FabTime Cycle Time Management Newsletter

Volume 14, No. 1 January 2013

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 addition of Uptime%, Downtime%, Operations-MfgTime%, OperationsUptime%, and OperationsDowntime% to tool-state trend and pareto data tables; and the addition of "exportable view" to home page tabs, to print or send to PDF.

Editor: Jennifer Robinson

Contributors: Scott Mason (Clemson University); Brad Richardson and John Pollock (Cypress Semiconductor)

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Welcome

Welcome to Volume 14, Number 1 of the FabTime Cycle Time Management Newsletter! We hope that the New Year finds you all well. Here at FabTime we've been busy with core product enhancements, installations for new customers (we're just kicking off Sites 33 and 34), and cycle time management training. We hope that holiday shopping ultimately drove business increases for all of you.

In this issue, we have one community announcement about a new production planning and control book published by three very long-time newsletter subscribers. Our software user tip of the month is about using the A20/A80 metrics to improve availability variability for tools. We have no formal subscriber discussion in this issue, but we have posed a few questions, in the hope of sparking some discussion for the coming year.

Our main article this month is about overcoming productivity losses that may occur during shift change. Whenever operators are measured (even self-measured) on move completions, there is a natural incentive not to start lots running that will not finish before the end of the shift. This leads to lost capacity on tools, as well as increased arrival variability to downstream tools. FabTime has been working with Cypress Semiconductor to develop a metric, called Earned Plan Hours, which attempts to overcome this behavior. As always, we welcome your feedback.

Wishing you a productive 2013. Thanks for reading – Jennifer and Frank

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Community News/Announcements

New Book Available on Production Planning and Control for Semiconductor Wafer Fabrication Facilities

September 27, 2012 -- Our long-time friend and colleague, **Professor Scott Mason**, brought to our attention his latest book. We thought that many of our readers would find it of interest. Here are the details:

Lars Mönch, John W. Fowler, and Scott J. Mason, Production Planning and Control for Semiconductor Wafer Fabrication Facilities: Modeling, Analysis, and Systems (Operations Research/Computer Science Interfaces Series), Springer Press, September 1, 2012. ISBN-13: 978-1461444718.

You can order this book from Amazon at http://www.amazon.com/exec/obidos/ASIN/1461444713/fabtimehomepa-20. (FabTime is an Amazon affiliate.)

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

FabTime User Tip of the Month

Use A20/A80 Charts to Measure Equipment Variability

A category of FabTime charts that we think may be especially useful to people right now are the Tool A20/A80 charts. A20 and A80 are metrics designed to measure the variability of equipment availability. We first learned about these metrics from a Future Fab International article by Peter Gaboury (see FabTime Newsletter 4.2 for more details). We have incorporated them into FabTime as follows.

For each tool, for each time period, tool available time = productive time + standby time, (as defined in the SEMI E-10 standard).

Tool availability% = (available time) / (total time).

If we measure repeated observations of this availability% over a period of time, for a set of like tools, and sort those in decreasing order, A20 is the best (highest) availability met or exceeded by 20% of the observations, e.g. it acts like an upper percentile of the availability distribution. It says, 20% of the time we reach this availability or better. When the tool is working really well, this is what we get. A80 is the best availability met or exceeded by 80% of the observations. This means 80% of the time, across all tools and time periods selected, we had at least this availability. Only 20% of the time do we get a worse availability than this. A80 is essentially a conservative lower bound on what performance you can expect from this set of tools going forward.

You can see the individual tool availability observations, as well as the A20 and A80 cutoffs, by generating a Tool Availability List in FabTime. Use the Tool: or TG: filter to specify a tool, or a set of similar tools (e.g. all of the implanters from a particular manufacturer). Set the period length to be at least a week, and experiment with sub-period lengths of 12 or 24 hours. Ideally, you'd like to have at least 30 observations of availability on the chart, to have a large enough sample size to calculate A20 and A80.

What we want on this chart is for A20 and A80 to be high and close together. This means that the availability from tool to tool, and time period to time period, is consistent. Tools that have a low A80 value (even if they have a high A20 value) are difficult to manage, because there's always a pretty good chance of having poor short-term availability.

While the Tool Availability List chart is most useful if you want to see in detail what is going on at a particular set of tools, you can use the A20/A80 Trend chart to look at what's happening with the A20 and A80 values over time. You'll likely need to edit to make the period lengths (Len:) at least a week. (Use the List version to see what settings work for this tool type.) The Trend chart can help you to determine whether or not downtime reduction programs are helping to improve the variability of your availability. The A20/A80 Pareto chart can also help in comparing the performance of different tool types. For example, you might create a Pareto chart for an area, sliced by tool group.

We know that all fabs are already focused on improving overall availability. The A20/A80 charts let you take that focus to the next level, by looking not just at overall availability, but at how that availability varies over time. Reducing your availability variability (by increasing A80), will help directly with cycle time improvement programs.

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

While no one submitted formal subscriber discussion topics this month, we did have a few questions come up at a training class that we presented that we thought we would extend to our subscribers. Perhaps some of these will spark further discussion.

- What percentage of lots on hold is appropriate for a fab? (And yes, none would be nice, but that's probably not realistic).
- What are people currently targeting for total hot lot percentage and number of hand carry lots? What we're seeing at sites we visit is that fabs are trying to reduce the number of hot lots relative to, say, 8-10 years ago. Is this a general trend?
- Are people currently estimating operator utilization percentages, or still relying more on some sort of moves per operator number?

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

Overcoming Productivity Losses during Shift Change

Introduction

We've observed that many fabs have an issue with productivity losses during shift change. These losses tend to arise when moves (or major step moves) are used to track operator performance. There is an incentive for the operators to finish short production runs toward the end of the shift, because that is the only way to get credit for a move. This may mean that tools are left idle at shift change, because there is no incentive in place to keep tools working. Operators have no incentive to start lots on tools unless the lot can be finished within the current shift. In the worst case, this behavior causes moves to spike up towards the end of the shift, and then drop to a very low level at the beginning of the next shift. These large swings in moves create downstream variability, and may lead to tool starvation and/or high cycle times. This behavior can also wreak havoc on dispatch compliance (and thus on things like on time delivery).

We've heard of fabs attempting to overcome this behavior by overlapping shift change (such that operators from the second shift come in before the operators from the first shift have left). However, it's not clear that this will fix the problem, because you still have the operator on the first shift running as many short production runs as possible before the next person comes in. Other fabs focus on dispatch compliance, hit rate, or target fulfillment measures to counteract shift-change productivity losses.

Our hypothesis is that a combination of these measures is required… with a dispatch compliance or hit rate metric to incentivize *desired* moves, and a volume metric (like earned plan hours) to incentivize *enough* moves.

New Earned Plan Hours Metric

We have been working with one of our customers, Cypress Semiconductor, to develop a new metric that may counteract this undesirable shift change productivity loss. The Earned Plan Hours metric gives operators an initial form of credit when lots are first tracked into tools, and continues to give them credit while those lots are being processed. When a lot is first tracked into a tool, credit is given for the planned queue time of the lot at its current flow/step. As the lot is processed, credit is given up to the end of the planned process time or shift change, whichever one comes first. In this way, operators are incentivized to start a lot running on a tool, even if there are just a few minutes left in the shift, because they will immediately receive credit for all of the lot's planned queue time. They will also receive credit for any portion of the planned process time up to shift-change, even if the lot doesn't move out of the tool until the next shift. This actually incentivizes people to start more difficult lots (with longer planned queue times) late in the shift. Used correctly, we believe that this metric will lead to less tool idle time during shift change.

During the shift, the Earned Plan Hours metric also improves productivity by only giving credit up to the planned process time. If lots sit on tools after they are finished processing, and don't get moved out, no one gets credit for that time. This should incentivize people to move lots out of the tools, as well as moving lots into the tools.

Interpretation

The Earned Plan Hours metric (let's call it EPH for short) has a natural interpretation at the factory level. If there are 1,000 wafers in the factory, and each of these wafers is being moved according to its plan, then on average each wafer should accumulate 12 earned plan hours during each shift. Thus there should be 1,000 * 12 = 12,000 earned plan hours for the factory. If there are more than 12,000 earned plan

hours for the shift, then the factory is generally ahead of its plan. If there are less than 12,000 EPH for the shift, then the factory is generally falling behind its plan.

Or, thinking about this at the wafer level, suppose that on average we recorded 22.5 earned plan hours per wafer yesterday. Since a day is 24 hours long, we know that moving each wafer on average of 22.5 planned hours closer to shipment means that we are falling behind the plan. The plan, by definition, is to move each wafer 24 planned hours closer to shipment each day. We are basically comparing how fast we are moving each wafer along the line to how fast we planned to move each wafer along the line.

In both cases, the aggregated EPH metric can be normalized and compared to one. In the first example, we can take the cumulative EPH number for the factory and divide by 12,000. If the result is greater than one, this means that the fab is moving things faster than the plan. If less than one, the fab is falling behind relative to the plan. In the second case, the per wafer EPH number is divided by 24, with the same result. An EPH ratio that is less than one is an early indicator that the fab needs to improve in order to meet targets. An EPH ratio that is consistently greater than one may suggest that the step-level planned cycle times are not accurate, and should be revisited.

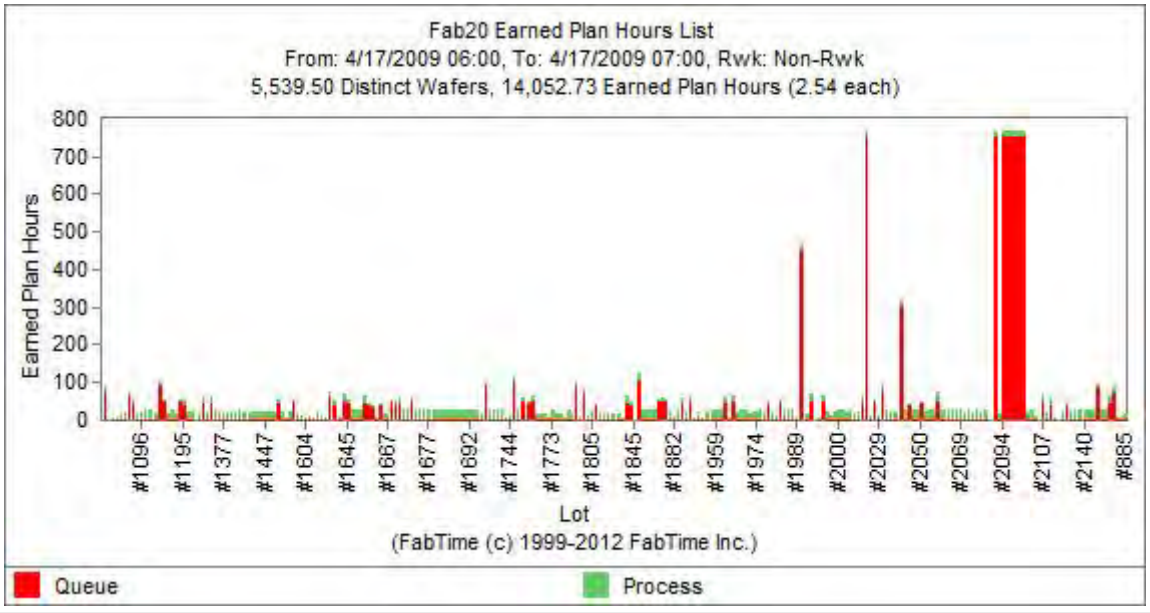
Example

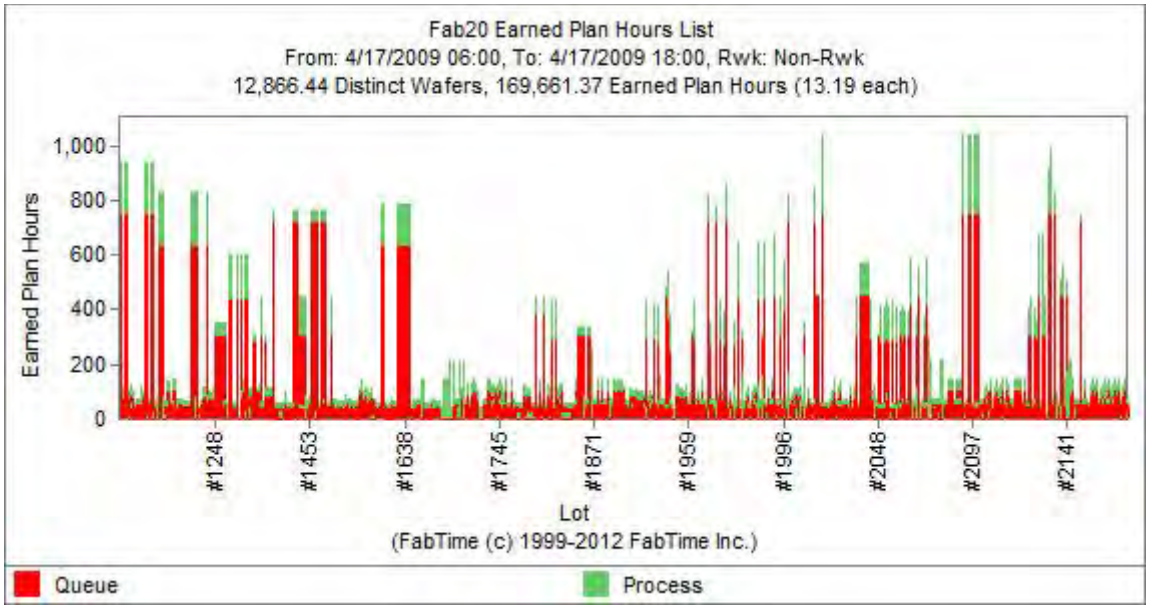
A sample EPH list chart is shown below for a one hour period. Each column of the chart represents an Earned Plan Hours data point for a single lot. The high red bars were generated by a batch run (which had a high queue time recorded for each wafer, and didn't finish processing during the shift). The bars that are primarily green in this example represent lots that finished processing during the hour, but started processing earlier.

The average EPH per wafer for the above one-hour time period was 2.54, much higher than the expected value of 1. However, this was skewed up by the start of a large batch. Such things smooth out over time. An example from a 12 hour shift is shown on the top of the next page. The EPH per wafer is 13.19 in a 12 hour shift, for an EPH ratio of about 1.1.

Earned Plan Hours and Dispatching

As with all move-related metrics, the Earned Planned Hours metric does potentially conflict with a pure dispatch focus. Near the end of the shift, the EPH metric encourages operators to find the lots that have the longest planned queue time. These may not be the lots that the





dispatch system cares about the most. In fact, hot lots are going to have a smaller planned queue time than regular lots (if this is reflected in your MES), so a focus on EPH alone could lead to worsened hot lot performance. But no move-driven metric is going to be perfect in isolation (using move outs can also lead to issues with dispatch compliance). We would suggest using these two approaches together. FIRST follow the dispatch list. And THEN use the EPH metric to encourage people to start the next lot in the dispatch list, even near the end of shift.

Conclusions

Loss of productivity during shift change is a direct consequence of move-based incentive systems in wafer fabs. Human nature dictates that people respond to incentives. If there is no incentive for an operator to start lots late in the shift (because someone else will get the credit), then many people will not start those lots. The Earned Plan Hours metric, developed by FabTime in partnership with Cypress Semiconductor, is an attempt to mitigate this problem. The Earned Planned Hours metric gives operators a credit equal to the lot's planned queue time when they start a lot, as well as credit for any remaining time that the lot spends processing during the shift (up to the planned process time). This incentivizes people to go ahead and start lots, even if it is late in the shift. It also encourages people to move lots out quickly when they are finished processing, as credit is only given up to the lot's planned process time (or the end of the shift).

In addition to driving positive behavior during shift change, the Earned Plan Hours metric, because it is directly based on planned cycle time, gives fabs a quick look at whether or not overall performance is meeting the plan. Earned Plan Hours is a metric that drives improvement in shipped lot cycle time, applies to multiple levels of responsibility, and gives an early indicator of overall fab performance.

Closing Questions for Newsletter Subscribers

What does your fab do to counteract productivity losses during shift change? Do you overlap shifts (and if so, has that helped)? Do you think that the EPHs metric will do what we're asking it to do?

Acknowledgements

FabTime would like to thank Brad Richardson and John Pollock of Cypress Semiconductor for discussions leading to the development of this metric. Mike Hillis of Spansion Semiconductor provided valuable feedback.

Subscriber List

Total number of subscribers: 2786, from 449 companies and universities.

Top 20 subscribing companies:

- Intel Corporation (149)
- Maxim Integrated Products, Inc. (140)
- Micron Technology, Inc. (115)
- Texas Instruments (82)
- Carsem M Sdn Bhd (80)
- International Rectifier (69)
- Western Digital Corporation (68)
- ON Semiconductor (66)
- X-FAB Inc. (66)
- GLOBALFOUNDRIES (65)
- Fairchild Semiconductor (63)
- TECH Semiconductor Singapore (59)
- STMicroelectronics (57)
- Analog Devices (52)
- Freescale Semiconductor (52)
- IBM (51)
- Infineon Technologies (49)
- Skyworks Solutions, Inc. (47)
- Telefunken Semiconductors (44)
- Seagate Technology (39)

Top 4 subscribing universities:

- Ecole des Mines de Saint-Etienne (EMSE) (13)
- Arizona State (8)
- Nanyang Technological University (8)
- Virginia Tech (7)

New companies and universities this month:

- Adesto Technologies
- dpiX
- eMagin
- Globosat Canais
- Northrup Grumman Aerospace
- Novati Technologies
- Power Integrations Inc.
- Solexel Inc.
- Solvay International Chemical Group
- University of L'Aquila
- Xilinx Semiconductors

Sampler Set of Other Subscribing Companies and Universities:

- ABB (4)
- Agilent Technologies (10)
- Alcoa (1)
- Andes University (1)
- Bristol-Myers Squibb (1)
- Cornell University (1)
- Diodes-FabTech (2)
- Fairchild Imaging (1)
- GNE Corp. (1)
- HEC Paris (1)
- MIT (1)
- Penn State University (3)
- PSI Technologies, Inc. (1)
- San Diego State (1)
- Semitool (1)
- Sensor Analytics (1)
- Sirris Belgium (1)
- Supertex Inc. (3)
- Toppan Photomasks (5)
- Zamil Steel (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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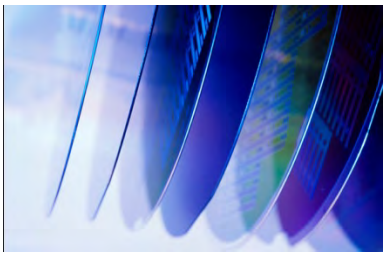
FabTime® Dispatching Module



Dispatch Configuration and Support

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

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

Custom dispatch rules and consulting from our dispatching expert available for additional fee

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.

Interested?

Contact FabTime for details.

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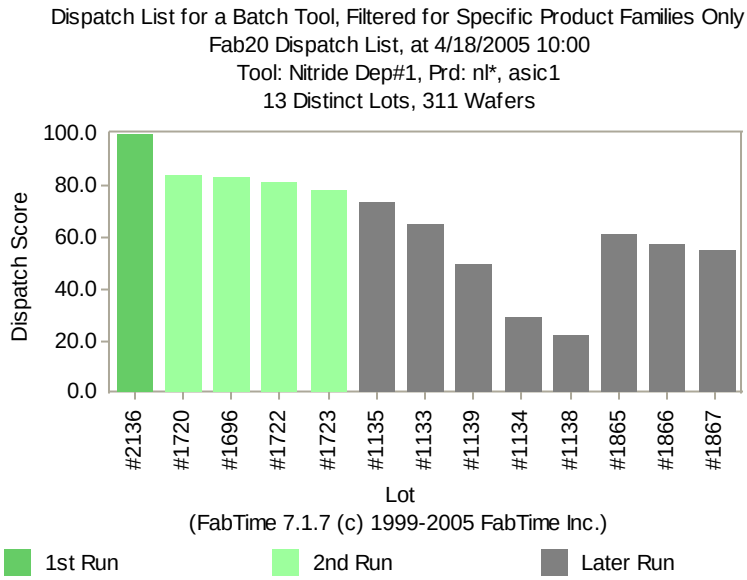
Web: www.FabTime.com

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.