Thornton Monitors Increase Productivity at South Korea Microelectronics Facility

Dissolved oxygen in rinse water can lead to significant losses in semiconductor fabrication. High-performance DO sensors are reassuring a world leading microelectronics company of their water quality.

DO sensors that measure to sub-ppb levels lead to increased productivity

One of the world’s leading semiconductor companies located in South Korea maintains over one thousand loops of dissolved oxygen measurement in their ultrapure water (UPW) system.

The fabrication of semiconductor wafers requires numerous rinse steps with UPW containing very low levels of DO. High levels of dissolved oxygen in UPW are a source of oxidation on wafers. The various deionized water rinse steps require accurate and fast measurement to maintain low DO levels. If DO levels rise above the company’s specified limit, wafers will be damaged and reduce the yield from production.

Analog DO sensors required extensive, costly maintenance

The customer noted that their previous DO system was costly and difficult to maintain, requiring polarization, calibration, reinstallation and lengthy time to stabilize DO measurement. The sensors required a complicated maintenance procedure with a long polarization time. Recalibration could take up to 6 hours per sensor. Maintenance of over 1,000 DO sensors twice per year with electrolyte change, membrane replacement and polarization was costing thousands of dollars and numerous hours on maintenance.

Thornton ISM sensors reduce operating costs

The customer requires a system that is easy to maintain with reduced downtime,
long-term stability with fast measurement response time to assure product quality and continuing high yields. By replacing existing analog sensors with the METTLER TOLEDO Thornton Intelligent Sensor Management (ISM) DO sensors combined with the M300 ISM transmitters, response time is significantly reduced. The new ISM sensors are extremely easy to maintain and exhibit long term stability. In addition, ISM technology provides an intelligent “handshake” between the sensor and transmitter, providing fast, error-free Plug and Measure installation.

The customer specified a DO system that would provide immediate notification of out-of-specification DO levels. The Thornton ISM DO sensors and M300 transmitter provide exactly this, instantaneously identifying the out-of-spec rinsing tool and helping to resolve issues with limited downtime and a lower impact on yield. METTLER TOLEDO Thornton’s high performance long-life DO sensors excel in demanding low-ppb level applications in the microelectronics industry. With calibration data stored in the sensors’ ISM electronic circuitry, the Plug and Measure feature saves significant labor and downtime.

Additional installations
With successful preliminary results, this customer is now converting their DO loops from older analog sensors to the new fast response Thornton DO sensors with ISM. They plan to immediately install Thornton ISM sensors in approximately 80 measurement loops (about 8% of the total installation) with additional installations expected in the future.

If you want to benefit from DO systems that reduce operating costs, go to:

www.mt.com/Thornton-DO

Concerns about DO in semiconductor fabrication
In semiconductor manufacturing, dissolved oxygen is undesirable in pure water for several reasons. In the purification process itself, there is concern that DO contributes to oxidizing ion exchange resins in mixed bed polishers, producing trace contamination downstream. In some processes, DO levels may influence the oxidation of the active silicon surface during rinse steps and this can have an impact on chip yields. High DO levels can support microbial growth in the water system. Changes in DO values can indicate the need for membrane degasifier maintenance or replacement, warning that excessive DO is going to the facility, with the risk of unwanted silicon oxidation and chip defects.

These critical applications require accurate and reliable DO measurement at low concentrations. Thornton’s high performance ppb-level dissolved oxygen measurement capability excels in the most demanding applications. Inherent in sensor design is a precise zero and a highly accurate response over the entire range of measurement. This allows the sensor to perform well at any level in addition to providing very fast response to changes from one oxygen concentration level to another. Intelligent Sensor Management provides digital conversion of the low level signal for increased reliability.

With the advantages of multi-channel, multi-parameter instrumentation and ISM, an operator can combine DO measurements with additional parameters of resistivity, temperature, pH, dissolved ozone and temperature in the same instrument. This is especially convenient when the combination of measurements fills the operating needs of a particular water treatment unit. Combined measurements are also helpful in maximizing the number of measurements in a given panel space, with one user interface, while reducing instrumentation costs and complexity.

For more information visit:

www.mt.com/Thornton-DO
Significant Advance in TOC Analysis
With Intelligent Sensor Management

Thornton’s 5000TOC analyzer detects trace organic contamination levels accurately and swiftly. Now, with the addition of Intelligent Sensor Management (ISM) technology, analyzer performance is improved and maintenance reduced.

Reliable, continuous TOC monitoring
Pure and ultrapure water production requires the monitoring of organic contamination throughout the treatment process. The new Thornton 5000TOC1 sensor provides continuous, fast, and reliable monitoring of TOC levels of reverse osmosis membranes, effectiveness of TOC destruct UV lamps, resin bed performance, organics shedding, and quality of final rinse water. With continuous on-line measurements, the 5000TOC1 sensor ensures TOC excursions will not be missed.

Mix-and-match sensor capability
The M800 transmitter is available in two- or four-channel versions. The two-channel version can accept one or two TOC sensors, or TOC plus one other parameter. The four-channel version can accept up to three parameters in addition to TOC, including conductivity, pH, ORP, dissolved ozone or dissolved oxygen, plus two pulsed flow sensors.

Benefits of the new 5000TOC1 sensor:
- Improves the quality and reliability of calibration with a semi-automated process which ensures consistent results
- Enables predictive maintenance requirements through convenient diagnostics and sensor status with intuitive iMonitor user interface
- Simplifies maintenance processes with in-depth diagnostic data, provided by detailed sensor status screens
- Automated Flow Control improves the reliability of continuous, real-time TOC analysis by eliminating sensitivity to system pressure changes
- Multi-parameter capability integrates TOC measurement with a comprehensive UPW monitoring system with up to four sensors, saving cost and complexity

High-performance TOC detection for microelectronics applications
Semiconductor fabrication processes have some of the most stringent specifications for ionic and organic contamination in pure and ultrapure water systems. Managing and measuring these contaminants in UPW systems has enabled semiconductor manufacturers to improve product quality and maximize yields. Advances in water purification technology and innovations for monitoring these contaminants have played a significant role in improving and measuring the quality of ultrapure water. These advances, in turn, have driven lower specifications for all contaminant levels in UPW systems.

Total organic carbon (TOC) analysis is a powerful technique for monitoring organic contaminants in ultrapure water and the ‘health’ of the UPW system. Over
Total Organic Carbon

the past few decades, TOC limits have decreased by several orders of magnitude, resulting in specifications in the low-parts-per-billion range and moving to the parts-per-trillion detection level.

As future-generation chip technology is projected to reach narrower line-widths, semiconductor manufacturers continue to demand their ultrapure water not only contains ever-lower levels of organic and ionic contamination, but that the instrumentation is capable of accurate, fast detection and response at these low levels of detection.

For more information visit:
► www.mt.com/TOC

What is ISM and why is it important for TOC measurements?
Intelligent Sensor Management (ISM) is a unique technology developed by METTLER TOLEDO to expand sensor performance while simplifying installation, operation and maintenance. ISM technology stores unique sensor identification and calibration information in a digital sensor for immediate recognition to provide fast error-free start up. In addition, measurement accuracy can be enhanced with stored calibration data to ensure the most accurate measurements available.

Maintenance is also simplified with predictive service notifications which allow for preventive maintenance to save time and costs. Dynamic diagnostics tools enhance sensor performance and prevent downtime. TOC analysis with ISM capabilities provides immediate, valuable information to enhance sensor performance with:
- Digital sensing for more reliable measurements
- Simple maintenance and reduced complexity
- Semi-automated calibration
- Automatic flow control
- New diagnostics capabilities
- Simplified compliance data
- Worry-free operation

Find out more at:
► www.mt.com/ISM

Frequently Asked Questions on Total Organic Carbon (TOC)

Water contamination from TOC can lead to significant losses in semiconductor fabrication yields. Therefore, it is essential to monitor TOC levels in fab water systems. Here, we answer some key questions regarding TOC and its measurement.

What is TOC?
Total organic carbon is a term used to describe the measurement of organic (carbon based) contaminants in a water system. Organic contamination can come from a variety of sources, since “organics” are compounds such as sugar, sucrose, alcohol, petroleum, PVC cement, plastic based derivatives, etc.

- Organics may exist in the feed water
- Organics may result from the leaching or shedding of various components within the purification or water distribution system
- Organics may result from the formation of biofilms (bacteria) in the water system

Why are TOC measurements used?
Generally, organic contaminants are non-ionic and as such are not detected by standard conductivity measurements. Therefore, a high resistivity (low conductivity) measurement may not provide an indication of TOC level in an ultrapure water system. High levels of TOC can degrade water purification systems and reduce wafer yields.

How is TOC measured?
TOC can be measured both on and off-line. Off-line measurements (lab methods) are typically used for high concentrations (> 1 ppm). On-line measurements are
typically used for sub-ppm (< 1000 ppb) detection and exhibit quicker response than lab methods. Most of the industries Thornton serves use online measurements for the faster response, which is required for process control.

Where is TOC measured?

- After reverse osmosis to monitor membrane efficiency (especially where Thin Film Composite membranes are used)
- After deionization beds to monitor resin life and efficiency and to monitor shedding from new resins
- After the final polish to ensure low organic levels have been maintained after storage of pure water in tanks
- On recycle (return of wet bench discharge waters) and reclaim (reusing discharged waters in secondary applications outside the fab) lines to ensure proper, low organic levels before return to the water system
- After TOC destruct UV lamps to monitor UV light efficiency
- Before the point of use distribution lines to ensure final water quality.
- On boiler feed water to prevent damage to turbines and other equipment

Are TOC measurements with continuous flow better than batch process TOC measurements?

Yes. A TOC analyzer, which measures continuous flow, can “see” the whole representative sample of organics in the water system. Much like a movie with continuous frames, a continuous flow does not miss a frame or a TOC excursion. However, a batch process is like a single frame photograph that takes a “snapshot” of the system. If “snapshots” are taken periodically, TOC excursions can be measured erroneously, as in a portion of an excursion where the magnitude of the excursion is missed, or an entire excursion may be missed altogether! If a batch process TOC unit has a response time of 5 minutes or 30 minutes, significant and important information may never be identified until it is too late.

What is response time vs. update time?

- Response time: The time it takes for the organics in water to be oxidized and measured in a TOC analyzer. This is the time water takes travelling from the analyzers first conductivity sensor, through the spiral quartz tube where oxidation of the organic contaminants by UV light takes place, to the second conductivity sensor, and then to process the TOC measurement. The response time for the 5000TOCi analyzer is less than a minute.
- Update time: The time it takes to update a measurement. The update time for the 5000TOCi is 2 seconds

What maintenance is required for the 5000TOCi?

- The 5000TOCi requires replacement of the UV lamp and TOC calibration every 4500 hours (6 months) of continuous operation
- The 5000TOCi should be fully calibrated on an annual basis
- TOC/resistivity calibration can be performed at the factory or in the field by a Thornton technician

Find out more at: [www.mt.com/TOC](http://www.mt.com/TOC)
METTLER TOLEDO Thornton introduces new cutting edge technology providing increased performance and higher accuracy for conductivity/resistivity measurements over a vastly wider range. The same robust titanium sensor can now operate in all stages of water treatment, without compromising sensitivity, reliability or accuracy.

**Unified, universal and ultimate solution**

Thornton, the technology-leading experts in conductivity/resistivity measurements, recognized these limitations and has made significant improvements in conductivity/resistivity sensor and measurement technology. Our engineers have developed a miniaturized measuring circuit that is embedded in the head of the sensor and sends a robust digital signal to the transmitter. This unified design reduces the effective wiring distance between the sensor and the measuring circuit to just a couple of centimeters. Without the effects of long cable capacitance and resistance, more sophisticated measuring techniques are possible. Leadwire effects are thus negligible, and electrochemical factors and sensor polarization affecting the measurement can be dealt with more directly to improve the sensor measurement range. Measurement from ultrapure water to seawater up to 50,000 μS/cm can now be made with a single UniCond sensor with excellent accuracy.

**Limitations of conventional sensors**

Conventional conductivity/resistivity measurements, especially with analog sensors and transmitters, are limited by the effects of sensor polarization in higher conductivity waters, transmitter errors and by interference from cable impedance and capacitance. This results in the need to utilize two or more sensors with different cell constants to cover the range from seawater, raw water, reclaimed or recycled waters through the purification stages to ultrapure water. Consequently, the use of multiple sensors, additional spare parts and fittings is required, which introduces the possibility of installation of an incorrect sensor for the application. Also, with conventional sensors the user must remember to manually enter the precise cell constant and temperature calibration data for each individual sensor into the transmitter’s memory to achieve rated accuracy.

In addition, conductivity/resistivity sensors are typically located at a considerable distance from the transmitter and control panel, resulting in accuracy errors caused by analog sensors and cable capacitance. Over the years, Thornton has optimized the wiring and signal handling to minimize cable capacitance and resistance effects so that accurate measurements are provided. Nevertheless, these multiple effects result in reduced accuracy and limitations in measurement range.

Covering the entire range of most water treatment systems, the UniCond sensor is universal and simplifies specification, documentation, installation, wiring, operation and ordering of spare parts. Now, just one spare part – the UniCond digital sensor – is required to cover a very broad measurement range.
Intelligent Sensor Management provides Plug and Measure convenience

UniCond sensors utilize METTLER TOLEDO’s Intelligent Sensor Management (ISM) technology. One of the many advantages of ISM is that sensors maintain precise factory calibration data, as well as sensor identification, serial number, etc. in the sensor’s internal memory. This enables simple Plug and Measure installation, eliminating manual data entry and any chance of operator error at startup.

When ISM sensors are used on the new M800 multi-parameter transmitter platform, the operator can access multiple features which monitor the sensor and provide information such as the Dynamic Lifetime Indicator, Time To Maintenance and Adaptive Calibration Timer. This intelligent diagnostics data allows real-time monitoring of sensor condition and provides valuable information for predictive maintenance and scheduled calibrations, thereby reducing downtime and service costs. The METTLER TOLEDO Thornton ISM conductivity/resistivity digital sensors and transmitters are the only digital measurement loop that allows for calibration of the sensor and the transmitter in the field, another breakthrough developed by Thornton engineers.

For more information, go to: www.mt.com/UniCond

Best Practice

On-line measurement means optimized production and lower operating costs

The continuous stream of data that on-line measurement provides lets you know that your processes are working as they should and informs you the instant that they are not, helping you to maximize production and reduce operating costs.

Discover more at: www.mt.com/Thornton
Ensuring DI Water Quality With Thornton Resistivity Sensors

Critical wafer cleaning recipes demand deionized water with low resistivity. A manufacturer of spin rinse-dryers uses Thornton sensors for this critical measurement due to their “consistent, reliable performance.”

Superior spin rinse-dryers
OEM Group East, Inc. in Coopersburg, Pennsylvania, USA (part of OEM Group headquartered in Gilbert, Arizona) manufactures high-performance spin rinse-dryers used to remove residual chemicals during the wafer fabrication process. Integrated into the units are Thornton sensors with measurement circuitry that communicates to a programmable logic controller to monitor the resistivity of deionized water used to clean wafers from 50 to 300 mm.

Thornton sensors provide accurate dependable results
During the cleaning operation, wafers are loaded into a cassette, placed onto a stainless steel rotor, and rotated at high speed so that centrifugal force locks them in place to prevent movement and subsequent particle production. Unlike early generation time-only rinse methods (typically lasting 4 to 8 minutes), the control system continually monitors resistivity between 12 and 17 MΩ. Once the preset measurement is achieved, cassettes are heated in a nitrogen atmosphere, ensuring residual chemicals are removed prior to proceeding to the next recipe step.

According to engineering manager Robert Werner, “These rinse-dryers provide a simple processing operation, however they are used in critical-path fabrication steps such as lithography, etching, and plating. We have found Thornton resistivity sensors to provide consistent, reliable performance in spin-rinse systems installed in wafer fabs around the world.”

Why measure resistivity?
Resistivity is the primary measurement of mineral contamination in water. As an on-line measurement it provides inexpensive, reliable monitoring of water quality through various stages of treatment. The technology for resistivity measurement has advanced through generations of analog and microprocessor-controlled measuring circuits to provide improved accuracy and temperature compensation. Sensor enhancements also include on-board memory that stores and communicates complete sensor identification and calibration data to the readout instrument for simplified startup and calibration. This same capability is also available for related parameters of pH, dissolved ozone and dissolved oxygen.

The primary requirement of measuring resistivity in UPW is the instrument’s ability to detect ionic impurities at very low concentrations. Today’s water systems produce UPW with part-per-billion ionic impurities, thus requiring accurate, repeatable measurement sensors. Thornton technology leadership is based on an intimate knowledge of critical ultrapure water measurement technology and extensive application expertise. Thornton has developed world-class technology in the parameters of TOC, pH, dissolved oxygen and dissolved ozone measurement to meet the demanding requirements of the global microelectronics industry.

For more information about Thornton pure water resistivity sensors, visit: www.mt.com/pro-micro

UniCond sensor
Keep Up-to-Date
New Microelectronics Competence Center

Thornton is dedicated to continuous improvement in producing instruments for the detection of impurities in microelectronics facility water systems. A new online resource keeps you informed as to our latest developments in monitoring and measuring pure water.

Essential monitoring of high purity water
The microelectronics industry requires large quantities of ultrapure water in production processes. Cleaning, rinsing and etching of wafers and substrates consumes thousands of cubic meters of UPW per day in a typical facility. Process analytical measurements are vital to optimize water usage and maximize recovery and reuse.

METTLER TOLEDO Thornton offers an extensive range of analytical instrumentation specially designed for use in the most demanding microelectronics processing applications. Thornton offers superior solutions for monitoring resistivity/ conductivity, TOC, pH, ORP, dissolved oxygen, dissolved ozone and sodium to increase the volume of water recovered, limit discharge and reduce processing costs.

The latest information
METTLER TOLEDO recently launched a new online resource for ultrapure water used to manufacture microelectronics. Learn more about in-line measurement solutions featuring the unique Intelligent Sensor Management (ISM) concept for Plug and Measure convenience in analytical measurement.

Resources in this competence center include instruments for monitoring and measuring ultrapure water used to manufacture semiconductor wafers, photovoltaic cells and flat panel displays.

■ Photovoltaic cells – Thornton enables photovoltaic manufacturers to improve product quality and maximize yields by providing innovative measurement and monitoring solutions for critical etching/texturing, cleaning and rinsing operations. Our in-line measurement solutions for UPW in a modern PV cell production facility include resistivity/conductivity, TOC, pH, ORP, dissolved oxygen and dissolved ozone.
  ➤ [www.mt.com/pro-pv](http://www.mt.com/pro-pv)

■ Flat panel displays – Thornton offers the flat panel production facility accurate and continuous real-time measurement solutions for resistivity/conductivity, TOC, pH/ORP, dissolved oxygen and dissolved ozone in order to increase yield from make-up and ultrapure water to water reuse, recycle and reclaim.
  ➤ [www.mt.com/pro-fpd](http://www.mt.com/pro-fpd)

■ Semiconductors – Thornton has in-depth knowledge of the critical measurements needed for semiconductor processing and ultrapure water production. Thornton instruments for resistivity/conductivity, TOC, pH, ORP, dissolved oxygen and dissolved ozone are specified to monitor and control UPW systems in the majority of semiconductor manufacturing facilities worldwide.
  ➤ [www.mt.com/pro-semi](http://www.mt.com/pro-semi)

Visit the new microelectronics competence center “In-line Measurement Solutions for UPW in Microelectronics” at:
  ➤ [www.mt.com/pro-micro](http://www.mt.com/pro-micro)
Predictive Maintenance
Intelligent Sensor Diagnostics

The multi-parameter, multi-channel M800 transmitter platform covers all major measurement parameters in one instrument. Intelligent Sensor Management (ISM) technology offers predictive diagnostics for proactive maintenance.

The M800 transmitter for ISM digital sensors incorporates a highly intuitive user interface, expanded measurement parameters and, most significantly, diagnostic maintenance capabilities.

iMonitor is an advanced sensor diagnostics utility. It anticipates maintenance intervals based on real-time sensor performance information rather than sensor failure alarms or imprecise estimates.

iMonitor evaluates each sensor’s condition and calculates remaining sensor (or integrated consumable) lifetime to predict when service or replacement will be necessary. The number of days until maintenance should be performed is displayed on the M800 with a red, yellow or green indicator bar, providing at-a-glance information based on traffic light color coding.

www.mt.com/M800

Your benefits

Intelligent diagnostics
With its unique iMonitor predictive diagnostics functionality, based on METTLER TOLEDO’s ISM technology, the M800 tells you not only what is wrong with a sensor but how to fix it – before an issue arises.

Multi-parameter and multi-channel
The M800’s multi-parameter abilities gives you greater flexibility, less complexity, and less training and inventory. Two- and four-channel models provide multiple measurements from a single unit.

Color touchscreen
The color touchscreen provides simple, convenient operation. Just touch and follow the intuitive user interface.
M800 multi-parameter, multi-channel transmitter
New Water Calculator App for Mobile Devices

A new water calculator application for smart phones and mobile devices enables water specialists to perform water calculations and unit conversions using an iPhone®, iPod touch®, iPad®, or Android™-compatible smart phone or mobile device.

This FREE application calculates:

- Conductivity, resistivity and total dissolved solids (TDS) conversions
- Flow and flow velocities for various pipe sizes
- Temperature versus resistivity and conductivity of ultrapure water
- Sample and process flow rate unit conversions
- Temperature conversion between °C and °F

For more information, visit:

► www.mt.com/pro-watercalc
► www.mt.com/Thornton