FabTime Cycle Time Management Newsletter

Volume 11, No. 5 December 2010

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 the ability to specify a default home page tab and formatting changes for display of very large numbers in data tables.

Editor: Jennifer Robinson

Contributors: Billy O'Donnell (National Semiconductor)

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Welcome

Welcome to Volume 11, Number 5 of the FabTime Cycle Time Management Newsletter! We hope that the holiday season finds you all well. Here at FabTime, as is the case with many companies in the industry, we're closing out a more successful 2010 than the previous year, celebrating four new customer sites and numerous software enhancements. We're optimistic that 2011 will bring good things to the economy as a whole and to the semiconductor industry in particular.

In this final newsletter issue of the year, we have community announcements about Future Fab International's new email publication, and the Fab Owners Association upcoming member meetings. Our FabTime user tip of the month is about adding complex logic within standard filters, using the new in-filter WHERE clause. We have subscriber discussion related to early lot delivery times, OEE, and the number of columns in the PDF newsletter (to switch to the PDF version, email newsletter@FabTime.com).

In our main article this month, we discuss the application of "reverse dispatch" in the presence of time constraints between process steps. Where there are time windows between steps, lots are usually held at the upstream step, and only released when needed by the downstream step. This poses an implementation issue for dispatch systems, which usually look at one tool at a time. What FabTime has been working on is a system called "reverse dispatch", by which the person running the downstream tool can look back at all of the WIP queued at the upstream tool, and then make the best dispatching decision for both steps.

Wishing you all a joyful holiday season, and a productive 2011! – Jennifer and Frank

FabTime

Tel: (408) 549-9932
Fax: (408) 549-9941
www.FabTime.com
Sales@FabTime.com

Community News/Announcements

Future Fab International

The November issue of Future Fab International is now available from http://www.future-fab.com. Future Fab also now offers an electronic newsletter. The newsletter includes abstracts and links to technical articles, as well as news briefs from the company's partner organizations (such as universities), and general industry news items. For example, we were interested to learn that:

- A Vanderbilt study showed no increased cancer risk for semiconductor industry cleanroom workers (article here); and that
- EE Times finds that falling IC Development productivity means lost engineering jobs (article here)

Fab Owners Association

The next two meetings of the Fab Owners Association (an international, not for profit, trade association of semiconductor & MEMS fab owners and associates who meet regularly to discuss and act on common manufacturing issues, combining strengths and resources to become more competitive) will be held:

- On February 17th at Triquint Semiconductor in Hillsboro, OR.
- On May 12th at Anadigics in Warren, NJ.

We hope to have representation from FabTime at both meetings.

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

FabTime User Tip of the Month

Add Complex Logic within Standard Filters

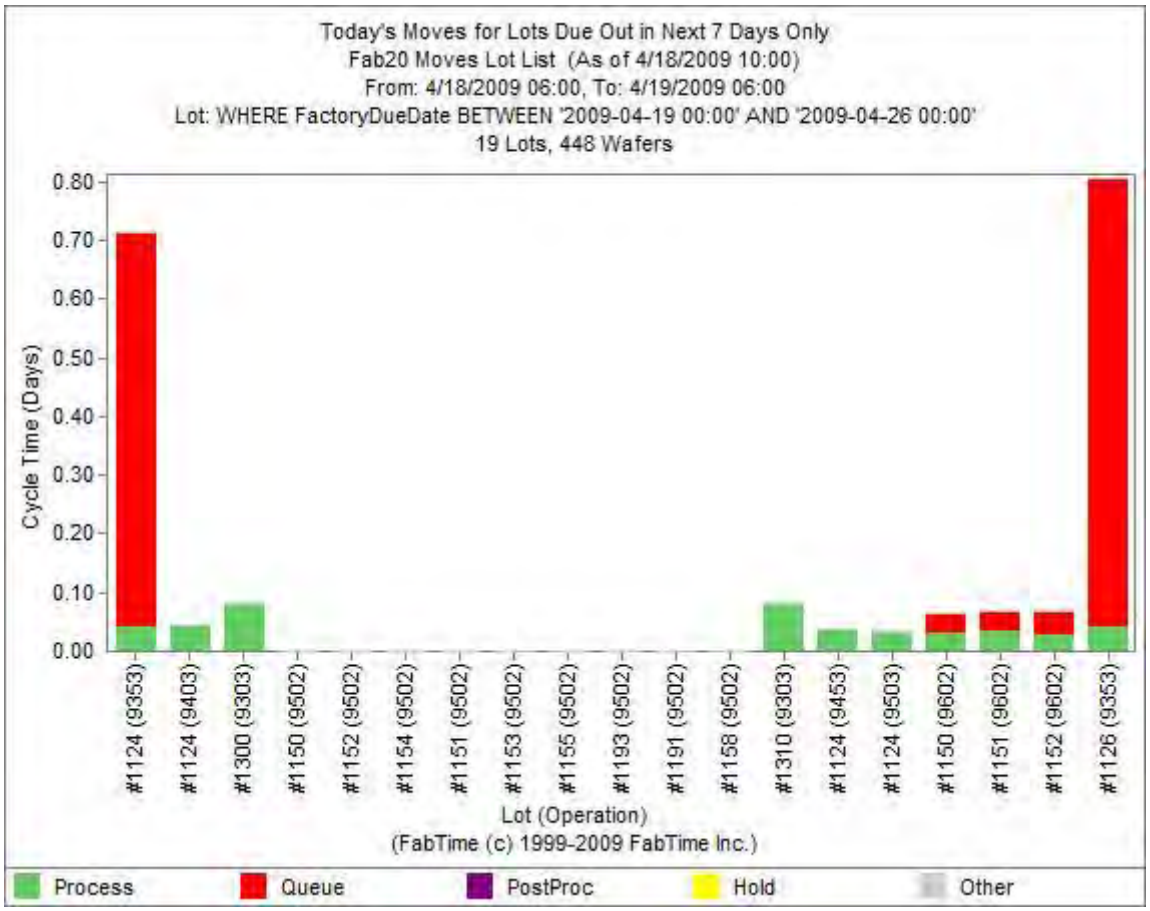
A new feature in FabTime (requires Patch 100, released in mid-October) is the ability to use a generic SQL Where clause from within standard object filters on charts. What this means is that you can add complex logic to the way that you specify filters, more detailed and flexible than the standard wildcards, exclusion filters, and comma separated lists. For example, suppose that you would like to restrict a Moves Lot List chart to only show lots with due dates within the next week. Just set the Lot filter to be:

WHERE FactoryDueDate BETWEEN '2010-12-15 00:00' AND '2010-12-22 00:00'

An example of this from our demo server (with slightly different dates to match the dates in the demo) is shown below.

Similarly, if you would like to restrict, say, a list of WIP by Operation to only show operations with descriptions that contain the word 'photo', set the Operation filter to be:

WHERE Description LIKE '%photo%'



This capability is different from the separate SQL filter -- the SQL filter is applied to the data table values AFTER the chart calculations are completed. Thus the SQL filter cannot be used to limit objects unless data about the objects is displayed in the data table. By contrast, the object filter WHERE clause is applied earlier, and can include data that isn't necessarily included in the data table at all, as long as that data is associated with the underlying table in FabTime.

We realize that not all users (perhaps not even very many users) are accustomed to writing SQL WHERE clauses. And you certainly don't have to use this functionality. But, as you can see from the above examples, the formats are actually quite logical and easy to learn. And this capability allows for virtually unlimited end user control over exactly what data gets included in charts. If you have some special case filtering need (like, "I only want to see what's happening over lunch hour across each day of the week" or "I only want to include lots that were started between December 1st and December 3rd"), your site system administrator, or FabTime's tech support staff, can help you find the right filter to include (and then you can save the chart to your home page for future use).

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

Early Lot Delivery

We don't have anything for attribution, but thought that it was worth noting that people from two different fabs emailed Jennifer to say that they had just been having discussions about the problems of early delivery times, and the impact of hot lots on regular lot cycle times. Apparently, the last issue was rather timely ;-)

Number of Newsletter Columns

Last month we asked for subscriber feedback on a proposed change from two columns to one. This change had been requested by a subscriber. We only heard from one other person, who asked that the newsletter continue to be sent in two-column format, as the two column format allows faster reading. So... unless we hear from anyone else with strong opinions, we'll stick to the two-column format for now.

OEE

Billy O'Donnell from National Semiconductor in Scotland wrote in response to last month's subscriber discussion comments on OEE. He said: "My own feeling is that OEE is a "useful" metric, but can be dangerous if used poorly. One major limiter is that it's often calculated based on the "planned" throughput of the tool. This doesn't encourage anybody to work on increasing the "planned" throughput rate towards the absolute maximum. This seems to me to be the most bankable way of increasing tool capacity. I also agree with your concern about the value of planned idle time. If you plot OEE for all the tools in a fab, I'd expect distribution with high numbers on the constraint tools, and others lower. I've not seen anything though on what shape you'd expect that curve to be for particular cycle time targets.

With all its limitations, we have had some success tracking OEE on all tools. It's really come when we focus improvement efforts on the right tools at the right part of the business cycle. When business is up, it's about the capacity constraining tools, getting more from the high capital cost tools, to increase capacity at minimum capital cost. When it's down, our focus has been on understanding OEE and running cost of tools, and focusing on driving up OEE to the point where we can turn off tools.

I would be very interested to see anything on OEE distribution across tools and tool sets."

FabTime Response: We think that Billy makes an excellent point about OEE not encouraging you to drive up the "planned" throughput of tools. We have not, however, seen any research that looks at the distribution of OEE across tool sets, let alone how this might vary depending on cycle time targets. Do any subscribers have anything to share on this?

FabTime welcomes the opportunity to publish subscriber discussion questions and responses. Simply send your contributions to Jennifer.Robinson@FabTime.com.

Time Constraints and Reverse Dispatch in Fabs

Introduction

In this article, we discuss the application of "reverse dispatch" in the presence of time constraints between process steps. As we've discussed previously in the newsletter (see issues 6.04 and 8.07), lot dispatching is normally applied at the individual tool level. A dispatch list is a list of all of the lots that are currently available and qualified to run on a particular tool, sorted according to the desired criteria. Each tool has its own dispatch list (though lots can appear on multiple lists, and dispatch lists can be displayed for multiple tools at one time).

The question is: how do you handle dispatching when WIP is queued not at the step of interest (e.g. a furnace), but instead at a prior step (e.g. a clean step). The reason to queue the WIP this way is the presence of time constraints between process steps. Such time constraints (also called time bound sequences or time windows) lead to forced rework if too much time passes between steps. Or, in this example, if too much time elapses after the clean step but before the furnace run. In this article we describe a methodology for dispatching in the presence of time constraints.

Time Constrained Processing in Wafer Fabs

Time constraints are one of the many complications that make operating wafer fabs a challenge. They exist for a variety of process reasons. As an example, the furnace step must take place within a certain time window of the clean step. Otherwise, the wafer can suffer yield problems, if the clean step is not repeated. In some cases, wafers must actually be scrapped if time constraints aren't met.

Capacity planning can be tricky in the presence of time constraints. If you have any intervening steps between two time-constrained operations, time constraints can lead to an unstable situation. This is because each lot that is reworked increases the utilization of the intermediate tool. But increasing the utilization of the intermediate tool increases the cycle time through that tool, which increases the chance of other lots missing their time constraint, and also having to be reprocessed. This becomes a vicious cycle. (See Robinson and Giglio, referenced below, for details - Jennifer did her dissertation on this subject.)

In practice, we believe that people handle time constraints in capacity planning by assuming some percentage of rework, and managing the tools carefully to ensure that this percentage is met. The question, then, is how to handle the time constraints on a day-to-day, operational basis, to minimize the chance of rework.

Reverse Dispatch

For customers who use FabTime for dispatching, we've been managing time constraints through what we call "reverse dispatch". In FabTime, in addition to specifying the current tool being dispatched, users can also filter for a particular "NextTool". If used, this means that only lots that will go on to the specified downstream tool next will be selected for processing. This can be used, for example, to temporarily ensure the feeding of a downstream bottleneck.

To apply reverse dispatching in a time constraint situation, the operator sets the NextTool filter on the dispatch list to be the downstream tool (e.g. the furnace), and sets the Tool filter to be the set of possible tools at the prior step (e.g. the clean tools). The filters on the dispatch list chart might look like this:

Tool: CLEAN*
NextTool: FURNACE22

What FabTime does in this case is look for all the WIP that is waiting for any of the CLEAN* tools, then generate all possible qualified combinations of clean-step / furnace-step tools, and then throw out any of these where the furnace-step tool is not FURNACE22. What we're left with is a dispatch list for FURNACE22, based only WIP that is waiting for the CLEAN* tools.

The operator (or operators) running FURNACE22 and the CLEAN* tools can generate this list while FURNACE22 is still busy processing, then decide on the next batch to run, and get that ready to go on one or more of the CLEAN* tools (depending on how much time is left for the current FURNACE batch, and what the time constraint is).

If there are any intervening steps between the clean processing and the furnace (e.g. perhaps a dummy step for visual inspection, etc), then FabTime works with the site to define the logic to identify these intervening steps. Once that is in place, the operator can simply specify the tool and NextTool filters and FabTime will automatically skip over the intervening steps.

In all cases, the furnace and clean steps (or other types of time-constrained tools, as applicable) are managed as a unit. WIP is held at the clean tools, and only released when the furnace is ready for it. The dispatching logic essentially starts at the furnace, and then looks backward at the clean step to decide what to process next through both operations. Other factors can also be taken into account in the dispatching decisions, including batch size optimization, due date performance of the lots, etc.

Forward-Based, Tool Qualification Approach

Another potential approach to this problem, instead of looking backward from the furnace, is of course to look forward from the clean step. It's possible to include tool qualification data in the MES for the clean steps for all of the downstream furnaces. One could then call up a dispatch list at the clean step by specifying FURNACE22 as the tool. In general, this amounts to a fudging of tool qualification data, so that it looks as if furnace tools are qualified for clean steps. However, this approach requires a considerable amount of data setup, maintenance, and documentation (to deal with the likely confusion later on when someone asks "why are these furnaces listed as qualified tools for clean steps that obviously don't run on a furnace?"), and doesn't seem to us to be as intuitive as the reverse dispatch method.

Essentially, this tool qualification approach is a push system, while the reverse dispatch method is more of a pull system. In a case where one has a short sequence of steps to worry about, and a critical time constraint, a pull system seems likely to generate less rework (though we have no analytical results on this). Of course care needs to be taken, with either system, to ensure that the downstream tool is not starved for WIP.

Conclusions

Time constraints between process steps are a fact of life in wafer fabs. The time constraints exist for process reasons, often to ensure that a lot is processed on a furnace within a set time window after being cleaned. When time constraints are missed, reprocessing (or even scrap) results. Time constraints pose capacity planning challenges, since the amount of reprocessing that will occur is variable.

To minimize reprocessing, lots are usually held at the upstream step, and only released when needed by the downstream step. This poses an implementation issue for dispatch systems, which often look at one tool at a time. In response to customer requests, FabTime has implemented a system of "reverse dispatch", by which the

person running the downstream tool can look back at all of the WIP queued at the upstream tool, and then make the best dispatching decision for both steps.

We have not seen this issue of the dispatch implementation in a time-constrained system addressed in the literature, and we thought that we would bring the topic to our subscriber community. We welcome your feedback! If you have published any articles on dispatching in the presence of time constraints, please send the reference to us, and we'll share it with the subscriber community in the next issue.

Closing Questions for FabTime Subscribers

How do you handle time constraints between process steps in your dispatch system? Do you think that this "reverse dispatch" approach makes sense? Or do you favor the forward-based, tool qualification approach?

Further Reading

- M.-Y. Hsieh, M.-H. Hsieh, P. Chen, and H. W. Shie, "Innovations in Time Constraint Management - The Trade-off Between Time Constraint and Cycle Time," *Proceedings of the 2002 International Symposium on Semiconductor Manufacturing (ISSM2002)*, Tokyo, Japan, 2002.

- J. H. Kim, T. E. Lee, H. Y. Lee, D. B. Park, "Scheduling Analysis of Time-Constrained Dual-Armed Cluster Tools," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 16, No. 3, 521-534, 2003.

- S. J. Mason, "Scheduling and Dispatching in Wafer Fabs," *FabTime Newsletter*, Volume 8, No. 7, 2006.

- J. K. Robinson and F. Chance, "Lot Dispatch for Wafer Fabs," *FabTime Newsletter*, Volume 6, No. 4, 2003.

- J. K. Robinson and R. Giglio, "Capacity Planning for Semiconductor Wafer Fabrication with Time Constraints between Operations." *Proceedings of the 1999 Winter Simulation Conference*, Phoenix, AZ. Available for download from FabTime .

- W. Scholl and J. Domaschke, "Implementation Of Modeling And Simulation In Semiconductor Wafer Fabrication With Time Constraints Between Wet Etch And Furnace Operations," IEEE Transactions on Semiconductor Manufacturing, Vol. 13, No. 3, 273-277, 2000.

- Muh-Cherng Wu, Yai Hsiung, and Hsi-Mei Hsu, "A Tool Planning Approach Considering Cycle Time Constraints and Demand Uncertainty," *International Journal of Advanced Manufacturing Technology*, Vol. 26, No. 5, 565-571, 2005.

Subscriber List

Total number of subscribers: 2743, from 454 companies and universities.

Top 21 subscribing companies:

- Maxim Integrated Products, Inc (180)
- Maxim Integrated Products, Inc. (175)
- Intel Corporation (147)
- GLOBALFOUNDRIES (134)
- Micron Technology, Inc. (84)
- Western Digital Corporation (77)
- X-FAB Inc. (67)
- Texas Instruments (66)
- International Rectifier (63)
- TECH Semiconductor Singapore (61)
- ON Semiconductor (56)
- STMicroelectronics (55)
- Freescale Semiconductor (54)
- Analog Devices (53)
- IBM (49)
- NEC Electronics (46)
- Infineon Technologies (41)
- Cypress Semiconductor (38)
- Skyworks Solutions, Inc. (35)
- ATMEL (32)
- National Semiconductor (32)
- Seagate Technology (32)

Top 4 subscribing universities:

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

New companies and universities this month:

- Axetris Microsystems (div of Leister)
- BH Electronics
- ISS Industrial Services & Solutions

Sampler Set of Other Subscribing Companies and Universities:

- Abbott Laboratories (18)
- Andy Stables Consulting (1)
- AU Optronics Corporation (5)
- Clayton Consulting (1)
- Colibrys (1)
- Defense Contract Management Agency (DCMA) (1)
- Ecole des Mines de Nantes (1)
- Feng Chia University (1)
- Global Communication Semiconductors (10)
- Hamburg University of Applied Sciences (1)
- Hendon Semiconductors (2)
- Hitachi (4)
- Intermolecular (1)
- Interpro Services (1)
- Marvell Semiconductor (1)
- National Institute of Technology Calicut (1)
- SAMES (1)
- SystatS Consulting (1)
- Teradyne (1)
- University of Pennsylvania (1)

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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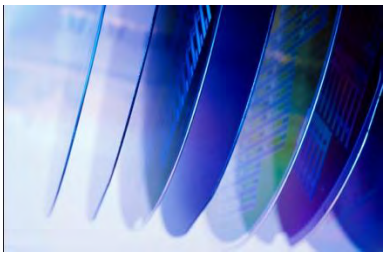
FabTime® Dispatching Module



Dispatch Configuration and Support

We offer our dispatching and planning modules together for a single, fixed monthly fee (on top of your regular FabTime subscription). This includes:

- Dispatch rule and factor configuration via user-friendly web-based interface.
- Training.
- Dispatch list feed to the MES (if applicable).
- Support and upgrades.

Dispatch Factors

- Batch code at the current tool.
- Lot priority.
- Downstream tool priority.
- Current tool FIFO.
- Current tool idle time.
- Downstream batch efficiency.
- Critical ratio.
- Earliest-due-date.
- Current step processing time.
- Remaining processing time.
- Current step qualified tool count
- WIP level or staging time at downstream tools.
- Up to 20 other site-specific factors.

Interested?

Contact FabTime for details.

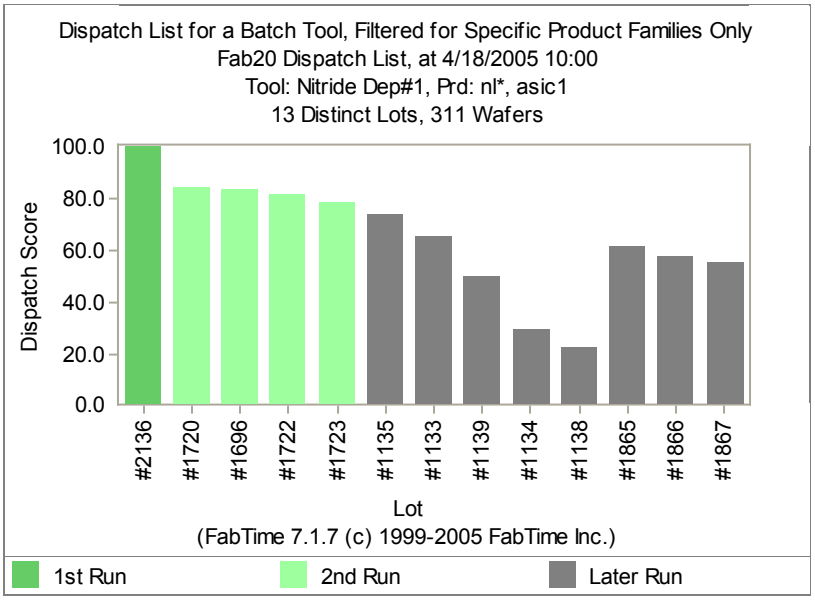
FabTime Inc.
Phone: +1 (408) 549-9932
Fax: +1 (408) 549-9941
Email: Sales@FabTime.com
Web: www.FabTime.com

Do your operators make the best possible dispatching decisions?

- Do you struggle to balance lot priorities and due dates with tool utilization and moves goals?
- Do your critical bottleneck tools ever starve?
- Do you use standard dispatch rules, but feel that your fab's situation is more complex, requiring custom blended rules?
- Do you know how well your fab executes your dispatch strategy?

FabTime's dispatching module is an add-on to our **web-based digital dashboard software**. At any point, for any tool in your fab, FabTime will show you the list of all lots qualified to run on that tool. This list will be ordered by the dispatching logic that your site has selected for that tool. This logic can use standard dispatch rules such as Priority-FIFO and Critical Ratio. However, you can also create custom dispatching logic using any combination of dispatch factors (shown to the left).

You can display dispatch lists in FabTime, and/or export them back to your MES. FabTime also includes a dispatch reservation system to hold downstream tools when a lot is started on an upstream tool, as well as dispatch performance reporting.



FabTime Dispatching Module Benefits

- Ensure that wafers needed by management are in fact the wafers that are run, while requiring less manual intervention on the part of management.
- Improve delivery to schedule, and the display of performance to schedule.
- Document the dispatching logic used by the best operators and make this available to all shifts.