



Additive Manufacturing of Metal Matrix Composites

Florian Wirth (IWF, ETH Zürich)

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CONFERENCE
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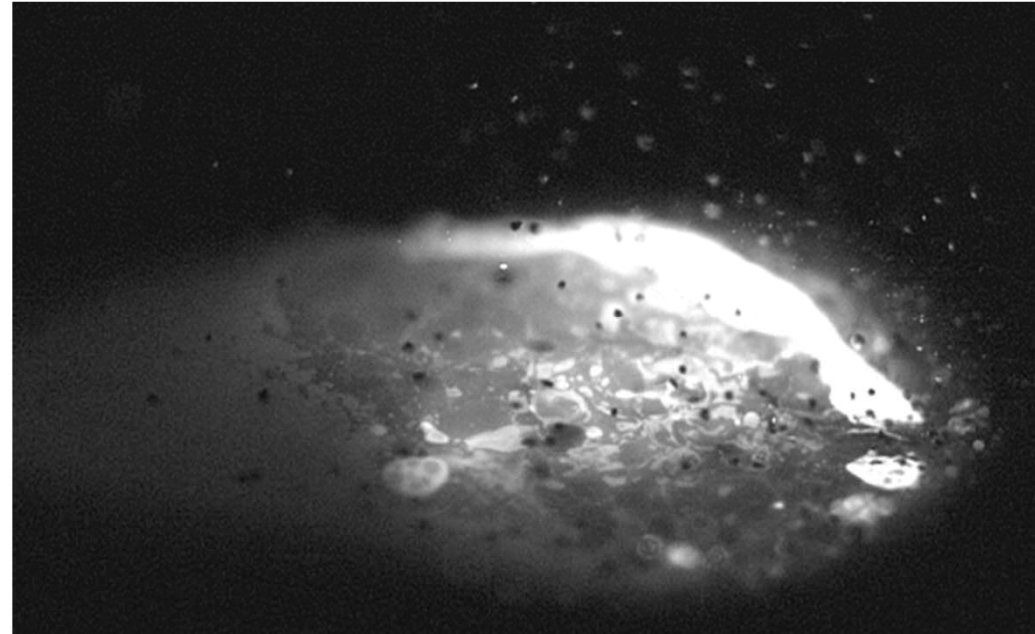
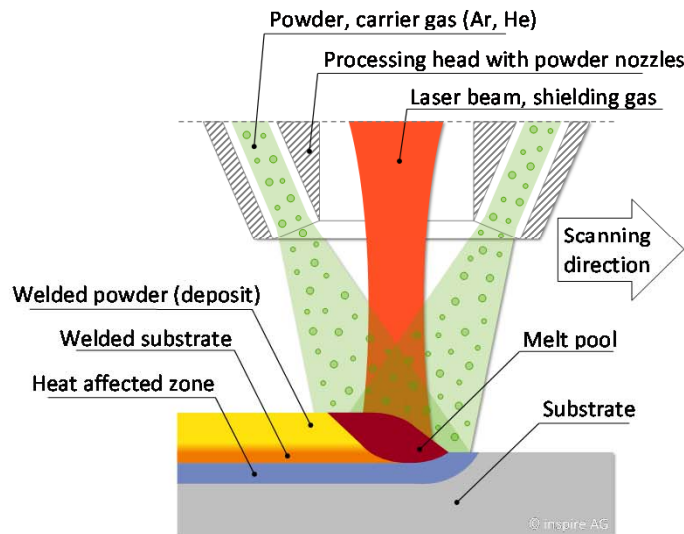
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Introduction: The LMD process

The Laser Metal Deposition (LMD) process



- Laser beam maintains a melt pool
- Powder supply into the melt pool
- Feed motion of laser beam and powder jet
 - Multiple overlapping weld beads form a layer/coating
 - Multiple layers form a 3D part

Application

- Coating against corrosion/wear
- Repair
- Additive manufacturing of 3D parts

material processing

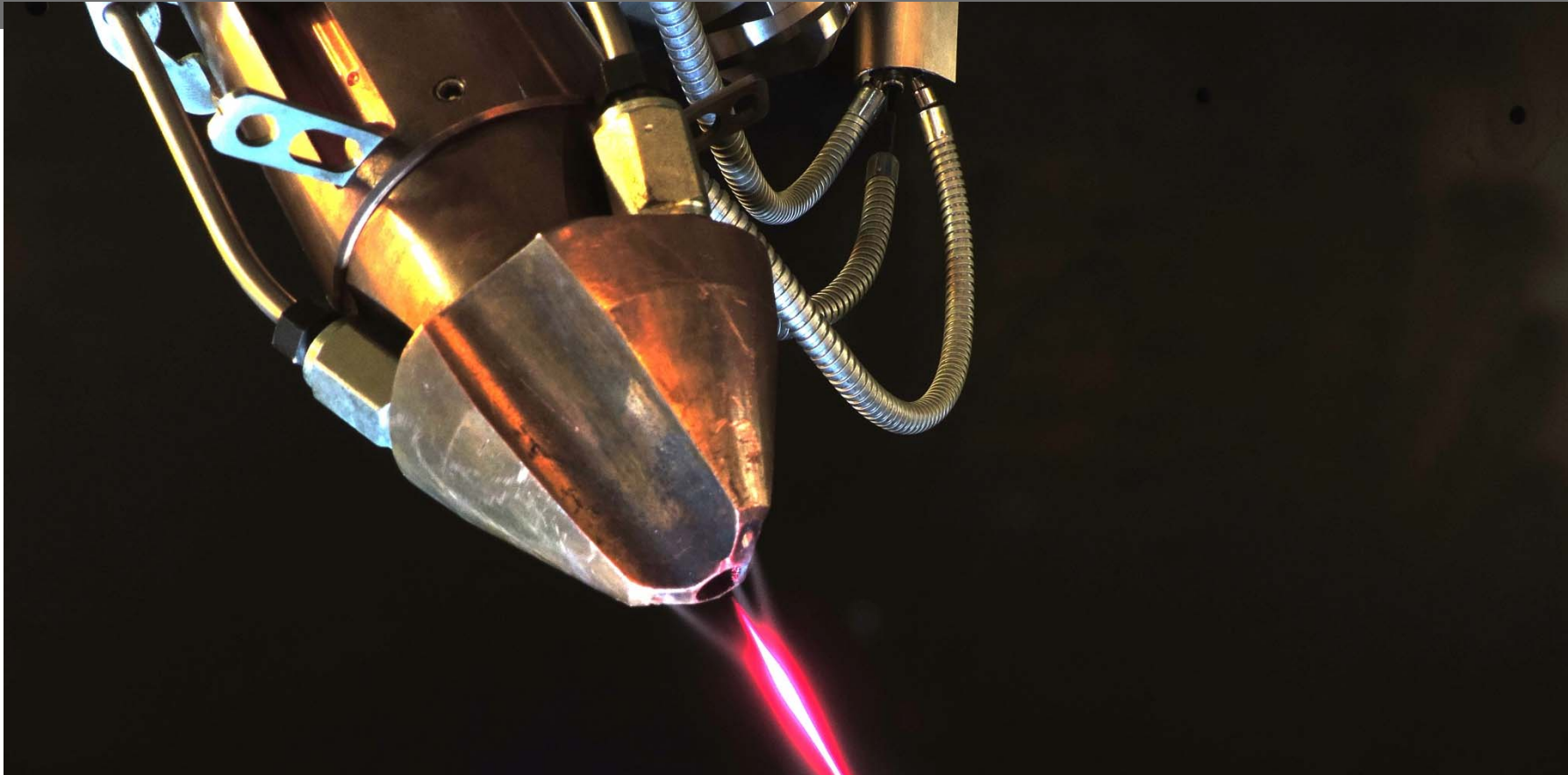


mining



power generation

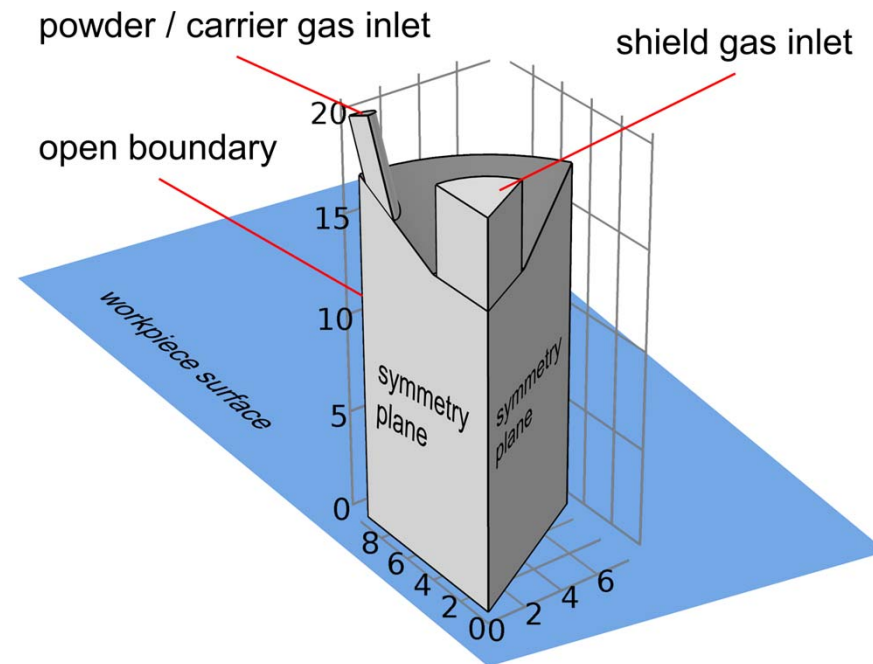




Powder nozzle simulation

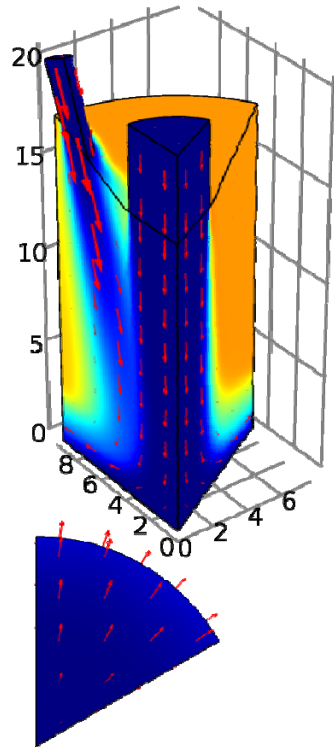
Powder nozzle model

- One sixth of the three-jet powder nozzle and the space below is modeled
- Used modules
 - Turbulent flow k- ϵ
 - Transport of concentrated species
 - 3 gases: He, Ar, Air
 - Particle tracing

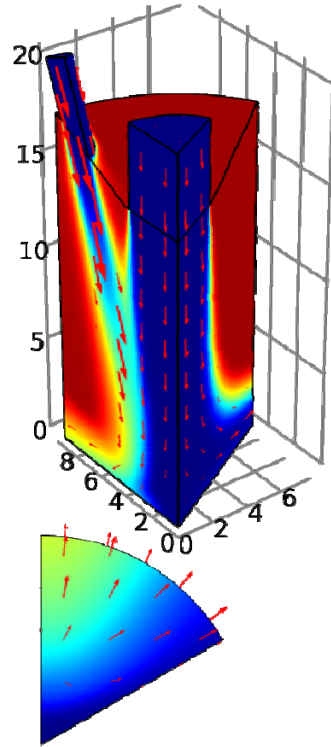


Results: Oxygen concentration, powder jet

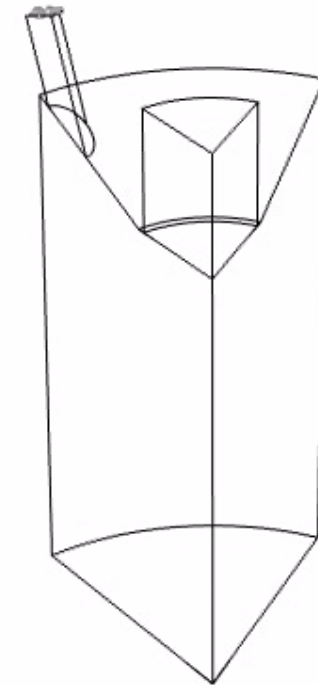
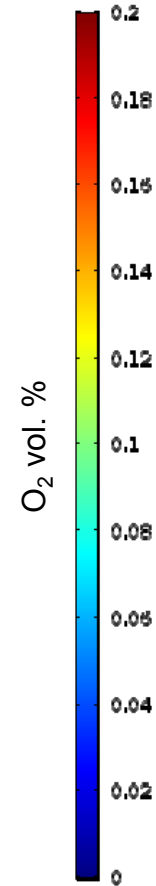
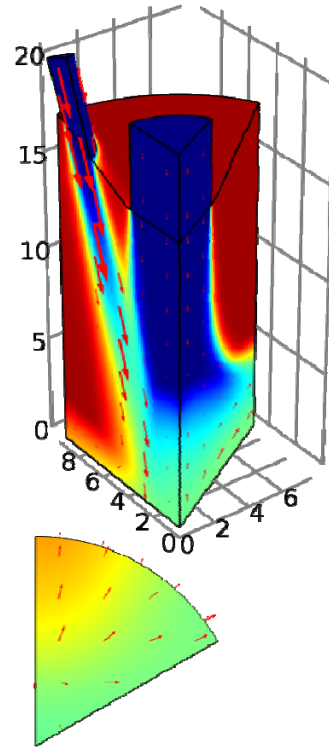
carrier gas 5 l/min He
shield gas 15 l/min Ar



5 l/min Ar
15 l/min Ar

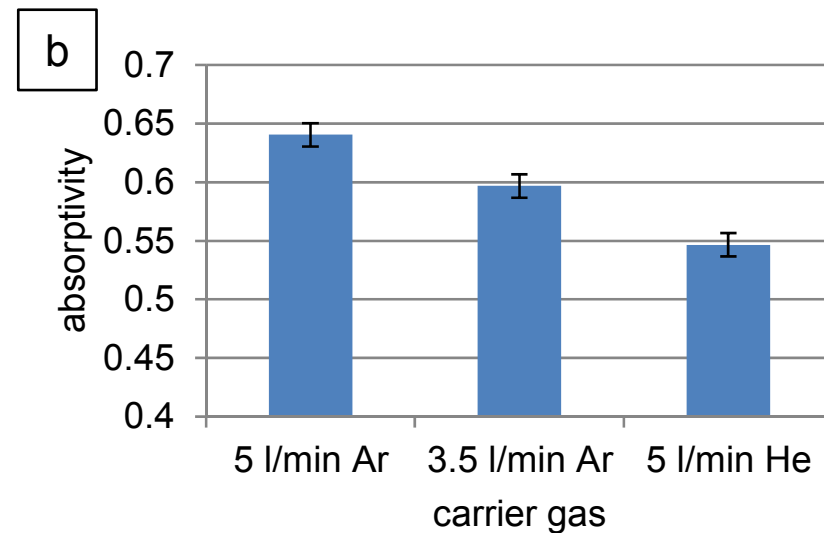
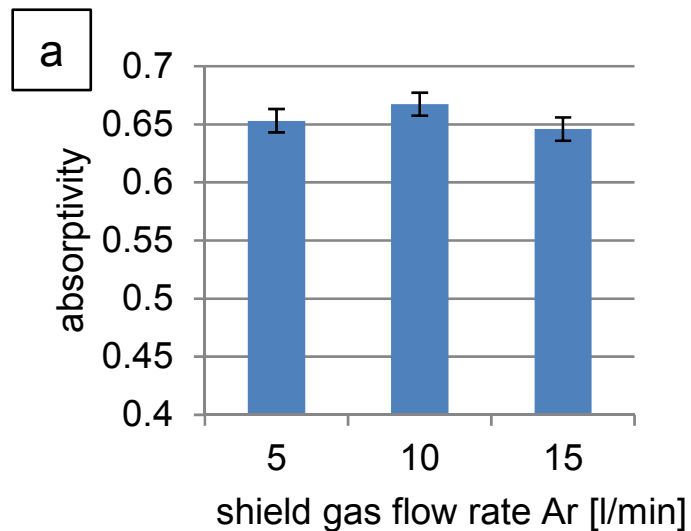


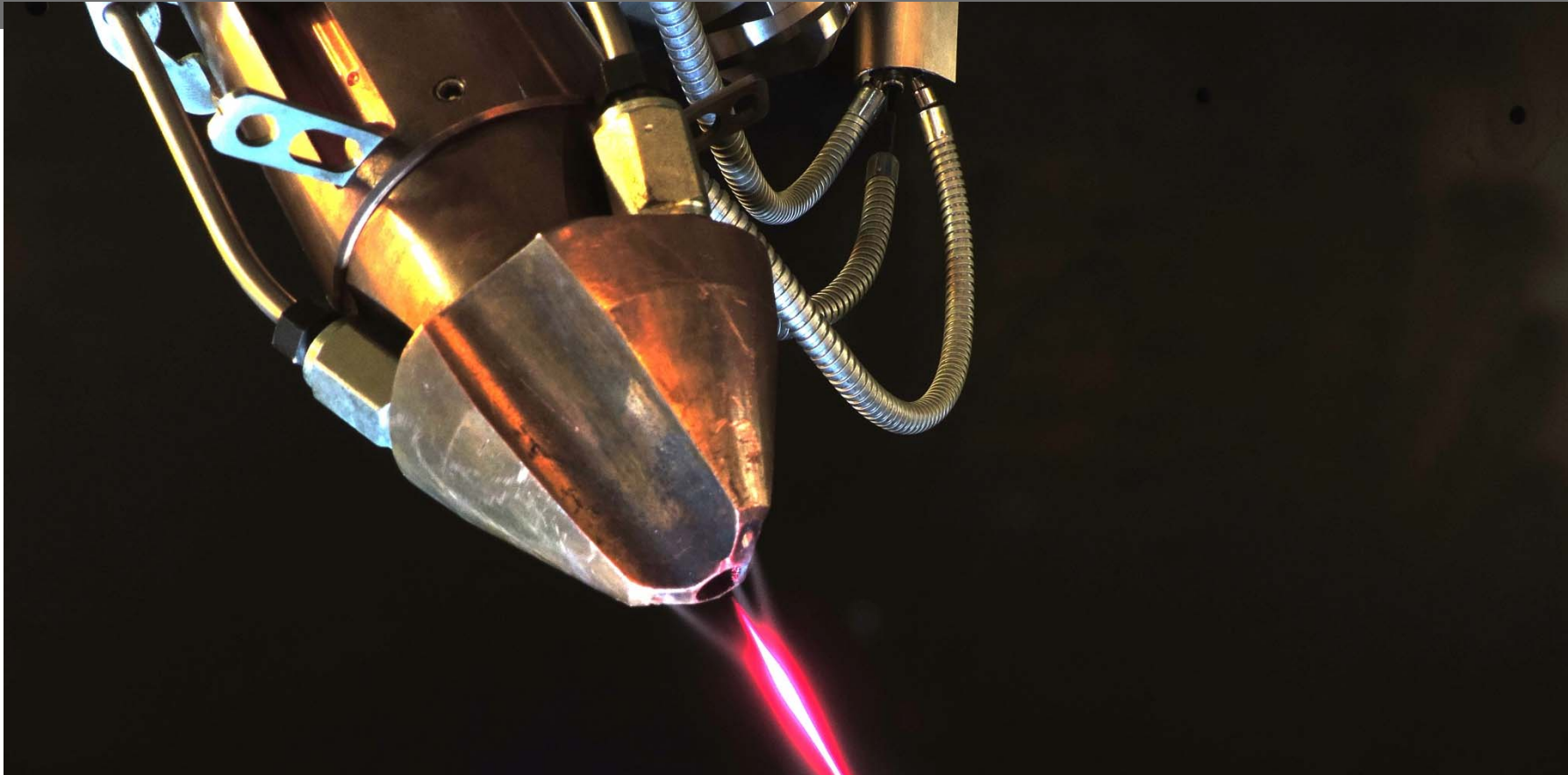
5 l/min Ar
5 l/min Ar



Absorptivity measurement

- Oxidation can be reduced by
 - He instead of Ar as carrier gas
 - Reduced carrier gas flow rate (often not possible)
 - Powder nozzle design: Larger powder channel \emptyset



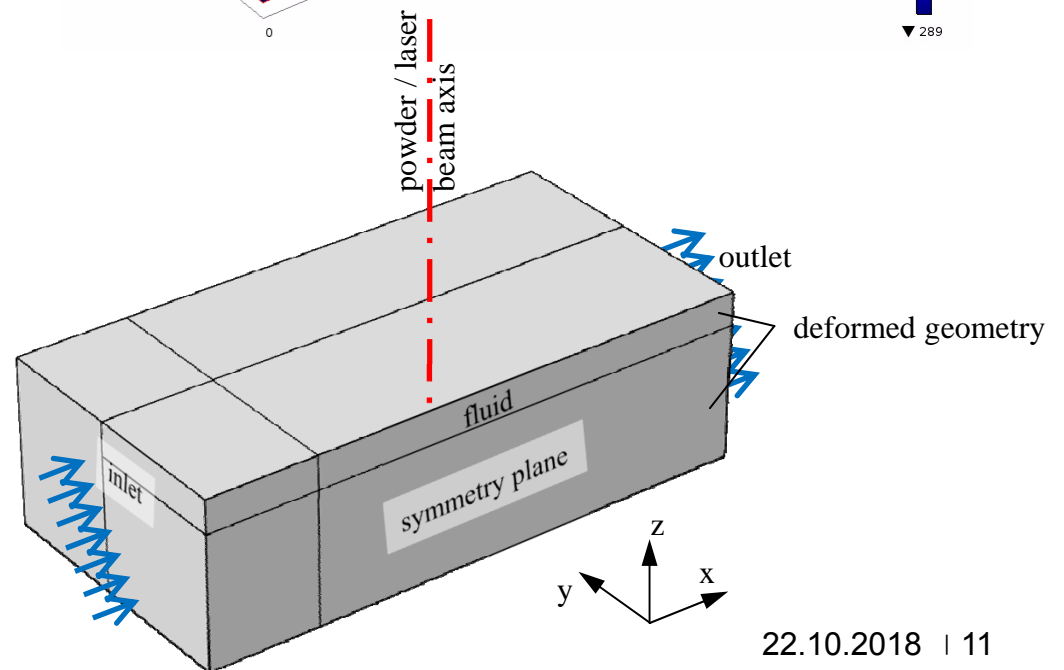
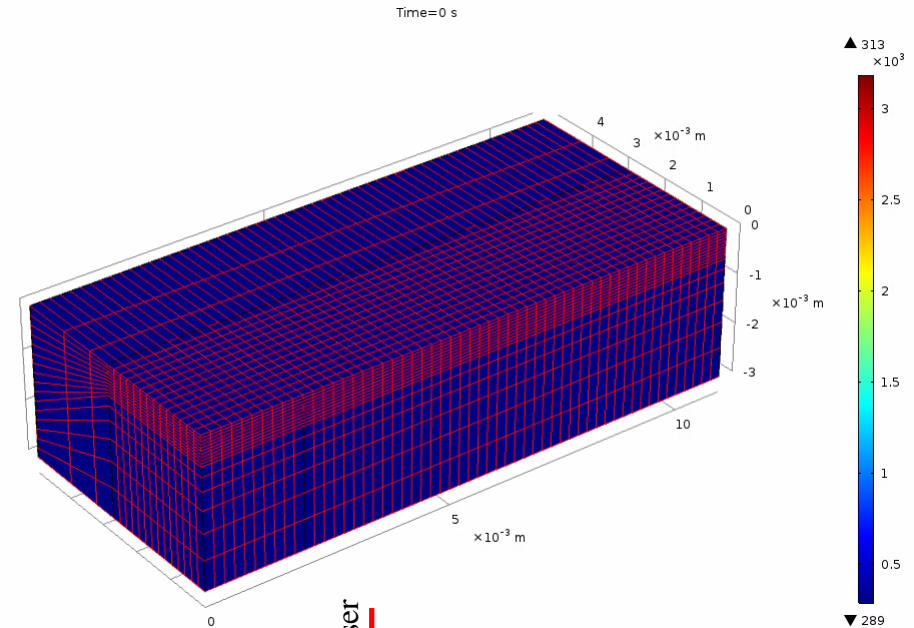


Melt pool simulation

Model overview

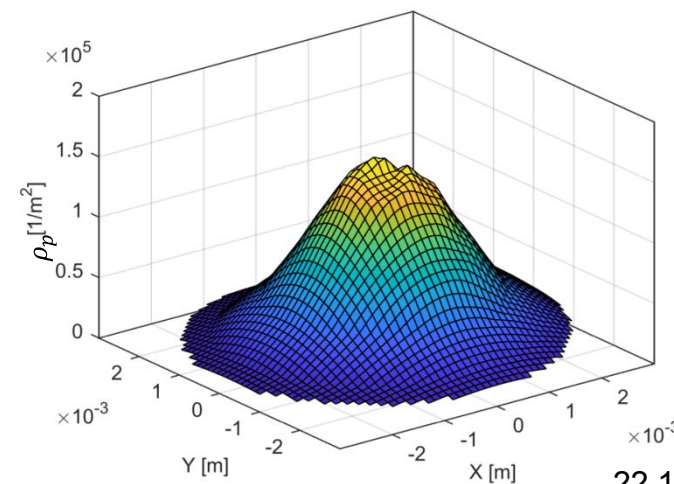
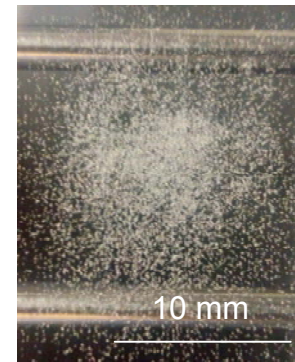
- Used modules (in the 1st step)
 - Heat transfer
 - Laminar flow
 - Surface tension, Marangoni effect
 - Deformed geometry
 - Boundary PDE
 - Tracing of freely deforming surface

- 2nd step
 - Particle tracing
 - Behavior of carbide particles inside the melt pool

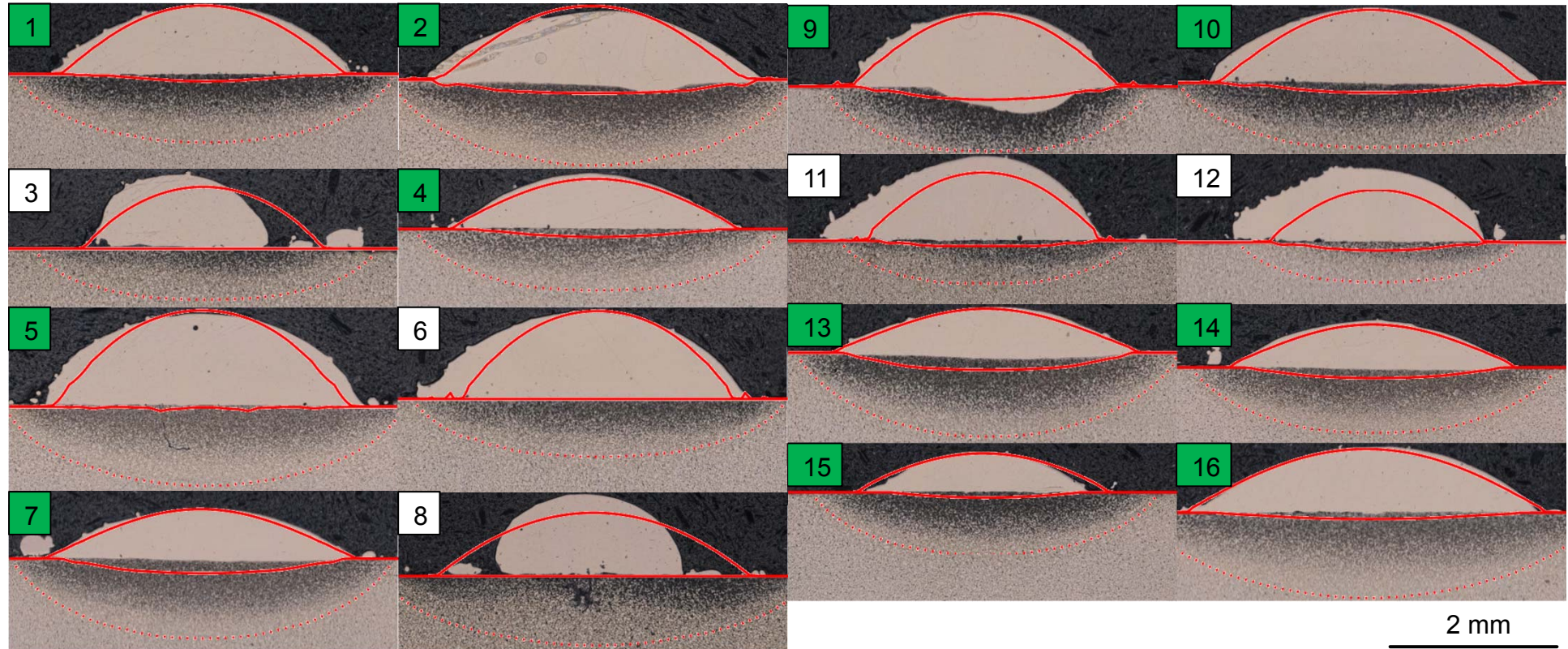


Crucial input data

- Absorptivity
 - Melt pool
 - Solid material
 - Powder
- (Attenuation → from powder jet simulation)
- Powder particle density distribution (→ powder jet \emptyset)



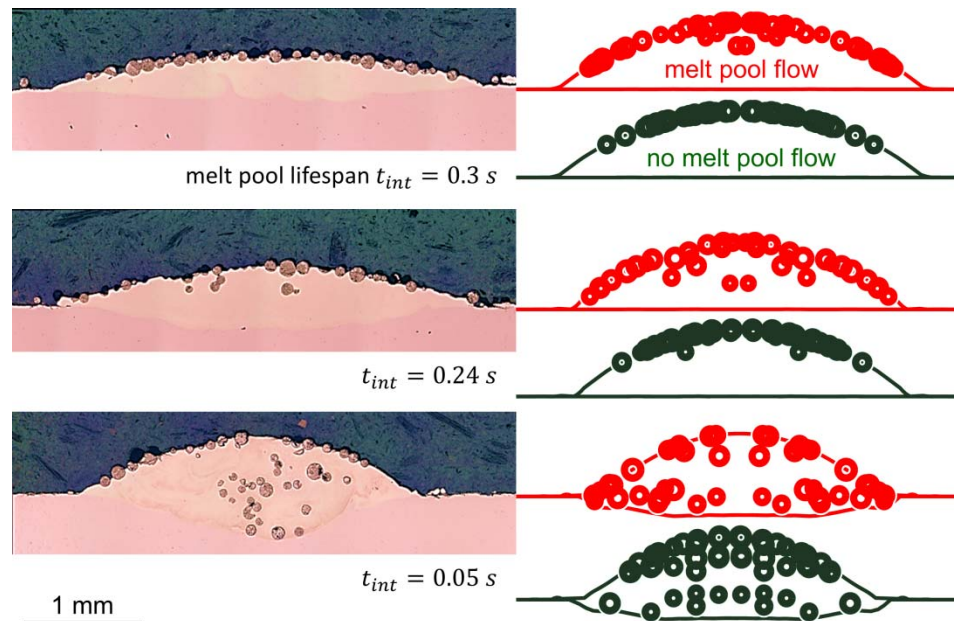
Validation



- Good agreement between experiment and simulation in the case of sufficient bonding and low dilution

Additive Manufacturing of MMCs

- Metal powder is mixed with carbide particle powder



- The melt pool flow has only a minor effect on the carbide particle distribution
- The homogeneity of the carbide particle distribution can be improved by a shorter melt pool lifespan and a proper choice of the particle size

Aknowledgement



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