FabTime Cycle Time Management Newsletter

Volume 6, No. 6 July 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 this version (7.5) include charts displaying dispatch performance and forecasted outs.

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Welcome

Welcome to Volume 6, Number 6 of the FabTime Cycle Time Management Newsletter! We hope that wherever you are, you're enjoying the summer, and we bring you a relatively short issue. This month we have an announcement about FabTime's sponsorship of the upcoming ISMI Symposium on Manufacturing Effectiveness. We hope to see you there! Our FabTime Software User Tip of the Month describes how to quickly view the status of all tools in a particular production area. We have no subscriber discussion this month, but we hope to hear from more of you next month.

Our main article this month is about the impact of holds on fab cycle time. This is not a topic that we've seen addressed in much depth in industry publications, despite being something that people who work in manufacturing deal with on a day to day basis. Holds negatively impact cycle time in two ways. First, the hold time itself is a direct addition onto cycle time. Second, holds increase variability in the fab, particularly when the time until a lot comes off hold is highly random. And as we know from our previous discussions, anything that increases variability in the fab is also increasing cycle time. We offer a few recommendations for managing holds, and we look forward to hearing your ideas.

Thanks for reading!—Jennifer

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Community News/Announcements

FabTime Sponsorship of ISMI Symposium

We are pleased to announce that FabTime will be a sponsor for the Second ISMI Symposium on Manufacturing Effectiveness, to be held at the Airport Hilton in Austin, Texas from October 24-26, 2005. The conference website reads: "The second annual symposium will share information and methodologies for reducing manufacturing expenses in both existing and next-generation fabs through advances in equipment, process, resource conservation, fab design, and manufacturing methods. Challenges will be addressed in several parallel sessions dealing with productivity, ESH, fab design, statistical methods, modeling and simulation, yield and metrology, and e-manufacturing. The Symposium will offer papers from selected ISMI projects and leading device and equipment manufacturers, along with a review focused on the Factory Integration section of the 2005 International Technology Roadmap for Semiconductors (ITRS) and a forum on critical issues facing the chip industry." More information is available at ismi.sematech.org/ismisymposium/. We recommend that you attend!

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

FabTime User Tip of the Month

View the Current Status of all Tools in Your Area

If you are responsible for a particular production area in your fab (photo, etch, implant, etc.), you probably need to know what's going on with the tools in that area. Which tools are up? Which tools are down for scheduled maintenance? Etc. You can use FabTime's "Tool WIP and State List Chart", which is available under "Tool State Charts" on the FabTime chart page. If you have no default filters set, and you press the "Go" button to generate this chart, FabTime by default will display all of the tools in the fab, along with their current state and amount of available WIP. Because there are so many tools in a fab, this chart is generally quite busy until you set at least one filter. Filling in your area in the "Area" filter to the left of the chart (and pressing "Go") will narrow the chart down to a particular area.

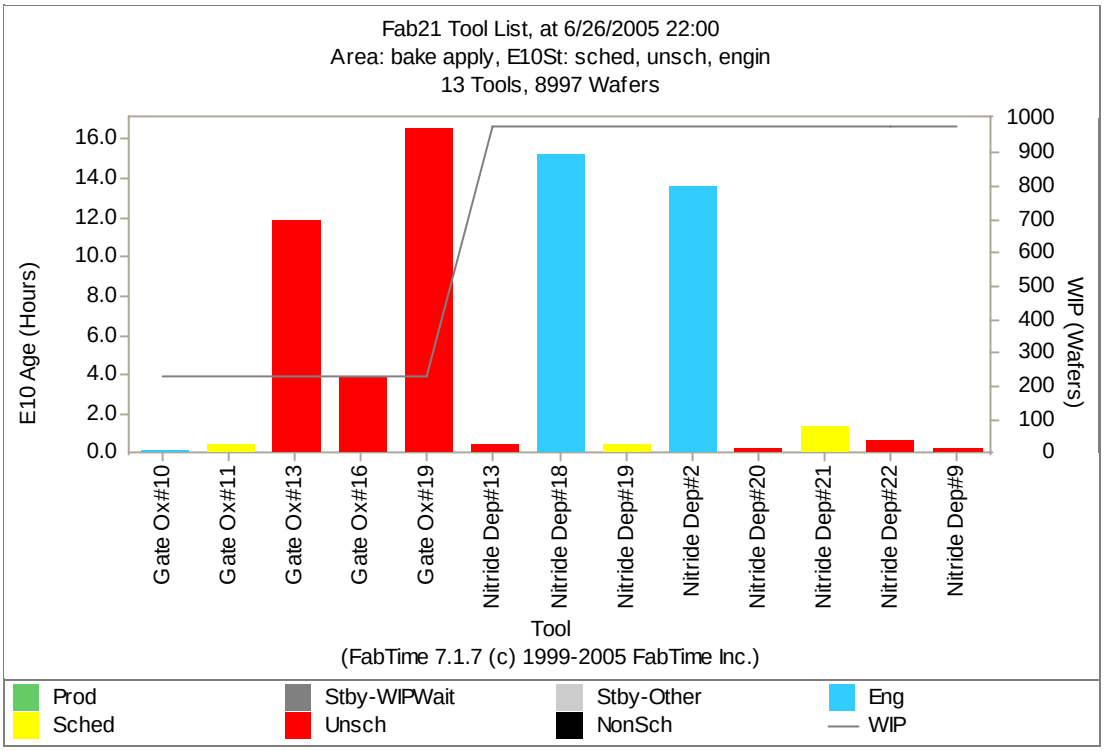
There will be a bar for each tool in the area. The height of the bar indicates how long the tool has been in its current state (displayed as E10 age on the left-hand axis). The color of the bar indicates the state, according to the SEM E10 tool states: Non-Scheduled, Scheduled Down, Unscheduled Down, Engineering, or Standby. A grey line indicates the amount of WIP (in wafers) currently qualified to run on the tool (against the right-hand axis), according to the tool qualification data imported from your MES.

Depending on the number of tools in your area, you may want to filter this chart

further, to only display down tools. To do this, type "Sched, Unsch" in the filter labeled "E10St" (adding "Engin" if you would also like to see tools in an engineering state). An example is shown below. Once you get the chart configured the way you like it, just click the "Add" button to add the chart to your home page.

Whenever your home page is refreshed, you'll see the current status of the tools in your area.

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

Perhaps due to the summer vacations, we have no new subscriber discussion this month. Some open topics from the past few issues include:

- The practical application of WIP turns
- Identifying the cause of declining moves in a wafer fab
- Correctly measuring theoretical cycle time in Overall WIP Effectiveness calculations.
- Improving lot tracking in less automated fabs
- Dispatching vs. scheduling in a fab

If you have any thoughts to share on these, or other fab performance-related topics, we would be happy to hear from you. Your comments can be published with or without your name and company name, as you prefer.

Cycle Time and Holds

Introduction

Lots on hold create cycle time problems for many wafer fabs, especially for fabs making development products. Reasons for placing lots on hold include:

- Waiting for an engineer to make a decision or a process change
- Waiting for the results of an inspection or other experiment
- Waiting for a down tool
- Slowing down the lot for sales reasons (e.g. the customer cancelled the order, and we're waiting to see if there is another order for this type of lot)

Another phenomenon that we've seen is the "future hold", in which an engineer makes a note in the manufacturing execution system (MES) that a lot should be placed on hold at some future operation. Depending on when the lot actually reaches this operation, the engineer may or may not be immediately available.

The Cycle Time Impact of Holds

Two primary cycle time problems arise from the presence of holds in the fab. First of all, the hold time itself adds directly to the lot cycle time. This leads to other negative consequences, such as increased WIP in the fab, poor due date performance, and possibly yield loss (see past newsletter issues 5.01 and 5.02 for a discussion of the relationship between cycle time and yield).

Holds also increase variability in the fab. Manufacturing personnel often don't know ahead of time when a particular lot will come off of hold. This can cause delays, if there is no one immediately available to process the lot. If many lots are released from hold at the same time, there can be WIP bubbles. Imagine a bottleneck starving for an hour, and then suddenly having eight lots come off hold, ready to go on the bottleneck tool.

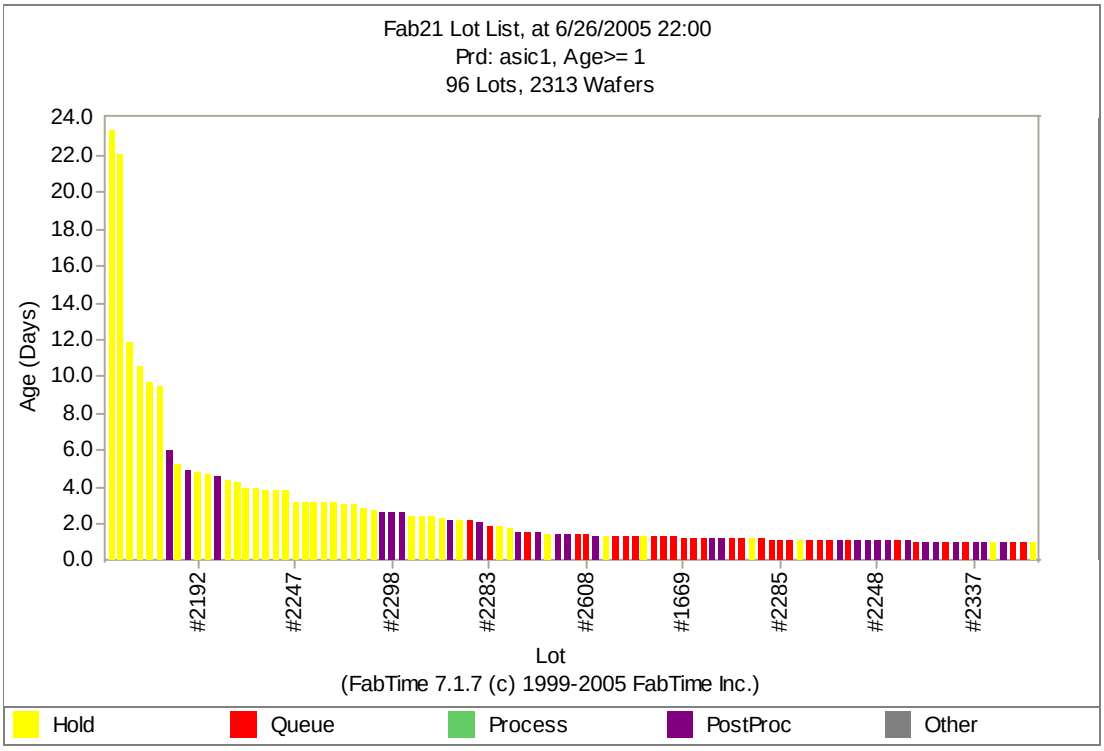
The duration of the hold time itself is also subject to variability. For example, if a future hold happens to come due when the engineer who requested it is out for a two-week vacation, the cycle time of the lot may be significantly increased. If a fab doesn't have procedures in place for regularly checking the status of lots on hold, held lots can slip through the cracks, and remain on hold long after they might have been released. This is primarily a communication issue.

All in all, this cycle time impact from holds can be quite significant, taking a fab that could be running with a cycle time of three times theoretical more into the range of four or five times theoretical.

Management Issues Related to Holds

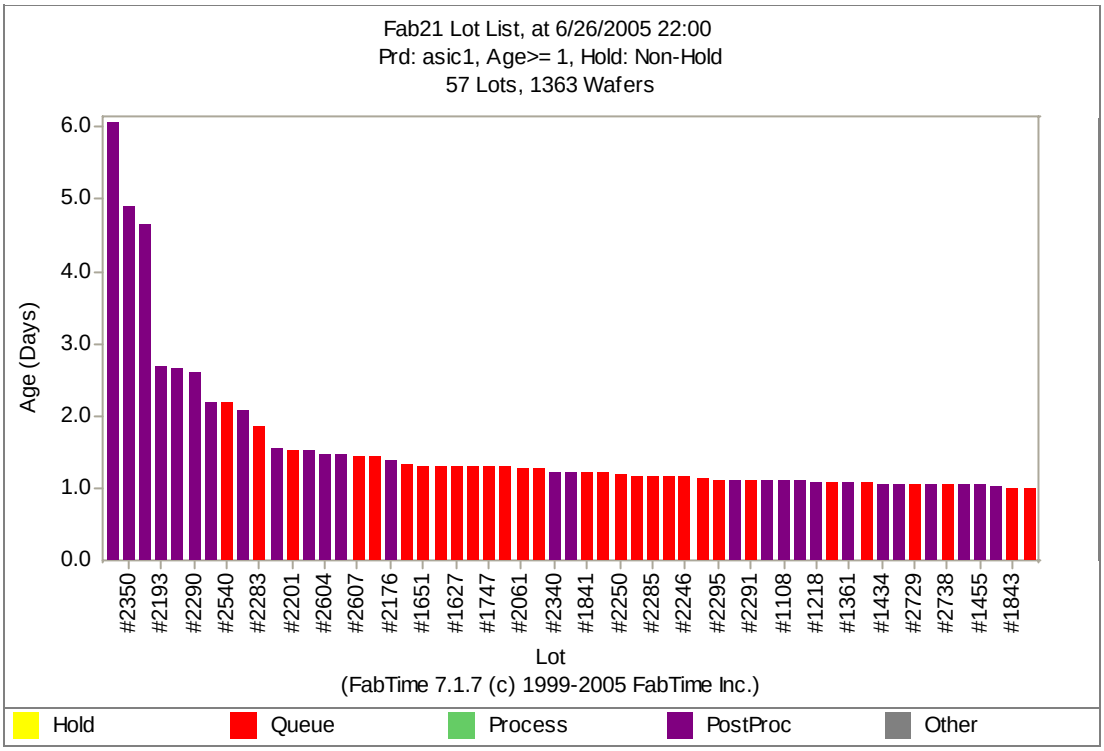
In addition to the direct cycle time problems that stem from holds, holds also make it harder to manage a fab. For example, a common management method used in fabs is to display all of the lots that are inactive, meaning that they have been at their current operation for more than some pre-defined period of time (e.g. 24 hours). Production personnel then focus on these inactive lots, and try to get them moving. However, if you display all of the inactive lots in a fab that has many lots on hold, you get something like the figure at the top of the next page.

This example displays all of the lots that have been at their current operation for more than 24 hours, for a single development product family. Yellow lots are lots on hold, red are in queue, green are in process, and purple are in post-processing (waiting to move out from the tool, or in transport). Each bar represents an individual lot (though not all lots are labeled on the x-axis, due to spacing constraints), with the height of the bar indicating the age at the current operation. The cluster of lots on extended hold tends to dominate the graph, making the lots in



queue (which could be worked on as soon as a tool is available) more difficult to see.

We have to filter out the lots on hold to get something that shows the lots in queue more clearly, as in the figure below (same as above, but with lots on hold not included). In this second graph, we can immediately see which lots require attention. In particular, we notice several lots that are in post-processing. It's not immediately clear why these lots, which have finished processing, have not been



moved on to the next step. However, this may be something that manufacturing can fix. We should remain aware, however, that when we filter out the lots on hold, they may lose our attention, and end up staying on hold longer than they should.

Another management issue related to holds is that sometimes when lots are placed on hold, the hold masks other problems. For example, a lot might be placed on hold because it requires a particular tool, and that tool is down for parts. Putting the lot on hold makes it clear to the operator that nothing can be done with the lot at present, and the operator moves on to something else.

This practice can lead to problems, however. First of all, the true queue time contributed by the tool in question is masked. When we try to look at the average queue delay per visit for lots going through this tool, the numbers may be highly skewed, because we've filtered out our worst cases by putting the lots on hold. The other problem with putting lots on hold for a down tool is that we need some procedure in place for re-classifying the lot once the tool does become available. If this procedure is insufficient, we can end up with lots that stay on hold, even after the required tool is back up and running.

Similar situations occur when lots are placed on hold because the reticle isn't ready, or because the fab is going to be shut down. First of all, this masks other cycle time problems, by taking the queue time for the lots out of standard reporting. Second, this exposes the fab to situations where lots could later be processed, but are not processed until someone releases them from hold.

Recommendations

Often people who work in manufacturing find it frustrating when there are many lots on holds, because they don't feel that there is much that they can do about the situation. And certainly the primary responsibility for reducing the number of lots on hold, if at all possible, must rest with the engineering organization. But if you do work in manufacturing, and consider holds a cycle time issue for your fab, our primary recommendations are these:

1. Don't put lots on hold when this hides other issues (e.g. shutdown, down tool, waiting for a mask, etc). It's better for the lot to show up as in queue for a down tool, for instance, so that the cycle time cost of the event remains apparent.

2. When you look at WIP in the fab, be sure to include updated status information for lots on hold, so that they aren't hidden, and slipping through the cracks. The more visible the holds are, the more likely it is that someone will do something to resolve them. (This may not be true for lots that are on extended hold for sales purposes, but is true for lots that are on hold waiting for one particular person to do something with them.)

3. Establish procedures for automatically notifying people about lots on hold, so that the right person is contacted about what needs to be done. This is especially important when managing future holds, so that when a lot goes on hold, the operator knows what to do, and who to contact. Consider setting thresholds, such that if a lot is on hold for more than some amount of time, the person who put the lot on hold is automatically pinged to see if anything can be done to get the lot off of hold.

Conclusions

The presence of lots on hold is a fact of life for many wafer fabs, especially those fabs running a high proportion of development lots. These holds are often outside the direct scope of responsibility for the manufacturing organization, as they are dictated by engineering requirements. However, holds can significantly drive up cycle time, and thus have an impact on the manufacturing organization. This is due to both the direct addition of the time on

hold, and to the increase in variability from hold durations and from lots coming off of hold. Therefore, in this article we have discussed management issues that stem from holds, and recommendations for reducing the cycle time impact of holds. We hope that you find them useful.

Closing Questions for FabTime Subscribers

Are holds a significant cycle time problem in your fab? Have you taken steps to mitigate the cycle time impact of these holds? Do you have any suggestions for other fabs that would like to reduce the number of lots on hold?

Further Reading

- J. L. Berry, N. Pierce, L. Serrano, S. Stankus, R. Darrington, W. Scott, B. Sinclair, "The Positive Cycle Time Impact of Closely Monitoring your Factory's Critical Tools," *IEEE 2000 Advanced Semiconductor Manufacturing Conference (ASMC '00)*, 75-80, 2000. The authors are from APRDL, Motorola (now Freescale Semiconductor), Austin, TX. (Mentions the significant proportion of lots on hold in the fab, and the impact on the need for a monitoring system.)

- Yu-Chi Chen, K. L. Young, and J. Y. Chou, "Key Factor for New Technology Transfer on the R&D Cycle-Time System," *Proceedings of the 2004 Semiconductor Manufacturing Technology Conference*, 182-185, 2004. The authors are from TSMC, Hsinchu, Taiwan. (Mentions the cycle time management challenge of "numerous engineering holds".)

- K. Hsieh, A. Ling, S. Huang, R. Luoh, M. Lin, L. Lee, "Super-Hot-Runs Management System," *Proceedings of ISSM 2000. The Ninth International Symposium on Semiconductor Manufacturing*, 363-366, 2000. (Mentions a focus on reducing hold time to improve hot lot cycle time.)

- H. Koike, F. Matsuoka, S. Hohkibara, E. Fukuda, K. Tomioka, H. Miyajima, K. Muraoka, N. Hayasaka, and M. Kimura, "Quick-Turnaround-Time Improvement For Product Development And Transfer To Mass Production," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 11, No. 1, 54-62, 1998. (Mentions efforts to reduce engineering hold time to improve cycle time.)

Subscriber List

Total number of subscribers: 1880, from 423 companies and universities. 25 consultants.

Top 10 subscribing companies:

- Intel Corporation (97)
- Analog Devices (79)
- Atmel Corporation (62)
- Infineon Technologies (57)
- STMicroelectronics (57)
- Freescale Semiconductor (52)
- Micron Technology (47)
- Philips (47)
- Texas Instruments (41)
- TECH Semiconductor (38)

Top 3 subscribing universities:

- Virginia Tech (10)
- Arizona State University (8)
- University of California – Berkeley (7)

New companies and universities this month:

- California State University – Fresno
- DayStar Technologies, Inc.
- Indian Institute of Management Ahmedabad
- Oregon State University
- Profactor
- RWE Schott Solar Inc.
- SEAL GmbH & Co KEG
- University of Alabama – Huntsville

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.

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FabTime® Software Capacity Planning Module

Installation

For a fixed price, FabTime will:

- Identify the source of any additional data needed for the planning module.
- Automate the process of importing the additional data into FabTime.
- Validate against client data.

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Do you need to answer questions like:

- Given a target product mix, do we need any new tools?
- Given the tools that we have, and the products that we are running, how many wafers can we expect to produce?
- Given our existing set of products and tools, what happens if the product mix changes? Where can we expect bottlenecks?

Are you tired of maintaining a standalone capacity planning spreadsheet?

FabTime's capacity planning module leverages the data already stored in the FabTime digital dashboard software, to make it easier to build capacity planning scenarios. The only required manual inputs are:

- Weekly ships per product.
- Product line yield percentages.

FabTime uses route information from the fab MES and calculates UPH data (tool speed) based on actual performance. FabTime also uses tool uptime performance to estimate availability (though this can be overridden). These inputs are used to generate predicted utilization percentages for each capacity type. Detailed intermediate calculations (UPH, tool productive time, tool rework percentage, etc.) are also available (an example for one tool is shown below). All outputs can be easily exported to Excel.

Capacity Planning Module Benefits

- Eliminate the need to maintain offline capacity planning models.
- Automatically update capacity planning data to reflect new conditions (process flows, tool uptime characteristics).
- Quickly run scenarios to anticipate (and avoid) bottlenecks caused by product mix changes.

C Type	Output	Value	Notes
1XStep	Rework Moves/Week	21	2004-09-06 10:00:00 to 2004-11-15 10:00:00
1XStep	Total Moves/Week	12310	2004-09-06 10:00:00 to 2004-11-15 10:00:00
1XStep	Rework Ratio	0	Rework Ratio = Rework Moves / Total Moves.
1XStep	Productive%	61	2004-09-06 10:00:00 to 2004-11-15 10:00:00
1XStep	Availability%	76.26	Availability = Productive% + Standby%.
1XStep	Historic Utilization%	79.99	Utilization (Mfg efficiency) = Productive% / Availability%.
1XStep	Productive(Rework)%	0.1	Productive(Rework)=Productive% * ReworkRatio.
1XStep	Net Availability%	76.15	Net availability% = Availability% - Productive(Rework)%.
1XStep	Arrivals (Units/Hour)	79.36	Based on total plan WGR=2025
1XStep	Tool Quantity	8	1XStep#1 ... 1XStep#8
1XStep	UPH	15.02	UPH = (TotalMoves/ToolQty) / (Productive% * 168)
1XStep	Required Hours/Day	126.84	Required hours = 24 * HourlyArrivalRate / UPH
1XStep	Predicted Utilization%	86.75	Util = 100 * ReqdHours / (24 * NetAvail * ToolQty / 100)
1XStep	Max WGR	2334.22	MaxWGR = PlanWGR / PredictedUtilization
1XStep	Historic WGR	2457.8	(Non Rework Moves) / (OperationCount / ProductCount).