

#### **Physical & Theoretical Chemistry**

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### Introduction

This study focuses on detecting compounds generated by laser and/or RF-generated plasmas, which find applications in semiconductor manufacturing processes. Chemicaland physical processes in such plasmas are of major interest for a deeper understanding of the dynamics of such systems.

An accurate analysis and monitoring method with high temporal resolution is required to achieve this goal. For this purpose, two time-of-flight mass spectrometers (TOF-MS) were built in close collaboration with the manufacturer (TOFWerk, Thun, Switzerland).

Ultra-trace level detection (>100 ppbV at total pressures of 5 Pa and below) is mandatory. High resolution  $(m/\Delta m > 8000)$  is required to distinguish between plasma constituents with the same nominal mass (e.g. m/z 18: NH<sub>4</sub><sup>+</sup>/H<sub>2</sub>O<sup>+</sup>).

A mass analyzing system suitable for the aforementio-

ding sensitivity. lenging environments.

- Split-flow turbo molecular/scroll pump system
- Aluminum housing
- Custom ion source for EI and "ion fly-through"mode
- Heated to max. 60 °C during operation due to sealing material (Viton O-rings)
- Base pressures ≥ 10<sup>-7</sup> mbar in the ionizer region



# Intercomparison Study of two High-Resolution TOF-MS for Ultra-Trace Detection in Plasma Environments

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ned requirements is time-of-flight-MS. Due the ability of recording entire mass spectra per ionization event, TOF-MS enables insight into complex ion-molecule reaction processes as they occur in plasmas.

Both TOF-MS used in this study feature orthogonal acceleration stages and allow for the event-synchronized recording of full mass spectra. The instruments can record up to 25000 spectra per second or can be synchronized with the plasma generating events, such as a laser pulse. They essentially represent two iterations for optimized ionization, ion guiding, and background signal reduction, while maintaining performance regar-

This work presents the characterization and comparison of these fundamental properties, representing a solid foundation for further applications in rather chal-



Considering the background spectra without the addition of analyte gas, a pressure difference of two orders of magnitude in the ionizer region is observed.

It is apparent that the water signal in the spectrum of instrument II has decreased drastically. The lower partial pressure in instrument II allows the detetion of water at ultra-trace levels, which was not possible with instrument, residual background the as exceeds the mixing ratio in releplasmas (approx. 10<sup>-8</sup> vant mbar). The recorded H<sub>2</sub>O signal in instrument II is about a factor of 2000 less than in instrument I, when normalized to the ionizer pressure.



### **High Resolution**

Particularly in the low mass range (m/z 1-200) high resolution is required to distinguish between plasma constituents with the same nominal mass. The unequivocal identification of such species is crucial for fundamental research in

- Separation of two peaks with nominal mass *m/z* 4
- One peak represents 10 ppmV He<sup>+</sup> from the noble gas mixture (exact mass = 4.002053 Da)
- The other signal arises from  $DH_2^+$ as  $H_2$  is used as matrix gas for the mixture (exact mass = 4.02943 Da; D/H ratio in ocean water = 1.6E-4)
- Separation of three peaks of residual gas with nominal mass *m/z* 28
- First peak represents <sup>12</sup>C<sup>16</sup>O<sup>+</sup> (exact mass = 27.994915 Da)
- The second signal arises from  ${}^{14}N_2^+$ (exact mass = 28.006148 Da)
- The third signal is assigned to  $^{12}C_2H_4^+$  (exact mass = 28.031300Da)



### **References & Acknowledgement**

• LTOF time-of-flight mass spectrometer; *Tofwerk AG, Thun, Switzerland* 

• P. H. Dawson, Quadrupole Mass Spectrometry and its applications, Ed. 1, 1976

• Data from NIST Standard Reference Database 69: NIST Chemistry WebBook

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