

Latest research activities in Coating technologies focusing on thermal spraying

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Coating Technologies

Coating Technologies – Research Group

Research focuses on coating development with high properties and performances for harsh conditions such as icing, corrosion and wear as well as additive manufacturing. Key coating technologies are thermal spraying and cold spraying.

“We are developing future coatings by starting from material optimization through coating processing to final performance towards more sustainable future.”

Group members:

- Ruqaya Khammas, Reza Jafari, Betul Aktas, Razieh Alikhanifaradonbeh (PhD researchers)
- Niklas Kandelin (Project researcher)
- Eero Helmi, Pentti Kalliotiura, Ahmed Tariq, Kamil Khan (Master’s thesis workers)
- Thermal spray operators: Jarkko Lehti, Anssi Metsähonkala



Coating Technologies – Research Group

Project examples:

2023-2027: Refurbishment and additive manufacturing accomplished by kinetic deposition, RE-MAKE, EU/HORIZON/MSCA-DN

2023-2025: Offshore Wind Turbine Farms, OFFwind, EU/Interreg/Aurora

2022-2025: Computationally aided systems engineering for marine advanced technology for the environment, CASEMATE, Business Finland

2020-2025: Sustainable Smart De-Icing by Surface Engineering of Acoustic Waves, SoundOfIce, EU/H2020/FET-OPEN

2019-2020: Cold spraying for harsh material repairs, MATINE, national funding

2018- Service research for companies



Interreg
Aurora



Co-funded by
the European Union

BUSINESS
FINLAND



SOUND of ICE



SOUNDofICE H2020-FETOPEN-2018-2019-2020-01 call GA n°: 899352

Research topics

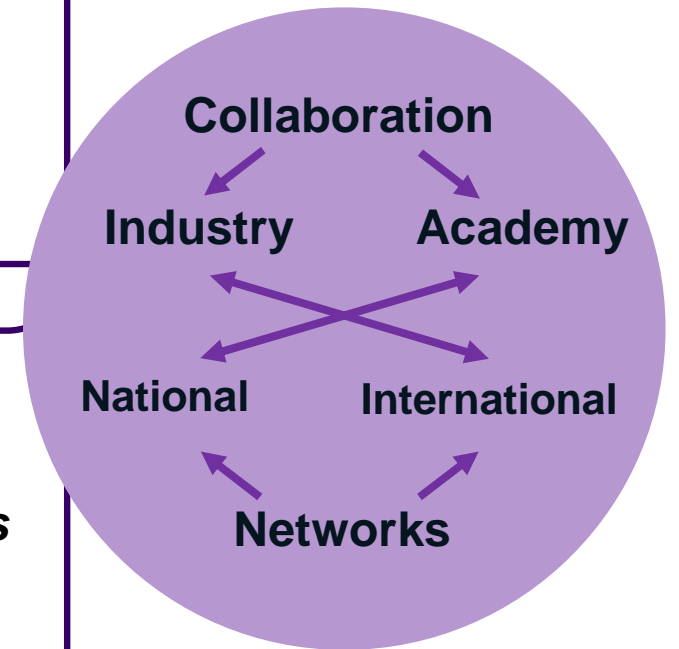
Coating technologies

- New potential applications
- Functional coatings
- Additive manufacturing
- Repair and restoration
- Thermal spraying
- Cold spraying

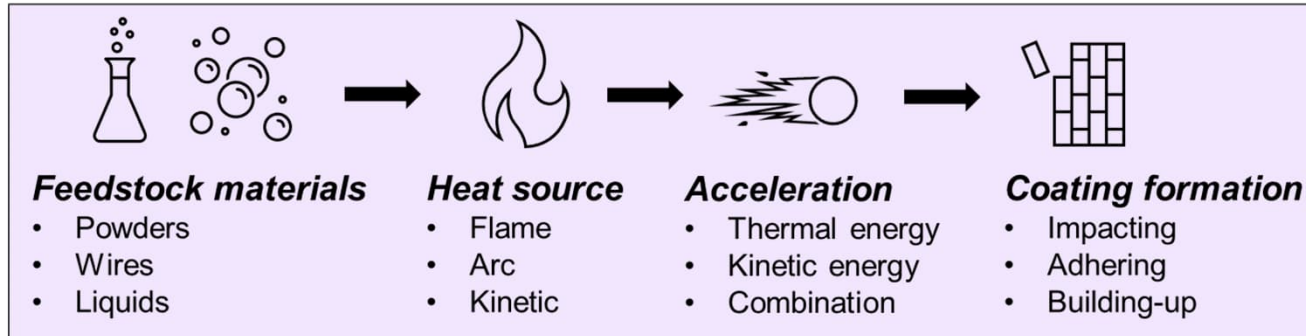
Icing research

- Developing research area
- De-icing and anti-icing
- Icephobic coatings and surfaces
- New applications

- *Future coating designs*
- *Sustainable coatings*
- *Application-related requirements*
- *Multifunctionality*
- *Energy and eco efficiency*



Thermal spraying



- Wide range of coating and substrate materials: Metals, alloys, hardmetals, ceramics, plastics and composites
- High deposition rate
- Good coating properties
- Potential of thermally sprayed coatings
 - Large material selection
 - Industrial scale coating manufacturing process for large areas
 - Onsite spraying, manual and automatized processes



Structure and surface modifications



Color tailoring by feedstock

Thermal spraying

Key research areas

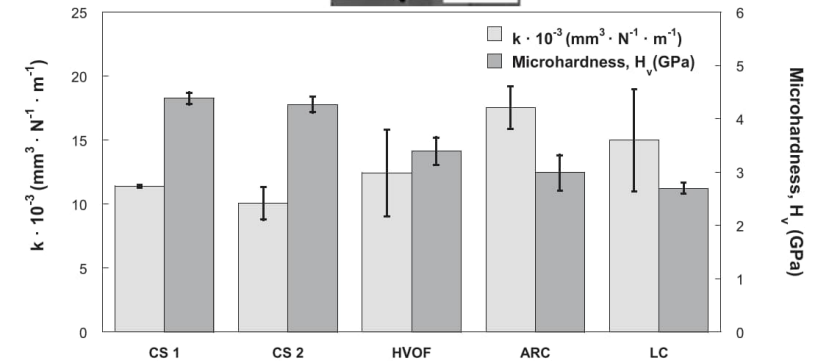
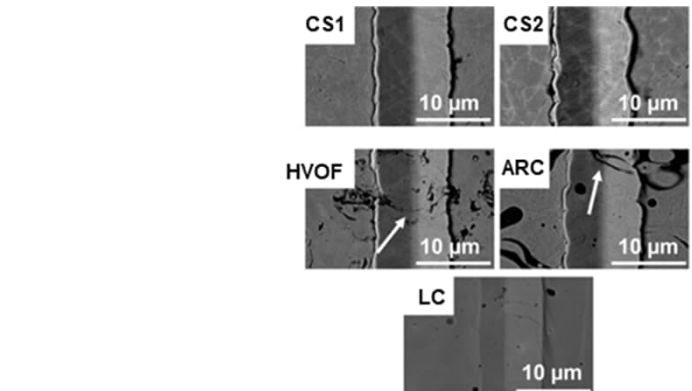
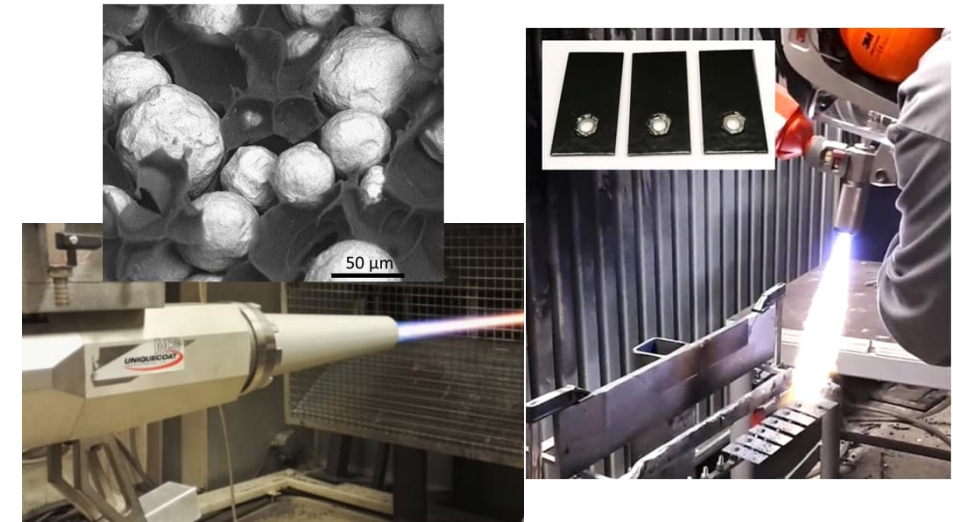
- Processing and manufacturing of coatings and surfaces by thermal spraying
- Material development and tailoring, novel coatings
- Requirements and performance

Thermal spraying

- Flame spraying, high velocity flame spraying (HVOF, HVAF) and plasma spraying
- Polymers, hardmetals, metals, ceramics and composites
- Functional coatings, corrosion and wear protection
- Coatings for harsh conditions (e.g., icing)

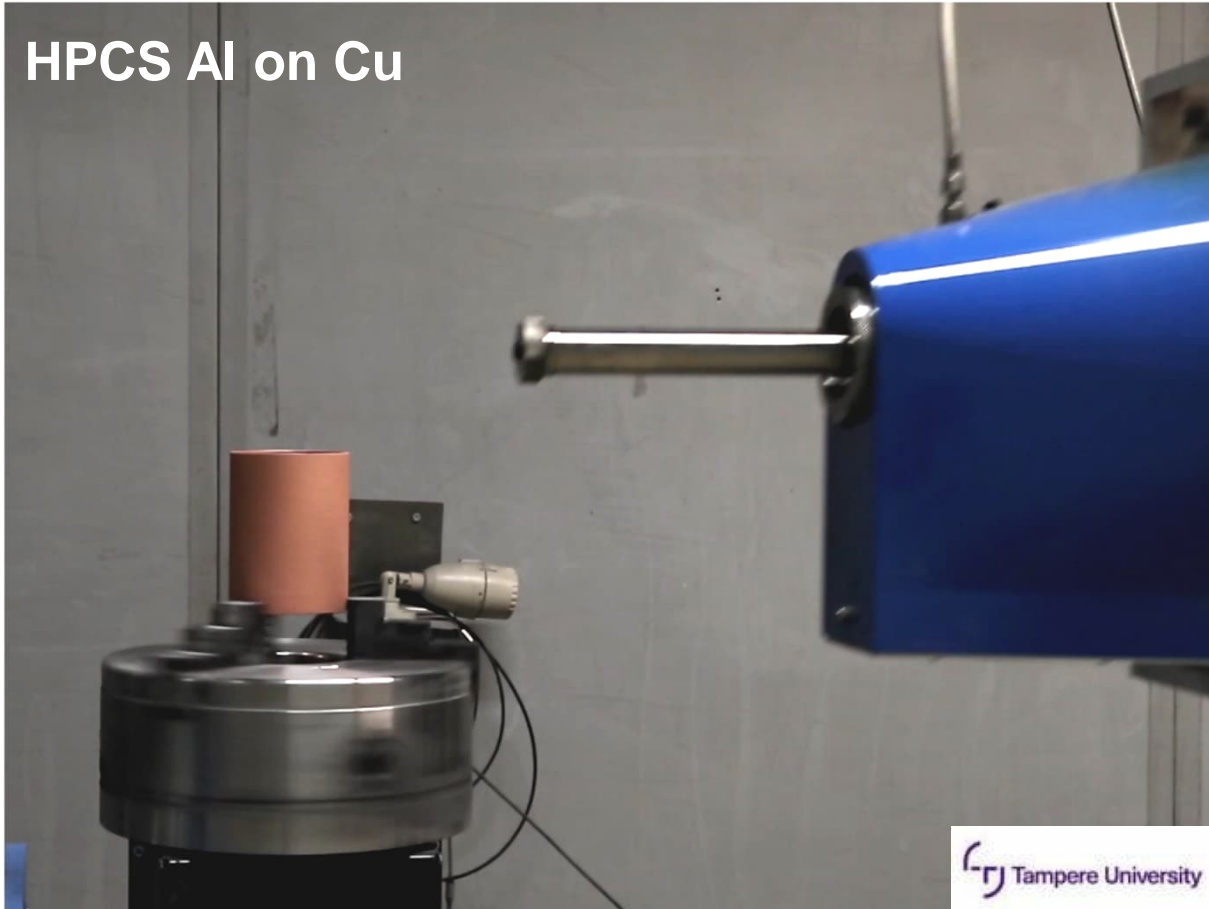
Latest publication:

R. Cortés, M.A. Garrido-Maneiro, H. Koivuluoto, G. Boilelli, S. Morelli, V. Testa, L. Lusvarghi, J. Kondas, P. Poza, Local wear resistance of Inconel 625 coatings processed by different thermal techniques: A comparative study, *Surface and Coatings Technology*, 2023, 470, 129831, doi: 10.1016/j.surfcoat.2023.129831

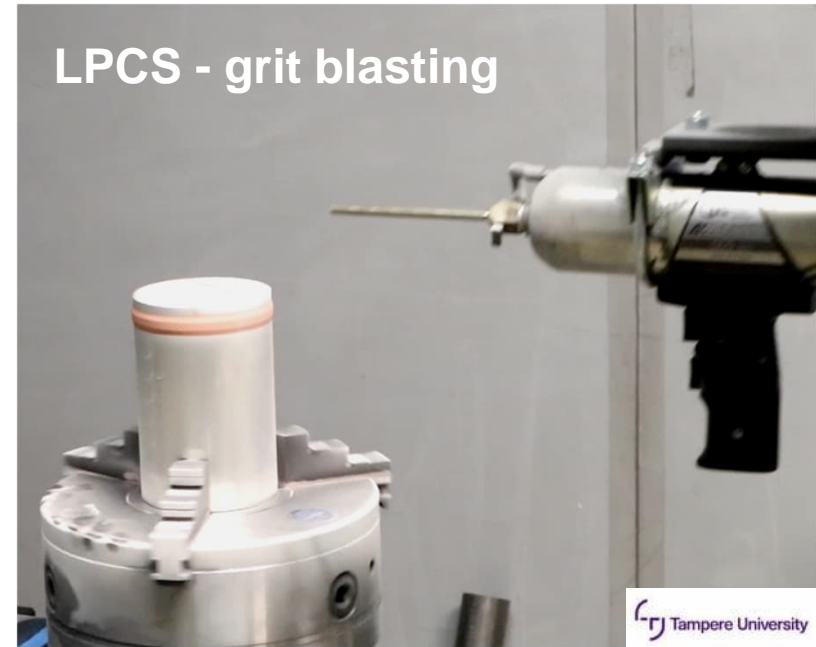


Cold spraying

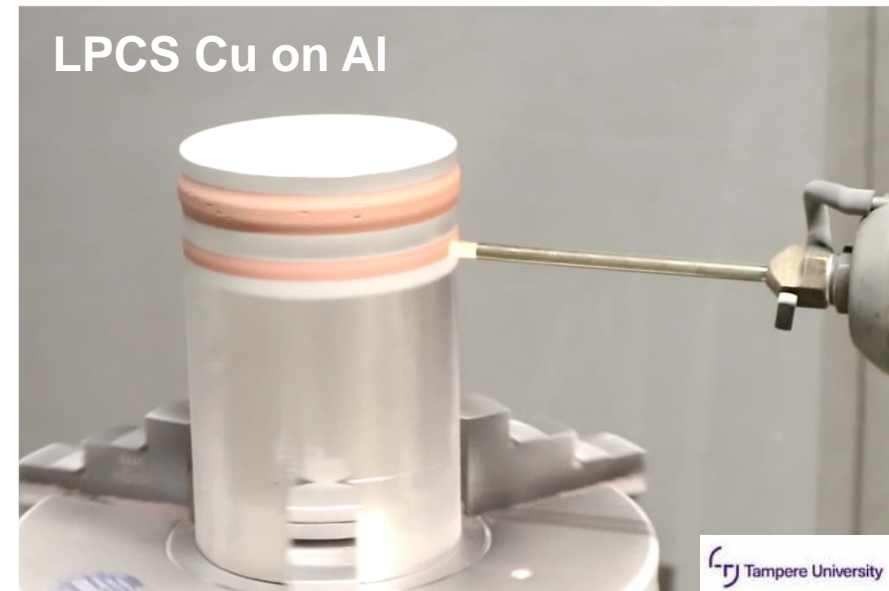
HPCS Al on Cu



LPCS - grit blasting



LPCS Cu on Al



Cold spraying

Key research areas

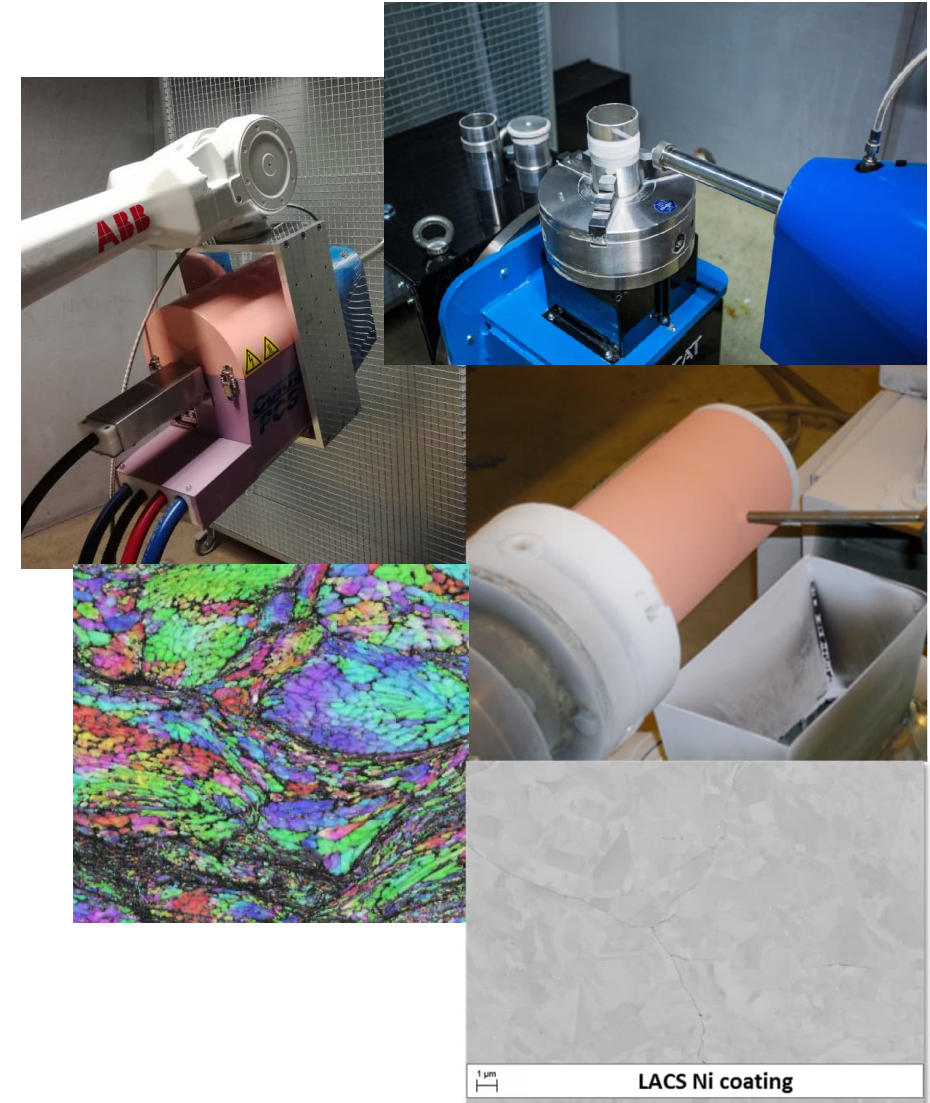
- Processing and manufacturing of coatings and surfaces by thermal spraying
- Multi-material solutions, additive manufacturing
- Requirements and performance

Cold spraying

- High-, medium- and low-pressure cold spray processes
- Laser-assisted cold spraying
- Metals and composites, polymers
- Dense and pure coatings, bulk material properties
- Corrosion, electrical conductivity, repair, AM

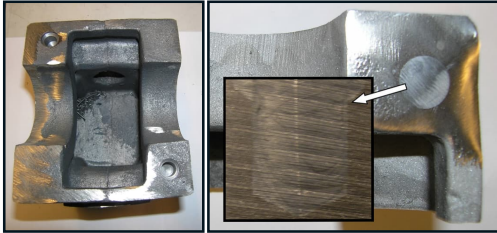
Latest publication:

R. Jafari, J. Kiilakoski, M. Honkanen, M. Vippola, H. Koivuluoto, Wetting Behavior and Functionality Restoration of Cold-Sprayed Aluminum-Quasicrystalline Composite Coatings, *Journal of Thermal Spray Technology*, 32 (2-3) 2023, 609-626, doi: 10.1007/s11666-022-01522-w



Cold spray - Repair

Valve body (gray cast iron)



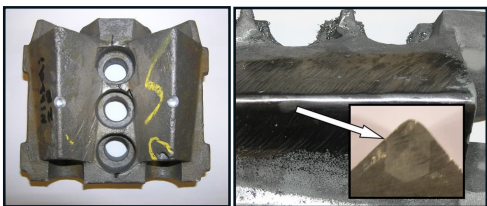
LPCS Zn+Al+Al₂O₃

Brake shoe (gray cast iron)



LPCS Zn+Cu+Al₂O₃

Tool holder (tempering steel)



LPCS Zn+Ni+Al₂O₃

Zn-based repair materials for LPCS

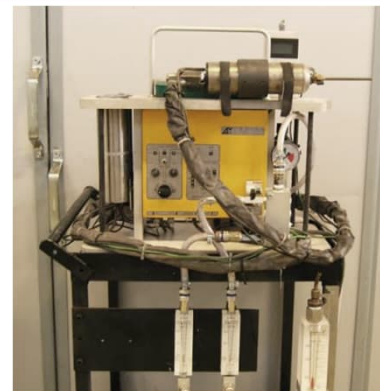
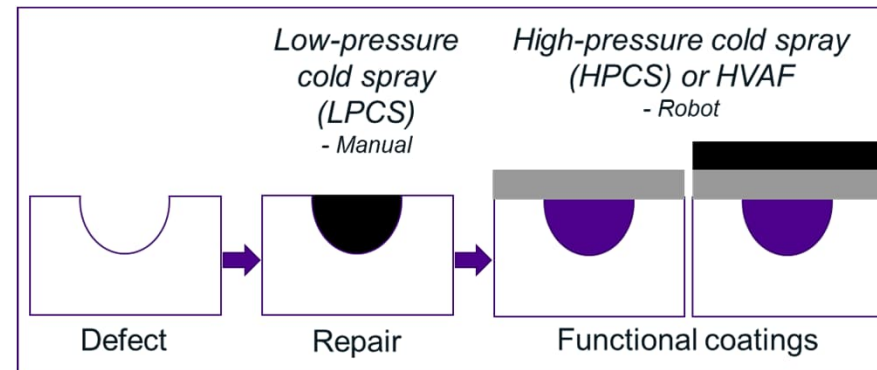


Needs for high performance surfaces



Functional coating on repaired component

Multifunctional cold spraying for repair



Corrosion protection
*Metallic materials

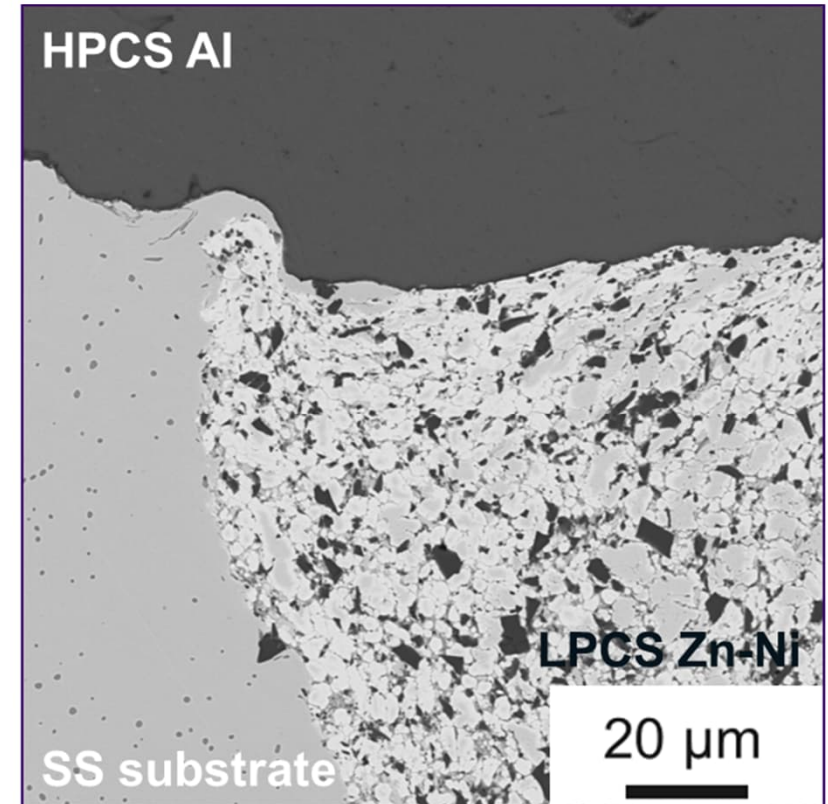
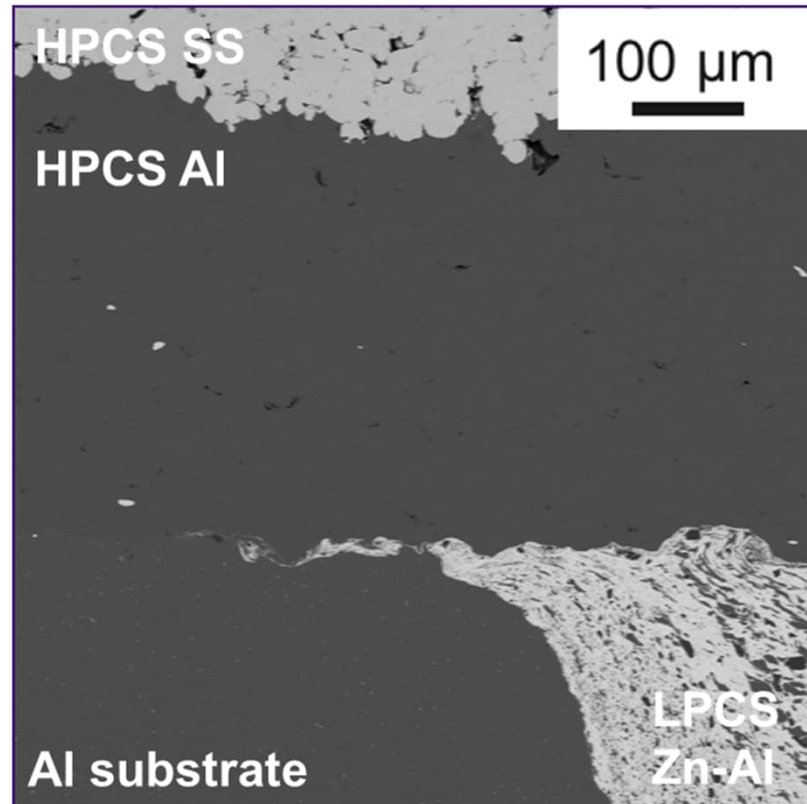
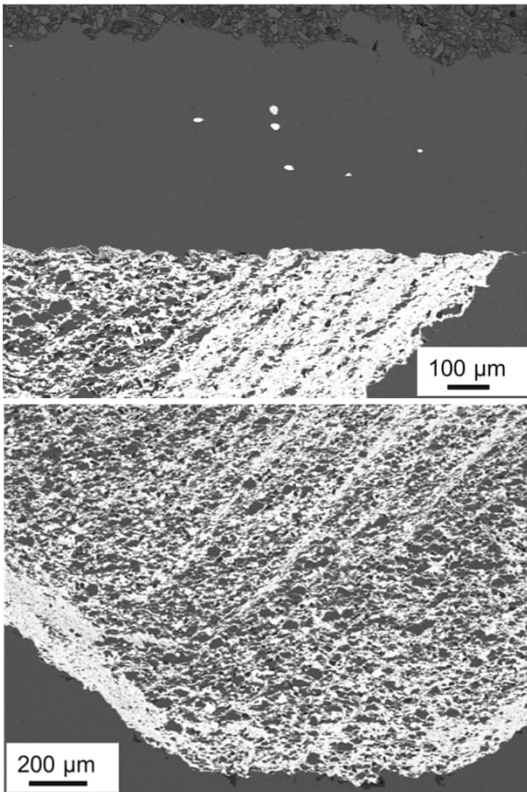
Wear protection
*Hardmetals



Koivuluoto et al., THERMEC'2023, Vienna, Austria

Multifunctional cold spraying for repair

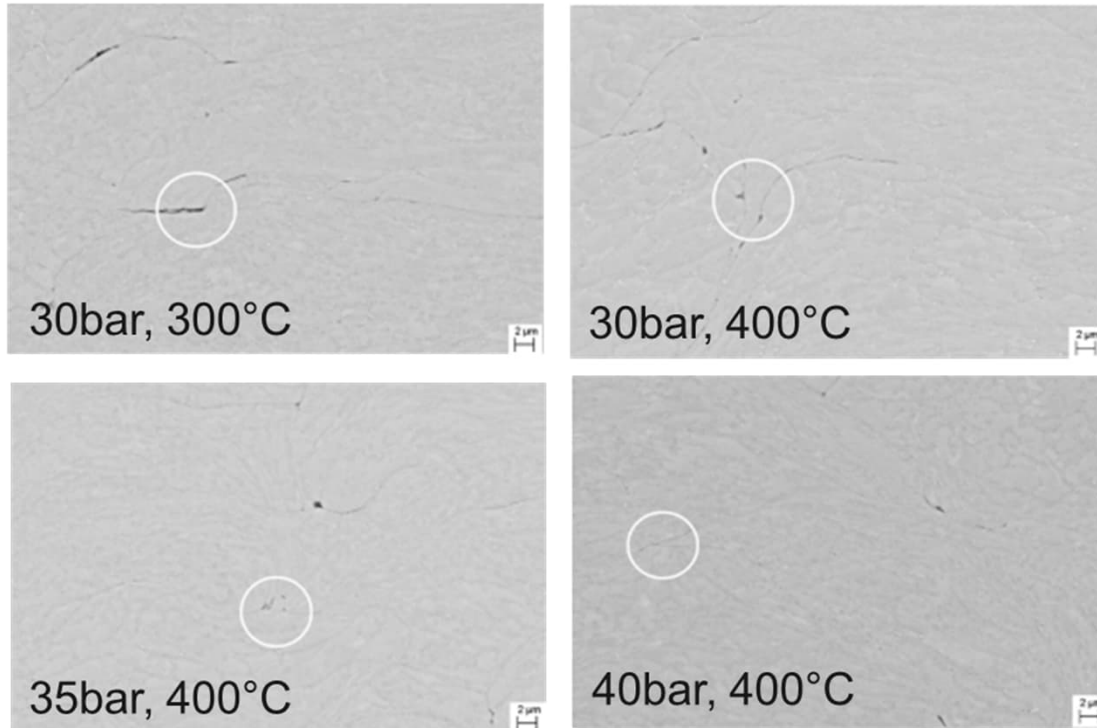
HPCS Al
 LPCS Zn-Al-Al₂O₃
 Al substrate



Koivuluoto et al., THERMEC'2023, Vienna, Austria

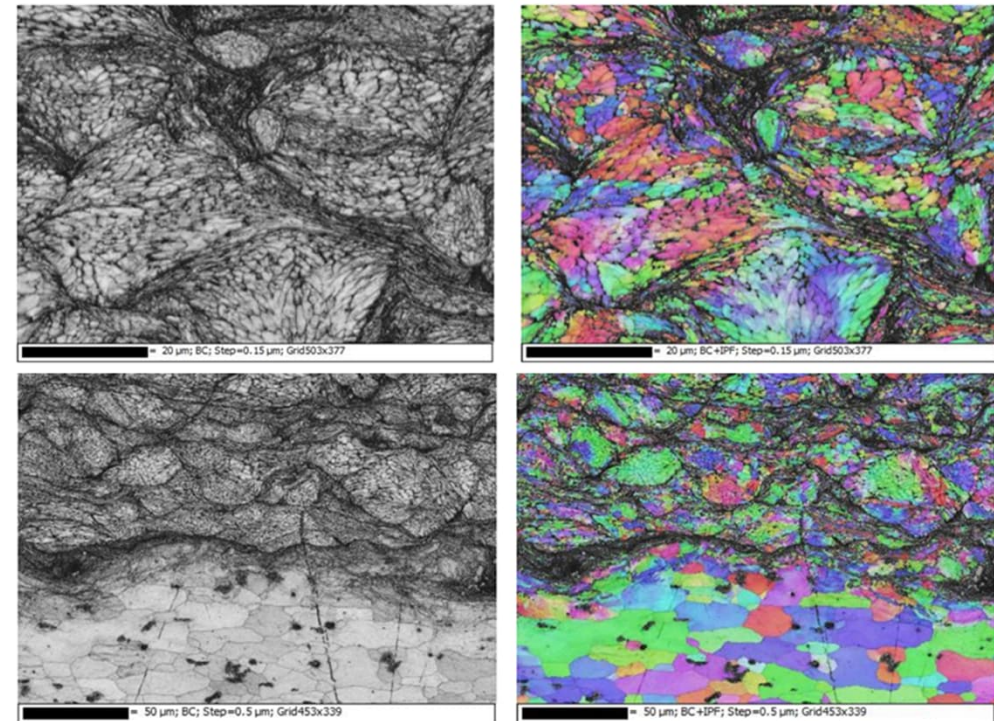
HPCS dense and protective coatings

HPCS Aluminium Al6061



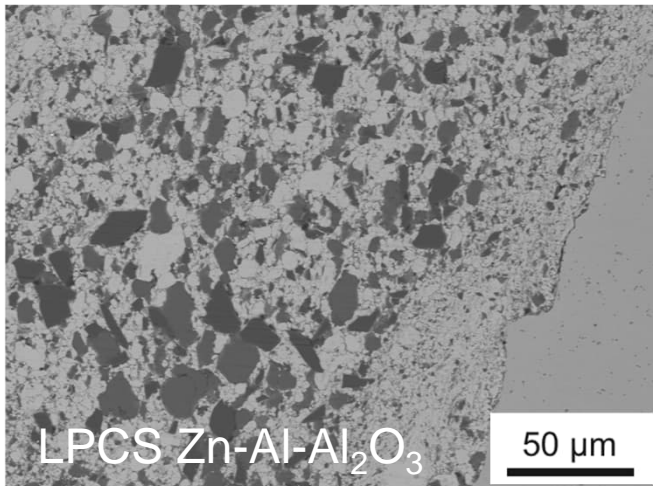
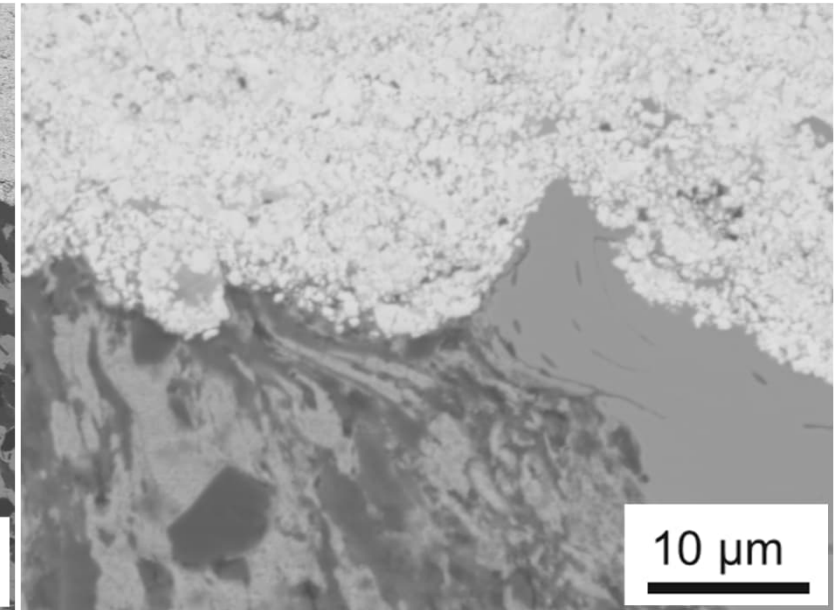
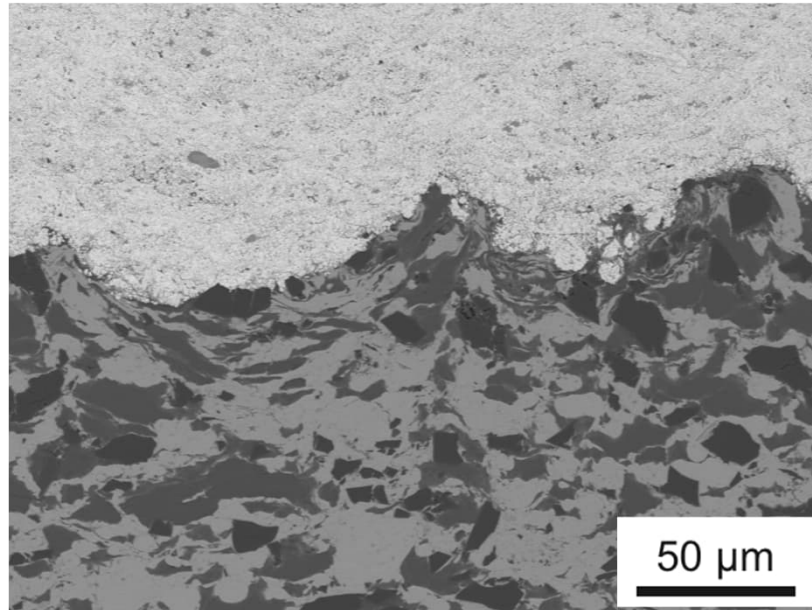
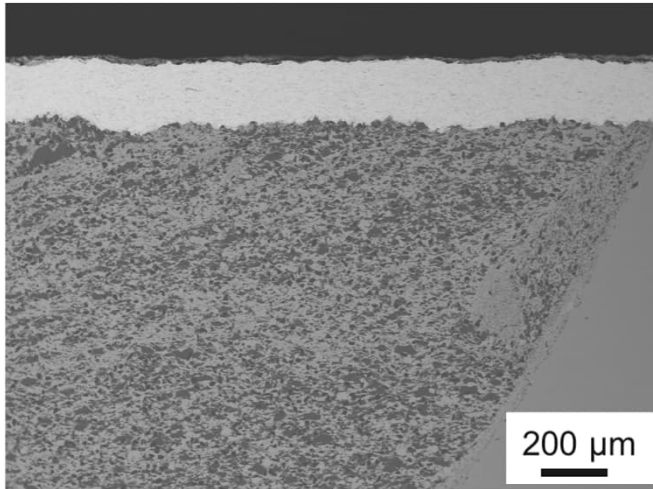
Koivuluoto et al., Coatings, 10 (4) 2020, 248

HPCS Aluminium Al2024



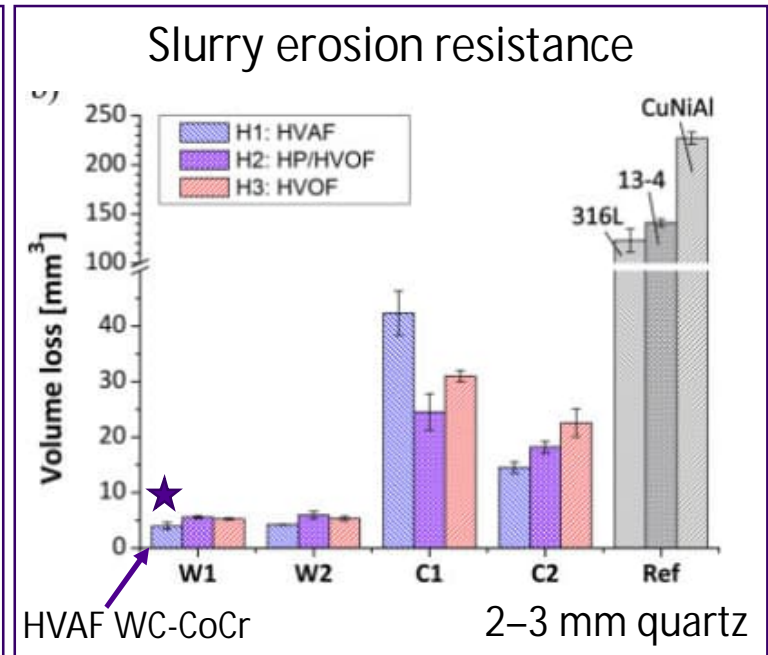
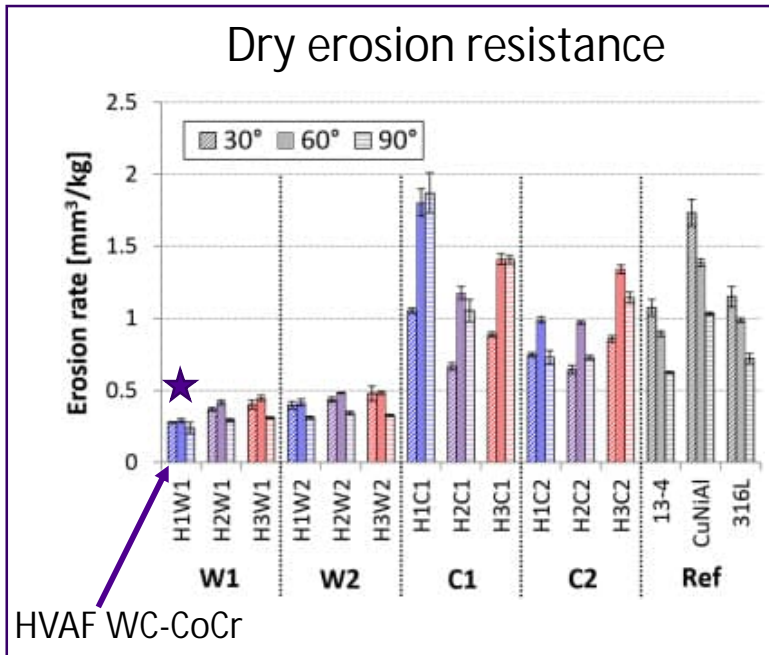
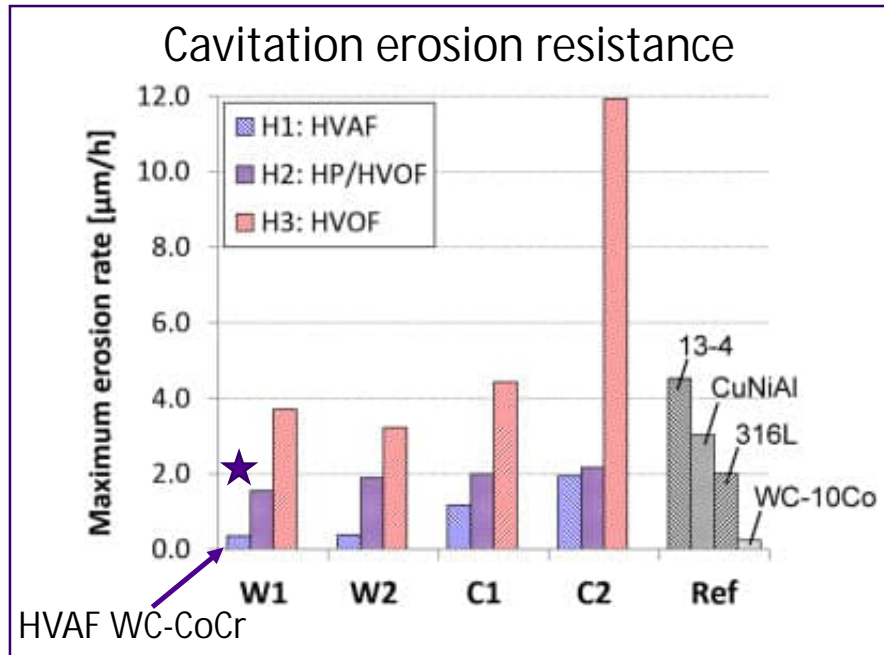
Koivuluoto et al., SCANDEM2022

Multifunctional repair (LPCS and HVOF)

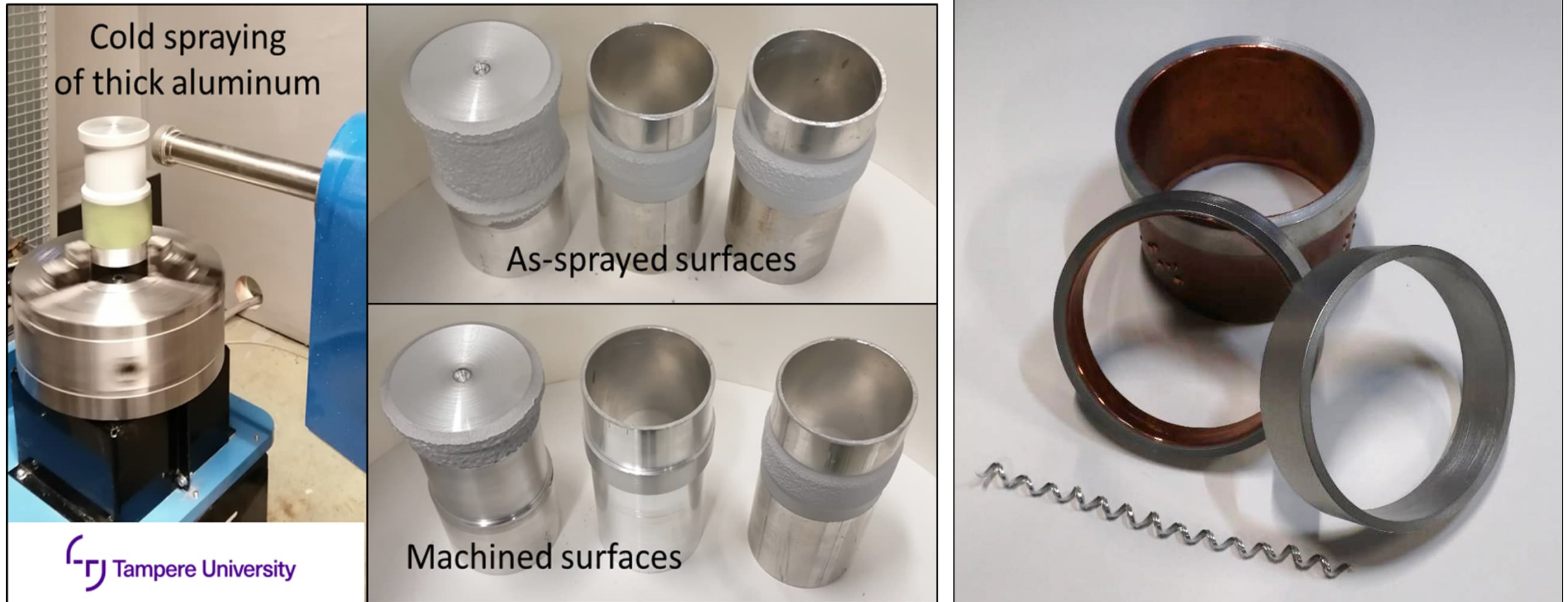


Process step	Material	Hardness HV _{0.3}
Coating	HVOF WC-CoCr	1312±60
Repair	Zn-Al-Al ₂ O ₃	80±6
Substrate	Stainless steel	260±8

HVAF WC-CoCr – Wear resistance



Cold Spray – Additive Manufacturing



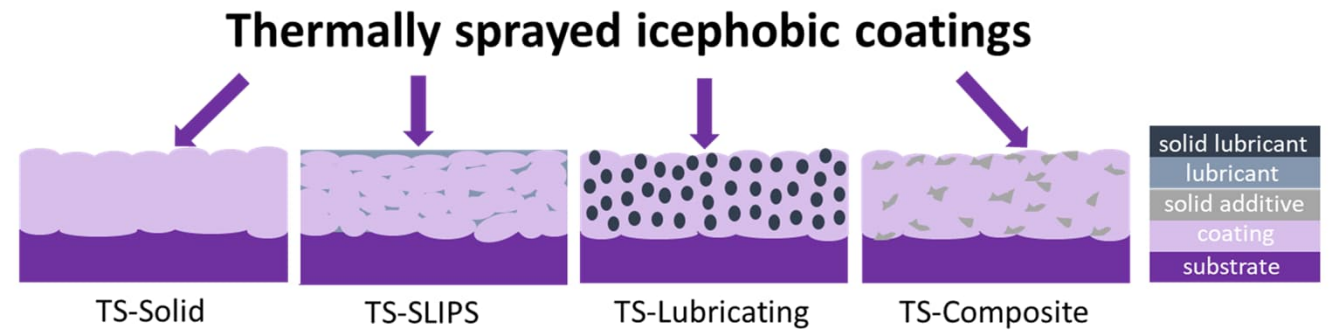
Icing research

Key research areas

- Development of icephobic coatings
- Ice laboratory with icing wind tunnel and ice adhesion measurement devices
- De-icing and anti-icing
- Icing behavior of different materials and surfaces
- Application-related development work

Latest publication:

R. Khammas, H. Koivuluoto, Durable Icephobic Slippery Liquid-Infused Porous Surfaces (SLIPS) Using Flame- and Cold-Spraying, Sustainability, 14 (14) 2022, 8422, doi: 10.3390/su14148422



Lower ice adhesion, higher icephobicity

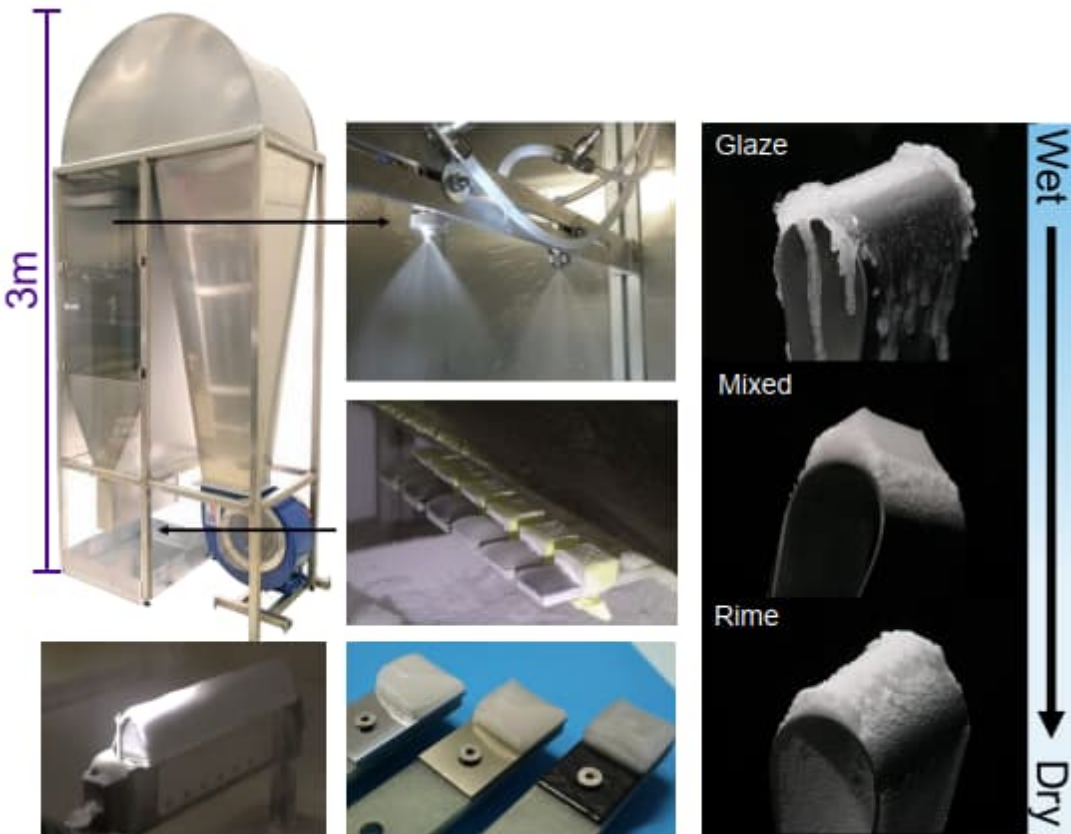
H. Koivuluoto et al., Thermally sprayed coatings: Novel surface engineering strategy towards icephobic solutions, Materials, 13(6) 2020, 1434



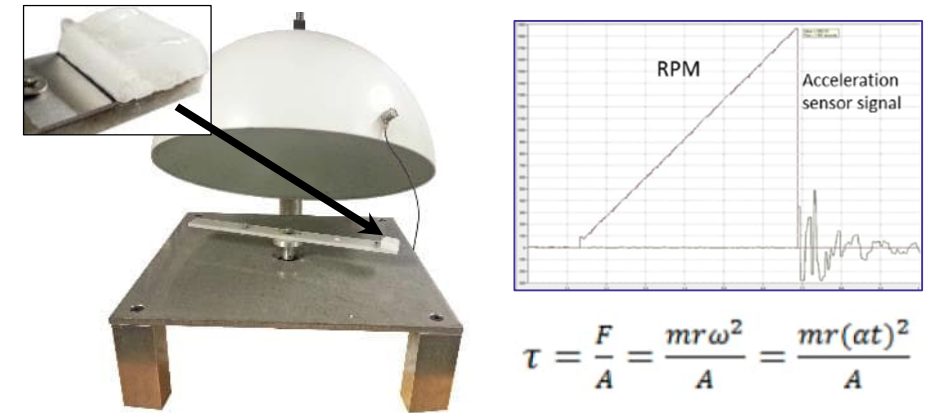
Photos: Jonne Renwall/TAU

ICE Laboratory

Icing wind tunnel (IWIT)



Centrifugal ice adhesion test (CAT)



Icing parameters:

- Temperature: -40°C – RT
- Wind speed: 0 – 25 m/s
- Droplet size: 25 – 1000 μm
- LWC: 0 – 4.2 g/m³
- Iced area: 0.5 – 50 cm²
- Ice type: rime, mixed glaze, glaze

Pushing ice adhesion test



Development of de-icing:

Sustainable Smart De-Icing by Surface Engineering of Acoustic Waves,
EU/H2020/FETOPEN -project



Conclusions

Advanced coatings for harsh conditions



Teamwork
Collaboration
New collaborators

- *Future coating designs*
- *Novel applications*
- *Environmentally friendly solutions*

Thank you for your attention!

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