End of the Year Meeting WPRD LMD 2025 – ENEA Polimi
Production and characterization of corrosion barrier on complex surfaces

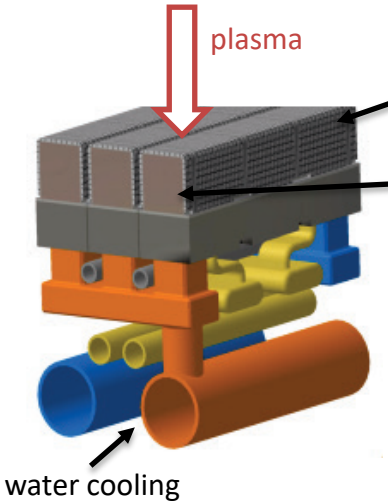
D. Dellasega, L. Bana, D. Vavassori, M. Bugatti,
L. Ferrante, M. Iafrati, M. Passoni

POLITECNICO MILANO 1863

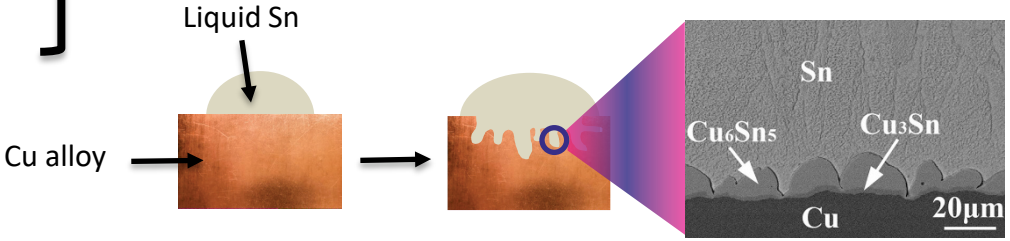
ENEA
Italian National Agency for New Technologies, Energy and Sustainable Economic Development

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

Summary of task: Corrosion barriers against liquid Sn



Liquid metals degrade structural materials!



N. Zhao et al., Sci Rep 2015

W in bulk form is compatible with liquid Sn

N. Kondo et al., Plasma and Fus Res 2021

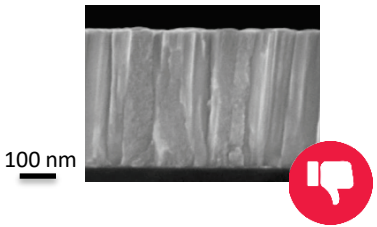
Aim: optimize W-based corrosion barrier against liquid Sn

1. From planar idealized case – to understand corrosion mechanism and protective performance
2. Moving toward the real component – include realistic substrate roughness and 3D geometry

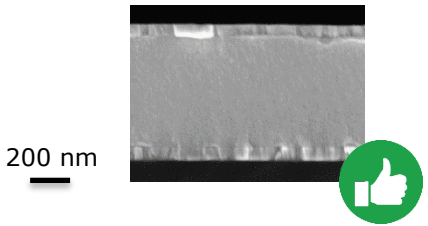
Progress so far in 2025

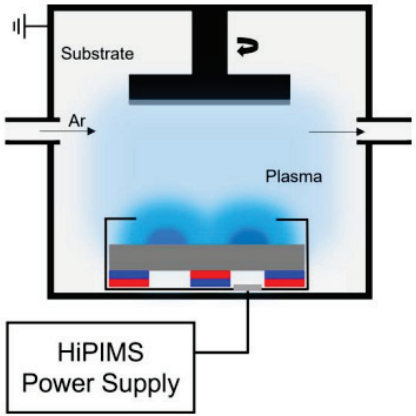
In 2024

Pure-W



W-WAl-W 3layer





Amorphous layer show promising protective performance (400°C, 10 h)

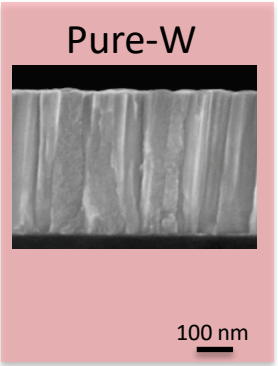
→ *D. Vavassori et al., Surf Coat Tech 2024*
M. Bugatti et al., J Fusion Energy 2025

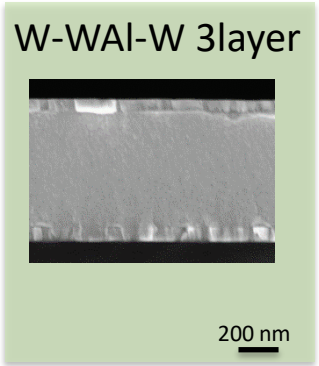
In 2025, we investigated alternative compositions to control film structure:

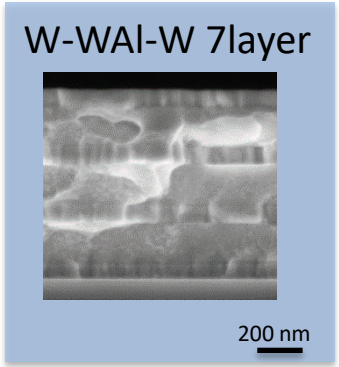
- WN with ion bombardment (HiPIMS)
- Other metallic elements: W, Cr, Ti
- Multi-layered architectures

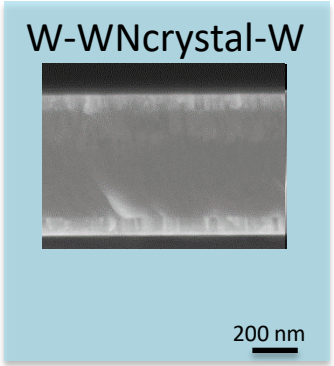
→ *L. Bana et al., MRS Adv 2025*
L. Bana et al., Surf Coat Tech 2025

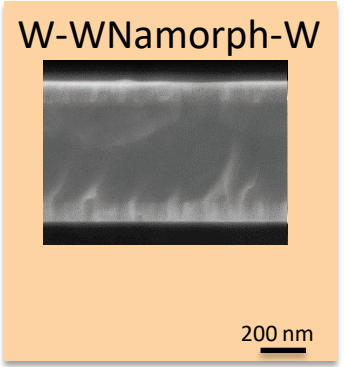
Progress by MTM 2025

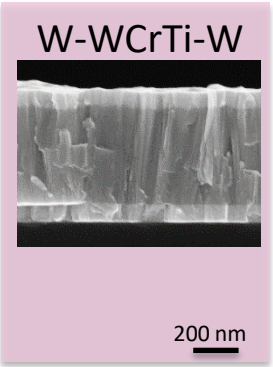


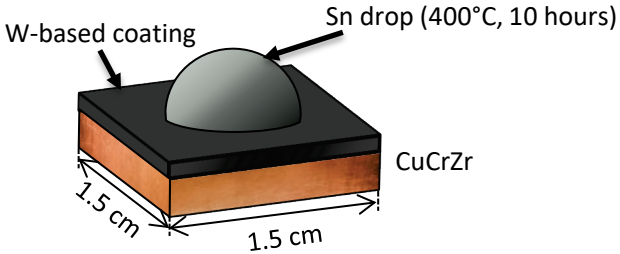












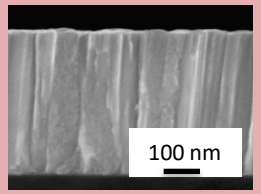
Liquid Sn exposure and results of optical microscopy will be presented in the next talk by Luca Ferrante

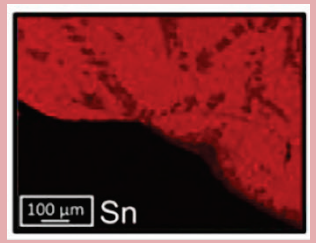
Amorphous and multilayer structures show the better protective performance, even without Al!

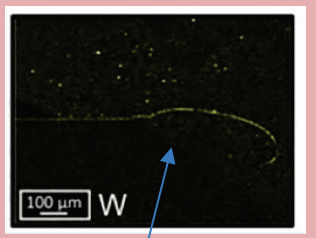
New activity to complete task

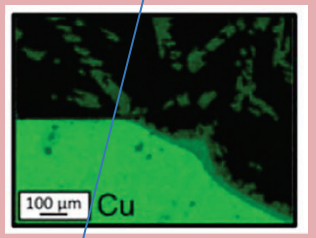
- Completed post-mortem characterization with SEM/EDX of liquid Sn exposed samples

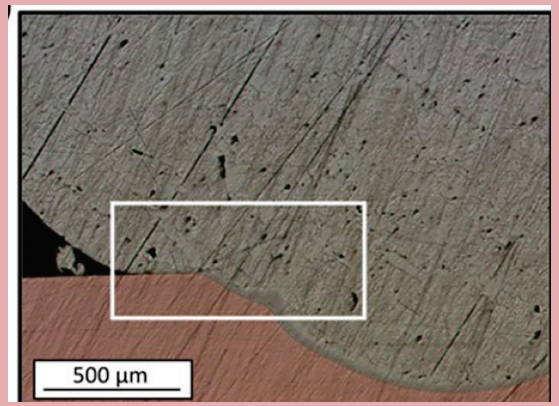
Pure-W

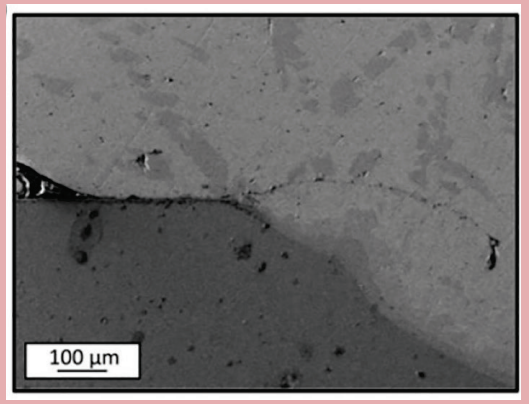








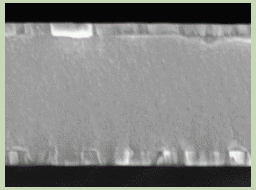


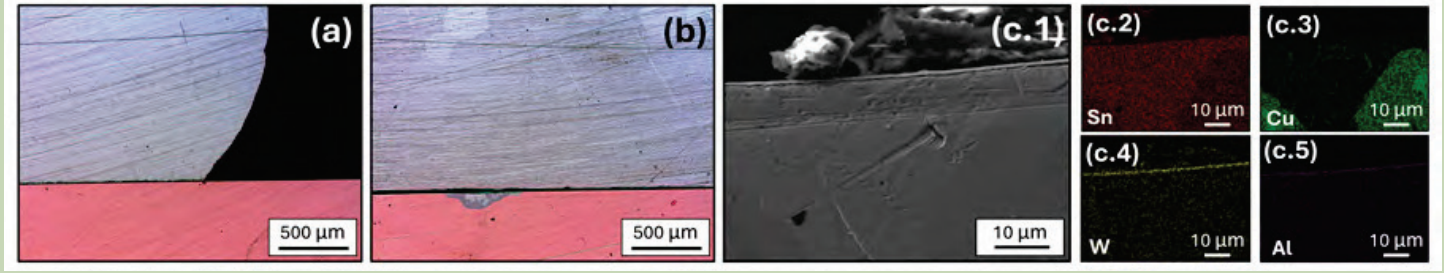


Curled film due to internal stresses

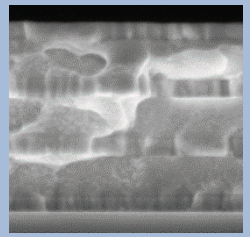
Post-mortem SEM/EDX of exposed samples

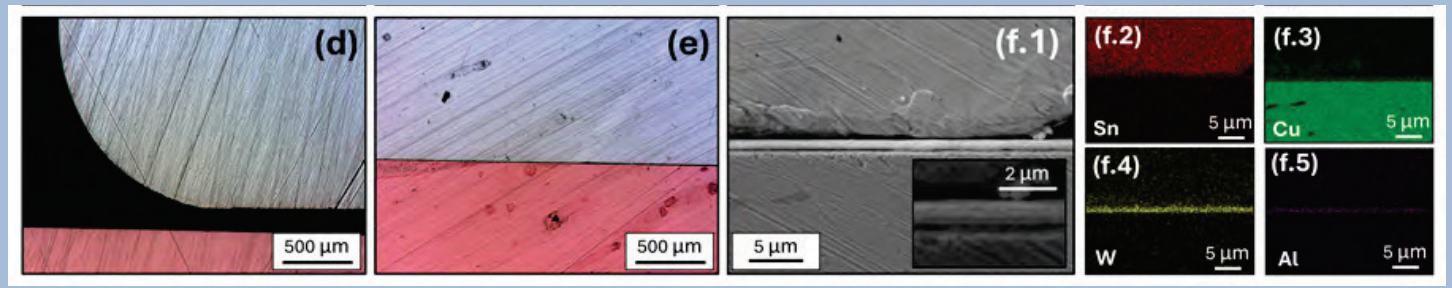
W-WAl-W 3layer





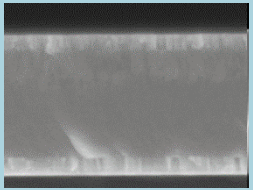
W-WAl-W 7layer

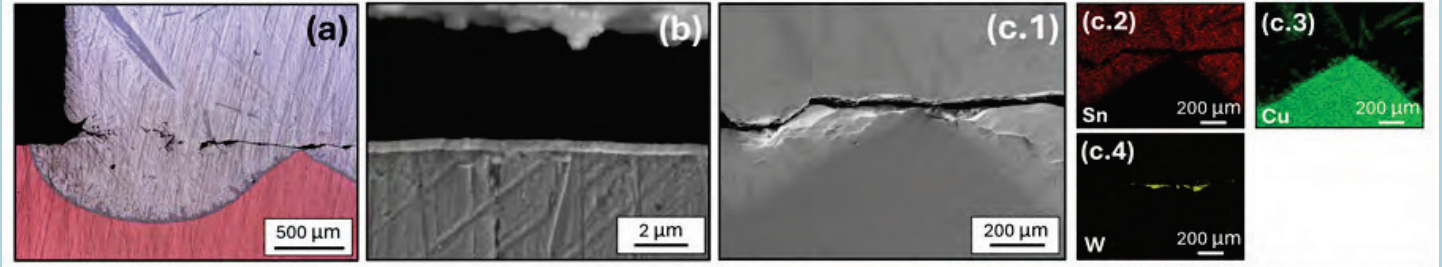




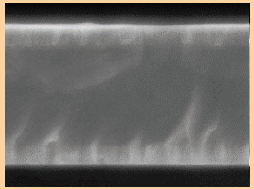
Post-mortem SEM/EDX of exposed samples

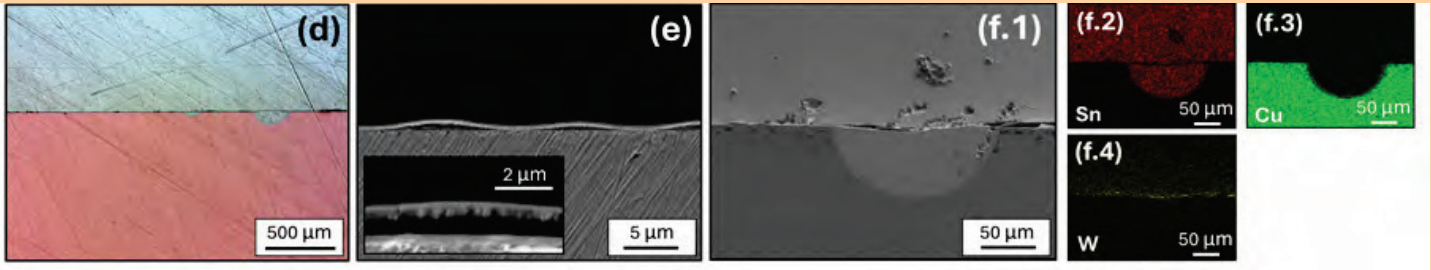
W-WNcrystal-W





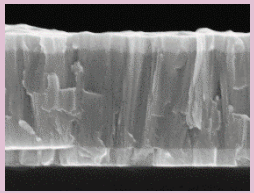
W-WNamorph-W

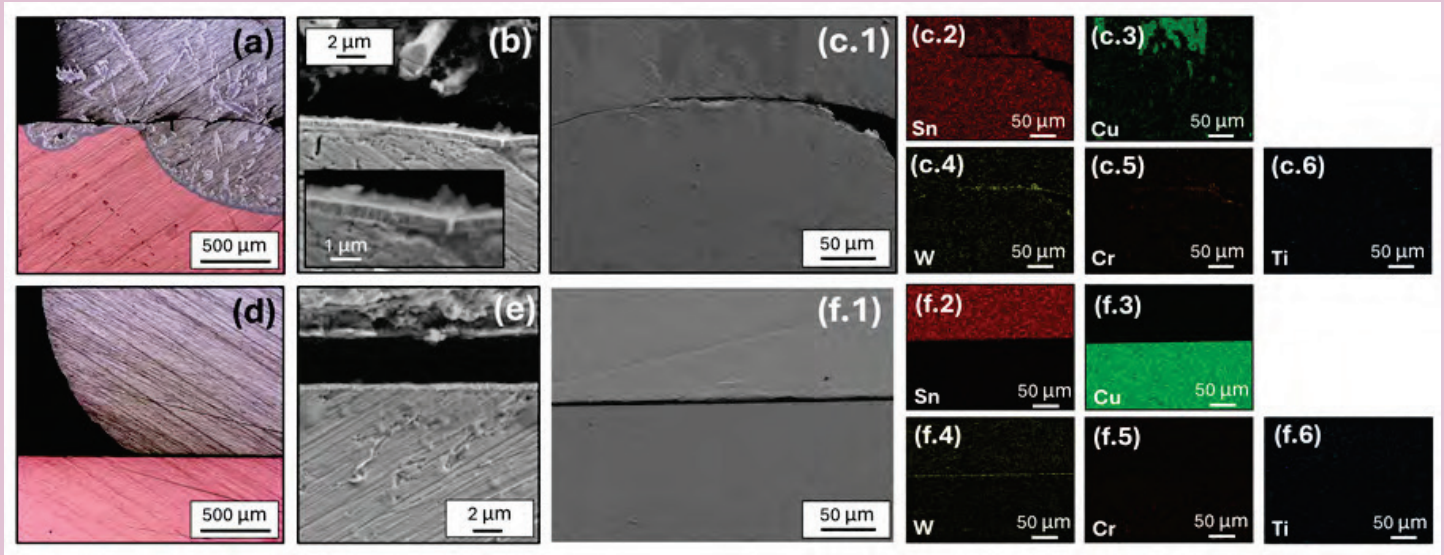




Post-mortem SEM/EDX of exposed samples

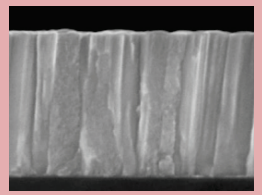
W-WCrTi-W

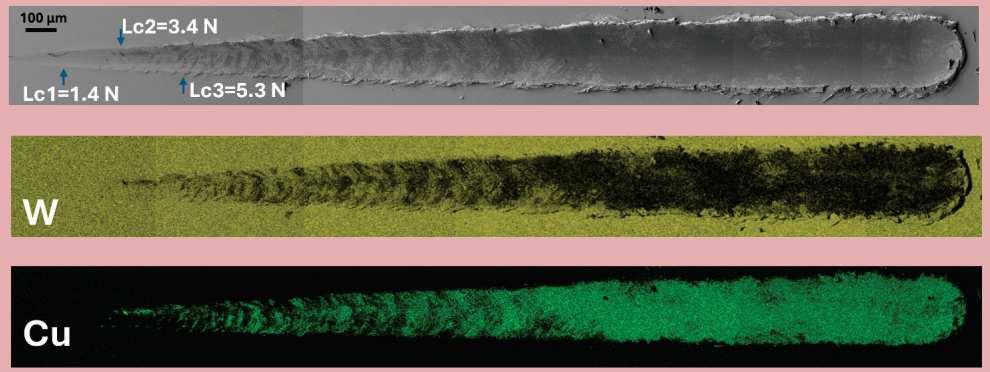




Address coating adhesion: scratch tests

Pure-W

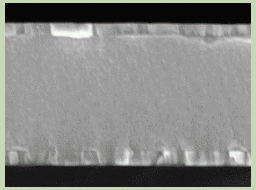


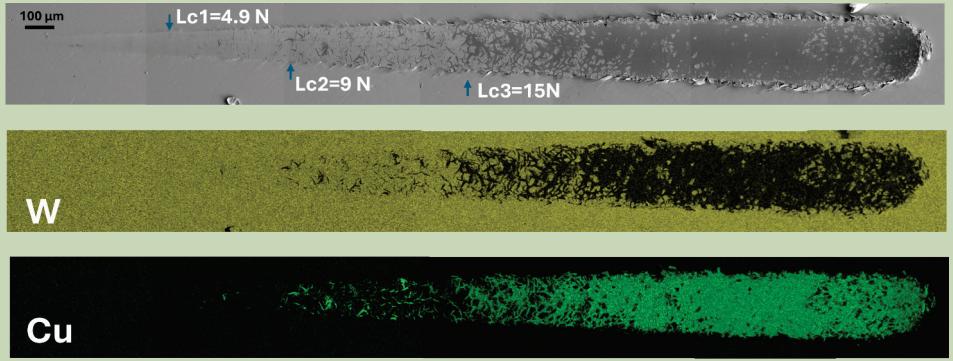


- Significant role of Cu substrate plasticity
- Pure-W is brittle unable to follow plastic deformation of Cu

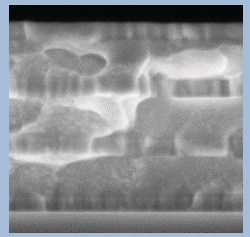
Address coating adhesion: scratch tests

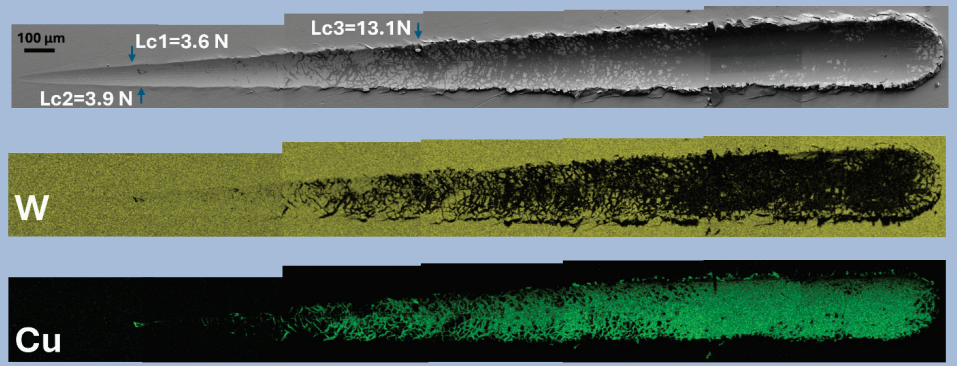
W-WAl-W 3layer





W-WAl-W 7layer

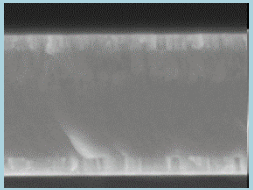


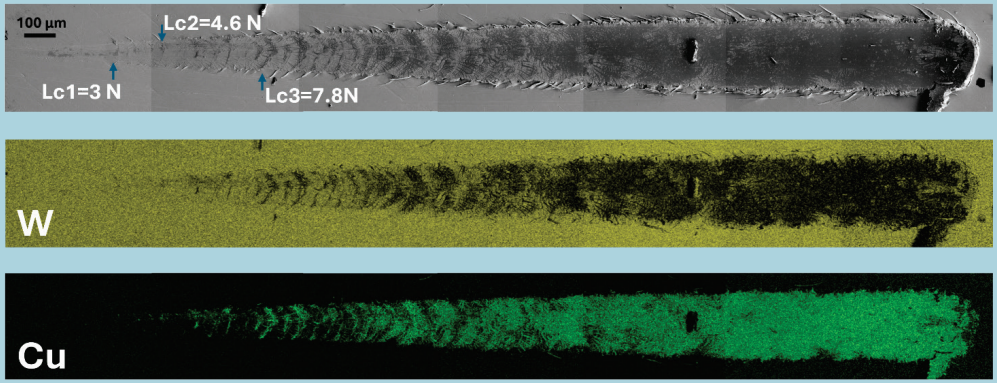


- increased toughness,
- dissipate stresses,
- arrest crack propagation,

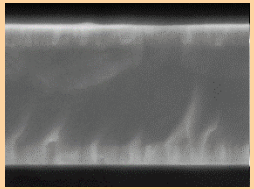
Address coating adhesion: scratch tests

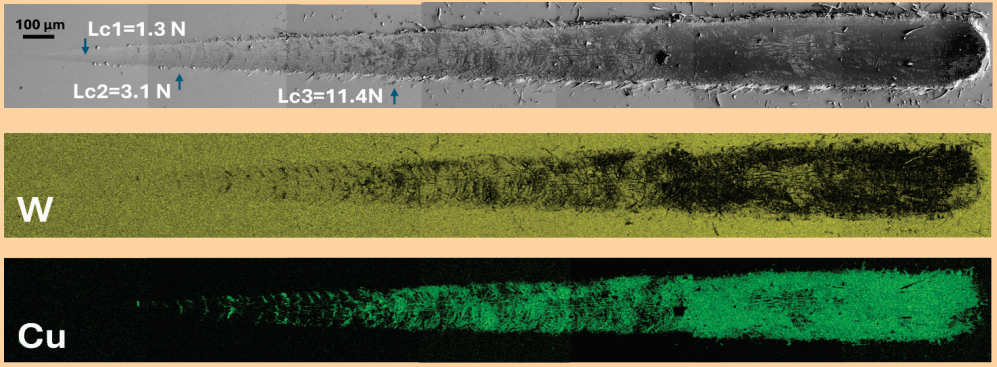
W-WNcrystal-W





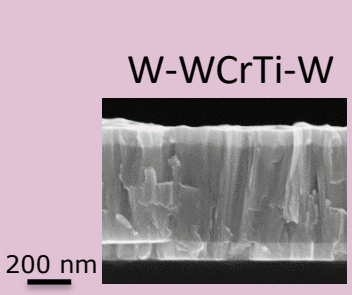
W-WNamorph-W

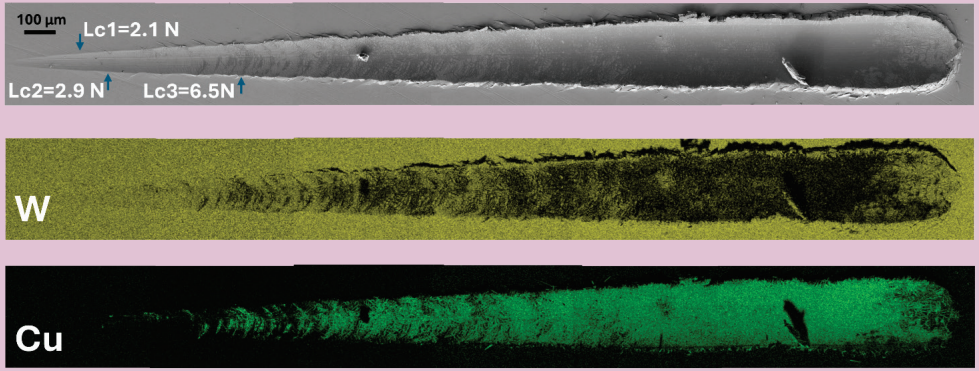




- brittle fracture with extensive spallation,
- relatively poor cohesive properties & toughness,
- consistent with the high hardness and low plasticity of nitrides.

Address coating adhesion: scratch tests



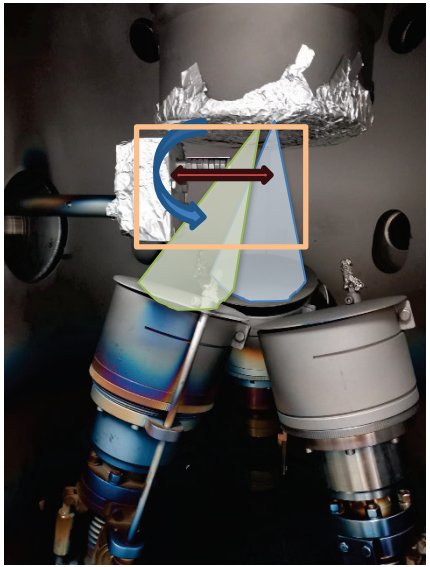


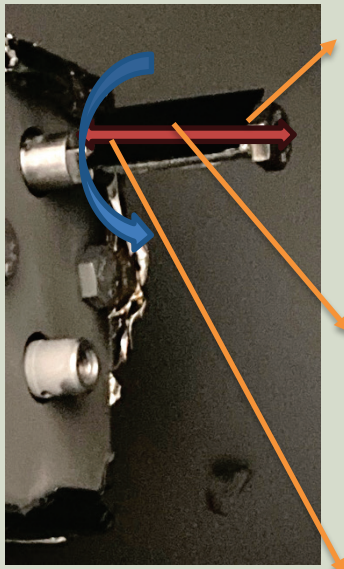
- limited edge cracking
- no evidence of large-scale lateral spallation.
- improved stress distribution wrt W–N coatings

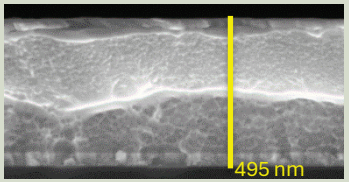
W-based coatings on 3D substrates (2)

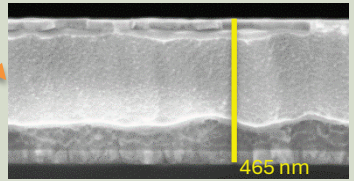
In 2025 working on reproducing the correct composition of W-Al layers (50% W, 50% Al)

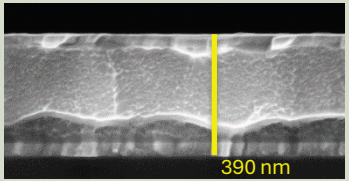
Bi-elemental films





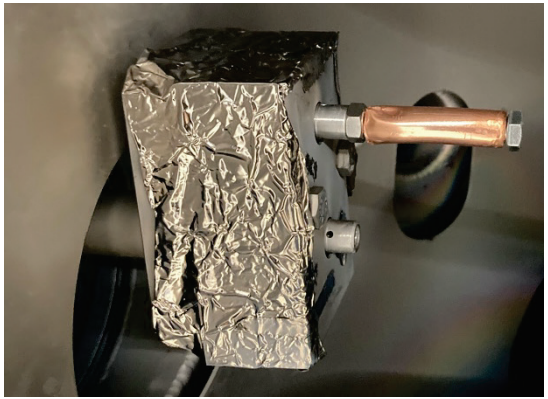


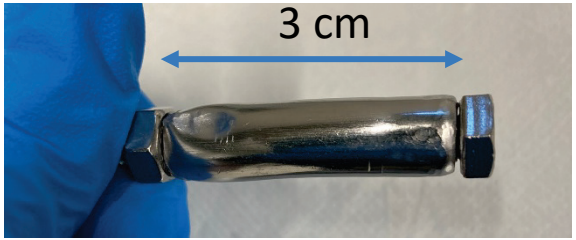




W/WAl/W 3layer on Si
Δz = ±20 mm, ω = 10 rpm
Δt = 30+50+20 minutes

Getting ready to coat the external surface of tubes





Summary of 2025

1. Amorphous W-based films with N in place of Al show promising performance BUT are more brittle with lower adhesion performances
2. Thicker films and multi-layered structures further improve protection AND show best adhesion properties
3. Decisive steps toward a mock-up: deposition on rough substrates and on tubes
4. Draft for the NME Special Issue on “P.R.D. in Fusion Technology” is almost ready

Plans for 2026

- Realize a coated tube, 5-8 cm long, and expose its lateral surface to a Sn-soaked CPS
- Assess stress and adhesion state of micrometer thick films
- Thermal cycling of selected samples: film integrity and crystallinity modifications