Results with Additive Manufacturing of accelerator components

Maurizio Vedani (Politecnico di Milano)
… and most importantly, the whole AM team of WP10

Where we are with task 10.2 so far

Our initial objectives, from I.FAST proposal:

T10.2: Additive Manufacturing. Survey of applications and potential development (M1-M36)

- Survey of current AM applications in accelerators and identification of needs for future development and research actions
- Promote initiatives to identify how AM can address the needs of the accelerator community
- Define strategic directions for future AM technologies and foster their impact on accelerator applications (sterilisation, medicine, industry), identifying technology barrier and challenges

Survey of AM applications

- IFAST-D10.1 and IFAST-MS44 submitted on end October 2023
- The D10.1 report also contains the output of a questionnaire distributed to the accelerator community
- “Review of metal additive manufacturing for particle accelerator applications”, to be published in Physical Review Accelerators and Beams

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Innovation Fostering in Accelerator Science and Technology

Horizon 2020 Research Infrastructures GA nº 101004730

DELIVERABLE REPORT

Potential AM applications in accelerators

DELIVERABLE: D10.1

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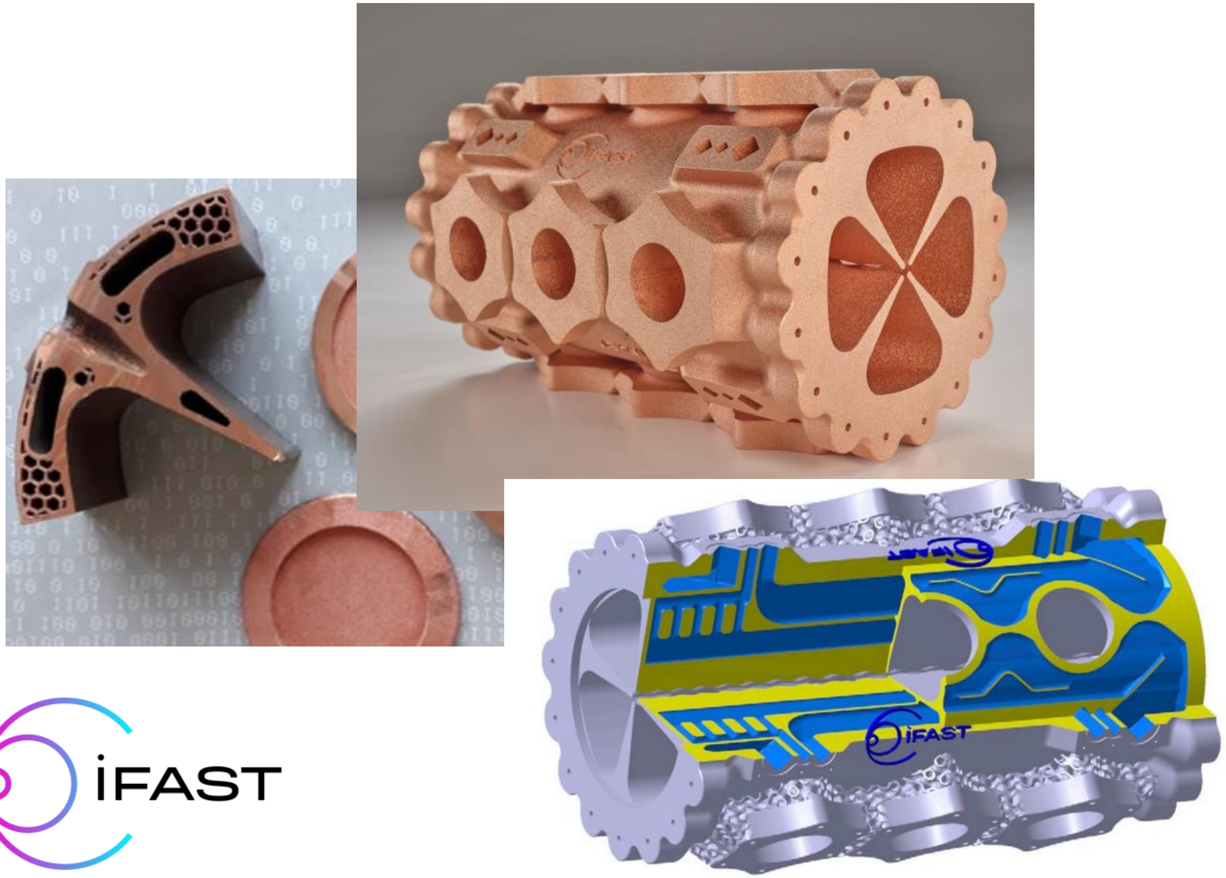
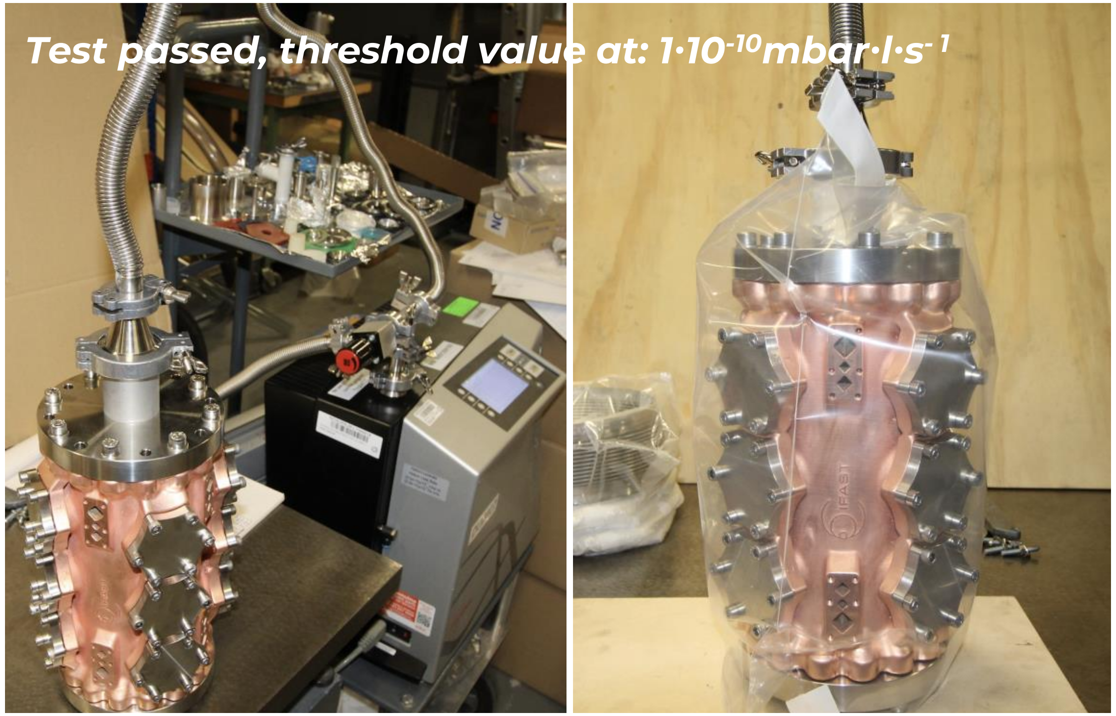
RFQ - related activities

The main demonstrator for WP10, after printing two versions of the full-section RFQ, tests have been done on one of the samples to investigate surface treatments, machining of functional surfaces, He leakage, …

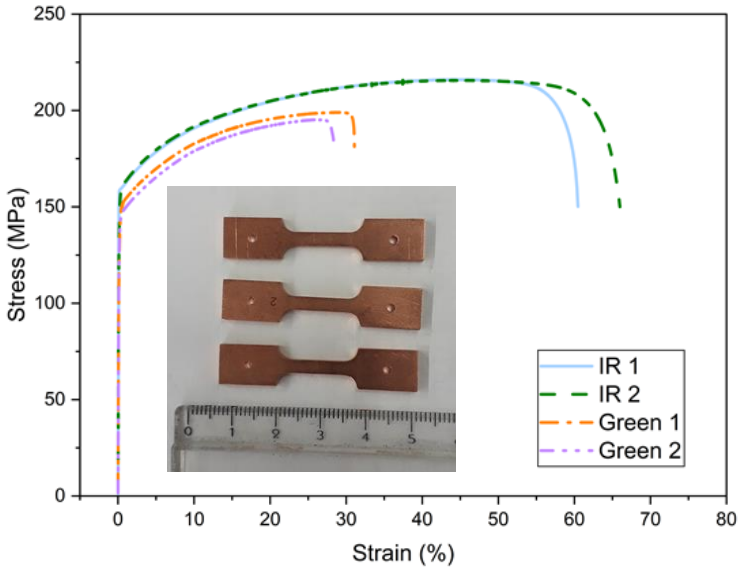




thanks to CERN TE-VSC, Cedric GARION and Hendrik KOS

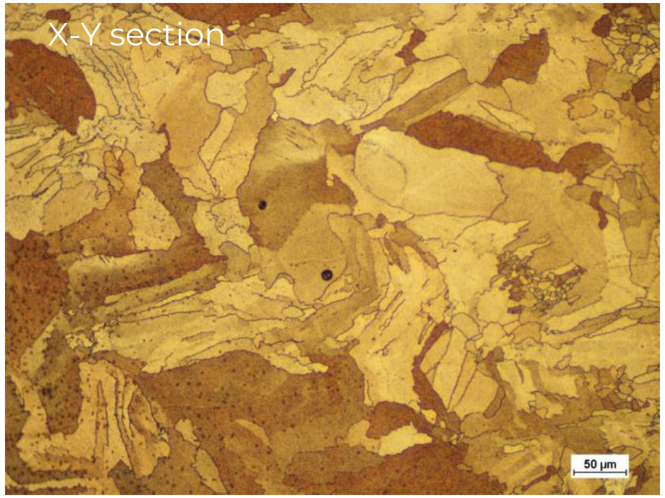
AM of copper and related properties

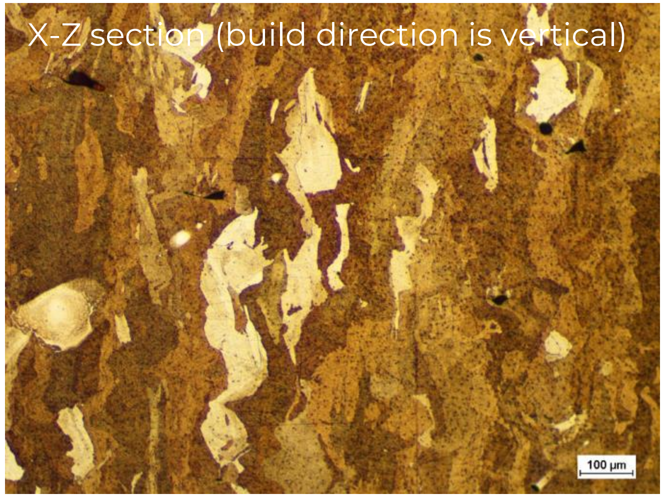
Copper has been printed by LPBF technology using both green and IR laser systems, both can provide the expected properties



Therm. diffusivity (cm^2/s @ 21°C)	reference Cu 99,99+%	IR laser BD	Green laser BD	Green laser TD
Average	1,174	1,166	1,172	1,165
%	-	99,32	99,82	99,23
Therm. conductivity (W/mK @ 21°C)	reference Cu 99,99+%	IR laser BD	Green laser BD	Green laser TD
Average	404,08	401,32	403,91	400,98

Electr. conductivity (MS/m @ 25°C)	IR laser BD	IR laser TD	Green laser BD	Green laser TD
Average	57,74	55,57	58,21	57,82
%	99,55	95,81	100,37	99,68
Vickers hardness ($HV_{0.05}$)	IR laser		Green laser	
	78.2 ± 1.9		75.5 ± 3.2	





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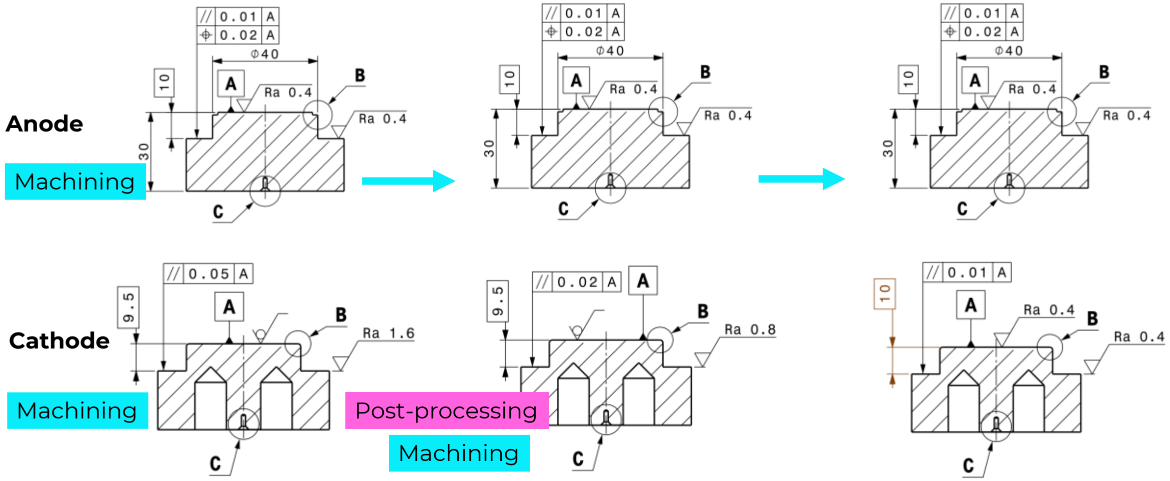
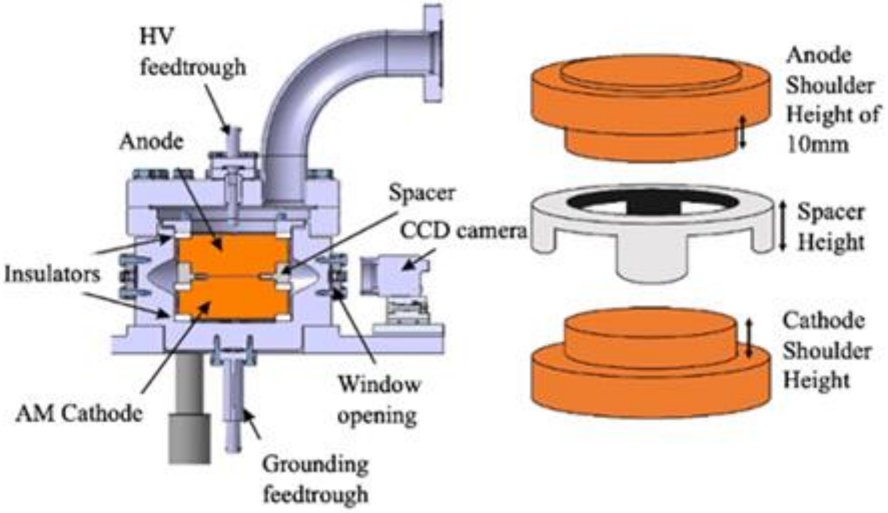
High-voltage behaviour of AM Copper

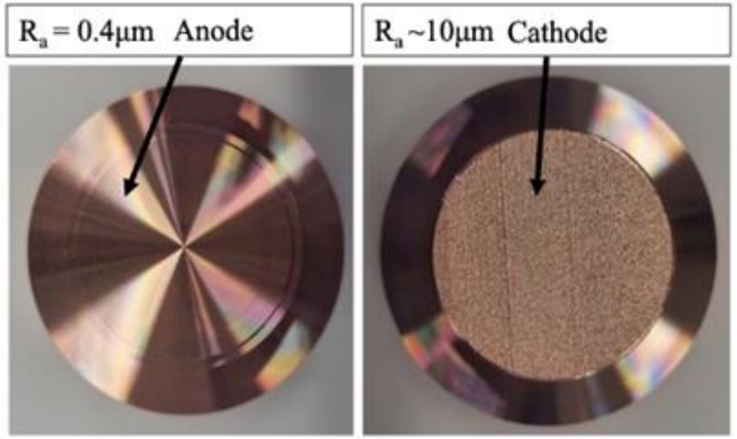
Different surface conditions are under investigation

Smooth – Rough | **Smooth – Post-processed** | **Smooth – Smooth**



CERN's pulsed high-voltage DC system





thanks to CERN SY-RF team W. Wuensch and V. Bjelland

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High-voltage behaviour of AM Copper

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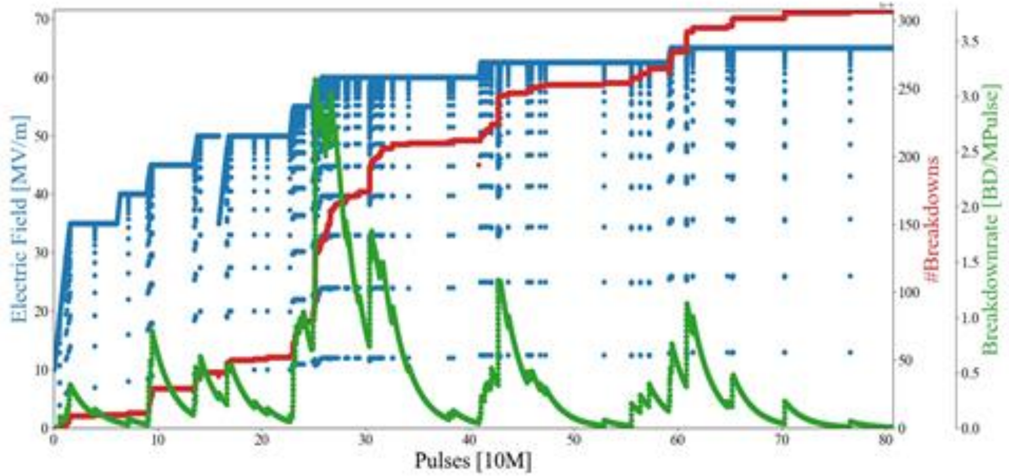

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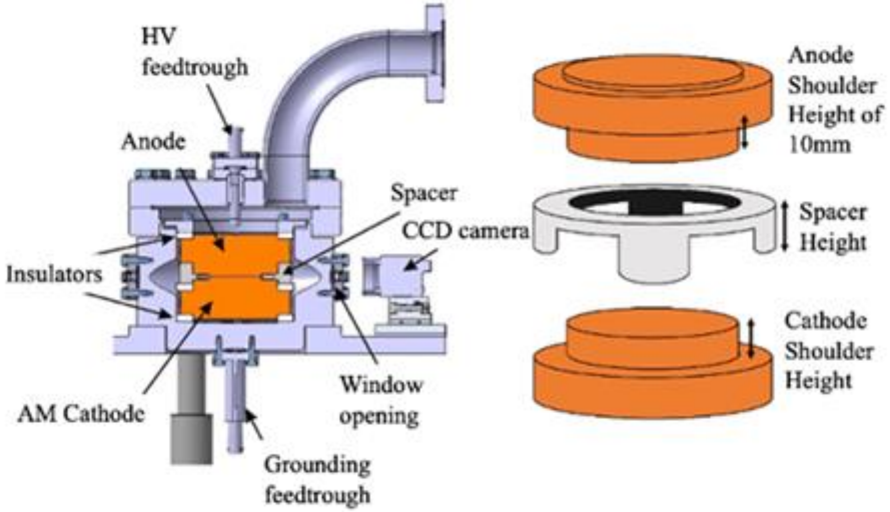

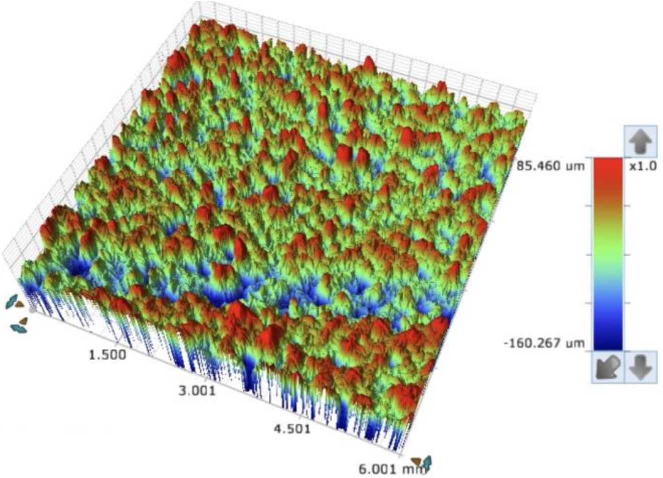

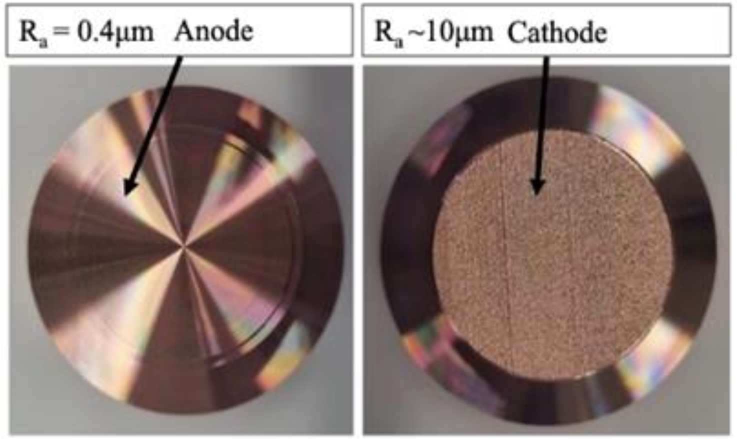

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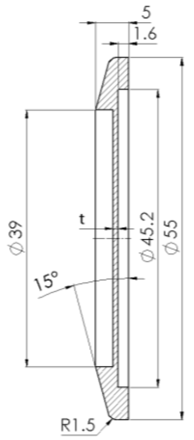
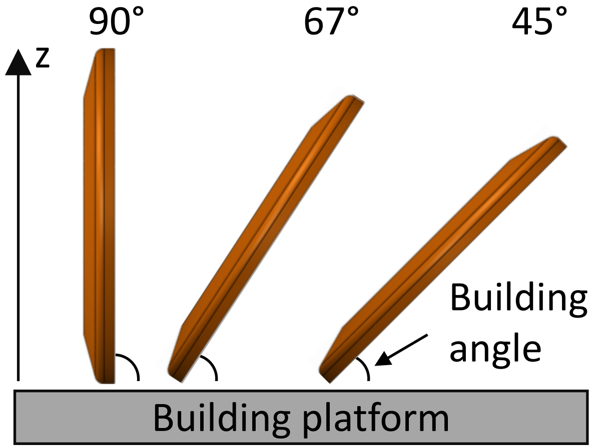
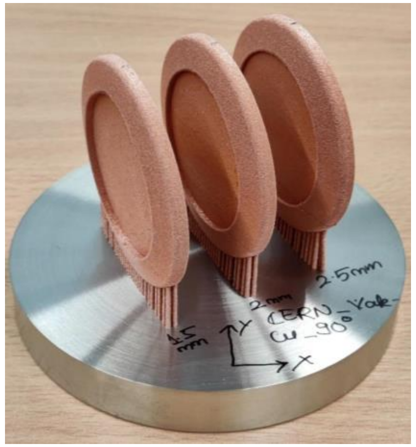
UHV tests on Cu printed membranes

Standard test membranes printed by a green laser with different thickness and print orientation

- Nominal thickness: 2,5, 5, 1,5, 1, 0,75, 0,5 mm
- Building orientation: 90°, 67°, 45°







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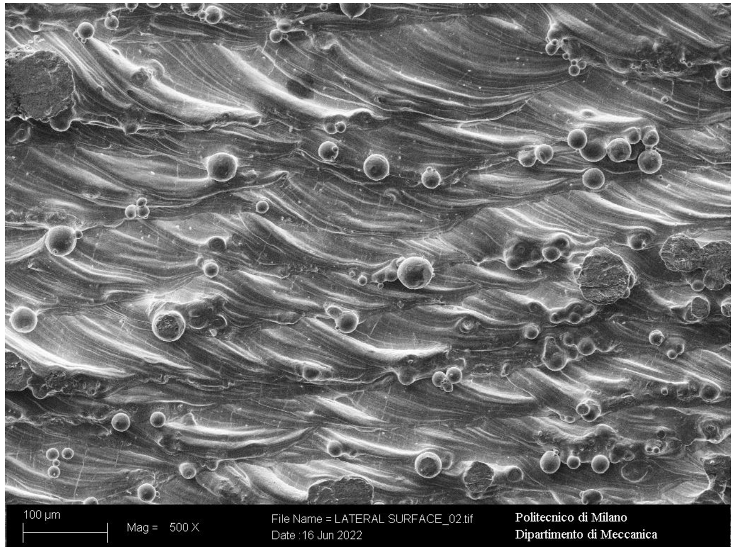
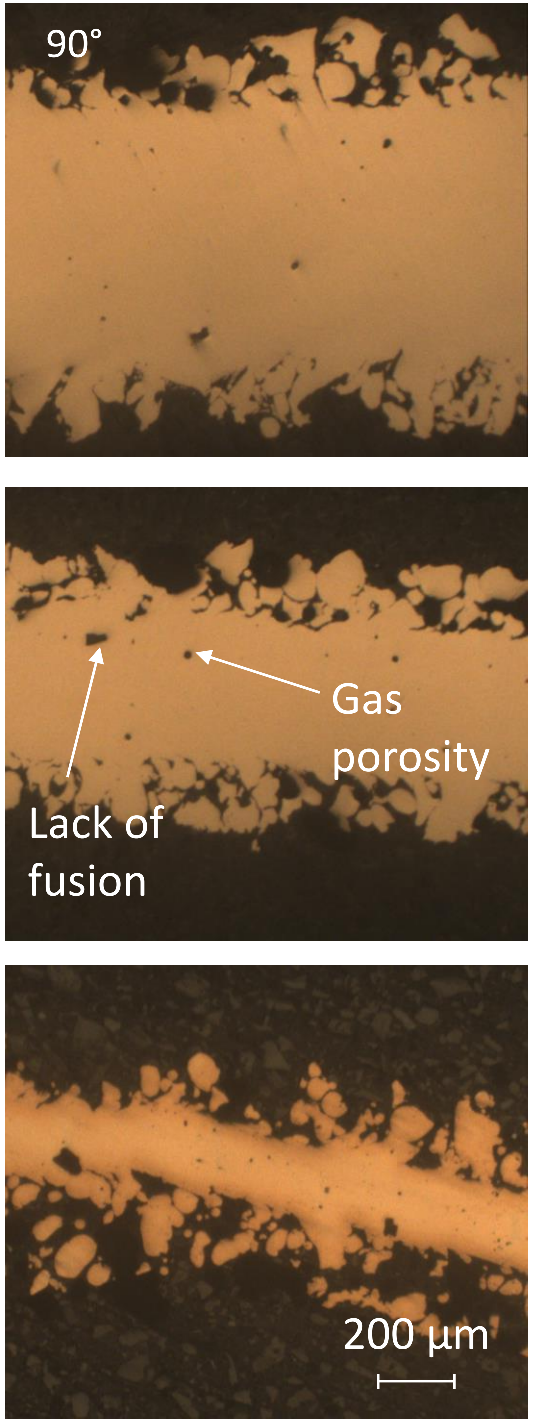
thanks to CERN TE-VSC, Cedric GARION and Hendrik KOS

UHV tests on Cu printed membranes

Only small-thickness membranes at highest angles failed the test due to actual thickness related to roughness

Nominal thickness (mm) \ Building angle	Helium leak rate (mbar l s^{-1}) 45°	67°	90°
2.5	PASS	PASS	PASS
2	PASS	PASS	PASS
1.5	PASS	PASS	PASS
1	PASS	PASS	PASS
0.75	PASS	PASS	$1.0 \cdot 10^{-6}$
0.5	PASS	$2.5 \cdot 10^{-3}$	$5.0 \cdot 10^{-2}$





1 mm

0.75 mm

0.5 mm

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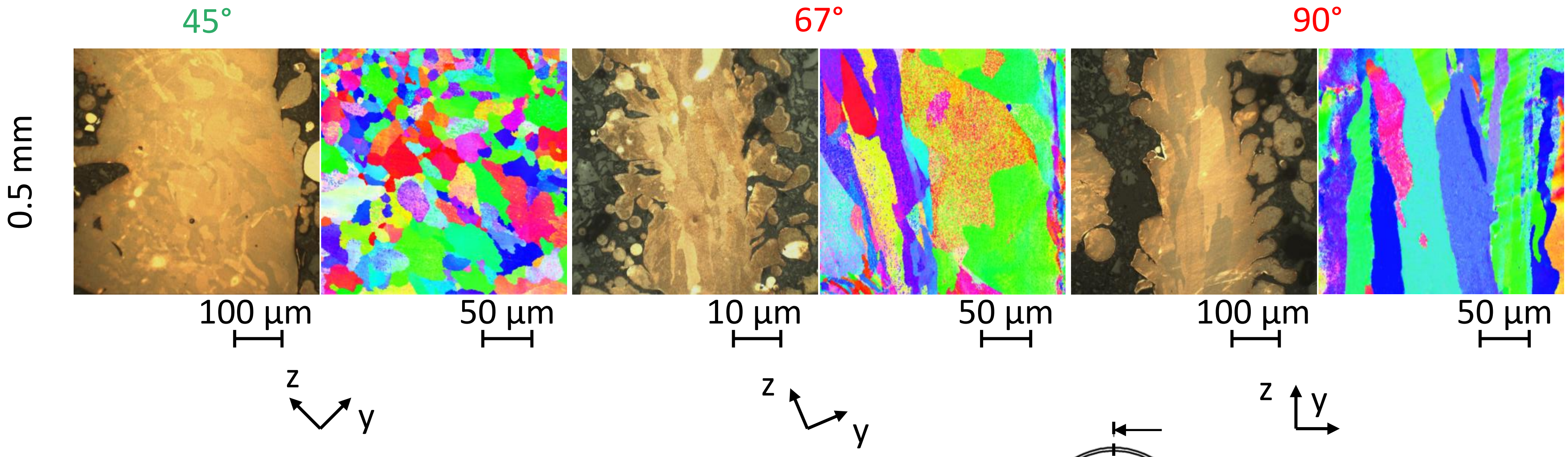
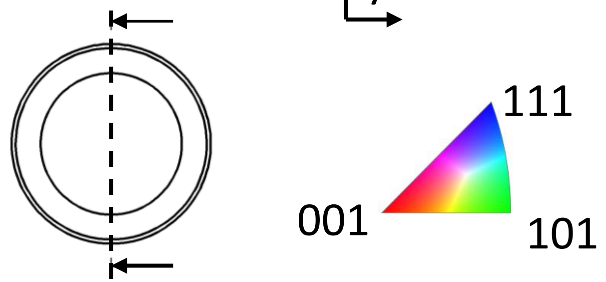
UHV tests on Cu printed membranes

- For fine-thickness membranes, building orientation plays a role on grain shape (equiaxed vs. elongated)
- Fine and homogeneous grain structure can reduce the risk of leaks





Final remarks

- This was not meant to be the final step of our activities for task 10.2
- These running efforts are supporting the definition of the most strategic directions for future research on AM technologies to enhance their impact on accelerator applications
- We are considering them as the starting point for a much longer journey, pushing ahead the current limits of AM for the design of more advanced accelerators

My personal and warmest thanks to the whole team!

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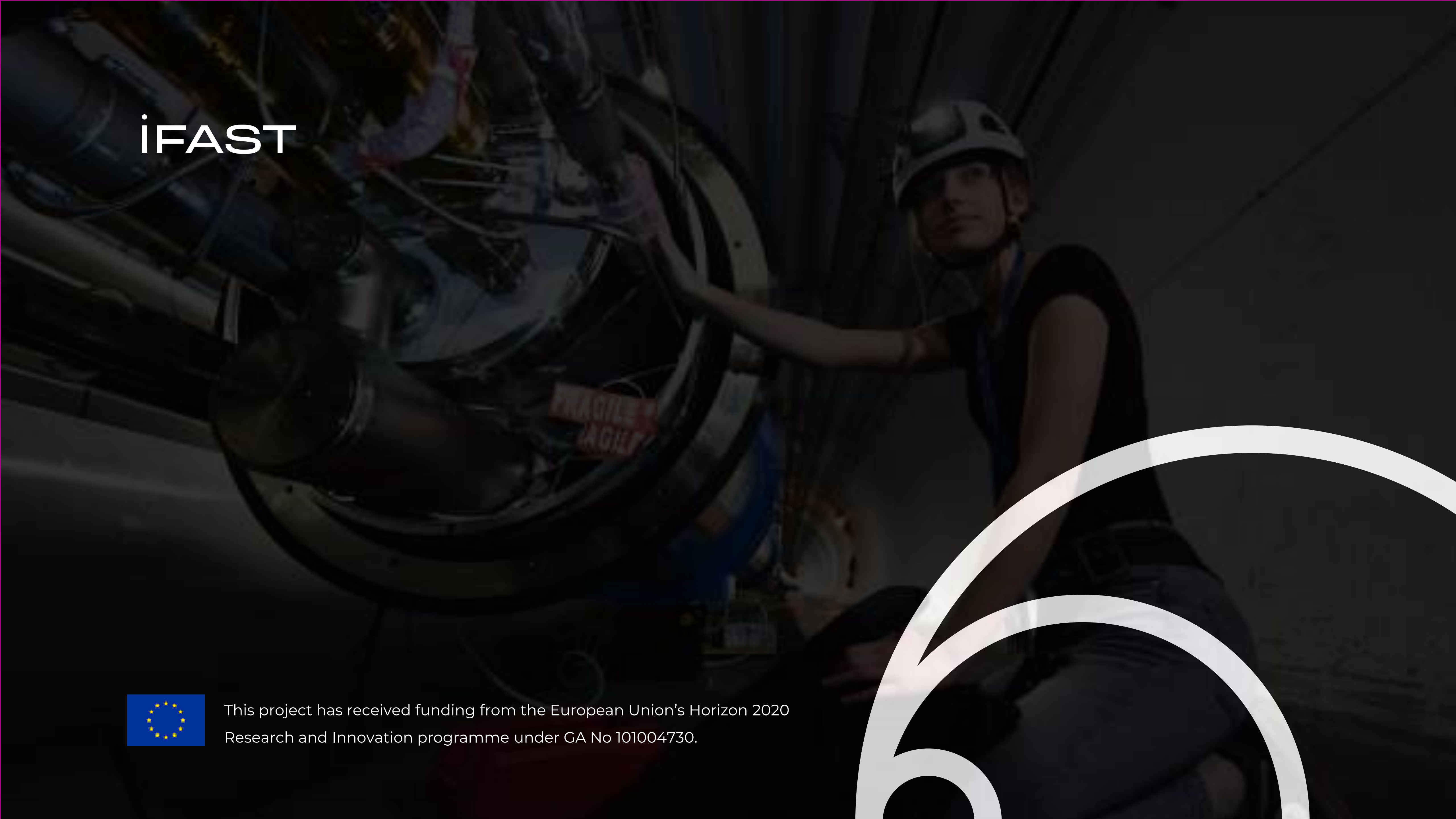

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