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Introducing the New TwoVol^2 Ablation Cell for NWR Platform

The Best Positional Reproducibility and Stage Return Accuracy Available

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ESI TECHNICAL NOTE

Exploring the Benefits of esi's TwoVol^2 Technology

esi is always looking for new ways to cement our reputation as the leading innovator in the field of laser ablation solid sampling, particularly in the area of ablation cell development since this area impacts the analytical result more than any other. esi's research and innovations on particle transport, gas dynamics and purge cycle have been incorporated into TwoVol^2, the third generation two-volume cell from esi.

Arguably the most important performance specification for an ablation chamber is the obtainable spatial reproducibility. TwoVol^2, due to its novel gas flows, constant tubing curvature and Typhoon purge mechanism yield a spatial reproducibility of < 2%RSD—within the stability specification of ICP-MS instrumentation.

Benefits of TwoVol^2 Technology

Figure 1. Images of the TwoVol^2 ablation cell

- Spatial Reproducibility < 2%RSD.
- Tubing curvature independent of sampling position—constant curvature.
- Constant cup to sample distance due to non-cantilevered cup support.
- Efficient Typhoon purge mechanism.
- Leak free operation.
- Accessible tubing for easy replacement.
- Stage reproducibility of < 1.5 microns achieved by direct mounting of cell on stage.
- Complex ablation pattern capability.
- Incorporated pinch valve to minimize pulse broadening and sample deposition.
- Compatible with off axis, large field of view camera.

Novel Sample Chamber Insert

The ability to accommodate the sample is a fundamental requirement of any ablation cell. In two volume cell technology this requirement is even more paramount since consistent spacing between the sample surface and cup is required. The TwoVol^2 is supplied with two standard sample chamber inserts:

- A spring-loaded insert with a spring mechanism to position samples (pucks and mounts) against a fixed surface for correct focal position.
- A "floating floor" for flexible sample accommodation.

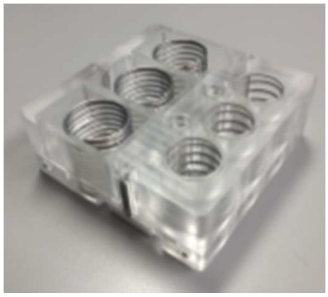

Figure 2. An image of the spring-loaded sample insert

Custom insert are available at request.

Cantilever-Free Stage Mounting

In many systems, the ablation chamber is mounted on a cantilever over the transmitted light and not over the stage unit that has to support its weight. This provides non-uniform support as cell position varies and can lead to variation in stage return accuracy.

esi's new generation of cells, including the TwoVol^2, have incorporated the advances of LED miniaturization into the chamber design to finally allow the removal of cantilevered stages without sacrificing the NWR's super-bright transmitted light and polarizing filter. The new chamber is mounted on top of the stages for consistent support and stage return accuracy, even at the extreme limits of the stage range.

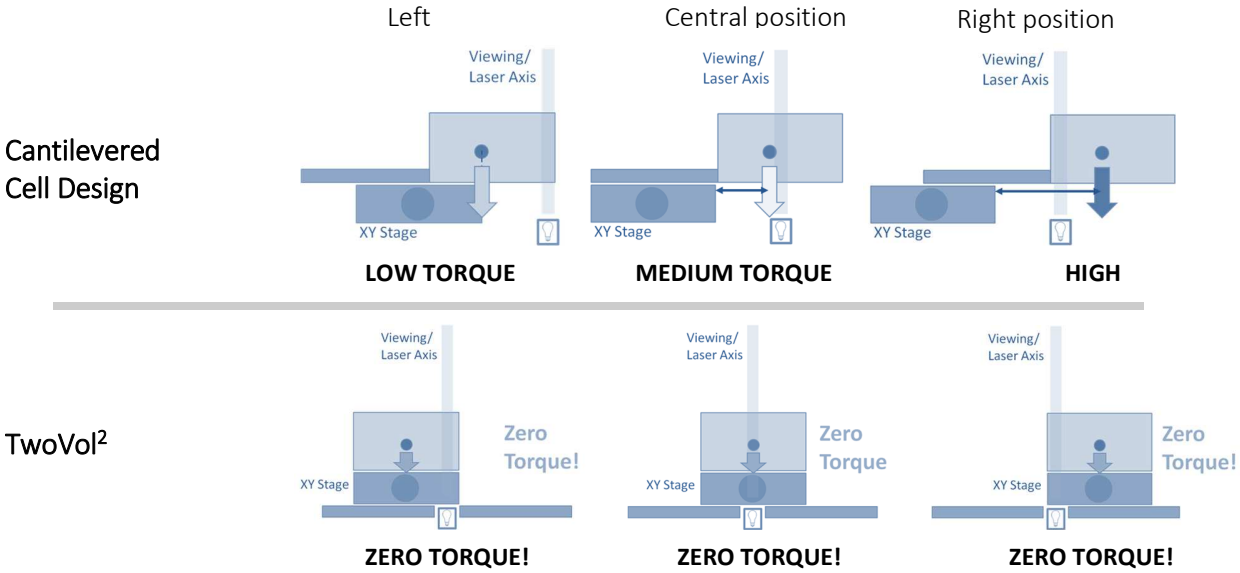

Figure 3. Cantilevered cells (top row) suffer from variable torque depending on position, whereas the TwoVol^2 Cell from esi (bottom row) that has the stage mounted directly underneath the weight of the chamber is not affected by torque effects at all.

Cantilever-Free Cup Positioning

A cantilevered arm is often used on some ablation cells to direct the aerosol collection device (or cup) around the chamber. Variable torque results in changes in distance between the sample surface and the cup at different sample locations which causes inconsistent gas dynamics and a positional sensitivity dependence.

In the TwoVol^2, the cup is supported evenly throughout the entire range of motion with a specially-designed internal movement system. This system also maintains constant curvature of the tubing between the ablation site and the ICP and results. This combination results in consistent gas dynamics and particle transport and ultimately, unmatched spatial reproducibility.

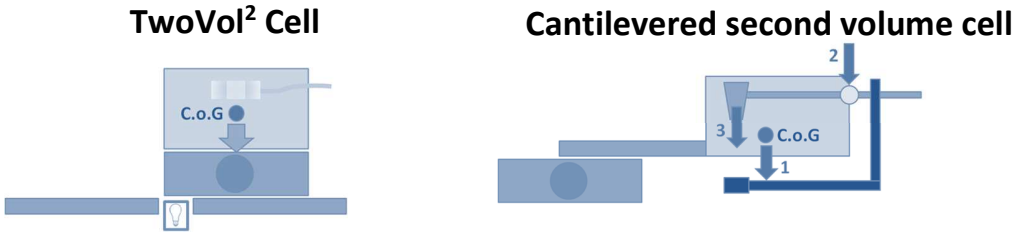

Figure 4. Variable torque in cantilevered ablation cells has a major effect on the function of the second volume. The TwoVol^2 cell from esi (left) has zero torque and a cup that is not connected to the main stage movement. Cantilevered ablation cells (right) apply different forces onto the cup depending on cell position.

Performance Testing of TwoVol^2 - Experimental

- TwoVol^2 technology was tested for signal, wash-out time and positional reproducibility.
- A NWR193UC equipped with TwoVol2 technology was connected to a quadrupole ICP-MS via a 0.5m length of tubing of 2mm I.D.
- Nine NIST612 certified reference materials were positioned at various regions in the TwoVol2 cell.
- The positional reproducibility of the TwoVol^2 cell was determined by performing line scan analysis on each of the individual NIST612 – a %RSD was then calculated. Parameters defined in Table 1 were employed.
- The NIST612 in the central position was used to determine the wash-out time (defined as the time taken for the signal intensity to fall to 1% of its maxima) by analysis of the signal intensity obtained from a single laser pulse using the parameters defined in Table 1.

Table 1. Instrumental parameters

Laser Ablation	NWR193 with TwoVol²
Fluence	3 J/cm²
Spot Size	50 µm/s
Scan Speed	10 µm/s
He Cell Gas Flow Rate	0.8 L/m
Repetition Rate	20 Hz
Line Scan Length	600 µm

ICP-MS	Agilent 7700
Forward Power	1400 W
Ar Gas Flow Rate	0.85 L/m
Integration Time Per Mass	5 ms

Results: Positional Reproducibility <2% RSD

Variation in signal response from different positions in the sample chamber is detrimental for analyses. Inconsistent gas dynamics, tubing curvature, or cup/sample height can cause changes in sensitivity, washout time, oxide formation, and elemental fractionation with position.

TwoVol^2 is equipped with Typhoon, the purge mechanism that enables the extraordinary positional reproducibility. The magnet-free cup control maintains constant curvature to avoid variable tubing bends and is supported throughout the chamber to avoid variable cup heights. The TwoVol^2 has a washout time of 700 milliseconds, which enables good spatial resolution while providing a steady sign al at lower rep rates without a signal smoother.

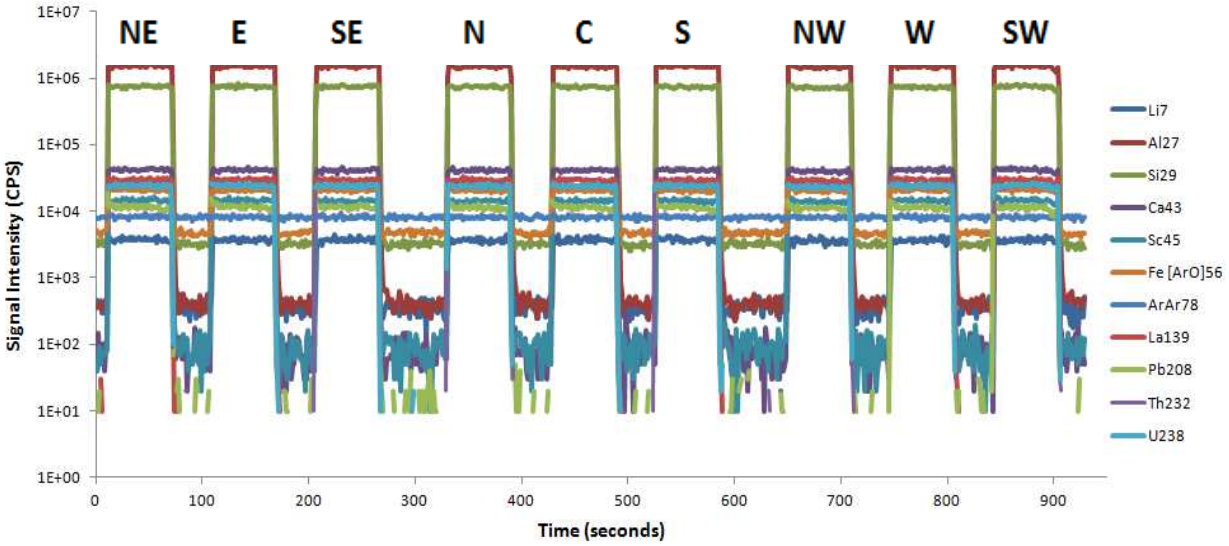

Figure 5. A chart to demonstrate the positional reproducibility of the ***TwoVol^2*** ablation chamber. The chart shows the signal intensity obtained for nine NIST612 glasses at the edges, corners, and centre of the chamber.

Table 2. Positional reproducibility of the TwoVol2 ablation chamber. The chart shows the %RSD obtained from consecutive analyses on nine different NIST612 throughout the chamber.

	^{7}Li	^{27}Al	^{29}Si	^{43}Ca	^{45}Sc	^{56}Fe	^{139}La	^{208}Pb	^{232}Th	^{238}U
NE	3785	1531463	751591	42146	14661	21132	29597	11542	25144	24278
E	3691	1511334	751207	41841	14510	20586	29607	11595	25298	24229
SE	3746	1501805	748582	41169	14175	20623	29335	11631	24449	24000
N	3618	1486079	739212	40777	14056	20534	28947	11306	24717	23601
C	3714	1480080	737536	41308	14233	20673	29199	11501	24348	23911
S	3759	1502807	739297	41758	14389	20606	29165	11498	24779	24017
NW	3584	1450804	719150	39916	13911	20320	28531	11149	24173	22981
W	3676	1488550	735146	41829	14424	20682	29527	11552	24735	24191
SW	3729	1509414	758512	42185	14497	21018	29453	11363	24790	24403
%RSD	1.78%	1.53%	1.58%	1.77%	1.68%	1.19%	1.20%	1.37%	1.45%	1.82%

Results: Ratio Reproducibility <2% RSD

The consistent curvature of TwoVol^2 allows the ablated aerosol to travel an identical path, whatever the sampling position in the cell. Monitoring ratios of light to heavy elements and ratios of oxide and non-oxide forming elements at various positions in the cell can be used as a measure of spatial reproducibility performance.

The results below show that the %RSD of these ratios obtained are extremely precise: U/Pb exhibits just 0.5 %RSD and Sc/Ca, La/Ca, and U/Ca are all under 1 %RSD. In particular the U/Pb reproducibility makes the TwoVol^2 the ideal candidate for U/Pb geochronology applications.

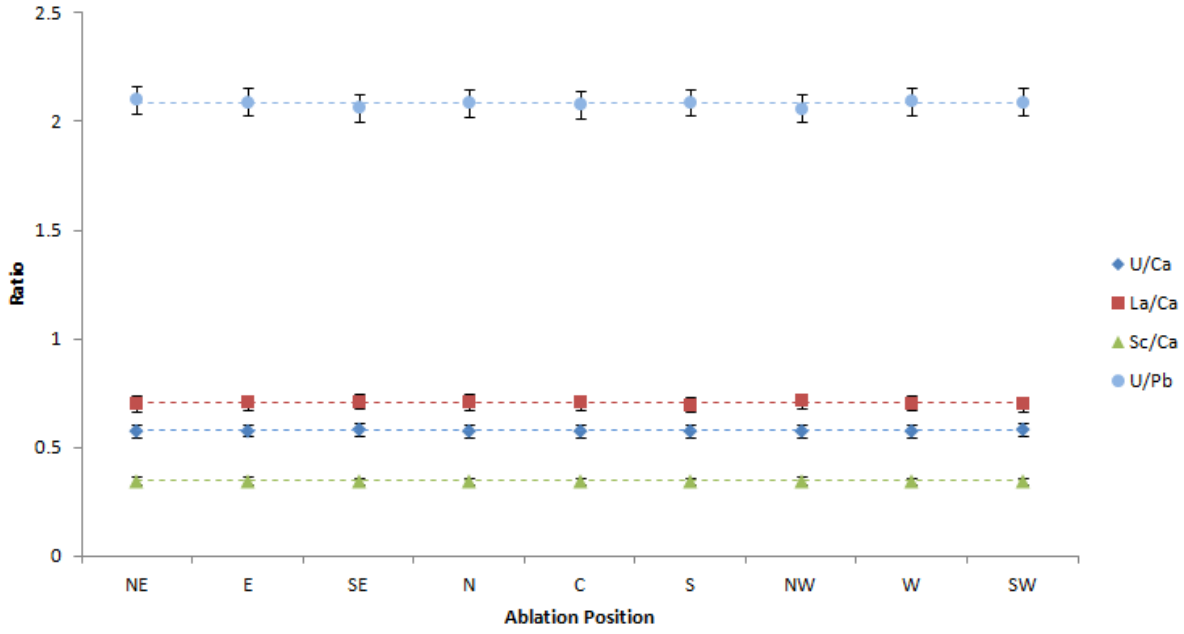

Figure 5. Elemental ratio reproducibility obtained by analysis of 9 NIST612 glasses at different sampling positions in the TwoVol^2 cell.

Conclusions

- The TwoVol^2 chamber has exceptional elemental and ratio spatial reproducibility. %RSDs of <2% are achievable, which dramatically reduces the effect of sample and standard placement as an error contribution, enabling more accurate results.
- TwoVol^2 offers the highest performance for any standard laser ablation chamber. The spatial reproducibility, constancy of cup height, and ability to do complex patterns with high reproducibility provide flexibility for a huge range of applications.