FabTime Cycle Time Management Newsletter

Volume 4, No. 9 September 2003

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. We are currently installing Version 5.6 of FabTime. New features in this version include the FabTime bulletin board – users with bulletin board permissions can create messages – as well as support for WIP transaction reversals.

Editor: Jennifer Robinson

Contributors: Daren Dance (WWK); Guy Gandenberger (Micrel Semiconductor); Jimmy Giles (STMicroelectronics); Andy Wichmann (Micron Technology)

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Welcome

Welcome to Volume 4, Number 9 of the FabTime Cycle Time Management Newsletter. Subscriber discussion topics for this month include two responses to last month's article about the performance metric Dynamic X-Factor, and new questions about managing in high-mix and R&D environments. We also have announcements about a new one-day version of FabTime's cycle time management course, a Cost of Ownership task force meeting, and the acquisition of WWK by its management team.

This month's main article is about metrics for identifying short-term bottlenecks in the fab. Last month we proposed the metric Dynamic X-Factor as a short-term indicator of overall fab performance. In this article, we focus more on tool-level performance metrics. The idea is to identify metrics that can be used at the start of the shift to highlight current or anticipated cycle time problems in the fab. We don't have all the answers here, but we would like to start a discussion with the newsletter community about this. Ultimately, we want to work towards developing useful short-term metrics. Therefore, we particularly welcome your feedback to this issue.

Thanks for reading!—Jennifer

FabTime

325M Sharon Park Dr. #219
Menlo Park CA 94025
Tel: 408 549 9932
Fax: 408 549 9941
www.FabTime.com

Community News/Announcements

New One-Day Version of FabTime Cycle Time Management Course

FabTime is pleased to announce the release of a one-day version of our wafer fab cycle time management course. The one-day course is a streamlined version of our previous two-day course, with more of a focus on operations, and less information about planning. It was developed at the request of customers, to be more convenient and relevant for operations personnel. It contains all of the most critical information from the two-day course. The two-day version is also still available upon request, for customers wishing to have more planning content, and extra time for questions and supplemental exercises.

The purpose of the course (both versions) is to provide wafer fab production personnel with a more in-depth understanding of the issues that cause cycle time problems in a fab, and to suggest several possible approaches for improving cycle times. The material in the course is drawn from, and expands upon, ideas described in our cycle time management newsletter and on FabTime's website. Both versions of the course include copies of all of FabTime's spreadsheet tools, including our new cycle time goal calculator and our enhanced operating curve generator.

The cost to have the one-day course at your site for up to 15 people is $4,950 US, plus travel expenses for one or two instructors to travel from California. The two-day version costs $6,000. Discounts are available for multiple sessions of the course scheduled on the same visit. We currently have dates available to give the course starting in late October. A half-day executive version of the course (aimed at senior managers) is also available as an add-on to the course, for an additional $2950. For more information, contact Jennifer.Robinson@FabTime.com, or use the form on our website, at www.fabtime.com/ctmcourse.shtml.

Management Team to Acquire Wright Williams & Kelly

Daren Dance submitted this announcement: "A team led by current senior management and original co-founders of Wright Williams & Kelly has announced that it has acquired the assets of the company. They will continue to operate the company as Wright Williams & Kelly, Inc. (WWK). WWK was founded in 1991 and, since 1995, was operated as a subsidiary of CH2M Hill Industrial Design & Construction (IDC), the semiconductor industry's leading engineering services provider.

In going forward with this new organization, WWK is seeking former associates of SEMATECH and other organizations to form a new consulting group to be known as WWK Consulting. This organization is being established to address the growing need for expertise by companies in the electronics, semiconductor and other technology industries. This consulting organization will be structured similar to a marketing cooperative and administered by WWK to provide sales, marketing and proposal support services to this network of recognized experts. This support organization will free the consultant's time to focus on adding value to clients. WWK will provide a commissioned sales staff, advertising in major trade magazines, and a focus for initial contacts. Independent consultants interested in working with WWK should contact Daren Dance at daren.dance@wwk.com for participation information."

Cost of Ownership Task Force Meeting

Daren Dance submitted this announcement: "The Cost of Ownership Task Force of SEMI's Metrics Committee is in the process of revising the E35 Cost of Ownership standard. The next meeting of this task force will be during the SEMI Standards Fall Meetings Oct 12-13th in Austin, TX. If you have interest in participating in this revision, please contact the task Force leaders: Daren Dance (daren.dance@sbcglobal.net) or David Bouldin (D-Bouldin@TI.com). You do not need to attend the meetings to participate in the revision."

FabTime welcomes the opportunity to publish community news and announcements. Simply send them to Jennifer.-Robinson@FabTime.com.

FabTime User Tip of the Month

Update Home Page Chart Settings on the Fly

In an effort to make this newsletter more useful to customers of our FabTime cycle time management software, we have added a new section: the FabTime User Tip of the Month. This very brief section will highlight new features, or suggested usages, that our customers may find helpful.

FabTime Version 5.5 includes a new "Update" control to let you modify a home page chart, without having to delete and re-add the chart. To use this function, simply click on the home page chart that you wish to change. This takes you to the detailed chart page. Make any changes to the chart that you like (e.g. period length or filters), or even switch to a new chart using the data table links or Quick Jump list, and press "Go" to store your changes. When you have the chart configured the way you want it, press the "Update" button in the upper left-hand corner (just below the red "Home" button in the FabTime toolbar). FabTime will replace your previous home page chart with the new version (which may be a completely different chart, or the same chart with different settings).

A number of FabTime users have asked about this feature in the past, and we are highlighting it here to make sure that our users know about it. 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 4.08 – Dynamic X-Factor

Guy Gandenberger (Micrel Semiconductor) wrote: "My reply to the Dynamic X factor.........Don't make it so complicated, so hard to measure. Try an operations/step turns level. If you are close enough to the line performance, you will notices these changes within hours."

Jimmy Giles (STMicroelectronics) wrote: "Regarding the Dynamic X-Factor: It seems to me that the Dynamic X-Factor can, at best, be used as a real-time warning for cycle time underperformance. We are pushing proactive / anticipatory reports and metrics. What we do is identify dynamic (soft) bottlenecks, which are the unplanned bottlenecks, based on projected WIP and availability. We project expected WIP buildup based on a short-term (5-day) AP Simulation (Brooks Automation). I would be interested to hear how other companies/sites predict and anticipate WIP buildups (at soft or hard bottlenecks)."

Line Management for High-Mix Fabs

An anonymous subscriber wrote: "Our fab is in a transition from a high volume, low diversified product mix to a high volume, highly diversified product mix. There is a need to re-evaluate and change the way in which the line and inventory is managed. Can you provide some direction on where I might find documentation/publication that specifically gives reference on the methods involved with line management in a high volume, highly diversified product mix environment."

FabTime Response:

We have a few references on product mix and semiconductor manufacturing (references below), but they are more focused on planning than on day-to-day line management. We're sure that there are some publications out there on managing fabs in a high-mix environment (this fab is certainly not alone in facing this transition). Therefore, we are posting this question to our subscriber discussion forum, to see if any other subscribers have references or experiences to share on this topic.

■ M. A. Dümmler (University of Würzburg), "Analysis of the Instationary Behavior of a Wafer Fab during Product Mix Changes," *Proceedings of the 2000 Winter Simulation Conference*, 2000. (available for download from www.informs-cs.org/wscpapers.html.

■ I-H Hong, Y-C Chou, C-Y Kuo, and L-C Lu, "Product Mix Planning in Semiconductor Manufacturing," *Proceedings of the 1999 ISSM Conference*, 1999.

■ R. Kotcher and F. Chance, "Capacity Planning in the Face of Product-Mix Uncertainty," *1999 IEEE International Symposium on Semiconductor Manufacturing Conference Proceedings*, Santa Clara, CA, October 11-13, 1999, 73-76. (available for download from www.FabTime.com/abs_ISSM99.shtml)

■ T. H. Yang, C. T. Su, and Y. C. Feng, "In Search of a Product Mix for Semiconductor Wafer Fabrication Facilities by a Combined Simulation/Neural Network Approach," *International Journal of Industrial Engineering - Theory, Applications, and Practice*, Vol. 8, No. 2, 142-149, 2001.

■ C. Y. Yu and H. P. Huang, "On-Line Learning Delivery Decision Support System for Highly Product Mixed Semiconductor Foundry," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 15, No. 2, 274-278, 2002.

Managing in an R&D Environment

Andy Wichmann of Micron Technology asked: "Have you found differences in your research between a R & D environment vs. a Production environment? (different challenges and solutions?)

As an R & D Planner I would like to find some literature specific to the R & D environment. Does FabTime have anything fitting in the archives? Could you recommend any leads to finding this info (websites, university studies, journals)?"

FabTime Response:

We think that R&D environments carry some particular challenges. The top thing that comes to mind is the number of one-of-a-kind, or single-path, tools in an R&D environment. Single-path tools are a big driver of cycle time, and are much more likely for low volume flows. One of the things that we show in our cycle time management course is that if you can go from single-path to dual path for an operation, at fairly high utilizations, you can decrease cycle time by about 50%. Of course other things like high product mix, having many low volume flows (difficult for batching and setups), and having higher scrap and rework than production flows, also tend to drive cycle time upward.

Regarding your question about references, the only paper that we have that touches on that at all is one that we wrote with AMD about getting "first silicon" lots out quickly, in a production fab. M. Hillis and J. K. Robinson, "Super-Expediting in a 0.18 Micron Wafer Fab," Proceedings of the 2002 Modeling and Analysis for Semiconductor Manufacturing Conference (MASM 2002). Tempe, AZ, April 10-12, 2002. (available for free download from www.fabtime.com/abs_MASM02.shtml.

But perhaps some of our other subscribers have references to share on this topic. Send your comments or references to Jennifer.Robinson@FabTime.com.

Identifying Temporary Bottlenecks in the Fab

Introduction

Last month we discussed the performance metric Dynamic X-Factor. Dynamic X-Factor measures, on a point-in-time basis, how much of the WIP in the line is currently being worked on, instead of sitting in queue. Dynamic X-Factor is calculated by taking the total number of wafers in the fab and dividing by the number of non-rework wafers actually being processed. Dynamic X-Factor measures the speed of the production line, on a short-term basis. This gives an early indicator of when cycle time problems are building. We asked subscribers for their feedback regarding this metric, and we received two responses. One said that Dynamic X-Factor was too complex, while the other, in essence, said that it was too simple. But both responses indicated that Dynamic X-Factor might not be enough of a forward-looking metric. In this month's article, then, we address a follow-up question. How can you identify short-term cycle time bottlenecks in the fab, without making the identification process too complex to be useful?

Short-Term Tool Performance - Simple Indicators

What we are looking for here is a metric that can be used on a start-of-shift basis to identify short-term bottlenecks, at the tool level. We believe that the overall largest driver of operation-level cycle time is tool utilization. The definition of utilization that FabTime uses is Productive Time / (Productive Time + Standby Time). That is, out of the time that is available to manufacturing for production, how much time is being used for production, vs. the remaining standby time? This is what drives cycle time. As the standby time becomes small relative to the productive time, utilization becomes high, and cycle time becomes correspondingly (and non-linearly) high. On a long-term basis, most fabs plan their capacity to prevent tool utilization from becoming too high. They aim for 85% or 90% maximum utilization on most tools. On a short-term basis, however, equipment downtime takes away standby time, and can drive operation-level cycle times rapidly upward.

For example, consider a one-of-a-kind (single path) tool that goes down for 24 hours of unscheduled downtime. Even if this tool has plenty of capacity on a longer-term basis, in the short term any lots already in queue for the tool are going to have to wait an extra 24 hours. And new lots will continue to arrive during the 24 hours, and be added to the queue, causing a WIP bubble to form. It's clear that this is a problem in the short-term. The question is, how do we identify this tool in our standard reports as a problem? At what point does it become a problem? When it's been down for four hours? Six hours? When the queue in front of the tool reaches 10 lots? 20 lots? 100 lots? What's the right forward-looking indicator for identifying these types of temporary bottlenecks? Is it different for single path tools than for tools with backup? Here are a few possibilities:

- Utilization – We can measure utilization (productive time / productive time + standby time) on a shift basis, by tool, and by tool group. However, utilization requires a time period to measure. By hour? By shift? By week? For tools with long process times, hourly utilization numbers aren't meaningful. However, if we wait until the end of the shift, we may not identify problems quickly enough to be useful in identifying new problems. The same arguments hold for measuring standby time.

- **Turns** – We can report the operation moves / starting WIP at the tool, and tool group, level. This will drift upward if either moves decrease or WIP starts to increase. It is a sensitive measure, and most fabs we know have shifted from looking at moves to look instead at turns on a shift basis. However, we have to decide on a time window to use when calculating turns. Moves per hour? Moves per shift?

- **WIP** – We can look at the number of lots assigned to a tool on a point in time basis, and set up our systems to notify someone whenever the WIP at a tool exceeds some threshold. This is easy to implement, and can be triggered at any point during the day. However, there is the problem of deciding what threshold to use. This could vary across types of tools. It also doesn't tell us anything about the WIP that's there. Did an upstream, high-capacity tool just come back online, and dump a bunch of WIP at this tool?

■ **Inventory Age** – We can take the time in queue for each lot waiting for a tool, and sum across all the lots, to get a total inventory age (or cumulative queue time) by tool. This is a more sensitive indicator than just looking at WIP, because it captures situations where the total number of lots waiting isn't changing, but some or all of the lots are sitting for a long time. We know one fab manager who looks regularly at the trend in inventory age for critical workcenters, and uses that to identify short-term bottlenecks (where the inventory age starts to drift upwards). But he would like to have something more forward-looking, which directly takes into account tool availability.

■ **Dynamic X-Factor** – We can't actually use Dynamic X-Factor at the tool level, because the denominator is number of non-rework wafers currently being processed. Once we get down to the level of a single tool, the denominator will often be zero, and Dynamic X-Factor will blow up. We can replace the denominator with one in those cases, but then DXF just reverts to WIP (and we might as well just use WIP as the metric).

■ **A80 Tool Availability** – As defined back in Volume 4, Number 2, A80 is the best availability reached within 80% of the periods in a set of periods (shifts, days, weeks, etc.). So, for example, if the availability is at least 75% for four out of five days, and then is some lower value on the fifth day, A80 for this set of days will be 75%. A80 is in a sense the availability that we can expect to achieve in the short-term, a more realistic number than the planned availability for a tool. However, A80 alone won't tell us about short-term bottlenecks, because we also need to know about WIP buildup (if we have poor availability at a tool which has no WIP waiting, it's not a big problem).

Short-Term Tool Performance - Aggregate Indicators

As described in the subscriber discussion forum above, ST is experimenting with simulation-based identification of short-term bottlenecks. Jimmy Giles wrote: "We project expected WIP buildup based on a short-term (5-day) AP Simulation." This approach sounds very promising. However, not all fabs have the resources to maintain a sufficiently detailed simulation model to use a method like this. Therefore, we propose here one possible short-term indicator that takes into account tool performance and availability, but does not require simulation.

For each toolset, start with the A80 value for the previous 7 days, and the WIP that is currently in queue for the toolset. Based on the toolset's processing rate and number of available tools, convert the WIP into required hours of processing. Inflate this required hours of processing by the A80 availability percentage to calculate an expected number of hours required to complete the WIP that's in queue. We'll call this indicator "WIP hours". Look for toolsets where the WIP hours value is greater than the length of the shift. Note that this method does not try to anticipate which lots will arrive during the shift. It merely says, of the lots that are already here at the start of the shift, can we process them during the shift, given the number of tools that we have available and their expected uptime during the shift?

For example, suppose that we have a toolset with three tools, two of which are currently available. Suppose the toolset's A80 value is 75% from the previous seven days. Then, a realistic assumption is that we'll have at least a 75% availability during this shift, or 9 out of 12 hours available for processing, on each of our two available tools. (Here we also assume that the tool that is unavailable will remain unavailable - a worst case assumption). Now suppose that we have 30 lots in queue earmarked for this toolset. If the average processing rate of each tool is one lot per hour, then we have about 15 hours of required processing (30 lots divided by 1 lot per hour divided by 2 tools). That is, we need 15 hours of productive time on each of the two tools to take care of the lots in queue.

We then divide by the A80 availability to get WIP hours. For each tool, we have 15 hours of required processing time divided by 75% availability = 15 / (.75) = 20 WIP hours. This means that we need almost two full shifts to process the WIP that's currently in queue (after accounting for the expected availability of the two tools). Since the WIP hours value (20 hours) exceeds the length of a shift, we would likely flag this toolset as a temporary bottleneck, especially if 20 hours is outside the normal WIP hours range for this toolset.

Of course this method will be more accurate if, instead of taking some sort of average processing rate for the tool, we include the theoretical cycle time (or expected process time) for each lot that is actually in queue. Provided that process time data is included in the MES, this should not be too difficult.

What is likely to be more difficult is quantifying the impact of tool qualification and dedication. Usually lots at a particular operation are qualified to run on a particular set of tools, any one of which can be used for processing. This is not so bad if these sets of tools are distinct. In that case (as above), we can take the WIP assigned to the toolset, and use the A80 value for the set of tools. Tools that are shared across tool groups make this much more difficult. But we think that it should still be possible to make some sort of virtual assignment of lots to tools. Remember that the purpose here is not to make a detailed schedule for the shift. The purpose is to identify places where there is a lot of WIP waiting, relative to the expected availability. Once we identify these locations, it may be possible to either improve the availability of the tool for the coming shift (e.g., by deferring engineering or preventive maintenance), or to assign some WIP to other tools.

Summary

People who manage fabs need to know, on a start-of-shift basis, where the current problems are in the fab. If we're driving to ever-shorter cycle times, then we need, as Jimmy Giles said above, "real-time warnings for cycle time underperformance". In this article, we have discussed a few simple metrics, and their relative applicability to this problem. We have also proposed a simple calculation (WIP hours) for identifying short-term bottlenecks without performing simulation, by estimating the hours of work in queue for a toolset. We realize that this metric is not perfect, but we would like to use it as a springboard for further discussions.

Closing Questions for FabTime Subscribers

How do you identify short-term bottlenecks in the fab? Do you just look at WIP? Inventory age? Tool availability for bottlenecks? Or do short-term bottlenecks cause so much pain that people in the fab already know where they are at all times, and you don't need a metric?

Subscriber List

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IZET Innovationszentrum Itzehoe (1)
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Jazz Semiconductor (4)
JDS Uniphase (2)
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Kav Project (1)
Kaveri Corporation (1)
Ken Rich Associates (1)
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Matsushita Semiconductor (1)
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Merak (1)
Merck Sharp & Dohme (1)
Metrology Group, Inc. (1)
Metrology Perspectives Group (1)
MFS Technology (1)
Micrel Semiconductor (4)
Microchip Technology (10)
MicroEmissive Displays Ltd. (1)
Micron Technology, Inc. (39)
Microscape Recruitment Ltd. (1)
Mid-Continent Engineering (1)
MIT Lincoln Laboratory (2)
MLI, Inc. (1)
MMC Technology (1)
Motherson Innovative Technologies & Research (1)
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Nova Measuring Instruments Ltd. (1)
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Singapore Inst. of Manufacturing Technology (SIMTech) (1)
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TDK (5)
TECH Semiconductor Singapore (27)
Technical University of Eindhoven (5)
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UMC (8)
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University of Ulsan - S. Korea (1)
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ZMC International Pte Ltd (2)
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V. A. Ames (Productivity System innovations)
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Daren Dance
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