spacetek
TECHNOLOGY

A Better Life on Earth

Time-of-Flight Mass Spectrometry for Highest Product Quality and a Clean and Safe Environment.

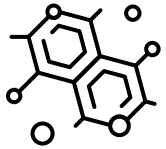
Agenda

Key Benefits

Disruptive Solution

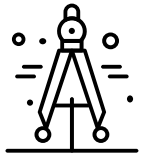
IN-LINE

Directly integrated with full remote control and supervision.



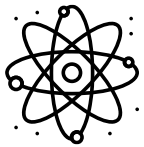
FULL QUANTITATIVE ANALYSIS & HEAVY MASSES

Full spectra up to 1200 u/e.



RESOLUTION & SENSITIVE

Unique insights into your production processes.

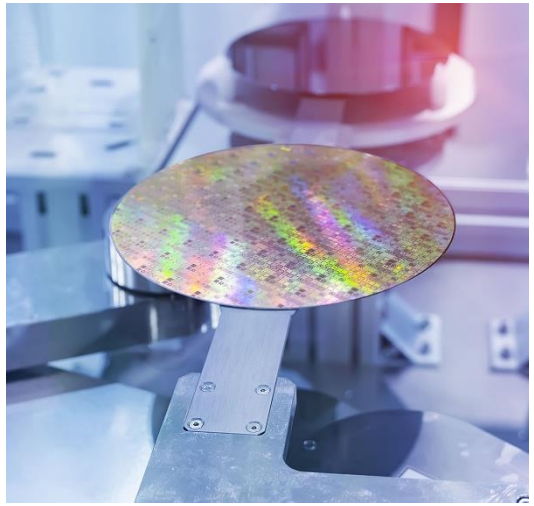


REAL-TIME

Full quantitative chemical analysis up to ten times per second.

Applications

Real-Time, In-Line and Full Quantitative Composition Monitoring



Wafer Manufacturing

CVD, PVD, ALD, and Etching Process Control

› Yield increase

Laboratory

Full Quantitative Analysis, Speed, and Resolution

› Increased sample throughput

Environmental

Full Quantitative Analysis, Speed, and Resolution

› Seamless sample throughput

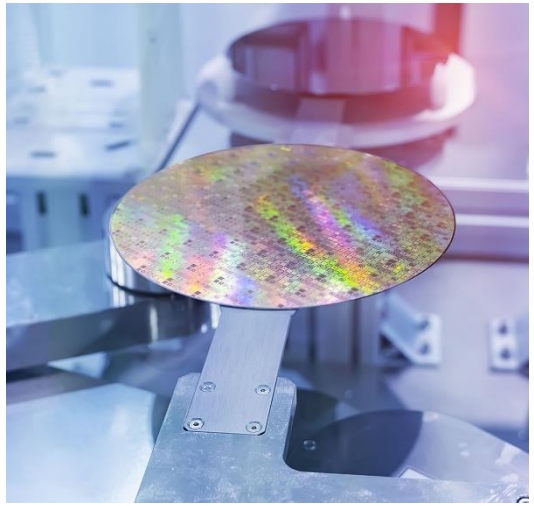
Academia

Research & Development with Full Quantitative Analysis

› Shortened development time

Applications

Yield increase in Semiconductor Industry



Wafer Manufacturing

CVD, PVD, ALD, and Etching
Process Control

Humidity Detection

Detection of humidity after maintaining the process chamber

› In-line, resolution

Minimize dead time during maintenance

› increased yield

Contamination Detection

Detection and analysis of contamination events – at present and in the past

› In-line, full quantitative analysis, heavy masses, resolution, real-time

Detection of faults during each production step and preventing error propagation

› increased yield

Cleaning

Control the time needed for process chamber purging

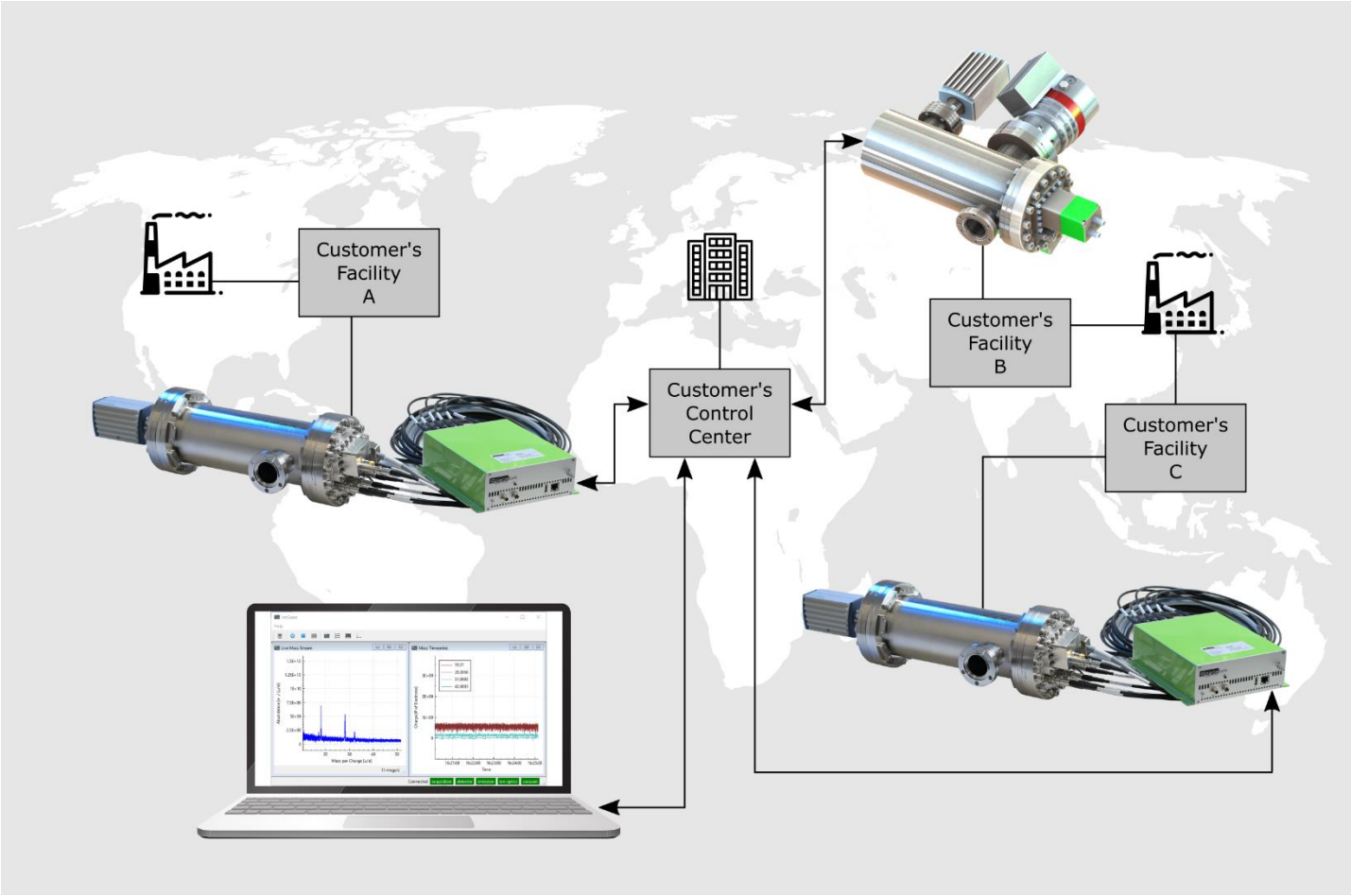
› In-line, full quantitative analysis, heavy masses, resolution, real-time

Minimize dead time during processing

› increased yield

Seamless Integration

Compact, In-Line, Online, 100% Remote Operation



Plasma etching of Silicon wafer

Plasma etching chamber

RF Plasma Etcher

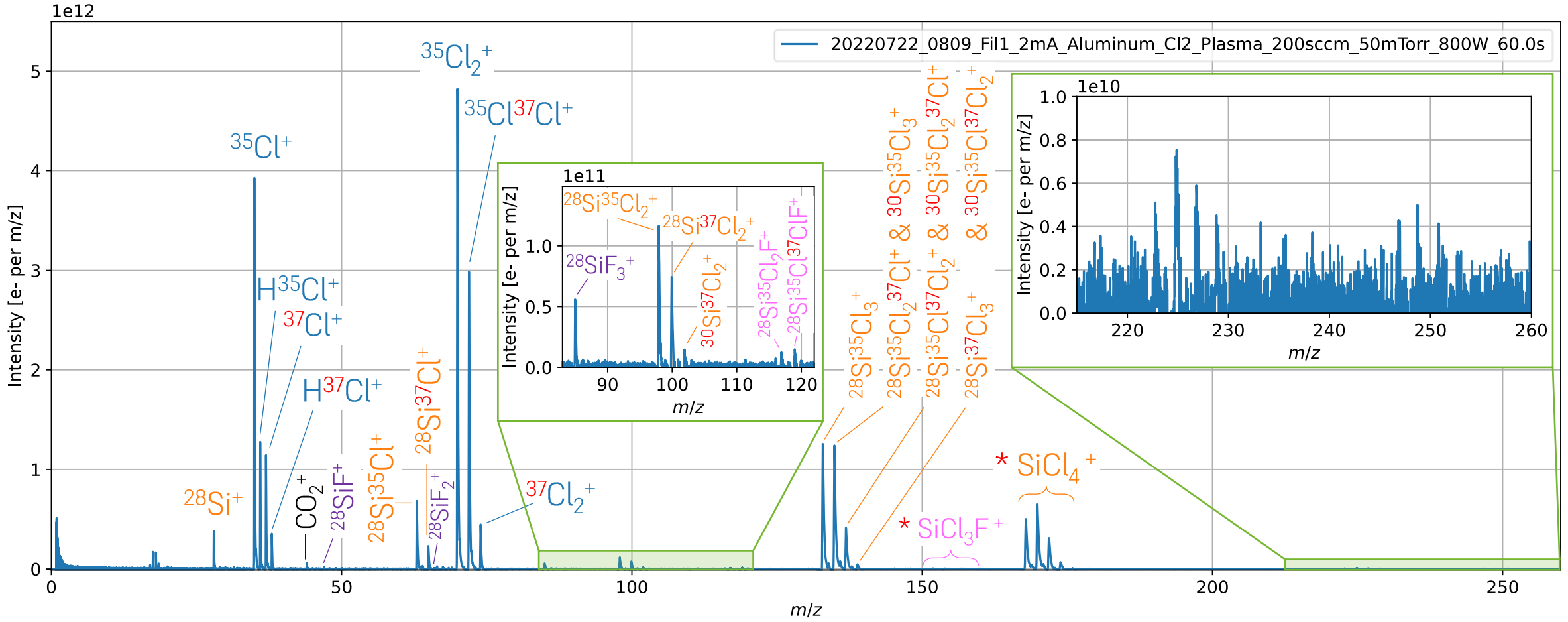
- Chamber:
  - APPLIED MATERIALS MxP+ 200mm Etch Chamber
- Process Gas:
  - Cl2, NF3, H2, CF4, O2, Ar, N2
- Dry Pump:
  - Pumping Speed : 160 m3/h
- Turbo Pump:
  - Rated speed : 48000 RPM
  - Pumping speed for H2 : 220 l/s
  - Pumping speed for N2 : 300 l/s
  - Maximum Vacuum Pressure : 10^{-9} Torr
- RF Power Range : ~1200 W

IonTamer™

- TOFMS compact process analyzer
- Installed at turbo pump exhaust line

Cl_2 plasma etching of Silicon wafer

Each measuring point: fully quantitative – high mass accuracy – heavy masses



cross contamination

* & isotopologues

Cl_2 plasma etching of Silicon wafer

Full quantitative analysis – high mass accuracy – heavy masses

Process description:

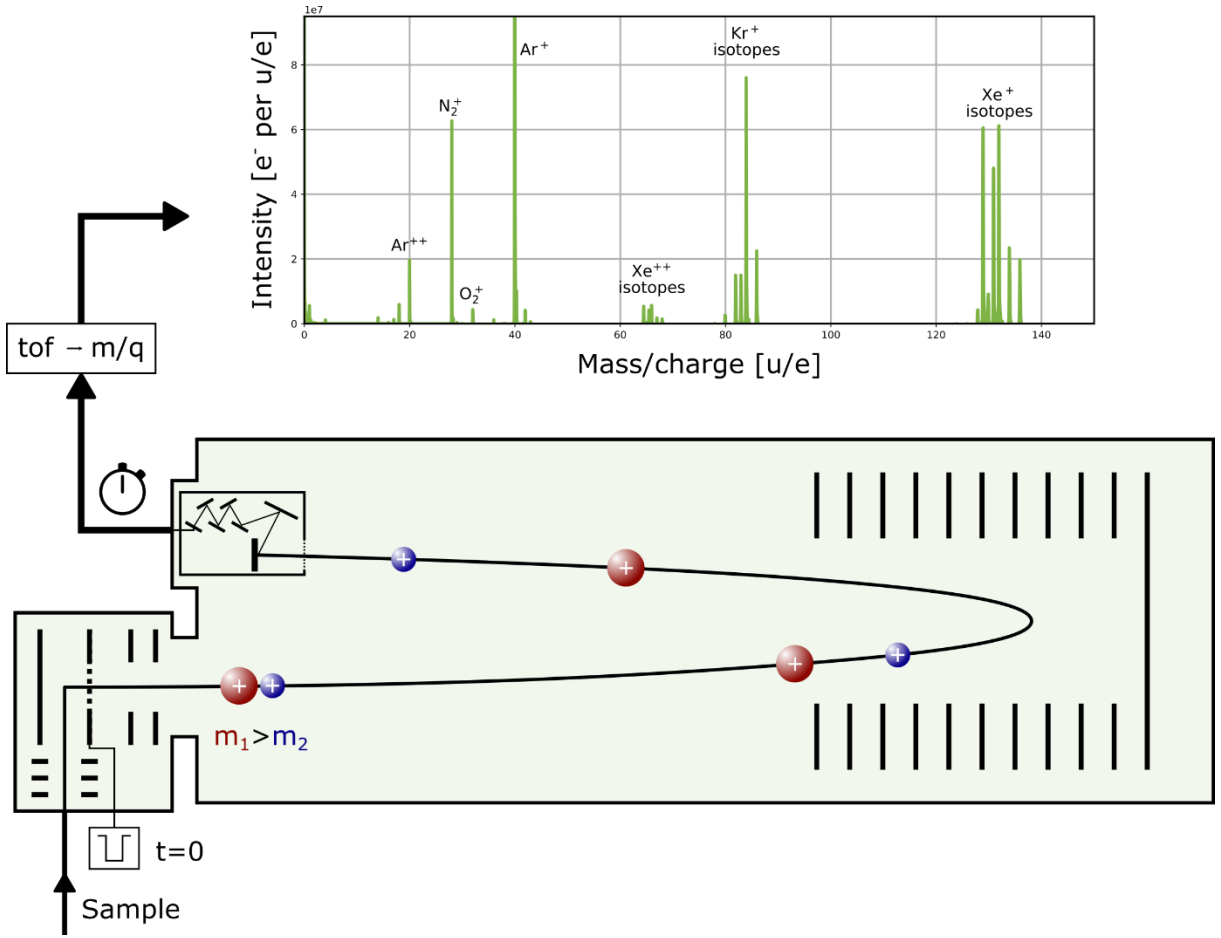
- Silicon dummy wafer
- **Etching with chlorine plasma**

Analysis:

- **Process gas** (chlorine) is detected, including
  - Natural isotopes
  - **Fragmentation pattern** due to ionization
- **Reaction products**
  - Silicon tetrachloride ($SiCl_4$)
    - Group of peaks due to **isotopologues**
    - Fragmentation pattern due to ionization: $SiCl_3$, $SiCl_2$, SiCl
  - **Heavy reaction products** at $m/z > 200$
  - Reaction products with silicon, chlorine, and fluorine
    - Identified thanks to high resolution. However, fluorine was not used for the experiment
    - **Cross contamination** from previous experiments
  - **Reaction products with water/humidity** in vacuum chamber
    - Chlorine reacted with water residuals and formed **hydrochloric acid** (HCl)

Technology

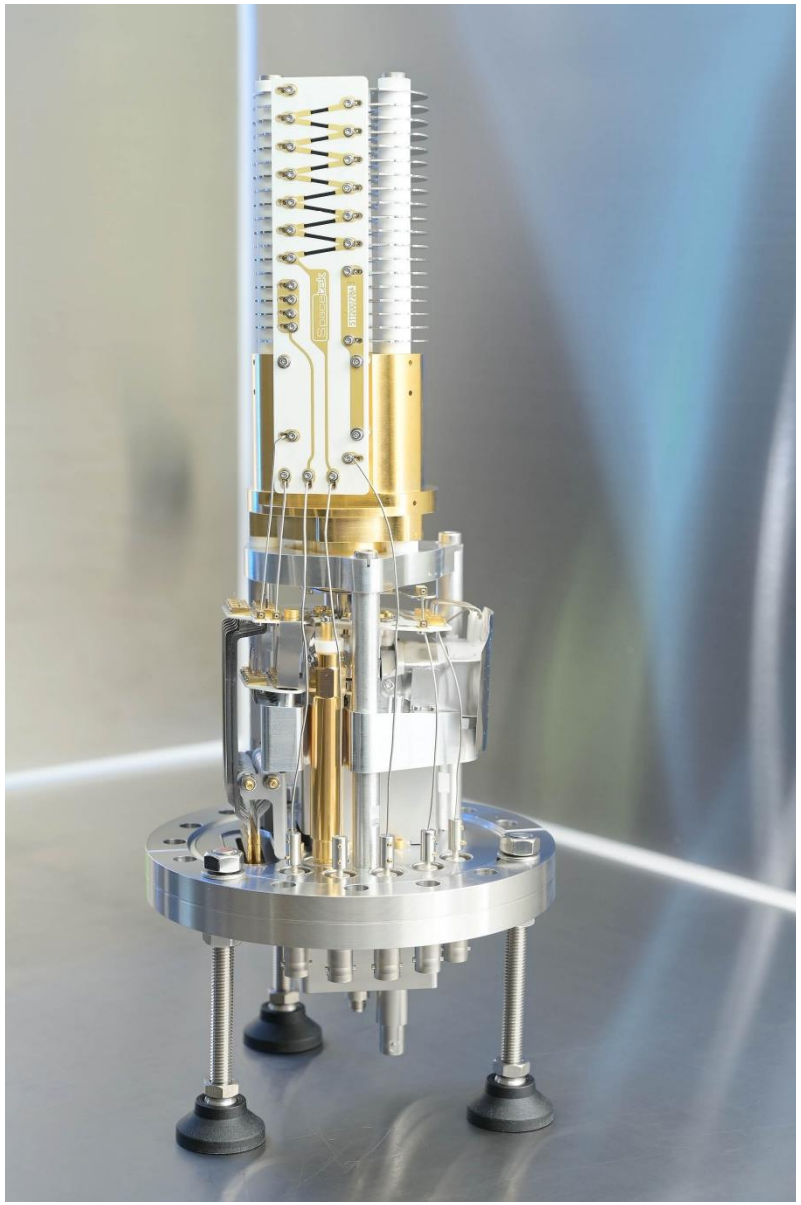
Time-of-Flight Mass Spectrometer for in-situ analysis



Key Performance Parameters

The TOF-RGA

Mass range	1 – 1200 u/e
Mass accuracy	±0.005 u/e
Mass resolution	1200 m/Δm at Xe
Dynamic range	$>10^7$
Detection limit	<0.1 ppm
Speed	10 full spectra per second
Detector	Dynode
Electron Ionization	Tungsten or yttria-coated iridium



Technology Comparison Matrix

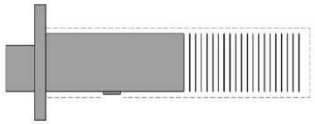
Process Mass Spectrometry

	Quadrupole		IonTamer™ Time-of-Flight (TOF)		Laboratory Time-of-Flight	
Mass accuracy	±0.5 u/e	✗	±0.005 u/e	✓	±0.005 u/e or smaller	✓
Mass range	1-100/1-200/1-300 u/e	–	1-1200 u/e	✓	1-1000 u/e or more	✓
Acquisition	Individual masses in a sequence	✗	All masses simultaneously	✓	All masses simultaneously	✓
Full quantitative chemical analysis	No	✗	Yes	✓	Yes	✓
Size	Compact (20 kg or less)	✓	Compact (14kg -25kg)	✓	Large (93kg and more)	✗
Environment	Industrial	✓	Industrial	✓	Laboratory	✗
Used Materials	Accepted by semi industry	✓	Accepted by semi industry	✓	Only for laboratory usage	✗

TOF Residual Gas Analyzer

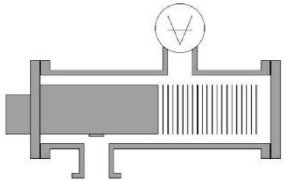
IonTamer™ Series

DI – Dive-In
open source

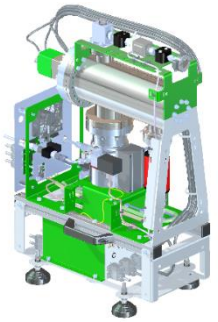


- Integration into existing equipment

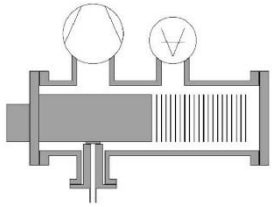
FA – Flanged
open source



- Direct connection to high vacuum
- Standard CF40 flange

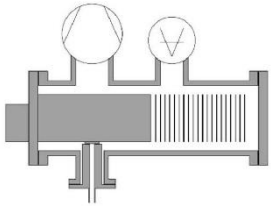


PS – Pumping System
closed source



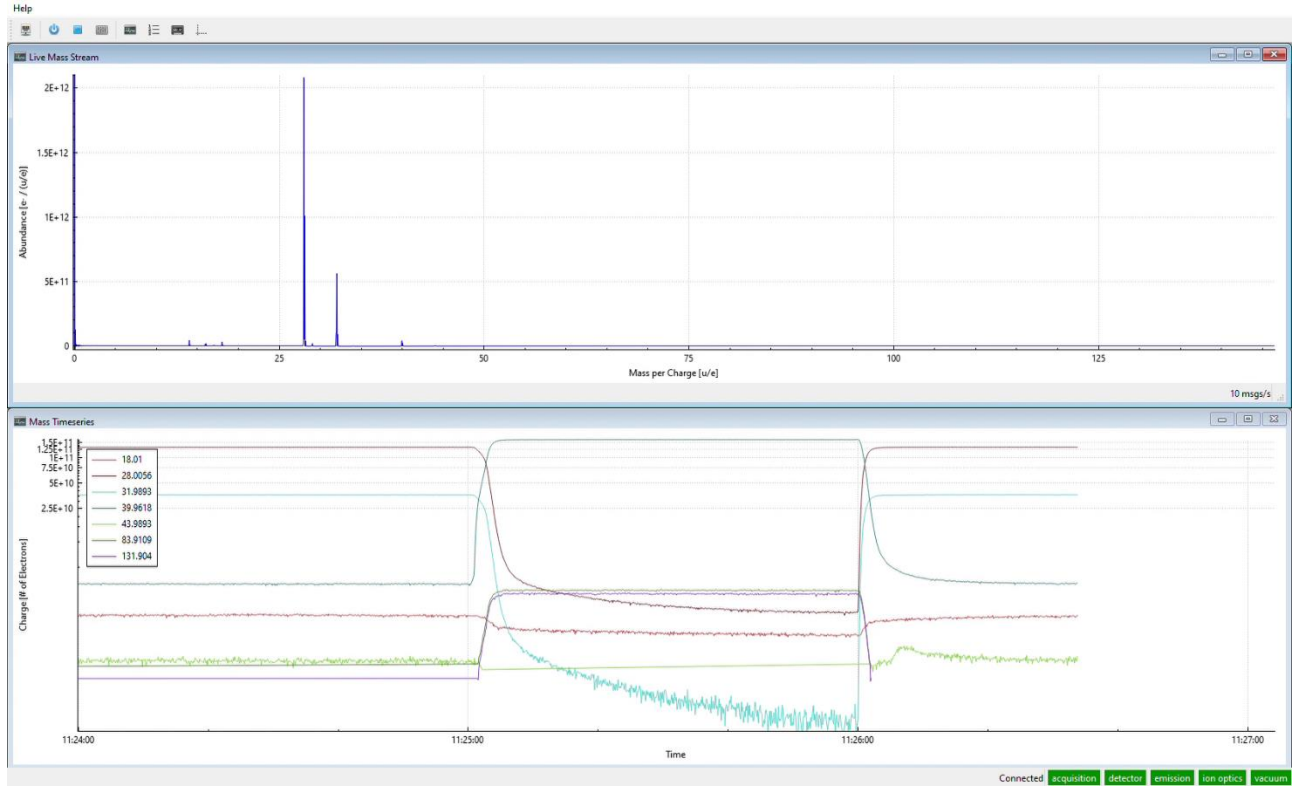
- Low vacuum operation – sensitive
- Mobile version for research & development

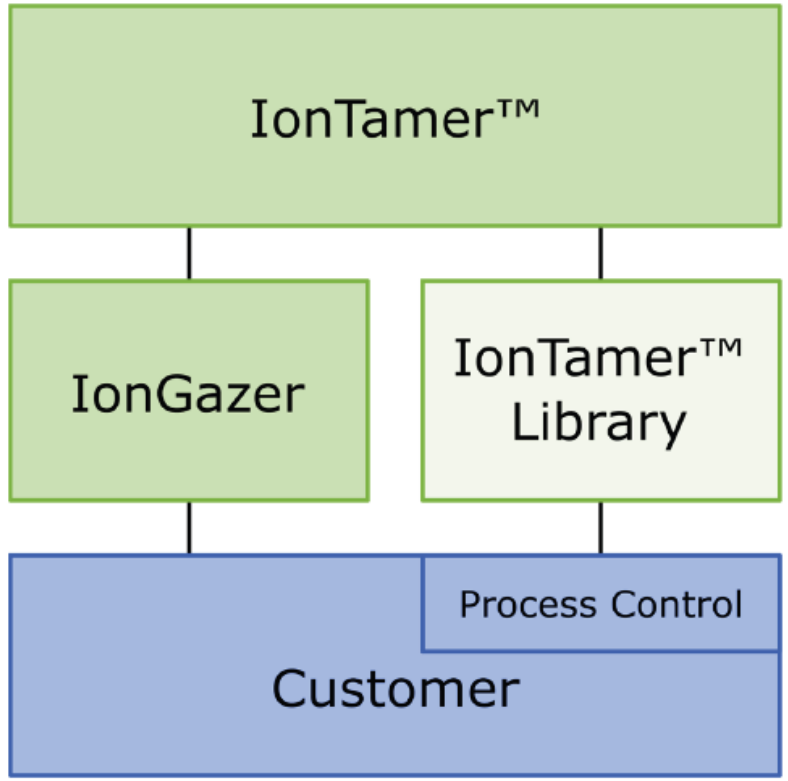
cPS – Compact System
closed source



- Low vacuum operation – sensitive
- Extra modular for compact integration

Software Products





The **IonGazer** is an interactive desktop user interface software for central control of the IonTamer™, visualization of the measurement data in real time, recording of the data stream to storage, and real-time data analysis.

The **IonTamer™ Library** is available as an option and provides data processing algorithms and usage examples to allow integration of the IonTamer™'s data stream into customer's applications and data pipelines.

IonTamer™ FA

TOF-RGA for high vacuum with open ion source

Materials for Harsh Environments
Completely polymer-free with stainless steel, gold, ceramic, and aluminum.

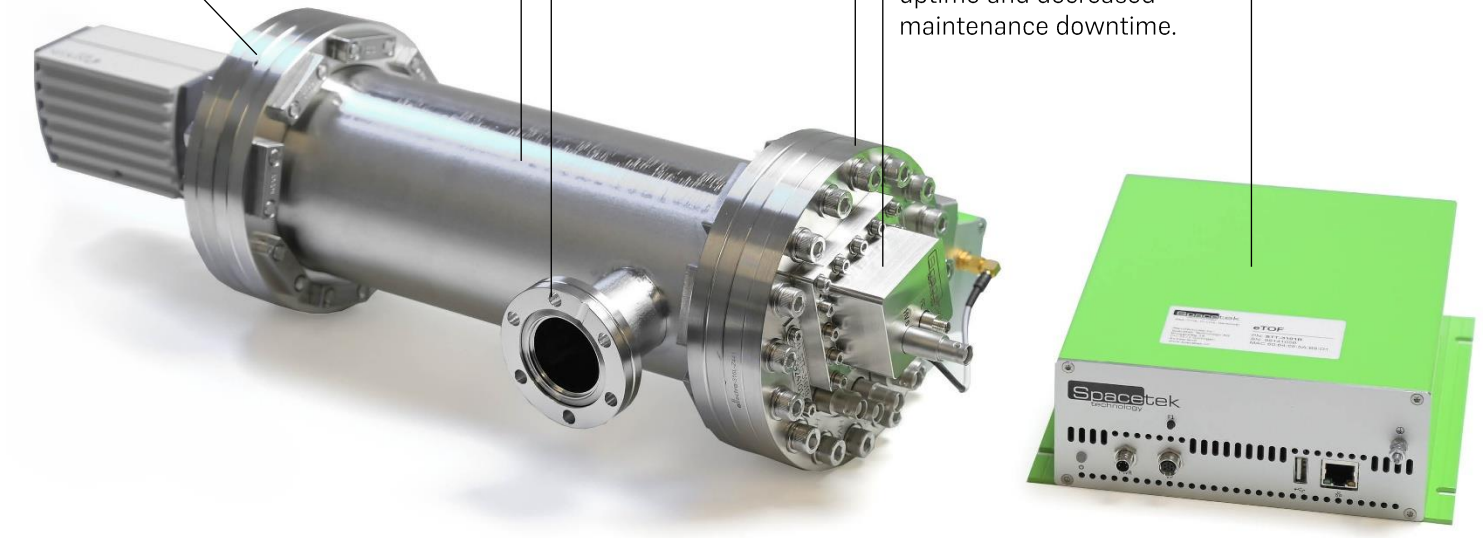
High-Performance TOF-MS Analyzer
Full mass spectrum measurement (up to 10 times per second).

Long-Life Ion Source
Low maintenance costs.

Compact Electronics Box
Continuous data stream without dead time.

CF40 Flange
Direct connection.

Innovative Dynode Detector
Increased production uptime and decreased maintenance downtime.



IonTamer™ PS

TOF-RGA with closed ion source

Innovative Dynode Detector

The specially developped TOF detector is operating at pressures below 1· 10^{-8}mbar and is replaceable in the field. This feature results in increased production uptime and decreased maintenance downtime.

Closed Ion Source

IonTamer™ PS includes a robust, field-replaceable closed ion source that separates the process gas pressure from the mass analyzer environment, thus increasing instrument sensitivity by a factor of hundred and increasing the pressure range during operation.

High-Performance TOF-MS Analyzer

IonTamer™ PS includes our newly developed time-of-flight analyzer with high sensitivity and resolution. The analyzer measures the full mass spectrum (1–1200 u/e) up to 10 times per second, while detecting simultaneously all masses within the mass range.

Materials for Harsh Environment

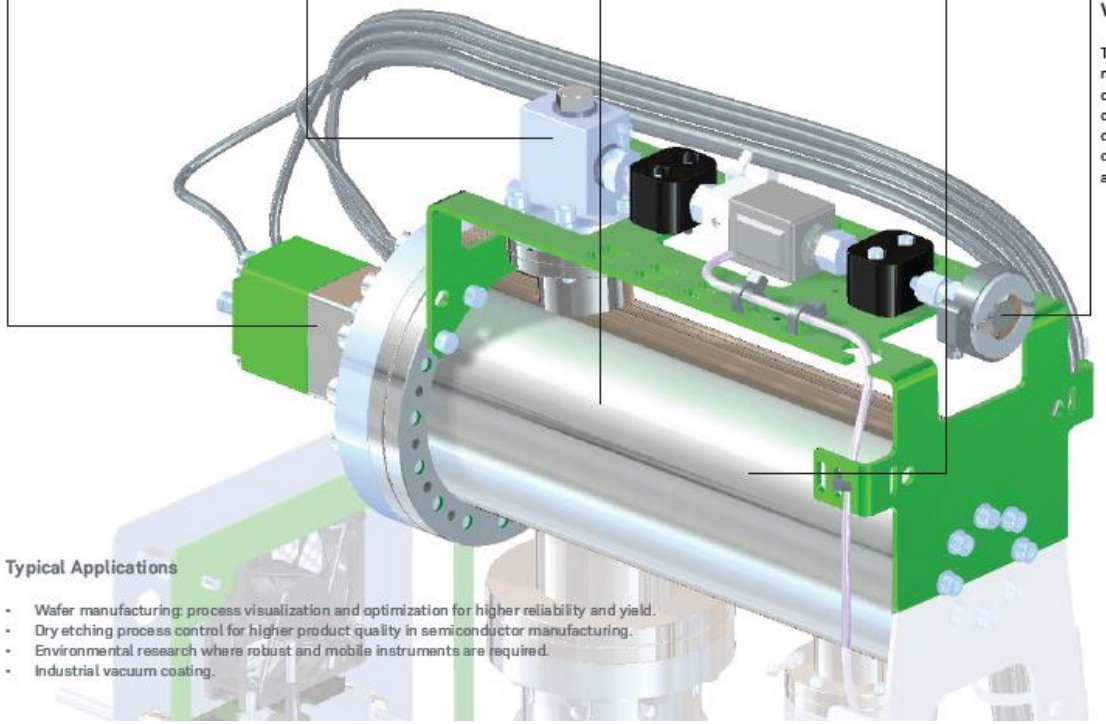
IonTamer™ PS-H is built completely polymer-free with stainless steel, gold, ceramic, and aluminum.

Vacuum Flange

The standard flange can be connected directly to a vacuum chamber without any restriction on the instrument's orientation during operation. Additional inlet options are available to increase accepted pressure range.

Compact Electronics Box

The extremely compact electronics box is connected to the instrument with two-meter cables and offers full remote control and monitoring of the instrument, including its vacuum system. Our fast, reliable, and miniaturized electronics are unmatched, delivering a continuous data stream without dead time.



Typical Applications

- Wafer manufacturing: process visualization and optimization for higher reliability and yield.
- Dry etching process control for higher product quality in semiconductor manufacturing.
- Environmental research where robust and mobile instruments are required.
- Industrial vacuum coating.

Periodical NEW Transistor Structures

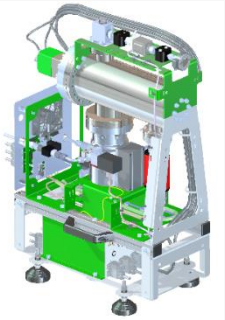
Moore's law – the number of transistors in a dense integrated circuit doubles about every two years

PROBLEM 1

PROBLEM 2

Development of new processes of the next generation transistor structure:

Spacetek's ***IonTamer™ PS*** is the first mobile technology to completely visualize of seamless vacuum manufacturing processes for significantly shortened development times.

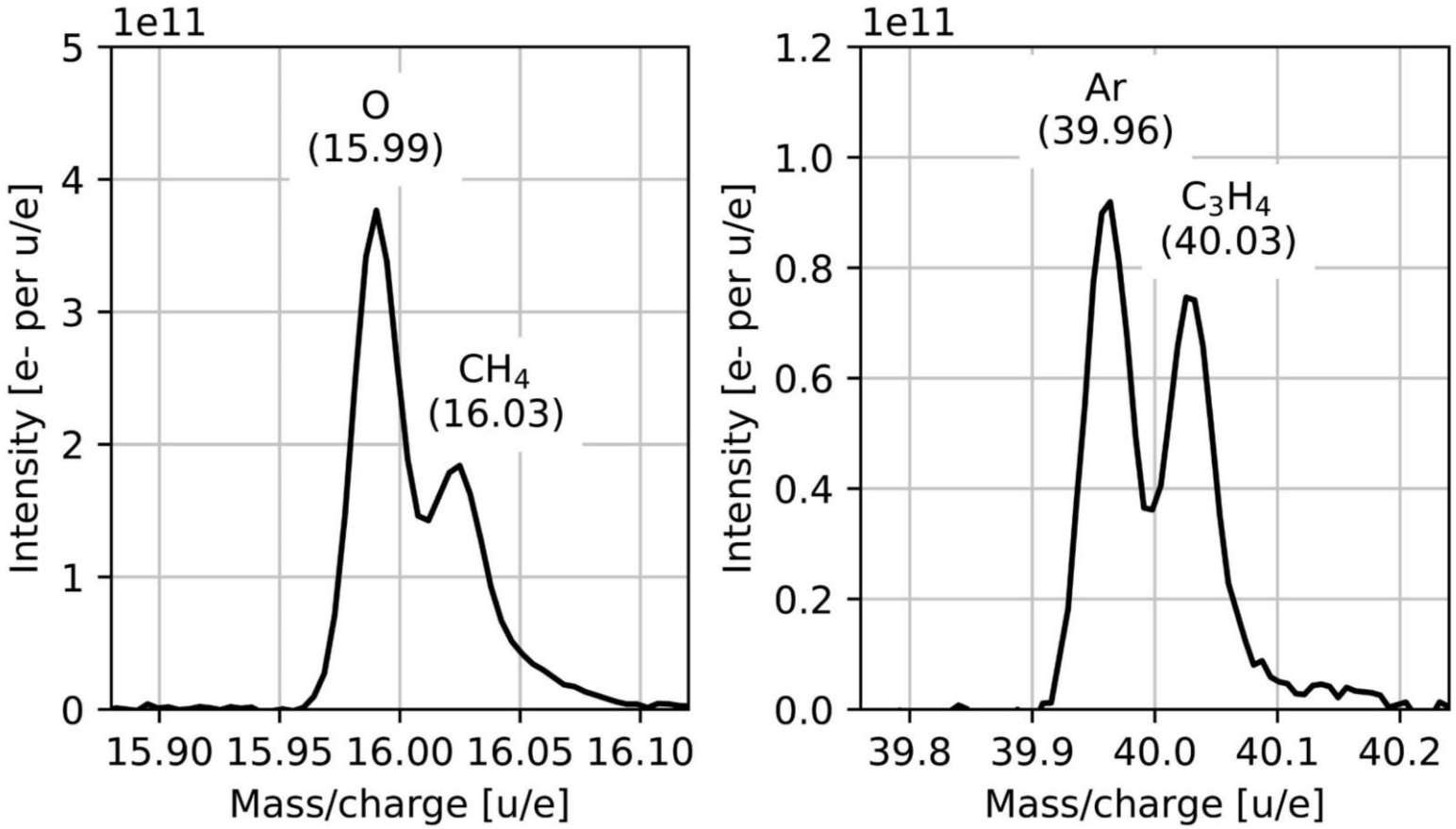


Establishing process control of the new transistor structure in new production lines:

Minimizing of dead time during production and maintenance including detection of faults during each production step with the capability to prevent the propagation of such errors. The wafer production yield can be increased up to several percentage with Spacetek's ***IonTamer™ cPS***.

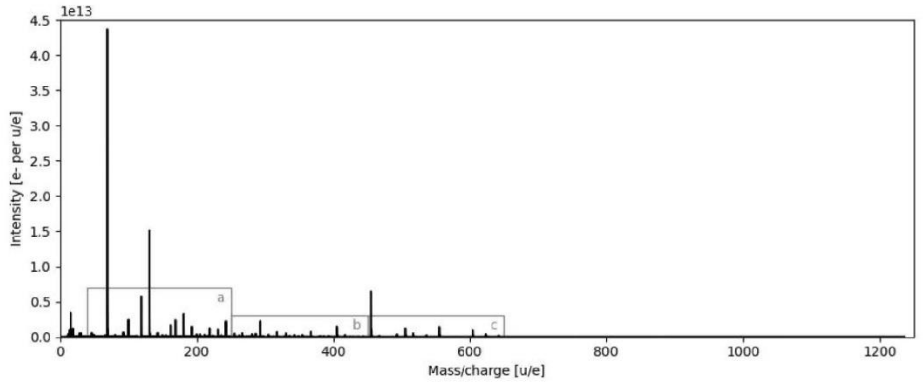
Resolution of Isobaric interferences

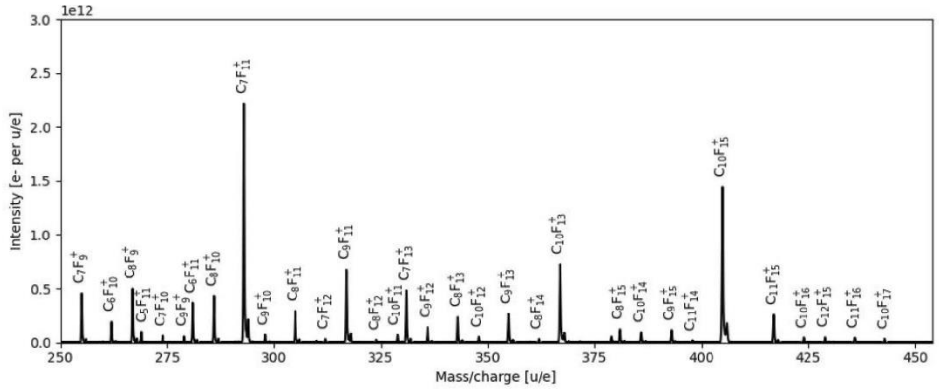
Separation of atomic oxygen and methane, or argon and C_3H_4

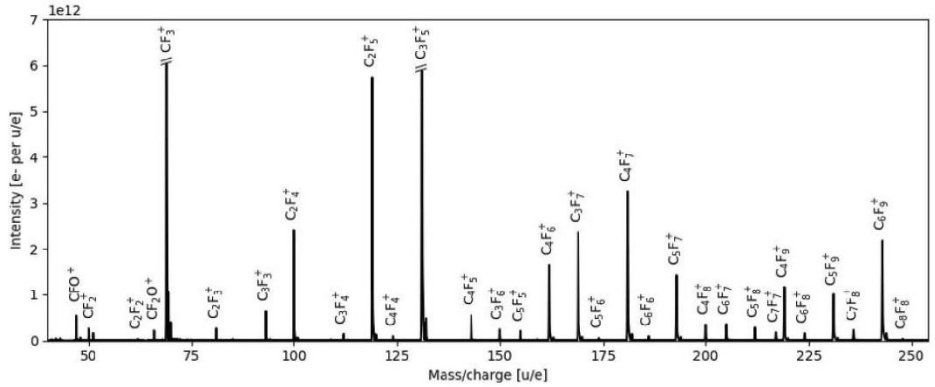


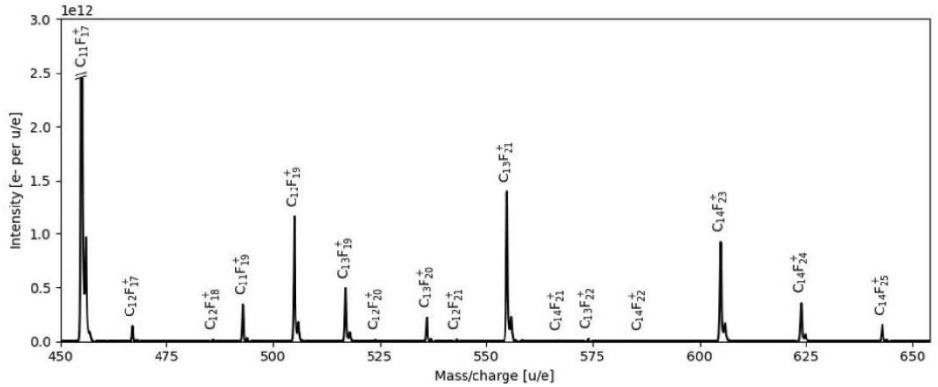
Analysis of heavy masses

Calibration substance FC5311 mass spectrum acquired with 70 eV & 180s integration



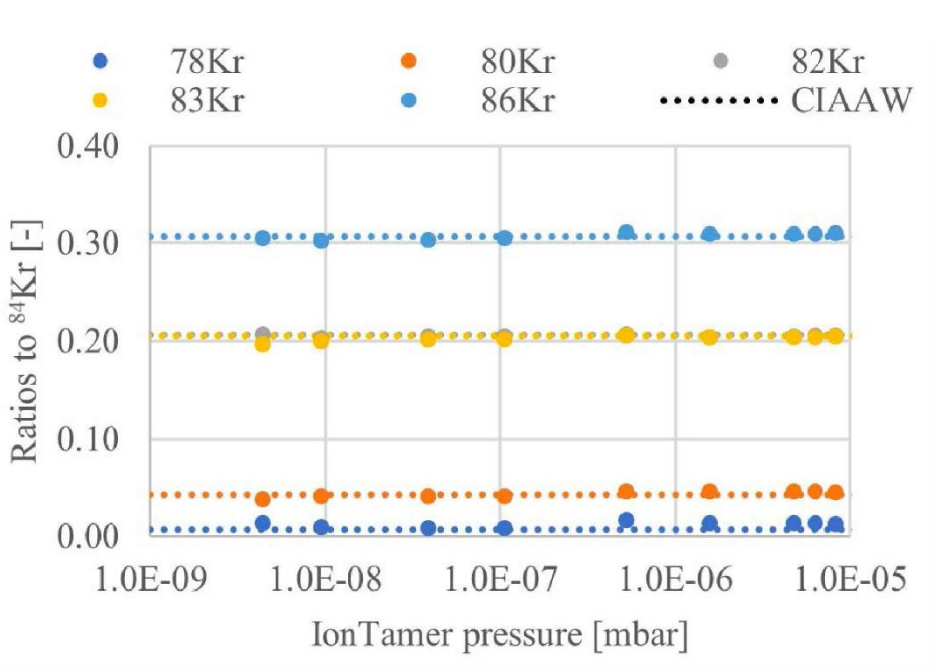


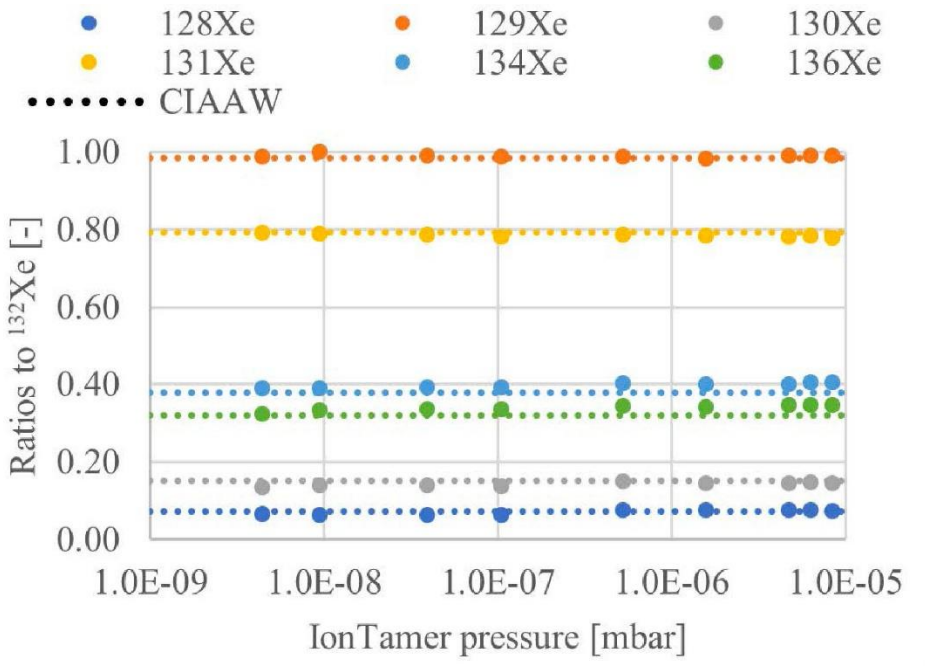




Excellent quantification – we count every ion!

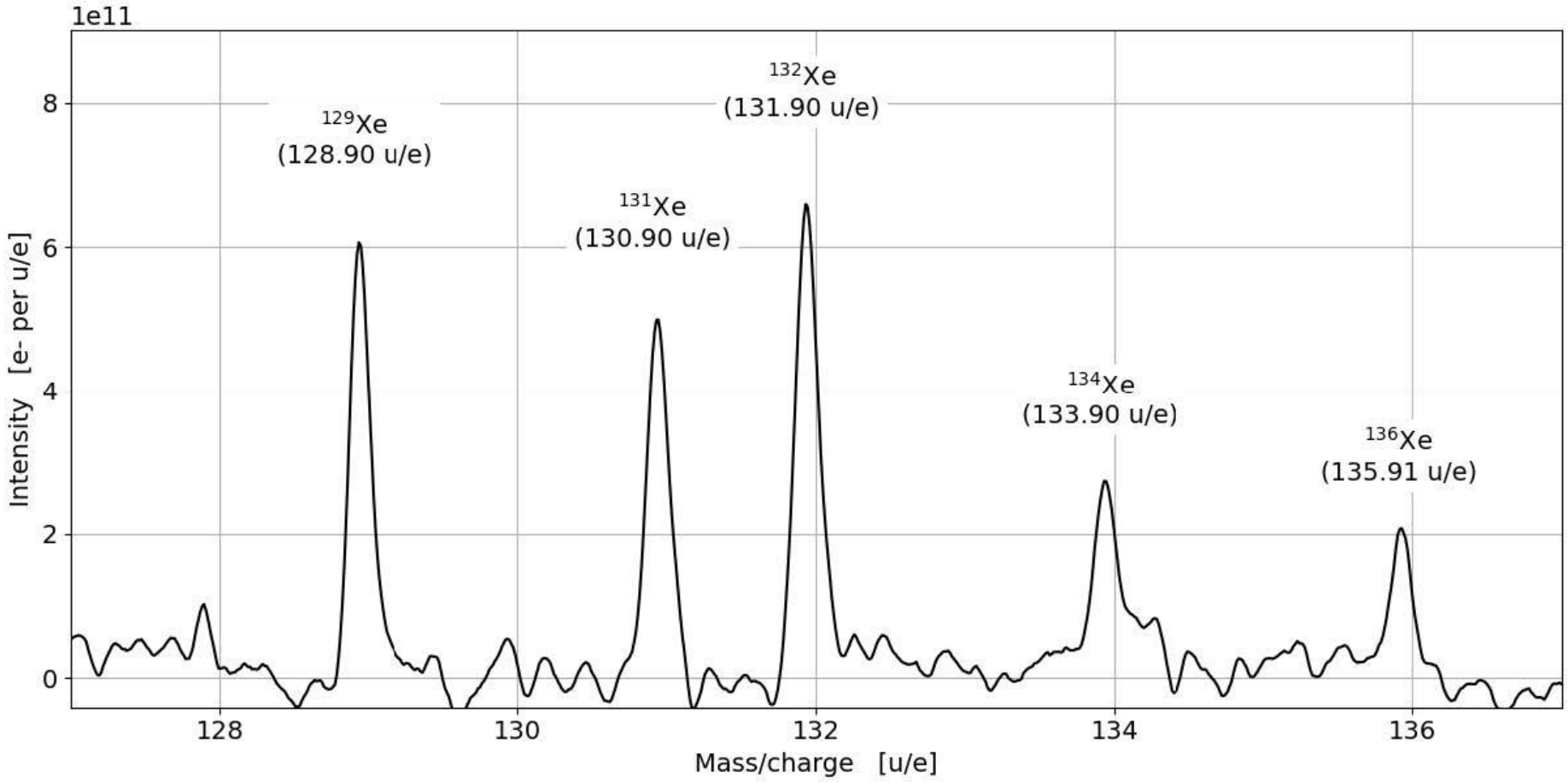
Analysis of Krypton and Xenon with high Accuracy, Repeatability & Reproducibility





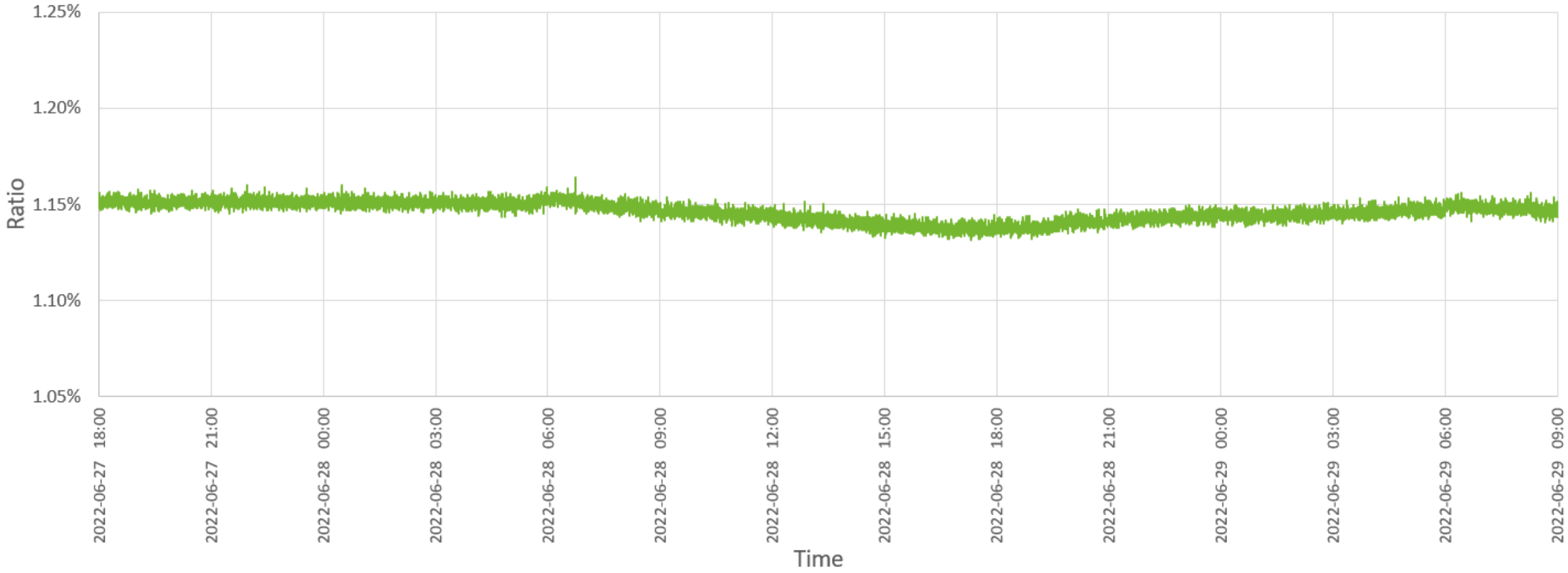
Measurement of Xenon in Air

Analysis down to 7.5 ppb



Long-term stability

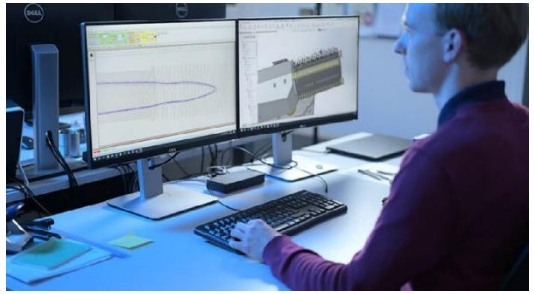
Variation of the ^{40}Ar ratio over time



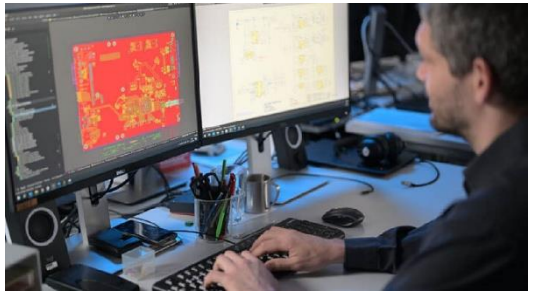
Note: the observed variations are due to a high temperature difference during the day-night cycle in summer.

Competencies

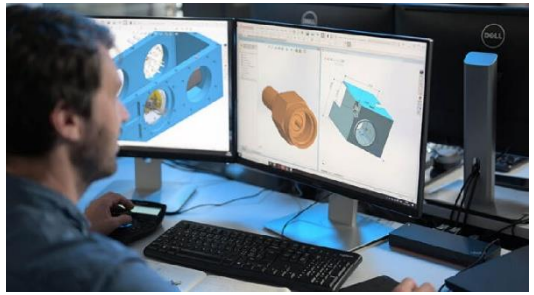
System integration, interface adaptation, production, calibration and analysis



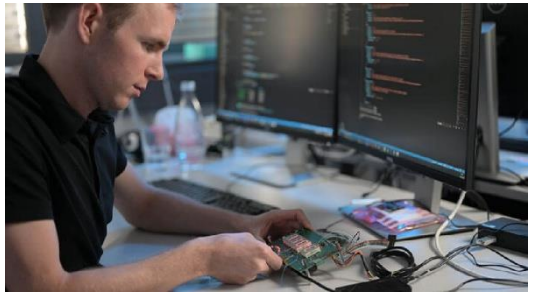
Ion Optics



Electronics



Mechanics



Software

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TECHNOLOGY

Thank you!

Let us work together for a better life on Earth

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