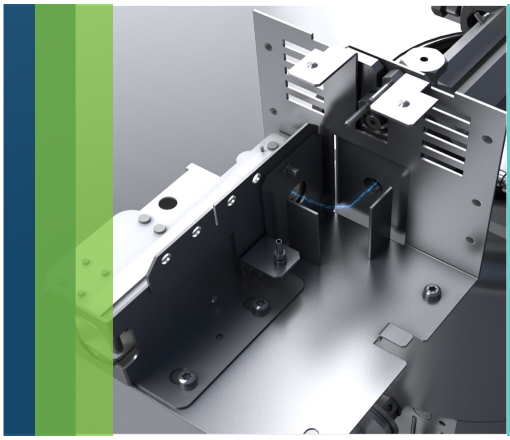

Wide Dynamic Range Electron Multiplier Detector

Agilent ICP-MS technology brief

Measuring major elements by ICP-MS

ICP-MS analysis uses direct measurement of ions, which gives high sensitivity, allied with good rejection of photons and neutrals to ensure that background signals are low. The combination gives a technique that is well-suited for trace element analysis.

Many applications, however, require major elements to be measured in the same run as the trace analytes. Some ICP-MS systems use a detector with ~9 orders of magnitude dynamic range. This range is not enough to span the concentration range from the lowest trace elements to the majors. Users of these ICP-MS systems must apply custom settings to measure high concentration analytes, for example by:

- Detuning ion lenses or cell voltages to reduce transmission for the expected major element masses
- Specifying a "low-gain" detector mode for the major elements

These approaches have a critical limitation; the user must know in advance which elements will be at high concentration, so the custom settings can be defined in the method.

Agilent ICP-MS systems take a simpler, more reliable approach. Using proprietary detector and amplifier electronics, Agilent ICP-MS systems can cover a full 10 or 11 orders of magnitude, allowing major elements to be measured without requiring custom settings.

Electron Multiplier Detectors for ICP-MS

Most ICP-MS instruments use an electron multiplier (EM) detector to measure ion signals. The EM consists of a series of charged plates or "dynodes". Each ion that strikes the first dynode releases several electrons which pass to the second dynode, where further electrons are released and the process is repeated. As the electron cascade passes down the series of dynodes, the signal is "multiplied" to the point that the counting electronics can register an ion count. This process is illustrated schematically in Figure 1.

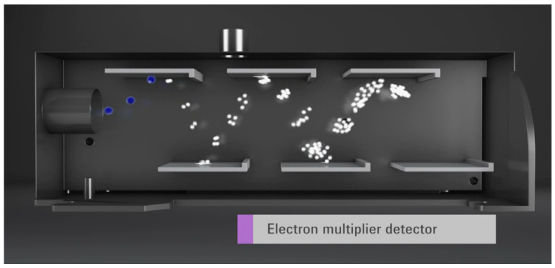

Figure 1. Electron multiplier detector, illustrating the electron cascade that leads to pulse-count signal generation.

Low intensity signals are measured in "pulse-counting" mode, where each individual ion that strikes the detector is recorded as a count. This "high-gain" mode enables measurement of low intensity signals above the baseline noise. At higher signal intensities, the pulse-count mode would be overloaded, and the response would become non linear. At these high signals, the EM is switched automatically to a "low-gain" mode, usually using analog signal detection.

In analog mode, an intermediate dynode measures the count rate as a current passing down the detector, rather than recording individual counts. When the signal exceeds the pulse-count threshold, the detector is "gated", so the signal does not pass to the later dynodes. In this case, the analog signal is used for the measurement, cross-calibrated to align with the pulse-count signals.

Electron Multiplier Detectors for ICP-MS

The usable analytical range of an ICP-MS instrument depends on multiple factors in addition to the detector dynamic range. Accurate analysis of low-level analytes requires good ionization of atoms in the plasma, high ion transmission, low background, and effective control of the trace interferences that affect many masses.

Analysis of the highest-level major elements requires good matrix tolerance and a robust plasma, as high concentration analytes contribute to the matrix, and can therefore cause signal suppression.

The combination of excellent sensitivity and industry-leading matrix tolerance means that Agilent ICP-MS systems can make full use of the wide linear dynamic range of the detector. Agilent ICP-MS detectors cover 10 or 11 orders dynamic range, depending on the model of ICP-MS or ICP-QQQ, as illustrated in Figure 2.

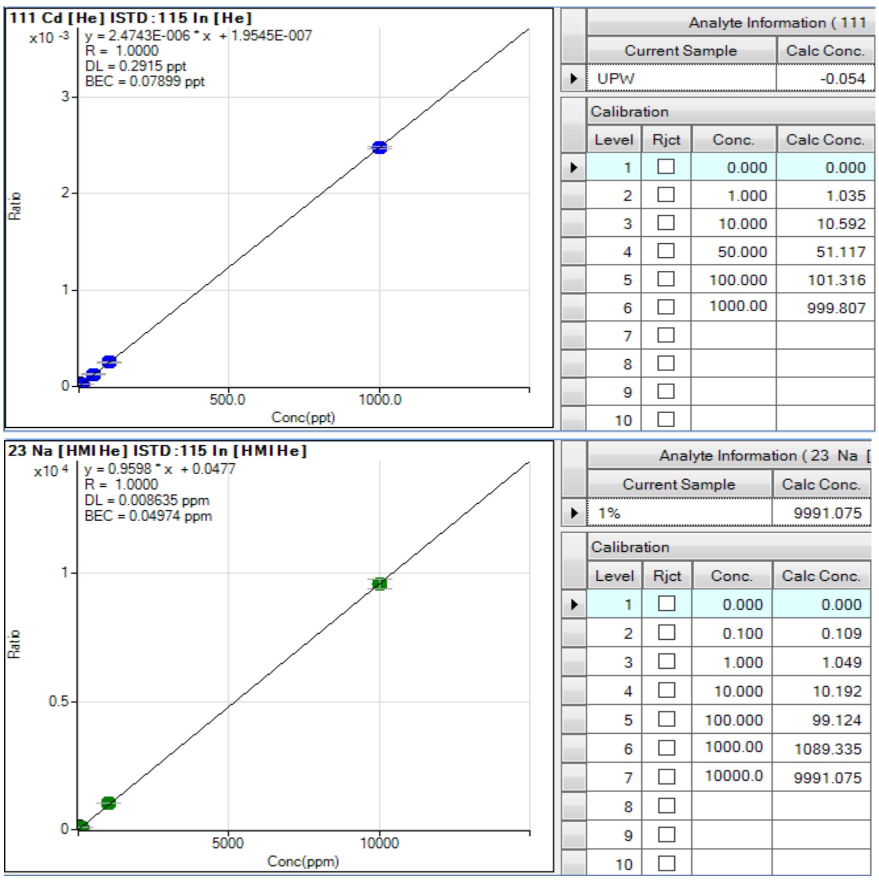

Figure 2. Low and high concentration analysis on the Agilent 7900 ICP-MS: Top, Cd calibration from 1 ppt to 1 ppb; BEC of < 0.1 ppt. Bottom, Na calibration from 0.1 to 10,000 ppm. Total concentration range covers 11 orders of magnitude.

For practical multi-element analysis of variable samples with unknown composition, the ICP-MS must be able to measure any analyte level without requiring extensive method setup. Agilent ICP-MS systems are typically operated using settings that support routine analysis, which means optimizing for robustness at the expense of high signal.

However, Agilent ICP-MS instruments use an optimized ion path with off-axis Omega Lens, which enhances ion transmission. As a result, extraordinarily high sensitivity is available for the analysis of low matrix samples. Ultrahigh sensitivity tuning is illustrated in Figure 3, which shows a U calibration from 0 to 100 ppt, with a DL of 1.3 ppq and sensitivity of 1.38 Gcps/ppm.

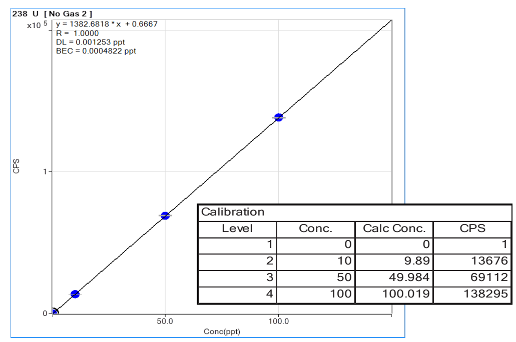

Figure 3. Ultrahigh sensitivity possible when the Agilent 7900 ICP-MS is optimized for sensitivity at lower robustness~2.5% CeO.

Conclusion

The wide dynamic range of Agilent ICP-MS detectors supports the analysis of trace and major elements in the same run. Only Agilent ICP-MS detectors provide a true 10 or 11 orders dynamic range at the detector. This wide dynamic range means that the lowest and highest concentration analytes can be measured together, without requiring custom conditions to be set up to attenuate selected, intense major-element signals.

Learn more:

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