FabTime Cycle Time Management Newsletter

Volume 6, No. 8 October 2005

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 version (7.5) include forecast outs trend, pareto, and lot list charts, and enhanced site-configurable password attributes.

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Welcome

Welcome to Volume 6, Number 8 of the FabTime Cycle Time Management Newsletter! This month we are pleased to announce a free one-hour talk on cycle time management, which we are offering to deliver onsite for fabs in the U.S. We have several announcements related to conferences and journals. October seems to be a popular conference month! We also have a notice about two jobs that are available at a U.S. wafer fab. Our FabTime software tip of the month concerns independent sorting of chart and data table information. We have subscriber discussion related to two open topics: fundamental drivers of fab cycle time, and identifying the cause of declining moves in a wafer fab. This month we're pleased to welcome subscribers from several new companies. And, for those keeping track, Intel just crossed the 100 subscriber threshold. Funny, I remember when there were fewer than 100 subscribers overall! It seems like yesterday sometimes.

In our main article this month we revisit the topic of hot lots. We talked about hot lots back in Issue 3.02, but thought that it was high time for a fresh look. This article is adapted from a section in our two-day cycle time management class, as well as from various discussions that we have had with our course and software customers. We discuss reasons for hot lots, the two primary types of hot lots, and the impact of hot lots on cycle time, and conclude with recommendations regarding hot lot management. We also include several references for further information on hot lots.

Thanks for reading!—Jennifer

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Community News/Announcements

Free One-Hour Talk on Cycle Time Management at Your Fab

Are you kicking off a new cycle time improvement effort? Do you want to ensure that your production personnel are thinking about cycle time as they make operational decisions? Do you use the best metrics for improving cycle time? FabTime is currently offering to have Jennifer Robinson visit your site to give a one-hour talk on the factors that influence cycle time in wafer fabs, and the best metrics for cycle time improvement. This talk is a sub-set of our one-to-two day cycle time management course, and is being offered at no charge to fabs in the United States. The talk will be paired with a one-hour demonstration of FabTime's web-based digital dashboard software, with emphasis on ways that the software supports cycle time improvement efforts. If you are interested in scheduling a visit, please contact Jennifer.Robinson@FabTime.com.

Job Listing

One of our subscribers contacted us about two immediate job openings at his company. This U.S. fab has openings for a Maintenance Supervisor and a Capacity Modeler. If you have experience and interest in either of these areas, please contact Jennifer.Robinson@FabTime.com, to be put in contact with the company.

FabTime Presentation: ISMI Symposium on Manufacturing Effectiveness

FabTime's Jennifer Robinson will be presenting the following talk at the ISMI Symposium on Manufacturing Effectiveness later this month.

WIP States and Overall WIP Effectiveness, by Jennifer Robinson and Frank Chance

Abstract: A common approach in monitoring fab performance is to take a tool-centered approach. This involves measuring overall equipment effectiveness (OEE) for bottlenecks, recording downtime characteristics, and tracking the time that tools spend in particular states. The tool centered view is very important in running a fab, because the individual tools are so expensive.

In this presentation, however, we promote a parallel WIP-centered view of the fab. That is, for an individual lot, we look at the time that the lot spends in various states (processing, waiting, traveling, etc.). These are analogous to tool states. We also use the WIP state information to calculate a performance measure parallel to OEE, called Overall WIP Effectiveness. We believe that understanding exactly where lots are spending their time is an important step in improving cycle time, and that WIP states and overall WIP effectiveness have the potential to add to the understanding of the fab.

The ISMI Symposium will be held in Austin, TX on October 24-26. More information is available at ismi.sematech.org/ismisymposium/.

Call for Papers: IEEE Conference on Automation Science and Engineering: October 9 & 10, 2006 in Shanghai, China

The 2nd annual IEEE Conference on Automation Science and Engineering (IEEE CASE), sponsored by IEEE Robotics and Automation Society, will be held on October 9 and 10, 2006 in Shanghai, China. The goal is for broad coverage and dissemination of foundational research on automation among researchers, academicians, and industry practitioners. The focus is on scientific methods for automating machines and systems operating in structured environments over long periods, and also for the explicit structuring of environments. The first IEEE CASE was successfully held in 2005 in Edmonton, Canada. The technical program of IEEE CASE will consist of tutorials, workshops, invited talks, paper presentations, and panel discussions. Papers describing original work on abstractions, algorithms, theories, methodologies, and case studies are invited. Semiconductor manufacturing papers are welcome.

Paper Submissions: Author(s) should submit full papers electronically in double column PDF format. All papers will be peer-reviewed, and selected ones will be published in CD-ROM. Six pages are allowed per paper, and detailed instructions for paper preparation and submission will be available on the conference web site: http://www.ieee-case.org.

General Chair: Michael Yu Wang, The Chinese University of Hong Kong, Hong Kong, yuwang@acae.cuhk.edu.hk

Program Chair: Deirdre Meldrum, University of Washington, USA, deedee@ee.washington.edu

IEEE Robotics and Automation Society: Technical Committee on Semiconductor Factory Automation

Co-Chairs: Prof. MuDer Jeng (NTOU, Taiwan), Prof. Mengchu Zhou (NJIT, USA), Dr. Thomas Wen-Yao Chen (TSMC, Taiwan)

Objectives: Semiconductor manufacturing is an established yet rapidly growing industry, and has highly automated factories. The automation of a semiconductor factory is a significant and challenging task due to its complicated production processes, sophisticated equipment, and harsh productivity requirements. For the last decade, we have seen more and more research and development activities contributed to this subject. This technical committee was founded in August 2001 to provide a forum for exchanging ideas among semiconductor factory automation researchers and engineers through scientific events, such as special conference sessions, workshops, and symposia, as well as through publications, such as special journal issues.

Topics of interest include semiconductor factory modeling, design, analysis, performance evaluation, planning, scheduling, layout, communication and monitoring, wafer release policies, and wafer dispatching techniques, among others.

Join Us! Anyone who is interested in joining this technical committee can send a message to jeng@mail.ntou.edu.tw. All comments, suggestions, and contributions to the technical committee activities are highly welcome.

Call for Papers: IEEE Robotics & Automation Magazine: Special Issue on Automation Science and Engineering

Introduction: Automation plays an increasingly important role in the global economy and in our daily lives. Engineers strive to combine automated devices with mathematical and organizational tools to create systems for a rapidly expanding range of applications and human activities. As the main dissemination means of the IEEE Robotics and Automation Society (RAS), RAM devotes this special issue to highlight the latest progresses made at various forefronts of the broad area of automation science and engineering. This special issue will complement the newly established IEEE Transactions on Automation Science and Engineering (T-ASE) that publishes archival journal papers on the abstractions, algorithms, theory, methodologies, models, systems, and case studies to significantly advance efficiency, quality, productivity, and reliability for society. Similar to T-ASE, the coverage of this special Magazine issue should go beyond Automation's roots in mass production and includes many new applications areas. Articles, however, should be presented in a magazine style for easy digestion and a broader readership. The content could describe novel applications, highlight practically oriented issues, or present surveys and reviews that summarize the state-of-the-art and practice of automation science and engineering.

Guest Editors: Professor Michael Yu Wang (CUHK) and Mike Tao Zhang (Intel)

Website: https://ras.papercept.net/journals/ram/information/SpecialIssues/automation.htm

Submission deadline: December 1, 2005.

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

FabTime User Tip of the Month

Sort Chart Columns and Data Table Rows Independently

By default, all Pareto charts in FabTime display the first 10 items as part of the chart image (e.g. moves by tool for the ten tools with the most moves). The first 25 items are included in the data table. You can change both of these settings. (To display more columns per chart use the "Format: Points" control located in the lower left corner of the page. To display more rows per data table, use the "Rows" control located above the data table). However, what often also works well is re-sorting the data, so that the data of most interest is included in the display. FabTime allows independent sorting of chart columns vs. data table rows.

To sort the columns displayed in the chart image, use the set of controls labeled "Sort" located just below the main set of chart filters in the left-hand column of the screen. You can sort by up to three different variables. Select the primary sort variable from the top-most drop-down list, and then select any required second or third variables from the remaining two drop-down lists. If any of the sorts should be in descending order, click the small box to the right of the sort variable. Clicking places a checkmark in this box, and tells FabTime to do the sort for that variable in descending order. Sort variables can include any data underlying the chart, even if the data is not explicitly displayed in the chart picture. For example, WIP Lot List charts can be sorted by lot size, even though lot size is not represented graphically on the chart. Once you have selected the desired sort variables, click the "Go" button located immediately below the sort controls. FabTime will re-generate the chart, sorted as specified.

To sort the data displayed in the data table, use the set of controls labeled "Sort" located just above the data table. These work exactly the same way as the chart column sort controls, but only act on the data table. This independence of the two sort controls is to allow maximum flexibility in your display and use of the data. As an example, suppose that you are looking at a Lot History chart. You might always want to see the chart sorted in its default operation order. However, you might want to bring to the top of the data table all operations with long queue times, to investigate these in more detail. Independent chart column and data table row sorts allow this type of analysis.

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

Issue 6.05: Fundamental Drivers of Fab Cycle Time

An anonymous subscriber wrote: "I had a couple of questions I wanted to run by you which stemmed from reading "The Three Fundamental Drives of Fab Cycle Time" article."

"1. Can you describe the factors going into theoretical cycle time? Is this the pure processing time or a summation of all the time required to complete a lot (queue time excluded)?"

FabTime Response: In our cycle time management class, we define theoretical cycle time as the sum of the process time for all required steps, plus any load and unload times. Travel time is usually excluded from this theoretical cycle time, as is any queue time. We tend to think of it as the minimum amount of time that it would take to process a lot, if tools were held idle such that the lot never had to wait. This definition, then, is lot size dependent. You might have a different theoretical cycle time for a single wafer lot than you would have for a 25-wafer lot. There is also an issue of whether to include all of the inspection steps in the theoretical cycle time. Our answer to that is that you should include in the theoretical cycle time any operations (including inspection operations) that will be included in the actual recorded cycle times of completed lots, with the exception of hold or rework operations.

"2. In the article you discuss an 85% utilization threshold. If variability increases then we would want the threshold to decrease. I was curious if there is an industry standard or rule-of-thumb for utilization at various levels of variation or is there some industry standard for a reasonable cycle time X-Factor (seems like a standard X-Factor, such as 3X, would be robust for variable and non-variable calculations)?"

FabTime Response: We have not seen anything that we would classify as an industry standard regarding adjusting the utilization threshold for different levels of variability. The formula that we use to estimate cycle time x-factor for one-of-a-kind tools is:

XFactor ~= 1 + [Utilization/(1-Utilization)] * [Variability Factor]

where the variability factor is the sum of the squared coefficient of variation of time between arrivals and the squared coefficient of variation of process times. This formula is adjusted for tool groups with multiple tools, but the same general behavior is observed. Cycle time increases as utilization increases and as variability increases.

The most common rule-of-thumb that we have seen people use is the one you mentioned: targeting 3X cycle times for the fab as a whole. Usually what happens in practice is that some tool groups have a high utilization, and hence have high cycle times. Many other tool groups in the fab, however, are operated at lower utilization values. These tool groups tend to have lower cycle times, and to be less affected by variation. Because variability has the greatest cycle time impact for heavily utilized tools, it makes sense to focus variability reduction efforts towards those more heavily loaded tools.

"3. Are you aware of any articles which 1) discuss raw process times, and 2) address handling standard multiples of raw process time when the processing times are extreme. I'm thinking of a multiple placed on a long Diffusion step as compared to a quick metrology type step."

FabTime Response: We have not seen any articles that discuss adjusting the multiple of theoretical (or raw) cycle time for extreme process times. We have, however, seen people plan for lower utilization values on their batch tools, so that they will have less of an impact on overall cycle time. We also recommend looking at straightforward queue times for individual operations, to target immediate cycle time improvement opportunities. For example, we have talked with people at a number of fabs that flag as "inactive" lots that have been in queue for more than some period of time (e.g. 12 hours). This is used in addition to looking at multiples of theoretical process time.

"4. Finally, are you aware of articles which address balancing utilization across the Fab to minimize arrival variability?"

FabTime Response: We do not know of any articles that focus explicitly on balancing utilization across the fab to minimize arrival variability. However, several articles that address the impact of variability on cycle time, and ways to manage it, are listed below.

- J. H. Jacobs, L. F. P. Etman, E. J. J. van Campen, J. E. Rooda, "Characterization of Operational Time Variability using Effective Process Times," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 16, No. 3, 511-520, 2003.

- H. V. Kher and L. D. Fredendall, "Comparing Variance Reduction to Managing System Variance in a Job Shop," *Computers & Industrial Engineering*, Vol. 46, No. 1, 101-120, 2004.

- S.-S. Ko, R. Serfozo, A. Sivakumar, "Reducing Cycle Times in Manufacturing and Supply Chains by Input and Service Rate Smoothing," *IIE Transactions*, Vol. 36, No. 2, 145-153, 2004.

- S. C. H. Lu, D. Ramaswamy, and P. R. Kumar, "Efficient Scheduling Policies to Reduce Mean and Variance of Cycle-Time in Semiconductor Manufacturing Plants," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 7, No. 3, 1994, 374-380.

- J. W. Patterson, L. D. Fredendall, C. W. Craighead, "The Impact of Non-Bottleneck Variation in a Manufacturing Cell," *Production Planning and Control*, Vol. 13, No. 1, 2002, 76-85

Issue 6.07: Identifying the Cause of Declining Moves in a Wafer Fab

Daren Dance from **WWK** submitted the following in response to an anonymous contributor's comments on declining moves in the last issue. "I always ask the following question: "Is the actual bottleneck in the fab where you expect the bottleneck to be?" If not, then I ask: "What has changed to cause the location of the bottleneck to change?" Typical causes of bottleneck relocation are:

- New products or processes with different manufacturing characteristics. If these exist, then recharacterize the process to understand if capacity changes need to be made.

- Recent major equipment outages and resulting dynamics in wafer movement and line balance. If this has occurred, then wait a day or two to let the process flow stabilize and reexamine the flows.

- Unidentified or unauthorized changes in operating procedures. These need to be immediately addressed. In one fab, we observed that 80% of the processing operations deviated from documented procedures. And they were wondering why production had declined!

If the bottleneck is as expected then start with a) and b) as your anonymous subscriber suggested last month (identify the bottleneck/key tools and analyze availability, and perform operator motion & time studies)."

Cycle Time and Hot Lots Revisited

Introduction

Back in Issue 3.02 (3 1/2 years ago!) we discussed the cycle time impact of hot lots. That article focused primarily on quantifying the impact of "front of the line" hot lots on the cycle time of regular lots. Since then, we have talked with people from many different fabs about hot lots, and we thought that it was time to share with you our current thoughts on the subject. In this article, we discuss reasons for hot lots, the two primary types of hot lots, and the impact of hot lots on cycle time. We also make recommendations regarding hot lot management. Finally, we include several references regarding hot lots. We welcome your feedback on this topic.

Background: Type of Hot Lots

Every wafer fab that we visit has hot lots. There are many reasons for these hot lots:

- Lots for certain customers may be run at a higher priority than lots for other customers.
- Lots made to order may be run at a higher priority than lots made to stock.
- Research and development lots are often expedited relative to regular production WIP.
- First silicon for new products is frequently given highest priority.
- A yield bust or downstream yield improvement can lead to re-prioritization of a portion of the WIP.
- Lots late in their process flow are sometimes expedited to meet weekly delivery goals.
- Short-term priority changes are sometimes made to fill WIP holes at critical tools, or otherwise manage product mix issues.
- Lots that are outliers in terms of cycle time are sometimes re-prioritized, particularly those that are behind schedule.
- Etc...

Although there are many types of hot lots, we can classify them into two primary categories in terms of how they are processed: front of the line hot lots and hand carry lots.

"Front of the line" hot lots (also called "regular hot lots") are lots that are given a higher priority than others for dispatching. These lots are non-preemptive, and do not require breaking setups or holding tools idle. They are sometimes stored in different-colored lot boxes, to make them easier to identify. There may be multiple sub-classes of front of the line hot lots (e.g. priority 0080, 0085, 0090, etc.).

"Hand carry" lots are the highest priority of hot lots. They may be preemptive, and require operators to break setups. Usually tools are held idle in advance of these lots, so that the hand carry lots never have to wait. Hand carry lots are generally very limited in quantity. Often a single person (per shift) is responsible for each hand carry lot as it moves through the fab.

We have heard many alternative names for hand carry lots over the past several years, and share some of them with you here: Zero-Queue Lots, Ambulance Lots, Racetrack Lots, Screamer Lots, Lightning Lots, Platinum Lots, Priority1 Lots, Nuclear Lots, Rocket Lots, Turbo Lots, and CEO Lots. We particularly like "ambulance lots" because of the clear image of everything else getting out of the way as the lot moves through the fab.

Impact of Hot Lots on Cycle Time

As discussed above, there are many good reasons to have hot lots in a fab. However, hot lots are not free. They increase variability in the fab, which drives up cycle time. They also frequently require special handling of some sort, which takes operators away from other things, and hence drives up cycle time. Hand carry lots are particularly disruptive. Whenever a tool is held idle for a hot lot, capacity is lost on that tool. Whenever a setup is broken, or an additional setup is required for a hot lot, capacity is lost. Whenever a batch tool is run nearly empty because of a hot lot, capacity is lost. And, as readers of this newsletter well know, any capacity loss on a tool decreases the buffer of standby time for the tool, and drives up cycle time.

Theoretically, this is less of a problem when dealing with front of the line hot lots. If tools are not held idle, and the lot priority is merely used to help decide which lot to process next, then all front of the line hot lots do is move queue time from one class of lots to another. That is, queue time is moved from the high priority lots (which go directly to the front of the queue) and added to the regular lots (which incur extra waiting time while the hot lots are processed). Issue 3.02 included a formula for estimating this impact. Briefly recapping here, our standard formula for estimating cycle time x-factor for a single tool is:

XFactor ~= 1 + [Utilization/(1-Utilization)] * [Variability Factor]

When we have front of the line hot lots, the cycle time of the regular lots is inflated by a multiplier, and we have:

XFactor ~= 1 + [Utilization/(1-Utilization)] *[Variability Factor] * [Hot Lot Multiplier]

where Hot Lot Multiplier = [1 / (1 – Hot Lot Utilization)].

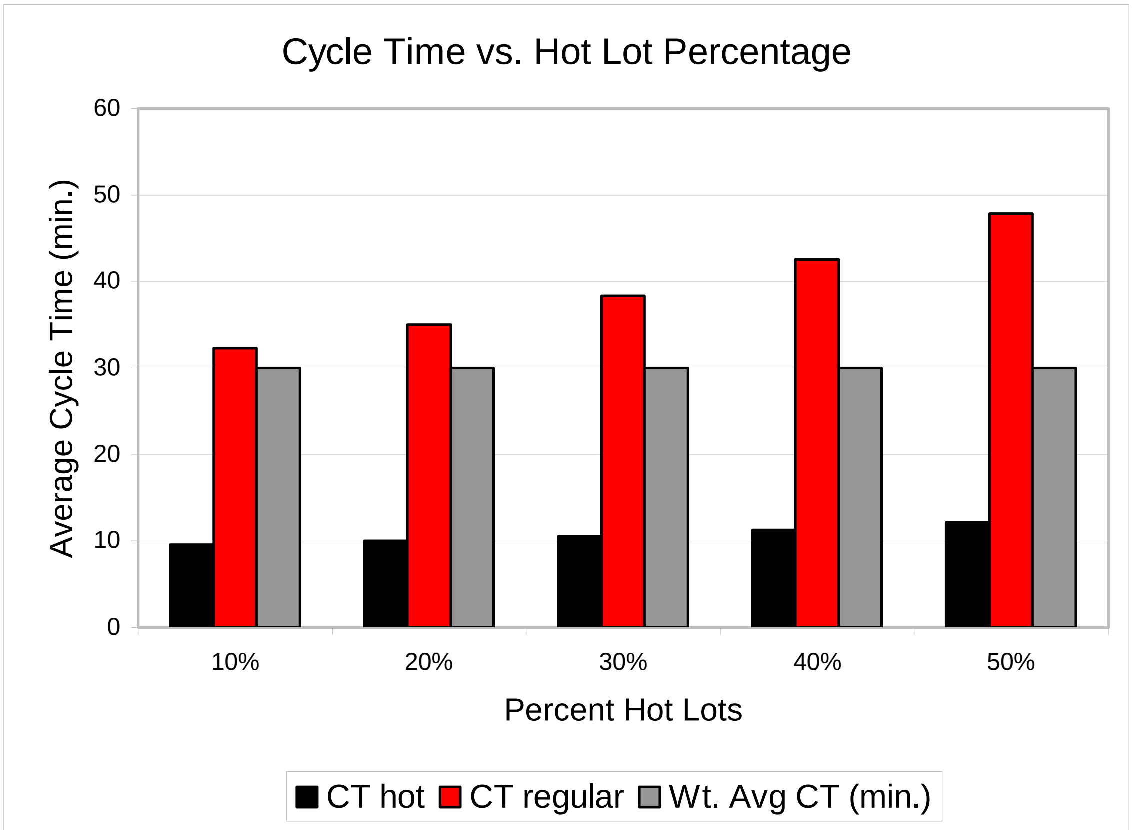
Hot Lot Utilization is simply what the tool utilization would be if only hot lots were present. It can be calculated by taking the overall tool utilization and multiplying by the percentage of hot lots. For example, if we have a tool with 85% overall utilization, and 10% hot lots, then the Hot Lot Utilization is 8.5%. The Hot Lot Multiplier in this case is [1 / (1 – .085)] = 1/0.915 ~= 1.09. That is, if we have 10% hot lots, at 85% tool utilization, then the cycle time of the regular lots is inflated by approximately 9%.

Note, however, that if we have additional hot lots, the cycle time increases non-linearly. In the above example, if we have 25% hot lots, then the Hot Lot Utilization is 21.2%, and the Hot Lot Multiplier is [1 / (1 – 0.21.2)] = 1/0.788 ~= 1.27. That is, with 25% hot lots, the cycle time of the regular lots is inflated by approximately 27%. A graph displaying regular lot and hot lot cycle times for a tool with different percentages of hot lots is shown at the top of the next page.

The above formula for the Hot Lot Multiplier is a lower bound. That formula assumes that no additional queue time is created – merely that queue time is moved from the hot lots and spread out over the higher volume of regular lots. The overall average queue time across all lots remains unchanged.

In reality, hot lots increase the overall average cycle time in the fab due to their impact on variability and tool capacity. This is true even for front of the line hot lots, if they lead to additional setups or smaller batches, and is particularly true for hand carry lots. The exact magnitude of this effect is difficult to quantify, even using simulation models, because so much is influenced by individual operator decisions (how long to hold a tool idle for a hot lot, for instance). The magnitude of the impact also depends on how heavily utilized the tools in the fab are to begin with. For tools that have excess capacity, holding the tool idle to wait for a hot lot is not likely to have a big effect. However, holding a very heavily utilized tool idle for an upcoming hot lot can lead to lost capacity that can never be recovered.

What we do know about the effect of hand carry lots on cycle time is that the more hot lots there are, the worse the effect. If there are more than one or two lots in the fab at a time, they will start to interfere



with one another, defeating the goal of no waiting for each lot. In abundance, hand carry lots may also be subject to a "boy who cried wolf" effect, in which people start to take them less seriously.

Recommendations for Managing Hot Lots

Front of the Line Hot Lots:

It is our recommendation, based on talking with people in fabs, and on the formula discussed above, that most fabs try to keep front of the line hot lots to below 10% of total WIP. An exception would be fabs in which there are truly separate classes of lots, as a fab that makes some WIP to order, and other WIP to stock. In the latter case, it might make sense to always prioritize the make to order WIP ahead of the make to stock WIP, and generally accept higher cycle times for the make to stock WIP. Overall, however, there are many fabs that try to keep hot lots to below 10% of WIP.

For a quantitative basis to this 10% threshold, remember our Hot Lot Multiplier above. For a relatively heavily utilized tool, 10% hot lots resulted in a slightly less than 10% penalty in the cycle time of the regular lots. As the percent of hot lots increased above 10%, however, the cycle time penalty for regular lots increased non-linearly. Also, above 10%, hot lots are more likely to interfere with one another, and hence the hot lot cycle times will be higher. In general, the fewer hot lots there are, the better their cycle time will be. And of course, if there are fewer hot lots then there will be less of an impact on regular lot cycle time.

The other general recommendation that we have regarding front of the line hot lots is to keep things as simple as possible. Any time you change lot priorities on the fly, or have some special class of hot lots that changes every few days, you are introducing variability into the fab. You are also making dispatching more complex, and potentially increasing queue time as operators search the queue for the right hot lot. The best solution for overall cycle time is always the lowest variability solution. It is far better to reduce the overall average cycle time across the entire fab than to struggle to manage ten different, ever-shifting classes of priority lots.

Hand Carry Lots:

For hand carry lots, we recommend no more than one or two lots in the fab at one time. This is partly because these types of hot lots are very disruptive to the fab, and to the cycle time of other lots, such that they should be used sparingly. Also, as mentioned above, in larger quantities the hand carry lots will interfere with one another, defeating their own purpose. Even in small quantities, if the hand carry lots are run too frequently, it will be difficult to get people to continue taking them seriously.

We worked with one of our customers on a procedure for super-expediting hand carry lots in a large wafer fab (see the Hillis and Robinson paper referenced below). This procedure involves setting a goal for the maximum handy carry lot queue time, setting a goal for the maximum number of hand carry lots in the fab, and establishing key resource buy-in for hand carry lots. The site uses FabTime's software as part of an automated tracking and alerting system, and has developed tactical communications plans regarding the hand carry lots. The customer applied this procedure to the first lot of a critical new product. This lot went from being 14 days behind schedule to shipping early (as described in the referenced paper). The conclusions regarding hand carry lots that came out of that study were:

- Production management buy-in is essential, because super-expedited lots are very disruptive to production, and will generate resentment unless their purpose is clearly understood. (That is, prevent the "boy who cried wolf" effect as much as possible.)
- Getting access to up-to-date information about fab performance is critical to success.
- Communication is the ultimate key to success.

Benchmarks

Whenever we talk about hot lots, people ask us for benchmarks in terms of hot lot performance. The usual caveat applies: what's realistic for your fab depends on your factory size, and the utilization of your various tool groups. However, we have seen benchmark numbers for front of the line hot lots of 1.4-1.5 times theoretical (1.4X-1.5X). For hand carry lots, it is possible, through disciplined application of a procedure like the one outlined above, to achieve cycle times of 1.15X. Be aware, however, that such aggressive hand carry lot cycle times will likely carry a penalty in terms of regular lot cycle time, especially for smaller fabs.

Conclusions

Hot lots appear to be a fact of life for wafer fabs. There are many reasons why people have hot lots, and there is no question that hot lots help in certain circumstances. For example, achieving great cycle times for first silicon lots can be a mission-critical undertaking affecting the overall success of a company. However, there is also no question that hot lots increase the cycle time of other lots. The cycle time impact on regular lots from front of the line hot lots can be quantified, and increases non-linearly with the percentage of hot lots. The cycle time impact on regular lots from hand carry lots can be much greater, due to both increased variability and to lost capacity from held tools, setups, etc. To minimize the impact on regular lots, and to maximize the chance that hot lots achieve their target cycle times, we recommend that fabs carry no more than 10% of their WIP as front of the line hot lots, with no more than one or two hand carry lots at one time. Fewer hot lots would be even better, and might leave manufacturing personnel with some additional energy for overall cycle time improvement efforts.

Closing Questions for FabTime Subscribers

Are there other reasons for hot lots that we're missing? Are these recommendations and benchmarks consistent with what you're seeing in your fab?

Acknowledgement

Special thanks to Mike Hillis (Spansion) for his contributions regarding the super-expediting of hand carry lots.

Further Reading

■ L. Condrey, "NPI Lite: Breaking the Paradigm on New Product Introduction TPTs," *Proceedings of the 2002 International Symposium on Semiconductor Manufacturing*, Tokyo, Japan, 2002.

■ B. Ehteshami, R. G. Petrakian, and P. M. Shabe, "Trade-Offs in Cycle Time Management: Hot Lots," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 5, No. 2, 101-105, 1992.

■ D. Fronckowiak, A. Peikert, and K. Nishinohara, "Using Discrete Event Simulation to Analyze the Impact of Job Priorities on Cycle Time in Semiconductor Manufacturing," *Proceedings of the 1996 Advanced Semiconductor Manufacturing Conference and Workshop (ASMC 96)*, Boston, MA, 151-155, 1996.

■ M. Hillis and J. Robinson, "Extremely Hot Lots: Super-Expediting in a 0.18 Micron Wafer Fab," *Proceedings of the International Conference on Modeling and Analysis of Semiconductor Manufacturing (MASM 2002)*, Editors G. T. Mackulak, J. W. Fowler, and A. Schoemig, Tempe, AZ, April 10-12, 2002. 106-111. This paper is available for free download from www.FabTime.com/bibliogr.shtml.

■ K. Hsieh, A. Ling, S. Huang, R. Luoh, M. Lin, L. Lee, "Super-Hot-Runs Management System," *Proceedings of ISSM 2000. The Ninth International Symposium on Semiconductor Manufacturing*, 363-366, 2000.

■ L. Labanowski and J. A. LaFreniere, "Effective Methodology for Movement of Rapid Turn Around Time (RTAT) Hardware In A Multi-Flow Fabricator," *IEEE 2000 Advanced Semiconductor Manufacturing Conference (ASMC '00)*, 68-74, 2000.

■ Y. Narahari and L. M. Khan, "Modeling the Effect of Hot Lots in Semiconductor Manufacturing Systems," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 10, No. 1,185-188, 1997.

■ J. Robinson and F. Chance, "Cycle Time and Hot Lots," *FabTime Cycle Time Management Newsletter*, Vol. 3, No. 2, 2002. Normally, past newsletter issues are only available to FabTime customers. However, since this issue is a precursor to the current issue, we will send it to current subscribers on request. Email Jennifer.Robinson-@FabTime.com.

■ K. Rust, T. Stanley, and J. Hasenbein, "Modeling Hotter Hot Lots," *Proceedings of the 2001 International Conference on Semiconductor Manufacturing Operational Modeling and Simulation*, 2001, Seattle, WA. A copy of this paper is available from Jennifer.Robinson@FabTime.com upon request.

■ W. J. Trybula, "Hot Jobs, Bane or Boon," *Proceedings of the 1993 IEEE/CHMT International Electronics Manufacturing Technology Symposium*, Santa Clara, CA, 317-322, 1993.

Subscriber List

Total number of subscribers: 1905, from 426 companies and universities. 23 consultants.

Top 10 subscribing companies:

- Intel Corporation (102)
- Analog Devices (79)
- Atmel Corporation (62)
- Infineon Technologies (62)
- STMicroelectronics (57)
- Freescale Semiconductor (55)
- Micron Technology (47)
- Philips (47)
- Texas Instruments (42)
- TECH Semiconductor (40)

Top 3 subscribing universities:

- Virginia Tech (10)
- Arizona State University (9)
- University of California – Berkeley (7)

New companies and universities this month:

- Bookham (Switzerland) AG
- CyOptics
- Dimatix
- Era7 Information Technologies S.L.
- Glimmerglass Networks
- Harcourt Assessment, Inc.
- Innos Ltd.
- WestOak Industries

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

$4950 plus travel expenses. On-site delivery for up to 15 participants, each additional participant $195. Discounts available for multiple sessions.

Interested?

Contact FabTime for a quote.

FabTime Inc.
Phone: +1 (408) 549-9932
Fax: +1 (408) 549-9941
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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 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.

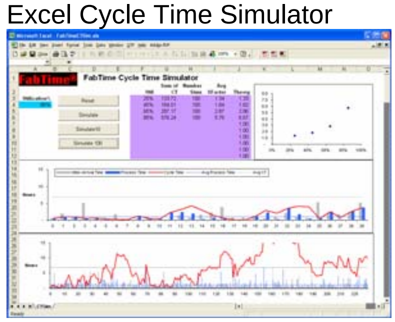
Skills Gained

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

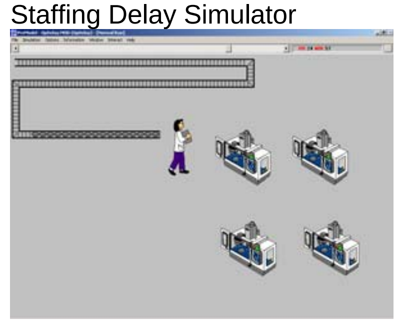
- Identify appropriate cycle time management styles.
- Teach others about utilization and cycle time relationships.
- Define and calculate relevant metrics for cycle time.
- Teach others about Little's law and variability.
- Quantify the impact of single-path tools and hot lots.
- Apply cycle time intuition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