FabTime Cycle Time Management Newsletter

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Information

Mission: To discuss issues relating to proactive wafer fab cycle time management.

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Welcome

Welcome to Volume 2, Issue 2 of the FabTime Cycle Time Management Newsletter. In this issue, we have responses to last month's newsletter on batching decisions from Tim Stanley, John Fowler, and Phil Fontes. We also have a job change notice from Navi Grewal, and a job announcement from Ron Whitney at Agilent. We're grateful to all of these contributors for helping to keep the newsletter interesting and relevant.

The new topic for this issue is the relationship between lot size and cycle time. We address the question of whether or not you should reduce lot sizes to reduce cycle times. First, we discuss why lot size reductions may reduce average cycle times, and then we review several items that we think you should consider before implementing such a change. We would especially welcome your feedback on this article, because it seems to be a question that a number of fabs are currently struggling with, and an area in which we can help each other by pointing out pitfalls and opportunities.

Thanks for reading! -- Jennifer

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Responses to Prior Newsletter Topics

Issue #2.1 (Impact of Batch Size Decision Rules on Cycle Time)

From Tim Stanley at SEMATECH: "One additional reason for not waiting to build a full batch in the real fab world is the necessity to start furnace operations with a known surface condition on the Wafers. For this reason there is often a specification on how long a wafer can wait between a clean and a furnace step. For example, oxide growth may require that there be less that 6 hours between clean and oxide growth. If the time limit is exceeded, the wafers must be re-cleaned."

From John Fowler at Arizona State University: "The batching article was right on the mark. The only thing I would add is that the batch decision can have a major impact at downstream implant operations because of the sequence dependent setups."

Phil Fontes at NEC, also contacted me to ask what I meant by utilization of batch tools. In the batching article, I talked about how the choice of decision rule depends on the utilization of the batch tool. Phil pointed out that this was unclear, since batch tools are often run with less than full batches, and common definitions of utilization are based on the fraction of time that a tool spends processing (regardless of batch size). Phil's point is well-taken, so I'll take a moment to clarify here. When I spoke of the utilization of batch tools, I should have used the term "capacity loading". Capacity loading is simply the ratio of current processing rate of the tool to maximum processing rate of the tool. So, if a tool is down 50% of the time, and busy processing 25% of the time, and idle 25% of the time, the capacity loading of the tool is 50%. This is because you could double the rate of product through the tool, before reaching zero idle time, so the tool is at 50% of the loading that would make it a bottleneck. If this tool was a batch tool, down 50% of the time, and busy the 50%, but on average only half-full when busy, the tool would also have a 50% capacity loading. So, when I talked about not applying a force-full policy to tools that are lightly loading, I was referring to tools with a low capacity loading, even though these tools might not have much idle time. In general, when you hear someone speak of utilization of batch tools, it's a good idea to find out exactly what the person means (is average batch size taken into account?). My thanks to Phil for catching me on an ambiguous explanation.

Should You Reduce Lot Sizes to Reduce Fab Cycle Times?

Background

Several people have talked with us lately about possible changes to their production lot sizes. For fabs running 50 wafer lots, changing to 24 or 25 wafer lots offers a potential cycle time reduction opportunity. However, there can be tremendous resistance to this idea, and there are a number of potential pitfalls. In this article, we first review the reasons for the cycle time reduction opportunity, and then discuss some of the pitfalls.

In a wafer fab, there are four primary categories of tools, where the categories relate to how wafers are processed. There are per-wafer tools, in which the wafers in a lot are processed one at a time through a single operation, and then the lot is sent on to the next operation. There are per-lot tools, in which the entire lot can be processed at one time. There are per-batch tools, in which the number of wafers that can be processed at one time is different from the number of wafers in a lot (usually larger, though some 12-wafer batch tools exist). Finally, there are cluster tools, in which a single wafer is processed through several operations in sequence inside a clean environment, and multiple wafers can be processed at the same time, in different chambers of the tool. Examples of per-wafer tools include steppers and implanters. Examples of per-lot tools include sinks and inspection tools such as CD-SEMs. Examples of batch tools include furnaces and vapor prime ovens. Examples of cluster tools include certain PVD and etch tools.

The justification of lot size reduction for cycle time reduction comes into play primarily due to the per-wafer tools, which can include critical tools such as steppers and implanters. Suppose that you have a lot size of 50 wafers, and a per-wafer process time of one minute. Then, if everything runs smoothly, to process a single lot through the operation takes 50 minutes (plus any applicable setup and load times). Each individual wafer spends 49 out of those 50 minutes waiting for the other wafers in the lot. This is true even if there are other tools free that could process the wafers in the lot (for operational and process reasons, a lot is not usually split across multiple tools, though this does happen in some cases). If you cut the lot size in half to 25 wafers, then each wafer only spends 24 minutes waiting for the other wafers in the lot, rather than 49 minutes. Over the course of passing through many single-wafer tools, this can lead to a reduction in overall cycle time.

Other Benefits of Smaller Lot Sizes

In addition to providing direct cycle time benefits at per-wafer tools, smaller lot sizes also make a fab more flexible, more adaptive in the event of problems, and reduce variability.

Yield: Smaller lot sizes can help mitigate yield problems. If an entire lot must be scrapped, it's clearly better to have that be a 25-wafer lot than a 50-wafer lot. Also, because smaller lots are completed more quickly through certain inspection tools, they can sometimes identify a yield problem more quickly, before other lots start a process sequence. This reduces scrap and rework, and generally reduces variability in the fab.

Smooth Flow: In addition to reducing waiting times at individual per-wafer tools, smaller lot sizes smooth the flow through sequences of tools, and reduce variability in arrivals to other tools. In a variability sense, it's better to have a 25-wafer lot arrive every 15 minutes than to have a 50-wafer lot arrive every 30 minutes.

Hot Lots: If you have a policy that says, finish whatever lot you're currently processing, but then move any hot lots to the front of the queue, you'll see shorter hot lot cycle times if the regular lots have smaller lot sizes. This is because lots are finished twice as frequently (at least on per-wafer tools), and thus the hot lots can be started more quickly.

So Why Wouldn't You Reduce the Lot Size?

There are a number of issues to consider before changing the lot size, any one of which might keep a lot size reduction from being worthwhile, or even render it detrimental. These include capacity, material handling, MES, and dispatching/complexity issues, as discussed below.

Material Handling: On the plus side, smaller lot sizes are lighter, and thus easier for operators to transport without ergonomic issues. However, this leads to an increased load on transport operators (more trips, with fewer wafers carried in each trip). This might translate into a need for additional operators. For fabs with automated material handling, the system may be configured for the larger lot sizes, and could be costly or disruptive to change. Just grouping two smaller lots into the space previously taken up by a single lot could lead to mis-processing errors (since you wouldn't necessarily know what wafers were in each lot from the outside). Yet if the system is just run using lots half as large, the load on the transport system will be doubled, which could cause capacity problems. In some cases, transport between bays is achieved using transfer batches that are larger than one lot to begin with. In this case, much of the benefit of switching to smaller lot sizes would be lost, as the wafers would still end up waiting to form transfer batches.

Capacity: The capacity issues come largely from per-lot tools. In some cases, it takes just as long to process a 25-wafer lot as it does to process a 50-wafer lot. Since cutting the lot size in half doubles the number of lots that must be processed, this can lead to capacity problems on the per-lot tools. You'll need to do some research to understand the process and capacity effect of the change on per-lot tools. This is an area in which having a good capacity model could be quite helpful. It's important that the capacity model not treat all of the tools as per wafer tools (a common feature of spreadsheet capacity models), because this will mask the effect of any lot size change.

Manufacturing Execution System: Cutting the lot size in half effectively doubles the number of lot move transactions reported in the fab. It's possible that this will put a strain on the fab manufacturing execution system (MES), or that a larger database will be required for storage of historic data.

Dispatching/Complexity Issues: As we mentioned in the last newsletter issue, if you have batch tools with many distinct batch ids, and small lot sizes, you might have trouble forming large enough batches. In general, the problem of deciding which lots to process next is more complex if there are twice as many lots to choose from. If a fab runs very high volumes, it may make sense to use larger lot sizes simply because it's hard to manage the sheer high number of lots in the fab with small lot sizes.

Two-Sentence Summary

Reducing lot sizes can reduce fab cycle times by smoothing the flow of lots through the fab, and reducing the time that individual wafers spend waiting for the rest of their lot. However, there are a number of issues that should be carefully considered before the lot size is changed.

Summary of Cycle Time and Lot Size Interaction Factors

If you reduce lot size from 50 wafers per lot to 25 wafers per lot, the following interactions may influence overall fab cycle times:

Factor	CT Impact
Smoother flow to downstream tools	Better
Less waiting at per-wafer tools	Better
Yield potentially improved	Better
Hot lot cycle times improved	Better
Increased transport system loading	Worse
Increased loading at per-lot tools	Worse
Increased complexity for dispatch	Worse

Conclusions

Lot size is a hidden assumption in many areas of a fab - in the MES, the transport system, the dispatching policies, the capacity model, perhaps even the reporting system. Breaking this assumption can have unanticipated consequences. For example, the reporting system might take the number of lots started and multiply by 50 to get wafer starts per week. This doesn't mean that you shouldn't change the lot size, but that you need to think through the potential consequences of the change carefully.

We have no black-and-white recommendation to make concerning lot sizes and cycle time. Smaller lot sizes may reduce cycle time, and make a fab more flexible. However, reducing the lot size can cause problems with material handling, capacity, MES performance, and fab complexity, particularly during the transition period. We suggest then, that you consider lot size reduction to reduce cycle times, but that you consider it very carefully.

Additional References

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Community News/Announcements

Job Availability Notice - Ron Whitey - Agilent Technologies

RF/Microwave technology is the building block of wireless and fiber optic communication industries. Fueled by the growing need for the integration of voice and data with Internet, the demand for Agilent's products has exploded.

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MWTC has experienced phenomenal growth in business and opportunities over the last several years. We are looking for an Industrial Engineer with interest in pursuing a rewarding career in semiconductor processing technology. For more information contact Ron Whitney at ron_whitney@agilent.com

Job Change Notice - Navi Grewal - Agere Systems

Navdeep (Navi) Grewal has left Seagate Technologies in Minneapolis, MN to take a position as manufacturing operations engineer with Agere Systems, in Reading, PA. You can reach Navi at ngrewal@agere.com.

FabTime welcomes the opportunity to publish announcements for individuals or companies. Simply send them to Jennifer.Robinson@FabTime.com.

FabTime Recommendations

■ FabTime's Book of the Month for February is "Necessary But Not Sufficient", by Eli Goldratt, Eli Schragenheim, and Carol Ptak. You can find this review at www.fabtime.com/necessary.htm. This is the latest book in Goldratt's series of Theory of Constraints business novels, a series that commenced with the popular book "The Goal" (also reviewed on our website, at www.fabtime.com/goal.htm). Also, one of our previous book reviews, for the book Factory Physics, was published in last month's IE Solutions Magazine (the magazine of the Institute of Industrial Engineers). Your positive responses to that book review inspired us to submit the review for publication.

■ Firewall Software. If you have an always-on, high-speed internet connection (cable modem, DSL, ISDN) at your home or small office, and you don't have a firewall, you're taking an unnecessary risk. I have a computer that's usually on and connected to a high-speed connection with a fixed IP address. I have firewall software on my computer, which is a good thing, because the software records an average of three or four unauthorized attempts to access this computer per day. Basically, if your computer is always connected, hackers randomly scanning for mischief opportunities can get in to your computer. This is especially true if you have a fixed IP address. To prevent these intrusions, we recommend that you use firewall software. We use ZoneAlarm (www.zonealarm.com), and have been very happy with it. ZoneAlarm 2.1.44 is free for personal use, while the newer professional version costs $39.95 for a single computer.

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