MAKING TITANIUM DEMISABLE THROUGH CONTROLLED POROSITY AND FUNCTIONAL COATINGS

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Titanium isn‘t going away

Titanium has a lot of heritage in propellant tanks, star trackers, reaction wheels, bipods, brackets, etc.

One of the problems: ***not*** *demisable*!

Industry trends to move to other materials, e.g. Al, for:

cost, **manufacturability** and **demisability**

But not every Titanium component has a replacement!

What if we can make Titanium **demisable**?

Making Titanium Demisable

- ✓ Intended porosity via advanced 3D printing
- ✓ Functional Coatings for Titanium

Porous Metal Structures for Demisability

Goal:	Establish tailored porosity
Approach:	Process parameter variation during Additive Manufacturing
Method:	Laser Powder Bed Fusion of Ti-6Al-4V

https://nikon-slm-solutions.com/de/slm-systems/slm280-ps/

LPBF machine

Porous sample

Solid sample

10 mm

3D Printed Porous Titanium – Feasibility of Bionic Geometries

Component application: Satellite bracket*

solid

medium porosity

high porosity

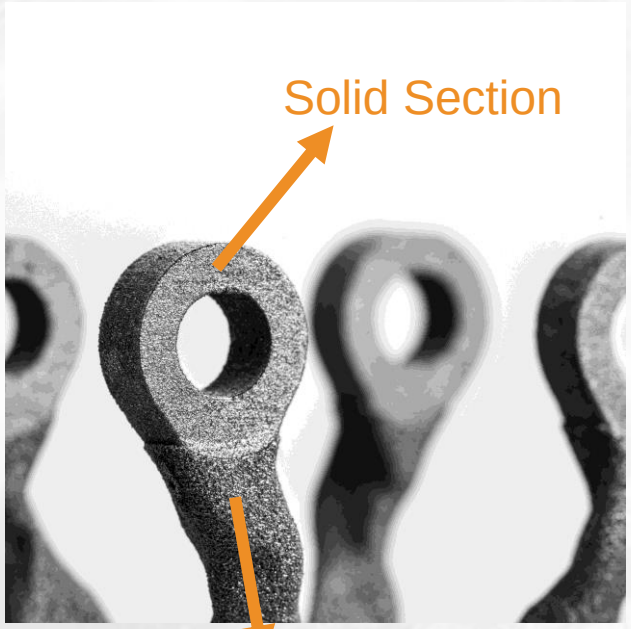
✓ Porous 3D printing approach applicable at component level

*Geometry thankfully provided by OHB

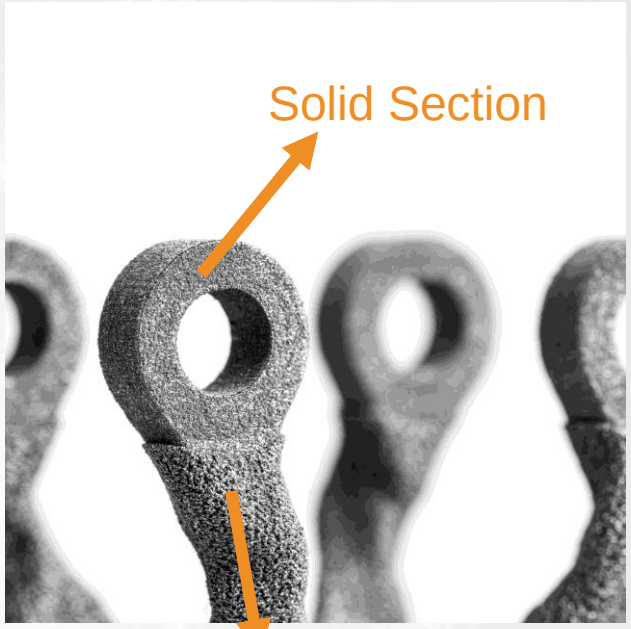
3D Printed Porous Titanium – Local Porosity Optimization

Component application: Satellite bracket

solid



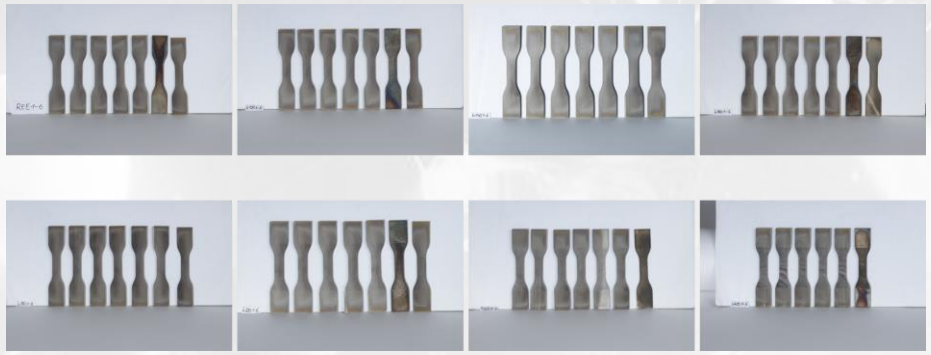
medium porosity

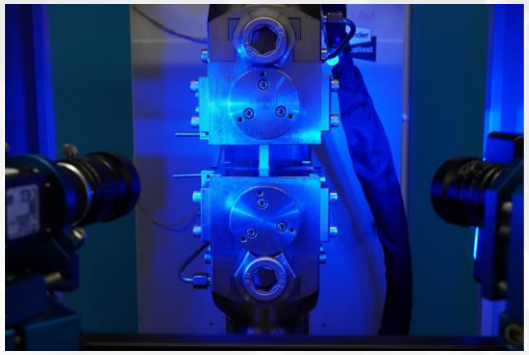


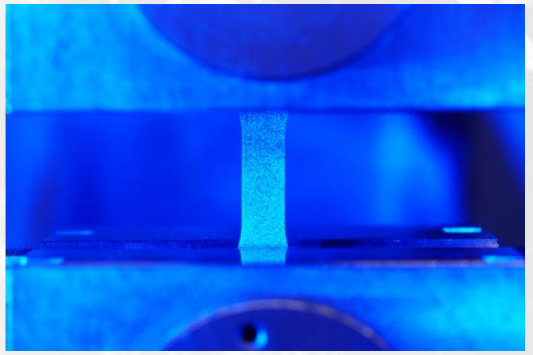
high porosity

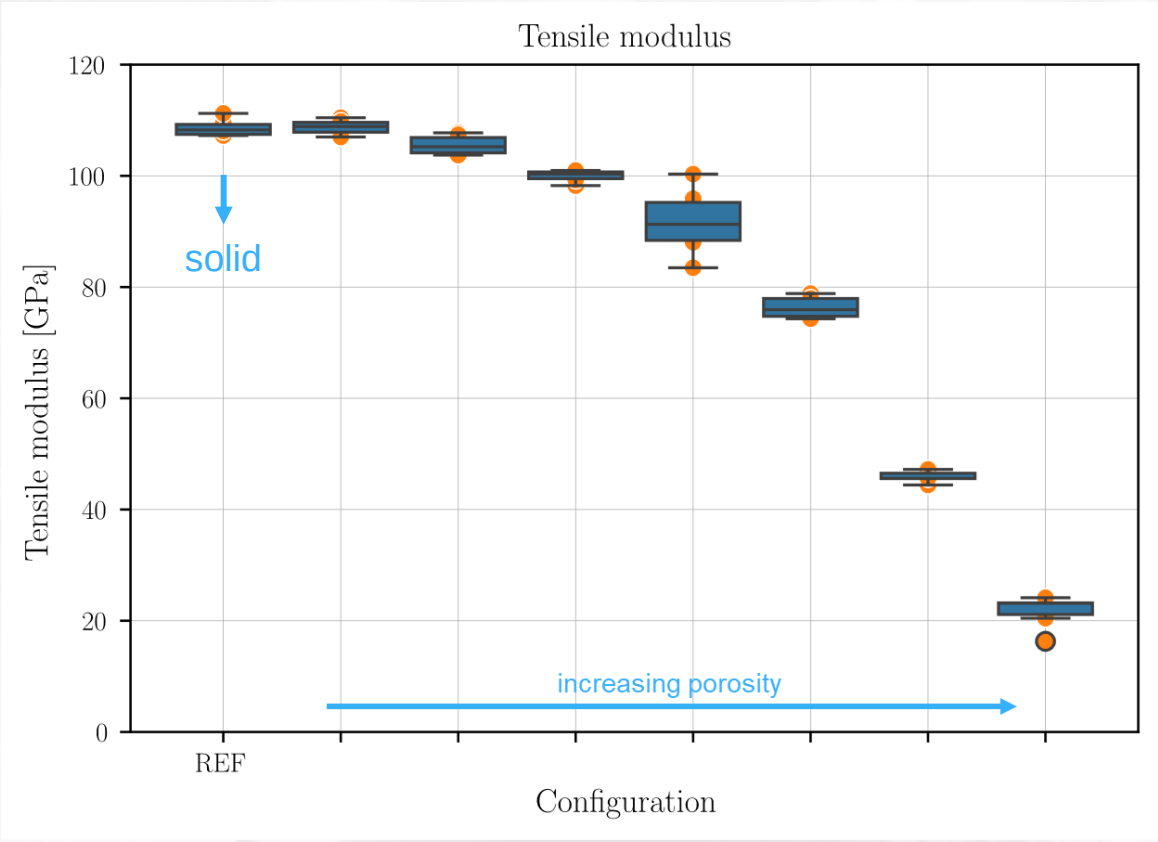
✓ Porous 3D printing approach applicable at component level

Mechanical Testing



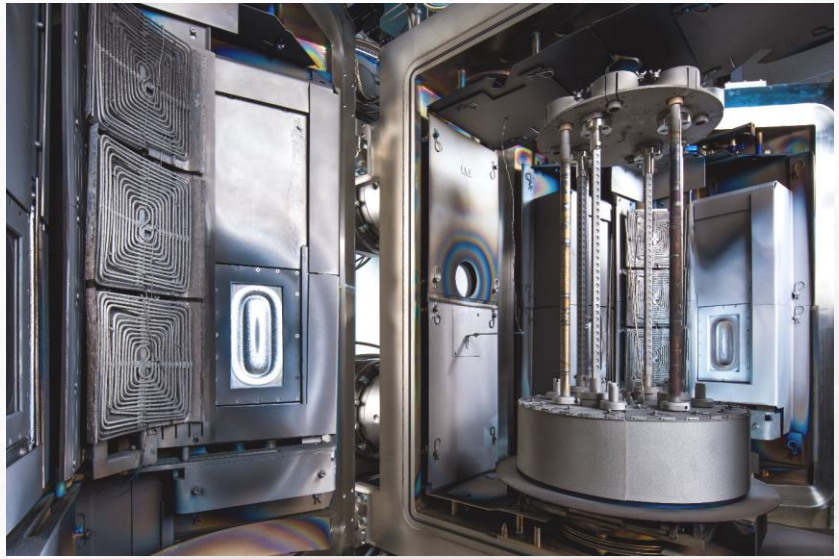






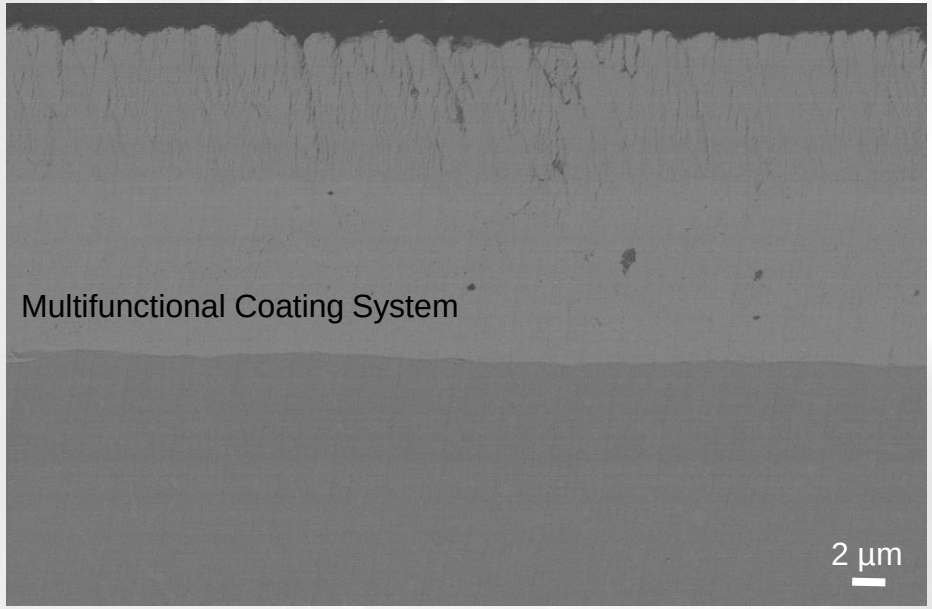
Coating Conventional Titanium for Demise

Goal:	Modification of surface and surface-near region
Approach:	Multifunctional coating system (diffusion, oxidation protection, low emissivity and high catalycity)
Method:	Magnetron Sputter deposition (PVD-technology)

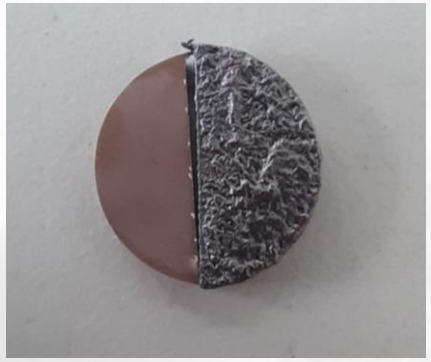


Coating conventional titanium for Demise

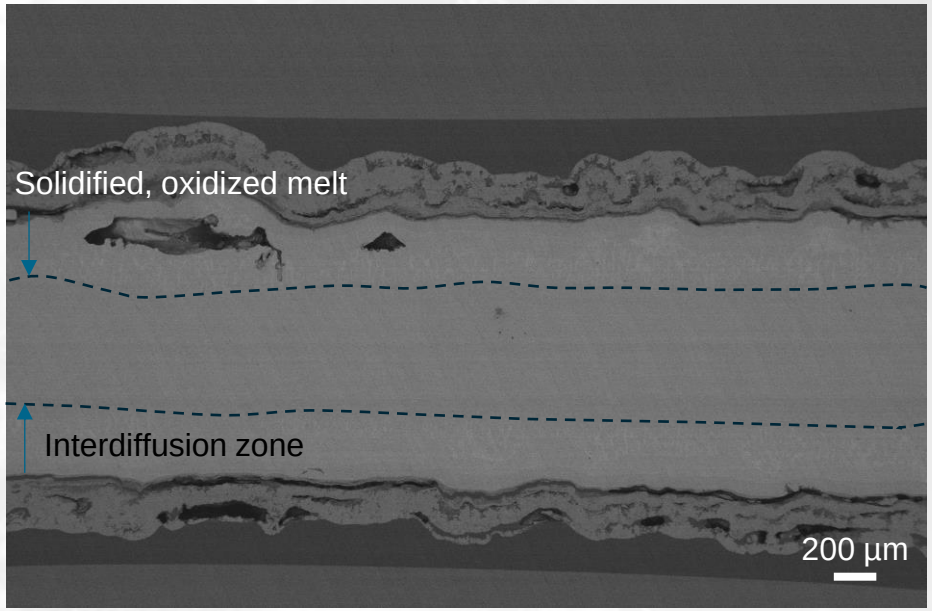
As-coated system on Ti-Al6-V4



Labsize Sample



Coating system on Ti-Al6-V4
after 15 min at 1200 °C



Demise Behaviour in Plasma Flow

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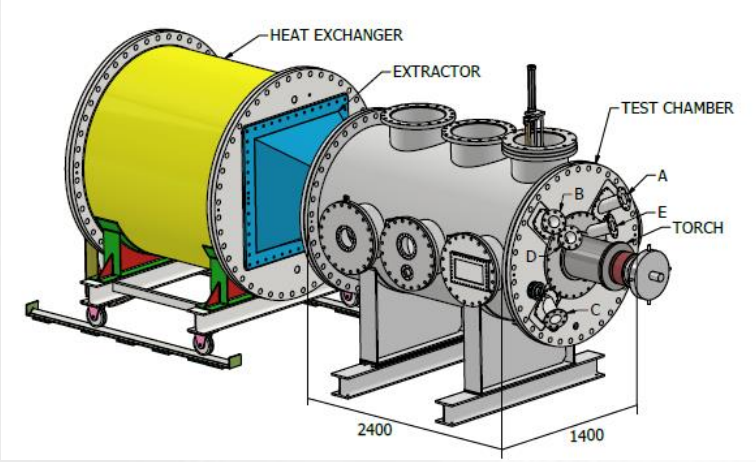
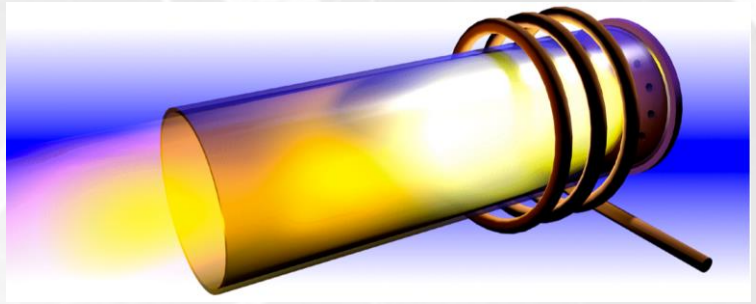
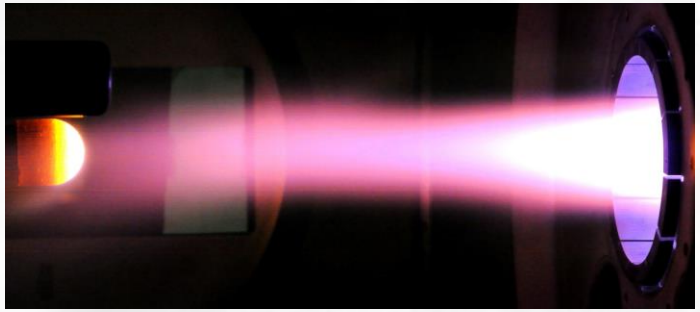
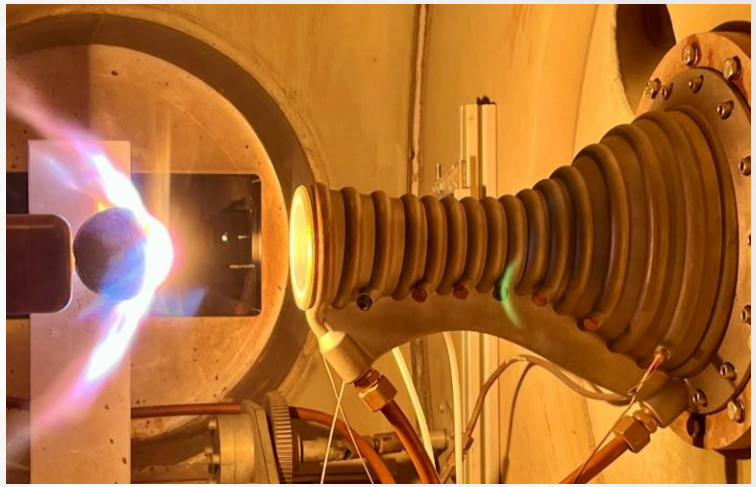
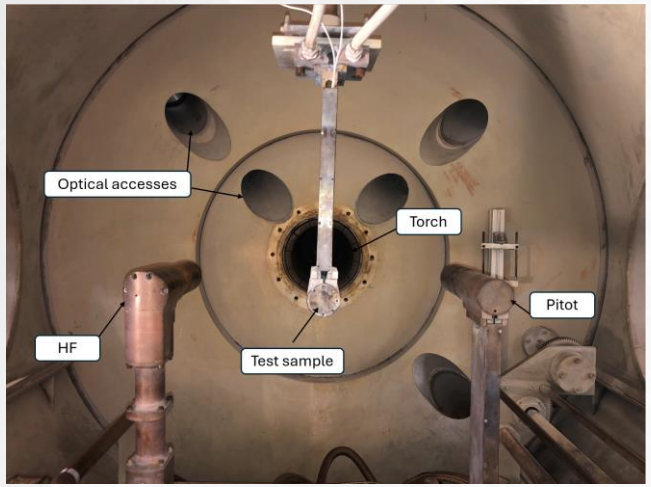
VKI Plasmatron



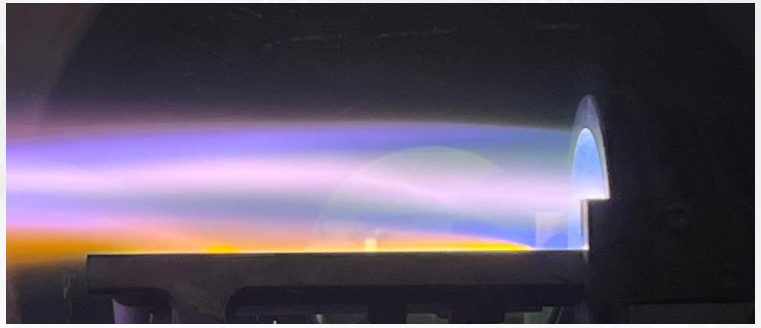






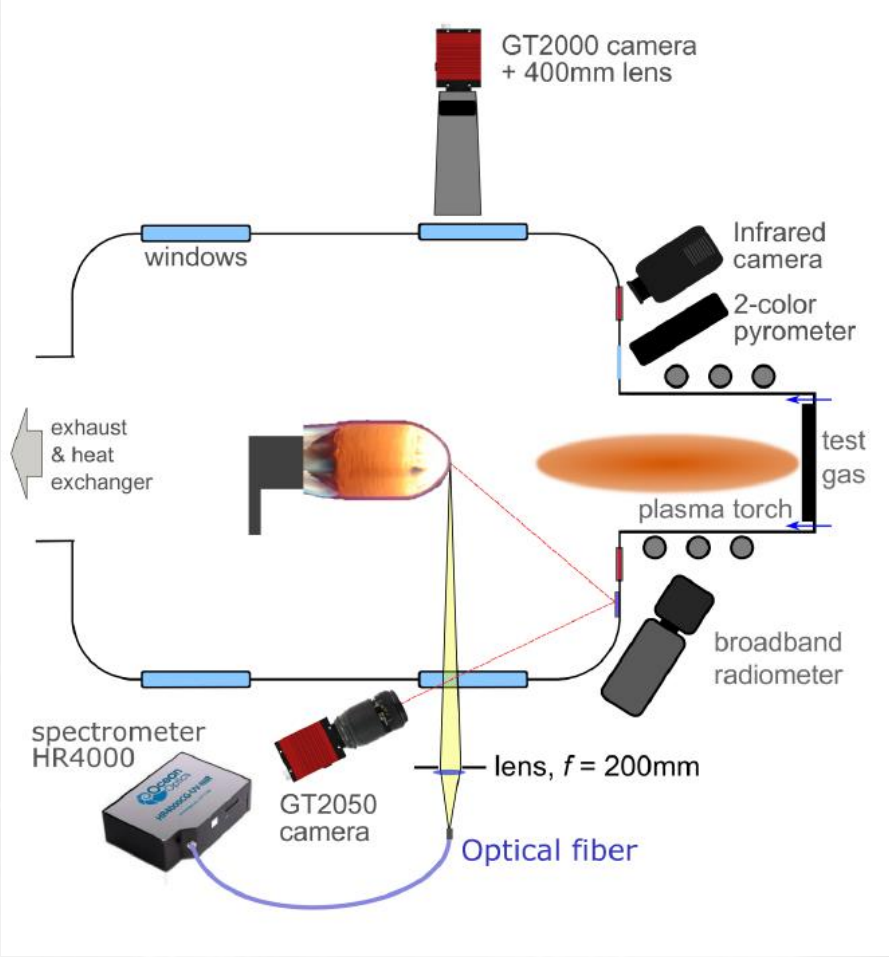


Gas	air, N_2, CO_2, Ar
Power	1.2 MW
Max. heat flux	15 MW/m^2
Pressure	10 hPa - 400 hPa



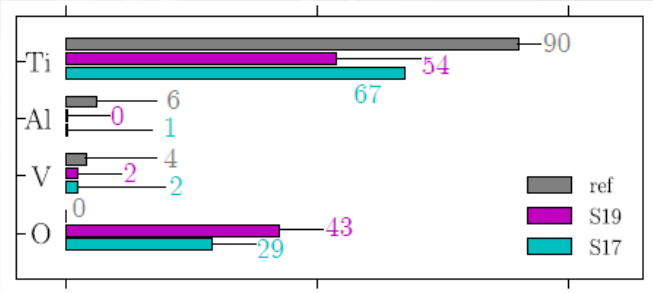
Demise Behaviour in Plasma Flow

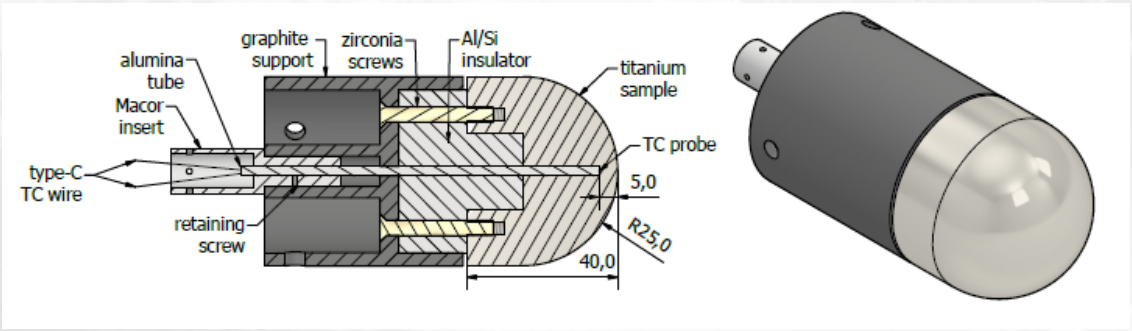
VKI Plasmatron Test Setup



1) Previous study on Titanium grade 5 and 2 (A. Fagnani)

test ID	Δm g	mix	$\dot{m}_{gas}$ g/s	P_{el} kW	p_c mbar	z mm
TiG5-HS50-D	0.55	OXAZ20	16	200	50	385





Demise Behaviour in Plasma Flow

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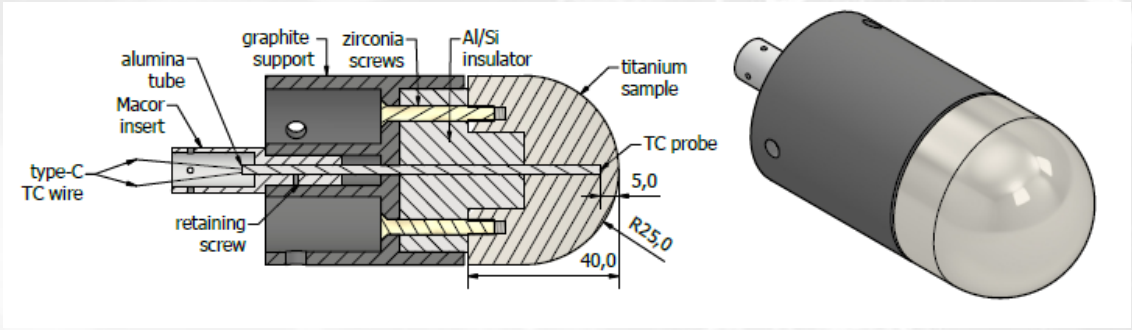
2) Current study on AM & coated Ti



	AM	Porosity	Coating	Power [kW]	HF_{cw} [kW/m²]	P_{tot} [hPa]	Time [s]	Comment
Con1	No	-	-	200	1400	50	66	Conventional TiG5–HS50–D (**no demise**)
AM1	Yes	-	-	200	1400	50	89	AM without porosity (**demise ~30s**)
AM2	Yes	Medium	-	200	1400	50	33	AM with medium porosity (**demise ~10s**)
AM3	Yes	High	-	125	430	50	94	Reduced HF, demise starting but not complete
C1	No	--	Yes	200	1400	50	74	Conventional titanium with demisable coating (**demise after 50s**)

Comparison: Additively Manufactured Titanium G5 demise

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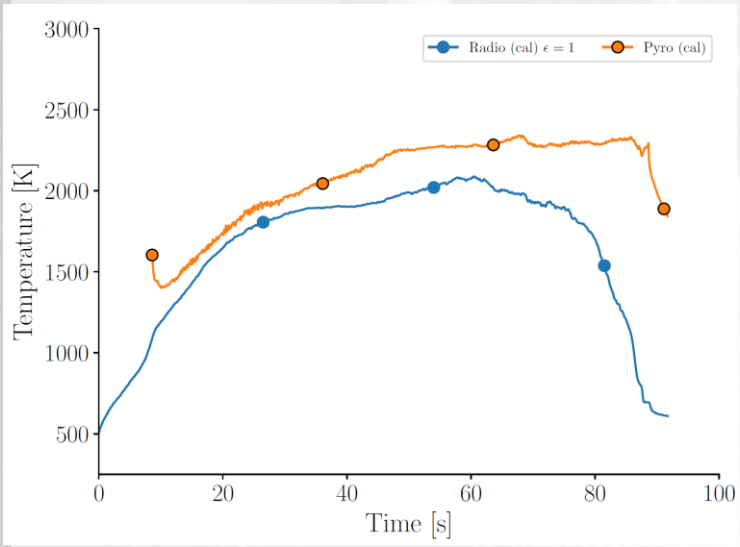
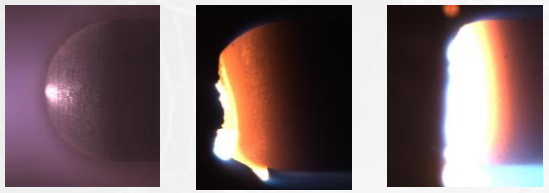
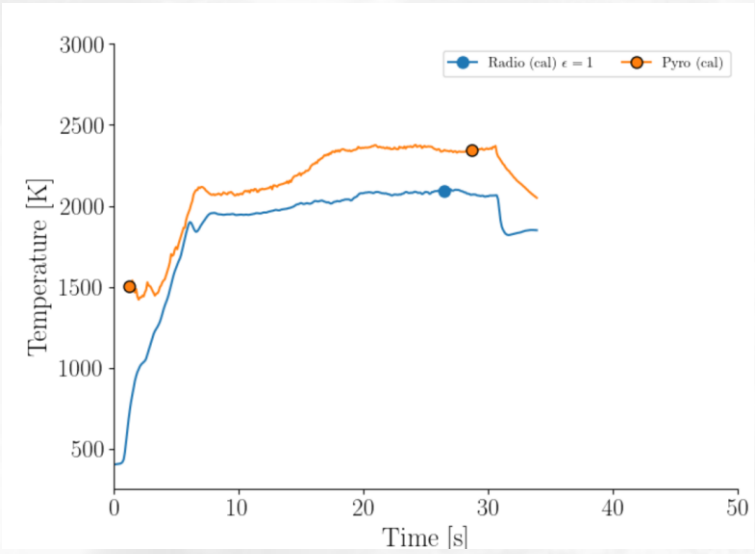
AM1, No Porosity
1.4 MW/m^2

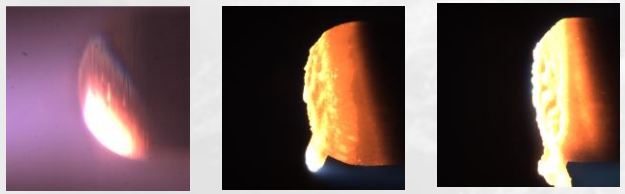




0 40 50

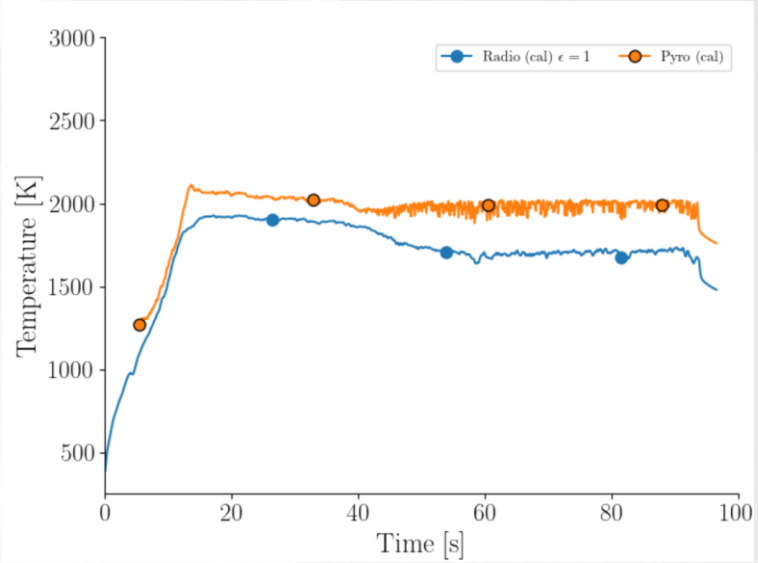
AM2, Medium Porosity
1.4 MW/m^2

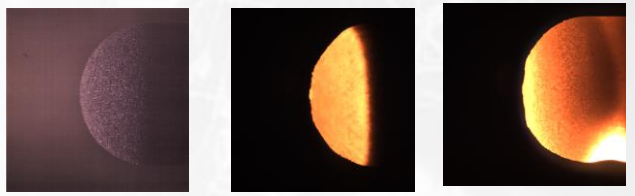




-1 10 15

AM3, High Porosity
0.4 MW/m^2





0 40 80

Comparison: solid AM vs porous AM Ti-G5 bulk

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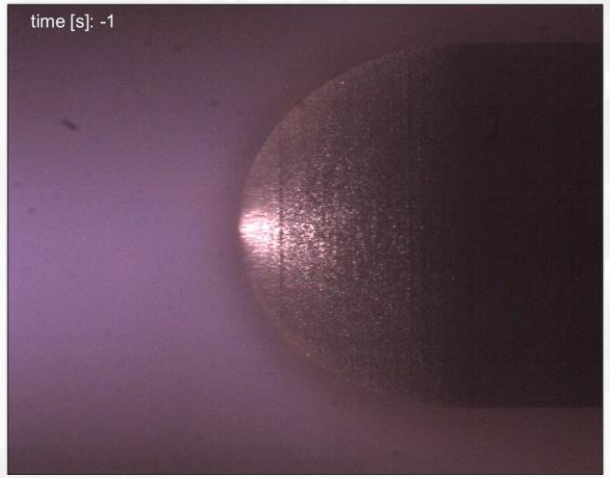
p_{tot} = 50 mbar, P_{el} = 200 kW, 1.4 MW/m^2

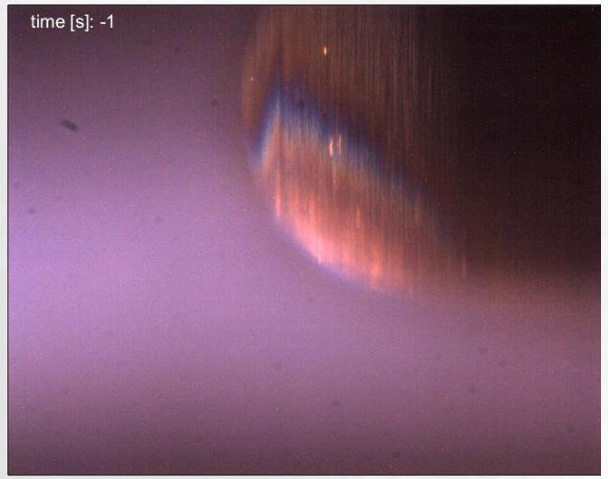
Solid sample



Time: ~ 60 sec

Factor 2

Porous sample



Time: ~ 30 sec

Comparison: solid AM vs porous AM Ti-G5 bulk

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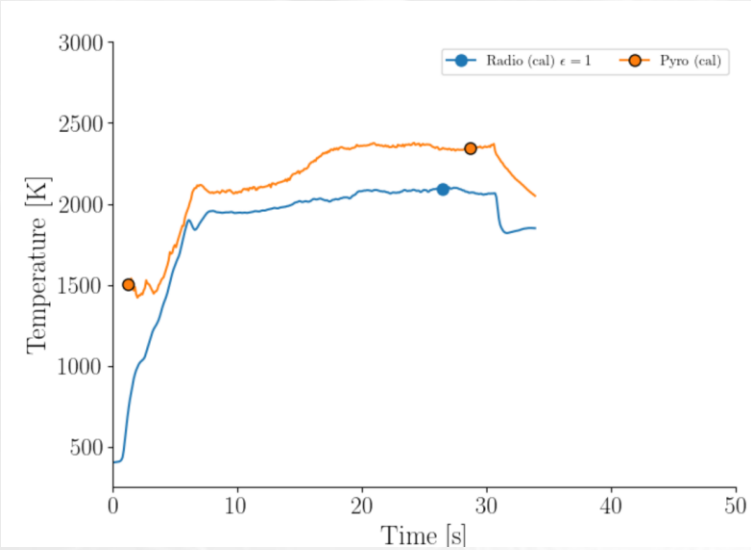
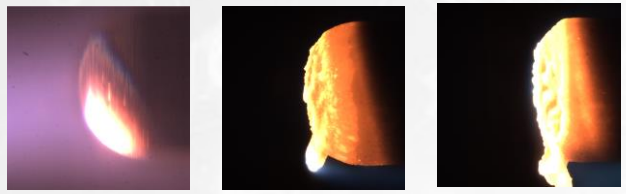
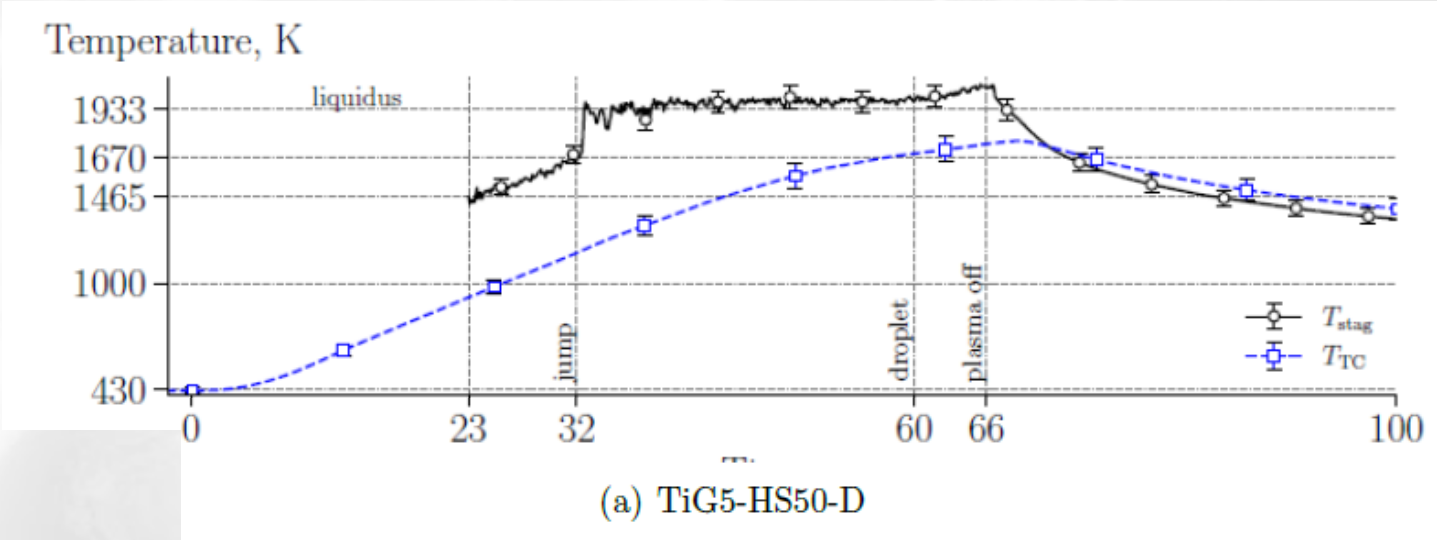
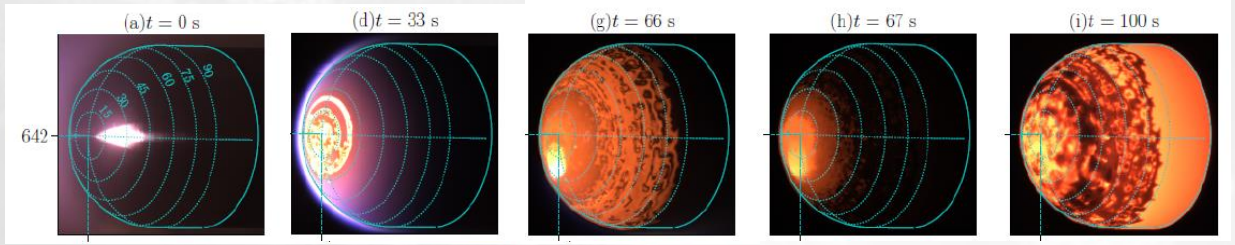
Medium Porosity
(test #2)





Conventional Ti
(TiG5-HS50-D), Fagnani, A.





p_{tot} = 50 mbar, P_{el} = 200 kW, 1.4 MW/m^2

Coated conventional bulk Ti-G5 sample

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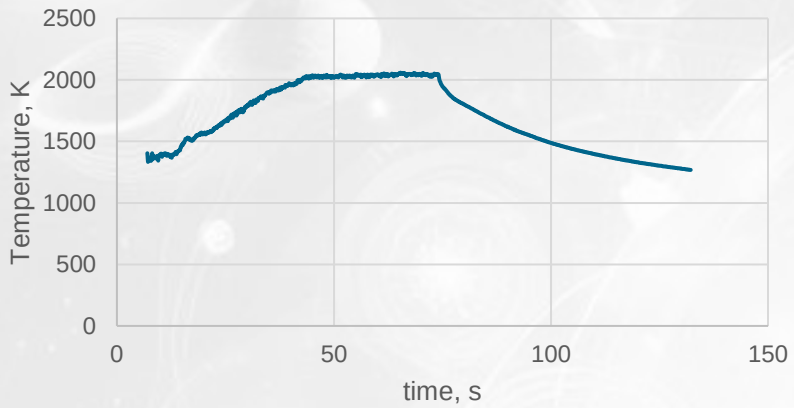
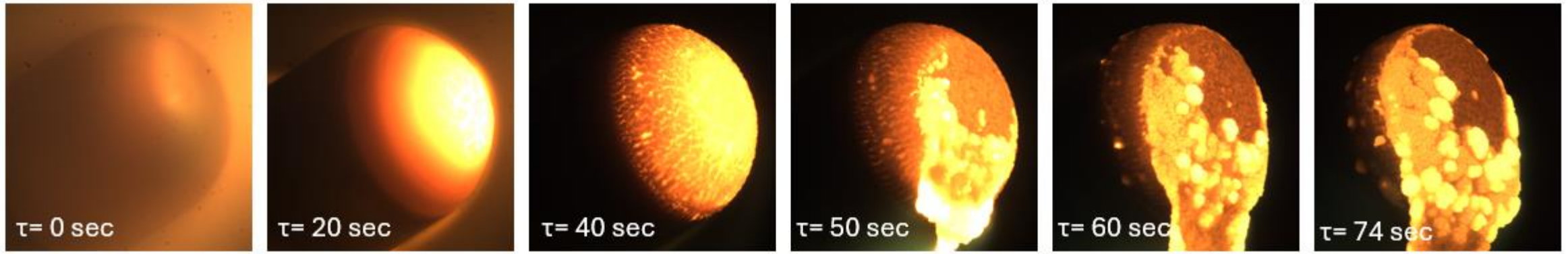
p_{tot} = 50 mbar, P_{el} = 200 kW, 1.4 MW/m^2



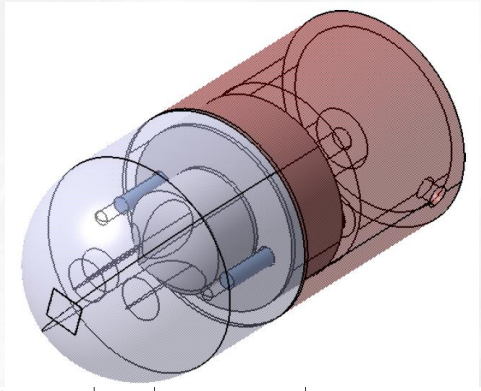


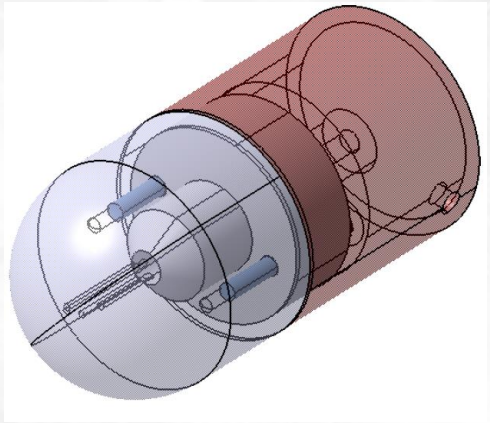
Markers in AM Titanium for DRACO

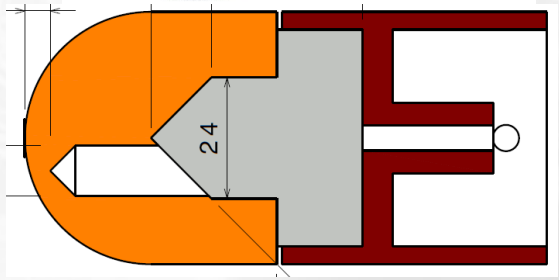
p_{tot} = 100mbar, P_{el} = 125 → 145 → 165kW) + flight spectrometer (DIAL) + flight camera (DIAL)

AM titanium with 3 markers

(lanthanum hexaboride, salt, no chromite)







Markers in AM Titanium for DRACO

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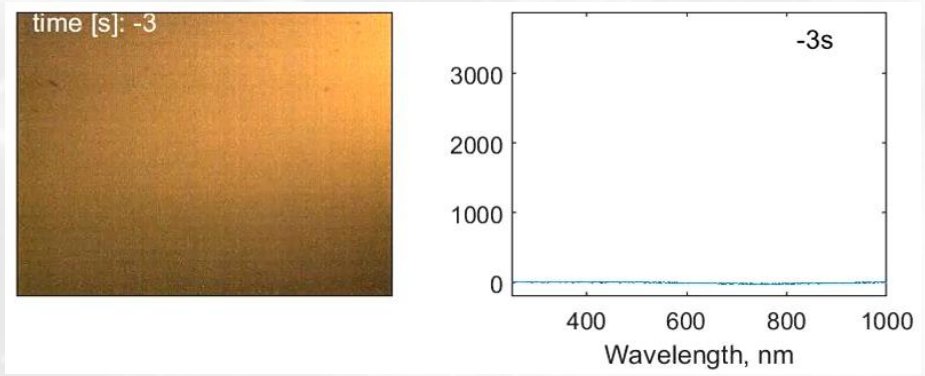

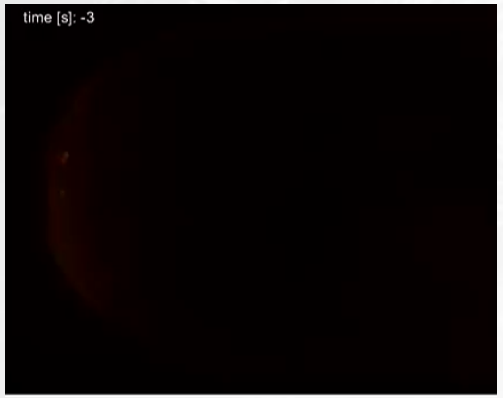

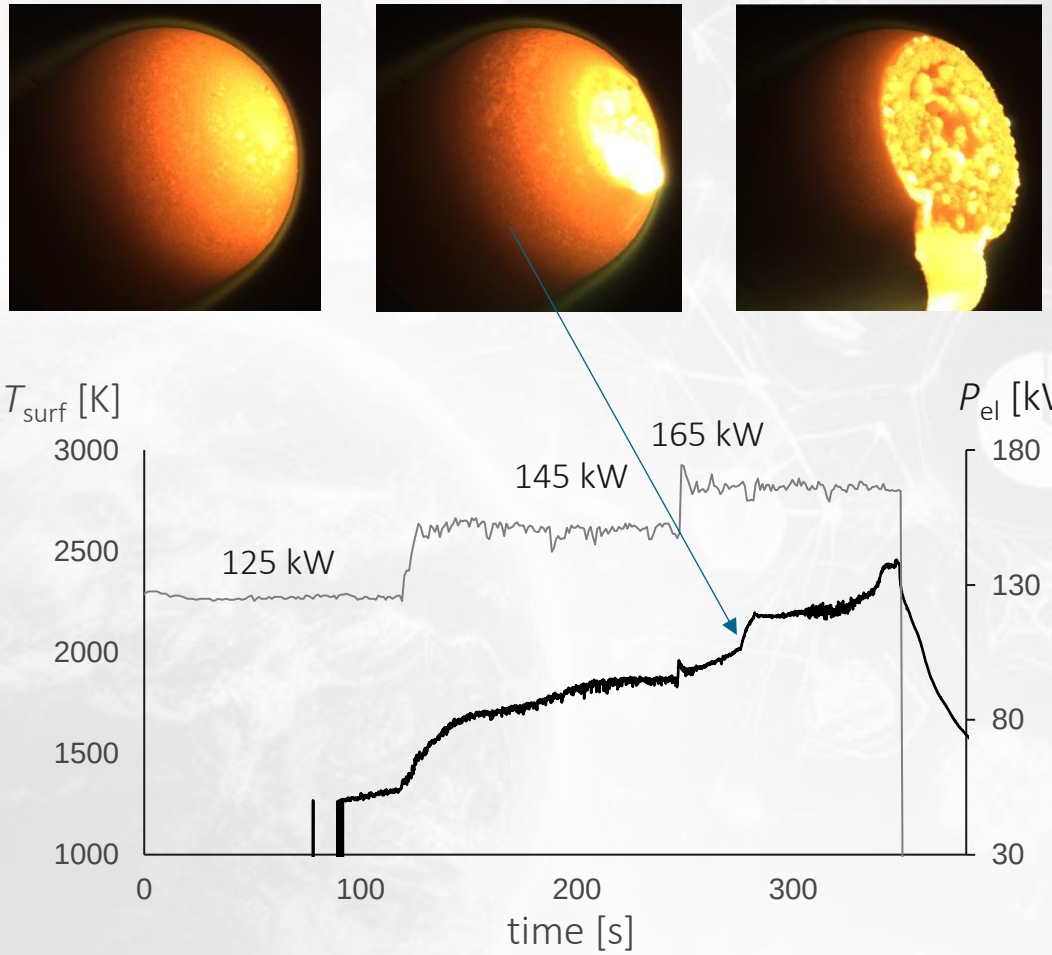

Thank you for your attention

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Website & Social Media

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