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Enhancing The Quality Of Metal Powder Feedstock For Laser PBF Through Cross-contamination Removal

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UNIVERSITÀ POLITECNICA DELLE MARCHE

DREAM
Driving up Reliability and Efficiency of Additive Manufacturing

INSTM

Introduction | Laser Powder Bed Fusion (LPBF)

Powder Bed Fusion (PBF) → The thermal energy (from a **laser** or **electron beam**) selectively **fuses** regions of a **powder bed** in a layer-by-layer fashion, according to a CAD model

PROBLEMS

High surface roughness

Porosity (poor densification)

Residual thermal stresses

Heterogeneous microstructure

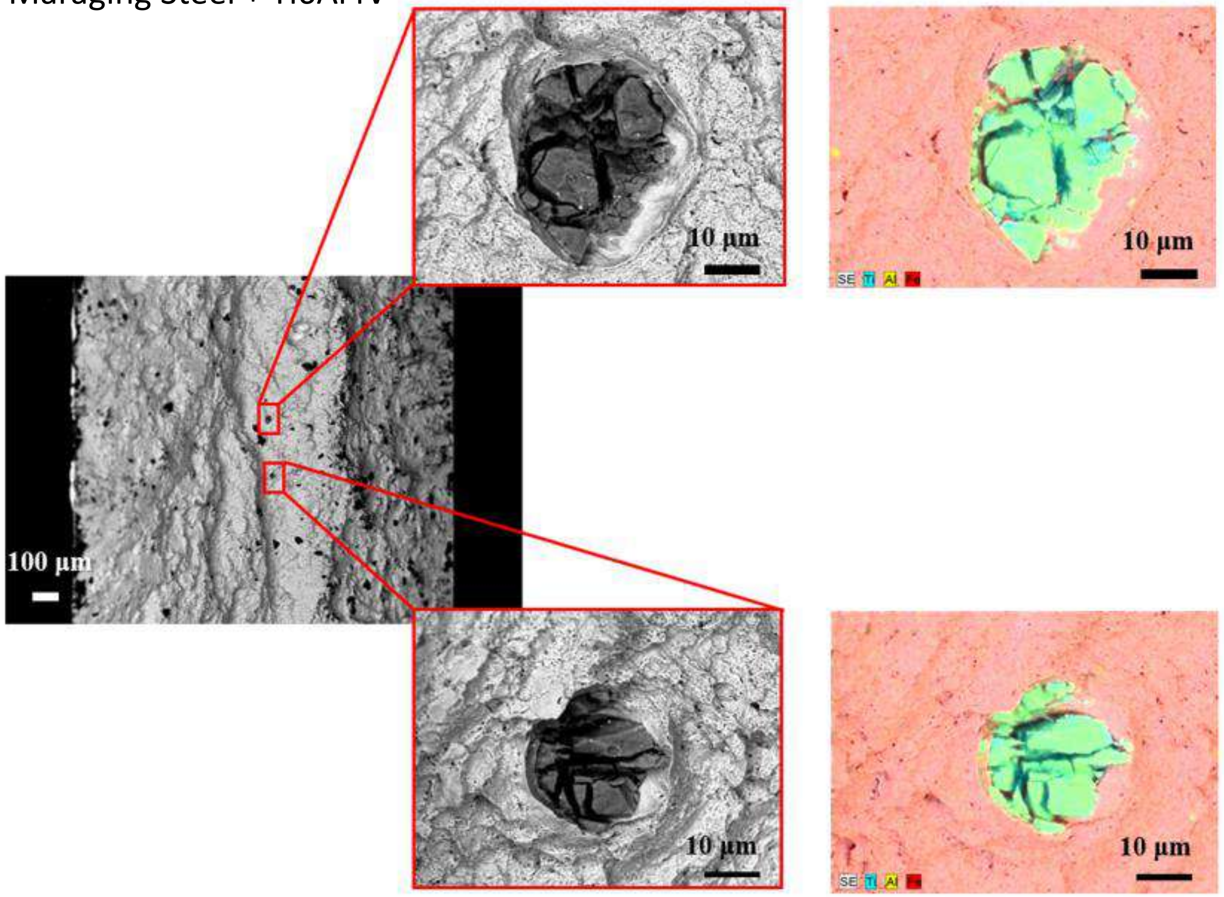
Powder contamination

- Foreign particulate contamination, such as light elements contamination
- Spatter particles - different particle size than the virgin feedstock but similar chemical composition
- Cross-Contamination particles - metal powders having a different chemical composition

Introduction | Cross-Contamination

Solidus-Liquidus

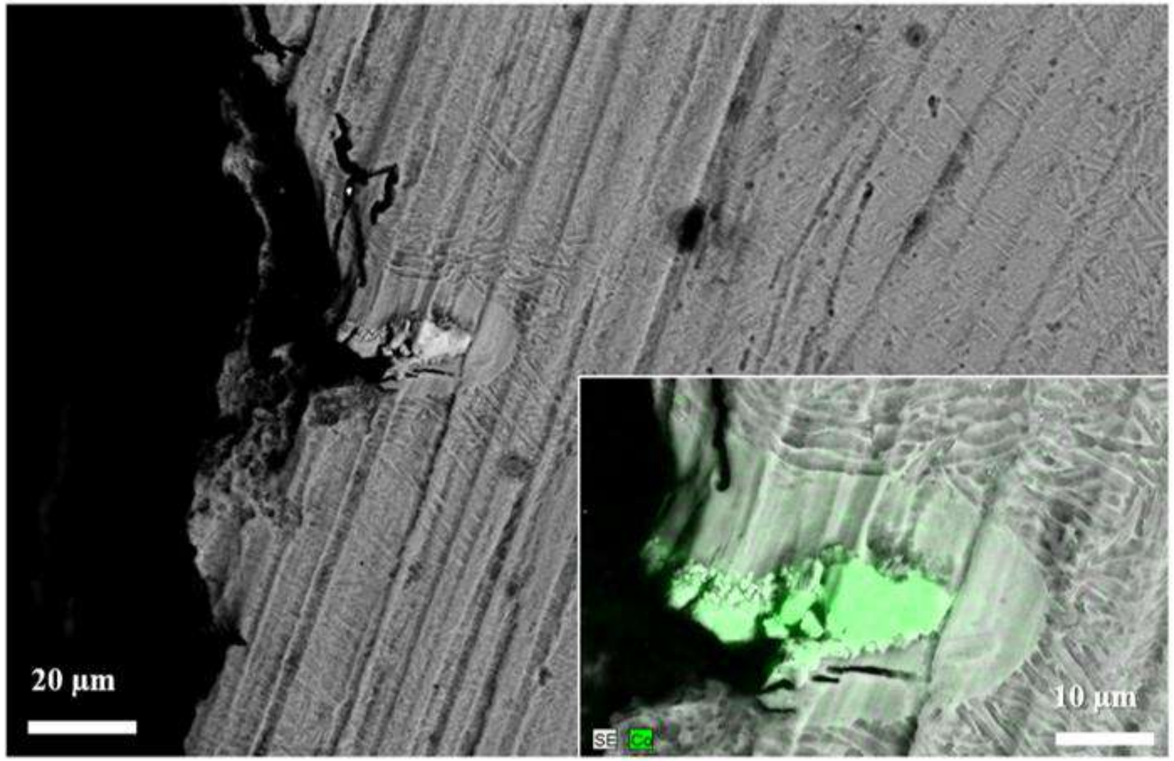
Maraging Steel + Ti6Al4V



Contamination has a melting point higher than the matrix

Liquidus-Liquidus

Ti6Al4V + CoCrMo



Contamination has a melting point lower than the matrix

Santecchia et al., Materials 12 (2019) 2342

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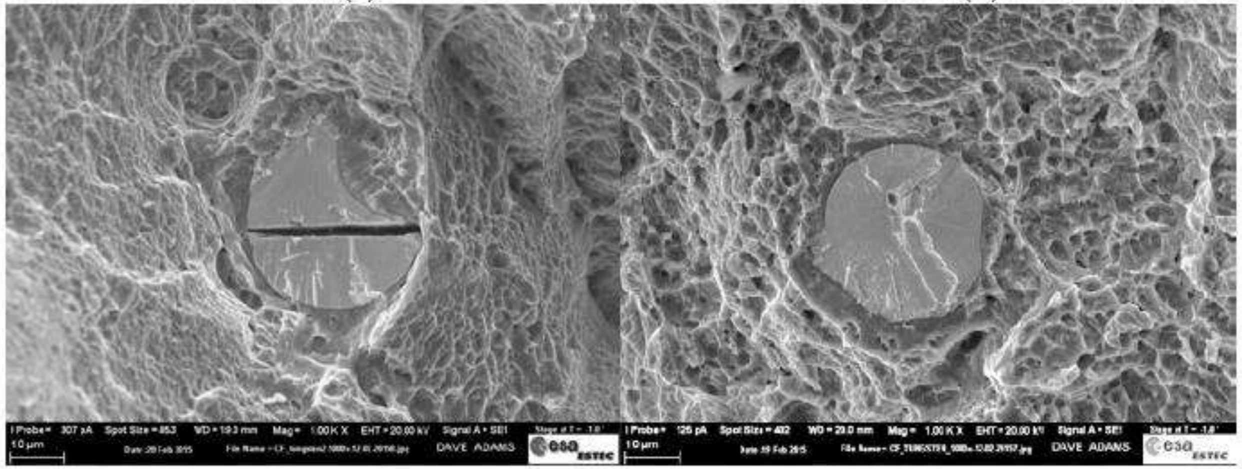
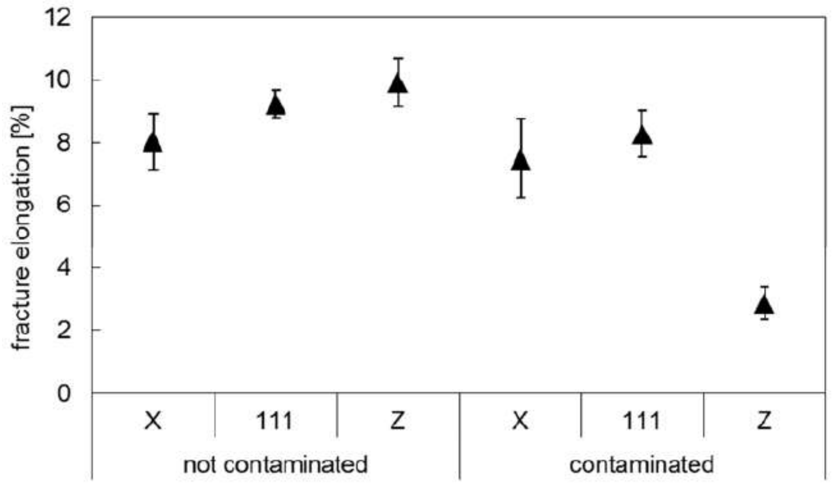
Introduction | Solidus-Liquidus Cross-Contamination

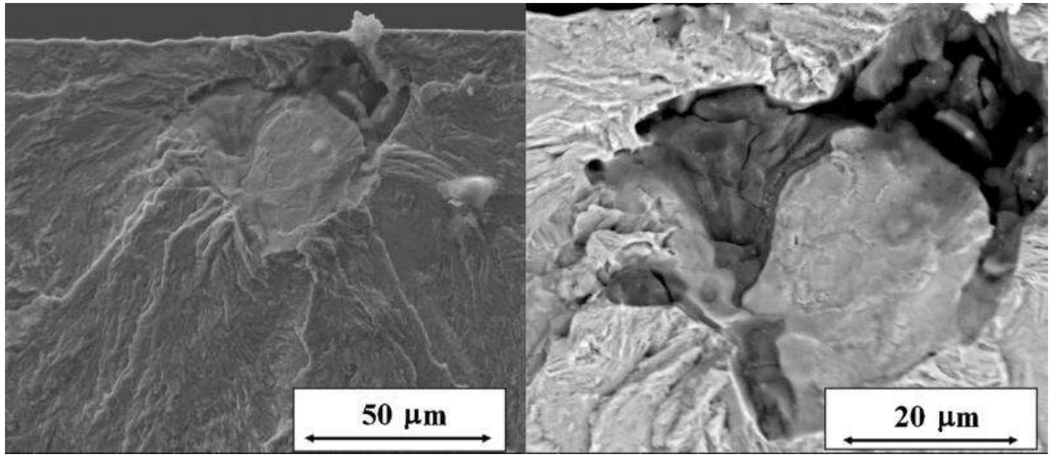
W particles in Ti6Al4V

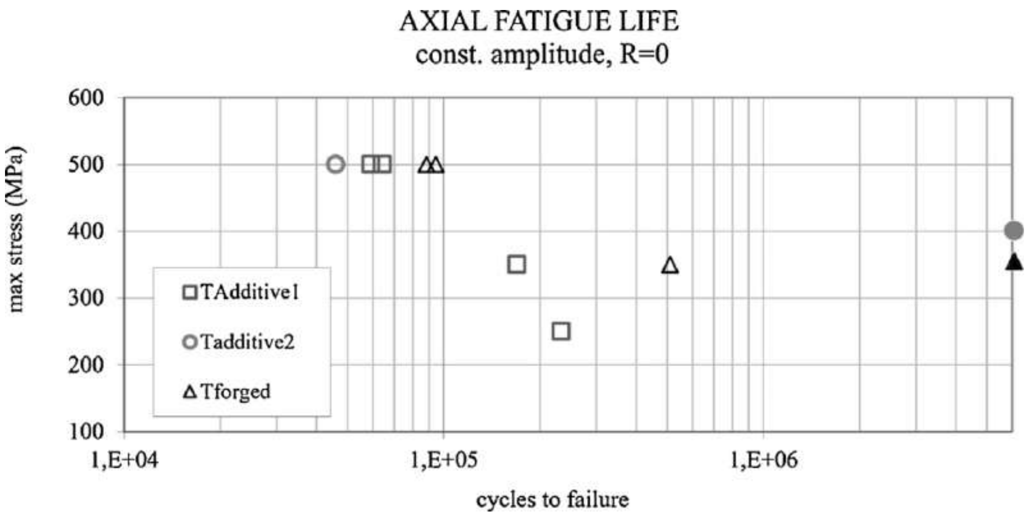




Brandão et al., Materials 19 (2017) 522

Ti- and Al-based oxides in Maraging Steel





Gatto et al., Additive Manufacturing 24 (2018) 13-19

Introduction | Ambition of the DREAM Project

ADLER ORTHO FRANCE

R.B.

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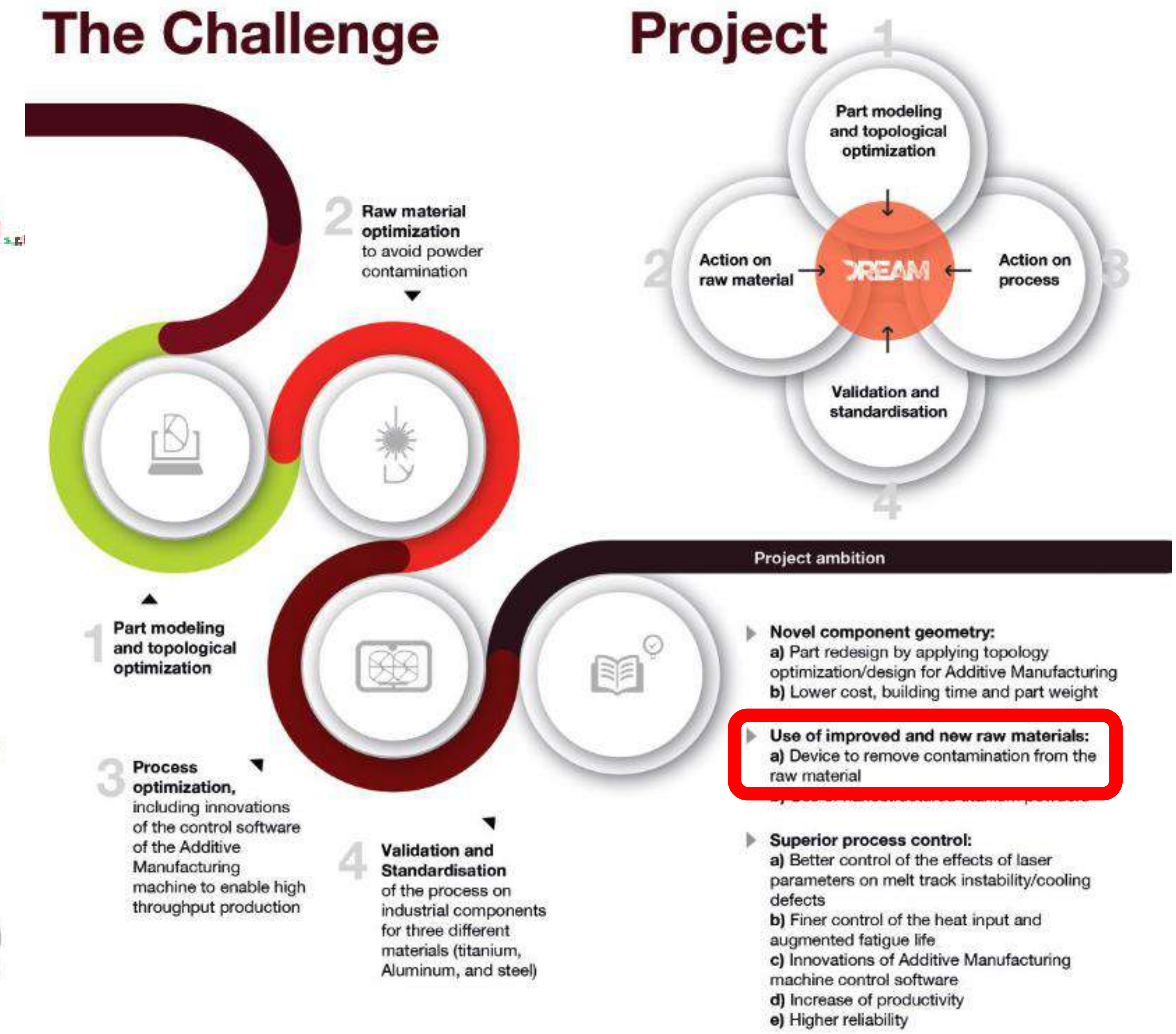
eos e-Manufacturing Solutions

INSTM

POLY-SHAPE additive manufacturing

Transilvania University of Brasov

MIND.4D one step beyond



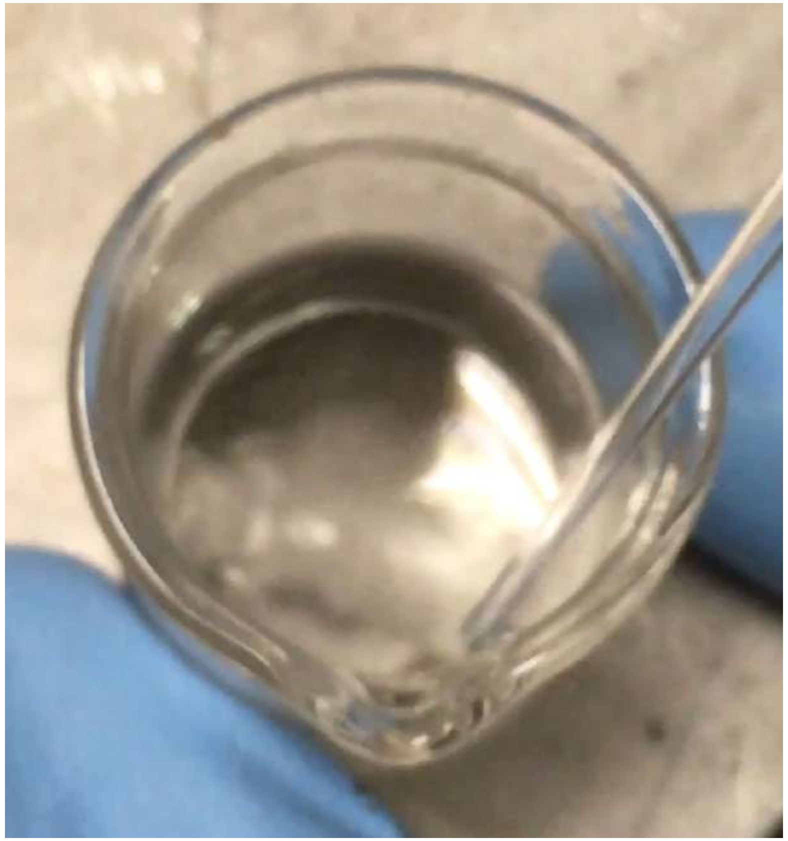
Experimental | Powder Separation Device

Maraging Steel + Ti6Al4V

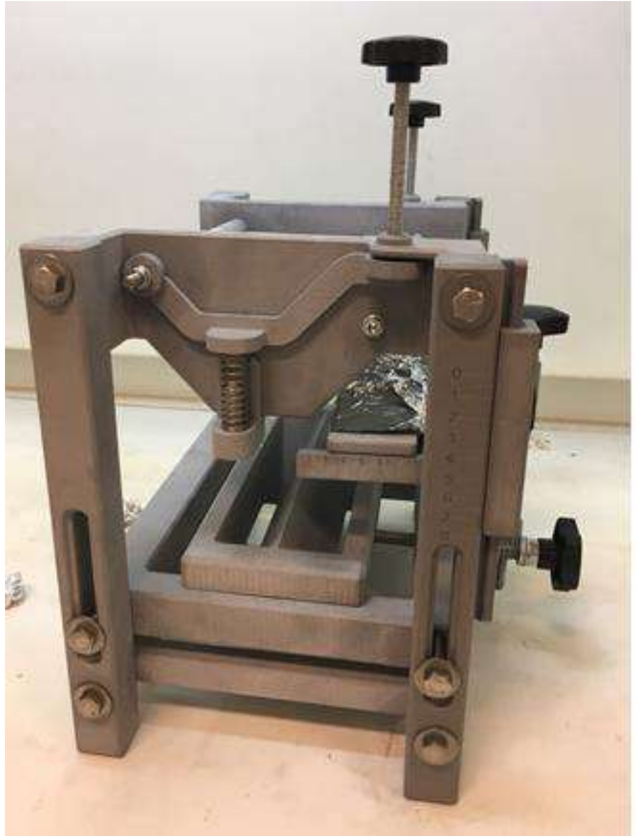
The development of the concentrator/separator device was based on the following considerations:

- The device must be as cheap as possible
- The device must not produce sparks

…sensitivity to magnetic field!



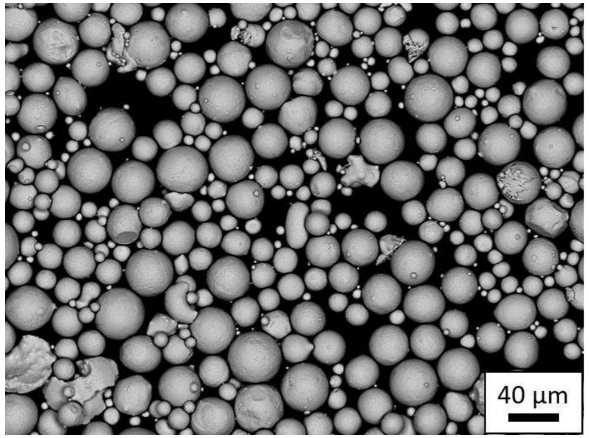
Magnetic-based device

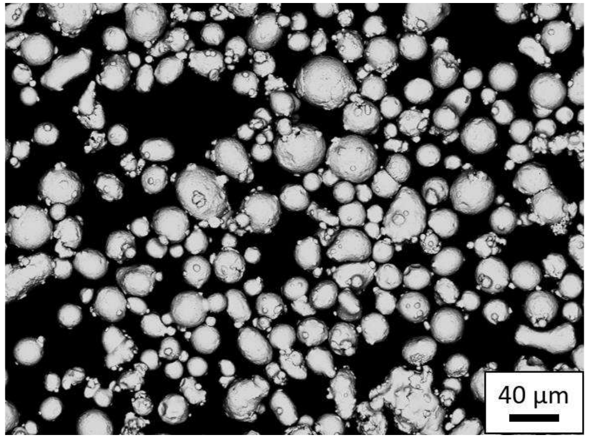


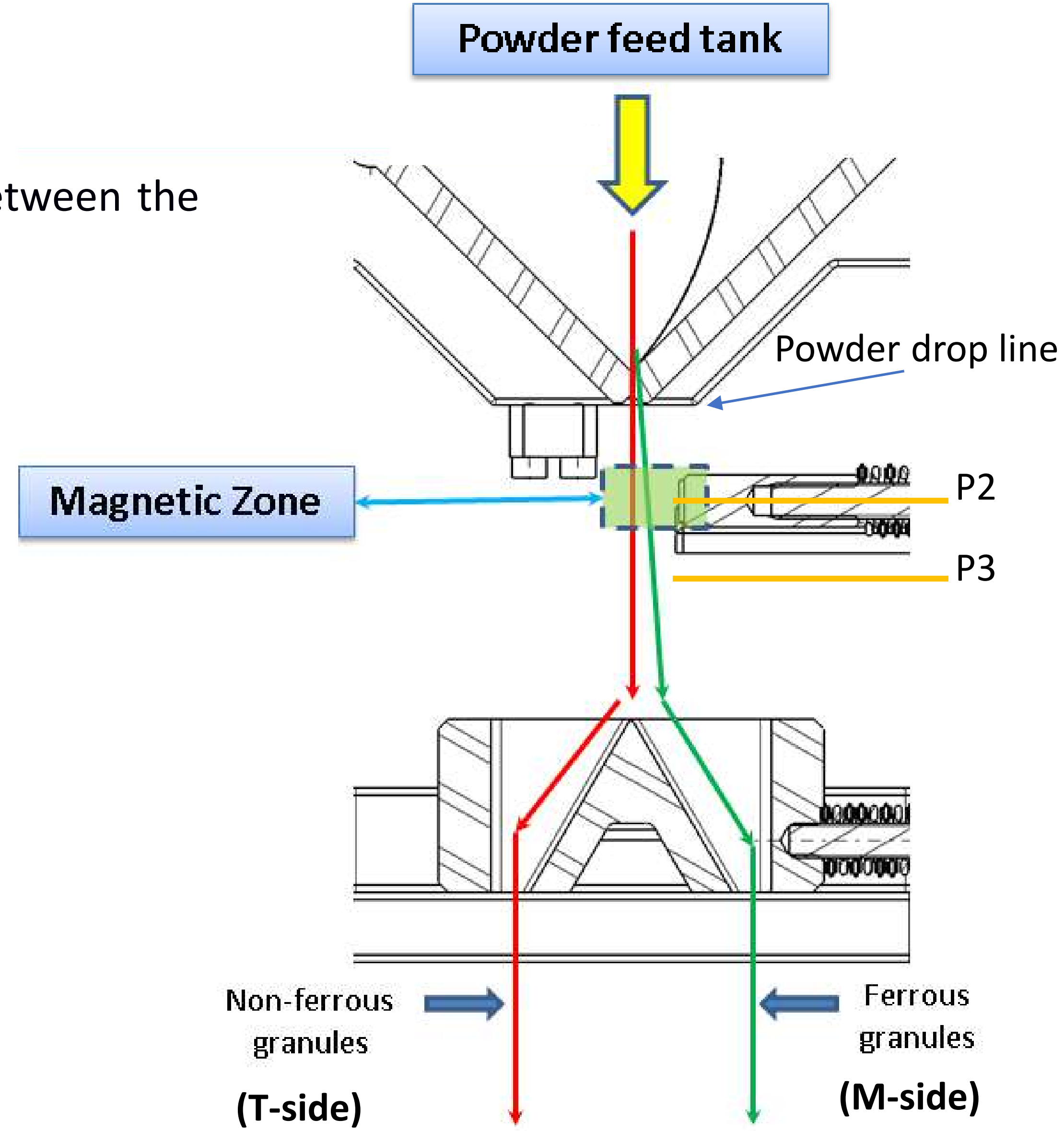
Experimental | Characterization techniques

Two Device Configurations:
a) magnets in position 2 (P2) - close to the powder drop line
b) magnets in position 3 (P3) - magnetic field in the middle between the powder drop line and the separation blade

Starting Powders: EOS MS1 + EOS Ti64







Characterization Techniques:
Scanning Electron Microscopy (FEGSEM) – Zeiss Supra 40
Energy Dispersive Spectroscopy (EDS) **-** Bruker Quantax Z200

Experimental | Samples

Tested Powder Mixtures: **1)** a mixture of 50 wt% Ti6Al4V and 50 wt% maraging steel (Ti64+50MS)
- low humidity status (H) – Heat treatment @ 60 °C for 2 h
- 1 cycle / 2 cycles (1M,1T – 2M, 2T)

2) a mixture of Ti6Al4V with 15 wt% maraging steel (Ti64+15MS)

Samples collected after the separation:

Name	Separation cycles	Side	Heat treatment	Magnets Position
1T	1	Non-ferrous	-	2
1T_H	1	Non-ferrous	Yes	2
2T	2	Non-ferrous	-	2
1M	1	Ferrous	-	2
1M_H	1	Ferrous	Yes	2
2M	2	Ferrous	-	2
1M_P3	1	Ferrous	-	3
1T_P3	1	Non-ferrous	-	3
1T_15	1	Non-ferrous	-	2
1M_15	1	Ferrous	-	2
1T_15_P3	1	Non-ferrous	-	3
1M_15_P3	1	Ferrous	-	3

Performance Check: Quantitative EDS on large areas (200x - 20KeV – 8.2 WD) to measure the Fe and Ti concentrations compared to reference

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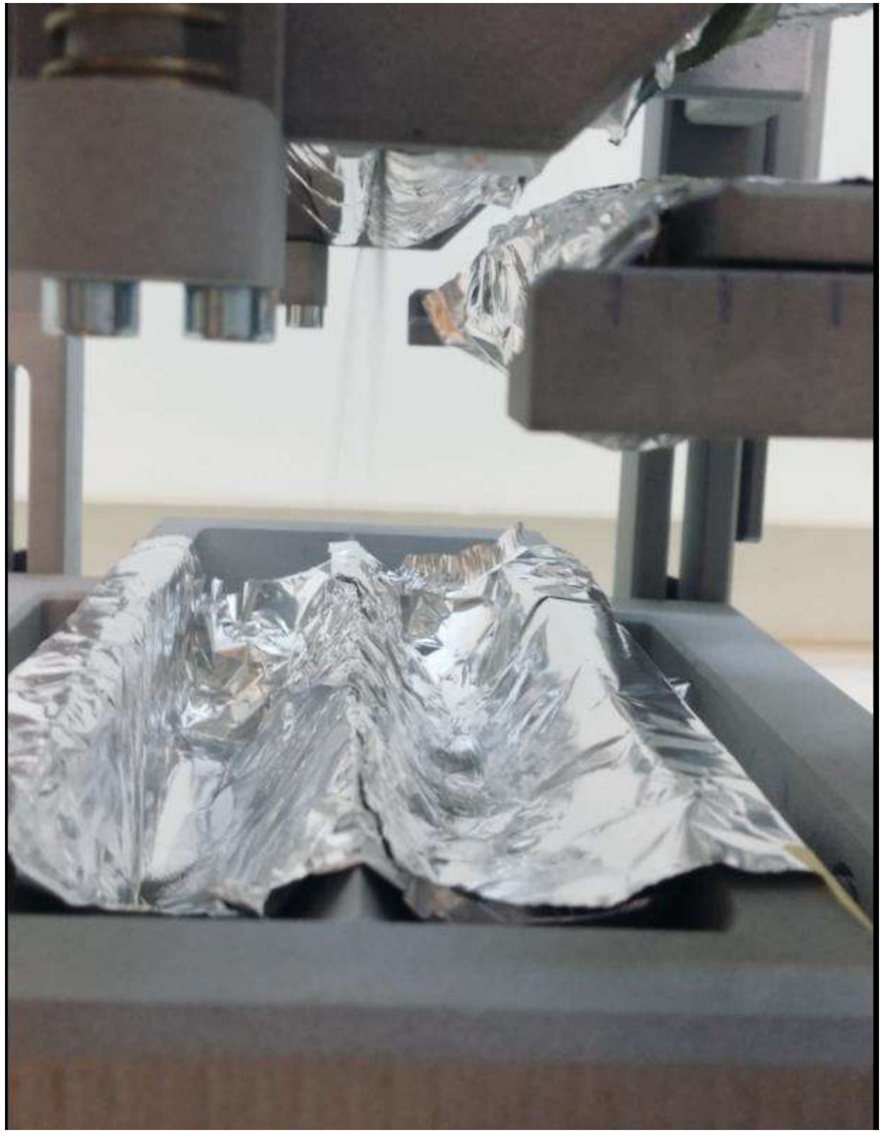
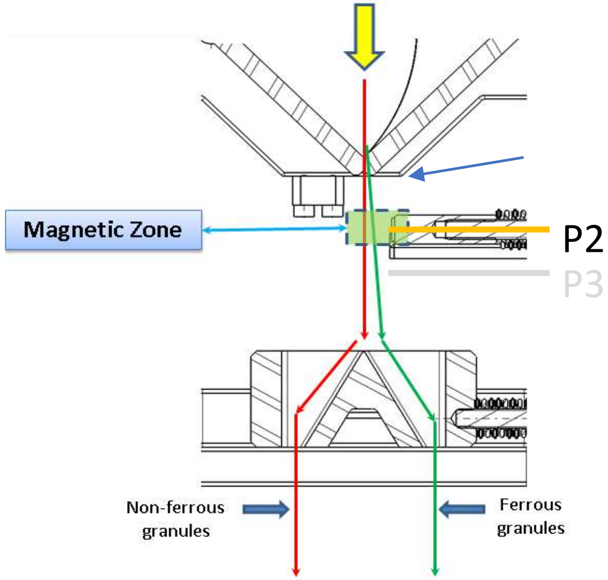
Results | Powder separation device

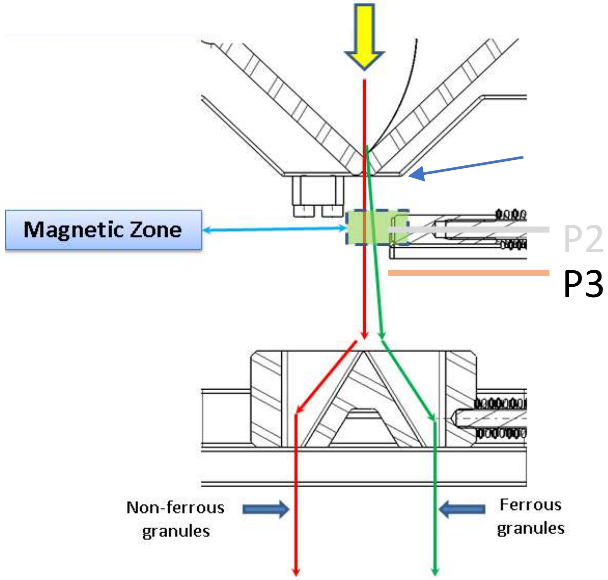


Results | Ti64 + 50MS



Sample	Fe (wt%)	Ti (wt%)
Ti64+50MS (Reference)	23 ± 3	63 ± 3
1T	23 ± 3	65 ± 3
1T_H	23 ± 3	63 ± 3
2T	24 ± 1	64 ± 1
1M	26 ± 4	61 ± 4
1M_H	28 ± 5	58 ± 7
2M	23 ± 1	64 ± 1

Sample	Fe (wt%)	Ti (wt%)
Ti64+50MS	23 ± 3	63 ± 3
1M_P3	32 ± 5	51 ± 6
1T_P3	21 ± 2	64 ± 3



Results | Ti64 + 15MS

To check if the separation performance could be influenced by the tendency of the maraging steel particles to aggregate

Sample	Fe (wt%)	Ti (wt%)
Ti64+15MS2 (Reference)	5.6 ± 1.6	84 ± 3
1T_15	5.4 ± 0.4	84 ± 1
1M_15	5.4 ± 1.4	84 ± 1
1T_15_P3	5.3 ± 1.2	82 ± 2
1M_15_P3	7.5 ± 1.2	80 ± 1

Conclusions

- The trial tests performed on the cross-contamination separation device showed that the position of the magnets, and the related magnetic field, has an influence on the performance of the device

- On the other hand, the tendency of the maraging steel powder particles to form aggregates showed to not have significant implications on the performance

- These results open the door to a redesign of the separation device and to the next standard for cross-contamination free metal powder feedstock

NEW EQUIPMENT! - Changed powder supply system to avoid powder agglomeration
- Different configuration to avoid «gravity» related effects
- Different magnetic field configuration

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MIND.4D one step beyond

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DREAM
Driving up Reliability and Efficiency of Additive Manufacturing

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RAM
Research on Additive Manufacturing

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