Agilent 8900 ICP-QQQ Semiconductor configuration

Specifications

Leave interferences behind with the Agilent 8900 Triple Quadrupole ICP-MS

The Agilent 8900 ICP-QQQ is the world's only triple quadrupole ICP-MS—a tandem mass spectrometer with MS/MS operation to ensure accurate and reliable analysis of your toughest samples.

The 8900 ICP-QQQ combines the proven robustness and dynamic range capabilities of Agilent's quadrupole ICP-MS instruments with the incomparable power of MS/ MS for effective interference removal in reaction mode. With double the sensitivity of the previous 8800 ICP-QQQ model, coupled with Agilent's unique Cool Plasma capability, the 8900 Semiconductor configuration is a unique analytical tool that can handle even the most difficult semiconductor samples and applications with ease.

Agilent Technologies

Agilent 8900 ICP-QQQ overview

The triple quad configuration of the Agilent 8900 ICP-QQQ offers fundamentally improved performance for interference removal in the collision/reaction cell, particularly in reaction mode. Yet, for such an advanced instrument, the 8900 ICP-QQQ fits easily into your laboratory and analytical workflows. Advanced method development tools, productivity functions, and software that is simple to learn and easy to use, make the 8900 ICP-QQQ as straightforward to implement as a conventional quadrupole ICP-MS. And at only 1060 mm wide and 139 kg, the 8900 ICP-QQQ is significantly smaller and much lighter than some conventional quadrupole ICP-MS systems—saving on valuable cleanroom bench space, minimizing shipping costs and simplifying laboratory and facilities planning.

The Agilent 8900 ICP-QQQ consists of a single, high-performance mainframe with one standard configuration ("Agilent 8900"), and two application-specific variants:

- Agilent 8900 # (option) 100 - Advanced Applications configuration (refer to separate specification sheet)
- Agilent 8900 #200 - Semiconductor configuration

All three versions offer the power and flexibility of MS/MS for controlled interference removal in reaction mode, a capability that has transformed ICP-MS analysis and led directly to the phenomenal success of the outgoing Agilent 8800 ICP-QQQ.

Agilent 8900 ICP-QQQ operating modes

The 8900 ICP-QQQ can operate in:

- "Single Quad" mode, with Q1 acting as a simple ion guide or bandpass filter, or
- MS/MS mode where Q1 operates as a 1 amu mass filter to control the ions that pass through to the collision/reaction cell. This mode is unique to the tandem MS configuration of the 8900 ICP-QQQ.

8900 ICP-QQQ technical and performance highlights include:

- Unique tandem mass spectrometer configuration
- MS/MS mode for controlled and consistent interference removal in the collision/reaction cell
- High ion transmission and low background provide superior detection limits, including for previously difficult analytes sulfur and silicon
- Fast transient signal measurement for nanoparticle characterization
- Extended mass range for analysis of high-mass reaction product ions
- Unique MS/MS measurement modes provide ultimate flexibility for research and method development
- The highest abundance sensitivity ever seen in ICP-MS (theoretically $<10^{-14}$)
- Many critical hardware components and ICP-MS MassHunter software platform shared with Agilent's proven 7800 and 7900 quadrupole ICP-MS systems

Model summary

The 8900 #200 Semiconductor configuration ICP-QQQ includes four argon gas line mass flow controllers. A fifth gas line for addition of alternative gases such as O_2/Ar for organics, or He carrier gas for laser ablation (LA) is also included.

Pre-set Plasma Conditions allow consistent setup from day to day and between operators—essential for reproducible data in quality control labs. Optimum plasma conditions are simply selected using One-click Plasma Setting.

The 8900 Semiconductor configuration uses a new argon gas flow path, constructed using advanced materials which minimize background signals for silicon and sulfur. This permits low level analysis of these elements (detection limit specification of 50 ng/L).

The sample introduction system consists of a high efficiency PFA nebulizer; quartz spray chamber and quartz torch with 2.5 mm injector. The 8900 #200 uses Pt-tipped interface cones, a new interface vacuum system, and a new high-transmission "s" type ion lens. These components provide significantly higher sensitivity suitable for the ultra-trace analysis of high-purity semiconductor reagents.

The Agilent 8900 Semiconductor configuration features Agilent's fourth generation octopole reaction system (ORS^4) collision/reaction cell (CRC), with high-frequency (14 MHz) octopole ion guide and four cell gas lines. The ORS features axial acceleration, which increases transmission (and therefore sensitivity) for slow-moving product ions, and controls the formation of higher-order cluster ions.

The triple quad configuration of the 8900 ICP-QQQ supports MS/MS operation, ensuring consistent, accurate results in reaction mode, and enabling routine analysis using highly reactive cell gases, a first for ICP-MS.

Further hardware developments include a wider Q2 mass range for access to high-mass cluster ions, and a new electron multiplier detector with 11 orders dynamic range and fast (0.1 ms dwell time) time resolved analysis (TRA) for single nanoparticle characterization.

The 8900 ICP-QQQ Semiconductor configuration includes methods, tuning and acquisition templates to simplify operation for all typical semiconductor applications, including the industry-standard cool plasma mode used for ultra-clean samples such as ultra-pure water (UPW) and hydrogen peroxide.

Agilent 8900 #200 ICP-QQQ Specifications

Sample introduction system

The 8900 #200 Semiconductor configuration ICP-QQQ sample introduction system includes an efficient, low-flow PFA concentric nebulizer, a temperature-controlled spray chamber and a high precision, 3-channel 10-roller peristaltic pump. All components are optimized for high sensitivity analysis of high-purity semiconductor reagents and process chemicals.

Nebulizer

Low flow concentric nebulizer, made from PFA. Typical sample flow rate is <0.2 mL/min.

Spray chamber

Low-volume, Scott-type, double-pass, quartz spray chamber, provides improved removal of larger aerosol droplets, compared to cyclonic or impact-bead designs. Peltier-cooling eliminates the need for a separate external cooling water supply.

- Controlled temperature range: -5 °C to +20 °C (with instrument cooling water at 15–40 °C)

Peristaltic pump

Low-pulsation, high-precision, 3-channel, 10-roller peristaltic pump, for precise delivery of sample and internal standard (ISTD), plus spray chamber drain.

Plasma

RF generator

High power-transfer efficiency and maintenance-free solid state digital drive 27 MHz RF generator with variable-frequency impedance matching. Provides significantly improved tolerance of changes in sample matrix; even highly volatile organic solvents can be introduced without affecting plasma stability.

- RF power range: 500 W to 1600 W
- Step size 10 W

Plasma gas control

The 8900 ICP-QQQ includes a four channel Agilent mass flow controller (AMFC) for precise and stable control of argon gas flows:

- Plasma (cool) gas
- Auxiliary gas
- Nebulizer gas
- Make-up gas

The 8900 Semiconductor configuration uses a newly developed argon gas flow path, which incorporates specialized materials to minimize background signals for sulfur and silicon. A further AMFC channel to control a 5^{th} gas flow for option gas addition, such as for organic solvent analysis (using a blend of O_2 in Ar) or laser ablation (He carrier gas), is included.

Torch

Easy-mount, one-piece quartz torch with 2.5 mm internal diameter (i.d.) injector. The exceptionally wide torch injector supports the industry's most robust plasma, providing good matrix tolerance and efficient ionization (high sensitivity) for poorly-ionized elements.

Torch position

Stepper-motor controlled in three axes (horizontal, vertical and sampling depth), with a step size of 0.1 mm. Expert AutoTuning delivers quick and reliable auto-alignment following maintenance.

- Horizontal and vertical position: ±2 mm
- Sampling depth: 3 to 28 mm (~18 mm sampling depth is needed for the best cool plasma performance)

ShieldTorch system

Agilent's unique Shield Torch System (STS) reduces plasma potential and thereby precisely controls ion energy and energy spread—essential for tuning stability, optimum cell performance and for effective cool plasma operation.

Interface

Sampling cone

1 mm diameter orifice, Cu base with Pt tip. Easy access to the interface region for routine maintenance; no tools are required for removal/refitting of sampling cone. The sampling cone-retaining ring insures reliable thermal contact and reproducible fitting, even with different operators, giving dependable long-term performance.

Skimmer cone

0.5 mm diameter orifice, Pt-tipped/Cu base. Precisely controlled skimmer tip temperature ensures minimal matrix condensation/deposition, providing good tolerance to high matrix samples. Small skimmer orifice reduces matrix contamination of the high vacuum region, reducing maintenance.

Ion lens

The redesigned "s"-type extraction and off-axis ion lens of the 8900 Semiconductor configuration provides high ion transmission (high sensitivity) and low backgrounds, combined with uniform mass response (same sensitivity across the mass range). Further lens options for specialized materials and cool plasma applications are available.

The ion lens is in front of the gate valve, and so can be accessed easily for scheduled cleaning, without venting the vacuum system.

Extraction lens

Positioned behind the skimmer cone, the extraction lens focuses the ions as they enter the intermediate vacuum stage, providing high ion transmission across the mass range, while also supporting cool plasma performance. The lens operates at fixed voltage for simple, reliable tuning and superior matrix tolerance.

Off-axis Omega lens

Protects the first quadrupole (Q1), ORS^4, and high vacuum region from contamination, by rejecting neutral species from the ion beam. The low voltage of this deflector lens contributes to the minimal mass bias and low background noise characteristics of the 8900 ICP-QQQ.

Octopole reaction system

The 8900 ICP-QQQ incorporates a new, 4th generation collision/reaction cell, the ORS^4, which provides exceptional interference removal. The ORS^4 operates at higher frequency, cell gas pressure and kinetic energy discrimination (KED) bias voltage to deliver improved performance in He mode, ensuring the 8900 ICP-QQQ can perform superbly in collision mode as well as reaction mode.

Octopole

Comprises a thermally-stabilized cell with high frequency (14 MHz) octopole ion guide operated with fixed RF amplitude for the full mass range. Permits fast analysis with uniform conditions, for stability and consistent interference removal. An octopole ion guide minimizes ion scattering at high cell pressures, providing high ion transmission and sensitivity. Axial acceleration capability on the 8900 Semiconductor configuration further enhances ion transmission for slow-moving product ions, and controls the formation of higher-order cluster ions.

Cell gas control

The 8900 ICP-QQQ ORS^4 includes four cell gas flow controllers with the following flow rates:

- Maximum flow rate of 12 mL per minute (typically used for He cell gas)
- Maximum flow of 10 mL/min (typically used for H_2)
- Maximum flow of 10 mL/min, corrosive gas resistant (typically used for NH_3 in He)
- Maximum flow of 1.5 mL/min, corrosive gas resistant (typically used for heavier reaction gases such as O_2)

Many other reaction gases are supported, including CH_4, C_2H_2, C_2H_6, C_3H_4, C_3H_8, CH_3F, CF_4, NO, N_2O, CO, CO_2, N_2

The combination of cell gas controllers on the 8900 ICP-QQQ ORS^4 provides unparalleled flexibility to ensure optimum performance can be achieved for all applications, while also facilitating method development and research into reaction processes.

The different cell gas modes can easily be acquired sequentially in one visit to the sample, enabling easy comparison of data from different modes. Cell gas changes occur automatically and with minimal switching time (~5 sec), due to the low internal volume of the octopole-based cell.

Mass analyzers

The 8900 ICP-QQQ's tandem mass spectrometer configuration incorporates two Agilent-manufactured quadrupole mass analyzers, each with the optimum hyperbolic rod profile and both operating at high (3 MHz) frequency.

A hyperbolic profile quadrupole provides superior ion transmission, resolution and abundance sensitivity at standard settings, so eliminating the need for multiple resolution settings to separate adjacent peaks. Higher operating frequency ensures that ions travelling down the axis of the quadrupole are subjected to more RF cycles, improving rejection of non-target (off-mass) ions.

The first quadrupole mass filter (Q1) is located before the ORS^4, and selects the masses which are allowed to pass into the cell. Pre-filter and post-filter rods control fringing fields and improve rejection of non-target ions. The second quadrupole mass filter (Q2) is located after the ORS^4, and filters the ions and reaction product ions that emerge from the collision/reaction cell, selecting the target ion or product ion mass which is passed to the detector for measurement.

- Q1 has a mass range of 2-260 amu;
- Q2 has an extended mass range of 2-275 amu, to permit the measurement of higher-mass product ions.

Each of the two quadrupoles of the 8900 ICP-QQQ has the following performance specifications:

- Mass scan speed:
  - Scan speed (Li to U, plus data collection at 40 intervening masses): >5000 amu/sec
- Abundance sensitivity in Single Quad mode (measured at Cs):
  - Low mass side: 5×10^{-7}
  - High mass side: 1×10^{-7}

In MS/MS mode, the overall abundance sensitivity (AS) of the 8900 ICP-QQQ system is derived from the product of Q1 AS x Q2 AS (so 10^{-7} x 10^{-7} = 10^{-14}). However, in practice this is impossible to verify, as the signal difference exceeds the dynamic range of the detector. The guaranteed AS performance specification for the 8900 ICP-QQQ in MS/MS mode is 10^{-10}.

Electron multiplier detector

Unique, auto-switching, dual-mode discrete dynode electron multiplier detector provides a wide dynamic range using standard hardware and operating conditions.

Fast measurement of transient signals is provided, with a 0.1 ms minimum integration time for TRA acquisitions, optimum for single nanoparticle analysis. The electron multiplier uses a proprietary analog amplifier, which operates with short integration times for spectrum acquisition (100 µs) in both pulse and analog mode.

- Minimum dwell time: 100 µsec
- Dynamic range: 11 orders

Vacuum system

Four-stage differential vacuum system using one split-flow turbo molecular pump, a second turbo pump for the ORS^4 chamber, and a single external rotary pump for interface evacuation and turbo pump backing, providing fast pump-down and simple maintenance. The vacuum pumping efficiency of the 8900 ICP-QQQ has been enhanced, contributing to the very high ion transmission and high sensitivity.

Unique AutoRecover mode returns the 8900 ICP-QQQ to standby (pumping) state when electrical power is resumed after a power failure, saving valuable time. No need to manually start the vacuum system following an overnight power failure.

The rotary pump is external to the cabinet and so can be located conveniently in the laboratory, or outside the cleanroom in an external service corridor (may require the extended 3 m vacuum hose option). The internal rotary pump hose on the Agilent 8900 ICP-QQQ is chemically inert for superior resistance to highly corrosive acids.

Software

Agilent's ICP-MS MassHunter Workstation software provides comprehensive functionality and ease-of-use features for the 8900 ICP-QQQ. With simplified Expert AutoTuning, extensive use of Pre-set methods and powerful context-sensitive help, even novice operators will quickly be producing reliable and consistent results.

MassHunter includes:

- An innovative, sample matrix-specific Method Wizard which enables all users, experienced and new, to confidently and consistently obtain high-quality data
- Pre-defined acquisition modes for precursor ion scan, product ion scan and neutral gain scan, to help with QQQ method development
- Batch-at-a Glance interactive data table with real-time update, including all sample data, ISTD/QC signal trend and calibration curves
- Built-in outlier and LabQC checks
- Fast, simple data reporting or export to LIMS

For full details and compatibility of Agilent ICP-MS MassHunter software for the 8900 ICP-QQQ and Agilent quadrupole ICP-MS systems, see separate ICP-MS MassHunter Specifications. The MassHunter software platform is common to all Agilent MS instruments, simplifying cross-training of staff, and reducing training costs.

Optional software

The power of ICP-MS MassHunter can be extended through a choice of optional software modules.

User access control

Provides multi-level user logon control for compliance with regulatory requirements on security and audit trails, with three levels of access authority, record of user name, operating system lock and more.

Together with Agilent's Spectroscopy Database Administrator (SDA), OpenLAB DataStore, or OpenLAB ECM, ICP-MS MassHunter with User Access Control satisfies compliance requirements of the US FDA's 21 CFR Part 11 and equivalent regulations in other countries.

Chromatographic software

Fully integrated Agilent LC or GC module control, method setup, and chromatographic data analysis tools for analysis of samples using LC- or GC-ICP-MS. Permits system configuration, method setup, single-PC sequencing, automatic recalibrations, retention time and ion ratio updates, Compound Independent Calibration, Snapshot, automated report generation and more.

Intelligent Sequencing

Provides comprehensive, configurable QA/QC functionality for automatic QA/QC checks and real-time actions during unattended operation. Includes templates for QC reports for routine methods.

Single Nanoparticle Application Module

Includes Pre-set Methods for both single nanoparticle (NP) analysis (spICP-MS) and NP analysis using field-flow fractionation (FFF-ICP-MS). The spICP-MS Method Wizard automatically calculates important analytical variables, based on a few user-entered parameters.

Provides comprehensive data analysis tools for processing NP signals. Calculations are included for both peak integration mode and single scan mode. A proprietary algorithm ensures that small particles can be reliably discriminated from the background signal, and calculation of the Background Equivalent Diameter is performed automatically, giving an estimate of the minimum detectable particle size capability of the method.

Site service requirements

Dimensions		
Mainframe	Width	1060 mm (41.8 in) (main cabinet, excluding peripump)
	Depth	600 mm (23.6 in) (main cabinet, excluding power cord)
	Height	595 mm (23.4 in) (main cabinet, excluding exhaust chimney)
	Weight	139 kg (306 lb)
Largest shipping container	Width	1510 mm (60 in)
	Depth	1080 mm (43 in)
	Height	1030 mm (41 in)
	Weight	169 kg (373 lb)

Environmental		
Operating temperature	Range	15–30 °C
	Rate of change	<2 °C/hr (max. change 5 °C)
Operating humidity	Range	20% to 80% (non condensing)

Utility		
Electricity supply	Voltage	Single Phase, 200–240 V, 50/60 Hz
	Current	30 A
Cooling water	Inlet temperature	15–40 °C
	Minimum flow rate	5 L/min
	Inlet pressure	230–400 kPa (33–58 psi)
Argon gas supply	Minimum purity	99.99%*
	Maximum flow rate	20 L/min
	Supply pressure	500–700 kPa (73–102 psi)
Cell gas supply	Minimum purity	99.999%
	Maximum flow rate	12 mL/min for He 10 mL/min for H_2, NH_3/He 1.5 mL/min for low-flow cell gas (e.g. O_2)
	Supply pressure	90–130 kPa (13–18.8 psi) for He 20–60 kPa (2.9–8.7 psi) for H_2, O_2, NH_3/He
Exhaust duct	Vent type	Single vent, 150 mm diameter
	Flow rate	5–7 m^3/min

Safety and regulatory compliance

Safety	IEC 61010-1:2001 / EN 61010-1:2001, CAN/CSA C22.2 No.61010-1-04,UL No.61010-1 IEC 61010-2-061:2005, EN 61010-2-061:2003, CAN/CSA C22.2 No.61010-2-061-04
	IEC 61010-2-081:2001+A1:2003, EN 61010-2-081:2002+A1:2003, CAN/CSA C22.2 No.61010-2-081-04
EMC	IEC 61326-1:2012, EN61326-1:2013, ICES-001:2006, AS/NZS CISPR 11:2011
ISO	Manufactured at an ISO 9001 and ISO 14001 certified facility

* For ultra-trace analysis of Si or S on the Agilent 8900 #200, minimum 99.999% purity is recommended

Hardware configuration for Agilent 8900 #200 Semiconductor configuration

	8900 #200
Nebulizer (concentric)	MicroFlow MFN 100 (PFA)
Spray chamber (Scott double-pass)	Quartz
Torch (with ShieldTorch system)	Quartz 2.5 mm ID injector
Plasma mass flow controllers (Ar)	4 (supporting ultra trace S and Si)
Additional (5th) gas line for alternative carrier gas, such as Ar/O_2 for organics, or He for laser	Included
High Matrix Introduction (HMI) capability	Not supported
Interface cones	Pt (brass skimmer base)
Standard ion lens type	s-Lens
Collision/reaction cell gas lines: one for He (max. 12 mL/min), two high-flow (max. 10 mL/min), one low-flow (max. 1.5 mL/min)	4
14 MHz octopole with axial acceleration	Included
Q2 mass range	2 - 275
EM detector dynamic range	11 orders
EM detector minimum dwell time in TRA mode	0.1 ms (100 µs)

Guaranteed performance for Agilent 8900 #200 Semiconductor configuration

		8900 #200
Sensitivity [Mcps/ppm]	Li (7)	200
	Co (59)	70*
	Y (89)	1200
	Tl (205)	450
Background [cps]	No gas	0.2 (measured at mass 9 and 238)
Oxide ratio [%]	CeO^+/Ce^+	3
No gas mode DL [ppt]	Be (9)	0.1
	Fe (56)	2*
	In (115)	0.05
	U (238)	0.05
H_2 mode DL [ppt]	Si (28)	50
	Fe (56)	3
	Se (78)	1
O_2 mode DL [ppt]	S (as SO^+)	50
	P (as PO^+)	50
Short term stability (20 min) [%RSD]	Li, Y, Tl	<3
Long term stability (2 hr) [%RSD (%Drift)]	Li, Y, Tl	<3 (4%)
Isotope ratio precision [%RSD]	$^{107}Ag/^{109}Ag$	<0.2
Abundance sensitivity [M-1/M, M+1/M]	Cs (M=133)	$1x10^{-10}$ (L, H)**

*Cool plasma mode
** MS/MS mode

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