Water Technologies & Solutions

Sievers* 500 RL^e

On-Line TOC Analyzer

ready for the resource revolution

Advancing the science of ultra low-level TOC measurement in microelectronics applications

overview

The Sievers* 500 RL^e On-Line Total Organic Carbon (TOC) Analyzer is the semiconductor industry's only on-line, reagentless TOC analyzer capable of accurately detecting problematic compounds such as urea, trimethylamine (TMA), organic acids and organic bases.

An on-line TOC analyzer should be as simple as possible, but not so simple that it exposes the fabrication operations to unacceptable risks associated with undetected organic transients. Recently the leading global semiconductor immersion tool manufacturer has required all TOC measurements of the water feeding their tools to include the accurate measurement of organic nitrogen compounds in the ultrapure water (UPW).[1] Some brands of TOC analyzers are simply not able to measure commonly present organic nitrogen compounds such as urea or TMA in the UPW.[1,2] The 500 RL^e accurately and reproducibly measures them to meet this new TOC performance requirement.

The 500 RL^e uses proprietary membrane conductometric technology, delivering ultra low-level accuracy and reliability by eliminating false positive and false negative readings associated with other simplified TOC technologies (see Figures 1 and 2).

The 500 RL^e automatically exhibits the best-in-class Instrument-to-Instrument matching and the lowest Limit of Detection (LOD) for reagentless online semiconductor UPW TOC analyzers. Five 500 RL^e Analyzers were placed on the same major semiconductor companies' 0.3 ppb C UPW and data was collected for two months. The large data set showed that 91% of all the Instrument-to-Instrument TOC readings were within ± 0.05 ppb C. Additionally, over 44,000 LOD analyses were performed on the same five analyzers, and 98% of the time the TOC LOD was less than 0.02 ppb C (see Figures 3 and 4). It is notable that this performance is achieved automatically without the need to do manual re-calibration operations or to send the analyzer offsite for special calibrations, as often required by other TOC sensors.

Design enhancements allow the 500 RL^e to operate on higher conductivity waters than the PPT while still delivering the same analytical performance. As a result, the 500 RL^e offers greater versatility and reliability. Specific attention has been paid to performance on low dissolved oxygen (DO) water systems, resolving TOC recovery issues that are problematic for other reagentless TOC analyzers.

applications

Microelectronics Ultrapure Process Waters

The 500 RL^e Analyzer's remarkable Instrument-to-Instrument matching allows you to confidently compare TOC results between different water loops in your factory and around the world. The very high sensitivity, as demonstrated by the LOD, allows you to see the smallest change in your system before it gets out of control.

For the most advanced state-of-the-art chip manufacturing facilities' requirements, there is never a question about unmeasured organics that may be affecting the lithography or another critical process. Because you are measuring all the organics with the 500 RL^e, your facilities engineers are given the best tool to optimize their processes. The top semiconductor companies in the world accept no other options for their critical UPW TOC measurements.

Low DO / Hydrogenated Water Applications

Low DO and hydrogenated water systems are becoming more common in microelectronics applications. Low DO systems present a significant challenge to reagentless TOC analyzers because all reagentless TOC analyzers rely on the process water as a source of oxygen for fully oxidizing the organics in the sample.

In low DO systems, there is insufficient oxygen available to facilitate full oxidation, resulting in artificially low TOC results. If a contamination event occurs, the lack of oxygen may prevent complete oxidation of the organics. Consequently, most analyzers will show little or no change in the TOC value. Only the Sievers 500 RL^e incorporates trace oxygen addition to ensure fully oxidized organics in low DO and hydrogenated water systems. This gives you the ability to see important changes in your water system that other analyzers completely miss (see Figure 2).

robust method

TOC Recovery

The 500 RL^e has been extensively tested to demonstrate comparability to the Sievers PPT Analyzer as well as superior performance relative to competitive TOC technologies.[1,2,3] Figures 1 and 2 show the performance of the 500 RL^e in normal and Low DO systems, compared to the PPT and alternative TOC technologies.

Risk of Simplified TOC Methods

Can you trust the TOC results from your analyzer to provide your fabrication engineers with the best

measurement tools? Simplified TOC methods used in other TOC analyzers expose the water system and fab to contamination risks from compounds that these simplified technologies can not detect. In numerous published studies and technical papers,[1,2,3] these simplified TOC analyzers have been demonstrated to be incapable of reliable performance in waters containing even the simplest organic compounds — compounds known to exist in UPW systems, introduced through the feed waters, resins, system materials, and production processes. The Sievers membrane technology dramatically enhances the ability to detect and manage variations in TOC contamination that can go unnoticed and uncontrolled with older, more simplified TOC sensors.

key features

Economical Designs

The 500 RL^e comes in two models to meet your needs. The 500 RL^e with Standard iOS (Integrated On-Line Sampling System) utilizes the familiar Sievers sample inlet device, allowing for on-site calibration and running standards and grab samples. The 500 RL^e Base Model utilizes a simplified sample inlet block, facilitating continuous on- line operation. On-site calibration may be performed using an optional iOS accessory. The 500 RL^e Base Model is cost-competitive with even the simplest TOC sensors, while still providing superior analytical performance and optional on-site calibration.

Higher Conductivity Limits

The 500 RL^e incorporates design elements from the Sievers 800 and 900 Series that enable reagentless TOC measurement in waters up to 25 µS/cm at neutral pH. Equally as important, this design enhancement means that upsets and abnormal fluctuations in UPW system conductivity from plant transients do not affect analytical performance.

Sensitivity, Accuracy, Instrument-to-Instrument Matching, and Stability

With microelectronic TOC limits being driven ever lower, it is critical that TOC analyzers operate accurately and reliably at sub-ppb levels. The 500 RL^e achieves the lowest detection limit of any TOC analyzer on the market — 0.03 ppb — and provides the confidence that all organics are being fully recovered regardless of chemical composition. The automated advanced TOC zero function provides world class Instrument- to-Instrument matching of ± 0.05 ppb C, allowing you to compare critical differences between water loops at your site or on the other side of the world. The combination of analytical sensitivity, Instrument-to-Instrument matching, robustness, and stable sub-ppb performance provides confidence that critical UPW and fabrication processes are controllable and that even the most subtle trends can be closely monitored to protect your manufacturing processes.

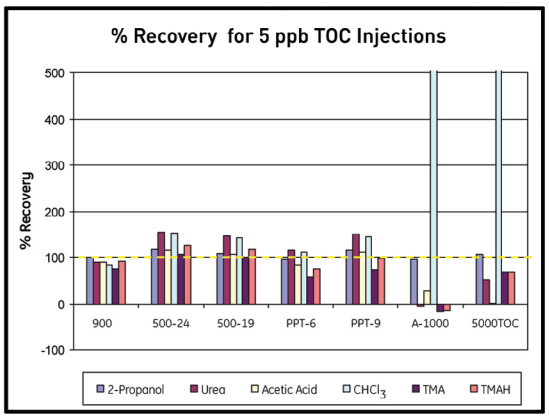

Figure 1. Recovery comparison of Sievers and other brands

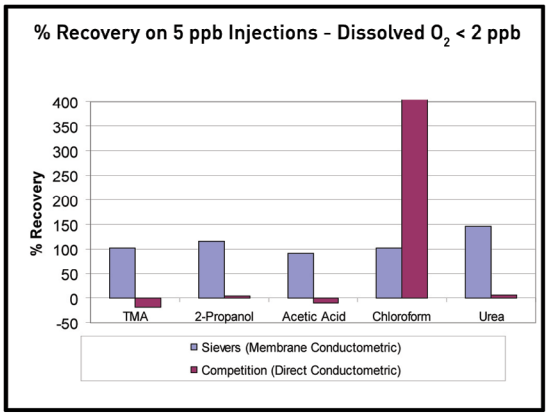

Figure 2. Recovery graph for TOC injections

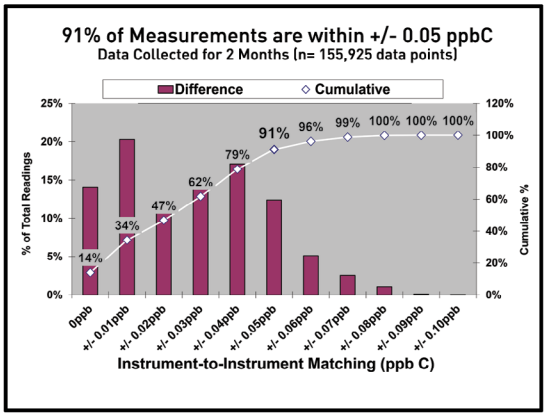

Figure 3. Instrument-to-Instrument study results proving the ± 0.05 ppb C match between five analyzers

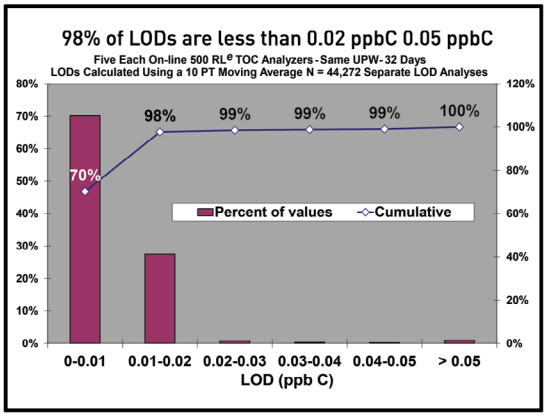

Figure 4. LOD study results proving the 0.03 limit of detection for multiple 500 RL^e Analyzers

system specifications

total organic carbon	
Range	0.03 to 2,500 ppb as C
Accuracy	± 0.1 ppb or ± 5% of measurement, whichever is greater
Precision	< 1% RSD or 0.03 ppb as C, whichever is greater
pH Range	5.5 to 8.0 in order to meet accuracy specification
Maximum Sample Conductivity	25 µS/cm at neutral pH
Analysis Modes	On-Line, On-Line Averaged, On-Line Timed
Analysis Time	Continuous mode: 6 minutes, Average and timed modes: 0.5, 1, 4, 8, or 24 hours
External Flow Rate	Minimum 50 mL/min
Sample Temperature	1° C to 95° C (34° F to 203° F)
Sample Pressure	Up to 100 psig
Interferences	Insensitive to organic heteroatoms and measures organic nitrogen
Calibration Stability	Typically stable for 12 months
Display Readout	3 significant digits

instrument	
Power	100–240 ±10% VAC, 50 W, 50/60 Hz
Normal Operating Environment	Intended for indoor use only
Ambient Temperature	10° C to 40° C (50° F to 104° F)
Maximum Relative Humidity	Up to 95%, noncondensing
Maximum Altitude	2,300 m (7,546 ft)
Inputs	One isolated binary input
Outputs	Three isolated 4-20 mA outputs, one Serial (RS-232),
	one USB port, one parallel printer port, four alarm outputs, and one Ethernet port
Installation/Overvoltage	Category II (protects against transients present in Category II power)
Safety Certifications	ETL, CE
Pollution Degree	2 (normally only non-conductive pollution)
Display	Backlit Quarter-VGA touchscreen display
Dimensions	H: 41.9 cm (16.5 in); W: 48.3 cm (19 in); D: 27.4 cm (10.8 in)
Weight	16.9 kg (37.2 lb)
IP Rating	Environmental enclosure: IP 45

consumables	
UV Lamp	6 months
Pump Tubing (with pump heads)	12 months
DI Water Cartridge	Typically 24 months (depends on water quality)
Inline filter	Replace as needed (depends on water quality)
DI Water Level Refill	As needed (check when replacing other items)

References

1. Godec, Richard D., *"Monitoring and Controlling UPW Organic Nitrogen Con- tamination to Improve Immersion Photolithography Process Control."* Presented at ULTRAPURE WATER Conference, Portland, OR, November 2011, Tall Oaks Publishing, Inc.
2. Godec, Richard D., *"The Performance Comparison of Ultrapure Water TOC Analyzers using an Automated Standard Addition Apparatus."* Published and copyrighted by Semiconductor Pure Water and Chemical Conference, 2000 Proceedings.
3. Kauffman, Jon S.,Ph.D., *"Validating On-Line TOC Analyzers for Real-Time Release."* Pharmaceutical Manufacturing, Nov/Dec 2006.

Hg The UV lamp inside this product contains mercury and must be recycled or disposed of in accordance with local, state, and federal laws.

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