THE GLUEBUSTER SUCCESS

In 2016, SUSS MicroTec Photomask Equipment, a leading supplier of photomask process equipment, engaged Eindhoven-based engineering and high-tech manufacturing specialist KMWE for support in developing its MaskTrack X GlueBuster process station. Following the successful completion of the initial project in 2018, SUSS MicroTec has now expanded the scope of its initial engagement with KMWE to include complete assembly of the MaskTrack X GlueBuster module.

Early 2018, SUSS MicroTec launched its new pellicle glue removal system, the MaskTrack X GlueBuster, to support the maintenance of 193i lithography photomasks. Pellicles are used to prevent particles from contaminating the pattern area of a lithography mask during transport, storage and use. These pellicles consist of thin membranes, which are transparent at the exposure wavelengths. The membranes are stretched across an aluminium frame, which is then glued-on to the mask surface.

While pellicles provide protection from exogenous particles, masks must still be re-cleaned from time to time. This is primarily due to contamination that grows on the mask surface around the pellicle frame and underneath the pellicle membrane. This contamination can originate from airborne molecular contamination, residual mask surface contamination and even outgassing of pellicle materials.

Prior to cleaning these masks, the used pellicles must be removed. This removal process typically leaves behind residual glue where the frame was once attached to the mask surface. Before a new pellicle may be installed, this residual glue must be removed without damaging the pattern area. In the past this was not possible, and removal of the glue residue was limited to highly aggressive chemicals. Today, elimination of these aggressive chemicals is possible following the development of the MaskTrack X GlueBuster.

The GlueBuster module is now available for stand-alone operation or it can also be clustered with the MaskTrack X photomask cleaning platform, which can perform a variety of fully-automated mask cleaning operations (Figure 1).

Localised cleaning

The MaskTrack X GlueBuster performs localised pellicle glue removal by combining tightly controlled physical forces with an innovative delivery method of specifically-selected chemicals. By acting on the glue residue itself, the process chemicals and its by-products are constrained to an area that lies outside of the pattern area, which serves to ensure its cleanliness and integrity. This localised approach also reduces the total volume and cost of process chemicals.

Track record

The GlueBuster is the outcome of a development project that started in 2016 to meet industry's demand for a solution to the pellicle glue removal problem. After the project was approved at SUSS, the decision was made to outsource engineering of the new process station while retaining some of the standard assemblies and architectures for the new module.

After evaluating various candidates, KMWE was selected due to its well-fitted expertise and excellent track record in the semiconductor and aerospace markets, its competences in mechanical design, value-add engineering, and its extensive manufacturing capabilities (CNC machining and additive manufacturing). SUSS also considered its past 10-year collaboration with KMWE in other projects, such as the re-engineering of a mask aligner which demonstrated KMWE's potential in generating designs and delivering products based on functional specifications.

EDITORIAL NOTE

This article was based on interviews with Davide Dattilo, process scientist and project manager at SUSS MicroTec Photomask Equipment, Martin Samayoa, jr. director at SUSS MicroTec, Maarten Coolen, sr. design engineer at KMWE, and Peter Veldkamp, account manager at KMWE.

1 *SUSS MicroTec's MaskTrack X photomask cleaning platform.*

Challenge

One of the requirements for the process station was a precise alignment of the mask's edges to the movement of a highly innovative process arm. Other requirements included integrating a compact multi-cavity media dispense and suck-back system, an adjustable contact force system, and a running wiper tape system to the process arm itself. Aside from the mechanical challenges, the engineering group at KMWE had to venture into other areas to complete the design, such as chemistry, ergonomics, health and safety. Figure 2 provides an impression of the complexity of the design, without going too much into detail, for confidentiality reasons.

Design topics

The main feature of the MaskTrack X GlueBuster system is containment of the cleaning action. This is not limited to the physical contact between the wiper tape and surface, but also pertains to the process chemistry and even the fumes in proximity to the process area. This was achieved by integrating a highly innovative nozzle which allows media dispense and suck-back surrounding the wiper tape.

The process arm itself is attached to a programmable X/Y-stage which is equipped with a programmable surface contact force control system. While the surface contact force has to be high enough to enable efficient cleaning, it must also be controlled within tight boundaries to avoid damaging the mask surface. The surface contact force is frequently monitored by a load-cell and automatically adjusted if needed. After removal of the residual glue along one edge of the mask, the chuck holding the substrate is rotated 90 degrees, to consecutively position all edges of the mask with respect to the cleaning head. This reduces the degrees of freedom and the complexity of the process arm design and motion control.

Another critical component is the nozzle for dispensing the process chemicals. Its design determines the maximum achievable cleaning speed. This required a special configuration for the flow distribution channels inside the nozzle, which could only be realised by additive manufacturing (AM). Based on prior experiences with the shared AddLab research facility, KMWE designed the nozzle and printed it in the AddFab printing factory (*www.addfab.nl*). The development process addressed issues such as the fragile nature of a thin-walled product and the required post-processing for achieving an acceptable surface roughness.

With exceptionally high cleanliness requirements, the process station incorporates 'clean' inox steel and technical polymer materials. To prevent friction that generates particle contamination, bearings and bushings were positioned as far from the process area as possible. The process area is also covered by a hood to provide a guarded, 'clean' environment which encompasses an opening for loading and unloading the masks. The hood also serves to confine chemical fumes if they would ever be present in this area, which is not the case in normal operation, provided they are evacuated by the suck-back function in the cleaning nozzle.

Partners

SUSS MicroTec

The SUSS MicroTec Group, headquartered in Garching, Germany, is a leading supplier of equipment and process solutions for micro-structuring applications with more than sixty years of engineering and manufacturing experience. The portfolio covers a comprehensive range of products and solutions for back-end lithography, wafer bonding and photomask processing, complemented by micro-optical components.

In close cooperation with research institutes and industry partners SUSS MicroTec contributes to the advancement of next-generation technologies such as 3D integration, EUV, and nanoimprint lithography, as well as key processes for WLP (wafer-level packaging), MEMS and LED manufacturing. With nearly 800 employees and a global infrastructure for applications and service, SUSS MicroTec supports more than 8,000 installed systems worldwide.

KMWE

Headquartered in Eindhoven, the Netherlands, KMWE is specialised in high-mix, low-volume, high-complexity products that involve machining of complex, functionally critical components, and high-quality (cleanroom) assembly and engineering of fully-tested mechatronic modules and systems for the aerospace & defence, semiconductor, medical and industrial markets. With over sixty years of experience, an international supplier network and more than 600 employees, KMWE is a global player with offices and partnerships in the Netherlands, Malaysia and India.

The capabilities of KMWE include engineering, machining, assembly of complex mechatronic systems in a cleanroom environment, additive manufacturing, sheet metal fabrication and thermal spraying.

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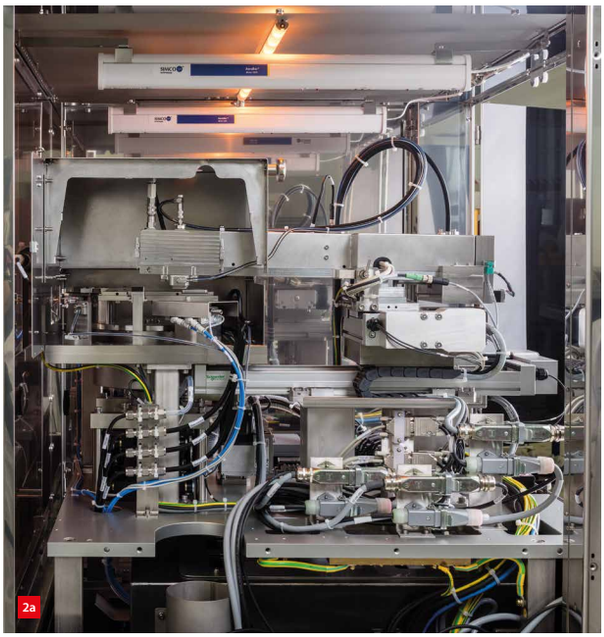

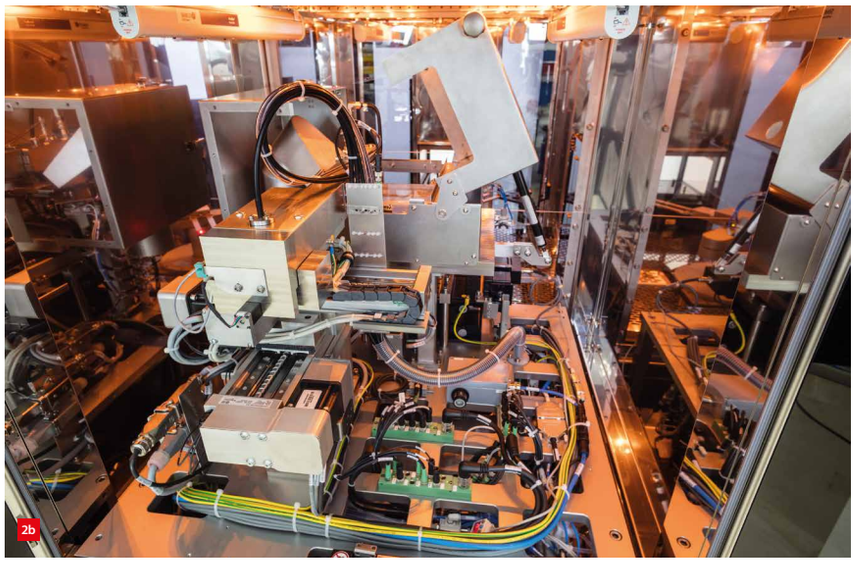

Close-ups of the MaskTrack X GlueBuster system.
(a) View of the process arm, engineered by KMWE, in the upper half of the photo, with the nozzle head on the left side.
(b) View of the X/Y-stage, which is used to position and move the nozzle as required to remove the pellicle glue residue without impacting the mask pattern area.

Another important design requirement was the operation of the cleaning wiper tape and the cassette from which it is dispensed. For moving the tape smoothly, in both directions, the effects of wetting and friction had to be taken into account. An innovative clamping mechanism featuring two spline axes was also designed, for rapid manual exchange of the tape cassettes.

Timeline

KMWE first engineered a functional alpha process station – a small-scale, table-top model comprising the mechanical parts of the process arm – which was delivered to SUSS in 2016, for preliminary testing and proof-of-concept. Based on the learnings from the alpha process station, a beta process station was then engineered in 2017 and assembled in close collaboration with SUSS. The beta module was later evaluated at a customer site in the USA. Most recently, a gamma process station, representing the first production-series version, has been delivered to SUSS for integration into the module. After final testing by SUSS, KMWE will complete the technical product documentation for the process station.

Future

At the time this article is being edited, three KMWE engineers are assisting SUSS engineers at its Sternenfels site with the assembly of a complete MaskTrack X Glue Buster photomask cleaning module (see Figure 3). This will provide KMWE the necessary experience and also assist in the creation of assembly documentation, covering the integration of the process station into the complete MaskTrack X GlueBuster module. KMWE may be contracted to assemble all future HVM MaskTrack X GlueBuster systems at one of its facilities, while pursuing continuous improvement and conducting value engineering to further enhance functional and cost performance.

This illustrates the close partnership and successful collaboration between SUSS and KMWE, which can be attributed to KMWE's technical capability and its ability to satisfy the customer's needs.

The SUSS-KMWE team at the SUSS MicroTec Photomask Equipment site in Sternenfels, Germany, working on the assembly of a MaskTrack X GlueBuster photomask cleaning platform.