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Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
POLITECNICO MILANO 1863
UNIVERSITÀ DI TRENTO

(PRIN 2022, COD. PROTOCOLLO: 2022H3S28T, CUP MASTER: D53D23005410006) FINANZIATO DALL'UNIONE EUROPEA – NEXT GENERATION EU, PNRR - MISSIONE 4 "ISTRUZIONE E RICERCA" - COMPONENTE C2 INVESTIMENTO 1.1 "FONDO PER IL PROGRAMMA NAZIONALE DI RICERCA E PROGETTI DI RILEVANTE INTERESSE NAZIONALE (PRIN)" D.D. N. 104/2022 "BANDO PRIN 2022". PE11 Engineering of Metals and alloys.

Exploring the Corrosion Resistance and Microstructural Evolution of Textured Aluminum Alloys using TMEMM

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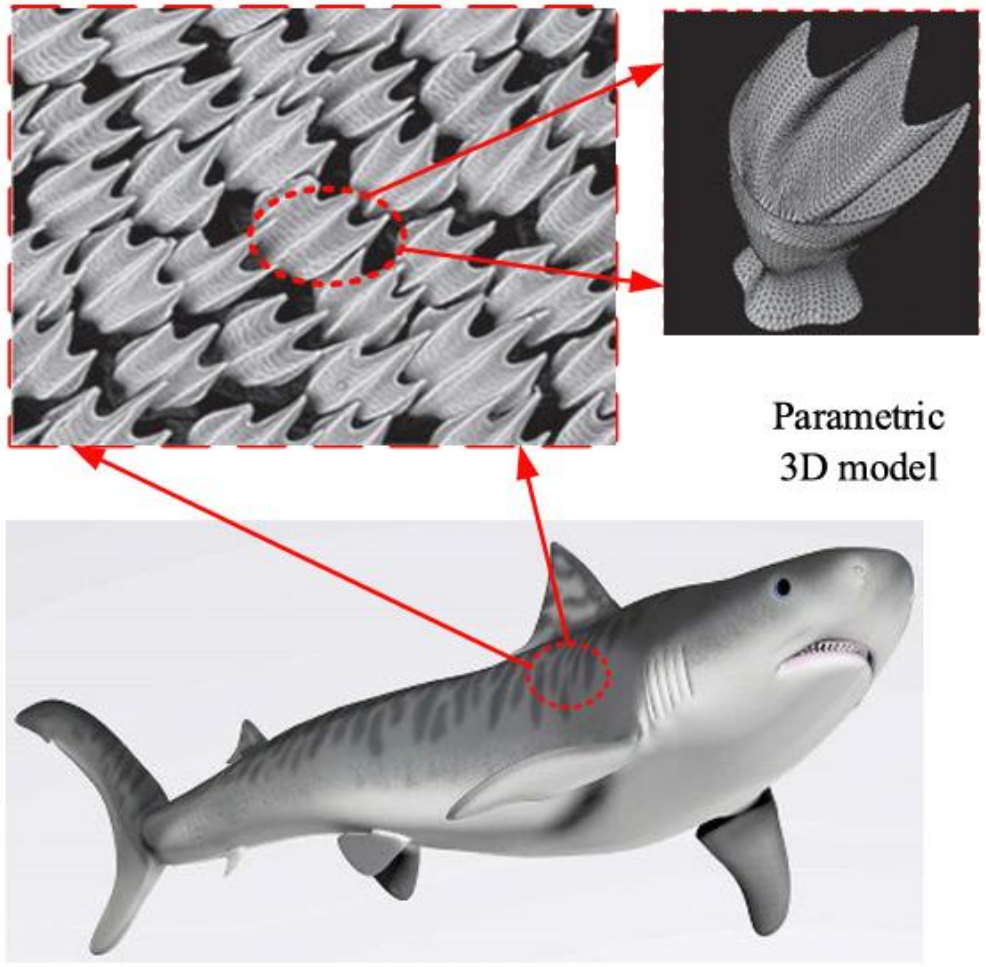
EMCR 2025
San Servolo (VE) | 15-19 giugno 2025



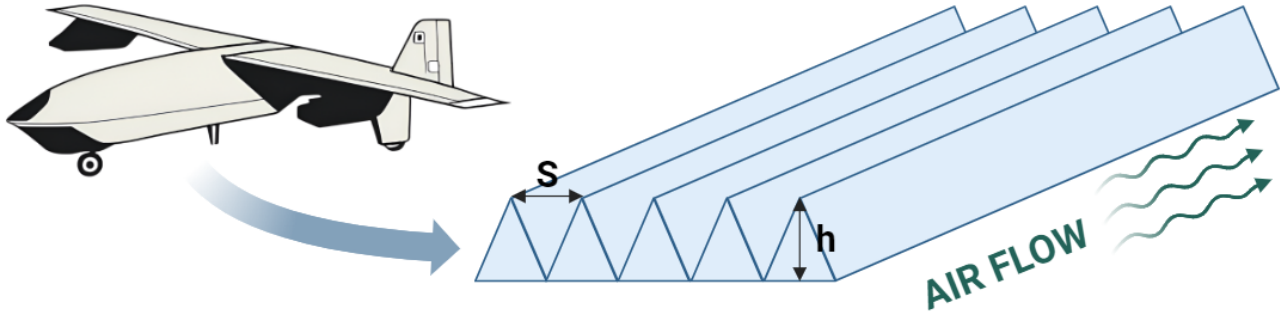
BIOMIMICRY: MAKO SHARK SCALE PROFILE

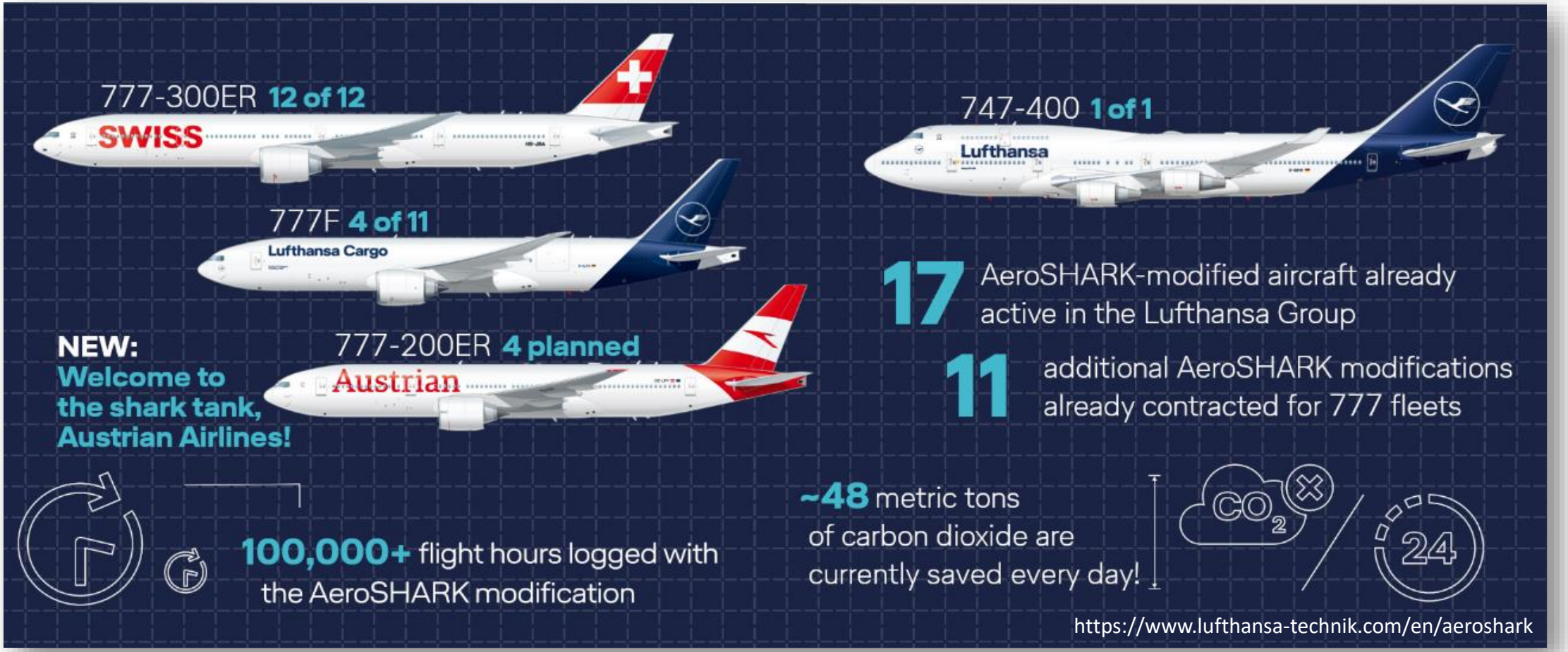
↓

REDUCTION OF AERODYNAMIC DRAG

↓

REDUCTION IN CO_2 EMISSIONS





APPLICATION OF POLYMER FILMS → WEAR → MAINTENANCE COSTS

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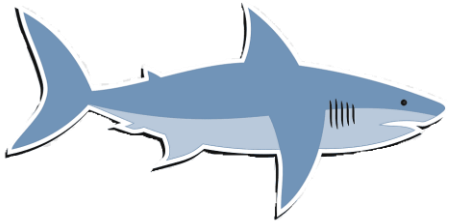
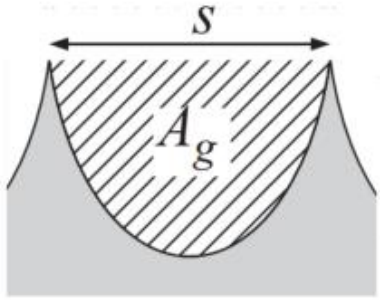
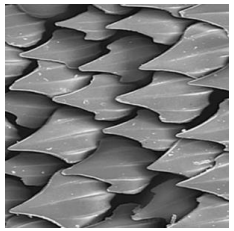
MAKO PROJECT ROADMAP

WP1
Definition of the Biomimetic Texture





WP2
Texture Fabrication via Electrochemical Etching (TMEMM)



UNITRENTO

WP3
PEO Treatment of Textured Surfaces

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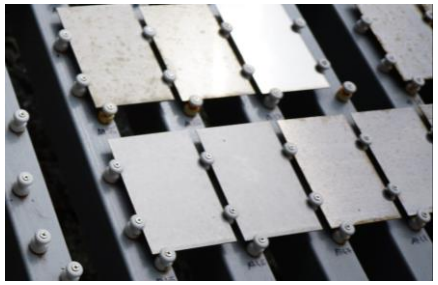
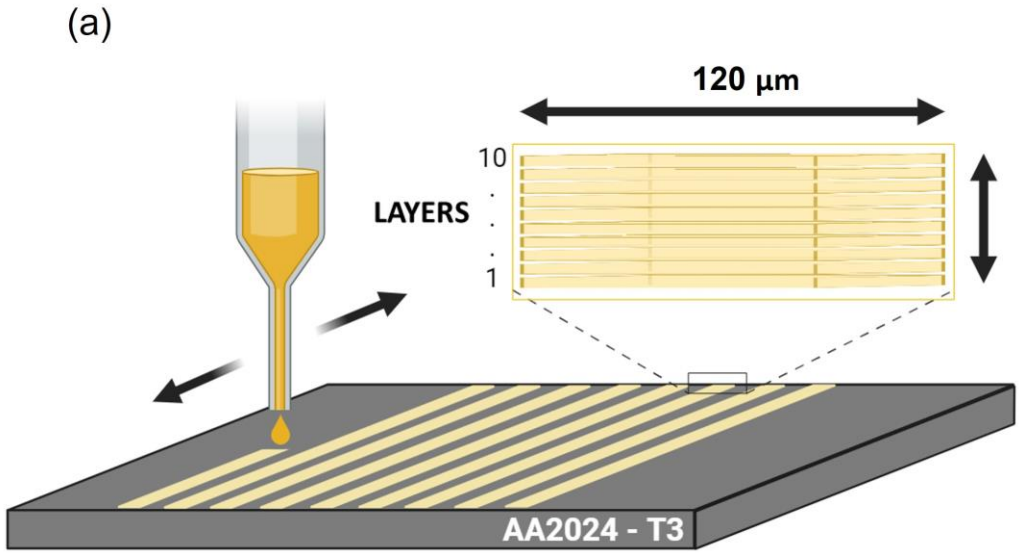
WP4
Evaluation of Corrosion Resistance

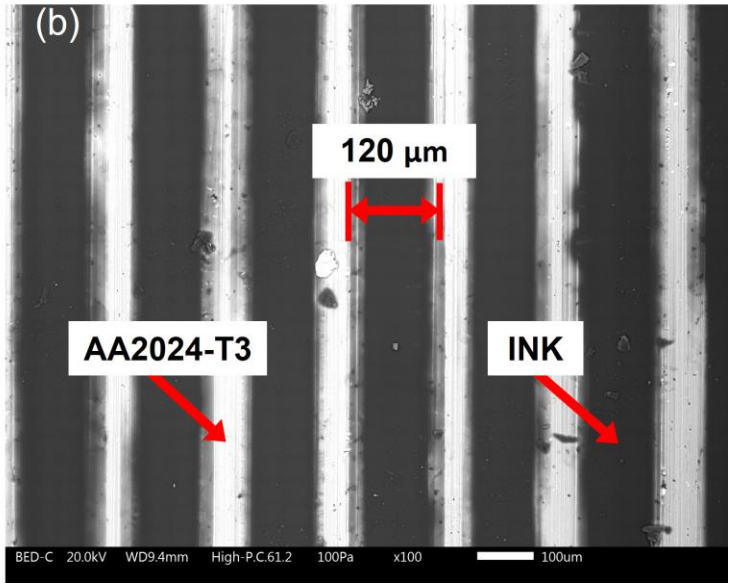


TEXTURING BY TMEMM

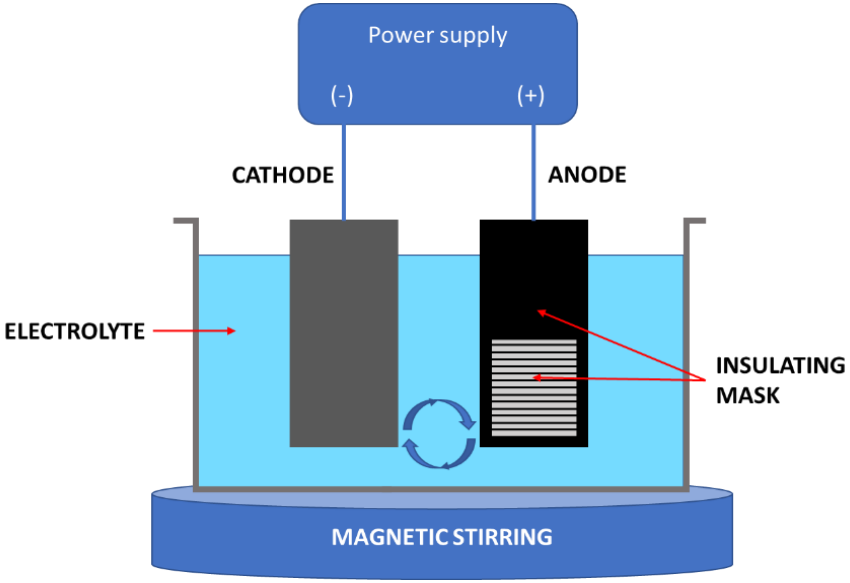
Through Mask Electrochemical Micromaching

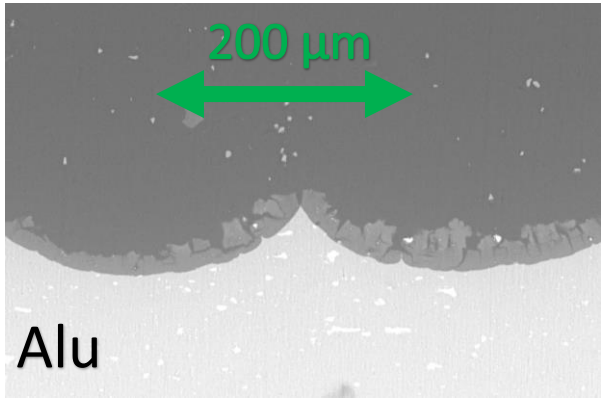
STEP 1: inkjet printing - polymeric mask creation





→ CERADROP F-Series (MGI group) inkjet printer – UV CURING





TEXTURING BY TMEMM

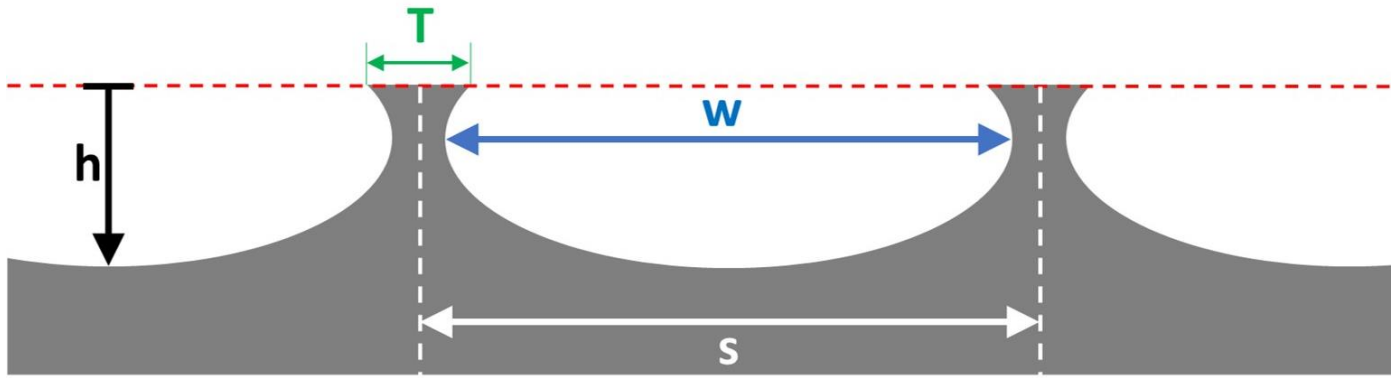
Through Mask Electrochemical Micromaching

STEP 2: anodic polarization – texture creation

- **Selective etching** of metal part not covered

by the insulating mask

- Variable optimum profile across different areas of the hull



- **STATE OF THE ART**

TMEMM studied on **pure metals** Cu, Ti, Ni, Al
TMEMM not yet explored for **riblets** production

- **ALUMINUM ALLOYS:**

AA2024 (4% Cu; 1.5 Mg; 0.5% Mn)
AA5005 (Mg 0.8%)
AA1050 (commercially pure)

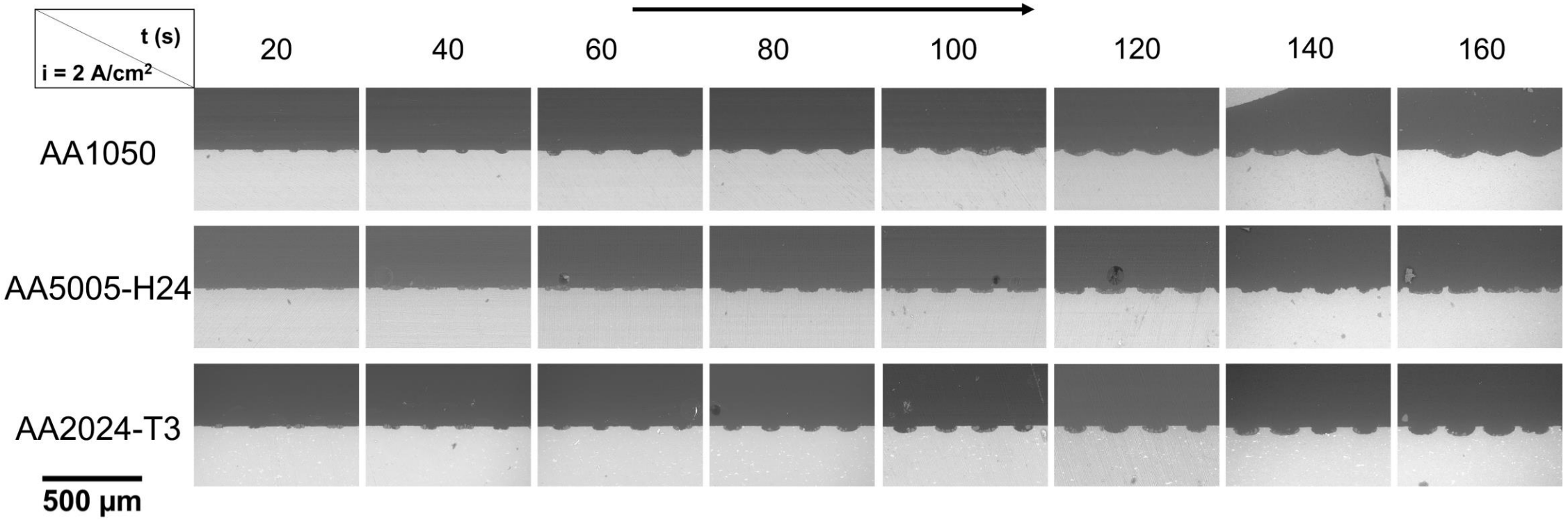
TMEMM ↔ IMPs ↔ CORROSION

- **AIM:**

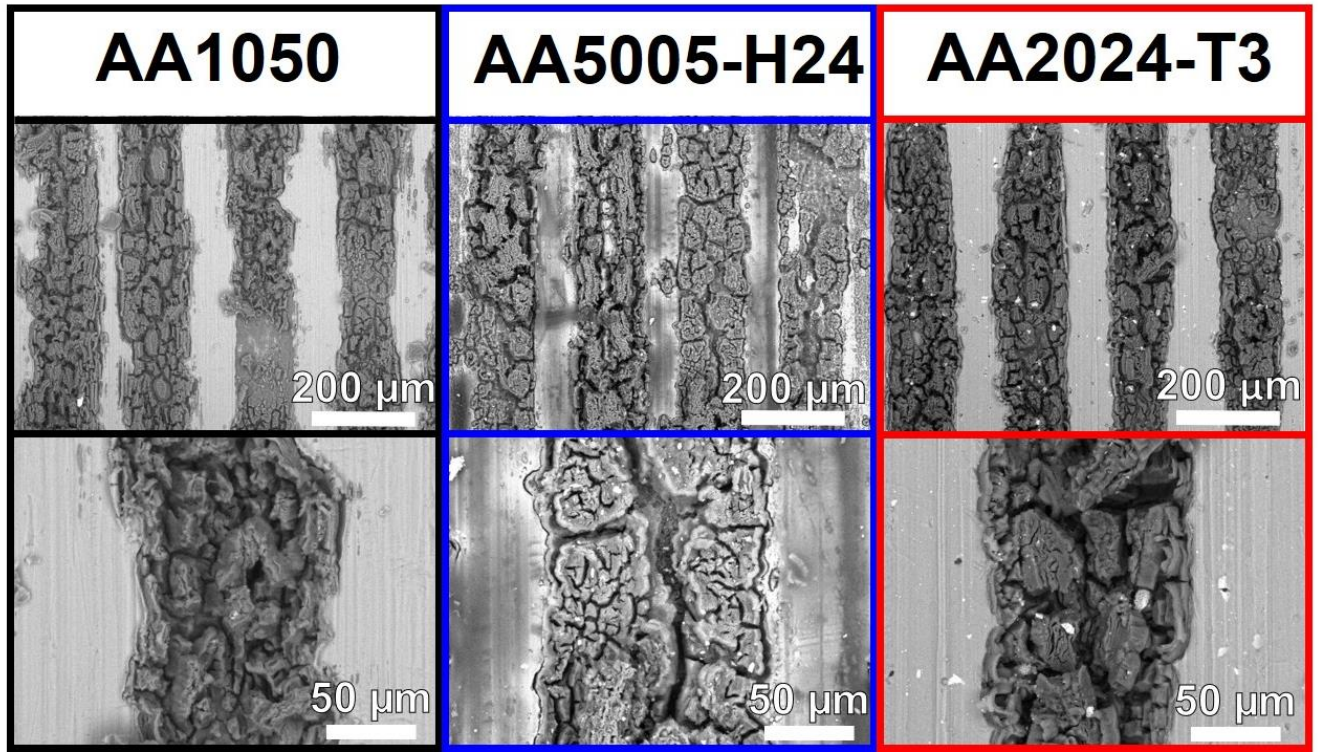
*To **investigate the influence of alloys composition (intermetallics)** on the **morphological evolution** of aluminum alloys during TMEMM and their derived **corrosion behavior***

GEOMETRY EVOLUTION – cross sections

increasing t (s), i = 2 A/cm^2, 100 g/L $NaNO_3$ electrolyte

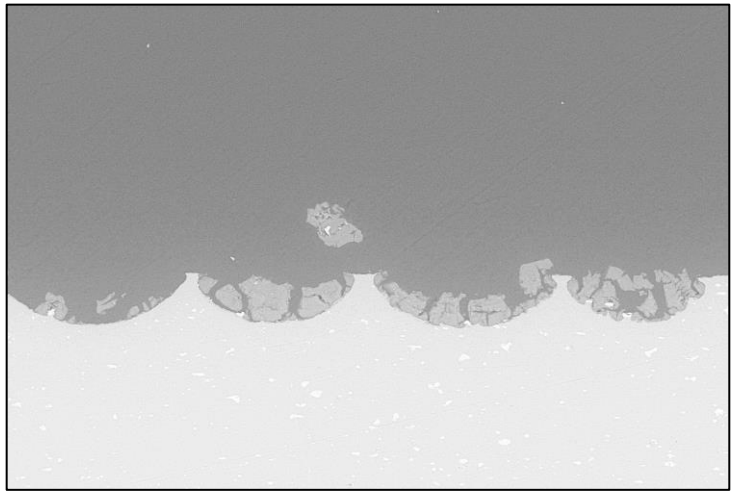


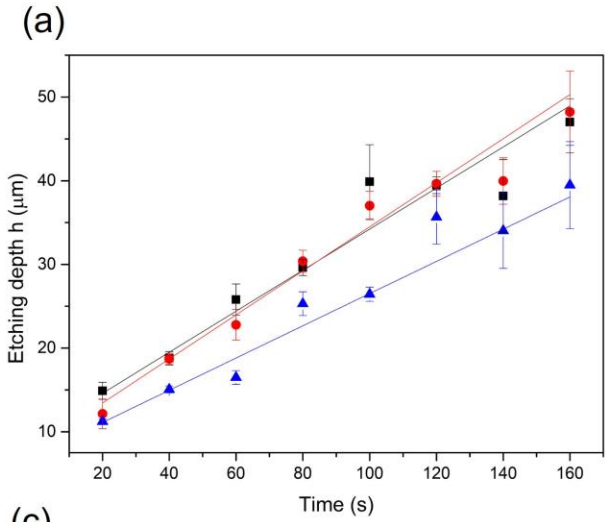
GEOMETRY AND CORROSION PRODUCTS DEPOSITS – top view

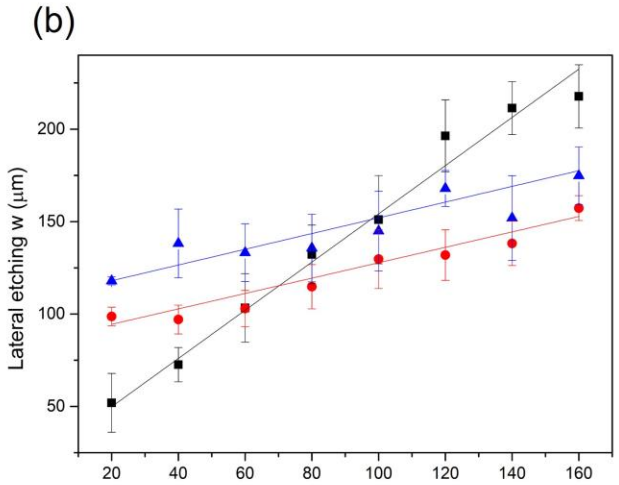


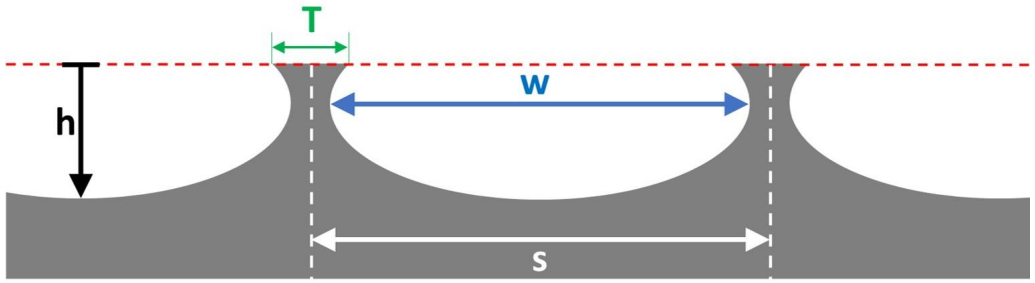
Oxide removal after texturing:

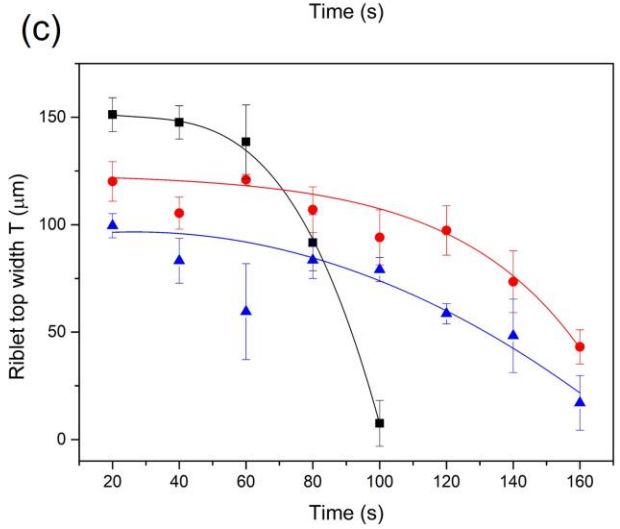
→ sonication for 2 min
in 0.1M HNO3

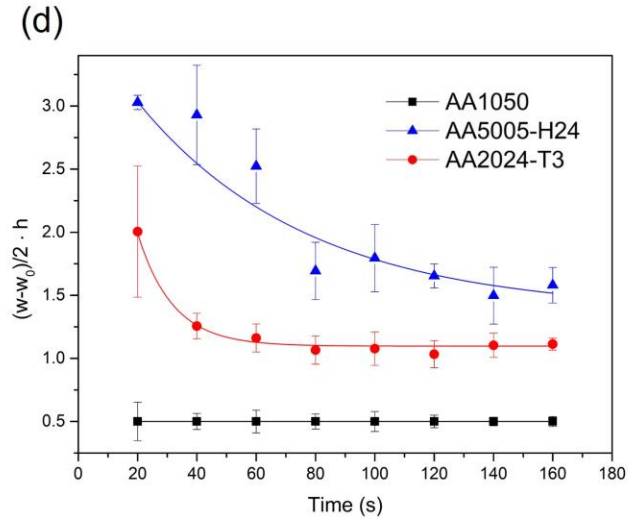






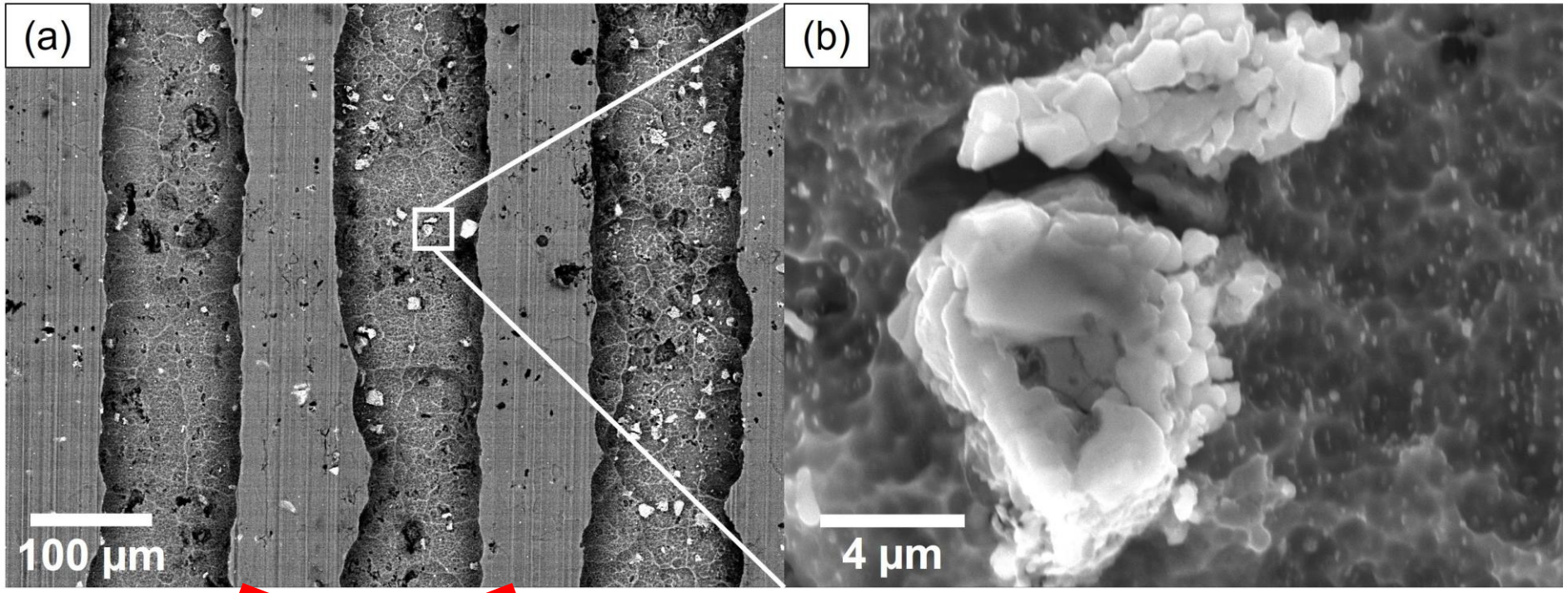






- Etching depth (h) increases with time
- Lateral widening (w) is alloy-dependent
- Riblet top width (T) → shaping precision
- Alloying determine etching anisotropy

RESIDUAL IMPs: AA2024

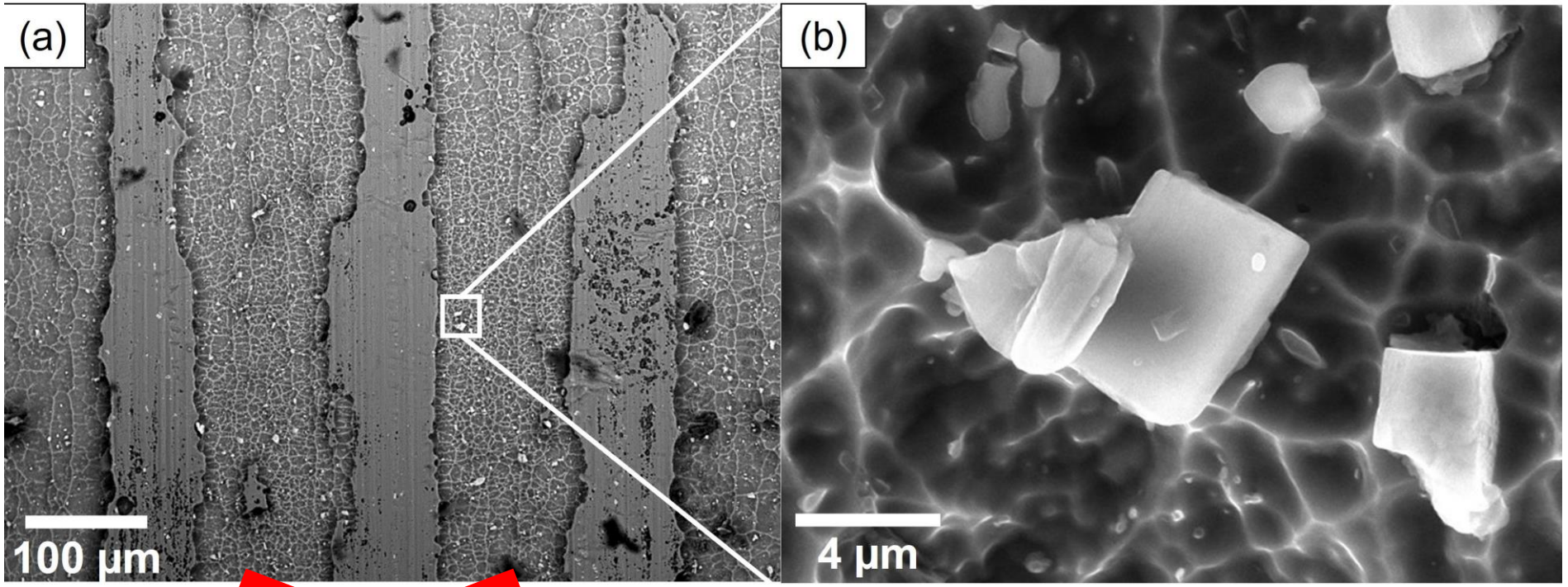


~~θ-phase (Al$_2$Cu)~~

~~Q-phase (AlFeSi)~~

$(Al,Cu)_x(Fe,Mn)_ySi$ (low Si)

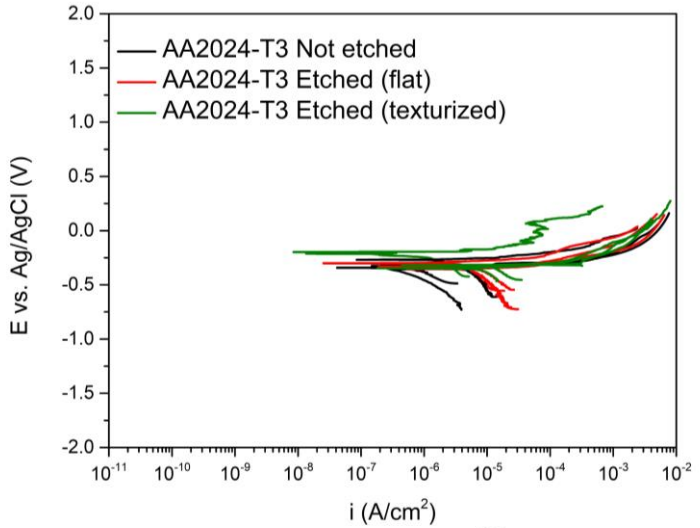
RESIDUAL IMPs: AA5005

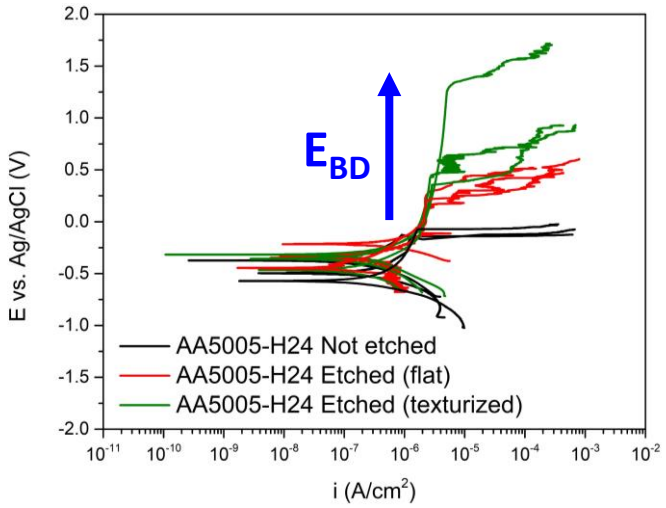


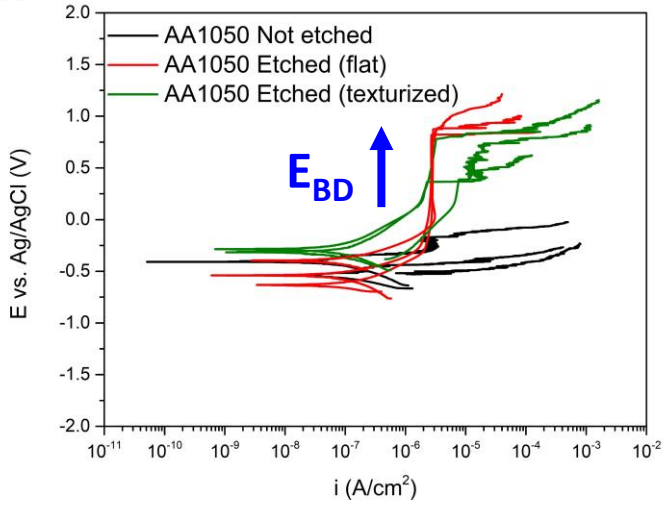
~~Al-Fe~~

~~β-phase (Al_3Mg_2)~~

Al-Fe-Si







POLARIZATION CURVES

- **AA2024-T3** is prone to **localized corrosion**, with no stable passive region due to Cu-rich IMPs.
- **AA1050 and AA5005-H24** benefit from anodic treatment with **enhanced passivity**.
- **Texturing does not degrade electrochemical performance** compared to flat etching.

REMARKS

• **TMEMM is a promising method** for aluminum alloy surface texturing, enabling microstructures with minimal damage

• **Alloy composition strongly affects etching behavior**:
- AA1050 allows deep vertical etching
- AA2024 achieves balanced and regular features
- AA5005 resists etching due to its corrosion-resistant oxide layer

• **Surface intermetallic particles (IMPs)** influence corrosion:
- Selective removal (e.g., β-phase in AA5005-H24) improves corrosion resistance (E_{DB})
- High Cu content in AA2024 hinders passivation

• **Texturing does not degrade electrochemical performance** compared to flat etching

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Advancing aeronautical surface texturing: Through-mask electrochemical micromachining of aluminum AA2024-T3 for drag reduction applications

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Influence of intermetallics on through-mask electrochemical micromachining for surface texturing of aluminum alloys

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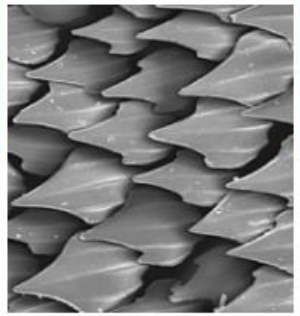

MAKO

Biomimetic Corrosion Resistant Aluminium for Aeronautics

Servizi di ricerca · 293 follower · 2-10 dipendenti

Stefano e altri 43 collegamenti seguono questa pagina

Invia messaggio ✓ Già segui ···