EXTREMELY HOT LOTS: SUPER-EXPEDITING IN A 0.18 MICRON WAFER FAB

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ABSTRACT

AMD's Fab 25 has a high rate of technological change that sometimes requires "super-expediting" of extremely high priority lots. AMD developed a seven-step procedure for managing such lots: 1) ensure production management buy-in for lot priorities; 2) identify a "key expediter" responsible for getting the lot out quickly; 3) clearly state expectations for all involved in processing the lots; 4) define tactical communication methods; 5) establish a system for tracking and forecasting lot performance; 6) execute the tracking and forecasting system; and 7) report progress and get assistance from management as needed. AMD applied this procedure to the first lot of a critical new product. This lot went from being 14 days behind schedule to shipping early.

INTRODUCTION

AMD's Fab 25 has a high rate of technological innovation that sometimes requires "super-expediting" of extremely high priority lots. AMD developed a seven-step procedure for managing these lots, and applied this procedure to the first lots of a critical new product. These lots went from being 14 days behind schedule to shipping early.

Fab 25 Background

AMD is the second-largest supplier of Microsoft® Windows® compatible PC processors, and a leading supplier of non-volatile (flash) memory. AMD's Fab 25, located in Austin, Texas, is a high-volume manufacturing facility producing integrated circuits such as the Athlon processor. Fab 25 has a production capacity of more than 5000 eight-inch wafers per week. The fab was designed to support several generations of process technology. The production management team at Fab 25 is accustomed to handling rapid technology revolution and long, complex, re-entrant process flows.

Use of Priority Lots in Fab 25

The high rate of technological improvements in Fab 25 requires the use of priority lots to prove innovations. AMD runs various levels of hot lots, each targeted for completion within some multiple of theoretical cycle time. The goal is to get the priority lots through the fab quickly, so that they can be tested and revised and new products introduced to market as soon as possible. Different levels of priority lots at AMD include hot, rocket, and platinum lots, with platinum lots being the most critical of the three. Each lot has a priority code corresponding to one of these levels.

Fab 25 uses the WorkStream Open manufacturing execution system (MES) to track lots, and uses the AutoSimulations Real-Time Dispatch (RTD) system to generate staging priorities at each operation. The MES tells operators which lots are in queue for each operation, while RTD establishes the location in queue for each lot, based on the lot priorities. Normally, progress of the regular and priority lots is passively monitored by the Production Control organization, with occasional emphasis from management on specific lots or lot families.

Need for Super-Expedited Lots in Fab 25

From time to time, this standard prioritization method is not sufficient. Highly urgent lots can arise, which must be monitored more closely. This can

happen due to urgent technology qualification lots, complex process debugging, or when increased cycles of learning are critical to technology delivery. Sometimes AMD is in a race with its competitors to get a new product to market quickly, and must "super-expedite" a small set of very important lots. The next section describes AMD's methodology for super-expediting these critical lots.

METHODOLOGY FOR SUPER-EXPEDITING LOTS

Fab 25 follows a seven-step methodology for super-expediting lots. The seven steps are:

1. Ensure production management buy-in on the lot priority.
2. Identify the owner of the lot (key expediter). This person is fully accountable for the lot completion date.
3. Identify other human resources for the project. Clearly state expectations of all involved in processing the lots.
4. Define tactical communications for the project. Establish 24X7 network for problem solving.
5. Establish a tracking and forecasting system that ensures success.
6. Execute utter commitment to meeting the schedule.
7. Report progress and get assistance from management as needed.

The steps in this methodology are described further in the remainder of this section. A case study is given in the following section.

Ensure Production Management Buy-In

The first step before any lot or collection of lots is super-expedited is to ensure that production management understands and accepts the reasons for super-expediting the lots. Super-expedited lots are very disruptive to production, and are only used as a last resort. When the production management team understands the reasons why particular lots must be expedited, their increased motivation dramatically improves the likelihood of success.

Identify Key Expediter

Ultimately, one person must take responsibility for getting the expedited lots out the door. This person is identified early in the process, and is referred to as the "key expediter". The key expeditor is a combination of drill sergeant and cheer-leader, and must be both detail-oriented and enthusiastic. The key expediter is responsible for tracking the location of the lot each day, identifying problems, and monitoring progress to the ultimate goal delivery date.

Define Human Resource Requirements

The key expediter is next responsible for identifying the remaining members of the team who will collectively work to process the super-expedited lots. Members of the team, and their responsibilities, are defined below:

Key Expediter (Mike Hillis): Facilitate lot movement for target lots through the fab. Ensure that the details of processing delays, both potential and real, are communicated and minimized. This entails communicating directly with integration, module engineering, and module operations personnel. Communicate expected operation completion times and follow up where unexpected delays occur. Do whatever else needs to be done to keep these lots moving.

Production Control: Ensure hand carry of target lots between operations. This requires being aware of expected completion times and any delays or schedule pull-ins. No less than Platinum protocol is to be followed for these lots.

Shift Facilitators: Comprehend the impact of these lots on shiftly production activities. Understand and facilitate tool preparation in a timely manner between modules. Assist in communication between modules when delays or schedule pull-ins occur. Track lot performance to schedule on at least an hourly basis.

Module Shift Managers: Communicate directly with module engineers accountable for process development for the super-expedited lots' process flow. Insist on detailed passdowns from these personnel regarding expectations and requirements. Escalate to the module engineer when delays due to technical (process or equipment) issues arise. Ensure that process and metrology tools are prepared well in advance of the expected arrival of the target lots. Ensure that queue time of these lots is kept to an absolute minimum.

Module Engineers: Perform a daily review of the operations that the lots are likely to encounter within the next 24 to 48 hours. Identify any known problem operations that will not meet the anticipated plan. Identify key tool qualifications or conversions and estimate the elapsed time to execute these changes. Ensure that process parameters and output metrology are well documented. Be available to respond to problems.

Integration Engineers: Same responsibilities as module engineers. Also be available to respond to questions regarding the technology, parameters or other questions as they arise.

Module Managers: Communicate the high priority of the target lots to employees within the module. Ensure that appropriate machine time is made available to enable minimum cycle time through operations within the module. Provide technical and operational resources as required to meet the schedule expectations.

Define Tactical Communication Plan

Once the full team is identified, the next step is to define a plan for tactical communication throughout the duration of the project. Key components to the tactical communication plan include:

1. Policies for communicating with on-floor personnel
2. Escalation policies dealing with unresolved issues
3. A defined communication system and telephone/pager/email tree

The central point of the communication plan is that the person immediately responsible for the lot can be found at any time, and that this person knows whom to contact in the event of questions or problems.

Establish Tracking and Forecasting System

Next, the key expediter must establish a project-specific tracking and forecasting system. This involves establishing a minimum completion time schedule, with targets for the completion date and time for each operation. This schedule is used for setting plans as well as tracking on-going performance, and identifying problems. This is described in more detail under the case study to follow.

Execute Tracking and Forecasting System

Once the tracking and forecasting system is in place, the team begins to execute according to the plan. The key expediter is notified of any deviation from the plan, and responds by communicating with shop floor or engineering personnel, as appropriate.

Report Results and Request Assistance

The key expediter reports interim progress to management on a regular basis – usually every day – for these super-expedited lots. This frequent reporting enables the key expediter to request management support if necessary (e.g., the production team needs a critical tool to get through the next step, but engineering will not release the tool).

CASE STUDY – FIRST SILICON TIME TO MARKET

Fab 25 had a critical "first silicon" lot of a new type of product. Although this lot had been given the highest priority in WorkStream ("Platinum"), it still was not getting through the fab quickly enough to meet AMD's aggressive target delivery date. The lot was 14 days behind schedule, and the prospect for meeting the schedule was seriously jeopardized.

Ensure Production Management Buy-In

AMD considered this first silicon lot to be critical to the company's plans for the future, and placed an extremely high priority on getting the lot completed on time. This high priority was sufficient to ensure production management buy-in for super-expediting the lot.

Identify Key Expediter

The key expediter identified was Mike Hillis, cycle time and line yield improvement manager for Fab 25. Mr. Hillis was asked to improve cycle time performance and to do whatever had to be done to get the lot out on time.

Define Human Resource Requirements

The key expediter obtained dedicated resources on each shift to monitor and hand carry the lot through the production process. One pager was shared between these resources. At any given time, the person with that particular pager is expected know exactly where the lot was located and its status.

Define Tactical Communication Plan

The key expediter also established formal communication with the engineering group for overcoming technical roadblocks, through the scheduling of a daily meeting. The key expediter committed to wearing his pager full-time throughout the duration of the project. The shift managers for each module in the fab (photo, etch, diffusion, etc.), as well as the shift facilitators, were made aware of the importance of the super-expedited lot. The idea was

that anyone coming into contact with the lot would know immediately that the lot was absolutely critical, and not to be delayed in any way.

Establish Tracking and Forecasting System

The key expediter next established a tracking and forecasting system specific to the super-expedited lot. He built an Excel spreadsheet containing all remaining process steps for the lot, with planned cycle times for each operation (based on zero queue time). He next established a minimum schedule for completion time based on the planned cycle time for each operation. This schedule told him, at any point, where the lot was expected to be located. He validated the cycle time numbers with engineers and manufacturing personnel to comprehend special processing needs, and made adjustments to the plan accordingly. This document served as the "Report Card" of lot progress as well as a scheduling instrument to prepare downstream operations. He used it to track performance of each operation in terms of queue time vs. processing time (with again, the goal of zero queue time). A sample of a similar spreadsheet is shown in Figure 1 (the data has been modified for confidentiality).

			Actual	Plan	Act	Expedite
oper	Plan In	Actual In	Out	CT (hrs)	CT (hrs)	Progress
a	8/5/01 10:51	8/5/01 10:51	8/5/01 12:15	1.00	1:24	5.92
b	8/5/01 12:15	8/5/01 12:15	8/5/01 12:22	0.20	0:07	5.94
c	8/5/01 12:22	8/5/01 12:22	8/5/01 12:25	1.00	0:03	5.98
d	8/5/01 12:25	8/5/01 12:25	8/5/01 12:31	1.00	0:06	6.02
e	8/5/01 12:31	8/5/01 12:31	8/5/01 12:47	1.00	0:16	6.02
f	8/5/01 12:47	8/5/01 12:47	8/5/01 12:47	0.00	0:00	6.05
g	8/5/01 12:47	8/5/01 12:47	8/6/01 1:09	5.00	12:22	5.63
h	8/6/01 1:09	8/6/01 1:09	8/6/01 1:58	0.50	0:49	5.61
I	8/6/01 1:58	8/6/01 1:58	8/6/01 2:53	0.50	0:55	5.62
a	8/6/01 2:53	8/6/01 2:53	8/6/01 2:53	0.00	0:00	5.65
b	8/6/01 2:53	8/6/01 2:53	8/6/01 5:11	2.00	2:18	5.73
c	8/6/01 5:11	8/6/01 5:11	8/6/01 5:45	1.00	0:34	5.74
d	8/6/01 5:45	8/6/01 5:45	8/6/01 6:23	2.00	0:38	5.75
e	8/6/01 6:23	8/6/01 6:23	8/6/01 7:13	1.00	0:50	5.75
f	8/6/01 7:13	8/6/01 7:13	8/6/01 7:34	0.50	0:21	5.75
g	8/6/01 7:34	8/6/01 7:34	8/6/01 7:34	1.00	0:00	5.79
h	8/6/01 7:34	8/6/01 7:34	8/6/01 7:34	1.00	0:00	5.83
I	8/6/01 7:34	8/6/01 7:34	8/6/01 11:57	5.00	4:23	6.25
j	8/6/01 11:57	8/6/01 11:57	8/6/01 11:57	0.00	0:00	6.28
k	8/6/01 11:57	8/6/01 11:57	8/6/01 13:06	1.00	1:09	6.72

Figure 1. Sample tracking and forecasting spreadsheet. The actual spreadsheet also included a "comments" column, in which the reason for any queue delays could be recorded.

Execute Tracking and Forecasting System

Once the above-described structure was in place, expediting of the lot began. To ensure compliance to the targeted zero queue time, the key expediter applied the FabTime® alert function. FabTime is a cycle time management system that had been recently installed in Fab 25. FabTime extracts lot move data from the MES in near-real time, stores it in a SQL Server database, and makes management reports available in a web browser. FabTime knew the expedited lot's location at all times, and notified the key expediter of any queue delay greater than 0.5 hours via both alphanumeric pager and email. This enabled the key expediter to instantly know when the lot was falling behind and initiate escalation as required. He was able to do this even when he was not on site, by having FabTime alert his long-range pager. He could then contact the person currently responsible for hand-carrying the lot (through the shared pager).

The key expediter also used FabTime's management reports to investigate high queue delays retrospectively, so that he could understand each event of delay. FabTime maintains a detailed lot history for each lot, broken down into queue time and process time. An example of the lot history chart is shown in Figure 2 (full history) and Figure 3 (close-up view of a few operations). This example (Figure 3) shows that although Operation 6550 has the highest cycle time of the recent operations, Operation 5600 included more queue time for the lot. For the actual super-expedited lot, the goal at AMD was to have the lot history chart show no queue time at all (no red columns). Any queue time that did occur would stand out immediately.

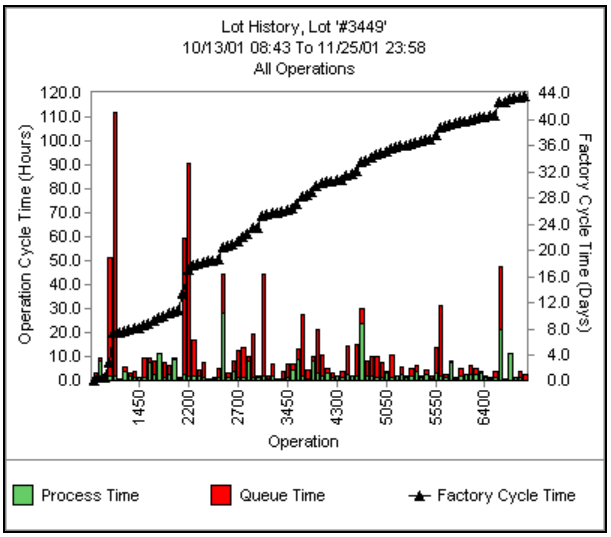

Figure 2. Sample lot history chart (not actual data) showing all operations. The black line shows cumulative cycle time against the right-hand axis. The chart has a column for each operation (not all are labeled on the x-axis), broken into red and green to show queue time vs. process time.

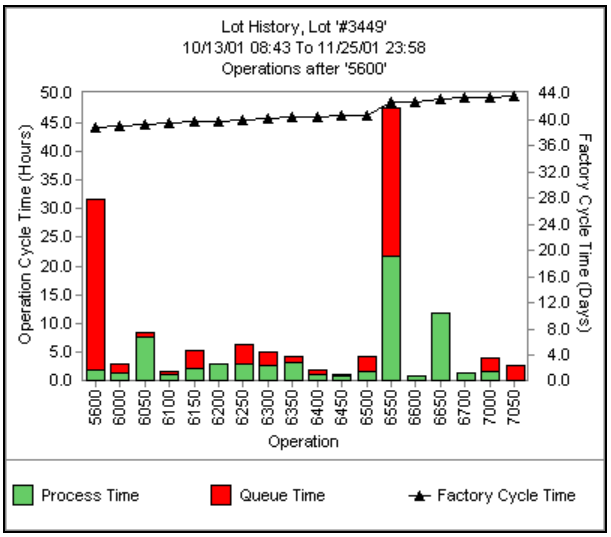

Figure 3. The same sample lot history chart, scaled to only show the most recent operations.

By keeping the lot history for the super-expedited lot constantly up and refreshed on his home page, the key expediter was able to review current performance as well as past performance for times that he was away from the fab. He could also export the lot history data into Excel, and compare it against his original schedule, to monitor progress to the overall goal. He used learning from this process to ensure that repeats of the same problem did not occur. For example, if there was a case where a tool was not ready for the super-expedited lot when that lot arrived, the key expediter would work with the module manager associated with the tool to ensure that the problem did not arise again.

Report Results and Request Assistance

Using the above method, AMD was able to overcome the entire 14-day lag of the lot, and meet the original ship date. The lot was actually shipped early. The progress of overcoming this lag is displayed in Figure 4 (axis labels have been removed for confidentiality). Note that the curve is not completely smooth – setbacks were sometimes encountered. However, the chart shows steady overall progress, and a final ship date that was earlier than the goal.

Because this effort was so successful, AMD has since applied this specific methodology and tracking system to other super-expedited lots. Other personnel at Fab 25 have been and are being trained in using FabTime, as well as other key tools. AMD has also built on this methodology by internally publishing the FabTime charts of lot performance over the previous 24 hours, so that even greater visibility can be obtained for super-expedited lots. To this day, charts such as Figure 3 are in regular daily use for tracking progress of qualification lots.

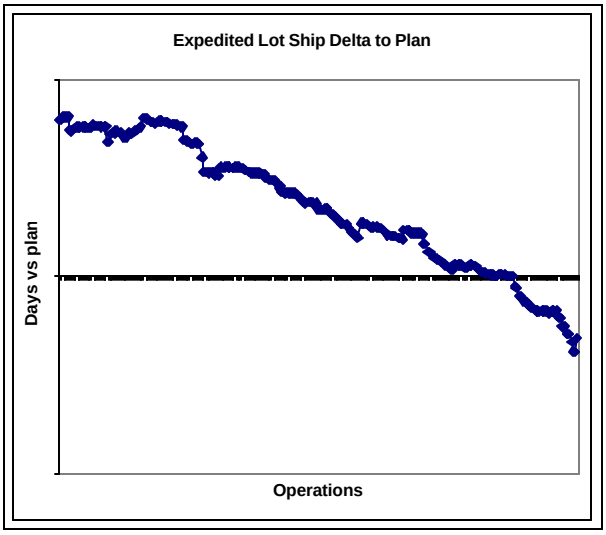

Figure 4. As the super-hot lot was expedited, the delta between the expected and planned ship date decreased, actually becoming negative (indicating that the lot would be shipped early). The horizontal line indicates the point at which the expected ship date met the planned ship date.

CONCLUSIONS

Sometimes, for a company like AMD that lives on the edge of the technology curve, applying standard lot priorities is not enough. Some lots need to be super-expedited – hand-carried and constantly monitored, so that they can get through production in the shortest possible time. AMD's Fab 25 developed a procedure for super-expediting that involved ensuring production management buy-in; identifying a key expediter and a multi-disciplinary team; defining a 24X7 network for communication and problem-solving; establishing a tracking and forecasting system; and executing to that system to ensure success. In the example described here, AMD used this method to take a critical new product lot that was 14 days behind schedule and (over a 17-day time period) get the lot out not only on time, but early. AMD expects to use the lessons learned from this project to help improve cycle times of other lots in the future.

The key expediter for this project would like to conclude with some important points to remember when super-expediting lots. First of all, production management buy-in is essential. Super-expedited lots are very disruptive to production, and will generate

resentment unless their purpose is clearly understood. Second, getting access to up-to-date information about fab performance is critical to success. Finally, communication is the ultimate key to success. In this case study, virtually all of people throughout the fab knew the lot ID of the super-expedited lot, and the reasons why it was important. It took work on the part of all of those people to reach the highly aggressive target of overcoming 14-days of cycle time.

FURTHER READING

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