FabTime Cycle Time Management Newsletter

Volume 3, No. 8 September 2002

Information

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

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Editor: Jennifer Robinson

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Welcome

Welcome to Volume 3, Number 8 of the FabTime Cycle Time Management Newsletter. During this past month the newsletter received its thousandth subscriber, something that I had set as a personal milestone. I'd like to extend a warm welcome to those of you who are new, and my thanks to those of you have been with us along the way. If you like the material in these newsletters, you may be interested in participating in the multi-company session of FabTime's 2-day Cycle Time Management Course, to be held November 6th - 7th at NEC Electronics Inc. in Santa Clara, CA. There are only 12 spots open, so let us know soon if you would like to attend. The cost is $875/person until October 18th, increasing to $950/person after that.

In this month's subscriber discussion forum we have continuing discussion on recipe management, batch size decision rules, and operator cross-training. For our new FabTime article this month, we describe a simple rule of thumb for making batching decisions in practice. We have discussed previously the idea that unless a batch tool (such as a furnace) is highly loaded, forcing the tool to run full batches tends to increase cycle time. While we were discussing this during our cycle time management course at Medtronic last month, the course participants raised the very practical point that if you know when another lot is due to arrive, sometimes it still makes sense to wait for that next lot. They asked us for a rule of thumb, or a spreadsheet tool, for deciding when to wait and when to go ahead and start the batch. This month's article is our first attempt at addressing this issue. We welcome your feedback.

Thanks for reading! -- Jennifer

FabTime

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Community News/Announcements

FabTime Receives Purchase Order from INNOTECH for Cycle Time Management Software

Menlo Park, CA. September 11th, 2002 - FabTime Inc. today received a purchase order from INNOTECH Corporation for the installation of FabTime's cycle time management software at an INNOTECH customer site in Japan. More details about the end customer will follow soon.

Founded in 1987, INNOTECH (http://www.innotech.co.jp/english/index.html) is a premier importer of high-end semiconductor devices and equipment and a skilled support partner to many of Japan's top electronics makers. The Company maintains direct relationships with every major semiconductor manufacturer in Japan. As an importer, the company leverages deep relationships with some of North America, Europe, and Asia's most advanced electronics and semiconductor device and equipment producers.

Bay Area Cycle Time Management Course Scheduled

A multi-company session of FabTime's 2-day Cycle Time Management Course will be held November 6-7 7at NEC Electronics Inc. in Santa Clara, CA. There are only 12 spots open, so let Jennifer or Frank know as soon as possible if you would like to attend. The cost is $875/person until October 18th, increasing to $950/person after that.

First 3 Issues of the Newsletter Available in PDF for the First Time

Past newsletter issues 1.01 to 1.03 are now available in PDF format (previously these were only available as text files). To request these past issues, send email to Jennifer.Robinson@FabTime.com with your request. These issues were devoted to the Hawthorne Effect, the P-K Formula, and Little's Law.

FabTime Cycle Time Management Newsletter Reaches 1000 Semiconductor Industry Subscribers, Inspires 2-Day Course

Menlo Park, CA. September 10th, 2002 - FabTime Inc. today announced that its cycle time management newsletter had received its thousandth subscriber. The newsletter is a monthly email publication devoted to wafer fab cycle time improvement. It contains articles about how various factors (hot lots, batch loading policy, lot size, etc.) affect fab cycle time and how to mitigate these effects. Each issue also includes a subscriber discussion forum, in which readers raise and address topics related to fab cycle time and performance improvement.

"The subscriber discussion forum has been particularly well-received," said Jennifer Robinson, Editor of the newsletter. "I think that people in the industry value having a place to share ideas and issues related to fab performance. Recent discussion topics have included starts methodologies, ramp planning, tool dedication, operator staffing levels and cross-qualification policies, and recipe management."

"The first resource I plug my Operations Managers into is the FabTime Newsletter," said Dan Siems, World-Wide Cycle Time Program Manager for Philips Semiconductor BU Foundries. "Getting a steady infusion of common sense rooted in good theory encourages them to keep their Cycle Time reduction efforts in the foreground of their organizations. FabTime's Subscriber Discussion Forum gives them real-life examples and strategies for being best in class. Our industry's cyclical nature requires new thinking -- a constant challenging of assumptions -- to remain competitive; my OM's are given exposure to that new thinking by reading FabTime."

Based on subscriber feedback regarding the value of this information to operations management personnel, FabTime has created a two-day course on cycle time management. More information on this course is available at www.fabtime.com/ctmcourse.htm.

More than 300 companies and universities are represented in the newsletter subscriber list. The companies with the most subscribers are Motorola, Intel, Advanced Micro Devices, Infineon Technologies, STMicroelectronics, Philips, Chartered Semiconductor, TECH Semiconductor, Seagate Technology, SEMATECH, Medtronic, and National Semiconductor. A newsletter subscription form is available at FabTimevs website.

FabTime welcomes the opportunity to publish community news and announcements. Simply send them to Jennifer.-Robinson@FabTime.com.

Subscriber Discussion Forum

Recipe Management

Venkat Thupakula, industrial engineering manager of Philips Semiconductors in San Antonio, sent the following in response to our ongoing subscriber discussion about recipe management. "I am sending you this PowerPoint presentation as an addendum to the "Recipe Management system" defined by Mr. Ames. We are in the progress of implementing this system in the San Antonio fab. The CAM Engineer who designed this system is Mr. Aldo Hernandez. This system will need considerable IT work, but once complete, it will almost be a bullet proof system to prevent misprocesses due to recipe errors." To request a copy of the presentation, or to contact the authors, please email Jennifer.Robinson@FabTime.com.

Campbell Boyd, from the Information Systems Department of National Semiconductor in the UK also sent in comments regarding recipe management: "Your subscriber describes a real problem which can affect cycle time, yield and engineering productivity. In addition to the problems described, it is easy to have different versions of essentially the same recipe in use on different tools at the same time thus lots could end up being parametrically different which might cause yield loss. Whilst a universal recipe management system (ie. for all tool types in a fab area) would be great, it is difficult to achieve in practice since the editing software for the recipes is always tool-type specific. For example, an engineer does not use the same software to edit a furnace recipe as they would to edit an implant recipe.

I worked on a project to improve this on our furnaces a couple of years ago. Because of the editing software issue the solution does not attempt to record what was changed inside the recipes. What it does do, is lock recipes (by using operating system file protection to make them read-only by any user) and copy them to whatever furnace stack the engineer specifies that uses a given recipe. If the engineer wants to edit a recipe, he/she unlocks the recipe, edits it, then relocks it. Recipes can also be added to the controlled list or deleted, both from the list and from those tools that used it. I wrote a graphical front end (in Tcl/Tk) so that the engineers had an easy to use, point & click interface and scripts to do all the boring stuff of copying files or changing their file protection. A log file is kept of who did what when to the controlled list of recipes.

A colleague created a similar system for implant recipes using similar concepts (ie. use a central store for all recipes, use operating system file protection so that unauthorised changes cannot be made and use scripts to control what can occur, who can do what etc.) So my answer to your subscriber's question is "we all used to have to live with this issue but if you talk nicely to your in-house IT people they might be able to produce a solution to some of the issues". In the implant case, the solution was implemented in about a week from original problem description. A major scrap had occurred because of the lack or recipe management."

Batch Size Decision Rules

Wendy Schlehuser (Hewlett Packard) sent the following comments: "Marianna Marshall and I are industrial engineers at Hewlett Packard in Corvallis, Oregon. We just completed a simulation analysis of a batch furnace process in our wafer fab. We're pleased to report our results were consistent with Newsletter Vol. 2 No. 1 "Impact of Batch Size Decision Rules on Cycle Time." Our approach tested both fixed batch sizes as well as variable. For the variable, we set the minimum and maximum batch sizes for the tool group and tested increasing lengths of time to wait for the maximum batch size. This analysis reflected the lowest cycle time when following a greedy policy. A 1-month trial has been started with the guideline of running lots as soon as they arrive or that will arrive off the previous tool within 1 hour. While the trial guideline is slightly different than greedy, it is quite an improvement from prior practice. We will be measuring average batch size, cycle time, and equipment utilization to compare to baseline data and our simulation results. Your FabTime discussion was very helpful for driving our recommendations into trial and hopefully implementation."

Operator Certification/Cross Training

FabTime recently conducted a two-day cycle time management training course at Medtronic. During a section on how operators affect cycle time, Sally Luster, Production Support Supervisor for Semiconductor Operations, asked us if we knew how many different operator certifications per operator was typical at other fabs. We did not know the answer to this question, but thought that it would be an excellent newsletter question. We have had some discussion of this issue in general, but thought that the number of certifications per operator would represent a nice tangible metric to look at this. If you know the answer to this for your fab, and are interested in this topic, please email me at Jennifer.Robinson@FabTime.com, and tell me three things:

1. At what level do you measure certifications (recipe, tool type, or module/area)?

2. In terms of the above, about how many certifications do you have, on average, per operator?

3. Approximately how many operators do you have (total, across all shifts)? This is so that we can see if the answers vary for larger vs. smaller fabs.

We will keep all individual responses confidential, and merely compile them. Summary results will go in the next newsletter, with more detailed results provided to people who send us data (this seems only fair - there should be some reward for taking the time to provide specific data like this). If this exercise yields useful results, we may use the same method for looking at other questions - leveraging our subscriber base to do some benchmarking.

A Simple Rule of Thumb for Batching Decisions

Introduction

When a batch tool (e.g. diffusion furnace) is available and there are one or more lots ready to be processed, the operator must decide whether to start the batch immediately, or wait for more lots. When a full batch of some recipe is available, the decision to start that batch is fairly easy. However, when less than a full batch of lots is available, the decision becomes more complex. On average, it is usually better for cycle time to start the batch immediately than to wait to form a full batch. This has been shown to be true for most batch tools, unless they are very heavily loaded, or have a very large mix of recipes. More detail on this can be found in Volume 2, Issue 1 of this newsletter (send email to Jennifer Robinson for a copy).

However, despite this general rule, there are sometimes specific cases where it makes more sense to wait for the next lot before starting the batch. For example, suppose that one lot is available for processing, and another lot of the same recipe is due to arrive in five minutes, while the process time for the batch is 24 hours. Clearly, it makes sense to wait for that second lot before starting the batch. However, the situation is usually less clear. Suppose that you have a furnace that can hold six lots, and four lots of the same recipe are ready to be processed, with a process time of eight hours. Now suppose that another lot of the same recipe is due to arrive in an hour. Should you wait for the fifth lot? Perhaps not. What if the process time is 24 hours? Does that make a difference? In this article, we propose a simple rule for deciding when to wait for the next lot, and when to just start the batch.

The Simplest Possible Case

Let's start with the simplest possible case:

- Single furnace
- Batch time = *ProcessTime*
- Lots ready to go = *NumberReady*
- Waiting for *NumberIncoming* lots that are due to arrive in *WaitingTime* hours (batch arrivals)

If we wait for the lots that are coming, then it will save those lots (*ProcessTime* - *WaitingTime*)**NumberIncoming* hours of cycle time.

However, waiting for the incoming lots will add *WaitingTime* * *NumberReady* hours of cycle time for those that are ready to go.

If we are comparing on the basis of average cycle time = (*Lot1CycleTime* + *Lot2CycleTime* + ...) / (*NumberReady* + *NumberIncoming*), then it's equivalent to compare on the basis of total cycle time = (*Lot1CycleTime* + *Lot2CycleTime*), because (*NumberReady* + *NumberIncoming*) is the same whether we start the batch now or whether we start the batch after *WaitingTime*.

Since we are adding the numbers together, we just need to know if the amount saved by waiting is more than the amount delayed by waiting, e.g.

If

TimeSaved = (*ProcessTime* - *WaitingTime*) * *NumberIncoming*

is greater than

TimeDelayed = *WaitingTime* * *NumberReady*

then it makes sense to wait for the incoming lot(s).

In the case where *NumberIncoming* = 1, this simplifies to:

If

(*ProcessTime* - *WaitingTime*) / *NumberReady* > *WaitingTime*, then it makes sense to wait for the incoming lot.

Example 1

- *ProcessTime* = 8 hours to process a batch (regardless of batch size)
- *NumberReady* = 4 lots ready to process right now
- *NumberIncoming* = 1 lot arriving soon
- *WaitingTime* = 2 hours until the incoming lot is due to arrive

If we wait for the one incoming lot, then

TimeSaved = (*ProcessTime* - *WaitingTime*) * *NumberIncoming*

= (8 hours - 2 hours)*1 lot = 6 hours, and

TimeDelayed = *WaitingTime* * *NumberReady*

= (2 hours) * 4 lots = 8 hours.

In this case, *TimeSaved* = 6 hours < *TimeDelayed* = 8 hours, and so it does not make sense to wait for the additional lot.

Note that because *NumberIncoming* = 1 in this case, we can use the slightly simpler calculation comparing (*ProcessTime* - *WaitingTime*) / *NumberReady* to *WaitingTime*. So we have:

(8 - 2) / 4 = 6/4 = 1.5 < 2

Again we see that it does not make sense to wait for the incoming lot.

Example 2

- *ProcessTime* = 8 hours to process a batch (regardless of batch size)
- *NumberReady* = 4 lots ready to process right now
- *NumberIncoming* = 2 lots arriving soon (at the same time)
- *WaitingTime* = 2 hours until the 2 incoming lots are due to arrive

If we wait for the two incoming lots, then

TimeSaved = (*ProcessTime* - *WaitingTime*) * *NumberIncoming*

= (8 hours - 2 hours)*2 lots = 12 hours, and

TimeDelayed = *WaitingTime* * *NumberReady*

= (2 hours) * 4 lots = 8 hours.

In this case, *TimeSaved* = 12 hours > *TimeDelayed* = 8 hours, and so it does make sense to wait for the additional lot.

Alternative Formulations and Intuition

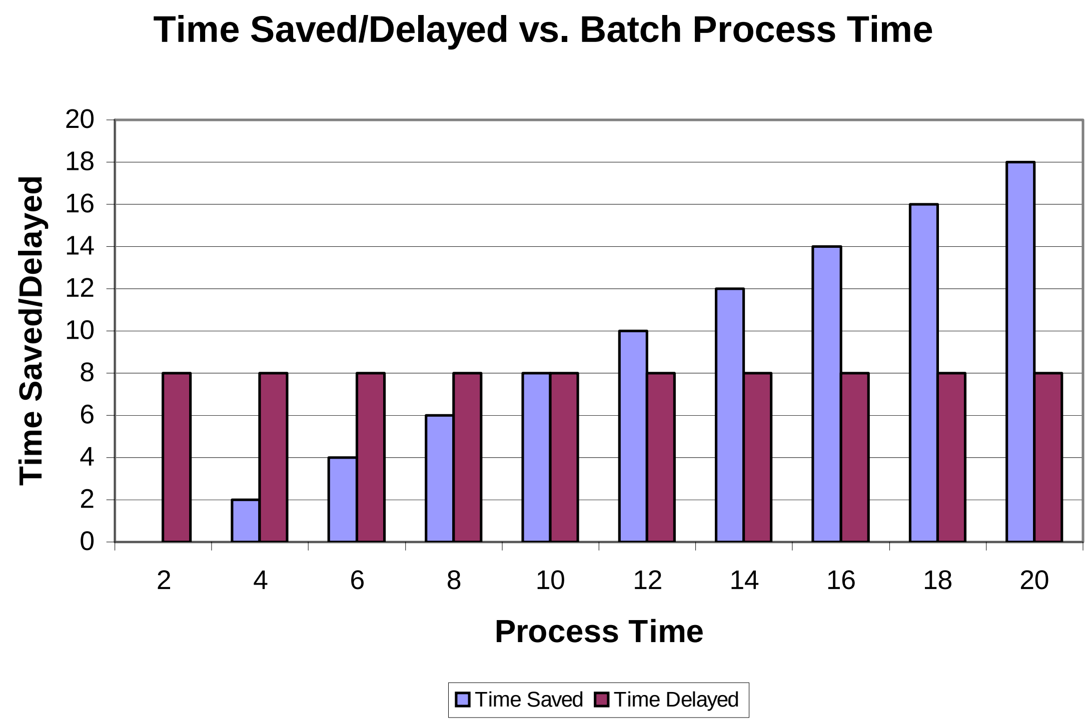
An alternative version of the above formula for single lot arrivals is:

If (*ProcessTime* - *WaitingTime*) / *WaitingTime* > *NumberReady*, then it makes sense to wait for a single incoming lot.

Or, for more than one lot, the formula is:

If (*ProcessTime* - *WaitingTime*) / *WaitingTime* > *NumberReady* / *NumberIncoming*, then it makes sense to wait for the incoming lots.

Looking at this formula, we can see that when *ProcessTime* is very large, it is more likely to make sense to wait. Similarly, when *NumberIncoming* is large, it is more likely to make sense to wait (since this is in the denominator on the right-hand side of the equation). This matches with our intuition. We are more likely to consider it worth waiting for more lots when the process time is very large. This is illustrated in the figure at the top of the next page, which shows *TimeSaved* and *TimeDelayed* for different values of *ProcessTime* (where *NumberIncoming* = 1, *NumberReady* = 4, and *WaitingTime* = 2).



When *ProcessTime* is below 10, *TimeSaved* is less than *TimeDelayed*, and it is better to start the batch. When *ProcessTime* is greater than 10, *TimeSaved* is greater than *TimeDelayed*, and it makes sense to wait for the incoming lot. If there were more incoming lots, then *TimeSaved* would increase more quickly.

Extensions - Max Batch Size

Suppose the *NumberIncoming* is greater than the number of spots available in the furnace. In this case, some of the arriving lots will have to wait, even if the batch is not started until they arrive. For simplicity, assume that the largest *NumberIncoming* that we will consider is the amount that will fill the batch. For example, if there are four empty spots in the batch, the maximum *NumberIncoming* that we will consider in the batching decision is four. Beyond that, the lots will not be processed in the next batch on this furnace, regardless. In this case, the formula for *TimeSaved* needs to be modified from:

TimeSaved = (*ProcessTime* - *WaitingTime*) * *NumberIncoming*

to

TimeSaved = (*ProcessTime* - *WaitingTime*) * (Min(*NumberIncoming*, *MaxBatchSize* - *NumberReady*))

where *MaxBatchSize* - *NumberReady* is the number of available spots in the furnace. If *NumberIncoming* is greater than the number of available spots, then the formula will simply use the number of available spots for the calculation.

Other Considerations

Naturally, there are several things that might make this batching decision more complex in practice (we are talking about a wafer fab, after all). A few are discussed below.

Multiple recipes/multiple furnaces - If there is another furnace which will be available before the arriving lots get there, then it may be best to start the furnace with the existing lots, and let any new lots use the other furnace. Similarly, if there are arriving lots of a different recipe type, this may affect which recipe should be processed first. In practice, however, dedication of recipes to particular furnaces, may simplify these issues.

Downstream serial machines - If the operation immediately following the batch operation is a serial step (a per-wafer or a per-lot tool), it may be better to start processing immediately than to wait for any additional lots. This is because the lots in the batch will end up waiting for each other at the serial step. The larger the batch, the longer some of the lots will have to wait.

Arrival process variability - If the prediction of when lots will arrive to the batch tool is not very accurate, then waiting for future arrivals makes less sense.

Separate future arrivals - Instead of having *NumberIncoming* lots arriving at the same future time, it may be that you have one lot arriving in 30 minutes, and another lot arriving fifteen minutes later. The calculations can be modified to account for this (*TimeSaved* can be calculated separately for each lot, then added together for the two lots). However, in practice the calculations might become too complex to be worth doing on a real-time basis, especially when the issue of arrival process variability is considered. The most realistic, implementable case will probably be the simple decision of starting the batch now, or waiting for one more lot to arrive.

Hot lots - All of the above considerations will sometimes be trumped by the arrival of a hot lot, especially in the case of hand-carry lots, for which tools are held idle. The above decision rule holds within priority classes, however. That is, if there are two hot lots waiting, and a third that will arrive shortly, you can use the formula to decide whether or not to wait for the third hot lot. Usually, however, you will end up just going ahead and processing hot lots as soon as possible.

Conclusions

One approach to take in deciding whether to start a batch now or wait for future arrivals is to calculate the *TimeSaved* for the future arrivals by waiting vs. the *TimeDelayed* for the lots that are already there. If the *TimeSaved* is greater than the *TimeDelayed*, then it is worth waiting. Otherwise, you should start the batch immediately, and process the future arrivals in a later batch. While the formulas described above apply to a very simple case, we believe that making the formulas much more complex would not be practical, since the rule is intended to be applied to real-time, operational decisions. We wanted something that people could do in their heads, or using a simple calculator, and we think that this formula fits the bill. Please let us know what you think.

Closing Questions for FabTime Subscribers

Do you have a rule like this at your fab? Do you think that a rule like this could be implemented, or would it conflict with the dispatching system that you already have? Is this rule too much of an over-simplification? How does your dispatch system handle the batch loading decision?

And a question for our university subscribers. Surely there is ongoing research and publication in this area. What are the best papers containing useful rule-of-thumb practices that can be implemented in real fabs? While we have seen simulation studies and scheduling algorithms that look at minimizing flow time through batch operations (see some examples below), we have not seen any papers that describe rule-of-thumb practices implemented in actual fabs.

Further Reading

■ E. Akçali and R. Uzsoy (Purdue University) and D. G. Hiscock, A. L. Moser, and T. J. Teyner (Intersil), "Alternative Loading and Dispatching Policies for Furnace Operations in Semiconductor Manufacturing: A Comparison by Simulation," Proceedings of the 2000 Winter Simulation Conference, 2000.

■ J. W. Fowler, G. L. Hogg, and D. T. Phillips, "Control Of Multiproduct Bulk Server Diffusion/Oxidation Processes. Part 2: Multiple Servers," IIE Transactions, Vol. 32, No. 2, 167-176, 2000.

■ J. K. Robinson, J. W. Fowler, and J. F. Bard, "The Use of Upstream and Downstream Information in Scheduling Semiconductor Batch Operations," International Journal of Production Research, Vol. 33, No. 7, 1849-1870, 1995.

■ L. Solomon, J. W. Fowler, M. Pfund, and P. H. Jensen, "The Inclusion of Future Arrivals and Downstream Setups into Water Fabrication Batch Processing Decisions," Journal of Electronics Manufacturing, Vol. 11, No. 2, 149-159, 2002.

FabTime Recommendations

Introduction

Although this site is about managing your actual time, rather than cycle time, we thought that you might find it interesting. The description on the website reads: "Results in No Time provides time management consulting and seminars ... offering both conventional time management--techniques to determine what to do--as well as the new discipline of inner time management--methods to optimize the way we work. Dr. Stephen Randall is President and founder of Results in No Time. Dr. Randall is committed to helping people toward mastery and peak performance in all aspects of life." You can find the Results in No Time Management website at www.manage-time.com/indxframe.html.

ShouldExist.org

This is a web site designed "to assist the free exchange and discussion of good ideas." It includes ideas posted by individuals, grouped under various subjects. We found the Hardware and Electronics section particularly interesting (wireless portable hard drives, laptop generators, etc.). Perhaps you'll find an idea actually worth pursuing, but at the very least, it's fun to browse. See www.shouldexist.org/.

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ABB (5)
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ADC (1)
Adexa Corporation (1)
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Advanced Sound Products (1)
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Shanghai Grace Semiconductor Mfg. (2)
SiGen Corporation (1)
Silicon Integrated Systems Corp (1)
Silicon Manufacturing Partners (4)
Silicon Sensing Products UK (3)
Silterra Malaysia Sdn. Bhd. (6)
SIM-BCD (1)
Sipex Corporation (1)
Skyworks Solutions, Inc. (2)
SMIC (2)
Solectron (1)
Sony Semiconductor (11)
SoundView Technology (2)
Southern Wire Industries (1)
SSMC (6)
STMicroelectronics (36)
Stonelake Ltd. (1)
Storage Technology de Puerto Rico (1)
Sun Microsystems (2)
SUNY-Binghamton (1)
Superconductor Technologies, Inc. (1)
Süss MicroTec AG (1)
Synquest (2)
Systems Implementation Services (2)
Takvorian Consulting (1)
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TDK (1)
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Technische Universitat Ilmenau (1)
Terosil, a.s. (1)
Texas A&M University (1)
Texas Instruments (21)
Tokyo Electron Deutschland (1)
Toppoly Optoelectronics (1)
Tower Semiconductor Ltd. (1)
Toyota CRDL (1)
Triniti Corporation (1)
TriQuint Semiconductor (8)
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UMC (7)
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University of California - Berkeley (6)
University of Cincinnati (1)
University of Federal de Santa Catarina (1)
University of Karlsruhe (1)
University of Southern California (2)
University of Texas at Austin (1)
University of Virginia (2)
University of Wuerzburg - Germany (1)
Univ. Muhammadiyah Surakarta (1)

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Virginia Tech (9)
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Vitesse Semiconductor (1)
Voltas Limited (1)
Wacker Siltronic (3)
WaferTech (13)
Win Semiconductor (1)
Wright Williams & Kelly (4)
Xerox Brazil (1)
X-FAB Texas, Inc. (3)
Yonsei University (1)
Zetek PLC (1)
ZMC International Pte Ltd (2)
Unlisted Companies (11)

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