Induction Mass Spectrometry Using a Hollow-Core Toroidal Coil

Janosch von Ballmoos[1], Davide Bleiner[1,2]

[1]Swiss Federal Laboratories for Materials Science and Technology (Empa), Überlandstrasse 129, 8600 Dübendorf, Switzerland
[2]University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland
Author email: janosch.vonballmoos@empa.ch

Current state-of-the-art detectors used in mass spectrometry are based on electron multipliers. These detectors show a number of drawbacks, such as fast-signal distortion, dead time and the requirement of a trigger, and they require complex and expensive instruments. The ion signal is dispersed upfront by means of a mass analyzer (e.g. TOF) or filter (e.g. QMS). All these technologies are dead-end, in the sense they cannot be carried out online for process monitoring.

The use of a hollow-core toroidal coil (HTC) [1] as an induction sensor was previously shown [2] to be a powerful tool that can overcome all these limitations. The induced voltage in the HTC allows measuring changes in the magnetic flux, e.g. a plasma released through laser ablation. The Fourier spectrum of this response signal can then be used to serve as a fingerprint of each material. This sensor offers ultrafast ion spectroscopy of fast transients at high sensitivity and simplicity, requiring very small amounts of material.

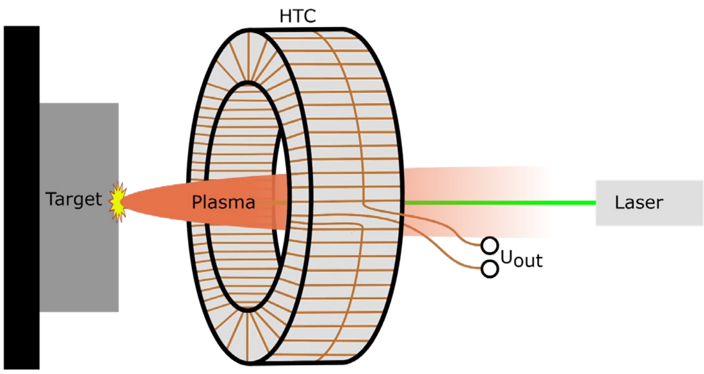

Figure 1: Experimental setup

In our work, we further investigated the characteristics of the HTC sensor by calibrating using ten metallic elements ranging from Aluminum as the lightest to Gold as the heaviest element. We show that the HTC sensor proves effective in enabling the differentiation of pure metals based on their unique response signal, revealing distinct patterns indicative of the respective elements. Through a newly written program, we were able to use cluster analysis or machine learning to assign measurements to the respective material automatically, achieving prediction accuracies between 73% and 100% depending on the metal. In addition, we also investigated the response signal for non-metallic compounds by measuring Lithium Fluoride as well as Calcium Fluoride.

[1] https://patents.google.com/patent/WO2017089517A1/en
[2] Y. Arbelo and D. Bleiner, Review of Scientific Instruments, **2017,** 88(2), 024710.