# Optimisation Of Next Generation Galvanising Pot Hardware

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# Galvanised Steel

## Corrosion protection

- Zinc provides effective protection against corrosion

## Galvanised coatings

- Zinc coatings applied to steel for corrosion protection

## Automotive industry coatings

- Smooth coating surface essential for paint application
- Zn-Al (GI) bath composition used in Tata Steel's Llanwern CG line

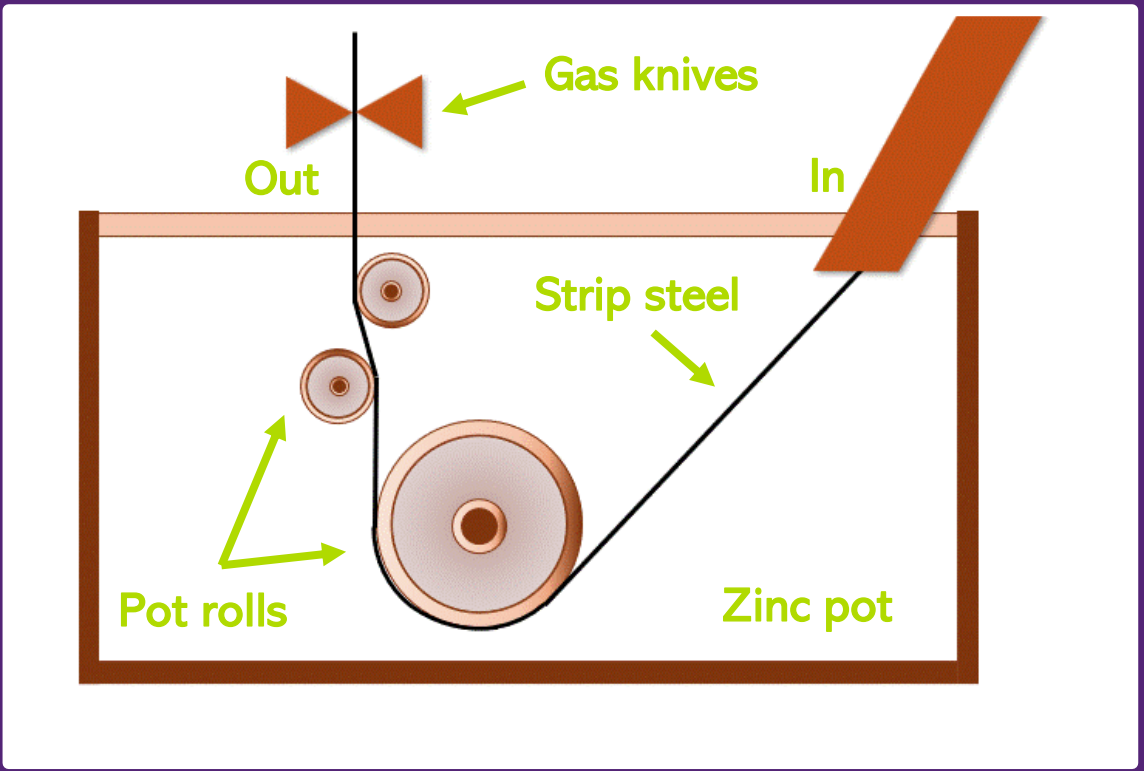
## MagiZinc® for weight reduction:

- Zn-Al-Mg coatings
- Offer superior corrosion protection with half the thickness of GI

*Galvanised steel is used for making car body panels*

# Continuous Galvanising

- The galvanising bath hardware guides the strip steel in the molten metal bath
- The hardware consists of submerged pot rolls and journal bearings



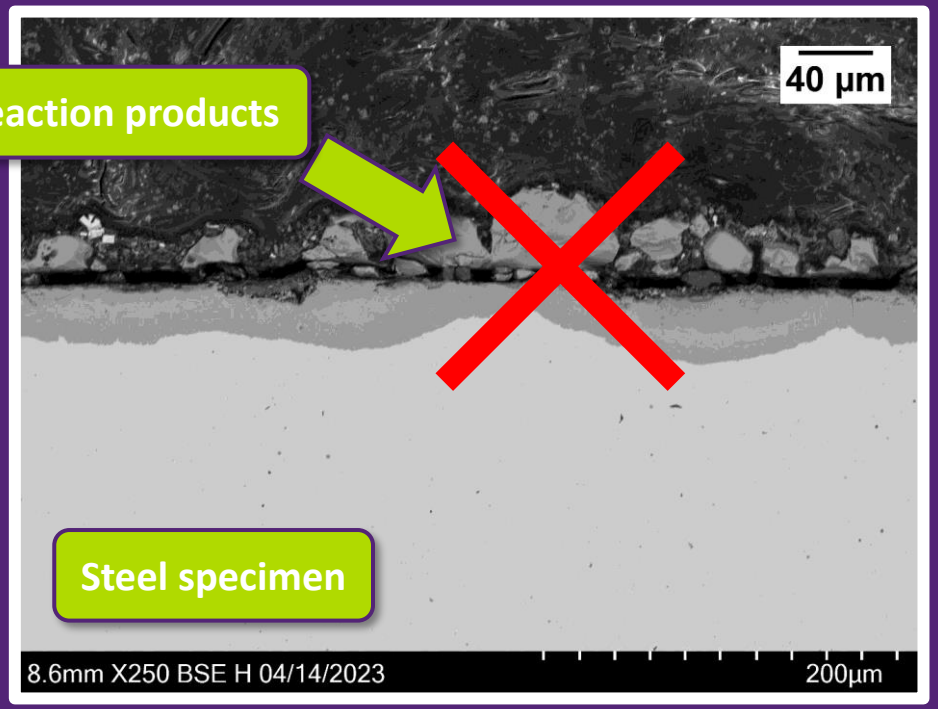

*Coating section of a continuous galvanising line*

# Galvanising Pot Hardware

- **Zn attack:** bearing materials react with molten zinc, forming complex reaction products
- **Limited service life:** the reaction products affect the durability of the bearings, leading to deterioration of the bearing surface
- **Improving durability:** Implementing bearings with extended lifetime reduces downtime for maintenance
- **Impact on production and quality:** higher production yields and improved quality


*Galvanising pot hardware*

# Scope of Research




*Cross-section of 316L stainless steel after immersion in Zn-Al*

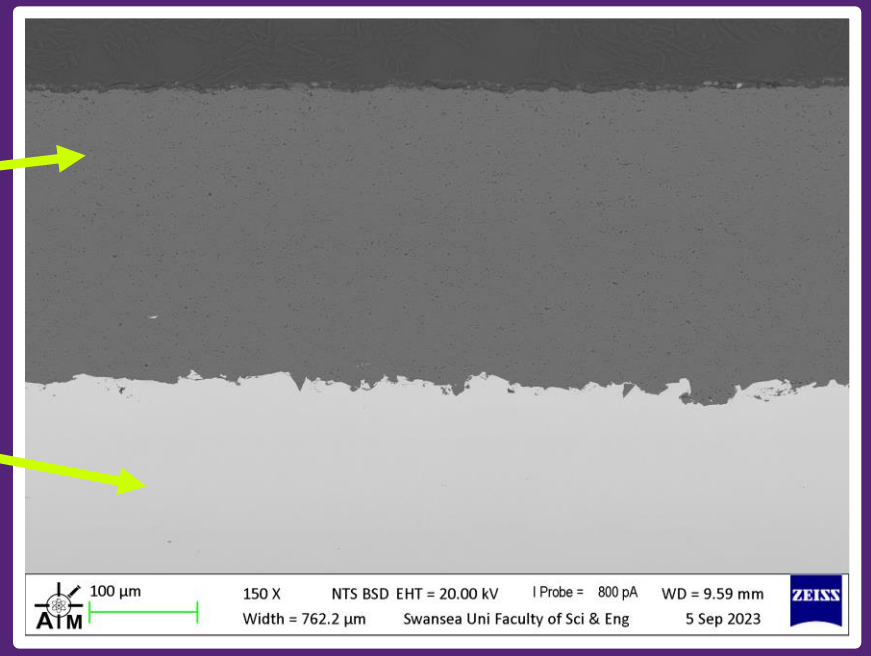
**Aim:** to suppress the reactions with the molten metal bath to the point of virtual inertness

**Ceramic materials** have potential to remain unreactive in many molten metals

Our previous work showed that $Al_2O_3$ is inert in Zn-Al and Zn-Al-Mg

# $Al_2O_3$ Coatings

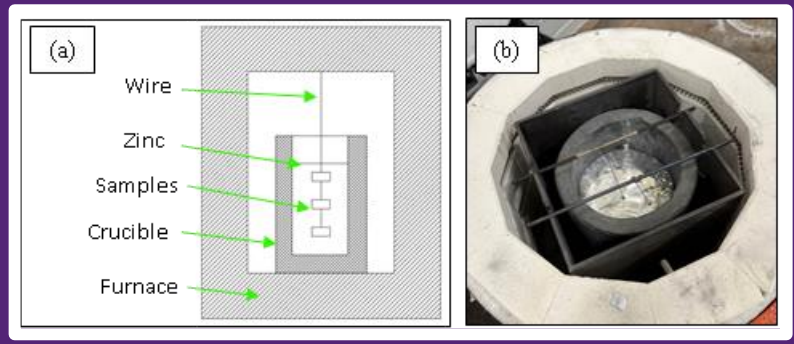
- A 250 µm **alumina coating** was applied via HVOF onto Stainless Steel 316L
- The thermal spray process was carried out by Engineered Performance Coatings (Cardiff, UK)
- The function of the coating is to shield stainless steel from the attack of liquid zinc




*SEM image of an untested HVOF alumina coating*

# Static Dip Testing

- HVOF applied Alumina coatings were immersed in two zinc alloy baths for five weeks
  - 0.3 wt% Al-Zn (**GI**)
  - 1.5wt% Mg-1.5wt% Al-Zn (**MagiZinc®**)
- The baths were kept at **465°C**
- Samples were removed after 1, 2, 3, 4 and 5 weeks of testing
- The residual Zn was removed with 35% HCl solution




*(a) Experimental setup; (b) Top loading furnace*

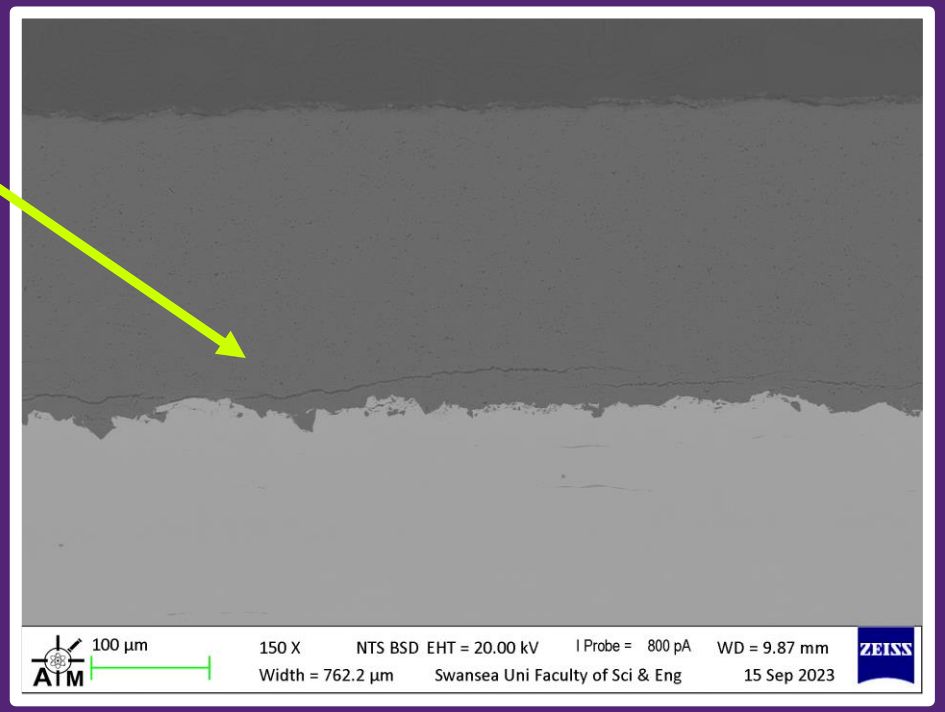
*ZEISS EVO SEM with EDS detector*

# Results

## Zn-Al bath

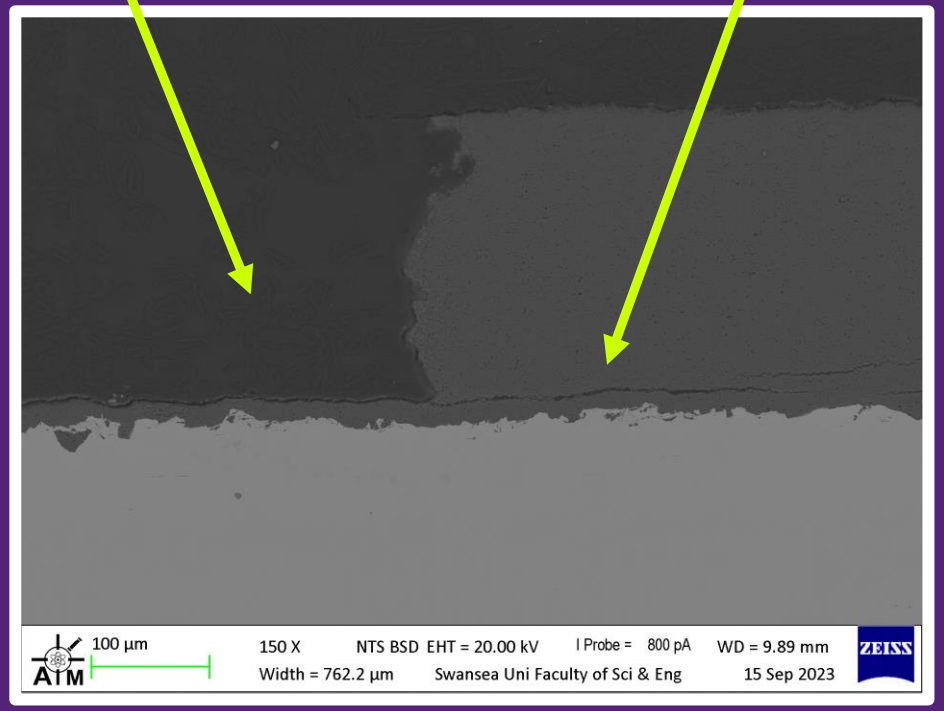
# 1 Week of Testing

horizontal cracks



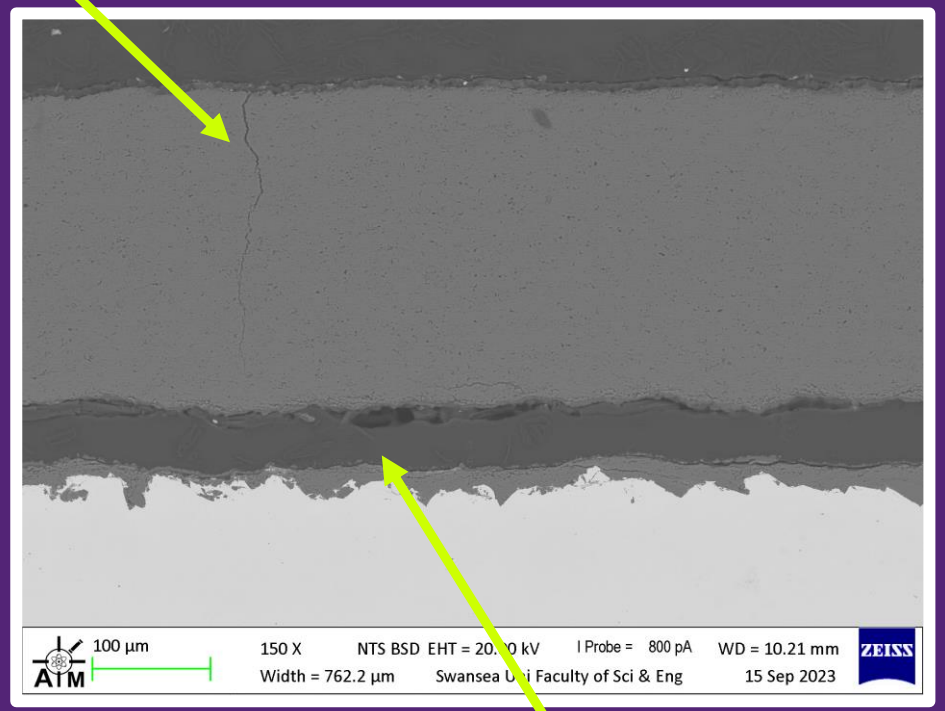

coating missing

horizontal crack



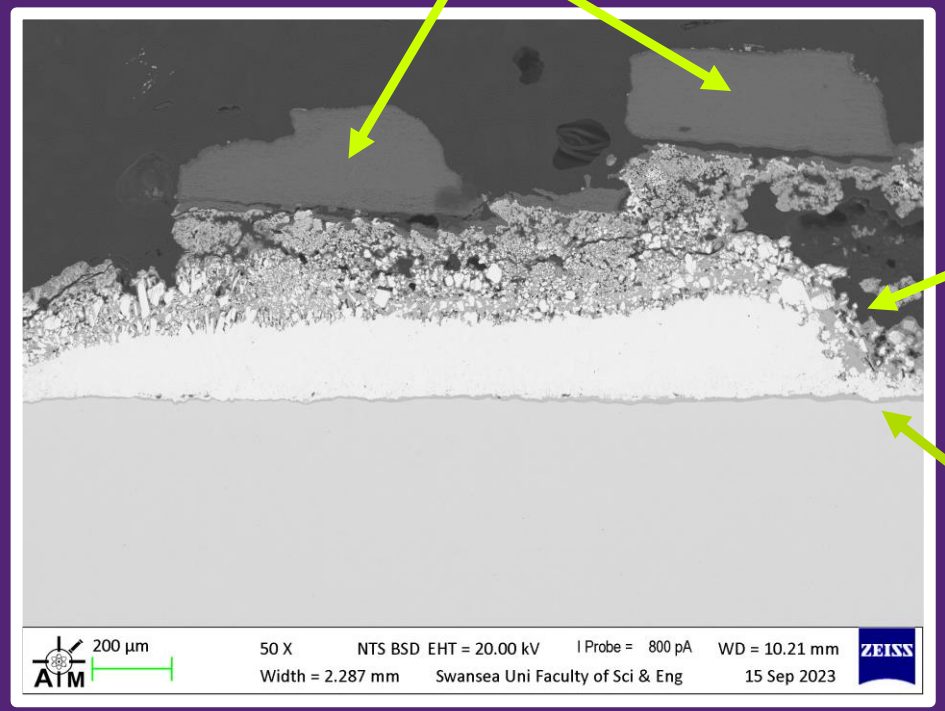
# 3 Weeks of Testing

vertical crack




large horizontal crack

fragments of coating




residual Zn

diffusion layer

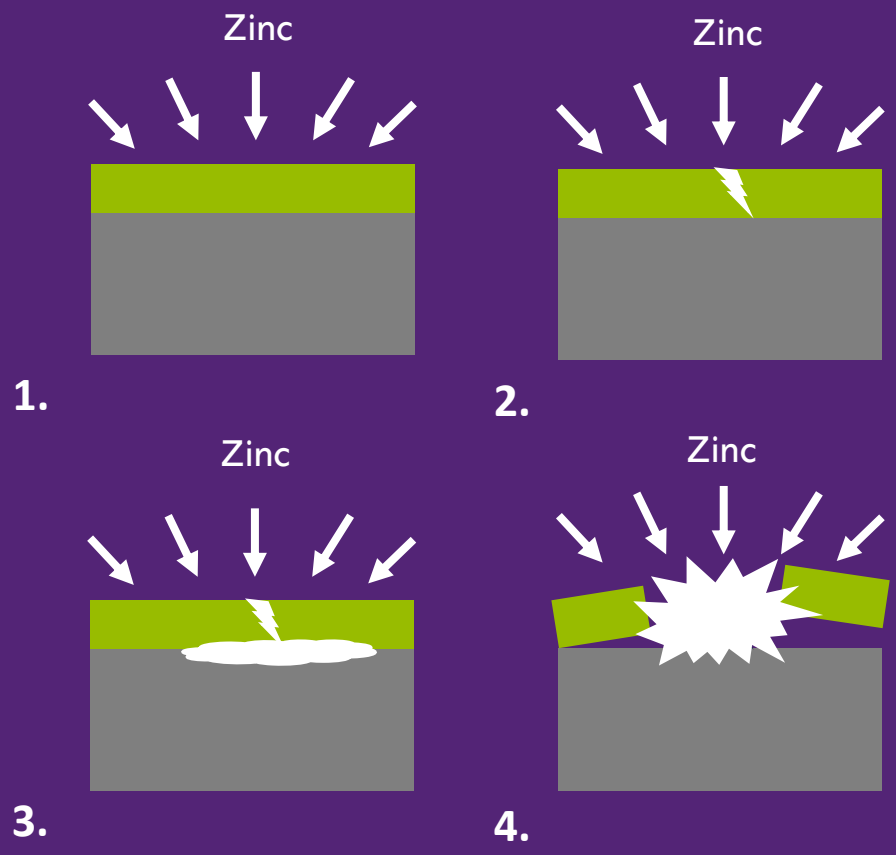
# Coating Failure

## Thermal expansion mismatch

- SS 316L: 20 x $10^{-6}$ $K^{-1}$ [1]
- $Al_2O_3$: 8 x $10^{-6}$ $K^{-1}$ [1]

## Coating break down

1. Wetting of the sample with liquid zinc
2. Zinc penetration through cracks
3. Accumulation of reaction products
4. Coating break down



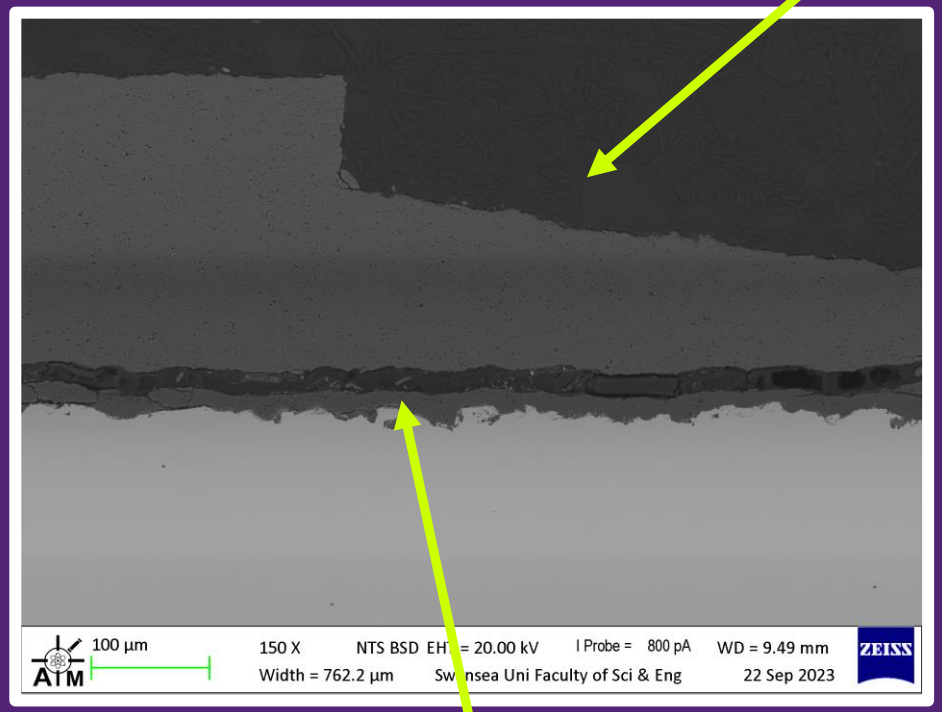

[1] MatWeb LLC. Material Property Data. [Accessed 21 January 2024]. Available from: https://www.matweb.com/index.aspx

# Results

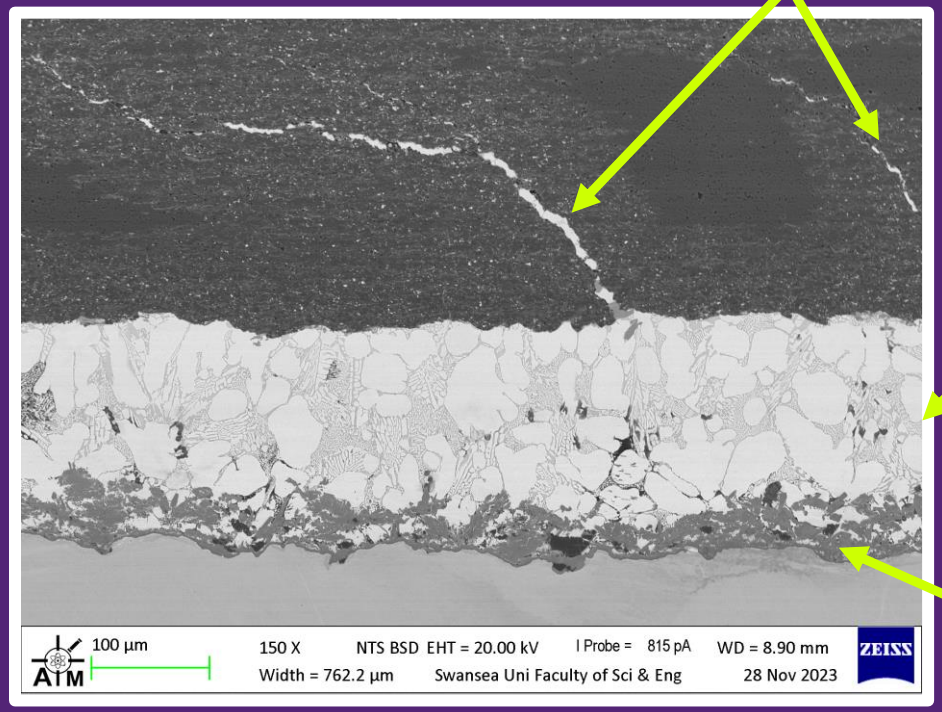
## Zn-Al-Mg bath

# Results Zn-Al-Mg

## 1 week of testing




## 4 weeks of testing

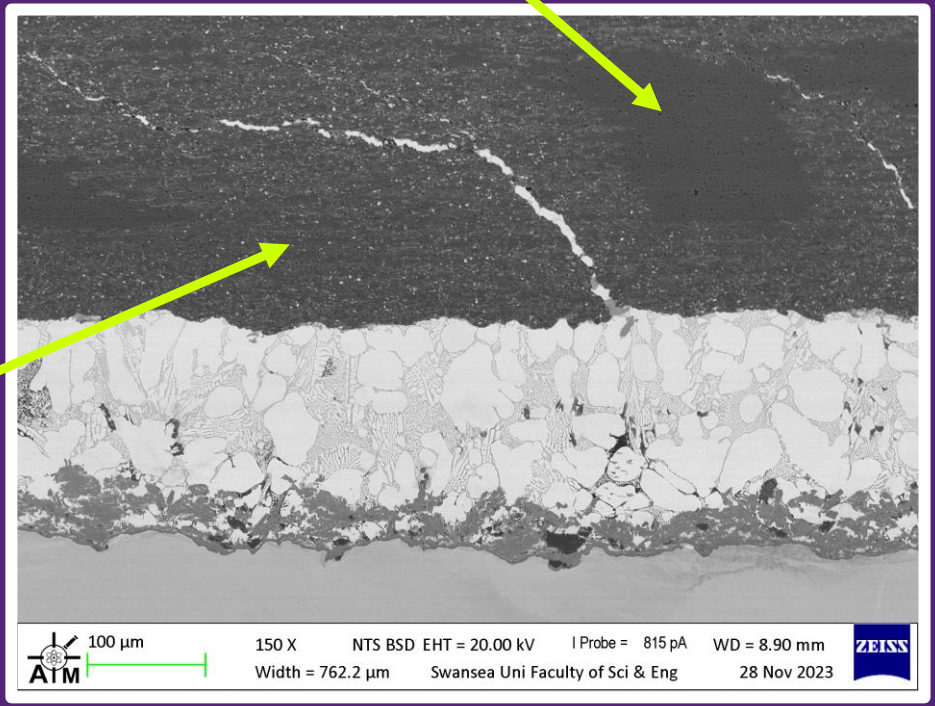


# Results Zn-Al-Mg

## 4 weeks of testing

No changes in the coating

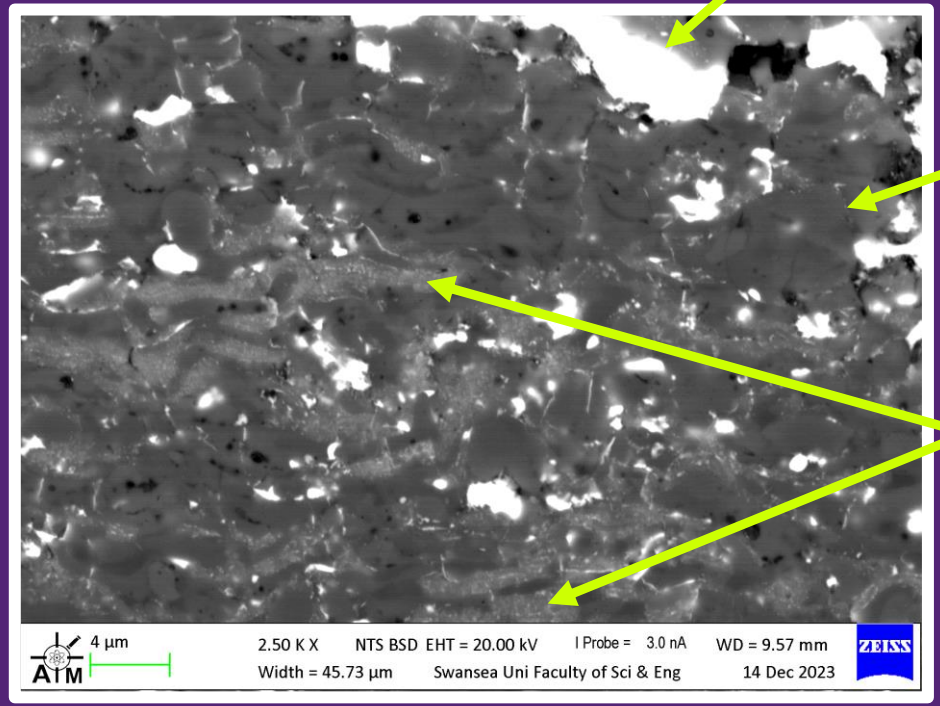
Changes in the coating




Zn penetration through cracks

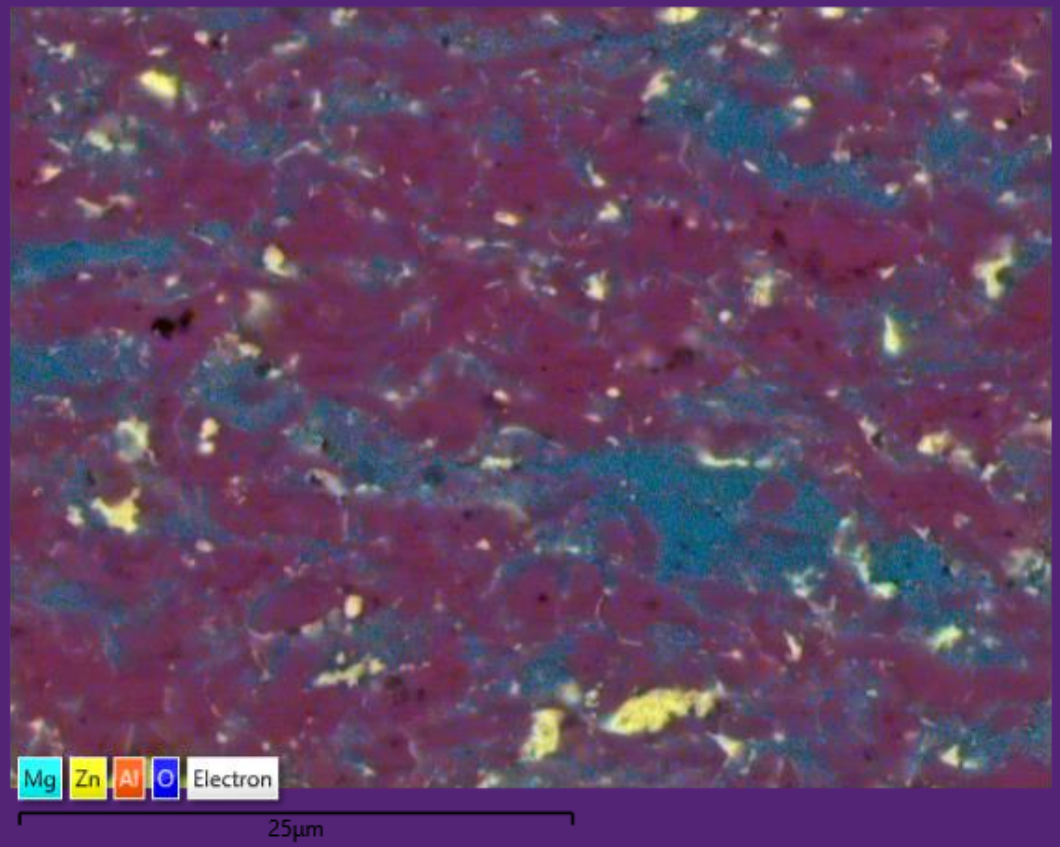
Darker phase

Brighter phase

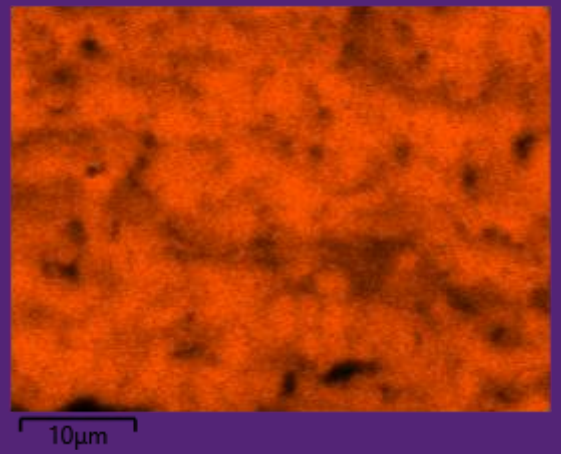


# EDS Maps

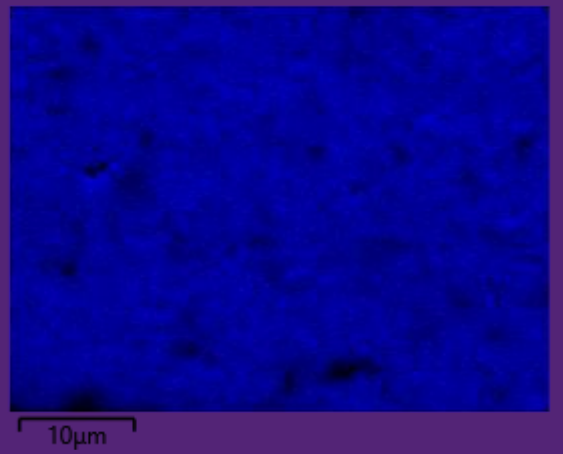
**EDS Layered Image**



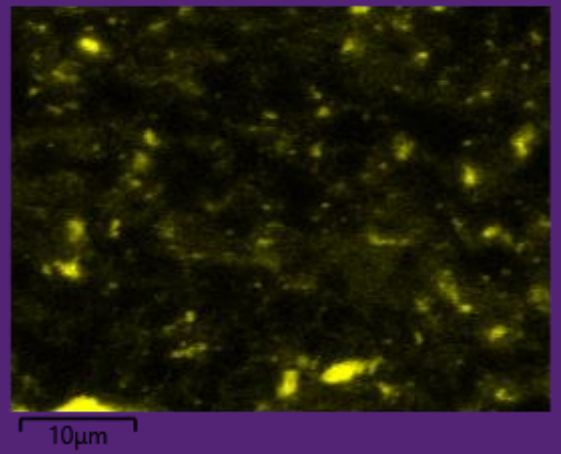

**Al**



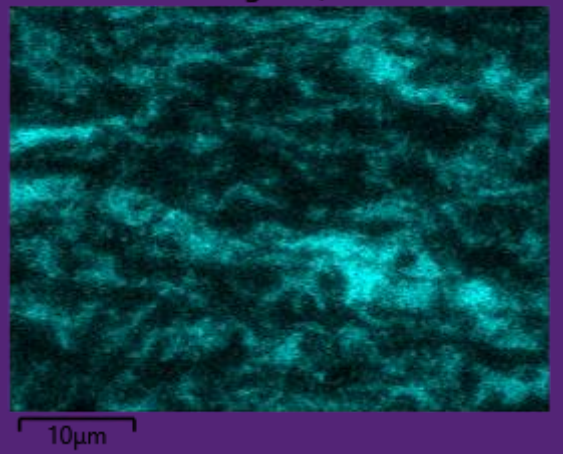

**O**




**Zn**




**Mg**



# Conclusions

$Al_2O_3$ coatings were dip tested for 5 weeks in Zn-Al and Zn-Al-Mg. It was found that:

- The coating remained inert in Zn-Al
- Coating failure occurred due to Zn penetration
- Cracking promotes interactions with Zn-Al-Mg bath

## Next steps

- Coating optimisation to prevent breakdown
- Testing other types of ceramics
- Dynamic testing

# Thank you

Any questions?

Acknowledgments:

Engineered Performance Coatings (EPC), Steel and Metals Institute (SaMI), Advanced Imaging of Materials Facility (AIM)