Materials Expertise - A Key Enabler for (future) Production

Univ.-Prof. Dr.-Ing. Dipl.-Wirt. Ing. Johannes Henrich Schleifenbaum
RWTH Aachen University Digital Additive Production DAP
Fraunhofer-Institute for Laser Technology ILT

Fraunhofer ILT
DAP Digital Additive Production
RWTH AACHEN UNIVERSITY

RWTH Aachen University is one of the best technical universities in Germany

Statistics

Annual budget 2015:	€ 869m
External funding:	€ 337m
Affiliated institutes (2013):	€ 66m
Students:	> 43,000
Professors:	538
Institutes	260
Large-scale institutes	22
Fraunhofer institutes	4
Research training programs	27

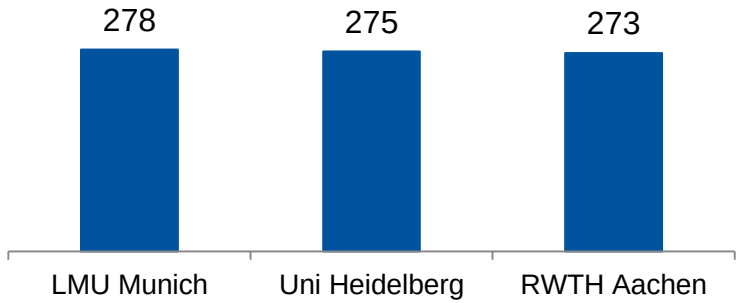
National Rankings

"Wirtschaftswoche" 2016

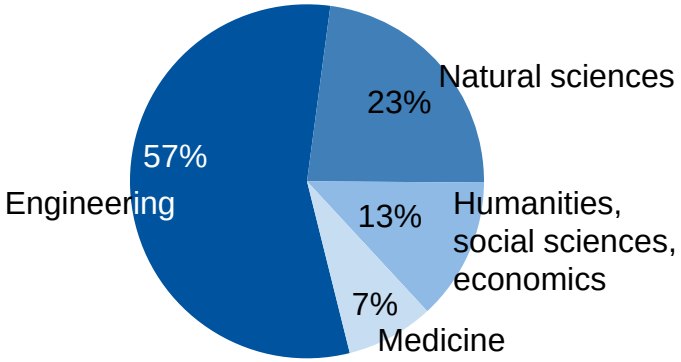
1st in Mechanical Engineering
3rd in Electrical Engineering
1st in Industrial Engineering
3rd in Natural Sciences
1st in Computer Sciences

Main competitors:
Berlin, Darmstadt, Munich

Funding Ranking DFG*
2011-2013 (€ Mio.)



Students by Discipline



Source: RWTH Aachen Department 6.0 Division 6.3 (2015), Ranking Report RWTH 2015 *) DFG: German Research Foundation

The role of materials was decisive in human history, from the bronze age…

… over the Iron and Middle Ages…

… and the industrial revolutions…

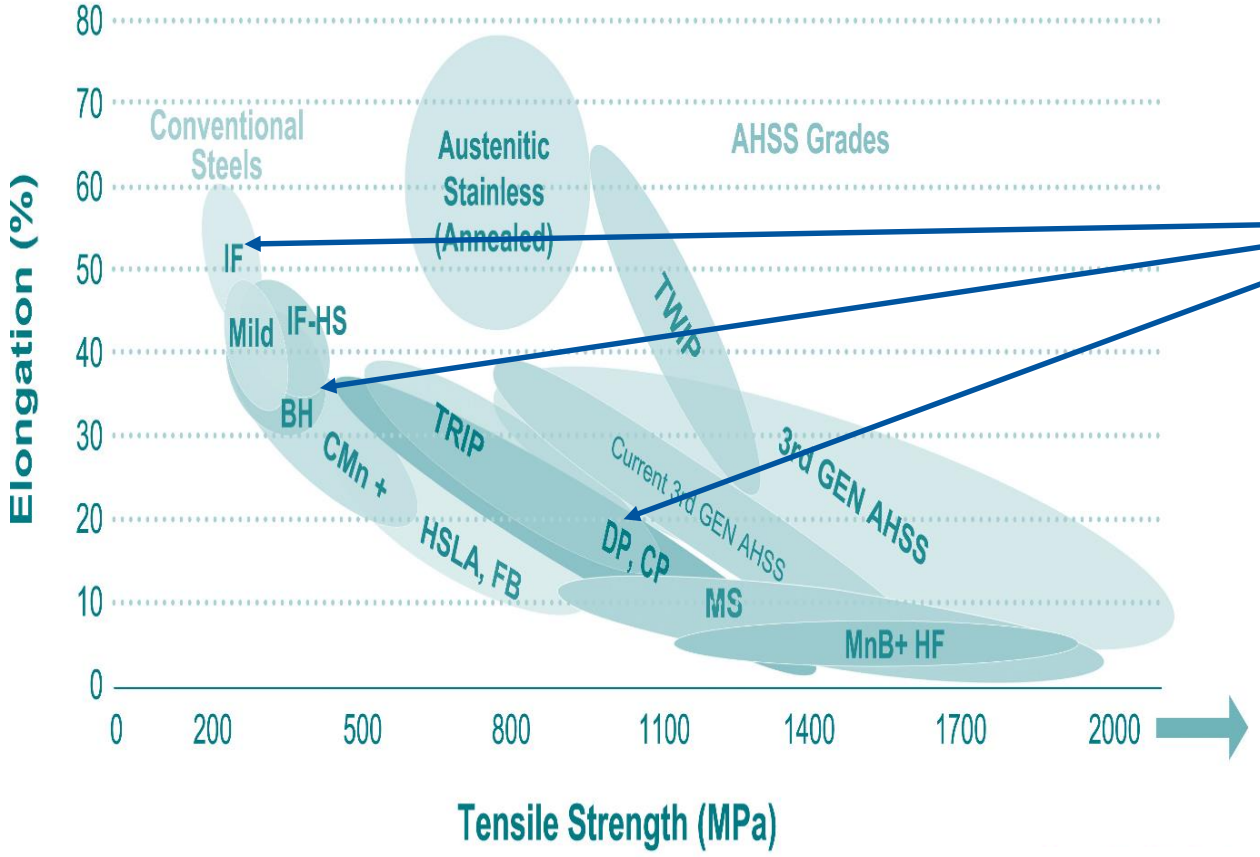
http://barrybradford.com/schedules/henry-ford-driving-america-forward-2/

“Any Customer can have a car painted any color that he wants so long as it is black”

Henry Ford

… till today! E. g. in the automotive sector or …

High performance steels in the automotive sector



Source: WorldAutoSteel

Source: volkswagen

Today‘s automotive alloys

- IF-Steels (e.g. HX180YD)
- DP-Steels (e.g. HDT580X)
- BH-Steels (e.g. HC300B)
- AHSS

… in the aerospace sector.

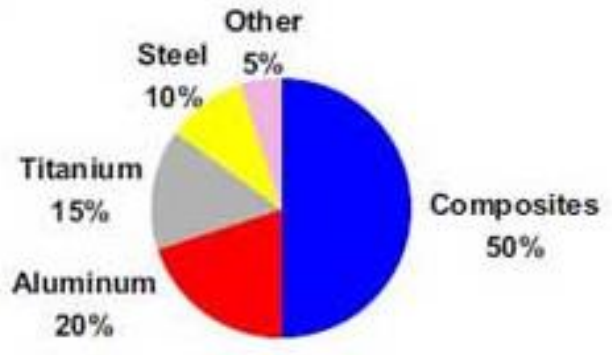
High Performance Alloys in Aerospace

Titanium-base alloys

Nickel-base alloys

Carbon composites

Aluminum



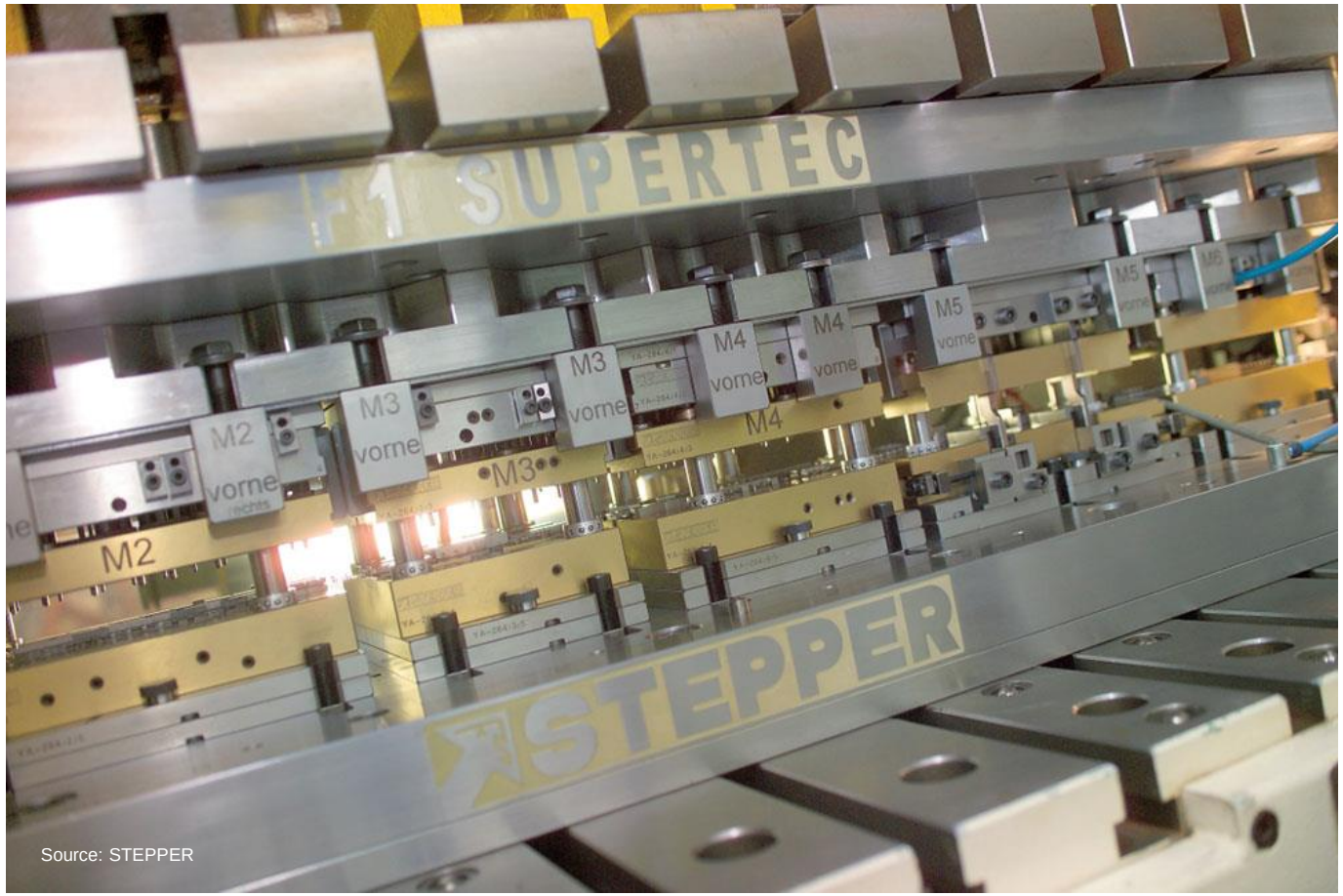
Source: www.ResearchGate.com

Maximizing Fuel Efficiency by reducing weight and increasing turbine efficiency

Pictures: www.shutterstock.com, Rolls-Royce, www.algiecompositeaircraft.com, www.experi-metal.com

The battle of materials leads to faster innovation cycles

High performance coatings e. g. in the tooling sector



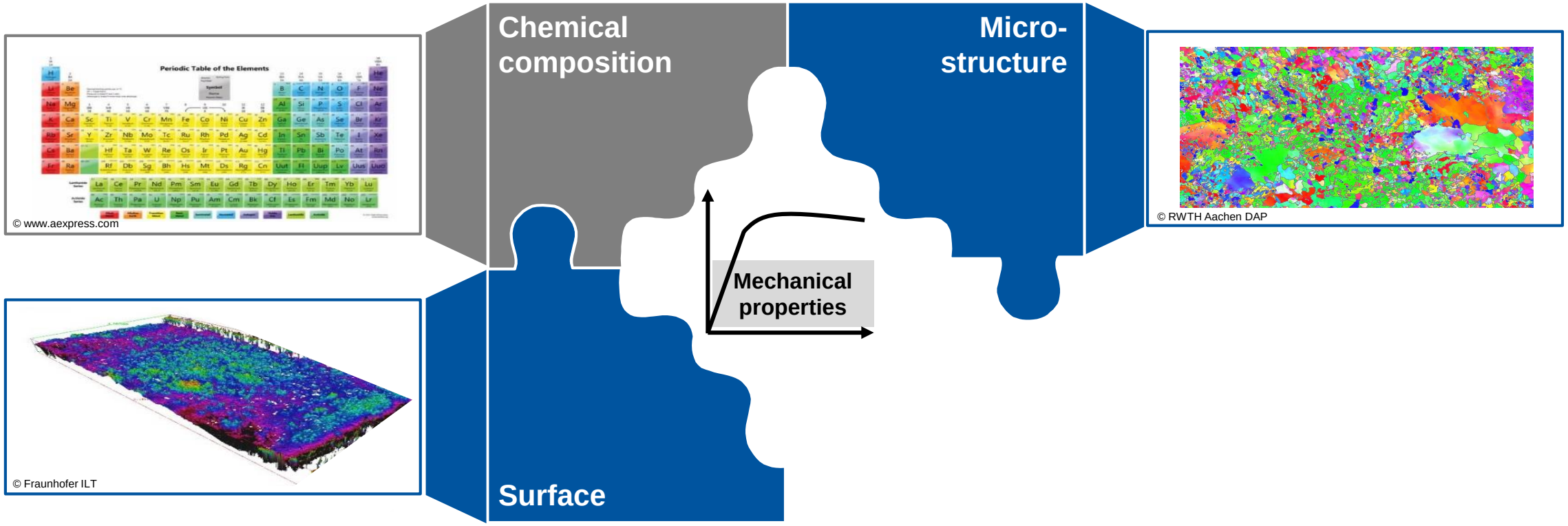
Source: STEPPER

- Challenges
  - Improving tool life
  - Improving maximum amount of strokes per minute
- Material Solutions
  - HSS, PM-Steel,
  - Special coatings (TiC, TiN, TiCN, diamond-like carbon, …)

→ Maximizing process efficiency, minimum cost per part

Definition of Material

*“Metal is the term used to describe chemical elements whose atoms combine with each other to form a crystal structure with free electrons. The mechanical properties are first and foremost dependent of its **chemical composition**, **microstructure** and **surface** […].”*



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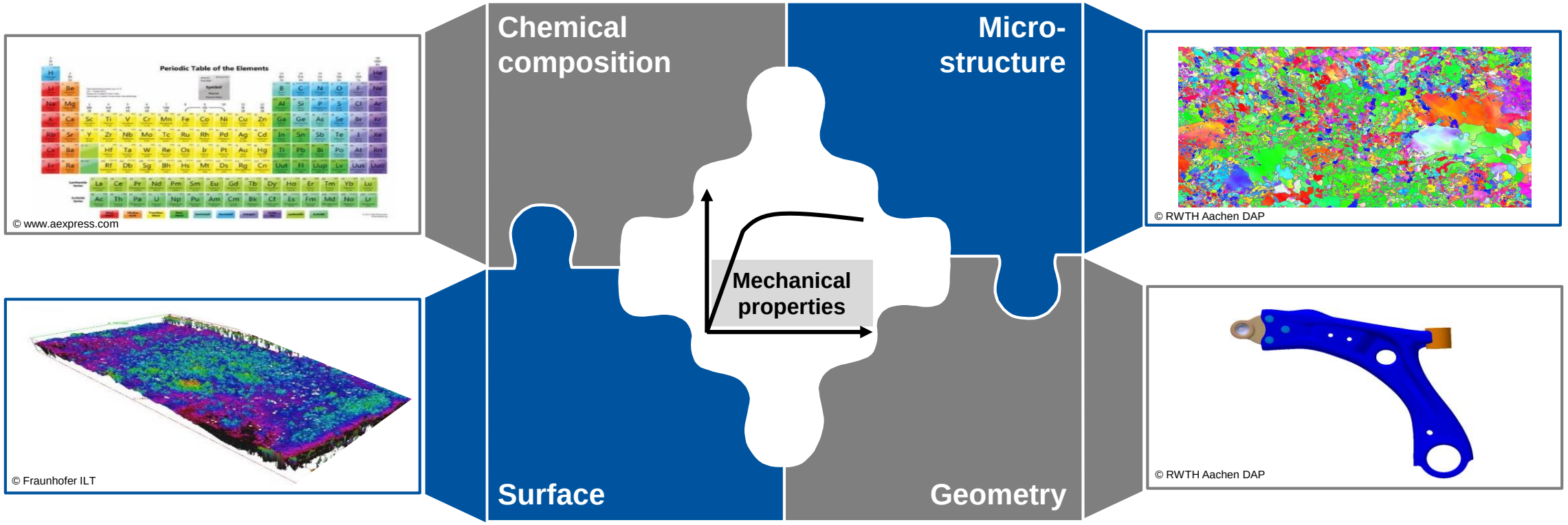
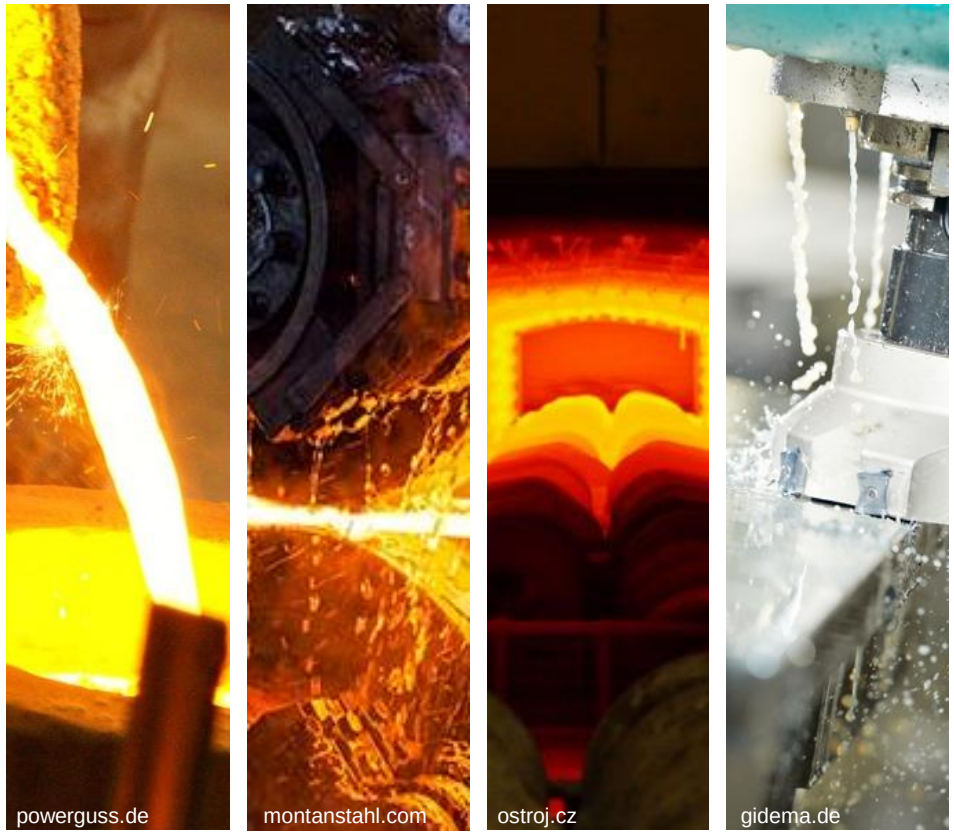
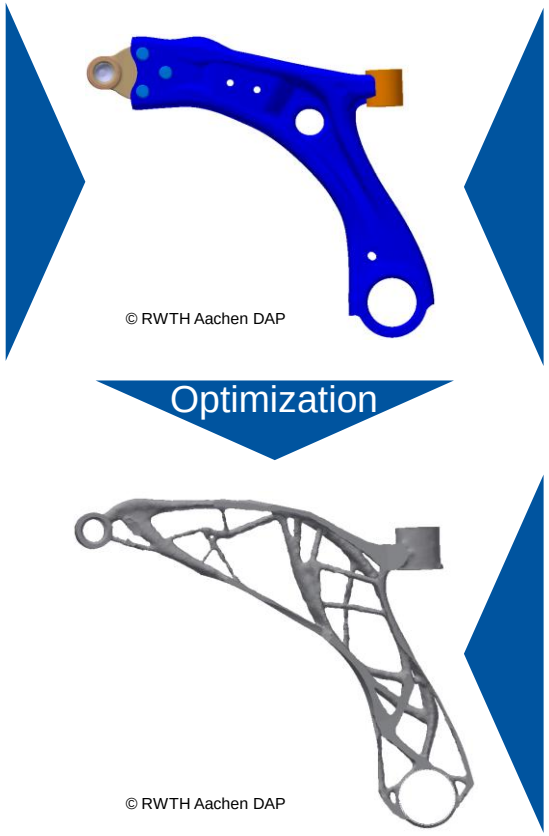


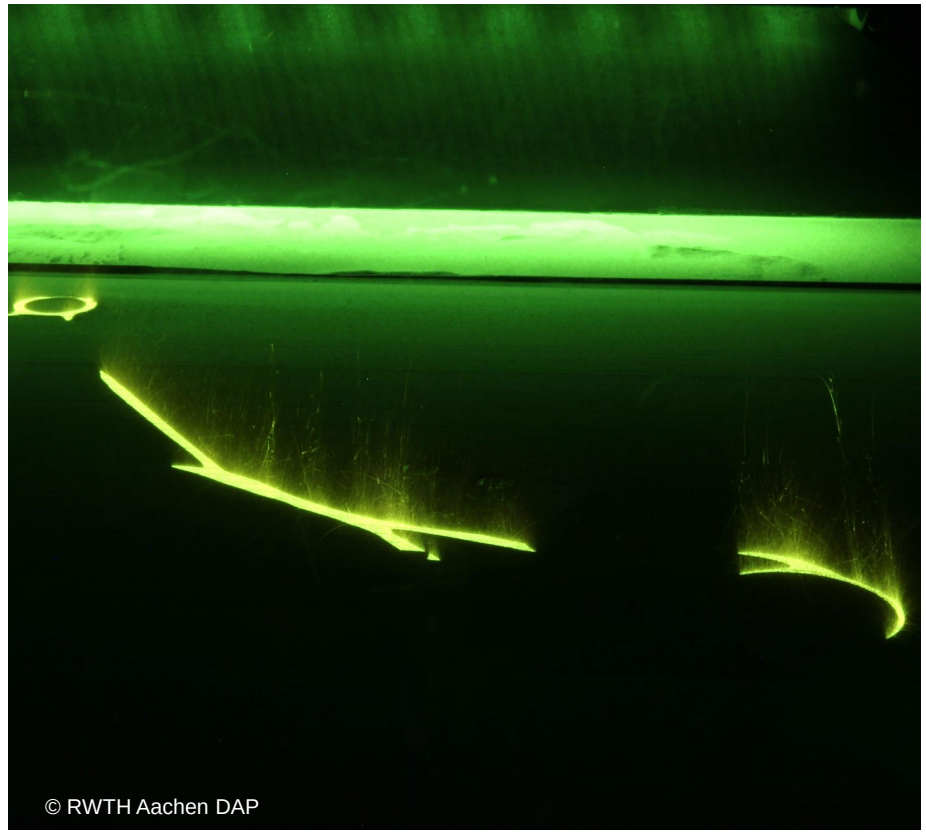
Conventional processing routes and the AM micro foundry

Conventional processing route

Additive Manufacturing (AM)







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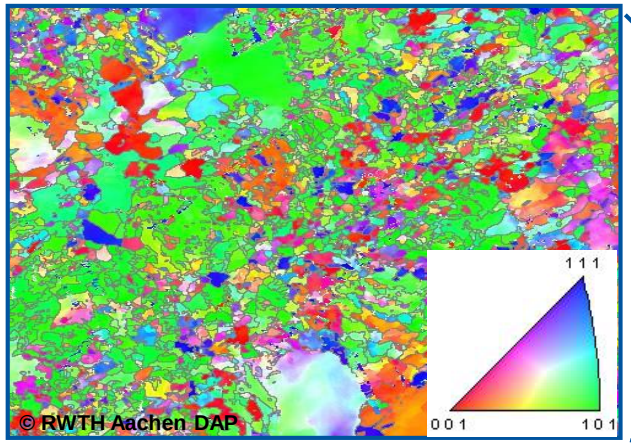
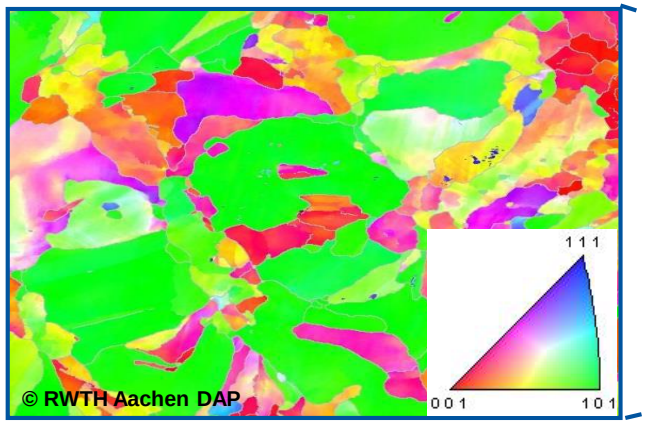
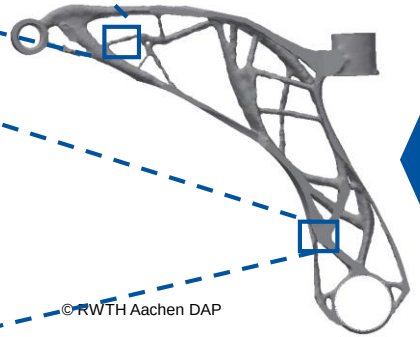
Besides geometry micro structure is a design objective in the AM micro foundry

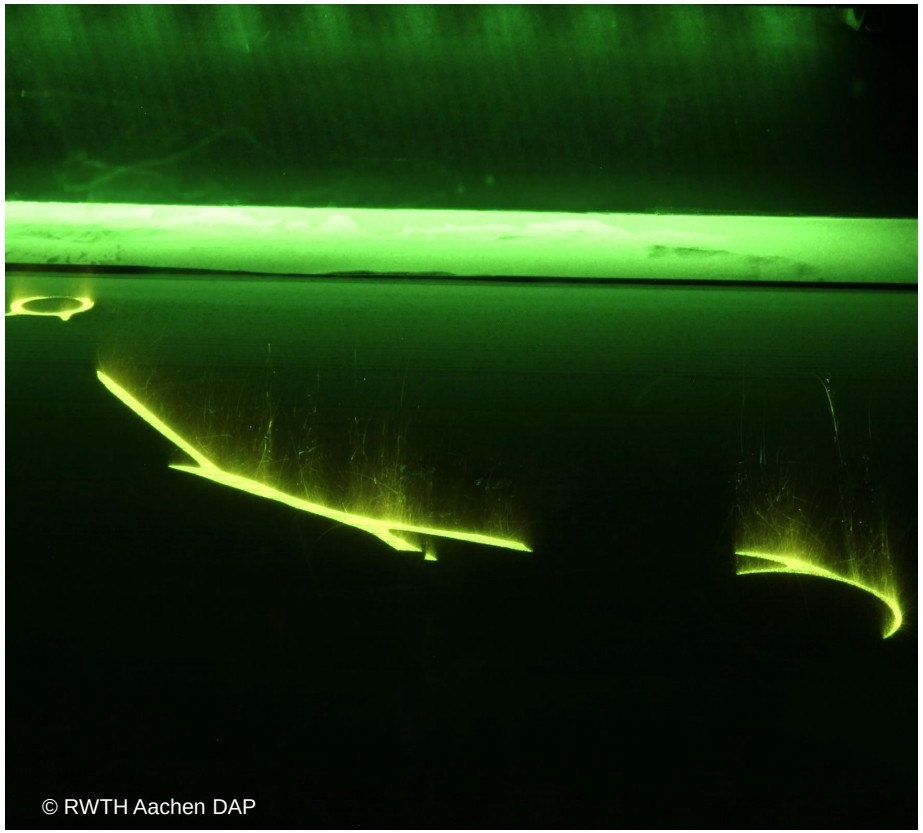




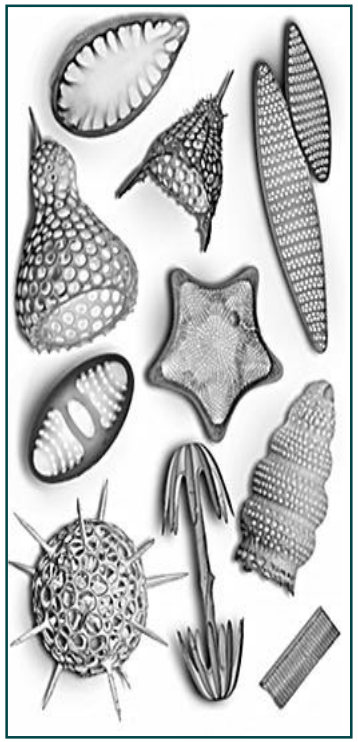
Optimization



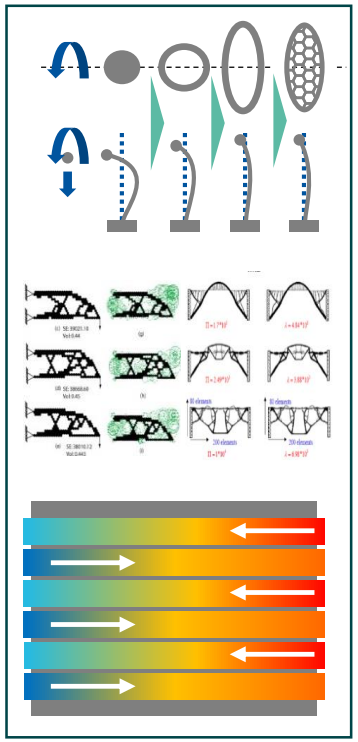
Additive Manufacturing (AM)



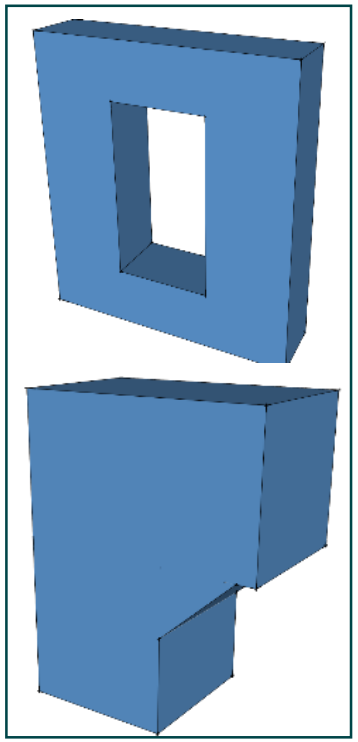
Algorithm-based design and additive manufacturing will enable holisitic “digital engineering”



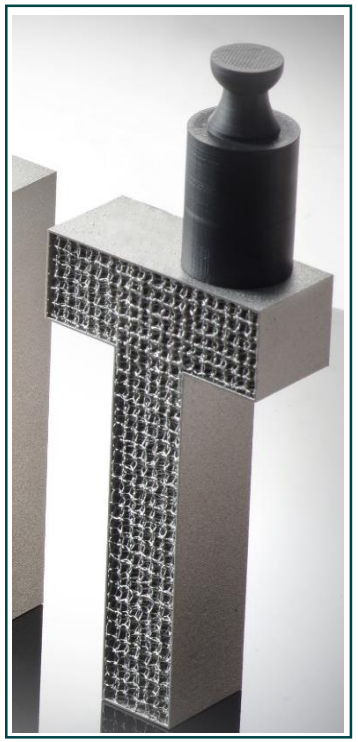
Bionic design



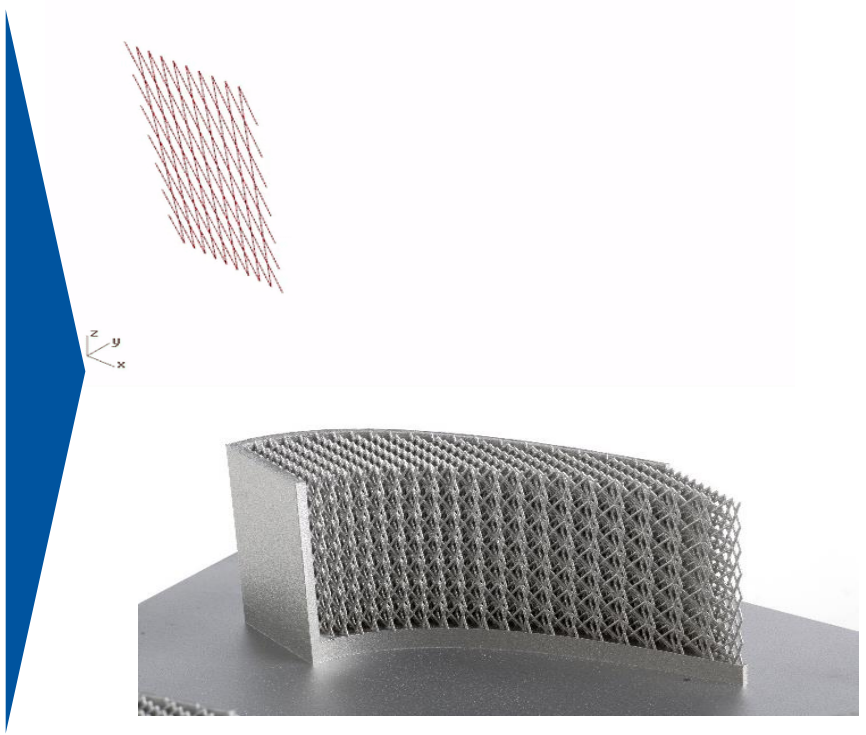
Design constraints



Mfct. constraints



Load constraints



Algorithm-based lattice structures

Sources: DAP/ILT

Fraunhofer ILT

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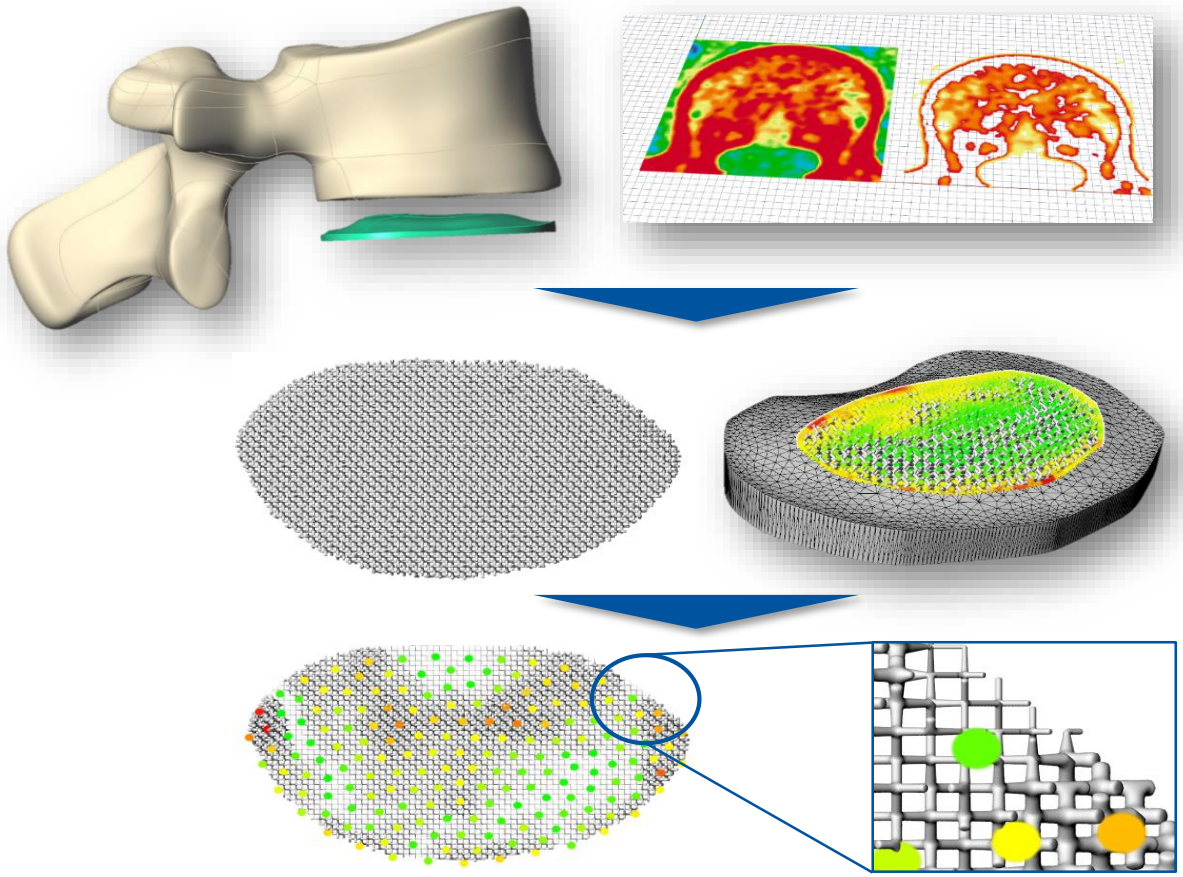
The concept of “digital materials” is a key enabler for product design of tomorrow

Example: Digital material for vertebral body implant



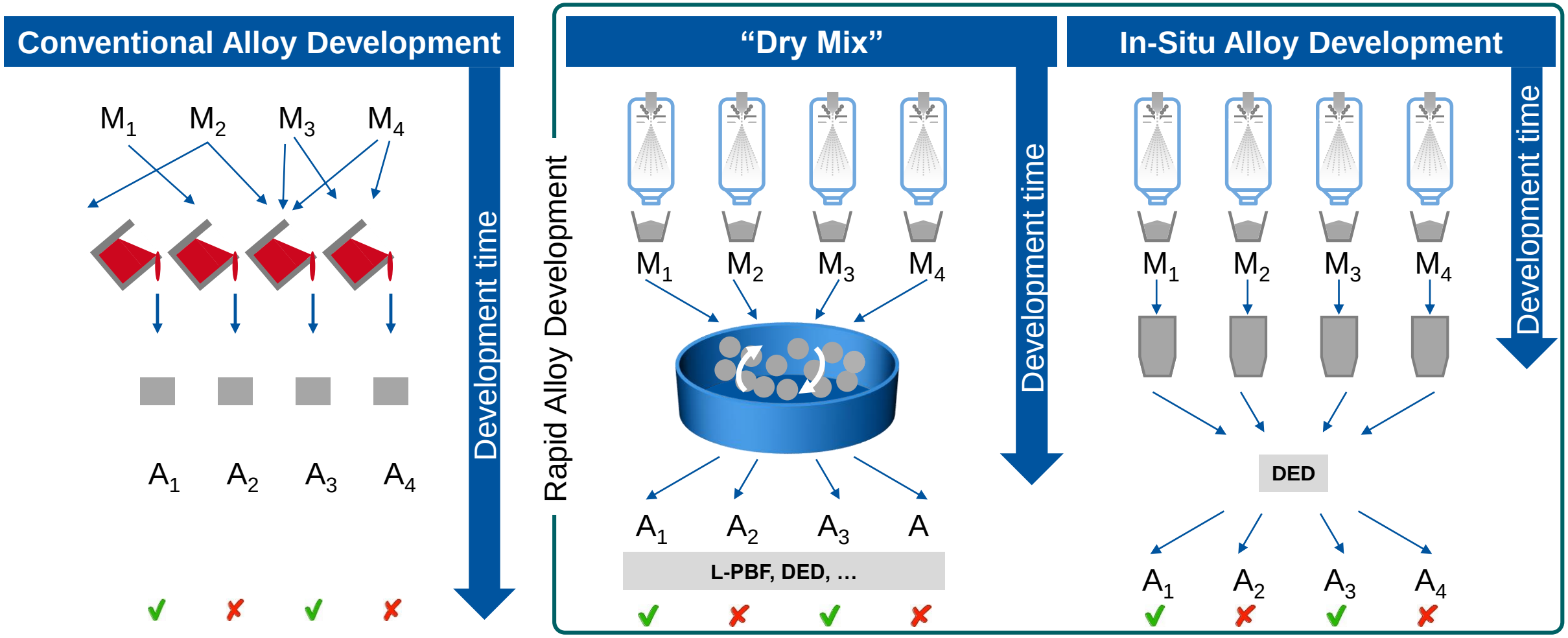
- Locally different bone stiffness
- Risk of local overload
- Goal: homogeneous implant loading by local adjustment of stiffness
- Extraction of bone stiffness using CT scan
- Determination of strut diameters from lattice material laws
- Mapping strut diameters to implant lattice structure

(Semi) automated adaptation to local bone stiffness

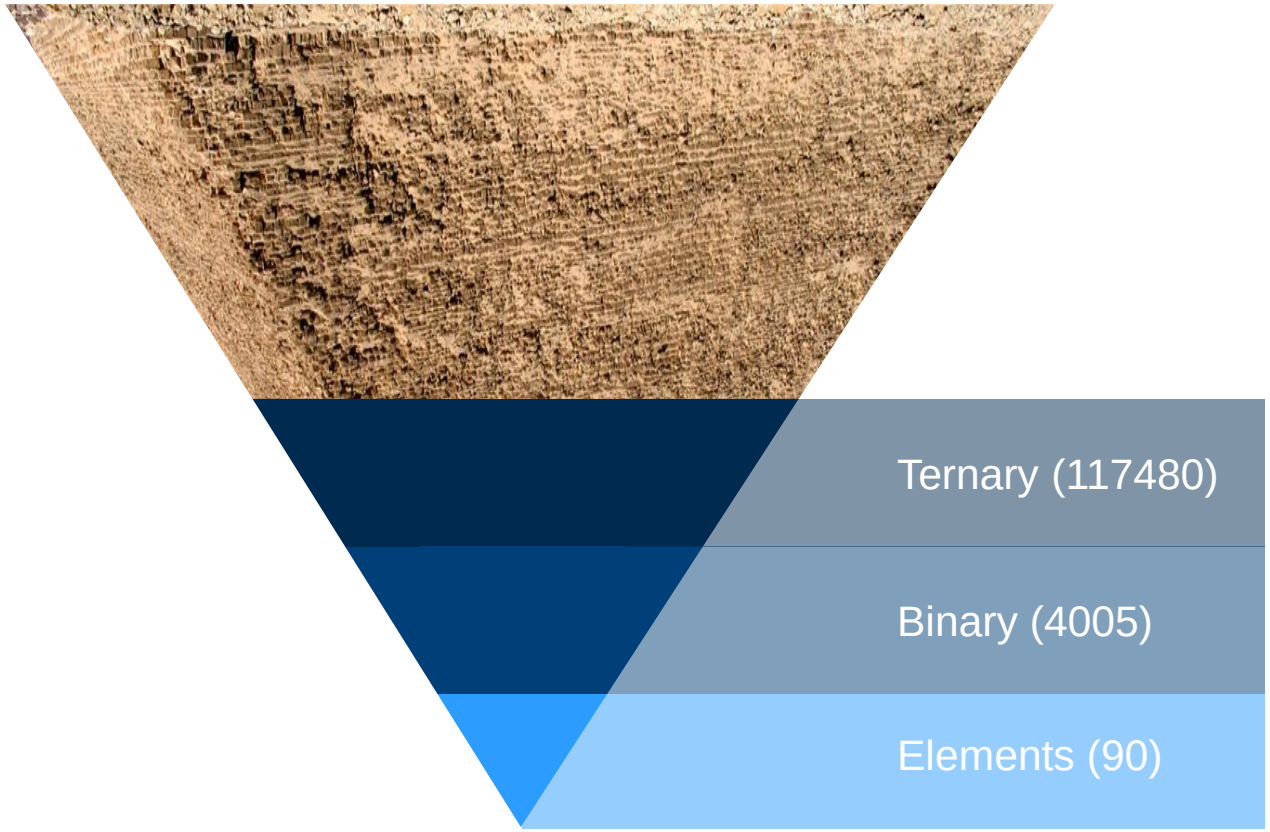
Sources: DAP/ILT

Rapid Alloy Development enables faster material screening

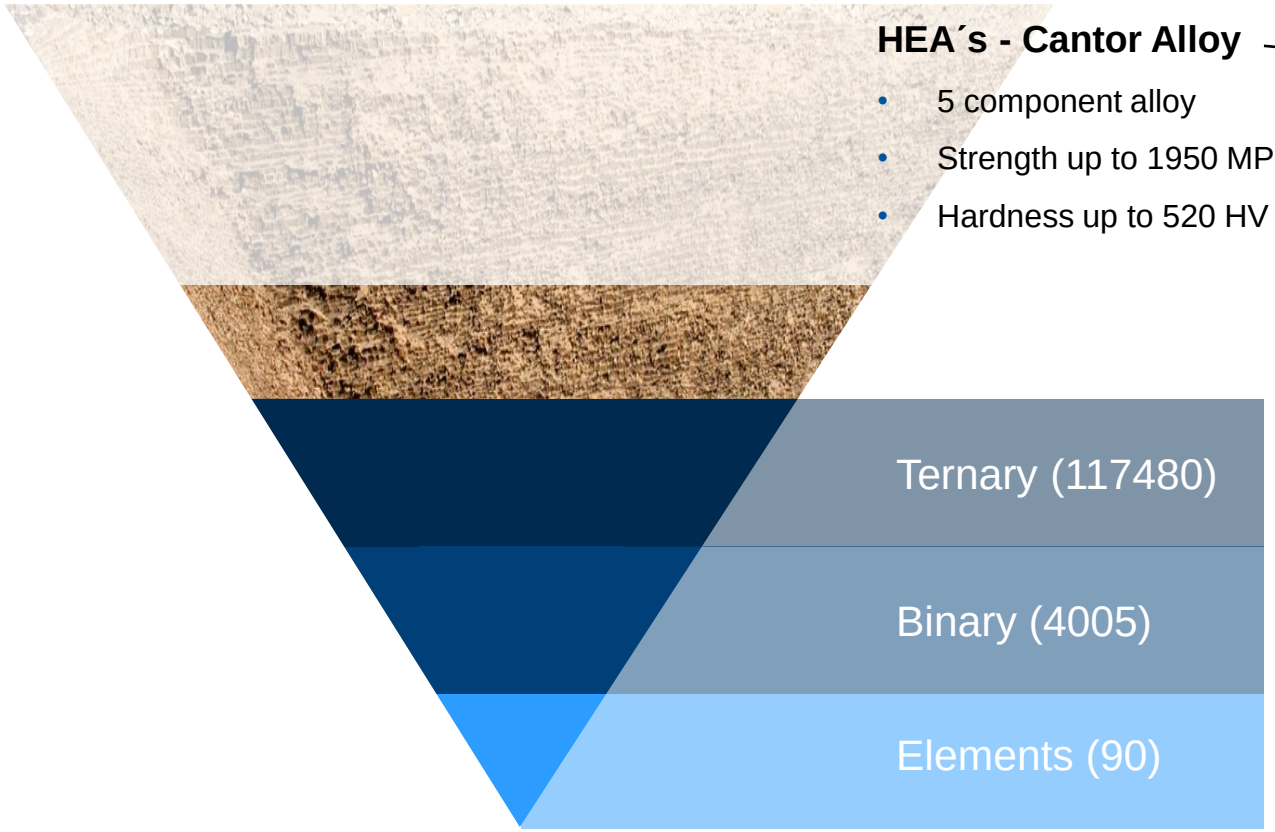
A revolution in creating new materials?



The inverted pyramid of materials…

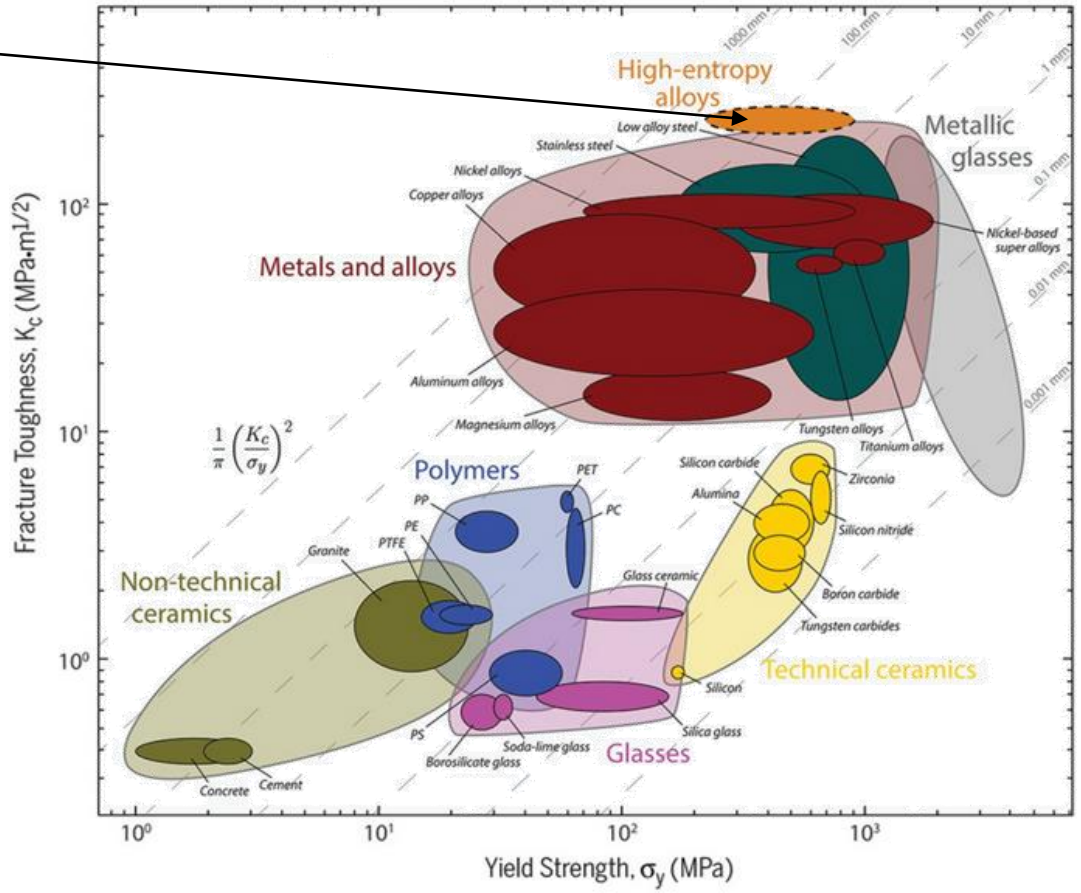


… and the fascinating example of high entropy alloys



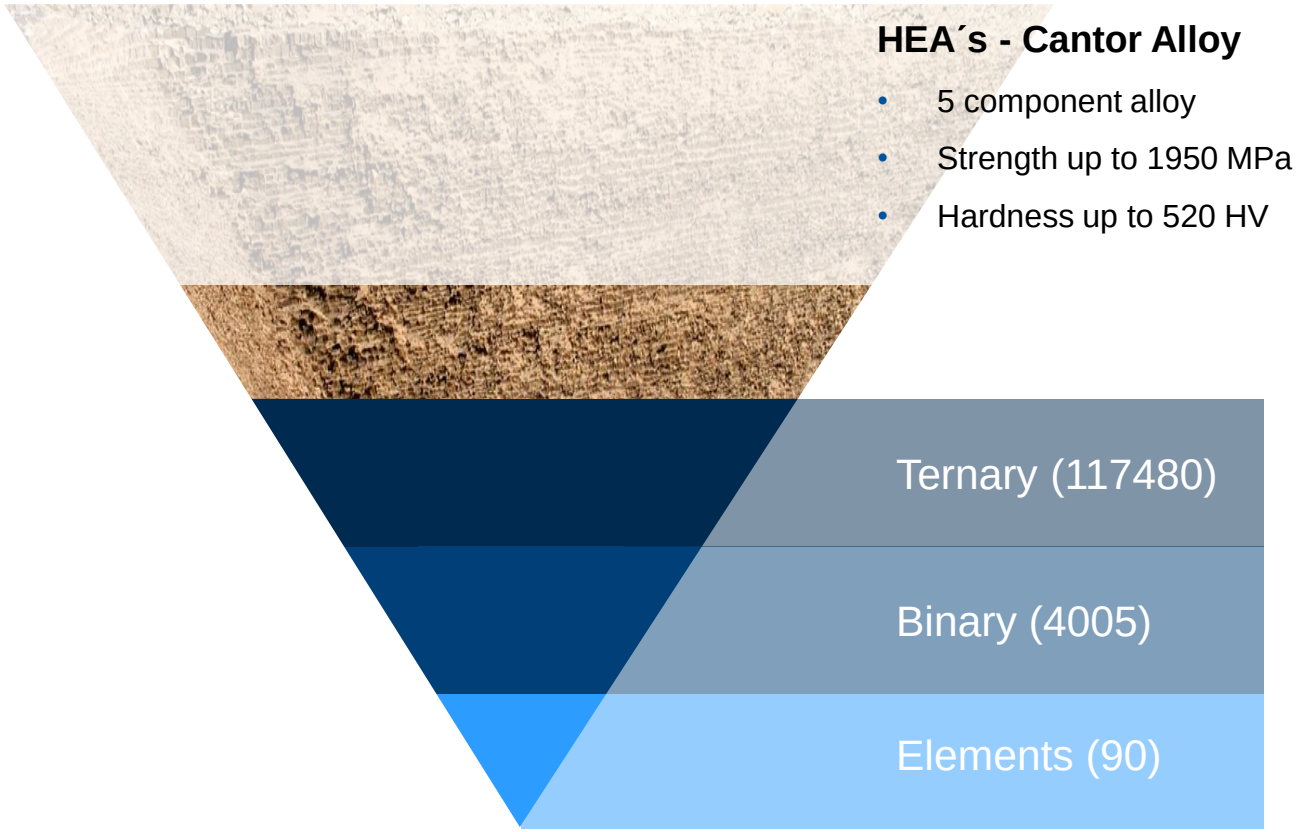
HEA´s - Cantor Alloy

- 5 component alloy
- Strength up to 1950 MPa
- Hardness up to 520 HV



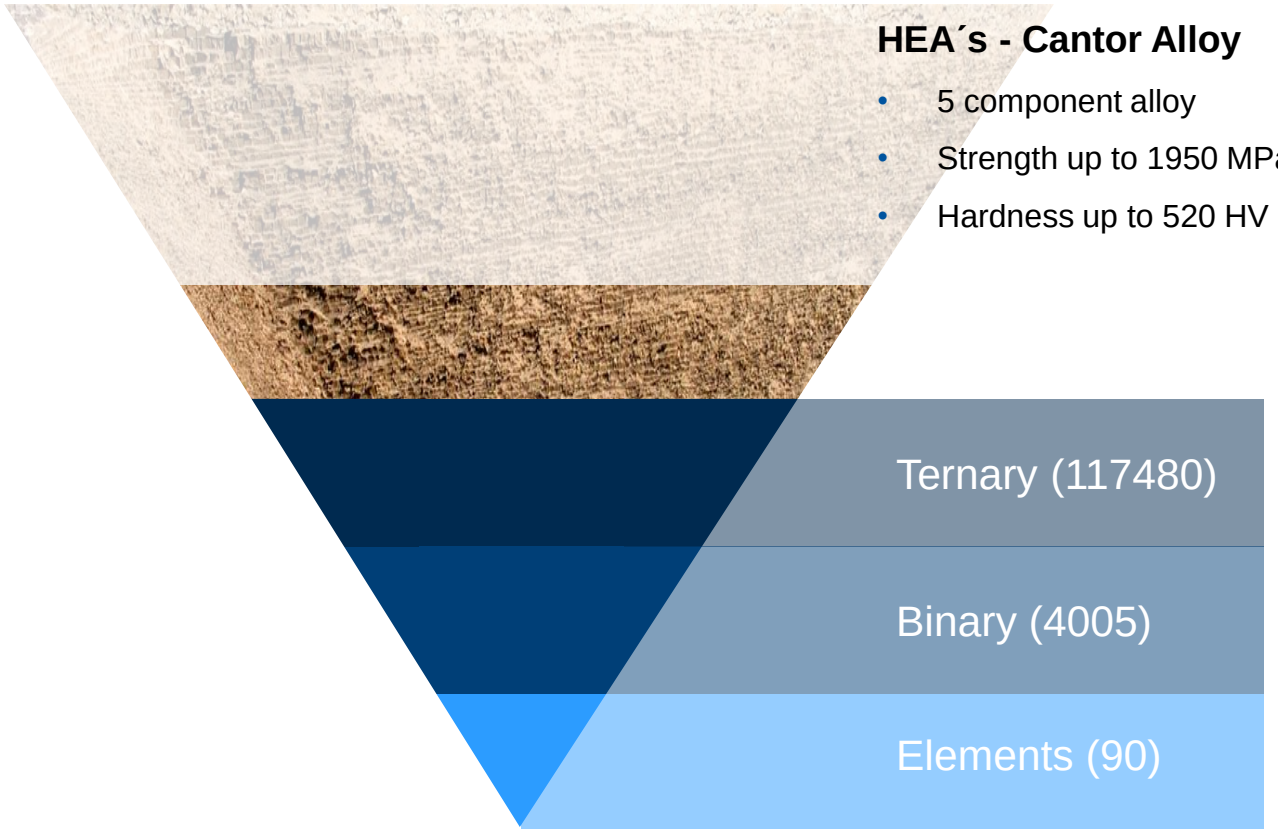
Sources: Gludovatz (2015)

… and the fascinating example of high entropy alloys



Element	Fe	Mn	Cr	Co	Ni
at.%	20	20	20	20	20
wt.%	19.92	19.58	18.55	21.02	20.93

… and the fascinating example of high entropy alloys



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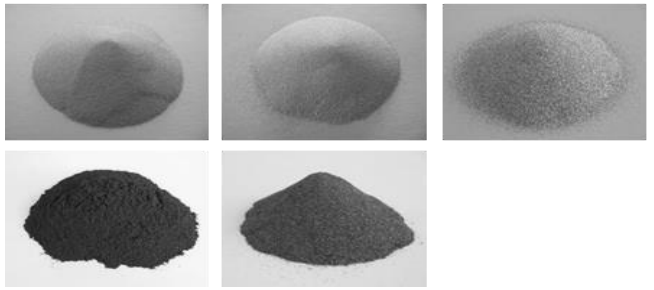

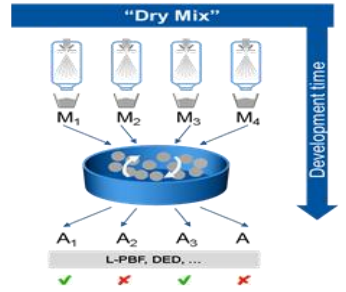

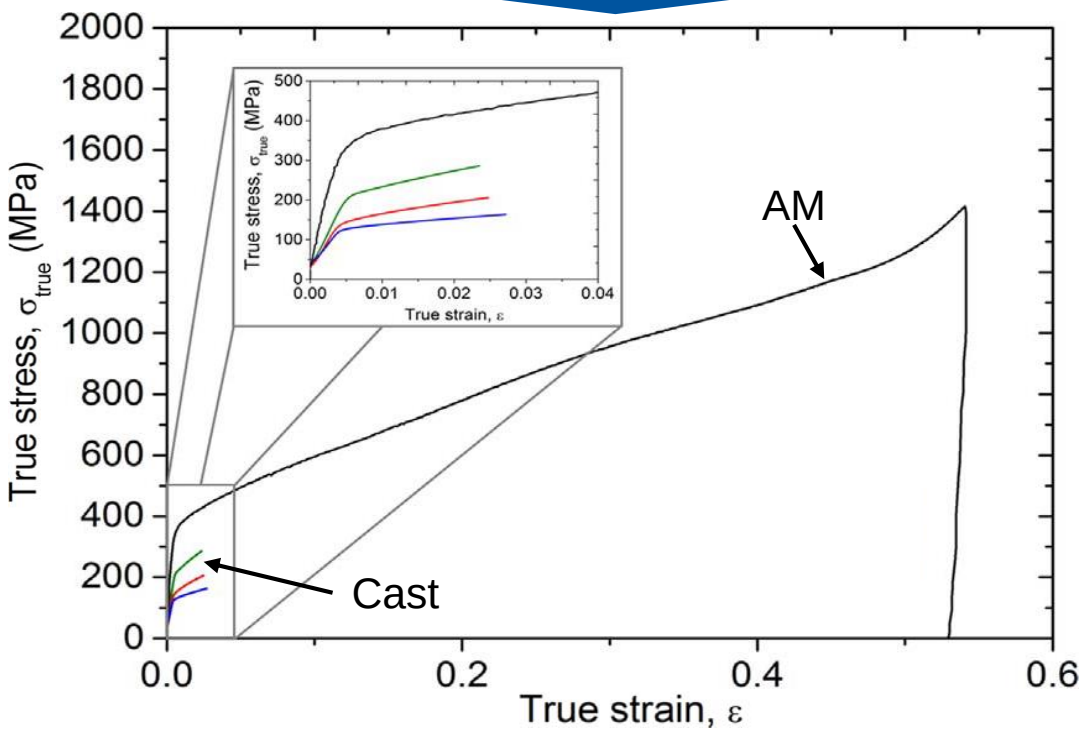

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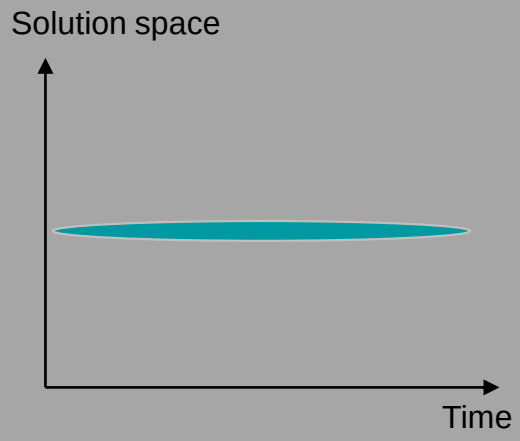
Where’s the way out?

Picture: www.labyrinth-shg.de

Collaboration is the key to leverage development in the future!

Development in the past

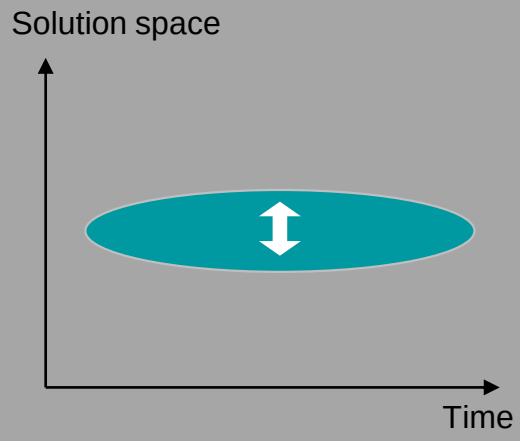
- Long development time
- Narrow solution space



Knowing where to find

Development today

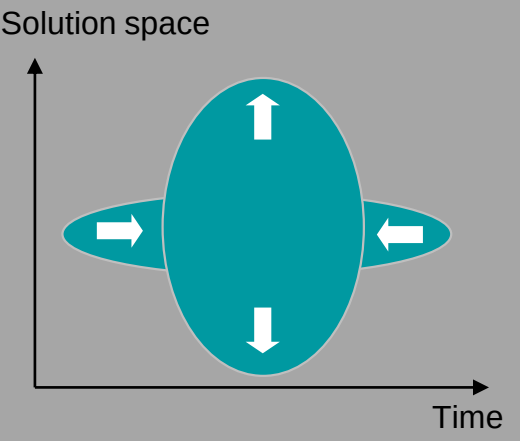
- Long development time
- Wider solution space



Knowing whom to ask

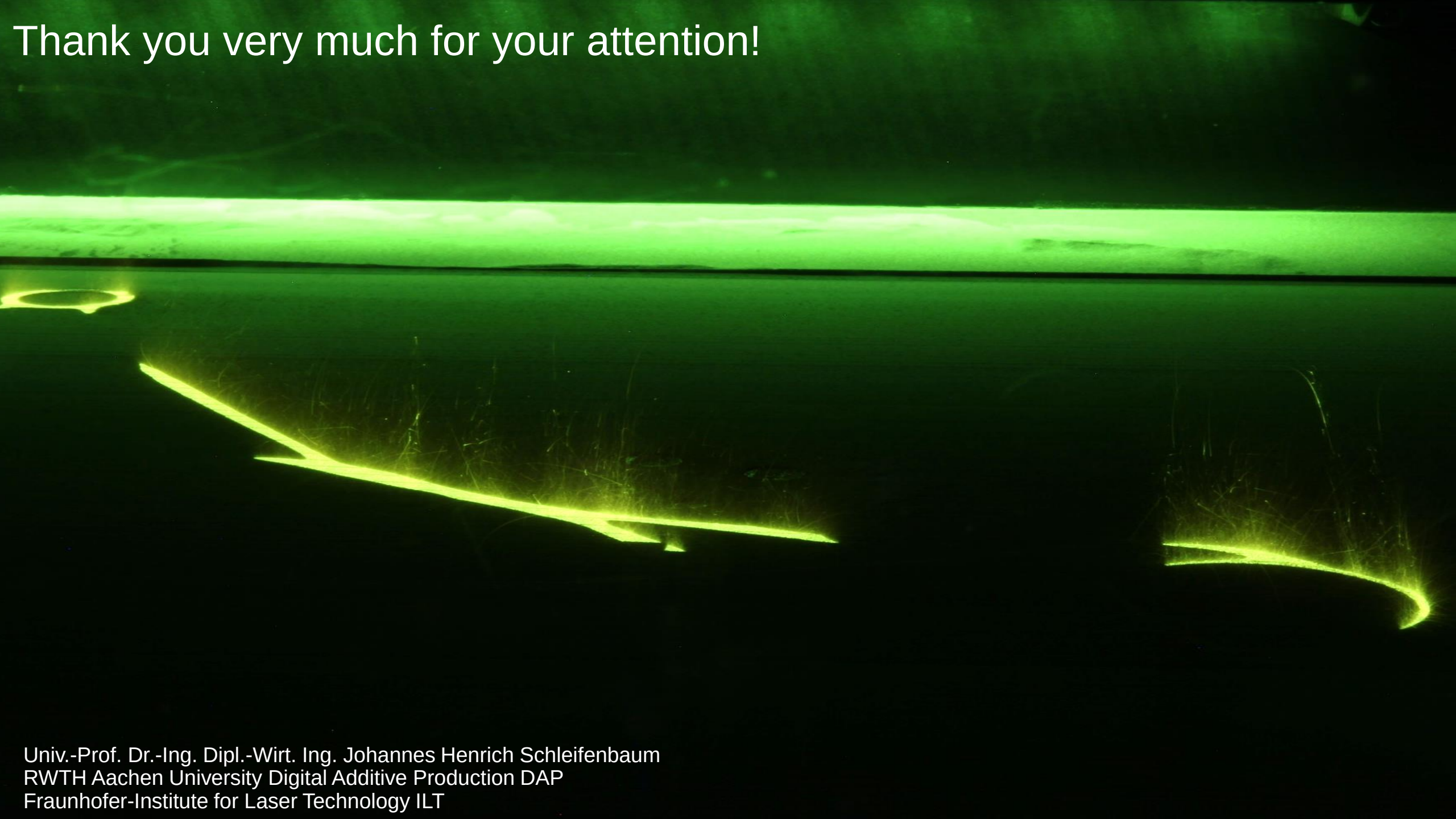
Development in the future

- Short development time
- Wide solution space



Knowing where knowledge emerges

Thank you very much for your attention!



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