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3DMD High-speed DED Process Challenges and Potentials

Additive Alliance
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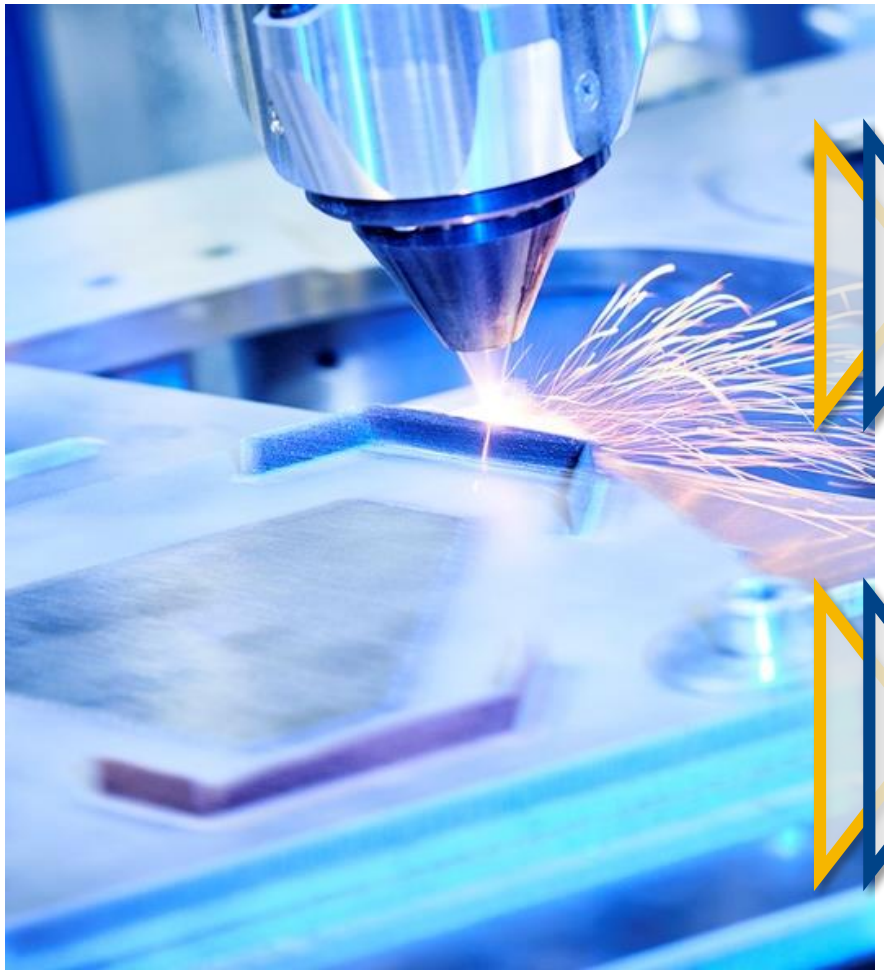
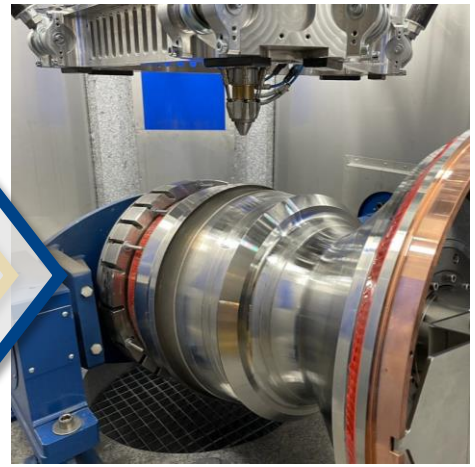
06.03.2024

www.ponticon.de

3DMD® Dynamic Material Deposition

Productivity, precision and material flexibility enable an unprecedented range of industrial AM and coating applications

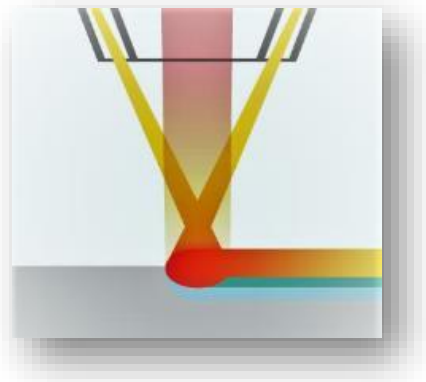




Tangible industrial applications span an unprecedented range from **commodity to high-value metal components.**

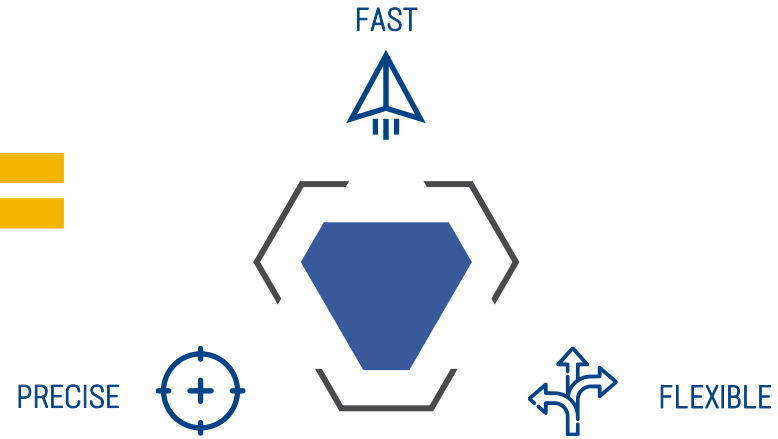
3DMD® builds on highly innovative scientific advances and sets Ponticon apart from other metal 3D printing and coating technologies

3DMD processing principle



Ponticon 3DMD system

Unique result



- Material interacts with laser beam before hitting the melt pool
- Strong metallurgical bond and flexible creation of alloy systems

- 3DMD® technology is 100x faster than DED
- State-of-the-art systems are unable to compete with Ponticon's high-speed kinematics

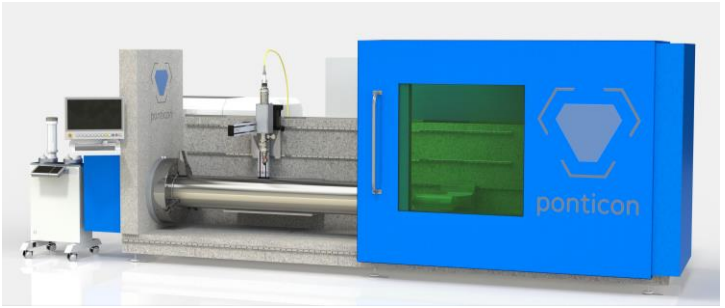
- Developments focus on building out a robust, industry-grade manufacturing process
- System has so far been selling to market for application research purposes

Ponticon Manufacturing Systems

High dynamics and precision enabled by advanced kinematics

Versatile development system

Large-scale system



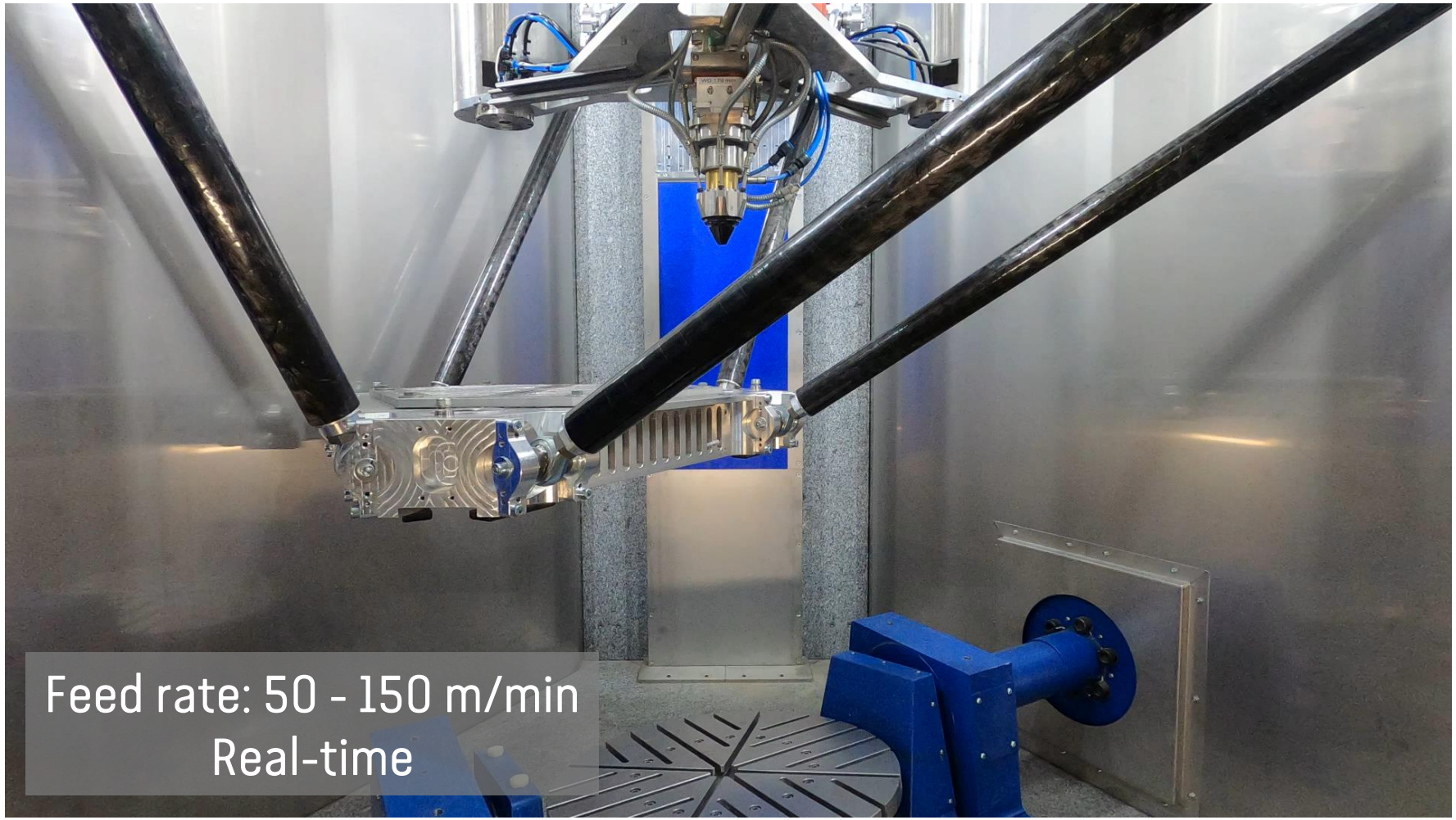
Industrial coating system

TECHNICAL SPECS:

- Wide range of feed rates: up to 200 m/min for smooth surfaces, high accuracy and high productivity
- Max. acceleration: 5G for maximum powder efficiency
- Up to 8 powder hoppers for material flexibility
- Real-time spot size control (typically 0.3 to 1.8 mm)
- Build envelope: up to 4,000 x 3,000 x 2,000 mm^3
- 3- and 5- axis operation
- All DED-LB and PBF-LB/M materials work with 3DMD
- Advanced sensors available

Kinematic principle

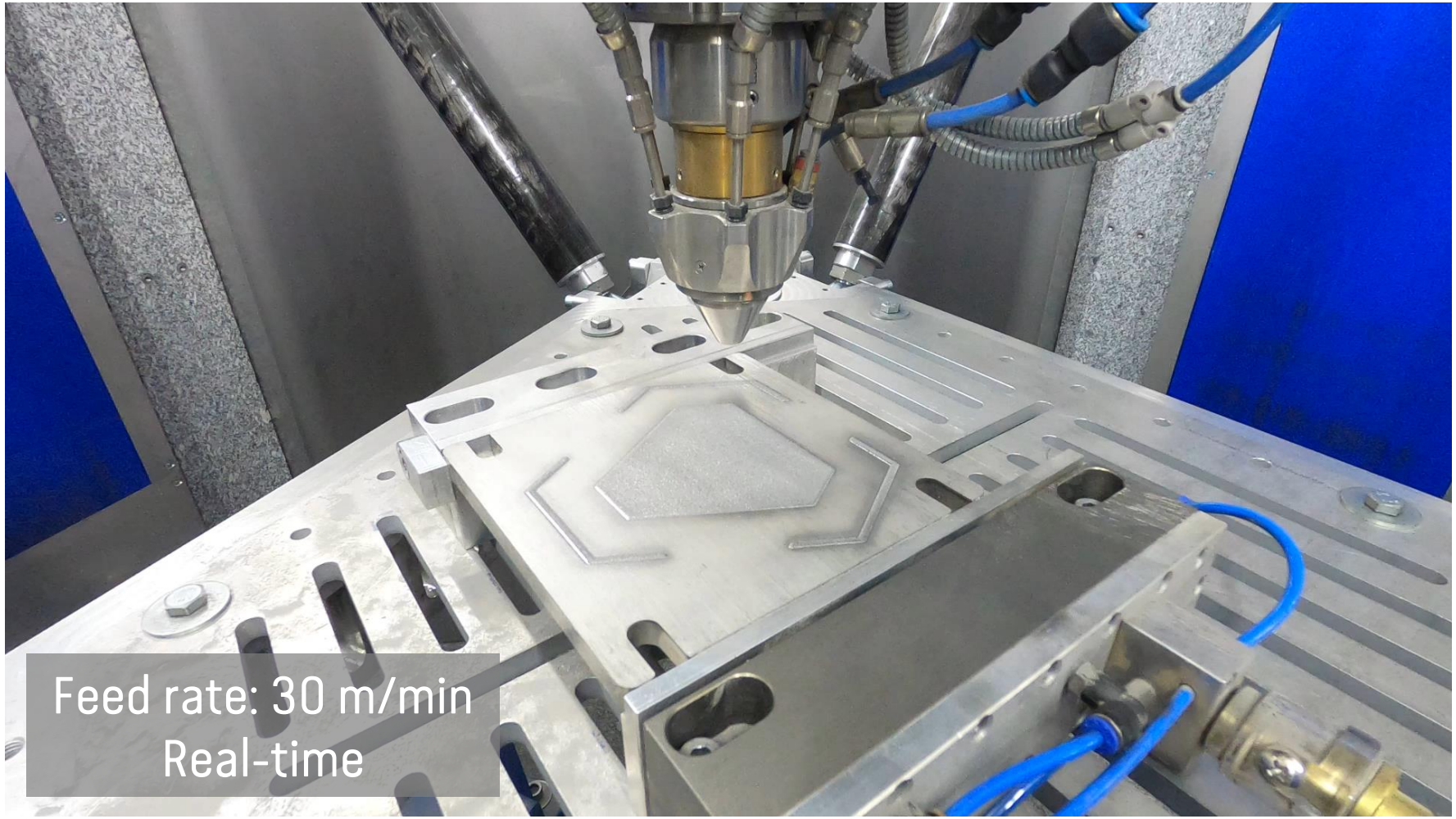
High dynamics and precision enabled by tripod parallel kinematics



Video link

Coatings

3DMD® sets new standards in metal coating and additive manufacturing applications



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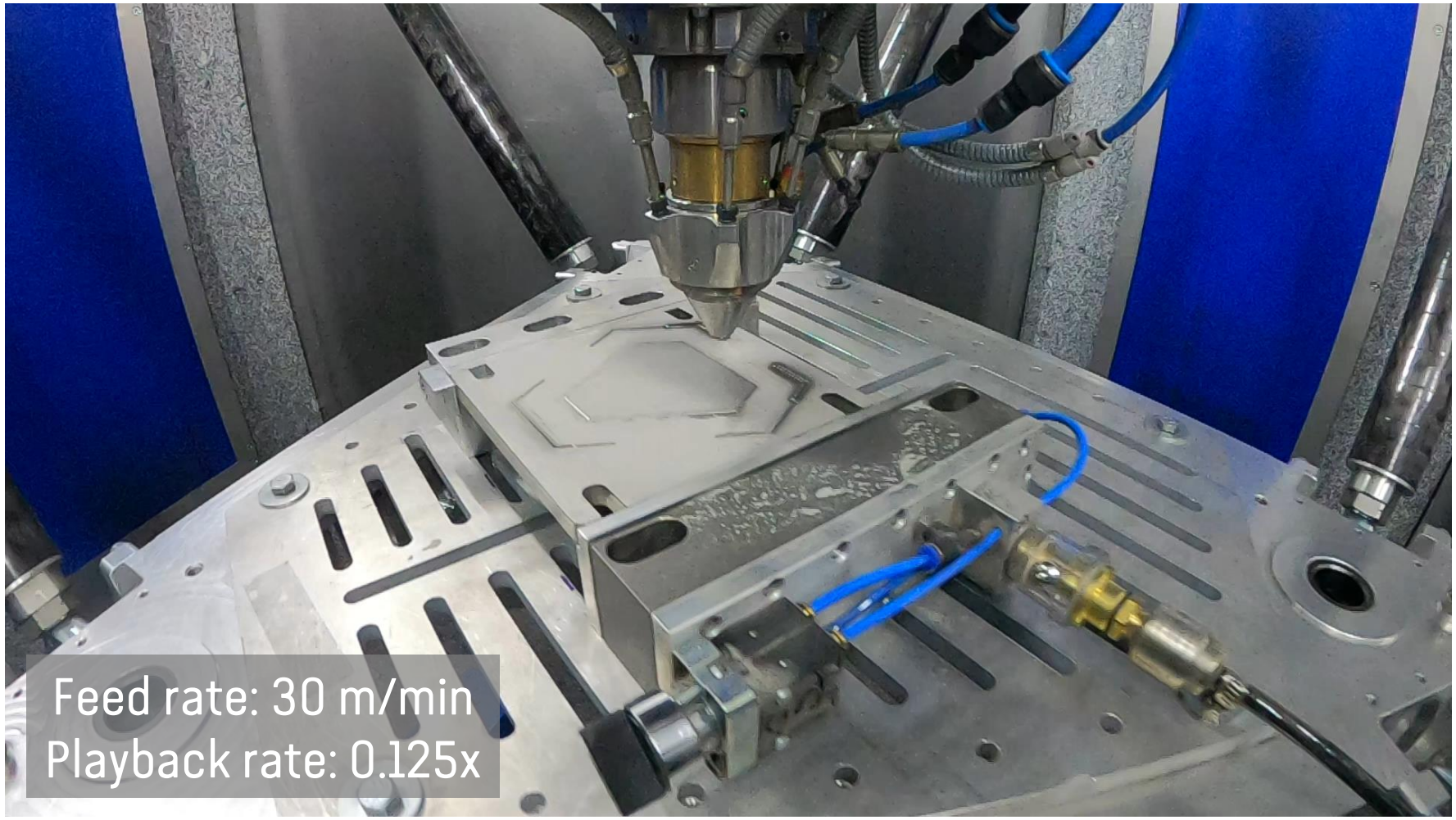


Video link

Additive Manufacturing

3DMD® sets new standards in metal coating and additive manufacturing applications

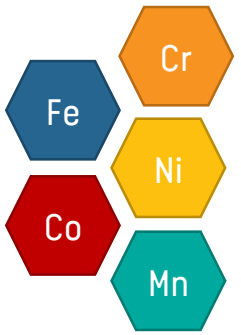
Video link

3DMD® processes come with unprecedented flexibility

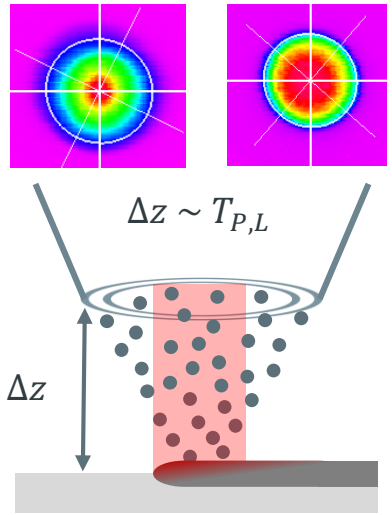
The interaction of powder material, substrate and laser energy can be precisely controlled in 3DMD

Powder feeding via nozzle → Melting by laser → Metallurgical bonding → Solidification → Cool-down

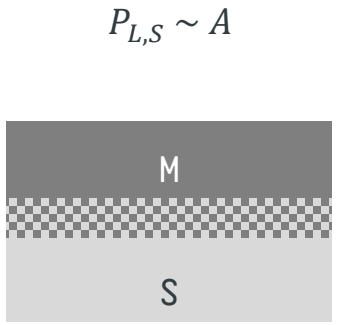
Chemical composition



Interaction time between laser and powder $T_{P,L}$



Dilution A



Solification rate S | Cooling rate C

- Solidification and cooling rate influence the microstructure

$$S = \frac{dx}{dt} = \boldsymbol{v_x} * \cos\theta \qquad C = \frac{dT}{dt} = \boldsymbol{v_x} * \frac{\partial T}{\partial x}$$

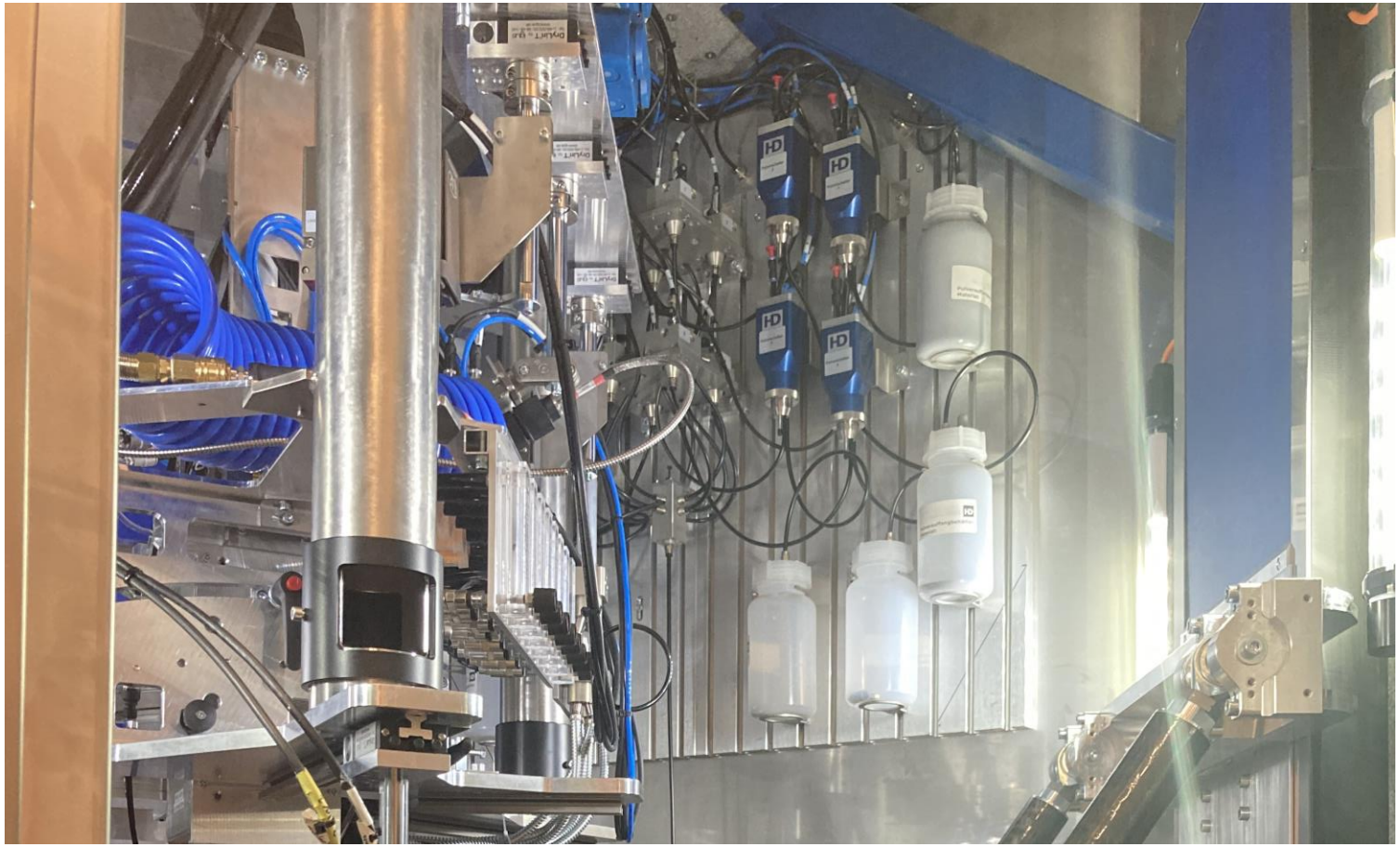
θ: Solidification direction perpendicular to surface normal

$\frac{\partial T}{\partial x}$: Thermal gradient

$\boldsymbol{v_x}$: Feed rate

In-situ mixing of multiple powders is a demanding task

Necessary periphery along the powder-gas-track



Material flexibility is key when developing and screening alloys in a time- and cost-efficient manner

Advantages:

- Real-time alloying with arbitrary chemical compositions
- No pre-mixing / pre-alloying required

Challenges:

- Homogenous, defined powder mixing
- Different melting points of utilized materials
- Inertia of powder feeding systems

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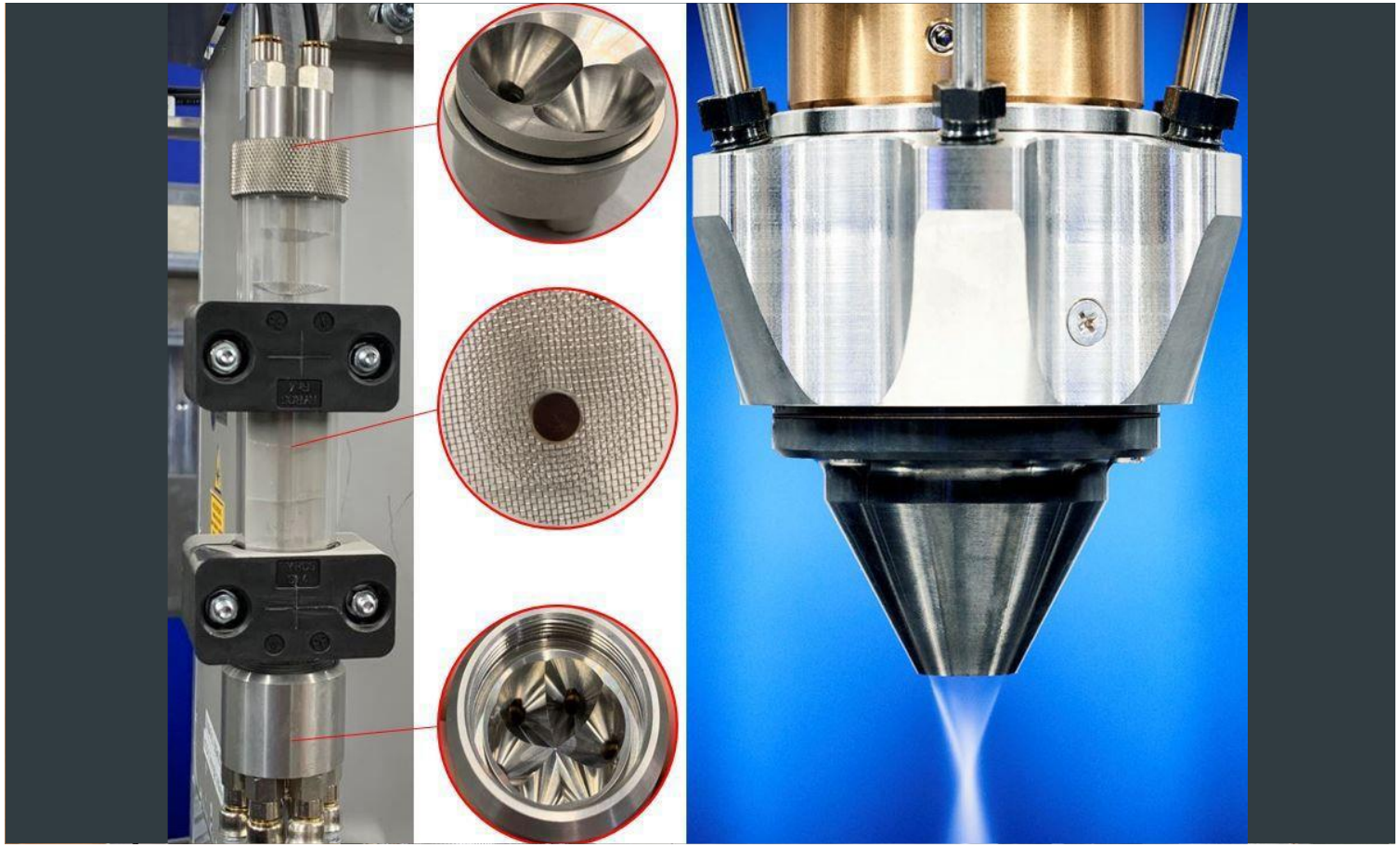

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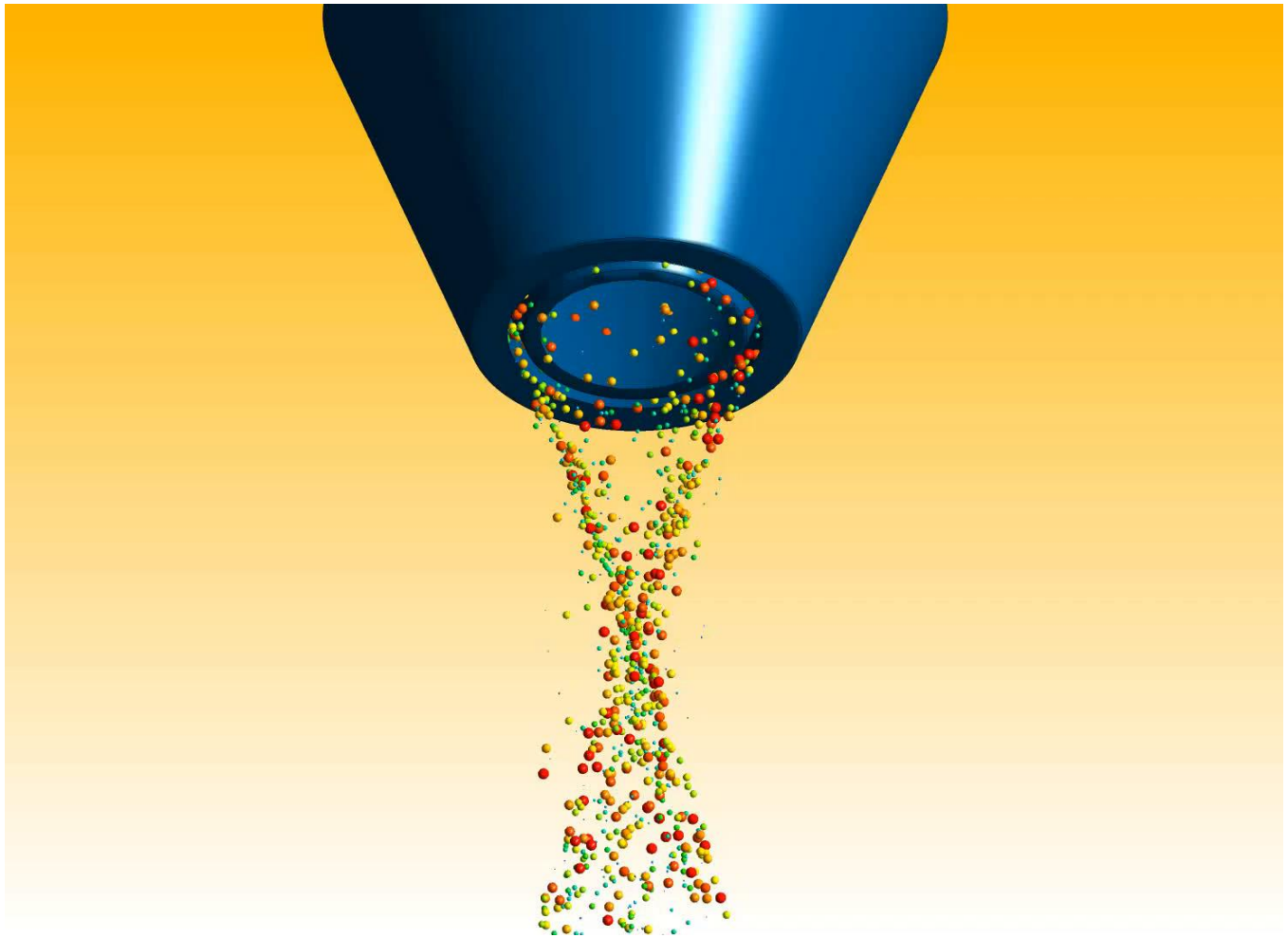
Experimental and simulative analysis of powder-gas-track

Understanding of particle behavior is a key enabler for industry-grade coating and AM processes



Sound understanding of interactions along the powder-gas-track is essential when setting up an industry-grade coating or AM process.

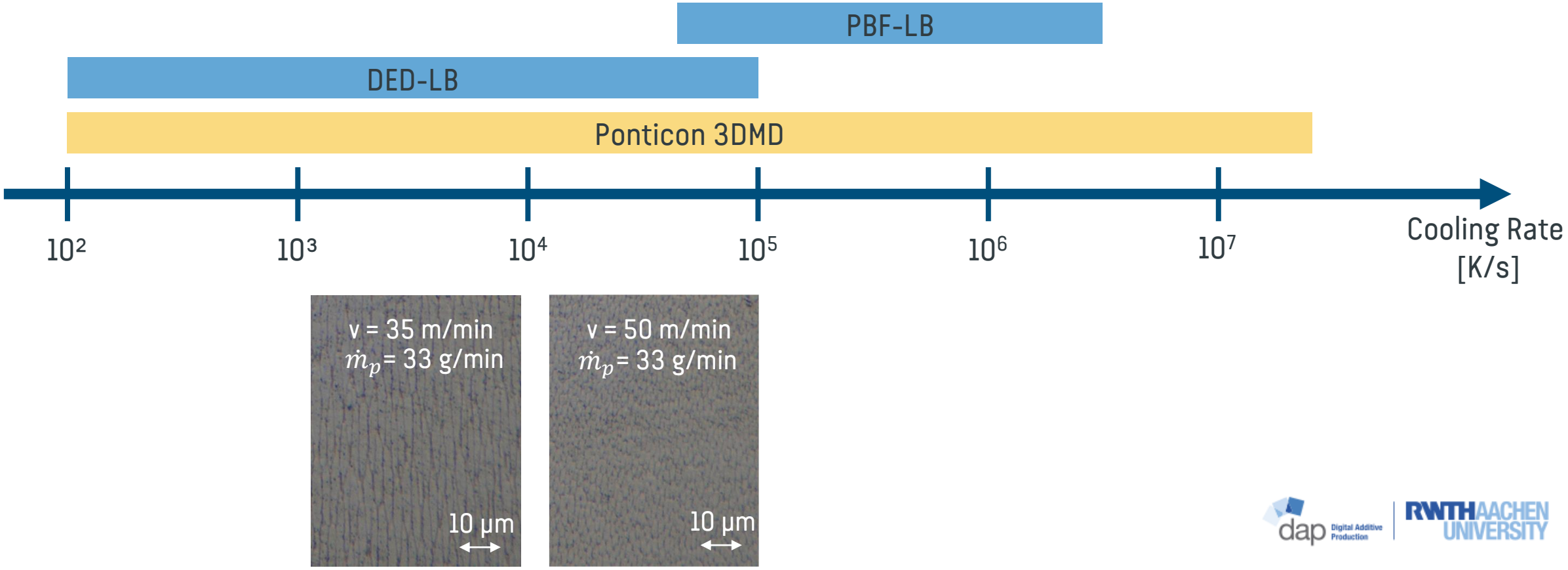
Advantages:

- Information on particle behavior (e.g. velocity) enables defined heat input
- Measurement of powder caustic is a mandatory QA procedure

Challenges:

- Validation of simulation models is time-consuming
- No standards regarding powder stream characteristics

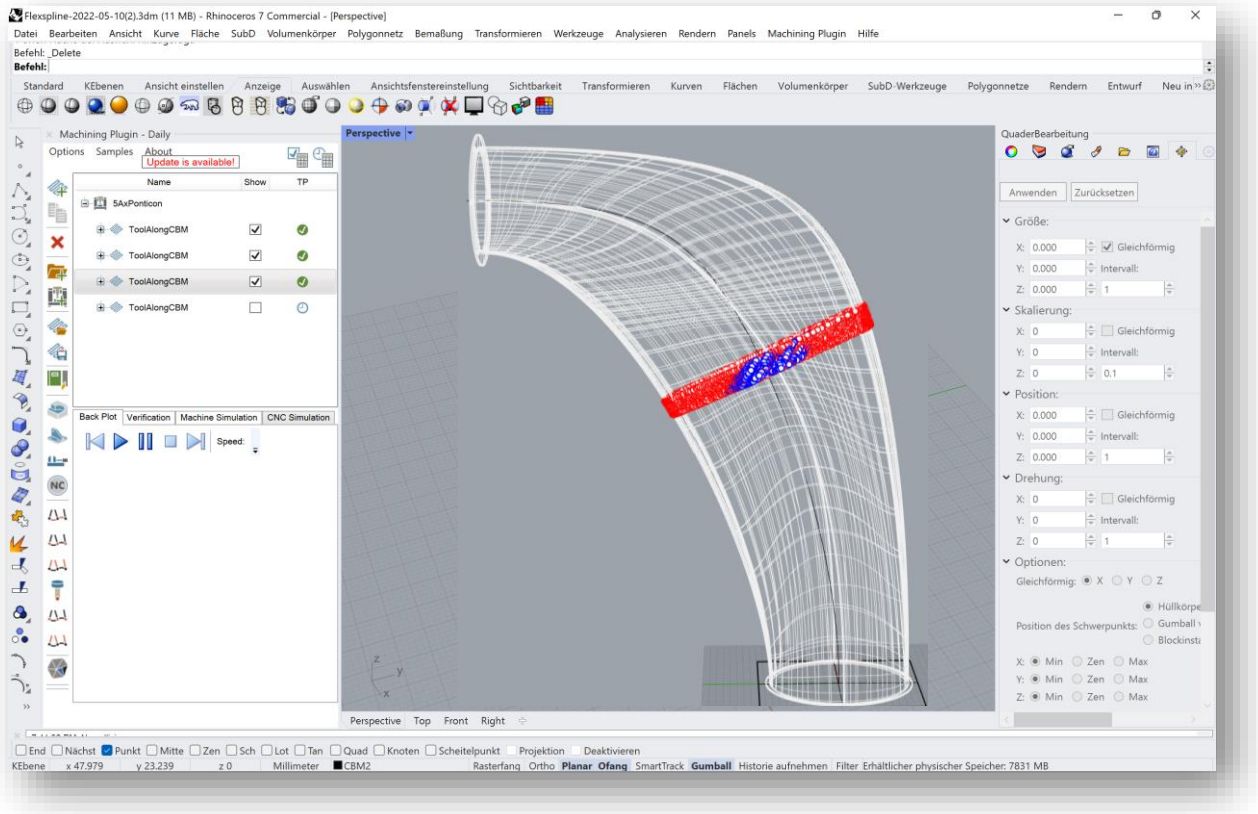
3DMD enables emulation of other processes' solidification behavior



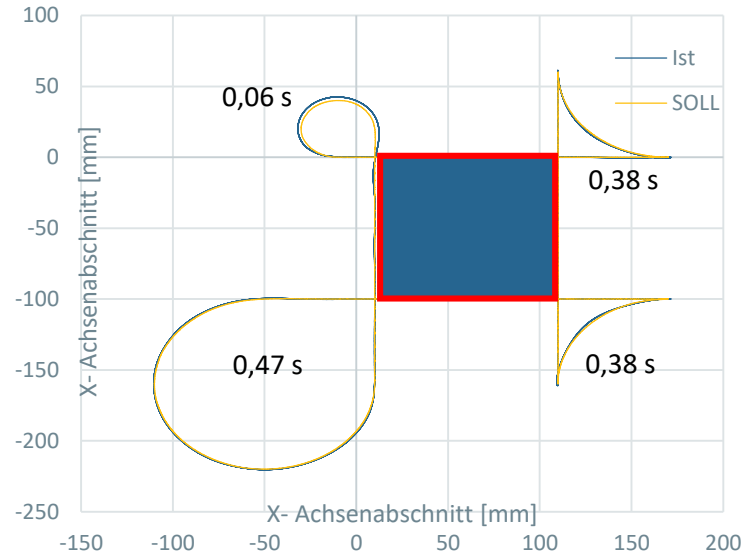
dap Digital Additive Production | RWTH AACHEN UNIVERSITY

Software is a key enabler for high-speed DED processes

Extraordinary dynamics of 3DMD technology require sophisticated interplay of software and hardware



- CAM environment with technology-specific processing strategies



- High dynamics and feed-rates require sky-writing strategies for 3DMD technology
- Trade-off between required time for re-orientation and path accuracy

Technology – Sensor Integration

Process monitoring and control is an important prerequisite for widespread industrial adoption

Layer height | Optical Coherence Tomography sensor

Temperature | Two-color pyrometer

Visual process emissions | Multi-spectrum sensor

Acoustic process emissions | Structure-bourne sound sensor

3D shape | Line-scanner

Powder particle trajectory | High-speed camera

Surface hardness | Barkhausen noise sensor

➔ Acquisition, fusion, interpretation and utilization of sensor data is complex task

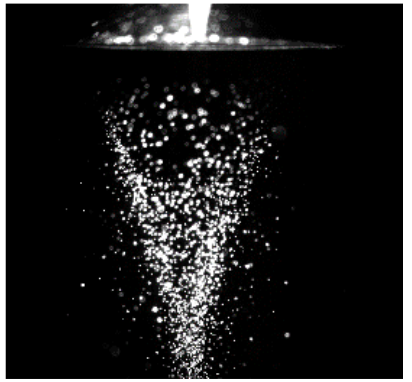
➔ Cooperation between institutes and Ponticon is key to transfer an academic approach

Technology – Advanced kinematic systems

Scaling to bigger parts

Technology – Advanced kinematic systems

Scaling to bigger parts



4 x 3 x 2 m
build envelope

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