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## *Agilent 7700 Series ICP-MS*

### Performance Specifications

The 7700 Series quadrupole ICP-MS from Agilent Technologies replaces the market-leading 7500 Series, and improves on the previous model in every way.

Comprising of two models, the routine workhorse 7700x and the semiconductor-configured 7700s, the 7700 Series provides unparalleled performance, in the smallest commercial ICP-MS ever made.

#### **7700 Series technical and performance highlights include:**

- New fast frequency-matching RF generator,
- New design ion lens, providing increased sensitivity and reduced background
- Unique, 3<sup>rd</sup> generation cell design (ORS<sup>3</sup>) which delivers significantly improved interference removal in helium (He) cell gas mode
- Unmatched consistency and simplicity, resulting from innovations in system setup and autotuning
- New MassHunter workstation software – common platform with other Agilent MS platforms; easy to learn and use

Specification		7700x	7700s
Sensitivity (Mcps/ppm)	Li (7)	50	50
	Co (59)		30 (cool plasma)
	Y (89)	160	240
Background on-mass (cps)	Tl (205)	80	120
	NoGas (9)	<2	<3
	He Cell Gas (9)	<0.5	<0.5
Oxide Ratio (%)	CeO/Ce	<1.5	<3
Doubly-Charged Ratio (%)	Ce <sup>2+</sup> /Ce	<3	<6
NoGas Mode Detection Limits (ppt)	Be (9)	0.5	0.5
	Fe (56)		3.0 (cool plasma)

	In (115)	0.1	0.1
	Bi (209)	0.1	0.1
H <sub>e</sub> Mode Detection Limits (ppt) *	As (75)	20	
	Se (78)	40	
H2 Mode Detection Limits (ppt)	Fe (56)	3 (option)	3
	Se (78)	1 (option)	1
Short-term Stability (%SD)	20 min	<3	<3
Long-term Stability (%SD)	2 hours	<4	<4
Isotope Ratio Precision (%SD)	Ag (107)/Ag (109)	<0.1	<0.1

\* H<sub>e</sub> mode detection limits for As and Se are performed in a matrix of 1% HNO<sub>3</sub>, 2% HCl and 100ppm Ca, demonstrating the effective removal of both ArCl and CaCl. All other tests are performed in a matrix of 1% HNO<sub>3</sub>

### **Site Requirements and Safety**

<b>Dimensions</b>		
Mainframe	Width	730mm (main cabinet, excluding peripump)
	Depth	620mm (main cabinet, excluding power cord)
	Height	595mm (main cabinet, excluding exhaust chimney)
	Weight	115Kg
Largest Shipping Container	Width	980mm
	Depth	980mm
	Height	850mm
	Weight	138Kg
<b>Environmental</b>		
Operating temperature	Range	15–30°C
	Rate of change	<2°C/hr (max. change 5°C)
Operating humidity	Range	20-80% (non condensing)
<b>Utility</b>		
Electricity Supply	Voltage	Single Phase, 200-240V, 50/60Hz

	Current	30A
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 (71-100psi)
Cell gas supply	Minimum purity	100.00%
	Maximum flow rate	12mL/min for H <sub>e</sub> and 10mL/min for H <sub>2</sub>
	Supply pressure	90–130kPa for H <sub>e</sub> and 20-60kPa for H <sub>2</sub>
Exhaust duct	Vent Type	Single vent, 150mm diameter
	Flow rate	5-7 m <sup>3</sup> /min.

#### Regulatory Compliance

Safety: IEC 61010-1:2001 / EN 61010-1:2001, CAN/CSA C22.2 No.61010-1-04,UL No.61010-1

EMC: IEC 61326-1:2005 / EN61326-1:2006, ICES-001:2006, AS/NZS CISPR 11:2004

ISO: Manufactured at an ISO 9001 and ISO 14001 certified facility

#### **Standard Mainframe Configurations**

	7700x	7700s
Nebulizer (concentric)	MicroMist (borosilicate glass)	MicroFlow (PFA)
Spray Chamber (Scott double-pass)	Quartz	Quartz
Torch (with ShieldTorch System)	Quartz, 2.5mm ID Injector	Quartz, 2.5mm ID Injector
High Matrix Introduction (HMI) capability	Included	Optional (see note 1)
Interface Cones	Ni	Pt
Plasma Mass Flow Controllers (Ar)	4	4
Option Gas Line for alternative carrier gas, such as Ar/O <sub>2</sub> for organics, or H <sub>e</sub> for laser	Option	Included
H <sub>e</sub> (collision) cell gas line	Included	Included
H <sub>2</sub> (reaction) cell gas line	Option	Included

3 <sup>rd</sup> cell gas line (low- or high-flow rate options)	Option	Option
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Note 1: To add HMI capability to the 7700s requires the following parts to be ordered:

Nebulizer: MicroMist (G3266-65003) or MiraMist (G3161-80000 or G3161A-80001) Ni Sampling cone: 7700x type (G3280-67040) - (or use 7700s Pt Sampling cone) Ni Skimmer cone: 7700x type (G3280-67041) Ion lens: 7700x type (G3280-67039 - includes stainless steel skimmer base (G1833-65591))

### **Unparalleled performance**

Both 7700 Series models benefit from improved plasma stability and tolerance of organic solvents, as a result of a new frequency-matching RF generator.

The 7700 features higher sensitivity across the mass range, and lower random background compared to the 7500, due to a redesigned ion lens.

Enhanced interference removal capability is provided by the redesigned ORS, giving improved performance in the cell gas mode, for unambiguous and reliable quantification, even in complex matrices.

### **Enhanced ease of use**

One-Click Plasma Setting is provided on both models, for simpler, more reproducible plasma optimization. Agilent's unique High Matrix Introduction (HMI) capability is standard on the 7700x model, and pre-set plasma conditions for hot and cool plasma operation are provided with the 7700s.

Expert AutoTuning delivers faster, more consistent tuning, giving reproducible instrument performance, even with multiple operators. One-touch torch positioning and tool-free removal and refitting of the sampling cone speed up routine maintenance. Data analysis and reporting are enhanced, with new MassHunter software with Excel 2007 for reporting.

### **Reduced operating costs**

Reduced exhaust flow rate (especially important in clean rooms) reduces installation costs.

The 7700 uses MassHunter-based software, which is consistent across all Agilent MS platforms, thereby simplifying and reducing the cost of staff training.

### **Significantly smaller footprint**

At only 730mm wide and 115kg, the 7700 is easily the world's smallest ICP-MS – saving on valuable bench space, and simplifying lab planning. The footprint of the 7700 is >30% smaller than any other ICP-MS but performance and usability have been improved. Despite the small cabinet size, the ion path length is actually increased compared to the 7500, and user maintenance and service access is improved.

### **Reduced environmental impact**

The 7700 mainframe is extraordinarily light for an ICP-MS (only 138kg when packed for air-freight), so CO<sup>2</sup> emissions from transportation are reduced. Stainless steel panels are used throughout the cabinet, reducing the amount of paint required.

### **Agilent 7700 Series ICP-MS**

Agilent is committed to eliminating toxic compounds from electronic components, promoting recyclability of plastics, and using recycled packing materials.

## **Model Selection Guide**

### **Agilent 7700x – workhorse mainframe for reliable high-throughput analysis of unknown samples.**

The 7700x features the ORS<sup>3</sup> with He cell gas line, for He collision mode, the standard mode for most elements in most sample types. This simplifies method development and routine analysis, by using consistent cell conditions for all interfered elements.

The ORS<sup>3</sup> significantly improves He mode performance for problematic elements such as Se and Fe, which means that H<sub>2</sub> reaction mode is no longer needed. Eliminating the added complexity and uncertainty associated with using H<sub>2</sub> (or mixed cell gas) reaction mode greatly simplifies operation and improves data quality.

HMI capability is standard on the 7700x, reducing sample preparation time and costs by significantly increasing matrix tolerance for the direct analysis of % level total dissolved solids (TDS) samples.

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

The combination of He mode, HMI and Pre-set tuning conditions simplifies operation while delivering consistently accurate results and superior performance in routine applications.

### **Agilent 7700s – unparalleled semiconductor performance**

The Agilent 7700s mainframe provides ultra-high performance, and is configured for semiconductor performance and clean-room operation. It offers the ultimate in detection power and interference removal capability, with all industry standard analytical methods (normal mode, collision, reaction cell operation AND cool plasma), provided in a single instrument – unique in ICP-MS.

Additional flexibility is provided with the inclusion of a hydrogen reaction gas line for the ORS<sup>3</sup>, and the addition of a 5<sup>th</sup> carrier gas line, required for Ar/O<sub>2</sub> gas addition for organic solvent analysis, or He carrier for laser ablation (both additional gas lines are also available as options for the 7700x).

The 7700s is compatible with methods, tuning and acquisition templates to simplify operation for all typical semiconductor applications.

## **Sample Introduction System**

The standard sample introduction system includes an efficient, low-flow concentric nebulizer, a temperature-controlled spray chamber and a high precision, 10-roller peristaltic pump. All components are optimized for high throughput routine analyses of samples with TDS up to 0.2% (2000ppm).

### **Nebulizer**

Concentric nebulizer, made from glass (on the 7700x) or PFA (on the 7700s) with low sample flow rate as standard (~0.2mL/min)

**Spray Chamber:** Quartz, low-volume, Scott-type double-pass 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 – 30°C)

**Peristaltic Pump:** Low-pulsation, high-precision 10-roller peristaltic pump, with 3 separate channels, for precise delivery of sample and internal standard (ISTD), plus spray chamber drain.

### **High Matrix Introduction Capability**

HMI Aerosol Dilution technology, standard on the 7700x, extends the TDS range to % level, while eliminating the added costs, time and potential errors of conventional liquid dilution.

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## **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: 500W to 1600W

**Torch:** Easy-mount, one-piece quartz torch with 2.5mm internal diameter (i.d.) injector. The exceptionally wide torch injector produces a highly robust plasma that efficiently decomposes the sample matrix, minimizing routine interface cleaning

**Torch position:** Stepper-motor controlled in three axes (horizontal, vertical and sampling depth) in 0.1mm steps. Expert AutoTuning delivers quick and reliable optimization following maintenance.

- Horizontal and vertical position:  $\pm 2$ mm
- Sampling depth: 3 to 28mm

**ShieldTorch System:** Shield Torch System (STS) precisely controls plasma potential and ion energy - essential to achieve high performance He mode and cool plasma operation.

## **Interface**

**Sampling cone:** 1mm diameter orifice, Ni-tipped (7700x) or Pt-tipped (7700s) with Cu base. Easy access to the interface region for routine maintenance; no tools are required for removal/ refitting of sampling cone. The large cone-retaining ring insures reliable thermal contact and reproducible fitting, even with different operators, giving dependable long-term performance.

**Skimmer cone:** 0.4mm diameter orifice, Ni (7700x) or Pt-tipped (7700s). Precisely controlled skimmer tip temperature ensures minimal matrix condensation, providing good tolerance to high matrix samples. Small skimmer orifice reduces matrix contamination of the high vacuum region, reducing maintenance

## **Ion Lens**

The redesigned extraction and off-axis ion lens of the 7700 provides high ion transmission (high sensitivity) and low backgrounds, combined with uniform mass response (same sensitivity across the mass range).

The 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. The lens design gives the characteristic “flat” mass response of the 7700, and operates at fixed voltage for simple, reliable tuning.

**Off-axis Omega lens:** Protects the ORS3 cell and high vacuum region from contamination, by rejecting neutral species from the ion beam. This contributes to the minimal mass bias and low background noise.

## **Octopole Reaction System**

The 7700 Series incorporates a new, 3rd generation cell, the ORS3, which provides superior interference removal in He mode. The ORS<sup>3</sup> is longer and narrower than the 7500 Series ORS cell, and operates at higher frequency, higher cell gas pressure and higher kinetic energy discrimination (KED) bias voltage. This delivers improved performance in He mode, eliminating the need for reactive cell gases for all applications except semiconductor.

**Octopole:** Comprises a thermally-stabilized cell with 12MHz 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 provides both high ion transmission and superior ion focusing, minimizing ion scattering at the high cell pressures required for effective KED.

**He cell mode as standard:** Only the combination of narrow ion energy distribution (due to ShieldTorch) and the 7700's unique octopole-based cell enables efficient removal of interferences using an inert cell gas (He) and KED. He mode provides several critical advantages compared to reactive cell gases:

- He mode is effective for all polyatomic interferences, not just reactive polyatomics
- Since He is inert, no new interferences are produced, regardless of the matrix
- Unlike a reactive cell gas, He does not react with any analytes, so consistent and predictable sensitivity is maintained

He mode is suitable for all analytes (no-gas mode can be used for uninterfered analytes) and can be used reliably for completely unknown sample matrices – a unique capability of the 7700. The use of He cell gas also eliminates safety issues related to reactive gases such as H<sub>2</sub>, H<sub>2</sub> mixes or NH<sub>3</sub>.

**Cell gas control:** The 7700x has a single He cell gas controller, while the 7700s adds a second (reaction) gas line. Other cell gases are available for research applications, e.g. H<sub>2</sub> option (for the 7700x), and xenon or ammonia.

If multiple cell gases are used in a method, the cell gas is automatically changed with minimal switching time (~5 sec), due to the low internal volume of the cell (only possible with an octopole).

## Mass Analyzer

**Quadrupole mass spectrometer:** The 7700 uses a true hyperbolic quadrupole, unique in ICP-MS, operating at high (3MHz) 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.

- Mass range: 2 - 260amu
- Mass scan speed: ➤ Slew rate (Li to U, no intervening peaks): 22,638amu/sec ➤ Scan speed (Li to U, plus data collection at 40 intervening masses): 2852amu/sec
- Abundance Sensitivity (at Cs): ➤ Low Mass side:  $5 \times 10^{-7}$
- High Mass side:  $1 \times 10^{-7}$

**Detector:** Unique, auto-switching, dual-mode discrete dynode electron multiplier detector provides a full 9 orders dynamic range with standard hardware and operating conditions.

Fast measurement of transient signals is provided, due to the use of a proprietary analog amplifier, which operates at the same short integration time (100us) in both pulse and analog mode.

- Minimum dwell time: 100 μsec.
- Dynamic Range: 9 orders

## Vacuum System

**Vacuum system:** Three-stage differential vacuum system using a single, split-flow turbo molecular pump and single external rotary pump for fast pump-down and simple maintenance. Unique AutoRecover mode returns the 7700 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 in an external service corridor (may require the extended 3m vacuum hose option). The rotary pump hose on the Agilent 7700s is chemically inert for superior resistance to highly corrosive acids.

## **Software**

ICP-MS MassHunter Workstation software provides comprehensive functionality and ease-of-use features for the 7700 Series. 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:

- Batch-at-a Glance data table with real-time update, including all sample data, ISTD/QC signal trend and calibration curves.
- Built-in outlier and LabQC check
- Fast, simple data report layout and export to Microsoft® Excel (provided with MassHunter software), or export to LIMS for final reporting. MassHunter Data Analysis is common to all Agilent MS platforms, so reducing training costs

## **Optional Software:**

The power of ICP-MS MassHunter can be extended through a choice of software options:

**User Access Control** - provides multi-level user logon control for enhanced security and audit, with three levels of access authority, record of user name, Operating System lock and more.

With Agilent's OpenLab Enterprise Content Manager (ECM), ICP-MS MassHunter with User Access Control satisfies compliance requirements of US FDA 21 CFR part 11.

**Chromatographic Software** - fully integrated chromatographic data analysis tools for analysis of samples using LC- or GC-ICP-MS. Permits automatic sequence 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 actions during unattended operation. Includes templates for QC reports for standard methods such as US EPA 6020 and 200.8.

## **Accessories and Peripherals**

**Parallel-path nebulizer (MiraMist).** Suitable for samples containing suspended particulates. Available in Teflon or PEEK.

**Integrated Autosampler (I-AS).** A compact, fully-integrated autosampler with cover and pumped rinse station. Ideal for ultra-trace analysis and small sample volumes (0.5 mL), and with flexible rack configurations offering maximum capacity of 89 vials, plus 3 rinse vials.



**ISIS-DS.** Integrated Sample Introduction System for Discrete Sampling. Delivers reduced matrix loading and improved productivity in high-throughput laboratories. In addition to DS, ISIS can be configured for low-pressure chromatography, hydride generation, matrix elimination and more.

**Inert (HF-resistant) Kit:** O-ring-free, PFA sample introduction kit provides lowest contamination levels in the determination of sub-ppt level impurities in high-purity reagents. The kit includes a demountable torch with platinum or sapphire injector.

**Organic Solvent Introduction Kit** includes sample introduction parts required for the direct analysis of volatile organic solvents.

**LC-ICP-MS Speciation Kits.** Includes all necessary tubing, connectors and cables for seamless interfacing of an Agilent LC to the 7700. Pre-configured kits are available, with column, connectors and methodology for the turn-key analysis of As species in urine and waters.

**GC-ICP-MS** Interface connects an Agilent 7890 GC to the 7700. The unique, fully heated inert SilcoSteel transfer line and torch with heated injector eliminates connections and cold spots, to enable routine analysis of labile and high boiling point compounds. Transfer line can be heated to 300oC.

**Laser Ablation** - The 7700 Series can be integrated with any commercially available laser ablation system for the direct analysis of solid samples. With its high sensitivity, fast simultaneous detector and 9 orders dynamic range, the 7700 is ideally suited to measuring transient signals from laser ablation.

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