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In our industry, an increasing number of substrates are deviating from the SEMI standard for silicon wafers. For example, reconstituted wafers for fan-out wafer-level-packaging applications show high warpages, and materials for the RF-MEMS area like lithium niobate ($LiNbO_3$) or lithium tantalate ($LiTaO_3$) are very brittle and tend to break easily. These new challenges are being addressed by novel handling solutions where robot end effectors or vacuum chucks are designed to tolerate higher substrate warpage. Nevertheless, especially with these non-standard materials, handling failures cannot be entirely avoided. Until now, typically the tool will stop any substrate transfers upon a handling error and the intervention of an operator is required to resolve the issue. Not only does this require highly trained and experienced personnel, it also leads to a loss of throughput. Even worse, scrap rates can also increase since during a complete handling stop substrates might stay in process stations for too long and become damaged. A typical example is overbaking in a hotplate with coatings that cannot be stripped afterwards.

SUSS tools are capable of using two different scheduling strategies. Depending on process requirements, either a fixed deterministic pattern can be used to ensure stable process timings (cyclic dispatcher mode), or a powerful and optimized scheduling algorithm can be chosen which adapts itself to the current status of the machine (Decision On the Fly dispatcher mode) and which provides the ability to run different sequences in parallel.

SUSS MicroTec has now further developed its leading Decision On the Fly scheduling algorithm by adding advanced error recovery functionalities. A handling error is typically detected by missing vacuum. Either after putting the wafer to e.g. a coater chuck (PUT), or after getting the wafer out of a module (GET) the vacuum on the chuck or end effector cannot be built up to a high enough level to be detected. The machine software interprets this as a lost substrate. Since the substrate might be still there but is just not detectable by vacuum (e.g. due to a high bow of the substrate and therefore a vacuum leak), the robot will perform a couple of safe moves with the new algorithms, and then continue processing the rest of the wafers currently in process.

First consider a single arm robot machine. In case of a PUT failure, the robot will then perform a PUT to a buffer station, just in case the wafer is still actually on the robot end effector. The same error handling will happen on a GET fail. The machine will assume that there is still a substrate on the end effector and transfer it to a buffer station. The machine will stop transferring any new substrates into the machine but as the end effector is available again, it can finish the substrates already started processing. The process module that was involved in the handling error is not used for finishing the substrates left and can be inspected afterwards.

Figure 1 *ACS200 Gen3*

In the case of a machine with a dual arm robot, the algorithm takes it even one-step further. First, the robot end effector involved in the handling error is cleared as described before. Then not only the process module is paused but also the involved robot arm is blocked for further use. As the second arm is still fully available the machine keeps on finishing substrates as with a single arm robot. After all wafers in the process chain are finished, an operator or equipment engineer can check the tool status and bring it up into full production.

With the new advanced error recovery features, SUSS MicroTec takes its Decision On the Fly scheduling algorithms to the next level. The machines behave more intelligently and help to mitigate any effects from handling errors. Less operator intervention, reduced scrap rate and increased throughput are the benefits for every customer.

The new features are available during Q1 2020 on most SUSS machines using the MMC software platform. Various customized recovery scenarios can be easily configured.

Michael Brennen received a degree in Computer Science from the University of Vermont in 1987. After graduating he worked at several companies on technologies ranging from telecommunications to financial trading systems. He joined SUSS Microtec in 1997 as a Senior Software Engineer and has worked on numerous projects for the bonder and coater product lines since then, including being the software lead for the company's first automated bonding system.