

# The ICP-MS Vacuum Interface

Agilent ICP-MS technology brief

## Role of the ICP-MS vacuum interface:

Mass spectrometers (MS) and ion detectors work best when they are operated under high vacuum (low pressure). Operating an MS at low pressure reduces ion scattering, increases transmission, improves peak shape, and reduces background noise.

Many types of MS instruments have the ion source inside the vacuum chamber, so it is easy to maintain the low pressure needed for optimum MS operation. But the ion source of an ICP-MS is at atmospheric pressure, so ions must pass through a series of interface “cones” into the high vacuum region. The ICP-MS interface therefore has two conflicting roles:

1. To transfer ions from the plasma (at atmospheric pressure) to the MS (in the high vacuum region)
2. To maintain the lowest possible pressure in the vacuum region for optimum MS performance.

The ideal (lowest) vacuum pressure would be achieved with no cone apertures at all, but clearly that is not practical, as it would also give no ion transmission. So an optimum design strikes a balance between providing good ion transmission and maintaining the high vacuum. A well-designed interface works with the rest of the system to deliver the best combination of matrix tolerance, sensitivity, background, and MS performance.

## ICP-MS interface design considerations

An ICP-MS vacuum interface consists of a series of conical plates or “cones”, which have small orifices or apertures in them. The cones are water-cooled to prevent damage due to their proximity to the high temperature plasma. Interface cones are typically manufactured from solid nickel, but nickel with a copper base is used on some systems for improved electrical and thermal conductivity.

As standard, Agilent ICP-MS systems (except semiconductor configurations) use interface components comprising a Ni sampling cone with a copper base, together with a solid Ni skimmer cone, as shown in Figure 1. For applications that require the best corrosion resistance, such as analysis of high purity acids, platinum-tipped and [nickel-plated cones](#) are available.

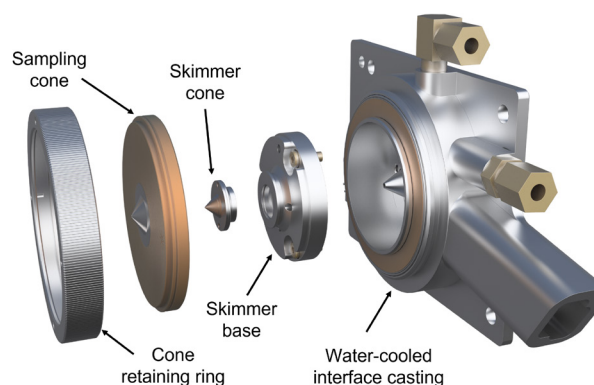


Figure 1. Interface components of an Agilent ICP-MS.

As well as transferring ions from the plasma to the mass spectrometer and maintaining the low pressure required for optimum MS operation, the interface also contributes to controlling space charge effects. This enables the ICP-MS to achieve high ion transmission and sensitivity for analytes across the mass range from Li (mass 7) to U (mass 238) (1). The interface design also controls the amount of sample matrix passing into the vacuum chamber.

## ICP-MS interface design and matrix tolerance

It is a common misconception that larger interface cone apertures prevent matrix deposition and so reduce signal drift. In reality, matrix deposition on the interface cones is mainly controlled by the robustness of the plasma (2). On an ICP-MS system with poor plasma robustness (CeO/Ce ratio >0.02, or 2%), a larger cone orifice might be necessary to delay the cone clogging that causes signal drift. But the larger cone aperture will also allow more of the undissociated matrix to pass through the interface and enter the high vacuum region, as shown in Figure 2.

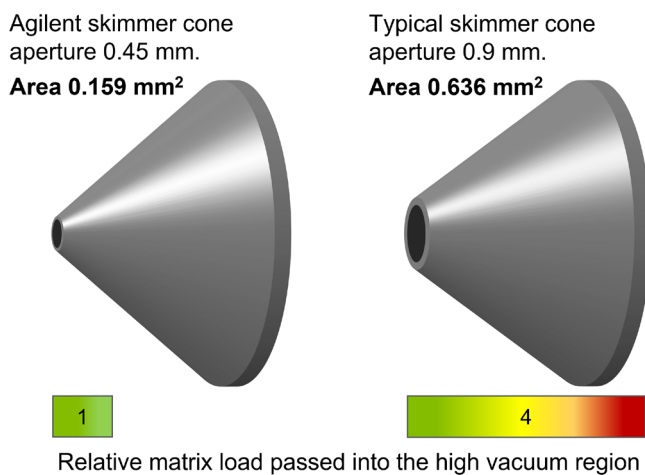


Figure 2. A skimmer cone with a 2x larger diameter aperture allows 4x more sample matrix to enter the high vacuum region.

A better way to control matrix deposition on the interface cones is to use more robust plasma conditions (lower CeO/Ce ratio). A more robust plasma decomposes the sample matrix more effectively, so there is less undissociated material to deposit on the cones.

Agilent ICP-MS systems are routinely operated with the most robust plasma conditions of any ICP-MS. Typically the CeO/Ce ratio on Agilent ICP-MS systems is around 0.01 (1.0%) for normal sample types, and as low as 0.003 (0.3%) CeO/Ce for high matrix samples. This CeO/Ce ratio is approximately 10x lower than the level typically achieved on some non-Agilent ICP-MS systems, indicating 10x better sample matrix decomposition.

Ten times better matrix decomposition and four times less matrix passing through the skimmer means that up to 40x less matrix enters the vacuum system of an Agilent ICP-MS compared to less well-designed systems.

Learn more:

[www.agilent.com/chem/icpms](http://www.agilent.com/chem/icpms)

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Another approach that helps prevent matrix deposition and drift is to control the operating temperature of the skimmer cone tip. Agilent ICP-MS systems use carefully selected materials and an optimized skimmer base design to ensure the skimmer cone tip operates at a precisely controlled, elevated temperature (Figure 3).



Figure 3. Left: Stainless steel skimmer base used with Ni skimmer cone. Right: Brass skimmer base used with Pt-tipped skimmer cone.

A raised skimmer tip temperature prevents condensation of residual matrix material and molecular species that pass through the interface, reducing the matrix deposition that is observed on systems where the skimmer is operated at lower temperature.

## Conclusion

The ICP-MS vacuum interface transfers ions from the plasma to the mass spectrometer while maintaining the lowest possible pressure in the vacuum region. The interface works with other components of the ICP-MS to deliver the optimum conditions for best performance of the mass filter and detector.

On Agilent ICP-MS systems, the interface design combines with a robust plasma and an efficient, high-transmission off-axis ion lens to give a unique combination of excellent matrix tolerance and extremely high sensitivity across the mass range.

## References

1. Agilent ICP-MS Journal issue 85, [5994-3758EN](#)
2. Agilent ICP-MS Journal issue 81, [5994-2203EN](#)