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ROLLING HORIZON PRODUCTION PLANNING IN A BORDERLESS FAB SETTING

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ABSTRACT

In this paper, we consider a borderless fab scenario where lots are transferred from one semiconductor wafer fabrication facility (wafer fab) to another nearby wafer fab in order to process there certain process steps of the transferred lots. Production planning is carried out individually for each of the wafer fabs. However, the modeling of the available and requested capacity in the production planning models of the two wafer fabs is affected by the lot transfer. Production planning is carried out in a rolling horizon setting. We show by simulation experiments that modeling the capacity in the production planning formulations correctly leads to improved overall profit compared to a setting where the lot transfer is not taken into account on the execution level and in the planning formulations.

1 INTRODUCTION AND PROBLEM SETTING

Production planning deals with determining releases into a wafer fab such that demand is met and some performance measure of interest such as profit or cost is optimized. It is an important planning function in semiconductor supply chains (Mönch et al. 2013, Mönch et al. 2018a). We consider a so-called borderless fab scenario. There are two wafer fabs that are located close to each other and specific process steps of some lots can be performed in the neighboring fab. Although such a setting can be found quite often in real-world situations it seems that it is rarely studied in the literature. We are only aware of Gan et al. (2007) where the impact of different lot batching sizes for the cross-fab process step on lot transfer frequency and cycle time is studied. In the present talk, we analyze the transfer of lots between bottleneck work centers of the two wafer fabs in the case of an heavy overload in one of the two wafer fabs and the consequences on individual production planning in the two wafer fabs. To the best of our knowledge, such a setting is not studied in the literature so far (Mönch et al. 2018b).

2 LOT TRANSFER SCHEME AND PRODUCTION PLANNING APPROACH

We assume that there are two wafer fabs. The first one, called delivering wafer fab, has a bottleneck that is heavily overloaded. The bottleneck work center of the second wafer fab, called consuming wafer fab, is less loaded. If the number of lots in front of the bottleneck of the delivering wafer fab n exceeds a threshold Δ at a certain point in time then $n - \Delta$ lots are transferred from the bottleneck work center of the delivering to the bottleneck work center of the consuming wafer fab. The exchanged lots are the most urgent ones, the ones with the smallest local due dates. These lots are then processed on the machines of the bottleneck work center of the consuming wafer fab. Afterwards, they are sent back to the delivering wafer fab for further processing. The exchange can be repeated if the bottleneck work center is visited several times by the same lot, i.e., if reentrant flows exist in the wafer fab. The setting can be generalized for arbitrary work centers and also for several consecutive process steps.

Production planning is carried out for each of the two wafer fabs using the Simple Rounding Down (SRD) production planning model described in by Kacar et al. (2013). In the case of the delivering wafer fab, the initial work in progress (WIP) in front of the bottleneck work center is reduced, whereas the initial WIP is increased in the consuming wafer fab. Moreover, it is important that the expected capacity consumption of the transferred lots in future periods is taken into account in the planning model of the delivering wafer fab.

3 COMPUTATIONAL EXPERIMENTS

The lot transfer scheme and production planning are carried out in a rolling horizon setting using discrete-event simulation. The MIMAC I simulation model (Testbed 2022) is used for each of the two wafer fabs. It contains two products with more than 200 process steps that are processed on more of 200 machines that are organized in 80 work centers. The planned bottleneck work center is the stepper tool group. We use a Normal distribution-based demand generation scheme that results in 93% - 96% planned bottleneck utilization in the delivering wafer fab. The consuming wafer fab has around 70% planned bottleneck utilization. All process steps of the transferred lots from the bottleneck work center are performed in the consuming wafer fab. We chose $\Delta = 8$ as threshold value. The simulation horizon is one year with a period length of a single day. The rolling horizon setting requires to perform production planning on a daily base. We are interested in maximizing the profit, i.e. the difference of revenue and the sum of WIP, inventory, and backlog costs. Five independent demand instances are used in the experiments. Moreover, five independent simulation replications are performed for each demand instance to compute the performance measure values in the face of execution uncertainty. The average profit is taken over all replications. We can see from the computational results that the profit has increased by 8.7 % in comparison to the non-borderless fab scenario.

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