FabTime Cycle Time Management Newsletter

Volume 9, No. 2 February 2008

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 month include support for site-specific WIP attributes and filters, and the addition of current estimated shipment date for each lot to the WIP Lot List data table.

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Welcome

Welcome to Volume 9, Number 2 of the FabTime Cycle Time Management Newsletter! We hope that all of you are having a productive 2008 so far. We are certainly keeping busy. In honor of a short month, we have a relatively short newsletter issue. We have one community announcement – a call for papers for the 2008 MASM conference. Our software user tip of the month is about showing and hiding data table columns in FabTime. We have no subscriber discussion this month, but we hope that our new topic will spark some future discussion.

In our main article, we discuss lot transfer between operations for non-automated fabs. Although material handling in automated fabs has gained considerable attention in the literature, we believe that lot transfer is also having a significant impact on cycle time in less automated fabs, and that this topic is relevant for many of our newsletter subscribers. Behaviors such as the use of carts for lot transfer and the use of performance incentives for operators that do not reward the movement of material between areas can lead to higher than anticipated cycle times. For those fabs that are experiencing delays due to lot transfer, we recommend working towards reducing transfer batch sizes between steps, either by physically purchasing smaller carts, or by changing the way that operators are assigned or measured. If a full-scale change in carts or operating practices is not possible, we recommend identifying the specific areas in which material movement issues are causing cycle time, and implementing changes in those areas first. We discuss these potential solutions in detail, and welcome your feedback.

Thanks for reading!—Jennifer

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Community News/Announcements

Call for Papers: Modeling and Analysis of Semiconductor Manufacturing Conference (MASM '08)

Conference chairs **John Fowler**, **Lars Mönch**, and **Chen-Fu Chien** have announced that the 4th International Conference on Modeling and Analysis of Semiconductor Manu-facturing (MASM 2008), held in Miami, FL, December 7-10, will again be a forum for the exchange of ideas and best practices between researchers and practitioners from around the world involved in modeling and analysis of high tech manufacturing systems. The MASM 2008 conference will be fully contained within the Winter Simulation Conference 2008 (WSC '08), the leading conference in discrete event simulation (http://www.wintersim.org/). You can find the call for papers, and detailed submission requirements, at http://www.wintersim.org/MASM.htm. The deadline for paper submissions is April 1st. The general chair for WC '08 is **Tom Jefferson** (Intel) and the Program Chair is John Fowler (Arizona State University).

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

FabTime User Tip of the Month

Show or Hide Individual Columns on Chart Data Tables

A new feature in FabTime (part of Patch 90) allows users to customize the columns included in the data table for each chart. Below the column name for each data table column, you'll now see the word "(Hide)" as gray underlined text. Clicking "(Hide)" for any column will cause that column to no longer be displayed. Once you have hidden one or more columns, two new links will appear immediately above the data table:

- "Show all hidden columns." Click "Show" to re-display all of the hidden columns.
- "Save current columns as default." Click "Save" to tell FabTime to use this column configuration by default, whenever you generate this type of chart in the future.

Note that if you have saved a data table configuration, and you later un-hide one or more of the columns, you will need to click "Save" again if you want your new configuration to be used in the future.

One other note: in order to allow the showing and hiding of each individual column, we have eliminated column titles that stretch across multiple columns. This required some editing of the column

names. If you notice any unexpected text in the new column titles, please use the Feedback form to let us know. We felt that this increased flexibility for users was worth some extra effort in managing the column titles.

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

FabTime welcomes the opportunity to publish subscriber discussion questions and responses. We have no subscriber discussion for this month.

Manual Lot Transfer in Wafer Fabs

There are many references available concerning the implementation and technical issues of automated material handling systems. What we haven't seen addressed in much detail in recent literature is lot transfer for fabs that use manual methods. We believe that lot transfer for non-automated fabs can have a significant impact on fab cycle times, particularly when this transfer is undertaken using carts. While carts are certainly helpful ergonomically, and can reduce scrap levels relative to hand transport, they can lead to a host of cycle time issues. These issues, and some recommended solutions, are discussed below.

Issues in Lot Transfer

The primary issue that we've observed in many fabs is that inter-bay transport is usually done using carts. These carts can typically hold anywhere from six to 25 lots at one time. It has been our experience, in talking with people from fabs, that carts are usually not moved from bay to bay

until they are full, or nearly full. This is human nature. It makes sense from the operator's perspective, and results in an efficient reduction of trips. However, from a cycle time perspective, these full carts are not a good thing. What happens is that the first lot placed on the cart may have to wait for quite a long time until the cart is moved, adding to that lot's cycle time. Then, when lots are transported downstream, they arrive in large bunches, and often have to wait longer than they would have if they arrived downstream in smaller batches. Thus we have additional queue time on both ends - while the lot is waiting to be transferred, and then again after the transfer takes place. This is queue time that fabs are willfully adding to lot cycle times, queue time that could be avoided.

The other issue, besides the size of the carts, that affects transport behavior in fabs is performance incentives for operators. Usually operators get credit for the number of "move out" transactions recorded. Once the "move out" is recorded, the lot goes onto a cart or a shelf, and the operator doesn't receive any further credit for taking the lot downstream. Upstream operators also get credit for the number of "move out" transactions that they record. Their incentive is that as long as they do have WIP available that they can process, there is no reason to waste time looking upstream for other WIP. And even when they do run out of WIP at a particular tool, they may be responsible for another tool that does have WIP, and thus incentivized to go and load that tool. The problem is that the most critical WIP for them to be processing, the WIP that will allow them to fill batches efficiently, or minimize setups, might be sitting on a shelf or a cart upstream. For fabs with dispatch systems (by which the operator is shown a list of what lots should be processed next), these issues are brought to light. For fabs that rely on more operator-selected manual dispatching, however, overall performance could often be much improved by getting lots to their downstream tools more quickly.

There's another dispatching issue associated with having lots sitting on carts. In most non-automated fabs, the "move out" transaction is used in lieu of a "move in" transaction at the next operation. Any travel time is treated as part of the queue time for the downstream operation. In most cases, this works fine, and saves operators time in not having to record near-duplicate information. However, when transport times become long, fabs can get into a situation in which the dispatch list at a particular tool shows lots which are actually still sitting on a cart in a different area, waiting for transfer. The operator has the choice of leaving the equipment idle and going in search of the lot, or not following the dispatch list and possibly getting marked down for noncompliance. This is part of why, in the presence of formal dispatch lists, some fabs have installed RFID and other lot tracking systems.

Lots sitting on carts can also affect the equipment state information reported in non-automated fabs. FabTime's software, for example, uses "begin run" and "move out" transactions to break down tool available time according to whether each tool is busy, standby because there is no WIP, or standby with WIP waiting. This third state, standby WIP waiting, is generally a flag indicating some sort of problem. Because clearly the best thing for cycle time is that if a tool is available, and has WIP ready to go, that tool should be running. What happens when lots are sitting on carts, instead of ready to process at the downstream tool, is that the time at the downstream tool is reported as standby WIP waiting time. However, from the operator's perspective, this is inaccurate, because the WIP wasn't actually there at the tool to be processed. In fact, this standby WIP waiting time is valuable

information in this case, since it does indicate that there's a problem with WIP that is ready to be processed, and a tool that could be processing it (but can't because the lot is physically somewhere else).

Potential Solutions

Smaller Carts: The simplest solution to the above issues is to purchase smaller carts. Or at least to put policies in place requiring carts to be moved downstream when the number of lots exceeds some lower threshold, or when any lot has been waiting for more than some target time window. We have worked with fabs that reduced the overall fab cycle time simply by installing smaller carts. This is a relatively inexpensive solution, and one that can, in some cases, have a significant effect. However, this issue is not always straightforward. If a fab is operator constrained, having the operators make more frequent trips to transport lots downstream may be impractical.

Runners: Some fabs that we have visited use dedicated transport operators (runners) who move lots between bays. For larger fabs, this can lead to ergonomic issues (as the operators have to walk considerable distances over the course of the day). There are also cost issues associated with hiring additional personnel. And, of course, these "extra" operators are likely to be the first ones cut in the event of a need for cost reduction. But this does solve the incentive problem discussed above, in a clean fashion. These operators would be judged based on some sort of travel time metric, instead of on "move outs".

Metrics: It may be possible to reduce lot transfer problems by changing the performance measures for operators, to incentivize either the upstream or downstream operators to physically move the lots. For example, if the upstream operator didn't get credit for a move until the lot was moved in at the next step, then that operator would have an incentive to move the lot. This would likely require switching from recording "move outs" to recording "move ins", however, or adding "move in" transactions, which would put additional workload on the operators. To incentivize downstream operators to go out in search of particular lots would probably require the use of dispatch lists, and performance incentives based on dispatch list compliance. However, such a scheme would need to be implemented carefully, to prevent tools from sitting idle while the operator is off seeking a specific lot.

Deciding Where to Start for Phased Solutions

Our recommendation, if the widespread use of the above methods is not practical (or palatable), is that fabs consider the selective use of runners and/or restricted load sizes on carts. The truth is that every single lot doesn't need to be breathlessly rushed downstream. Often when a lot gets to the next operation, it is going to sit for a while, because there's a big queue at that operation. In a case like this, it's less critical that the lot be immediately brought to the downstream tool. [Though of course it's important to keep in mind that the sooner the lot does arrive downstream, the better equipped the operator at that downstream tool will be to make batching and setup decisions.]

But what we really don't want is to see lots sitting waiting for transport to a bottleneck tool that is being temporarily starved. This leads to immediate cycle time issues for the waiting lot, as well as future cycle time issues on the bottleneck, which will have difficulty making up for the lost productive time. You know which tools are your bottlenecks. What you need to do is check the tool state data for those bottlenecks, to see if there is any standby WIP waiting time. If there is, this may be an indicator that material transport issues are driving up cycle time. Your operators can probably tell you. And if this standby WIP waiting

time is caused by something else (maybe a lack operators to run the tool), that's useful information, too.

You will probably also need to keep an eye on tools that aren't technically bottlenecks, in a utilization sense, but have long cycle times. These are tools that offer the opportunity for improvement through changes in operating practices, without capital spending. If the overall utilization of a tool is low, but the cycle time is high, this behavior may be caused by irregularity in how lots arrive to the tool. [Alternatively, of course, this may be caused by availability issues.] Again, the standby WIP waiting time is a potential indicator.

It may also be possible to use MES data to identify disconnects between when the MES thinks that WIP should be in front of a tool, relative to what the operator does see. If your operators log tools to states like "idle, no WIP", this data can be compared to the MES "move out" transactions. Where you find a disconnect, this tells you that carts are causing a particular problem.

Once you have identified the tools or areas in which lots waiting on carts may be causing specific cycle time problems, those are the paths for which you should first explore smaller carts and/or dedicated transport operators. Of course you'll need to keep in mind that situations in a fab can change rapidly, and that the patterns of special transport policies will likely vary over time. In the long-term, we still recommend attempting to reduce the size of transfer batches, either through changes in operator policies and allocations, or through the physical implementation of smaller carts.

Conclusions

While there is considerable technical literature concerning the use of automated material handling in wafer fabs, we believe that material handling issues in non-automated fabs also warrant discussion. Where carts are used to transport lots between steps, the natural human tendency towards efficient trip management leads to full carts, and higher cycle times. Even when carts are not specifically used, but lots sit on racks awaiting transport, delays can occur. The primary performance incentives for operators in most manual fabs, move completions, do not necessarily lend themselves to optimal lot transport, since no credit is typically given for the time spent transferring lots between bays. These factors can, in many fabs, combine to cause higher than necessary cycle times. For those fabs that are experiencing delays due to lot transfer, we recommend working towards reducing transfer batch sizes between steps, either by physically purchasing smaller carts, or by changing the way that operators are assigned or measured. If a full-scale change in carts or operating practices is not possible, we recommend identifying the specific areas in which material movement issues are causing cycle time, and implementing changes in those areas first. We believe, and have seen in the fabs that we've worked with, that reducing transfer batch sizes between steps can lead to a significant improvement in overall fab cycle time. We welcome your input on this topic.

Closing Questions for FabTime Subscribers

Do you use carts for manual transport of lots in your fab? How many lots can you fit on a cart? Have you experimented with larger or smaller carts? Do you use dedicated "runners" to transport material, or is the transport done by regular operators?

Further Reading

■ C. D. Geiger, R. Hase, C. G. Takoudis, and R. Uzsoy, "Alternative Facility Layouts for Semiconductor Wafer Fabrication Facilities," *IEEE Transactions on Components, Packaging, and Manufacturing Technology. Part C: Manufacturing*, Vol. 20, No. 2, 152-163,

1997. Results of a simulation study looking at different layouts show "that cellular layouts, where machines are dedicated to a limited number of process steps, require more machinery but perform well when setup and transfer times are high and machinery is reliable. As machines become more unreliable, the flexibility of the process layouts becomes a major advantage. An interesting result is that the addition of modest amounts of extra capacity at critical workstations can significantly improve the cycle time performance of a fab."

■ A. I. Sivakumar, "Simulation Based Cause and Effect Analysis of Cycle Time Distribution in Semiconductor Backend," *Proceedings of the 2000 Winter Simulation Conference*, 2000. (All WSC papers since 1997 are available for free download from www.informs-cs.org/wscpapers.html). This paper looked at the effect of various factors, including material handling time, on cycle time, via simulation model.

■ R. Yu (TSMC), "Modeling the Transportation Manpower of Staffing Requirement with a Semiconductor Manufacturing Stack Fab," *Proceedings of the 2004 International Symposium on Semiconductor Manufacturing (ISSM 2004)*, Tokyo, Japan, 2004. In this study, the authors "establish a model to evaluate the proper manpower for transportation activity across the complex environment included multi-floors and twin-fab to solve the staffing problem that persecutes manufacturing managers all the time."

Subscriber List

Total number of subscribers: 2807 from 477 companies and universities. 21 consultants.

Top 20 subscribing companies:

- Maxim Integrated Products, Inc (249)
- Intel Corporation (164)
- Micron Technology, Inc. (84)
- Analog Devices (67)
- ATMEL (66)
- Infineon Technologies (66)
- Freescale Semiconductor (64)
- X-FAB Inc. (64)
- Texas Instruments (62)
- STMicroelectronics (59)
- International Rectifier (57)
- Cypress Semiconductor (55)
- TECH Semiconductor Singapore (54)
- Chartered Semiconductor Mfg (51)
- ON Semiconductor (50)
- NXP Semiconductors (48)
- IBM (45)
- Spansion (37)
- Seagate Technology (33)
- BAE Systems (30)

Top 3 subscribing universities:

- Virginia Tech (11)
- Ben Gurion Univ. of the Negev (8)
- Nanyang Technological University (7)

New companies and universities this month:

- Capovani Brothers Inc.
- Heptagon Micro Optics
- PriceWaterhouseCoopers
- SAIPA Corporation
- University of Albany

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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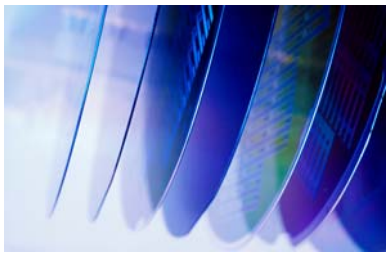
FabTime® Dispatching Module



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.
- 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 at downstream tools.
- Up to five other site-specific factors.

Interested?

Contact FabTime for technical details.

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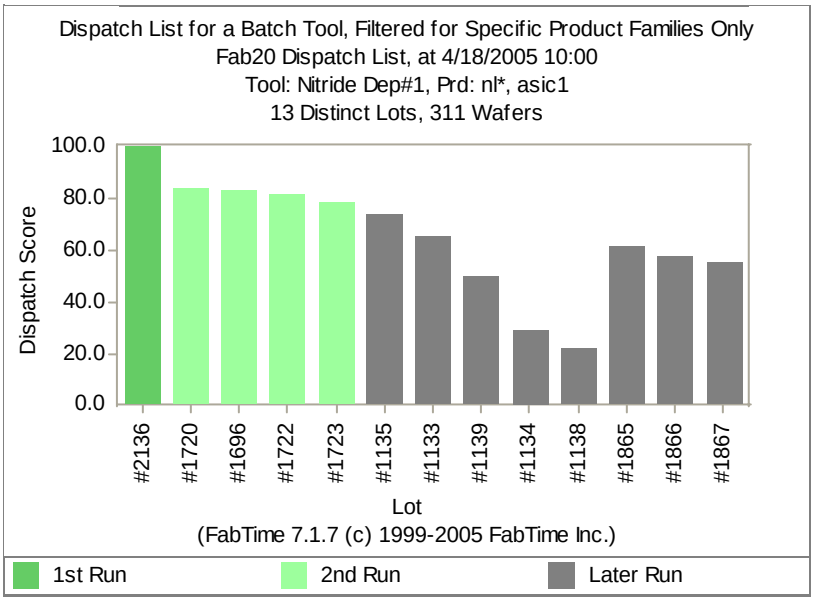
Do your operators make the best possible dispatching decisions?

- 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.