# Scheduling on Parallel Metrology Tools for Risk Reduction in Semiconductor Manufacturing

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## 1 Introduction

Semiconductor manufacturing operates in a dynamic environment driven by increasing demand and diverse product requirements. This demand surge is fueled by expanding markets with a growing need for electronic devices across various applications. Customers aim to minimize costs while ensuring the reliability and quality of products. Production machines are closely monitored to maintain product conformity. This monitoring involves control operations on increasingly expensive metrology tools. Hence, minimizing the ridk by measuring the right lots while considering metrology capacity is a critical concern in semiconductor manufacturing.

In our problem, scheduling each lot of products (job) for measurement plays a vital role in mitigating risks associated with the production machines used for processing these lots. Therefore, the allocation of lots to metrology tools should be optimized. However, as highlighted when modeling the problem, our objective diverges from conventional scheduling criteria of the literature, which primarily focus on completion times.

## 2 Problem description

A set of $N$ lots must be measured on a set of $M$ parallel metrology tools. Each metrology tool can handle one lot at a time, and each lot $l$ has a measurement time $p_{l,m}$ on machine $m$. A lot $l$ can only be assigned to a metrology tool that is qualified (eligible) to measure which $l$.

A set of $R$ risks must be controlled. From an industrial standpoint, each risk can be seen as a source of variability in the fabrication process. In the simplest scenario, each risk is associated to a production machine that can generate scraps or reworks. The contribution of lot $l$ to risk $r$ is related to the reduction of the number of Wafers At Risk ($W@R$). The contributions to reducing the Global Sampling Indicator introduced in [1] are stored in matrix $D$, where $D_{r,l}$ is the contribution of lot $l$ to the reduction of risk $r$.

The objective function aims to maximize the gain on the risks over time, by placing higher value on information obtained early :

$$\max \int_{t=0}^{T} \sum_{r=1}^{R} \max_{l, C_l \leq t} D_{r,l} \; dt$$

# 3 Solution methods

## 3.1 A column generation approach

We reformulated our initial compact model to propose a column generation approach. The complexity here comes from the fact that the information between the column is linked. Indeed, if a lot is scheduled on a machine, then the risk is reduced and the marginal gains on the risks of all the waiting lots decrease. Hence, the columns to generate are not only feasible partial schedules (that are used in some scheduling problems solved by column generation) but time-indexed feasible partial schedules as in [2] to evaluate in real time the contribution of the lots to decrease the risk level. We also studied several stabilization methods [3] to accelerate the convergence of the column generation approach.

## 3.2 Heuristics

We also developed two greedy heuristics. The first heuristic method prioritizes lots based on their potential in terms of marginal risk reduction. The second heuristic is grounded in an exact algorithm that solves the problem with a single metrology tool. Both heuristics are very efficient, as they provide very good solutions in short computational times.

# 4 Conclusion

In this abstract, we have addressed a scheduling problem on parallel metrology machines for risk minimization, which arises from semiconductor manufacturing. Although relevant, this problem has not been explored much. A column generation approach and two heuristics have been provided. Additional details on these approaches will be provided in the conference, together with numerical results that will be discussed.

# Références


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