FabTime Cycle Time Management Newsletter

Volume 10, No. 7 September 2009

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 software this month include support for lot-level planned x-factors, and maintenance of lot-level factory start time and cumulative post-start plan/theoretical CT with each data update.

Editor: Jennifer Robinson

Contributors: Mike Hillis (Spansion); Billy O'Donnell (National Semiconductor)

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Welcome

Welcome to Volume 10, Number 7 of the FabTime Cycle Time Management Newsletter! As I write, FabTime's tech team is hard at work on a new FabTime installation project. We're also in the process of making changes to increase the flexibility of the software's real-time alerts. We hope that this issue finds you all well, and your fabs busy. In this issue, we have announcements about registration for two upcoming industry conferences, a new member of the Fab Owners Association, and a new issue of an industry publication dedicated to cost modeling. Our software user tip of the month is about filtering the WIP line on the tool state charts in FabTime (and other modifications to the tool charts). Our subscriber discussion forum this month has two responses to last month's main article about forecasting lot completion dates. We expect readers to find these responses quite useful.

In our main article this month, we discuss a central management issue in running wafer fabs, the constant need to translate short-term signals into actions to drive long-term goals. Of course the translation of longer-term goals into shorter-term actions is a task that people undertake every day, in many areas of their lives. This task is particularly complex in wafer fabs, however, because of the high volume of data available, and the high degree of complexity and variability. In this article, we discuss some of the real-time signals that indicate problems in fabs, as well as some intermediate goals that are used as early warnings regarding longer-term goals. Our conclusion is that while access to good data is essential in translating from short-term signals to long-term goals, the human element remains necessary, too. We welcome your feedback on this topic.

Thanks for reading!—Jennifer

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Community News/Announcements

Registration Open for Two Conferences

Registration is open for SEMICON Europa, to be held in Dresden, Germany October 6-8, and for the ISMI Symposium on Manufacturing Effectiveness, to be held in Austin, Texas October 21-22. More details can be found at http://www.semiconeuropa.org and http://ismi.sematech.org/ismisymposium.

Fab Owners Association Welcomes New Device Maker Member - Telefunken Semiconductor

On August 10, 2009, the Fab Owners Association (www.waferfabs.org), a non-profit, mutual benefit corporation composed of semiconductor and MEMS manufacturers and suppliers, announced that Telefunken Semiconductor is a new device maker member of the organization. The announcement says: "TELEFUNKEN manufactures Analog & Mixed Signal Semiconductors with Applications in Power Management for the Consumer Electronics and the Automotive sector. The foundry is a specialty Analog & Mixed Signal facility with ISO Automotive and Industrial Class Certification. TELEFUNKEN, a recognized leader in electronics for more than a century, provides cutting edge 0.35 micron Analog and Mixed-signal IC technologies, specifically:

- Analog & Mixed Signal CMOS
- BiCMOS
- SiGe
- BCDMOS/SOI (Silicon On Insulator)

These processes allow TELEFUNKEN to build World Class Analog ICs for RF, Power Management, and High Voltage High Temperature Automotive Applications."

FabTime is an associate member of the FOA, and will be attending the next FOA meeting, at SVTC Austin in November.

New Issue of Applied Cost Modeling Available from WWK

We thought that some of our newsletter subscribers might be interested in this publication about cost modeling in the semiconductor industry. Here is this month's announcement:

"September 17, 2009 (Pleasanton, CA) - Wright Williams & Kelly, Inc. (WWK), the global leader in cost and productivity management software and consulting services, announced today that the latest edition of its much acclaimed free E-Zine "Applied Cost Modeling" is now available on its web site (www.wwk.com) under their "Newsletter" link. First published in 1994, "Applied Cost Modeling" has been the mainstay for manufacturing and assembly industries in disseminating information on hot topics such as cost of ownership (COO), overall equipment efficiency (OEE), cost and resource evaluation, and discrete-event simulation.

The latest edition includes the feature article: "Hi-Tech Equipment Reliability: A Practical Guide for Engineers and Managers" and is presented as the eleventh installment in an on-going series from the book of the same title. The second edition of this book is now in print and can be ordered through the WWK web site under the "Resources" link. "Overall Equipment Efficiency (OEE): A Tutorial" discusses the history of OEE and how it fits into other equipment metrics. Additional information is also provided on WWK's upcoming COO seminar at Solar Power International 2009 which will be held in October at the Anaheim Convention Center as well as WWK's recently announced software maintenance amnesty program."

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

FabTime User Tip of the Month

Filter the WIP Line on Tool State Charts

Over the past couple of months, FabTime has made some changes to the tool state charts. You may have already noticed that when you bring up any tool-related chart from the Chart list, if you don't include any Tool filters, you'll see this message: "Warning: Please enter one or more tool filters. If you wish to see results for all tools (this will likely be very slow!), set the tool filter to *." FabTime's previous behavior was to initially report results across ALL tools in the database, and allow people to filter the chart from there. What we found in talking with people was that their next step was almost always to filter the chart to look at a much smaller sub-set of the available tools. Skipping straight to the filtered version, without displaying the full version, improves FabTime's performance. If you still need to see the data across all tools, just enter a "*" in the Tool filter.

We also have added some new filters to the Tool State Trend and Pareto charts. You can now filter the WIP line displayed on the chart, in addition to filtering which tools are included. For example, if you enter a value in the product, owner, or priority fields, FabTime will use that value to filter the WIP line that is displayed. These filters don't affect what tool state data is displayed, of course (since product, owner, etc. are not tool attributes), but they will affect the WIP data that's included. When you drill down via the "Actual Start WIP (Wafers)" column in the data table, the WIP filters are applied to the resulting chart. We've also added filters for E10 tool state, substate, and reason code, to make the Tool State Trend and Pareto Charts more flexible. We hope that you find these changes useful!

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

Subscriber Discussion Forum

Issue 10.06: Forecasting Lot Completion Dates

Mike Hillis from **Spansion** sent us some detailed thoughts in response to last month's main article about forecasting lot completion dates. He wrote: "As you know the topic of the recent FabTime newsletter has long been near and dear to my heart (ed note: we wrote a paper on this topic with Mike in 2002, you can find it here: http://www.fabtime.com/abs_MASM02.shtml). From that time forward I spent a great deal of time and energy identifying expected output dates for lots. There are a few notes I would like to make regarding that process and what I learned. Basically, we used the planned cycle time as a baseline for our routine lots. This was based on a statistical assessment of historical cycle times by operation rather than an X-factor multiple of theoretical cycle time (TCT). While we have data on what the TCT should be for each operation, empiricism required us to avoid

that simple approach. My experience is that the variability you mentioned in the article really drives the planned cycle time. Some operations with excess capacity approach theoretical while others (again as you mentioned, single stream or bottleneck tools) may run many multiples of TCT. Certainly we can do a pretty good job of estimating average cycle time in this way, and many lots will be close to this time. It is extraordinarily difficult however, to predict the specific out date of a particular common lot.

However, with lots of high interest and concomitant priority, one can be very accurate in describing a shipment date. In these cases, using a factor of theoretical is a very good methodology for establishing a cycle time budget. Setting this expectation and enforcing particular operational rules (holding tools, light loading, batching, etc) for moving the lot are key steps in "making it happen". I have used X factors of 1.25 to 2.0 depending on the priority level of the particular lot. I have a number of anecdotes where lots shipped within hours of the original estimate after completing the entire process "beach to ship". Considering the length and complexity of a typical state of the art process I never failed to marvel at the effectiveness of this approach.

Another key to accuracy it to understand the exact flow a high visibility lot will undergo. I found it very important to carefully review the lot's intended path including any special engineering work, splits, qualifications, etc. In those cases where there were non-standard operations the default X-factor cycle time is modified to accommodate the extra work. Failure to take this step is sure to end in frustration. However, for a vanilla lot, it shouldn't be necessary.

As you may recall, we use a method we call a "worm chart" for tracking the progress of the lot through the line. One curve is the planned location at time X, the second is the actual location. This tool can be used to make decisions regarding appropriate priority level (Is promotion required? Can the lot be demoted and still meet the targeted out date?). Additionally it can provide an updated estimate of the actual ship date (like your "3 days late" example in the article). These can be manually generated or created via some factory system or other application.

The problem with this approach is that it requires quite a bit of intervention into the system. One needs to be able to discretely adjust cycle time targets throughout the line in order for it to be hyper-accurate. Of course the reporting of results is much more easily done than the set up. So while this process is clearly not a simulation, it is not exactly a simple static model either. As executed at our fab, it has been a moderately labor intensive activity in the set up and execution phases. Tracking is automated, and so communication of results is immediate and widely available. This approach has been very successful for us for several years now. I don't recommend it for more than a few key lots where there can be commitment on the part of the factory to tolerate the potential disruption these kinds of activities engender."

We also received feedback on forecasting lot completion dates from **Billy O'Donnell** at **National Semiconductor**. Billy said: "Although our fab is in the "large scale production" group, we use a very similar approach to help predict volume output by day. Our planning approach is to use our planned cycle time per step and add the remaining planned cycle time to the elapsed cycle time, to give an indication. The additional step we've taken is to track the mean cycle time by step over time, and use moving average of that to replace the planning cycle time. We've found that this gives us another level of granularity and, over a reasonable time period, captures more of the variation that the fab sees. I'll be interested to hear more on this."

FabTime Response: We have been working with Mike Hillis since Spansion installed FabTime's software in 2001, and we first met Billy O'Donnell back in our time at Sematech in the mid-90s. As these comments show, we continue to learn from both of them. We found it interesting that both Mike and Billy talked independently about using actual historical data for planned cycle times for volume production lots, rather than a multiple of theoretical. We'll also note that Mike's "worm chart" is similar in nature to FabTime's Lot Progress chart. We think that Mike's comments on understanding the exact flow that a high visibility lot will undergo are particularly important in practice. In any event, we appreciate this feedback from Billy and Mike, which validates for us that we're going in the right general direction with this, and helps us to refine our approach further.

FabTime welcomes the opportunity to publish subscriber discussion questions and responses. Send your comments to Jennifer.Robinson@FabTime.com.

Using Short-Term Indicators to Improve Long-Term Performance

Introduction

We've talked before (see Issue 7.06) about how a fundamental conflict for people who run wafer fabs is the simultaneous pressure to increase throughput while reducing cycle time. This is a difficult balancing act, because increased throughput generally requires increased tool utilization, which in turn leads to increased cycle time. As we've said before, the two solutions that we know of for this problem are 1) to reduce tool unavailable time (converting unavailable time, of whatever stripe, into time available for production) and 2) to reduce variability.

Today we'd like to discuss another fundamental barrier that confronts people who operate wafer fabs and other complex manufacturing facilities. The issue is that what ultimately matters is overall fab performance (getting out the expected number of good wafers in the expected time period). However, what we have to work with for identifying concrete actions is a set of much shorter-term indicators from within the fab (what state are the tools in now, how late are individual lots, etc.). People who run fabs are constantly trying to use these short-term indicators to determine the right actions to improve overall performance. And while most people who've been doing this for a while are pretty good at it, the exact steps to take are not always clear.

This is true in any type of manufacturing facility, of course. However, the situation is particularly difficult for fabs because we have SO MUCH data. The process flows are long and complex. There are hundreds of different tools, and sometimes thousands of different lots. And we have variability in tool uptimes, in product mix, in lot sizes, and many other areas.

Goals

We do have metrics that function as early indicators of problems:

- Moves per day (we know what we need to move each day to meet the overall throughput goals)
- Shipments per day (if we don't meet the daily goal, we're going to have trouble meeting the total for the quarter)
- Turns (moves relative to WIP, an early indicator of cycle time)
- Dynamic x-factor (another early indicator of cycle time - see issues 4.08 and 5.03)
- Number of wafers that have been recently scrapped (an indicator of yield problems)
- etc. (see issues 1.06 and 2.08 for others)

These types of metrics give us an idea of where we're going to have problems meeting our larger goals. But the numbers don't necessarily tell us what to DO. If we're not making our moves goals, we can drill down to see which area isn't making their moves goals. But the problem might be that there's no WIP in that area, because it's piled up in another area. And so on. It's not usually so straightforward that we can just say: "oh, higher level metric A is out of spec, so let's take concrete action B."

Signals

On a shorter-term basis, we have lots of signals that indicate where the problems are right now. Or, sometimes they aren't even problems, but just places where some action is needed. For example:

- Lots that are behind schedule
- Tools that are down
- Tools that are up but idle, and have WIP in front of them, and need to be loaded
- Tools that are running, but have more WIP in front of them than usual (because of arrival variability, or a prior downtime)
- WIP that's piling up on a cart or a rack
- Lots that are going to exceed some time constraint between process steps soon
- Hot lots that are sitting in queue
- etc. (see issue 4.07 and 5.08 for others)

These signals all offer opportunities to take concrete action. If a lot is behind schedule, we can increase its priority. If a tool is down, we can send someone to fix it. If a hot lot is sitting in queue, we can call the shift supervisor, and get it moving. People who supervise manufacturing facilities take these sorts of action every day.

However, we don't have any automatic way to ensure that our actions in responding to the signals are going to lead to improvement in the fab's overall outcomes. For example, if five tools are down, there's no automatic way to know which one to fix first. If there are multiple lots that are behind schedule, there's no automatic way to know which one is the one that should be moved first. We generally take the common sense solution. We fix the tool that has the biggest pile of WIP in front of it first. We prioritize the lot that's latest to run first. But there's no way to really know which of these actions will help us the most to meet our longer-term goals. That's because we can't predict the future, and there's a lot of uncertainty in any fab.

Bridging the Gap between Signals and Goals

It's the job of the people who run a fab to bridge the gap between signals from the floor and outcomes from the fab. It's their job to identify the actions that will steer the fab in the direction of the overall goals. In practice, we can't reinvent the wheel for every little decision, and so we use rules to guide us in the more routine situations. We

have rules for making dispatch decisions at each tool, rules for when to take down a tool for maintenance, rules for when to hold tools for hand carry lots, etc.

People use a combination of past experience and research to get a sense of which rules will tend to move the fab in the right direction. We don't know what the optimal set of actions is to perform right now (and if we could calculate that, the situation would change in about five minutes). However, we do know that in general a greedy loading policy for batch tools is more robust to changes in product mix than a full batch policy (see issue 9.03), so we implement that. We know that dispatch rules like critical ratio, which take the lot's current due date performance into account, will tend to improve on-time delivery, and so we use those. We know that if we allow the bottleneck to starve, bad things happen, and so we prioritize WIP headed towards the bottleneck. And so on.

People who run today's fabs have a tremendous amount of experience and intuition about which indicators matter, and which actions will most likely lead to the right overall outcomes. But they're still fundamentally in a situation where they have to use short-term indicators and day to day activities to drive long-term goals, in a complex and changing environment. It's not easy.

Of course, here at FabTime, we think that having good data helps. You can't even begin to make the right decisions if you don't have the data in hand. You need to be able to see your indicators quickly, and be able to keep an eye on your goals every day, every shift, every hour. If you can take data from multiple locations in the fab, and incorporate it into your rules in real-time, you can streamline the process, and make better decisions. If you have solid data, and a good baseline set of rules, you're off to a good start. But the thing about fabs is that things change, frequently and unpredictably. So you're always also going to need people who can make decisions in response to problems, decisions that will hopefully keep everything moving in the direction of those long-term goals.

Conclusions

This conflict between short-term indicators and longer-term outcomes is an issue that comes up every day in fabs. We need to use real-time indicators to see the current problems, but then we need to extrapolate forward, to know which decisions are going to lead to the right outcomes. Conversely, we look at the overall indicators, even in the shorter-term, but then we need to translate misses into the right short-term actions. We need to do all of this in a highly complex environment, one chock-full of variability. This variability and complexity mean that it's difficult (sometimes impossible) to project a particular action forward, and know how it will influence the fab's overall outcome. While experience-based rules help, and access to good data is essential, we believe that the human element in managing fabs will always be necessary, too.

Further Reading

All of the past FabTime newsletters listed below are by J. Robinson and F. Chance. If you would like copies of any of these referenced issues, please send your request to newsletter@FabTime.com.

- "Performance Measures Typically Used in Wafer Fabs," *FabTime Newsletter*, Volume 1, No. 6, 2000.
- "Impact of Batch Size Decision Rules on Cycle Time," *FabTime Newsletter*, Volume 2, No. 1, 2001.
- "Setting Goals for Fab Performance," *FabTime Newsletter*, Volume 2, No. 8, 2001.
- "Identifying Real-Time Cycle Time Problems," *FabTime Newsletter,* Volume 4, No. 7, 2003.

- "Dynamic X-Factor", *FabTime Newsletter*, Volume 4, No. 8, 2003.
- "Dynamic X-Factor Revisited," *FabTime Newsletter*, Volume 5, No. 3, 2004.
- "Real-Time Alerting based on Fab Conditions," *FabTime Newsletter*, Volume 5, No. 8, 2004.
- "Resolving the Cycle Time vs. Utilization Conflict," *FabTime Newsletter*, Volume 7, No. 6, 2006.
- "Batch Loading Policies for Wafer Fabs," *FabTime Newsletter*, Volume 9, No. 3, 2008.

Subscriber List

Total number of subscribers: 2755, from 463 companies and universities.

Top 20 subscribing companies:

- Maxim Integrated Products, Inc. (197)
- Intel Corporation (149)
- Chartered Semiconductor Mfg (87)
- Micron Technology, Inc. (81)
- Western Digital Corporation (76)
- X-FAB Inc. (71)
- Texas Instruments (65)
- ON Semiconductor (59)
- Analog Devices (56)
- TECH Semiconductor Singapore (56)
- Freescale Semiconductor (55)
- International Rectifier (52)
- NEC Electronics (51)
- IBM (46)
- STMicroelectronics (46)
- Infineon Technologies (44)
- NXP Semiconductors (38)
- Cypress Semiconductor (38)
- Seagate Technology (37)
- ATMEL (32)

Top 3 subscribing universities:

- Virginia Tech (11)
- Arizona State University (8)
- Ben Gurion Univ. of the Negev (8)

New companies and universities this month:

- Centrotherm
- Gadir Solar

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 Training

"It was helpful to see best-in-class methods for wafer fab cycle time management. Discussing these matters in-depth with you was quite valuable, as we could ask questions specific to our fab and processes."

Shinya Morishita
Manager, Wafer Engineering
TDK Corporation

Course Code: FT105

This course provides production personnel with the tools needed to manage cycle times. It covers:

- Cycle time relationships
- Metrics and goals
- Cycle time intuition

Price

$7500 plus travel expenses for delivery at your site for up to 20 participants, each additional participant $300. Discounts are available for multiple sessions.

Interested?

Contact FabTime for a quote.

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Do you make the best possible decisions?

- Do your supervisors possess good cycle time intuition?
- Are you using metrics that identify cycle time problems early?
- Can you make operational changes to improve cycle time?

FabTime's Cycle Time Management Training is a one-day course designed to provide production personnel with an in-depth understanding of the issues that cause cycle time problems in a fab, and to suggest approaches for improving cycle times. A two-day version is also available upon request.

Prerequisites

Basic Excel skills for samples and exercises.

Who Can Benefit

This course is designed for production personnel such as production managers, module managers, shift supervisors, hot lot coordinators, and production control.

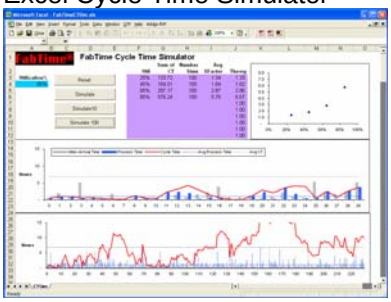
Skills Gained

Upon completion of this course, you will be able to:

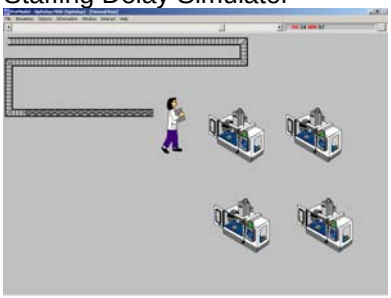
- Identify appropriate cycle time management styles.
- Teach others about utilization and cycle time relationships.
- Define and calculate relevant metrics for cycle time.
- Teach others about Little's law and variability.
- Quantify the impact of single-path tools and hot lots.
- Apply cycle time intuition to operational decisions.

Sample Course Tools

Excel Cycle Time Simulator



Staffing Delay Simulator



Additional Half-Day Modules

- Executive Management Session.
- Site-Specific Metrics Review.
- Capacity Planning Review and Benchmark.