FabTime Cycle Time Management Newsletter

Volume 17, No. 2 April 2016

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 development for FabTime include shipped lot x-factor charts, instant click from x-axis of a chart to a filtered home page tab, and ability for FabTime to request authentication before display of certain data.

Editor: Jennifer Robinson

Keywords: Dispatching, WIP Management

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Welcome

Welcome to Volume 17, Number 2 of the FabTime Cycle Time Management Newsletter! In this issue we have calls for papers for two upcoming conferences, both of which include topics that may be of interest to the newsletter community. Our FabTime tip of the month is about controlling the way that slice-by objects are filled in (when they have no WIP) on WIP and Moves Pareto charts. We have no subscriber discussion this month, though we do welcome your questions or feedback on fab manufacturing-related topics.

In our main article, we introduce the methodology included in FabTime's new short-interval scheduling module. The scheduler attempts to solve certain issues inherent in traditional dispatch systems by looking forward to create a series of reservations for each tool. This better handles fab complexities like back-to-back time constraint regions and setup avoidance planning. We welcome your feedback.

Thanks for reading – Jennifer

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Community News/Announcements

2016 APC Conference, October 17-20 in Mesa, Arizona: Call for Papers

Summary: The 2016 APC Conference will address Advanced Process Control needs and solutions for manufacturing in the semiconductor and related industries. www.apcconference.com

Call for Papers: As manufacturing processes become more complex with greater yield and cost objectives, the methods to increase productivity and quality become vital. Semiconductor, photovoltaic, display, MEMS, LED, and other industries are experiencing unparalleled cost/quality pressures. Cost/quality objectives have made Advanced Process Control (APC) absolutely critical for profitable manufacturing. The Integrated Measurement Association is pleased to again host this year's conference and announce the APC Conference XXVII Call for Papers.

This call for papers is directed to Integrated Circuit and related industries. Manufacturers, equipment suppliers, software solution providers, sensor, and metrology suppliers are all welcome to submit abstracts. Advancements in related industries, such as solar devices, flat panels, LEDs and MEMs, will also be discussed in order to assess how synergy between these industries can be better leveraged. The conference will focus on recent technical advancements, current challenges, and future needs and trends.

Conference Topics: The conference will include topics like the following (extracted from larger list):

- Predictive maintenance, predictive scheduling, predictive yield
- Big data, data mining, Hadoop, and cloud-based solutions
- Real-time data collection and management, data quality, time synchronization
- Factory-wide and enterprise-wide applications and deployment
- Integration with yield/maintenance management, adaptive scheduling, DFM

Direct questions/inquiries via email to Info@APCconference.com.

Important Dates:
Abstract Submission Deadline: 7/15/16

Abstract Acceptance Notification: 8/12/16

PowerPoint Presentation/Extended Abstract: 9/30/16

2016 e-Manufacturing & Design Collaboration Symposium: September 9, 2016: Call for Papers

Scope: The Symposium attends to recent technological advancements to align the needs of designers, manufacturers, equipment suppliers, software vendors, solution providers and researchers. It offers a public arena for the exchange of up-to-date experiences among manufacturers for adoption of technological developments. With green notions of supply/engineering/value chains, coverage of the joint symposium includes, but is not limited to, the following topics of interests (extracted from larger list):

- Data Collection/Quality/Storage/Management
- Fab Management/Scheduling/Dispatching
- Factory Integration/Operations
- Factory Physics & Queueing Operations
- Manufacturing Control and Execution Systems
- Manufacturing Strategy and Operation Management

For more information click here.

Paper Submission: The deadline for paper submission is June 1, 2016.

FabTime User Tip of the Month

Control How Slice-by Objects Fill In on WIP/Moves Pareto Charts

New in FabTime is an option to control how slice-by objects are filled in on WIP and Moves Pareto charts. Select this option via the new "Fill-In" control, which appears directly above the "Slice" control in the left pane of WIP and Moves Pareto charts.

The choices for the Fill-In control are:

1. "Auto" (Default): If the slice-by object filter is non-blank, and does not contain any wildcards, comparisons, or negations, then add slice-by objects that match this filter even if they have no WIP. This choice most closely mimics the previous behavior.

2. "None": Do not fill-in any slice-by objects.

3. "Add Matching": If the slice-by object filter is non-blank, add slice-by objects that match this filter, even if they have no WIP. If you have no wildcards, comparisons, or negations, then "Auto" and "Add Matching" will give the same results. "Add Matching", however, lets you use wildcards or ranges to display all matching objects. "None" will not show the matching objects, whether you are using wildcards or not.

For example, this change allows WIP sliced by operation and filtered for Operation>2000 to display all operations (set Fill-In control to "Add Matching"), even if they don't currently have WIP. A chart like this, when sorted by operation (or operation sequence, if you have defined sequences for operation), is useful for looking at the distribution of WIP throughout the line. Undefined objects are excluded from the fill-in unless 'Undefined' is specifically included in the slice-by object type filter. An example is shown at the top of the next page.

Note that sorting operations by object sequence will only provide a meaningful sort if you have defined object sequences for operations (e.g. to tell FabTime that operation AA75 comes before BE15). Check the View Data page for operations to see if you have non-zero object sequence values for each operation.

Thanks to FabTime's Mike Krist for suggesting this tip. If you have questions about this item, or any other FabTime software questions, just use the Feedback form inside FabTime's software. Subscribe to the separate Tip of the Month email list (with additional discussion for customers only). 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 this month.

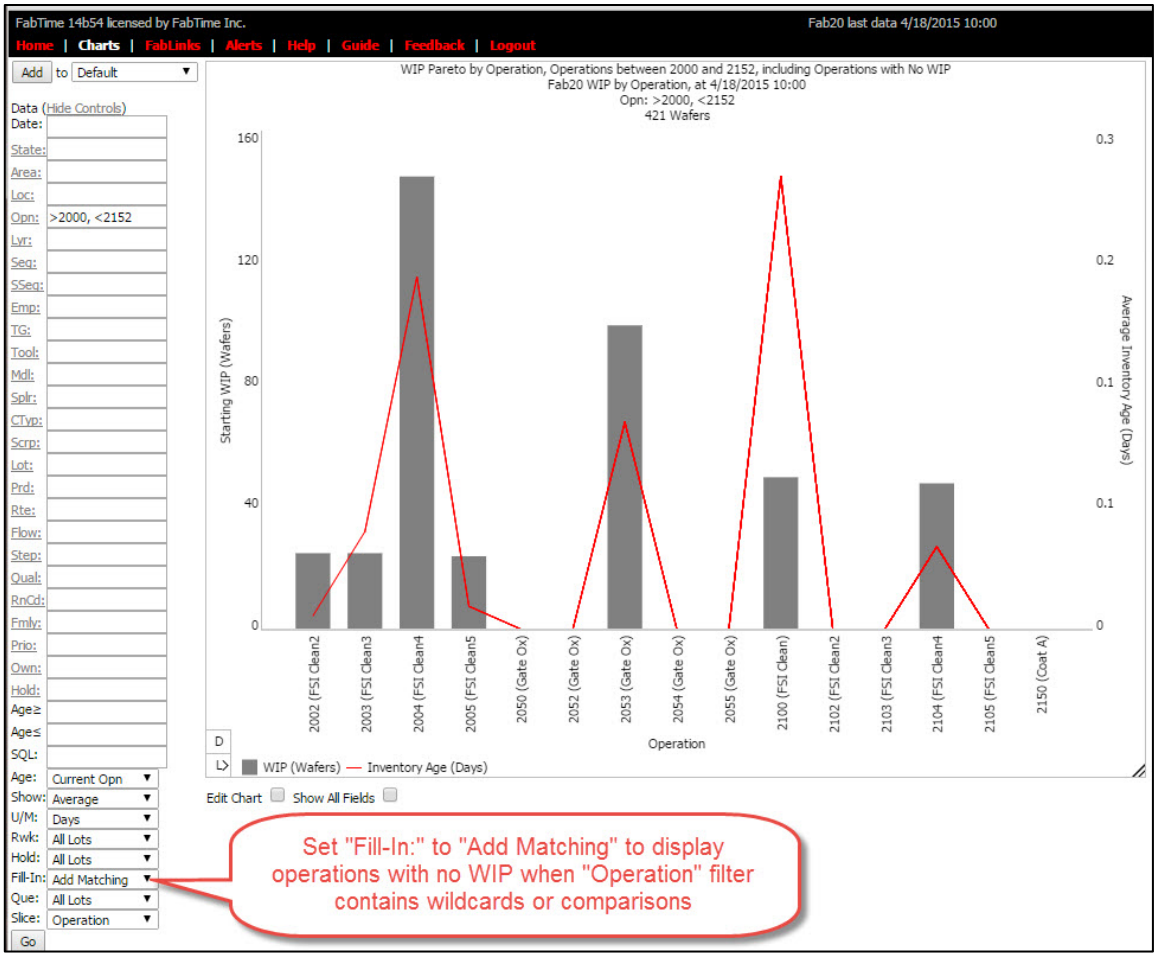

Figure 1: Sample of New Fill-In Control on WIP Pareto Chart

FabTime Short-Interval Scheduling

By Frank Chance and Jennifer Robinson

FabTime has offered an optional lot dispatching module for a number of years. This module is in use in several of our software customer sites, and was originally developed in partnership with International Rectifier (now Infineon Technologies). Recently we worked with another customer site, Microchip Technology Inc. in Gresham, Oregon, to add a short-interval scheduling capability to FabTime. We presented our work with Microchip at the FOA Collaborative Forum in February.

In this article, we provide a general overview of the new scheduler. This article is not a case study regarding our implementation at Microchip. [We leave that as a potential newsletter topic for another day.] Nor does this article describe all aspects of our dispatching and scheduling logic. Rather, this is an overview of the methodology used in the scheduler as compared with conventional dispatching. We welcome your feedback, as this development project remains ongoing.

Scheduling and Dispatching

Conventional lot dispatching involves sorting, at any given moment in time, the list of lots that are available to run on a given tool. FabTime's core dispatch module allows sites to sort dispatch lists according to any number of weighted dispatch factors. These factors include conventional inputs such as time in queue and lot priority as well as more sophisticated factors such as line balance. Dispatch lists are re-generated whenever new data becomes available. While FabTime allows sites to include any available data in the dispatch factor calculations (such as downstream WIP levels), the dispatch lists are inherently local.

FabTime's short-interval scheduler provides a new back-end for dispatching calculations. The end result remains a dispatch list showing which lots to run on which tools, but the list is driven by the scheduler. The scheduler creates tool-based reservations that satisfy hard constraints (such as time constraints and setup limits). Lots are prioritized and scored via global factors such as hand carry and starvation-avoidance. In addition, the scheduler applies local rules such as setup-avoidance, pilot-avoidance, and travel-time penalties.

Why Scheduling?

Traditionally, dispatch lists are based upon a variety of global and local factors, for example prioritization of hand carry lots, line balance scoring, critical ratio scoring, setup-avoidance, etc. The limitation to this approach is that the dispatch list represents a single point in time, and thus it does not plan for what is about to happen. For example, assume lots are scored based on setup-avoidance in implant. Three lots A/B/C may receive a high score due to matching an implanter's current setup, but suppose that after the next lot is run, the tool must switch gas type to satisfy processing constraints. The operator is presented with a dispatch list showing lots A/B/C in positions 1-3 on the list. Once the operator picks lot A and begins running it, the next lot must be from a different gas type. Thus when the dispatch list is refreshed, lots B/C that were previously in positions 2/3 on the list may suddenly drop to the bottom of the list, and lots of an alternate setup will rise to the top. In this example, and in many others, traditional dispatch lists are jumpy. This jumpiness makes life difficult (and frustrating) for operators. The traditional dispatch list does not reflect what happens once the operator chooses the first lot on the list.

In contrast, the scheduler sees that lots A/B/C currently have the best priority and highest score, and arranges them in this order for potential selection. It selects lot A, and creates a reservation for lot A on the tool. Given A's reservation and the implanter's current setup status and setup limits, lots B and C are not eligible to run immediately after A (because they have the same setup as A, and a setup change is required), and thus other lots will be scheduled to run on the tool after A. The dispatch list generated by the scheduler reflects what happens after the operator chooses the first lot on the list.

Traditional dispatch lists also make it difficult to implement heuristics-like recipe grouping and minimization of travel and setup times. They make it difficult to enforce capacity constraints for back-to-back time constraint regions. The scheduler is able to take a broader view, and take all of these aspects into account.

Tool-Based Reservations

Scheduler-based dispatch lists are per-tool (based on tool/recipe restrictions), and each lot is listed at the approximate time when it should begin processing. In essence, each lot holds a reservation for a particular tool and time period, based on the lot's planned process time. This reservation is comparable to an airline

reservation that is valid for a particular flight that is leaving the airport at a given time. For batch tools, multiple lots may hold reservations with identical begin-run times, just like multiple passengers can hold tickets for the same departing flight. Lots may hold a reservation at a tool even if they have not yet physically arrived at this tool, just like passengers can hold tickets for connecting flights, even though they have not yet arrived at the departure gate for the connection.

The scheduler currently maintains reservations for each lot on particular tools for a site-defined window in the future (e.g. six to eight hours), or for the complete duration of a time constraint loop. The scheduler takes into account current and planned information, such as batch loading policies and planned maintenance events. The system creates a feasible path for lots entering time constraint regions, and will not let lots enter the region unless a feasible path exists.

The reservation lists are calculated and maintained inside of FabTime, and can be displayed in the form of FabTime charts. However, to use the information, the actual reservation list can be fed into each site's existing system for operator lot selection. Managers can then use FabTime's dispatch compliance charts to determine how closely operators are following the reservation lists.

Lot Priority and Score

The scheduler uses site-specific logic to compute a priority and score for each lot. For example, lot priorities might be "Hand Carry", followed by "Priority A Lots", followed by all other lots. Lot scores can include factors such as starvation-avoidance, critical ratio, and queue time.

Reservation Bumping

Once created, reservations may be bumped (taken over) by other lots, just like passengers getting bumped off a plane if a platinum-level customer appears and wants a seat. We would like higher priority (or scoring) lots to take precedence over lots that may already have a reservation... but only up to a point.

Bumping is NOT allowed in the following cases:

1. A lot is committed to a time constraint region.

2. A lot is already in a load port (tracked in), but has not yet begun processing.

3. A lot is already in queue, is first in line, but not yet tracked in.

4. A lot's planned start-run time is within the "no-bump" window (e.g. 60 minutes).

5. A lot is already in queue, and the higher priority/score lot has not yet arrived.

Recipe Grouping

When feasible, the scheduler groups lots with like recipes. It counts the number of consecutive track-ins for the current recipe on each tool, and pulls lots with matching recipes to the front of the queue. It also groups reservations with like recipes on the future schedule for each tool. Grouping is performed up to a site-specified limit, e.g. four lots, to limit consecutive runs of the same recipe.

Reticle Management

The scheduler maintains a list of all reticles, their desired location (reticle stocker or a particular stepper), and their last known location. This list is updated after each MES extract, and includes a flag indicating if the desired location is a move request from the reticle's current location. Reticle move requests are triggered by site-specific business rules.

Time Constraint Regions

If a lot is in queue at the staging step for a time constraint region, the dispatcher will attempt to create reservations for the lot through the entire time constraint region,

plus any following back-to-back constraint regions. If it cannot create a full set of reservations that allow the lot to travel through all time constraints without violation, it rolls back all reservations and leaves the lot waiting at the staging step.

Implementation

FabTime's short-interval scheduler runs in core FabTime code. The scheduler is multi-threaded, to cut the length of schedule refresh cycles. Each thread runs continuously, refreshing the lot with the longest time since its last schedule refresh, and pausing automatically when FabTime is updated with new MES data. The implementation of this multi-threading capability has resulted in dramatic speed improvements, something critical for a live dispatching system. The goal is a maximum refresh delay of 3 minutes for all lots. The scheduler code contains numerous call-outs where site-specific code may be added. The combination of core code and site-specific code provides the flexibility to implement a wide variety of global and local dispatch logic. This combination also allows sites such as Microchip to maintain confidentiality of their detailed operational methods, which are implemented in site-specific code.

Conclusions

How each fab chooses to dispatch lots can have a tremendous impact on fab performance. Dispatch rules used by fabs have become more sophisticated over the years, as they incorporate downstream information, move targets, and other data from the fab. However, there are some inherent issues with dispatch lists, including jumpiness, lack of memory, and inability to handle multi-step complexities such as time constraint regions.

In an attempt to solve these problems, FabTime worked with Microchip Technology to create a heuristic-based short-interval scheduler that creates tool-based reservations that satisfy hard constraints (such as time constraints, chamber configurations, and setup limits). The scheduler generates a plan, within some site-specified time window, for each tool. While the schedules are re-calculated whenever new information becomes available, priority is given to lots that already have reservations, so that the schedules do not change radically from minute to minute. This makes the scheduler a much more operator-friendly system than a conventional dispatch system.

We believe that the use of this scheduler will allow fabs to make the next leap in performance improvement. This won't necessarily be a quick or easy process - implementation of detailed operational logic can be quite complex. However, the potential bottom-line improvement is significant.

Questions for FabTime Subscribers

Have you attempted to use scheduling (vs. pure dispatching) in your fab? Do you have any lessons learned to share with other newsletter subscribers?

Acknowledgement

FabTime would like to thank the team from Microchip Technology Inc., particularly Jason Burk and Steven Novella, for their work with us on the scheduling module, and for presenting this project with us at the Fab Owners Association this winter.

Subscriber List

Total number of subscribers: 2772

Top 20 subscribing companies:

- Infineon Technologies (145)
- Micron Technology, Inc. (140)
- Intel Corporation (133)
- Maxim Integrated Products, Inc. (116)
- ON Semiconductor (108)
- GLOBALFOUNDRIES (100)
- Carsem M Sdn Bhd (71)
- Fairchild Semiconductor (71)
- Texas Instruments (65)
- X-FAB Inc. (58)
- STMicroelectronics (57)
- Freescale Semiconductor (53)
- Western Digital Corporation (50)
- Skyworks Solutions, Inc. (49)
- Microchip Technology (47)
- Seagate Technology (46)
- Analog Devices (45)
- Atmel Corporation (41)
- NXP Semiconductors (35)
- Cypress Semiconductor (32)

Top 4 subscribing universities:

- Ecole des Mines de Saint-Etienne (EMSE) (18)
- Arizona State University (8)
- Nanyang Technological University (7)
- Virginia Tech (7)

Sampler Set of Other Subscribing Companies and Universities:

- AltF5 Software LLC (1)
- AmFor Electronics (1)
- Amkor (4)
- Andes University (1)
- Continental Device India Ltd. (2)
- Feng Chia University (1)
- IDC (2)
- IMEC (5)
- Korea Information Society Development Institute (1)
- Lite-On Semiconductor (1)
- Novellus (2)
- P Squared Enterprises (1)
- Rose-Hulman Institute of Technology (2)
- SanDisk (5)
- Shanghai Grace Semiconductor Mfg. (GSMC) (5)
- Singtel (1)
- SPI Analysis (1)
- TDK (31)
- USound Technology GmbH (1)
- Yonsei University (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.

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® Cycle Time Management Training

"It was helpful to see best-in-class methods for wafer fab cycle time management. Discussing these matters in-depth with you was quite valuable, as we could ask questions specific to our fab and processes."

Shinya Morishita
Manager, Wafer Engineering
TDK Corporation

Course Code: FT105

This course provides production personnel with the tools needed to manage cycle times. It covers:

- Cycle time relationships
- Metrics and goals
- Cycle time intuition

Price

$7500 plus travel expenses for delivery at your U.S. site for up to 20 participants, each additional participant $300. Discounts are available for multiple sessions.

Interested?

Contact FabTime for a quote.

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Web: www.FabTime.com

Do you make the best possible decisions?

- Do your supervisors possess good cycle time intuition?
- Are you using metrics that identify cycle time problems early?
- Can you make operational changes to improve cycle time?

FabTime's Cycle Time Management Training is a one-day course designed to provide production personnel with an in-depth understanding of the issues that cause cycle time problems in a fab, and to suggest approaches for improving cycle times. A two-day version and a half-day executive management version are also available upon request. The course is only available for delivery at sites within the United States, unless it is delivered in conjunction with software training for FabTime customers.

Prerequisites

Basic Excel skills for samples and exercises.

Who Can Benefit

This course is designed for production personnel such as production managers, module managers, shift supervisors, hot lot coordinators, and production control.

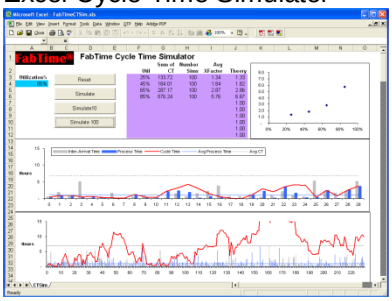
Skills Gained

Upon completion of this course, you will be able to:

- Identify appropriate cycle time management styles.
- Teach others about utilization and cycle time relationships.
- Define and calculate relevant metrics for cycle time.
- Teach others about Little's law and variability.
- Quantify the impact of single-path tools and hot lots.
- Apply cycle time intuition to operational decisions.

Sample Course Tools

Excel Cycle Time Simulator



Staffing Delay Simulator