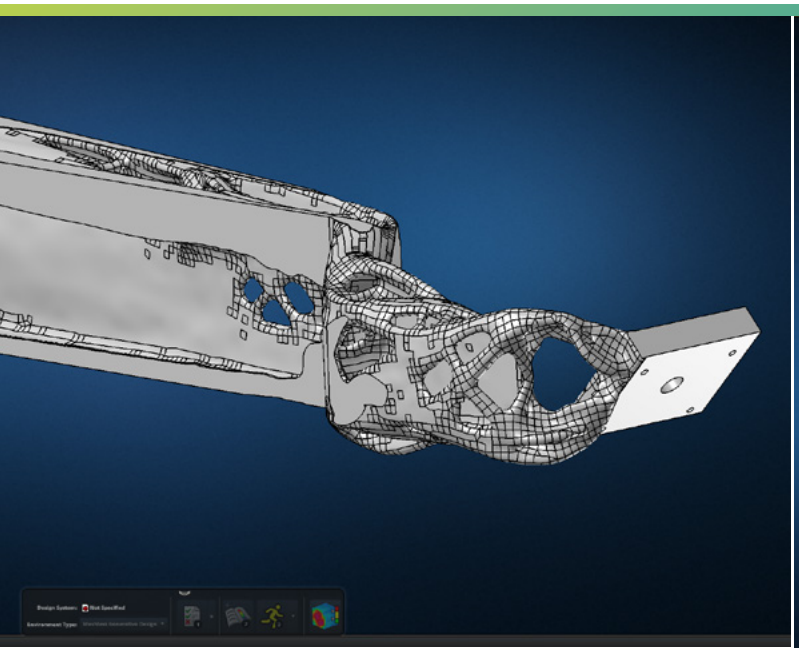
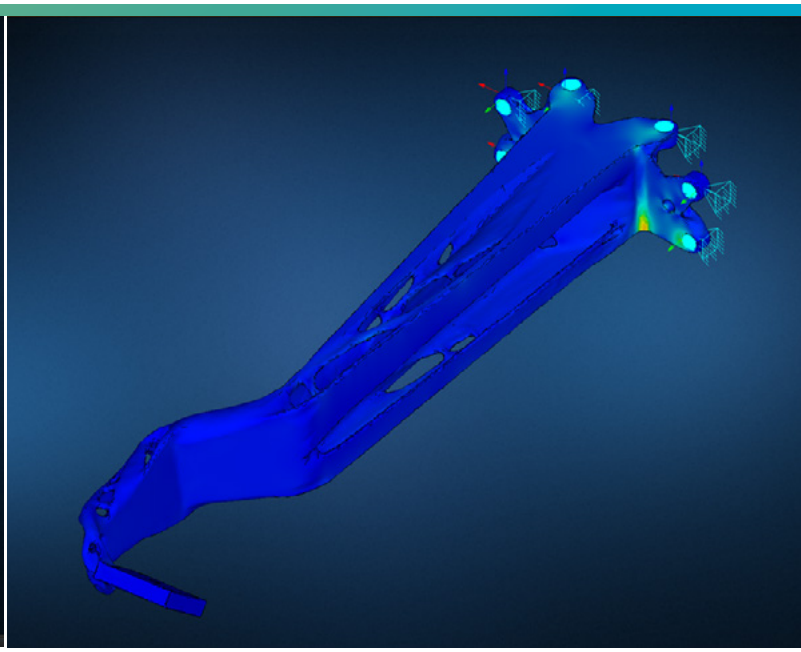
HEXAGON | MSC Software

Case study

Optimizing semiconductor production hardware

Utilizing generative design computing to drive future computing power by ensuring high quality and high performance manufacturing

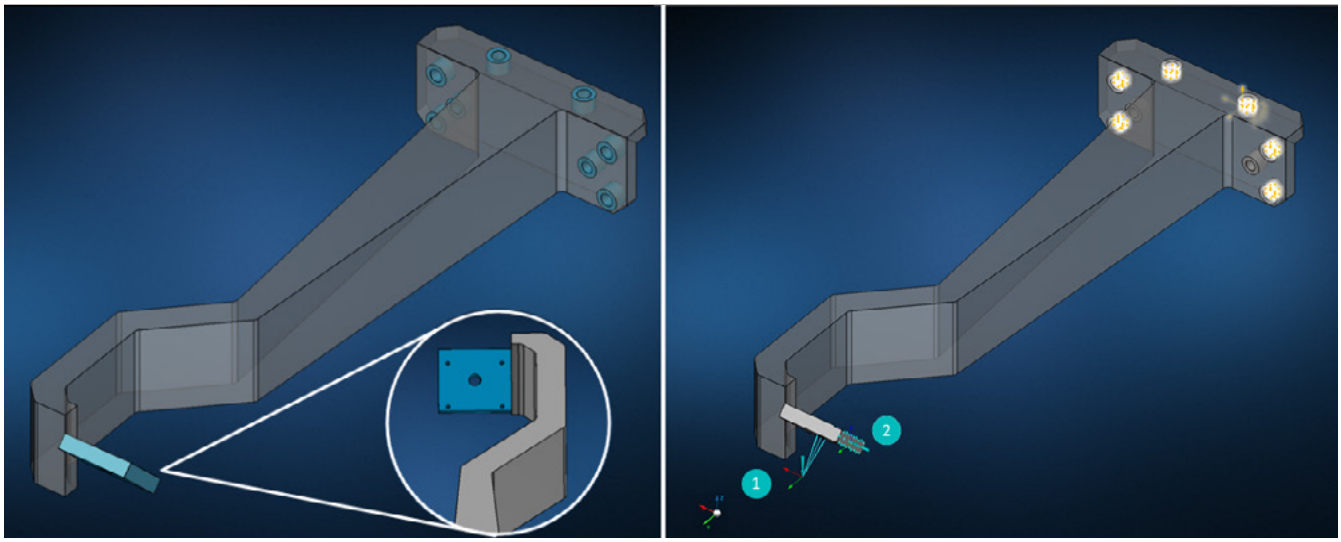




To increase computing power, the semiconductor industry has to find ways to downsize the electronic components further and further. A new generation of metrology tools is required to control the performance of the production in the nanometer range. To do so, MSC Apex Generative Design has been applied to create new designs.

Today, simulation is a key driver of further technological enhancements. This has been fostered by a major increase in computing power in recent years, enabling the creation of more realistic simulations, reducing calculation times and exploring different scenarios without much effort to arrive at advanced innovations. The electronic components must be downsized more and more in order to increase computing power.

In recent years, the semiconductor industry has taken one big step forward in this process with the development of extreme ultraviolet light (EUV) lithography, pushing the wavelength from 193-nanometer light to just 13.5 nanometers – a completely new dimension. This focused light is then used to erode and coat different layers from and to a silicon wafer. This creates a specific electric characteristic that will ultimately make up the next generation computer chip. Laser systems are the essential part of this coating process, and it must always be ensured that they are in their exact position.



Optimization model with design space and stress based simulation with very homogenous stress distribution

Thus, the new processing facilities require a new generation of metrology tools, which make it possible to control the optical performance of EUV lithography components in the nanometer range. RI Research Instrument supplies the right tools to major players in the semiconductor industry, which comply with the requirements for precision and cleanliness essential for EUV lithography. To create this new generation of tools, a consultancy project with TRUMPF – a pioneer in the field of AM with 20 years of experience – in cooperation with MSC Software was initiated to optimize and manufacture a metrology component.

Optimization requirements of the sensor arm

One part of an EUV qualification is the so-called sensor arm. Sensors are mounted on a plate positioned at an angle of a long arm extending from the primary structure into the measurement chamber. The arm has an “L-shaped” mounting, and with the self-weight of the sensor there is only one load case to be considered. The goal of optimization is to achieve a design which is lightweight and thus inexpensive to manufacture, as well as to maximize the stiffness of the overall structure. In addition to this, the first Eigenfrequency shall be maximized.

Further requirements are made for the shape of the geometry: viewed from the side of the structure, the surface shall be minimal. As no foreign particles are allowed to contaminate the highly sensitive equipment, consequently cleaning the core elements of the qualification tool is also hugely important. Therefore, the geometry shall not have small gaps or thin undercuts which are difficult to clean. Given these objectives, the part’s structural analysis for the actual optimization was started.

First, an analysis of the original part design was conducted using MSC Apex Structures to retrieve the values for displacement, stress and first Eigenfrequency. With the comprehensive tools of MSC Apex Structures this was easily obtained and is for comparison. Then the first optimization with MSC Apex Generative Design was prepared.

Given the original geometry, the model for the optimization was set up quickly. The design space was defined with a few clicks, the non-design spaces for the mounting was reduced to only small bolts in order to maximize the design freedom for the optimization. Steel was chosen as the first material to test. The overall model was defined in less than 10 minutes.

Applying different materials for generative design

The result for the steel material only achieved a small reduction in weight, the stiffness increased by a factor of five. Another run was conducted with the aluminum alloy AlSi10Mg. Here, another load case was applied to the optimization with a load pushing from the side against the plate. This intended to increase stiffness and thus also drive the first Eigenfrequency upwards.

The result was much better than before: The weight was reduced by 42% for the original part design, from 1,227g to only 711g. Another optimization was started in order to check whether a titanium alloy may be even better owing to a higher material stiffness, but since it is much heavier, it could not beat the aluminum geometry. In order to validate the values and the overall geometry, the optimized structure was checked again with MSC Apex Structures. With the new Nurbs functionality of MSC Apex Generative Design, the bionic result generated was transferred with the mesh-to-CAD feature to solid Nurbs, making it easy to

Key highlights:
Product: MSC Apex Generative Design
Industry: Electronics
Benefits:
More lightweight and higher stiffness
Good to manufacture
Less shading in the lithography chamber

import and process the optimization result in MSC Apex Structures. The analysis obtained excellent improvements: alongside the 42% weight reduction, the optimized structure increased in stiffness by 400% and exhibited an increase of 105% for the first Eigenfrequency.

The manufacturability was checked with Simufact Additive. The orientation assistant suggested placing the part in a straight position with a slight angle. Due to the long dimension of the arm, this is necessary to fit into the build chamber of the manufacturing machine.

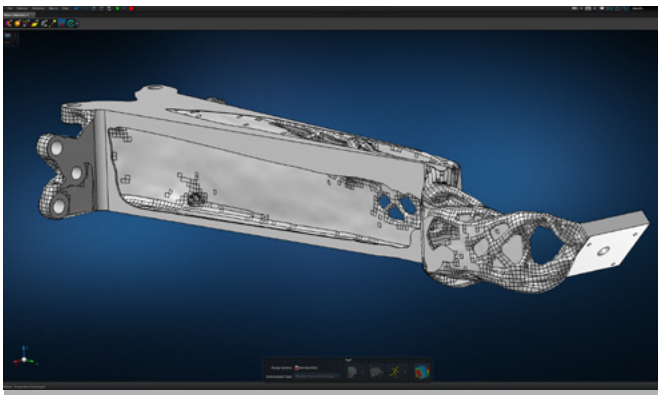
The TruPrint 3000 by TRUMPF is ideal for this task, being a universal medium-format machine with industrial part and powder management, designed for flexible series production of complex, metal components using 3D printing. And the simulation also guarantees that no support structure is built upon the part itself. The support structure is further optimized by the software, and further analysis is performed to achieve a perfect print result without any manufacturing issues. The production is scheduled to take place in the last quarter of 2020 with a subsequent installation and test of the new design.

Integrated workflow for FEA validation and production

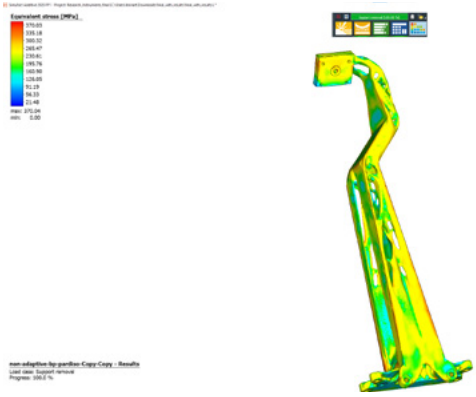
The production of high-end semiconductors is among the most advanced technological challenges, but it is also the enabler of tomorrow's technologies. It is only logical to apply the chip-enabled high computing power to improve the production of themselves. Generative design utilizes this computing power to generate different, optimized structures for a certain design challenge.

A significant improvement was gained by applying MSC Apex Generative Design to the optimization of a sensor arm of an EUV metrology tool. The good data communication between virtual design and the manufacturing simulation of MSC Software's additive workflow generated a better part design overall without much effort.

A significant improvement in all relevant objectives was achieved, increasing the performance of EUV metrology tools – making more powerful chips possible for even better simulations in the future.



MSC Apex Generative Design transitioning of the optimization result to Nurbs for an easy processing with MSC Apex Structures



Manufacturing simulation with Simufact Additive to optimize for the manufacturing with TruPrint 3000

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Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

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