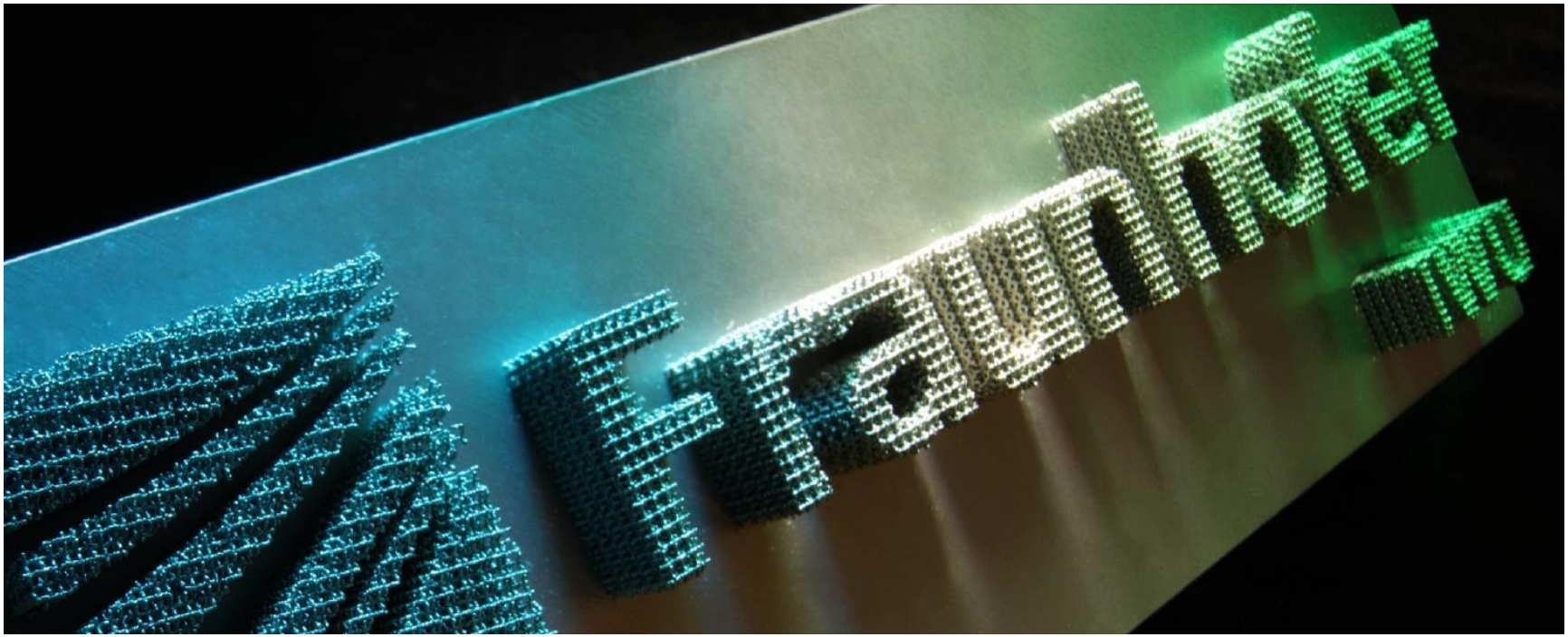
# MATERIAL EFFICIENCY
## POTENTIALS OF INNOVATIVE PRODUCTION METHODS

Dr.-Ing. Bernhard Mueller

Spokesman, Fraunhofer Additive Manufacturing Alliance

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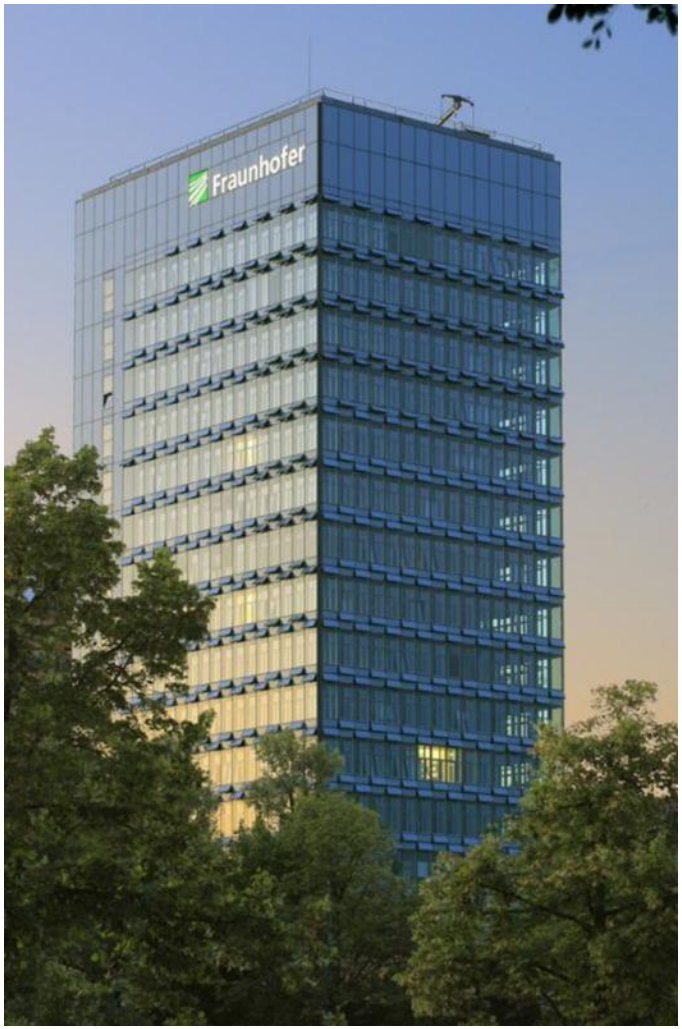
# The Fraunhofer-Gesellschaft




- Promotes and conducts applied research
- In an international context
- To benefit private and public enterprise
- Is an asset to society as a whole
- Our Customers
  - Industry
  - Service Sector
  - Public Administration

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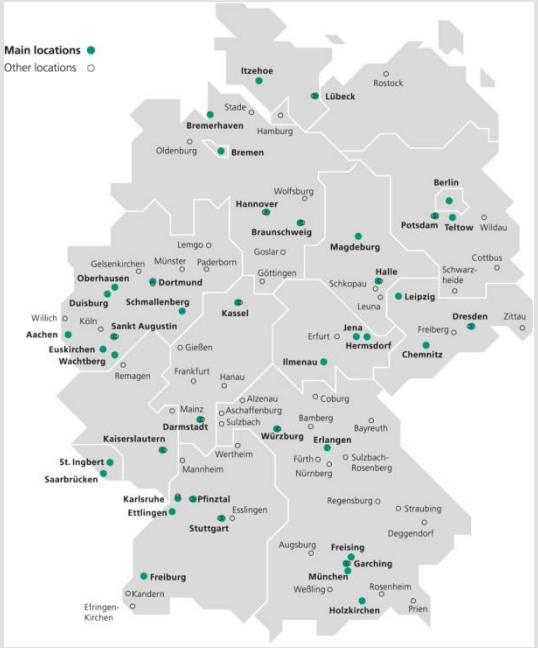
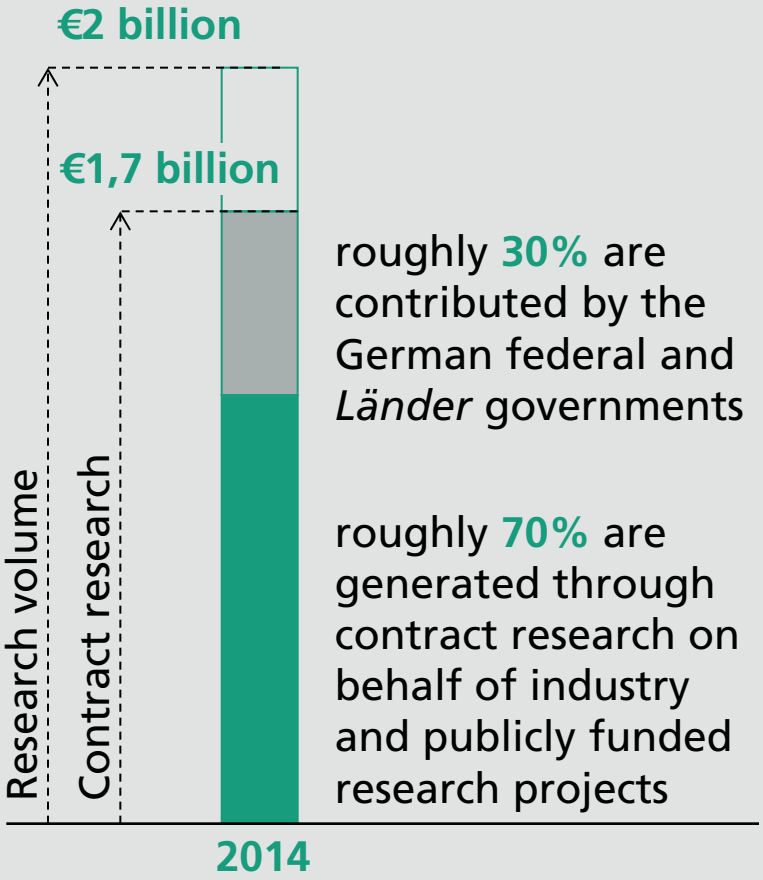
# The Fraunhofer-Gesellschaft at a Glance

## Applied research for immediate utility of economy and benefit of society

More than
**24 000** staff




**66** Institutes and
research units




roughly **30%** are contributed by the German federal and *Länder* governments

roughly **70%** are generated through contract research on behalf of industry and publicly funded research projects

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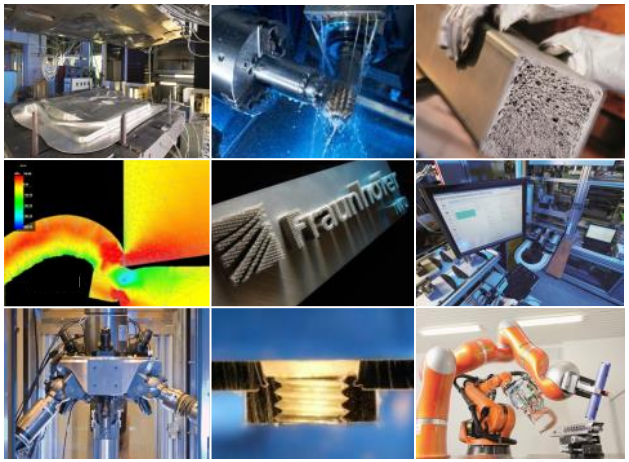
Fraunhofer IWU

# The Fraunhofer IWU
## Profile

- Founded in 1991
- About 620 employees
- €41,5 million annual budget
- Locations in Chemnitz, Dresden, Augsburg and Zittau

**Research under the heading “Resource-efficient Production“**



- Scientific fields
  - Mechatronics and lightweight structures
  - Machine tools, production systems and machining
  - Forming technology and joining

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# The Fraunhofer-Gesellschaft
## Fraunhofer Alliances

The Fraunhofer Alliances facilitate customer access to the services and research results of the Fraunhofer-Gesellschaft. Common points of contact for groups of institutes active in related fields provide expert advice on complex issues and coordinate the development of appropriate solutions.


**Adaptronics (IWU)**


**Additive Manufacturing (IWU)**


AdvanCer


Ambient Assisted Living


**AutoMOBILE Production (IWU)**


Battery


Building Innovation


Big Data


Cloud Computing


Cleaning Technology


Digital Cinema


Embedded Systems


Energy


Food Chain Management


**Lightweight Structures (IWU)**


Nanotechnology


Photokatalysis


Polymer Surfaces


**Simulation (IWU)**


Space


Traffic and Transportation


Water Systems (SysWasser)


**Vision (IWU)**

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# The Fraunhofer-Gesellschaft
## Fraunhofer Additive Manufacturing Alliance

- Objectives
  - Collaborating closely with national and international partners
  - Developing new rapid strategies, concepts, technologies and processes
  - Enhancing performance and competitiveness of SME
- Business areas
  - Engineering
  - Technologies
  - Materials
  - Quality

**Central office**
Fraunhofer IWU

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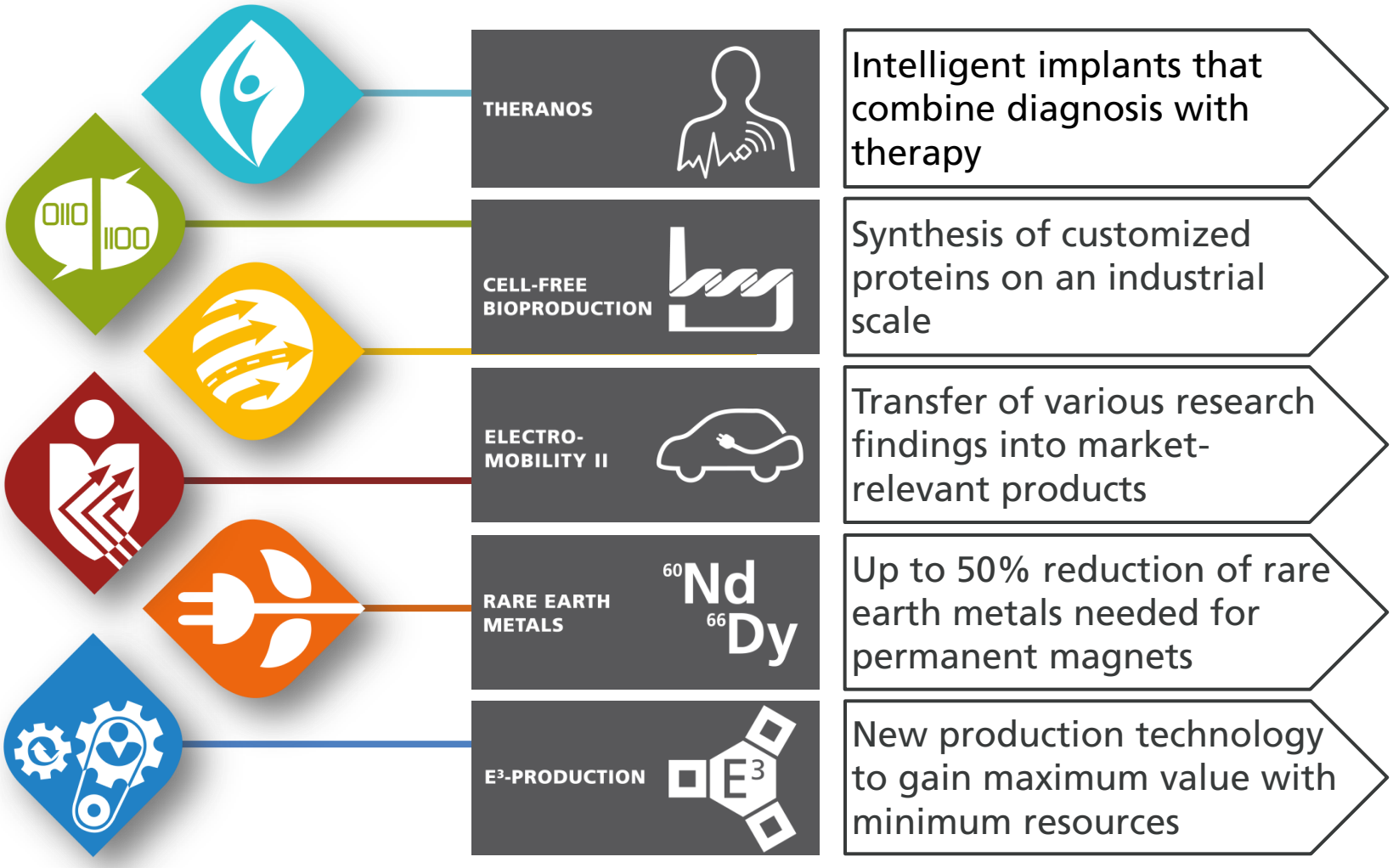
# The Fraunhofer-Gesellschaft
## Lighthouse projects

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# The Fraunhofer-Gesellschaft
## Lighthouse project: E³-Production

E³-PRODUCTION

- From “maximum profit with minimal capital investment“ towards “maximum value creation with minimal use of resources“

- Mission: contribution to
  - the national sustainability strategy
  - the establishment of production research skills into the E³-concept
  - strengthening the production engineering expertise inside the Fraunhofer-Gesellschaft


- Involved Fraunhofer Institutes:
  FIT, IBP, ICT, IFF, IGB, ILT, IML, IPA, IPK, IPT, IWU, UMSICHT
- Project leader: Prof. Putz , Fraunhofer IWU

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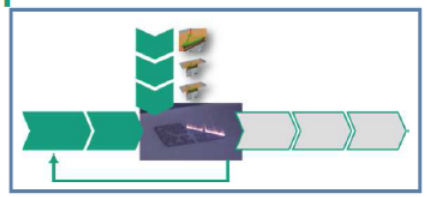
# The Fraunhofer-Gesellschaft

## E³-Production: Approach within the project

E³-PRODUCTION

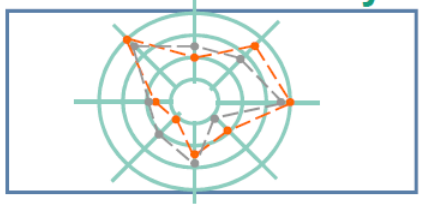
### Analyze of the process chain



*Key questions*

- Analyze state-of-the-art process chain
- Material and geometry of the reference components
- Borderline of the scope of the balancing
- Analyze process chain with additive manufacturing

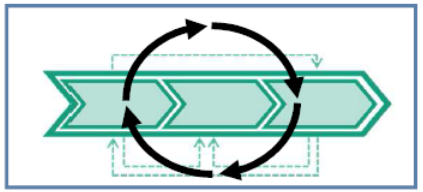
### Assessment of the resource efficiency



*Key questions*

- Identification of relevant resources drivers
- Quantification of all necessary resources
- Assessment of resource needs of single processes

### Holistic assessment



*Key questions*

- Development of appropriate assessment tools and methods
- Holistic assessment of resource needs

Source: Fraunhofer IPT

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# The Fraunhofer-Gesellschaft

## E³-Production: Shorten process chains

E³-PRODUCTION

### Challenges

- Expansion to the whole process chain
- Quantification of the resource consumption
- Development of an evaluation methodology
- Identification of potentials for optimizing the process chain

### Additive Manufacturing Process Chain

INVESTMENT CASTING OF **TIAL** WITH ADDITIVE MANUFACTURING


### Objectives within the project

**TECHNOLOGICAL ASPECT**

- Layout of additive manufacturing processes for realizing concrete reference components

**METHODICAL ASPECT**

- Development of a model to assess the process chain and its resource efficiency

Source: Fraunhofer IPT

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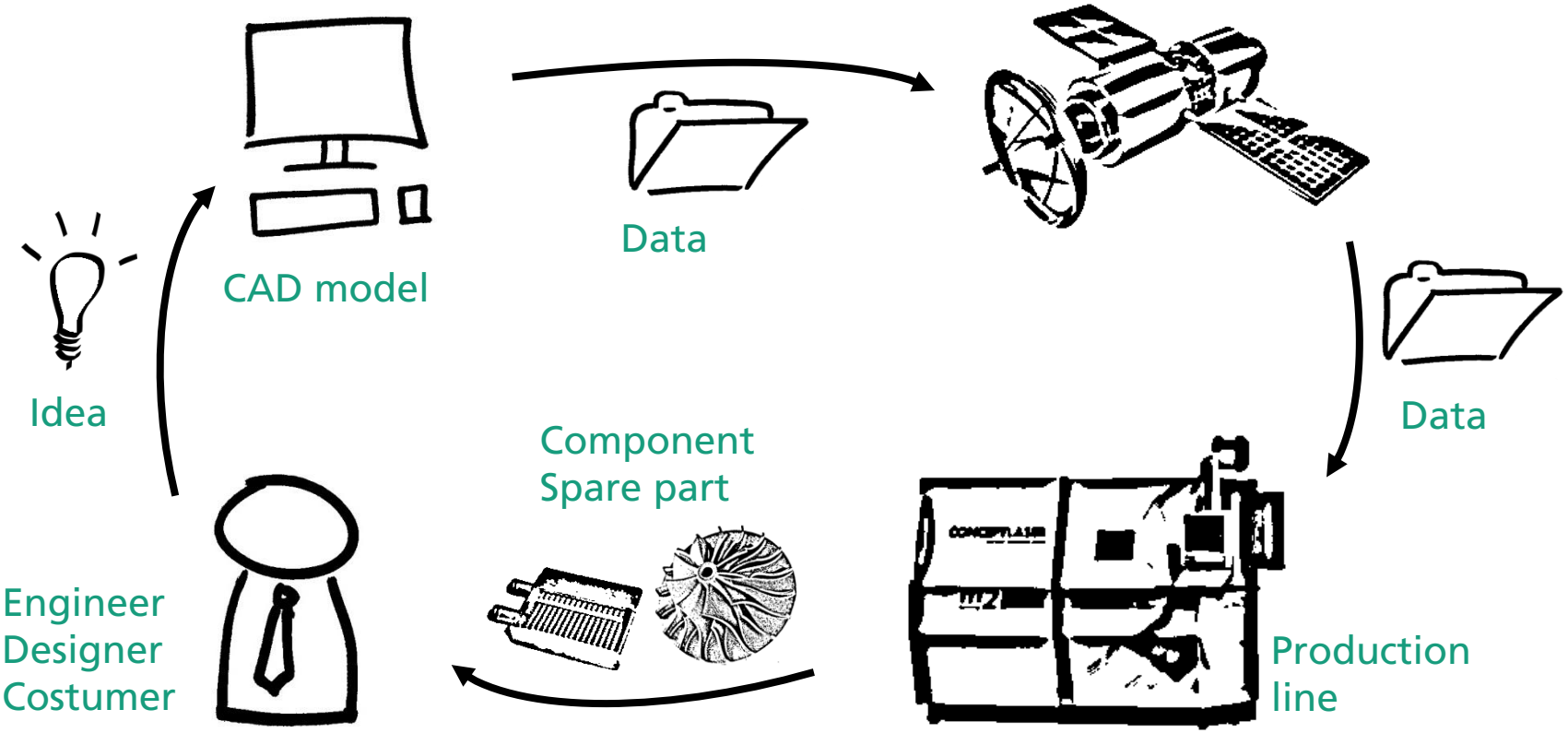
# Global Trends

## Individual, flexible and ressource efficient products

- Digitalization of value added chain

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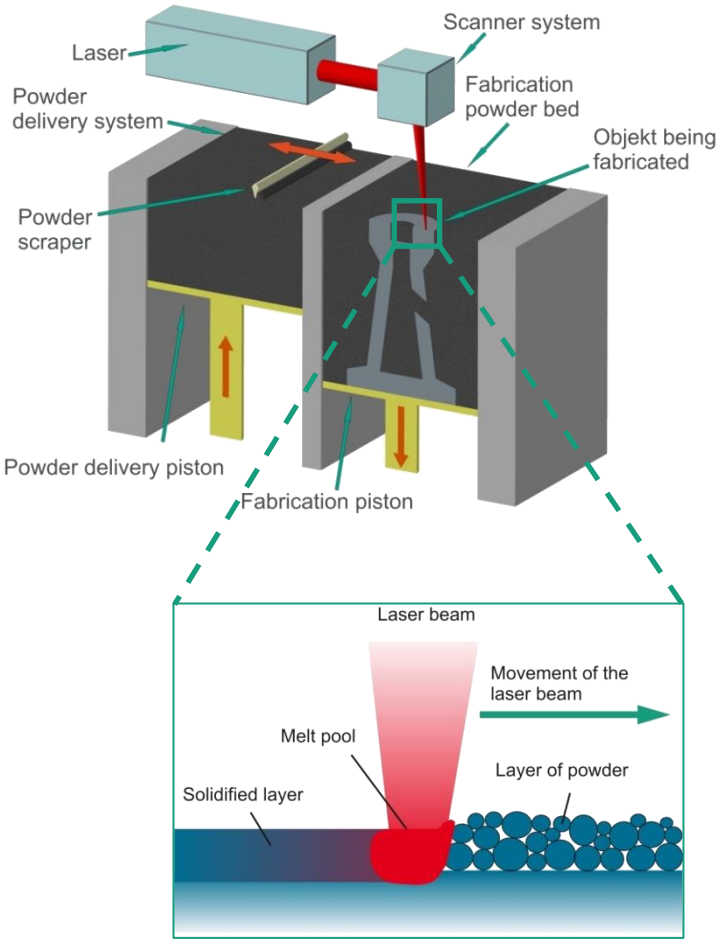
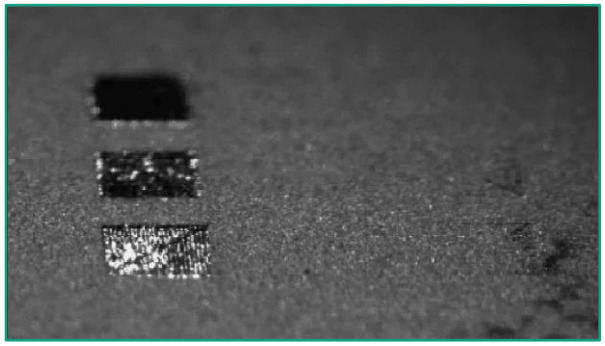
# Global Trends
## Key Technology: Additive Manufacturing




- Main advantages
  - Short time to product
    - no tools and NC programming
  - Freedom of shape
    - Lightweight design
    - Functional integration
  - Material diversity



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# Global Trends
## One Approach

AGENT3D
ADDITIV GENERATIVE FERTIGUNG

- Additive Manufacturing
  - The 3D revolution for product manufacturing in digital age


- Objectives
  - Placing industry-specific, additively manufactured products successfully on international markets
    - Cost reduction > 20%
    - Performance increase > 20%
  - Sustainable process chains and customer-supplier-relationship with complete value creation in Germany
  - Interlinking science and industry to a driver of innovation



Source: Fraunhofer IWS / AGENT-3D e. V.

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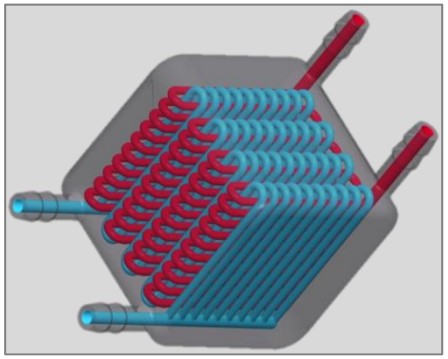
# Trends and Examples
## Engineering / Component development

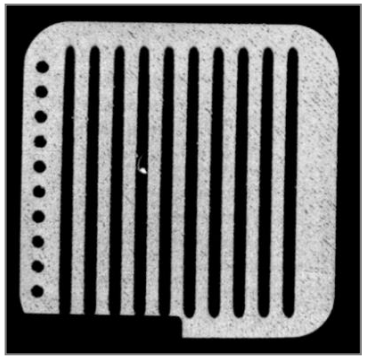
- Trends
  - Extreme lightweight design, downsizing / miniaturization
  - (Mass) Customization / individualization
  - Integral part design / functional integration
  - Full-strength materials from all technically relevant metal alloy groups

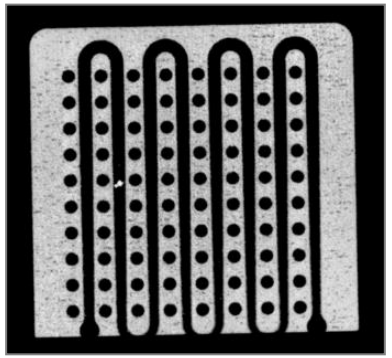
- Example: Innovative heat exchanger



3D CAD model

Additively manufactured parts





Evaluation / inspection by µCT scan

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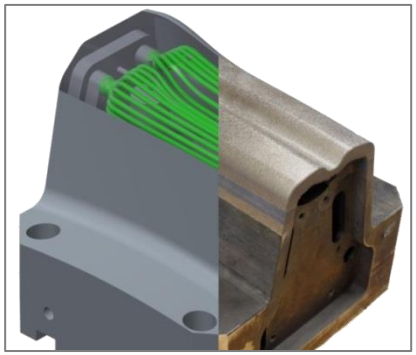
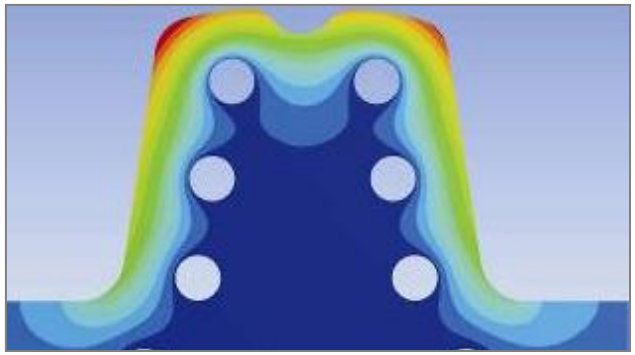
# Trends and Examples
## Production tooling

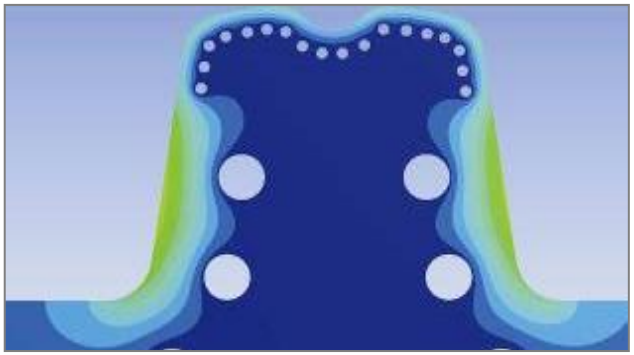
- Trends
  - Highly efficient, real-time cooling / thermal management
  - Integration of sensors in dies and moulds
  - Load case oriented and structured design of tooling
- Example: Tooling for hot sheet metal forming
  - forming press locking time reduced by 50 % → total cycle time reduced by 20% → energy consumption in typical car body production (reference plant) reduced by 245 MWh (equals 146 t $CO_2$)



Press hardening tooling segment



Conventionally drilled cooling bores



conformal cooling channels (design for AM)

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# Trends and Examples
## Medical engineering

- Trends
  - Customized, patient-specific implants
    - Based on medical imaging data like CT or MRI
    - Tool-free manufacturing in medically approved materials
  - Functional integration in implants

- Example: AktiLoc – Implant with integrated shape memory actuators
  - Homogeneous and stable fixation of cement-less hip stems
  - Increase the primary stability by an optimal force distribution at the bone-implant interface using Shape Memory Alloy (SMA) elements

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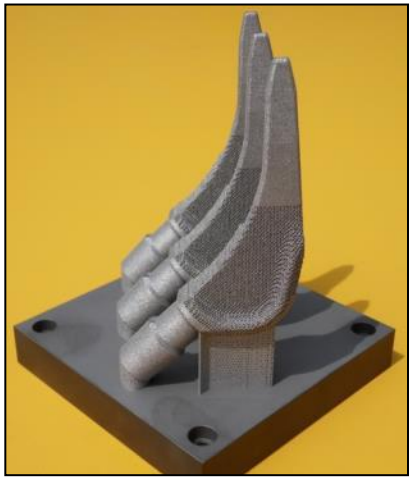
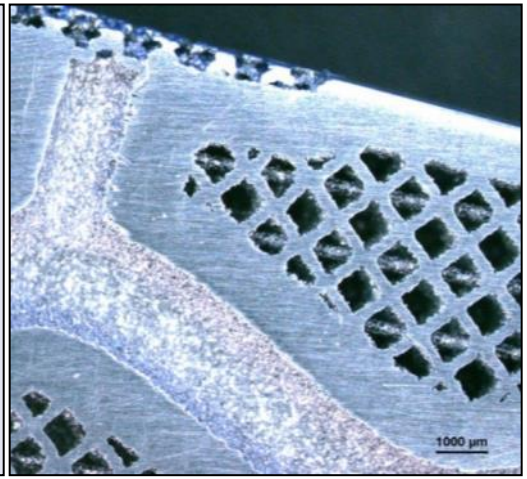
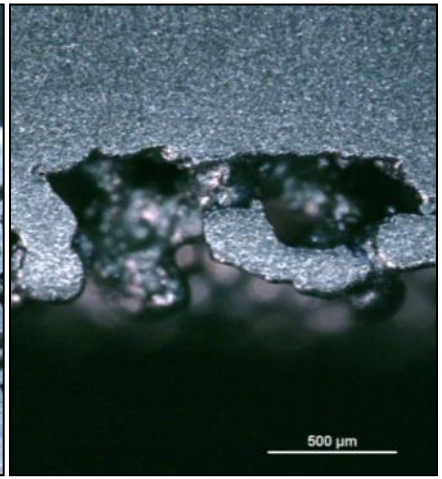
# Trends and Examples
## Medical engineering

- Example: MUGETO® – Implant with functional channels and cavities
  - additively manufactured by Laser Beam Melting in titanium TiAl6V4 ELI
  - macro-porous surface structures → osseo-integration
  - inner cellular structures → stiffness adaption to bone
  - channels and cavities → drug depot, endoscopic inspection, filling gaps, …





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# Additive Manufacturing

## Necessary adoption steps for wide use in production

| Challenges for AM | Necessary Steps | Fraunhofer contribution |
|---|---|---|
| Missing technical standards | Standardisation | Contributing to ISO activities, e.g. through the Association of German Engineers VDI |
| Reproducibility | Quality control systems / in-situ feedback control systems | Various R&D activities together with the German Laser Beam Melting machine manufacturers |
| Costs | Gained productivity | Development of High Power Laser Beam Melting Machines (1 kW Laser) and novel scanning strategies |
| Education with regard to AM design | Widely spread teaching of AM principles at universities / colleges | Implementing AM principles in lectures at Fraunhofer-linked universities |
| Material variety (e. g. carbon steel, copper, ceramics) | Material and process development | R&D activities with regard to processability of more material types and alloys |

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# Additive Manufacturing
## A Fraunhofer perspective

- So far
  - AM technologies are prepared for industrial use
  - There is a large variety of different technologies – picking the right one is crucial to succeed
  - Additive Manufacturing will not replace other technologies:
    - it is a complementary manufacturing method
    - it is able to extend the possibilities and add value to products
  - A profitable use of AM, most often depends on a different way of thinking:
    - This may affect product design as well as the overall production process
  - Development will be more a continuous evolution than a disruptive revolution
  - Fraunhofer is active in many fields of AM and looking forward to cooperation with industries willing to adopt AM technology

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# Fraunhofer Direct Digital Manufacturing Conference DDMC
Berlin (Germany), March 16 and 17, 2016

- SCOPE: Encouraging dialogue!
- Range of topics:
  - Product Development
  - Technologies
  - Material
  - Quality
  - Innovative and visionary approaches
- Keynotes:
  - Prof. Boris Chichkov, Laser Zentrum Hannover
  - Dr. Richard Bibb, Loughborough University
  - Dr. Tommaso Ghidini, ESA
  - Dr. Martin Hillebrecht, EDAG
  - RA Prof. Dr. L. Grosskopf LL.M.Eur., Uni Bremen
  - Wouter Gerber, Aerosud (Pty) Ltd, Südafrika
- More information: [www.ddmc-fraunhofer.de](http://www.ddmc-fraunhofer.de)


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