Proceedings of the 2009 Winter Simulation Conference
M. D. Rossetti, R. R. Hill, B. Johansson, A. Dunkin, and R. G. Ingalls, eds.

SIMULATION OF A FULL 300MM SEMICONDUCTOR MANUFACTURING PLANT WITH MATERIAL HANDLING CONSTRAINTS

Jean-Etienne Kiba
Gilles Lamiable

850 rue Jean Monnet
Department of Industrial Engineering
STMicroelectronics
F-38926 Crolles, FRANCE

Stéphane Dauzère-Pérès
Claude Yugma

880 route de Mimet
Department of Manufacturing Sciences and Logistics
Ecole des Mines de Saint-Etienne, CMP Georges Charpak
F-13541 Gardanne, FRANCE

ABSTRACT

Generally, simulation models encountered in the literature in the context of semiconductor manufacturing are obtained with many assumptions (aggregations) and from partial model simulation of the facility (also called fab). The results obtained can be satisfactory for certain types of studies but, when precise results and understanding of the detailed behavior of local or global parts of the fab are needed, these simplifications may no longer be adequate. A more detailed model and a full-scale simulation are then needed. This article presents a detailed simulation model of the production system and Automated Material Handling System for a 300 mm semiconductor plant. Some of the studies performed with this model are discussed.

1 INTRODUCTION

Today, the Automated Material Handling System, AMHS for short, is the backbone of semiconductor manufacturing, mostly since the wafer diameter moved from 200mm to 300mm Brain and Lin (2007). The reality is that the market requires both higher performance devices using the latest process technology and shorter delivery time using the latest production technology Wakabayashi et al. (2004). Most of the time, simulation of a real model, especially semiconductor manufacturing plant, is considered time consuming to construct due to a complex system configuration and requires long execution times to statistically produce valid estimate results Nazzal and McGinnis (2007). The complexity of semiconductor manufacturing – due to re-entrant flows (the number of steps is larger than the number of machines), stochasticity introduced by the inherent variability of processing times, unplanned tool outages, etc... – discourages full-fab simulations. However, a partial model simulation does not only provide a local vision of the fab but also an inaccurate vision of the dynamic interactions between entities due to the lack of details. A model is a representation of an actual system and should contain enough details to answer the questions you are interested in, without considering more details than necessary. Historically, the slowness of computers led to the implementation of only some of the details. Today this *limitation* is no longer true. Often, partial model assumptions lead to an inaccurate measure of fab performances. Zimmerhackl et al. (2007) write that the fab performance cannot be measured through a single indicator. Thus, there is a need for several accurate indicators. Simulation is well-suited for a system which is so complex that simple formulas cannot predict events within the system. We will consider that *a full model building is a model that has the necessary details to virtually emulate the actual fab, both from the production or the AMHS points of view*. The aim of this paper is twofold:

- To underline the limitations due to partial fab simulation in the context of the growth of an actual fab,
- To propose a fast approach for a full fab model building.

The remainder of this paper is organized as follows. The originality or our contribution is discussed in Section 2. Section 3 is dedicated to the generic behavior of the fab. The particular case of AMHS will be studied. Details will be presented since they are important to understand the challenges of fab performance improvement. Section 4 is focused on model building. Data externalization is required to gain speed in model building. An example of relevant results will be provided in Section 5. Some conclusions and perspectives end this paper.

978-1-4244-5771-7/09/$26.00 ©2009 IEEE

2 RELATED PAPERS

In the literature, fab simulations are either *focused on production with assumptions on transport features* or *focused on transport with assumptions on production features*. Looking at production simulation with assumptions on transport, Lange et al. (2008), for example, propose an approach for the automated generation and parameterization of detailed cluster tool models based on bottleneck analysis. The impact of transport on the management of cluster tools is not analyzed. Schmidt and Rose (2008) show the benefit of small lot size and mini-batch or single wafer. Transport time is assumed to be the same for all lots. Nazzal and McGinnis (2007) propose an Extended Markov Chain model to estimate the response time for closed loop AMHS with multiple vehicles. In this approach, transport times are also considered constant. The problem is that the geographic positions of tools induce transport variabilities which are not captured by these assumptions.

Concerning transport simulation with assumptions on production, Zimmerhackl et al. (2007) analyze the effect of small lots on tool operations. The influence of tools are not taken into account. Gan, Chan, and Turner (2006) try to combine transport and production by using two commercial software: AutoMod (to model the AMHS) and AutoSched AP (to model the manufacturing Process). They conclude that the disparity in the time granularity of the models and the frequent model interactions are obstacles to good execution performance.

In this paper, we propose to transport and production within the same software. Our approach differs from Kong (2007) as we use one software (AutoMod) without precomputed data for both the production system and the AMHS. Kondo (2007) proposes three steps to perform advanced simulation. Our approach completes all of his recommendations. In Jimenez et al. (2008), the authors describe a method for classifying wafer fab models by their level of details. Six levels of details for building production capacity and six levels of details for building the AMHS. Referring to this classification, our model is in the fourth quadrant (high accurate wafer fab analysis). The authors show the lack of tools that allow for the combination of detailed production capacity models with detailed AMHS models. The originality of our approach is to provide both a fast approach for fab model building and accurate details. To do that, a comprehension of the global behavior of the fab is required.

3 GENERIC FAB WORK

In general there are 3 major systems that manage semiconductor manufacturing plants:

1. The MES - **M**anufacturing **E**xecution **S**ystem – *the order giver*,
2. The ECS - **E**xecution **C**ontrol **S**ystem – *the information exchanger*,
3. The AMHS - **A**utomated **M**aterial **H**andling **S**ystem – *the order executor*.

Figure 1 gives a global vision of the interaction between these systems. Wafers are transported into carriers called Front Opening Unified Pods (FOUP for short). The MES has the information on the FOUPs (*ID, source, destination and priority*) and gives the orders on the wafers steps. The *Automation*, through equipment interfaces, exchanges and updates information on tool statuses with the MES. The *Execution Control System* is the center of information processing. It is mainly composed of *Activity Manager* and *Real Time Dispatching*. Activity manager is the *decisional heart* of the system (i.e transports, lot scheduling, etc.). The AMHS is in charge of the FOUP storage, safety and transport. The performance of the fab is linked to the quality of the rules implemented in Activity Manager.

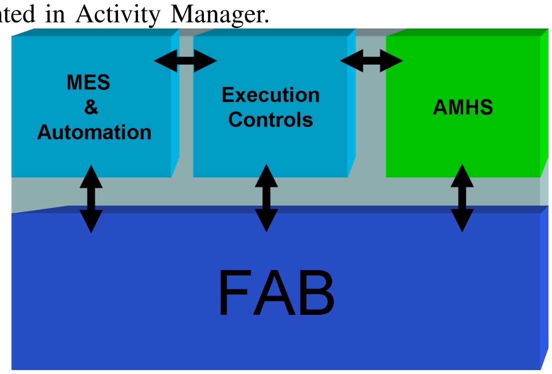

Figure 1: Components of a general fab model

This generic fab behavior underlines two important features for model building: the data and the quality of implementation. Even if the transport is only a service for the production and is considered as a non-added value task, it is a common talk that lot cycle time, especially for full-fab automation, depends on the AMHS capacity to be at the right place and at the right time. This implies an efficient management of the vehicle stream.

3.1 Vehicle Stream Management

In the literature, vehicle management is mainly focused on vehicle policies. As an example, Luo et al. (2005) develop an optimal path algorithm for auto-recovery in the control of AMHS using an Ant Colony System algorithm. Dong-Yeh et al. (2002) demonstrate that the notion of PULL concept is better than the notion of PUSH concept. In the PULL concept, the lot transportation is predefined in the MES and is triggered by the AMHS (*the lot transportation does not depend on the operation flow*). In the PUSH concept, the AMHS is designed to "acknowledge" *what is the destination of each lot*. Liao and Fu (2002) develop Dynamic vehicle allocation and dispatching policies in a large-scale 300mm AMHS fab. Kiba et al. (2008) introduce a policy for non-assigned vehicles called "Turn Around in Zone" to reduce the lot cycle time and to improve vehicle reactivity. Each vehicle policy has its advantages and disadvantages. At the STMicroelectronics 300mm fab of Crolles, the vehicle stream is controlled within each bay by using two parameters: *Low Water Mark* (LWM) and *High Water Mark* (HWM). The first one represents the minimum number of non assigned vehicles that the bay will permanently try to keep inside, in order to quickly react to a transport request. The LWM can be seen as a *minimum service*. If the total number of non assigned vehicles in a bay is below LWM, the information is sent to the Overhead Hoist Transport Control (OHT). The OHTC is in charge of counterbalancing the missed vehicles by dispatching the "*surplus*" vehicles to the unbalanced bays. The *High Water Mark* is the second parameter associated to each bay. It represents the maximul number of non assigned vehicles above which the risk of traffic jam or congestion becomes high. If the number of non assigned vehicles is larger than HWM, the surplus vehicles are pushed out of the bay.

The two parameters defined above are important, since transport requests are assigned to a vehicle by bay controllers *if and only if* the vehicle is inside the bay. The Overhead Hoist Transport Control is only informed by bay controllers on the need of vehicles in bays. The role of the Overhead Hoist Transport Control is to guarantee a *minimum service* while avoiding traffic jam or congestion in each bay. *The main quality that any automated system must supply is repeatability*. This is well illustrated in Kiba et al. (2008). All the vehicle stream management problems underlined above are very difficult to model in a partial fab simulation because of the dynamic interactions.

3.2 Storage

A stocker is equipped with an inside track-robot (crane) and a robot transfer mechanism for lot exchanges. It has a large storage capacity but with a long access time and can thus quickly become a bottleneck. To handle that, Overhead Hoist Buffers (OHBs), with a storage capacity of one FOUP, are used. Placed either at one or both sides of the rail, OHB access time is six times faster than the stocker access time. OHBs are thus well suited for storing production lots. In addition, OHBs do not have electronic devices and hence rarely fall down.

In the 300mm site of Crolles of STMicroelectronics, OHBs are grouped to form *default stockers*. To each tool is associated one default stocker. If it is full, another default stocker called *alternate* (for alternative solution) is dedicated to the tool. An efficient management of the size (i.e. number of OHBs), and the geographic position (related to delivery time) is required to efficiently manage the flow of lots in the fab.

To better illustrate the importance of the management of OHBs, let us use the following example. Suppose two tools E_1 and E_2 and three default stockers B_1, B_2 and B_3. Let us assume that the default stocker of tool E_1 is B_1 with alternates B_2 and B_3 in this order. This means that, when B_1 is full, the surplus of lots will go to alternate B_2 (another default stocker) and then B_3 if B_2 is full. Let us dedicate the default stocker B_2 to the equipment E_2 with alternates B_1 and B_3 in this order. The way that default stockers B_1 or B_2 will be fulfilled is non linear. For example if tool E_1 is solicited more often than E_2 and has long process time, it is clear that the default stocker B_1 will be filled mainly with lots dedicated to E_2. So, tool E_2 will use its second alternates, i.e B_3. It increases transport variability (different geographic positions) and even the risk of fab overcapacity. Indeed, the number of OHBs is limited.

Here again, as for vehicle stream management, a local vision of the fab could not handle this problem because all default stockers are required for storage optimization.

3.3 Production Constraints

When simulating AMHS, adding production constraints in the simulation increases not only its accuracy to make it more realistic but also its complexity. Taking into account all production constraints is difficult in terms of modeling and analysis of results. The release of two complementary software like AutoSched AP (lot scheduling, tool capacity) and AutoMod (well suited for automated transportation in semiconductor fabs), both from Brooks Automation, illustrate this point.

Nevertheless, it is possible to overcome this difficulty. Kong (2007) proposes a two-step simulation: the production simulation step is followed by the AMHS simulation step. In the first step, the throughput of the production line can be predicted. In the second step, the capability of the AMHS is predicted. Batch constraints are also taken into account in the literature. In our simulation, we took into account the following production constraints:

- **Lot scheduling**: This is justified by the fact that production lines are not linear and that we need to tackle the problem of re-entrant flows. The impact on the AMHS is evaluated on the traffic jam in a bay. The rules used in our simulation are based on the choice of the fastest equipment with the smallest queue.
- **Lot storage**: This is justified by the fact that the contribution of lot storage to fab performance is double: keep the right lot close to the equipment (leading to short delivery time) and help to guarantee an effective fab throughput. This constraint is also very important since it helps to significantly reduce the Carrier Exchange Time, which is explained in the next section.

3.4 Fab Performance Indicators

Zimmerhackl et al. (2007) write that fab performance cannot be measured by a single indicator. Due to the nature of our simulation (transport and production constraints), indicators have to take into account both the AMHS performance and the production constraints to correctly evaluate the model. The indicators we have chosen are the following:

- the equipment *Carrier Exchange Time* (CET). The CET is an indicator that measure the speed of the equipment loading and unloading. The CET is important to ensure continuous processing and particularly important for critical equipment. The goal is to *feed* equipment load ports at a rate that minimizes the equipment idle times. The CET characterizes this rate by measuring the cycle time between unloading a lot and loading a new lot.
- the *vehicle delivery time*, Minimizing delivery times and controlling their dispersion is also important to control transportation.

The choice of these two indicators is justified: Kondo and Honold (2006) illustrate that transport time reduction seems to reach physical limitation. This means that the vehicle delivery time reduction depends on other factors than the vehicle speed or the number of vehicles. Zimmermann et al. (2008) determine an appropriate number of FOUPs for a given order release rate that will yield acceptable values for on *time delivery performance*, cycle time and throughout. Lubke (2008) demonstrates that one of the AMHS challenges is to meet short CETs at the tool especially for 450mm wafers. The author shows that small lot size manufacturing will magnify this challenge. Gupta et al. (2008) propose to use cluster tools to improve operation performances and thus to meet a short CET. Lubke (2008) shows how to perform both unload and load time commands for the same tool to improve vehicle delivery times.

4 MODEL BUILDING

In the case of semiconductor manufacturing, there are so much data that determining *key* data is not obvious. Our approach to tackle the problem of key data identification is made of two steps :

1. Identification of major data,
2. Identification of basic lot attributes.

4.1 Identification Of Major Data

To determine the major data to externalize, our approach is based on the two scenarios that drive the entire fab: *Where Next* and *What Next*. The Where Next scenario, also called *unloading scenario*, consists in finding the closest storage spot where the lot will wait until a qualified equipment becomes available. It is at the lot initiative. Data needed for the where next scenario are: storage name, physical position and storage state (busy or not). These data correspond to the answer to the question: Where to store the lot until ? The What Next scenario, also called *loading scenario*, consists in selecting the right lot for the right equipment at the right time. It is at the equipment initiative. This decomposition shows the need of data like equipment names, physical positions, number of load ports, default stockers, alternates and processing times. Once this has been done, we used filters with the desired criteria to gather the data as illustrated in Figure 2. We used three criteria:

- Data update frequency (data with high frequency are kept),
- Data impact on scenario changes (data with a big impact),
- Easiness for use by non specialists.

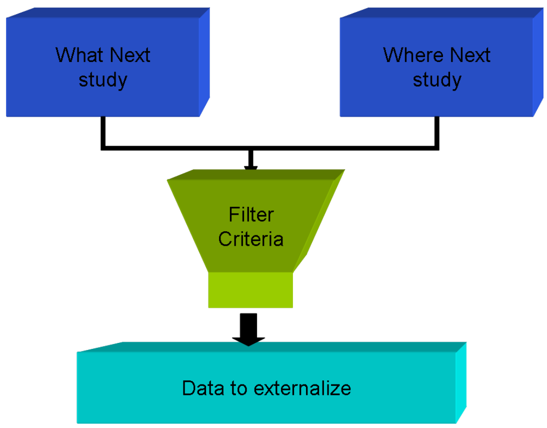

Figure 2: Our approach to determine the major data to externalize

4.2 Identification Of Basic Lot Attributes

In our approach, the considered basic lot attributes are:

1. Steps,
2. Default stocker names and positions,
3. Alternate names and positions,
4. Load port numbers and positions,
5. Equipment recipes.

This approach has many advantages. First, it gives *flexibility* to the model by allowing quick scenario changes and data updates. Second, the code structure design is made by itself and extensions are easy to set up. Third, implementation time is reduced and data errors are better tracked. Fourth, we can descend to an impressive level of details.

4.3 Model Details

The model includes the actual layout, e.g. bays that fit in terms of distances with the real fab. All the storages types and their alternates have also been modeled. The stocker crane and its constraints, such as the inside track-robot time, have been modeled for all stockers. The real size of the stocker is considered. *The only storage in our simulation with infinite capacity is the entering and exit points of the fab*. Equipment positions and main features such as lot unlock and lock times, set up times, process times (including sampling) have also been modeled. Only the recipe download time has not been taken into account. Detailed representation of the transport is done: Vehicle acceleration, deceleration, forward and curve speeds, stop and brake distances, hoist speed. The vehicle behavior has also been modeled such as capacity to bump, priority management, information exchange with the Execution Control System. Distances between barcodes have been considered. The MES has been modeled together with the information exchanges with the Execution Control System. For confidentiality reason, we are not allowed to provide more details on this. Each equipment queue is modeled and the management of the queue is performed by selecting the equipment with the right recipe and based on the following criteria: (1) smallest queue, (2) fastest equipment.

4.4 Data As Flexibility Lever And 3-D Visualization

Data gathering is a hard task which is emphasized in semiconductor manufacturing. A primary quality that a simulation must have is *flexibility*, i.e fast and easy scenario changes. Our approach to gain flexibility consists in *not directly implementing key data* into the software but in external text files. *Data externalization reduces modifications in the software. With good data externalization, you do not need to be an expert to run different scenarios*. This approach is particularly well suited for managers who want to try various possible extensions of the fab. this approach can be generalized for any simulation software that can exchange data with external files.

3-D visualization is not only the main advantage of commercial simulation software, but also the best way for non simulation specialists to better understand simulation. A Chinese proverb says that *a picture is better than thousand words*. The AMHS is not the easiest fab component to simulate but, as mentioned in the introduction, it is the backbone of 300mm fabs. It is unacceptable to let the AMHS be the cause of fab slowing down since transport is a service for production and does not add value to the lots. Our simulation takes into account most of the transport situations that could happen in the real 300mm fab of Crolles, like vehicle bumping, vehicle pushing out, etc. The advantages of 3-D visualization for managers are the possibility to let them directly interact with the software on different scenarios. For example congestion is faster detected using 3-D simulations than with analytical simulations.

5 FIRST RESULTS

5.1 Simulation Characteristics

We used the AutoMod software v12.1 with Microsoft XP Professional. The processor is an Intel(R) Xeon(R) CPU E5420 @2.50GHz(4 CPUs) with 3040MB RAM. We simulated 20 days of production with 90 days to reach the steady state. The number of wafers started is 2500 per week. The model includes the total number of lots, the routes followed by the lots, the number of tools and their positions and features (batching, cluster, etc.). The different stockers and their characteristics (number, positions, etc.) are modeled.

For confidentiality reasons, we cannot show the actual values of the simulation tests, and in particular of the Carrier Exchange Time (CET). We are allowed to present the result of a study that aims at finding the optimal value of the Low Water Mark (LWM) in the metrology bay to minimize the delivery time. The values of Low Water Marks and High Water Marks in other bays are fixed.

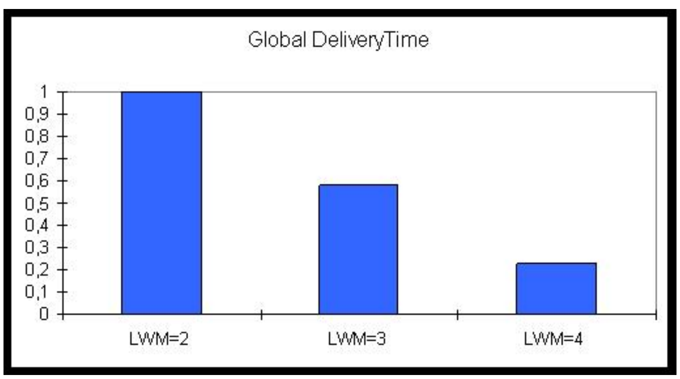

Figure 3: Average delivery time variation depending on the LWM value at the metrology bay

Figure 3 shows the variation of the average delivery time with the value of the LWM (HWM = LWM) at the Metrology bay. The measured delivery time is the time while a vehicle carries a lot from one point to another including pick up and drop down times. The values of the LWM and HWM for the other bays are fixed to 1. The surplus of vehicles for one bay is parked in the main bays where there is no equipment. We chose the metrology bay because of the important traffic in this area in the fab considered in this study. The results show that the LWM has an impact on the delivery time which decreases when LWM increases. This first conclusion has to be carefully analyzed because of the numerous entities that could effect the delivery time like: throughput, vehicle stream, etc...

Figure 4 shows the variation of the average retrieving time for three values of LWM. Recall that the retrieving time represents the travel time needed by an empty vehicle to pick up a lot. Note that the delivery time decreases drastically

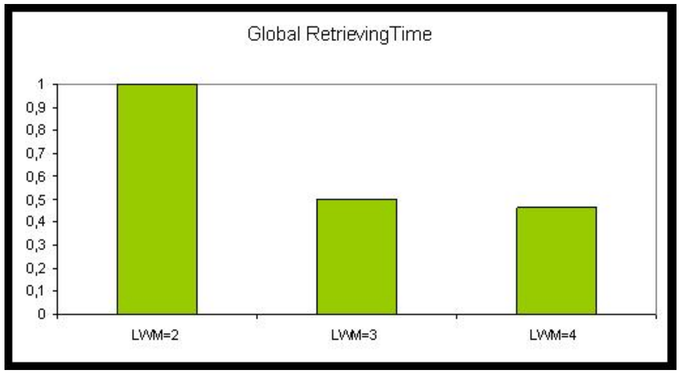

Figure 4: Average Retrieving time variation depending on the LWM value at the metrology bay

with the first two values of LWM, but only slightly when LWM varies from 3 to 4. This suggests that, when the number of vehicles in a bay is sufficient, adding other vehicles does not increase the vehicle reactivity.

At this point, a natural trade-off appears between the values of the LWM that could provide effective delivery and retrieving times.

6 CONCLUSIONS AND PERSPECTIVES

In this paper, we modeled a 300 mm full-fab. Even if most of the time simulation is considered time consuming, data externalization provides *flexibility* and fast fab model building. Our conclusion is that a full-fab simulation gives an incomparable, complete and accurate way to study fab behavior. The introduction of 3D animation in the simulation is a plus to understand the simulation results but also to support the interactions with managers. Jones (1992) states that "*Computer simulation serves a management scientist or an operations research analyst the same way that the laboratory experiment serves a physical scientist*."

The determination of optimal values for Low Water Marks and High Water Marks is quite complex due to the dynamic aspects of the problem. Moreover, these values cannot be determined with a partial view of the fab. Using our complete model, we are able to simulate and test some values. These values are directly linked to fab performance indicators like delivery time, Carrier Exchange Time, vehicle balancing, etc. These are topics of our current research.

Storage places management aims at reduce process time variability and contributes to guarantee continuous processing. An effective storage configuration must ensure that lots are at the right place. The main challenge is to determine both the optimal sizing (number of Overhead Hoist Buffers) and the optimal locations (close to the tools). This will be considered in our future research.

REFERENCES

Brain, M. D., and P. Lin. 2007. Impact of speed on the performance of vehicle-free transport. In *Proceedings of the 2007 International Symposium on Semiconductor Manufacturing*, 1–3.

Dong-Yeh, J., Y. Chen-Chung, S. Yean-Jyh, and Y. Jorsun. 2002. A new approach to improve transporting efficiency of amhs. In *Semiconductor Manufacturing Technology Workshop*, 115–118.

Gan, B. P., L. P. Chan, and S. J. Turner. 2006. Interoperating simulation of automatic material handling systems and manufacturing process. In *Proceedings of the 2006 Winter Simulation Conference*, ed. L. F. Perrone, F. P. Wieland, J. Liu, B. G. Lawson, D. M. Nicol, and R. M. Fujimoto, 1129–1135. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.

Gupta, A. K., P. Lendermann, A. I. Sivakumar, and J. Priyadi. 2008. Simulations analysis of cluster tool operations in wafer fabrication. In *Proceedings of the 2008 Winter Simulation Conference*, ed. S. J. Mason, R. R. Hill, L. Mönch, O. Rose, T. Jefferson, and J. W. Fowler, 2141–2147. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.

Jimenez, J. A., G. T. Mackulak, and J. W. Fowler. 2008. Levels of capacity and material handling system modeling for factory integration decision making in semiconductor wafer fabs. *IEEE Transactions on Semiconductor Manufacturing* 21 (4): 600–613.

Jones, K. C. 1992. Manufacturing simulation using virtual reality. Technical report, Department of Operations Research, Washington University, Washington, California.

Kiba, J.-E., S. Dauzere-Peres, C. Yugma, and L. Vermarien. 2008. Improve vehicle management for large unified amhs in semiconductor manufacturing facilities. In *Progress In Material Handling Research: 2008*, ed. E. Kimberly, M. Russel, K. Michael, A. Brett, D. D. Taylor, and J. Usher. Dortmund, Deutchland: Material Handling Institute.

Kondo, H. 2007. Advanced simulation framework for amhs. In *Proceedings of the 2007 IEEE International Symposium on Semiconductor Manufacturing*, 1–4.

Kondo, H., and A. Honold. 2006. Timed move command for improved on-time amhs delivery. In *Proceedings of the 2006 IEEE International Symposium on Semiconductor Manufacturing*.

Kong, S. 2007. Two-step simulation method for automatic material handling system of semiconductor fab. *Robotics and Computer-Integrated Manufacturing* 23 (4): 409–420.

Lange, J., K. Schmidt, R. Boner, and O. Rose. 2008. Automated generation and parameterization of throughput models for semiconductor tools. In *Proceedings of the 2008 Winter Simulation Conference*, ed. S. J. Mason, R. R. Hill, L. Mönch, O. Rose, T. Jefferson, and J. W. Fowler, 2335–2340. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.

Liao, D.-Y., and H.-S. Fu. 2002. Dynamic oht allocation and dispatching in large scaled 300mm amhs management. In *Proceedings of the 2002 IEEE International conference on Robotics and Automation*, 3630–3636.

Lubke, J. 2008. Requirement for amhs in 450mm era. In *Proceedings of the 2008 IEEE International Symposium on Semiconductor Manufacturing*, 189–192. Tokyo, (Japan).

Luo, M., J. B. Zhang, M. M. Wong, L. Q. Zhuang, K. C. Ng, and S. W. Aung. 2005. A heuristic approach to auto-recovery in the supervisory control of heterogeneous automatic equipment for material handling. In *Proceedings of the 31st Annual Conference of the IEEE Industrial Electronics Society*, 2325–2330.

Nazzal, D., and F. McGinnis. 2007. Expected response times for closed-loop multivehicle amhs. *IEEE Transactions on Automation Science and Engineering* 4 (4): 533–542.

Schmidt, K., and O. Rose. 2008. Simulation analysis of semiconductor manufacturing with small lot size and batch tool replacements. In *Proceedings of the 2008 Winter Simulation Conference*, ed. S. J. Mason, R. R. Hill, L. Mönch, O. Rose, and J. W. F. T. Jefferson, 2118–2126. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.

Wakabayashi, T., S. Watanabe, Y. Kobayashi, T. Okabe, and A. Koike. 2004. High-speed amhs and its operation methods for 300mm qtat fab. *IEEE Transactions on Semiconductor Manufacturing* 17 (3): 25–28.

Zimmerhackl, O., J. Rothe, K. Schmidt, L. Marshall, and A. Honold. 2007. The effects of small lot manufacturing on amhs operation and equipment front-end design. In *Proceedings of the 2007 international Symposium on Semiconductor Manufacturing*, ed. S. Mason, R. Hill, L. Mönch, O. Rose, and J. F. T. Jefferson, 1–5.

Zimmermann, J., L. Mönch, J. S. Mason, and J. W. Fowler. 2008. Determining an appropriate number of foups in semiconductor wafer fabrication facilities. In *Proceedings of the 2008 Winter Simulation Conference*, ed. S. J. Mason, R. R. Hill, L. Mönch, O. Rose, T. Jefferson, and J. W. Fowler, 189–192. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.

AUTHOR BIOGRAPHIES

JEAN-ETIENNE KIBA is a Ph.D. student at Ecole Nationale des Mines de Saint-Étienne, France. He works as an Engineer in the Industrial Engineering Department at STMicroelectronics Crolles. He received his M.S. degree in Applied Mathematics from the Pierre & Marie Curie University, Paris 6, France, 2004. His Ph.D subject is about Automated Material Handling Systems modelization and optimization. His email address for these proceedings is `<jeanetienne.kiba@st.com>`.

STÉPHANE DAUZÈRE-PÉRÈS is Professor at the Provence Microelectronics Center of the Ecole des Mines de Saint-Etienne, where he is heading the Manufacturing Sciences and Logistics Department. He received the Ph.D. degree from the Paul Sabatier University in Toulouse, France, in 1992; and the H.D.R. from the Pierre and Marie Curie University, Paris, France, in 1998. He was a Postdoctoral Fellow at the Massachusetts Institute of Technology, U.S.A., from September 1992 to December 1993, and Research Scientist at Erasmus University Rotterdam, The Netherlands, from February 1994 to July 1994. He has been Associate Professor and Professor from 1994 to 2004 at the École des Mines de Nantes in France. He was invited Professor at the Norwegian School of Economics and Business Administration, Bergen, Norway, from March

1999 to July 1999. Since March 2004, he is Professor at the École des Mines de Saint-Etienne. His research mostly focuses on optimization in production and logistics, with applications in planning, scheduling, distribution and transportation. He has published more than 20 papers in international journals and 70 communications in conferences. He is also the co-author of An Integrated Approach for Production Planning and Scheduling (Springer- Verlag, 1994).His email address for these proceedings is <dauzere-peres@emse.fr>.

CLAUDE YUGMA is an associate professor at the Provence Microelectronics Center of the École des Mines de Saint-Étienne. He received the Ph.D. degree from the Institut National Polytechnique of Grenoble, France, in 2003; He was a Postdoctoral student at the École Nationale Supérieure de Génie Industriel, Grenoble, from 2003 to 2004 and from 2005 to 2006 at the Provence Microelectronics Center. His research includes scheduling problems in production and logistics, scheduling simulation in semiconductor context, etc. His email address for these proceedings is <yugma@emse.fr>.

GILLES LAMIABLE is AMHS & Sorter Group Manager belonging to the Industrial Engineering Department of STMicroelectronics Crolles 300MM. He joined Crolles site in early 1992 as maintenance engineer. In 1997, he received is Engineering degree and introduced new operator interface concept in the 200mm line. Early 2001 as Methods manager, he participated to the AMHS supplier selection program for the new 300mm line and then was in charge of the specifications and installation in the Fab. In 2006, he was in charge of the functional scenarios and operator interface of the system to assure the full integration into the manufacturing and R&D line. Today, he is focused on AMHS continuous improvement program and on future system expansion. He is also involved in several SEA and MEDEA R&D projects for STMicroelectronics Crolles. His email address for these proceedings is <gilles.lamiable@st.com>.