Tensile behavior at cryogenic temperatures of Al 7075 + 1.8%wt Zr alloy processed by L-PBF

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Aerospace and aeronautic industries → mass reduction of parts [1,2]
- ➢ 3D printing → complexes parts with voids

Aerospace → parts works at low temperatures (77K, 4K, etc.)
- ➢ Mechanical behaviors at those temperatures?

Space4Relaunch project → **mechanical characterization of L-PBF printed aluminum alloys at cryogenic temperature**

Studied powder : A7075 + 1.8%wt Zr [3,4]

Atom (%wt)	Al	Cr	Cu	Fe	Mg	Si	Zn	Zr
Ref – A7075 T6	Bal.	0.18	1.51	0.08	**2.55**	0.04	**5.93**	-
Powder	Bal.	0.22	1.56	0.08	2.48	0.02	5.36	1.86
Printed sample	Bal.	0.22	1.52	0.08	**1.73**	0.03	**3.27**	1.84

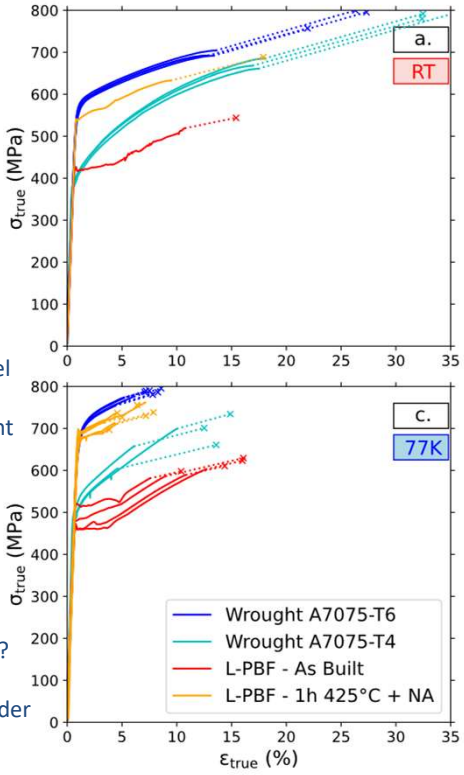
Printable powder [4] but loss of Zn and Mg ⇒ η & η' ?

A7075 alloy at cryogenic temperature [5,6]

AB state
Low stress level
Good ductility, especially at 77K
PLC effect at RT but not 77K
Lüders plateau
Stress dispersion, related to L-PBF processing

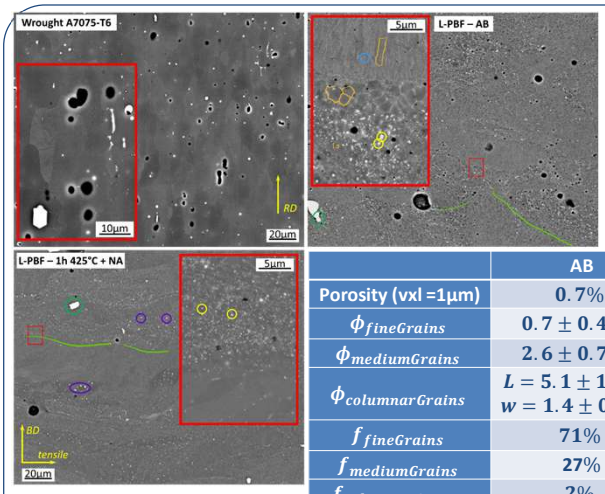
Annealed state
Promising stress level
Lower ductility compared to wrought Al 7075 T6
Lüders plateau

Promising static properties
Dynamic properties ?
No η & η' ⇒ modification of powder to reach better properties



Microstructure

SEM & EBSD
Small grains
1µm-size precipitates



	AB	1h 425°C + NA
Porosity (vxl =1µm)	0.7%	0.1%
$\phi_{fineGrains}$	$0.7 \pm 0.4\mu m$	$1.0 \pm 0.4\mu m$
$\phi_{mediumGrains}$	$2.6 \pm 0.7\mu m$	$2.6 \pm 0.7\mu m$
$\phi_{columnarGrains}$	$L = 5.1 \pm 1.5\mu m$ $w = 1.4 \pm 0.2\mu m$	$L = 6.1 \pm 2.4\mu m$ $w = 1.7 \pm 0.6\mu m$
$f_{fineGrains}$	71%	69%
$f_{mediumGrains}$	27%	27%
$f_{columnarGrains}$	2%	4%

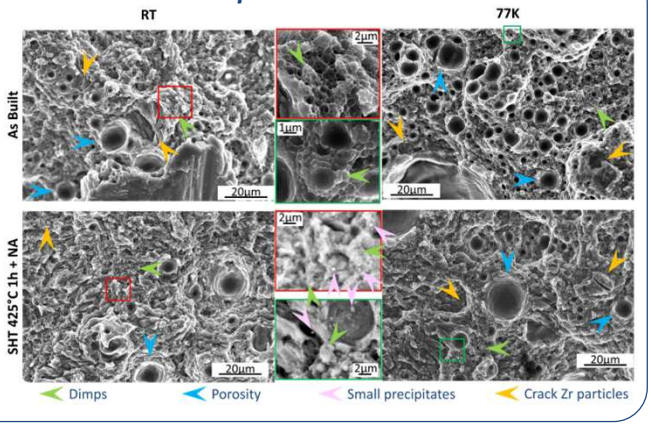
- Al_3Zr
- Zr particles
- $MgCu$-rich precipitates
- $MgCuZn$-rich precipitates
- $MgCuFe$-rich network
- Melt pool

TEM
Quantification of nm-scale precipitates
Al_3Zr, $AlCrMg$
No η & η', even when AA

Fracture mechanisms in temperature

No clear effect of annealing nor testing temperature on fracture surfaces

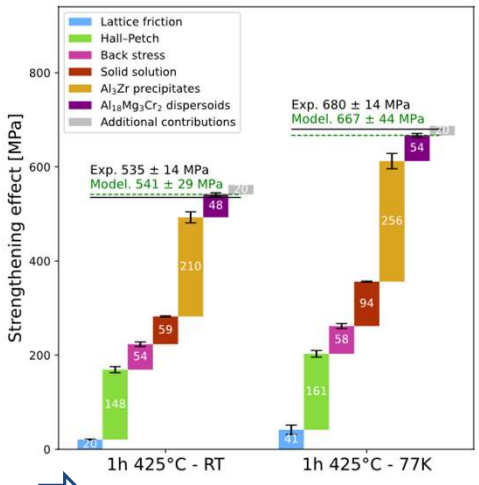
Need for interrupted tests



Strengthening mechanisms in temperature [5-8]

Athermal stresses versus thermal stresses

$$\sigma_y(T) = \sigma_{fric}(T) + \sigma_{GB}(T) + \sigma_{BS}(T) + \sigma_{SS}(T) + \sigma_{PS}(T)$$



Consistent model for mechanisms

Conclusions & perspectives

First characterization of L-PBF printed samples at 77K of Al 7075 L-PPBF processed samples
Interesting deformation level at 77K
Higher static properties than L-PBF processed Scalmalloy [9]

Optimization of properties through thermal treatment after printing
Further analysis to understand deformation mechanisms
Study of other effects (printing direction, $\dot{\epsilon}$, etc.) on properties

Zn and Mg evaporation during processing ⇒ no η & η'

Compensation of Mg & Zn to harden to material after T6 HT

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