Hidden Gold in Your Manufacturing Facility: It's All Around You!

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Psst, hey, want to see ~0.5 to 4 percent yield improvement in under a year? You're missing an easy one!

- Did you know there's a lot more variability going on, under your nose, that you can't keep up with because you're taking static readings from sources parked under the floor, on the ceiling and all over the walls?
- When an event occurs, do you have to hunt for the location of the problem?
- Do you really want to rely only on static readings to track what is going on in your fab?
- Do you know what the temperature variation is in your diffusion furnaces?
- Do you know that you are throwing away ($$$) partially filled gas bottles?
- Did you know you're likely pulling much more air through your fab than you need to, driving up energy costs accordingly?
- Do you know how much your chilled water temperature is varying?
- Do you know whether your compressed air pressure is varying all over the place?
- Did you get the early warning that an air pressure leak exists in your material handling equipment? Whoops, you have probably lost a cassette or two of wafers recently …
- Did you know that your tools are down longer than they need to be, because you can't trace the problem to its source fast enough?

These are all scenarios that happen in fabs (your fab) all the time.

Why is that?

We have spent the past few months investigating this issue, and detail what we have learned below. We hope it helps you, and believe the industry will benefit by applying what we have learned.

Background

Out of approximately 396 fabs in operation today, roughly 34 percent of the silicon output comes from fabs built after 2003.[1] It turns out that 66 percent of the silicon output comes from fabs built between 1985 and 2003. These fabs are almost fully depreciated. They play a very important role in a company's cash flow and margin. With that much output coming from these older fabs, their current expense structure and operational efficiency are of great interest and importance.

These older fabs share one very important relationship to technology's maturation curve: They were built prior to the arrival of inexpensive, more-capable and less-invasive approaches to data acquisition and monitoring. Here lies the opportunity.

Fab managers who have the ability to "see" and adjust critical attributes of raw materials such as gases, water and electricity into and out of their fabs have a significant advantage over those who don't. We have created three simple models to begin quantifying the potential value for those fab managers. One of them, the yield improvement model, is described below.

Today, several hundred process data points can be collected on an hourly or sub-minute basis by very small, simple, inexpensive metering techniques. This enables better awareness and thus control of the major inputs into a fab and its tools, e.g., gas pressures, water temperature and air flow rates, among others.

How Do I Know My Situation Matches?

Does your world match any or all of these scenarios?

- Squeezing out profits
- Current fab yields 75–90 percent
- Growing desire for higher-mix manufacturing lines, e.g., contract fabs
- Many "small" upsets that lose 50–200 wafers per month
  - Chilled water loop loss (~$30K/incident)
  - Overconditioned air (2x electricity usage above what is necessary)
  - High-value materials loss monitoring, e.g., helium leaks
  - Disaster scenarios/troubleshooting, e.g., cooling water systemic loss ($75K pump replacement plus one full week downtime)
  - Small deviations over time that cause large loss, e.g., transformer blowing after years/months of current fluctuations
  - Lateral troubleshooting (mean time to respond) in hours rather than minutes.
- Need inexpensive ways to boost responsiveness

Often, it is a missing piece of data that indicates a problem is happening, or that unless something changes, it will happen, that drives the above scenarios, and many dozens of others. We believe a sea change in capability to easily and inexpensively collect data has occurred in the past two years, and it is time for the industry to leverage that change into a real business benefit.

Gauge-based Monitoring ca. 2000

1. Static reading analog gauges are many, with valuable data running across them all day long. A typical fab uses approximately 5,000 unmonitored gauges, many of them hidden.
2. Gauges are typically in places that are far from power/network drops; some are 25' or more off the ground.
3. Many are underneath floors.
4. Very few are connected to any sort of data collection capability.

The cost/hassle factor of connecting and powering hundreds of gauges inhibited their connectivity at time of installation.

They are not connected to remote monitoring capability, and are read once per day or week, by direct visual check, which gives a single static reading only. They are important indicators when a hard failure occurs, but only if you know where to look to read them.

After 2004, Two Things Changed

1. Power requirements for a typical data collection device dropped substantially
2. Wireless networking electronics shrank in size/cost

This has enabled a new, second look at how best to enhance real-time knowledge of temperatures, pressures and flows throughout a fab, relating to a specific area or a specific tool type.

Gauge-based Monitoring ca. 2008

Integrating this new capability into the fab does not require interruption of operations. This is key to upgrading existing facilities that run on tight margin and volume parameters as part of an overall corporate financial plan.

The new capability we have evaluated performs real-time conversion of analog readings into digital values, collected on a range of intervals from milliseconds to hours/days. This data is invaluable not just as calibrated individual data points, but in enabling the evaluation of trends over time as well as variation spikes that currently go undetected. This provides a baseline to determine where future improvements need to be made – where there is more Gold!

Once a data point has been captured, the reader transmits that reading wirelessly to a data collection device, which can be directly queried via a provided Web interface screen. It can also be tightly integrated into an existing system via high-speed GEM/SECS, OPC, BACnet.

What's the Value?

The value is derived from three broad benefits: faster response to upset situations; shorter troubleshooting timeframes; and better monitoring enabling better predictive control and management.

We have derived three models to quantify aspects of these three benefits:

1. Wafer production reduction, e.g., hold output volume constant but reduce production start volume
2. Raw material conservation (water, specialty gases, bulk gases, electricity)
3. Wafer yield improvement, e.g., hold wafer starts constant and get more product out

We applied these models to segments of existing fabs, with volume of roughly 20K WSM. In the interest of space for this article, only the wafer yield improvement approach is illustrated. It assumes that higher Wafers Out volume is needed to satisfy market demand. Bottom-line results are predicted with a goal of improving yield by 1 percent by identifying the areas of greatest vulnerability and potential losses. For detail on the models, contact the authors directly.

Fab Monitoring Data Model

The purpose of this model is to illustrate the benefits resulting from the implementation of simple, wirelessly connected gauge readers in the fab infrastructure with little or no disruption to normal operations.

The benefit calculations are based on the net additional revenue per wafer accruing to the company. Our model discovers that these numbers quickly become large (see Table 1).

The illustration contained in the model is based on current industry averages. It has been kept intentionally simple and high-level, to enable quick "what-if" discussions and decisions, while zeroing in on the specific areas of a fab that will net the largest benefit from additional real-time monitoring capability.

To make this relevant to a specific company's fab operation, a small amount of data can be loaded into the model to customize the model. This data includes:

1. Wafer Starts/Month
2. Wafers Out/Month
3. Cost per Wafer Out
4. Revenue per Wafer Out
5. Numbers quantifying major wafer loss areas

As this data is entered, the bottom-line results change automatically. Based on this information, we can quickly evaluate the

Potential Gauge Impact Assessment		
	Industry Average Fab	Representative Fab
	8" wafer	8" wafer
	50" sq. (avg)	50" sq. (avg)
Gauge Estimate Fee	$1,250	$1,250
Gauge Annual Maintenance Estimate	$188	$188
WGR Units Installed	1,335	137
Equipment	1,315	96
Facilities	0	30
Process	0	5
Wafer Handling	20	5
Other	0	1
Gauge Cost	$1,668,750	$171,250
Maintenance Cost	$250,313	$25,688
Total Cost	$1,919,063	$196,938
Yield Improvement Attributable to WGR	1.32%	0.57%
WGR Yield Improvement (Monthly)	$453,891	$196,713
Annual Revenue Improvement	$5,446,688	$2,360,555
Breakeven Month	4	1

Table 1. Net Revenue Representative Model

financial benefit of data monitoring in areas which have a high potential to prevent or reduce future losses.

OK, the Model Looks Compelling. How Is This Done?

An example of how to do this, that we have recently seen, is Cypress Systems' wireless gauge reader (WGR). It is available today, and has been installed in six fabs in targeted applications such as chilled water loop, gas cylinder and air-handling flow rate monitoring. It is a noninvasive approach (see Figure 1), and is installed and fully integrated in under an hour by clipping the reader to the front of a gauge and performing a calibration step. It is conceptually similar to putting on a dive mask and adjusting a regulator prior to a scuba diving expedition. The data is sent via a proprietary packet structure connection to a device that can be perused via a Web browser interface, or the data can be sent periodically to existing systems (e.g., SCADA, fault detection correction systems, BlackBerry, etc.) to alert operations people of an event or problem.

Other installations are planned for Q1'08; benefit analyses will be detailed at various conferences throughout the year such as SEMICON West 2008 and ISMI 2008 in Austin. Additional papers and case studies will be published on an ongoing basis in a variety of publications.

Figure 1. Example of Wireless Gauge Reader for Round Gauges

We believe addressing this area of fab manufacturing management will extend the life of existing facilities, reduce unnecessary operating expense, and contribute to the health of the semiconductor industry. We are actively engaged in measuring and modeling potential cost benefits for a variety of situations, and will be pleased to add new situations to the mix. Feel free to contact us.

Reference

1. ISSM 2007, ISS 2008 presentation and VLSI Research data integrated by TD Partners, Inc.

About the Author

Rebecca Taylor is general partner of Taylor-Deininger Partners, Inc., a business strategy and technology forecasting consultancy serving the semiconductor, software and VC industries. She was previously director of Software Platforms at AMD, Personal Connectivity Solutions division. From 1991-2002, Ms. Taylor served as president/CEO of Terrace Mountain Systems, delivering software strategy and design services to the Global 2000, on four continents. She is a senior member of the IEEE, holds four patents and has a B.S. in computer science.