2nd munich technology conference
10–11 October 2018
TU Munich / Germany

mtc 2

Block F: Materials for AM

10.10.2018

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- Metals
- Polymers
- Ceramics

Innovation in material und process enable new products

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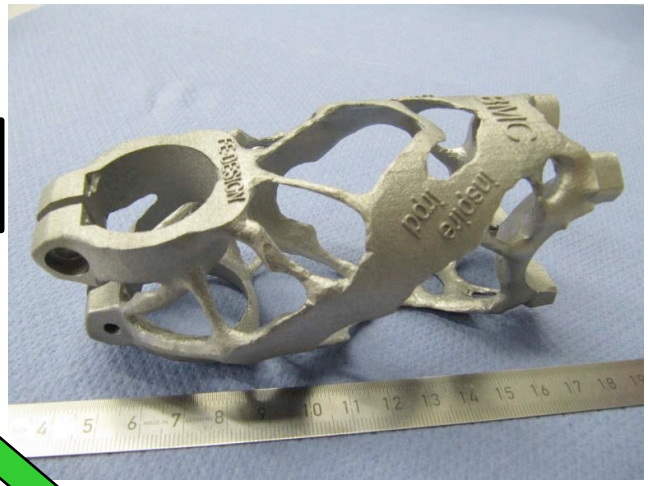
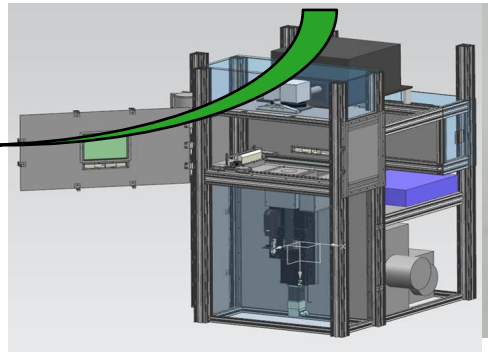
- Material- and process development depend on each other

Product innovation



Material innovation

Process innovation



AM – Processes for Polymers

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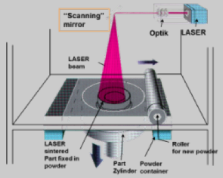
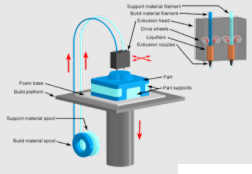
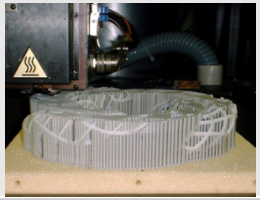
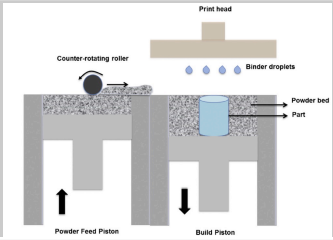
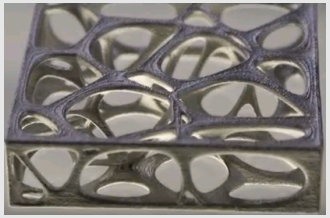
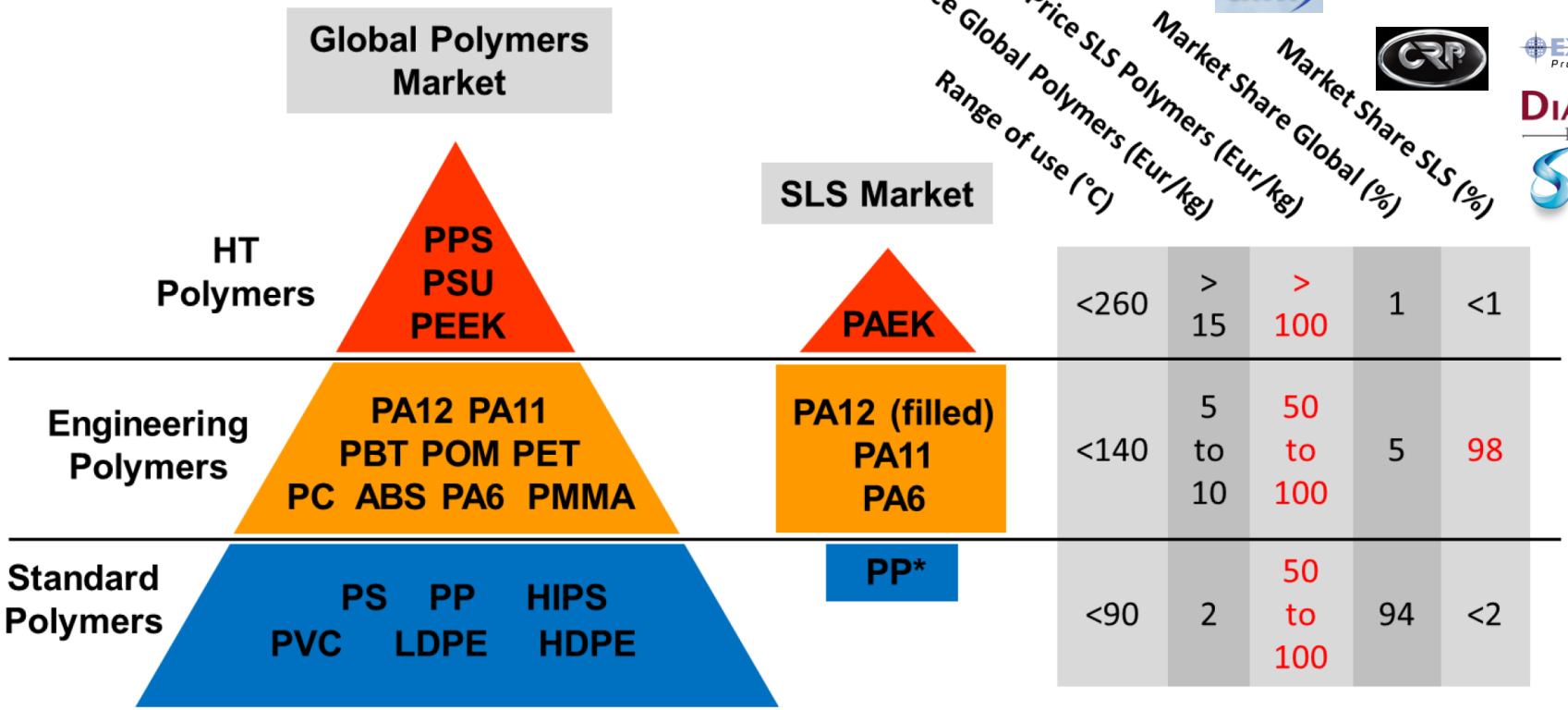
Domain	Processes	Materials	Principle
Polymers	**Selective Laser Sintering** (SLS)	Pulver - PA12, (PA6, PA11), PP - Z.T. gefüllte / modifzierte Varianten	 
Polymers	**Fused Deposition Modeling** (FDM)	Filaments - ABS, PC, PA, PLA, PEEK - Generally thermoplasts	 
Polymers	**Binder jetting** (BJT)	Powder - Thermoplastic materials PA, PMMA,	 
Polymere	**HP Multijet fusion** Printing of absorber ink and heating by light source	- Thermoplastic materials	 

Polymers: Total and SLS material market



- The market volume of polymer powders for SLS is tiny in comparison to the total polymer market. ➔ high price for limited material spectrum

SLS new material icoPP

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icoPP™ Polypropylene

- First coPP introduced in the Swiss/German market by Inspire
- High impact & chemical resistance
- Outstanding Elongation at Break > 200%
- Great detail resolution
- Seal-ability with other PP-parts
- Serializable (medical)

Thermische Eigenschaften

Eigenschaft	Methode	Wert
Schmelzpunkt	DSC - DIN 53675	**≥ 120°C**
Kristallisationspunkt	DSC - DIN 53675	**≤ 90°C**
Wärmeformbeständigkeit HDT-A	ISO 75-1 (1.82 MPa)	**ca. 50°C**

Mechanische Eigenschaften

Eigenschaft	Methode	Wert
Dichte (Bauteil)	intern	**≥ 0.9 g/cm^3**
E-Modul (Zugversuch)	ISO 527-1	**≥ 800 MPa**
Zugfestigkeit	ISO 527-1	**≥ 18 MPa**
Reissdehnung	ISO 527-1	**≥ 200 %**
Schlagzähigkeit - Charpy	ISO 179-1/1eU	**≥ 40 kJ/m^2**
Kerbschlagzähigkeit - Charpy	ISO 179-1/1eA	**≥ 5 kJ/m^2**

AM – Processes for Metals

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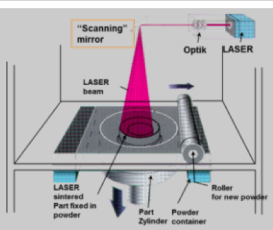
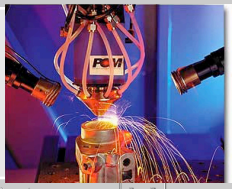
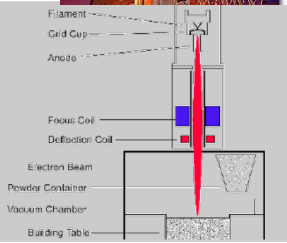
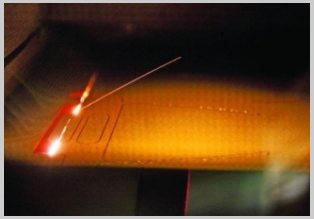
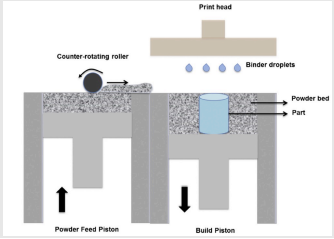
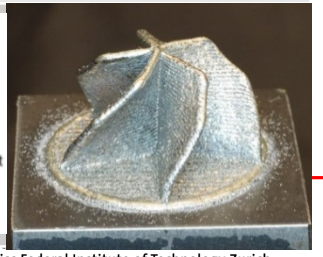
Domain	Processes	Materials	Principle
Metals	**Selective Laser Melting** (SLM)	Powder - Stainless steel, tool steel - Ni-base alloys - Aluminum, Titanium - Copper, bronze, …	 
Metals	**Direct Metal Deposition** (DMD)	Powder or wire - Metals (see above)	 
Metals	**Electron Beam Melting** (EBM)	Powder - Metals (see above) problem: ferromagnetic material	 
Metals	**Binder jetting** (BJT)	Powder - All metals, including WC and other hard metals - Sintering step	 
Metals	**MIG based direct metal deposition** (WAAM, Arc-DMD)	Pulver - Metals, (weldable)	 

SLM of different IN738LC batches
AM-specific material required

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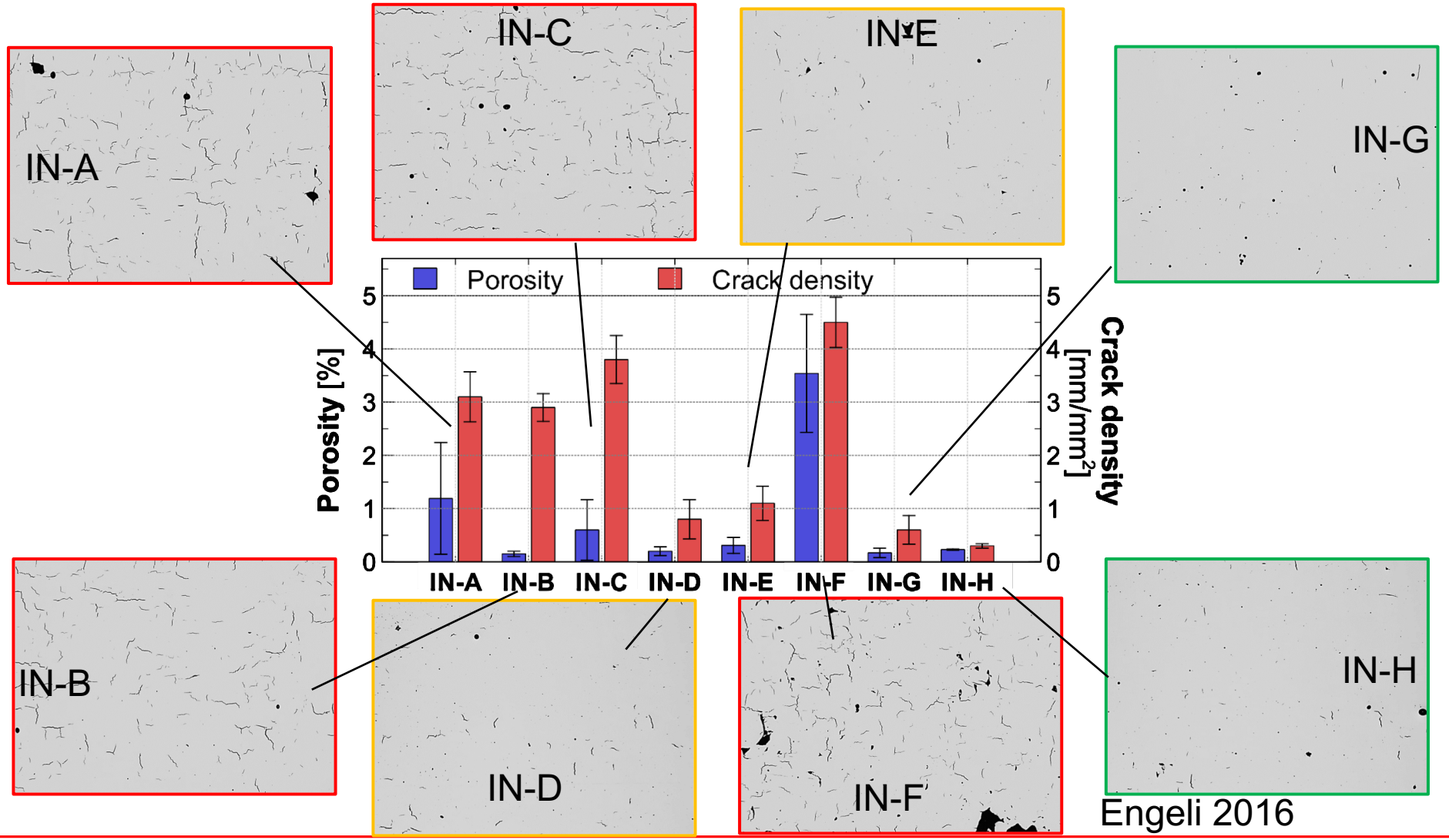
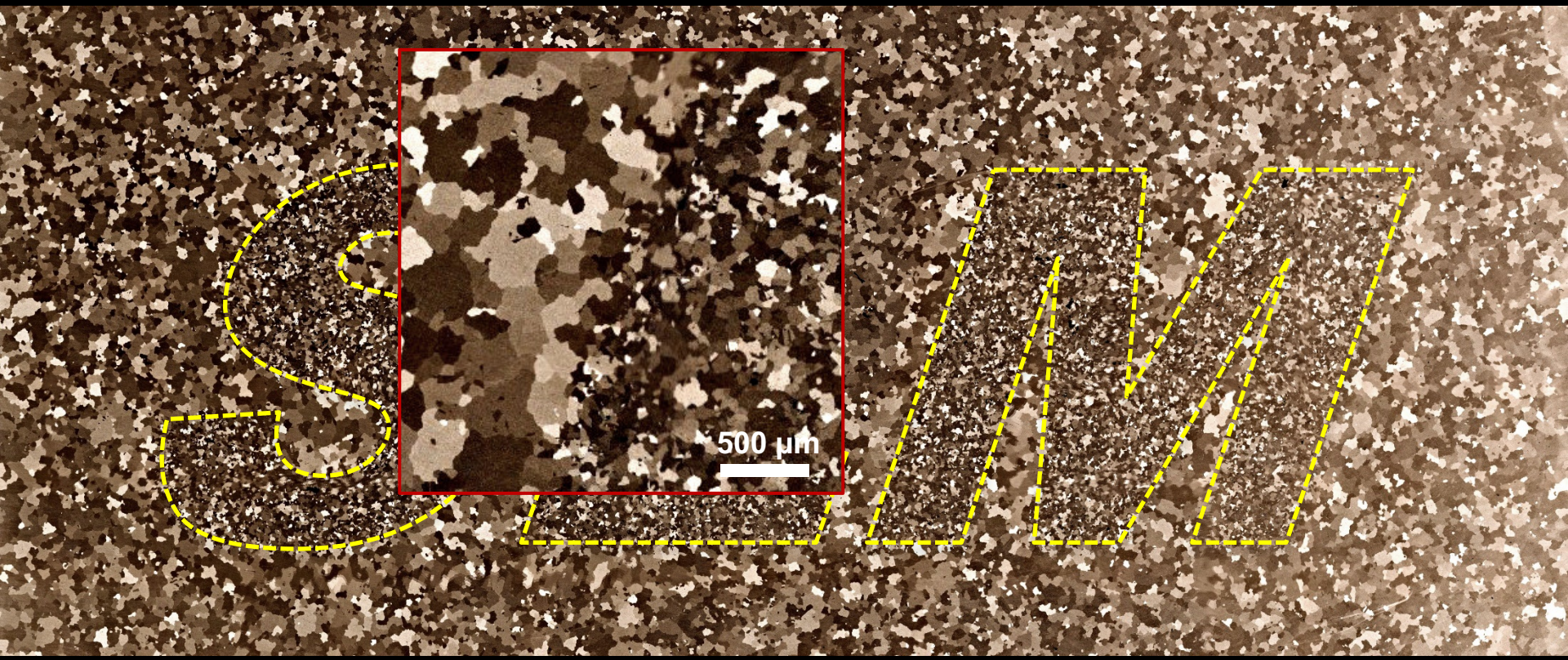


Engeli 2016

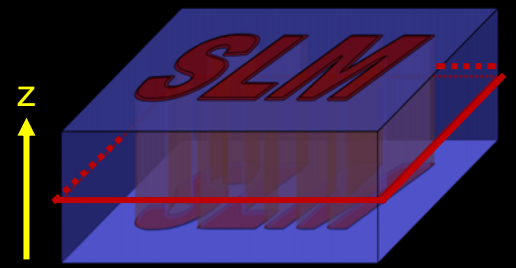
- Engineering the material
- AM as material generator
- Alloying by mixing, ie. Diamond dispersions in metal
- Grading of materials



Build-up direction (z)

5 mm

Engeli 2017



Structural aluminum

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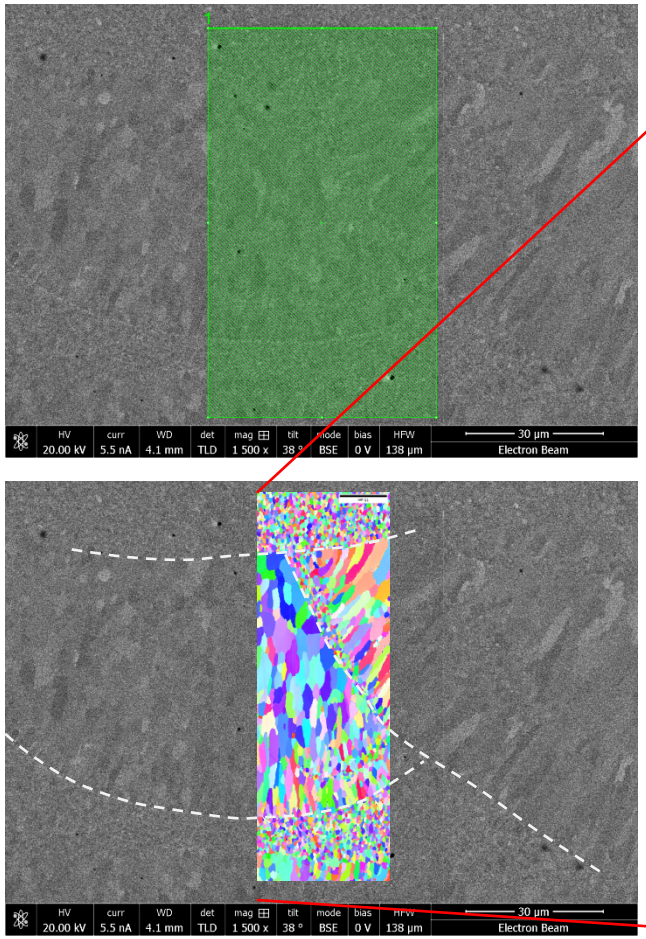
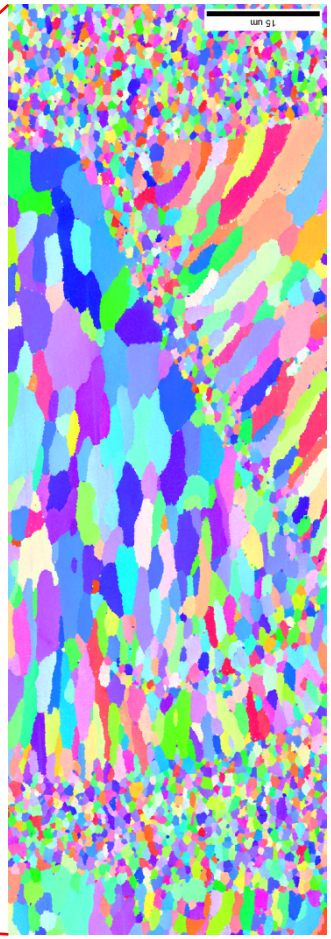
- **Micro structure**



heat treated 350°C/4h



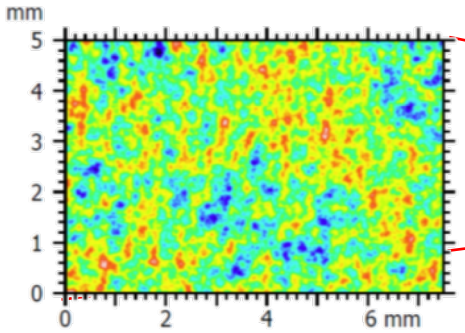
Source: inspire-icams

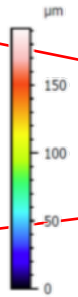
- ➔ Scandium-alloyed Aluminum
- ➔ Duplex structure consisting of fine and columnar grains
- ➔ Quasi isotropic
- ➔ Principle of SLM specific materials with low texture

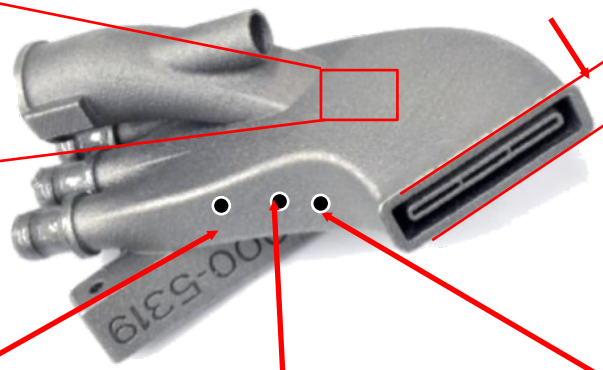
Spierings 2015

- Contents of quality in additive manufacturing
- Material and Geometry are made in the same process step
- Process monitoring and qualification instead of part inspection

Surface properties

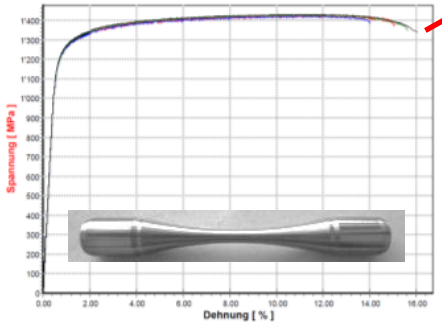




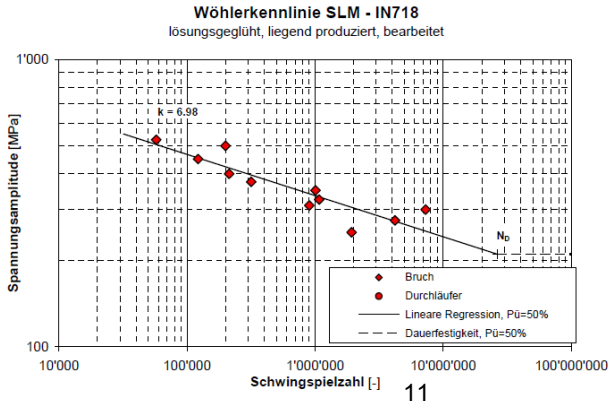


Geometric accuracy

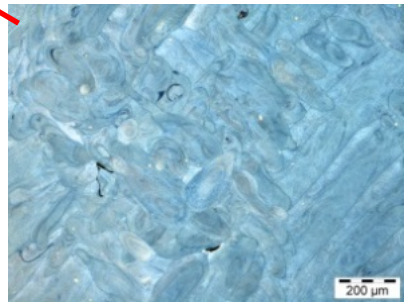
Material-properties static



Material-properties dynamic



Micro structur



AM part of the total process chain
➔ functionalization

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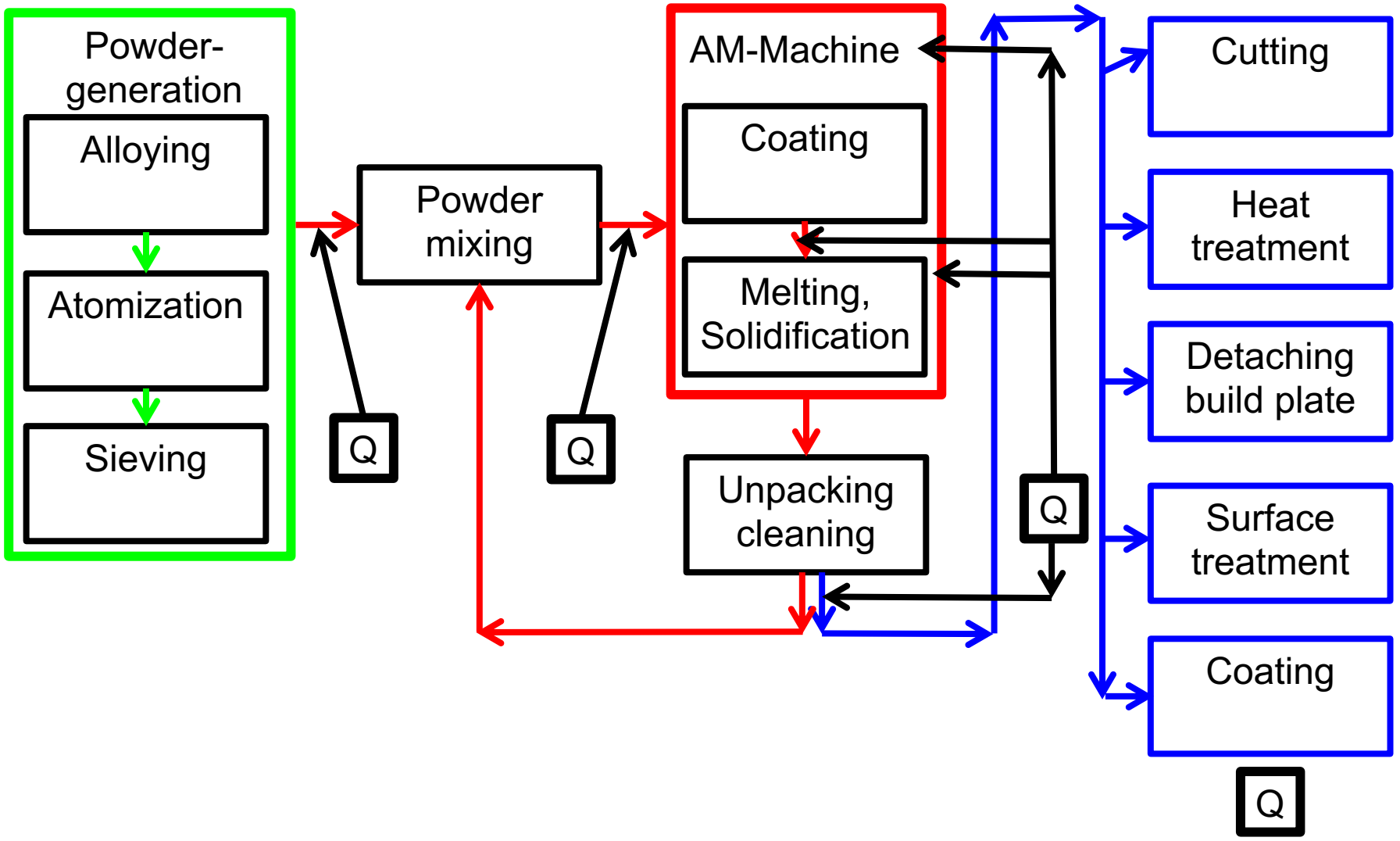


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