Achieving Sustainability and Positive ROI with UPW Reclaim and Reuse

The cost of UPW production and environmental considerations means simply discharging wastewater is not acceptable. Adopting reclaim/recycle/reuse strategies can recover up to 85%. Process analytical measurements are the key to maximizing water recovery efficiently and economically.

The need for recycling
Modern microelectronics fabs are dependent upon a continuous flow of UPW for normal operations, requiring 500 cubic meters per hour or more to manufacture product. Each new fab uses 4,000 to 12,000 cubic meters per day just for wafer processing. As the industry continues to expand and develop more advanced technologies, an even greater burden is placed on limited water, sewer resources and local water infrastructure.

The cost of producing this water, both in capital expenditure and discharge costs, is continually rising as worldwide fab capacity expands and electronics technology improves. The solution to these technical challenges is to reprocess the water, allowing recycling or reuse in the same or another process within the facility.

Fab managers are increasingly aware of the value of reclaim/recycle/reuse and limited discharge, especially with an ultrapure water system. For example, every 1 US$ worth of water purchased by a semiconductor manufacturer requires at least 20 US$ to bring it to UPW levels, and a further 10 US$ to treat it for discharge.

Continuous monitoring and measurement of UPW is critical
The only cost-effective, long-term solution for efficient fab management is continuous measurement, control and proper segregation and collection of waste rinse waters as part of the implementation of a true recycling strategy.
Manufacturing semiconductor wafers necessitates ultrapure water with extremely low levels of contaminants, requiring accurate measurements with specialized temperature compensation algorithms to obtain high accuracy. The semiconductor fabrication process requires large volumes of UPW plus considerable quantities of chemicals, generating significant volumes of wastewater.

Most of the water consumption is for processes such as chemical mechanical planarization, lithography, wet etch, stripping, wafer cleaning and back grind, which produce a wide and continually varying wastewater stream. Wide disparities in pH, dissolved oxygen, conductivity/resistivity, TOC, dissolved and suspended solids and metallic contamination present major challenges for facilities treating this wastewater. The wastewater requires proper treatment and continuous monitoring of a variety of analytical parameters to ensure effective reclaim/recycle/reuse for the facility or to meet environmental discharge requirements.

Leading fabs implement strategies obtaining up to 85% reuse

Recycled water in the microelectronics industry is the reuse of water that had previously been purified to an extremely high quality level and used for wafer processing. After use, it is collected, retreated and reused to process wafers. The SIA National Technology Roadmap for Microelectronics has identified water use reduction as one of the top three technical challenges in microelectronics environmental safety and health. In fact, the SIA cites water usage problems as a major contributor to limitations in the selection of fab location and size for certain geographic regions.

Currently, some facilities have water recovery rates as low as 10–20%, while others are recovering more than 40%. However, most leading global corporations have implemented strategies to increase reclaim/recycle/reuse to over 80%. In locations with strained water resources such as southwest U.S., Taiwan, Singapore and Israel, serious questions are being raised about the long-term viability of microelectronics manufacturing. In reality, it is now possible to achieve typical wastewater reclaim/recycle/reuse rates up to 85% for a wafer fab or foundry. The current challenge is to achieve those levels in the 300-mm wafer foundries employing reduced linewidth architecture.

Improved efficiency and lower costs for UPW

In today’s business environment there are several compelling reasons to implement reclaim/recycle/reuse:

- **Financial performance**
  UPW is expensive to produce; reclaim/recycle/reuse provides a positive return on investment

- **Environmental performance**
  Water reuse and other green engineering technologies promote sustainability for the microelectronics industry

- **Community relationships**
  Reclaim/recycle/reuse demonstrates awareness of the importance of water to the local community

The primary strategy for reuse is to match water quality available with water requirements in the fab to reduce overall water consumption. Water conservation can be...
characterized in at least three different categories:

- Improve the efficiency of UPW systems
- Reclaim or recycle water used throughout the system
- Design for the environment (design water waste out of the production process)

METTLER TOLEDO has intimate knowledge of critical measurements needed for ultrapure water production. Our instruments are specified in the majority of semiconductor manufacturing facilities worldwide to monitor and control ultrapure water systems. Thornton analytical measurements include conductivity/resistivity, TOC, temperature, pH, ozone, ORP and dissolved oxygen to provide microelectronics facilities with critical sensors designed to continuously measure and control, while enabling an increase in the volume of water reclaimed for other uses.

Using a multi-parameter measurement system, a single instrument platform can provide input capability for analytical (conductivity/resistivity, pH, dissolved oxygen, TOC) as well as physical (flow, pressure, level, temperature) and electrical (voltage, current for CEDI) parameters. A new multi-parameter platform uses UniCond conductivity/resistivity and other sensors with Intelligent Sensor Management (ISM) that automatically communicate their identity and calibration data to the transmitter as soon as they are connected. The multi-parameter concept provides flexibility in signal handling, much like a programmable logic controller.

**Reduced processing expenditure**

The microelectronics facilities of today are upgrading to the latest in analytical control technology to increase the volume of water recovered, limit discharge and reduce processing costs. In real-time control of the reclaim/recycle/reuse process, Thornton’s multi-parameter ISM transmitters and UniCond conductivity/resistivity, pH and TOC sensors provide the accuracy and control technology required by global microelectronics leaders.

Find out more at:

- [www.mt.com/UniCond](http://www.mt.com/UniCond)
- [www.mt.com/5000TOC](http://www.mt.com/5000TOC)
Touch the Future of Multi-parameter Analysis

Innovation has always been central to success. For our customers, our developments have meant more reliable processes and improved productivity. Years of refining universal transmitters and digital sensor technology have now led to our most advanced measurement system yet.

Built-in Intelligence
If you do not move forwards, you go backwards. The history of Mettler-Toledo Thornton can be mapped by our product innovations; two of these being multi-parameter transmitters and Smart Sensing technology which allow fast and simple commissioning of measurement systems.

The next generation of Smart Sensing, Intelligent Sensor Management (ISM), is embodied in the new M800; a touchscreen-enabled, multi-parameter process analytical transmitter.

ISM digital technology is integrated into a “press and go” measurement platform which features unique sensor diagnostics and predictive maintenance features for applications in the microelectronics industry. Multi-parameter measurement is ideally suited for microelectronics facilities where precise measurement of total organic carbon (TOC), dissolved oxygen (DO), resistivity and temperature compensation of ultrapure water are critical.

M800 with iMonitor – knowledge is power
The M800 transmitter for ISM digital sensors brings intelligence to Smart Sensing and 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.

Typically, measurement systems show counters or error code messages that must be retrieved and manually interpreted from a user manual. The M800’s iMonitor displays diagnostic conditions in real time, informing the user of a potential problem with actionable information, rather than communicating with a cryptic warning symbol or incomprehensible error message. The specific diagnostic information displayed with iMonitor confirms the old adage that knowledge is power.

Dynamic Lifetime Indicator: The DLJ estimates in real time the remaining lifetime of the sensor. A unique algorithm uses actual and historic measurement and calibration values to calculate a real-time lifetime indicator.

Adaptive Calibration Timer: Based on sensor behavior, the ACT predicts the time until the next calibration will be needed.

Time to Maintenance: TTM indicates when maintenance will be required.
Multi-parameter measurement is the industry standard

Multiple measurement parameters include conductivity/resistivity, TOC, pH, ORP, DO, dissolved ozone and flow, accessed from one universal transmitter – a Thornton innovation. Today, this approach is becoming common in process instrumentation because the multi-parameter platform brings significant added value to users.

ISM-equipped, multi-parameter transmitters communicate directly with ISM sensors via firmware handshake. Upon successful recognition, information from the sensor is uploaded to the transmitter, which automatically configures itself to measure the particular parameter. This Plug and Measure functionality means, for example, that a four-channel transmitter can measure four of the same or different parameters depending on the sensors installed for the application, without the need for time-consuming setup. Multi-parameter transmitters offer more flexibility, less system complexity and simpler inventory. Now, you need order only one model of transmitter for your process analytics needs.

Digital ISM sensors

New ISM sensors bring advanced digital sensing advantages to the Thornton portfolio. Digital sensing means the measurement electronics are seamlessly integrated within the sensor itself, eliminating vulnerable transmission of analog signals between sensor and transmitter.

With ISM technology, a robust digital signal is sent to the transmitter via standard communication cables, incurring no signal loss due to cable capacitance, insulation leakage or interruption from potential electrical interference sources within a facility. This results in more reliable measurements with less possibility of signal interruption or data loss that could cause critical process alarms or unanticipated downtime. Furthermore, because all measurements and calibrations are contained within the sensor, higher measurement accuracy is achieved.

Complete control at a touch

The large, high-resolution color touchscreen simplifies all transmitter operations. The freely programmable display of up to eight measurement values and diagnostics information on one screen provides all vital information at a glance. Fully tailorable wizard set-up allows you to reach any menu function in only three touches. This revolutionary concept reduces training effort and configuration failures to an absolute minimum.

Better by design

The combination of predictive diagnostics, multi-parameter measurement capability, touchscreen operation, digital sensing, and Plug and Measure functionality means the M800 with ISM sensors is the most powerful, adaptable and user-friendly analytical measurement system Mettler-Toledo Thornton has yet produced.

Discover more about the M800 and ISM at:
www.mt.com/M800
www.mt.com/ISM
Precise Flow Measurement

in particular, require the transport of UPW, or often UPW combined with other high purity liquids. In many cases, these liquids are raised to extreme temperatures (close to 100 ºC) to increase their effectiveness. In this instance, flow instrumentation directly affects wafer tool performance. For the tool to be most effective, and operate economically, dispersion of these liquids needs to be carried out with accuracy, precision and repeatability. This ensures a consistent process and demonstrates the quality of both the process and the tool.

Therefore, flow component selection is a critical part of the tool design process. Tool manufacturers will perform in-house testing prior to deciding on one flow device over the next, as they do for other components. They design a limited number of standard systems, customizing them to the specific needs of their customer. A number of these key manufacturers have selected Thornton’s PFA vortex flow meter as their sensor of choice.

The PFA vortex flow meter used in these wafer tools measures fluids under unique dynamic and chemically challenging conditions. The PFA vortex flow meter has many characteristics that make it the best choice for this application.

Long life, low maintenance

The PFA vortex flow meter body is constructed of molded virgin PFA (perfluoroalkoxy copolymer resin). This material has excellent thermal properties and, with the exception of fluorine at elevated temperatures, is extremely resistant to chemical attack. These properties make this material ideal for wafer tool applications.

The physical design of the flow meter body has no internal moving parts. This feature supports the extended service life and low maintenance desired by the tool manufacturer, and eliminates a potential source of particulates in the water system. The molded bluff body alters the flow stream, creating the vortices needed for flow measurement, while minimizing pressure loss. The ultrasonic transmitter and receiver are located opposite each other, adjacent to the outside wall of the flow body. The frequency of vortex creation at the bluff body is proportional to the flow velocity; as the velocity changes so does the vortex frequency, and so does the signal received by the ultrasonic flow receiver.

Discover more at: www.mt.com/Thornton-flow
Low dissolved oxygen limits
A large U.S. water treatment provider maintains the 100 GPM (380 LPM) ultra-pure water treatment system for a high level semiconductor research and production facility in California. In addition to complete deionization, the treatment system includes dual train membrane degasifiers to remove virtually all dissolved oxygen. Degasifier performance is monitored by measuring the dissolved oxygen concentrations at the inlet (near 700 ppb) and at the outlet (at only 0.0 – 0.5 ppb). In fact, outlet DO concentrations are so low that the user implemented a specialized zero calibration technique using high purity 99.999% nitrogen gas as the standard.

DO measurement enhances security
Changes in DO values can indicate the need for membrane degasifier maintenance or replacement as well as a warning that excessive dissolved oxygen is going out to the facility which could cause unwanted silicon oxidation and microchip defects. The system originally included expensive, high-maintenance instrumentation from another supplier to make these measurements.

In the evaluation of the Thornton high performance DO instrumentation in this system, a discrepancy was noted between measurements on the outlet of the degasifier. After several checks and moving sensors between locations, it was concluded that the original instrumentation was giving large errors, erroneously indicating acceptable low DO at the outlet though it was actually very high. The Thornton equipment was reading correctly at all locations. In fact, one of the degasifier membranes was faulty and had been allowing high DO water out to the system for some time.

Since then the treatment system has been upgraded with two Thornton multi-parameter transmitters with two high performance DO sensors on each. They monitor the inlet and outlet of both membrane degasifiers. Instrument maintenance requirements have been reduced with the Thornton sensors and now call for routine calibration at three-month intervals and probe membrane cartridge and electrolyte replacement annually, if needed. The simple probe maintenance (which greatly reduces the chances of errors in cleaning, treatment and re-assembly experienced with the old probe) plus the track record of excellent performance with the Thornton equipment, has greatly boosted the confidence in DO readings at this site.

If you need accurate DO measurement at your facility, go to:

www.mt.com/Thornton-DO
The Information you Want
is at www.mt.com/pro

The new-look METTLER TOLEDO Process Analytics website contains a vast amount of up-to-date information on all our products and services.

Content is localized for your country and tailored to suit your selections.

Simple layout allows you to quickly find the information and features you are looking for.

- Learn about our most recent product developments
- Register for free webinars
- Request further information on products and services
- Obtain a quote quickly and easily
- Download our latest white papers
- Read case studies relevant to your industry
- Access buffer and electrolyte solution certificates
- and more...

The home page has been designed to get you quickly to the products and news you are interested in.
**Product pages** provide a product overview and quick access to all important details and documentation.

**Application pages** help guide you to the products that are right for your processes.

- Read the latest product news
- Access our newsletter archive
- Find out when our next trade show or exhibition is in your area
- Register for free webinars presented by our industry experts
- Download our white papers
One Transmitter for Multi-parameters for TOC, pH, Conductivity, DO …

Thornton solution

Mettler-Toledo Thornton is the market leader in critical ultrapure and pure water analytics.

Our 770MAX instrument is a multi-parameter meter with a broad range of measurement sensor options.

The in-line 5000TOCe rapidly detects organic contamination in real time.

As well as TOC, Thornton produces sensors for monitoring pH/ORP, DO₂/DO₃, conductivity, flow and pressure.

- 770MAX multi-parameter transmitter
- 5000TOCe sensor for continuous Total Organic Carbon measurements
- pH for ultrapure water applications
- 2-electrode and 4-electrode conductivity sensors

Wide range of instruments for your processes …
One Transmitter for Multi-parameters
for TOC, pH, Conductivity, DO …

Wide range of instruments for your processes …

Thornton benefits

■ All-in-one supplier with sensors for all your pure water analytics needs

■ Multi-parameter transmitter saves panel space and lowers costs per parameter

■ 5000TOC allows a real-time TOC measurement, in-line, all the time

■ No gases or reagents to handle, store or replace for TOC sensor; absence of moving parts minimizes routine maintenance

■ Smart Sensor technology offers “Plug and Measure” communication from sensor to transmitter

■ Sterilizable sensors designed for exceptionally long lifetime
New Conductivity System for More Reliable Data

Introducing UniCond with Intelligent Sensor Management (ISM) for the M800 transmitter. This next generation conductivity system from Mettler-Toledo Thornton features Plug and Measure for simple installation and real-time process control. ISM sensors communicate digitally, providing more reliable up-to-the-second process measurement data in addition to sensor diagnostics for managing and maintaining optimum sensor performance.

www.mt.com/M800