Proceedings of the 2006 Winter Simulation Conference
L. F. Perrone, F. P. Wieland, J. Liu, B. G. Lawson, D. M. Nicol, and R. M. Fujimoto, eds.

SIMULATION BASED SCHEDULING SYSTEM IN A SEMICONDUCTOR BACKEND FACILITY

Sebastian Werner

Infineon Technologies
01099 Dresden, GERMANY

Sven Horn
Gerald Weigert

Electronics Packaging Laboratory
Dresden University of Technology
01062 Dresden, GERMANY

Thomas Jähnig

Qimonda
01099 Dresden, GERMANY

ABSTRACT

The semiconductor manufacturing process is usually divided in two parts: frontend and backend. In contrast to the frontend, where the manufacturing process is dominated by cluster-tools and cyclic routes, the backend has a predominant linear structure. In contrast to the frontend flow which is mostly controlled by dispatch rules, the backend process is suitable for real scheduling. A scheduling system for the backend of Infineon Technologies Dresden based on a Discrete Event Simulation (DES) system was developed and tested in the real industrial environment. The simulation model is automatically generated from the databases of the manufacturer. The system is used for short term scheduling - from one shift up to one week. The paper will focus on the aspect of optimizing the process flow and calculating exact release dates for lots. The basic principles are applicable not only in the semiconductor industry but also in other industrial sectors.

1 INTRODUCTION AND LITERATURE SURVEY

Approaches for backend scheduling are stated in publications over the last 10 years. To this day there is no general solution which answers “how to optimize”. No commercial product that is ready to use and no all-in-one solution is available on the market for the daily scheduling tasks or optimization in backend facilities.

Chang et al. (1997) used DES together with a simplified assembly area model, he scheduled the whole demand of a backend facility and made experiments with different release policies and product mixes. The goal was to maximize throughput and demand fulfillment. Domaschke et al. (1998) describe an approach with the very fast DES system Factory Explorer™ and a parameterized backend model with data coupling to a data warehouse. The project scope was to get general answers and recommendations, like convenient batch policies or elimination of bottlenecks caused by tool dedication.

Sivakumar (1999) was one of the first who used deterministic online simulation of the facility and automatic model creation, plus optimization applied to a backend test facility. Also an online parameterized model is described in (Potoradi et al. 2002). Here the scheduling of the wire bonder equipment group as the current bottleneck, also with the simulation system Factory Explorer™ was accomplished. A further heuristic approach for wire bonder scheduling is described in (Tovia et al. 2004). Heuristic methods for maximizing the throughput of the equipments are explained, too. Quadt (2005) recommends the use of the scheduling system Asprova, but extended with a customized scheduling logic, for optimizing the allocation of parallel machines in semiconductor backends (flexible flow lines). Several publications are available about the examination of batching rules, especially for the burn in ovens in backend, e.g. (Sung et al. 2002) or (Wu et al. 2004). Most of these papers focus only on this special task, but often the method of DES is applied, too.

All these publications are especially focused on the special behavior of backend process flows. A wide experience of using DES for semiconductor production flows can be taken from similar articles about semiconductor frontend processes, e.g. (Mönch and Zimmermann 2004) or (Rose 2005).

Furthermore, Wang and Wu (2002) examined semiconductor manufacturing lines and describes a relationship of yield and cycle-time. The use of backward simulation was proposed by Jain and Chan (1997) for determining exact lot release dates. As the main handicap the author mentioned the inability to follow the sequence of operations at successive process steps as predicted by backward simulation. Summarizing the previous aspects, it can be stated that still no uniform way has been argued. Stochastic simulation, online and offline studies, simulation of demand quantities or single lots – several approaches with various software systems are in use and a lot of them are still under development.

2 MOTIVATION

The wide variance of solutions for simulating and optimizing the backend process supplies the motivation for the present work: our goal was to develop a DES-based approach for the complete backend which is suitable for the case of changing bottlenecks and different line scenarios. Fulfilling these needs the solution can be used over a longer period of time without larger redesign caused by changes in the technological process. Precondition is an auto-generated, data-driven model which meets the process-accompanying concept - established by the authors in similar projects (Section 4). Output of the system should be a complete schedule in the granularity of lots and an exact release date calculation for all individually started lots.

Due to the special character of the backend process on development sites: over 50 % of the lots have special attributes and process flows, an interactive approach was chosen, which tries to combine the advantages of the raw usage of scheduling systems (e.g. Asprova, Quadt 2005) - the interactivity, and DES (e.g. Factory Explorer, Domaschke et al. 1998) – to be fast and exact. Section 6 focuses on this issue.

At the beginning of the project it was not clear how the final goal – the optimization of the process flow in the daily business can be fulfilled. The examination of convenient scheduling rules like EDD, or ATCS for bottleneck equipments was one alternative, just as the appliance of heuristic optimization like Threshold Accepting (TA) or Genetic Algorithms which are able to solve such tasks. The resulting composite method is explained in Section 5.

It was important to consider that the simulated backend in this project is characterized by high amount of engineering, widely varying lot sizes and unequally distributed process times. This is typical for development sites. Nevertheless we tried to optimize against classical objective values like cycle time, utilization and lateness.

3 DATA COUPLING

As in most simulation projects, the majority of the effort was expended in collecting and preparing data to construct a valid model of the factory. All data needs to be available online in contrast to usual simulation studies, where data can be processed manually. Furthermore, the data needs to be electronically readable and of high quality to reduce manual review and post-processing to a minimum in terms of time consumption. In semiconductor industries these requirements are fulfilled.

Only in special cases a fall-back of reading and parsing spreadsheet data is necessary, which is very error-prone. In the majority of cases, however, the data is available via relational database access or integrated libraries which provide access to production critical ERP and MES systems. Only access to databases containing staff data is not granted, saving the employees rights. In this case we are forced to provide the possibility of manual input for the planner.

The concept used in this project was the set up of a simulation repository as a separate database which operates like a collecting box for all simulation relevant data (Figure 1).

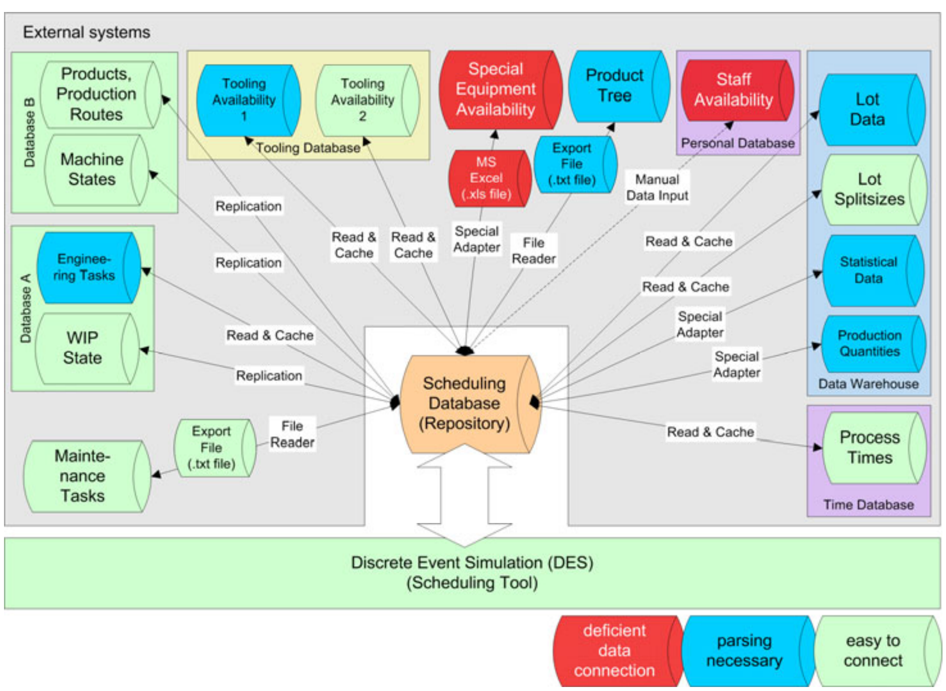

Figure 1: Data Coupling Architecture of the Project

This architecture allows the storage of snapshots of the real production environment over a period of time. The data coupling of the repository and the external systems is realized by:

- Oracle Materialized Views,
- PL/SQL routines,
- Various data adapter modules in .NET,
  - Flat file parser,
  - MS Excel parsing routines, and
  - API access module.

A more detailed description of the data coupling techniques for the repository architecture and the concept can be found in (Horn et al. 2005).

4 AUTOMATED MODEL GENERATION

As an argument for auto-generated models often the safety is referred, avoiding error-prone processes. Similar techniques are used today in Supply Chain Modelling (SCM). For online simulation in process accompanying understanding it is a precondition. The developed system uses a sectioning of the models into components (subsystems) so called mini-models. This concept is described in Weigert et al. (2006) in detail. It is an important note that the model is not only parameterized, the whole model including the process flows and process structure is also auto-generated from the data.

The concept makes sense because changes in the process flow are frequent and can force a model correction or expensive redesign by simulation experts. Selke (2005) describes a similar theory and includes an extended examination of this issue. Data coupling architectures for model creation in the field of semiconductor fabrication are also defined in Watt (1998). This way is often called *Integrated Simulation,* Guus et al. (2000).

The used DES system simcron MODELLER allows a fast model creation using the built-in interfaces. The model creation process for the specified optimization-part of the backend (Section 5) consumes in the best case approximately 5 seconds. The simulation time itself (simulation of up to 190 jobs over 115 machines) takes additional 4 seconds. A larger model including the test facility is built in approximately 2 minutes and consumes 22 seconds of raw simulation time. These specified data of time consumption were detected with a usual PC (1.5 GHz) but can only show the dimension. A significant reduction of the runtime will be expected because the current program code still includes redundant instructions (e.g. debug output) which will have been purged in the final robust application.

In our approach, every time a planning task is being performed by the users, a new model is built. The permanently updated simulation model is advantageous to include all occurred changes and the complete transparency for all changes in process flows, equipments, lot information and planning decisions.

5 SIMULATION BASED OPTIMIZATION

A simplified structure model of the simulated backend process flow is shown in Figure 2. The considered backend region starts with the lot release (Wafers) over the Preassembly (Dicing, Grinding, ..) and ends with the lot transfer to the test facility (Burn In).

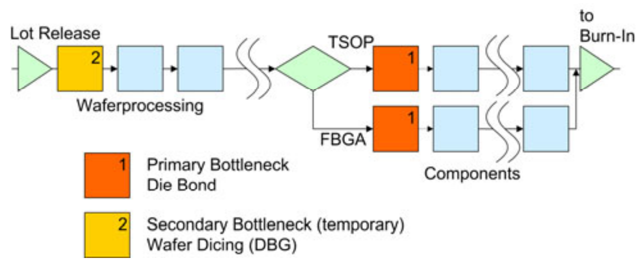

Figure 2: Simplified Structure Model of the Process Flow

All equipment is redundant (2…n). The product flow is divided into two main technologies: FBGA and TSOP products. The main bottleneck of this area is the process step *Die Bond*, in special situations the *Wafer Dicing* step can be the major bottleneck, too. The lot flow is mainly steered over the bottleneck and is affected by a complex rule set. These rules are hard constraints and/or soft constraints and involve:

- Availability of staff for setups (headcounts),
- Setups for higher priority lots,
- Consideration of tool availability,
- Setups for booked engineering times,
- Periodic setup changes for ensuring the product mix,
- Equipment dedication, and
- Lot split before the bottleneck.

The equipment set includes a complex setup matrix depending on the properties of the lots. After establishing online a simulation model of this backend process flow, we began the implementation of all existing rules, especially setup rules into the model.

The benchmark of the simulated schedules against the real production shows that optimization of the results is strongly necessary. Based on snapshots of backend situations we tested several options of iterative process flow optimization. One promising strategy we examined was the iterative usage of the ATCS scheduling rule described in Mönch and Zimmermann (2004).

Figure 3 shows a typical optimization result measured with the backend model. The scaling parameters of the ATCS rule in Figure 3 were set to 1:1 between slack and setups. Fitness value is a constructed target called *Die Bond Makespan* (DBMKS) which is explained in Figure 4. This target is measured for all bottleneck equipments and excludes standby at the discontinuation of the model. Minimizing this target lowers setup times and standby breaks.

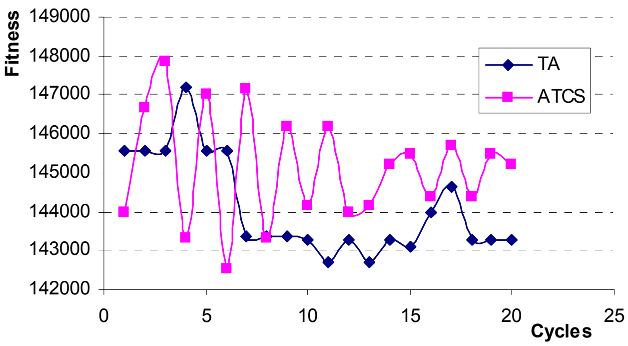

Figure 3: Optimization Convergence of the ATCS Scheduling Rule and Threshold Accepting (TA)

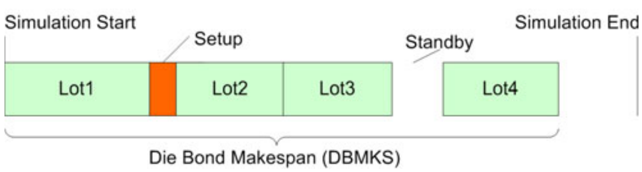

Figure 4: The Fitness Value DBMKS

Caused by the complex and non-linear setup rules the usage of ATCS does not show any advantage over the use of a simple heuristic like Threshold Accepting (TA). TA is a widely used local search method and is described in Dueck and Scheuer (1990). Due to the fact that the Threshold Accepting was simpler, more stable, and the parameters of the ATCS rule need to be adjusted carefully, we chose the simpler heuristic.

We also tried combinations of setup rules and different setup-avoidance rules found in literature. Further tests with heuristic optimization algorithms like a Genetic Algorithm and Threshold Accepting which are plug-ins to an experimental optimization module of the simcron MODELLER have been added to the optimization procedure. The optimization achievements were always checked against the online snapshots of real backend situations. The different methods encapsulated as modules in the simulation system, allowed an effective testing and recombination to different production scenarios. The final result the five-step procedure described in Figure 5, which combines methods from scheduling rules, heuristic optimization, analytical calculations and backward simulation (Figure 6).

In a first step a start schedule is being created in a single simulation run. The released lots were started in a product mix resulting from performing a round-robin over all product groups. All lots start immediately. The model includes priority dispatch and setup avoidance rules. This start schedule is not optimal in terms of utilization, because a disadvantageous lot sequence from the lot release causes standby at the bottleneck equipments.

	Step	Type	Objective
1	construction of a start solution -lot release strategy, round robin, prio -setup rules / dispatch rules	dispatch - heuristic/ simulation	setup optimization utilization ↑ product mix
2	optimization (<100 Cycles) -only lot sequence, start VMD -lot sequence on bottleneck -product sequence on bottleneck	heuristic TA / GA	utilization ↑ lot cycle time ↓
3	„Packing" -Transfer of optimized lot order from bottleneck (Bonders) to release order	calculation	utilization ↑
4	„Repair" -preferring lots in sequence if size and product is comparable	calculation	lot cycle time ↓
5	backward simulation from bottleneck to start, delayed release dates	calculation / simulation	lot cycle time ↓

Figure 5: Five-Step Optimization Procedure

In a second step a heuristic optimization is being applied using Threshold Accepting. The algorithm optimizes the lot release sequence and the product (lot) sequence on the bottleneck equipments. It is important to know that only the near-term part of the lot release sequence has impact on the utilization of the bottleneck equipments. The heuristic optimization performs cyclic simulation runs and is limited to max. 100 cycles for saving computational time. The result is a higher utilization at the bottleneck equipment and an improvement of the average lot cycle time.

The third step is called "Packing" and transfers the lot working order from the bottleneck equipment *group* to the lot release order at lot start. This causes an optimal lot release order for the utilization on the bottleneck equipments. The lot sequence is changed again by step four called "Repair". This repair mechanism tries to exchange comparable lots. Comparable means that the lots are of the same product and nearly of the same quantity. This step allows to forward lots with higher amount of consumed wait time.

The last step (five) is the construction of an inverted model. It starts with the scheduled lot sequence (fixed) on the bottleneck and allows to determine the feasible lot release dates by backward simulation. Scheduled equipment downs, planned engineering times and equipment dedication are considered thereby. Because of the strict line structure of the process in front of the bottleneck machines, the optimal release date for every single lot can be determined by the inverse simulation model. The goal is to release all lots just in time for reduced cycle time and to avoid idle time of the bottleneck machines.

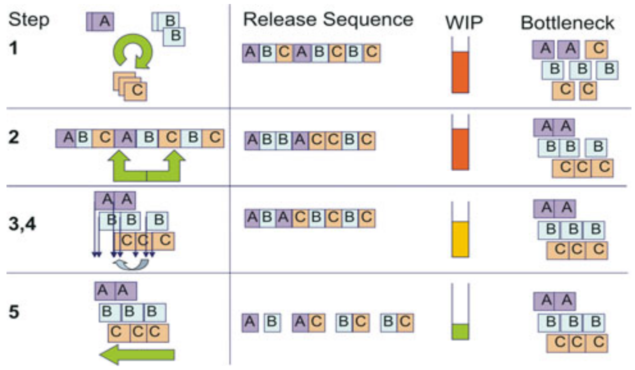

Figure 6: Schematic Representation of the Optimization Procedure

For the final report an additional safety buffer of 3-5 hours is considered if possible. This safety offset is divided into two parts. **(A)** The release date of the lot in the backward simulation is not its exact start time on the bottleneck machine. The point in time is shifted to the left to provide a time buffer for lot arrival at the bottleneck. This shift is only performed if the adjustable buffer was considered in forward simulation, too. Otherwise the final release date of the lot can shift into past of the real time. **(B)** The second part of the safety offset is simply added on the final release data calculation of the lot (Figure 7).

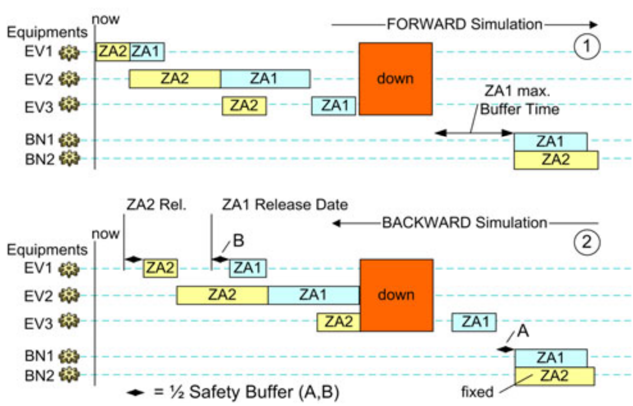

Figure 7: Forward- ① and Backward Simulation ② near a Scheduled Down, for Lot Release Date Calculation

Figure 7 shows the method considering an additional scheduled down on the previous non-bottleneck machines EV1 … EV3. BN1 and BN2 symbolize the bottleneck equipments themselves. The lots ZA1 and ZA2 are processed simultaneously on different bottleneck equipments.

This 5-step-optimization gave us the possibility to have an acceptable schedule under different line conditions. It is suitable for steady state line situations and also for start-up situations after a line stop i.e. This last case normally does not occur in production, but is possible after large engineering tests or equipment moves (shop floor layout changes) in the cleanroom and has appeared in one of the practical field tests.

Figure 8 shows the optimization progress over the five steps compared with two pure heuristic search graphs. The larger scatter plot area (A) represents the search space density for changing lot release dates in the granularity of hours, scanned with a random walk procedure over 5000 cycles. Of course, this includes the optimization of the lot release sequence. The smaller scatter plot area (B) in the upper right corner represents a random walk for the lot release sequence only, without release dates. In this case all lots can start immediately.

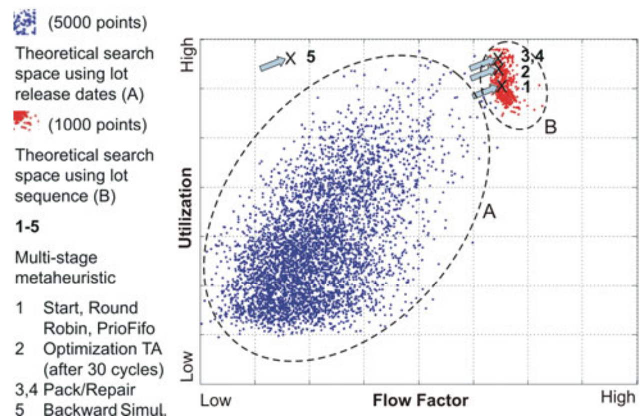

Figure 8: Optimization Results from an Online Snapshot of the Backend Process from Lot Release to Burn-In

The advantage of the combined method in terms of Utilization and Cycle Time (Flow Factor) is observable. The used simulation model was also a snapshot of a real situation from the backend production.

6 INTERACTIVE SCHEDULING

The rollout of the developed method into the daily business requires its embedding into a complete software solution. As the line staff has to use the application in daily business, the focus of the design moved to clarity, simplicity and calculation speed.

The final software application called "BackendPlanner" is completely operated by the use of two forms (Figure 9). The first form is the lot disposition form where the user can check and edit the demand values, the lot inventory and the lot disposition data for all lots. Also the calculated release dates for the lots are reviewed in this form. The amount of visualized data per lot is very high. On the one hand several options exist for a lot in shipping policies, end-product choice and so on, and on the other hand much lot information restricts these choices. The application can perform an automatic disposition proposal. Due to the fact that many of the lots have special requirements this disposition is done manually in parts.

The second form is an interactive Gantt-Chart which allows different views on the current schedule. Mostly this chart is filtered to the bottleneck equipment group. The Gantt chart allows to add and edit engineering times on equipments, to edit equipment constraints and to move lots between the machines.

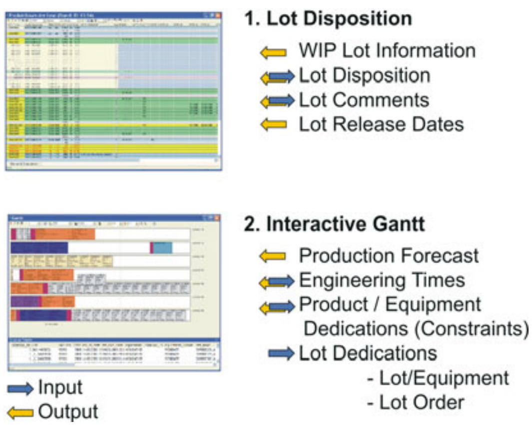

Figure 9: The Two Use-Cases of the Application, Lot Disposition and Scheduling

The lots can individually be fixed on equipments, or forced by product constraint to machine sets. Also the sequence of selected lots can be fixed. The concept follows the principle that all scheduling relevant data can be edited in one view. After all manual adjustments (Figure 10) and changes the schedule is re-simulated and optimized in the remaining degree of freedom, and the given release dates for the lots are updated.

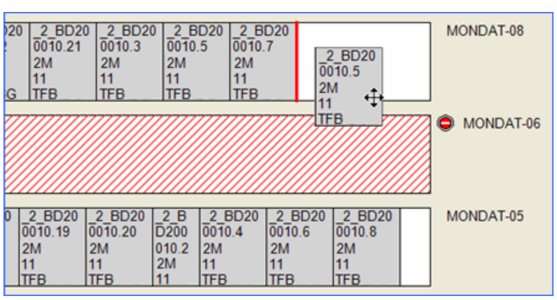

Figure 10: The Interactive Gantt-Chart, Assisted by Event Discrete Simulation (Product name altered)

The consequences of manual adjustments in the schedule according to the optimization results are very difficult to measure. Nevertheless we made an evaluation of this issue and found what we expected: Minor changes are possible without compromising the target values. Figure 11 shows these results of the measurements. The situation was taken from a regular week in production. The lots were moved manually between bottleneck equipments as well as the lot sequence at the bottleneck itself was changed without adding new setups to the schedule. Exception is the point *16%*$^{+2}$ in which the manually performed moves cause 2 additional setups. That increases mainly the target DBMKS. The initially achieved improvements (in %) are only the results of step 2 (TA). The improvements by the other optimization steps (1, 3-5) are not affected by the lot moves.

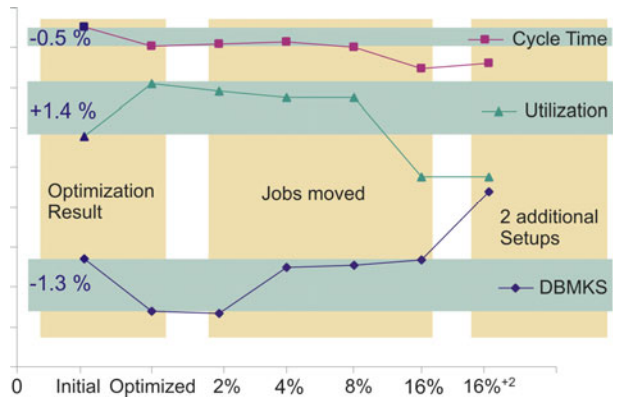

Figure 11: Effects Caused by Manual Moves of Lots

The DES and the interactive Gantt is coupled by using rules. Every moved and fixed lot adds an additional rule to the current rule set of the initial situation. This rule ensures the hand-made constraints of the Gantt chart, but reduces the possibilities of the optimization. The occurrence of deadlocks is avoided by limiting changeability only to the bottleneck equipments.

7 SIMULATION RESULTS

Currently the shop floor staff releases the lots with a high safety margin of time to prevent standby on bottleneck equipments. This increases the average cycle time over the considered production part. We measured the theoretical potential of lowering this safety margin to 5 hours in maximum. The safety margin is still necessary because of the fact that process times vary over (±10…20)% and in addition miscellaneous unexpected events can occur.

Figure 12 shows the amount of potential by some individual lots grabbed from a current schedule from production and in contrast the simulation of the same lots. The remaining potential after incrementing the average cycle time by the safety margin of 5 hours reaches up to 0.4 days. The measurement scope reaches from lot release to the finish of the process step on the bottleneck equipment.

The analysis of the average values also considers the deviation of the real process times versus the simulated process times in the observed period. It was ensured that the measured potential is a result of the early lot release by a second analysis from lot release to the lot arrival at the bottleneck equipment group.

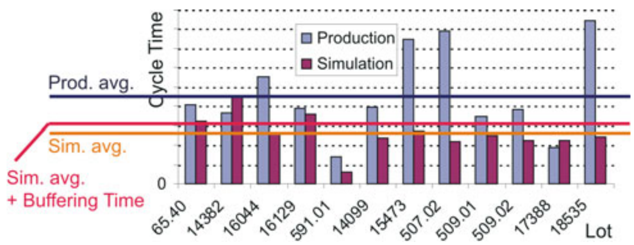

Figure 12: Cycle Time Improvement Potential for some Sample Lots (Lot Names Altered)

Figure 13 shows a similar analysis for different product types. P5 is a prioritized product which possibly implies additional setups when the lots arrive at the bottleneck equipment group.

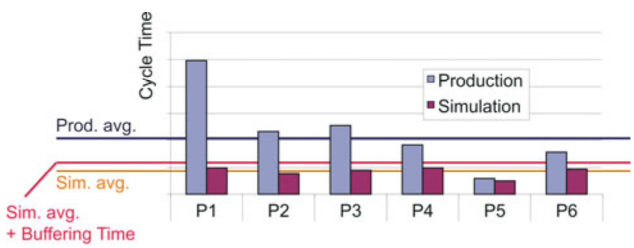

Figure 13: Cycle Time Improvement Potential for Different Product Types (Product Names Altered)

8 PARTNERING WITH LINE CONTROL AND PRODUCTION

The described functionality to perform manual changes was crucial in the process of getting acceptance by the line staff and the line control. Also the other requirements on the schedule were checked periodically with the line control staff and fixed in a catalog of requirements. The application was tested in several field tests with a scope of 3 days to 1 week (24 hours a day).

After the field tests we started a step-by-step rollout. First step was the rollout of the application for disposition, shift communication and line control communication with the shop floor. This phase is currently closed and successful. Now, we try to improve the acceptance of the calculated release dates and schedules, where the manual adjustments which are necessary for valid schedules are the most significant part. The critical path is the expenditure of time by the shop floor staff and the understanding what manual changes effect.

9 DEVELOPMENT OVERVIEW

The effort for development, tests and research is similar to other projects of this type (Selke 2005); the quantitative breakdown of tasks is shown in Figure 14. The main part of expense is assigned to the data mining, that means data analysis, development of data interfaces, data validation and interviews with production staff.

The application design, ensuring multi-user capability and management of user rights was an important part, too. The application including all views and forms is built as a Microsoft .NET framework application using C#, all simulation and optimization procedures are implemented in the simcron MODELLER, where add-ons are placed in the scripting engine. The repository is an Oracle database.

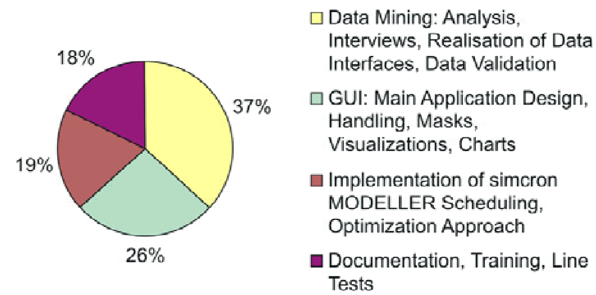

Figure 14: Development Efforts of the Project

ACKNOWLEDGEMENT

The work for this paper was supported by Infineon Technologies Dresden, now Qimonda, and by the EFRE fund of the European Union and funding of the State Saxony of the Federal Republic Germany (project number 8007/1289). The authors are responsible for the content of the paper. A special thanks goes to Petra Schönig for excellent support and collaboration in the project.

REFERENCES

Chang, Y. S., S. H. Choe, and C. B. Besant. 1997. Discrete event simulation in a semiconductor assembly area. *Proceedings of the 1997 5th International Conference on Factory 2000 the Technology Exploitation Process* Cambridge April 2-4 1997 IEE Conference Publication, ISBN: 0537-9989, 183-188.

Domaschke, J., S. Brown, J. Robinson, and F. Leibl. 1998. Effective implementation of cycle time reduction strategies for semiconductor back-end manufacturing. *Proceedings of the 1998 Winter Simulation Conference*. Piscataway, NJ: Institute of Electrical and Electronics Engineers.

Dueck, G., T. Scheuer. 1990. Threshold accepting: a general purpose optimization algorithm superior to simulated annealing. *Journal of Computational Physics* 90, 161-175

Guus, K., C. Ruiter,, J. Sluijs, and W. Stoutjesdijk. 2000. Simulation for recurring decisions. *Proceedings of the 2000 Winter Simulation Conference.* Piscataway, NJ: Institute of Electrical and Electronics Engineers.

Horn, S., G. Weigert, and S. Werner. 2005. Data coupling strategies in production environments. *Proceedings of the 28th International Spring Seminar on Electronics Technology*, ISSE 2005. Wiener Neustadt, Austria.

Jain, S., Chan, S. 1997. Experiences with backward simulation based approach for lot release planning. *Proceedings of the 1997 Winter Simulation Conference.* Piscataway, NJ: Institute of Electrical and Electronics Engineers.

Mönch, L.; and J. Zimmermann. 2004. Improving the performance of dispatching rules in semiconductor manufacturing by iterative simulation. *Proceedings of the 2004 Winter Simulation Conference.* Piscataway, NJ: Institute of Electrical and Electronics Engineers.

Potoradi, J., O. S. Boon,, S. J. Mason, J. W. Fowler, and E. M. Pfund. 2002. Using simulation-based scheduling to maximize demand fulfillment in a semiconductor assembly facility. *Proceedings of the 2002 Winter Simulation Conference.* Piscataway, NJ: Institute of Electrical and Electronics Engineers.

Quadt, D. 2005. Scheduling a semiconductor backend: from theory to practice. *Proceedings of the 3rd International Conference on Modeling and Analysis of Semiconductor Manufacturing,* MASM 2005, Singapore Institute of Manufacturing Technology.

Rose, O. 2003. Accelerating products under due-date oriented dispatching rules in semiconductor manufacturing. *Proceedings of the 2003 Winter Simulation Conference.* Piscataway, NJ: Institute of Electrical and Electronics Engineers.

Selke, C. 2005. Entwicklung von Methoden zur automatischen Simulationsmodell-generierung. Forschungsberichte Band 193, ISBN 3-8316-0495-9 Herbert Utz Verlag.

Sivakumar, A. I. 1999. Optimization of cycle time and utilization in semiconductor test manufacturing using simulation based, on-line, near-real-time scheduling system. *Proceedings of the 1999 Winter Simulation Conference.* Piscataway, NJ: Institute of Electrical and Electronics Engineers.

Sung, C. S., Y. I. Choung,, J. W. Fowler. 2002. Heuristic algorithm for minimizing earliness-tardiness on a single burn-in oven in semiconductor manufacturing. *Proceedings of the International Conference on Modeling and Analysis of Semiconductor Manufacturing* (MASM 2002), Tempe, AZ, 217-222

Tovia, F., S. J. Mason, and B. Ramasami. 2004. A scheduling heuristic for maximizing wirebonder throughput. IEEE Transactions on Electronics Packaging Manufacturing, (27):2,, pp. 145-150.

Wang, Z. J., and Z. D. Wu. 2002. Multi-object optimal scheduling for semiconductor manufacturing line based on satisfactory control. *Proceedings of the 2002 American Control Conference*, Vol. 1-6, 1603-1608

Watt, D.G. 1998. Integrating simulation based scheduling with MES in a semi-conductor fab. *Proceedings of the 1998 Winter Simulation Conference.* Piscataway, NJ: Institute of Electrical and Electronics Engineers.

Weigert, G., S. Horn, T. Jähnig, and S. Werner. 2006. Automated creation of DES models in an industrial environment. To appear in *Proceedings of the 16th International Conference Flexible Automation & Intelligent Manufacturing*, FAIM ’06, Limerick .

Wu, D.L., H. L. Lo, C. C. Pan, Y. T. Chang, and C. L. Peng. 2004. Automatically form batch via real time dispatcher for furnace operation in 300 mm fab. *Proceedings of the 2004 Semiconductor Manufacturing Technology Conference*, 29-32

AUTHOR BIOGRAPHIES

SVEN HORN studied Computer Science at the University of Leipzig, Germany. He was also employed as a Software Engineer for developing telecommunications and financial software. Since 2003 he is a Research Assistant at the Centre of Microtechnical Manufacturing of the Dresden University of Technology. His main interests are simulation and optimization of manufacturing processes as well as database systems and their practical application. His e-mail address is <horn@avt.et.tu-dresden.de>

GERALD WEIGERT is an Assistant Professor in the Department of Electrical Engineering and Information Technology of the Dresden University of Technology. Dr. Weigert works on the field of production control, simulation & optimization of manufacturing processes, especially in electronics and semiconductor industry. His e-mail address is <weigert@avt.et.tu-dresden.de>

SEBASTIAN WERNER was a Research Assistant at the Centre of Microtechnical Manufacturing of the Dresden University of Technology, until 2005. He obtained his masters degree in 1997 and is now in a Ph.D. program, moved to Industrial Engineering at Infineon. His e-mail address is <sebastian.werner@infineon.com>

THOMAS JÄHNIG is a Staff Engineer for manufacturing, simulation & scheduling. He obtained his masters degree in 1997 from Dresden University of Technology and is now in a Ph.D. program while he moved to Industrial Engineering at Qimonda. His main interests include factory logistics, automation, algorithms, factory analysis tools, and simulation. You can reach him by e-mail at <thomas.jaehnig@qimonda.com>