FabTime Newsletter

Volume 23, No. 4 **August 2022**

Information

Publisher: FabTime Inc. FabTime sells cycle time management software for wafer fab managers. FabTime's mission is to help the people who run fabs improve performance by 1) helping them to understand the factors that drive fab performance and giving them the data to identify current improvement opportunities; 2) letting them control that data by setting parameters for their own charts, so they don't have to go back to IT every time they want a different piece of information; and 3) including them in a community of people around the world who are all working to drive better fab operations.

Editor: Jennifer Robinson

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Keywords: Holds; Fab Management; Reporting

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Welcome

Welcome to Volume 23, Number 4 of the FabTime Cycle Time Management Newsletter. It's been a busy summer both within FabTime and around the industry. We are pleased to announce three new FabTime employees (one already with us and the other two starting soon). We also share several industry news tidbits from Jennifer's LinkedIn, including the fact that wafer fab investments are headed to a record high this year. As suppliers to wafer fabs, we are grateful to see this capital expenditure. As long-time observers of the industry, we remain a bit nervous about potential capacity over-expansion. But we are overall hopeful!

We have no subscriber discussion in this issue. Perhaps all our readers were on vacation when the last issue came out.

In our main article this month we return to a topic last addressed here more than 15 years ago: the cycle time impact of holds. We discuss several ways that holds increase cycle time and share some associated management challenges arising from holds. We close with several recommendations for minimizing the impact of holds. In this month's software tip, we focus on how to remove holds from the list of inactive lots, while keeping them visible using other charts. As always, we welcome your feedback.

Thanks for reading! – Jennifer, Frank, Lara, and the FabTime Team

Community News/Announcements

New FabTime Employees

It's been a busy summer! Please join us in welcoming three new employees to our team:

- **Erica Flint** is our new Sales Assistant. Erica is a recent graduate of Cal Poly in San Luis Obispo with a degree in Political Science. She will be managing our contract renewal and invoicing process, as well as assisting Jennifer with our newsletter and contact maintenance efforts. Erica started with FabTime in June.
- **Elaine Jacobson** will be our new Director of Customer Success. Elaine comes to us with many years of wafer fab Industrial Engineering experience, most recently at onsemi (previously AMI Semiconductor) in Pocatello, Idaho. Starting in mid-August, Elaine will be an end-user advocate during FabTime installations, driving stronger post-installation adoption of FabTime's software.
- **Jonathan Schreiber** will be our newest applications engineer. He also comes to us as a recent graduate of Cal Poly, with a degree in Computer Science. Jonathan will report to Lara Nichols and support our software installation projects.

A Few Highlights from Jennifer's LinkedIn

Jennifer continues to share articles about business management, the semiconductor industry, and productivity improvement on her LinkedIn feed. Recent links have included:

- An article from Semiconductor Engineering about wafer fab investments heading to a record high. Fab investments "could reach a total of $109 billion this year, according to SEMI. That number is an all-time high for the semiconductor industry, and a 14.7% increase from last year. SEMI tracks more than 1,400 facilities and lines around the world, including 133 facilities and lines planned for the future." The article in Semiconductor Engineering discusses some of the potential headwinds, including staffing, substrate and rare mineral constraints. [The LinkedIn posts on Jennifer's page and on the Semiconductor Professionals Group page both have comments.]
- A WSJ piece about Micron's muted earnings that includes some projections regarding the chip shortage. "Chip shortages have hit the automotive, medical devices and other electronics-dependent industries hard. The chokepoints have largely been older-style chips, though, not memory.

  Micron, Mr. Mehrotra said, expects several customers in the PC and smartphone businesses to adjust their inventories due to consumer demand weakness. The company is bracing for a decline of 10% this year in PC sales and a decline of around 5% in smartphone sales, Mr. Mehrotra said in a call with analysts.

  Mr. Mehrotra said the company expects to reduce its spending plan on chip-making capacity expansion for the next fiscal year, which will now decline from this year's level, and would use existing inventory to address customer orders." [LinkedIn Post.]
- An article by Daniel Nenni on SemiWiki sharing research on worldwide wafer fab capacity from Stephen Rothrock of ATREG. In addition to wafer size there is data by technology node. We agree with Daniel that the sheer "capacity and growth of the so called mature nodes is impressive." Thank you to Thomas Beeg for the link. [LinkedIn Post.]
- A CNBC piece about the rapid U.S. House of Representatives passage of the CHIPS Act, the day after it passed the Senate. [LinkedIn Post.] News about the CHIPS Act has been widespread.

For more industry news, connect with Jennifer on LinkedIn.

FabTime welcomes the opportunity to publish community announcements, including calls for papers. Send them to newsletter@FabTime.com.

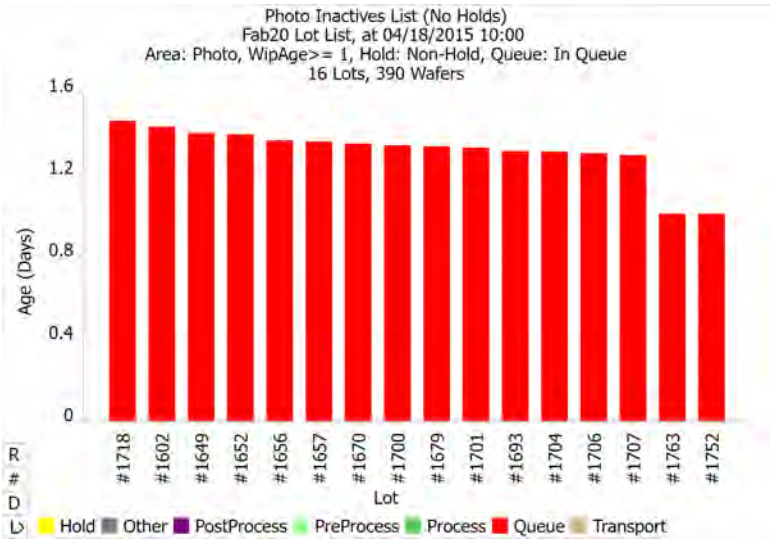
FabTime® User Tip of the Month

Separate Lots on Hold from the List of Inactive Lots

In our main article this month, we discuss the cycle time impact of lots on hold. We note that for fabs that rely on using lists of inactive lots, lots on hold can dominate the inactives list, making it difficult to use. In this tip, we discuss how to exclude lots on hold from the inactives list and what charts to use in parallel to make sure that the lots on hold also remain visible.

Many fabs flag lots as "inactive" or "static" if they wait in queue for more than some amount of time. Commonly used thresholds for this are 12 or 24 hours. You can use FabTime to generate lists of inactive lots for the entire fab, or for a particular area, tool group, or operation. To do this:

- Type "WIP Lot List" into the FabTime search bar and then select "WIP Lot List" from the results.
- Use the filters to the left-hand side of the screen to restrict the lot list to a particular area, tool group, or operation, if applicable.
- Use the "WipAge >=" filter to set the threshold for labeling lots as inactive (e.g., enter 12 for a 12-hour cut-off or 24 for a 24-hour cut-off). Make sure that the "WipAge" drop-down control is set to "Current Opn", and that the "Time" drop-down is set to units consistent with your threshold value (either hours or days). Use the "Queue" drop-down control at the very bottom of the list to select only lots "In Queue".
- To remove holds, set the "Hold" drop-down control to "Non-Hold." Press "Go" and FabTime will show you a list of all the lots that are not on hold and have been in queue for more than your threshold value. If you add this chart to your home page, it will automatically update to show the latest available data whenever your home page is refreshed. An example is shown to the right.



- If instead you would like to only see the lots on hold, simply change the "Hold" drop-down to "Hold." An example is shown below in the main article (Lots on Hold in Photo).
- To instead see the total number of wafers on hold together with the average duration of the holds, use the Hold Time Trend or Hold Time Pareto charts. To see the number of wafers on hold together with the percentage of wafers on hold, use the % on Hold Trend or % on Hold Pareto. The Hold Time List has a column for every lot hold instance that has taken place within the time period of the chart. The height of the bar is the duration of the hold, while the color indicates whether or not the lot is still on hold (yellow for on hold, green for off hold). An example of the Hold Time List is shown below in the main article.

We hope you find this tip useful.

FabTime software customers can subscribe to the separate Tip of the Month email list (with additional discussion for customers only) here: http://www.fabtime.com/tip-of-the-month.php. Thanks!

Subscriber Discussion Forum

FabTime welcomes the opportunity to publish subscriber discussion questions and responses. Simply send your contributions to Jennifer.Robinson@FabTime.com. We have no subscriber discussion in this issue.

Main Article: Cycle Time and Holds Revisited

Introduction

We last wrote about holds more than 15 years ago, in Issue 6.06. In this article we revisit and refresh that article to incorporate feedback received during our cycle time classes. We also showcase new charts and alerts that we've added to our software to make holds more visible.

A lot is on hold when an issue keeps it from being processed. Lots on hold typically do not show up as available for dispatch. Lots on hold create cycle time problems for many wafer fabs, especially for fabs making development products. To improve cycle time, holds typically need to be reduced.

Reasons for placing lots on hold include:

- Waiting for an engineer to make a decision about a lot or enable a process change.
- Waiting for the results of an inspection or other experiment.
- Waiting for a down tool or missing reticle.
- Slowing down the lot for sales reasons. For example, the customer cancelled the order, and we're waiting to see if there is another order for this type of lot. [These types of holds are less common in 2022's capacity-constrained environment.]

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. Just about every fab for which we've conducted cycle time improvement classes has acknowledged using some level of future holds. A problem with future holds is that, depending on when the lot reaches the future hold operation, the engineer may or may not be immediately available.

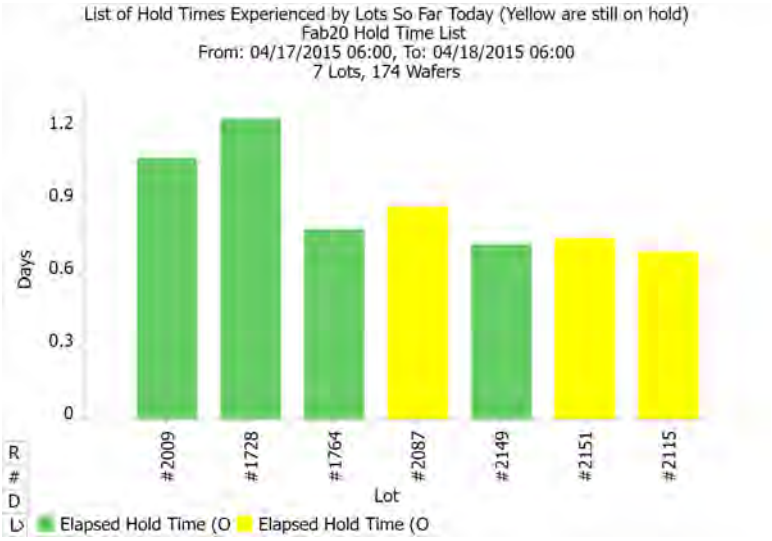
The Cycle Time Impact of Holds

Several cycle time problems can arise from the presence of holds in the fab. First, 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, wider cycle time distributions, and possibly yield loss. (See 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 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 starved 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.

The chart to the right shows instances of lots having been on hold during the current shift. The green bars show lots that have come off hold, while the yellow bars show lots still on hold. This example is from a simulation – a real fab will typically show *much* higher variability, with some hold times lasting for days or weeks.



Finally, for inspection-related holds, if the lot on hold needs to be re-tested, this can lead to unplanned capacity loss on the tool in question. As readers of this newsletter well know, any unexpected capacity loss can increase fab cycle time.

Overall, the cycle time impact from holds can be 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 the lots that are inactive, meaning that they have been in queue 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 we display all the inactive lots in a fab that has many lots on hold, we frequently see a cluster of lots on extended hold (with age at the current operation ranging into weeks). These lots on hold 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 need to filter out the lots on hold to get something that shows the lots in queue more clearly, so that operators/supervisors know where to focus. (See Issue 6.06 for an example.)

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. It's important to be able to both exclude the lots on hold on the inactive charts and include updated hold status on other charts (as in the example to the right, which shows lots currently on hold in a Photo area, with the height of the bar equal to the time on hold so far).

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, the true queue time contributed by the performance of 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

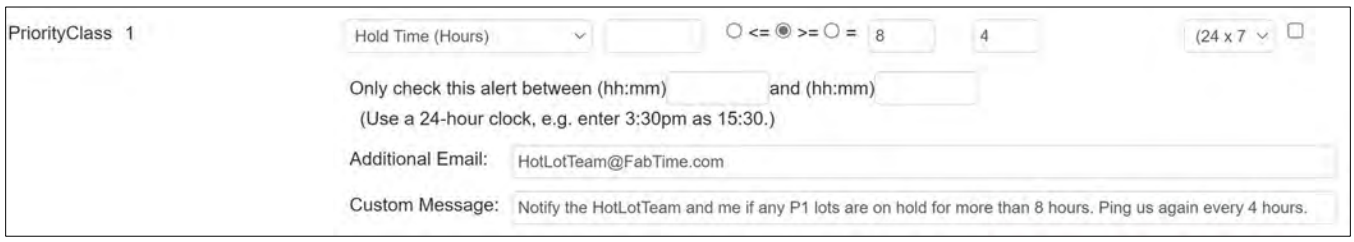
the lots on hold. The other problem with putting lots on hold for a down tool is that we need some procedure in place for re-classifying the lot once the tool does become available. If this procedure is insufficient, we can end up with lots that stay on hold, even after the required tool is back up and 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, 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 should 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. It's also less likely that the lot will remain on hold after the issue is resolved.
2. When you look at WIP in the fab, be sure (at least some of the time) to include updated status information for lots on hold. This ensures 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 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, someone is automatically pinged to see if anything can be done to get the lot off hold. An example is shown below. Some fabs use tiered alerts, where a different person is notified if the lot remains on hold for a longer time.



4. For future holds, if possible, ensure that a backup is specified for the primary engineer who placed the lot on hold. That way if the primary engineer is out of the office or on vacation, a pathway exists to at least potentially keep the lot moving.

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 increase 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 hold. 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 Newsletter 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? Do you use future holds?

Further Reading

We looked but did not find any recent articles about hold time reduction in wafer fabs. The article below all touch on hold times but are mostly more than 20 years old. If you have any newer published work on this topic, please let us know.

- 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: 2850

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- onsemi (186)
- Infineon Technologies (146)
- Analog Devices (132)
- Intel Corporation (129)
- Micron Technology, Inc. (120)
- Microchip Technology (100)
- GlobalFoundries (92)
- NXP Semiconductors (82)
- STMicroelectronics (69)
- Carsem M Sdn Bhd (66)
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Top 3 subscribing universities:

- Ecole des Mines de Saint-Etienne (EMSE) (7)
- Arizona State University (6)
- Virginia Tech (6)

New companies and universities this month:

- Argo AI
- AT&S
- IceMOS Technology
- Johnson & Johnson
- MathWorks Japan
- Teltonika
- Tignis

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.

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FabTime® Software: If you would like more information about our web-based dashboard for improving fab cycle times, please visit our website. A sample home page and a sample page from FabTime's new Charts menu are shown below.