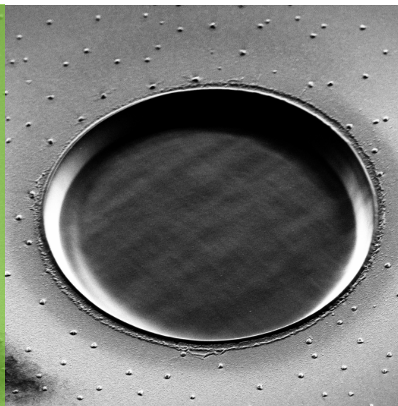

Image courtesy of Teledyne Photon Machines

Factors That Affect Performance of Laser Ablation (LA)-ICP-MS

Agilent ICP-MS technology brief

Trace-level analysis by ICP-MS.

ICP-MS instruments can measure elements over an extremely wide concentration range – up to 11 orders of magnitude – but the technique is most commonly used for trace element analysis. Accurate analysis at trace levels requires an ICP-MS with:

- High sensitivity, from good ionization in the plasma and high ion transmission through the interface, ion lens, collision/reaction cell (CRC), and quadrupole.
- Low background, from good rejection of photons and neutrals in the ion lens, and a detector with low noise characteristics.
- Good control of spectral interferences, provided by a robust, low oxide plasma and effective CRC operation.

High sensitivity and low background are even more critical when the amount of sample analyzed is low, as in small crater laser ablation (LA). The same performance requirements also apply when short integration times are used for fast, time-based LA-ICP-MS measurements such as depth profiling and imaging.

A wide dynamic range detector is another critical ICP-MS requirement for LA-ICP-MS users who use a matrix element internal standard to correct for ablation yield.

Performance requirements for LA-ICP-MS

Some LA-ICP-MS applications – such as single-shot, small feature, and fluid inclusion analysis – generate signals lasting a few seconds or less. Applications that use time resolved analysis (TRA), for example depth-profiling and imaging, produce a signal that varies throughout the analysis. These types of measurements require an ICP-MS that can operate with fast scan speeds to collect multielement data with good time resolution during the short-lived or variable signal.

However, the integration time (dwell time per mass) must be balanced against the required detection limits. Shorter integration times give fewer counts for each mass and greater variability in the measurement of the background signal, which means higher detection limits, as illustrated in Figure 1. The decrease in the counts measured for each mass when using shorter dwell times means that high ICP-MS sensitivity is even more critical for applications involving multielement analysis of fast transient signals.

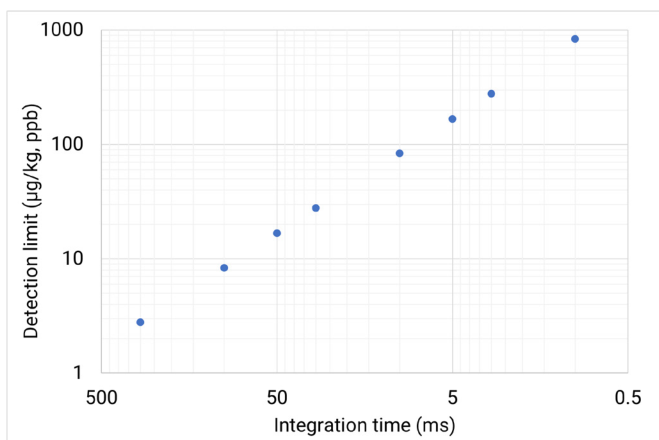

Figure 1. Shorter integration times lead to higher detection limits for LA-ICP-MS. Assumes the same number of raw counts and the same total analysis time per sweep.

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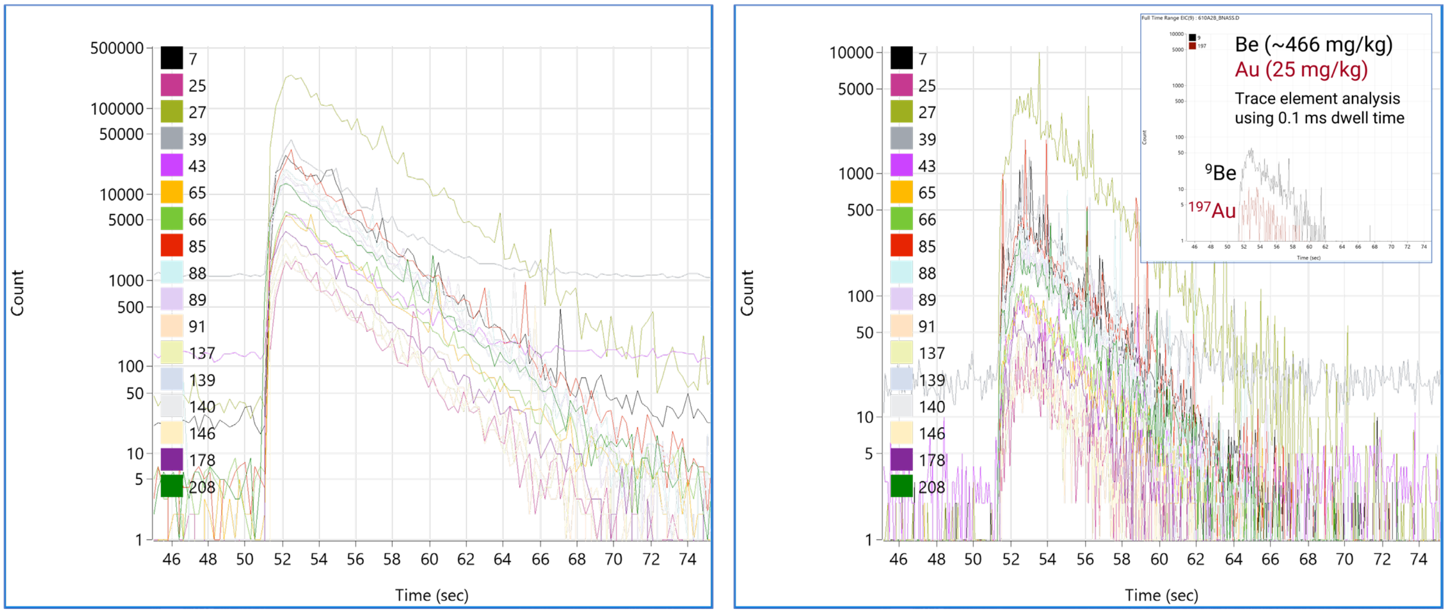

Figure 2. Elements in ASTM E2927-16E1 (*1*) measured during a 1 second ablation of NIST 610. 40 masses in total. **Left (A)**: Dwell time of 5 ms per mass gives excellent signal to noise and low detection limits (DLs). **Right (B):** Dwell time of 0.1 ms per mass gives better time resolution, but poorer DLs.

Optimizing LA analysis parameters

Laser conditions can be optimized to suit the analytical requirements, for example by using multiple shots at low energy to maximize signal from a small feature. Lower laser energy also causes less damage to the sample.

Multielement LA-ICP-MS analysis at trace levels (ppm or below) requires an ICP-MS with the highest possible sensitivity and lowest backgrounds, to maximize signal to noise and minimize detection limits. High ICP-MS sensitivity allows short (0.1 ms) dwell times to be used for the analysis of multiple elements – including trace level analytes – in short-lived signals. This is illustrated in Figure 2, which shows the Agilent ICP-MS signal from a 1 second ablation of NIST 610 Glass standard.

The 17 elements shown (out of 40 measured in total) are based on the analytes in ASTM Standard E2927-16E1 (*1*). The timechart in Figure 2, left, shows the excellent signal to noise (S/N) obtained with a 5 ms dwell time per mass. Faster scanning at 0.1 ms dwell time per mass (Figure 2, right) shows more detail of variations in the signal profile, but poorer S/N and therefore higher detection limits.

Due to the very high sensitivity of the Agilent ICP-MS, trace analytes could be determined, even under the 0.1 ms dwell time per mass fast scanning conditions (Figure 2, right). Au, present at 25 ppm in NIST 610, was one of the 40 masses included in the analysis and gave a signal of 100,000 counts per second. There was no need to increase the dwell time (and thereby compromise the time resolution) for trace level analytes like Au. Timecharts for Au and Be are shown in the inset plot in Figure 2 (right).

Conclusion

The high sensitivity of Agilent ICP-MS systems in dry plasma conditions makes them ideally suited to LA-ICP-MS applications. The high signal to noise of the Agilent ICP-MS enables accurate measurement of trace level analytes when using short 0.1 ms dwell times to characterize short-lived LA signals. This is especially important for multielement analysis of short-lived signals from feature/inclusion analysis or from depth-profiling and imaging applications.

Reference

1. ASTM Standard E2927, **2022**, Standard Test Method for Determination of Trace Elements in Soda-Lime Glass Samples Using Laser Ablation Inductively Coupled Plasma Mass Spectrometry for Forensic Comparisons

Learn more:

www.agilent.com/chem/LA-ICP-MS

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