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DEPLOYING AN ADVANCED A.I. DIFFUSION SCHEDULER AT A RENESAS FAB

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ABSTRACT

Scheduling the diffusion area in a front-end wafer fab poses challenges. This industrial case focuses on scheduling diffusion at Renesas' Palm Bay Fab, which is always seeking scheduling system improvements. Transitioning to an advanced system, considering fab-wide impacts on diffusion batching, enhances Key Performance Indicators (KPIs). Our A.I. scheduler utilizes optimization, heuristics, and live data updates every five minutes. Collaborating with FabTime integrates the scheduler with the fab's MES, ensuring frequent updates. It optimizes batching, tool allocation, and launch times, aligning with Renesas' objective to balance competing goals. Initial results show a 36% and 13% increase in diffusion batch sizes at clean and expensive furnace toolsets. The minor impact on cycle time reflects the scheduler's focus on batching efficiency. This approach improves efficiency and meets Renesas' goals, marking a positive step in optimizing their wafer fab operations.

1 EXISTING METHODS FOR SCHEDULING THE DIFFUSION AREA

Diffusion is vital for semiconductor fab operations. Diffusion interacts with multiple areas of the fab and involves re-entrant flows. Time constraints limit the maximum duration to move to a subsequent tool to avoid the risk of rework or scrap, which introduce additional complexity and with the need to efficiently batch lots together and given the high running costs and long processing times at furnace tools we are dealing with one of the most complex problems to solve in wafer manufacturing. Even for the most experienced operators, it is challenging to find the best trade-off between the risk of avoiding rework and assessing the impact on cycle time and delivery performance. While dispatch lists have traditionally been used as the main decision-making tool, they require a highly skilled workforce to make manual decisions. The implementation of advanced scheduling systems can demonstrate positive improvements, as shown in GlobalFoundries recently (Wu, Huang, Wang, and Zheng 2022). There are still limitations because of low adherence and infrequent schedule updates with new data. We will demonstrate how to enable operators to adhere to decisions from an advanced scheduling system and how to achieve more frequent updates in an industrial use case at a Renesas front-end wafer Fab.

2 RENESAS DIFFUSION USE CASE

Renesas is a global leader in microcontrollers, analog, power, IoT and SoC products, Renesas provides comprehensive semiconductor solutions for a broad range of applications including automotive, industrial, home electronics, office automation, and infrastructure.

The industrial case study presented here refers to the implementation of an advanced scheduling system in their Fab in Palm Bay, USA. The Renesas Fab aims to consider the impact on all KPIs from a global perspective when making batching decisions. This is an improvement on the more locally focused dispatching heuristic methods they have been using. The advanced scheduling system also simplifies the workflow, which makes the operators more productive. The scheduling system automates manual processes and requires less operator time to execute the batching decision. Scheduling automation like this simplifies and greatly accelerates the onboarding of new operators who will not have extensive knowledge of the Fab's processes.

3 IMPLEMENTATION

Our scheduler uses a combination of mathematical programming, decomposition techniques and heuristics to solve large-scale problems. The technology, hosted in the cloud, pushes schedules to the Fab every five minutes in a closed-loop, allowing it to respond to new data.

The partnership with FabTime played a significant role. FabTime, a unified end-to-end reporting solution, streamlines fab reporting enabling non-IT staff to access KPI charts without manual MES integration or report creation. Using FabTime, we efficiently gathered key data like lot locations and machine qualifications. The scheduler directly retrieves live data from FabTime's database, expediting deployment without the need for a new data feed setup. The Flexciton scheduler generates schedules through detailed Gantt charts, which are presented on a web application. They are automatically pushed to the fab and integrated via FabTime's dispatch list, providing operators with clear visibility on upcoming dispatches.

A multi-objective optimisation approach is used, allowing the scheduler to be configured based on the fab's requirements. The scheduler does not require extensive data or parameter tuning, unlike some machine learning algorithms or real-time dispatch systems. Change management can present challenges. However, as we demonstrated during the live trials, operators' feedback can accelerate acceptance of this automation change.

4 RESULTS

An analysis compared shifts before and post advanced scheduler deployment, examining September 2022 and June 2023 months with comparable WIP levels and similar operational conditions. We assessed actual Fab KPIs, accounting for adherence and adoption. Despite higher WIP volume and moves (+6%) during the advanced scheduler's active period at diffusion clean, there were 20% fewer batches due to a 36% increase in average batch size. On days with similar throughput, the data shows that the scheduler resulted in fewer batches. At the furnaces, even with lower moves -8%, there was a 13% increase in average batch size. It is important to highlight that this increase in efficiency was achieved with a slight increase in operational cycle time in furnaces and diffusion clean tools, yet satisfied the objective Renesas defined during that period of the case study.

REFERENCES

Wu, K., E. Huang, M. Wang, and M. Zheng. 2022. "Job Scheduling of Diffusion Furnaces in Semiconductor Fabrication Facilities". *Journal of Operational Research* 301(1):141–152.