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Fraunhofer Institute for Casting, Composite and Processing Technology IGCV

FIDENTIS

Rapid.Tech 3D 2024

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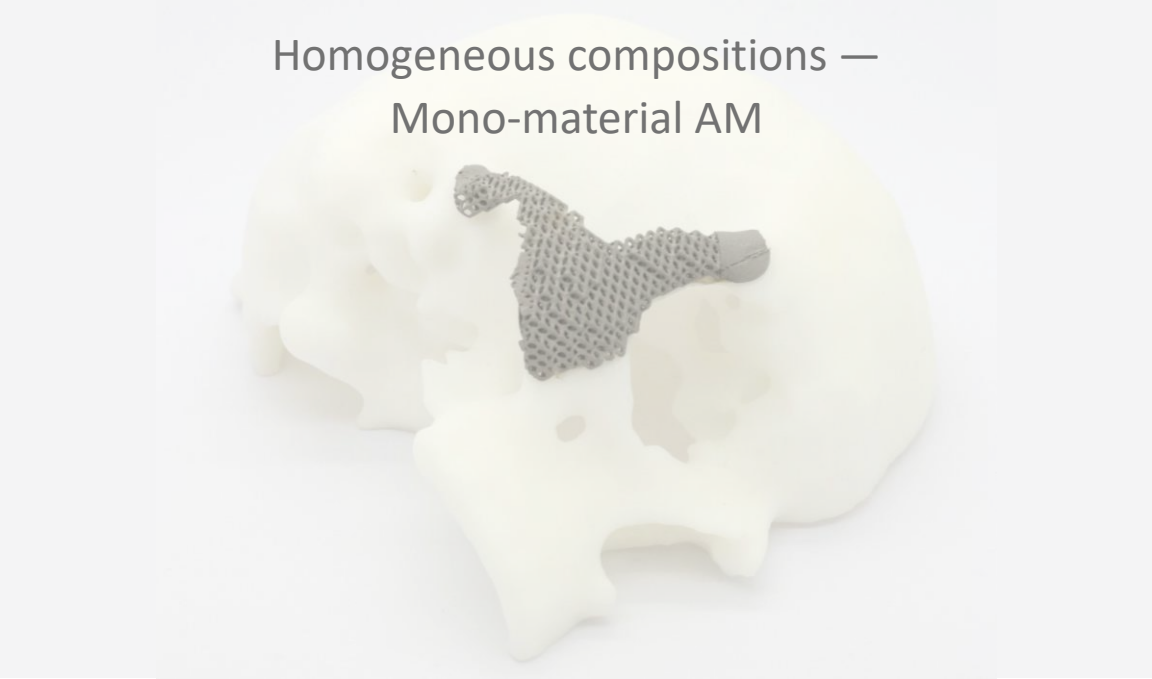
Transition zone parameter development in multi-material powder bed fusion: A general approach

What do we see as functionally graded materials (FGMs)?

Definition

Additive manufacturing (AM) of FGMs […] is a layer-by-layer fabrication technique that intentionally modifies process parameters and gradationally varies the spatial of material(s) organization within one component to meet intended function. [1]



[1] ISO/ASTM TR 52912

Why use powder bed fusion (PBF) for multi-material parts?

Motivation – selected examples

Function integration or improvement

Multi-material injection nozzle

10 mm

Manufacturing improvement

Pin used in high-voltage switchgears

10 mm

Left: Schneck, Horn et al. 2022, https://doi.org/10.3390/met12010044
Right: Bareth, Stapff, Ringel, Horn et al. (unpublished), Project KINEMATAM

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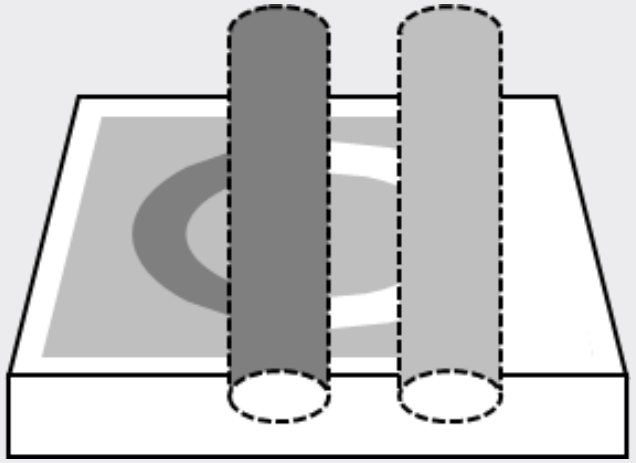
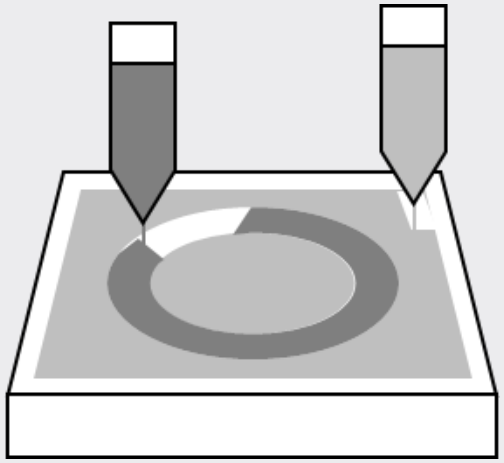
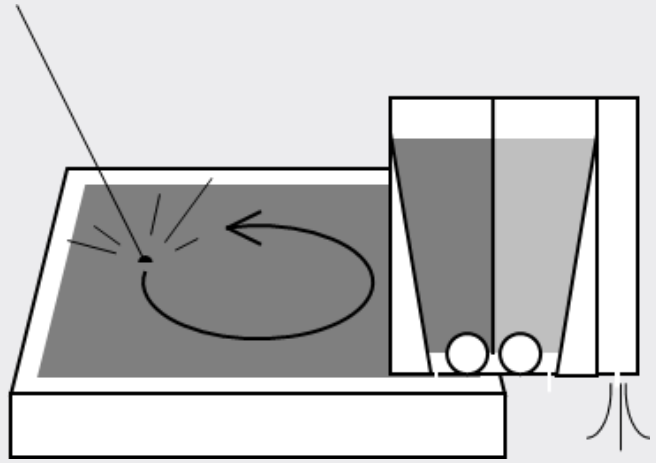
How to create multi-material parts using powder bed fusion (PBF)

Technology background – powder deposition systems

Masked	Nozzle-based	Holohedral
		

Source: Schneck, Horn et al. 2020, doi: https://doi.org/10.1007/s40964-021-00205-2

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Multi-material with nozzle-based powder deposition

Technology background – nozzle-based powder deposition

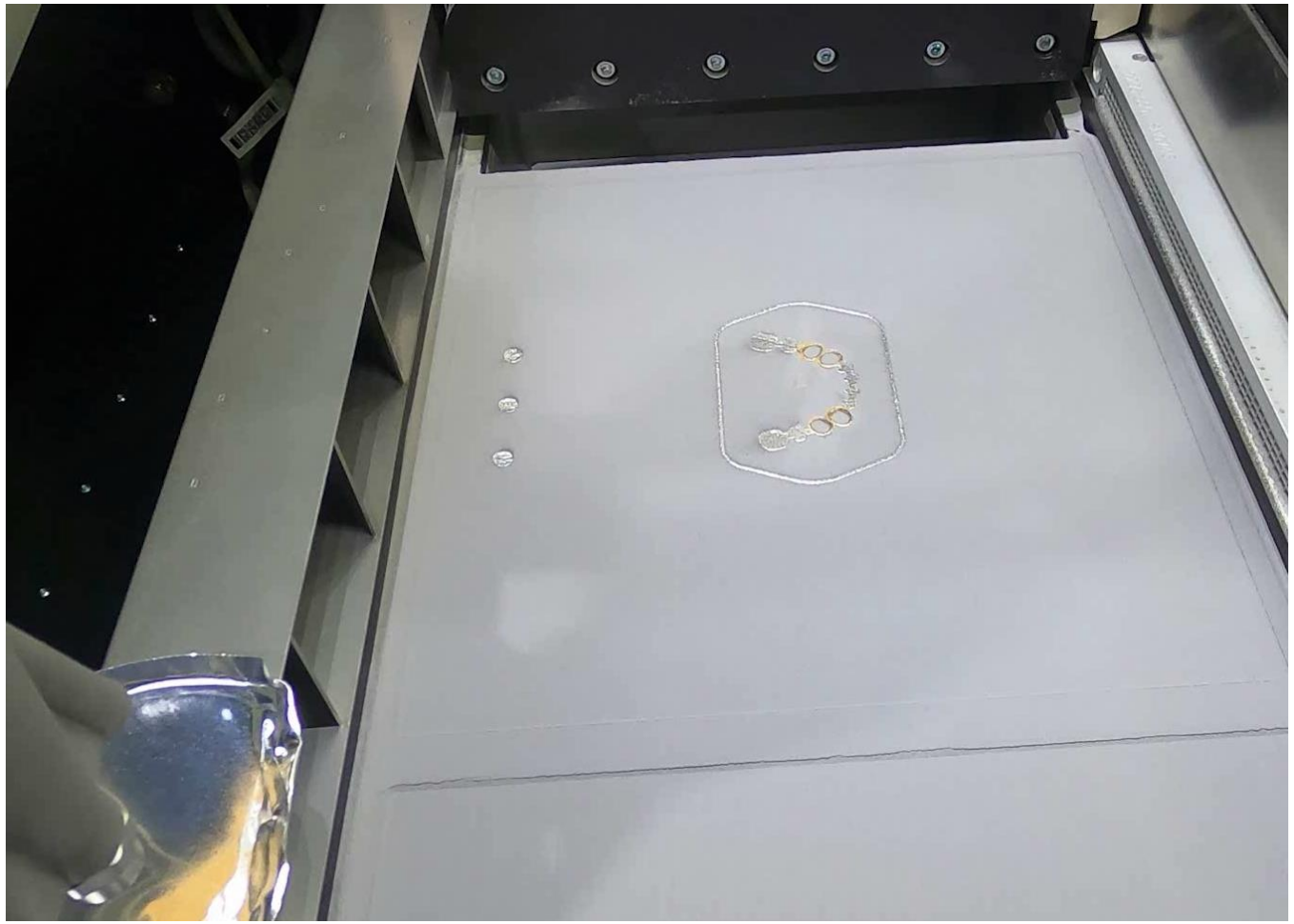

Image source: FIDENTIS

AMCM Additive Manufacturing Customized Machines

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Multi-material with holohedral powder deposition

Technology background – holohedral powder deposition

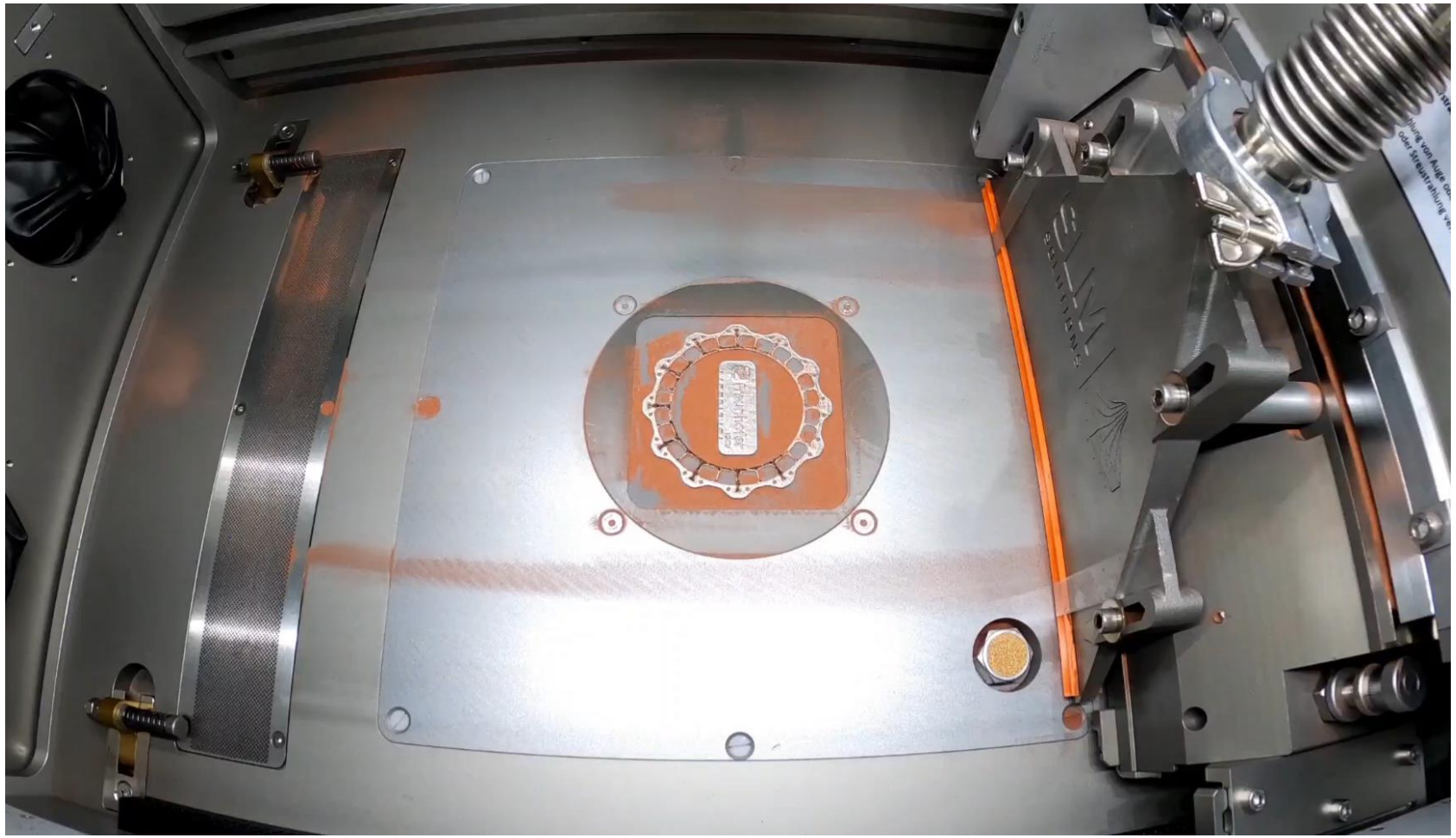


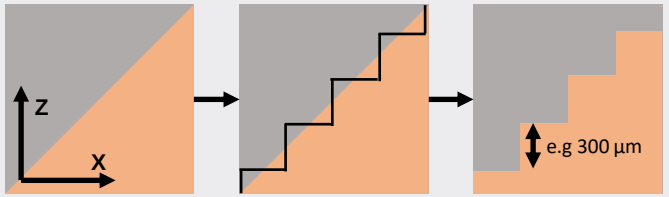
Image source: Fraunhofer IGCV

The innovative idea of printing multi-material transition zones

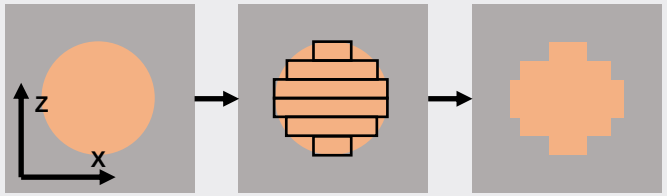
Solutions for material transition zones in xy-plane, in z-direction and beyond

Discretize the problem

Theory



Transfer to 3D structures

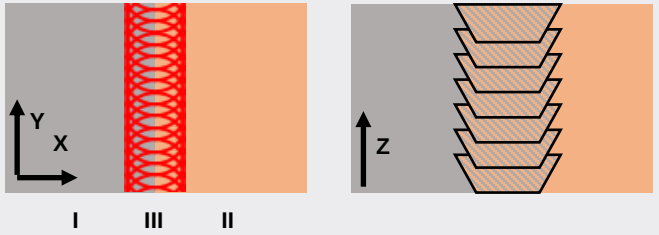


Material A

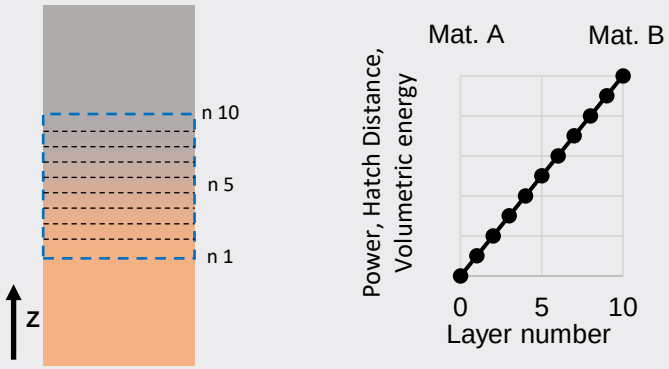
Material B

Solutions for transition zones

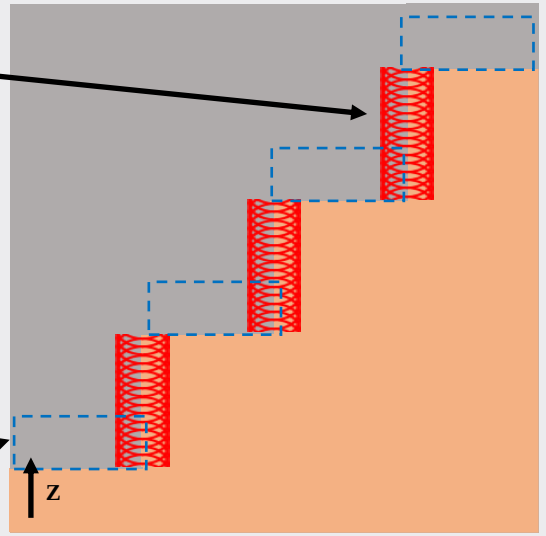
Wobbling in xy-plane



Graded energy input in z-direction

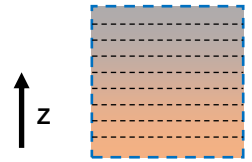


Strategy for multi-material

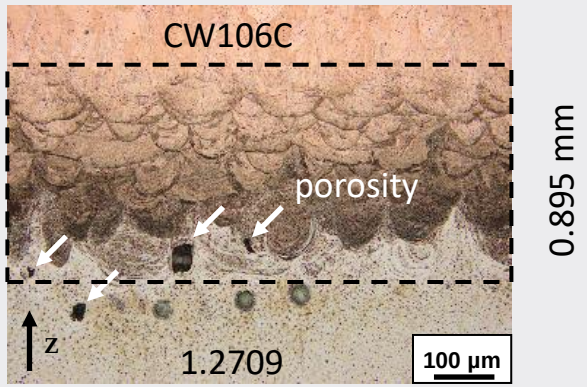


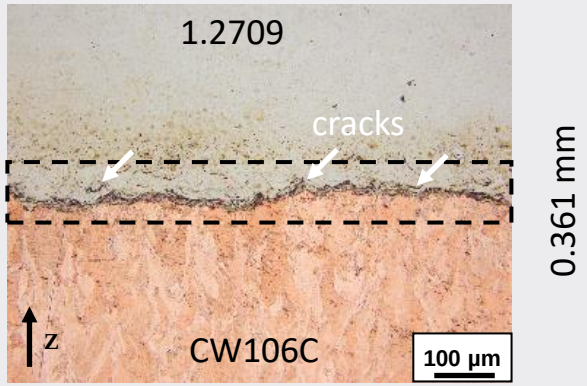
From theoretic approach to reality

Material build up in z-direction using a graded energy input

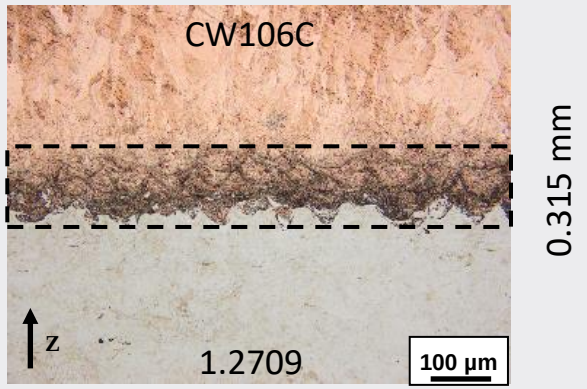


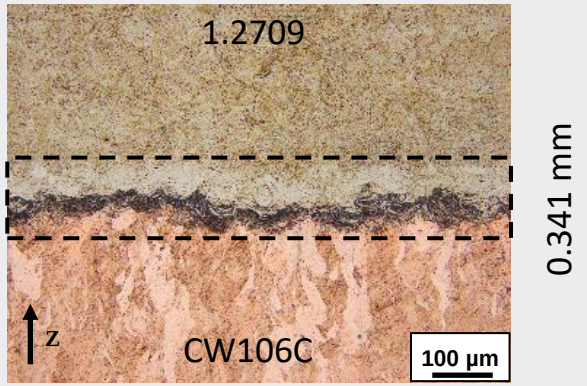
Reference situation



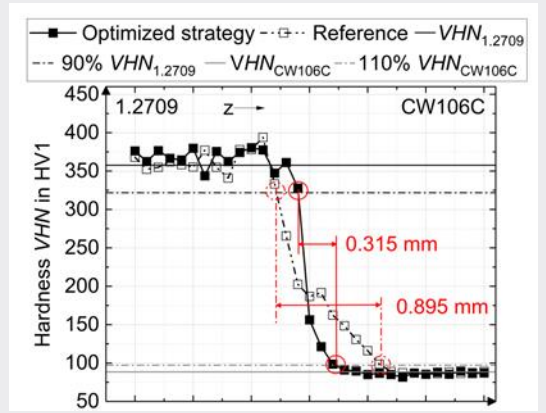


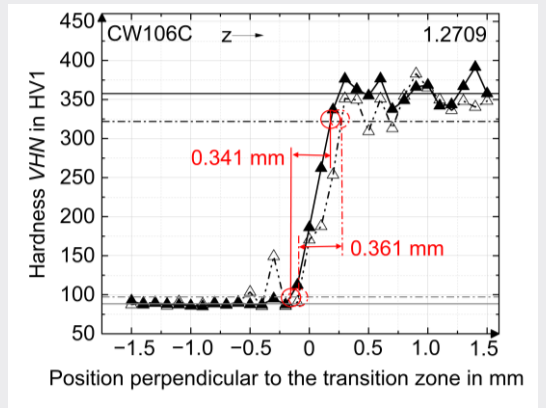
Graded energy input





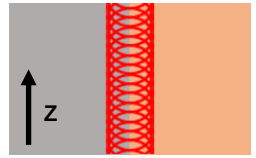
Proof of functionality





From theoretic approach to reality

Material build up in xy-plane using vector overlap and wobbling

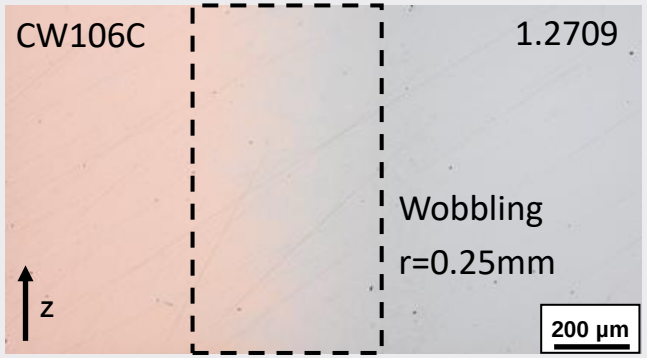


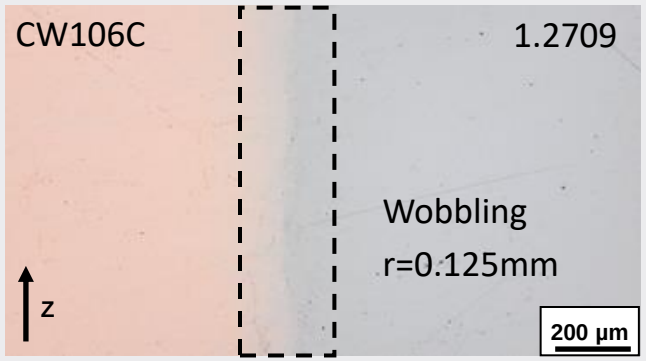
Reference situation

Strategy 0.2 mm scan vector overlap[1]

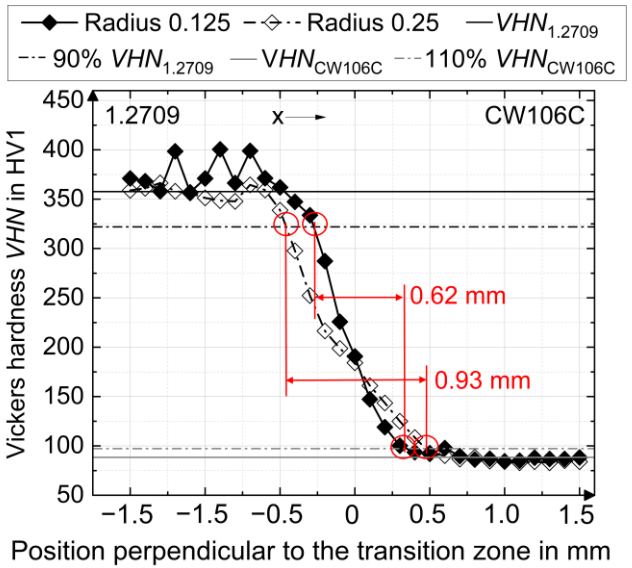
Wrong parametrization of bonding zone

Wobbling the transition zone





Proof of functionality



Source: Anstaett 2020, Multimaterialverarbeitung mittels Laserstrahlschmelzen am Beispiel von metallischen Verbindungen mit der Kupferlegierung CW106C

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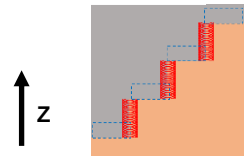
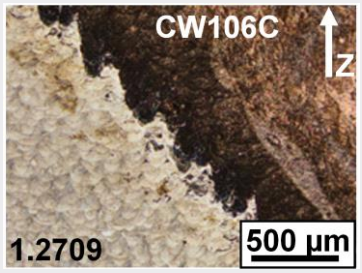
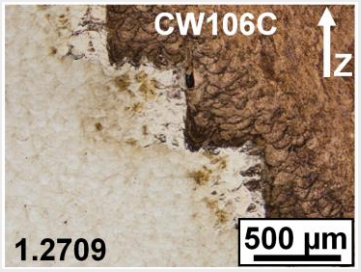
Transfer to multi-material transition zones in 3 dimensions

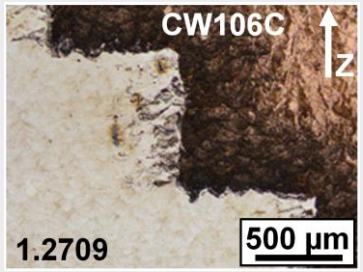
The stair step approach for multi-material printing

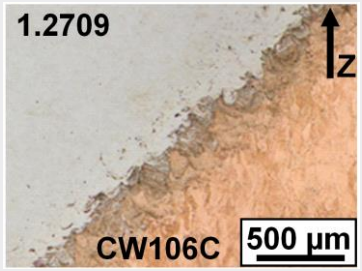


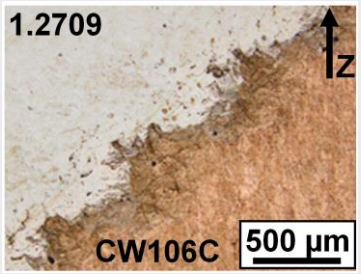
Variation of step size

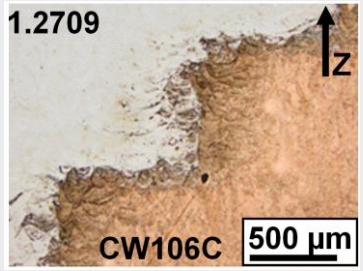






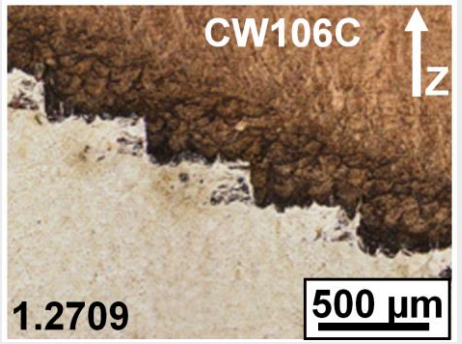


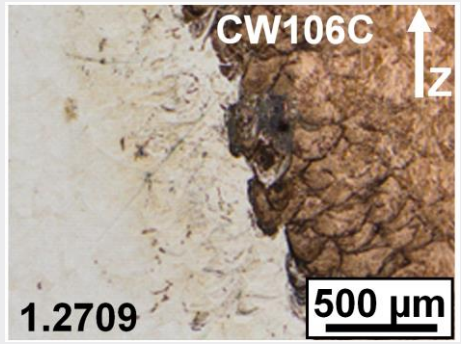


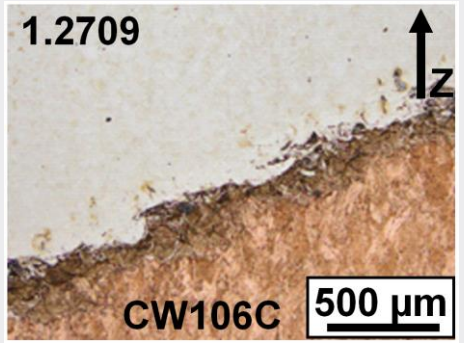


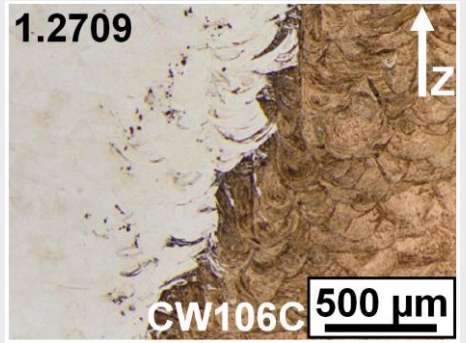
0.3 mm step height | 0.6 mm step height | 0.9 mm step height

Variation of transition angle



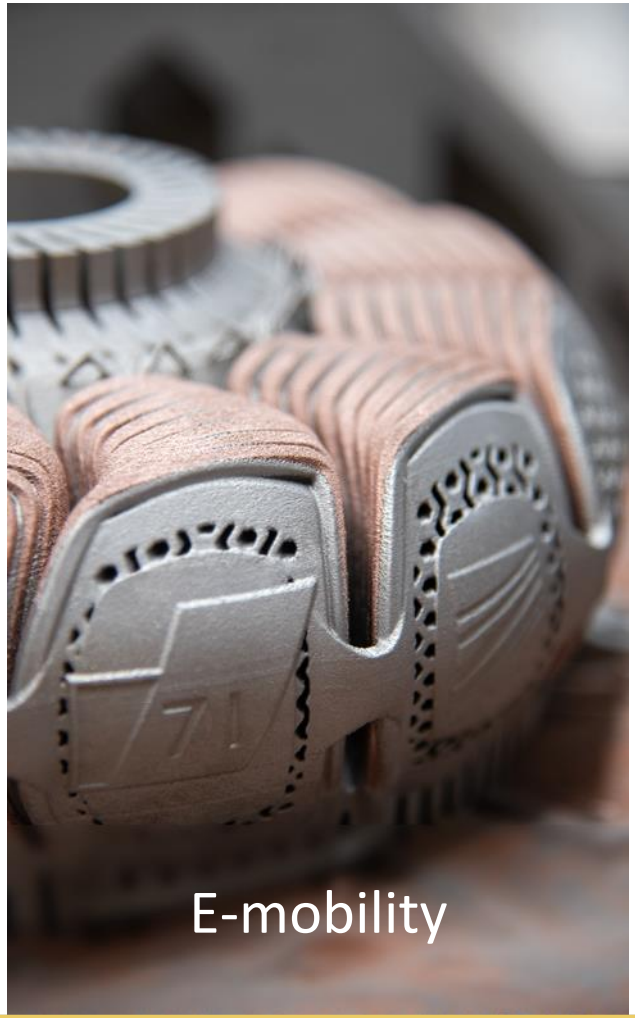






22.5° angle | 67.5° angle

Applications for multi-material processing are versatile and extend across various industries



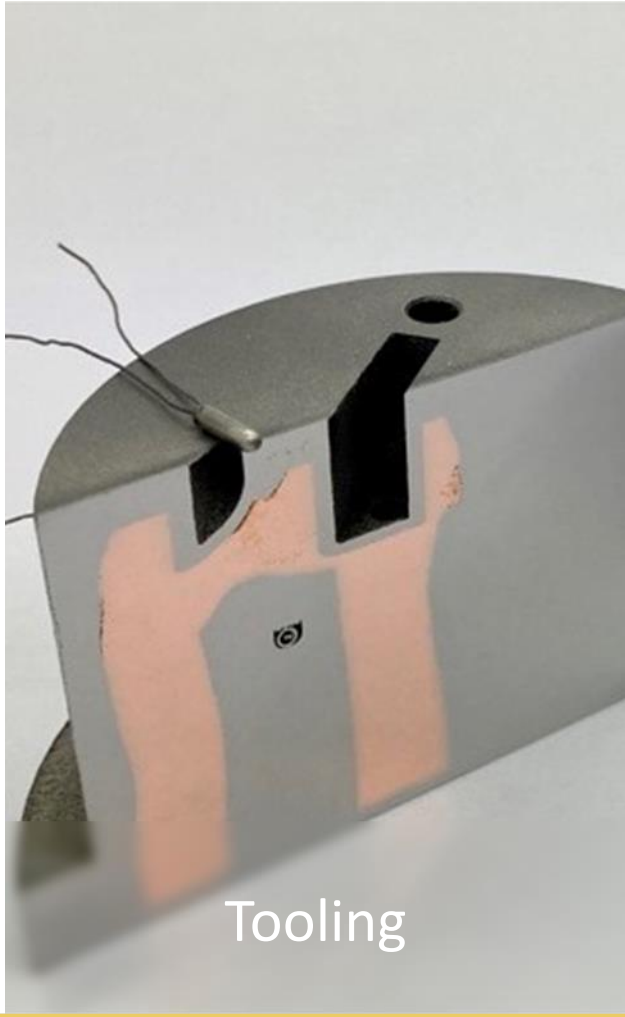
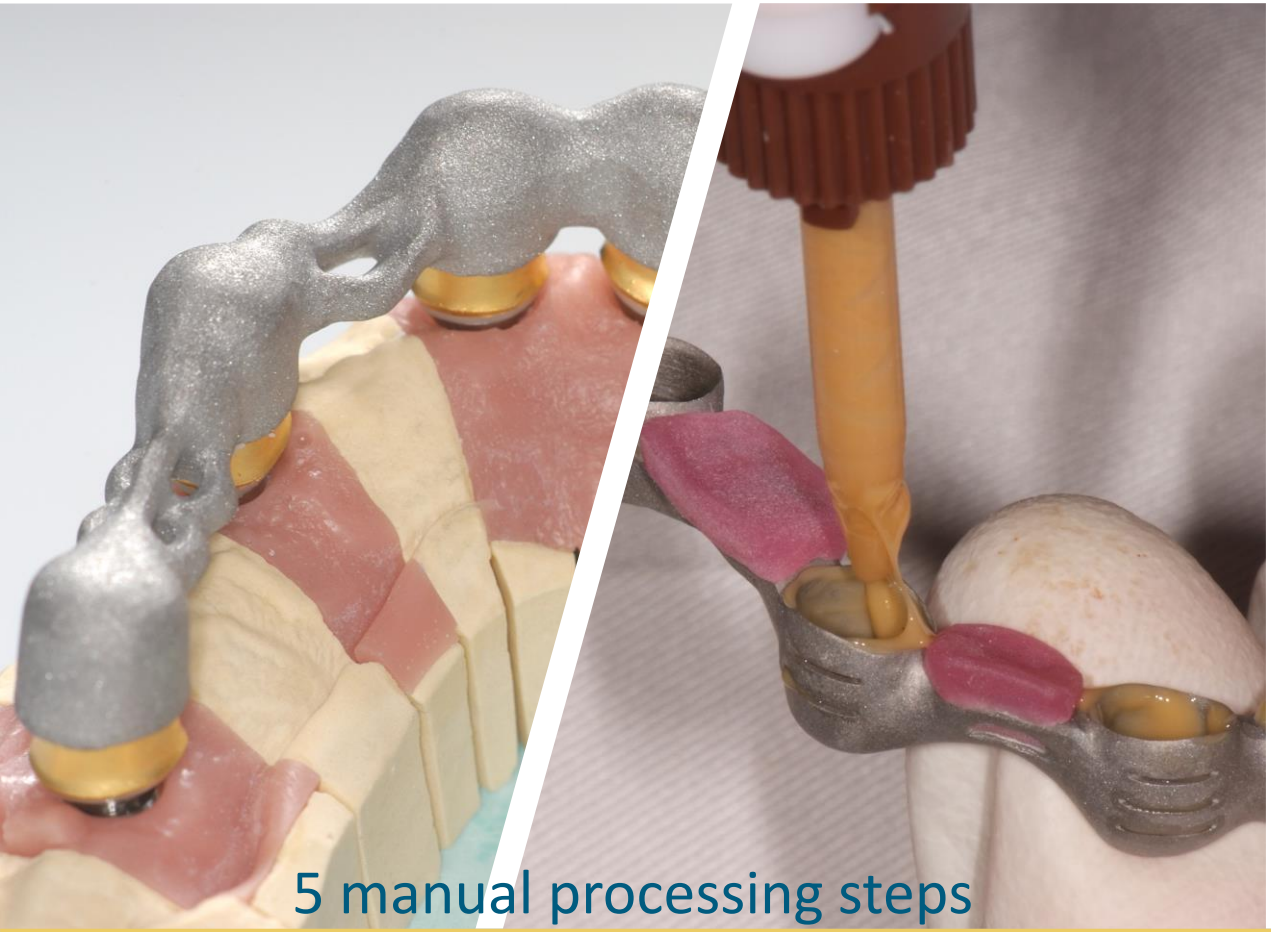


Image source: FIDENTIS / Fraunhofer IGCV

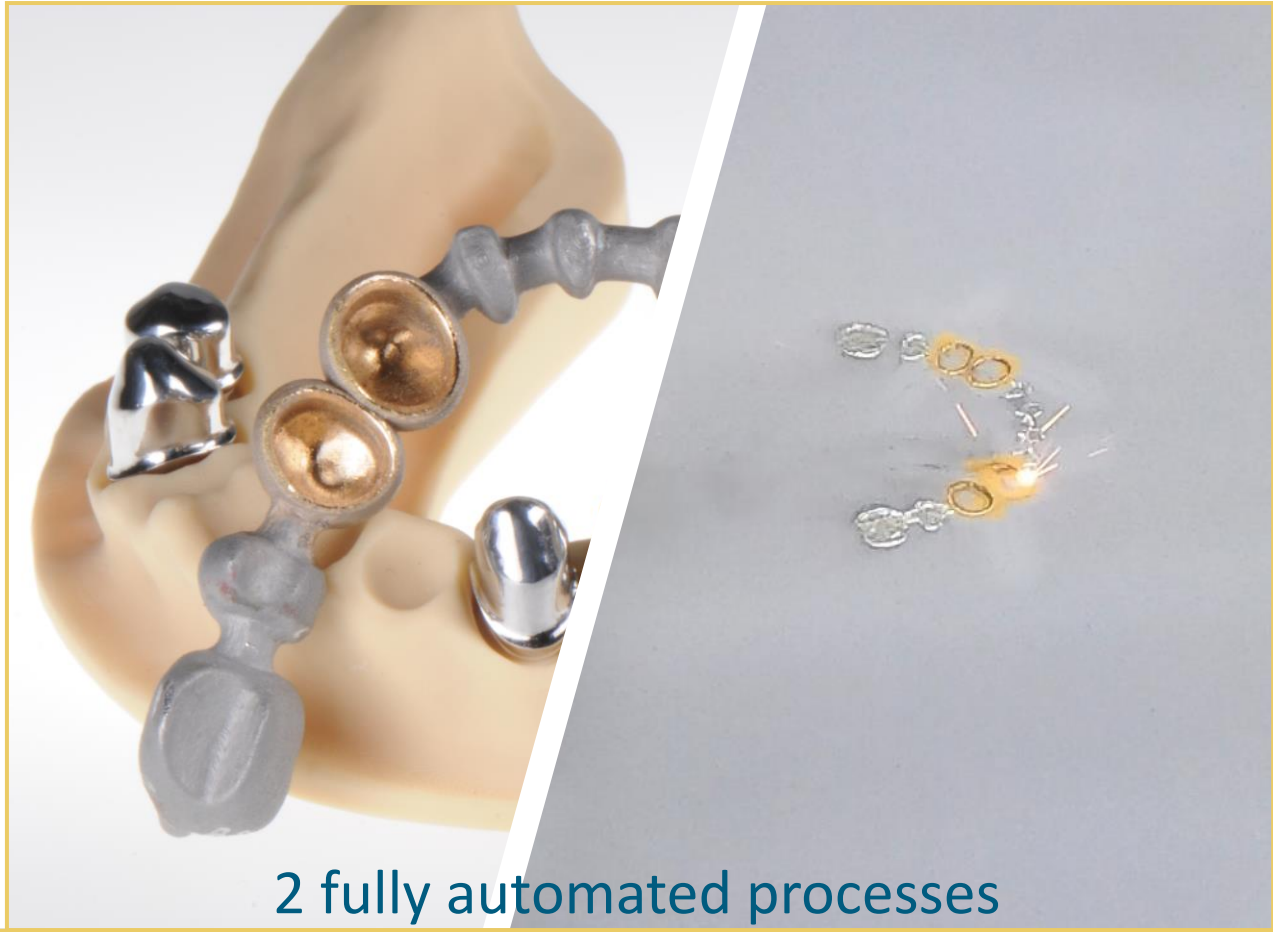
Through multi-material printing, the spin-off **FIDENTIS** ensures the provision of high-quality and affordable dentures.

Conventional manufacturing



5 manual processing steps

FIDENTIS solution



2 fully automated processes

Image source: left: LMU Klinikum, right: FIDENTIS

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Let’s get in touch and discuss your multi-materials applications!

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