CASE STUDY

Improving Wafer Fab Capacity by Applying Advanced Scheduling to the Photolithography Area

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Improving Wafer Fab Capacity in the Photolithography Area

The Challenge

Derry, Northern Ireland, is home to the Springtown Facility of Seagate Technology – a leader in data storage and the production of hard-disk drives. The facility is one of two Seagate fabs that together produce around 40% of the world's read-write heads. Being an integrated device manufacturer (IDM), they control the production of all the components that make up their final product. Seagate's Springtown facility is responsible solely for the production of read-write heads which are fabricated onto wafers made from aluminium titanium carbide (AlTiC). This process is incredibly complex as a result of the highly re-entrant nature of the fab, with each wafer undergoing 1,600 unique steps.

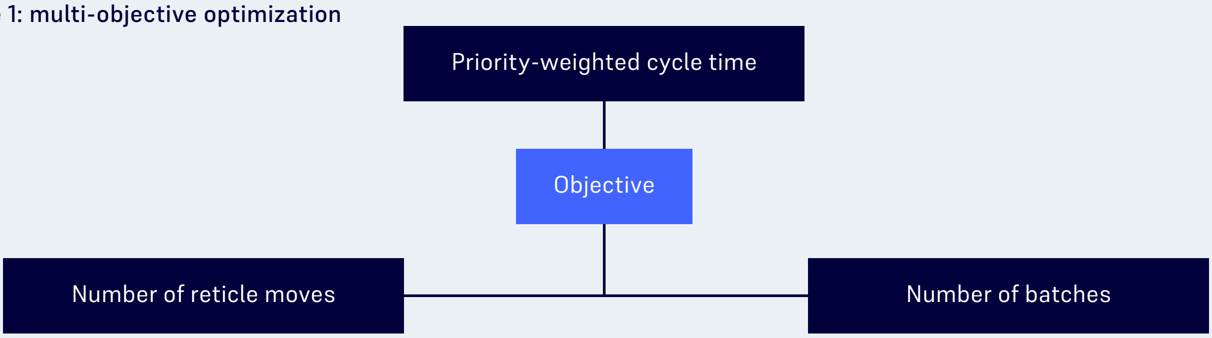
At the heart of this operation is the photolithography area, which is the cutting-edge of semiconductor manufacturing, requiring the most complex and expensive equipment. This is a rate-limiting area, so increasing its throughput should fundamentally mean increasing the throughput of the entire fab. This makes it of critical importance for Seagate to utilise the tools to their maximum capacity, however, their reliance on fragile and finite auxiliary resources called 'reticles' creates scheduling complexities which often result in the photolithography area becoming a bottleneck.

Reticles (also known as photomasks) are transparent plates used to create a pattern on a wafer. Their fragility means that each movement of a reticle comes at a risk, and not only are they expensive to replace, but the process can also take several weeks. Because of this, the minimisation of reticle movements helps to mitigate the risk of damage, but may consequently sacrifice the fab's fundamental objective of reducing cycle time. This presents a challenge for Seagate, as they want to maximise the throughput of their photo tools whilst reducing the risk of reticle breakages. There are four different types of toolsets in the photo area at Seagate, each with a unique set of characteristics. The results from this case study are gathered from one toolset which has an internal reticle library and, unlike the other toolsets, reticles can be moved individually between tools and cabinets rather than transported in pods to an automated stocker.

The Solution

To combat the problem of balancing reticle moves with cycle time, Seagate applied Flexciton's advanced technology to their photolithography area. Flexciton's solution is an optimization-based scheduler that was designed specifically to solve the most complex wafer fab scheduling problems. It can optimize for specific toolset KPIs whilst respecting all different constraints and a number of conflicting objectives, which in this case are cycle time and

Figure 1: multi-objective optimization



reticle moves. The scheduler allows the user to quantify the different outcomes of the tradeoff by applying multi-objective optimization (Fig 1). This is a form of multiple-criteria decision-making that concerns optimization problems involving more than one objective to be optimized simultaneously.

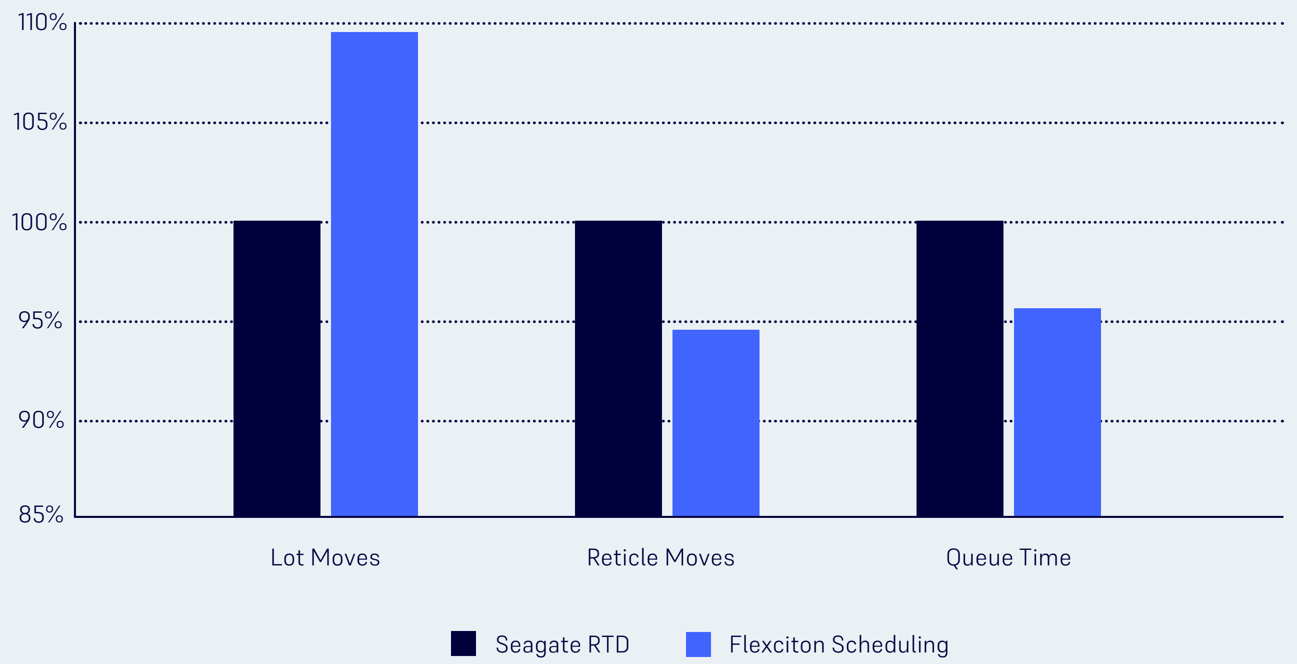
In this particular case, the core objective across all tools is to reduce the priority weighted cycle time of the wafers, which is defined as the time it takes from their arrival on the rack at the machine to the time when it has finished processing. We use priority weighting to reduce the cycle time of a high priority wafer over a low priority wafer. For example, if a high priority wafer is weighted as over twice as important as a low priority wafer, the scheduler might increase the cycle time of the low priority wafer by 2 hours in order to save 1 hour of cycle time for the high priority wafer. However, it can result in too many small batches, which are difficult for the operators to manage. To avoid this, we added an additional term to reduce the number of batches we build. We can weight the importance of the batch size term against our overall objective in order to balance the reduction of cycle time with batch size.

Finally, we added a term for the number of reticle moves so that there is a cost associated each time we move a reticle between machines or to its storage. In practice, this trade-off works by allowing the user to select to what degree they would like to prioritise cycle time over reticle moves and vice versa. If a fab wants to prioritise cycle time, then the scheduler will allow more reticle moves in order for wafers to be processed as quickly as possible. If a fab heavily prioritises reducing reticle moves, then only unavoidable moves will take place, which will have a negative impact on cycle time.

Results

Since deploying this model onto one of the photolithography toolsets at Seagate, we have seen incredibly encouraging results. The toolset had a 9.4% increase in throughput whilst reticle moves were reduced by 5.3%. These improvements mean

Figure 2: the results of applying Flexciton to the photolithography area at Seagate.



that Seagate have been able to significantly increase the number of wafer moves through this important area of the fab whilst also reducing the risk of costly reticle breakages. Furthermore, the toolset also saw a 4.3% reduction in queue time *despite* the increase in throughput (Figure 2). These KPIs represent significant gains for the Springtown wafer fab in their search for more capacity, and Seagate will next look towards deploying Flexciton 24/7 on all of the remaining tools in the photolithography area. This is expected to provide a positive step change in cycle time and throughput KPIs for the entire facility.

About Flexciton

Flexciton is applying cutting-edge technology to optimise the world's most complex manufacturing process – semiconductor wafer fabrication. Utilising 10 years of academic research, their engineers have developed a hybrid-optimisation model that solves production scheduling problems that were previously unsolvable.

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About Seagate

Seagate Technologies has provided innovative, precision-engineered data solutions for over 40 years and is the leading provider of bytes globally – with over 3 zettabytes1 of data shipped.

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