FabTime Cycle Time Management Newsletter

Volume 10, No. 3 April 2009

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 new average WIP trend and pareto charts, and support for (optional) dispatch scoring of lots on hold.

Editor: Jennifer Robinson

Table of Contents

Welcome

Welcome to Volume 10, Number 3 of the FabTime Cycle Time Management Newsletter! We hope that spring has arrived, wherever you are. In this issue, we have two announcements, one concerning social networks, and the other a call for papers. Our FabTime user tip of the month is about identifying cumulative cycle time contributors, across the lifetime of lots. In this month's subscriber discussion forum, we have two responses to topics raised last month (dispatch compliance metrics and correlation in wafer fab data), as well as a new subscriber question about tracking of late lots.

Our main article this month is a relatively brief discussion of equipment state and availability-related definitions. We review the SEMI E10 definitions for equipment states, and discuss our intention to transition from using the term "Availability", which is not defined in terms of the E10 tool states, to using separate terms relevant for maintenance personnel vs. manufacturing personnel. For maintenance effectiveness tracking, we will use the metric Equipment Uptime (Productive + Standby + Engineering), reflecting the time that the tool is available for either production or engineering use. For manufacturing personnel, however, we will continue to report Manufacturing Time (Productive + Standby), which is the time that the tool is available for manufacturing use. It is, of course, the utilization of this Manufacturing Time that drives cycle time performance. We welcome your feedback.

Thanks for reading!—Jennifer

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Community News/Announcements

Social Networks

FabTime's Jennifer Robinson recently joined the LinkedIn social networking site, to better stay in contact with people during these trying economic times. Please note that to protect the privacy of newsletter subscribers; Jennifer will never import her contact list to LinkedIn. However, if any newsletter subscribers would like to connect with Jennifer there, she would love to hear from you. Her profile is http://www.linkedin.com/in/jenniferrobinsonfabtime. You can also find Jennifer on the semiconductor industry-specific social networking site Future Fab Connect http://futurefabconnect.ning.com/profile/JenniferRobinson.

Call for Papers: ISMI Symposium on Manufacturing Effectiveness

ISMI Manufacturing Week will be held October 19-22, 2009 in Austin, Texas. Fab managers, industrial, process and equipment engineers, equipment and materials suppliers, software manufacturers, facilities engineers, and ESH professionals are invited to present at the ISMI Symposium on Manufacturing Effectiveness. Please submit your abstract no later than May 4, 2009. Full submission details can be found on the ISMI Manufacturing Week website: http://ismi.sematech.org/ismisymposium

Topics for productivity and cost reduction strategies related to facilities, equipment, processes, and labor may include (but are not limited to):

- Process productivity improvements
- Yield modeling and yield improvement methodologies
- Real-time data collection and management
- Lean manufacturing
- Non-product wafer reduction techniques
- Cycle time reduction techniques
- Real-time factory/equipment data management
- Defect inspection
- Global ESH strategies
- Facilities operations
- Facility systems reliability improvements
- Design and analysis of semiconductor experiments
- Advanced process control, run to run and fault detection and classification
- Equipment productivity improvements
- Factory and integrated metrology
- Factory productivity optimization using simulation
- Factory scheduling, dispatching optimization
- e-Manufacturing implementations
- Design for manufacturing
- Factory automation
- Manufacturing sustainability and resource conservation
- Green manufacturing
- Statistical techniques for process improvement and control
- Novel approaches to the analysis and visualization of manufacturing data

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

FabTime User Tip of the Month

Identify Cumulative Cycle Time Contributors

Last month, we talked about using FabTime to identify short-term cycle time contributors (by using the Operation Cycle Time and WIP Pareto charts). This month, we'd like to highlight a chart that looks back across the entire history of completed lots, and reports total time spent by area, operation, and toolgroup, added up across all visits. The Factory Cycle Time Contribution Pareto chart is available from the Factory Cycle Time Charts category. By default, this chart looks at all the lots shipped during the current day and displays, for each production area, the total time that lots spent in that area averaged across all of the shipped lots. This time is further broken out into non-process delay (the red) and process time (the green). So, for example, we might see that for all of the shipped lots analyzed, they spent, on average, 540 hours of their time in the fab in photo, of which 80 hours was process time, and the rest was non-process time (in queue, on hold, etc).

Several control settings make this chart more useful. First, you will most likely want to extend the date range, to look back for a week or more. Since this chart is used to look at relatively long-term behavior (the lifetime of the shipped lots), the results will likely be more useful if a larger number of shipped lots are included in the averages. Second, you can use the "Slice:" control to look at this data by toolgroup or operation, instead of by area. If slicing by operation, may also wish to also filter by route. And, of course, you'll want to use any other filters that you customarily use when looking at shipped lot cycle time data (owner, etc.).

We like this chart because it gives a picture of the total cycle time impact of areas, operations, toolgroups, etc. For example, a 24-hour queue delay per visit might seem acceptable for a bottleneck tool, when looking at the Operation Cycle Time chart. However, if this 24-hour per visit queue delay occurs at every visit, and a toolgroup is visited 20 times, that will show up as highly significant on the Factory Cycle Time Contribution chart. More significant than a 48-hour queue delay that occurs at a toolgroup that is only visited once or twice. The drawback to this chart is that it only applies to lots that have shipped, making it a trailing metric. However, we think that looking at the Factory Cycle Time Contribution Pareto chart remains an important part of overall understanding of where cycle time tends to accumulate in your fab. We used this chart often back when we worked on full-fab simulation models, finding it a valuable medium-term indicator of which tools were contributing the most to cycle time. (See, for example, the paper available for download here: www.fabtime.com/abs_Sea98.shtml)

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

Dispatch Compliance Measurement

Last month, we asked: "what are good performance measures for dispatch compliance?" We didn't receive any subscriber responses, but FabTime's Frank Chance wanted to share a new dispatch compliance metric that we've been working on, with one of our customers. We call it **Dispatch Precision**.

This is how Dispatch Precision is calculated for non-batch tools. For batch tools it is similar but is based on batch sequencing rather than lot sequencing:

- If there is only one lot on the dispatch list, and you run it, dispatch precision = 100%
- No matter how many lots are on the list, if you run the first lot, dispatch precision = 100%
- If there are two lots on the list, and you run the 2nd lot, dispatch precision = 50%
- If there are ten lots on the list, and you run the 2nd lot, dispatch precision = 90%

Note: If you have many lots to choose from, running the 2nd lot is favored as "more precise" than running the 2nd lot if there are only two lots to choose from.

General formula:

Dispatch Precision% for a Lot = 100% * (1.0 - ((Lot's order on dispatch list) - 1)*(1/(#lots on list)))

What do you all think? Does Dispatch Precision make sense as a dispatch compliance metric? Anyone have other ideas?

Issue 10.02: Correlation in Wafer Fab Data

Last month we wrote about metrics for looking at possible correlations in wafer fab data. We received one subscriber response:

An anonymous subscriber wrote: "One form of the XY graph my group has tried to use from time to time is the 4-quadrant graph, where CT delta to goal is plotted on one axis (showing positive and negative values), and various other measures vs. target plotted on the other axis (which would also show positive and negative values). There are several advantages to displaying indicators this way, but we have yet to get an indicator set like this to really become useful and persist. What has been other folks experience with 4 quadrant graphs for summarizing fab indicators and showing correlation, and have they found any exceptionally useful combinations of data this way?"

FabTime response: We haven't seen this in use for cycle time analysis in the fabs that we visit, but we are opening the question up to our other subscribers. Does anyone use a 4-quadrant graph for looking at fab data?

Tracking of Late Lots in Wafer Fabs

We received a question from another subscriber interested in how other fabs identify lots that are behind schedule. In FabTime, we look ahead based on planned operation-level cycle times, and compare each lot's expected shipment date to the planned due date for that lot. In the data table of our WIP Lot List chart, we display the lot's current status, in terms of the projected delta from the lot's due date. That is, if we meet the planned cycle time targets for all of the future steps, this lot will be 12 days late, or 8.1 days early, etc. This gives an early look at lots likely to be shipped late. But we also have a planned schedule for each lot to meet its due date (based on scaling the planned operation-level times to meet the due date). So we know, at any given point in time, that a particular lot might be 12 hours ahead of schedule, or 6 hours behind schedule, based on where the lot is supposed to be

right now. So the question is, should we be using the estimated future times, and focusing on the overall due date of the lot, or should we instead focus more locally on what time the lot reached its current location, vs. what time we thought it should reach this current location? Does anyone have experience to share on using one vs. using the other?

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

Equipment Availability versus Equipment Uptime and Manufacturing Time

Introduction

We've talked in the past about "availability" as the time that a tool is available to manufacturing to process wafers, or the sum of Productive Time plus Standby Time. And while this is a useful quantity to know for manufacturing personnel, it has been brought to our attention that calling productive time plus standby time "availability" is not particularly helpful for maintenance personnel. This is because maintenance personnel have also been successful in their jobs when they've made a tool available for engineering experiments. We decided to dig into this in a bit more detail, going back to the original SEMI E10 standard, and to consider modifying our uptime definitions to better serve these two different audiences. In this article, we revisit the SEMI E10 states and discuss the difference between the metrics Equipment Uptime and Manufacturing Time.

SEMI E10 Tool States

The SEMI E10-0304 specification for definition and measurement of equipment reliability, availability, and maintainability was originally published in 1986. It has been modified several times since then. The latest version was approved for publication by SEMI's global Audits and Reviews subcommittee on October 15th, 2003 (with further editorial modifications in 2004). The purpose of the SEMI E10 standard is to establish "a common basis for communication between users and suppliers of semiconductor manufacturing equipment by providing standards for measuring RAM performance of that equipment in a manufacturing environment." The primary section of E10 that FabTime uses is Section 5, Equipment States. E10 defines "six basic equipment states into which all equipment conditions and periods of time must fall":

Productive: Time when the equipment is processing wafers. Includes rework and engineering runs done in conjunction with production units (but does not include engineering experiments).

Standby: Time when the equipment is in a condition in which it could be running wafers, but is not being operated. Reasons for the equipment to be in this state can include lack of operators, lack of WIP, lack of support equipment (probe cards, etc.), and lack of input from the automation system.

Engineering: Time spent conducting engineering experiments, such as process characterization, equipment evaluation, software qualification, etc.

Scheduled Downtime: Planned downtime, including preventive maintenance, consumables change, and setup.

Unscheduled Downtime: Unplanned downtime, including repair time, waiting for repair, and verification after unscheduled repairs are made.

Nonscheduled: Time when the equipment is not scheduled to be used, such as during non-staffed shifts and factory shutdowns.

More detail, particularly about the breakdown of time into sub-states of scheduled and unscheduled downtime, can be found in the E10-0304 document, available for purchase from SEMI. The E10 states are well-known across the industry, and are quite valuable in tracking and improving tool performance. The E10 states also form the basis for OEE calculations.

A Note about Standby Time

FabTime has been using the E10 tool states extensively in our software for several years. In addition to allowing customers to map various sub-states into the basic E10 states, we also break Standby time down (automatically) according to whether or not WIP is available at the tool. This is because when there is no WIP, the tool can't be expected to be used for processing. There are no management issues with this. When the tool is in a Standby state, but has qualified WIP available, something is wrong. For example, there could be a lack of operators or supporting equipment (such as reticles), or there could be some other dispatching / lot location issue. We feel that it is important to distinguish between these two conditions. Thus, our Tool State chart, though based on the E10 states, actually shows seven states (with Standby broken into Standby-WIP Waiting and Standby-Other). However, for the purposes of the remainder of the discussion in this article, we will refer to Standby time as one state, rather than talking about the "WIP waiting" vs. "Other".

From Availability to Equipment Uptime and Manufacturing Time

The SEMI E10 standard defines Availability as "the probability that the equipment will be in a condition to perform its intended function when required." Another SEMI standard, the SEMI E79 standard for Overall Equipment Efficiency (OEE), defines Availability Efficiency relative to Scheduled and Unscheduled Downtime losses. E79 does not include Engineering Time as an Availability loss. Instead, Engineering Time is considered an Operational Efficiency loss. E10 does not define Availability in terms of the six basic states, however, which has perhaps led to some confusion in the use of "Availability" as a tool state-based metric. Is it Availability for manufacturing use, or Availability for any use? Instead of defining a state-based Availability, E10 defines Equipment Uptime and Manufacturing Time.

Equipment Uptime is the sum of Productive Time, Standby Time, and Engineering Time. Equipment Uptime is a useful metric for judging the effectiveness of maintenance support, since it measures how well the team does in keeping each tool available for either manufacturing or engineering use. Equipment Uptime can be alternatively written as Total Time - Nonscheduled Time - Scheduled Downtime - Unscheduled Downtime. While Nonscheduled Time is usually outside of the maintenance staff's control, driving Equipment Uptime incentivizes the team to reduce the sum of Scheduled and Unscheduled Downtime. This in turn leaves more time available for manufacturing or engineering.

Manufacturing Time is the time that the tool is available to be used for manufacturing wafers. Manufacturing Time is the sum of Productive Time and Standby Time. This is the value that manufacturing personnel would like to see maximized, for two reasons. First, of course, they want as much time as possible for production of manufacturing wafers. Second, it's the utilization of Manufacturing Time (defined as Productive / Productive + Standby) that drives cycle time (as we've discussed extensively in the newsletter). Conversion of Scheduled or Unscheduled Downtime into Manufacturing Time gives the manufacturing team the option to either run more wafers or improve cycle time, or some combination of the two.

To avoid confusion, we propose to modify our terminology, both in the newsletter and in our software, to refer to Equipment Uptime and Manufacturing Time, instead of "Availability". Equipment Uptime (Productive + Standby + Engineering) can be used as a metric to track the efficiency of maintenance personnel, while manufacturing personnel can continue tracking their own utilization of Manufacturing Time (Productive + Standby). Does this seem reasonable to all of you? Are we missing some critical aspect to these definitions? We welcome your feedback.

Impact on A20/A80

We have talked in the past about A20/A80, where A20 is the availability met or exceeded by the best 20% of availability observations, and A80 is the availability met or exceeded by the best 80% of availability observations. If we transition from "availability" to "equipment uptime" and "manufacturing time", we will need to decide if the A20/A80 metric is based on "equipment uptime" or "manufacturing time". As A20/A80 is used primarily by maintenance personnel (to our knowledge), it seems that it should be based on "equipment uptime", rather than "manufacturing time" (the current definition).

Conclusions

It is important to have a consistent and well-defined set of definitions, so that less time is spent discussing what we mean by "availability", and more time is spent solving real manufacturing problems. In this article, we have reviewed the SEMI E10 definitions for equipment states. We have also discussed our intention to transition from using the term "Availability", which is not defined in terms of the E10 tool states, to using separate terms relevant for maintenance personnel vs. manufacturing personnel. For maintenance effectiveness tracking, we will use the metric Equipment Uptime (Productive + Standby + Engineering), reflecting the time that the tool is available for either production or engineering use. For manufacturing personnel, however, we will continue to report Manufacturing Time (Productive + Standby), which is the time that the tool is available for manufacturing use. Our definition of Utilization (Productive / (Productive + Standby)) will not change. It is this Utilization of Manufacturing Time that drives cycle time performance.

Questions for FabTime Newsletter Subscribers

Do you use the SEMI E10 states at your fab? Do you report availability as something separate from manufacturing uptime?

Further Reading

- SEMI E10-0304E, "Specification for Definition and Measurement of Equipment Reliability, Availability, and Maintainability (RAM)", 2004. Available for purchase from http://www.semi.org (please note that FabTime cannot share this specification with you directly, due to the nature of our limited license for this document).

- Walt Trybula and Margaret Pratt, "Applying SEMI E10 Guidelines to Manufacturing," *IEEE/CPMT International Electronics Manufacturing Technology Symposium*, 1994.

- Kan Wu, Leon F. McGinnis, and Bert Zwart (Georgia Tech), "Queueing Models for Single Machine Manufacturing Systems with Interruptions", *Proceedings of the 2008 Winter Simulation Conference*, Miami, FL, December 7-10, 2008. (All WSC papers since 1997 are available for free download from www.wintersim.org/pastprog.htm). (From abstract: "Queueing models for each category are proposed, and event classifications are compared from both the SEMI E10 and queueing theory points of view.")

Subscriber List

Total number of subscribers: 2835, from 474 companies and universities.

Top 22 subscribing companies:

- Maxim Integrated Products, Inc. (220)
- Intel Corporation (150)
- Chartered Semiconductor Mfg (85)
- Micron Technology, Inc. (83)
- X-FAB Inc. (72)
- Western Digital Corporation (68)
- Texas Instruments (64)
- Freescale Semiconductor (59)
- Infineon Technologies (58)
- Analog Devices (57)
- ON Semiconductor (56)
- TECH Semiconductor Singapore (56)
- International Rectifier (55)
- NEC Electronics (53)
- STMicroelectronics (47)
- NXP Semiconductors (46)
- IBM (45)
- Cypress Semiconductor (43)
- Seagate Technology (36)
- BAE Systems (30)
- National Semiconductor (30)
- Spansion (30)

Top 3 subscribing universities:

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

New companies and universities this month:

- GLOBALFOUNDRIES
- Hayes Lemmerz International, Inc.
- OPTIMedical Systems
- TELEFUNKEN Semiconductors

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® 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 site for up to 20 participants, each additional participant $300. Discounts are available for multiple sessions.

Interested?

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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 is also available upon request.

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.

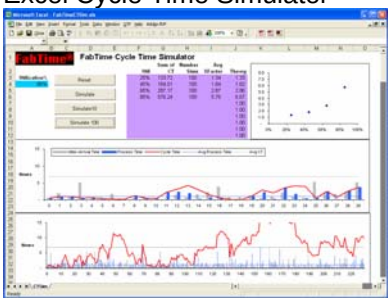
Skills Gained

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

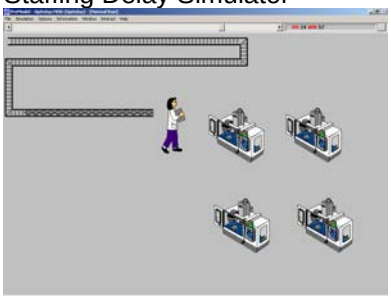
- Identify appropriate cycle time management styles.
- Teach others about utilization and cycle time relationships.
- Define and calculate relevant metrics for cycle time.
- Teach others about Little's law and variability.
- Quantify the impact of single-path tools and hot lots.
- Apply cycle time intuition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

Sample Course Tools

Excel Cycle Time Simulator



Staffing Delay Simulator



Additional Half-Day Modules

- Executive Management Session.
- Site-Specific Metrics Review.
- Capacity Planning Review and Benchmark.