Analysis of EUV-induced plasma ions using an ion transfer upstream a high resolution TOF-MS

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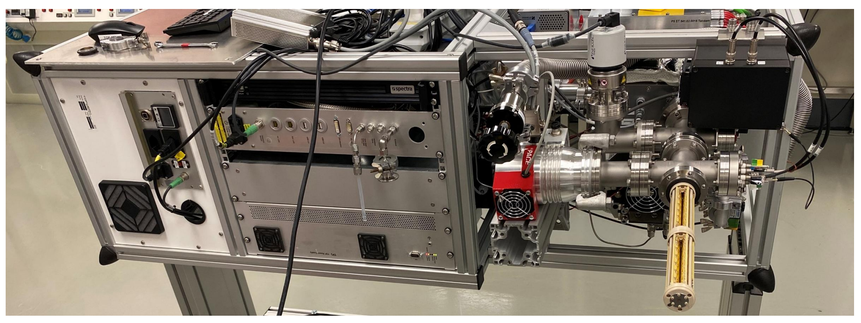
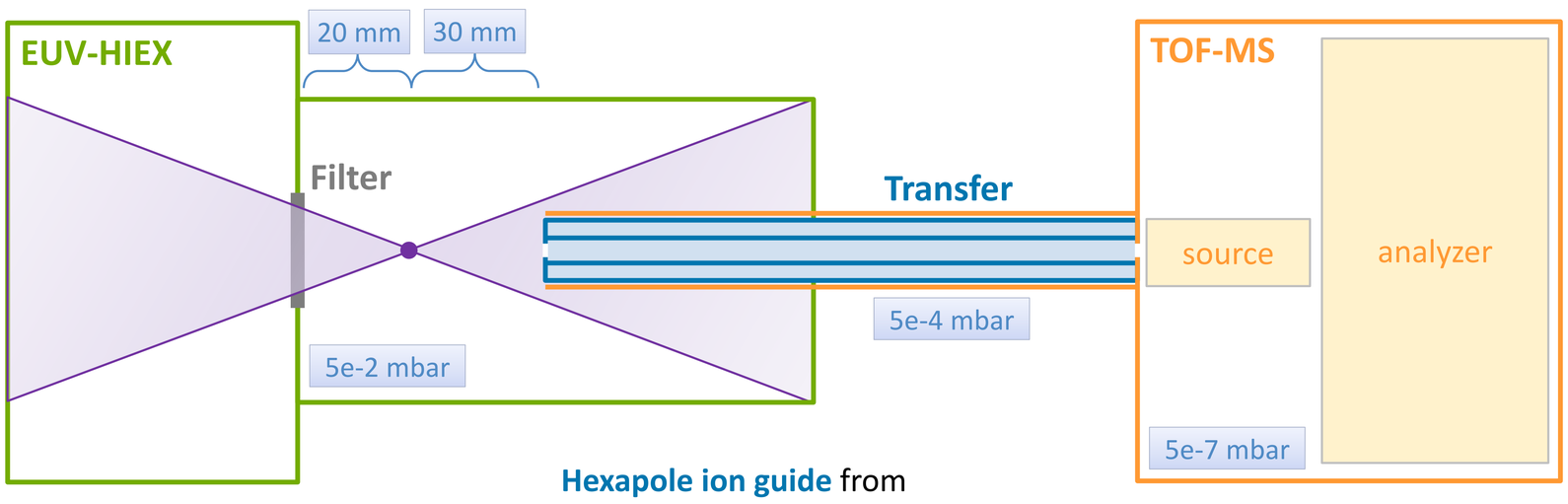
Introduction

To enhance comprehension of the gas phase chemistry induced by extreme ultraviolet (EUV) radiation, an ion guide is employed to sample ions generated in an EUV beam path close to their origin and guide them into a time-of-flight mass spectrometer (TOF-MS). This combines high resolution analysis and sampling with as little ion loss as possible. The examined gas phase generally consists of hydrogen, where a low-density plasma is induced by the EUV radiation. This phenomenon is not unknown, but the detailed analysis of ions especially at their origin is still challenging. To optimize the integration of the transfer into the EUV high-intensity exposure (EUV-HIEX) irradiation setup and their operating parameters, an argon plasma is induced due to the higher ionization cross-section.



Methods

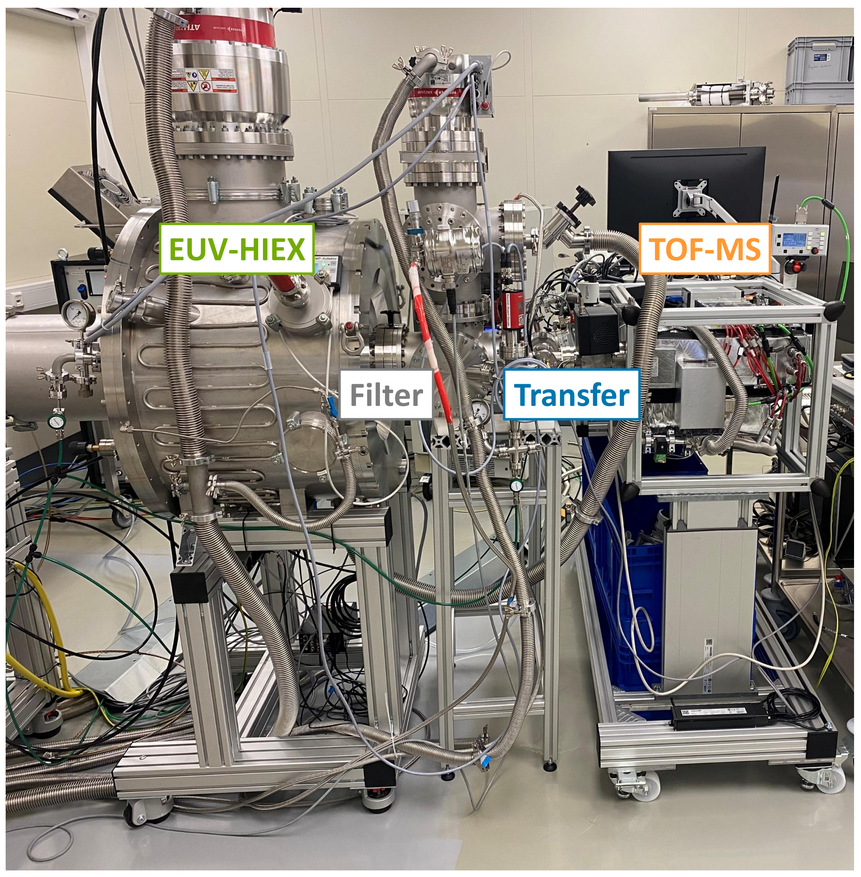


EUV high-intensity exposure setup at TOS, RWTH Aachen
- discharge-produced Xe plasma EUV source
- beam conditioning system to focus radiation in 60 µm spot
- intensity of 100 mW/mm²

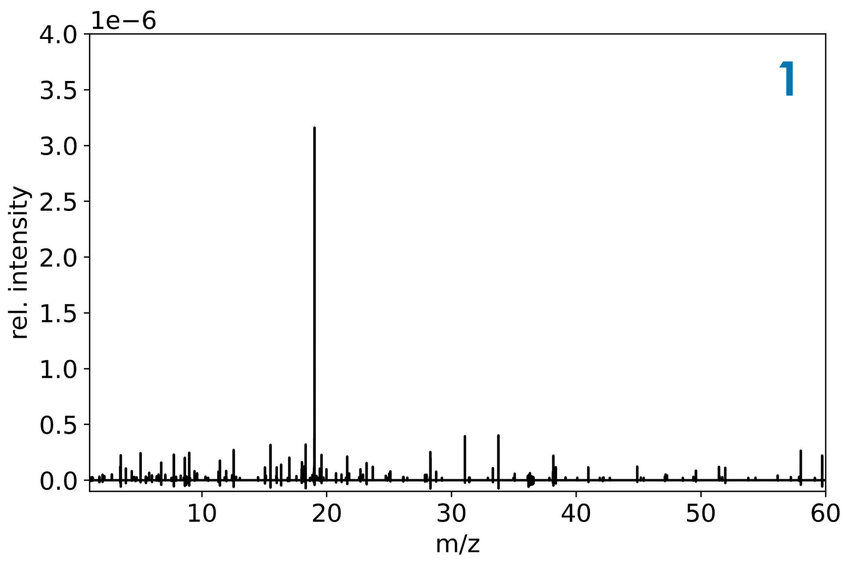
Hexapole ion guide from Fasmatech, Athens GRC
- total length of 600 mm
- optional DC bias

Spectral purity filter based on SiN/Zr layer system
- transmission of 25% at 13.5 nm
- spectral purity > 100.000

Time-of-flight mass spectrometer from TOFWERK, Thun CHE
- costume-built ion source
- ion transfer quadrupole with 100 mm rod length
- flight tube folded with a path length of 2700 mm

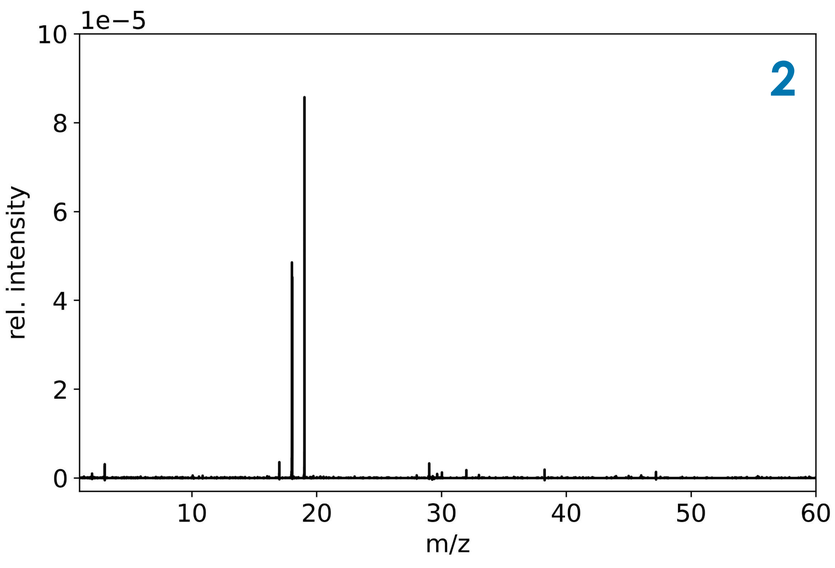


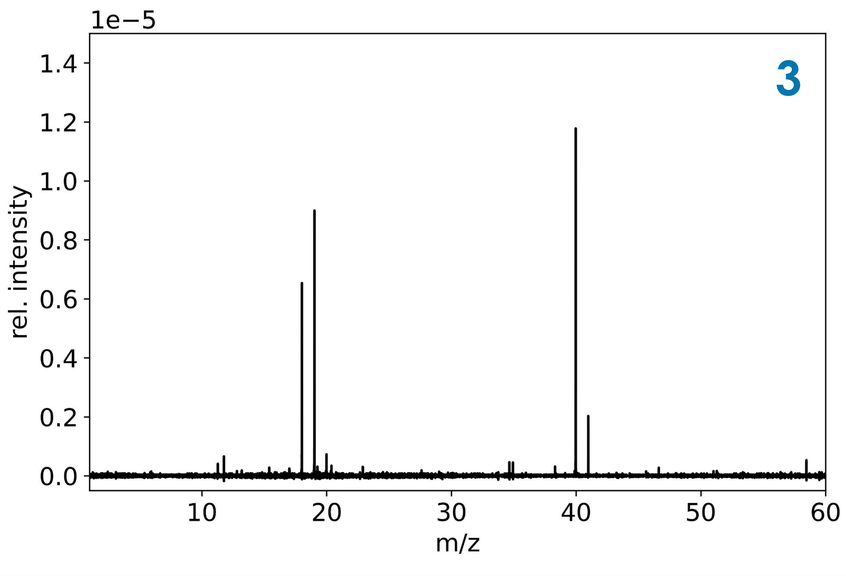
Experimental Results



1 - Native ions from EUV plasma
Ion signal at 3 Pa hydrogen and added DC bias in the hexapole. No H_3^+ signal due to low mass discrimination, only single H_3O^+ ions are detectable. Filter in use, high spectral purity.

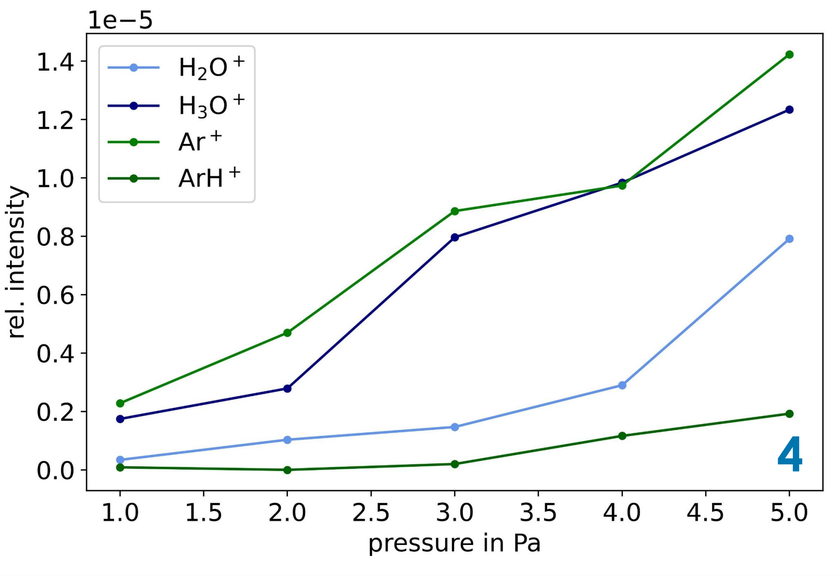
2 - Native ions from unfiltered light
Significant signal increase and characteristic spectrum, due to a broader wavelength range when the filter is not used.





3 - Native ions with argon addition
By adding argon instead of hydrogen, an improved signal can be achieved due to the ionization cross-sections. However, the hexapole settings are not designed for this composition, which could lead to diminished signal intensities.

4 - Pressure dependence of ion signal
The measurements indicate a linear correlation between ion signal and pressure, when argon added. This trend is anticipated.



Acknowledgment

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