# Mid-term planning for a semiconductor backend facility : At the crossroad with scheduling

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**Mots-clés** : *production planning, semiconductor back-end manufacturing*

## 1 Introduction

Semiconductor is the industry that aims to produce chips (also known as Integrated Circuits). The whole manufacturing process is split into two parts : the first one, called front-end manufacturing, where hundred of chips are manufactured on silicium wafers, and the second part (framed in blue in picture 1) called back-end where the wafers are sliced and the chips are encapsulated and tested.

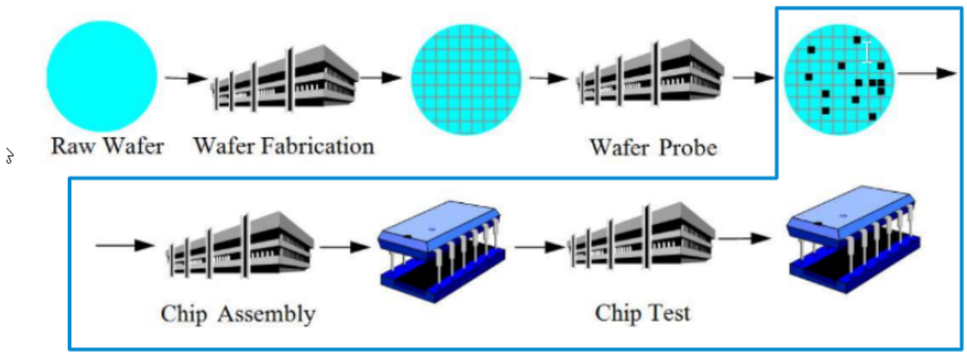


FIG. 1 – Overview of a semiconductor manufacturing Supply Chain (Schömig and Fowler, 2000 [3])

Back-end semiconductor manufacturing may not be as complex as the front-end part but it offers some serious challenges at the tactical level. Literature on the subject is generally more focused on the scheduling (see Fu et al., 2011 [2]) of the already sized batches with an horizon of one week split into period of one day or a shift (8 hours).

In our case, we face a lot-sizing problem with multiple level's bills of material (hundreds of products are considered), an horizon made of 35 time periods, production process with 14 to 40 steps. The objectives are numerous and conflicting : There are the classical lost sale and backlog costs, but also setup costs and workload balancing costs on some resources. The computational time allowed is at most 40 minutes.

To go into the detail of the model, we are producing a daily release plan of production with some lots that are already sized and some that are not. The problem is constrained by the capacity on two dimensions : the work centers (tooling, machines) and the workload groups (human resources). Material procurement's are known and fixed, they are also a limitation of the problem. Structural data (e.g. process lead-time, work center maximal capacity, bill of material) are almost all time-dependant.

The problem in itself is not easy to solve. But, a set of almost-scheduling features make the problem even more difficult. We propose to review a few of these requirement and how they were handled.

## 2 Feature and issues encountered

The first issue was to model the demand process. The factory has a strong commitment with its customers. The customers can decide either of the release date or of the shipment date for their orders, with a given quantity. Sometimes they can also put orders on the intermediate products. Solving the problem as a scheduling problem could have been considered if it was not for the need to determine the processing (lot size and release date) of the wafers (raw product) and of a part of the intermediary products.

The second most important concern was to deal with multiples steps with heterogeneous lead times : from a few minutes to 72 hours. It opens the question of the duration of the periods : If the period's duration is too short, it will increase the size of the model and many steps will span several buckets. Else if we use longer period, the model loses in precision because many steps will be processed in the same period and it may impact the global objective of the project which is to build a feasible daily release plan.

A third issue was the request to have a software that is not too specific and can adapt to various contexts. For example, the company is famous for handling products at the start of their life cycle which implies the company improves on their processes even during the tactical horizon. Thus, all the data related to the process may change after an anticipated amount of time. The company also wanted to introduce the choice of making a batch wait more in some specific buffer, also known as variable lead time, in order to gain more control on the system load. The optimization model for such particular processes is inspired by Beraudy et al., 2022[1] but it is not possible to use column generation as described in the paper, mainly due to the workload smoothing objective and also to the number of binary variables.

A few other issues will be shown and addressed in the presentation.

## 3 Conclusions and perspectives

In the end, the problem is modeled as a single MILP solved by a lexicographic optimization, using IBM Ilog Cplex. Although the optimization model is able to produce acceptable solutions (with a gap under 10%), we are at the limit of the problem size that can be tackled by the solver. The main objectives to decide the timing of the batches needs nearly 250 000 binary variables and as many constraints. The computational time of the solver is mostly spent in the heuristics to generate a first solution rather than the branch and bound. As the business of our client will grow, decomposition method will be needed to be considered in the near future.

## Références


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