

MODELING AND CHARACTERIZATION OF A MODIFIED EN AW 7075 ALLOY FOR ADDITIVE MANUFACTURING

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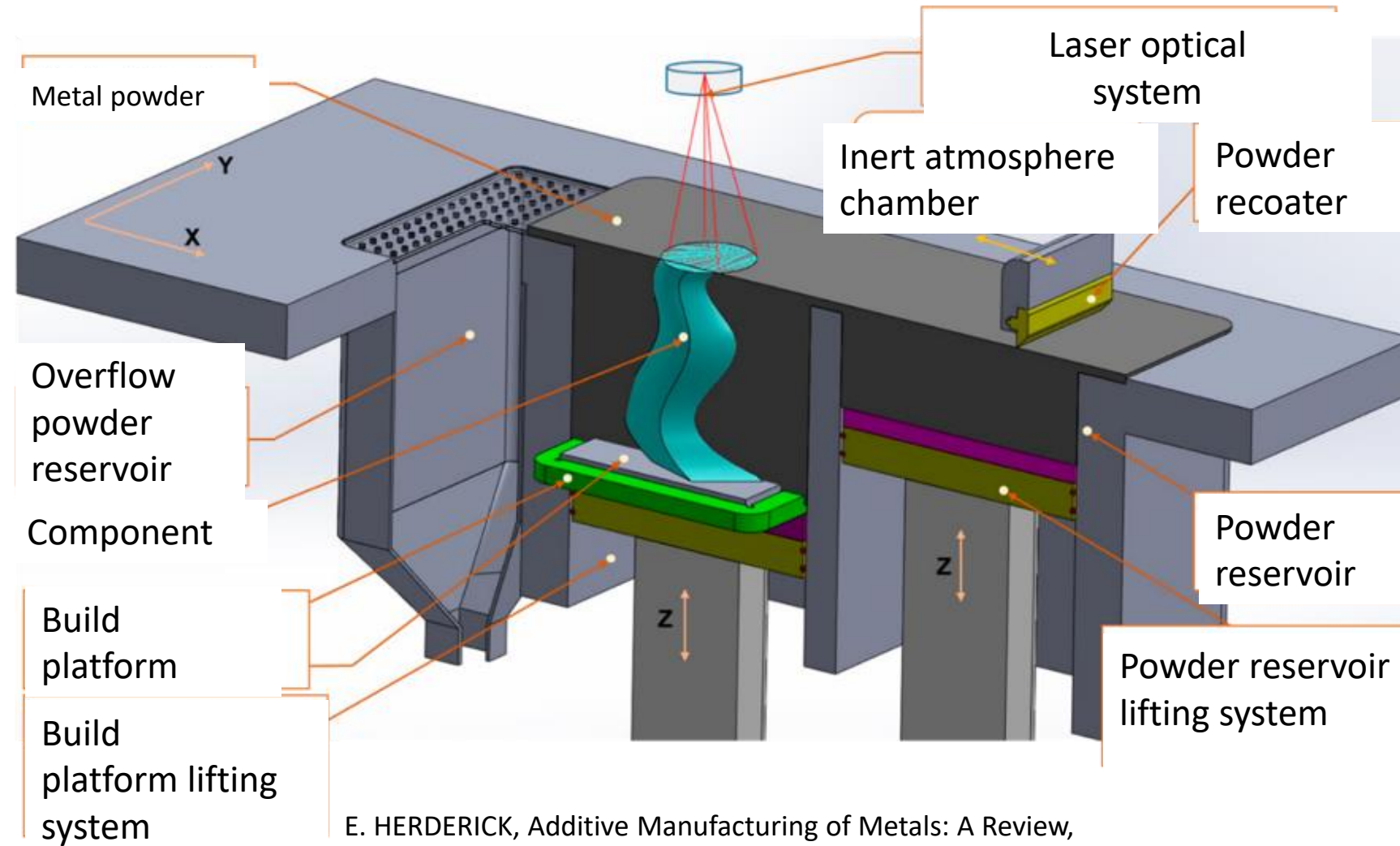


TOFA 

20th DISCUSSION MEETING ON THERMODYNAMICS OF ALLOYS
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Selective Laser Melting (SLM)

is a powder bed fusion additive manufacturing technology in which a high-energy laser selectively melts and consolidates metallic powder particles layer by layer to produce fully dense three-dimensional components.



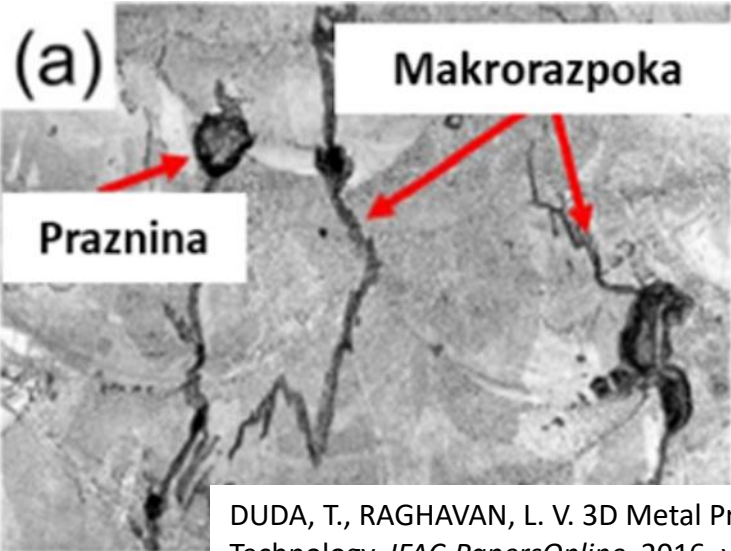
E. HERDERICK, Additive Manufacturing of Metals: A Review, Materials Science and Technology 67 (2015) 580–581.

SLM is a technology characterized by extremely high thermal gradients and cooling rates, which influence the formation of various types of defects in the material: porosity, cracks, Laser cladding, surface defects and Residual stresses.

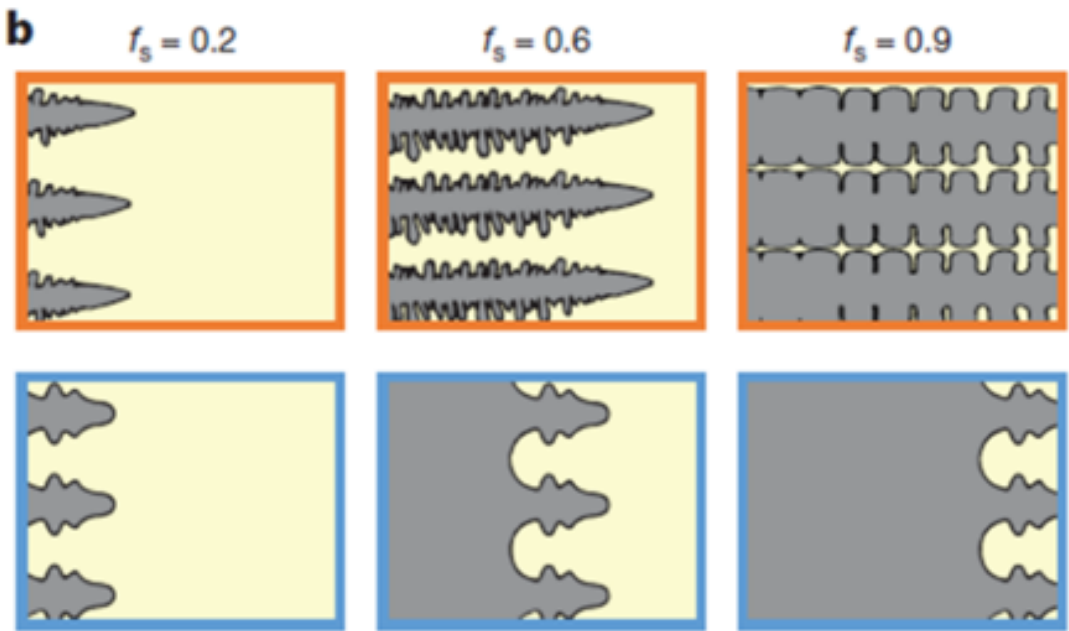
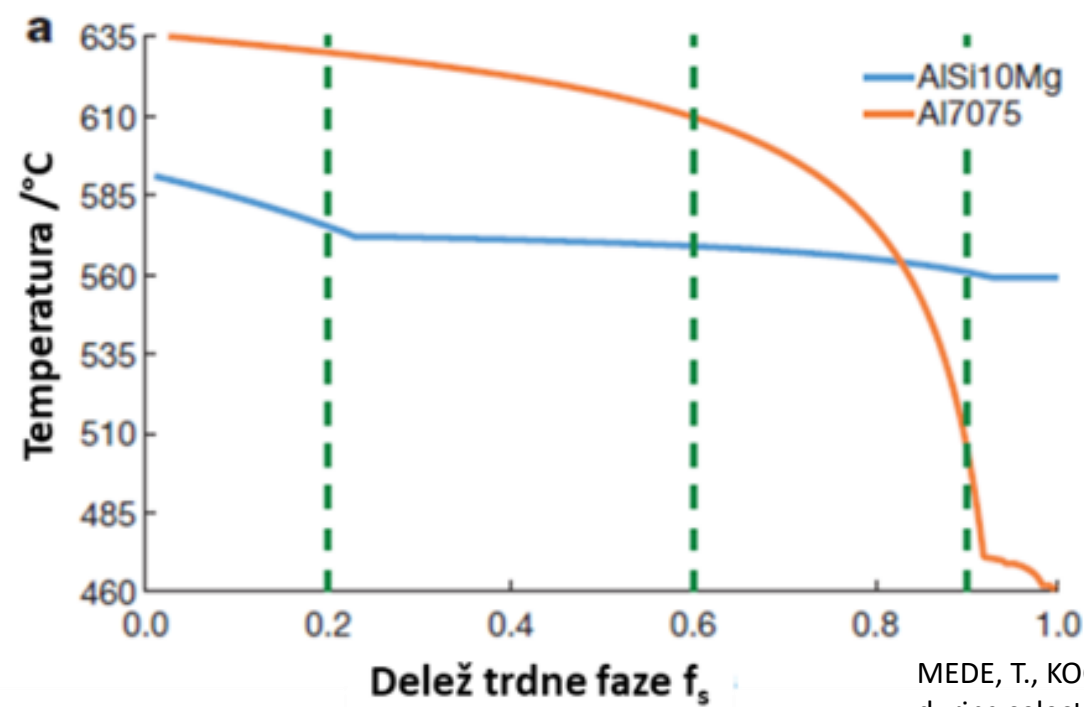
Aluminium alloy EN AW 7075

is a high-strength aluminum alloy from the 7XXX series, in which zinc and magnesium are the principal alloying elements.

Processing EN AW 7075 using additive manufacturing technologies such as **Selective Laser Melting (SLM)** is extremely challenging due to its physical characteristics, including a wide solidification temperature range and the high thermal gradients inherent to the process.



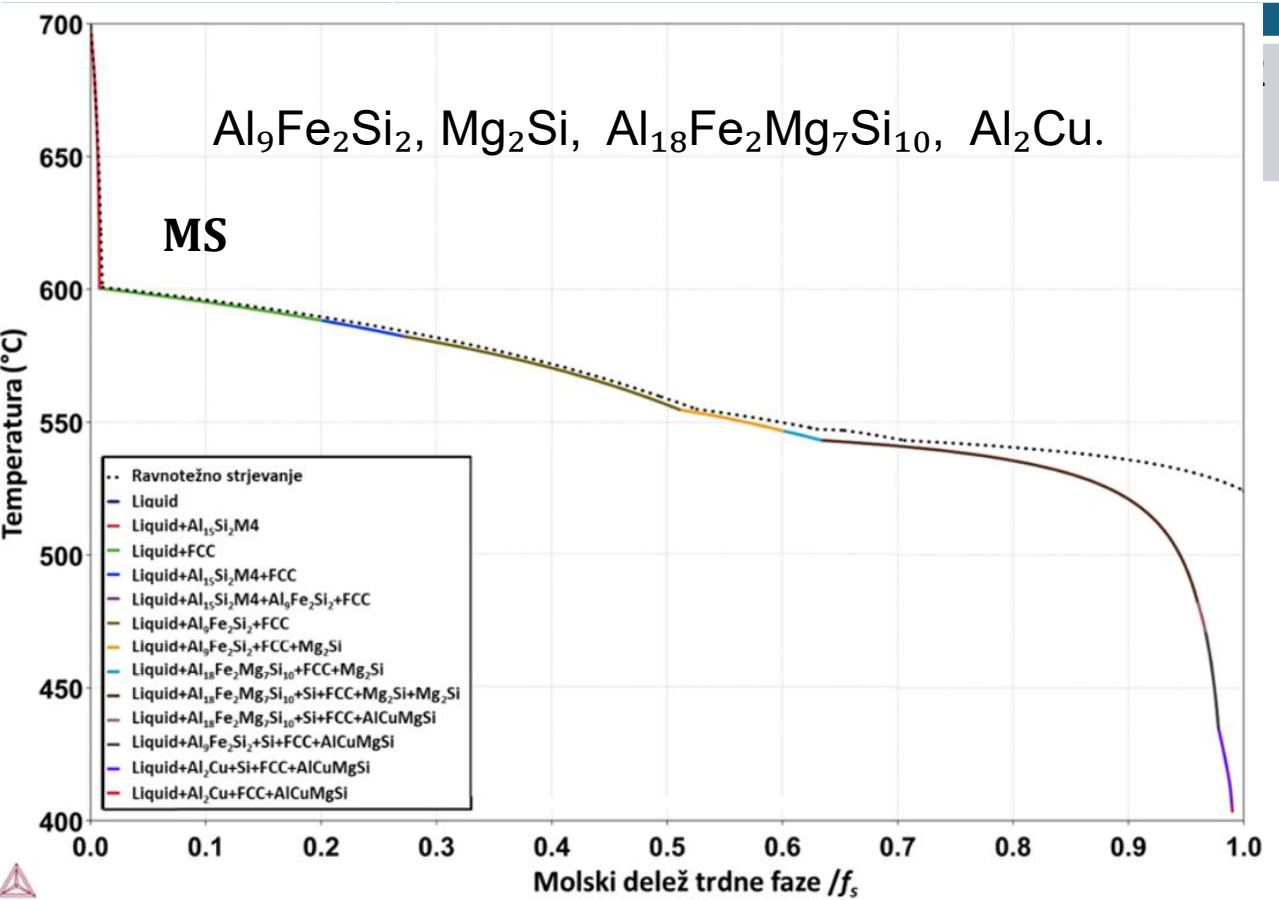
DUDA, T., RAGHAVAN, L. V. 3D Metal Printing Technology. *IFAC-PapersOnline*, 2016, vol. 49, no. 29, str. 103–110.



MEDE, T., KOCJAN, A., PAULIN, I., GODEC, M. Numerical mesoscale modelling of microstructure evolution during selective laser melting. *Metals*, 2020, vol. 10, no. 6, art. no. 800.

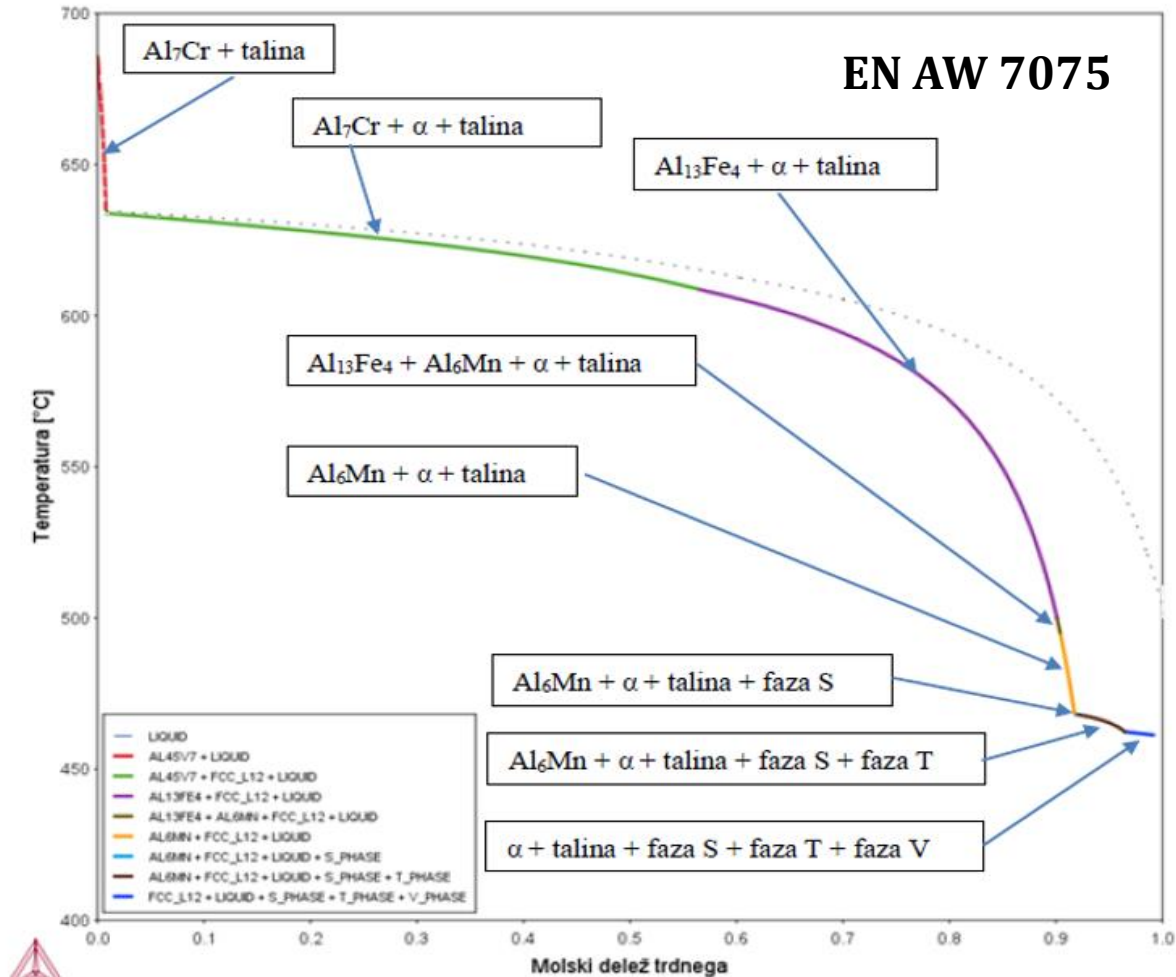
wt. %	Si	Zn	Mg	Cu	Cr	Fe	Al ost.
EN AW 7075	0,06	5,5	2,3	1,4	0,01	0,19	90,47
MS	5,3	7,4	3,0	0,86	0,17	0,41	82,86

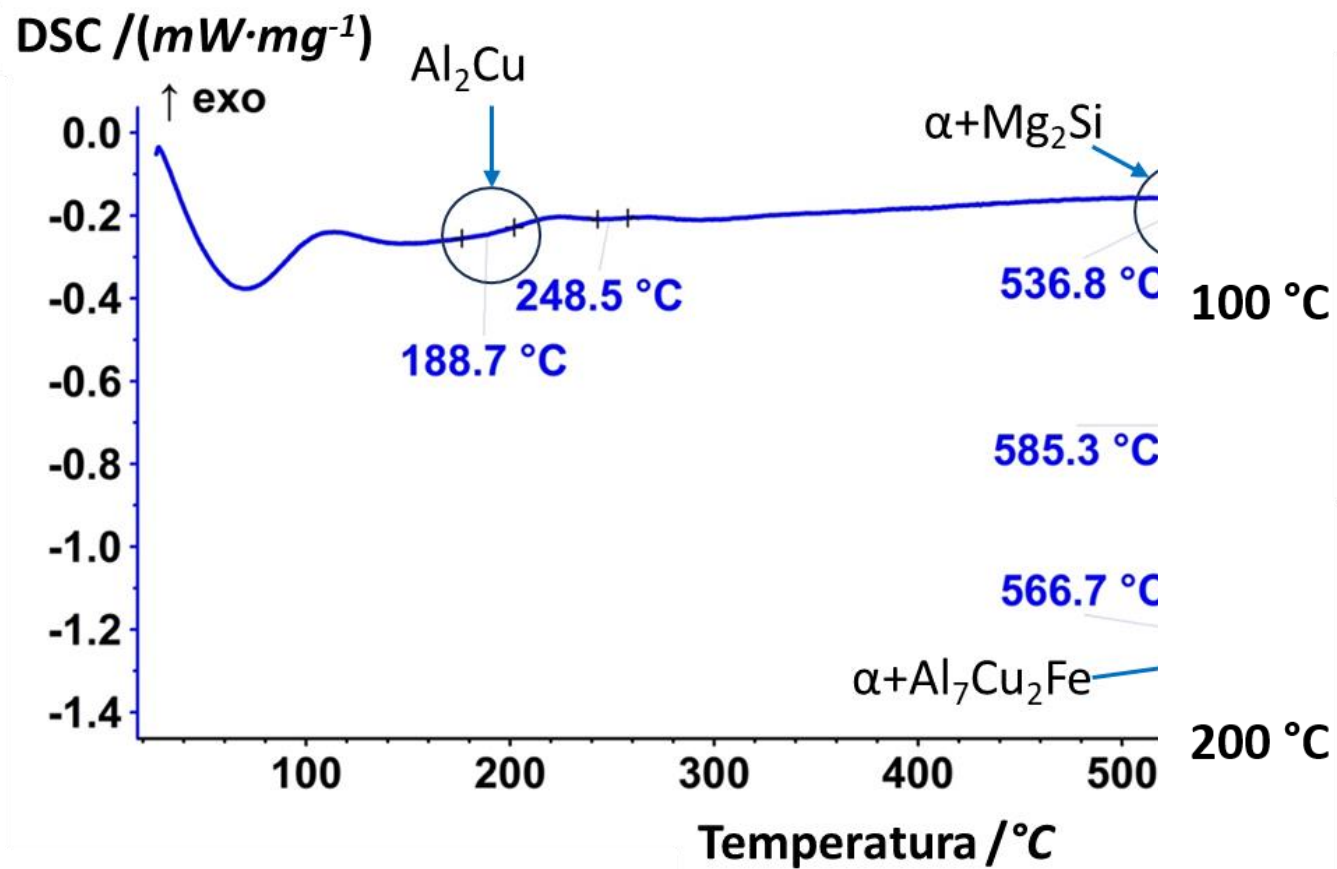
MS After atomisation	5,0	6,1	2,9	0,77	0,11	0,66	84,46
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Chemical composition

Al₁₃Fe₄, Al₂Mg₃Zn₃, Al₂CuMg, Mg₂Zn₁₁





EN AW 7075

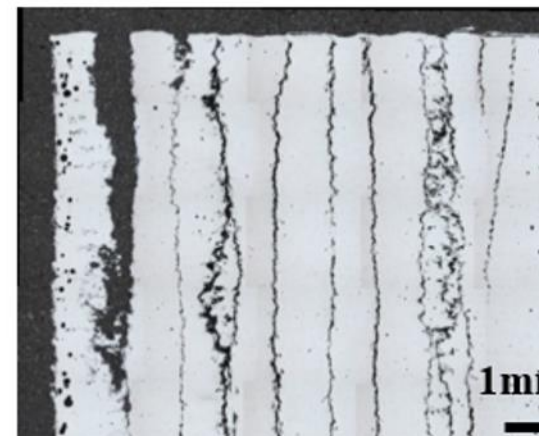
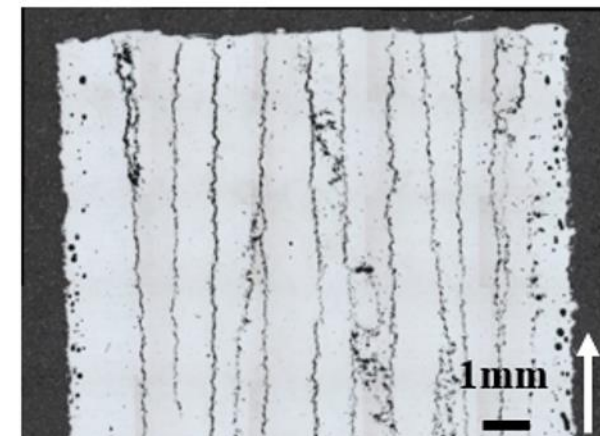
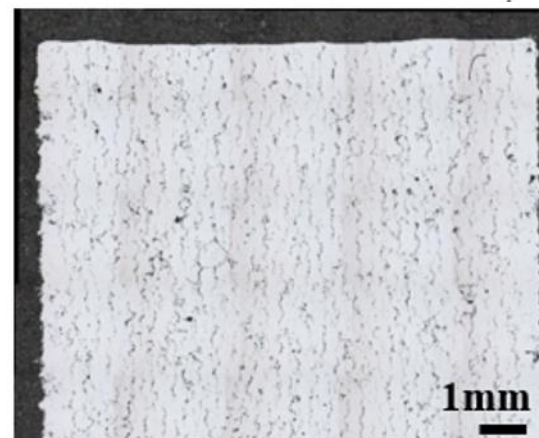
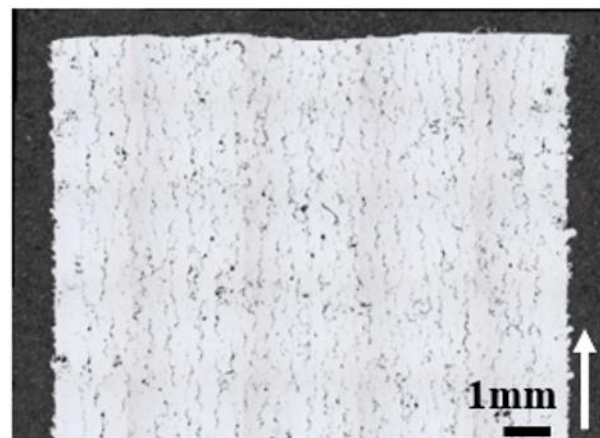
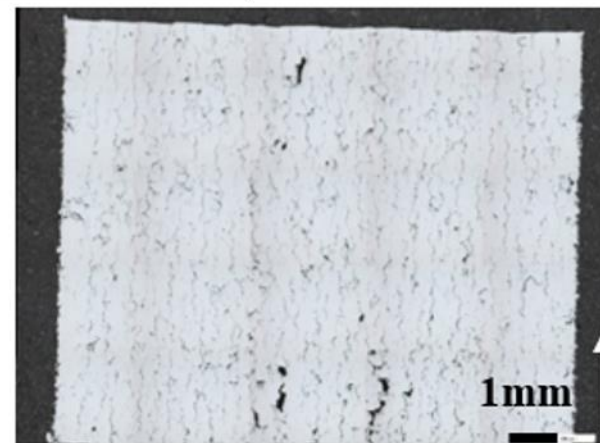
Cracks in the build direction

Preheating had no effect on grain size and shape.

At 400 °C, there is no reduction in the number or intensity of cracks.

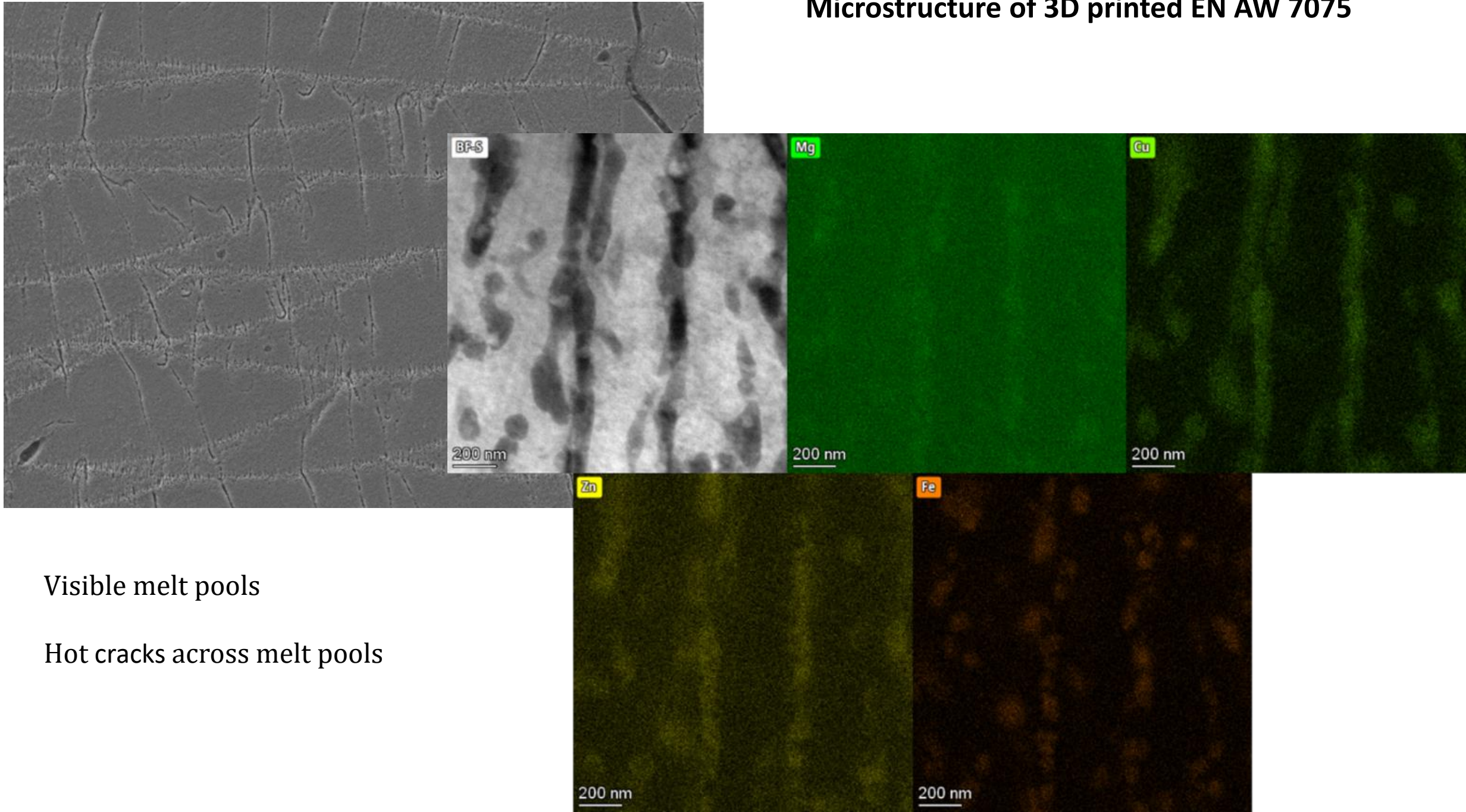
200 W, 800 mm·s⁻¹

300 W, 600 mm·s⁻¹



400 °C

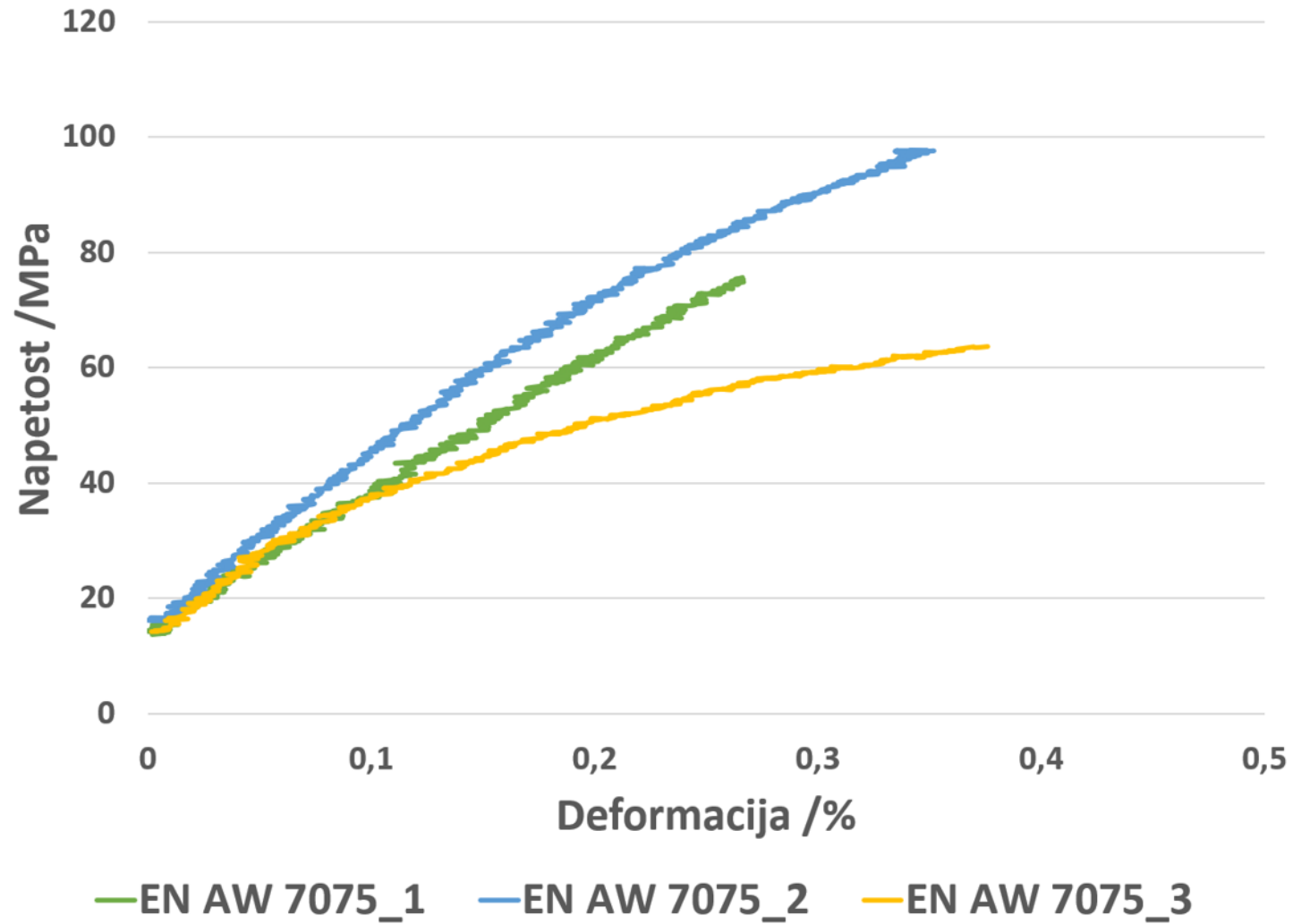
Microstructure of 3D printed EN AW 7075



Visible melt pools

Hot cracks across melt pools

Mechanical properties of EN AW-7075 after SLM fabrication



Conventional manufacturing methods:
540–570 N·mm⁻²



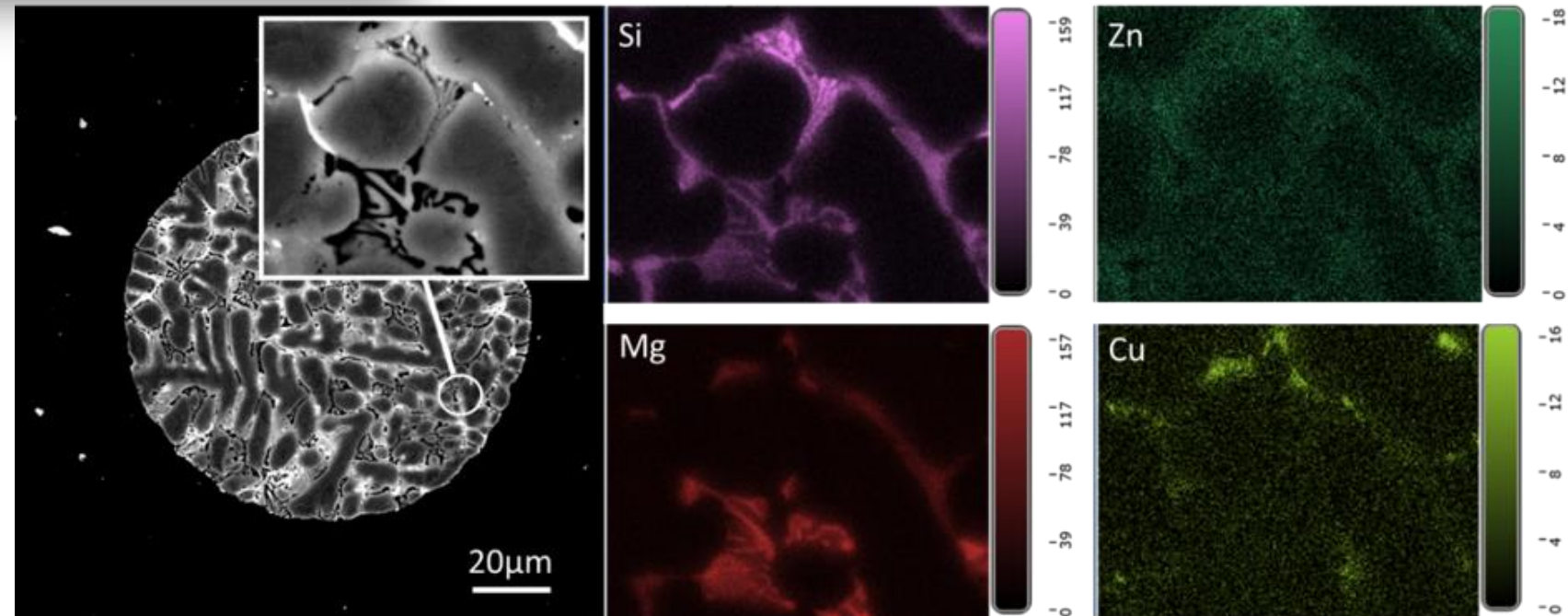
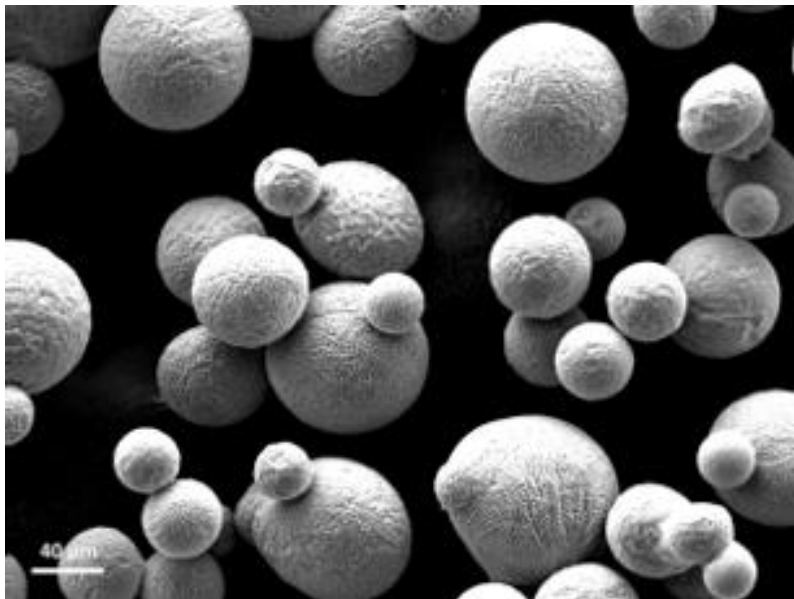
Powder production

Cast

Al	Si	Zn	Mg	Fe	Cu	Cr
84,5	5,3	7,4	3,0	0,6	0,9	0,2

Atomized

Al	Si	Zn	Mg	Fe	Cu	Cr
84,6	5,0	6,1	2,9	0,6	0,8	0,1



MS



1,1 360 W, 600 mm·s⁻¹



1,2 400 W, 569 mm·s⁻¹

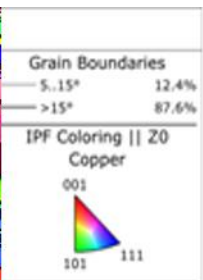
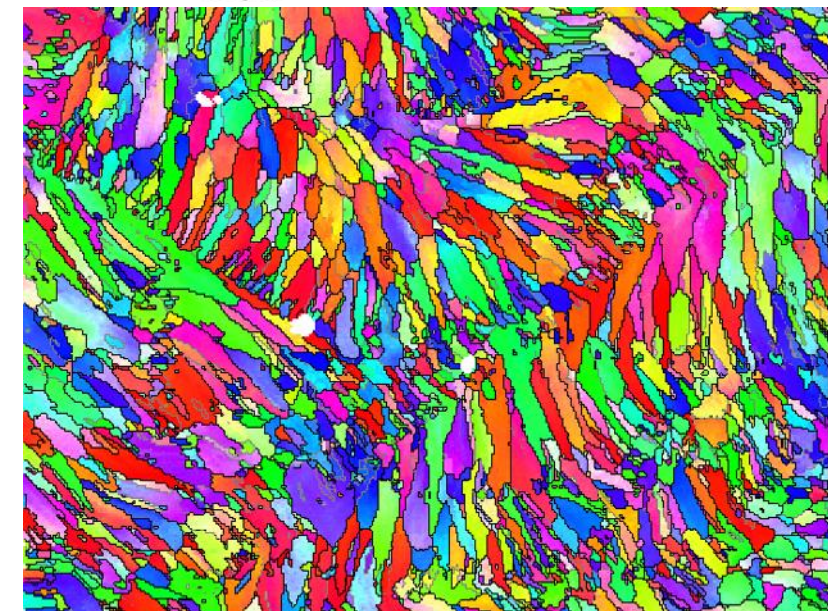
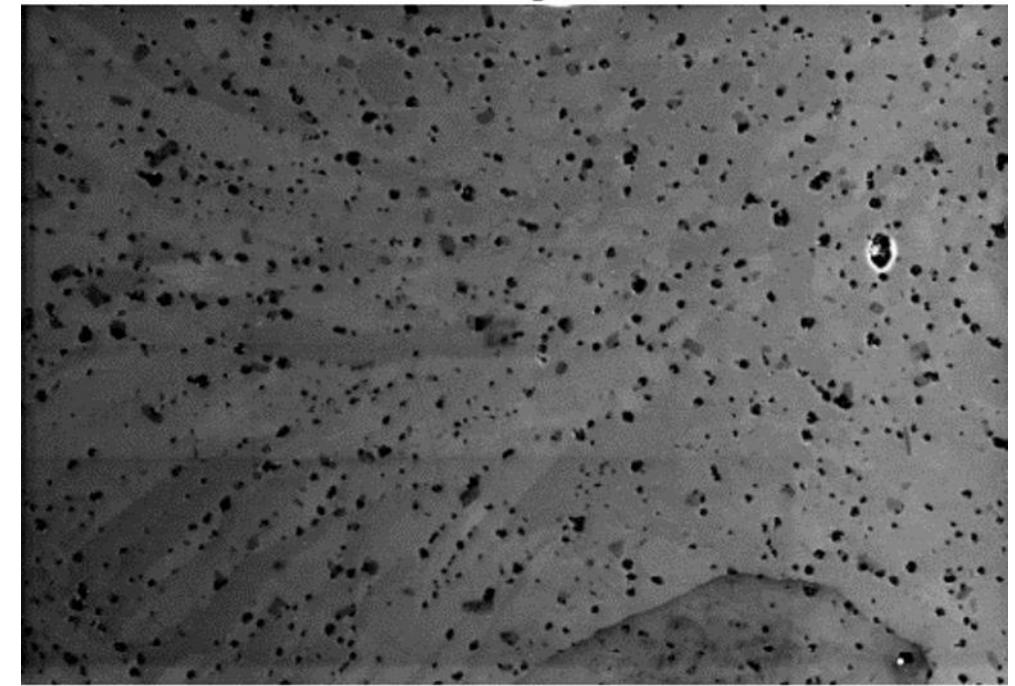


1,3 400 W, 340 mm·s⁻¹

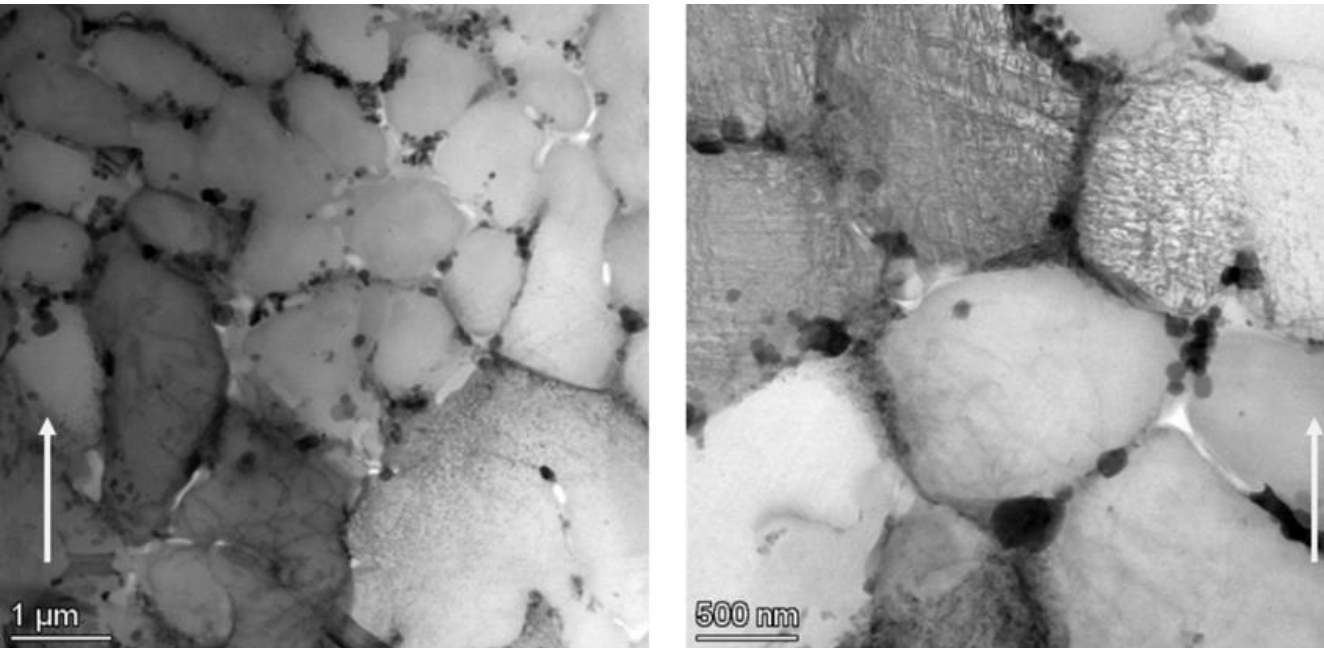


1,4 400 W, 300 mm·s⁻¹

Without cracks, porosity present

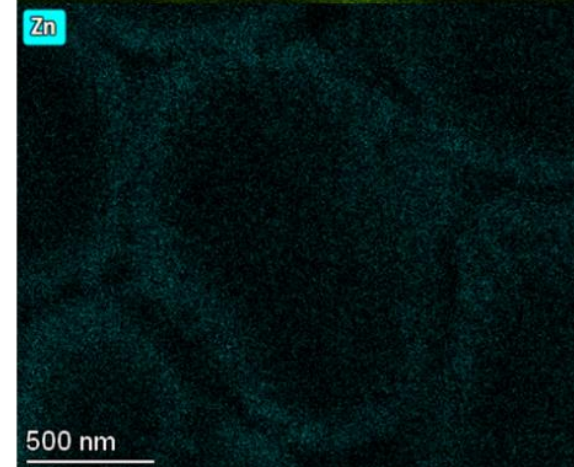
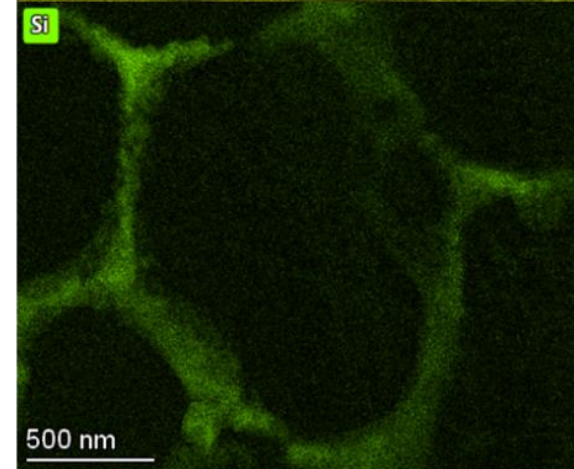
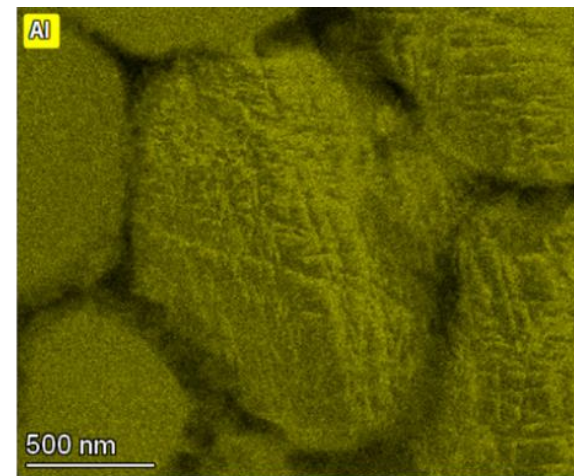
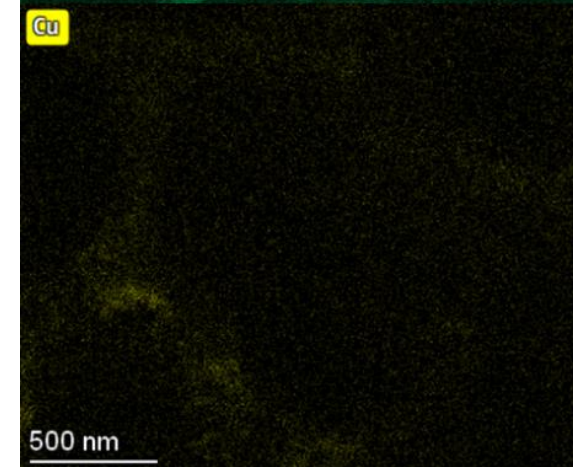
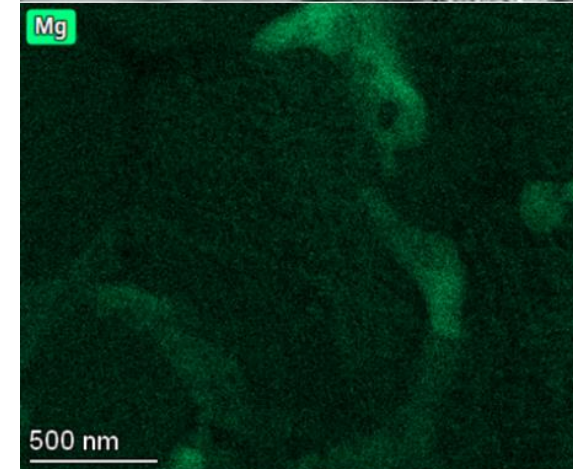
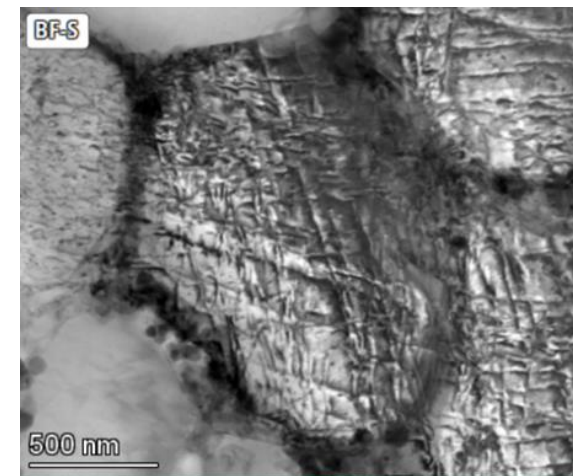


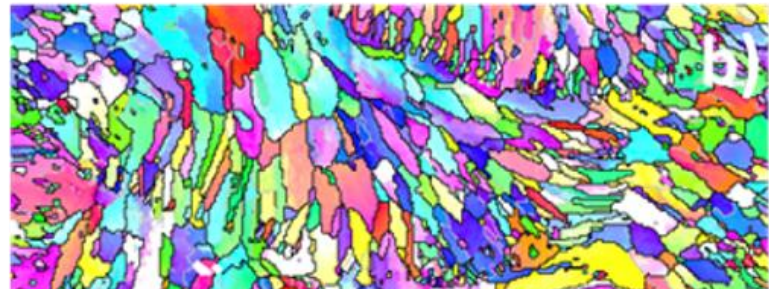
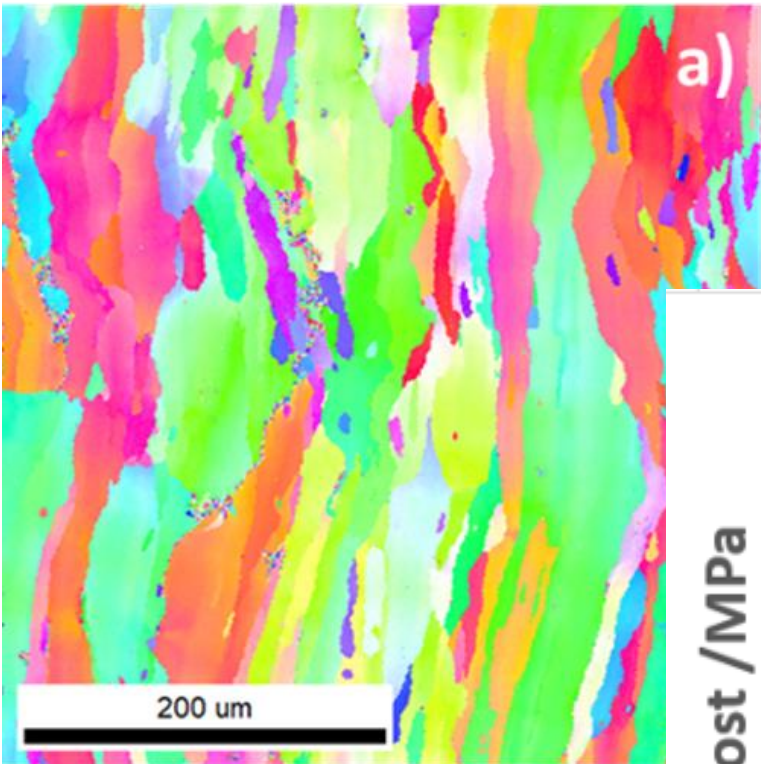
Microstructure of MS



Micrograph of the MS microstructure obtained via transmission electron microscopy.

TEM image of the microstructure of an EN AW 7075 aluminum alloy sample after the SLM process, together with EDS analysis results.

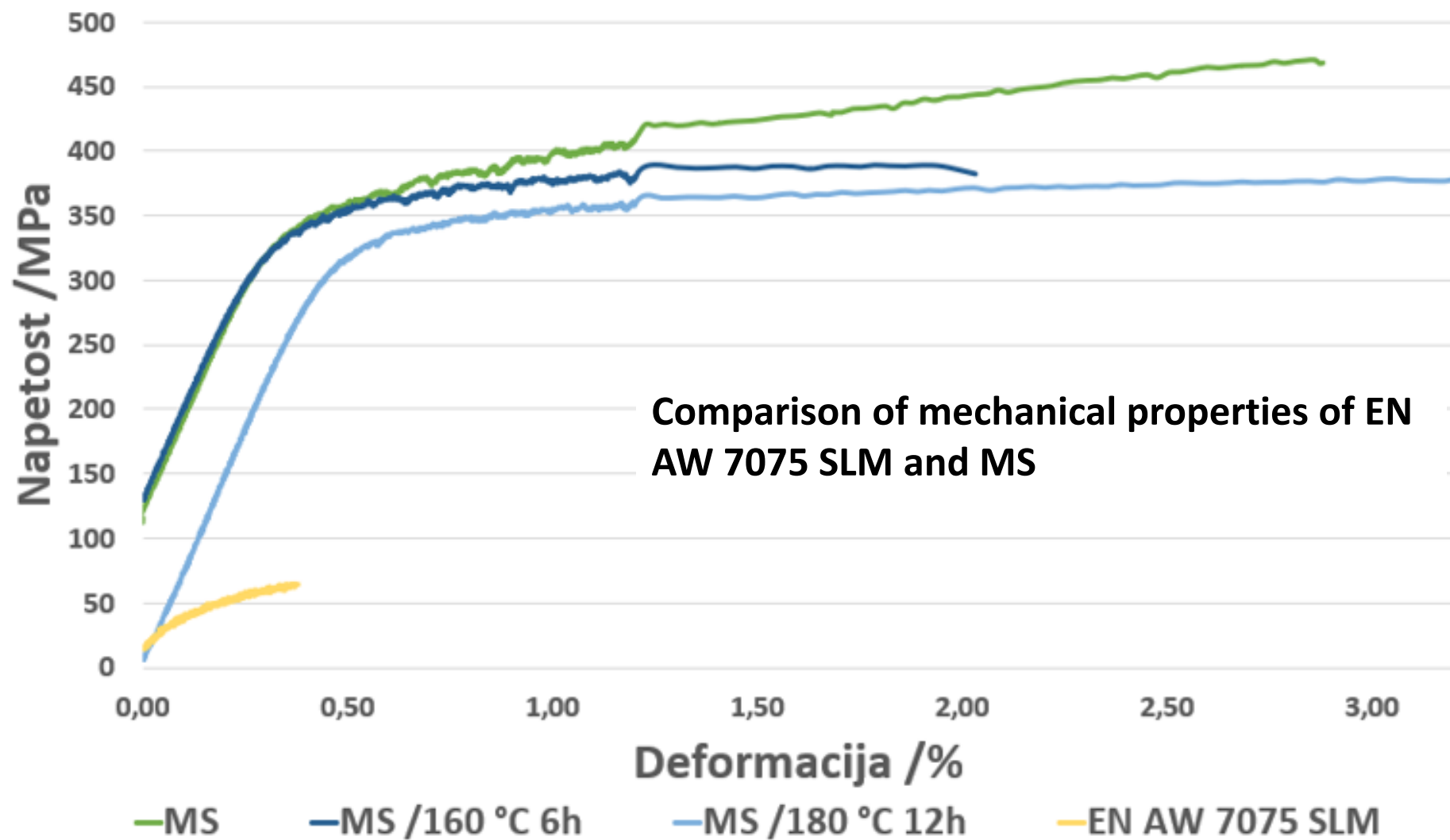




EBSD map, IPF orientation
distribution:

a) EN AW-7075 SLM

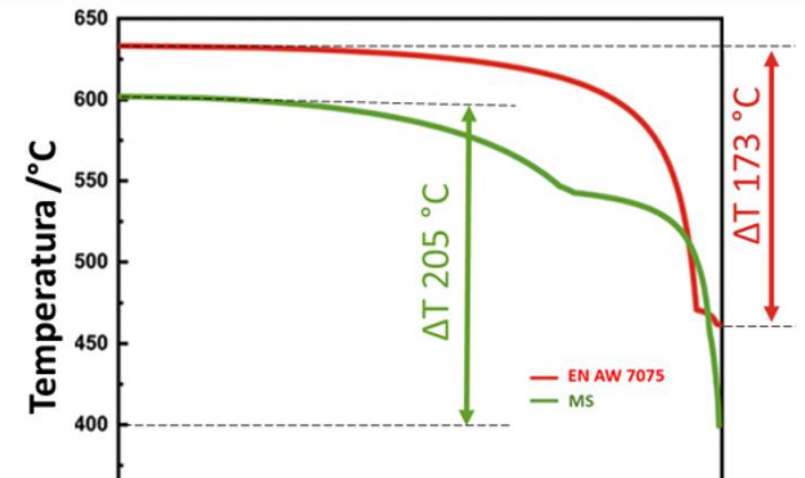
b) MS SLM



Conclusions

EN AW 7075

- Preheating the build platform during the SLM process affects the microstructure and material defects.
- Process windows for the EN AW 7075 alloy → samples produced without preheating exhibit a high susceptibility to cracking.
- Changes to laser parameters (power, scanning speed, beam size) did not eliminate the cracking.



MS

- Modification of chemical composition (addition 5 wt.% Si) → changes solidification mechanism → formation of Mg_2Si
- Microstructure of MS alloy: fine-grained, homogeneous microstructure free of cracks
- Mechanical properties of MS: improved ($R_m \approx 480$ MPa)

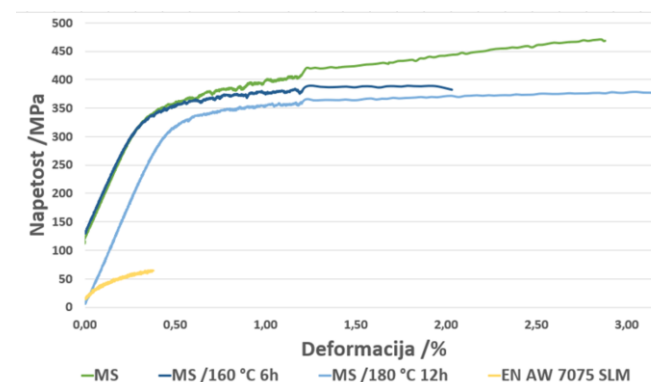
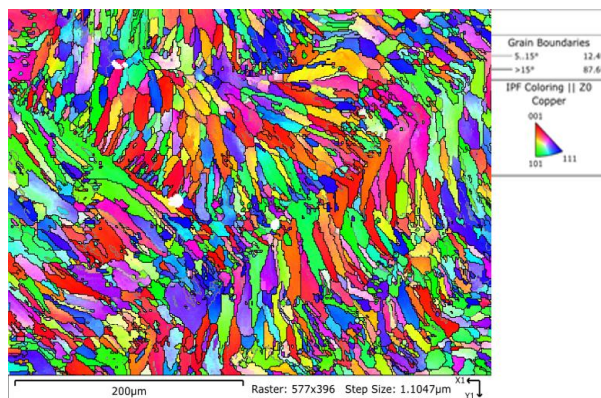
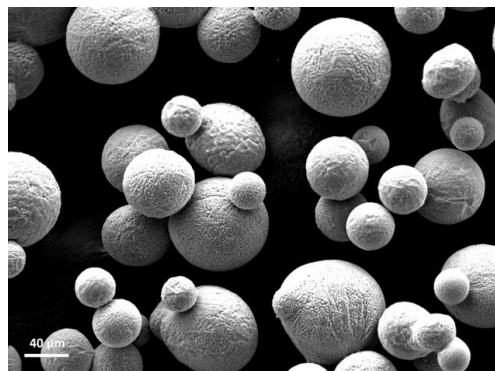
Zn – content?



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Thank you for your attention!



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We thank you for your participation and for the excellent presentations, discussions... and, of course, the pleasant socializing.

See you at TOFA 2028.