Analysis of Objectives for Multi-criteria Scheduling in Semiconductor Manufacturing

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1 Introduction

Semiconductor manufacturing includes the most complex manufacturing processes. Scheduling problems to be addressed at the operational level involve a rich set of constraints and criteria. Besides, the performance of the semiconductor industry highly relies on the use of effective scheduling approaches in wafer fabrication facilities, as show [3]. As a result, multi-objective optimization algorithms are increasingly preferred over dispatching rules, especially in complex production areas, such as the photolithography area which is considered in this paper.

To schedule operations in the site of Crolles of *STMicroelectronics*, multi-criteria mathematical programming models are used. In the photolithography area, the problem consists in scheduling a set of jobs on a set of parallel machines. To be processed, each job requires an additional resource, called reticle or mask, that can be transported from one machine to another (see for instance [1]).

2 Objective Functions

In the site of Crolles of *STMicroelectronics*, the photolithography scheduler is based on an epsilon-constraint method, which is one of the state-of-the-art approach for multi-objective optimization (see for instance [2]). In this latter, industrial objectives are considered in the following order :

1. Minimization of the risk associated to violating maximum time lag constraints, where the risk function is a quadratic function of the time spent (in percentage) in each constraint ;
2. Minimization of the number of moves of auxiliary resource between machines ;
3. Maximization of the total number of consecutive jobs of the same family, i.e. jobs which do not require any setup time ;
4. Minimization of the weighted flow factor, i.e. the ratio between the completion time of lots and their respective shortest processing route, weighted by the lot priority.

The optimization engine is run in real time with a time limit of 10 minutes for all the objectives.

3 Analysis of the Objective Functions

A functional analysis of the objectives revealed that some of these objectives were not well defined such as objectives 2 and 3, which both do not fulfill their underlying purpose. Some

counter-examples will be shown in the conference along with new expressions for these objectives. The expression of objective 3 is also redesigned to better capture the waiting time of the lot in the area in the decision-making process. Finally, a criterion proposed in [4], and that aims at meeting production targets, is considered.

In practice, schedules are generated on a long time horizon (between 24 and 48 hours). However, because of the high uncertainty, jobs at the end of the schedule are much less likely to be completed in accordance with the proposed schedule than the jobs at the beginning of the schedule, although the contributions of these late jobs to objective functions are significant in the solution approach. To consider this, new formulations for objectives integrating a time uncertainty threshold are proposed, which are inspired from [5] and [1].

4 Data-driven Multi-objective Optimization

In addition to the existing values of epsilon and the solution time allocated to each optimization phase, the updated formulations of the objectives lead to the definition of new hyper-parameters such as the time uncertainty threshold or the maximum number of reticle moves that can be performed in the area. These hyper-parameters must be properly tuned to reach the desired trade-off solution. Different strategies have been discussed and tested on industrial data with an industrial Constraint Programming solver : A static approach but also a dynamic approach based on the current state of the factory. Relationships between some objectives are also investigated in order to confirm or adjust their ranking in the lexicographical order of objectives.

5 Conclusions

Additional details on the analysis of the objective functions, and on the various hyper-parameters and strategies will be detailed in the conference. Numerical results will also be discussed.

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