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DISPATCHING TO IMPROVE CHEMICAL USAGE AT CLEANS TOOLS IN A SEMICONDUCTOR FAB

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ABSTRACT

In this effort, we discuss a scenario in the cleans area in semiconductor manufacturing, where optimizing the work-in-progress(WIP) management strategy was important to keep the overall cost at minimum. There were various conflicting cost component behaviors. We discuss how by using simulation and studying the behavior of the important performance parameters versus changes in input controllable factors, we were able to drive operational improvement and cost reduction. The simulation approach helped the project team to present the results to stakeholders and proceed with physical tests and final implementations.

1 INTRODUCTION

The manufacturing process in a semiconductor fabrication factory (Fab) consists of hundreds of processing steps (like thin film, photolithography, chemical mechanical planarization (CMP), diffusion, ion implantation, etching processes, cleaning and measurement), being executed layer by layer onto a bare silicon wafer. Due to the cyclic nature of the manufacturing process, same tool sets are often used for processing wafers at different steps creating reentrant flows. This adds to the complexity of scheduling and dispatching wafers in a semiconductor Fab making it a complex flow shop with reentrant flows. Dispatching and scheduling algorithms are designed to balance tradeoffs between competing objectives of cycle time, tool throughput, quality, cost and on-time delivery and optimize overall Fab performance.

2 CHEMICAL CONSUMPTION AT CLEANS – A FUNCTION OF OPERATION SCHEDULING

With the evolution of complex semiconductor fabrication, increase in etch, deposition and cleaning processes are becoming ever more critical. There may be different tool types for executing the same process in a semiconductor fab. This happens because, the capacity of a fab increases over multiple years of business growth and investments. Hence equipment's that get purchased evolve with time. The cleaning requirements differ for wafers with different features and devices. The cleans module use considerable amounts of liquid chemical agent, usually an acid. So for manufacturing the same product, the amount of the acid that gets consumed at different tool types varies. Also, during switch-overs of products from one type to another one, there is chemical pre-dispensing to make the processing area suitable enough. Hence the increase in number of change-overs leads to increase in the amount of chemical consumption.

Based on the above explanation, we may conclude that, in order to minimize the usage of chemicals in the cleans module, we should try to run only certain product types at certain tools and minimize the number of change-overs as much as possible. This is possible, if we have enough WIP for all product types at all times to load the various tools. However, having enough WIP for all product types is a fairly challenging objective as quality requirements do not allow stocking WIP for longer durations. Subsequently there is only one strategy to ensure the above, when we do not have lots belonging to preferred product type, and that is to make the tool wait for the preferred lot to arrive if it is not already in queue. However this approach will induce idling of the tools, and there needs to be a balance between tool idling and chemical consumption. Hence it is important to analyze all aspects of the matter in detail, to take appropriate actions.

3 SIMULATION OF SCENARIO AND RESULTS

In order to proceed on the matter, we analyzed the data. We took the data from the factory and fed into a simulation algorithm to see the type of behavior based on above discussed strategy and algorithm. The data considered was for an area with 14 tools that would have overlapping incoming WIP, for a duration of one week. The simulation was conducted for 0 wait minutes, x wait minutes and various multiples of x as wait minutes. The output schedules of lots were analyzed for various aspects like percentage of preferred lots scheduled on the tools, amount of cascading of lots of similar types on a specific tool, average utilization of the tools, average cycle-time of lots from the schedule.

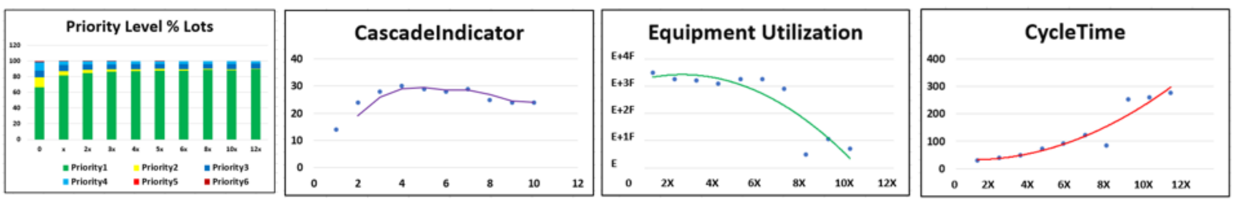

Figure 1 : Plots of various performance parameters from the strategy simulation

From the results, it was seen that as we increase the wait-times for loading preferred lots, the percentage of preferred lots loaded on the tools increases. However the amount of increase was high for the initial increases in wait-times, similar to a logarithmic increasing function. We also see that the cascading of lots of similar product types increases with increase in wait-times. In this case too, the improvement only happens to some extent of increase in the wait-times. With respect to equipment utilization, it remains similar to no wait-times for some increase in wait-times, but continuously decreases there after. Lastly with respect to lot cycle-time, the same also increases in a cubic fashion. Hence we may hereby conclude that the key performance indicators have a conflicting behavior if we increase the wait-times for the less-preferred lots. While the chemical usage and the cascading improves with the increase in wait-times, however the equipment utilization and the lot cycle-times deteriorate with the increase in wait-times. Hence the wait-time duration needs to be defined in a manner, so that the overall cost objective is kept to optimum levels. Hence based on multiple simulation outcomes, we could study the behavior of the overall cost versus the wait-time considered and finalize a wait-time value where the overall cost stays optimized.

4 CONCLUSION

After the solution proposal and further data analysis and simulation analysis, the manufacturing team was convinced that the strategy should be implemented and tested in the shopfloor. So the capability was implemented in the floor across multiple weeks and the performance of the floor on various aspects were monitored and savings in chemical usage was achieved. It was helpful to do some simulation and study the behavior of the important performance parameters versus changes in some of the input controllable factors. It gave the team an insight into how much to tune some of the factors to optimize the final outcome. It helped the project team to present the simulation results to various stakeholders from the factory and get agreement to proceed with physical tests and final implementations. This case certainly re-iterates the benefits of the usage of simulation as a productivity enhancement tool in manufacturing in the organization and encourages others to try similar techniques and approaches in their own field.