APPLICATION NOTE 30685

The Jet Interface: improving sensitivity of trace element analysis

Authors: J. Roberts, G. Craig, T. Lindemann, C. Bouman, N. Lloyd, L. Bracciali; Thermo Fisher Scientific, Bremen, Germany

Keywords: ICP-MS, Jet Interface, Element 2, Element XR, Laser ablation, Geosciences

Introduction

The latest Jet Interface for the Thermo Scientific™ Element™ Series HR-ICP-MS sets a new standard for sensitivity in elemental analysis.

With the Jet Interface, sensitivities of up to 6 x 10^7 cps/ppb can be achieved. Here we demonstrate the improvement in sensitivity relative to the standard interface in both dry and wet plasma conditions.

What is the Jet Interface?

The Jet Interface is available for the Element Series HR-ICP-MS as well as MC-ICP-MS. It consists of:

1. A **High Capacity Air-cooled Dry Interface Pump** (100 m^3/h pumping speed), providing greater pumping capacity at the sample interface.
2. The **Jet sample cone** (Figure 1).
3. The **X skimmer cone** (Figure 1).

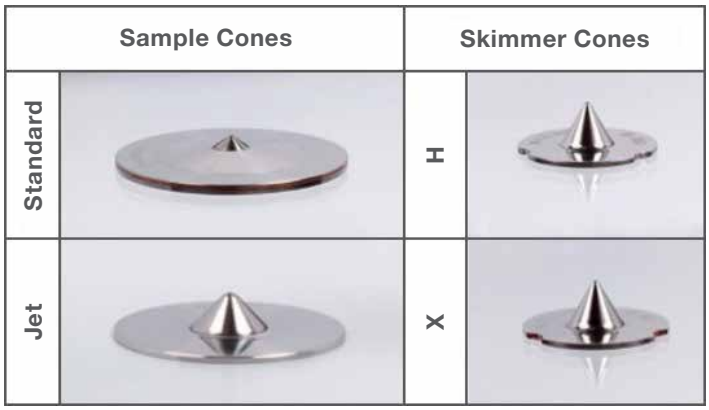

Figure 1. Comparison of cones used in the standard vs. Jet Interface.

The high capacity interface pump improves the vacuum between the Jet sample cone and the X skimmer cone thus increasing the transmission of ions into the analyzer section of the mass spectrometer.

The Jet sample cone has a different geometry compared to the standard sample cone and the X skimmer cone has a tapered profile. Such a geometry is optimized to enhance transmission of ions compared to the standard interface. As a result of more ions being introduced into the mass spectrometer, the sensitivity is maximized.

Methods

Three different sets of experiments were performed on an Element XR HR-ICP-MS to demonstrate the change in sensitivity associated with the Jet Interface. The Element tune solution, a glass reference material and an organic sample were measured.

Tune solution (wet and dry plasma)

The Element tune solution (1 ppb Li, Sc, Co, Ga, Y, In, Ba, Lu, Tl, U) was measured in low resolution on the Element XR HR-ICP-MS with the set-ups shown in Table 1. All tests carried out in wet plasma used a Twinnabar™-type cyclonic spray chamber and a 200 µL/min MicroMist™ nebulizer. The dry plasma tests were performed using an Aridus3™ Desolvating Nebulizer System (Teledyne CETAC Technologies) and a 100 µL/min PFA nebulizer.

Table 1. Experimental set-ups for measurement of 1 ppb tune solution in wet and dry plasma.

Experiment	Interface pump	Sample cone	Skimmer cone	Plasma condition
a)	Standard pump	Standard	H	Wet
b)	Jet pump	Jet	X	Wet
c)	Standard pump	Standard	H	Dry
d)	Jet pump	Jet	X	Dry

Laser ablation

The Element XR HR-ICP-MS was coupled to a NWR 193™ laser (Elemental Scientific Lasers).

Two different sample types were ablated:

1. Glass NIST SRM™ 610™. The glass standard was measured in low resolution, once with the standard interface and once with the Jet Interface.
2. Organic sample: breast cancer tissue that had been treated with Cd-labelled antibodies.

For the NIST glass 610, the laser conditions were held constant for both the standard and the Jet Interface set-ups (He = 600 mL/min; N_2 = 5 mL/min; fluence = 4.9 J/cm^2; rep. rate = 10 Hz; spot size = 35 µm).

For the organic sample, the laser conditions were held constant for both the standard and the Jet Interface set-ups (He = 600 mL/min; N_2 = 5 mL/min; rep. rate = 1 Hz; spot size = 20 µm).

For all samples, plasma conditions were tuned to minimize oxide production (ThO/Th = 0.2) and the U/Th ratio was = 1.1.

Results

Tune solution (wet and dry plasma)

In wet plasma, the upgrade from the standard interface to the Jet Interface resulted in an increase in sensitivity by a factor of 4 to 5 for the lighter isotopes, 2 to 3 for the intermediate isotopes and >1 for the heavier isotopes (Figure 2).

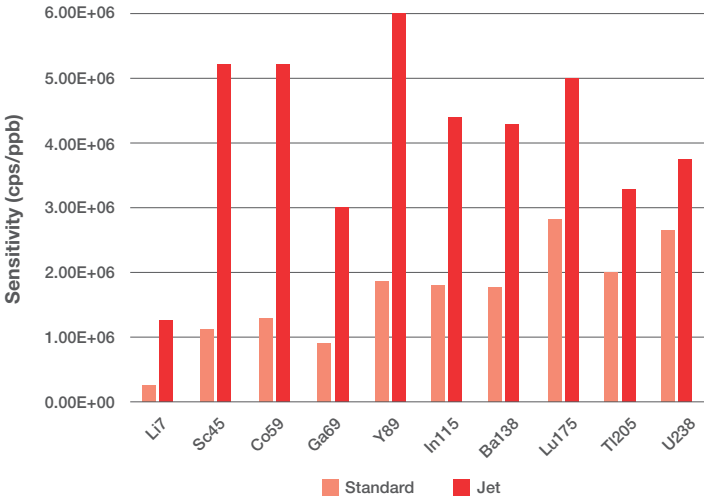

Figure 2. Comparison of sensitivity that can be achieved in wet plasma by switching from the standard interface to the Jet Interface.

In dry plasma, the upgrade to the Jet Interface increases the sensitivity on average by a factor of 7 (Figure 3).

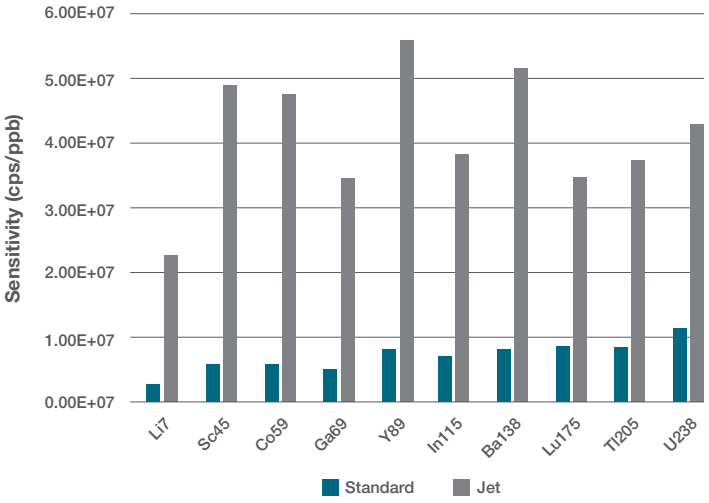

Figure 3. Comparison of sensitivity that can be achieved in dry plasma by switching from the standard interface to the Jet Interface.

Laser ablation

Using LA-ICP-MS, the intensities achieved with the Jet Interface were on average a factor of 4 higher than when using the standard interface. The increase in sensitivity is particularly strong for the lighter isotopes, with an increase in sensitivity by a factor of 10 (Figure 4).

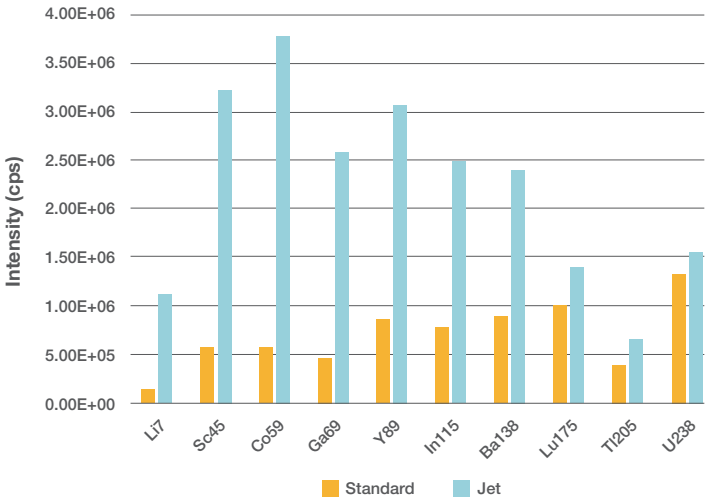

Figure 4. Comparison of sensitivity that can be achieved via LA-ICP-MS (optimized to minimize oxide formation) by switching from the standard interface to the Jet Interface for NIST SRM 610.

Bio-imaging using LA-ICP-MS

LA-ICP-MS can be used to generate semi-quantitative maps of elemental concentration variations in biological samples (Figure 5). The improvement in sensitivity from using the Jet Interface over the standard interface is apparent.

Conclusions

- The Jet Interface increases the sensitivity of trace elemental analysis both in wet and dry plasma conditions.
- In wet plasma, the Jet Interface increases sensitivity by a factor of 4 to 5 for the lighter isotopes, 2 to 3 for the intermediate isotopes and >1 for the heavier isotopes compared to the standard interface.
- In dry plasma (using a desolvator) the Jet Interface increases sensitivity on average by a factor of 7 compared to the standard interface.
- In dry plasma (using LA-ICP-MS), the Jet Interface increases sensitivity on average by a factor of 4 compared to the standard interface. Lighter isotopes are particularly affected, with increase of sensitivity by a factor of up to 10.

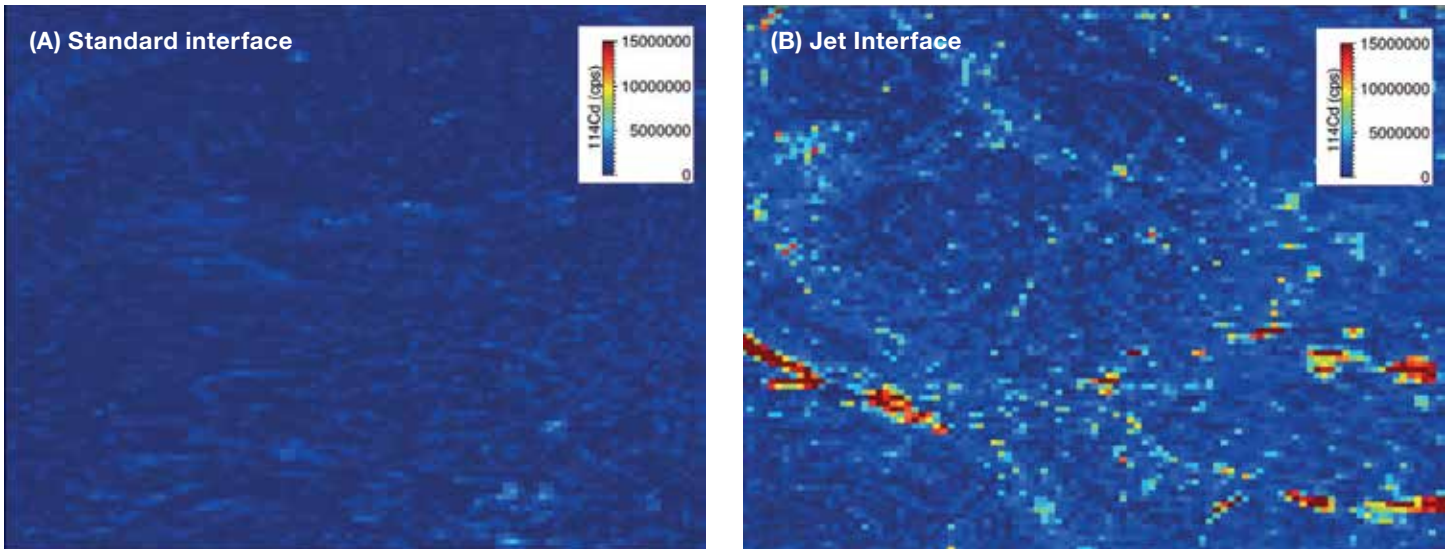

Figure 5. Bio-image of breast cancer tissue treated with Cd-doped antibodies. Comparison of sensitivity that can be achieved using LA-ICP-MS by switching from the standard interface to the Jet Interface.

thermo scientific

References

1. Burraston, J.D. (2015) *Advancing the Analysis of Low Level Uranium and Plutonium in Bioassay Samples using SF-ICP-MS,* PhD Thesis, University of Southampton.
2. Evrard, O., Pointurier, F., Onda, Y., Chartin, C., Hubert, A., Lepage, H., Pottin, A.-C., Lefèvre, I., Bonté, P., Laceby, J.P., Ayrault, S. (2014) *Novel insights into Fukushima nuclear accident from isotopic evidence of plutonium spread along coastal rivers.* Environ. Sci. Technol. 48, 9334.
3. Igarashi, J., Zheng, J., Zhang, Z. et al. (2019) *First determination of Pu isotopes (239Pu, 240Pu and 241Pu) in radioactive particles derived from Fukushima Daiichi Nuclear Power Plant accident.* Sci Rep 9, 11807.
4. Jakubowski, N., Prohaska, T., Vanhaecke, F., Roos, P.H., Lindemann, T. (2011) *Inductively coupled plasma- and glow discharge plasma-sector field mass Spectrometry,* J. Anal. At. Spectrom. 26, 727.
5. Men, W., Zheng, J., Wang, H. et al. (2018) *Establishing rapid analysis of Pu isotopes in seawater to study the impact of Fukushima nuclear accident in the Northwest Pacific.* Sci Rep 8, 1892.
6. Pullen, A., Ibáñez-Mejia, M., Gehrels, G. E., Giesler, D., Pecha, M. (2018) *Optimization of a laser ablation-single collector-inductively coupled plasma-mass spectrometer (Thermo Element 2) for accurate, precise, and efficient zircon U-Th-Pb geochronology.* Geochemistry, Geophysics, Geosystems, 19.
7. Zheng, J. et al. (2015) *Evaluation of a new sector-field ICP-MS with Jet Interface for ultra-trace determination of Pu isotopes: from femtogram to attogram levels.* J. Nucl. Radiochem. Sci. 1, 7–13.

Note

Performance data presented here exceed the product specifications hence are not warranted.

Find out more at **thermofisher.com/ICP-MS**

ThermoFisher SCIENTIFIC