

## Technology Is No Longer King

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For more than 40 years, the semiconductor industry has been ruled by Moore's Law and the drive toward smaller, faster, better chips. But, while technology has not lost its significance, the new imperative is to reduce cycle time and improve productivity. As Areih Lev Greenberg, senior principle at Qimonda AG (Munich, Germany) emphasized in his keynote address at the 18th Annual Advanced Semiconductor Manufacturing Conference (ASMC) in Stresa, Italy, last Tuesday, to stay competitive, short cycle time manufacturing is where it's at. "In a current fab, introduction of new technologies can increase cycle time by 30%," Greenberg said. "Priority number one in the industry has to be reducing cycle time."

He suggested that no less than a paradigm shift is underway in the manner in which fabs are set up and operated, which is requiring drastic changes at the tool level, automated material handling system (AMHS), dispatching and scheduling levels. Perhaps most significant to realizing the throughput and cycle time changes that he and others envision in the factory of the future is the substantial changes that must take place at the tool design level. "You can't tell me that when one module in a cluster tool goes down the whole system doesn't go down," Greenberg said, calling for simpler, smaller tools that require less maintenance.

"Problems such as low equipment availability and reliability, variation in parameters, high losses from batching and the low efficiency associated with inherently complicated tools are ridiculous, and can no longer be tolerated," Greenberg said. He talked about the impact from "batching" -- how, too many times, wafers in the whole lot are waiting for the rest of the lot to be processed. Tool setup times are also long.

There are also the logistics of managing at the fab level. "We have 1000 chambers to match, an increasing number of mask layers and the introduction of new materials," Greenberg said. He added that preventive maintenance is a must. "Just as you would not fly from Milano to London in a plane not maintained using preventive maintenance, and the time has come for semiconductor tools to start operating more cost-effectively."

One of the key factors to consider is a standard lot size change.

Many people today are advocating that rather than the 13-wafer FOUP that the industry currently uses for 300 mm, an eight-wafer batch might be more economical, especially for fabs with high product mixes. Even a 12-wafer batch makes more sense. Greenberg said the next-generation needs for short cycle time with high product mixes calls for selective minibatch processing (perhaps 25 wafers), perhaps different lot sizes in a fab, or all single-wafer processing, depending on the fab and its specific needs. One change that could significantly increase throughput would be by shortening lot-to-lot setup time.

He added that traceability between wafers, parts and assemblies is needed. In addition, the manufacturing flow must be synchronized with scheduling.

Fabs also need the ability to redirect wafers to any carrier or tool. Greenberg suggested that the reticles should share the same delivery system as the wafers for maximum efficiency.

Reticle delivery in a high product mix fab can be the limiter to cycle time, especially as tool throughput increases. A focus on increasing the delivery efficiency of reticles can speed overall cycle time. Greenberg broke down key areas where cycle time could be increased. He estimated that operational efficiency, driven by fab efforts, could be increased by ~24%. He said that profound bottlenecks in the fab could be reduced, which account for ~17%. Next he detailed areas that affect the fab and tool suppliers. A transition to single-wafer processing or minibatch could reduce cycle time by 9%. By going to a lot size of 12 wafers, cycle time could be reduced by 10%. Next-generation fab changes, the most ambitious of all, could result in a 22% reduction in cycle time.

Factory of future will be 300 mm

Has the 450 mm wafer argument been put to bed? Of course not. Greenberg said that it is very important for the industry to discuss and debate 450 mm wafers at meetings such as ASMC. However, he conceded, as did many others at the conference, that scant resources are probably best spent improving the productivity of 200 and 300 mm fab facilities, while delaying 450 mm implementation, scheduled for 2012, according to the International Technology Roadmap for Semiconductors (ITRS).

A second keynote speaker at ASMC, Iddo Hadar, chief technology officer of foundation engineering at Applied Materials (Santa Clara, Calif.), agreed that accelerating productivity of 300 mm is more important than looking to the next wafer size. "Wafer scale-up is the single most risky change a fab can make," Hadar said.

He outlined the three most important goals of 300 mm Prime: cut the losses that exist between tool throughput and fab throughput; reduce the use of resources (water, power, etc.) in fabs; and reduce non-productive wafer time. Hadar said that the current average percentage of time that a product wafer spends actually being processed is only 10%. Despite industry awareness and improvements in individual tool throughputs over the years, this metric does not seem to have risen much since the early days of Sematech, when the consortium showed that average equipment effectiveness in fabs was only ~30%.

With a focus on improving the productivity, efficiency and cost-effectiveness of fab operations, ASMC is now hitting at the core of what will help keep semiconductor manufacturers and its suppliers competitive. "We tried to go after innovation in the initial designs of 300 mm fabs," Hadar explained. But, he concedes, drastic improvements are still needed. "We need to pursue revolutionary changes to get the benefits of efficiency and productivity that are needed. This is a new way for companies to differentiate themselves."

From the tool side, he suggested a move to small lot manufacturing and smarter, more flexible tools. Certainly, if Applied Materials makes a move to redesign its tools for significantly higher productivity, it could drastically impact the industry. We will see in the months to come what the products of 300 mm Prime will be.