

# Highly Sensitive Ion Trap Mass Spectrometer for Inline Process Control



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## INTRODUCTION

**Semiconductor manufacturing equipment (CVD, Epi, etc.) require measuring instruments which provide information on:**

- Drifts in process gas condition
- Variations in chemical reaction in the process chamber
- Healthiness of the process chamber
- Contamination level and type

### Classical approach:

Differentially pumped Residual Gas Analyzer (RGA)

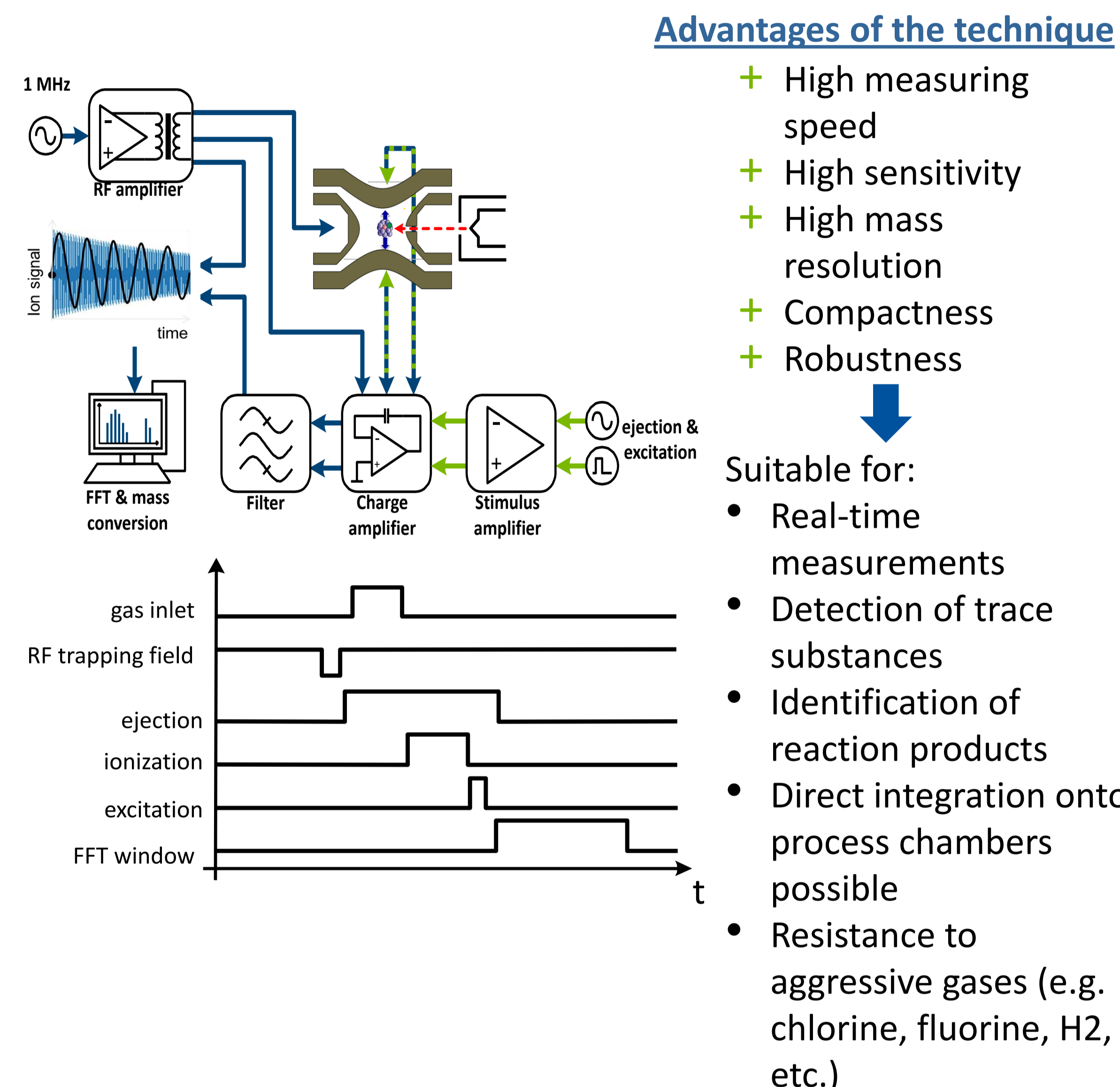
- limited sensitivity @ input pressures 1000 mbar to 10-3 mbar
- sensitivity loss when detecting larger molecules
- long scanning time
- detector degradation in aggressive gas environments
- Nonlinear signals @ high gas loads

### New approach:

**iTrap technology based on FT Ion Trap:**

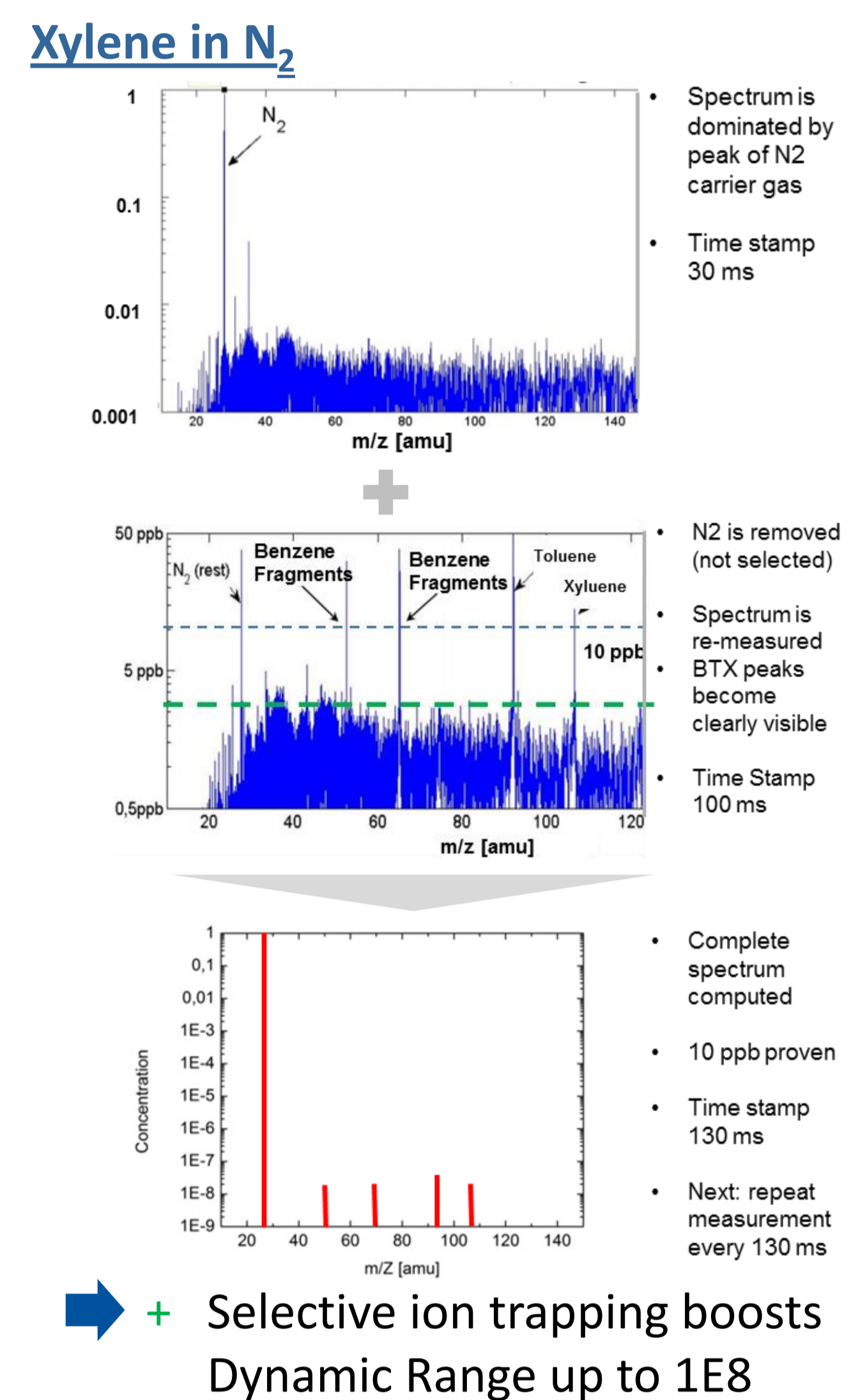
- + High measuring speed
- + High sensitivity
- + Compactness
- + Robustness

## WORKING PRINCIPLE OF iTrap® TECHNOLOGY



## LARGE DYNAMIC RANGE & VERY LOW DETECTION LIMIT

**50ppb Benzene/53ppbToluene/50ppb Xylene in N<sub>2</sub>**



## CONCLUSIONS

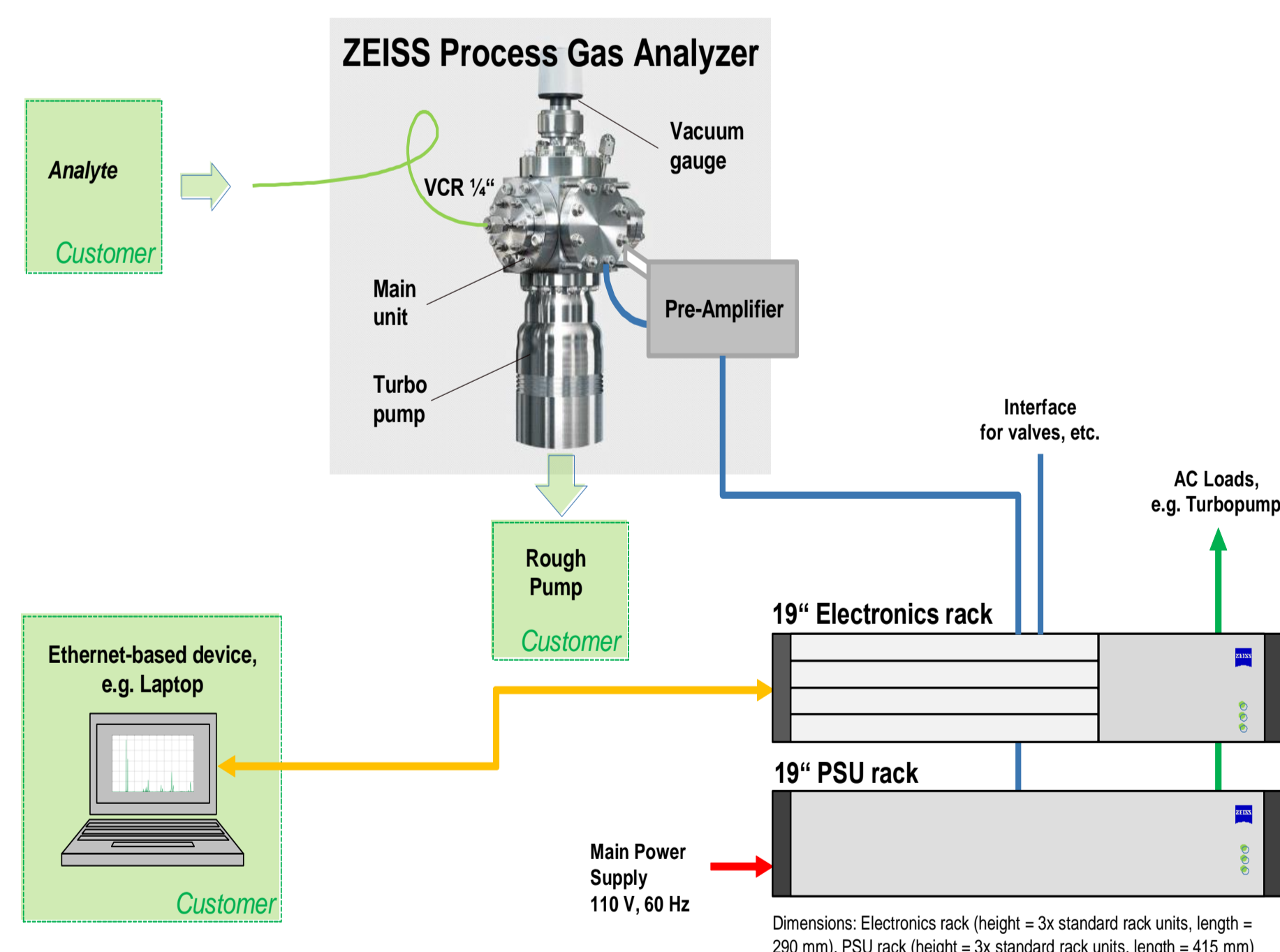
The mass spectrometer iTrap® of ZEISS has successfully demonstrated

- **Very high sensitivity** by detecting **sub ppbV or even sub pptV** dopant levels in H<sub>2</sub> carrier gas.
- **Robustness against aggressive gas**
- Capability to detect in **real-time process reaction products and dopants memories effects**
- Ability to **monitor process chamber events**.
- **SnH<sub>4</sub> fragments** from plasma cleaning process can be **detected** with **sampling rate of ~1 Hz**.

## REFERENCES

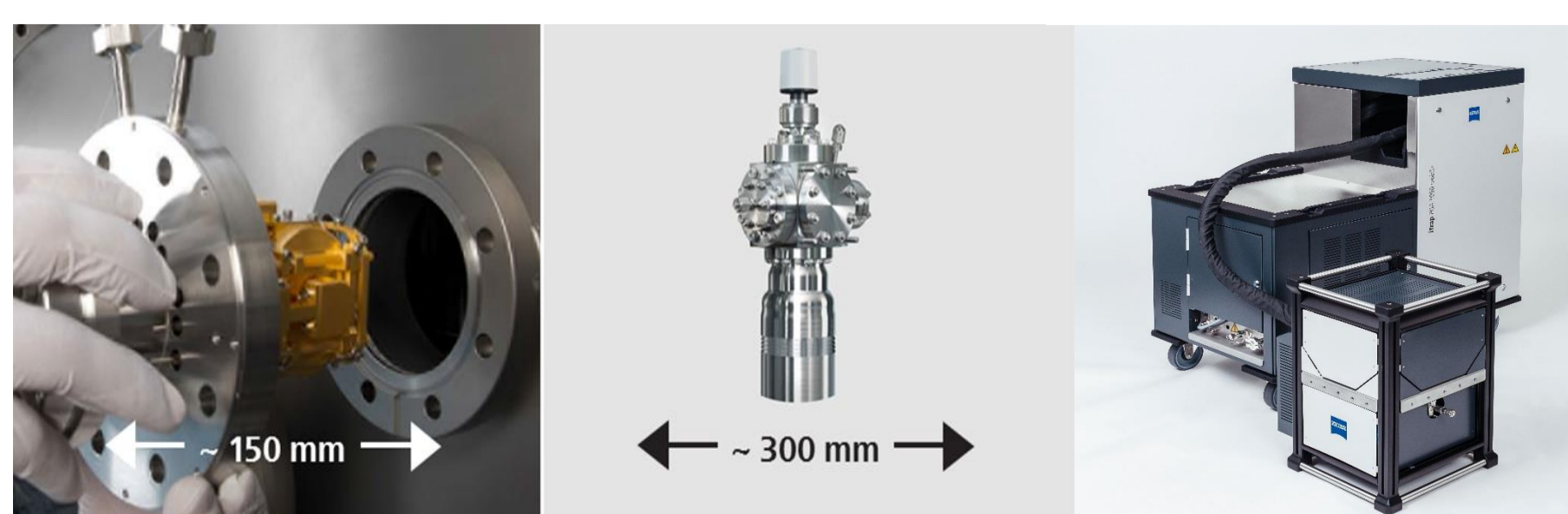
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## THE iTrap® SYSTEM



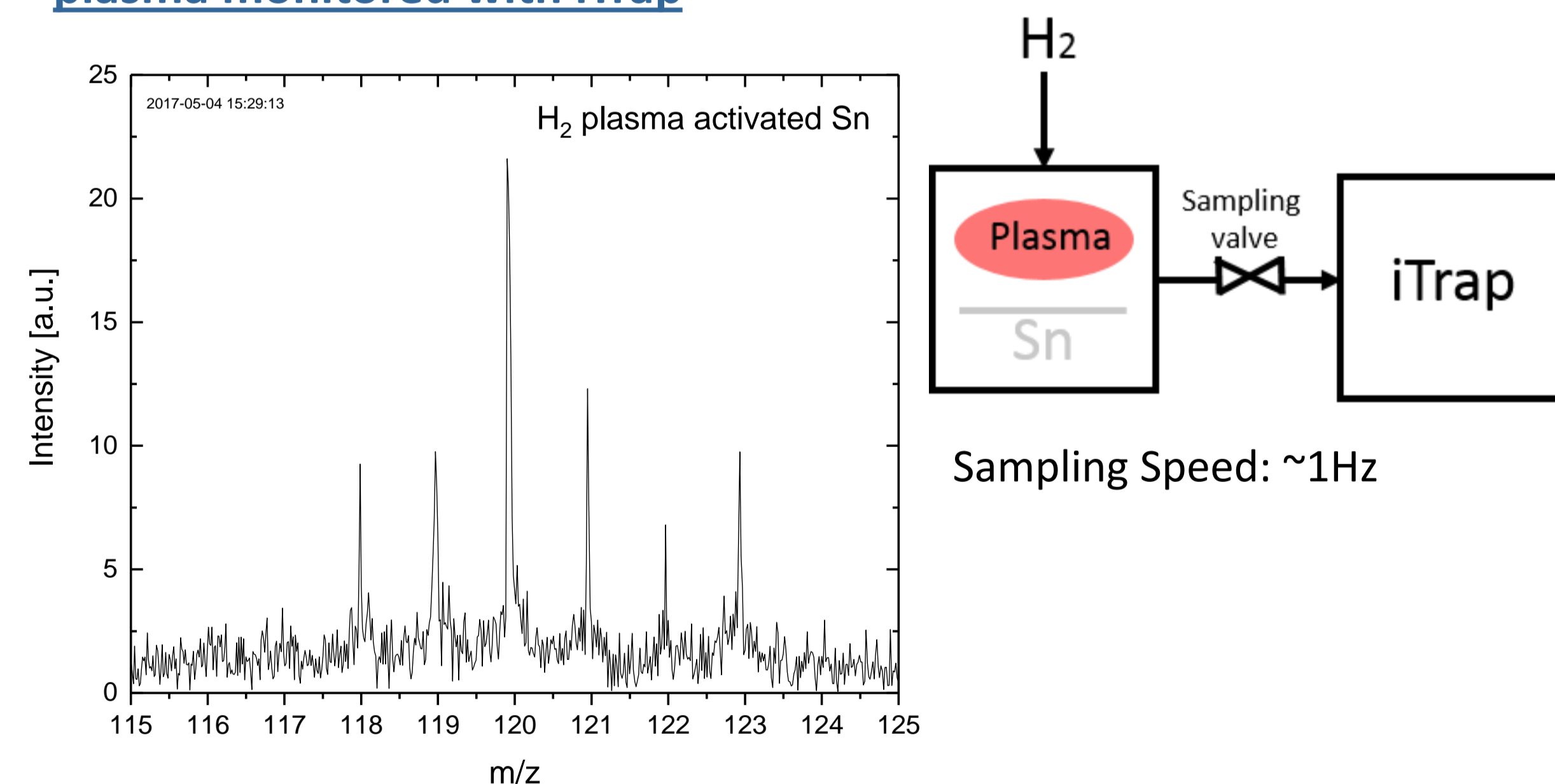
### Three possible versions

- PGA 1000 vacuum**
  - For p < 1E-6 mbar
  - To be integrated in UHV process chamber (e.g. UHV processes or as add-on detector in analytics tools)
- PGA 1000 atmospheric**
  - For pressures up to 1000 mbar
  - To be coupled to process chamber (e.g. CVD, Epi or Etch)
- PGA 1000 mobile**
  - For R&D
  - Highly flexible



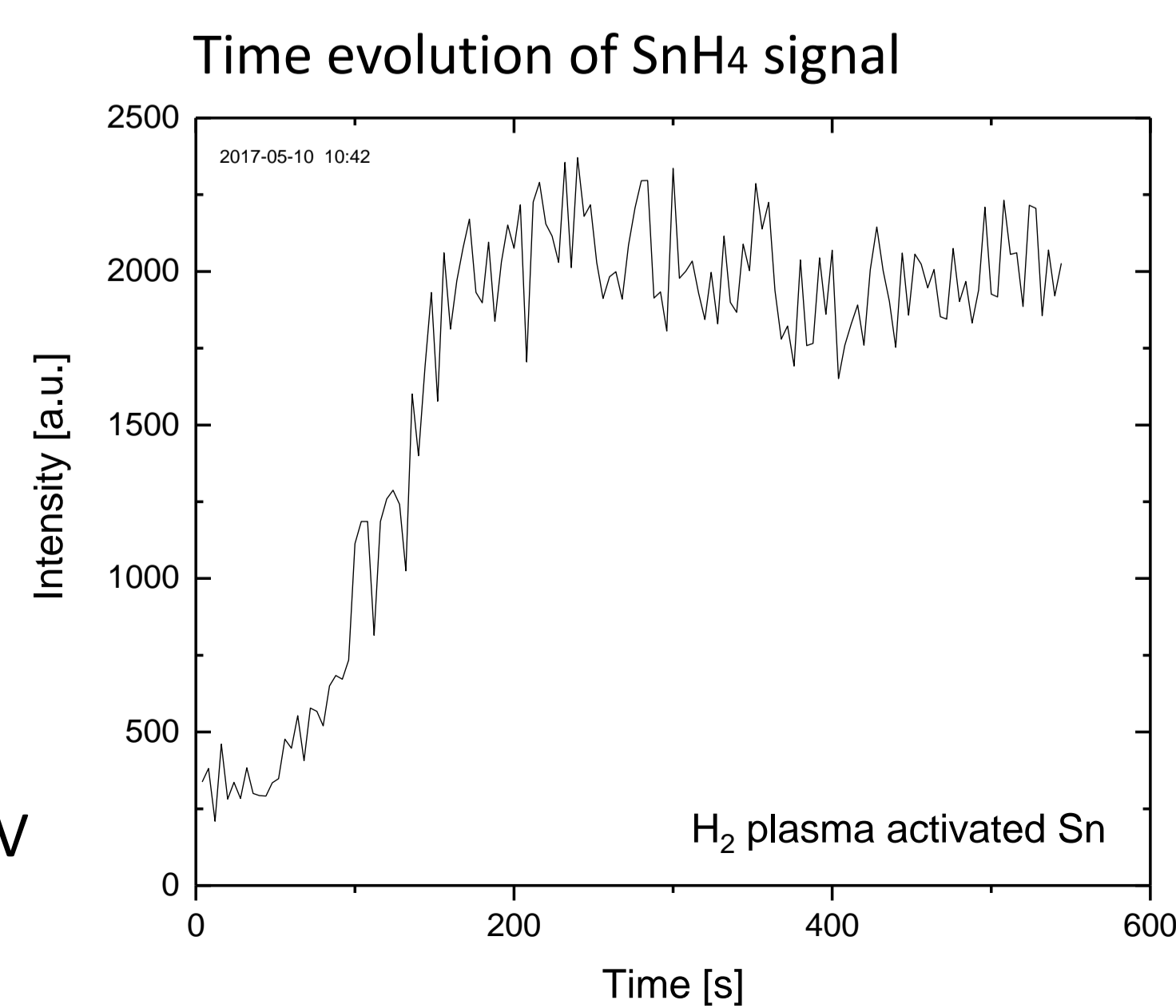
## SnH<sub>4</sub> MEASUREMENT DURING PLASMA CLEAN

**Cleaning of a tin contaminated process chamber using a hydrogen plasma monitored with iTrap**



**Conclusion:**

- H<sub>2</sub> Plasma capable to remove Sn contamination.
- SnH<sub>4</sub> and fragments clearly detectable with iTrap.
- H<sub>2</sub> plasma can be used to remove tin contaminations in vacuum systems like EUV optics.



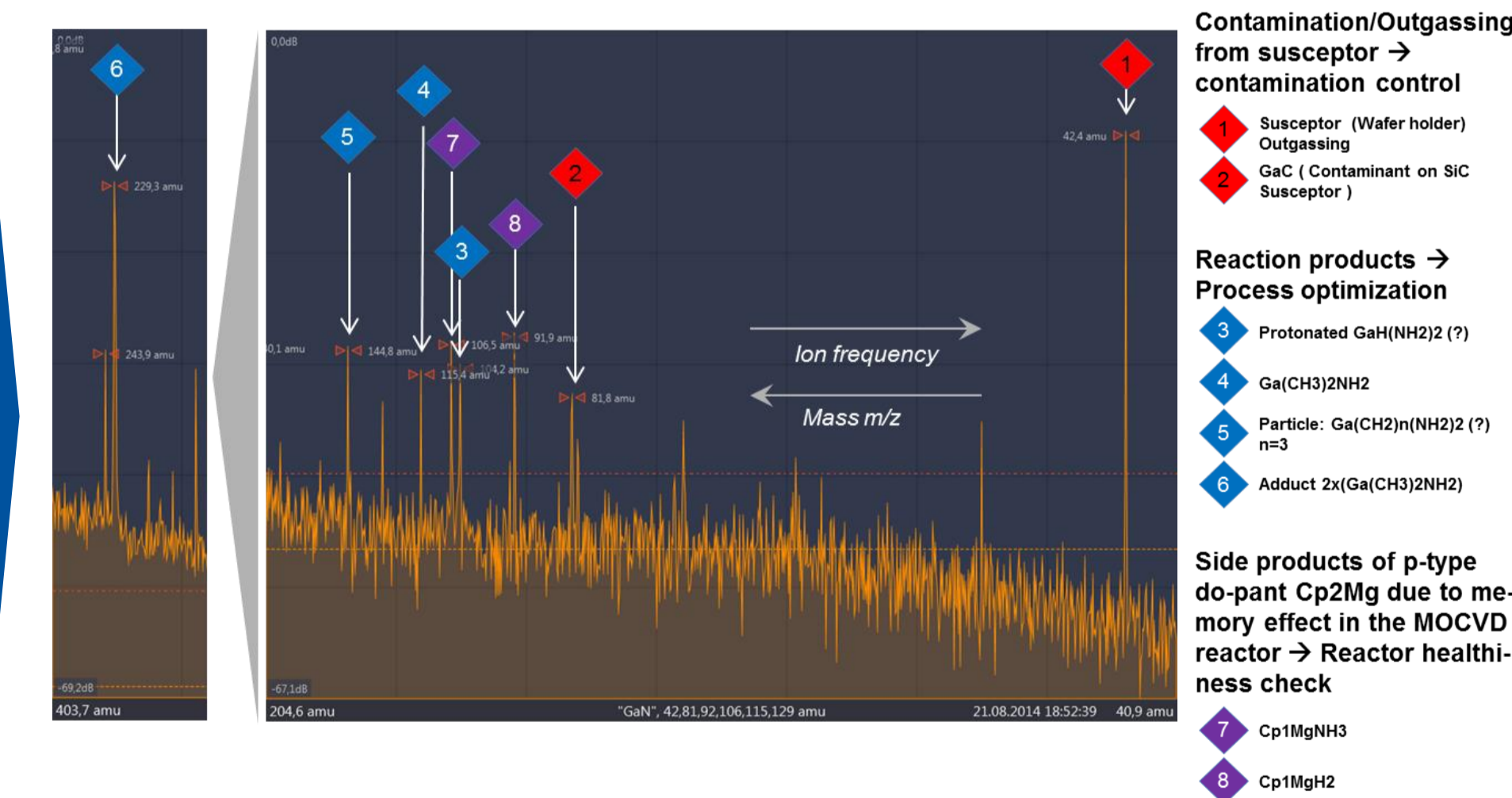
## REAL-TIME PROCESS GAS ANALYSIS

**Real-time process gas monitoring during GaN growth for MOCVD**



**Measurement Conditions:**

- Process gases: Ga(CH<sub>3</sub>)<sub>3</sub>, NH<sub>3</sub>, N<sub>2</sub>, H<sub>2</sub> (100mbar);
- Process temp. 1000°C;
- Gas sampling @ chamber exhaust



**Further observation:** no degradation of the interior of the ion trap after weeks of Cl<sub>2</sub> exposure

- ➔ **Robust against aggressive gases**

**Real-time monitoring of polymer outgassing during sample loading/de-loading**

