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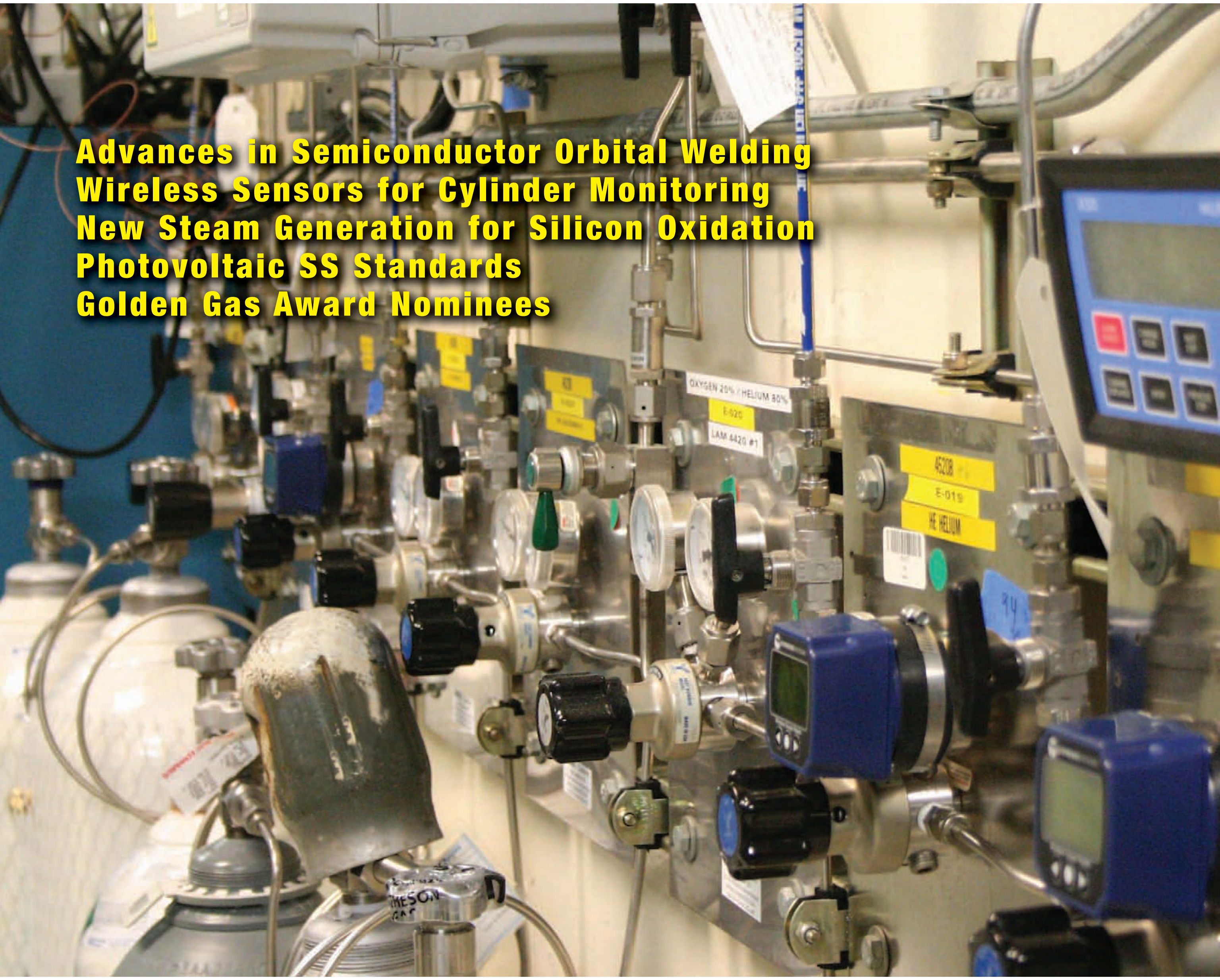

Advances in Semiconductor Orbital Welding
Wireless Sensors for Cylinder Monitoring
New Steam Generation for Silicon Oxidation
Photovoltaic SS Standards
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Reducing Costs Using Wireless Sensors for Cylinder Monitoring: A Case Study

By Paul Nesdore

How non-invasive sensors can monitor key cylinder characteristics such as pressure and weight to reduce downtime and man-hours

The Challenge

Micrel owns a 150mm fab with a capacity of 30,000 wafer starts per month. The fab was constructed in the 1980s and is considered a legacy fab without the full benefits of current automation technology.

The company constantly assesses technology upgrades to reduce cost and improve productivity in order to keep their competitive edge. Managing the use of process gases, which is labor intensive and prone to gas shortages and/or waste, was identified as a key area of potential improvement.

The Solution

To prevent shortages and waste from occurring, Micrel installed new automation technology that did not incur disruption to ongoing processes and required minimal installation cost. The solution was a non-invasive wireless sensor which "clips-on" to existing gauges and/or transducers.

Background

As new semiconductor fabs continue to be built globally, there are over a hundred mature fabs in the United States and many more worldwide that are still the workhorses of the industry. These legacy fabs are often twenty years or older, and produce millions of chips for a huge array of electronics every day. While many newer fabs have automation features built in to enable peak efficiency and performance, older fabs seek new solutions to increase productivity, reduce downtime, and decrease operating costs.

Micrel is such a company. Located in San Jose, California, Micrel manufactures product for the analog, Ethernet and high bandwidth markets. The company manufactures high performance analog, power, advanced mixed-signal and radio frequency semiconductors, high speed communication, clock management, and Ethernet switch and physical layer transceiver integrated circuits. End markets served include cell phones, portable and enterprise computing, enterprise and home networking, wide area and metropolitan area networks and industrial equipment. Founded in 1978, Micrel has been profitable for 25 of its 26 years with revenues of $280M and regional sales and support offices, distributors and technology design centers throughout the Americas, Europe and Asia.

Gas Level Monitoring

For Micrel, it is critical to minimize unplanned downtime at its core San Jose 150mm fab. At this facility, which has a capacity of 30,000 wafer starts per month and houses 500 semiconductor manufacturing tools, wafer production requires hundreds of process recipes that use various combinations of gases to produce the desired chips. It is critical that the required gases are provided for each wafer process step or the output will be unusable resulting in system downtime. Semiconductor production hinges

Figure 1. A typical Micrel gas cylinder area

Figure 2. Non-invasive mounting for wireless gauge reader

on the availability and regulation of these gases. The gases, supplied by about 300 different cylinders (Figure 1), are a precious commodity, ranging in cost from $800 to $17,000 per cylinder.

For years, like many older fabs, monitoring gas cylinder levels has been a manual process. At Micrel, once every 12-hour shift, an employee armed with a clipboard has to walk to each gas cylinder location and manually check the pressure regulator gauges and/or the weigh scale depending on the gas type. This process takes about four hours each time or about eight labor-hours per day. By 2001, a bar code system was employed to identify each gas cylinder, but an employee was still required to manually read and record each data point, so the process was labor-intensive and error-prone.

In addition to monitoring gas levels manually, to further reduce risk of low or empty cylinders, gases were typically replaced on a regular schedule— which meant that a given cylinder might be changed out even if it is a quarter or even a third full. Despite these precautions, gas supply disruptions still periodically occurred due to unforeseen circumstances (e.g. cold weather impacts which can condense a gas) and were not discovered with the manual rounds. Such disruptions often resulted in lost yield and process downtime, which translated into additional operational expense.

As these gas and downtime related expenditures continued to add up year after year, it became clear that this situation needed to be addressed. Operations management needed to find new ways to better utilize manpower, ensure gases were expended before replacing bottles, and proactively detect situations that could cause downtime.

	Wireless Gauge Reader	Wired Transducer
Process Downtime (Est)	$0	$1,000
Transducer/Sensor	$1,200	$300
Installation/Wiring Labor, Materials, Design	$50	$1,500
Bring legacy system up to the present day safety/fire codes (where applicable)	$0	$1,000
I/O Panel Termination	$0	$200
Total Cost (per point)	$1,250	$4,000

Table 1.Comparison of installed cost-per-point for traditional transducers vs. wireless gauge readers

	Annualized Savings
Labor Savings: One Full-time equivalent technician	$95,000
Gas Savings: 10% of gas usage	$80,000
Reduced Downtime: $5,000 per incident, avg. 8 per year	$40,000
Total Savings Per Year:	**$215,000**

Table 2. Savings from wireless gauge reader and wireless transducer reader

Cost per point for WGRs	$1,250
Number of Points installed	100
Total Cost of WGR Systems	$125,000
Payback period (based on annual savings of $215,000)	***7.0 Months***

Table 3. Payback Analysis for Wireless Gauge Reader and Wireless Transducer Reader

Evaluation of Traditional Automation Solution

Micrel considered replacing manual gauges with all-new transducer-based gas panels, which would automate the monitoring of gas levels. However, making this change would require Micrel to stop the affected production line for up to a few days or even weeks while it reconfigured gas piping and retested for leaks and safety. This could also involve a much larger rework of the entire wiring system to conform to the latest safety and fire codes when a legacy subsystem is significantly modified.

Micrel chose not to implement this solution due to the prohibitive cost of the equipment, the installation and rework labor, and most of all, the associated downtime and lost production, which altogether approached $4,000 per gas cylinder (or more than $400,000 to change 100 cylinders).

The Cypress Envirosystems Solution

In 2007, Micrel learned of new wireless gauge reader and wireless transducer reader technologies from Cypress Envirosystems that provide automated gas cylinder monitoring without the high cost and disruption of installing traditional transducer-based panels. The wireless gauge readers non-invasively "clip" onto the front of the legacy manual gauge, and transmit the reading wirelessly to a central server (Figure 2). Similarly, the wireless transducer readers simply attach to existing gas weigh scales without the need to remove or replace the scale. Pre-set alarms of low gas levels may be programmed to alert operator stations, pagers, or cell phones. (See sidebar for an explanation of this technology)

Micrel decided to implement the wireless solution because it incurred no process downtime, required minimal installation labor and training, and did not need retesting for leaks and revalidation. The installed cost of $1,250 per point (or $125,000 to change over 100 cylinders) is just 35% of the cost of traditional transducer panels (Table 1).

Benefits

In the fall of 2007, Micrel decided to install a mix of 100 wireless gauge readers and wireless transducer readers to monitor its most critical process gases, along with the Cypress Envirosystems' Blue Box Receiver, which sends the data to Micrel's existing network and operator stations. Each data point required between 10 and 30 minutes to install, and did not involve breaking any pressure seals anywhere in the gas system or any process downtime. Additionally, future integration of the data with existing operator software is also possible via industry standard OPC and/or BACNet protocols. Within the first two months of operation, the following benefits were identified:

- Reduced the manpower devoted to making gas rounds by one full-time equivalent technician, who could then be redeployed to other tasks.
- Decreased gas consumption by approximately 10% annually, by using more gas in each cylinder before change-out
- Minimized unplanned downtime (e.g. the system detected loss of gas pressure/gas condensation due to unseasonably cold weather—a situation which can now be anticipated and avoided in the future).

The combined operational savings are estimated to be in the range of $215,000 per year (see Tables 1, 2 and 3). The resulting investment payback period is only seven months (for the $125,000 initial installed cost). G&I

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The Technology

Gauge Reader: The Wireless Gauge Reader (WGR) clamps onto the front of a gauge and uses image sensing and processing technology to digitize a dial gauge reading, and then uses a 2.4Ghz wireless mesh network to transmit data with a range up to 1000m. A receiver/hub collects the data for trend analysis, notification, or statistical process control, and has battery life of two to three years under typical sampling rates. Its built-in database stores up to three years of data in typical applications. Its web server allows simple browser access to data from any LAN connected PC, and the device also allows two-way text messaging for sending notification messages as well as on-demand data requests from mobile handsets. The receiver/hub has an optional OPC or BACnet interface for integration with existing automation systems.

Transducer Reader: The Wireless Transducer Reader (WTR) connects to existing transducers (e.g. weigh scales, flow meters, pH meters, thermistors, etc.) and uses the wireless mesh network to transmit data to a receiver/hub, much like the WGR. This unit can be configured to read a variety of transducer inputs including 4-20mA, 0-5V, 0-10V, Type J and K thermocouples, thermistors, and RS-232 and RS-485 serial communication. When paired with non-invasive clamp-on current meters and clamp-on ultrasonic flow meters, the WTR can measure electrical consumption and flow rate of chilled water or steam and transmit the data wirelessly. Installation typically takes minutes, and may be uninstalled and moved easily around a facility if needed. It uses the same receiver/hub as the WGR, which has an optional OPC or BACnet interface for integration with existing automation systems.