Case Study: Lithography Machine Wafer Stage

Additive Industries

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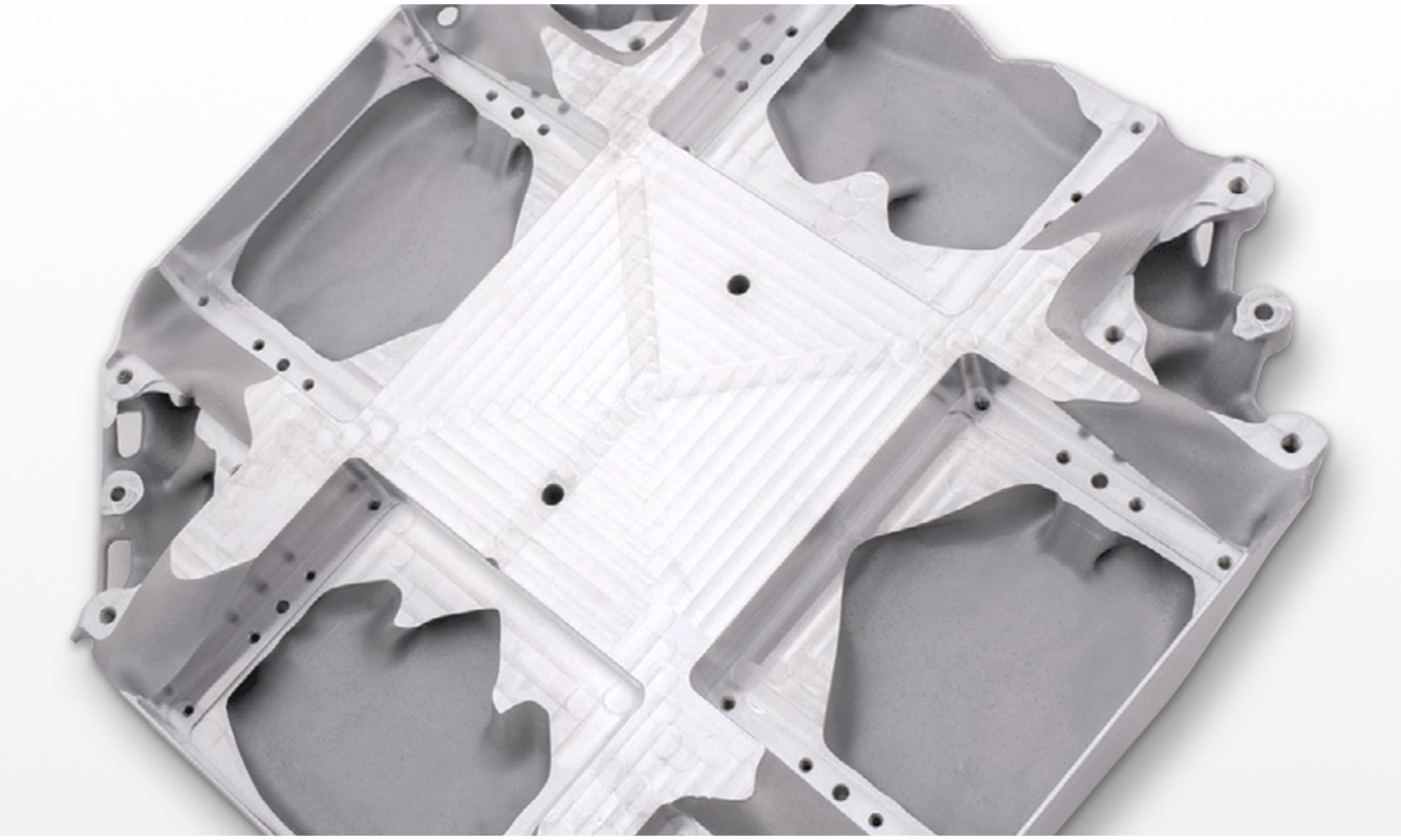
Case Study | High-Tech Sector
Lithography Machine Wafer Stage

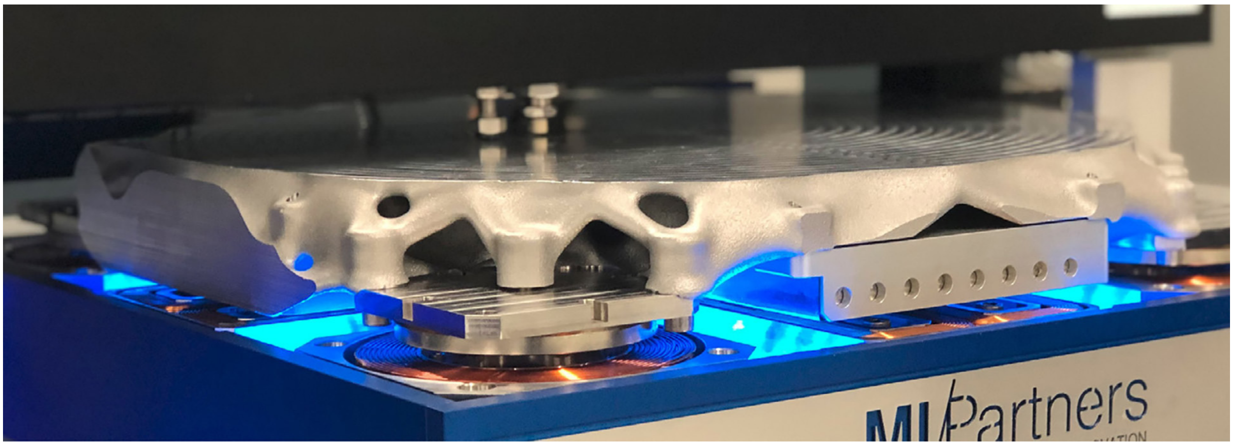
MetalFab technology used to produce topologically optimised components for high precision motion systems



ASML TU Delft MI Partners nexperia infinite NWO

Lithography Machine Wafer Stage

A collaboration between Additive Industries, ASML, Delft University of Technology, MI-Partners, Nexperia, Infinite Simulation Systems and supported by NWO (Dutch Research Council) has used the MetalFab system to manufacture wafer stage components for semiconductor equipment.



Introduction

The wafer stage is a crucial component in the semiconductor chip manufacturing process – part of a high precision motion system used in the positioning of wafers in the lithography process equipment. The accuracy and speed of movement are critical for productivity, however this must be balanced against the mechanical vibrations which can be introduced, negatively impacting the outcome. The design must address the delicate balance between stiffness and mass which drives performance. Further to this, the demands on time to market are always increasing therefore any time saved in the design process is advantageous.

The move to an automated topological design process from a manual approach will help to reduce this time to market, whilst also offer new opportunities in the engineering design where the optimisation of stiffness and mass can be tailored and iterated in very short cycle times.

Process

The topological design process is carried out taking into account the key structural and mass requirements along with all of the key manufacturing steps and constraints such as overhang limitation and minimum feature size as well as heat treatment, milling and assembly. Following the cycle of FEA, simulation, design interpretation and CAD geometry output it was demonstrated that an optimised design can be created in a single day. Further iterations of optimisation can subsequently be carried out to gain a further desirable outcome.

The full details of this approach are detailed extensively in the published paper found at https://www.sciencedirect.com/science/article/pii/S2214860422004031.

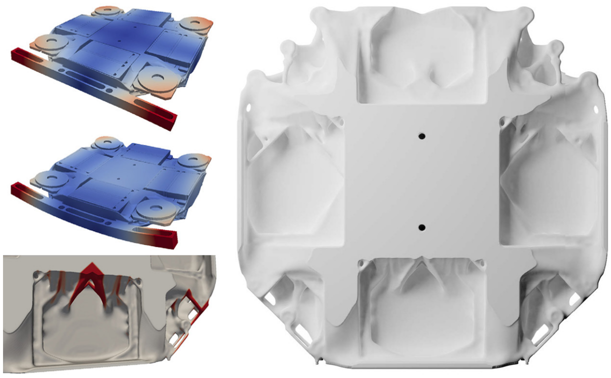


Figure 1 - Finite element analysis & topology optimisation output

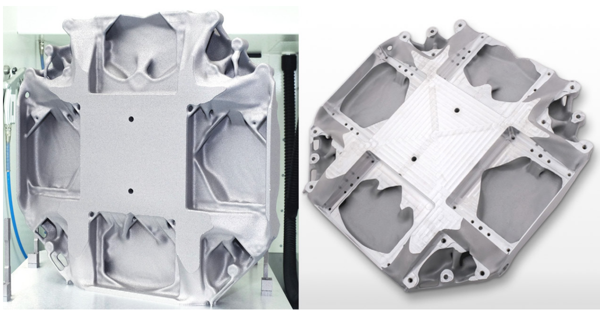


Figure 2 - Parts on plate after production in MetalFab / fully machined & post processed part

The parts are setup in optimal build orientation in the MetalFab Build Processor job preparation software, taking advantage of the 420 × 420 × 400mm available build extents. There is no requirement for additional supporting structures due to the AM build constraints being an input in the topological design process. For this particular case, two parts were required for the necessary test program, however it is possible to fit up to 6 parts on a single plate if needed. Due to the full scan field capability of the 4 x 500W lasers on the MetalFab system good productivity would be achieved with high efficiency of laser utilisation per layer.

They are then produced in Aluminium alloy AlSi10Mg, using Additive Industries 'quality' parameter set to balance material quality, surface finish, accuracy and productivity, with a direct attachment to the MetalFab base plate and minimal material stock added for the wire EDM separation process. Parts are stress relieved to ensure geometric accuracy before separation from the build substrate plate, ahead of final machining of key interfaces.

Results

The final machined wafer stages weigh 8.5kg each, and during physical testing are shown to achieve superior performance to the conventional design - a performance improvement of around 15%. Also it was shown that during experimental validation the optimized design was measured within 1% accuracy of the simulated performance.

Conclusion

The outcome of this study also opens many opportunities for this workflow to be executed in a wide range of high-tech dynamic systems applications. Not only has the expected improved performance been achieved and shown to correlate with the simulations carried out within the analysis phase, but also the simulation and optimised manufacturing considerations have been proven effective in production of the parts.

Further, when this approach is employed on a system level there is great oppotunity to achieve wider ranging improvements in performance.

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At Additive Industries, our objective is the success of our customers in achieving the lowest cost per part at market leading part quality.

We pride ourselves on our flexibility to work with our MetalFab users in achieving their industrial goals.

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