ASML AND MORE

Precision engineering is one of the foundations of the Dutch knowledge and innovation economy. This became clear once again on 10 and 11 November 2021, during the 20th edition of the Precision Fair, organised by Mikrocentrum. A record number of exhibitors, 320, presented their innovations to visitors. The focus was on the future of precision engineering, culminating in the keynotes by Jelm Franse of ASML and Prof. Cheng of Brunel University. Naturally, the present and the past also received ample attention: in the lecture programme, on the exhibition floor and at the 20 Years Precision Fair expo.

The huge importance of precision engineering to our rapidly changing society was the common thread during the Precision Fair 2021 (Figure 1). Over the past 20 years, the fair has grown into the annual meeting point for the high-tech industry, playing an important role in the Dutch, and increasingly also the European, high-tech ecosystem. Also, the Precision Fair's collaborations with Big Science projects have resulted and continue to result in a large number of assignments for business.

As usual, the industrial liaison offers from the Big Science projects presented recent developments and upcoming tenders. In one of the newer fair items, the Young Talent Pitch programme, young talents from the universities of technology, the universities of applied sciences and the Leidse instrumentmakers School presented their innovative high-tech projects to the public. Belgium was this year's partner country, while Enterprise Europe Network organised another international Meet & Match in collaboration with Mikrocentrum.

Precision engineering challenges

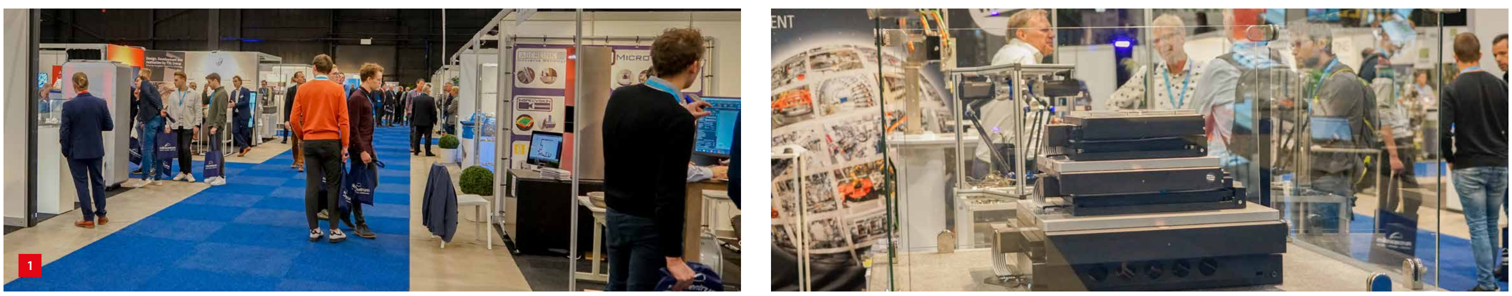
Jelm Franse, senior director Mechanics at market-leading lithography machine builder ASML, delivered a keynote lecture about ASML's precision engineering challenges. Franse (Figure 2) discussed current topics, trends, barriers and urgent breakthroughs that need to investigated. Driven by Moore's law (the ongoing shrinkage of IC features), ASML's product performance roadmap for its lithography machines, regarding overlay, throughput and image quality, requires ever more accurate and faster movements, as well as more accurate and stable optical imaging capability, which must be achieved with modules and parts that exhibit low or even no wear. The overlay and throughput requirements are driving precision mechanics and mechatronics solutions from micrometer to nanometer and picometer regimes.

It all starts with applying the right design principles. Referring to a presentation of a 2025 update by precision engineering professors from the Dutch universities of technology, delivered at the Precision Fair 2019, Franse gave an overview of the 'ten commandments' of design principles for accuracy and repeatability:

- Kinematics design.
- Design for stiffness.
- Design for lightweight.
- Design for damping.
- Design for symmetry.
- Design for low hysteresis.
- Design for stability (long-term effects).
- Design for low sensitivity (short-term effects).
- Design for load compensation.
- Design for minimal complexity.

These design principles are applied to numerous (sub) modules and parts, in each case to enable one or more of the four types of precision engineering patterns that can be discerned within ASML machines, as summarised by Franse:

- Fast and precise motion, to be achieved with, for example, the wafer and the reticle stage.
- Stability and standstill, required for the metroframe, mechanical frames, and sensing and measuring modules.



1

The 20th edition of the Precision Fair was held in a new, Covid-19-safe location: the Brabanthallen in Den Bosch (NL). (Photos: Mikrocentrum / Susanne van Doornik)

- Accurate photon delivery, through the optical (sub) systems, from laser to tin droplet in the EUV source (for EUV light generation), as well as in the projection optics box within the machine.
- Careful handling, concerning the mounting and clamping of reticle and wafer, and the prevention of particle contamination (using, for example, the pellicle assembly mounted in front of the reticle).

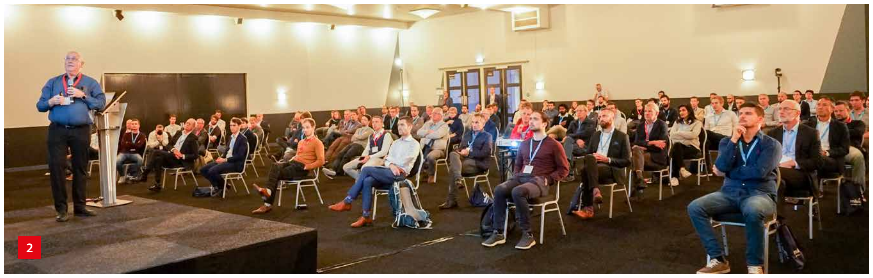
Next, Franse gave a casual overview of the gaps in the product performance roadmap and the required breakthroughs for each of the four patterns. These gaps range from thermal effects and micro-slip to defectivity and optics degradation. To address these gaps and create breakthroughs, ASML Development & Engineering has mastery of over 200 technical competences, including the aforementioned precision engineering principles, tribology and additive manufacturing, down to bolted components.

To illustrate the competence development required, Franse picked a few issues. The first one was concerned with the cable slab, which connects the fast-moving and accelerating wafer stage with the fixed outside world. This cable slab affects system performance by introducing disturbance forces on the short stroke of the wafer stage. In addition, the continuous deformation of the cable slab causes wear and hence particle generation by cables, hoses, clamps, end-stops and O-rings. In the end, this contamination leads to defectivity issues with the wafers produced in the machine.

The cable slab issue is part of the general dynamic links challenge. The number of dynamic links, for water, gases, vacuum, data and electric power, increases with each new machine generation, adding to the problem of unwanted forces (disturbances) that can be transmitted. This goes as far as the cooling-water flow inducing unwanted vibrations in the system.

A nice design principle example presented by Franse involved the well-known elastic elements. These are used in flexure supports that have to deal with large deflections in the newest machines, leading to a decrease of stiffness and fatigue problems. In collaboration with Delft University of Technology, ASML is investigating metamaterial- and origami-based beam flexures, for achieving large deflections with high support stiffness.

Franse also discussed a 'new' design principle. Until recently, damping was discarded because of the risk of position uncertainty due to hysteresis. But now, as the ever-higher control bandwidths required can no longer be achieved with the conventional stiff, lightweight design, passive damping comes to the rescue. At Eindhoven University of Technology, part-time professor Hans Vermeulen, senior principal architect EUV optics system at ASML, is conducting research on passive damping.



Jelm Franse of ASML delivering his keynote lecture. The photo shows only half of one lecture room; two other lecture rooms were filled with Precision Fair visitors following the presentation via a video link.

To conclude, Franse talked about the manufacturing challenges for producing precision parts in hard materials. He has high hopes for PECM (precision electrochemical machining), as it combines the advantages of conventional milling and EDM (electrical discharge machining). It is a relatively fast and low-cost process, which is non-contact (no tool wear) and burl-free (no defectivity issues), introduces no mechanically or thermally induced stresses in the product, and involves no copper (as with EDM), which is forbidden in the wafer area. According to Franse, PECM is an enabling technology for elastic elements as discussed above. Just to show that manufacturing technology, as an enabler for (new) design principles, is part of the future of precision engineering.

Ultraprecision machining

While Jelm Franse concluded his presentation with the manufacturing challenges of ASML, the keynote by Kai Cheng, professor in Manufacturing Systems at Brunel University, London (UK), was devoted entirely to ultra-precision machining. Prof. Cheng (Figure 3) discussed machines, systems and future perspectives for industrial-scale ultraprecision machining. This covered high-precision components and devices, such as ultraprecision machines, tooling, machining processes, in-process monitoring and measurement, and their seamless integration for forming ultra-precision manufacturing systems. In this way, Cheng combined the future of precision engineering with the future of manufacturing.

Prof. Cheng talking about future perspectives for ultraprecision machining.

INFORMATION
WWW.MIKROCENTRUM.NL
WWW.PRECISIEBEURS.NL