High throughput elemental screening - redefined

Figure 1. Fully automated LaserTRAX system connected to a ESL193 and Agilent 7900.

Industrial high throughput trace element analysis by laser ablation ICPMS

Rapidly assessing bulk trace element composition of solid samples is important across a wide range of industries, from manufacturing, to mineral exploration, to clinical, to food monitoring, and beyond. Existing analytical methods may involve intensive sample preparation, expensive or unsafe reagents, slow time-to-result, a high cost of ownership, or be insensitive.

Laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) addresses these challenges: it is sensitive enough to meet lowering detection requirements and directly analyzes the solid samples, eliminating the need for expensive or dangerous reagents. Until now the technique has been limited mostly to R&D and academic facilities due to complexity and low sample throughput. Laser SC resolves these issues to bring laser ablation into the industrial setting.

Figure 2. Li-tetraborate fusions and plastic beads suitable for Laser SC analysis

A sequential approach

Conventional LA-ICPMS uses a batch approach; samples are accommodated in a large chamber and purged simultaneously, a step that is required every time the chamber is opened. This approach is preferred by research labs but is not compatible with high-throughput industrial analysis.

In the conventional approach, increasing throughput requires that either the sample chamber volume must increase (greater purge time) or the sample size must decrease (increasing the effort and time spent focusing on samples, increasing time-to-result, and potentially adding a step to cut the samples).

In the sequential approach used by Laser SC, each sample is presented and analyzed one at a time. The chamber volume is greatly reduced, drastically reducing the purge time from 4 minutes to <5 seconds per sample. Samples are presented at a reproducible location in the sample chamber, so operator time and potential error are reduced, enabling a completely automated analysis. Time-to-result is short because the analysis doesn't require a full batch to begin sampling. Increasing the number of samples does not increase the complexity or reduce the throughput, and a calibration can even be started before unknown samples are delivered to the lab.

Self-Seal

The enabling technology is ESL's new 'Self-Seal' sample chamber. A piston raises and lowers the sample into position and the sample itself forms the gas-tight volume. When the analysis is complete the sample can be moved away and the next sample moved in. Presenting samples in this way ensures that the sample arrives at the correct focal plane even if variations in thickness exist between samples.

Buildup of ablated debris after a large number of samples is managed by gas flushes and filters that clean off the chamber between samples, minimizing contamination and carryover.

Performance

How does opening and purging the chamber impact the analytical results?

A NIST610 sample was repeatedly analyzed (n=10) by line scan using the Laser SC. Between each line, the sample chamber was opened to the atmosphere, closed again, and re-purged (approx. 10 seconds total). The Laser SC gives excellent signal reproducibility between replicate samples with %RSD of between 2% and 4% per element based on this data (Figure 3), equivalent to a high-performance two volume sample chamber.

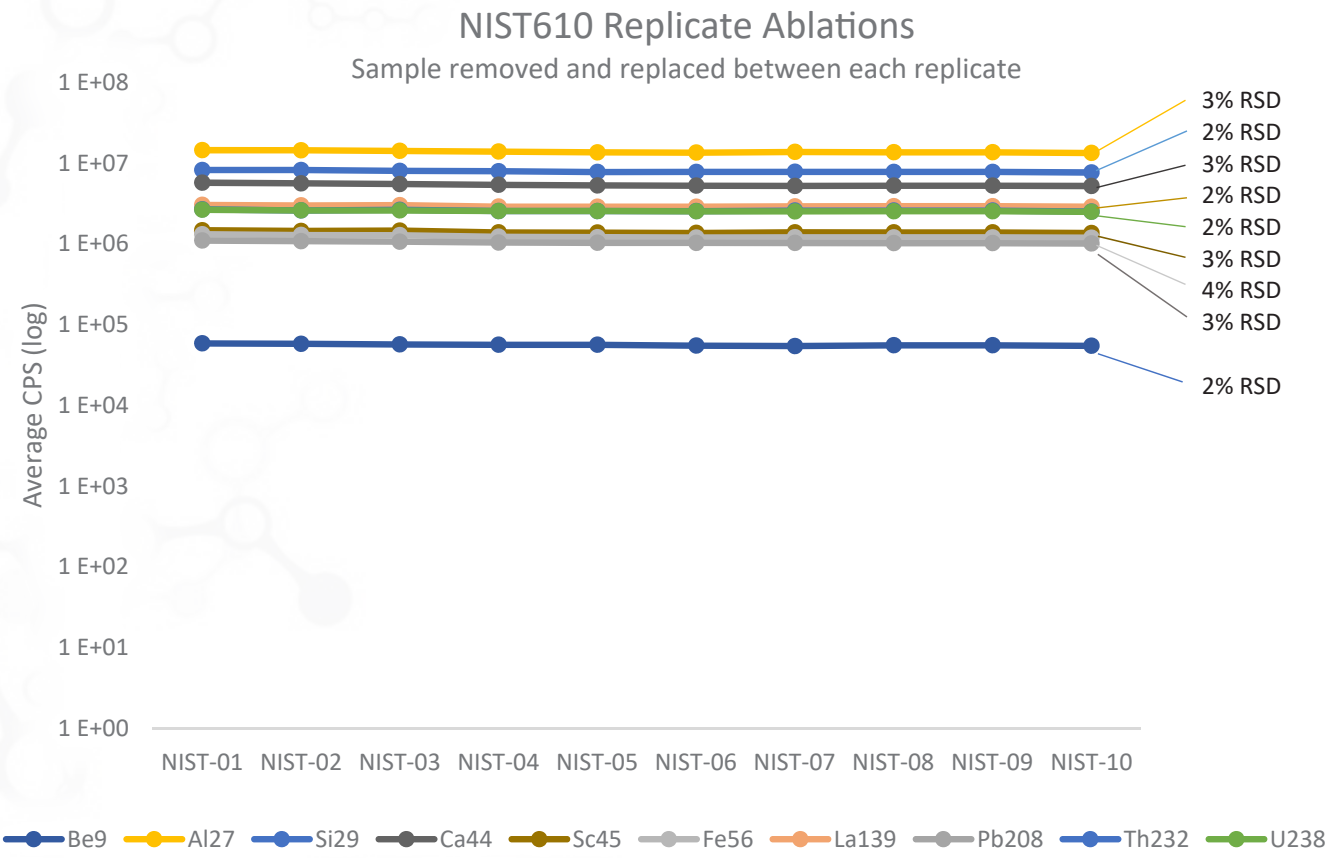

Figure 3. Mean results per isotope shown for each of the 10 opening and purging events. Isotopes were selected to be representative of major and trace abundances, oxygen relativities, and mass ranges.

Laser SC variants

The form factor and requirements may vary between different sample types. ESL can provide variants of the Laser SC that use the base technology customized for the specific needs of the intended application, as sample holders can be customized to fit different samples. Existing Laser SC configurations include: pressed pellets (food, soils, ceramics, etc.), XRF beads, metallurgical samples, blood spot cards, filter papers, glasses, and plastics.

A carousel with a wheel rotates successive samples into position for low throughput applications. The wheel is filled with samples and the Laser SC runs the samples in programmed sequence until the required set is complete. Up to 20 samples can be run automatically before the wheel needs to be exchanged – a 1 minute procedure.

For higher throughput requirements (e.g. 1000 XRF beads per day) a robot is integrated with the LaserTRAX system, allowing the samples to run continuously. The robot employs a barcode scanner to automatically correlate data in a LIMS system or batch list.

ESL offers the Laser SC in 193nm, 213nm, and 266nm wavelengths for optimum performance on any sample.

Figure 4. Samples loaded into Laser SC Carousel in preparation for analysis.

Cleaning and maintenance

The gas dynamics and transport lines inside the chamber minimize cleaning frequency, including the use of a pinch valve for easy cleaning and reduced clogging by particulate. The chamber, coated quartz window and O-rings are removable. The chamber can be cleaned in methanol.

Conclusions

Laser SC and LaserTRAX have been designed for high-throughput, automated analysis by LA-ICPMS. They have been optimized for use in an industrial facility. The flexible technology allows many sample types in any batch size to be analyzed with low sample preparation and minimal operator input.