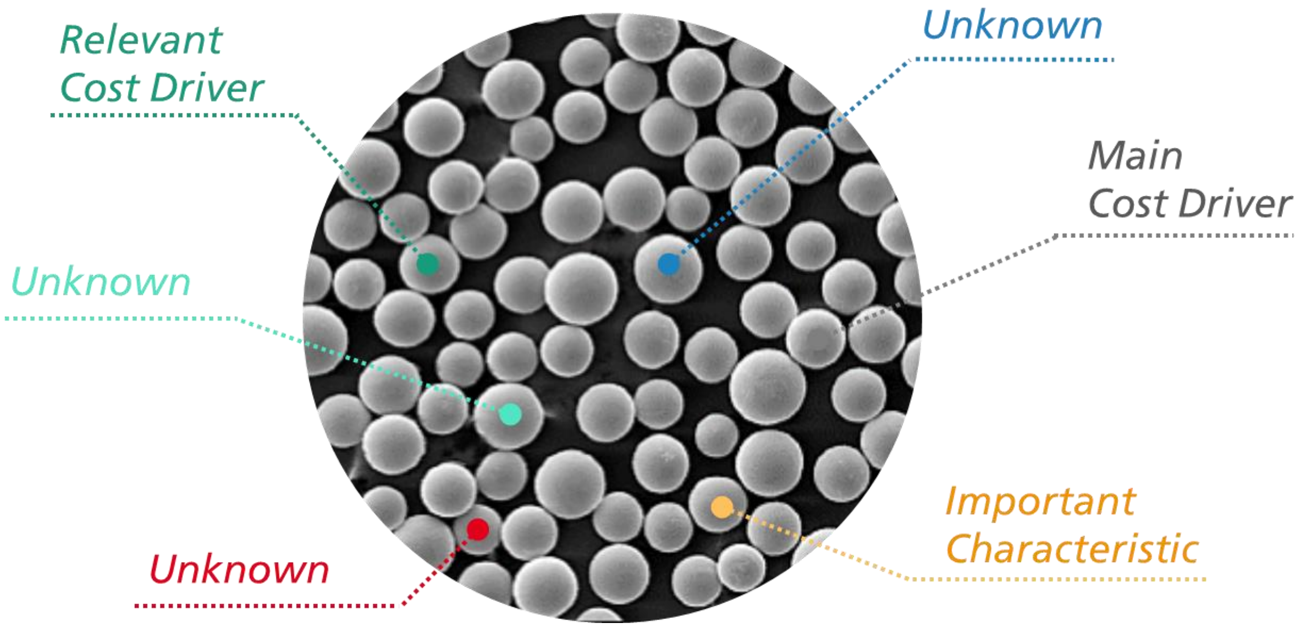
COST EFFECTIVE POWDERS FOR LBM

Alliance Deep Dive 2021

EXCLUSIVE



Fraunhofer IAPT

THE AUTHORS

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Project Manager

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Head of Materials and Finish

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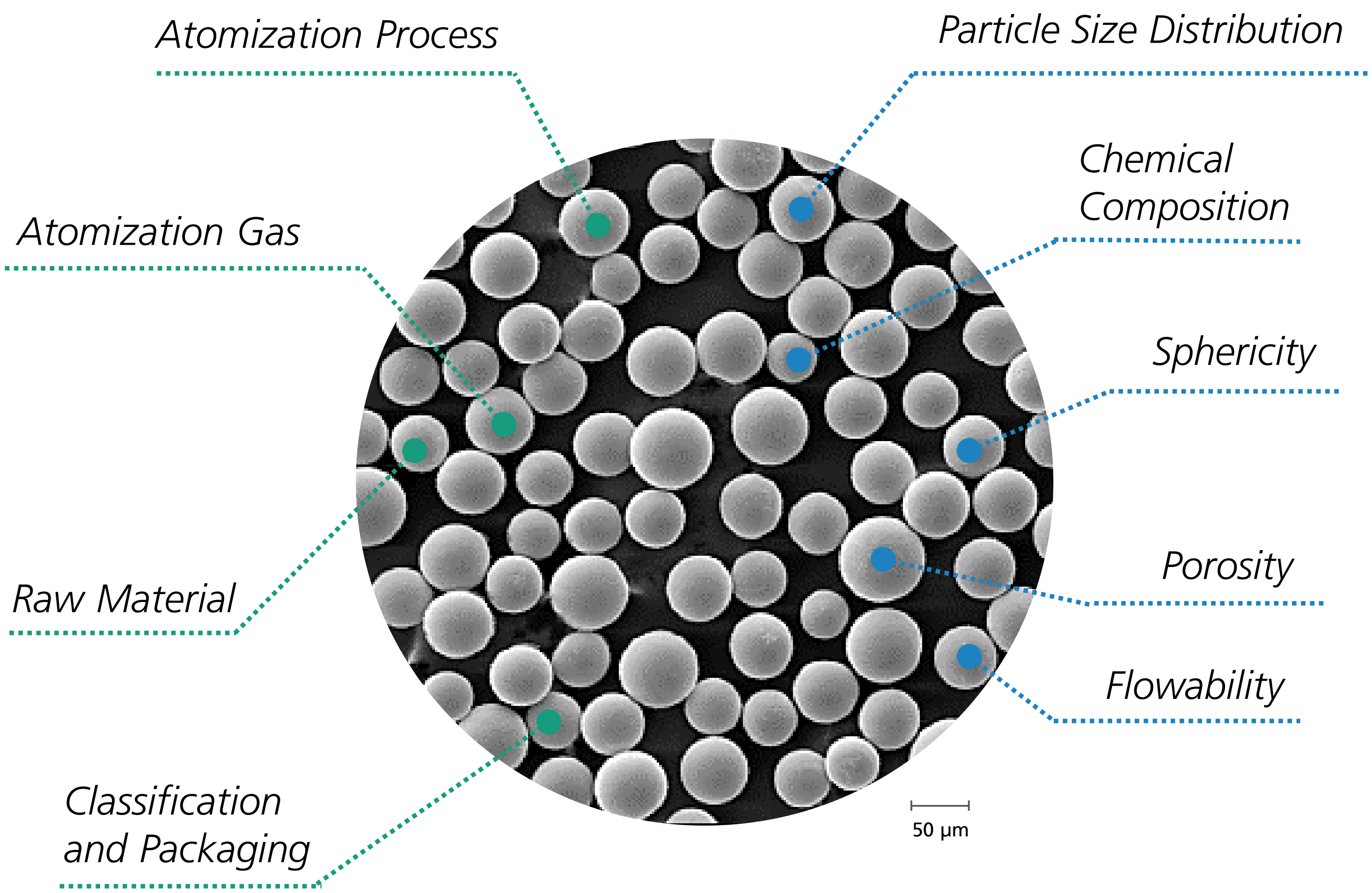
Motivation

Situation

- AM Market is heading for higher productivity rates and cost reduction potentials
- The powder costs show high reduction potentials, but also a lot insecurities regarding the required characteristics

What are the relevant cost drivers regarding powder production?

How is the quality of my parts effected?



LBM Metal Powder

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Motivation

More background

	Layer thickness	Particle Size
10 years ago	20-40 µm	10-45 µm
Last years	30-60 µm	20-63 µm
Most recent	30-90 µm	20-63 µm

Why not getting coarser?

Fine Particles

Powder Handling	❖ Sticks to walls/ handling equipment/ parts ❖ blocked and polluted filters ❖ High hover times
Health	❖ Alveolar = Harmful to health ❖ Higher explosiveness
Laser Process	❖ High specific surface = increased O_2 and H uptake;

Get rid of fine particles

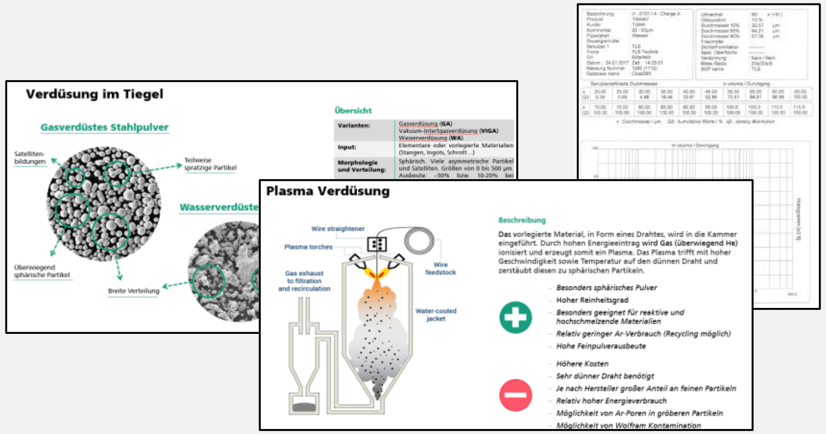
Check quality and costs

Approach of the Deep Dive

Theoretical part

GUIDEBOOK POWDER PRODUCTION

- Overview of Powder Atomization Processes
- Potential Cost Drivers



Experimental part

PRINTABILITY Ti6Al4V 45-106µm

Comparison of typical powder (PSD: 20-63 µm) and coarse powder (PSD: 45-106 µm)

Evaluating price reduction potential and quality

+ having hidden cost drivers and advantages in mind due to less fine powders

Powder Characterization

- Particle Size Distribution
- Morphology
- Flowability
- Packing Density

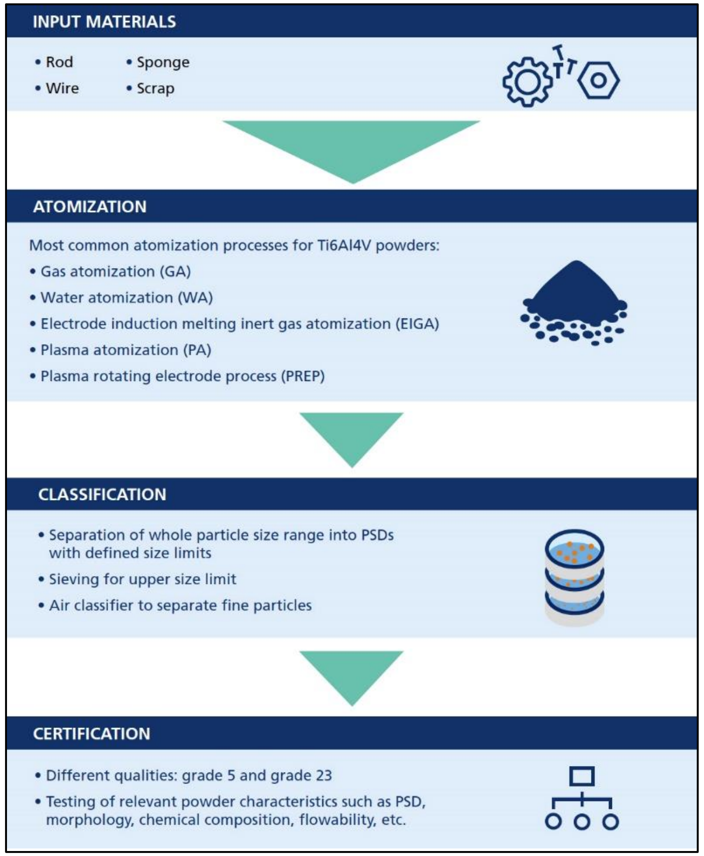
Part Characterization

- Surface Roughness
- Density
- Tensile Properties

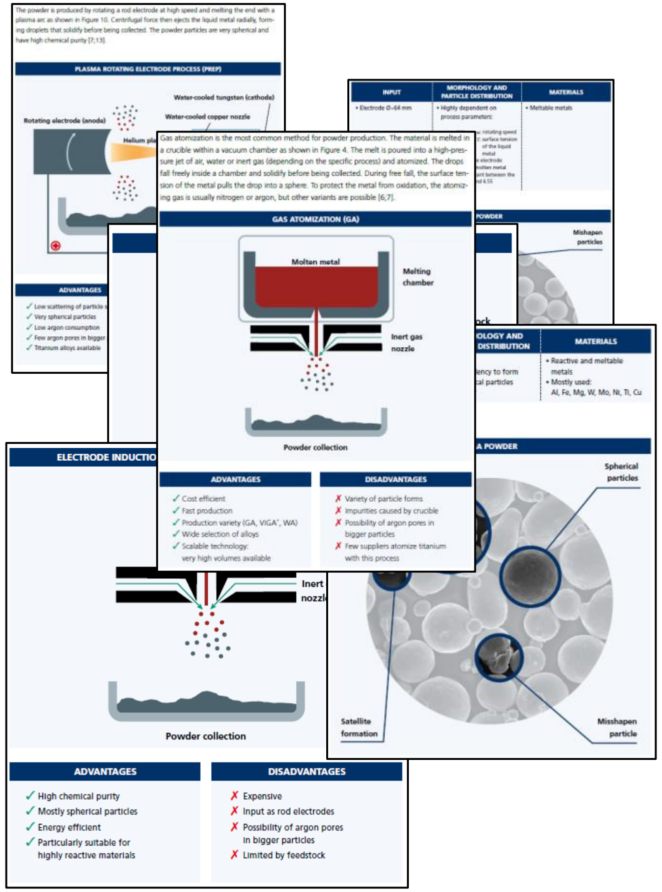
Theoretical part

Powder Guide Book – Supply chain and atomization processes

Powder production process chain



Atomization processes



Powder Guide Book – Powder Costs

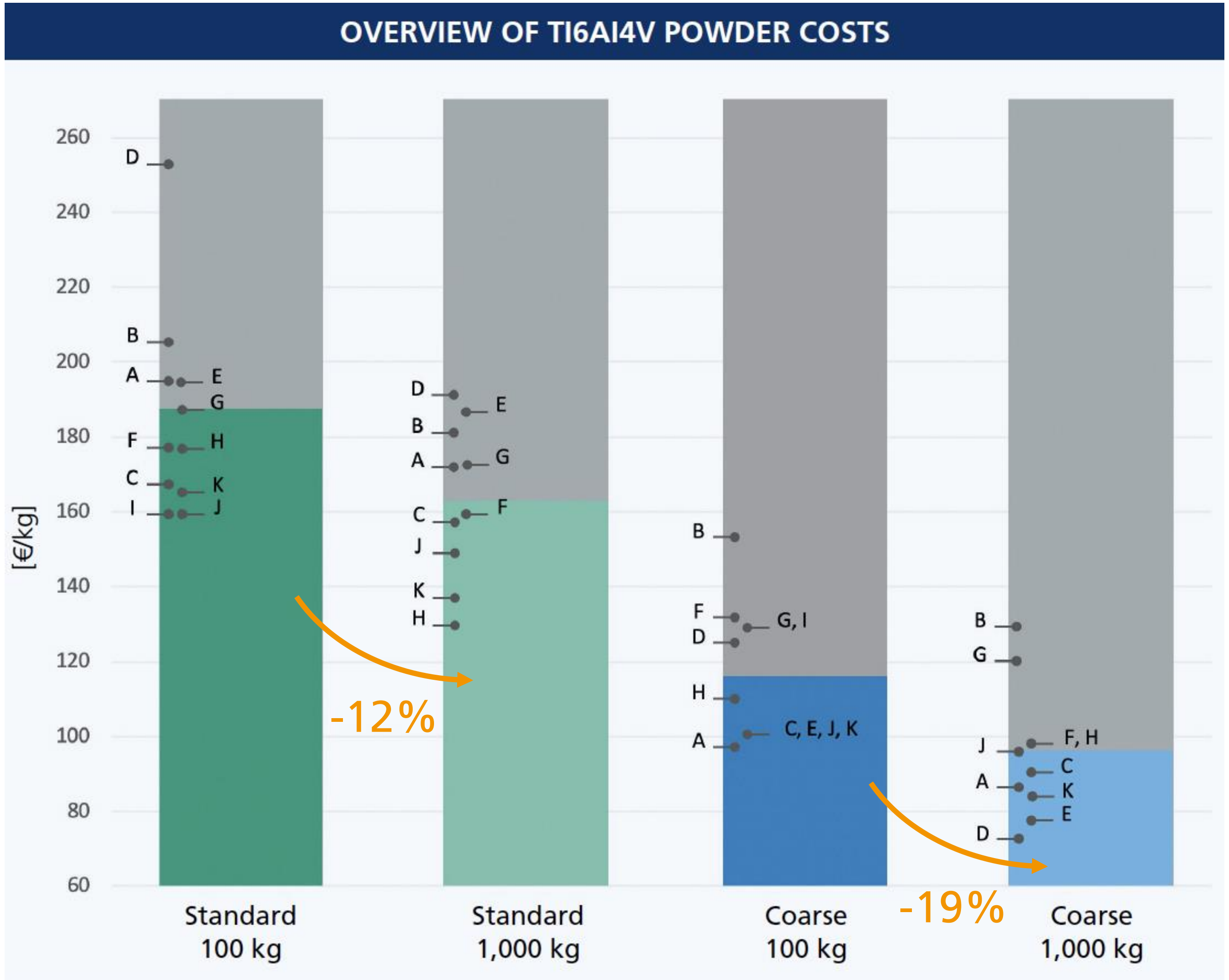
Standard: ≈ *20-63 µm*
Coarse: ≈ *45-105 µm*

Market Survey

- Ti6Al4V ELI (grade 23) for coarse and standard PSD for each 100 and 1,000 kg
- Quotations were obtained from a total of 22 suppliers, of which 15 responded with an official offer. Consideration of 11 suppliers

Scaling

- Cost reduction for standard powder of an average of 12%
- Cost reduction for coarse powder of an average of 19%



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Powder Guide Book – Powder Costs

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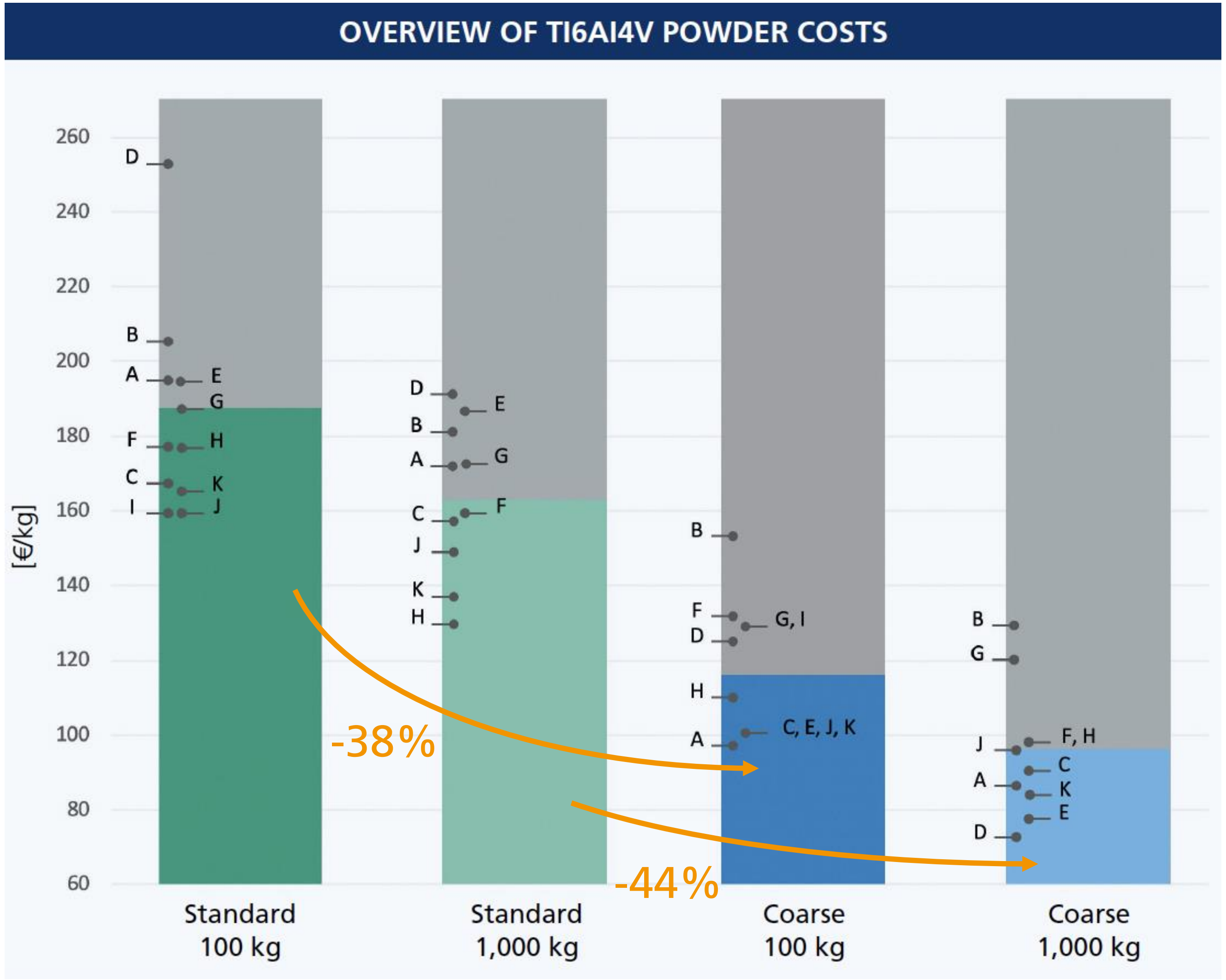
PSD

- Cost reduction for 100 kg of an average of 38 %
- Cost reduction for 1,000 kg of an average of 44 %



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Powder Guide Book – Powder Costs

Market Survey

- Ti6Al4V ELI (grade 23) for coarse and standard PSD for each 100 and 1,000 kg
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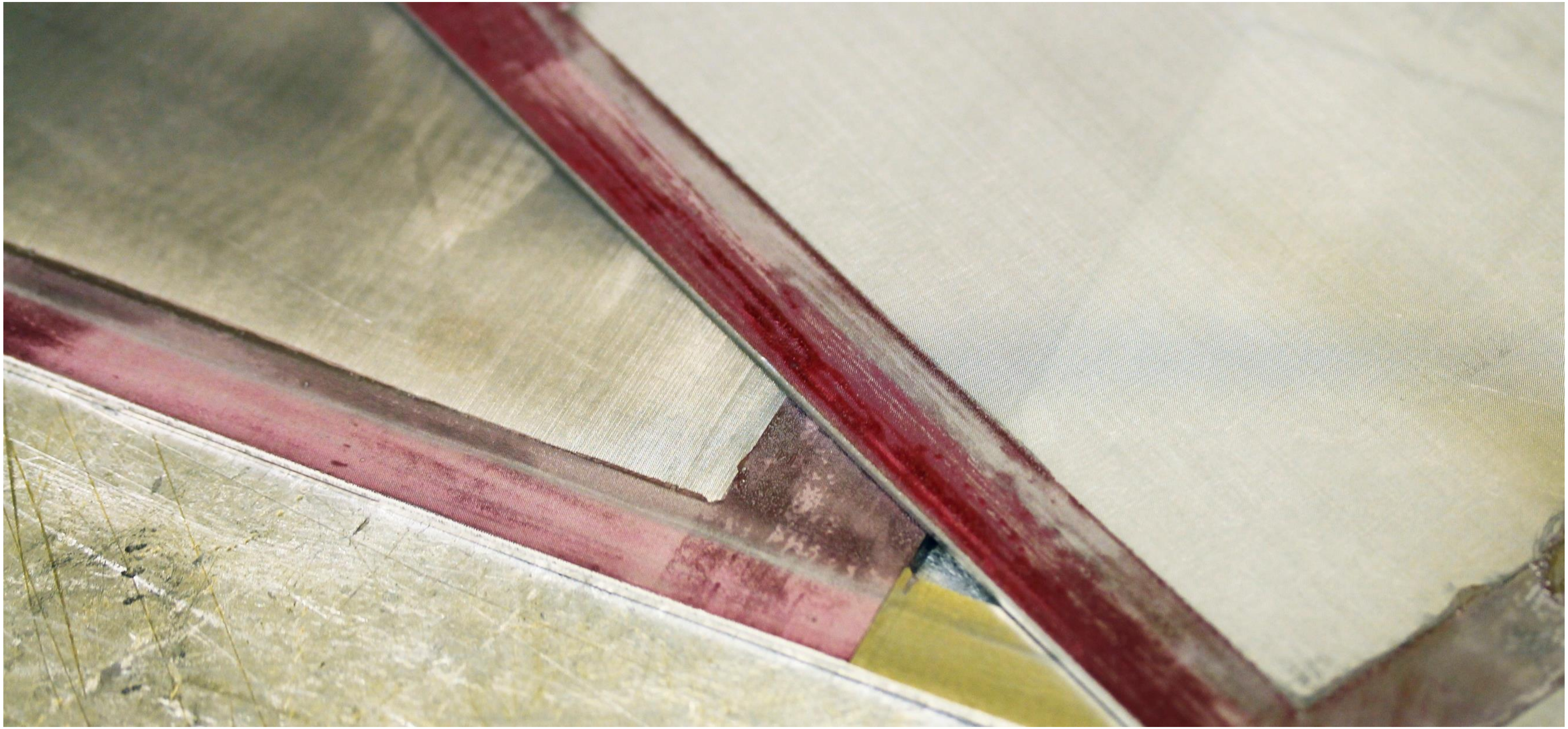
CHEAPEST PRICES			
Standard 100 kg: 162.31 €	Standard 1,000 kg: 130.20 €	Coarse 100 kg: 97.20 €	Coarse 1,000 kg: 71.20 €

Experimental part

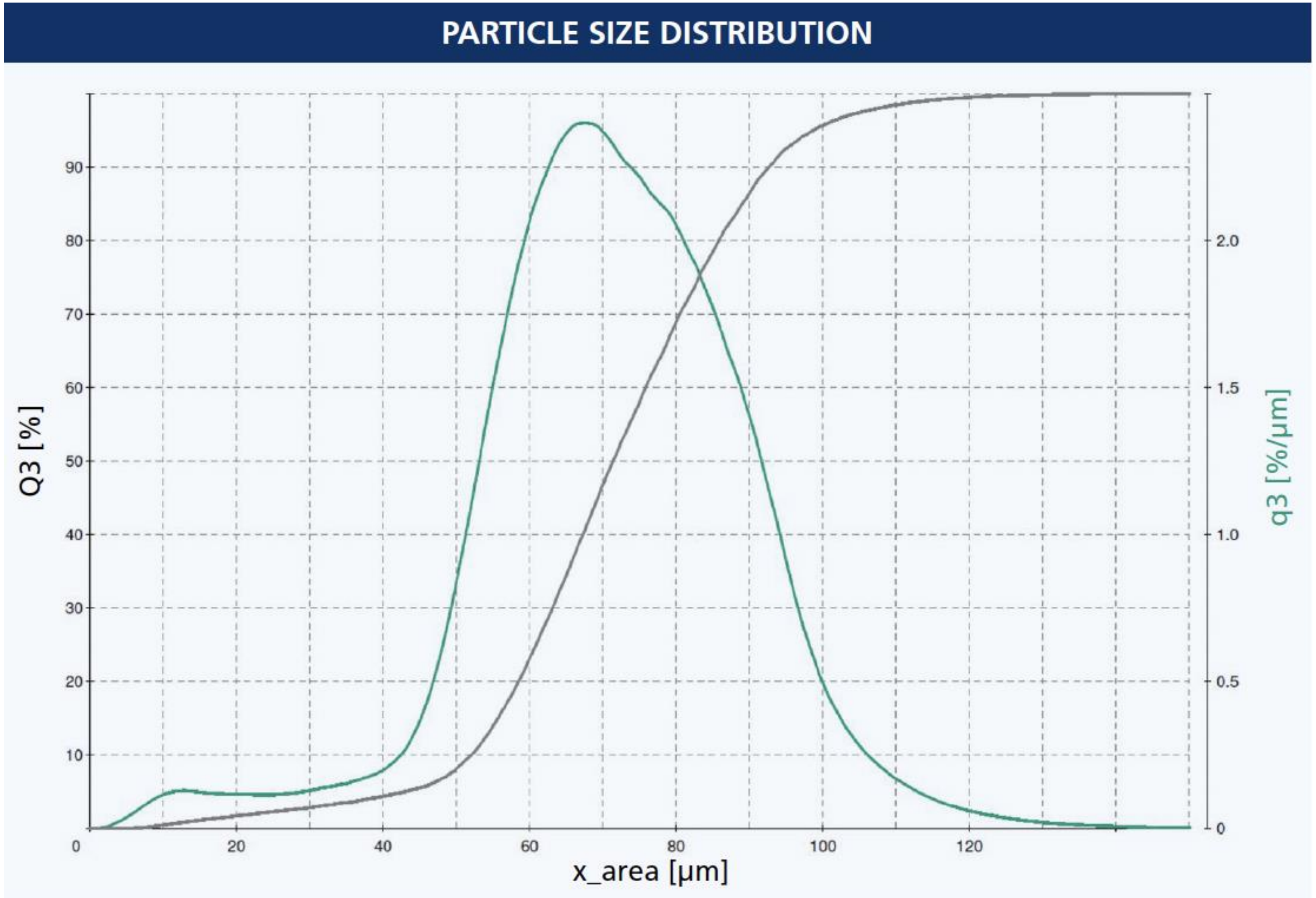


Printability of Coarse Ti64 Powder – Powder Specification

Investigated powder

- Ti6Al4V ELI (grade 23)
- PSD of 45–106 µm
- Puchased for 30 €/kg

Chemical composition was within the specification



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Printability of Coarse Ti64 Powder – Powder Specification

Investigated powder

- Ti6Al4V ELI (grade 23)
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Flowability

POWDER	BULK DENSITY [g/cm³]	TAPPED DENSITY [g/cm³]	HAUSNER RATIO	FLOWABILITY [s/50g]
20–53 µm	2.46 +/- 0.00	2.68 +/- 0.01	1.09	26.75
45–106 µm	2.30 +/- 0.01	2.53 +/- 0.01	1.10	25.20

Printability of Coarse Ti64 Powder – Experimental Set Up

Parameter study

- Investigations were carried out on an SLM 250 HL and on a Concept Laser M2
- Mainly laser power, scanning speed and hatch distance were varied

DENSITY CUBE POSITIONS

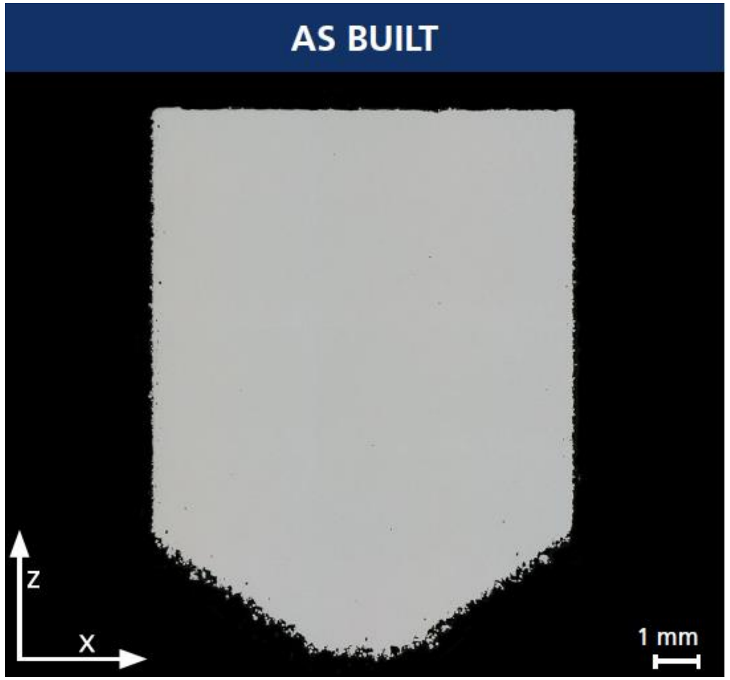
Printability of Coarse Ti64 Powder – Results

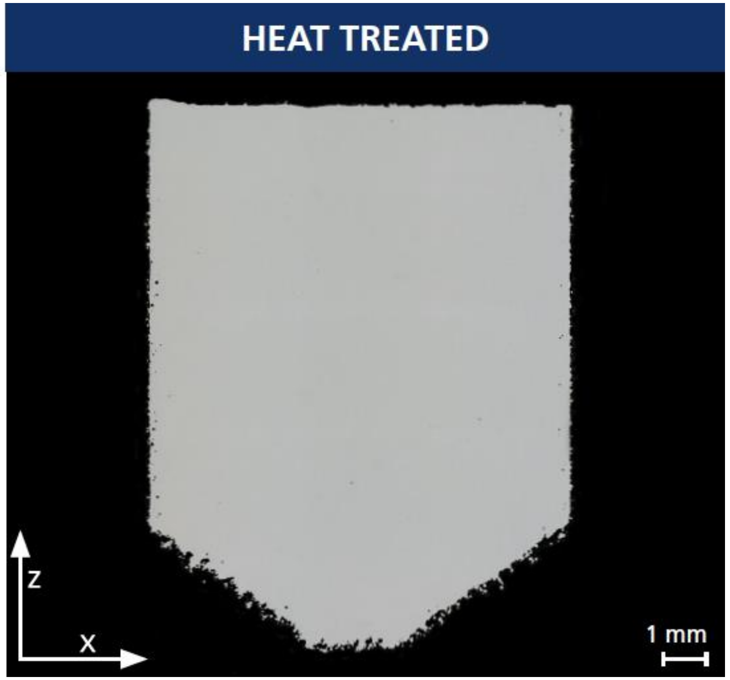
Parameter study

- Investigations were carried out on an SLM 250 HL and on a Concept Laser M2
- Mainly laser power, scanning speed and hatch distance were varied

PARAMETER	VALUE
Layer thickness [µm]	60
Laser power [W]	320
Scanning speed [mm/s]	1,400
Hatch distance [µm]	80
Built rate [cm³/h]	24,14

Reaching density of **> 99,9%**





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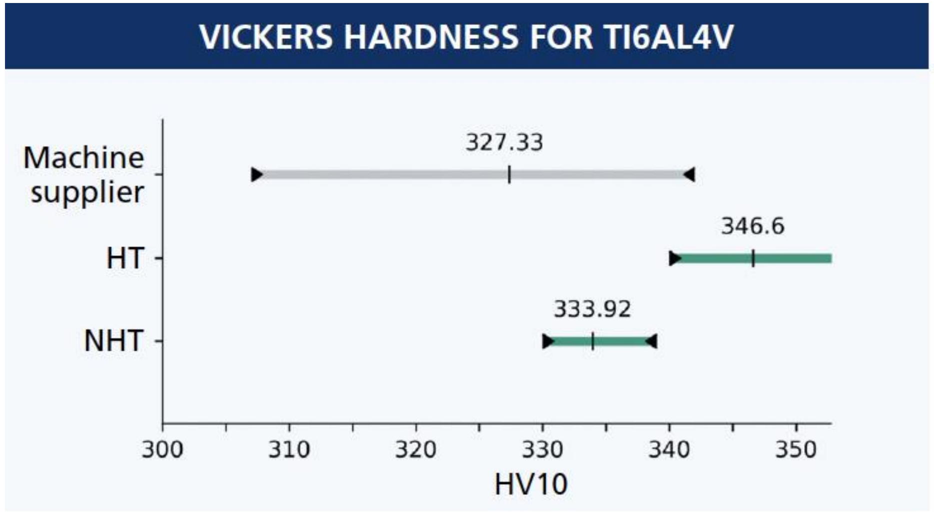

Figure 20: Vickers hardness for Ti6Al4V

minimum *maximum* *mean*

Approximately **6 µm** above IAPT reference data

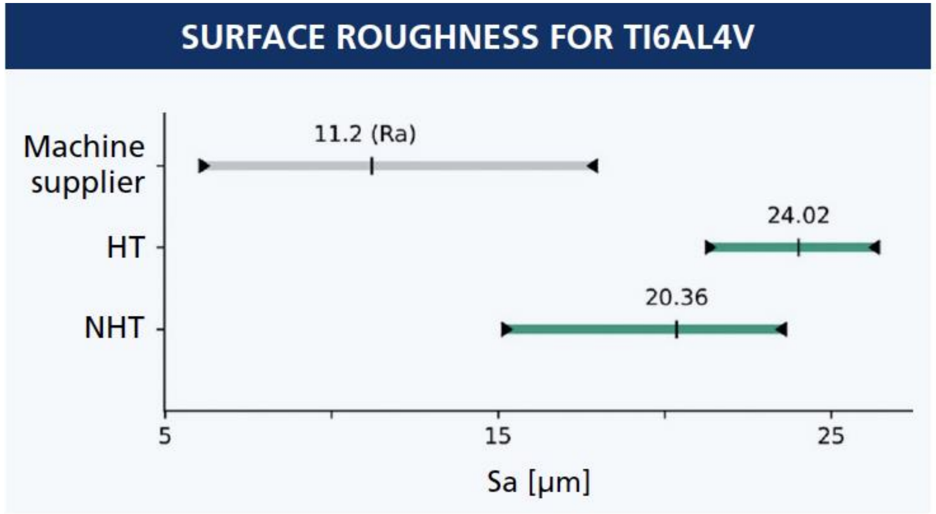

Figure 21: Surface roughness for Ti6Al4V

minimum *maximum* *mean*

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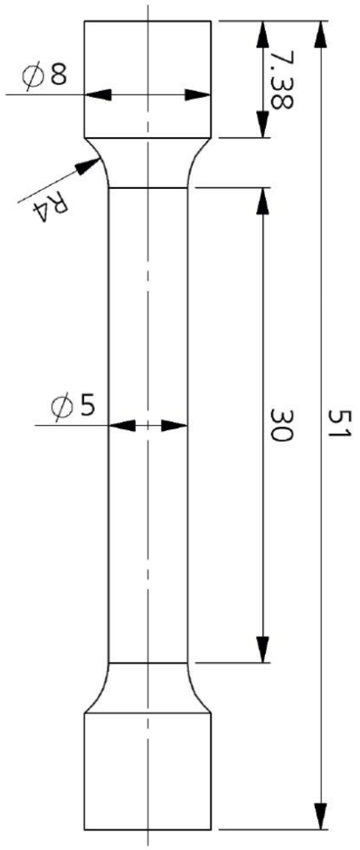
Printability of Coarse Ti64 Powder – Experimental Set Up

Printing of tensile specimens

- Printing of 12 Tensile specimens
- heat treated at 800 °C for 2 hours before being separated from the build plate by wire cut eroding EDM

Form B d_0 = 5 mm
according to DIN 50125



Printability of Coarse Ti64 Powder – Results

Printing of tensile specimens

- Printing of 12 Tensile specimens
- heat treated at 800 °C for 2 hours before being separated from the build plate by wire cut eroding EDM

VERTICAL 0°	R_m [MPa]	$R_{p0.2}$ [MPa]	A [%]	E [GPa]
IAPT 45–106 µm (M2 Cusing 60 µm/400 W)	1,018.2	906	17.92	116
EOS (EOSINT M 280-400 W; EOS M 290-400 W)	1,100	1,000	14.5	110
SLM (60 µm/400 W)	991	905	15	130
GE (Laser M2 Series 5; 60 µm)	1,050	995	14.5	119

HORIZONTAL 90°	R_m [MPa]	$R_{p0.2}$ [MPa]	A [%]	E [GPa]
IAPT 45–106 µm (M2 Cusing 60 µm/400 W)	1,051	955	14.62	118
EOS (EOSINT M 280-400 W; EOS M 290-400 W)	1,100	1,000	13.5	110
SLM (60 µm/400 W)	987	894	12	112
GE (Laser M2 Series 5; 60 µm)	1,050	995	13.5	118

Slightly lower strength, but higher ductility

Conclusion

Powder cost levers

- Cost reduction due to scaling between 12 – 19 %
- Cost reduction due to PSD between 38 – 44 %

Printability of coarse powder

- Density of > 99,9 % achieved
- Comparable hardness and slightly worse surface roughness
- Comparable tensile performance with the tendency to lower strength and higher ductility

Outlook

- Optimizing surface parameters
- Using higher layer thicknesses

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THANK YOU FOR YOUR ATTENTION!

QUESTIONS?