FabTime Cycle Time Management Newsletter

Volume 9, No. 6 July 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 a new user interface for setting and viewing dispatch parameters, and the ability to use average WIP (instead of starting WIP) in WIP turns calculations.

Editor: Jennifer Robinson

Contributors: Amrita Sehgal, Ken Kozlik, and Ravi Guruswamy (ON Semiconductor)

Table of Contents

Welcome

Welcome to Volume 9, Number 6 of the FabTime Cycle Time Management Newsletter! This is, astonishingly, our 85th issue. It just doesn't seem that long ago that I off-handedly voiced the idea in a conference call. "Hmm... maybe we should start an email newsletter." And here we are, 85 issues and 2800 subscribers later. The newsletter led directly to our cycle time management course (with thanks to Steve Brown from Medtronic for the idea). Most of our 17 software customers have found us either through the newsletter or through the course. FabTime would probably still be here today if we hadn't started the newsletter, but we certainly wouldn't be as successful. So, we would like to take this opportunity to thank all of you who subscribe to the newsletter, and especially those of you who have been with us since the early issues in 2000. We hope that you are having a wonderful summer.

In this relatively brief issue we have no community announcements. Our FabTime user tip of the month is about using the SQL filter to remove outliers from a down tools list. We have one subscriber contribution, concerning the use of Dynamic X-Factor at On Semiconductor in Gresham. In our main article this month, we review potential definitions for short-term line yield metrics, definitions that take into account the particular complexities of wafer fabs. We are seeking input from the newsletter community because we would like to include one or more detailed definitions for line yield in FabTime's metrics lexicon. We believe that these definitions will be useful to the community as a whole.

Thanks for reading!—Jennifer

FabTime

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

Community News/Announcements

FabTime welcomes the opportunity to publish community announcements. Send them to newsletter@FabTime.com. We have no announcements this month.

FabTime User Tip of the Month

Use FabTime's SQL Filter to Restrict Tool WIP and State List by Duration of Downtime

Back in Issue 6.06 (3 years ago this month) we published a tip about how to view the down tools in your area (you can find it on the tips page by searching for "View the Current Status"). This tip involved using the Tool WIP and State List chart and filtering the "E10St:" field to display tools with states "Unsch" and "Sched" (to display all tools down for scheduled or unscheduled downtime). When this filter ("Unsch, Sched") is applied, the resulting chart shows how long each down tool has been down, and how much WIP is in queue that could be being processed on the tool.

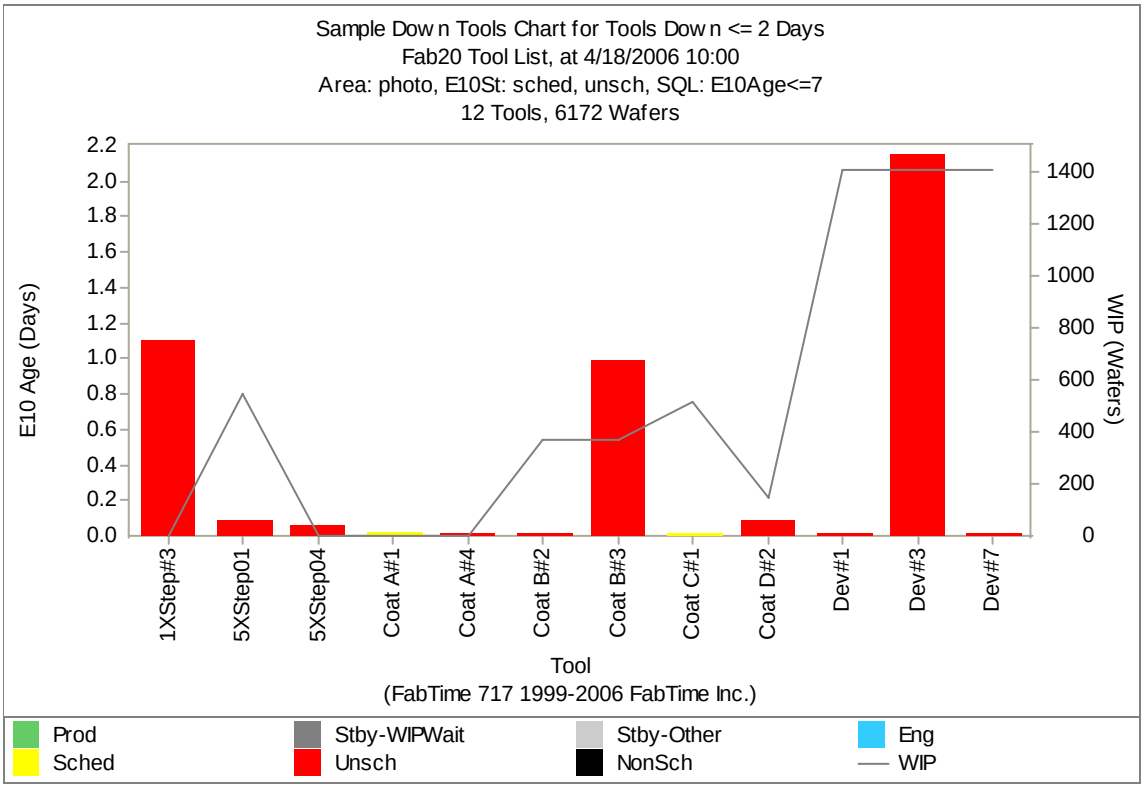
As we've watched people at various sites use this chart over the past couple of years, we've noticed that a common problem is that this chart often includes one or more tools that have been down for a very long time (perhaps tools that are currently inactive, but are still in the MES database). These long downtime tools tend to overwhelm the chart, making it hard to monitor more current tools.

This issue can be resolved by using the "SQL:" filter on the Tool WIP and State List chart. The SQL filter is a special filter in FabTime (available on most charts) that allows you to filter the results displayed on the chart by any data that underlies the chart. In this case, although there's no filter to the left of the chart to filter by E10Age (the length of time that the tool has been in the current state), you can use the SQL filter to filter by the E10Age. For example, if you would only like to see tools that have been in their current state for less than 7 days, simply enter:

"E10Age<=7" (without the quotation marks) into the SQL: field. Make sure that the "U/M:" drop-down on the chart is set to "Days" (or modify the units of the above accordingly). FabTime will then only include tools on the chart that have been down (scheduled or unscheduled) for less than or equal to seven days. An example, filtered for tools down for less than 2 days, is shown at the top of the next page.

You can use the SQL filter for many other types of special filtering, such as eliminating lots that have a particular due date or other attribute not included in the standard filters. The SQL filter gives you flexibility for these types of situations, without requiring us to keep making the set of standard filters longer and longer.

If you have any questions about this feature, or any questions about the software, just use the Feedback form inside FabTime. Thanks!

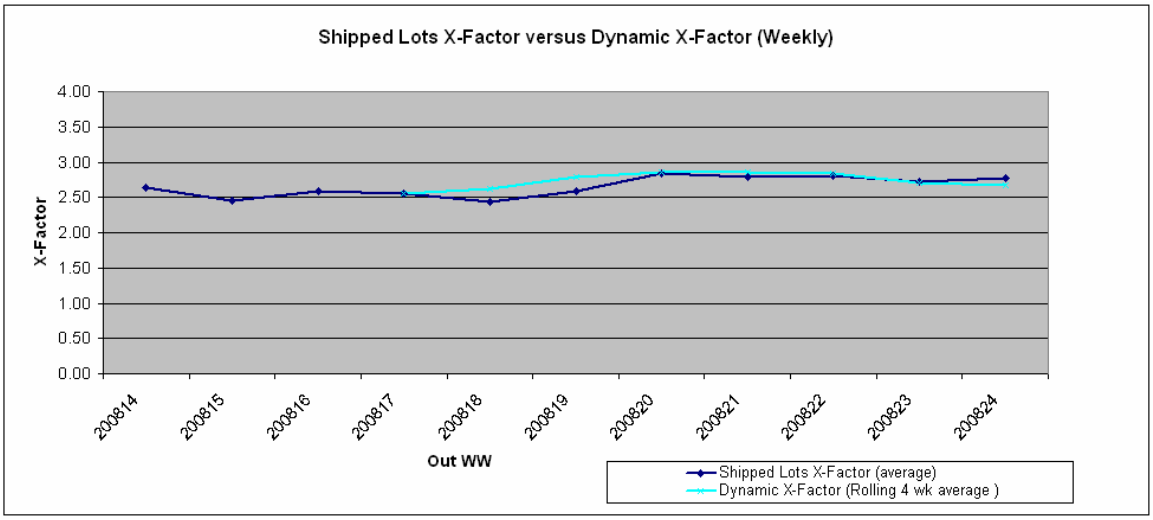


Subscriber Discussion Forum

Dynamic X-Factor

Amrita Sehgal, Ken Kozlik, and Ravi Guruswamy from ON Semiconductor Gresham submitted the following response (and illustration) to Volume 9, Issue 4.

"In Gresham, ON Semiconductor's shipped lot average X-Factor seems to be close to our rolling average Dynamic X-Factor, as shown in the diagram above (rolling for a period that equates to total



cycle time of the technology). Dynamic X-Factor is one of the tools that we use for monitoring cycle time as a part of fab performance. We also use DPML (Days per masking layer) for the same purpose. An advantage of DXF over DPML would be that it is comparable across technologies irrespective of number of masking layer and masking layer distribution (process time between masking modules). A disadvantage of DXF is the rolling duration, which is based on some assumed cycle time. As pointed out in the previous newsletter, and also observed in our fab, there are factors that causes deviation in the relation DXF = shipped lot X-Factor. These factors include the fab's changing product mix, lots on extended hold, scrap, rework, engineering run requests, logging issues, etc. Also note that the theoretical (denominator) used for calculating shipped lot X-factor is what is used in the system for scheduling (TrackIn-Track Out) and not true theoretical."

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

Definitions for Short-Term Line Yield Metrics

Introduction

Although our primary focus is on cycle time, we know that it's important to for fabs to drive improvement in all productivity measurements. Yield is always a metric of particular concern for fabs, because it ties so closely to financial performance. Most people believe that line yield and fab cycle time are related (that fabs with shorter cycle time will, in general, have better yields, and vice versa). See Volume 5, Issue 1 and Issue 2 for details. In this article, we turn our attention to a seemingly straightforward question. How to do you measure line yield on a short-term, ongoing basis, so that you can monitor your performance, and catch problems quickly?

In our software right now, we report number of wafers scrapped in trend, Pareto, and list charts. Adding up the scrap transactions across time, or across operations or other attributes, is quite straightforward. Our customers would like us to also have line yield charts. However, what we're finding is that the calculation of line yield on a real-time basis is somewhat complex. In this article, we explore some potential ways for calculating real-time line yield, given moves, scrap, and shipment data. We welcome your feedback.

Long-Term Line Yield Definition

In the long term, average mechanical line yield is measured simply as Wafers Out / Wafers In. Usually "Out" refers to wafers that complete processing in the fab, before they are sent to parametric test. That definition is fine if you want to measure, say, the overall line yield for a fab in a year. However, it requires special interpretation to use it, say, on a weekly basis. There can easily be a 6-8 week delta between when wafers start into the fab and when, on average, they ship. If you're comparing wafers that ship from the fab in a given week to wafers that start into the fab during that same week, you're not likely to be comparing the same wafers. You could easily have more wafers ship than you have starting during a given week, if your starts are declining over time (or if you just

happen to pull lots late in the flow, to meet shipment targets late in the quarter). And it's not like you can just take what's shipped this week and look back to the week that the lots started, because you'll find that some of the lots shipping this week started only three weeks ago, while others started much, much earlier. Basically, the temporal nature of the fab, especially in the presence of changing product mix, means that a simple wafers out / wafers in definition for line yield is computationally impractical as a short-term metric. Fortunately, there are other options.

Possible Short-Term Line Yield Metrics

Our customers have suggested three possible short-term line yield metrics. They are sorted in order of increasing computational complexity.

A. Rolling Line Yield Charts

Rolling Line Yield = Wafers Shipped / (Wafers Shipped + Wafers Scrapped)

where Wafers Scrapped refers to the number of wafers scrapped during the week of interest (regardless of whether or not the scrapped wafers were ever part of the shipped lots). That is, we'll compare how many wafers we shipped this week to how many wafers we scrapped this week. The advantage of this metric is that it is easy to calculate, and gives you a sense of the relative impact of the scrap that's occurring right now.

B. Shipped Lot Line Yield Charts

Shipped Lot Line Yield = Wafers Shipped / (Wafers Shipped + Wafers Scrapped for the Shipped Lots)

where Wafers Scrapped for the Shipped Lots refers to the number of individual wafers scrapped from the shipped lots, regardless of when that scrap occurred. This one requires knowing the initial and current lot size of each lot (or knowing how many wafers were scrapped from each lot in some fashion). It comes closer to a traditional yield metric, by showing us how many wafers shipped relative to the ones that started. However, it's not quite clear how to include lots that are scrapped in their entirety. It's also not clear how to handle split lots. If there is scrap for a parent of a split that ships, and there are other split children from this same parent that ship, how can the scrap from the parent be properly taken into account, without double-counting it?

C. Flow Yield Chart

For each flow/step combination (an operation within a flow), compute Wafer Moves / (Wafer Moves + Wafer Scrap) to obtain a step yield ratio. For steps with no moves, use a 1. Then multiply the step yield ratio across all of the steps in the flow, to obtain an overall flow yield value. The advantage of this approach is that it's possible to estimate the yield for low volume flows that may not ship very many lots.

Questions

Do you report short-term, real-time line yield performance? If so, what metric do you use? Which of the above metrics do you think that we should be using in FabTime, and why? If you have shipped lot line yield charts, how do you handle split lots? Are there other subtleties that we're missing here?

Conclusions

Like many aspects of wafer fabs, line yield seems straightforward; until you actually sit down to calculate it on a short-term basis. And then the complexities arise, complexities that stem from the long cycle times and high product mix of fabs, as well as from activities like splits and merges. What we're trying to do with this article is agree upon one or more definitions that account for these complexities, and allow fabs to use short to medium term yield estimates to track and improve performance. We welcome your feedback, and will publish a follow-on article if we receive a sufficient response.

Further Reading

- J. A. Cunningham, "The Use and Evaluation of Yield Models in Integrated Circuit Manufacturing," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 3, No. 2, 60-71, 1990.
- M. C. Wu, C. W. Chiou, and H. M. Hsu, "Scrapping Small Lots in a Low-Yield and High-Price Scenario," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 17, No. 1, 55-67, 2004.
- T. M. Smith, "Wafer Fab Line Yield Improvement at TriQuint Semiconductor," *Gallium Arsenide Integrated Circuit (GaAs IC) Symposium, Technical Digest 1994*, 16th Annual Volume, Issue 16-19, Oct. 1994, 115 - 118.

Subscriber List

Total number of subscribers: 2841, from 473 companies and universities. 22 consultants.

Top 20 subscribing companies:

- Maxim Integrated Products, Inc. (235)
- Intel Corporation (158)
- Micron Technology, Inc. (80)
- Chartered Semiconductor Mfg. (72)
- Western Digital Corporation (72)
- Analog Devices (66)
- X-FAB Inc. (64)
- Infineon Technologies (63)
- Freescale Semiconductor (62)
- ON Semiconductor (61)
- Texas Instruments (58)
- International Rectifier (55)
- NEC Electronics (55)
- Cypress Semiconductor (54)
- TECH Semiconductor Singapore (54)
- STMicroelectronics (50)
- NXP Semiconductors (45)
- IBM (43)
- Spansion (36)
- ATMEL (35)

Top 3 subscribing universities:

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

New companies and universities this month:

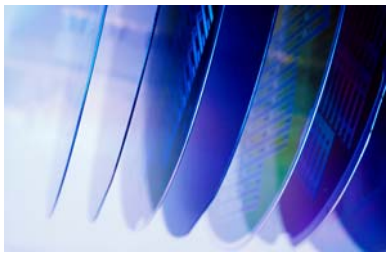
- Federal Mogul
- Flextronics Invotronics Inc.
- UTC Power

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.

To subscribe to the newsletter, send email to newsletter@FabTime.com, or use the form at www.FabTime.com/newsletter.htm. To unsubscribe, send email to newsletter@FabTime.com with "Unsubscribe" in the subject. FabTime will not, under any circumstances, give your email address or other contact information to anyone outside of FabTime without your permission.

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.

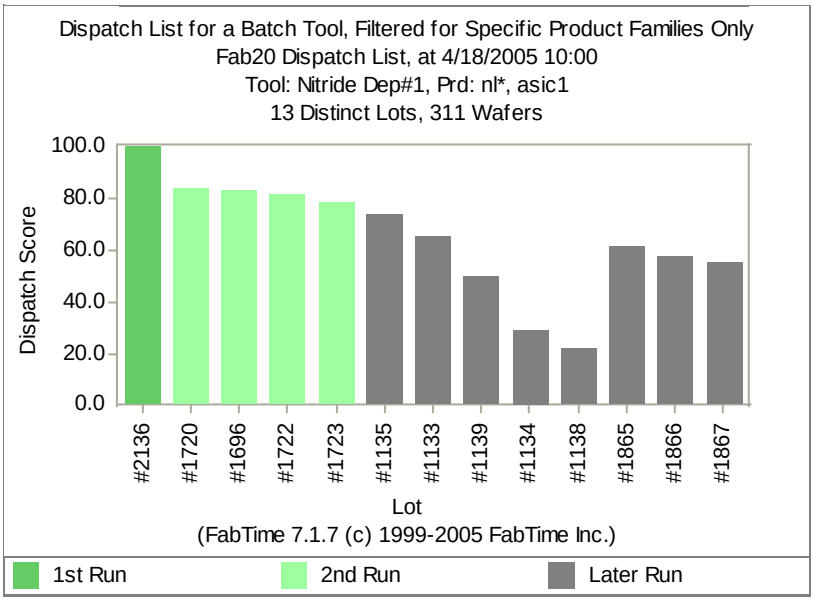
FabTime Inc.
Phone: +1 (408) 549-9932
Fax: +1 (408) 549-9941
Email: Sales@FabTime.com
Web: www.FabTime.com

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.