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Comparison of ionization efficiencies by Cavity Source and conventional Thermal Ionization Mass Spectrometry for sub-ng loads of Uranium

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Thermal Ionization Cavity (TIC) sources were developed and studied at radioactive beam facilities [e.g. 1, for a review] and subsequently applied to Thermal Ionization Mass Spectrometry (TIMS) with the goal of analyzing actinides [e.g 2, for a review]. Multiple surface contacts of sample atoms within the confined volume of the cavity, combined with electric fields generated by the space charges of the ions and electrons within the cavity, enhance the probability of ionization compared to one-surface contact by conventional single-filament TIMS.

This paper presents a novel, in-house built TIC source prototype. For its design charged particle trajectories were numerically simulated according to [3], i.e. including space charge but for conditions preventing the formation of a plasma within the cavity. The ion optics of the extraction lens stack were completely re-designed to best match the mass analyser of a MAT262 instrument. Additional major innovations are: (i) a graphite plate to prevent electrons from the impact heating reaching the space in front of the cavity orifice, thus improving peak tailing and reducing multiply charged interferences (ii) a stacked cavity design for easy loading of the sample at the bottom of a cavity.

The ETH TIC source presently yields an experimentally verified 10-fold increase in overall efficiency (i.e ions detected per sample atoms loaded) compared to conventional TIMS for U loads in the sub-ng range. This is in good agreement with simulation results, assuming identical ionization temperatures.

[1] Kirchner (1990) Nucl. Instr. and Meth. A292, 203-208
[2] Zhai et al. (2011) Int. J. of Mass Spectr. 161, 27-39
[3] Maden et al. (2016) Int. J. of Mass Spectrom. 405, 39–49