



Novel titanium-based sulfur containing bulk metallic glass for PBF-LB/M

Hanna Schönrath

Jan Wegner, Maximilian Frey, Martin A. Schroer, Xueze Jin, María Teresa Pérez-Prado, Ralf Busch, Stefan Kleszczynski

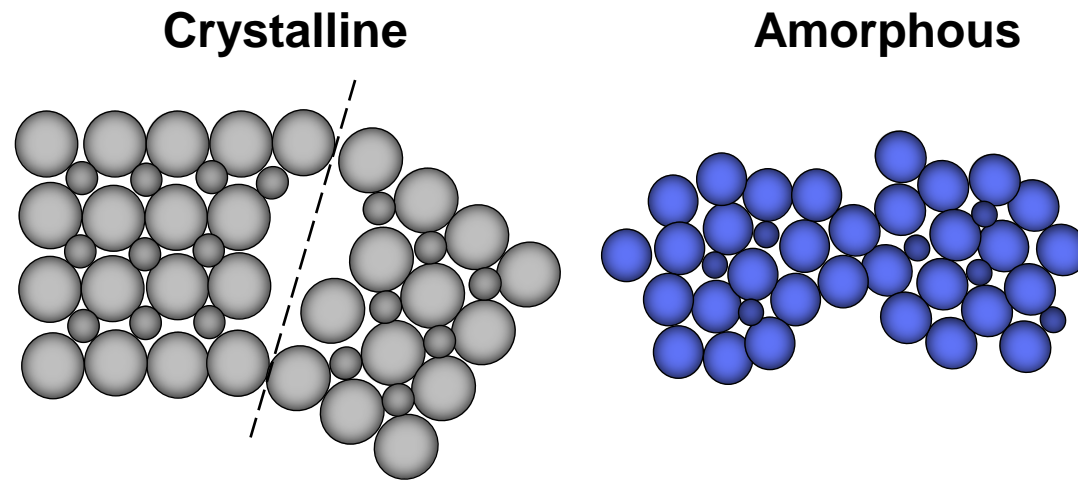
UNIVERSITÄT
DUISBURG
ESSEN

RapidTech | 2024

Offen im Denken

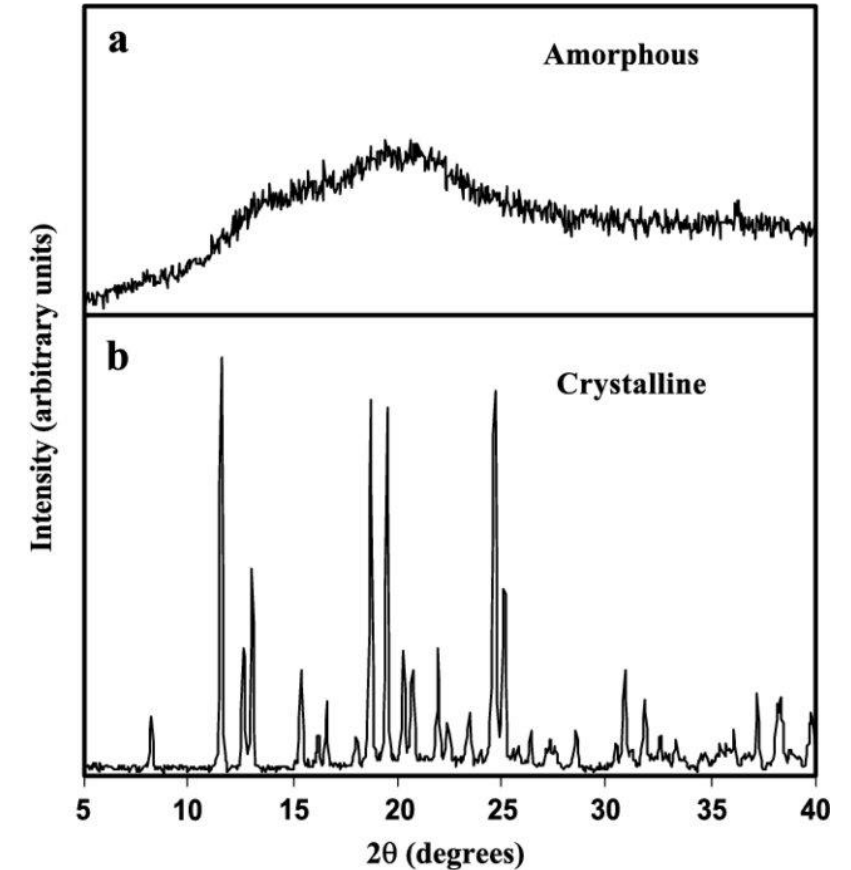
Introduction

Bulk Metallic Glasses – BMGs



- Amorphous arrangement of constituent elements,
- High strength and elasticity
- (mostly) Isotropic properties

X-ray diffractogram

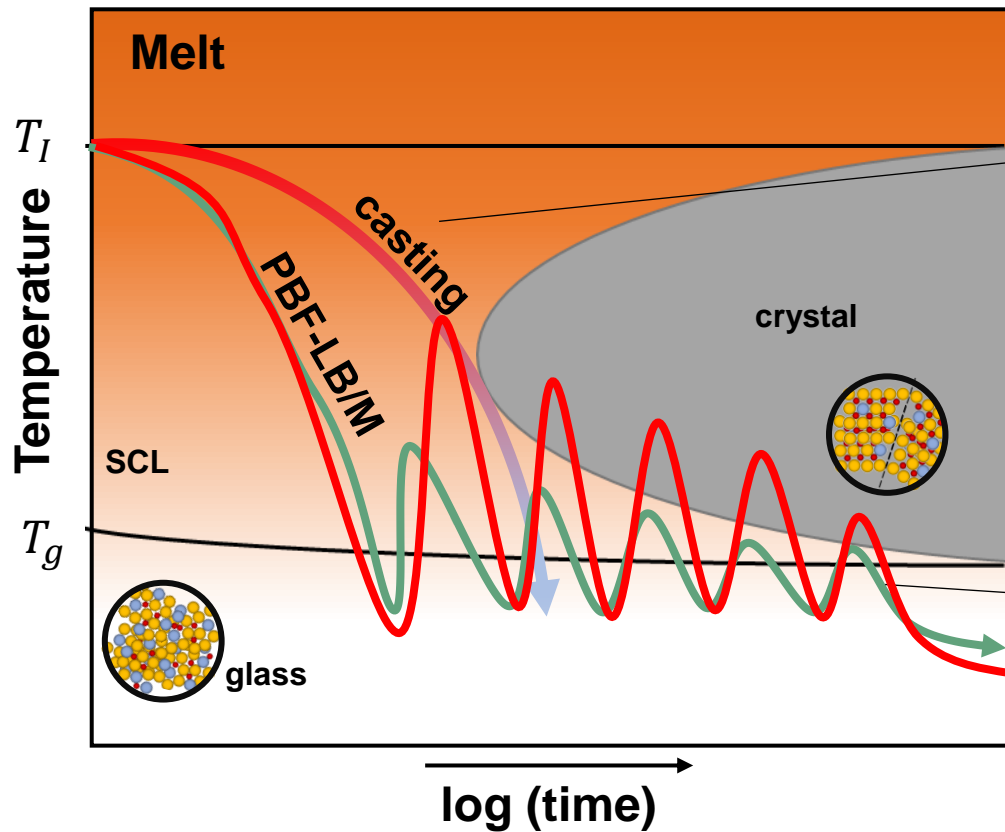


[Nunes, 2005]

Fundamentals

Fabrication of BMGs

TTT

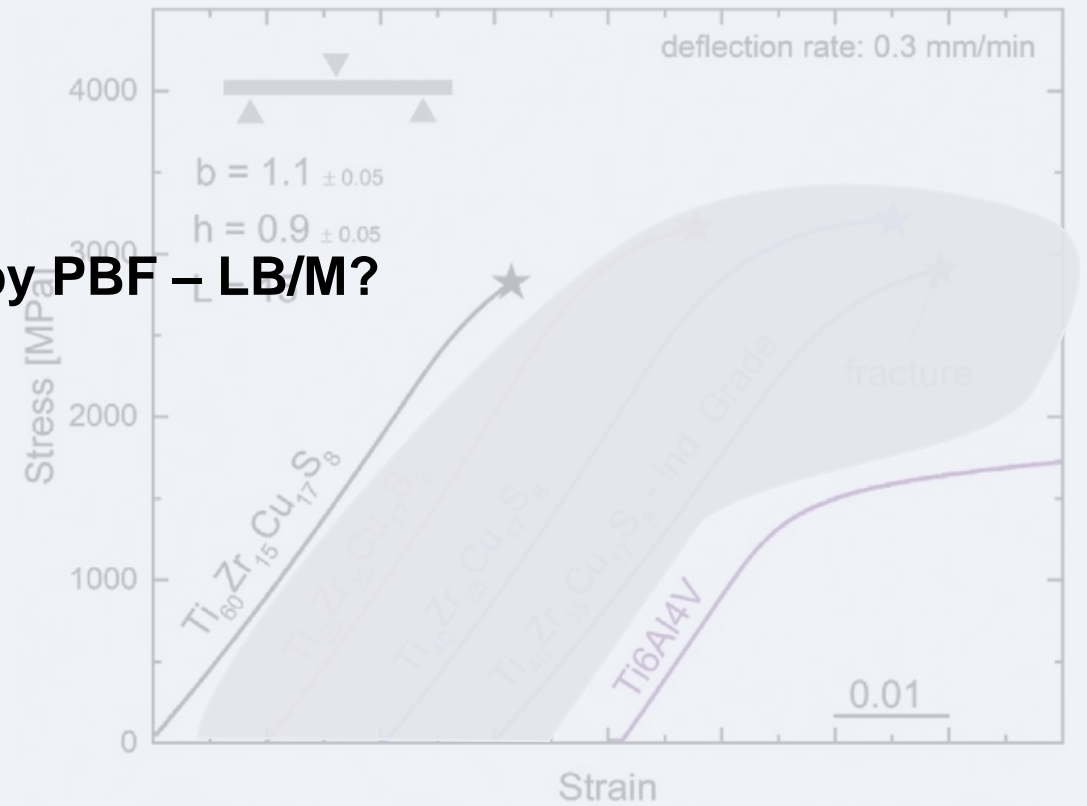
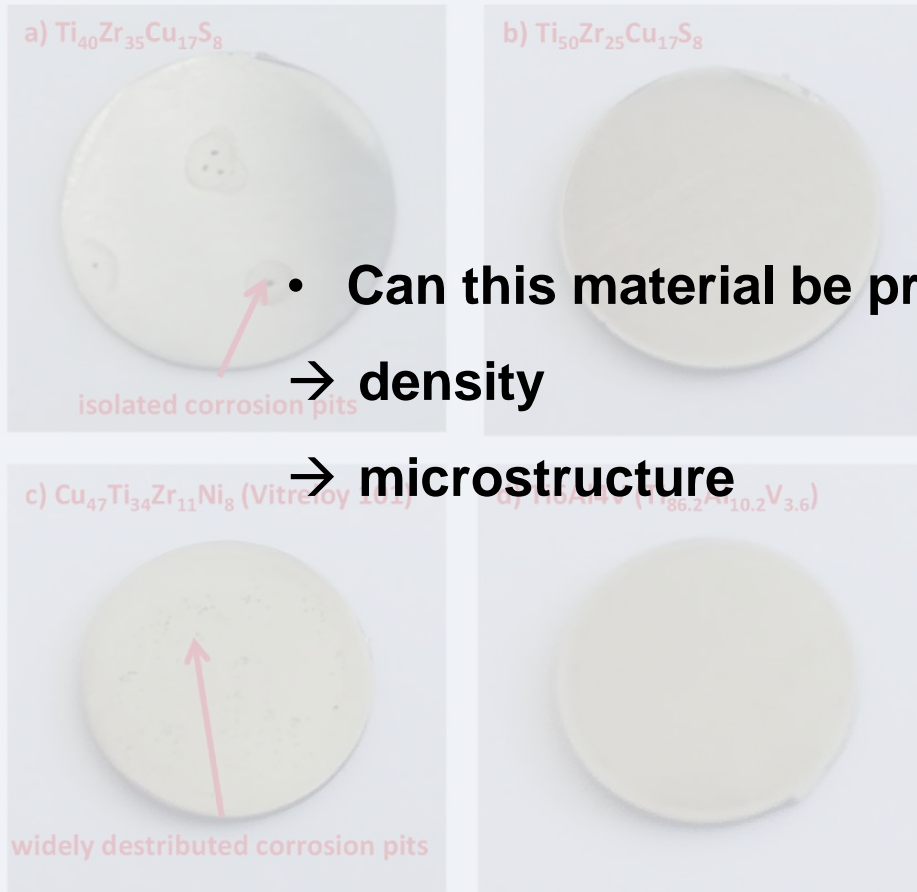


[LMW Saarland; Thorsson 2022; Wegner 2021]

Motivation

Novel Material: Ti- based sulfur containing BMGs

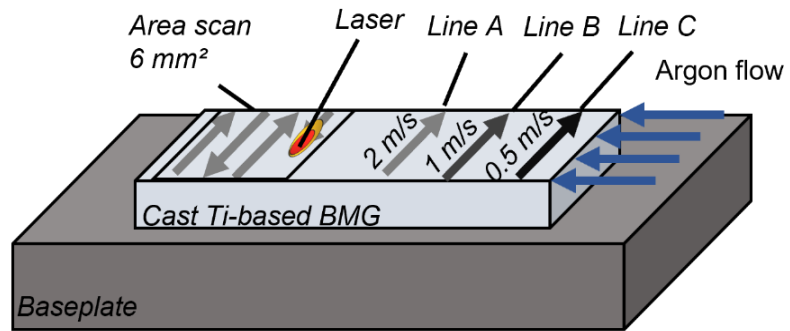
Material: $Ti_{60}Zr_{15}Cu_{17}S_8$



Frey, 2021; Kuball, A., 2018; Kuball, A., 2019

Methods

Preliminary study: Laser treatment of cast material



Atomization



[amazemet.com]

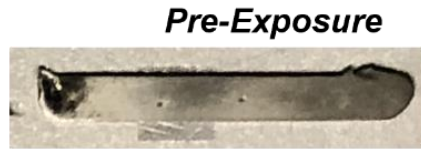
PBF-LB/M



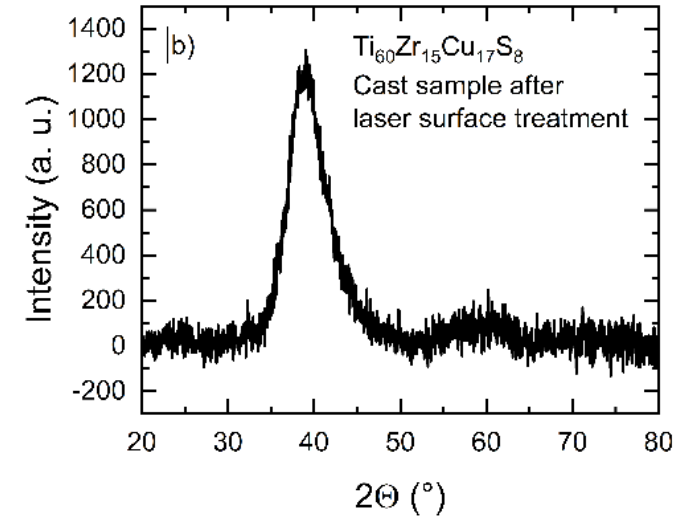
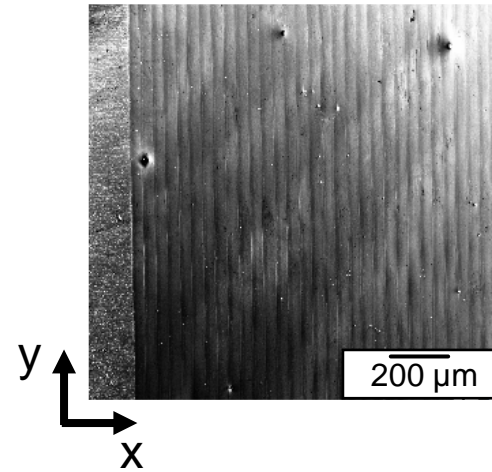
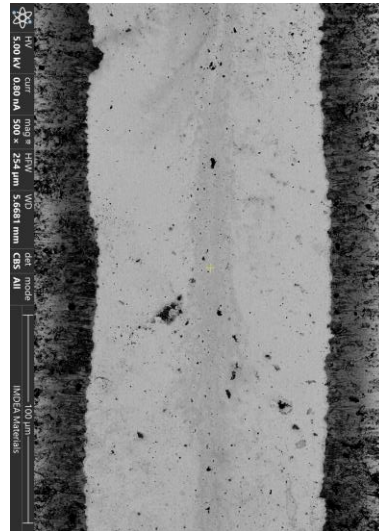
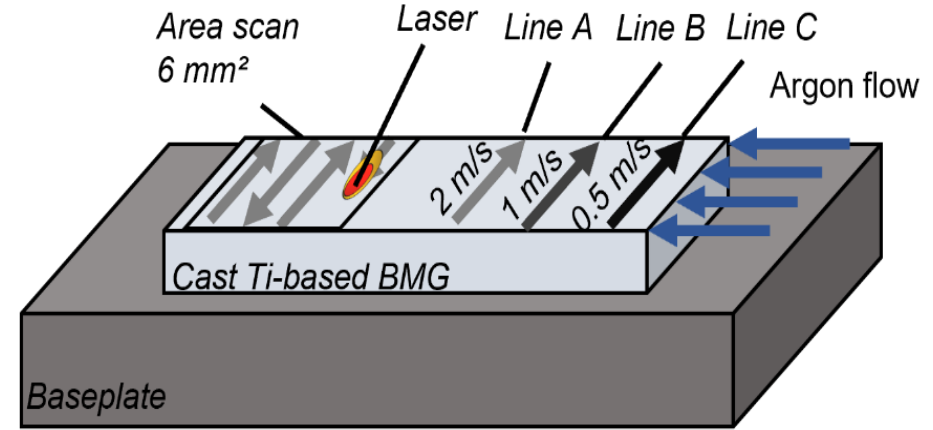
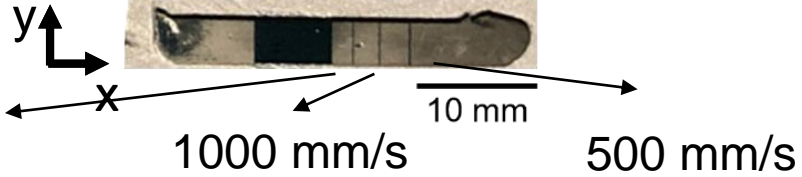
[slm-solutions.com]

Results

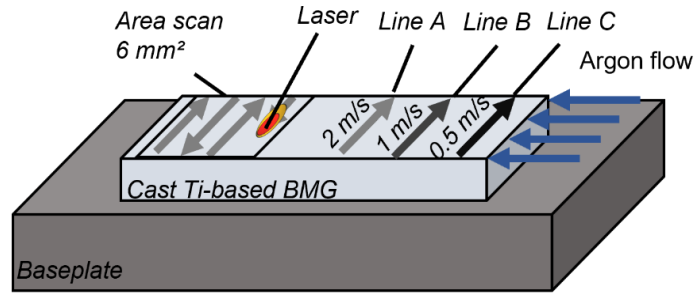
Laser treatment



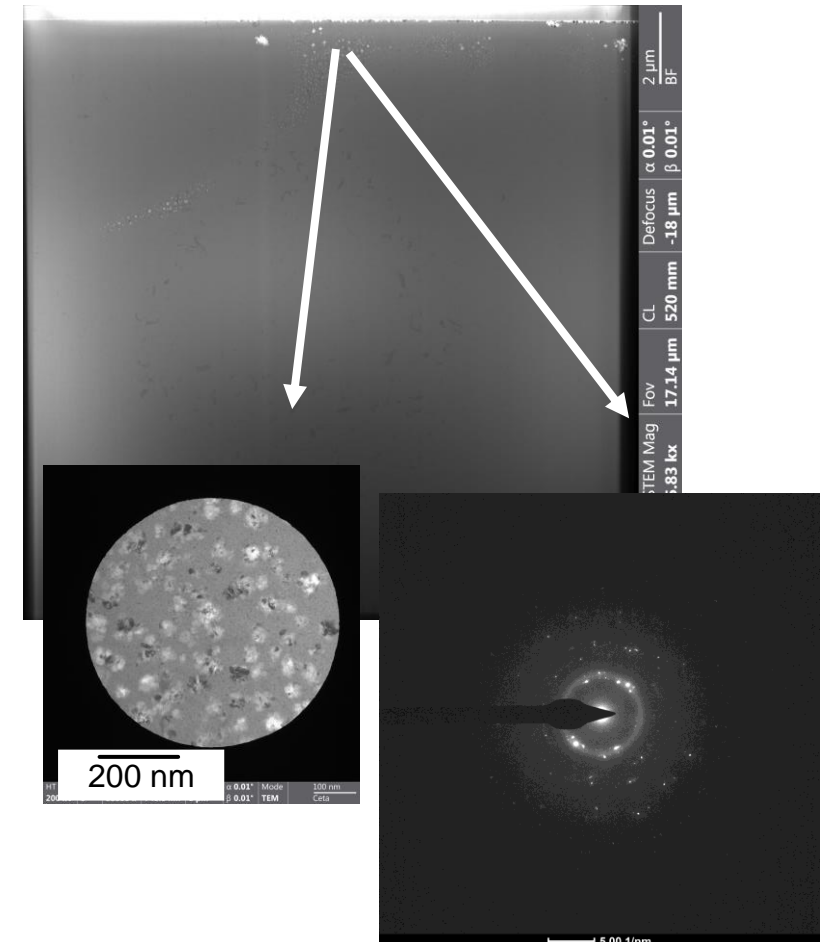
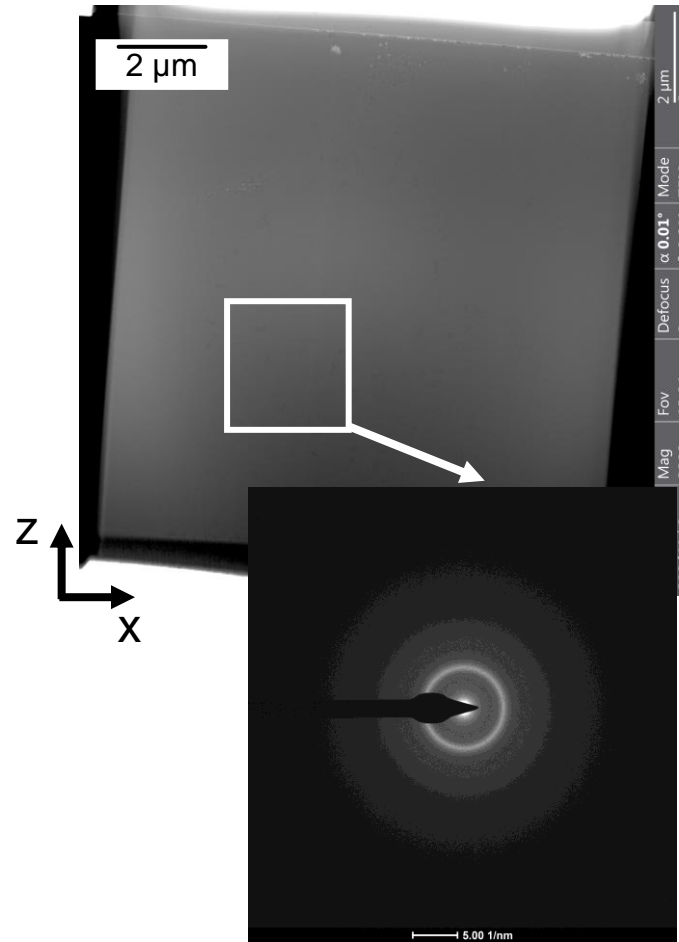
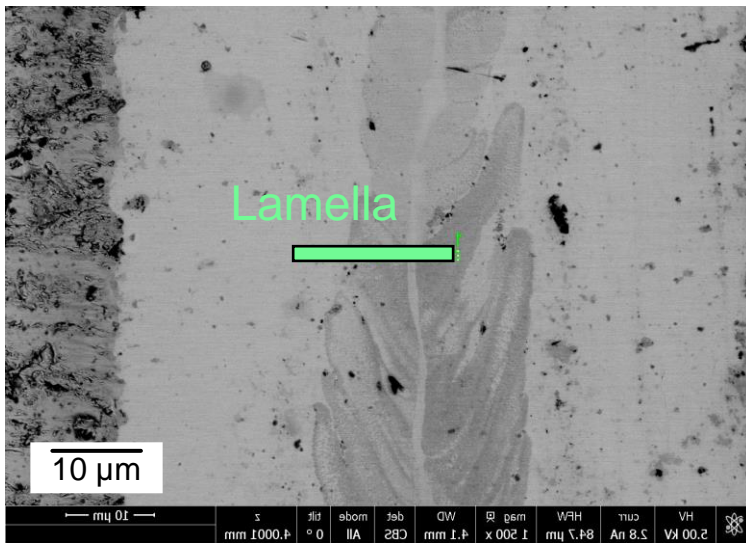
70 W
2000 mm/s



Results



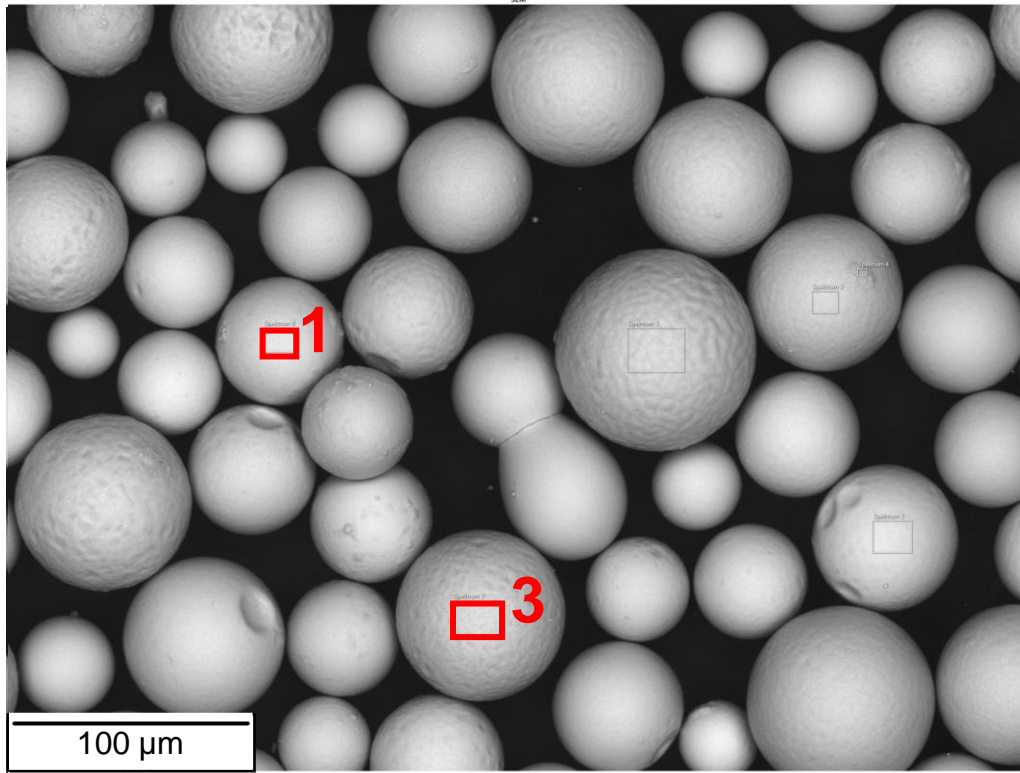
Line A – 70 W 2000 mm/s



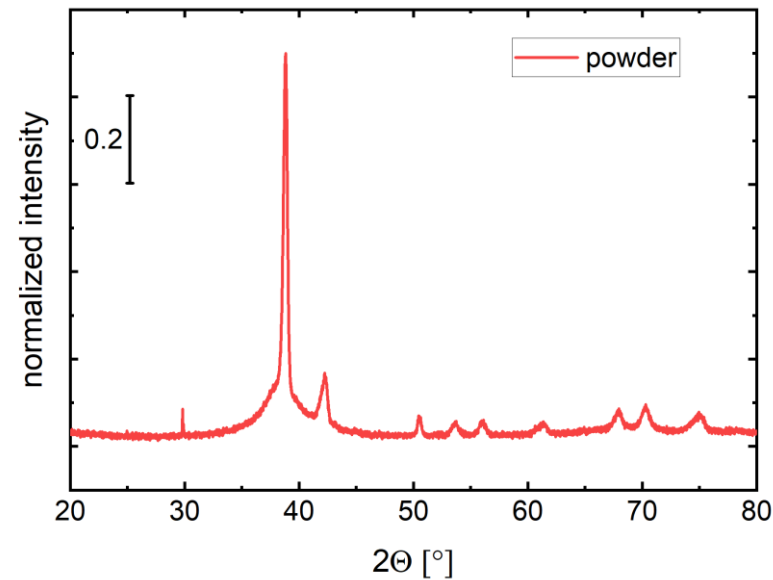
Amorphous structure within weld track

Results

Atomization



At%	Ti	Zr	Cu	S	W	Al
target	60.0	17.0	15.0	8.0	0	0
1	67.41	13.80	10.39	6.63	1.08	0.70
3	62.85	13.96	15.10	7.51	0	0.59

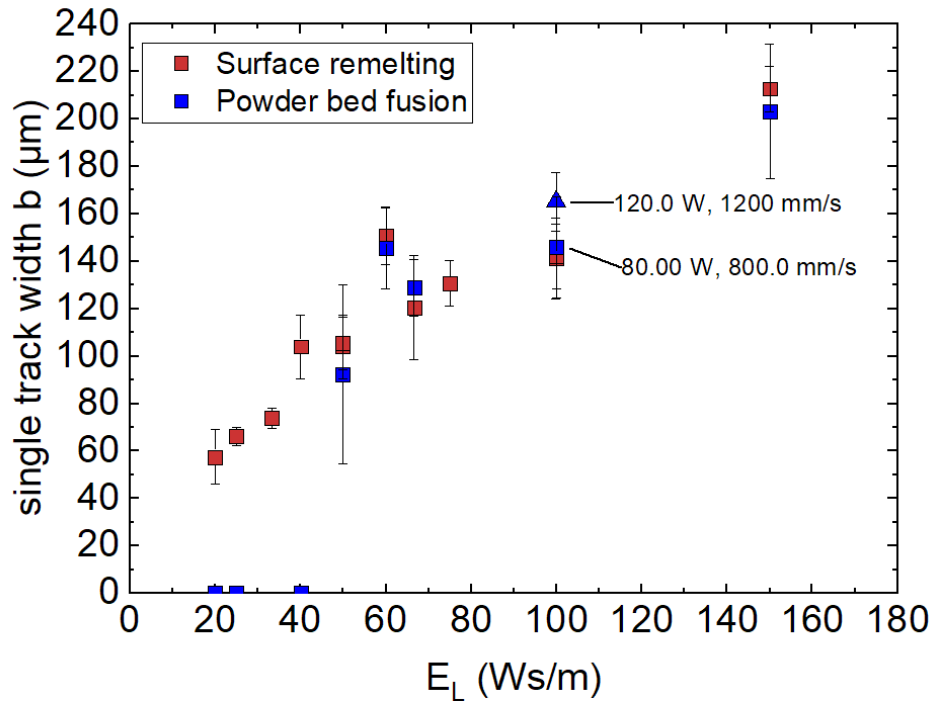


- Compositional offset
- Oxygen intake:
Cast → powder
0.05 wt% → 0.17 wt%

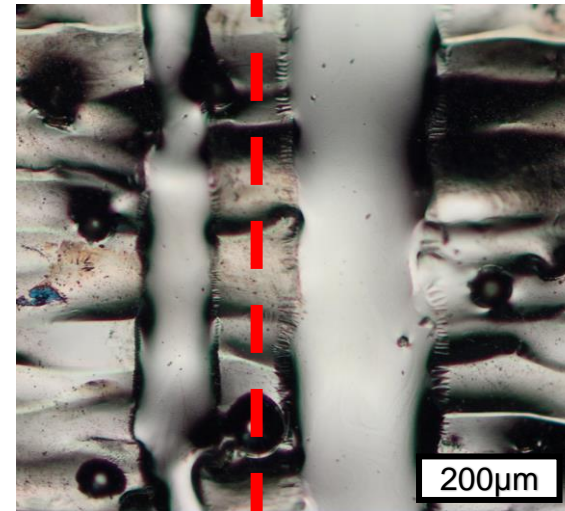
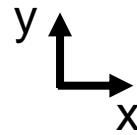
Spherical, crystalline powder

Results

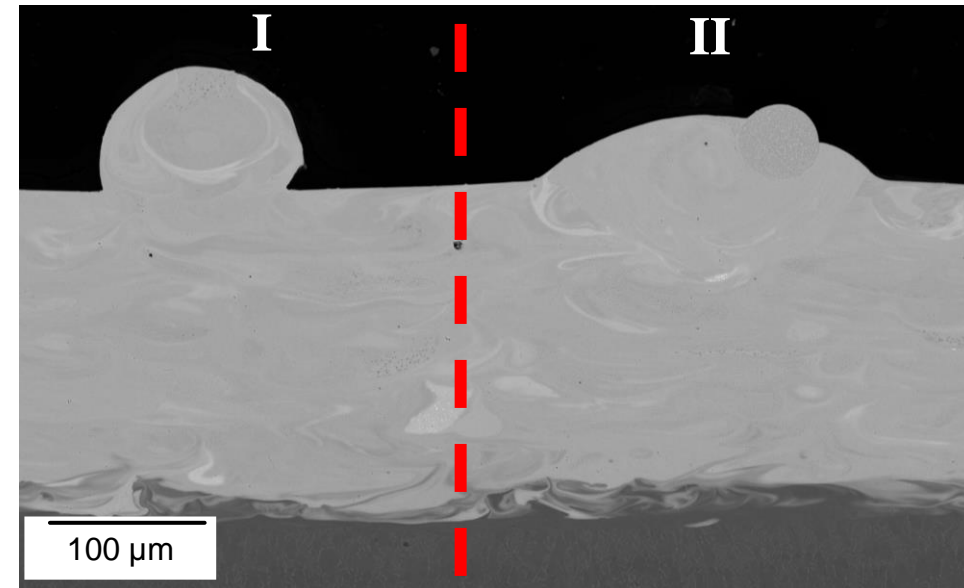
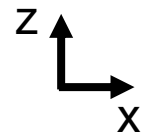
Laser-material interaction



80 W
1600 mm/s



120 W
800 mm/s



Single
tracks

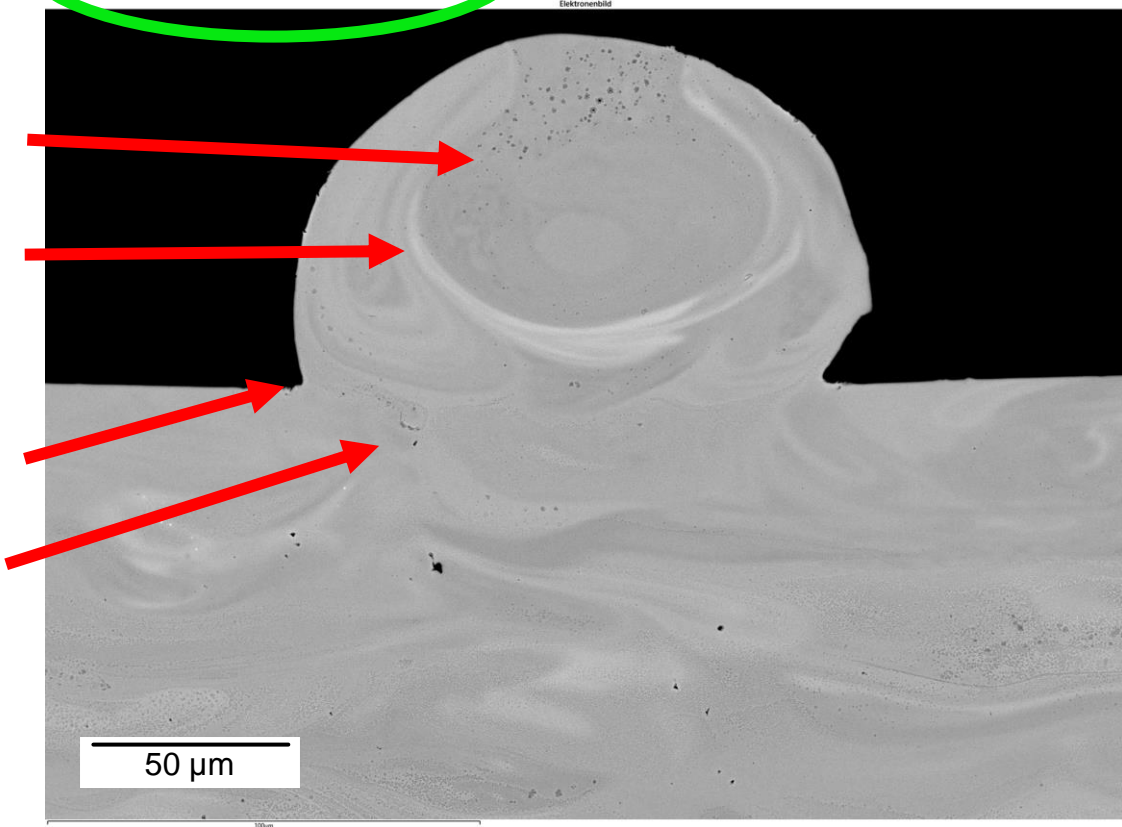
10 layers:
leveling base

Build plate

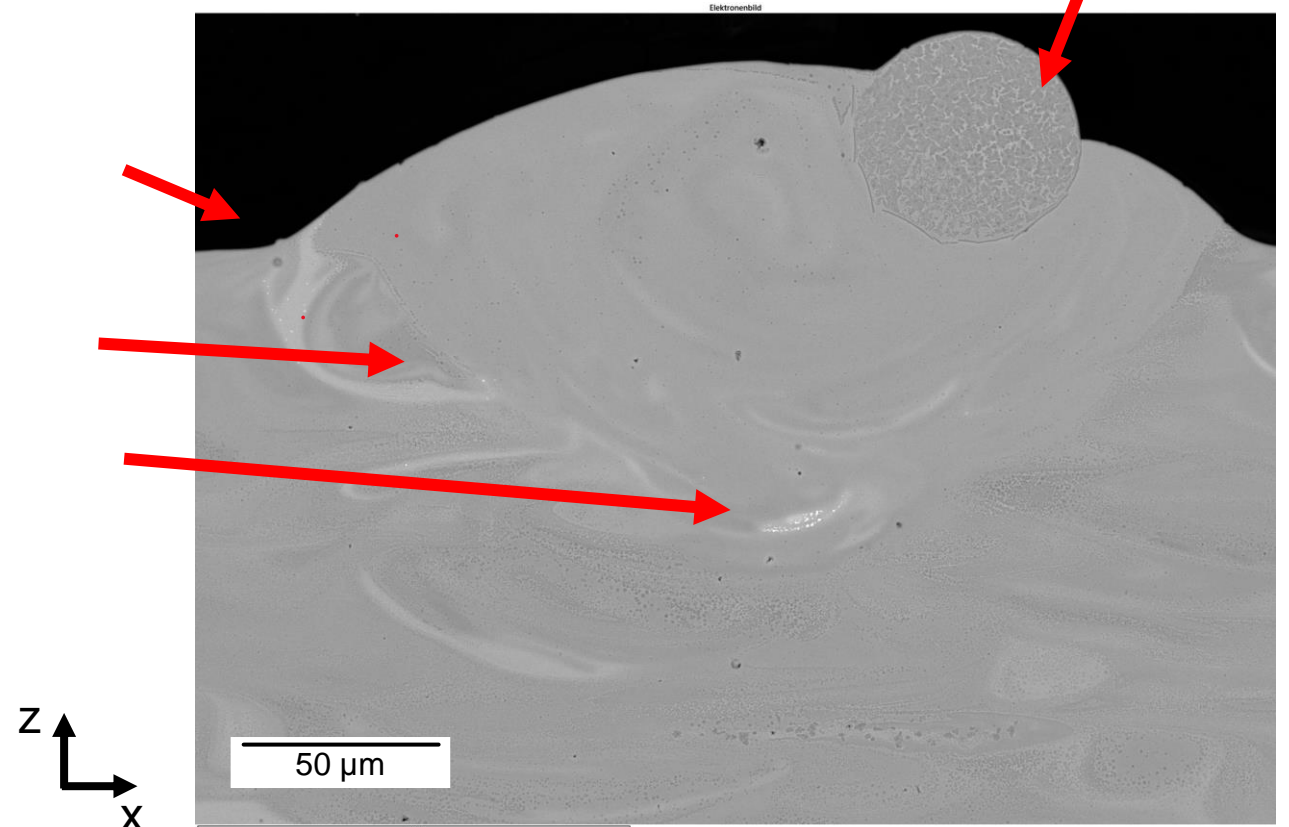
Results

Laser-Material interaction

80 W 1600 mm/s



120 W 800 mm/s



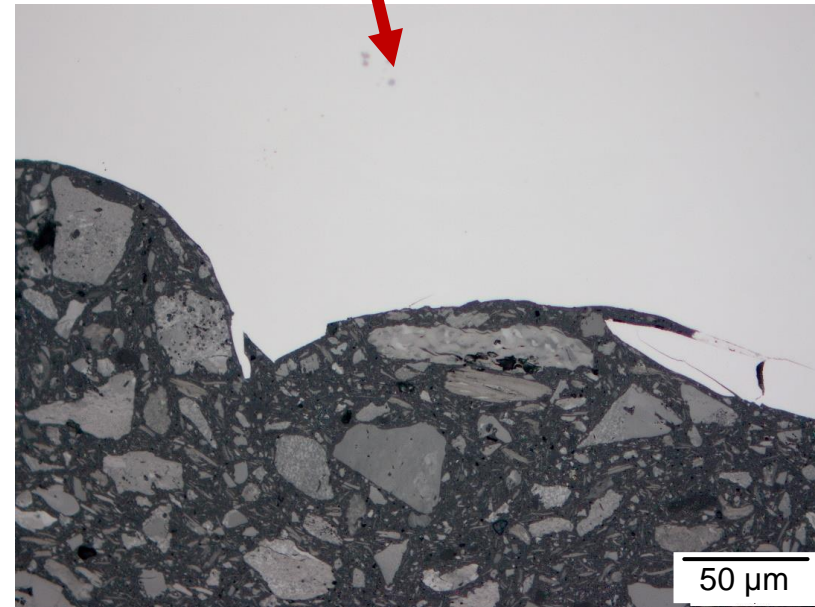
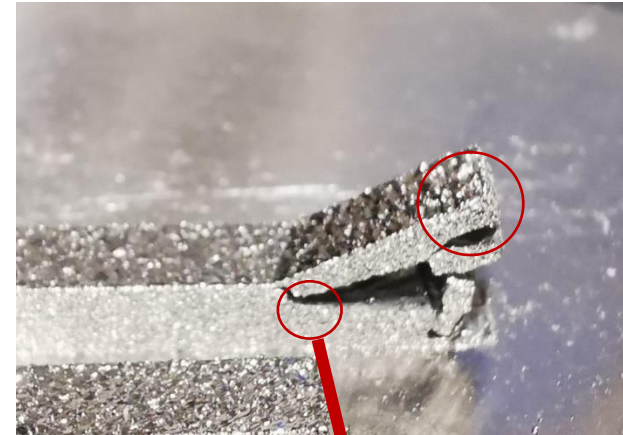
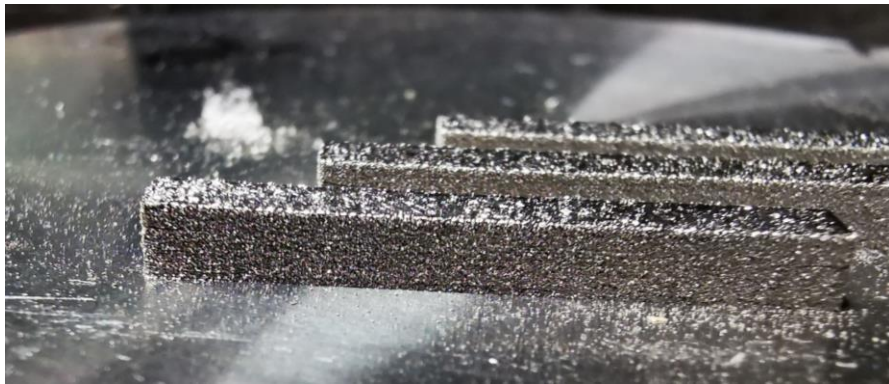
Results

Manufacturing of bulk material



80 W
1600 mm/s

30 x 3 x 2 mm beam

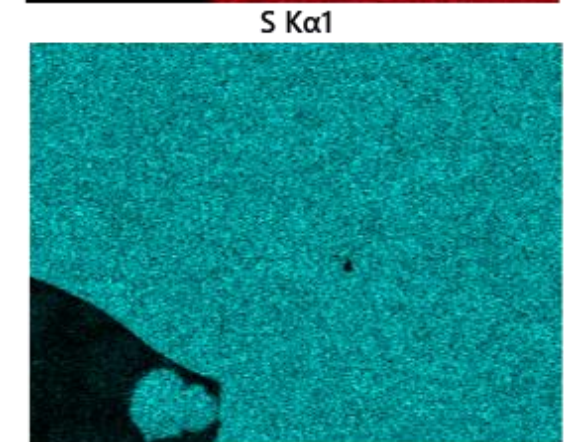
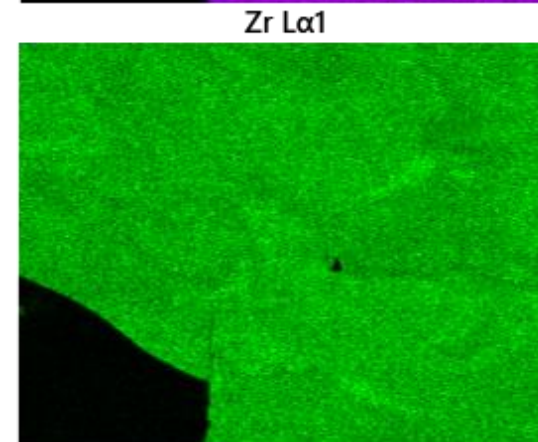
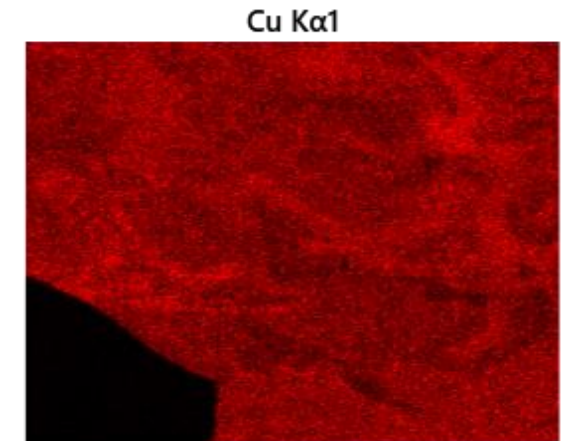
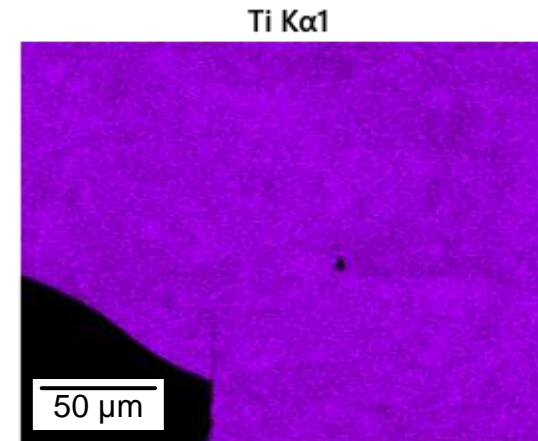
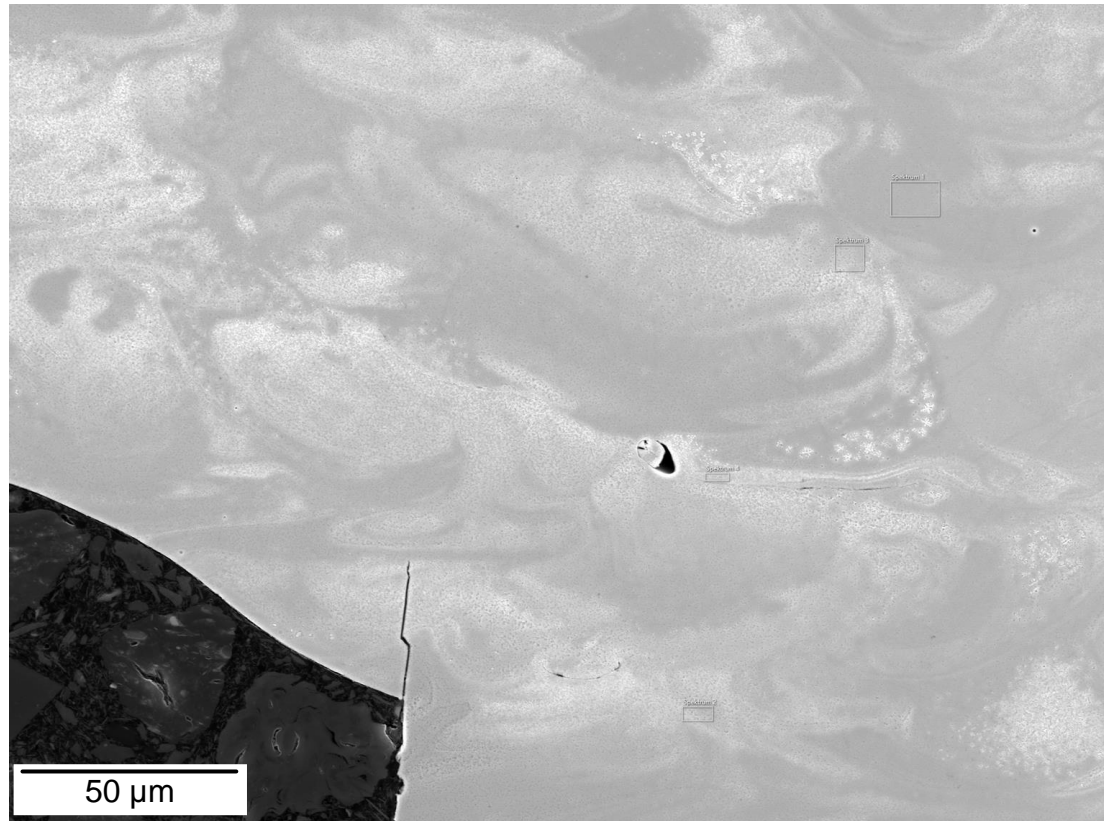


Relative density: >99%

Results



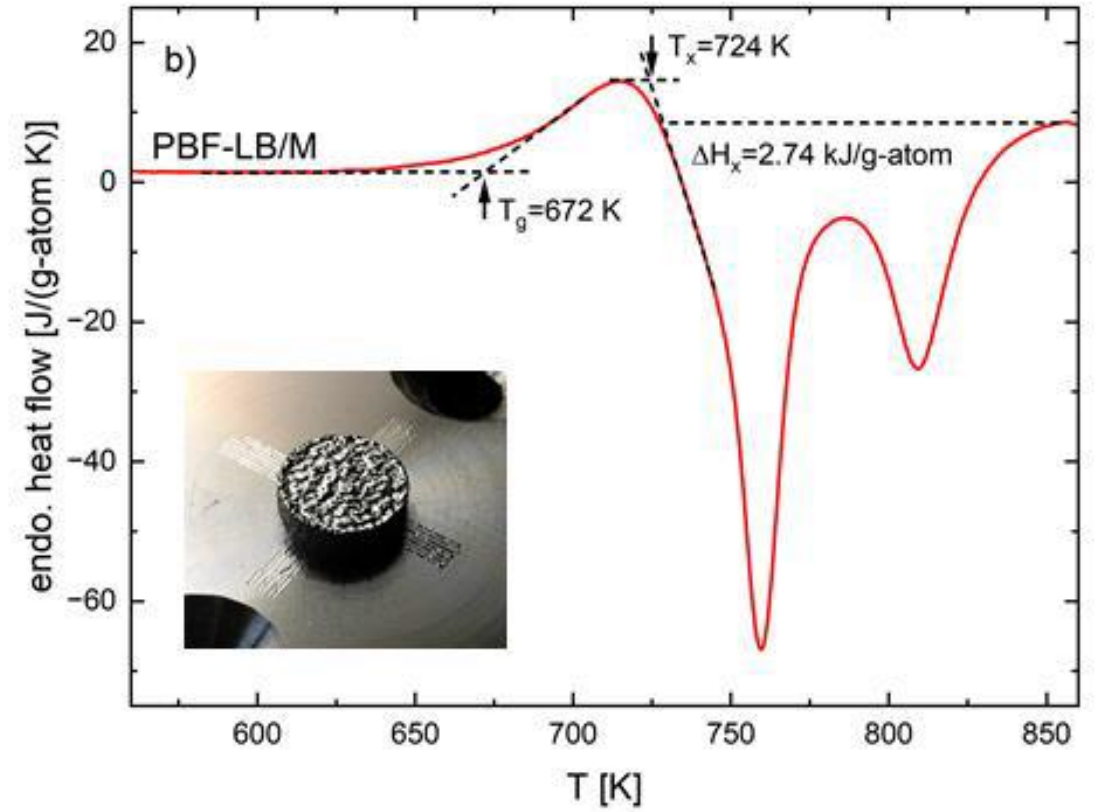
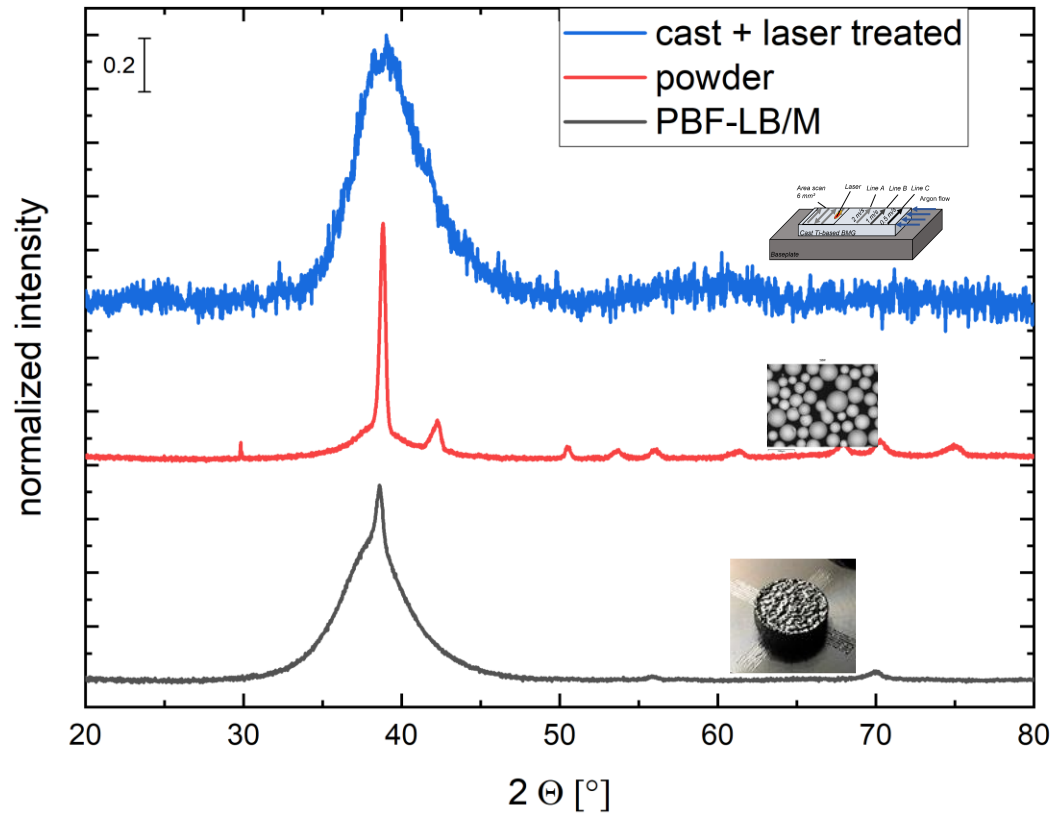
SEM & EDX & Analysis of bulk material



Elemental segregations detected, no oxidation

Results

Microstructural analysis – XRD & DSC

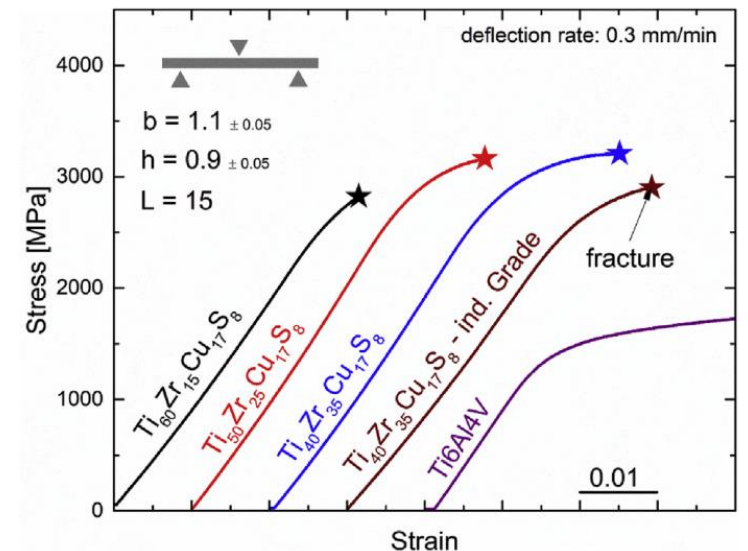


DSC: AM part is 50% amorphous

AM of Ti-based sulfur containing BMG

Summary & Outlook

- Laser treatment of cast surface leads to amorphous structure
- Spherical, crystalline powder received by atomization
- Additive manufacturing:
 - High relative density achieved
 - Partially crystalline microstructure
- Challenges:
 - Elemental offset & increased oxygen content
 - Partially crystalline microstructure in bulk material
 - In-process cracking





Thank you for your attention!

Hanna Schönraht

RapidTech | 2024

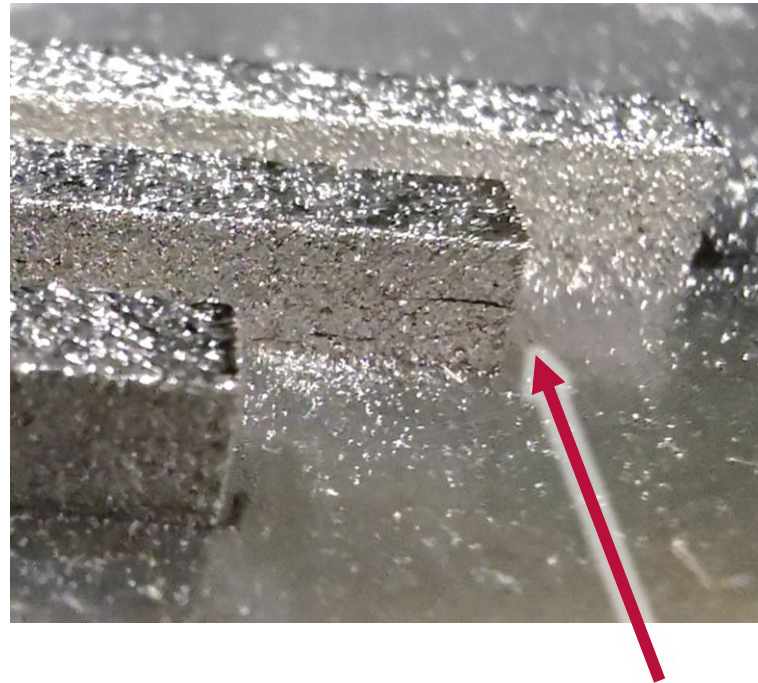
UNIVERSITÄT
DUISBURG
ESSEN

Offen im Denken

AM of Ti-based sulfur containing BMG

Challenges

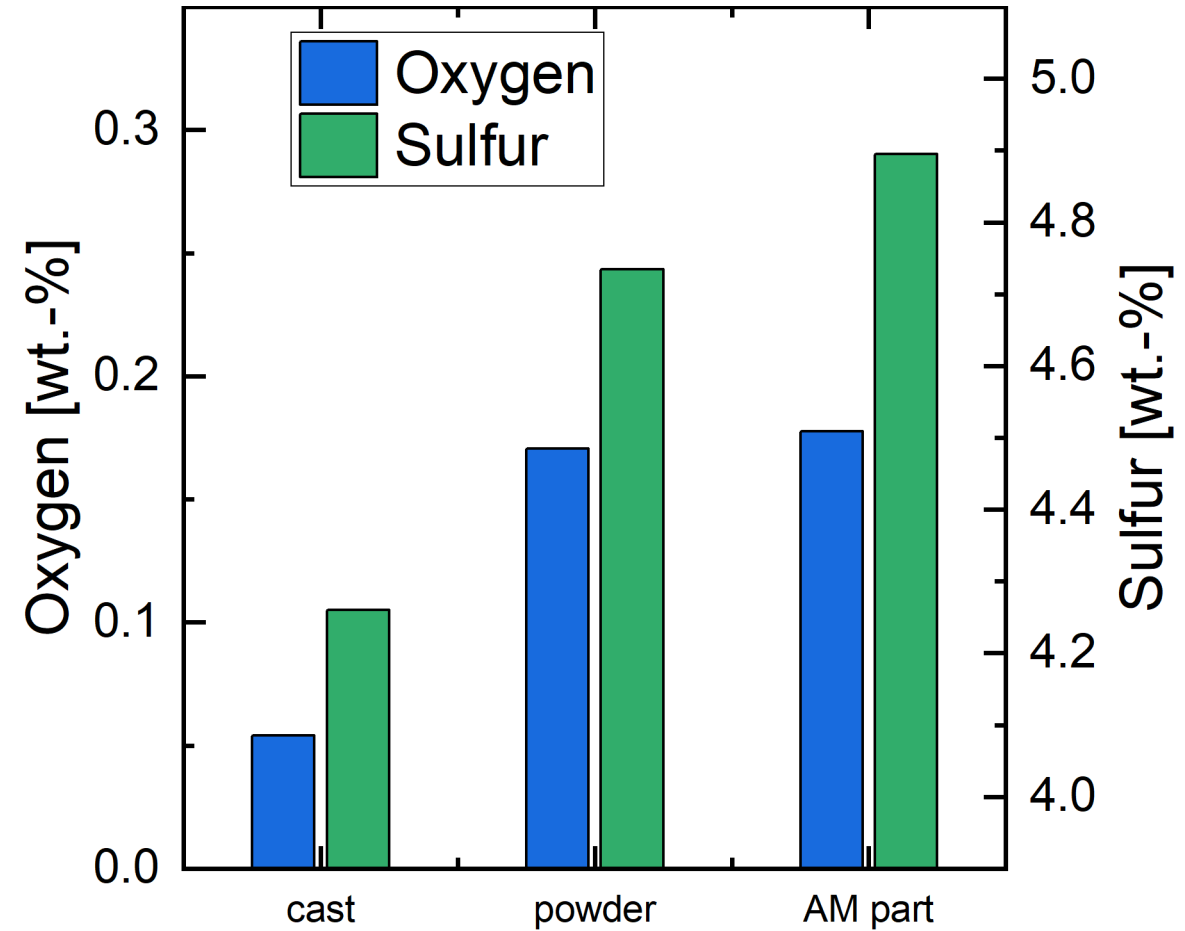
- In-process cracking
- Crystalline phase formation
- Atomization:
 - Oxygen
 - Elemental composition



Results

Oxygen and Sulfur

- Oxygen contamination during atomization
- Low oxygen intake during additive manufacturing



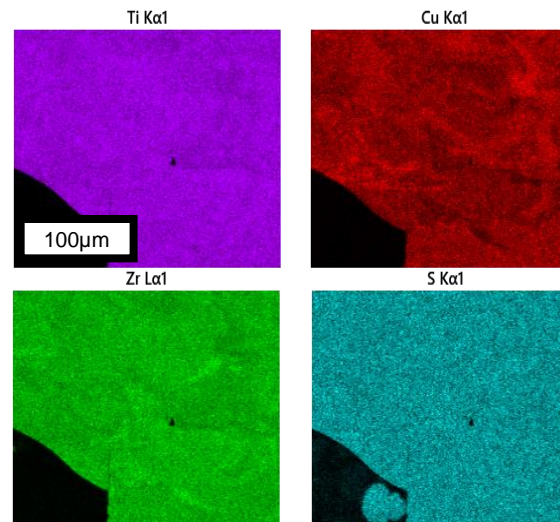
AM of Ti-based sulfur containing BMG

Outlook

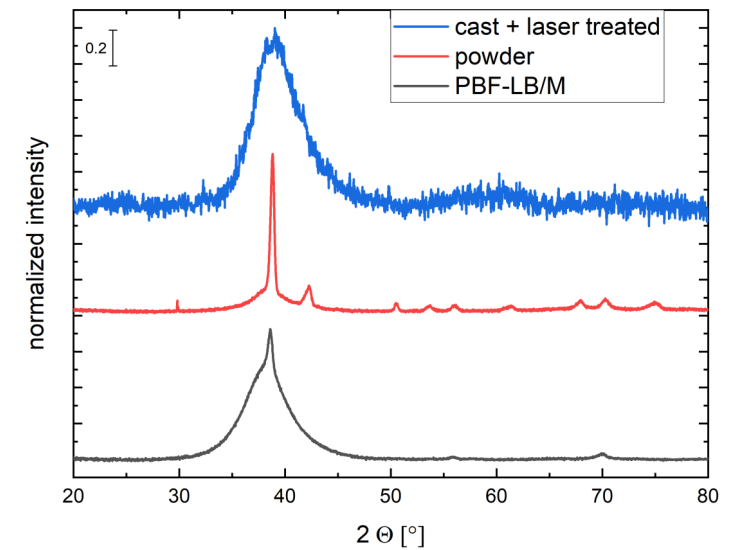
Crack initiation
prevention



Elemental
composition



Amorphous
microstructure



Methods

Analysis

TEM



[thermofisher.com]

Microscopy

SEM



[jeol.com]

17.05.2024

RapidTech | 2024

Microstructural analysis

XRD



[Rigaku Inc.]

DSC



[perkinelmer.com]

19

