Supplementary File:

Arduino-Controlled Pulse Electrodeposition for Low-Cost Zinc Coating on Stainless Steel

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Supplementary Method

1-Substrate preparation:

The stainless steel was cut into a 2 × 1 cm sample after polishing, and a partial cut was made at the corner to obtain pieces for analysis using different instruments (XRD, XRF, EDS, XPS).

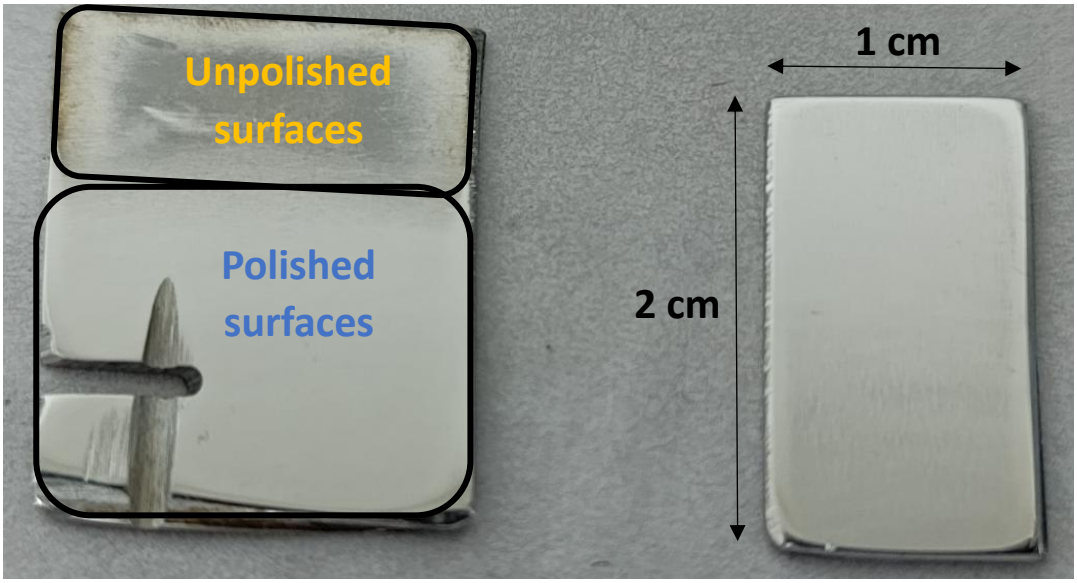


Figure S1: A polished Stainless-Steel substrates

2-Electrical connections:

An Arduino Uno microcontroller board was employed to control the pulse signal supplied to a 1-channel solid-state relay (G3MB-202P-DC-AC-PCB-SSR; 5V DC input, 240V output), which subsequently converted the DC current into a square-wave pulse.

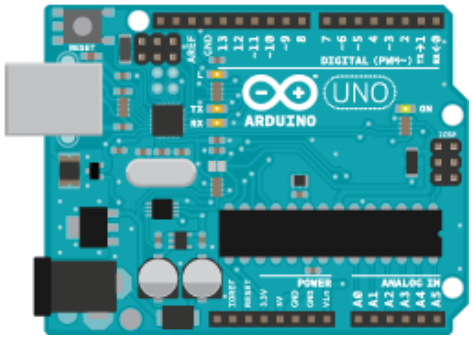


Figure S2: Arduino Uno microcontroller board

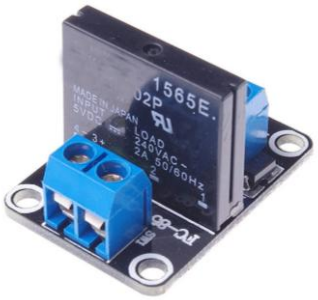


Figure S3: one channel solid state relay

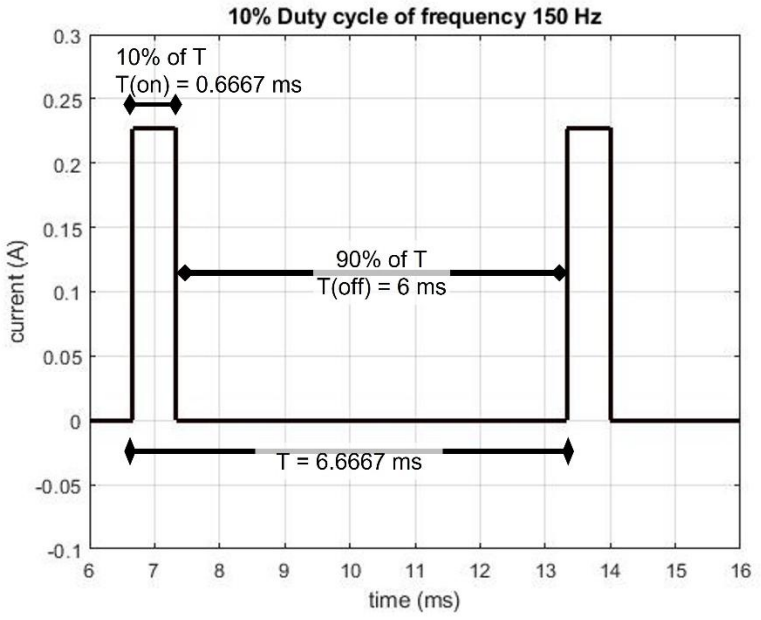


Figure S4: 150 Hz Pulse signal with a Duty cycle 10%

A second Arduino Uno microcontroller board was used to control the servo motor and maintain the desired rotational speed of 15 RPM.

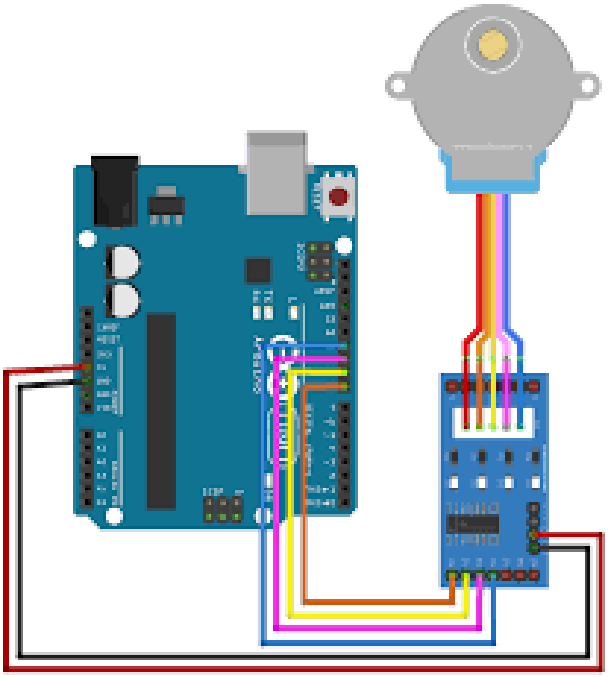


Figure S5: Arduino Uno microcontroller board connected to a servo motor

Figure S6: Pure Zinc rod was used in Pulse electrodeposition (Left), Servo motor was used to rotate the stainless steel substrate (Right)

A short representation of the coating process is shown in the following clip:

https://drive.google.com/file/d/1bIpyWpwcwiCqw5M7FlW8hjtyQfAEOFzP/view?usp=sharing

Supplementary Figures:

Each sample was observed using SEM at multiple locations and magnifications. Furthermore, the surface was characterized using EDS

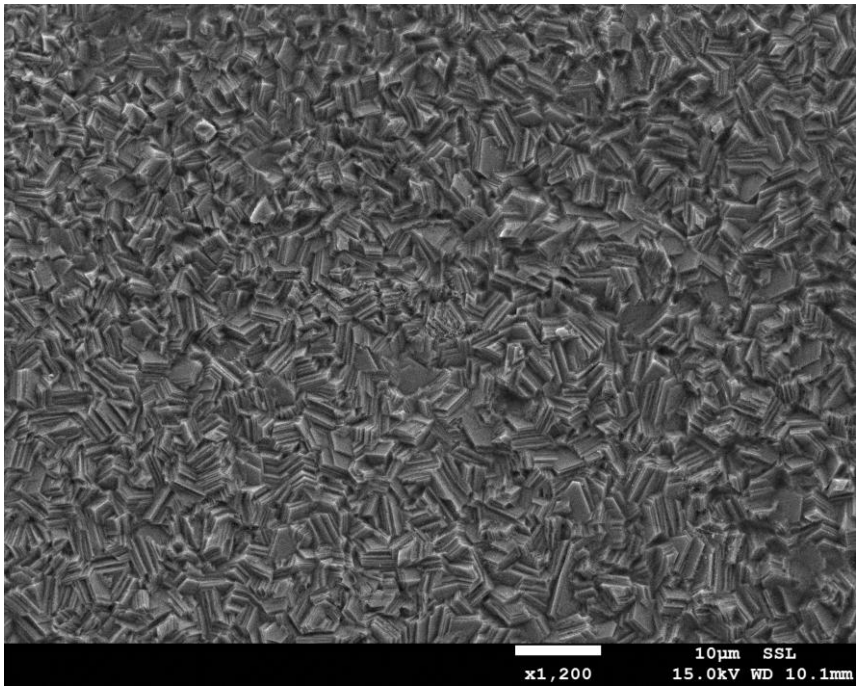


Figure S7: SEM image of the coated substrate surface at frequency 150 Hz, at 1200× magnification.

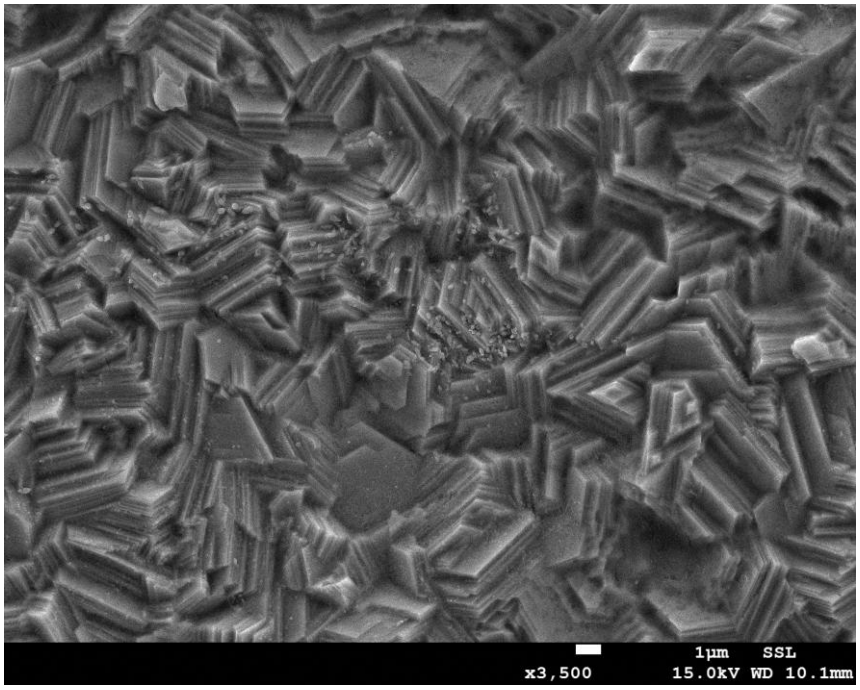


Figure S8: SEM image of the coated substrate surface at frequency 150 Hz, at 3500× magnification.

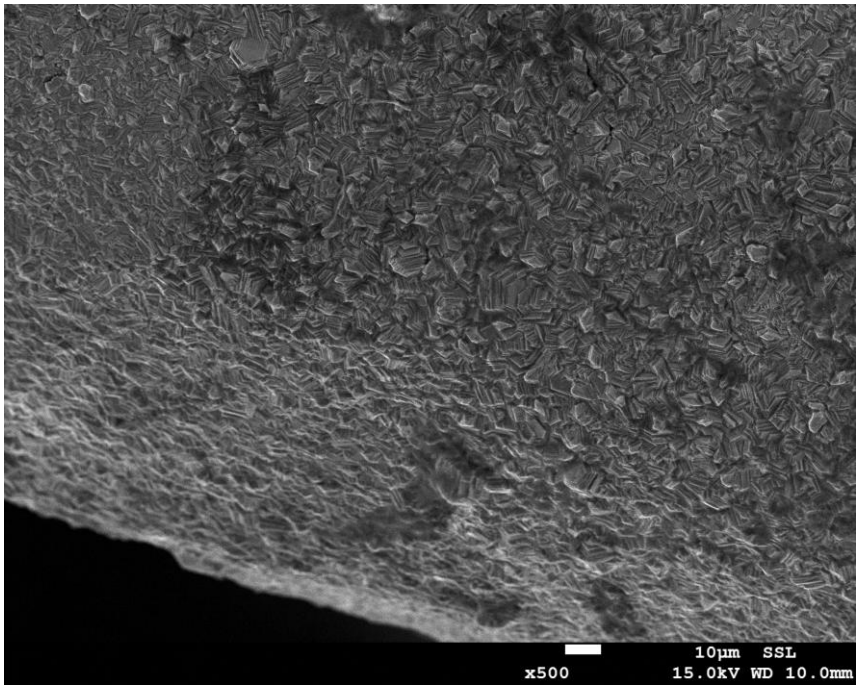


Figure S9: SEM image of the coated substrate (edge) at frequency 150 Hz, at 500× magnification.

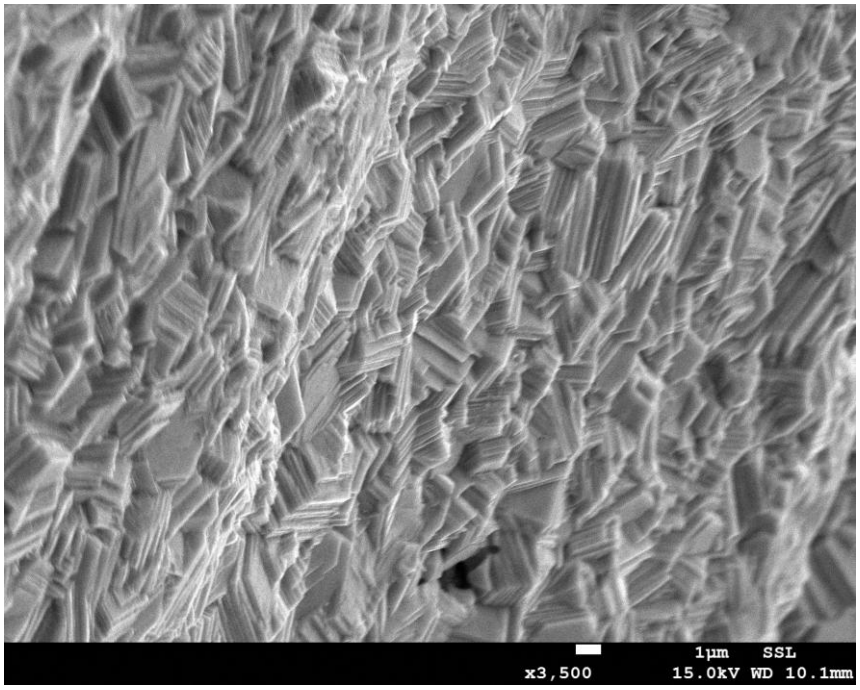


Figure S10: SEM image of the coated substrate (edge) at frequency 150 Hz, at 3500× magnification.

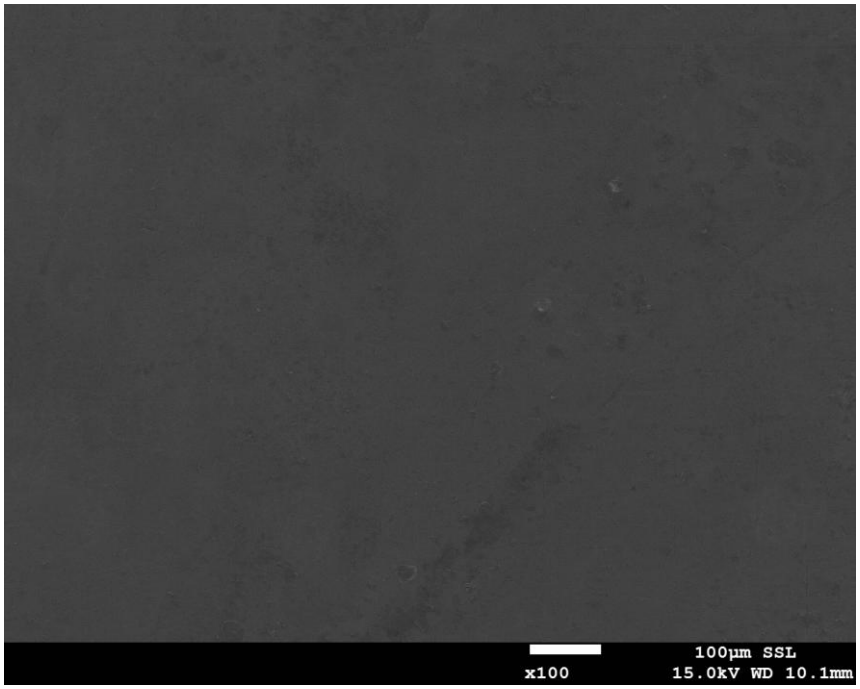


Figure S11: SEM image of the coated substrate surface at frequency 175 Hz, at 100× magnification.

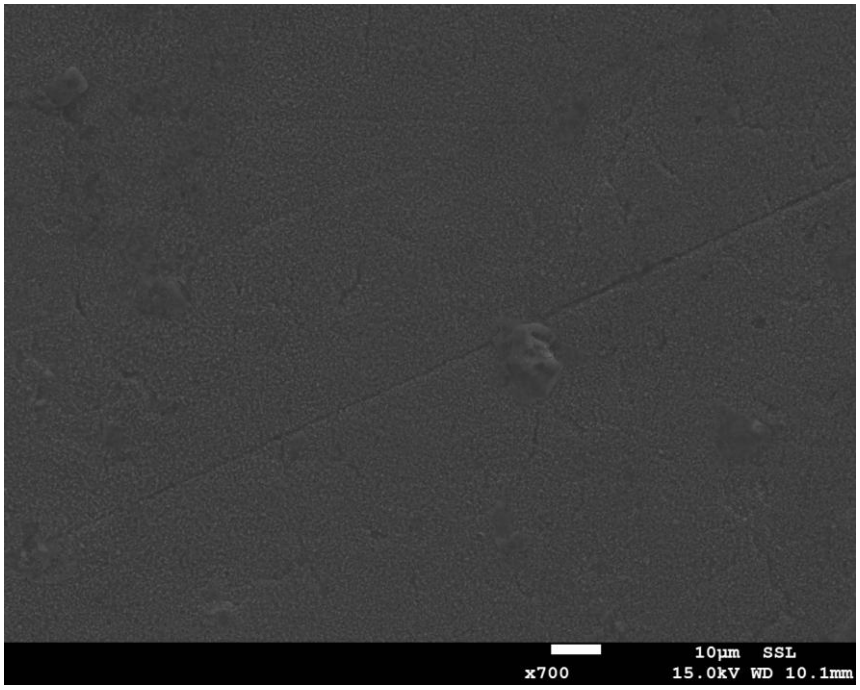


Figure S12: SEM image of the coated substrate surface at frequency 175 Hz, at 700× magnification.

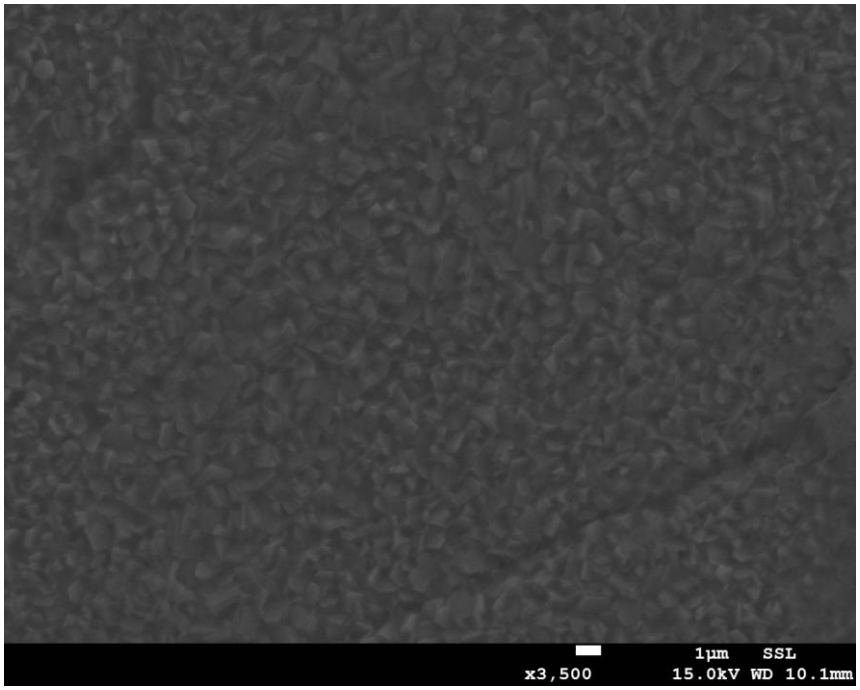


Figure S13: SEM image of the coated substrate surface at frequency 175 Hz, at 3500× magnification.

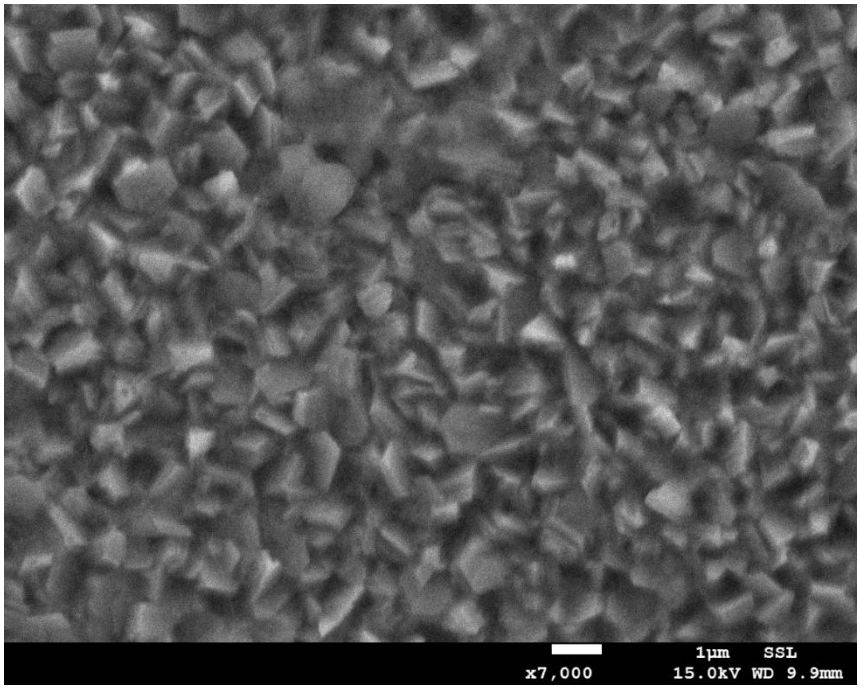


Figure S14: SEM image of the coated substrate surface at frequency 175 Hz, at 7000× magnification.

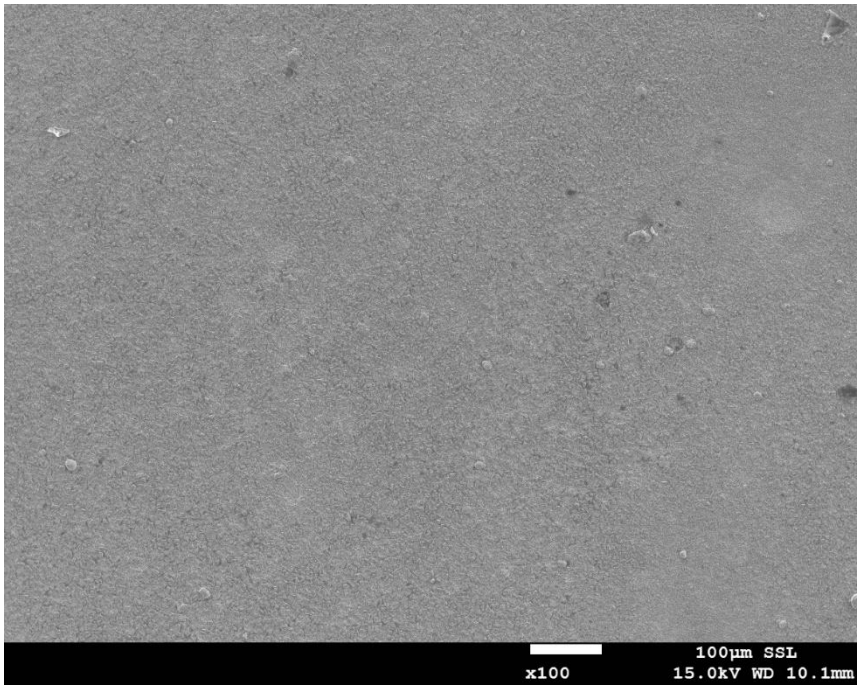


Figure S15: SEM image of the coated substrate surface at frequency 200 Hz, at 100× magnification.

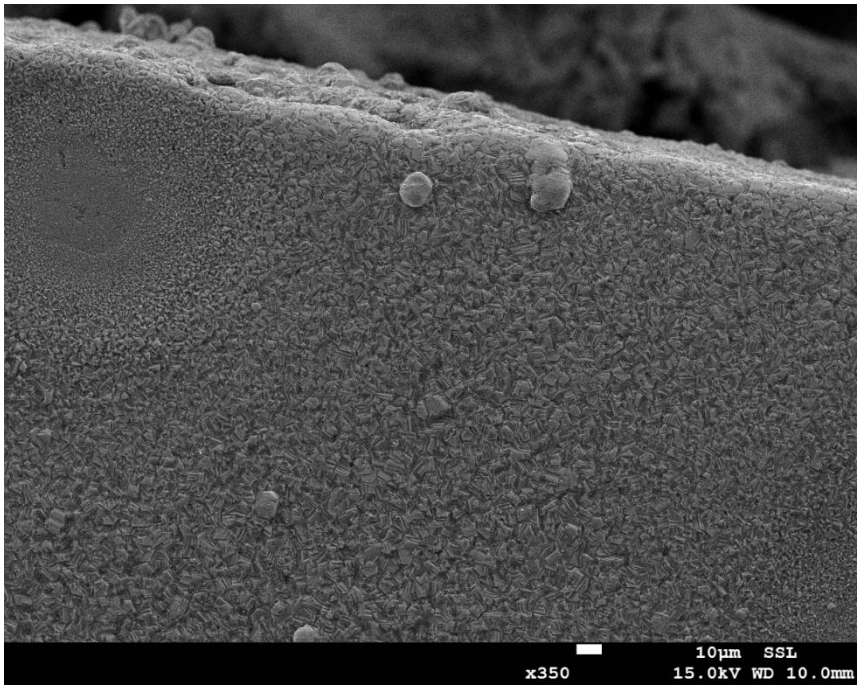


Figure S16: SEM image of the coated substrate surface at frequency 200 Hz, at 350× magnification.

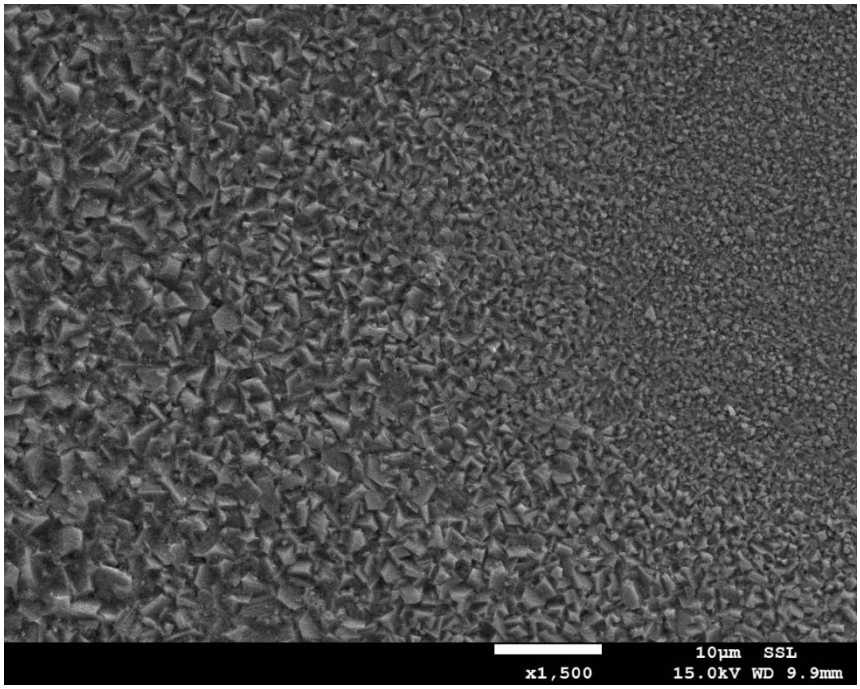


Figure S17: SEM image of the coated substrate surface at frequency 200 Hz, at 1500× magnification.

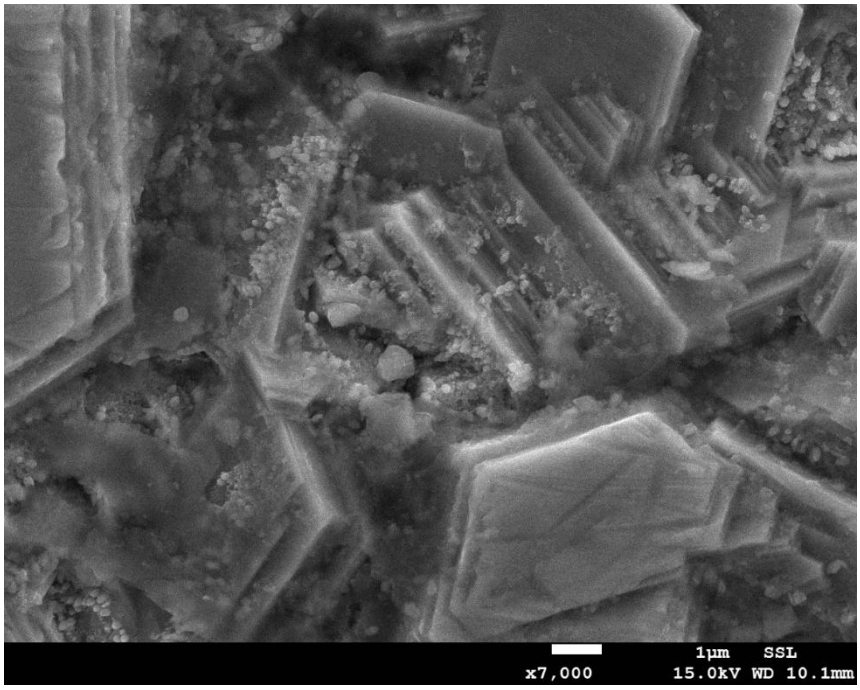


Figure S18: SEM image of the coated substrate surface at frequency 200 Hz, at 7000× magnification.

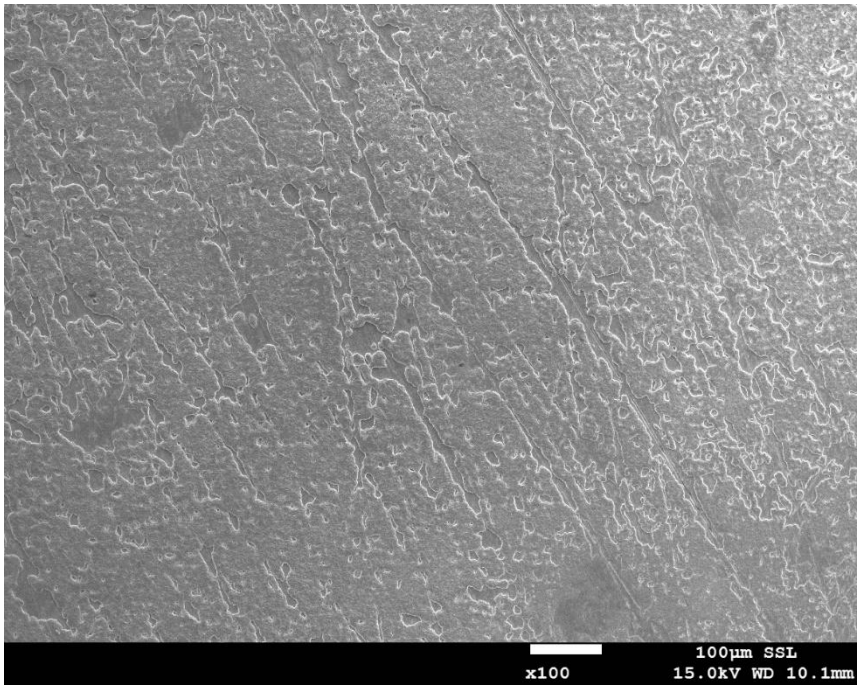


Figure S19: SEM image of the coated substrate surface at frequency 250 Hz, at 100× magnification.

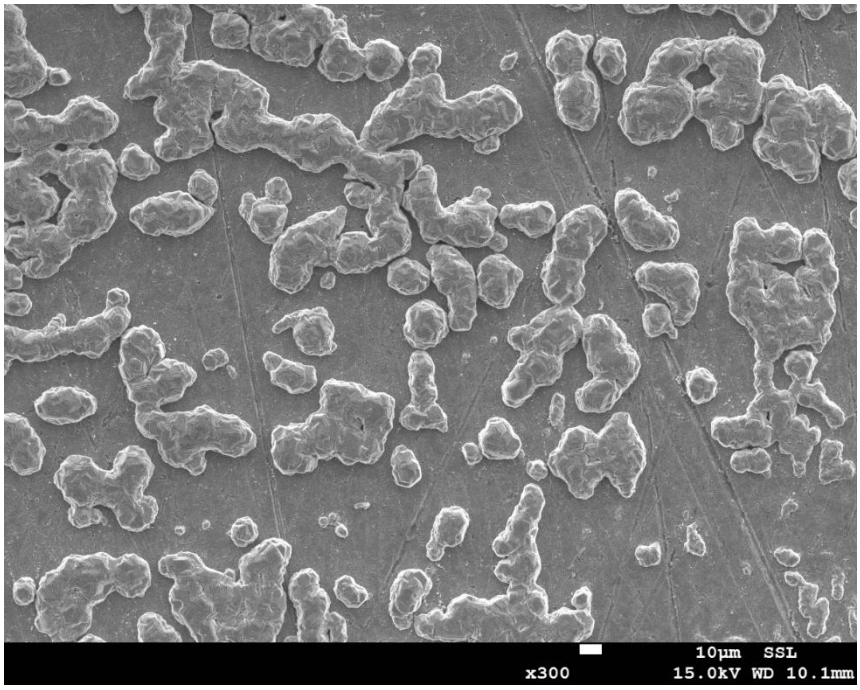


Figure S20: SEM image of the coated substrate surface at frequency 250 Hz, at 300× magnification.

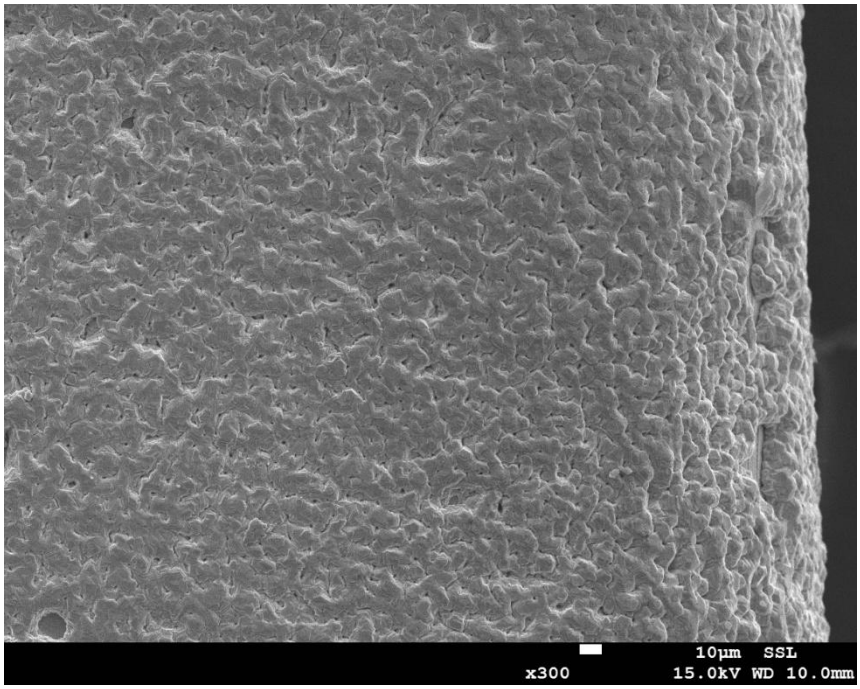


Figure S21: SEM image of the coated substrate (edge) at frequency 250 Hz, at 300× magnification.

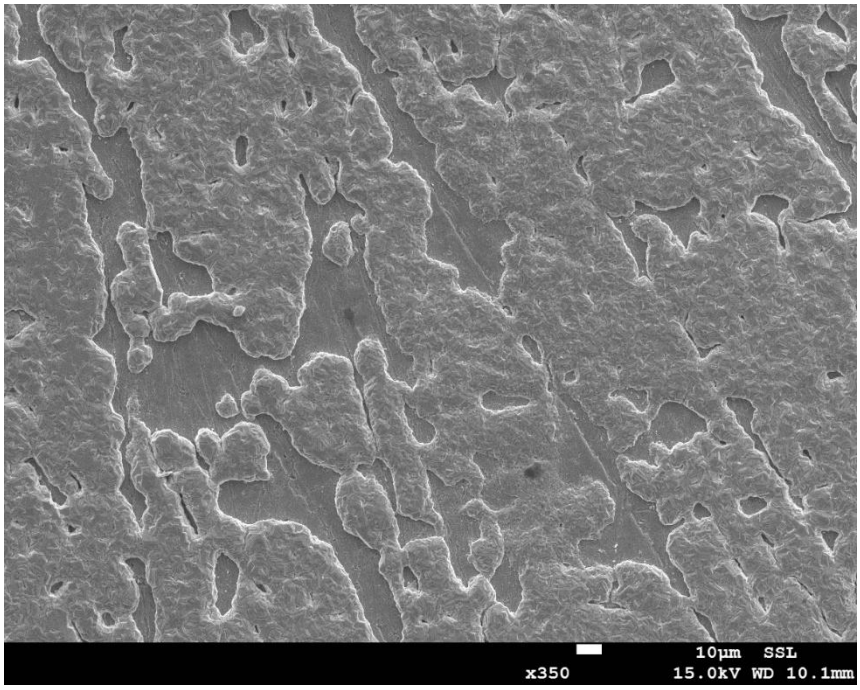


Figure S22: SEM image of the coated substrate surface at frequency 250 Hz, at 350× magnification.

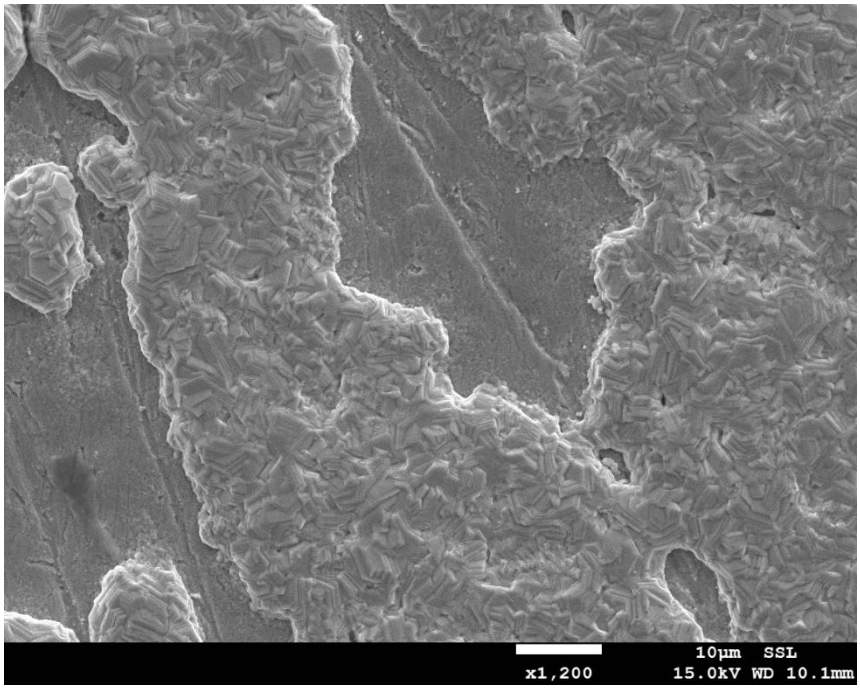


Figure S23: SEM image of the coated substrate surface at frequency 250 Hz, at 1200× magnification.

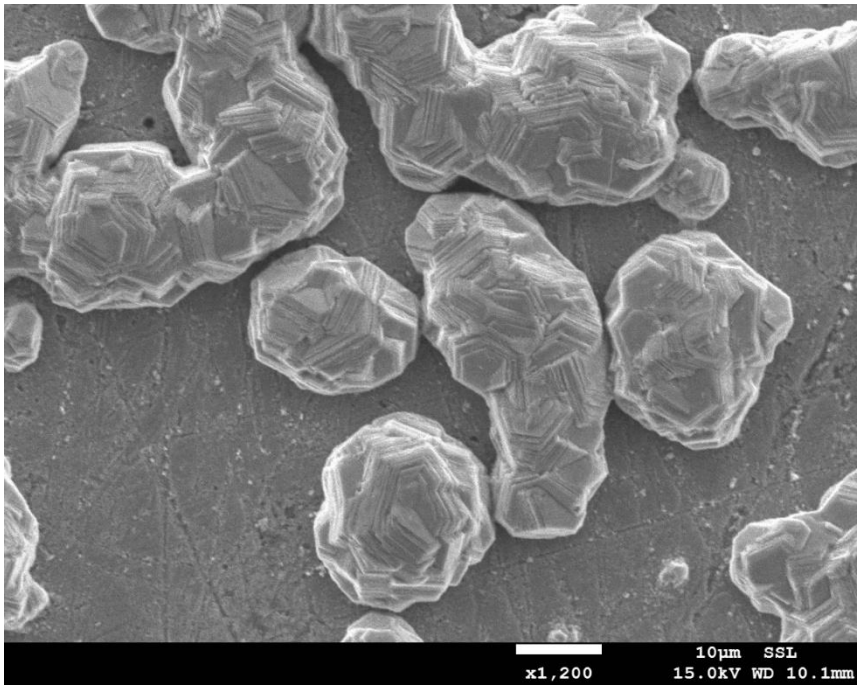


Figure S24: SEM image of the coated substrate surface at frequency 250 Hz, at 1200× magnification.

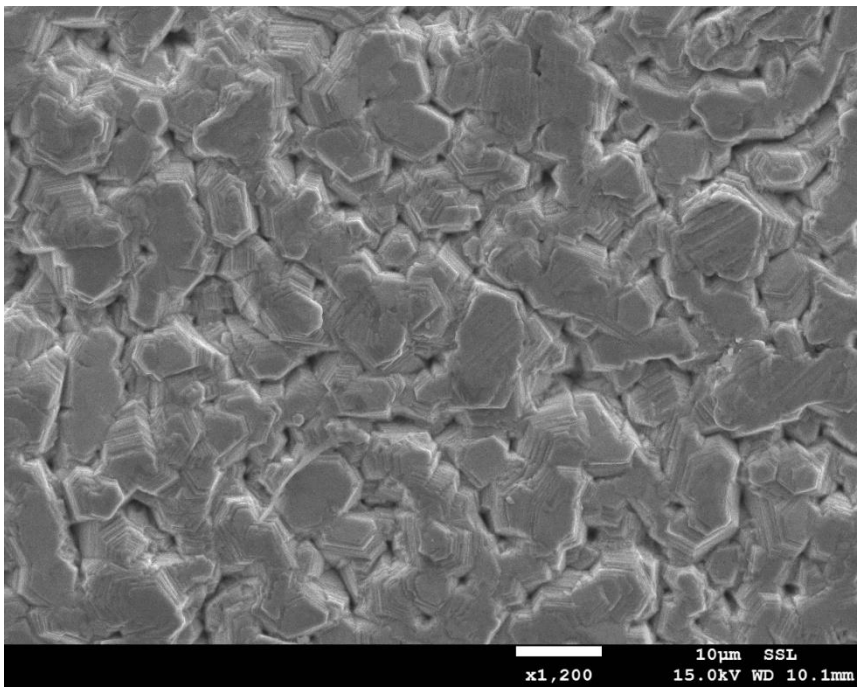


Figure S25: SEM image of the coated substrate surface at frequency 250 Hz, at 1200× magnification.

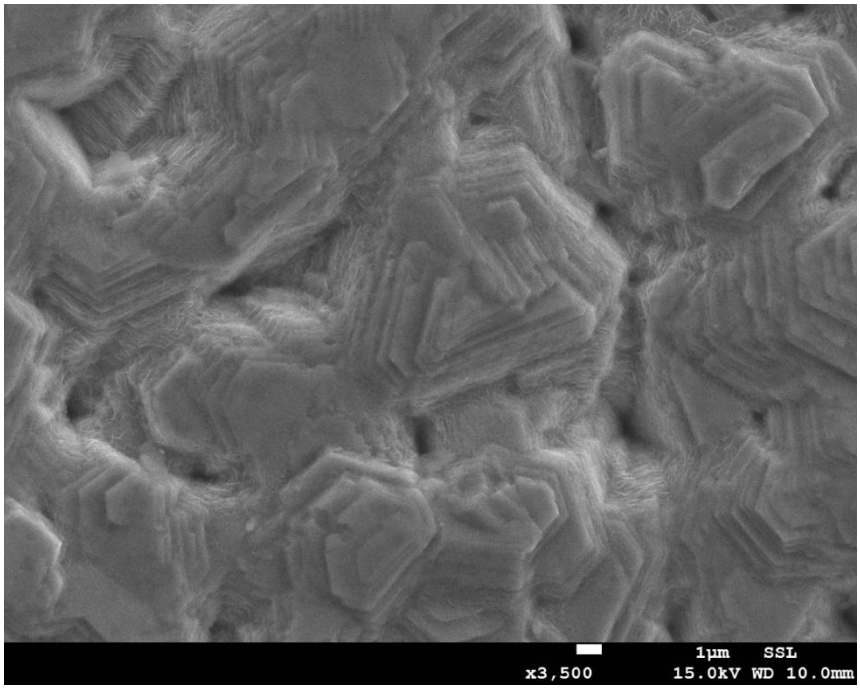


Figure S26: SEM image of the coated substrate surface at frequency 250 Hz, at 3500× magnification.

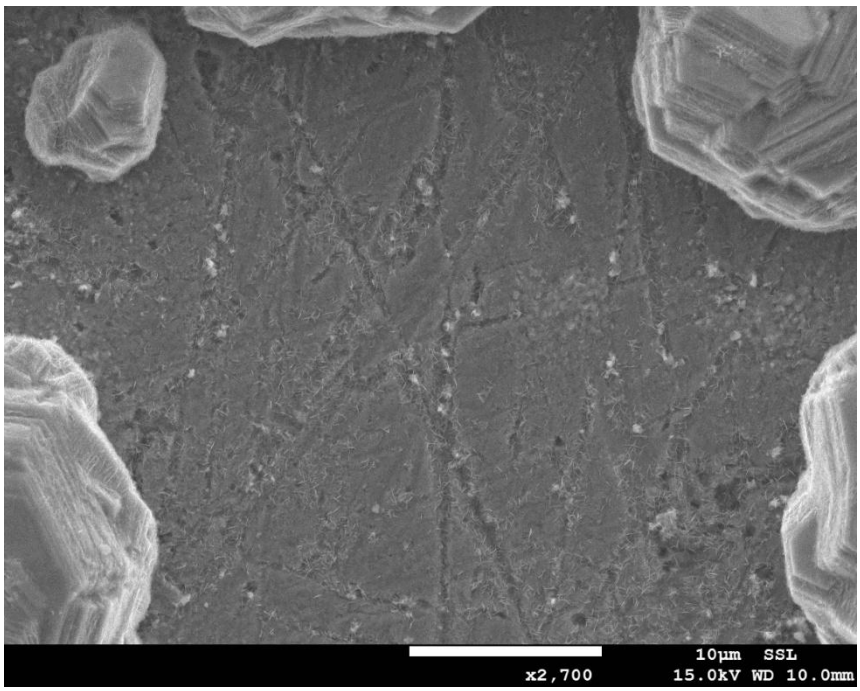


Figure S27: SEM image of the coated substrate surface at frequency 250 Hz, at 2700× magnification.

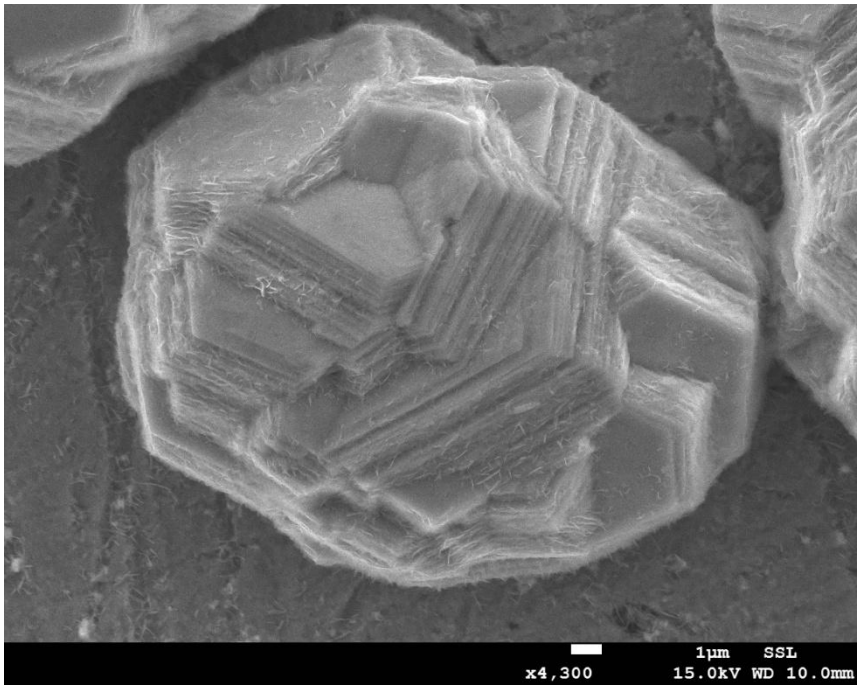


Figure S28: SEM image of the coated substrate surface at frequency 250 Hz, at 4300× magnification.

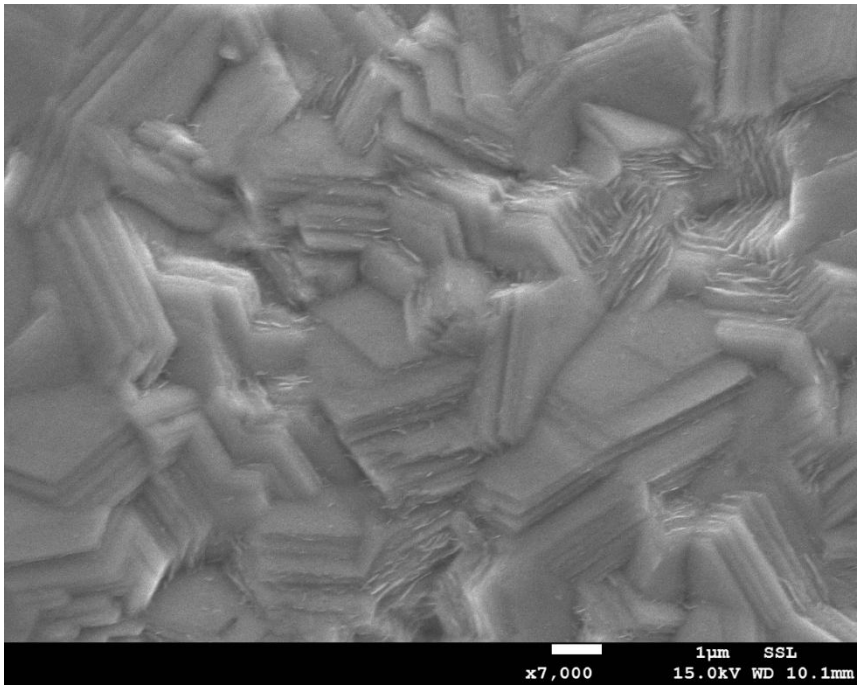
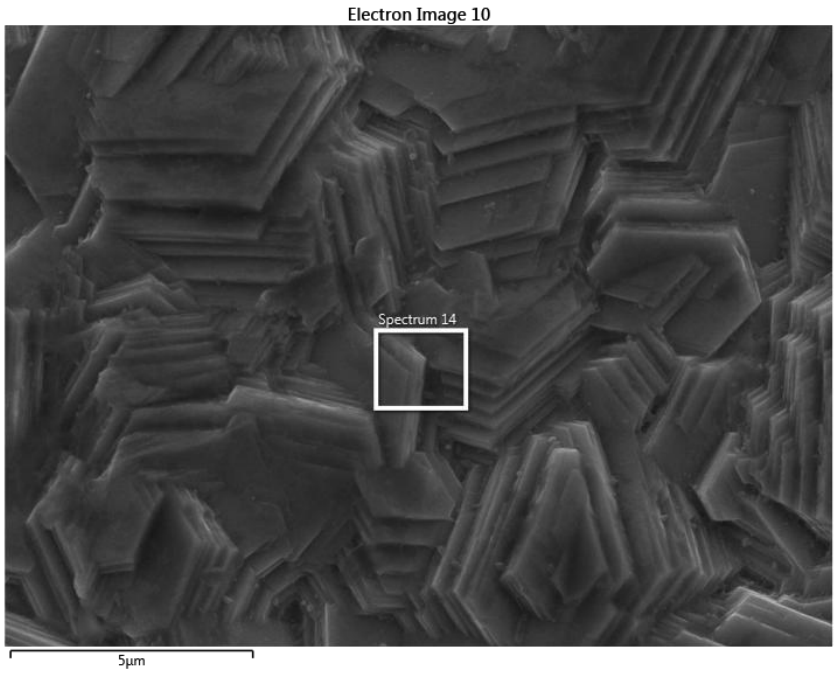


Figure S29: SEM image of the coated substrate surface at frequency 250 Hz, at 7000× magnification.

a)



b)

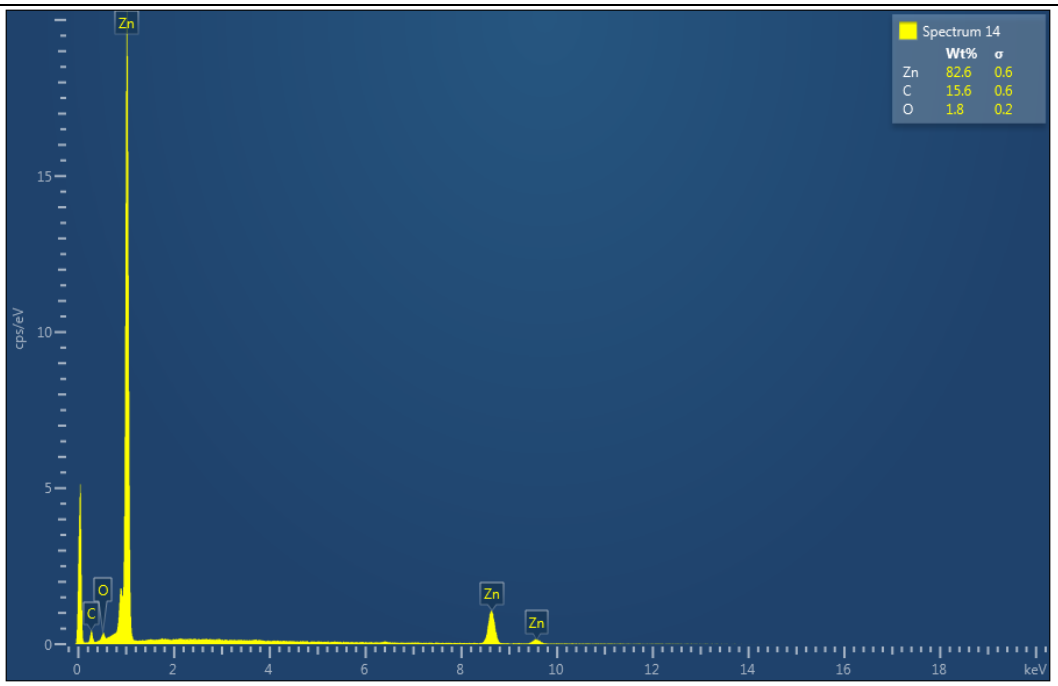


Figure S30: a) SEM image of the coated substrate surface at frequency 150 Hz, b) the corresponding EDS spectrum showing the elemental composition.

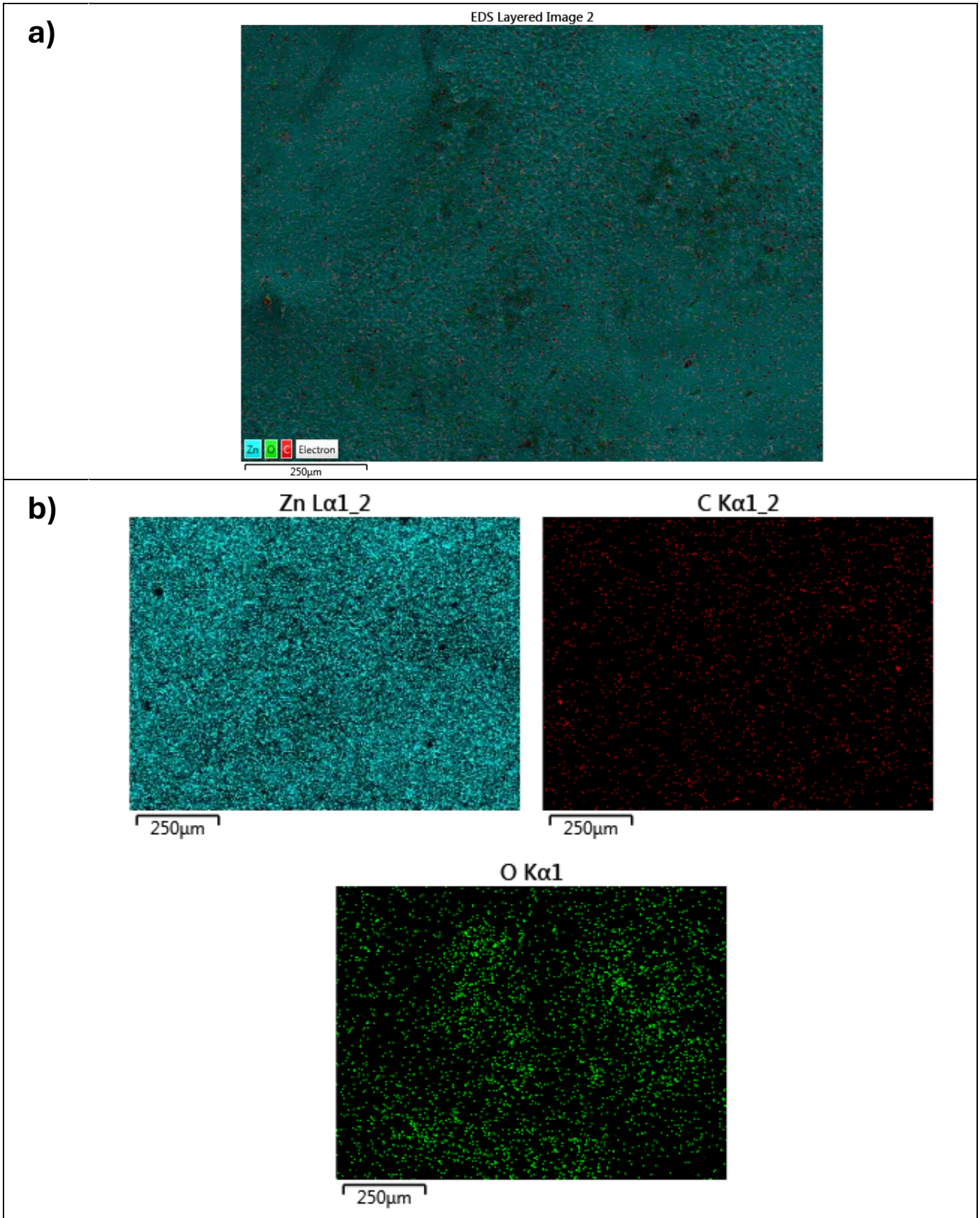
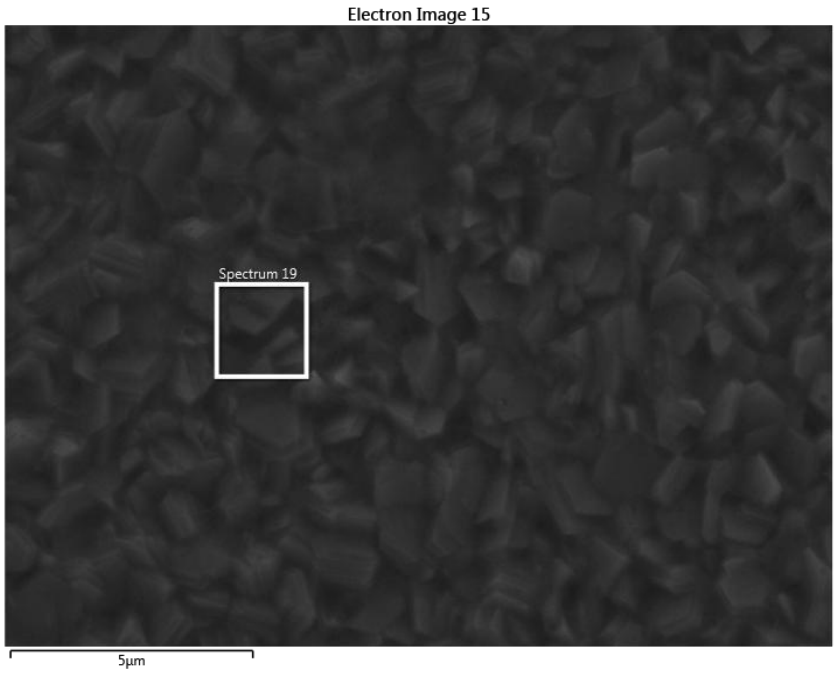


Figure S31: a) SEM image of the coated substrate surface at frequency 150 Hz, and the corresponding EDS elemental maps (Zn, C, O), confirming the distribution of elements across the coating

a)



b)

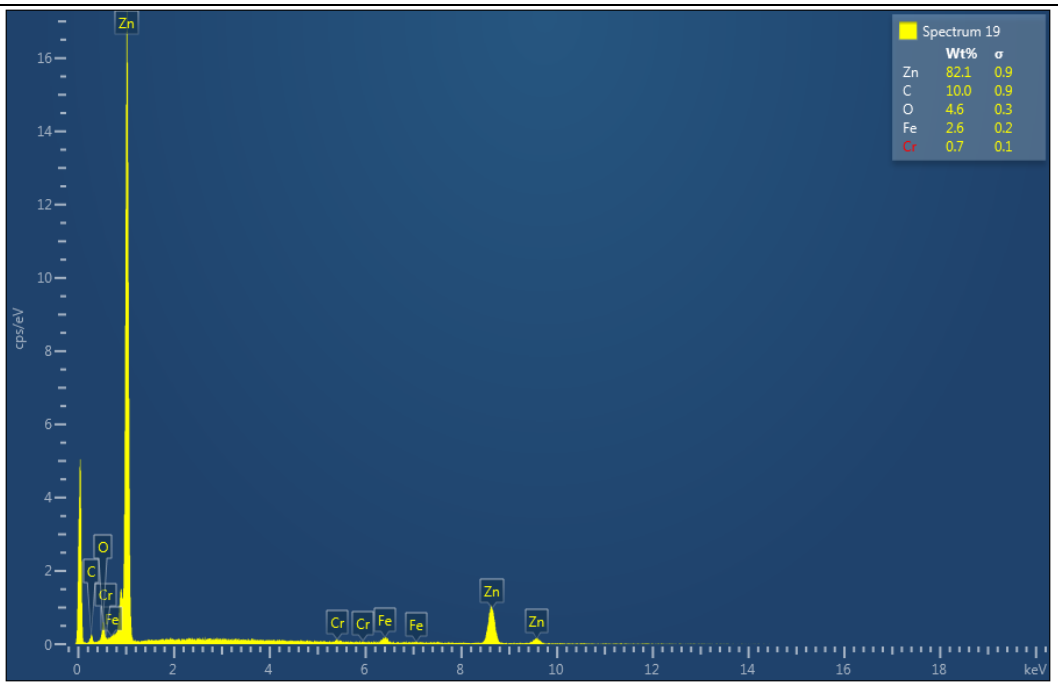
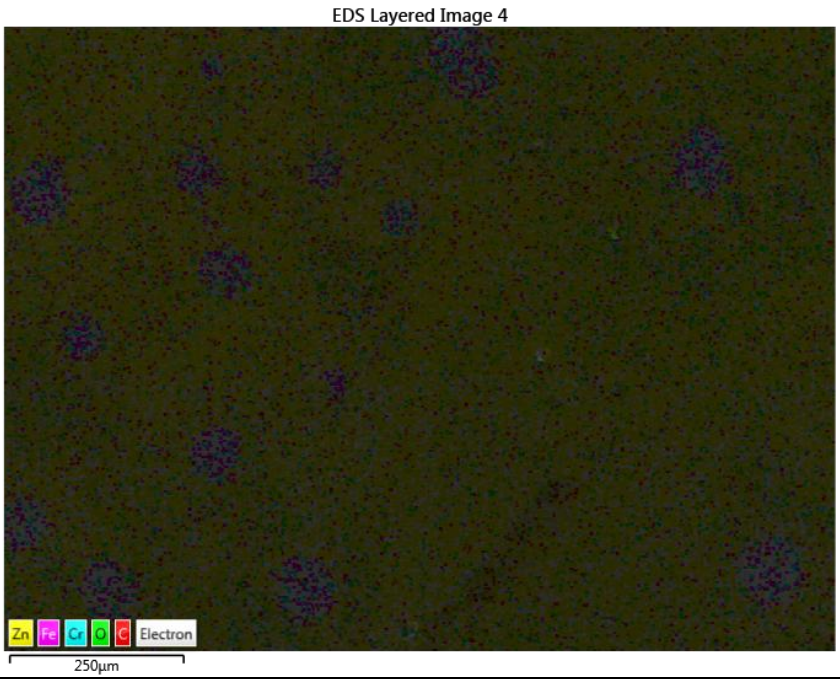


Figure S32: a) SEM image of the coated substrate surface at frequency 175 Hz, b) the corresponding EDS spectrum showing the elemental composition.

a)



b)

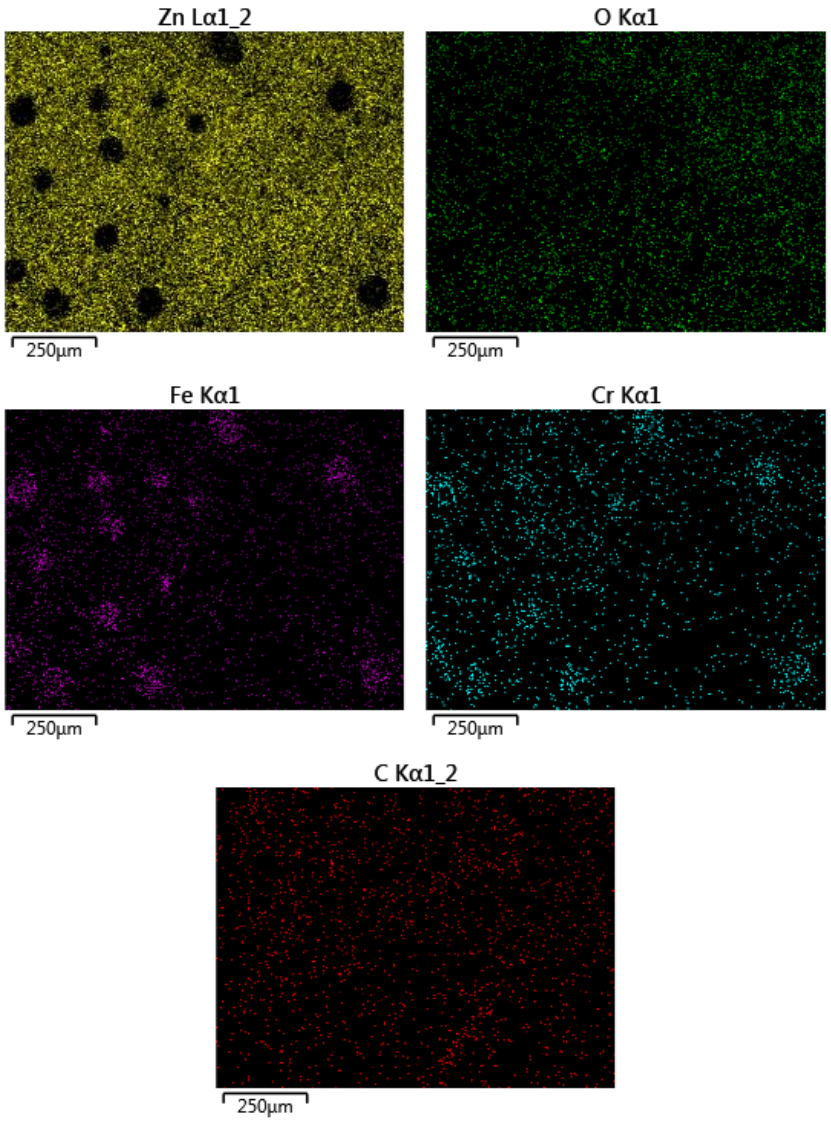
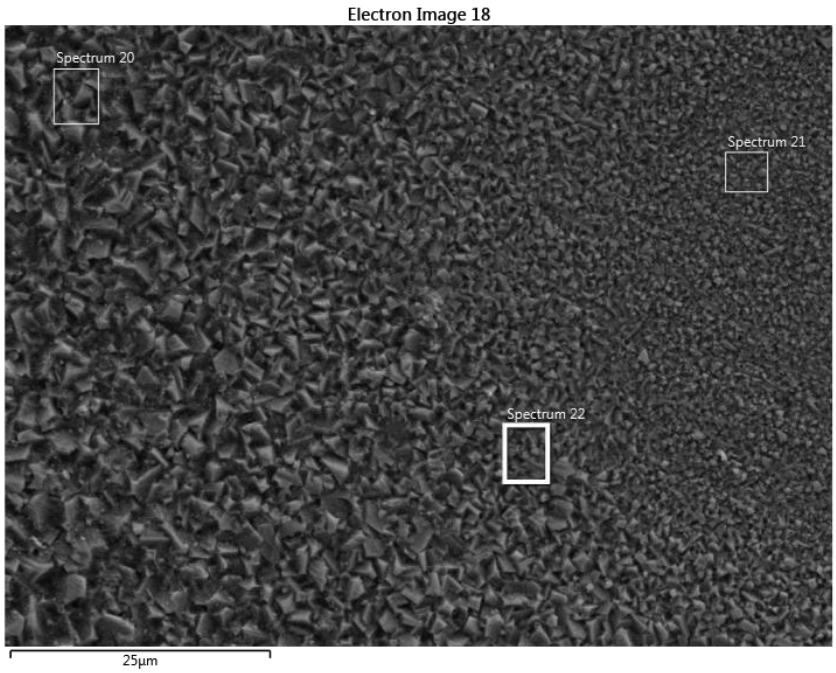


Figure S33: a) SEM image of the coated substrate surface at frequency 175 Hz, and the corresponding EDS elemental maps (Zn, Fe, Cr, C, O), confirming the distribution of elements across the coating

a)



b)

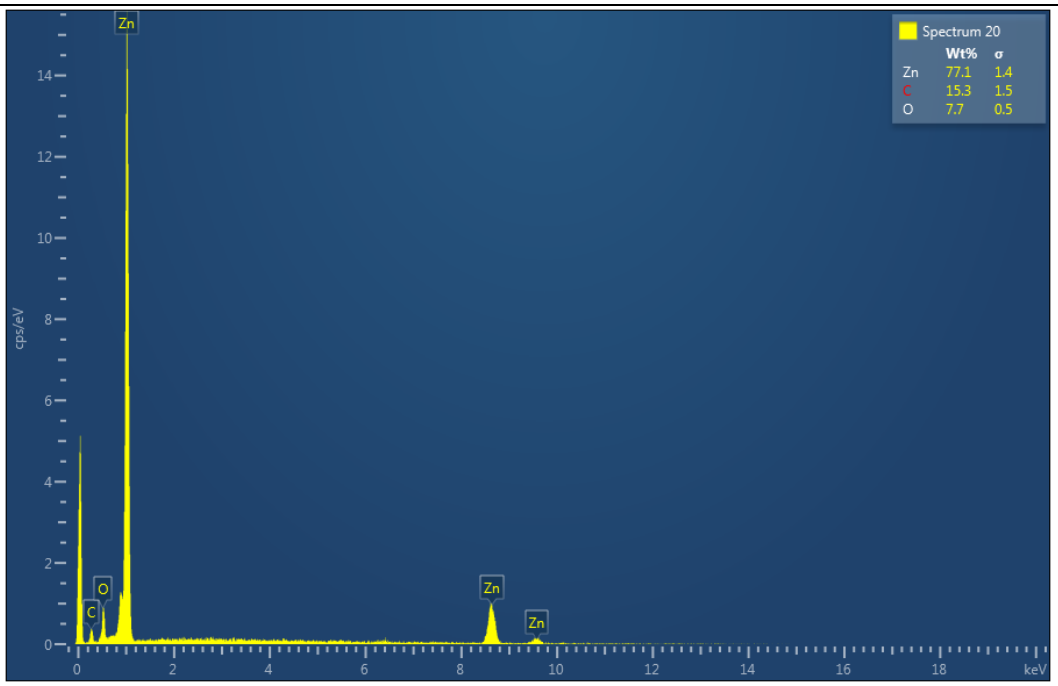
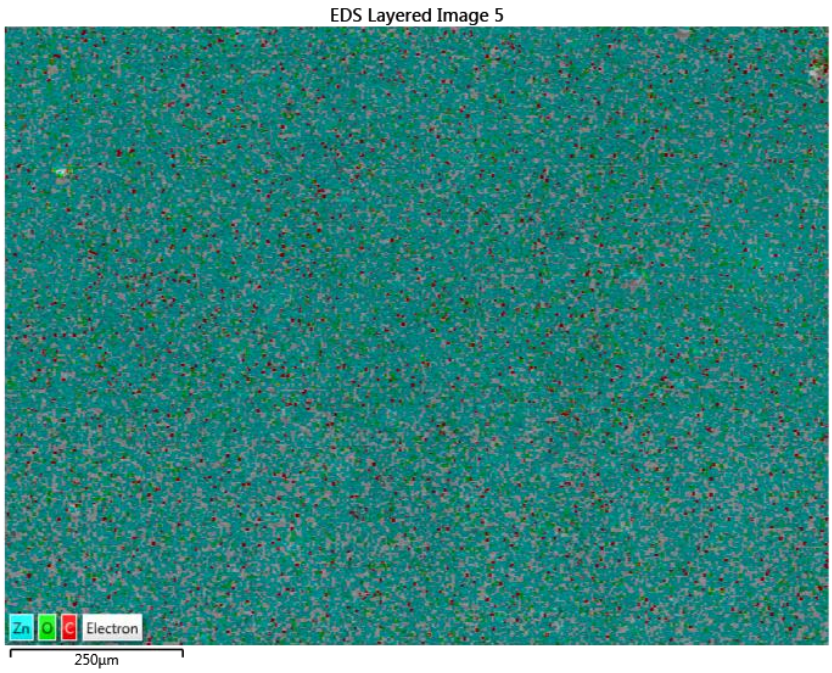


Figure S34: a) SEM image of the coated substrate surface at frequency 200 Hz, b) the corresponding EDS spectrum showing the elemental composition.

a)



b)

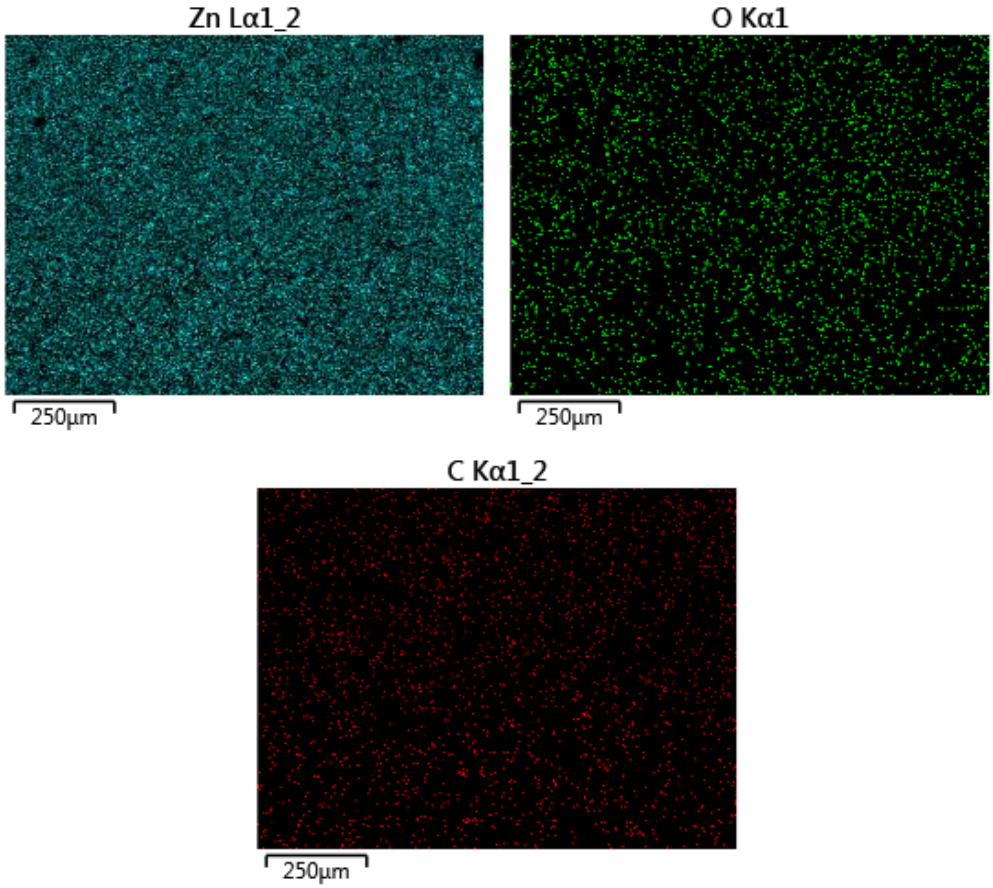
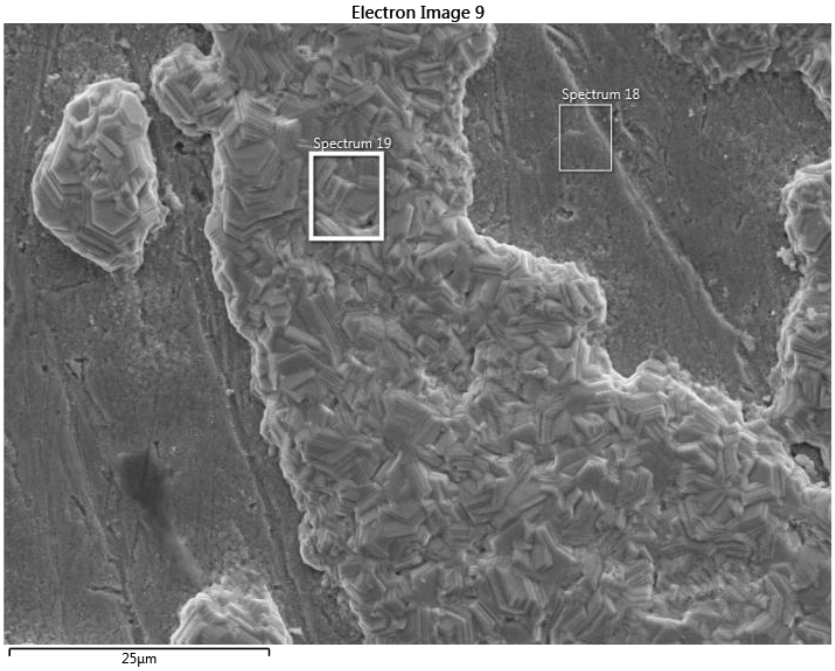


Figure S35: a) SEM image of the coated substrate surface at frequency 200 Hz, and the corresponding EDS elemental maps (Zn, C, O), confirming the distribution of elements across the coating

a)



b)

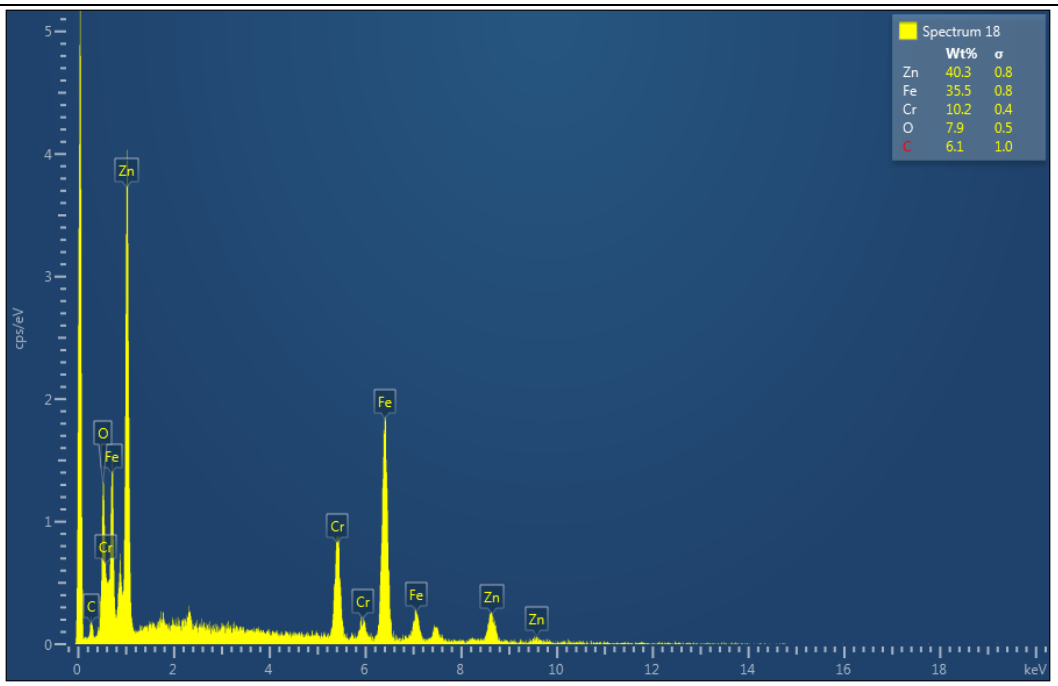
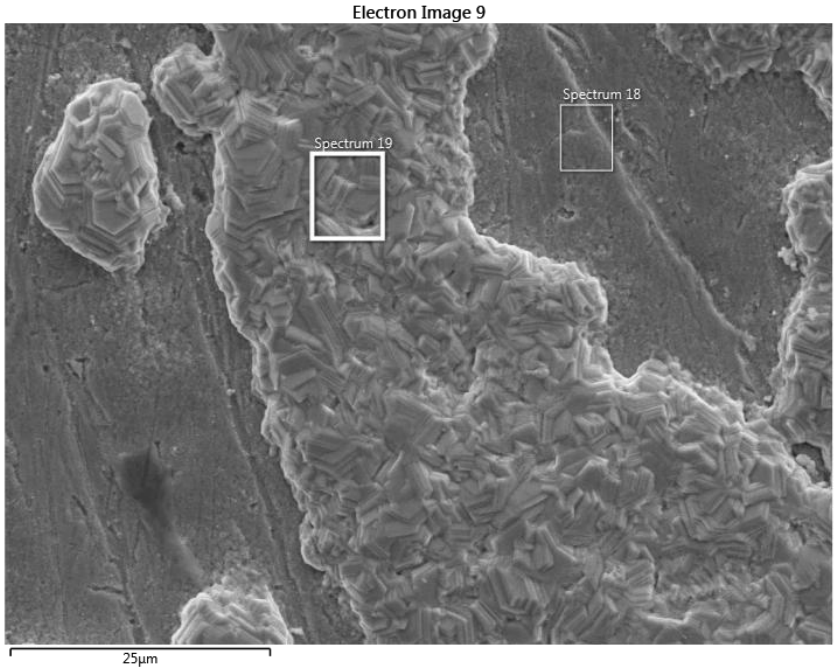


Figure S36: a) SEM image of the coated substrate surface at frequency 250 Hz, b) the corresponding EDS spectrum showing the elemental composition at location spectrum 18.

a)



b)

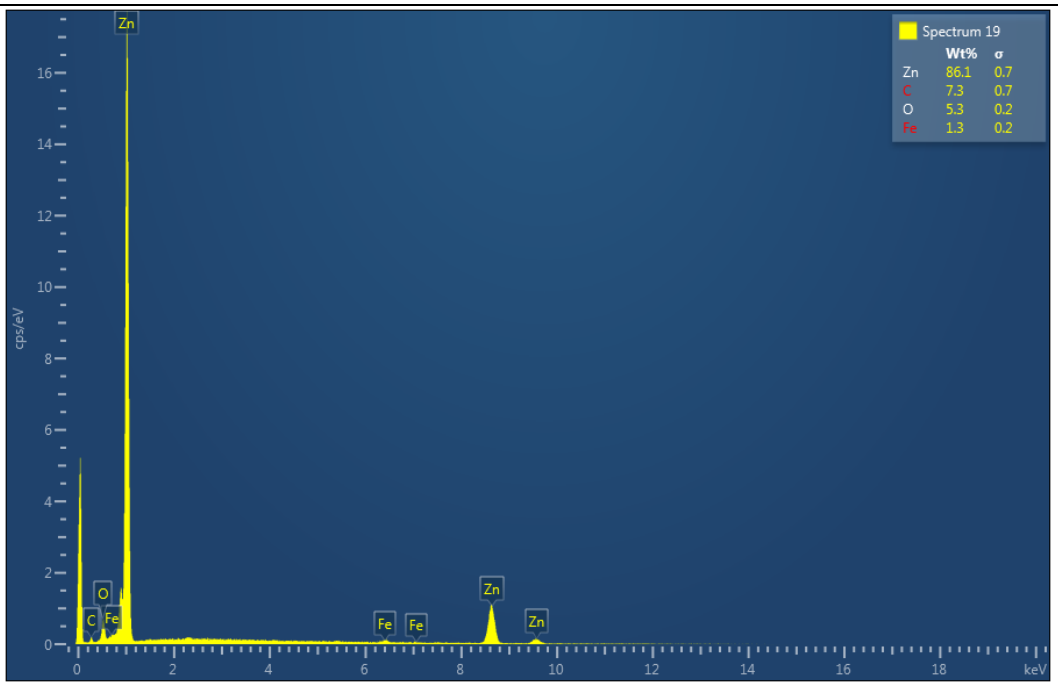


Figure S37: a) SEM image of the coated substrate surface at frequency 250 Hz, b) the corresponding EDS spectrum showing the elemental composition at location spectrum 19.

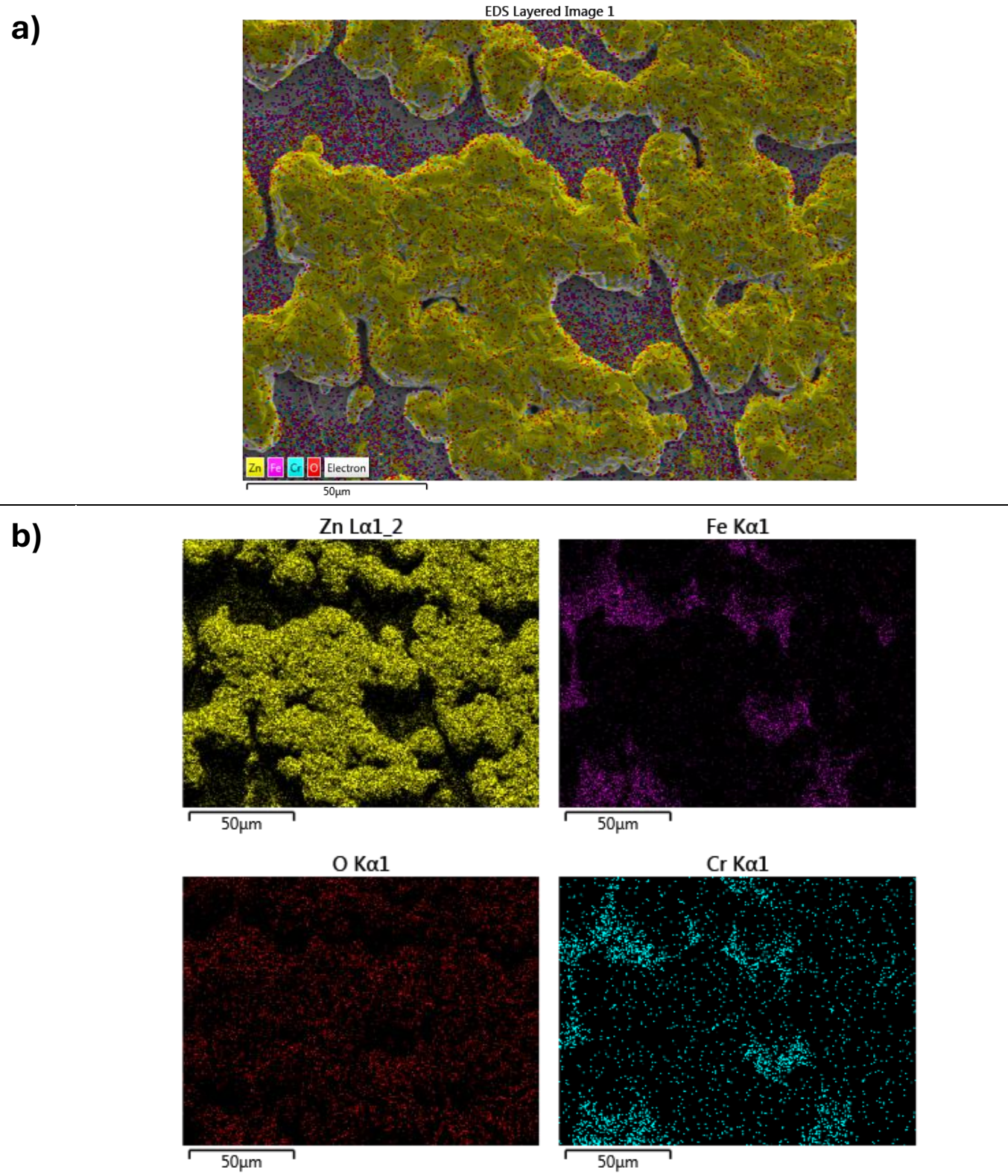


Figure S38: a) SEM image of the coated substrate surface at frequency 250 Hz, and the corresponding EDS elemental maps (Zn, Fe, Cr, O), confirming the distribution of elements across the coating