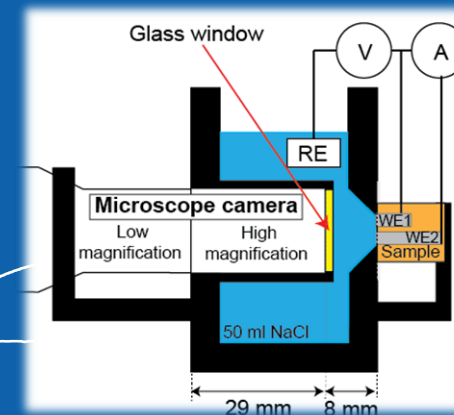


Monitoring corrosion inhibition by optical-electrochemical analysis



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Correlimage

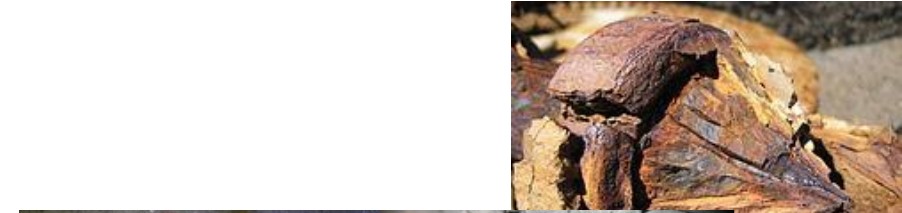
M. (Matteo) Olgiati, MSc.
Delft University of Technology
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Topics

- ① Introduction optical technique
- ② Introduction electrochemical technique
- ③ Detecting corrosion inhibition
- ④ Conclusions and further research





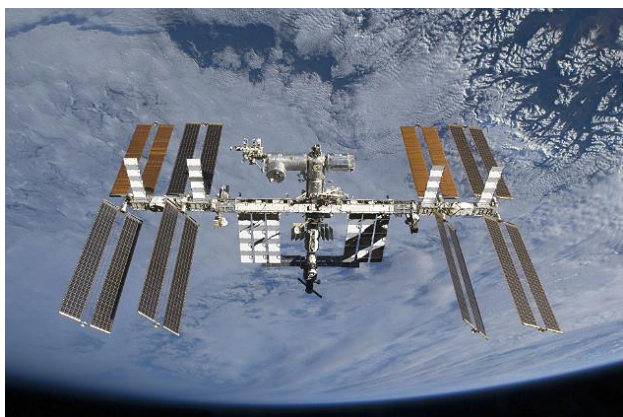
Definition



Corrosion

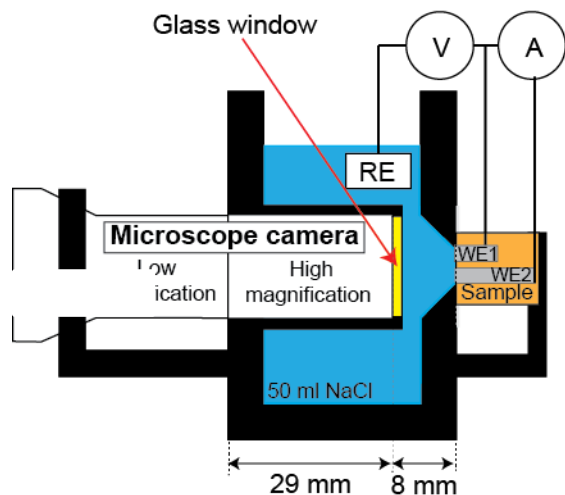


Deterioration of a material (usually a metal) that results from a chemical or electrochemical reaction with its environment

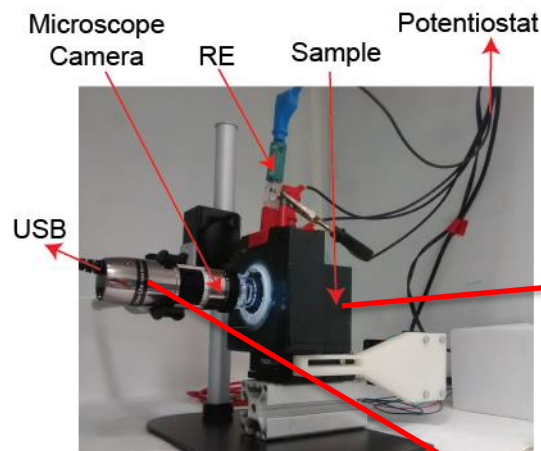




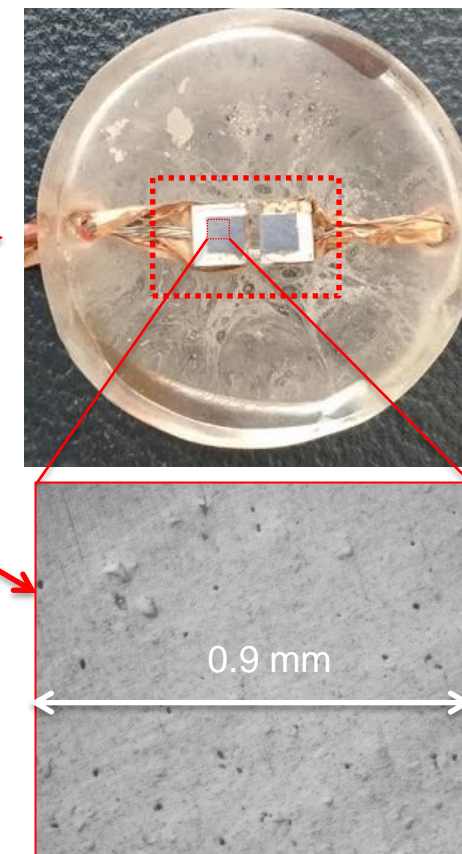
Optical technique



- ✓ Visual = intuitive
- ✓ Simultaneous
- ✓ Real-time
- ✓ In-situ
- ✓ Good resolution ($< 1 \mu\text{m}$)



Sample



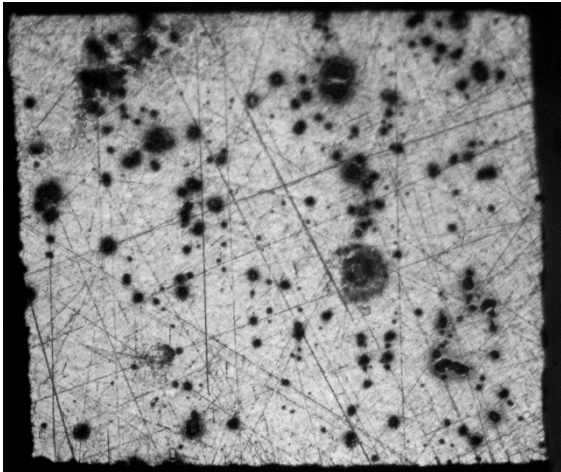
P.J. Denissen, A.M. Homborg, S.J. Garcia, Interpreting Electrochemical Noise and Monitoring Local Corrosion by Means of Highly Resolved Spatiotemporal Real-Time Optics, J. Electrochem. Soc. 166 (2019) C3275–C3283. doi:10.1149/2.0341911jes



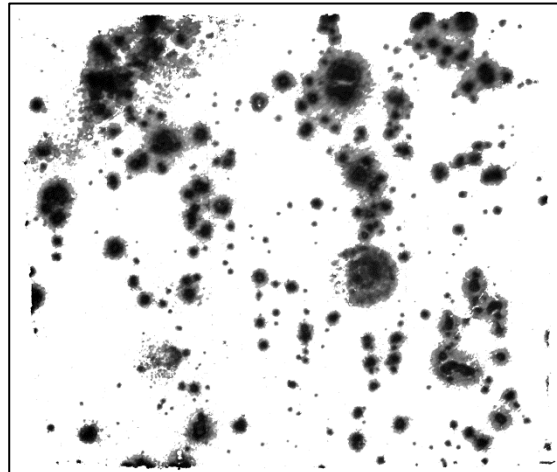
Principle of optical technique

Image analysis

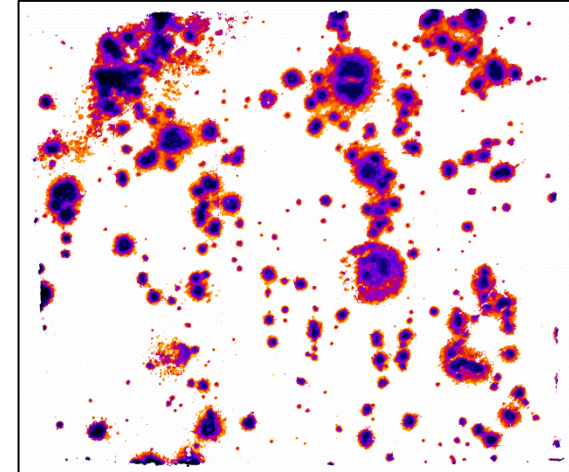
Original image



Background removal



Analysis - colour scale



Degradation

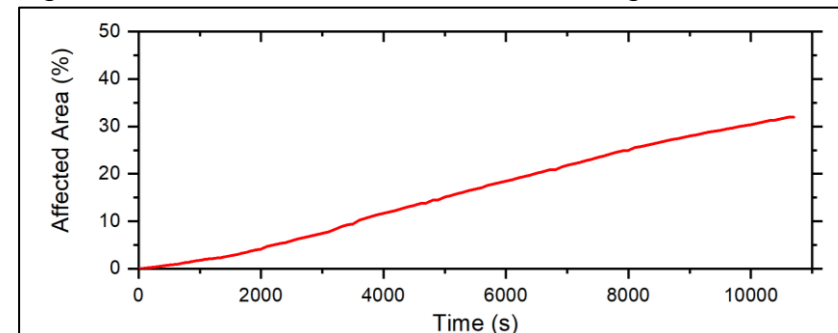


Degradation

Affected Area %



$$AA\% (t) = \frac{N_{changed}(t)}{N_{TOT}} \cdot 100\%$$



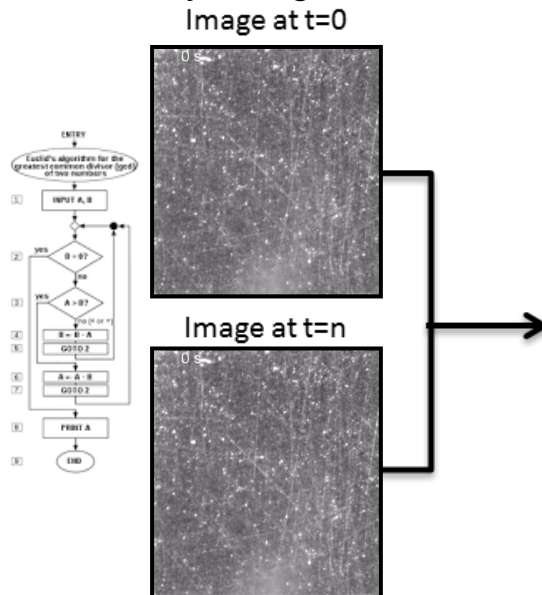


Optical data analysis

Conditions:

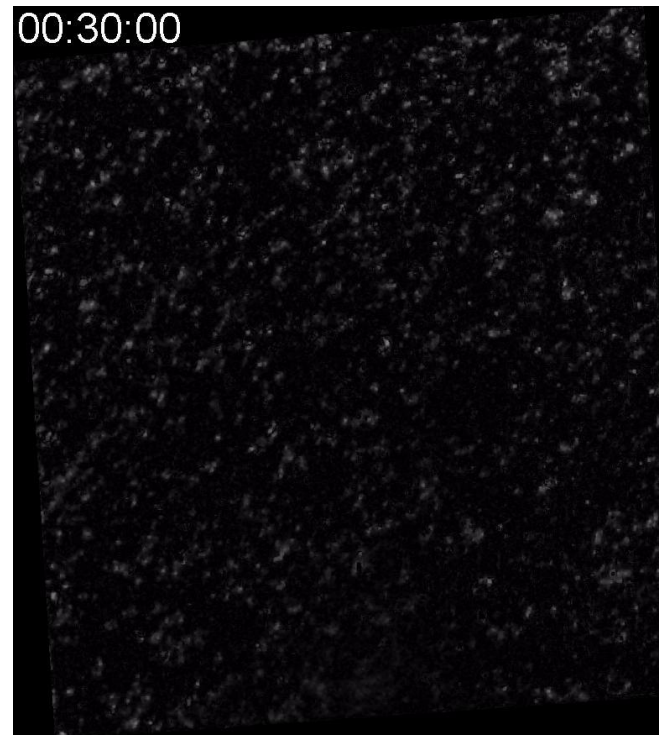
- AA2024-T3
- 0.05 M NaCl
- $t = 0-1,8$ ks

Analysis algorithm

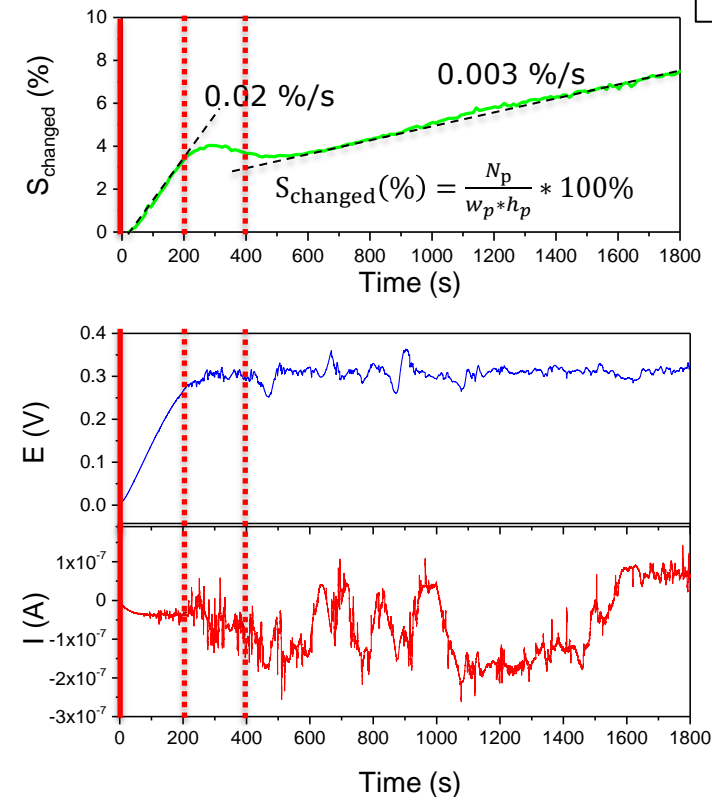


$$i_{\text{Difference}}(x,y) = |i_n(x,y) - i_0(x,y)|$$

Visualisation of results



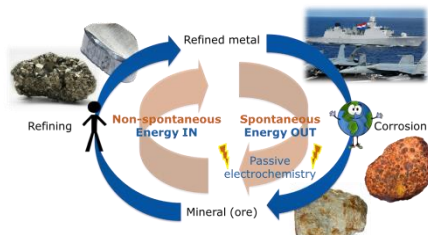
Quantification



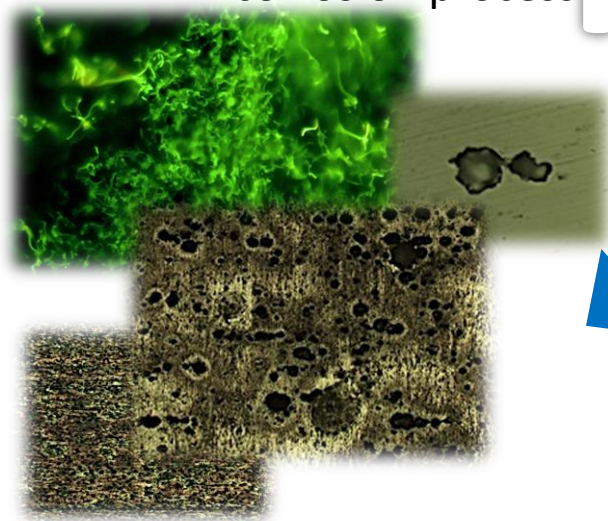
P.J. Denissen, A.M. Homborg, S.J. Garcia, Interpreting Electrochemical Noise and Monitoring Local Corrosion by Means of Highly Resolved Spatiotemporal Real-Time Optics, J. Electrochem. Soc. 166 (2019) C3275–C3283. doi:10.1149/2.0341911jes



Principle of electrochemical technique



T/F characteristics are used as identification criteria for the corrosion process

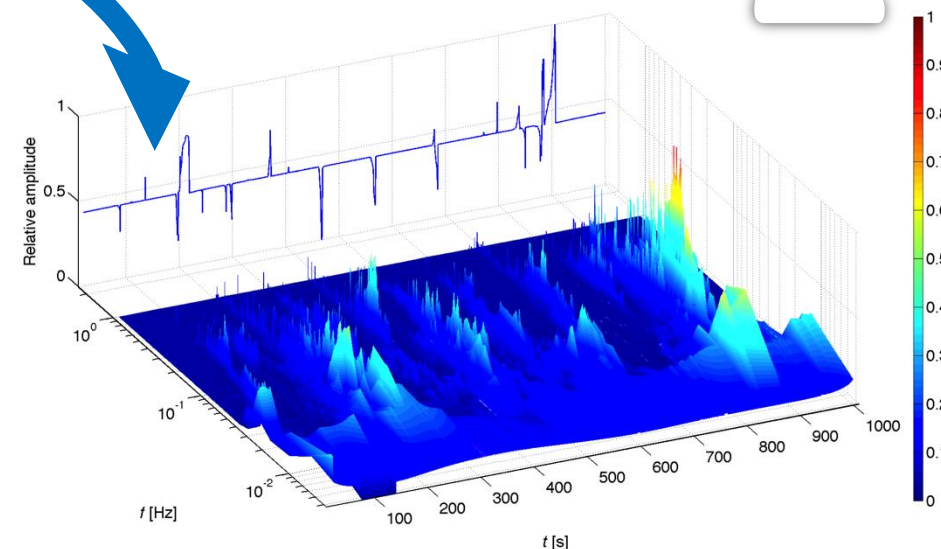


Every corrosion process generates characteristic charge fluctuations, or electrochemical noise

Representing the signal in both time and frequency domains

Electrochemical noise reflects the kinetics of the corrosion process

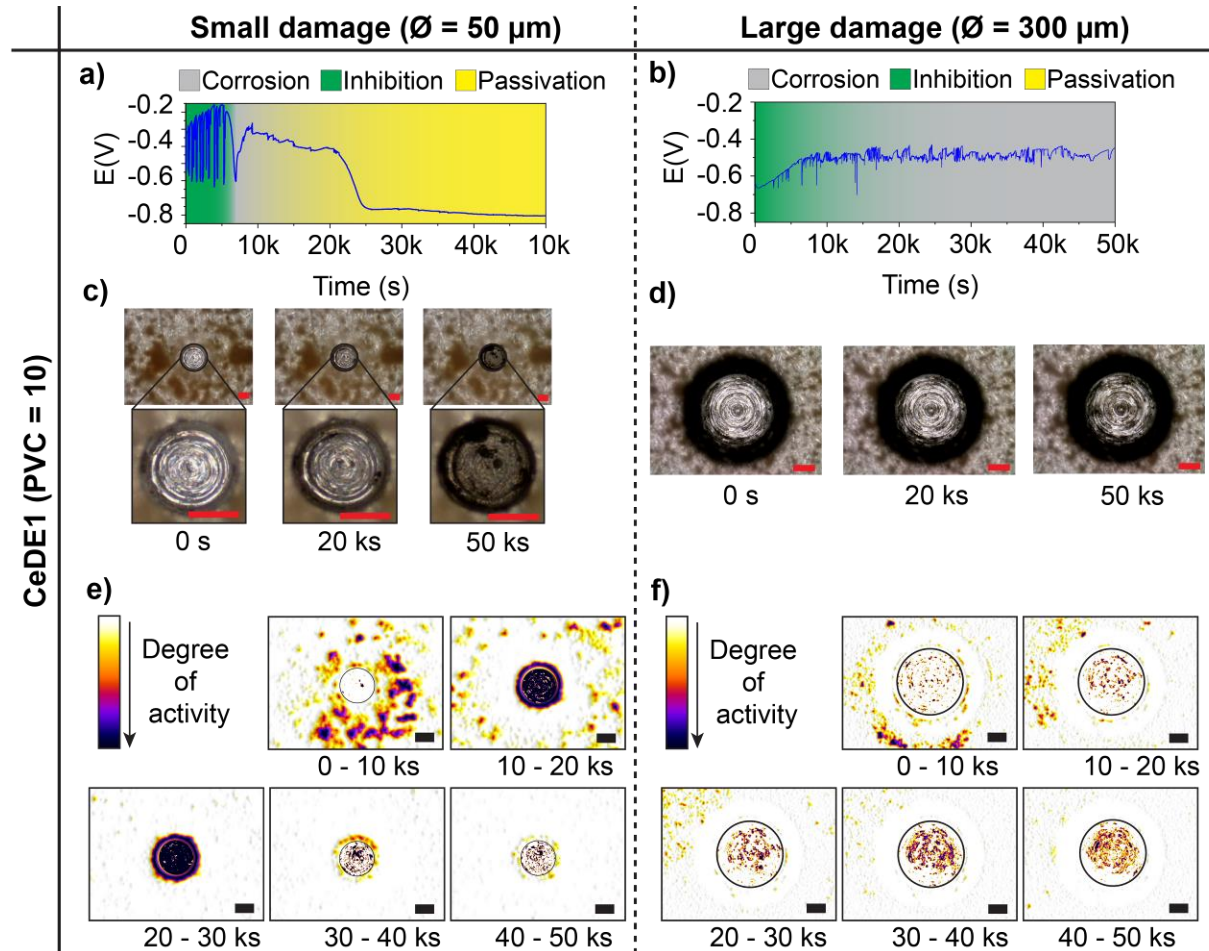
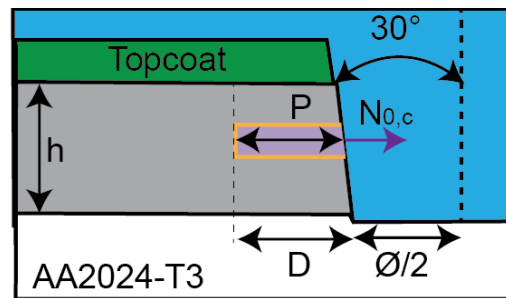
These kinetics leave specific fingerprints in the T/F domain





Continuous supply of Ce(III) by inhibitor pathways inside coatings

Single particle release

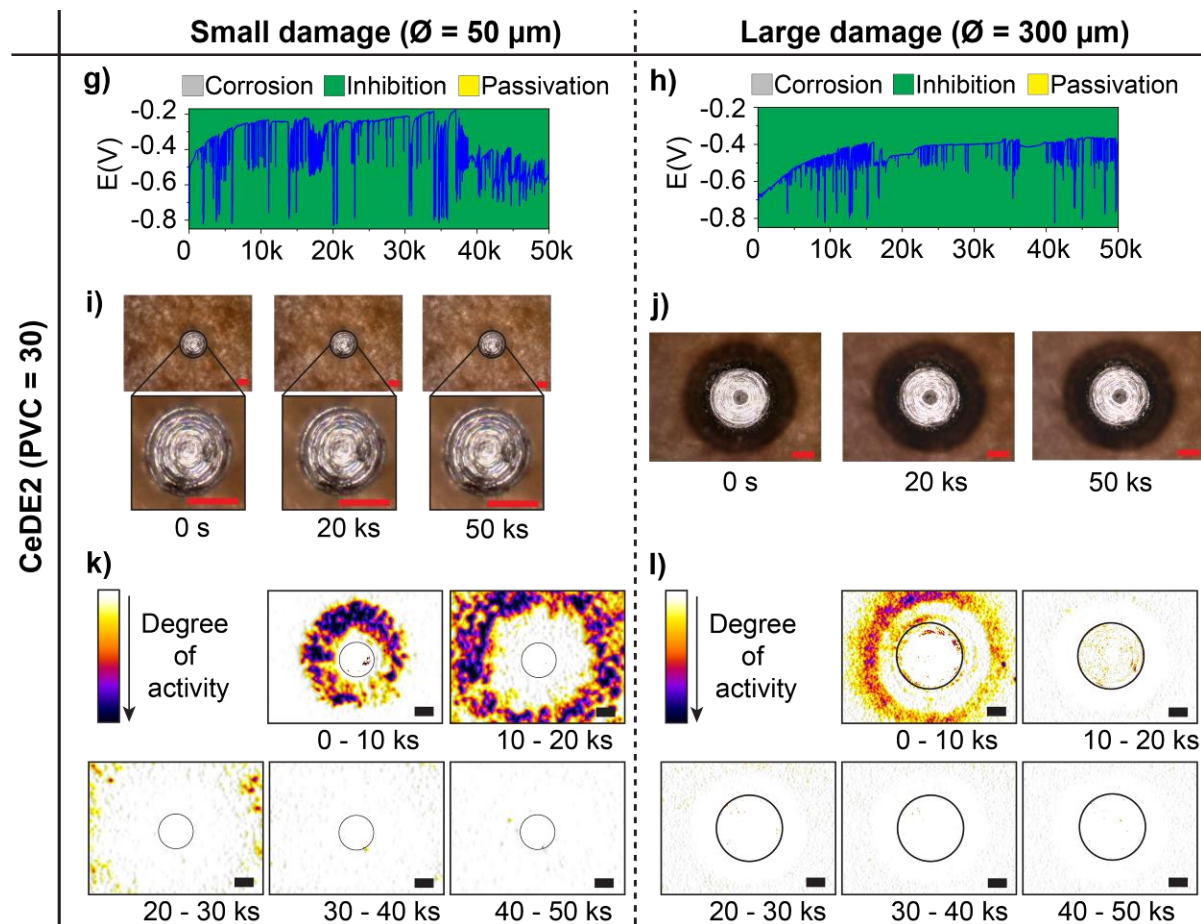
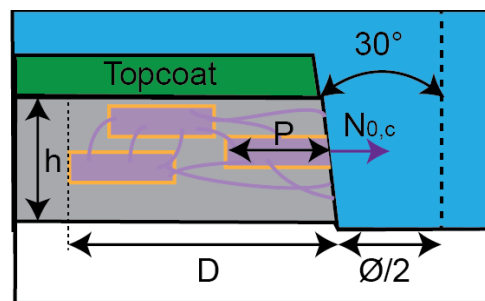


Paul J. Denissen, Axel M. Homborg, Santiago J. García, Under submission



Continuous supply of Ce(III) by inhibitor pathways inside coatings

Inhibitor pathways



Paul J. Denissen, Axel M. Homborg, Santiago J. García, Under submission



Conclusions and further research

Benefits:

- Local optics provide high spatial resolution
- Local optics detect inhibitor release and quantify corrosion and inhibitor activity
- EN identifies the kinetics of the system, discriminates between corrosion and inhibitor activity

Currently on-going work by the team: space-temporal identification of the source of noise transients:

- Relation between individual transients and intermetallic activity

Potential for further research:

- How can data from EN and local optics be correlated after longer exposure times?
- How can EN and local optics effectively be implemented into research on Cr(VI) alternatives?



Further reading

P.J. Denissen, V. Shkirskiy, P. Volovitch, S.J. Garcia, Corrosion Inhibition at Scribed Locations in Coated AA2024-T3 by Cerium- and DMTD-Loaded Natural Silica Microparticles under Continuous Immersion and Wet / Dry Cyclic Exposure, *ACS Appl. Mater. Interfaces*, 12 (2020) 23417–23431

P.J. Denissen, A.M. Homborg, S.J. Garcia, Interpreting electrochemical noise and monitoring local corrosion by means of highly resolved spatiotemporal real-time optics, *J. Electrochem. Soc.* 166 (2019) C3275–C3283

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A.M. Homborg, R.A. Cottis, J.M.C. Mol, An integrated approach in the time, frequency and time-frequency domain for the identification of corrosion using electrochemical noise, *Electrochimica Acta*, 222 (2016) 627-640

A.M. Homborg, T. Tinga, E.P.M. van Westing, X. Zhang, G.M. Ferrari, J.H.W. de Wit and J.M.C. Mol, A critical appraisal of the interpretation of electrochemical noise for corrosion studies, *Corrosion*, 70, 10 (2014) 971-987

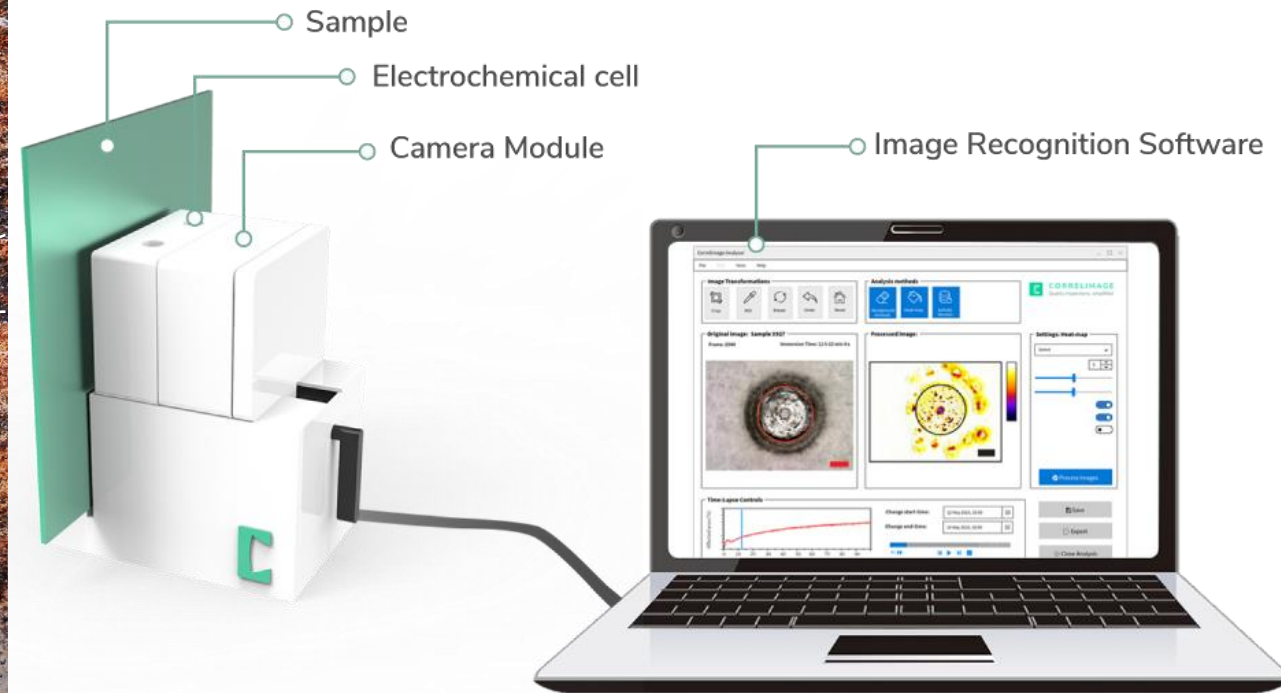


Thank you for your attention

The Faculty of Aerospace Engineering of Delft University of Technology and the Netherlands Defence Academy are kindly appreciated for accomodating this research work

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The Corrosion Imager



info@correlimage.com