Binder based AM of Mg-Alloys for Biomedical Application - an Overview

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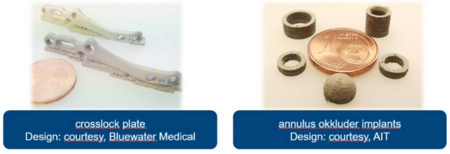
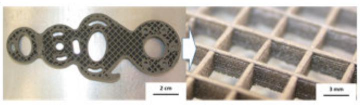
Introduction: Aim & Benefits of binder- & sinter based 3D-printing for patient adapted individual implants

Next to **ultra-light-weight** applications, novel research introduces Mg-alloys also into **binder based** processing techniques, such as **MIM** for near net shape mass production, as well as 3D-printing (**FGF**) for individual prototyping, even with **hollow structures** inside.

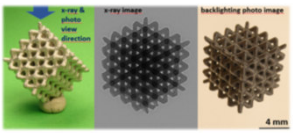
FGF (Fused Granular Fabrication)

Fast future prototyping for individual patient adapted biomedical implants

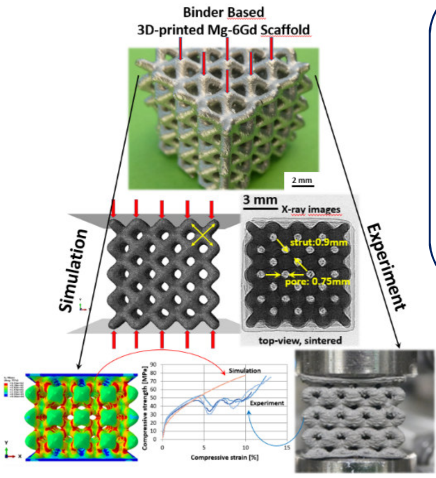




FGF implant demonstrator showing hollow inside structure

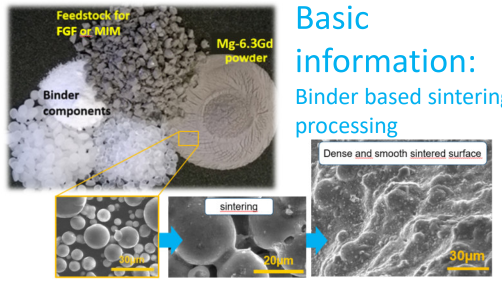


Printed open & interconnected porosity

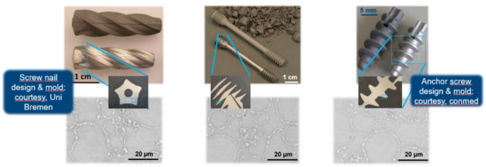


Wolff et al, *JMA*, (2023) https://doi.org/10.1016/j.jma.2023.08.004
Comparison between compression tested and simulated Mg-6.3Gd bone scaffolds produced by binder based additive manufacturing technique

Basic information: Binder based sintering processing



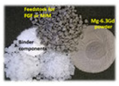
MIM (Metal Injection Molding)



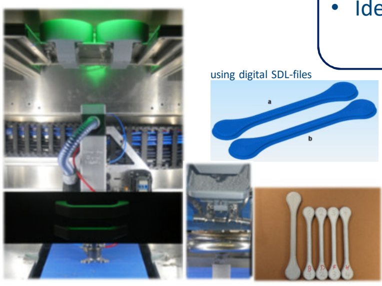
Homogenous isotropic microstructure independent of the part geometry

Methods: 3D-printing (FGF) vs. MIM

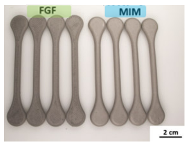
- Identical Feedstock can be used for both methods, FGF and MIM



FGF



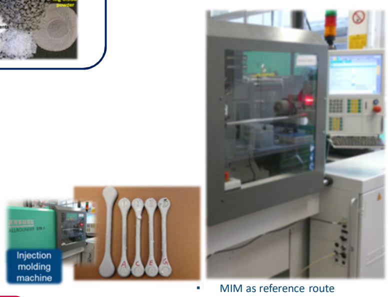
- FGF (Fused Granular Fabrication), a 3D Printing technique for individual prototyping



Processing

Solvent debinding: 15 h in hexane at 40 °C
Thermal debinding: 4 h in Argon, 24 l/h at 20 mbar
Sintering: 8 h under Argon, 640 °C

MIM



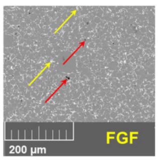
- MIM as reference route
- MIM for industrial mass production

Results & Discussion: good agreement

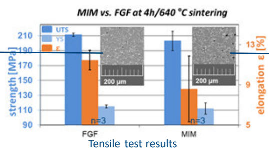
FGF

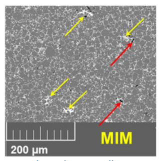
Strengh & microstructure

Good agreement between the mechanical properties and microstructure of FGF-material in comparison to MIM-reference material



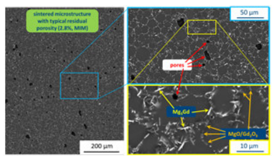
secondary phases: yellow arrows
pores: red arrows





secondary phases: yellow arrows
pores: red arrows

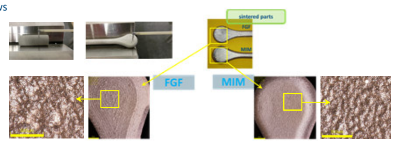
MIM



Details of MIM microstructure showing pores (red arrows) and different types of secondary phases (yellow and orange arrows)

Surface assessment & optimisation

Prozess optimisation trough:
- Feedstock granule size
- Nozzle size

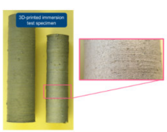


Dense & smooth surface roughness
Different on macro scale
Identical on micro scale

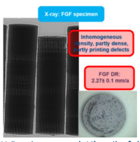
Surface roughness: macro scale
MIM: Rz=19.6 – 20.2
FGF: Rz=33.3 – 35.2

Immersion test setup

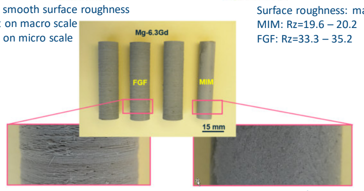
- semistatic conditions
- for 7 days
- 37 °C
- 5% CO_2



3D-printed immersion test specimen: Green part (left) and sintered part (right)

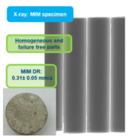


X-Ray image and 1st trail of degraded immersion test specimen



Pancake stack like FGF surface

Smooth MIM surface



X-ray image of corresponding MIM specimen

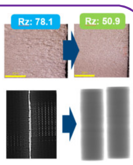
Outlook

Combination of MIM and 3D-printing: 3D-printing of mould cavity for MIM

New approaches in 3D-lithografie of Mg-alloys (comming soon)

Conclusion

Achievements	MIM	FGF
Successful 3D-printing approach		☺
Identical mechanical properties	☺	☺
Successfull surface assessment	☺	☺
Good infill ability	☺	☺



Successful 3D-printing of demonstrator parts

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