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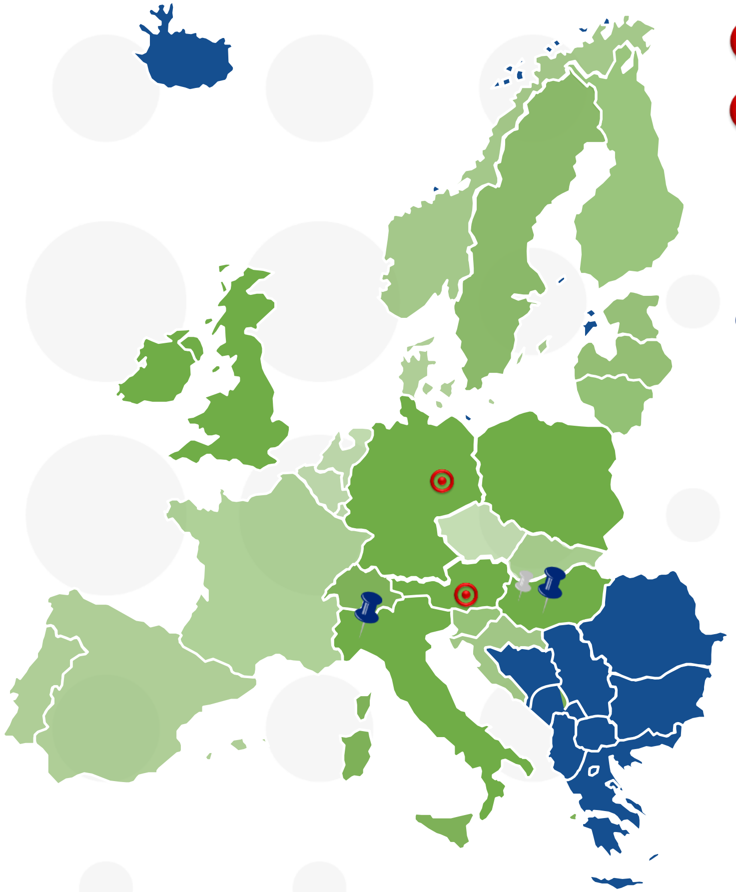
Pushing the boundaries in AM of Al alloys: material candidates for high-performance applications

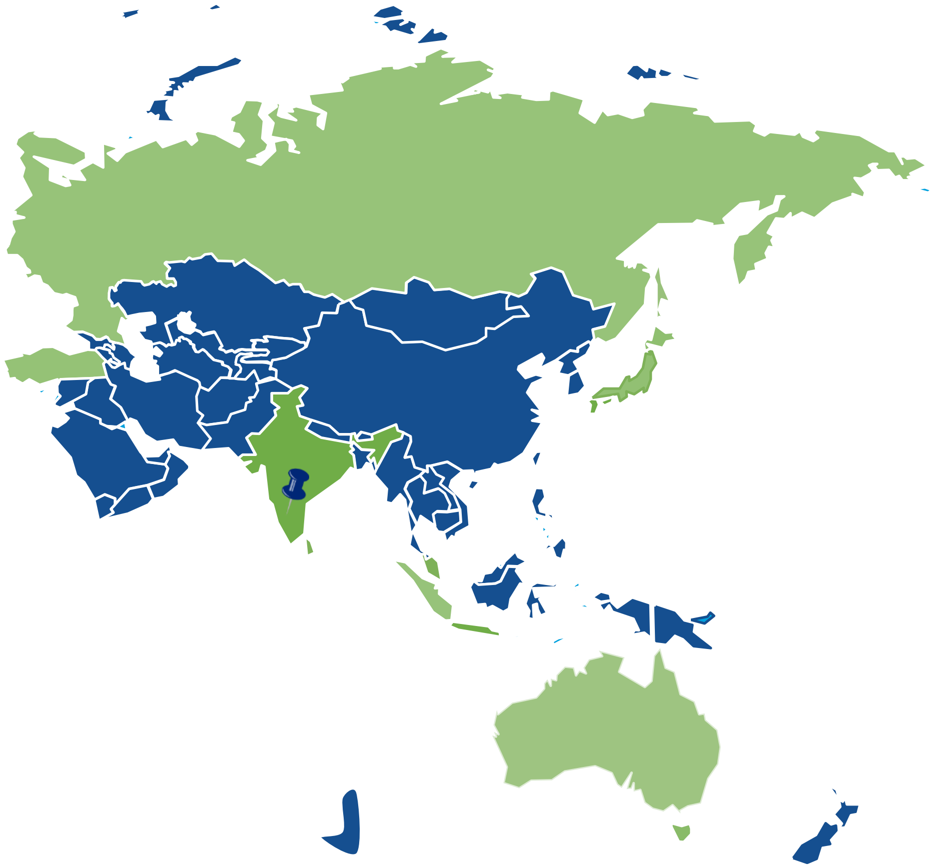
Burghardt Klöden

The m4p story...

Rapid regional and global expansion



- **Magdeburg/DE Produktion 2015**
- **Feistritz i.R./AT Produktion 2017**
- **Torino/IT** – Subs - Distribution EU- Sout/West 2020
- **Bangalore/IN** – Subs Distribution APAC 2021
- **Budapest/Hun** – Subs Distribution Central-East Europe 2022

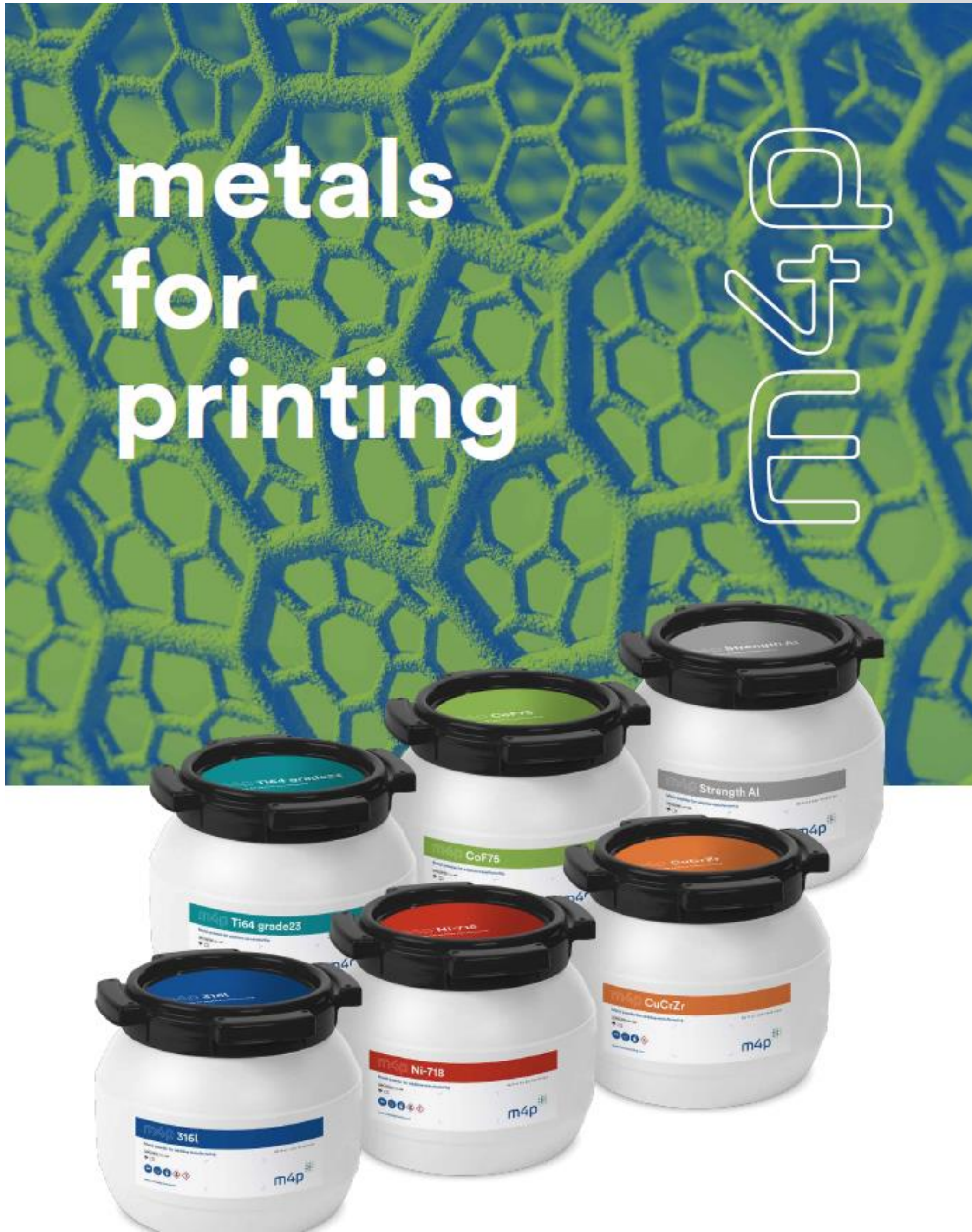


We serve all Countries in Europe and most of APAC countries - US/CA entry planned for 2023

Metal powder

Material Portfolio....

- All relevant Material Families: Fe, Al, Cu, Ti, Ni, Co, W
- > 110 Powder Specs in the Portfolio
- > 50 Items on stock
- Available in different PSD
- Materials for all relevant Metal AM technologies: L-PBF, EBM, DED, BJ
- Customized Materials available

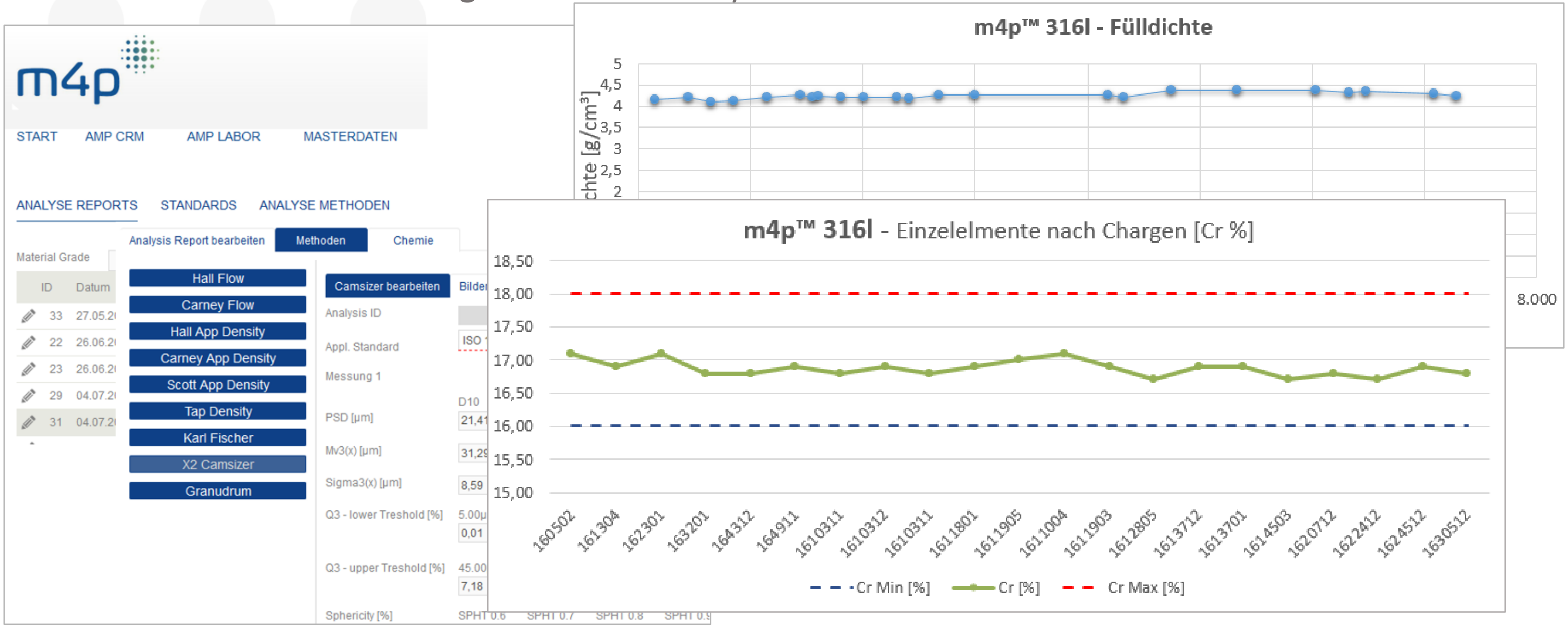


Laboratory Analysis

The m4p story...

The digital approach:

All analysis data is stored in the **m4p Company portal** and enables gapless tracking of all materials at batch level through the entire lifecycle.



Single values & parameters can be traced on batch level

QM: ISO 9001 – Implementation started in 2021 – in progress

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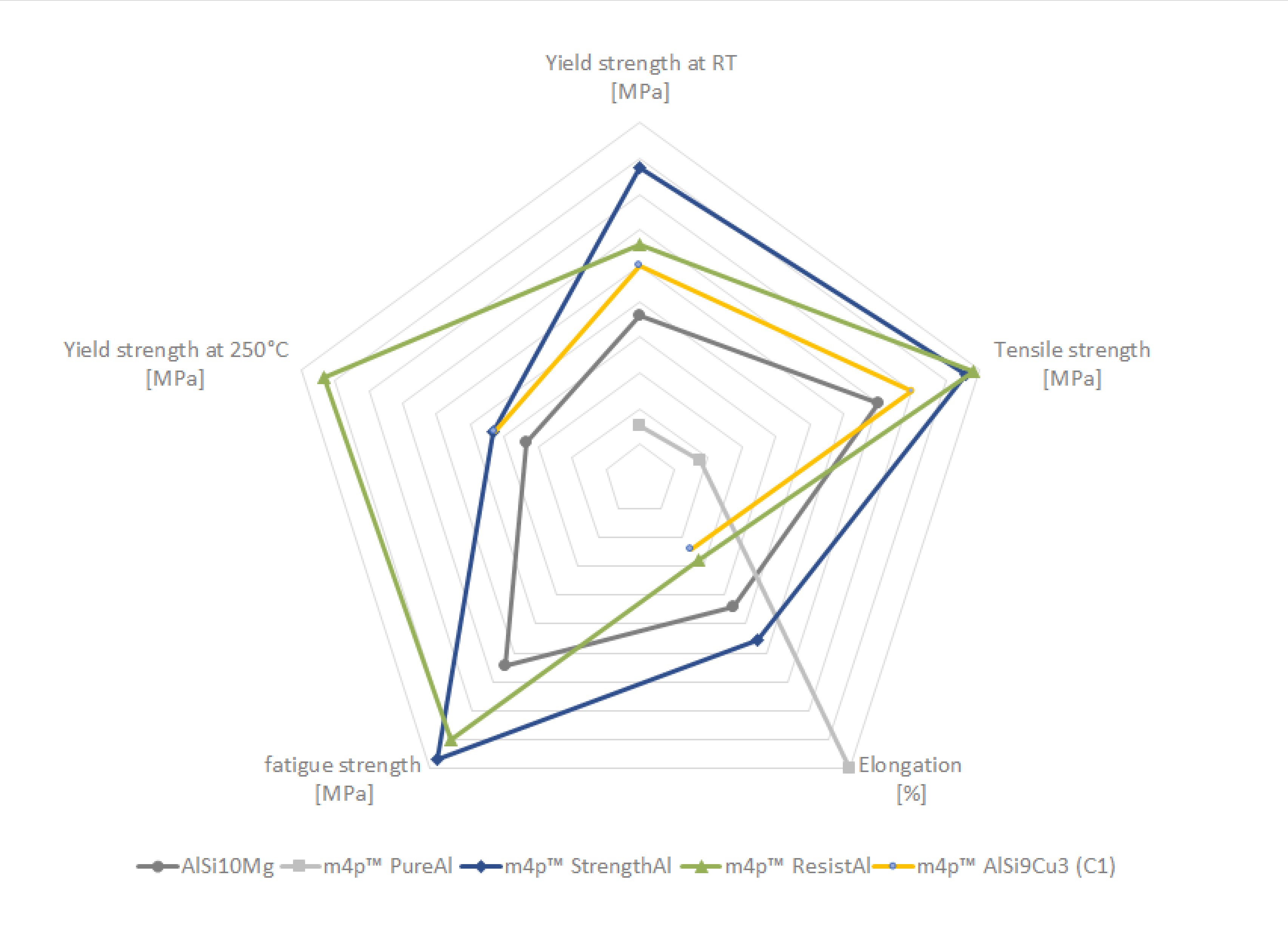
High-performance Al – alloy overview



m4p^{TM} StrengthAl

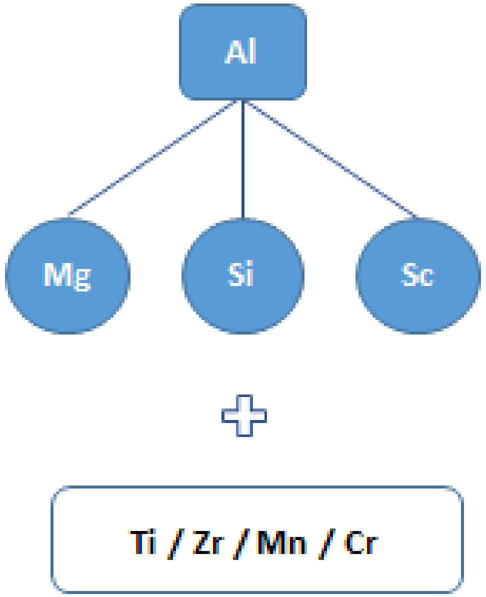
Material summary

Properties

- Combination of high specific strength and high ductility
- microstructure is stable up to ca. 200°C
- low anisotropy of properties

Applications

- (aero)space, motorsports
- Weight-optimized applications in general mechanical engineering, lightweight constructon and automotive engineering (mostly no MMC-material allowed)
- decorative elements (by anodization)



State / property	yield strength [MPa]	tensile strength [MPa]	elongation [%]	specific strength [Nm/g]	hardness [HV10]
as-built	260 - 280	320 - 350	10 - 24	120 - 130	85 - 95
after heat treatment	420 - 440	465 - 500	12 - 17	175 - 185	130 - 170

process: EOS M290 | layer thickness: 30µm | build rate: ca. 11 cm^3 / h | heat treatment: 350°C, 6h

m4p™ StrengthAl

Case study (I): Politecnico di Milano

Process Specifics

- Machine: Renishaw AM 250
- Full factorial DoE, maximum density (99,97%) reached at $E_V = 173\ J / mm^3$
- Subsequent heat treatments: T = 300 … 400°C, t = 1 … 24h

Main Results (mechanical properties)

- Yield strength and tensile strength are in the same range as m4p values (EOS M290)
- Elongation: some dependence on temperature, same range @ 375°C, 8h

Table 4
Mechanical properties of the Al-Mg-Zr-Sc alloy heat treated at 375 °C and 350 °C for 8 h and 24 h, respectively, and.

	Yield Strength [MPa]	Tensile Strength [MPa]	Elongation at Fracture [%]
Aged 375 °C – 8 h	460 (± 10)	489 (± 6)	14.3 (± 2.7)
Aged 350 °C – 24 h	454 (± 2)	485 (± 3)	12.1 (± 4.0)
As-built	280	350	23

m4p^{TM} StrengthAl

Case study (II): PUNTOZERO

Goals

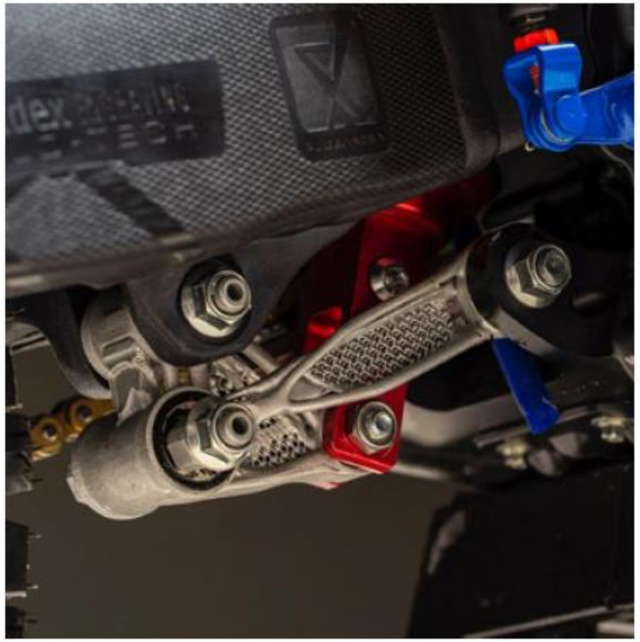
- Redesign of a conventionally manufactured motor bike linkage, while taking into account AM manufacturability
- Increase stiffness while maintaining lowest possible weight
- Original part is manufactured in AW-7075 → very challenging for PBF-LB, m4p^{TM} StrengthAl was chosen as alternative

Main Results

- Weight reduction: -51%
- Stiffness increase: +64%

Original Component	Material	Weight [g]	max. Deflection [mm]	max. Load [kN]
Link 1	AW-7075	207	0,18	26
Link 2	AW-7075	316	0,60	13

Optimised Component	Material	Weight [g]	max. Deflection [mm]	max. Load [kN]
Link 1	StrengthAl	121	0,08	26
Link 2	StrengthAl	136	0,20	13

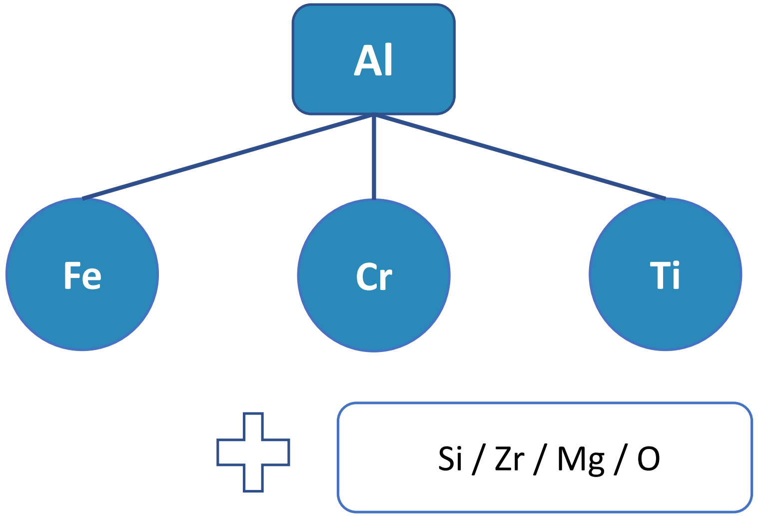


m4p™ ResistAl

Material summary

Properties

- Developed for high-temperature applications with respect to mechanical properties
- microstructure is stable up to ca. 400°C
- no additional heat treatment needed



Applications

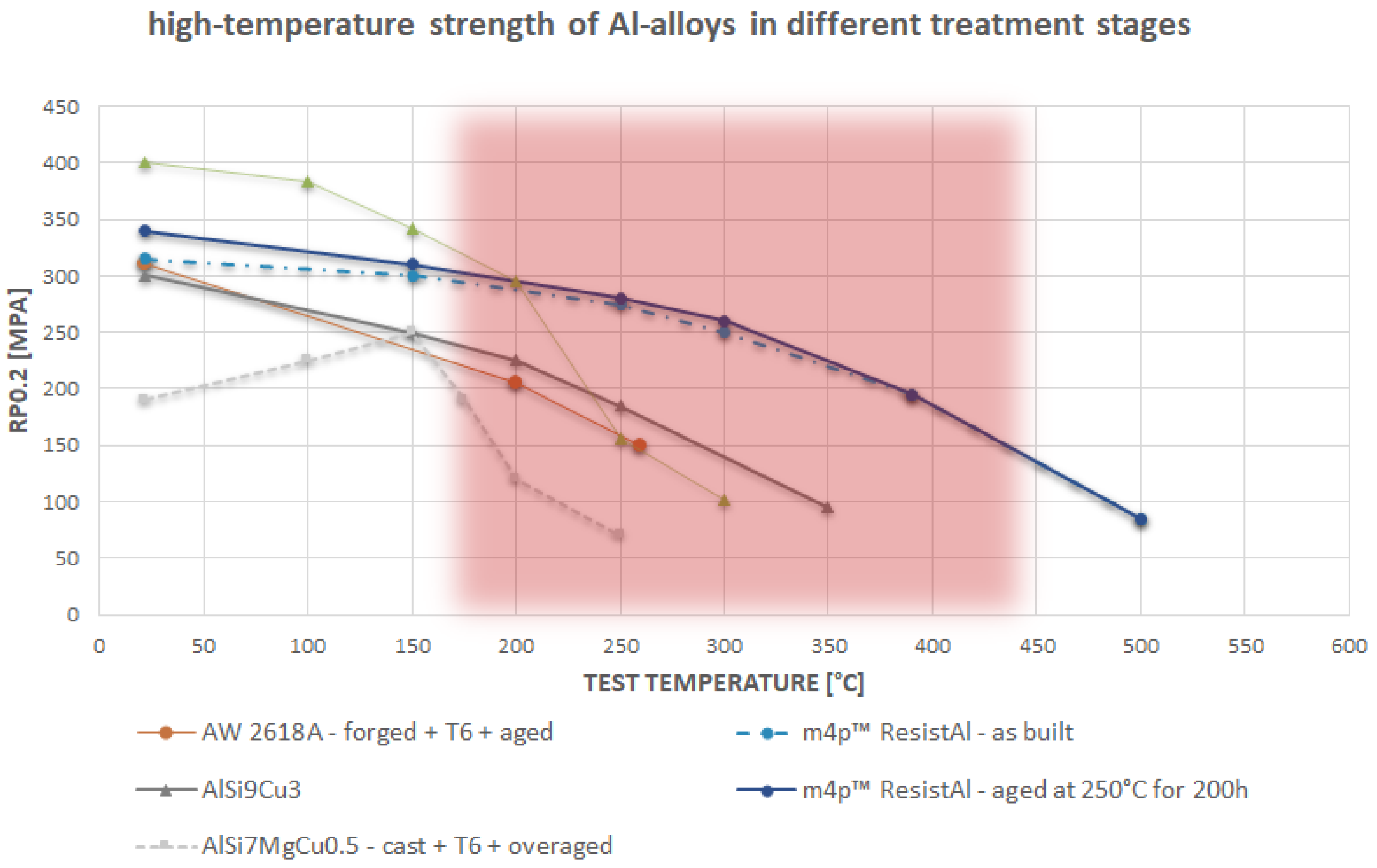
- Mechanically-loaded parts for high temperatures (250 – 400°C) in (aero)space, motorsports, automotive
- Weight-optimized & mechanically-loaded applications in general mechanical engineering

temperature	yield strength [MPa]	tensile strength [MPa]	elongation [%]
25°C	330	490	7
250°C	280	350	7

process: EOS M290 | layer thickness: 40µm | build rate: ca. 20 cm^3

m4p™ ResistAl

Material properties (I): high-temperature yield strength

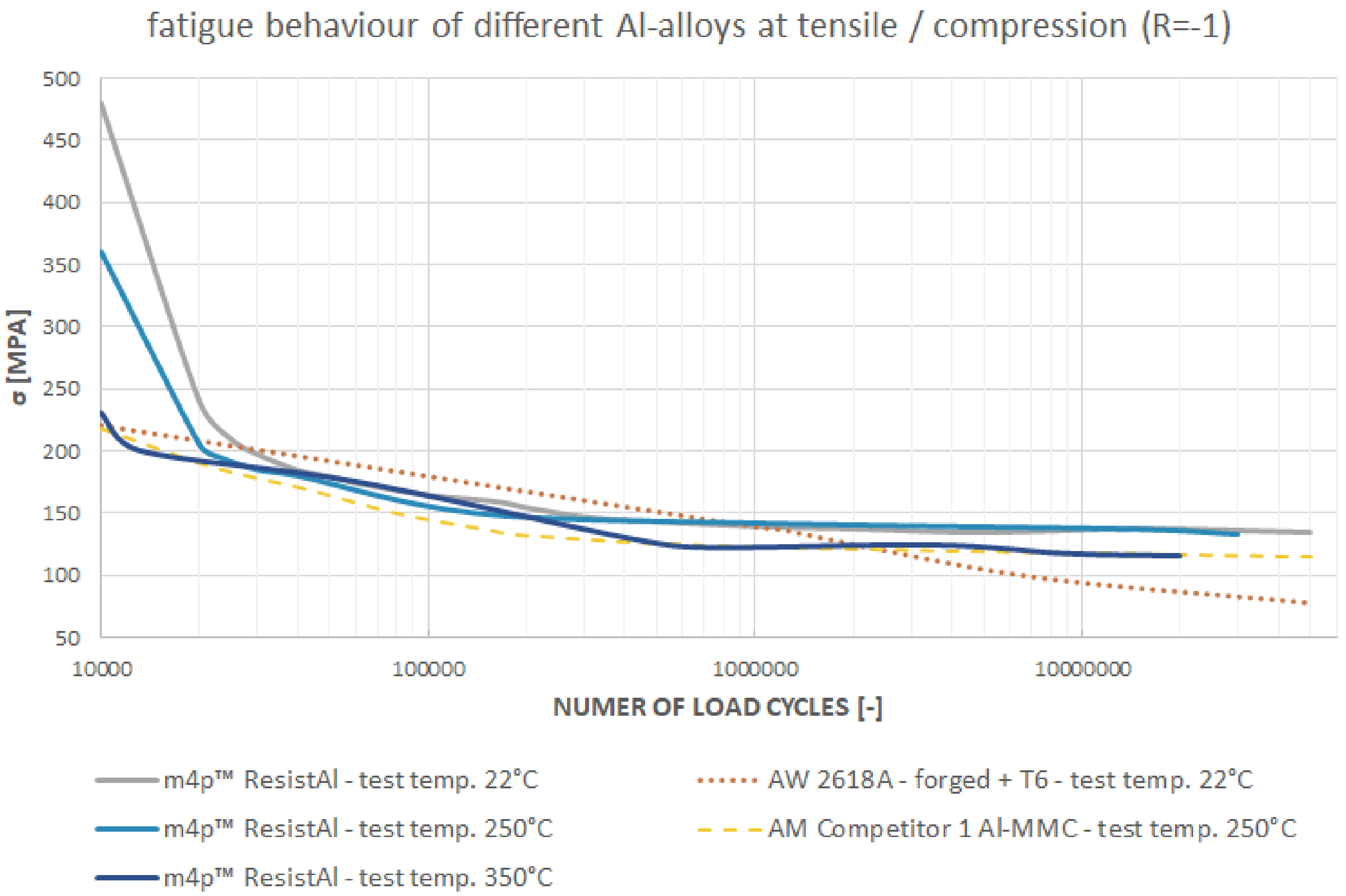


Results

- 80% higher yield strength (at 250°C) compared to conventional used AW2618 after aging
- High-strength MMC-competitors show large strength drop at 200°C

m4p™ ResistAl

Material properties (II): fatigue



Results

- Number of tested samples for each temperature: 16 machined specimens
- Same fatigue strength at room temperature as at 250°C
- Low effect of temperatures up to 350°C
- Ideal for operating temperatures up from 200°C

m4p^{TM} PureAl

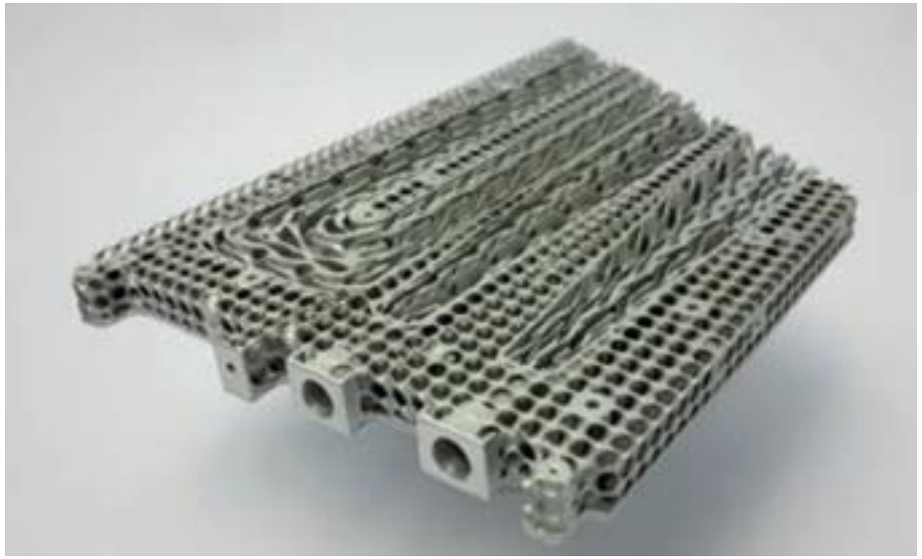
Material summary

Properties

- High purity
- High thermal and electrical conductivity in combination with low density
- Easier to process then pure Cu

Applications

- Mechanical engineering
- Chemical industry
- Aerospace



state	yield strength [MPa]	tensile strength [MPa]	elongation [%]	Thermal conductivity [W/(m*K)]	Electrical conductivity [MS
As built	75	88	26	235	29

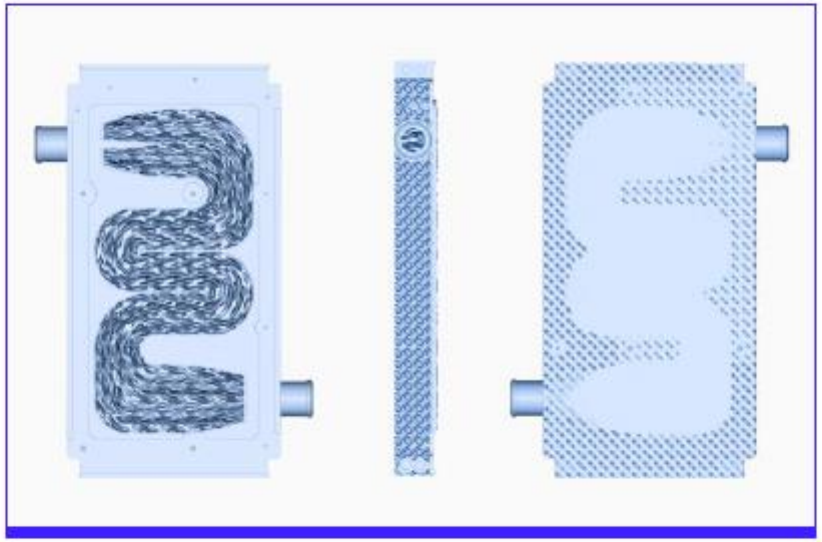
process: EOS M290 | layer thickness: 30µm | build rate: ca. 26 cm³ / h

m4p™ PureAl

Case study: PUNTOZERO

Goals

- redesign of a cold plate of the power electronics of Dynamis PRC’s electric race car, taking into account AM manufacturability
- improvement of fluid flow and heat transfer



Main Results

- improvement targets were met
- in addition, lattice structures were applied for reducing production costs and weight, furthermore manufacturability was improved & contact surface was increased

Lightweighting	Heat Transfer	Fluid Flow	Accuracy	Material	Manufacturing
25% reduced weight	3x increased surface area	High Velocity & Uniform	< 200 microns deviation	m4p PureAl	EOS M 290

m4p

High-performance Al alloys

Summary

- There is a world beyond AlSi10Mg
- Depending on material properties, tailored material solutions have been developed for:
  - high strength
  - high temperature strength
  - high conductivity
- Case studies were performed on several alloys in order to assess the application potential, wich in all cases is very promising

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Thank you for your attention