FabTime Cycle Time Management Newsletter

Volume 6, No. 2 February 2005

Information

Mission: To discuss issues relating to proactive wafer fab cycle time management

Publisher: FabTime Inc. FabTime sells cycle time management software for wafer fab managers. New features in the current version (7.0) include support for die quantity and WIP / tool-state transaction comments.

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Welcome

Welcome to Volume 6, Number 2 of the FabTime Cycle Time Management Newsletter! This month we have several community announcements, including notice of the formation of a new semiconductor manufacturing group called the Fab Owners Association (FOA). We believe that this association may be of particular interest to some of our newsletter subscribers. Our FabTime software user tip of the month is about viewing home page charts in slide show view. This issue also brings subscriber discussion related to WIP utilization %, product mix, shift change effects, and improved lot tracking for less automated fabs.

In our main article this month we propose a set of basic states for recording how lots spend their time in the fab (we call them WIP States). These are analogous to the tool states defined in the SEM E10 standard, except that they apply to time spent by a lot, rather than time spent by a tool. We propose a set of six basic states, which encompass most of the time that a lot spends in the fab, and discuss several subtleties and possible extensions. Next month we will expand on this topic by proposing a higher level metric derived from the WIP States, Overall WIP Effectiveness. We welcome your comments and feedback, as we attempt to develop useful metrics to provide a WIP-centered view of the fab.

Thanks for reading!—Jennifer

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Community News/Announcements

FabTime Newsletter Commences 6th Year of Publication

San Jose, CA. January 18, 2005 – FabTime Inc. today announced the 6th year of publication of its FabTime Cycle Time Management Newsletter. The newsletter is a forum for introducing and discussing best practices in semiconductor wafer fab cycle time management. It is a free monthly email publication, currently distributed to more than 1700 people across the semiconductor industry. It contains technical articles related to cycle time management, as well as subscriber discussion and industry announcements. 50 issues have been published to date.

Recent newsletter articles have included:

- Product Mix and Cycle Time
- Management Behavior and Fab Cycle Time
- Analyzing Capacity Using MES Data
- Real-Time Alerting based on Fab Conditions
- Quantifying the Effect of Tool Downtime
- Cycle Time Constrained Capacity

Recent subscriber discussion topics have included:

- Paperless cleanrooms (Do people have them? Is the benefit clear-cut?)
- 300 mm cycle times (Are they longer than 200 mm cycle times? If so, why?)
- Benchmark cycle times for single-path toolsets (What is a reasonable goal?)
- Setting WIP targets (How should these be set? How often should they be changed?)
- Managing time constraints between process steps (How should these be managed? How do you plan their capacity?)

More than 400 companies and universities are represented in the newsletter subscriber list. The companies with the most subscribers are Intel (NASDAQ: INTC), Analog Devices (NYSE: ADI), Infineon Technologies (NYSE: IFX), STMicroelectronics (NYSE: STM), Freescale Semiconductor (NYSE: FSL), Philips (NYSE: PHG), Micron Technology (NYSE: MU), Texas Instruments (NYSE: TXN), Advanced Micro Devices / Spansion (NYSE: AMD), and Seagate Technology NYSE: STX). The universities with the most subscribers are Virginia Tech and Arizona State. A newsletter subscription form is available at FabTime's website, www.FabTime.com/-newsletter.htm.

Article Referenced in Last Month's Issue

Last month's newsletter article referenced the following paper:

C.-S. Bong and K. V. Karuppiah, "Cycle-Time Reduction Under Product Diversity in Semiconductor Back-End Manufacturing," *Proceedings of the International Conference on Modeling and Analysis of Semiconductor Manufacturing (MASM 2002)*, Editors G. T. Mackulak, J. W. Fowler, and A. Schoemig, Tempe, AZ, April 10-12, 2002. 260-263.

Several people have asked about availability of this paper, and we are happy to report that the first author (C.-S. Bong of Infineon Technologies) has sent an electronic copy of the paper to FabTime. If you would like a copy of this paper, email Jennifer.Robinson@FabTime.com to request it.

Semiconductor Fab Owners Form Association

February 7, 2005 – San Jose, California – Senior manufacturing executives from nine global semiconductor companies today announced the formation of an international, not for profit, semiconductor manufacturing association. The semiconductor manufacturers represented

in the Fab Owners Association (FOA) have combined annual revenues of over $7B and control nearly 500,000 8" equivalent silicon wafers manufactured in the world on a monthly basis. The current announcing member companies are:

- AMI Semiconductor
- Cypress Semiconductor
- Delphi Electronics
- Fairchild Semiconductor
- Intersil
- LSI Logic
- Micrel Semiconductor
- ON Semiconductor
- ZMD AG

The Fab Owners Association recently concluded its third quarterly membership meeting identifying solutions for common manufacturing issues among its members. "Our vision is to provide a cooperative environment for executives to examine common manufacturing issues and identify practical solutions," said L.T. Guttadauro, executive association director. "The FOA can look at a larger sample of the silicon manufacturing segment than a single company can. By surveying our members for best practices and meaningful metrics, we can help our members weigh themselves against their silicon competition," continued Guttadauro.

In conjunction with their vision, the Association will facilitate and provide solutions on issues related to the semiconductor manufacturing industry that are more effectively undertaken as an industry association. "FOA provides a forum to talk about the non-proprietary issues facing our business today and in the future," stated Christopher Seams, EVP, technology development and worldwide manufacturing for Cypress Semiconductor and FOA founding member and managing association director.

"All Silicon manufacturers use similar manufacturing equipment and process technology. FOA provides member companies a forum to maximize our non-proprietary technologies, combine our resources and requirements to become more competitive. This is just the beginning of what the FOA has the potential to accomplish" said Gunter Ziegenbalg, EVP, ZMD AG, and FOA founding member and managing association director.

"Member companies can gain a practical advantage over non-member companies by contributing to the open discussion and gaining practical advice given by manufacturing executives on non-proprietary issues" said Gene Norrett, association director. "Our member surveys are focused on membership derived issues, resulting in indices and metrics useful to manufacturing executives striving to take the cost out of their semiconductor products, improve operational efficiencies and share or reduce basic development costs.

About FOA:

Fab Owners Association (FOA) is a not for profit, international association for semiconductor manufacturers. We are headquartered in Cupertino, California, in the heart of Silicon Valley. FOA provides a forum for semiconductor manufacturing executives to discuss common manufacturing issues. The association was founded in 2004. Member companies must own and operate a semiconductor or MEMS fabrication facility. Other membership levels are available. Please log onto www.waferfabs.org to receive additional information about the Association. "Fab Owners Association" and the "FOA" logo are trademarks of Fab Owners Association, a California corporation. References to other companies and their products use trademarks owned by the respective companies and are for reference purpose only.

Contact: Fab Owners Association, L.T. Guttadauro, (408) 253-2449, lt@waferfabs.org

MASM 2005 Conference Announcement

The third International Conference on Modeling and Analysis of Semiconductor Manufacturing (MASM 2005) will be held in Singapore on 6/7 October 2005 at the Suntec International Convention & Exhibition Centre.

- Full Paper Submission Due Date: 15 May 2005
- Notification of Acceptance: 1 July 2005
- Camera-Ready Due Date: 15 August 2005

MASM 2005 will be a forum for the exchange of ideas and best practices between researchers and practitioners from around the world involved in modeling and analysis. While we seek to know what's going on within the semiconductor industry, neither presenters nor attendees need to be in the semiconductor industry to participate. Any methodologies, research, and/or applications from other industries, as well, that might also be utilized for the semiconductor industry, will be considered relevant for this conference.

The conference includes tutorials, tea breaks, lunches and related software demonstrations. An international panel supervises each track. A broad range of papers is sought, including theoretical developments, applied research and case studies. Interested individuals within academia, government agencies, equipment suppliers, manufacturers, students, contractors, and other interested parties are encouraged to participate.

The conference will be built around the following five tracks:

1. Equipment Productivity
2. Operational Modeling and Simulation
3. Statistical Methods
4. Supply Chain Management
5. Enabling Computing Techniques

For more information, see www.simtech.a-star.edu.sg/masm2005/. Peter Lendermann (MASM 2005 General Chair) and John Fowler (MASM 2005 Programme Chair).

FabTime welcomes the opportunity to publish community announcements. Send them to newsletter@FabTime.com.

FabTime User Tip of the Month

View Your Home Page Charts in Slide Show View

FabTime's home page tabs are very useful for viewing a selection of metrics simultaneously, via a digital dashboard interface. However, you sometimes wish to scroll through a sequence of home page charts, looking at each chart individually. Of course you can do this by drilling down from the home page to the more detailed chart view. However, there's an easier way to do this. Simply click on the "Slide Show" button, located slightly below the "Home Page Tab" drop-down for any home page. This takes you to an enlarged view of the first chart on the home page tab (the upper left-hand chart), and provides controls for scrolling through the remaining charts on that tab one at a time. Simply press the "Goto" button to advance to the next chart. This can be particularly useful for morning production

meetings. As with regular home page charts, you can click on any chart image to drill down to the detailed chart page (with filters, links, etc.). Simply use your browser's "Back" button to return to the slide show. You can change the size of the charts displayed using the "Width" and "Height" text boxes, and you can switch between home page tabs using the drop-down lists in the upper left corner of the screen.

One newer feature of slide shows is that you can now set an Auto Play interval for any slide show. Simple enter the number of seconds between advancements in the "Auto Play: Seconds" text box and press the "Go" button underneath. FabTime will continue scrolling through the home page charts on the tab, returning to the first chart after the last. Each time a chart is displayed, it is automatically updated to display the most current information available. Some of our customers have been using this Auto Play functionality to display a rotating series of key performance measures on a fab monitor. We think that this capability is particularly useful, and we wish to bring it to the attention of all of our software customers.

If you have any questions about this feature (or any other software-related issues), just use the Feedback form in the software.

Subscriber Discussion Forum

Issue 5.05: WIP Utilization Percentage

Douwe van Engen (Philips Semiconductors) wrote: "I have a question about WIP Utilization %. We still calculate on a daily basis how many moves must be done on specific equipment. The result of this calculation is strongly dependent on the amount of WIP in front of the equipment. In my opinion we can forget all those difficult target settings when we concentrate on the WIP utilization percentage. For bottleneck equipment this must be 100%, and for non-bottleneck equipment you may allow a lower percentage. It is a simple approach but very clear to the operators. The only negative point I see is that there is no direct control of the excess of downtime. Can you tell me if there is already some experience with this indicator?"

FabTime Response: WIP Utilization % [defined in Volume 5, Number 5 as Productive Time / (Productive Time + Standby WIP Waiting)] was designed to do exactly as you say. As long as the operator always runs the tool whenever qualified WIP is available, WIP Utilization % will be 100%. This is true even for non-bottlenecks (although you may certainly choose to still drive them to a slightly lower WIP Utilization %, allowing for the fact that you don't staff them all of the time). We have no specific results that we can report about people using this metric, but we have heard a number of positive responses to the metric. It is included as part of the standard charts in our FabTime digital dashboard software, so I know that

all of our customers have access to it. But we will have to leave people to speak for themselves about whether or not they are using it, and so are opening up this question to other subscribers for response.

Issue 6.01: Product Mix

John Fowler of **Arizona State University** wrote in response to the last issue. "Of course, the latest issue of the newsletter was up to your usual high standards! I found the product mix discussion quite interesting. In fact, Barry Nelson (Northwestern), Bruce Ankenman (Northwestern), Jerry Mackulak (ASU), and I have a research project related to this. The project is funded by the Factory Operations Research Center II (FORCe II), which is supported by NSF, SRC, and the International SEMATECH Manufacturing Initiative. The project is entitled "Multi-product Cycle Time and Throughput Evaluation via Simulation on Demand". In this project, we are attempting to create the next generation of semiconductor factory simulation tools, which we call complete response-surface mapping (cRSM). More specifically, we will perform basic research and software development necessary to produce the capability to provide simulation results on demand for cycle-time measures as a function of throughput and product mix. This builds upon the NSF sponsored CT-TH curve generation research we have done for single products or a fixed product mix." If you are interested in learning more about this project, you should email Jennifer.Robinson@FabTime.com. I will be happy to put you in contact with John.

Another subscriber, who chose to remain anonymous, had these comments regarding product mix: "One practice that was useful at a high-mix fab where I used to work was this: when a new product started to ramp someone would "be the lot" and follow it through its process flow in the fab. This often turned up tool restriction, qualification, and other issues that wouldn't have been apparent otherwise in the noise of the mix."

Issue 6.01 (Software Tip of the Month): Shift Change Effects

An **anonymous subscribe**r wrote: "Regarding shift change, at my last fab we focused on this for a while but it was a "flavor of the week" type of deal. Working the best known practices across shift never got standardized before the next program became critical."

Improving Lot Tracking in Less Automated Fabs

Cynthia Williamson of ST Microelectronics wrote: "I'd like to submit the following question to FabTime and your subscribers: What has been found most effective to improve lot tracking in fabs that aren't fully automated? For example, are bar code readers used to track lots on WIP shelves? And, if operators aren't forced to use the implementation, e.g., they can by-pass scanning lots onto a WIP shelf, what has been done to ensure tracking?" We, and Cynthia, welcome your responses.

A WIP-Centered View of the Fab: Part 1: WIP States

Introduction

A common approach in monitoring fab performance is to take a tool-centered approach. This involves measuring overall equipment effectiveness (OEE) for bottlenecks, recording A20 and A80 and downtime characteristics, and tracking the time that tools spend in particular states (especially the dreaded "standby with WIP waiting" state). The tool centered view is very important in running a fab, because the individual tools are so expensive.

In this article, however, we would like to propose a parallel WIP-centered view of the fab. That is, for an individual lot, we can look at the time that the lot spends in various states (processing, waiting, traveling, etc.), and these will be analogous to tool states. We can also use the WIP state information to calculate a performance measure parallel to OEE, called Overall WIP Effectiveness. We believe that understanding exactly where lots are spending their time is an important step in improving cycle time, and that WIP states and overall WIP effectiveness have the potential to add a great deal to the understanding of the fab.

In Part I (this issue) we will define and discuss standardized WIP states. In a companion article (Part II) we will define the performance measure Overall WIP Effectiveness.

WIP States

As a lot goes through the fab, it spends time in a variety of states. We believe that by measuring this time and grouping it into set categories, fabs can learn a great deal about how lots are spending their time. This, of course, is the first step towards reducing the time spent in less productive categories, and hence improving cycle time. As a first pass, we propose that lot time be broken into the following six WIP states:

- Processing
- In Queue
- On Hold
- Post-Processing (e.g. waiting for unload)
- Traveling
- In Crib (extended hold, or storage near the end of the line)

The difficulty of capturing time in each state will vary from fab to fab. At the most basic level, if Begin Run (start processing a lot on a tool) and Move Out (finished processing, move to next step) transactions are logged, then it is possible to split time into two states: process time and queue time. Generally holds and crib time will be logged independently, making it possible to split hold time and crib time out as well. If End Run is logged separately from Move Out (say by tool automation), then we can split queue time into post-process queue time and regular queue time. Splitting out travel time will also be possible if transfer times are logged in detail.

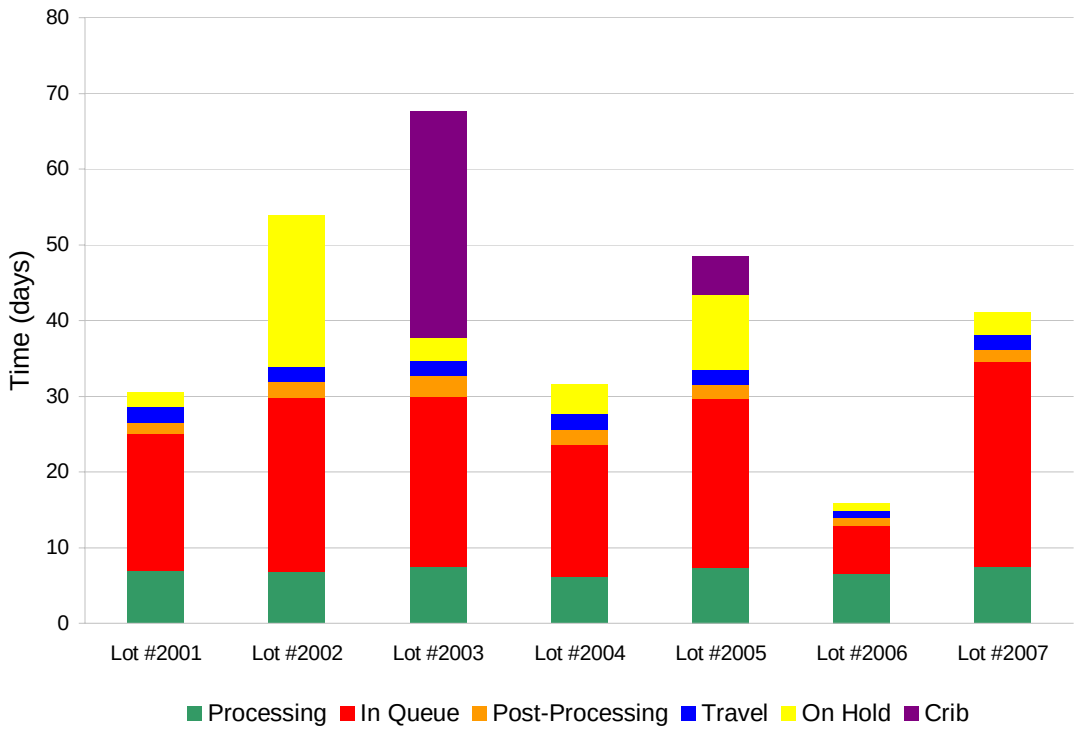
Two examples of potential WIP state charts are included on the following page. The upper figure shows the total cycle time for each lot (for seven sample lots) in days, broken into the six states described above. The other figure displays the WIP states as a percentage of total time for each lot.

Extensions to the Basic WIP States

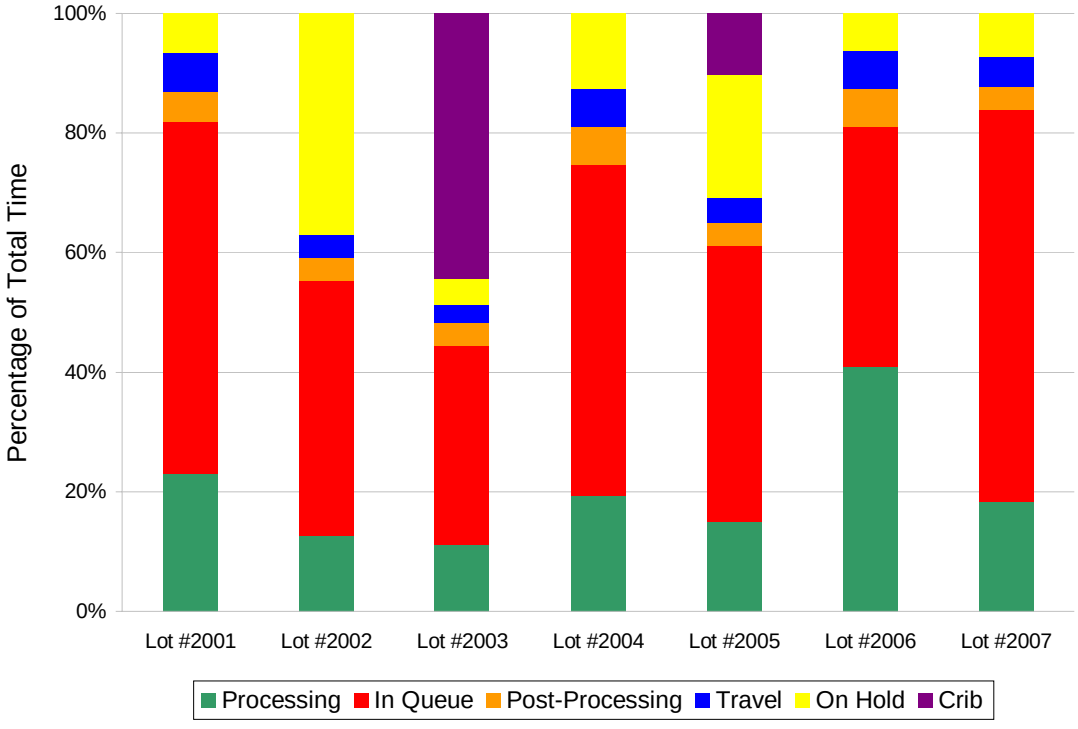
Much of the benefit in having a set of common WIP states lies in having there be a few, readily-defined states. This is true of the SEMI E10 tool states, of which there are six primary states. However, we do have to decide how to handle several other special cases.

Rework: We would, naturally, like to minimize the time that lots spend being reworked. Therefore, it may be necessary to break up the process time above into processing - regular and processing -

Sample WIP State Chart for Seven Lots - Height is Total Cycle Time



Sample WIP State Chart for Seven Lots, Displayed as % for Each



rework. Further, we need to account for rework parents and children in some way. The simplest thing is probably to only measure the states for the parent (primary lot), but to count the time spent waiting for the rework child as processing - rework (since part of the lot is processing, but at a rework operation).

Speed Losses: It's fairly easy to measure actual process time for a lot at an operation, provided Begin Run and end run transactions are both recorded. (If End Run is not logged separately from Move Out, then Begin Run to Move Out provides an estimate of process time). However, this alone will not tell us anything about how that actual process time compares to the planned process time for the operation. This could be handled by adding a third processing category, called processing - speed loss. This would require the creation of a virtual transaction to mark the end of the planned process time. The time between that time and the actual End Run time would be recorded as processing - speed loss. However, we believe that capturing this is not as important as capturing the basic states, as defined in the previous section.

Load Time / Unload Time: Load/unload time can be separated out from process time. However, since it is generally required in order to complete an operation, we recommend breaking it out from process time only if a particular load time reduction project is underway (and even then only for key tools).

Setup Time: When viewing tool states, setup/qualification time is generally treated as part of scheduled downtime. Setup is time that the tool is unavailable, but it is "planned" in the sense that the tool dispatching policy drives how much setup time is required. Qualification time at the end of maintenance events is similarly planned. In the case of WIP states, setup time should probably just be treated as part of queue time (since the tool is unavailable for the lot during the setup, and the setup time is not inherently part of the lot's process time).

Further Extensions to WIP States - Breaking Down Time in Queue

To even better understand where lots are spending time, and why, we might break the time in queue down into several smaller buckets:

In Queue – Waiting for Other Lots to Finish (another lot is being processed on the tool, and/or the lot is not at the front of the queue)

In Queue – Waiting for Operator (the lot is at the front of the queue, and the tool is available, but no operator is available)

In Queue – Waiting for Scheduled Down (the lot is at the front of the queue, but the tool is down for maintenance)

In Queue – Waiting for Unscheduled Down (the lot is at the front of the queue, but the tool is in an unscheduled downtime).

Note that we only count time as waiting for operator or downtime when the lot is at the front of the queue. This is because if the lot is further back in the queue, it wouldn't be processed next, even if the tool were available. This is queue time waiting for other lots to finish. This type of queue time is generally driven by equipment utilization (the busier the tool, the more likely that other lots will be ahead of this lot in the queue).

These additional sub-states could provide useful additional information about why lots spend time in queue. However, they are more difficult to measure, because they require knowing which lot is at the front of the queue at all times, even when the tool is not available. Because multiple tools may be qualified to run a particular lot, this can get tricky. Therefore, as above, we recommend starting with the basis states outlined previously, and only breaking up the queue time into sub-states for key

tools, or where automated tracking systems make this data to capture.

Conclusions

In the classic tool-centered view of the fab, tool performance is measured using tool state charts (often following the E10 standard for definition of the tool states). This approach is very helpful in providing direction for equipment improvement programs. What we have done is this article is propose a similar set of states that apply to the time that each lot spends in the fab. That is, we will break up a lot's history, and measure how much time it spends in several basic states such as queue, process, post-process, hold, transport, and crib. Having ready access to this information can help fabs to identify opportunities for improvement. Having a graphical representation of the WIP state data will in turn help to track and visualize the improvements. The natural extension to this, development of an overall WIP effectiveness metric, will be discussed in the next issue.

Closing Questions for FabTime Subscribers

Do you break down WIP time into different states? If so, what states do you use? Are there any that you think should be added to those listed above? How would you transform the WIP state data into an Overall WIP Effectiveness metric? We welcome your feedback.

Further Reading

For more background on tool states and overall equipment effectiveness, see:

- J. Robinson and F. Chance, "FabTime Newsletter – Vol. 5, No. 7 – Quantifying the Effect of Tool Downtime," 2004.
- J. Robinson and F. Chance, "FabTime Newsletter – Vol. 4, No. 10 – Tool Standby and Productive Time Reporting," 2003.
- J. Robinson and F. Chance, "FabTime Newsletter – Vol. 3, No. 1 – OEE and Cycle Time," 2002.
- SEMI E10-0699, "Standard for Definition and Measurement of Equipment Reliability, Availability, and Maintainability," SEMI, 1986.

Subscriber List

Total number of subscribers: 1767, from 418 companies and universities. 26 consultants.

Top 10 subscribing companies:

- Intel Corporation (85)
- Analog Devices (79)
- Infineon Technologies (54)
- Freescale Semiconductor (52)
- STMicroelectronics (50)
- Philips (43)
- Micron Technology (42)
- Texas Instruments (38)
- Seagate Technology (37)
- AMD/Spansion (36)

Top 5 subscribing universities:

- Arizona State University (10)
- Virginia Tech (10)
- Georgia Tech (6)
- Nanyang Technological University (6)
- University of California – Berkeley (6)

New companies and universities this month:

- Acer
- Air Antalya
- Cyberalert
- Dell Global
- GNE Corp.
- The Productivity Pro
- Raytheon Aircraft
- University of Teesside – UK
- ZettaCore

Note: Inclusion in the subscriber profile for this newsletter indicates an interest, on the part of individual subscribers, in cycle time management. It does not imply any endorsement of FabTime or its products by any individual or his or her company.

There is no charge to subscribe and receive the current issue of the newsletter each month. Past issues of the newsletter are currently only available to customers of FabTime's web-based digital dashboard software or cycle time management course.

To subscribe to the newsletter, send email to newsletter@FabTime.com, or use the form at www.FabTime.com/newsletter.htm. To unsubscribe, send email to newsletter@FabTime.com with "Unsubscribe" in the subject. FabTime will not, under any circumstances, give your email address or other contact information to anyone outside of FabTime without your permission.

FabTime® Cycle Time Management Software

"Instead of spending time preparing reports, shift facilitators can get the data they need quickly from FabTime, and then spend their time making real improvements."
Mike Hillis
Cycle Time and Line Yield Improvement Manager
AMD Fab 25

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One fixed price includes

- Site license, unlimited users.
- Implementation & training.
- Software maintenance.

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For $4950, FabTime will

- Identify key contributors.
- Benchmark common metrics.
- Review results at your site.

Interested?

Contact FabTime for technical details or a pilot project quote.

FabTime Inc.
Phone: +1 (408) 549-9932
Fax: +1 (408) 549-9941
Email: Sales@FabTime.com
Web: www.FabTime.com

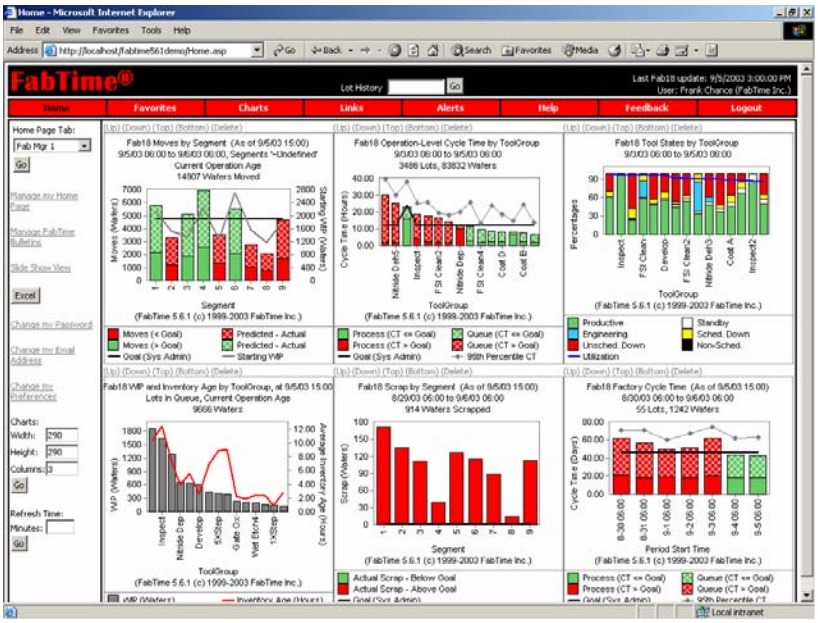
Do you have the best possible information?

- Are your supervisors swamped with daily reports, but lacking real-time information?
- Is it difficult to link equipment performance to cycle time?
- Does each new cycle time analysis require IT resources?

FabTime is a digital dashboard for your fab. In real-time, it provides a comprehensive view of fab performance data – everything you need for proactive management of cycle time. FabTime is designed for hands-on use by managers and supervisors, unlike traditional reporting tools, which were designed for programmers.

A Web-Based Digital Dashboard

"I use FabTime every day, and so do the supervisors who report to me. The data that I need is right on my home page where I need it when I come in every morning."
Jim Wright
Production Manager
Headway Technologies



FabTime Benefits

- Cut production cycle times by 10%, hot lot cycle times by 20%.
- Focus improvement efforts on the tools that inflate cycle time.
- Improve supervisor productivity – cut reporting time by 50%.