Predictive Approach Improves Litho Scheduling

Efficient lithography utilization has always played an important role in gaining a competitive advantage in the semiconductor industry. With litho tools costing $40 million each and heading sharply upward, improvements are now even more critical to a company's survival.

According to the ITRS, lithography tools now account for about a third of the cost of manufacturing an integrated circuit. Litho productivity dictates the output of the entire fab and is a gating factor for moving products through a fab more quickly, thereby improving the all-important time-to-market metric.

A manufacturing strategy that maximizes productivity and minimizes operational losses is essential to competitiveness, particularly if it targets the losses caused by a non-optimal lot processing sequence and an ineffective reticle management plan.

SmartSched™, Applied Materials' breakthrough predictive scheduling software, helps customers achieve measurable improvements in cycle time, equipment utilization, and capacity. One customer has seen tool throughput improve by 2.1%, resulting in an annual revenue increase of $7.8 million by using the litho tool set more efficiently. The return on investment has been greater than 4X, and payback came in just three months.

At the heart of SmartSched is the capability to predict WIP, based on orders and fab-component cycle times, then use this information to create optimized schedules for dispatching. Benefiting from its seamless integration to the dispatch engine, SmartSched is an iterative real-time scheduler that generates a new schedule every few minutes. The end result is higher fab capacity and a much-improved utilization rate [1].

Because it is intimately connected to Real-Time Dispatcher (RTD™), the new schedule from SmartSched is added to the RTD cache instantly. Applied is the only vendor able to seamlessly add a new schedule directly into the RTD system; solutions from other vendors are not built on the same platform and do not have this immediate transfer capability.

SMARTSCHED AND PHOTOLITHOGRAPHY

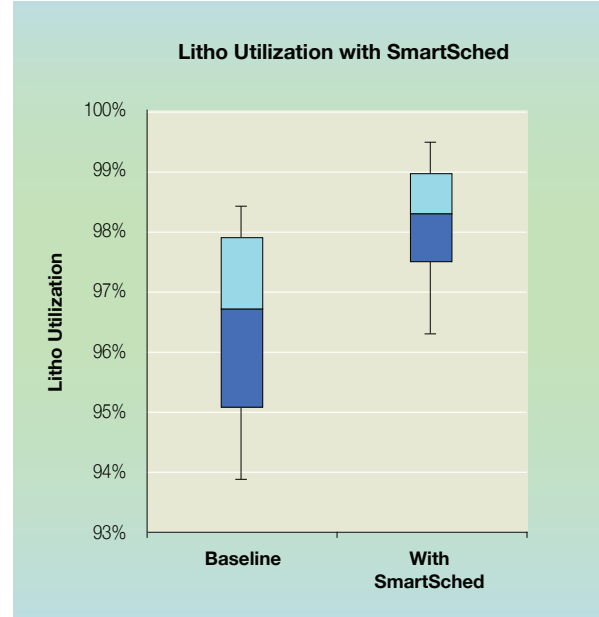
SmartSched's predictive scheduling techniques uncover issues in the fab due to so-called "bad white space." Bad white space is an

ineffective use of available tool processing time, characterized as non-productive time when there is WIP available to be processed.

SmartSched, in real time, looks upstream and downstream to see the status of the WIP in the fab in order to better plan and schedule work in the litho area. One common source of bad white space in lithography occurs when WIP is available at a tool, but the reticle required for processing of that WIP is not yet available. This often happens in a traditional dispatch system because, although the system can quickly respond to changes in the environment, it has difficulty "looking ahead" to select the optimal lot.

By looking ahead, SmartSched helps prevent a reticle from being "locked down" for processing on one tool, when a less flexible tool requiring the same reticle could soon become idle. This look-ahead capability also allows SmartSched to properly link the schedule of reticles for inspection to reticle dispatching for processing wafers. Knowing where a particular reticle needs to be at a future time is a useful way of increasing the effectiveness of a fab's expensive lithography equipment.

SmartSched groups lots better, reducing tool white space and processing more wafers (2.1%) through the litho module. One early customer used SmartSched to achieve a >1% improvement in litho utilization (see Figure 1). SmartSched also significantly tightened the equipment variability by optimal scheduling of the workflow through the litho module. This increases the precision of wafer movements through the litho cell.



▲ **FIGURE 1.** A customer boosted litho utilization by using SmartSched's predictive scheduling.

SmartSched reduces tool white space to enable higher wafer output, moving wafers more efficiently through the litho module. One early customer used SmartSched to achieve a >1% improvement in litho utilization. SmartSched also significantly improves the utilization variability by systematizing the workflow through the litho module. This increases the predictability of wafer movements through the litho cell, enabling a smooth post-litho process flow.

LOOKING AHEAD

Applied is continuing to enhance SmartSched's prediction capability and flexibility. For example, in lithography, the one-hour fixed lead time scenario for reticle scheduling is being replaced with a load-port-availability (LPA) calculation, which helps determine more precisely the time a reticle is required on the tool. In most fabs, the reticle is required to be on the scanner before the lot is delivered to the track. Knowing when a lot will be removed from a load-port (or when a load port is available), is critical information for an effective reticle delivery schedule.

And SmartSched is by no means limited to photolithography. The predictive technique at the core of SmartSched can be applied to minimize the costly setups in final test, improve batch sizes in diffusion and decrease the idle time caused by queue time limitations in areas such as wet sinks, diffusion, and other complicated dispatching areas, including implant.

The movement from reactive to predictive operations in the fab represents the next generation in fab productivity and waste reduction. In today's economy, where reducing waste time is essential to a company's survival, SmartSched represents one of the newer innovations from Applied that will help today's fabs migrate to a predictive approach to production and better use of capital assets. ■

REFERENCES

(1) D. Muller, M. Anderson, D. Norman and D. Hanny, "Solving Complex Fab Challenges with Real-Time, Short Interval Scheduling," Nanochip Fab Solutions, Vol. 4 No. 2, (2009).

(2) D. Norman and M. Anderson, "Technological Approach to Short-Interval Scheduling in Photolithography," Proceedings of the SPIE Metrology, Inspection, and Process Control for Microlithography XXIV Conference, San Jose, CA, (February 2010).

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