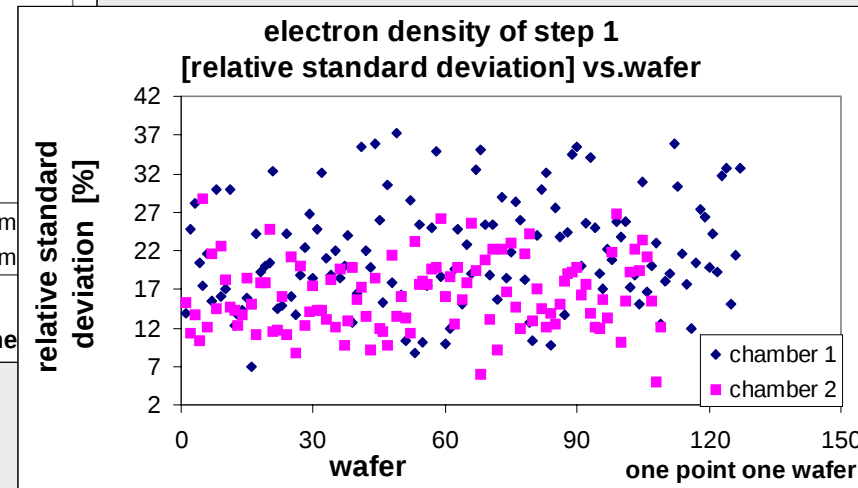
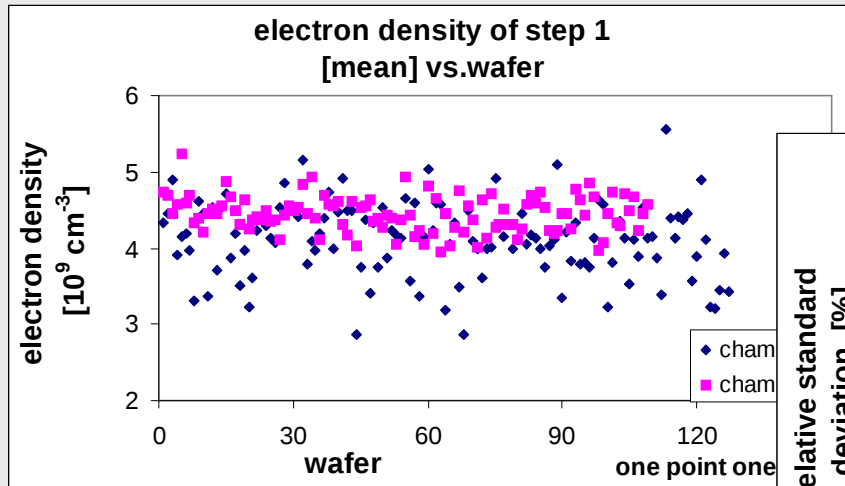


- ❑ Chamber 1 (blue points) shows
 - significant higher mean values of electron collision rate

- ❑ Chamber 1 (blue points) shows
 - lower relative standard deviation
 - lower range of relative standard deviation wafer to wafer

Poly-Si etch step 1:

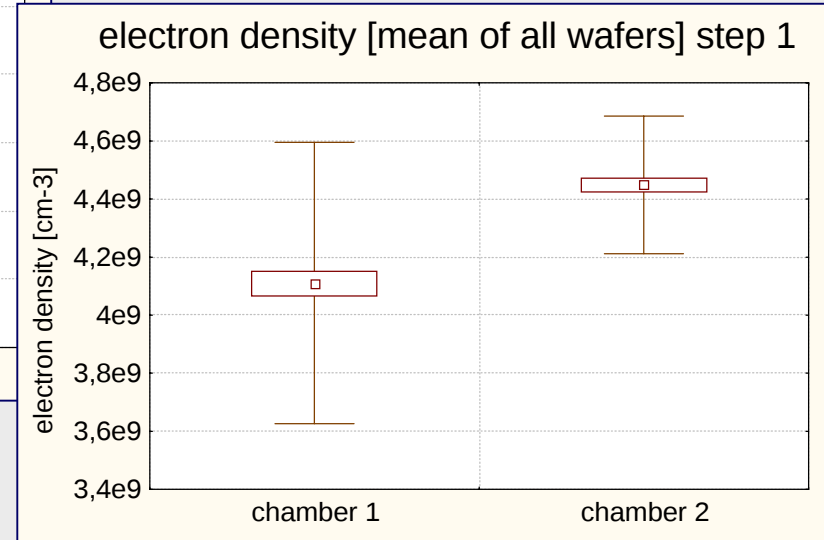
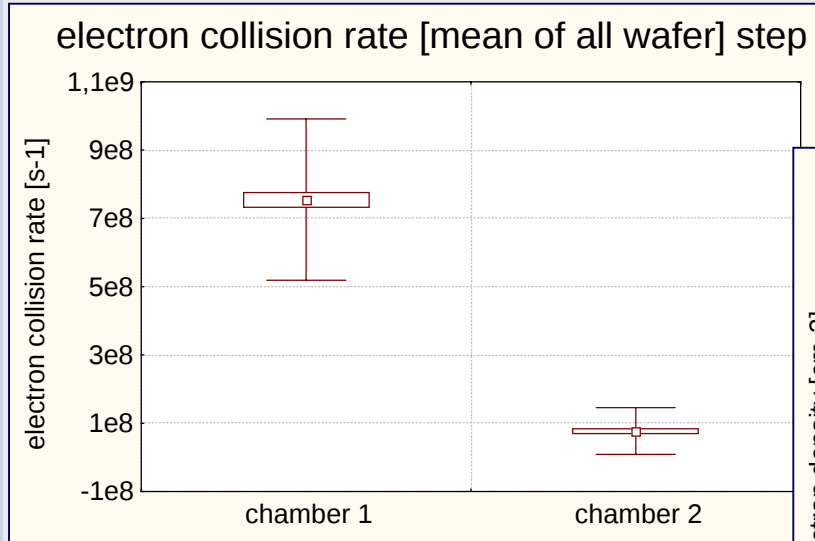
Chamber comparison by use of electron density



- ❑ Chamber 1 (blue points) shows:
 - slightly lower mean value of electron density
 - significant larger mean value variation wafer to wafer
- ❑ Relative standard deviation of chamber 2 is slightly lower than at chamber 1

Poly-Si etch step 1:

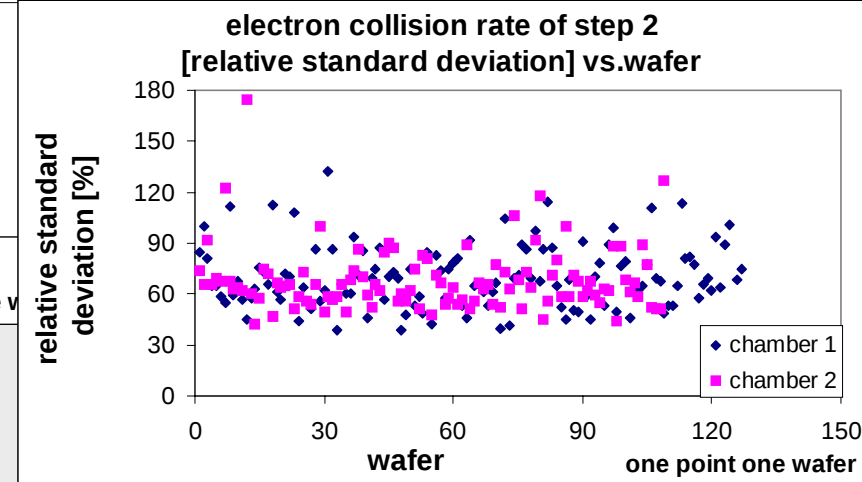
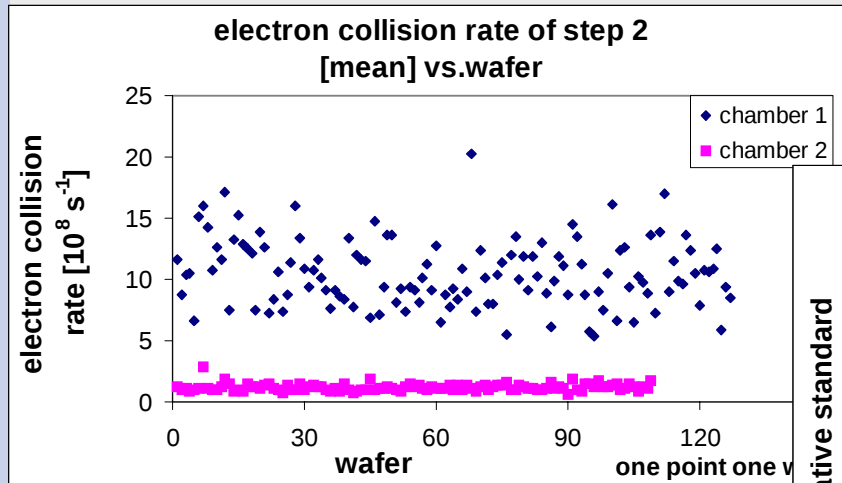
Chamber comparison by plasma parameters, summary



- Summary of chamber comparison at Poly - Si etch step 1:
 - Both plasma parameters indicate lower wafer to wafer range at chamber 2
 - Mean values of electron collision rate and electron density show opposite behaviour

Poly-Si etch step 2:

Chamber comparison by use of electron collision rate



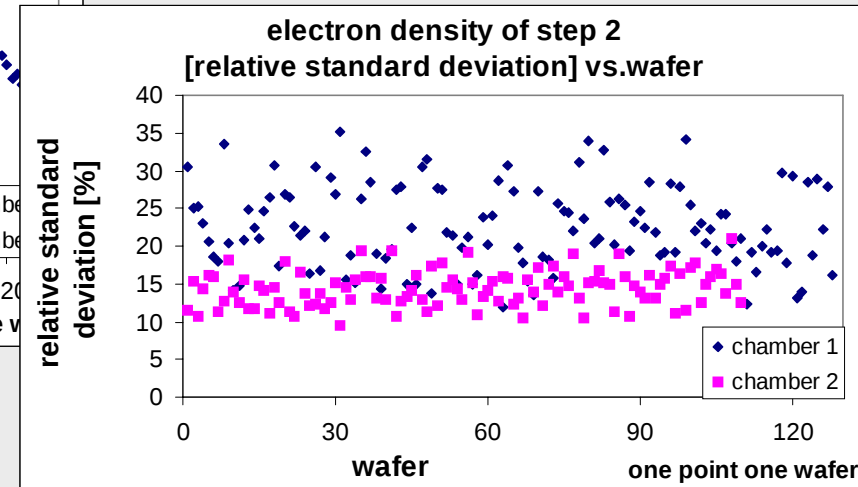
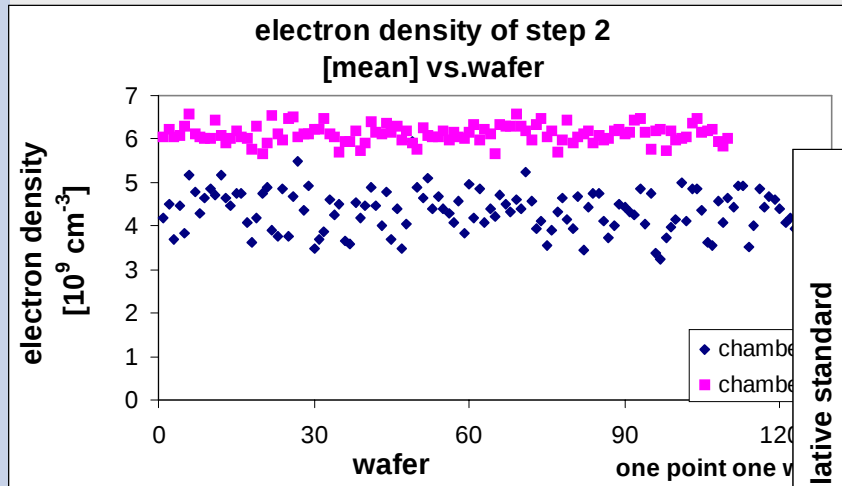
- Chamber 1 (blue points) shows
 - significant higher mean values of electron collision rate

- Relative standard deviation of electron collision rate has the same level and wafer to wafer range in both chambers



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Poly-Si etch step 2: Chamber comparison by use of electron density



- ❑ Chamber 1 (blue points) shows:
 - significant lower mean electron density
 - larger mean range wafer to wafer

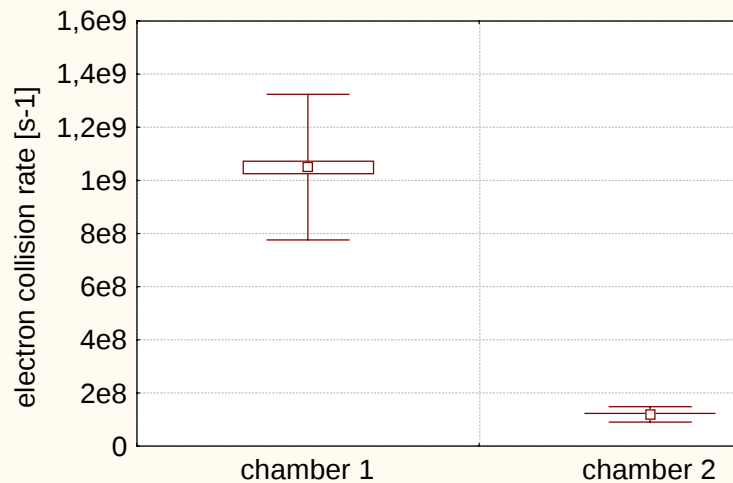
- ❑ Chamber 1 shows:
 - higher relative standard deviation than chamber 2



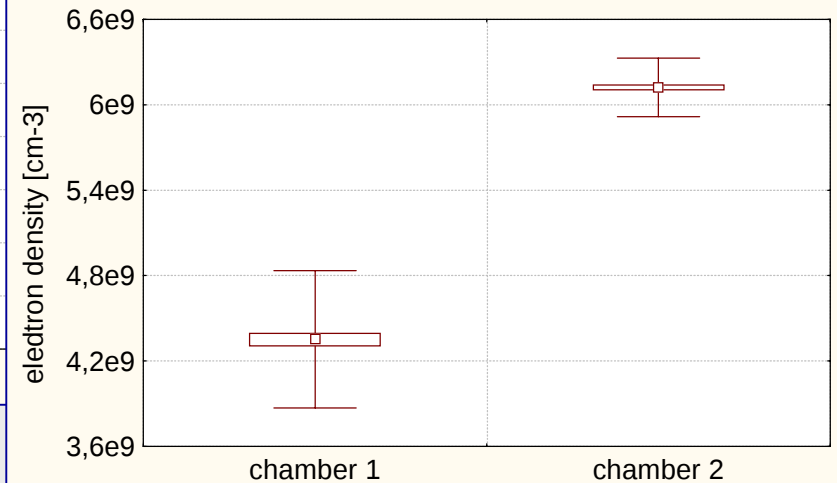
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Poly-Si etch step 2: Chamber comparison by plasma parameters, summary

electron collision rate [mean of all wafers] step 2



electron density [mean of all wafers] step 2



- ❑ Summary of chamber comparison at Poly - Si etch step 2:
 - Both plasma parameters indicate lower wafer to wafer range at chamber 2
 - Mean values of electron collision rate and electron density show opposite behaviour
- ❑ Results are similar to Poly - Si etch step 1 mainly

Poly-Si etch step 3: Chamber comparison by use of electron collision rate

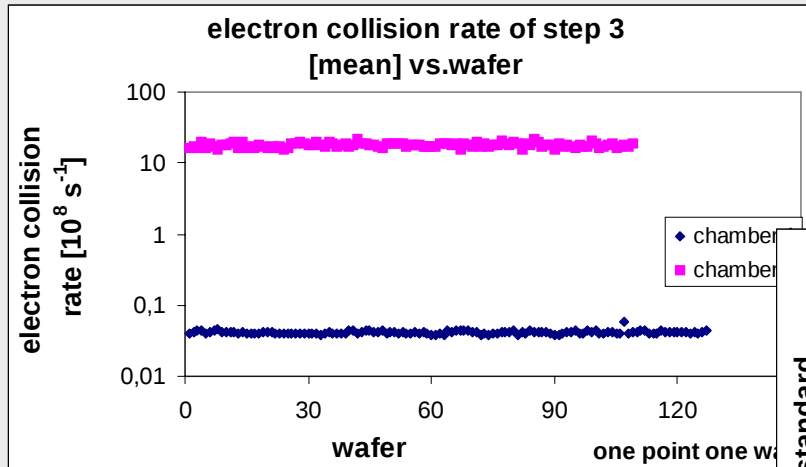
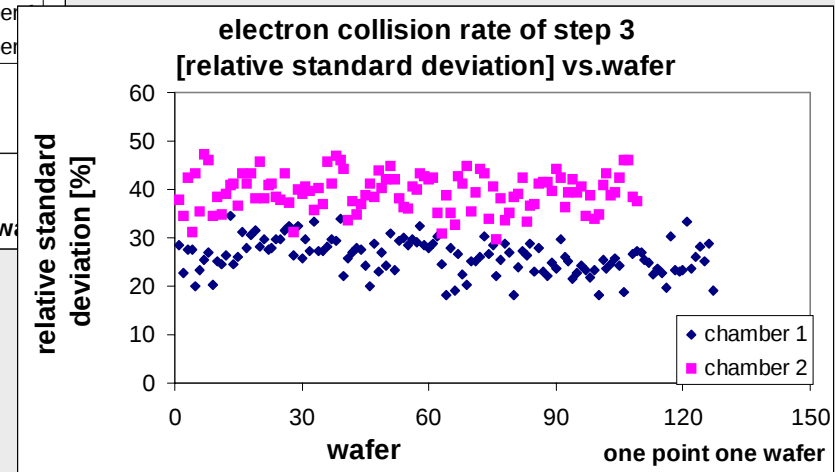


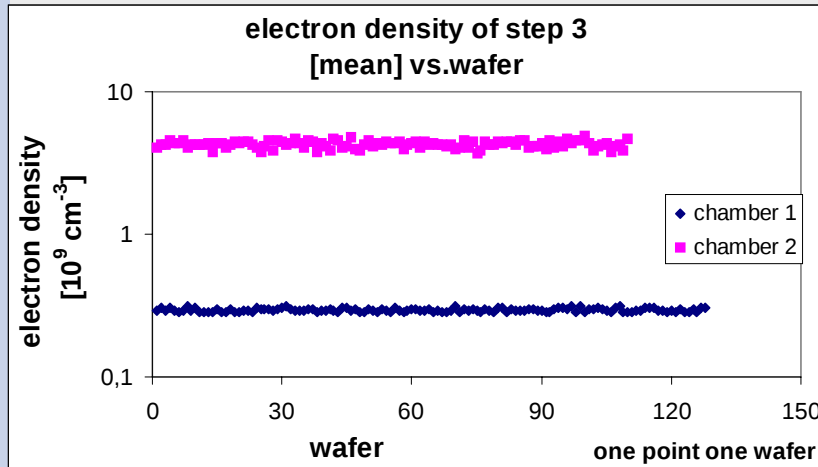
Diagram of mean values
has a logarithmic scale



- Chamber 1 (blue points) shows much lower electron collision rate !

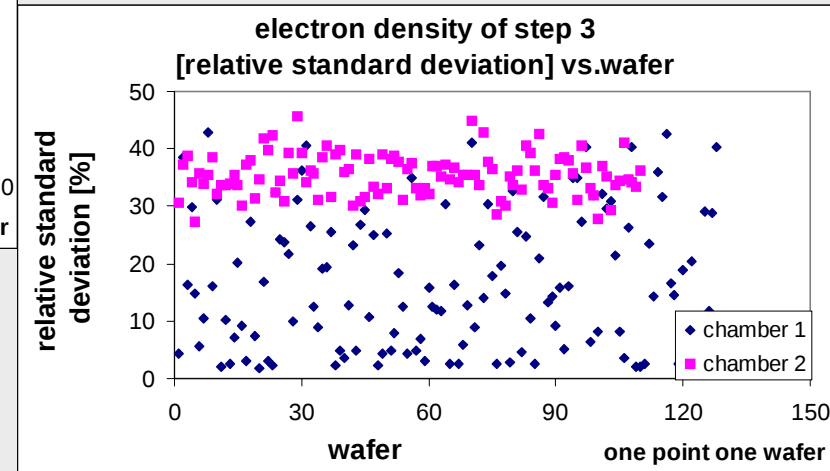
- Chamber 1 has slightly lower rel. standard deviation at electron collision rate

Poly-Si etch step 3: Chamber comparison by use of electron density



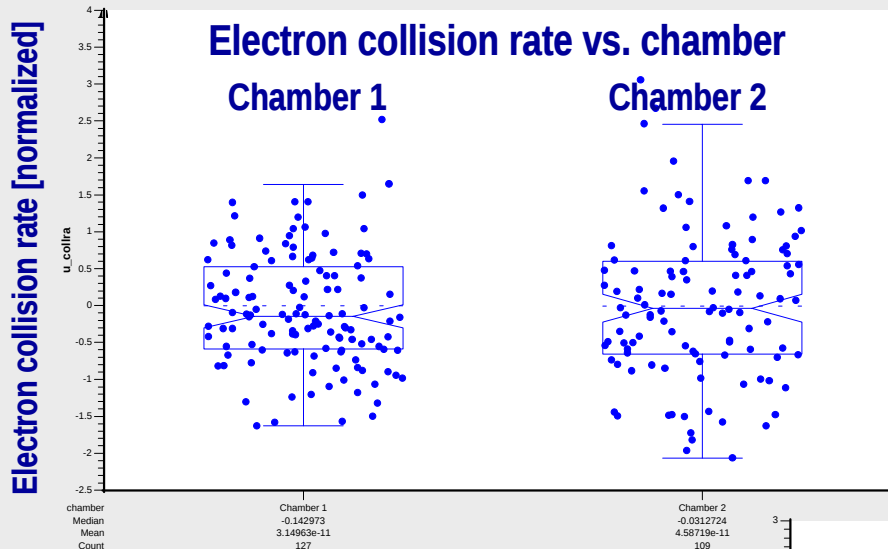
- Chamber 1 (blue points) shows much lower electron density !

Diagram of mean values
has a logarithmic scale



- Chamber 1 shows significantly lower relative standard deviation, but a larger range wafer to wafer

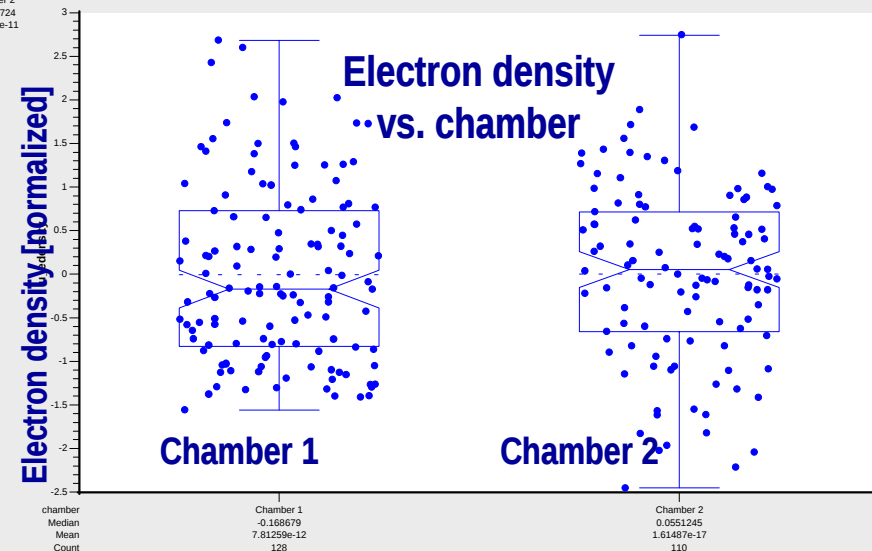
Poly-Si etch step 3: Chamber comparison by plasma parameters, summary



Large difference of absolute values at chamber 1 and 2 → both parameters are normalized for chamber comparison:

$$u_i = (x_i - x_q) / s$$

- Summary of chamber comparison at Poly - Si etch step 3:
 - range of both plasma parameters slightly lower at chamber 1
 - but statistically not significant



Summary and conclusions

- ❑ Mean electron density:
 - is higher in chamber 2 at all etch steps.
 - indicates higher plasma density in chamber 2
- ❑ Process stability:
 - Depending on etch step, the relative standard deviation of electron collision rate and electron density show different results.
- ❑ Range wafer to wafer:
 - electron collision rate and electron density show significant lower range in chamber 2 at etch step 1 and 2
 - no statistical significant difference at etch step 3
- ❑ As a result we conclude, that plasma parameter measurements indicate higher plasma density and lower wafer to wafer range in chamber 2.
- ❑ Plasma parameter measurement is a useful method for tool and chamber comparison.