Development and Optimization of an Accumulation Ion Source

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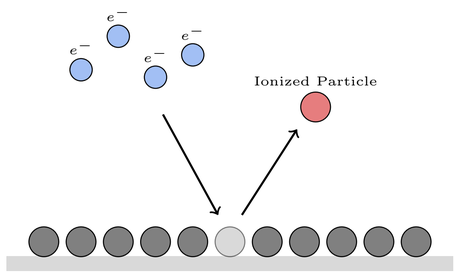
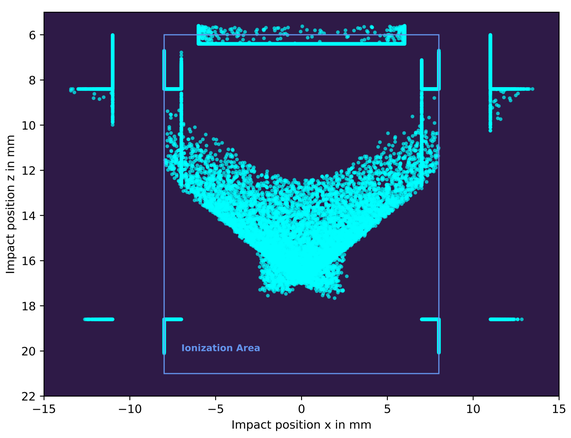
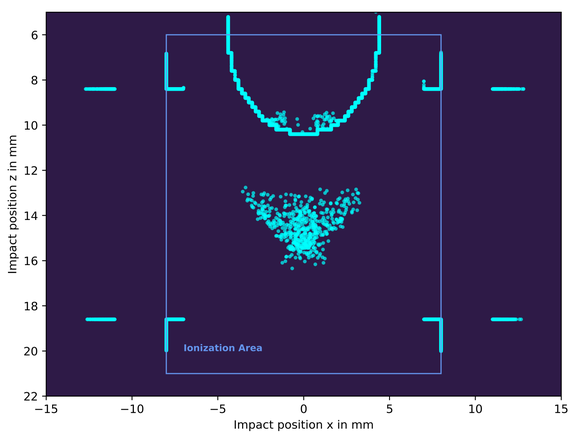
Motivation

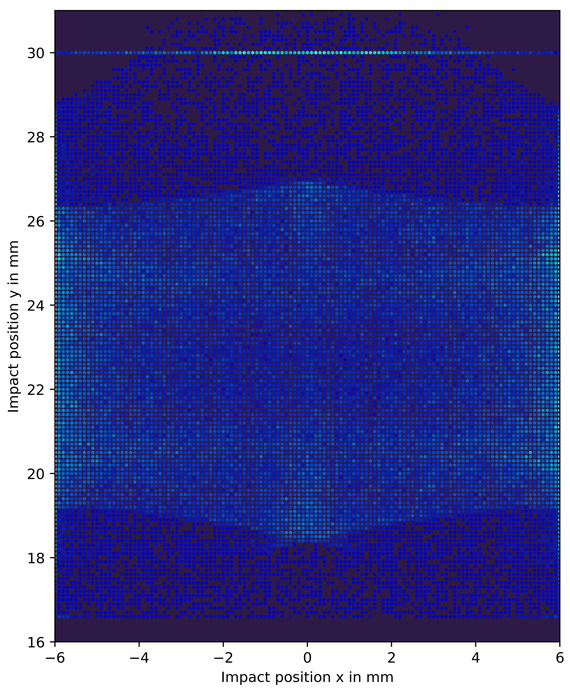
- The enrichment of analytes is a widely employed technique for the detection of molecules at partial pressures below the detection limit of electron ionization (EI).
- Mass spectrometry (MS) at ultra-trace levels requires optimized sampling and acquisition systems, capable of measuring gaseous metal hydrides with maximum sensitivity.
- The presence of these metallic fragments has been observed on surfaces.
- In a plasma chamber, metal hydride fragments form when metal interacts with ionized gases.
- Such fragments readily decompose on EI source walls and subsequently desorb from the surfaces due to electron-induced desorption.

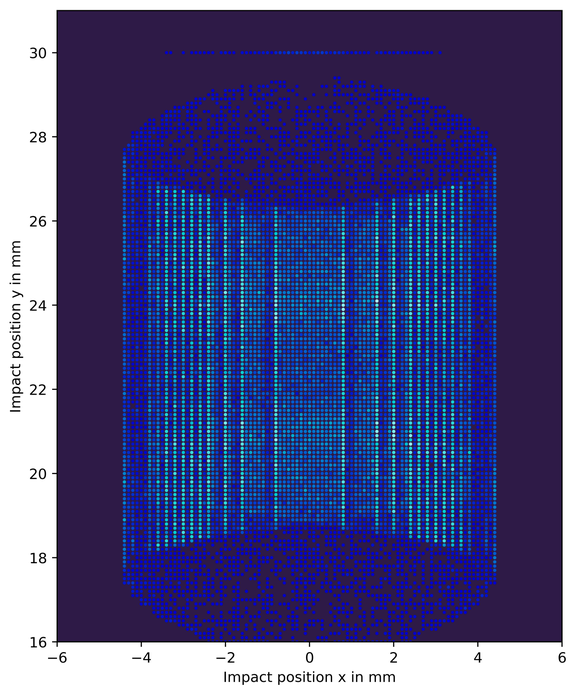


Electron Impact on the Target Surface









Cuboid-Shaped Target (CuT)

- Numerical simulations[1] were conducted to generate a heatmap, facilitating a detailed analysis of electron trajectories and their interaction dynamics.
- Approximately 65.5 % of the emitted electrons reach the target, and a total of 79.2 % of the target surface is covered.

Cylindrical-Shaped Target (CyT)

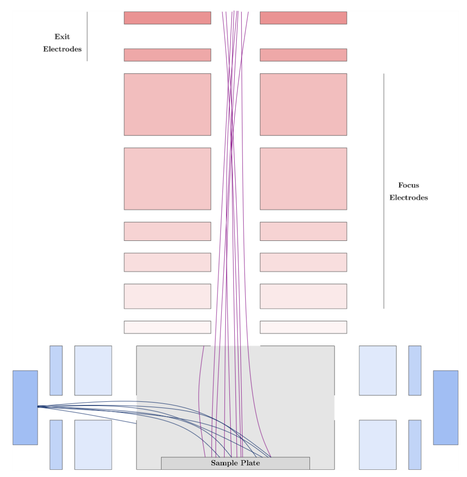
- The electron transmission to the target is approximately 75.3 %, and about 77.1 % of the target surface is effectively covered.
- 85 % of the generated ions reach the exit of the source, with the majority impinging on the last electrode.

Conclusion and Outlook

The ion source, designed for the analysis of trace gases from a plasma chamber at partial pressures below the detection limit of the mass analyzer, enables indirect measurements where direct methods are not feasible. Both simulations and experimental results validate the functionality of the concept. Development of a final version integrating insights is currently in progress.

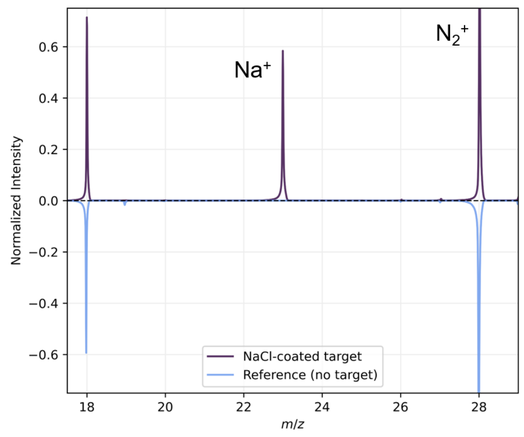
Trajectories of Charged Particle

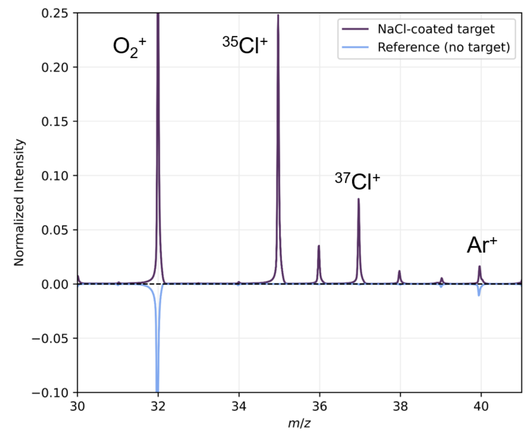
- The ion source is designed for the purpose of sample accumulation, with a probe inserted in-situ into a plasma chamber.
- Following the enrichment of the analytes on the heated metal surface, the probe is transferred back into the ion source with a linear actuator. The ion source is positioned directly in front of the ion optics of a cTOF MS[2].
- Two filaments positioned adjacent to the sample, each equipped with a lens system, generating an electron beam directed towards the probe surface.
- A further lens system guides generated ions into the quadrupole and the mass analyzer.
- Exit electrode potential allows a variation of the kinetic energy.



Results and Performance

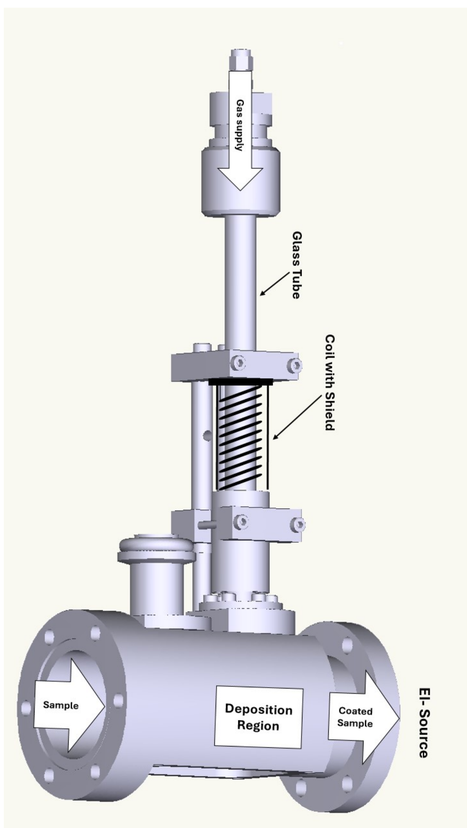
Successful desorption from salt samples has already been demonstrated for NaCl, as reflected in the measured spectra. Pronounced electron-stimulated desorption (ESD) was observed for NaCl films, with both Na- and Cl-containing desorption products detected. This shows that salt-based samples respond efficiently to electron excitation, making them well suited for ESD studies.





Since metal ions cannot be readily desorbed from bulk metallic materials by electron bombardment, the target is instead coated with thin metal-containing films. This approach is intended to lower the effective desorption threshold and facilitate the electron-stimulated release of metal ions from the surface.

The plasma coil was used to deposit the coating onto the target. RF power sustains a hydrogen plasma inside the coil, generating reactive hydrogen species. These species interact with a metal source, releasing metal-containing species into the gas phase. The gas flow transports these species toward the target, where they are deposited as a thin coating.



References and COI Declaration

[1] D. A. Dahl. "Simion for the Personal Computer in Reflection"; doi: 10.1016/S1387-3806(00)00305-5 SIMION (v. 8. 1. 2. 30); ion optics and trajectory simulation program; http: simion.com
[2] cTOF time of flight mass spectrometer; *Tofwerk AG, Thun, Switzerland*

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