Fraunhofer ILT

RWTH AACHEN UNIVERSITY

FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

DIGITAL PHOTONIC PRODUCTION

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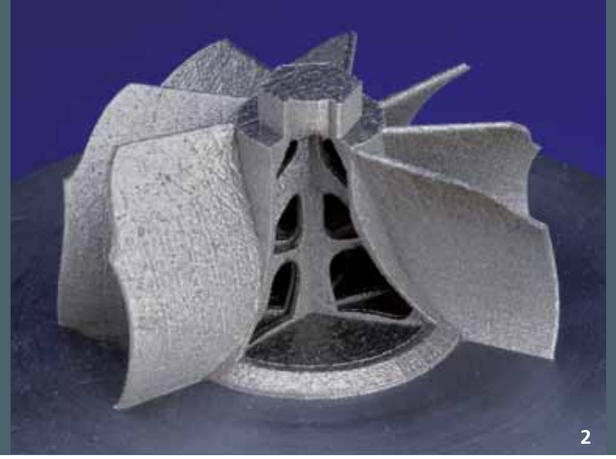

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TAILOR-MADE SOLUTIONS IN SERIES

Trends and Challenges of Modern Production

For commercial enterprises, production conditions are subject to constant change, as are the products themselves. Not only do customers demand more and more complex products, but tailor-made ones as well. In some branches, the number of pieces ordered ranges from many thousand to the lot size of one. Under the pressure of optimizing business processes economically, constructors and those responsible for production are encouraged to dimension and manufacture components as individual and, at the same time, as inexpensive as possible. This is true for the aerospace or the automobile industry, where weight savings are becoming more and more important to reduce fuel consumption as well as to fulfill customer's wishes. To accomplish economies of scale, many components today are oversized. The challenge consists in dimensioning these components to bear their actual loads, which classically, however, has always proceeded along with an increase in complexity. Digital Photonic Production (DPP) will allow users the ability to create components related to their function but without increasing production costs. An example is the tailor-made component for the aerospace industry.

In medical technology, the trend is also moving toward individuality. In demand are, for example, implants specially adapted to an individual patient. This requires more complex parts, which have to be produced in the lot size of one at justifiable costs. New materials, such as those that can be resorbed by the body, also require high flexibility in production processes. Whether in medical technology or in airplane construction, expensive components are produced predominantly using conventional processes. These techniques can, in part, produce up to 90% waste. In addition to avoiding such wastage, some are calling for the industry to sustainably deal with available resources, leading them to rethink the production process itself.

The end customer has also become more discerning and is now demanding more individual products with which he can stand out from the rest. In an ideal case, he would like to design his own component before ordering it, as, for example, a piece of jewelry. On the manufacturer's side, this necessarily leads to an increase of product complexity and to a higher flexibility in production. The conventional, mostly mechanical processing and the standardized production steps come up upon their limits here – technologically as well as economically.

Individual and series production are growing together, on their way toward a fourth industrial revolution, as are the open virtual and real producing worlds. The tool »light« represents the connecting member between both of these worlds. Digital Photonic Production offers the customer the ability to participate actively in both the creation and production processes. Thanks to the laser, products that have been designed and optimized on a computer can be produced in series and at justifiable costs.

1 Individualized dental prosthesis made with Selective Laser Melting.
2 Complex component geometries in small lot sizes.
3 Mold insert for injection molds with conformal cooling channels and copper core.

Digital Photonic Production – Complexity and Individualization for Free

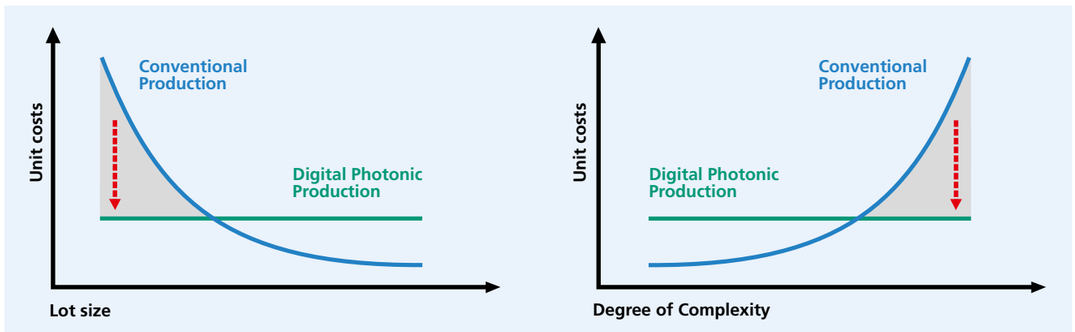
In industrial practice, the production costs of a work piece increase with its complexity and its uniqueness. The different processes of Digital Photonic Production face up to this difficulty of scale-to-scope by creating constant unit costs for each component as a unique part – independent of complexity and lot size. Only the weight of the component and thus the material usage still determine the unit costs. Thus, work pieces can be produced immediately from the available CAD data when additive laser-based manufacturing processes are used. Higher unit costs, which incur in conventional production processes in the production of molds, for example, do not occur in DPP processes. This tool, light, is controlled flexibly, contact-free and specific to a component by a computer. The CAD information is transferred to the material by means of light: from bits to photons to atoms.

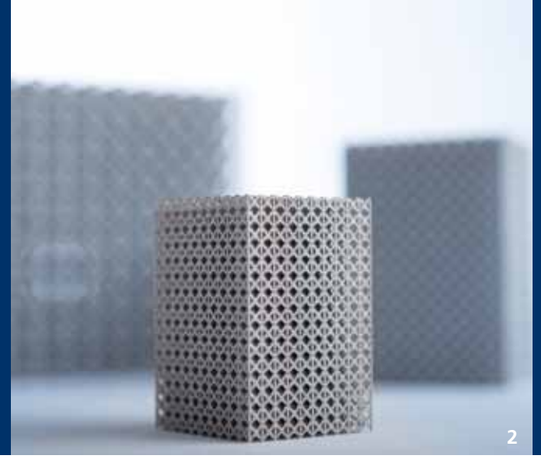
Digital Photonic Production – From Bits to Photons to Atoms

Laser-based production processes fulfill the market's requirements for higher component complexity and individualization at simultaneously attractive costs. Digital Photonic Production forms the »spearhead of evolution« for promising production processes. The Fraunhofer Institute for Laser Technology ILT has significantly prepared the way for this trend by developing Selective Laser Melting (SLM) as well as laser polishing and new laser processes for micro-processing. At the Fraunhofer ILT, Digital Photonic Production stands at the center of its industrial contract research and foundational initial research.

To shift the competitiveness of DPP with conventional production processes toward higher lot sizes, the system costs have to be reduced systematically. In DPP processes, an essential cost factor is the laser beam source within the machine tool. The Fraunhofer ILT is currently developing newer and less expensive laser beam sources, making the most modern manufacturing engineering available at an economical price. In this process, the Fraunhofer ILT is cooperating with leading laser manufacturers and specialized system suppliers. Laser users apply the know-how of the Fraunhofer ILT to raise the performance of their plants beyond the state of the art or to develop application-specific procedures, beam sources and systems.

The Fraunhofer ILT understands Digital Photonic Production as an integrated system – from the beam source to processing system and from material through the manufacturing process to the product itself.





DIGITAL PHOTONIC PRODUCTION – THE FUTURE OF PRODUCTION

Digital Photonic Production (DPP) stands for future and customer-oriented production. The Fraunhofer ILT is systematically pushing the additive and cladding DPP process forward. Successful pioneering work has already been accomplished in the sectors of medical technology, tool production and aircraft engineering in close partnership with industrial key players of each sector.

Additive DPP Processes

Additive processes can be used wherever complex component geometries, short reaction times and a method conserving resources are required. Among the innovative, multiple award-winning developments of the Fraunhofer ILT count Selective Laser Melting: Similar to a laser printer, which applies the stored data on a piece of paper in two dimensions, SLM generates the work piece in layers measuring a few micrometers and in three dimensions on the basis of CAD data. High-performance lasers melt the metal or ceramic powder and build the work piece layer by layer. In this way, highly complex geometrical components can be accomplished and an end product can be simultaneously individualized according to the needs of the customer. The products are generated 1:1 from the calculated construction data. For industrial applications, CAD drawings are used as data, and for medical-technological applications, data from computer tomography or other imaging processes are used.

For plastics, comparable rapid manufacturing processes have been in use for many years. For ceramic and metallic working materials, the long processing and production times have hindered their usage in industrial series production. With the beam sources and processes developed at the Fraunhofer ILT, additive laser processes are now profitable for these working materials. The high-speed plants developed in Aachen are ten times faster than conventional SLM systems. A further technology from this family of additive processes is laser cladding, which, for example, is used for producing and maintaining airplane turbines. In this sector, among the pioneering achievements of the Fraunhofer ILT counts the overhaul of blade-integrated disks. Thanks to laser cladding, it is no longer necessary to completely replace these highly expensive turbine parts. Industrial customers can thus open up entirely new business sectors – in the areas of maintenance, repair and overhaul – at marketable prices.

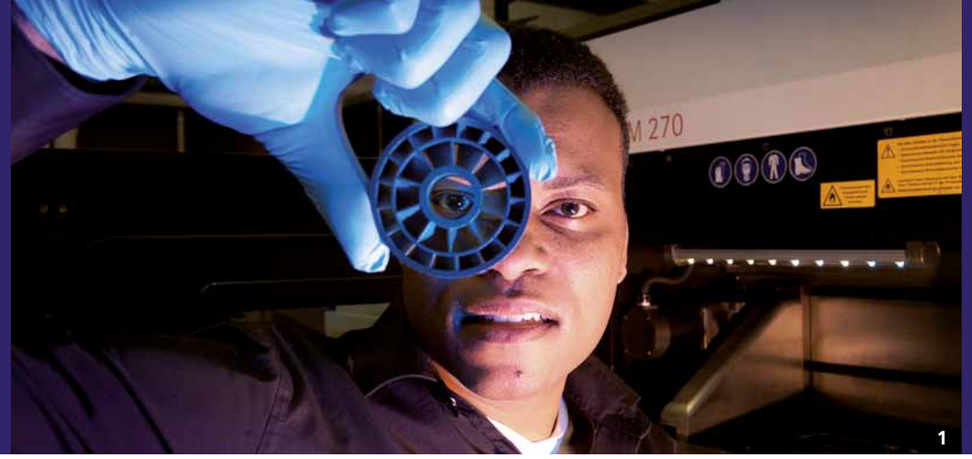
Digital Photonic Production enjoys advantages wherever it is a matter of individuality with simultaneous mass production, short reaction times and processes conserving working materials.

Ablating DPP Processes

Ablating DPP processes also connect the virtual with the real world. Instead of cladding material where it is intended in the CAD data, here material is removed – precisely, quickly and without molds. In order to meet the highest requirements upon precision, the Fraunhofer ILT is pushing the ultra-short pulse laser technology (USP) systematically forward. Laser pulses in the nano- or femtosecond regime (10^{-9} to 10^{-15} seconds) remove or modify the basic material on the surface of the work piece at high precision. The significant advantage of this technology lies in “cold processing”.
Different from the processes with continuous beam guidance, the working material is not heated around the processing location. Thermal effects and damages can thus be avoided as far as possible. With the ablating USP process, it is possible to process work pieces made of nearly all materials: plastics, hard metals, but also glass and ceramics. As with the additive processes, structures can be transferred from CAD data 1:1. The interior of translucent materials such as glass or plastic can also be processed (in-volume) with lasers. In addition, 3D structures and markings under the surface can be accomplished within a single operating cycle.

With this USP technology, new horizons open for customers working with surface treatment, in-volume structuring, or precision drilling. The Fraunhofer ILT provides holistic solutions that reach from planning to development and production all the way to test operation of new systems and prototype plants.

1 Complex micro component made with Selective Laser Melting.
2 Component with grid structure for ultra-light construction made with Selective Laser Melting.
3 Cutting glass with USP technology.
4 Homogeneous illumination of surfaces: the plastic component spread the incident light over micro lenses, which are produced by impression of tools structured by USP.



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FRAUNHOFER ILT – PARTNER OF INNOVATORS

With more than 420 employees and over 11,000 m² of usable floor space, the Fraunhofer ILT is one of the most important development and contract research institutes in the areas of laser development and laser application.

In more than 25 years of practical experience, the Fraunhofer ILT has acquired expertise recognized worldwide in the sectors of production-based laser technology. Around 400 patents in 25 years speak for the result of the creativity and innovative power of a highly specialized and motivated team of engineers and scientists.

Every year, the institute conducts several hundred research and development projects contracted by innovative companies. The certification according to DIN EN ISO 9001 ensures compliance of recognized quality standards. Moreover, the Fraunhofer ILT coordinates numerous national and international joint projects which act as a signal for many branches of the industry.

The institute develops flexible laser-based solutions for the manufacturing industry, in particular for challenging tasks. Numerous satisfied customers confirm the quality of the results and the excellent cooperation.

Thanks to its network in scientific as well as in industrial surroundings, the institute has access to cooperation partners in its own country as well as abroad, if required. The integration in the Fraunhofer Society – with more than 80 research facilities in Germany – ensures that high standards of quality are maintained when projects are carried out, including all contractual and proprietary questions.

Short decision paths put the motivated and dynamic team in the position of responding to the customers' requirements flexibly and quickly.

Digital Photonic Production Research Campus

The Aachen region has a density of research facilities seldom seen in Europe. At the top stands the excellent RWTH Aachen University. The Fraunhofer ILT has worked with several RWTH chairs and research areas for a long time.

On the RWTH Aachen Campus, one of the largest research landscapes in Europe for industrial-scientific cooperation is currently being built on 250,000 square meters in close proximity to the Fraunhofer ILT. One of the planned 19 research clusters on the RWTH Aachen campus is entirely dedicated to the topic »Digital Photonic Production« and is coordinated by Professor Reinhart Poprawe, director of the Fraunhofer ILT. Here, companies can set up business in their own offices, seminar and laboratory spaces and accomplish a new quality of cooperation with the RWTH Aachen University and research institutes such as the Fraunhofer ILT.

The technical and scientific equipment of the Fraunhofer ILT sets international standards. For example, the Fraunhofer ILT has one of the largest industrially relevant laser parks in Europe. Here, commercially available systems can be used for a wide variety of applications, as can highly specialized systems developed in house. In addition to established cutting and joining laser processes, the Fraunhofer ILT has access to modern laser plants for additive and ablating processes. Here, it offers its customers holistic solutions that contain the newest R&D innovations.

Tailor-Made Cooperation

The individual requirements of the customer are mirrored in the individual and flexible way the Fraunhofer ILT models its type of cooperation.

- Short-term cooperation: Bilateral R&D projects specific to a company are appropriate for a firmly limited task.
- Middle-term cooperation: Joint projects are directed at more basic questions of preliminary research. Several companies can work on a topic relevant to a branch along with the Fraunhofer ILT or the cooperating chairs of the RWTH Aachen University. If necessary, companies can make use of subsidies from the national ministries or the EU Commission.
- Long-term cooperation: For this, the Fraunhofer ILT offers its industry partners their own office and laboratory space within its building. This spin-in model has been implemented in 1985 and has been intensively used by close partners of the Fraunhofer ILT. Companies or research groups can also set up offices in the neighboring RWTH Aachen Campus, thereby taking further advantage of these services.

In diverse ways, the business partners can profit from cooperating with the Fraunhofer ILT in the Digital Photonic Production Research Campus:

- Access to personnel and infrastructure resources of the Fraunhofer ILT and the RWTH Aachen University.
- Access to the network and all services of the Fraunhofer-Gesellschaft.
- Short paths for research and development thanks to the proximity.
- A decisive head start in acquiring highly qualified young professionals.

1 Digital Photonic Production – the quick and efficient way to individualized components.

2 RWTH Aachen Campus – Options for innovative companies to settle in direct proximity to the Fraunhofer ILT and RWTH Aachen University.

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