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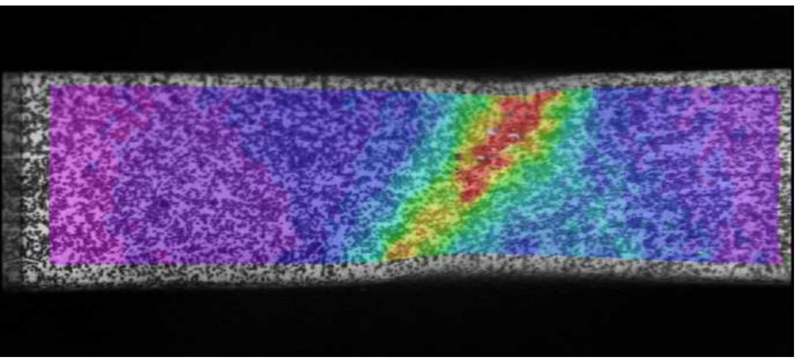

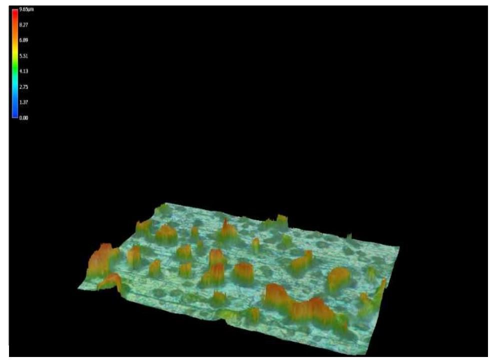

Influence of corrosion on dynamic tensile properties of stainless steel

Eric Hicks

1528/Darrick Jones/Brett Sanborn, Bo Song & Miguel Atencio

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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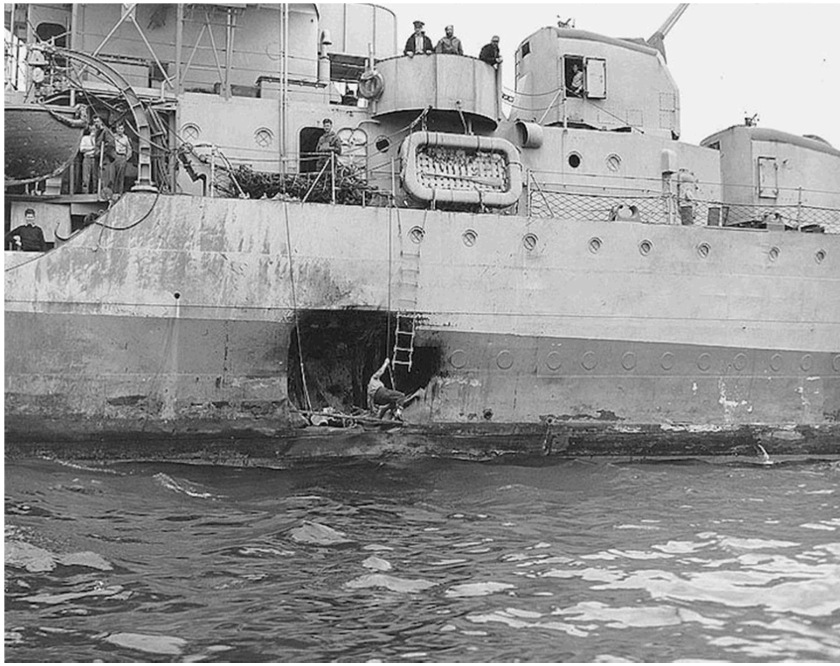
Corrosive Environments



Kamikaze damage
http://www.navsource.org/archives/05/0540712.jpg

USS New York
https://upload.wikimedia.org/wikipedia/commons/c/c2/USS_New_York_in_the_Hudson_River_200911.jpg

- High strain rate situations
- Possible loss of failure strength
- Little data available

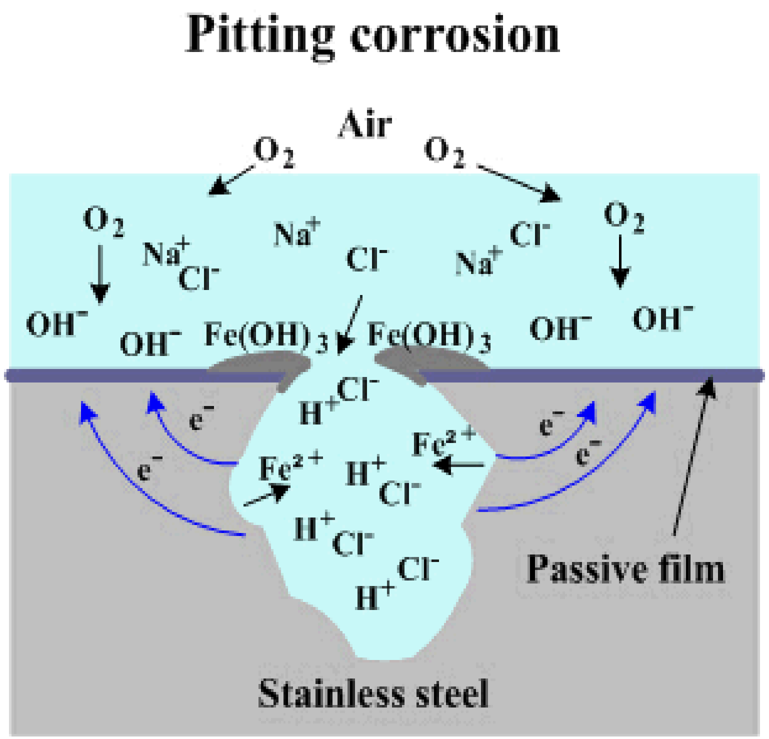
Corrosion

Rust Formation

$$Fe^{2+}(aq) + 2\,OH^{-}(aq) \longrightarrow Fe(OH)_2(s)$$

$$4\,Fe(OH)_2(s) + O_2(g) + 2\,H_2O(l) \longrightarrow 4\,Fe(OH)_3(s)$$

- Pitting is the most common
- Difficult to measurer & detect
- Pit acts as anode
- Surface acts as cathode
- Causes material to fail much sooner
- Measured by mils/year corrosion rate
  - Speed at which a metal deteriorates in a specific environment.



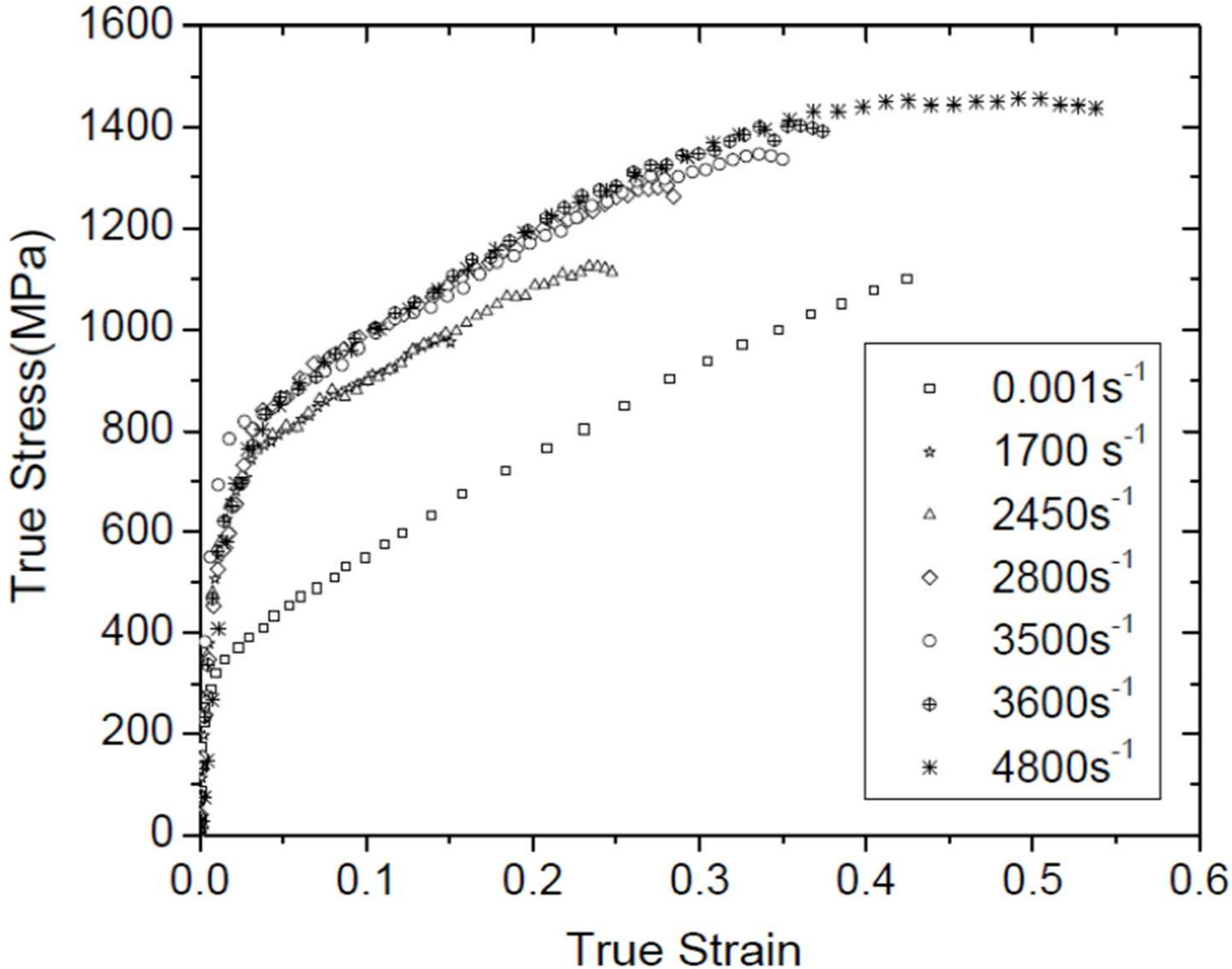
How stainless steel is affected by, and resists, corrosion.
http://sassda.co.za/stainless-steel-and-corrosion/

$$R = \frac{(3.45 * 10^6) * \Delta m}{\rho * A * t}$$

ρ = Density
A = Surface area
t = time exposed to corrosion
m = mass

Effect of High Strain Rate

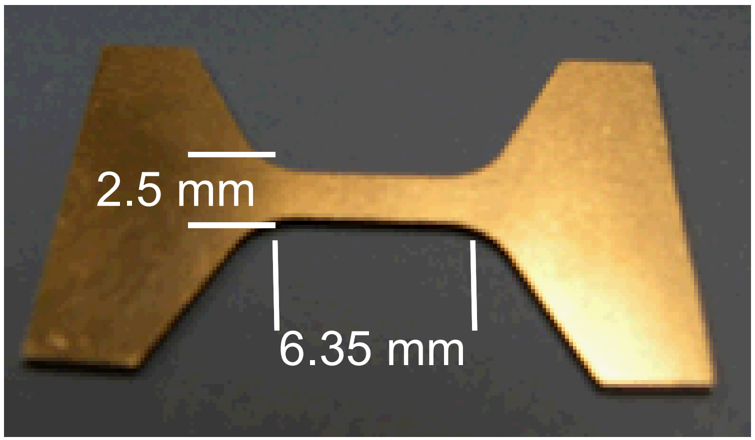
- Increased failure strength with increased strain rate

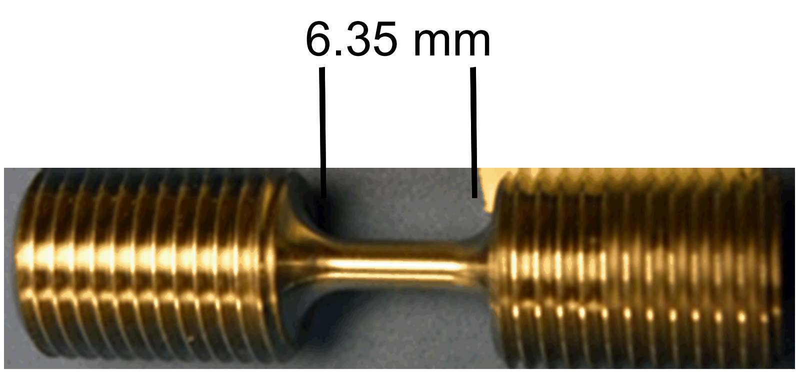


Mechanical Behavior of SS 304 LN at High Strain Rates in Compression, SEM (Sumit V Prasad, 2012)

Materials

- 304 stainless steel flats??????
- 304L cylindrical specimens
- Rubber coating used to protect specimen ends





Material Properties (tension)

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- 304 Stainless Steel Properties (quasi-static)
  - Yield Strength -- 215 MPa
  - Ultimate Strength --- 505 MPa
  - Modulus of Elasticity -------------------------------------- 193-200 GPa
  - Corrosion resistant
  - High ductility
- 304 Stainless Steel Properties (High Strain Rate)
  - Yield Strength -- 500-800 MPa
  - Ultimate Strength -- 1000-1500 MPa
  - Modulus of Elasticity -------------------------------------- 193-200 GPa

	%Fe	%C	%Cr	%Ni	%Mn	%Si	%Mo	%P
304 Steel	70.9756	0.0667	18.12	9.58	0.602	0.3644	0.2898	0.0015

Corrosion Method

- Singleton Cyclic Chamber
- 5% solution salt-fog cycle
- ASTM B117 standard
- Constant exposure
- 7 & 14 day increments

High Strain Rate Testing

- Kolsky (Split-Hopkinson) bar
- Compression or tension
- Strain rates from 500 to 10,000 per second
- Developed in 1949

Bar Strain

$$\varepsilon_{i,r,t} = \frac{2 * V_{out}}{G_f * V_{ext} * gain}$$

Strain Rate

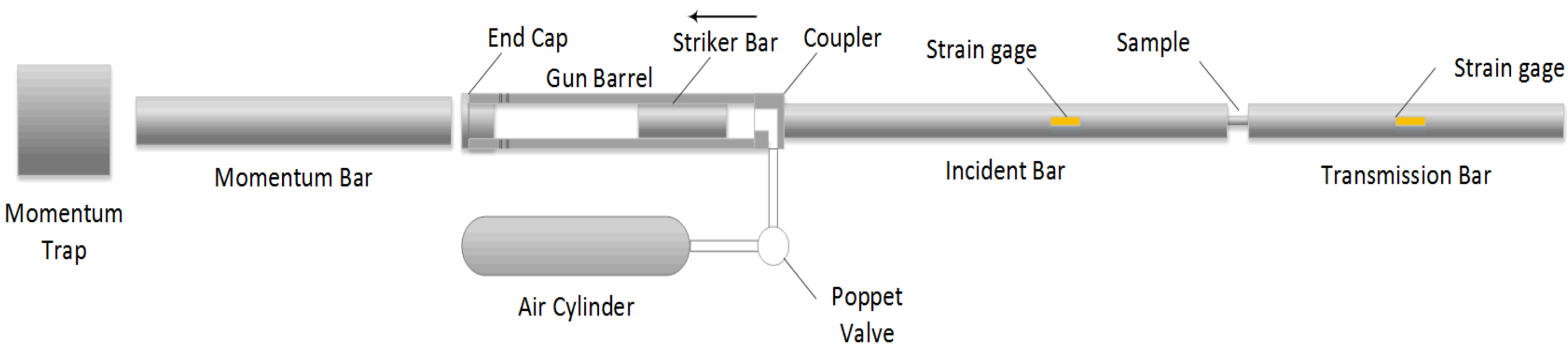
$$\dot{\varepsilon} = -2\frac{C_B}{L_s}\varepsilon_r$$

Specimen Strain

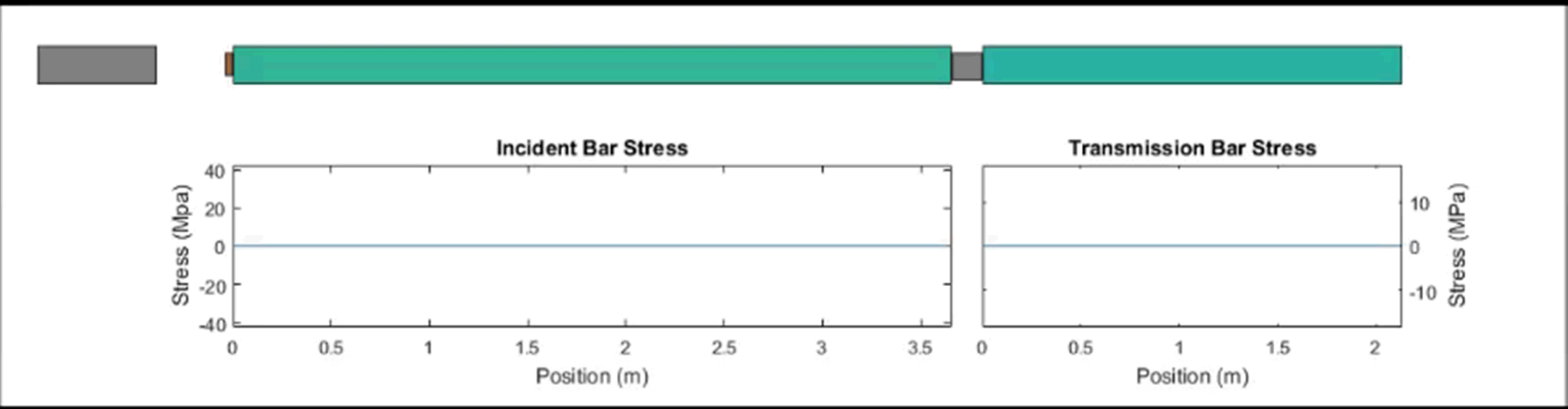
$$\varepsilon_s = -2\frac{C_B}{L_s}\int_0^t \varepsilon_r \, dt$$

Specimen Stress

$$\sigma = \frac{A_B}{A_S} E_B \varepsilon_t$$



Compression Test Example

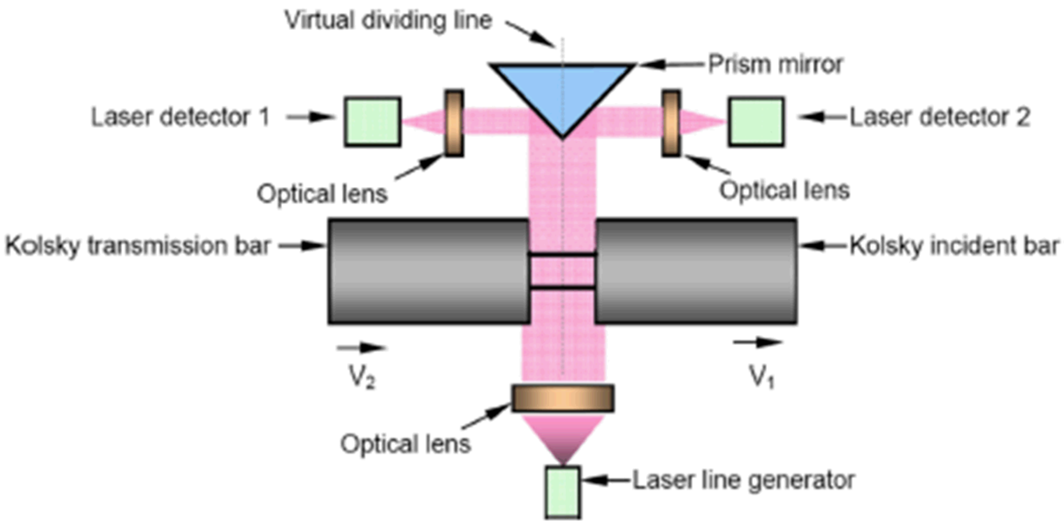


Kolsky Bar Lab @ Sandia

- 1” Tension and compression bars
- 3” Compression bar

Laser Based Strain Measurements

- Independent source of strain measurement
- Reflected wave strain measurement is not as accurate
- Calibration needed before ever session
- Correction factor needed

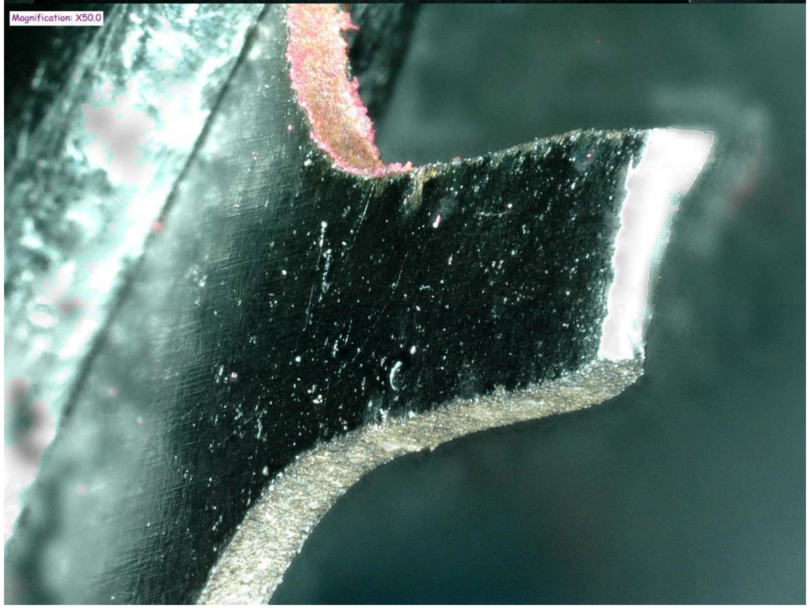


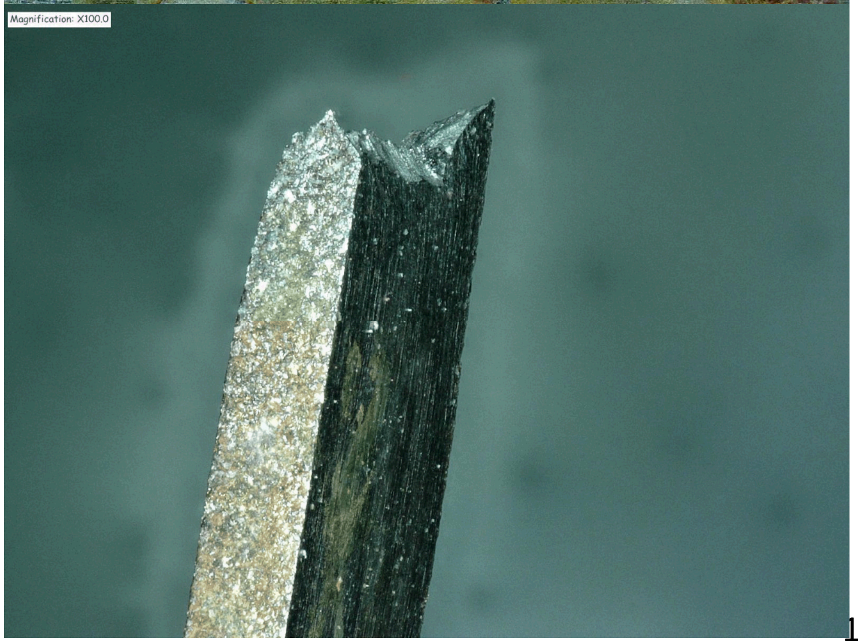
$$c' = \frac{\Delta L_s}{\Delta L + \Delta L_s} = 0.62$$

$$\varepsilon_s = c' \frac{L_1 - L_2}{Gauge\ Length}$$

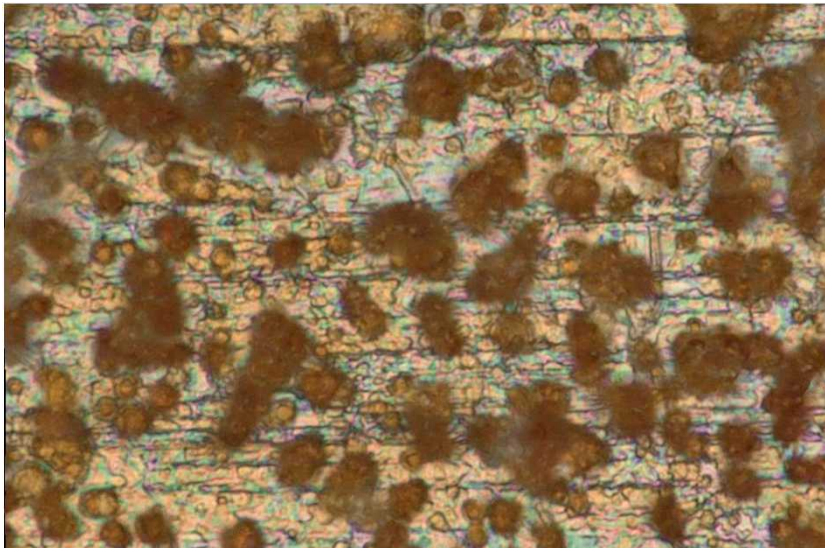
Dynamic Tensile Characterization of Vascomax Maraging C250 and C300 Alloys
(Bo Song, Peter Wakeland, Michael Furnish)

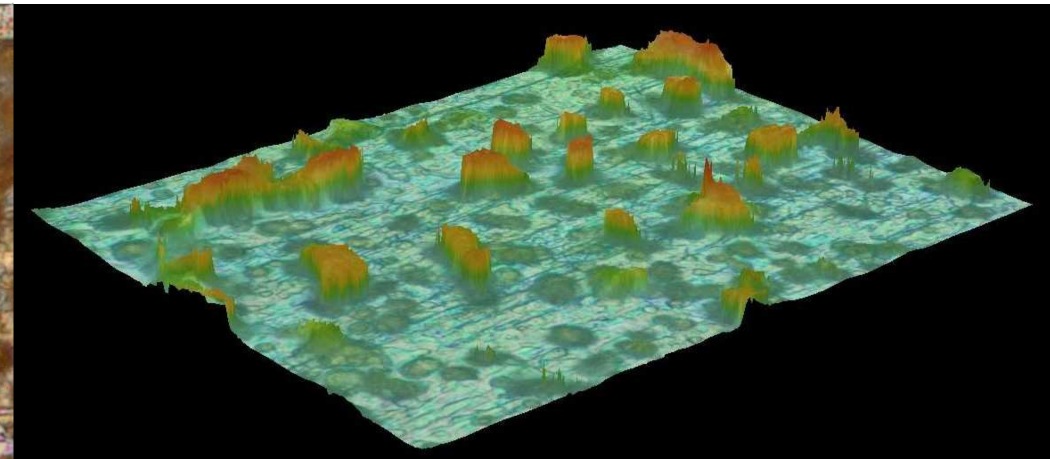
Post Salt-Fog – 7 days





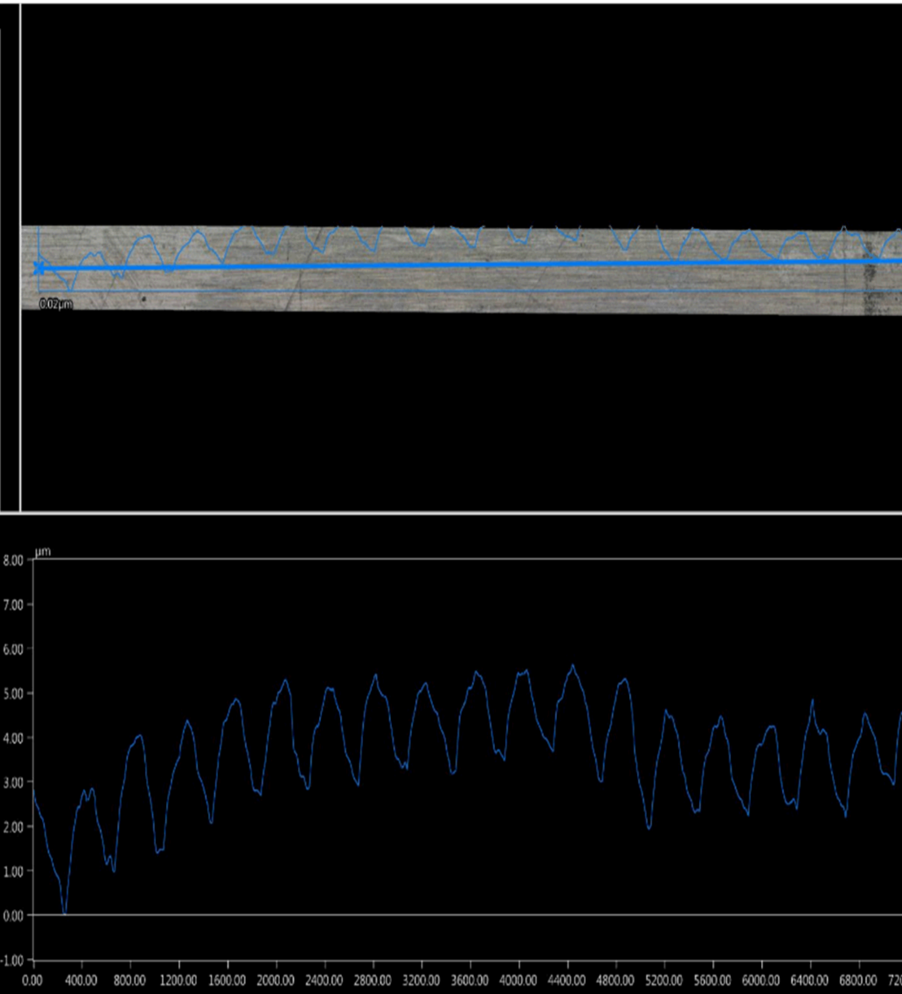
Post Salt-Fog – 14 days



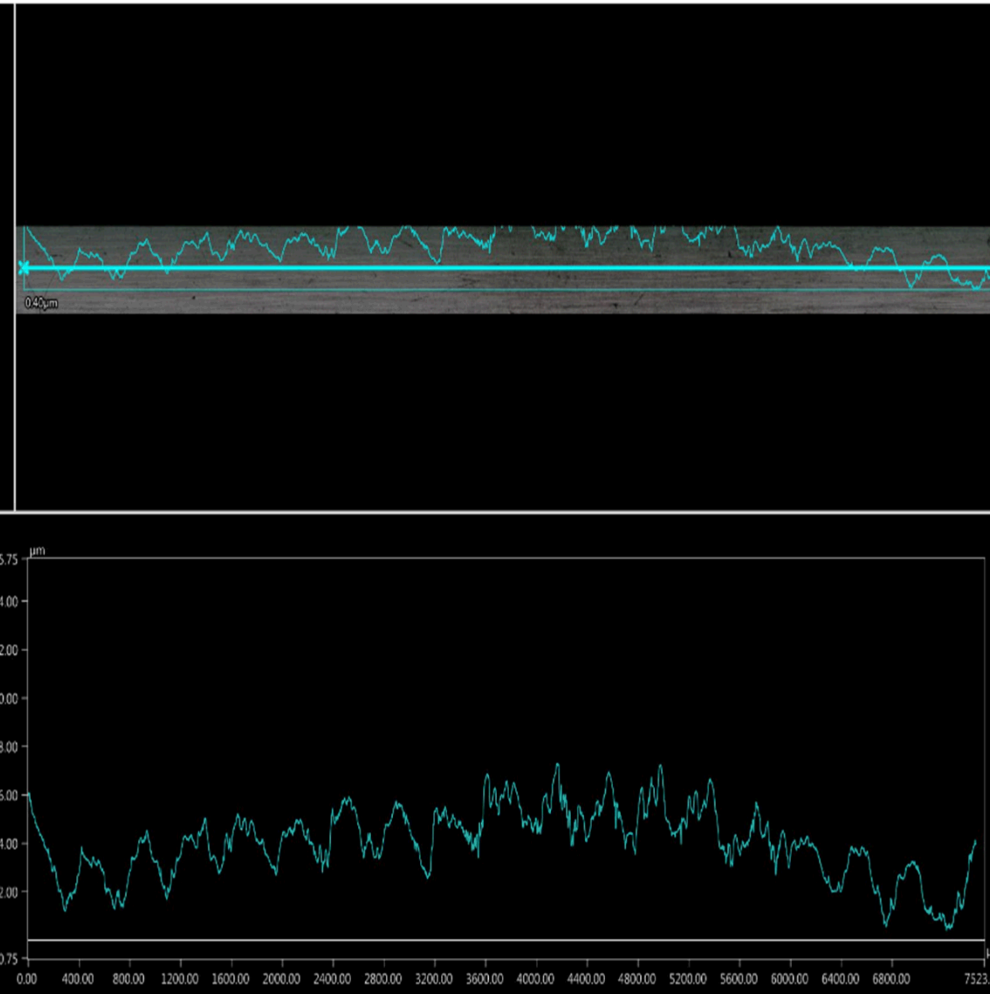


Surface Profile Before/After

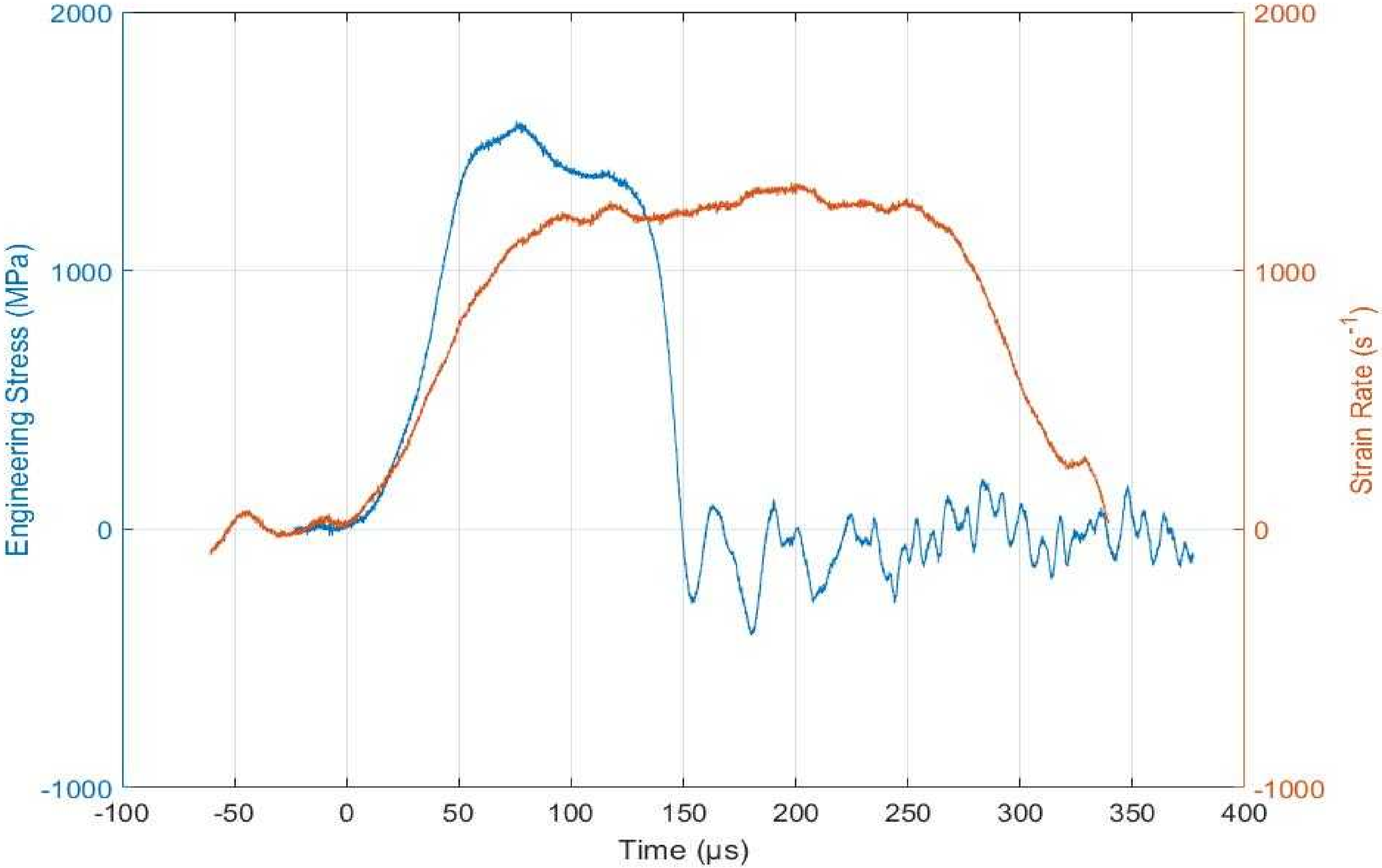
Surface profile (Pre salt-fog)



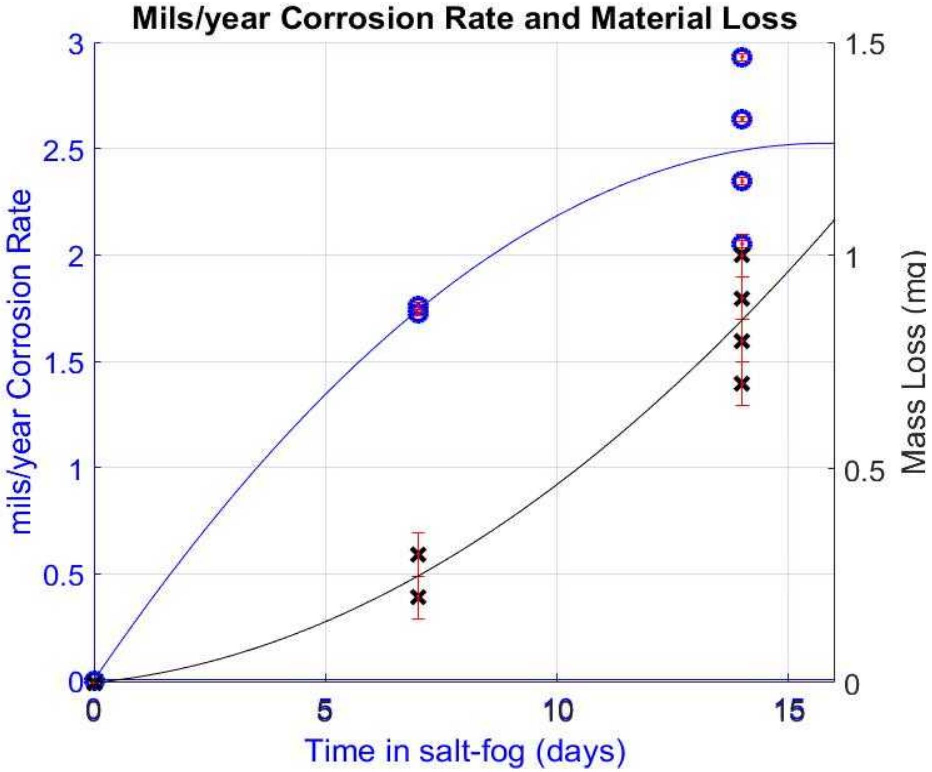
Surface profile (post 14 days of salt-fog)



Constant Strain Rate

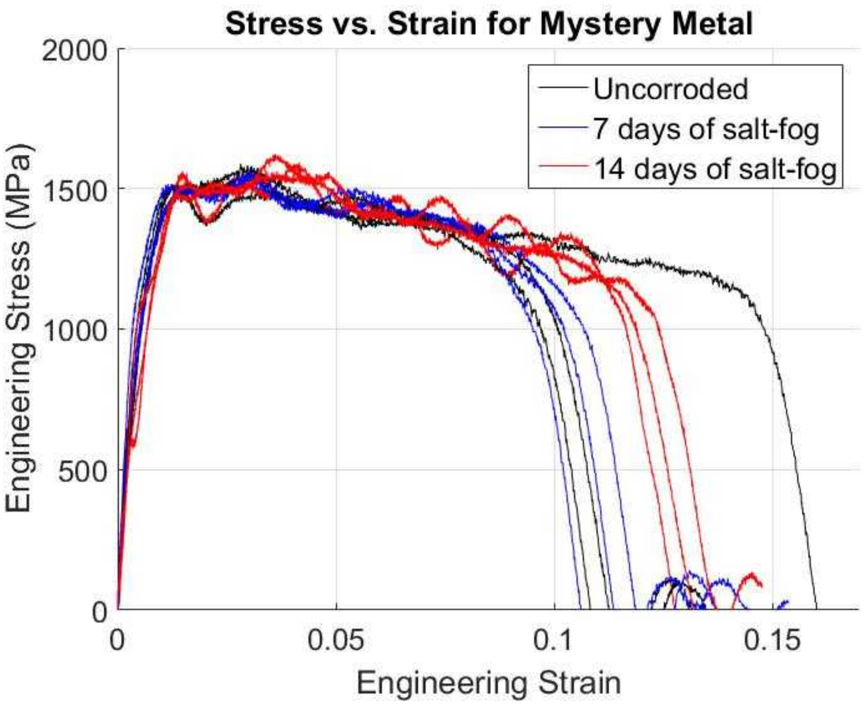


Results

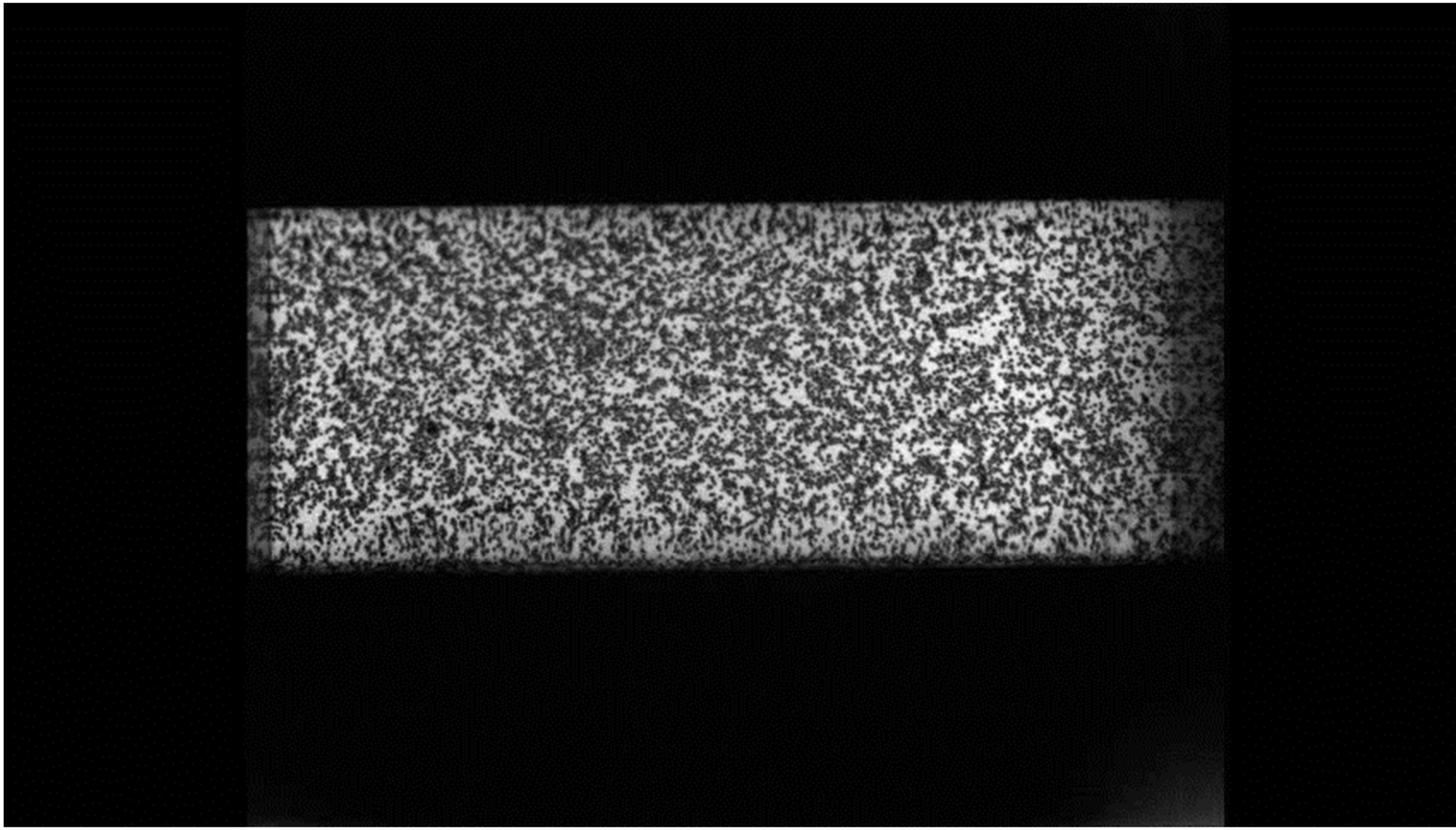


- Mass loss is consistent
- Longer time duration needed

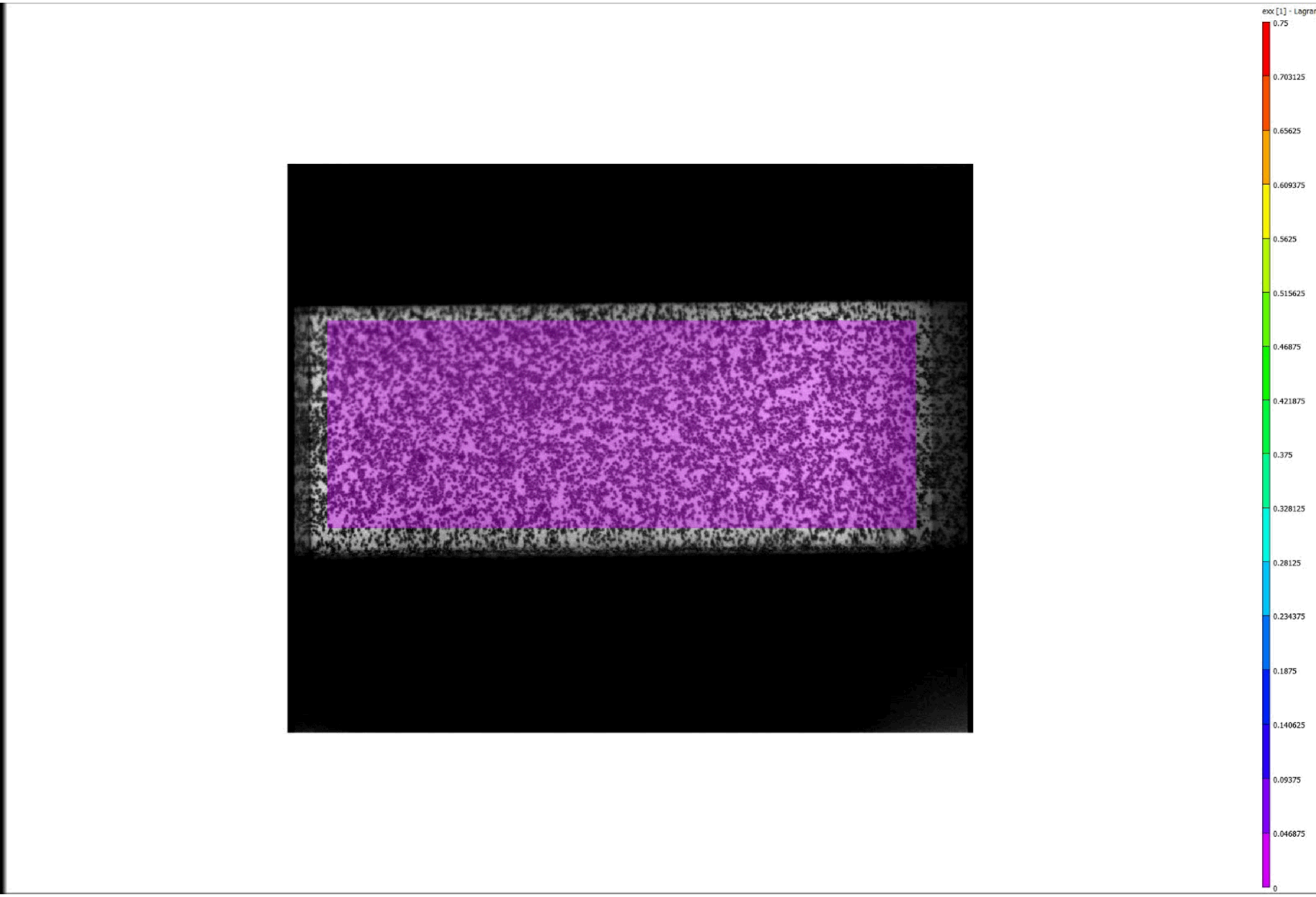
- Failure Strength = 1500 MPa
- Failure Strain = 10 – 15 %



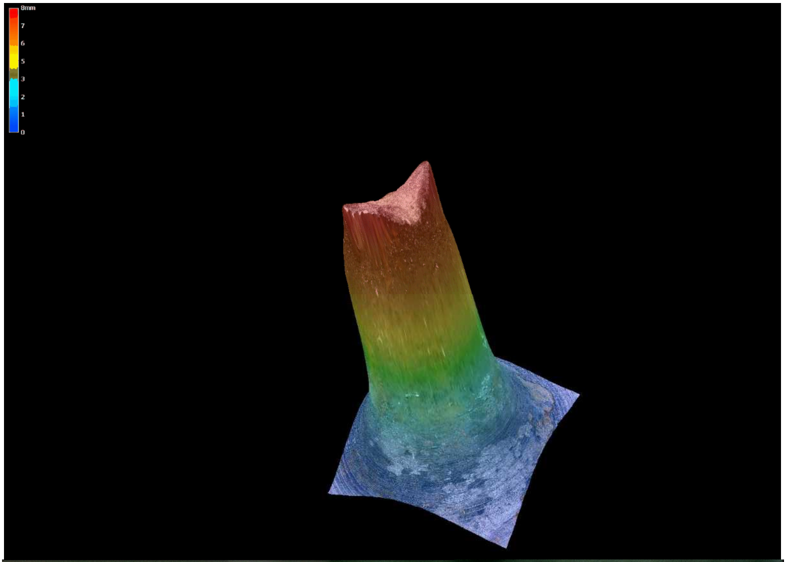
Digital Image Correlation (DIC)



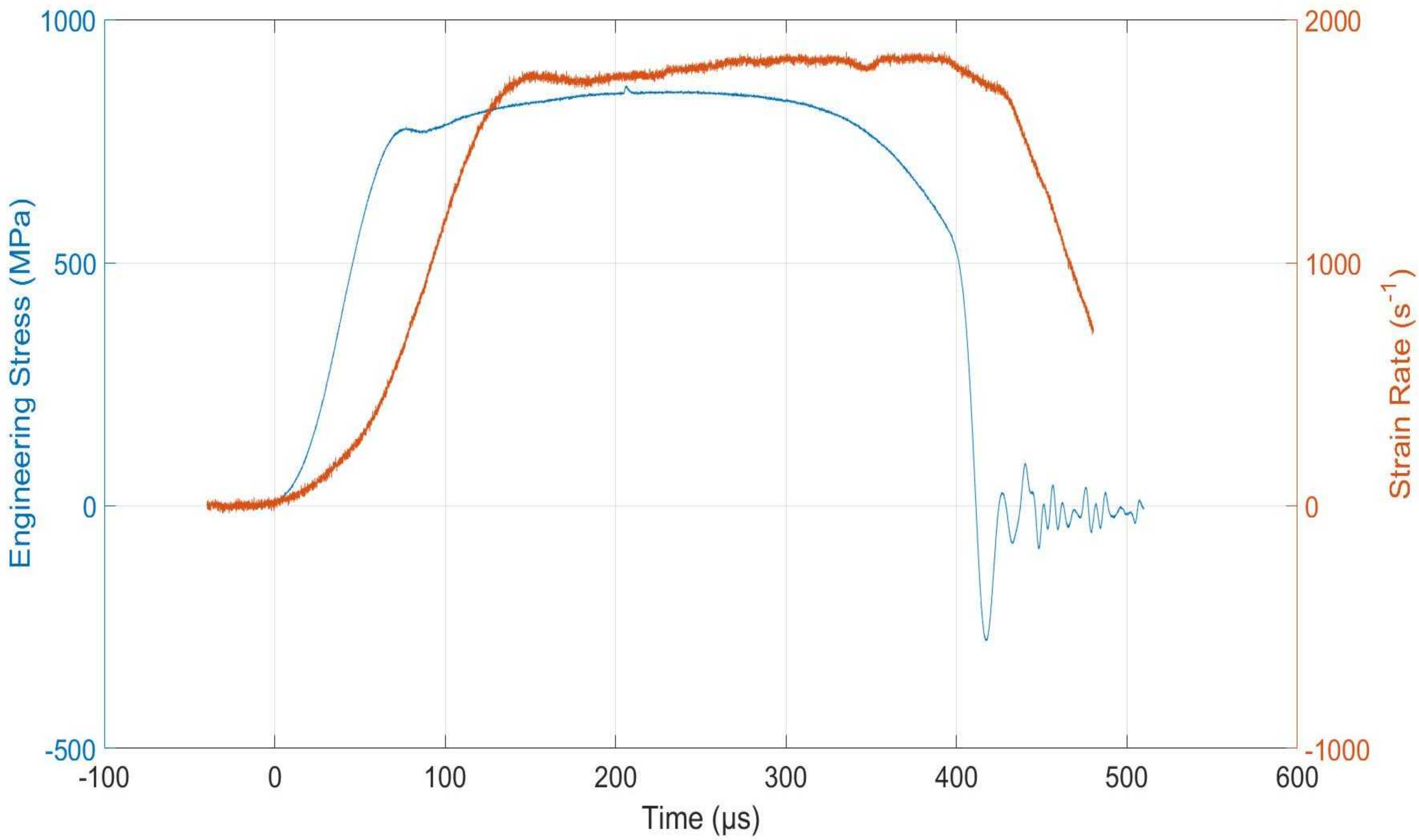
Digital Image Correlation (DIC)



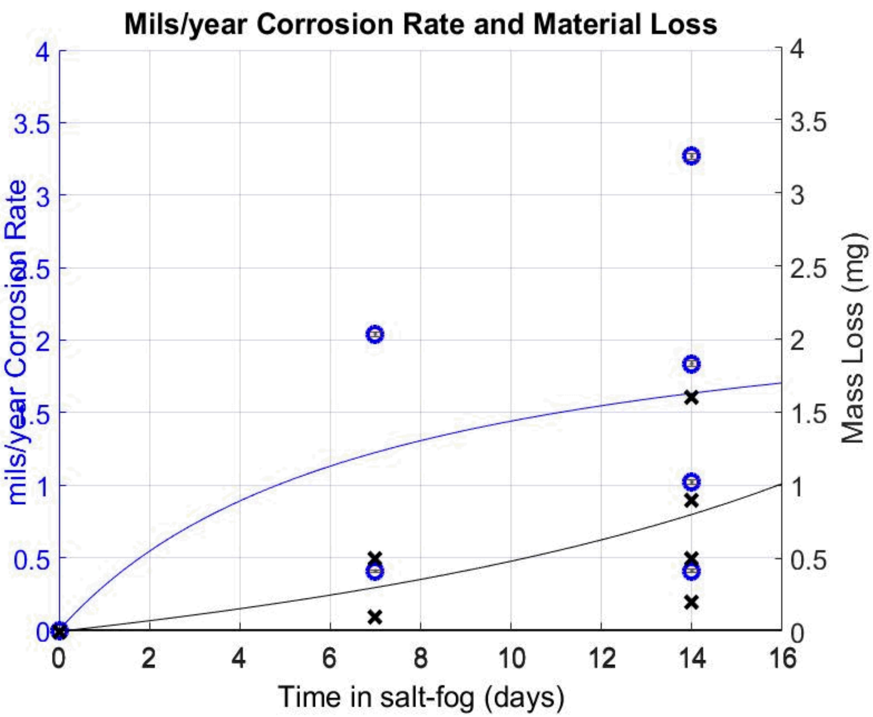
Cylindrical Sample Post Salt-Fog



Constant Strain Rate

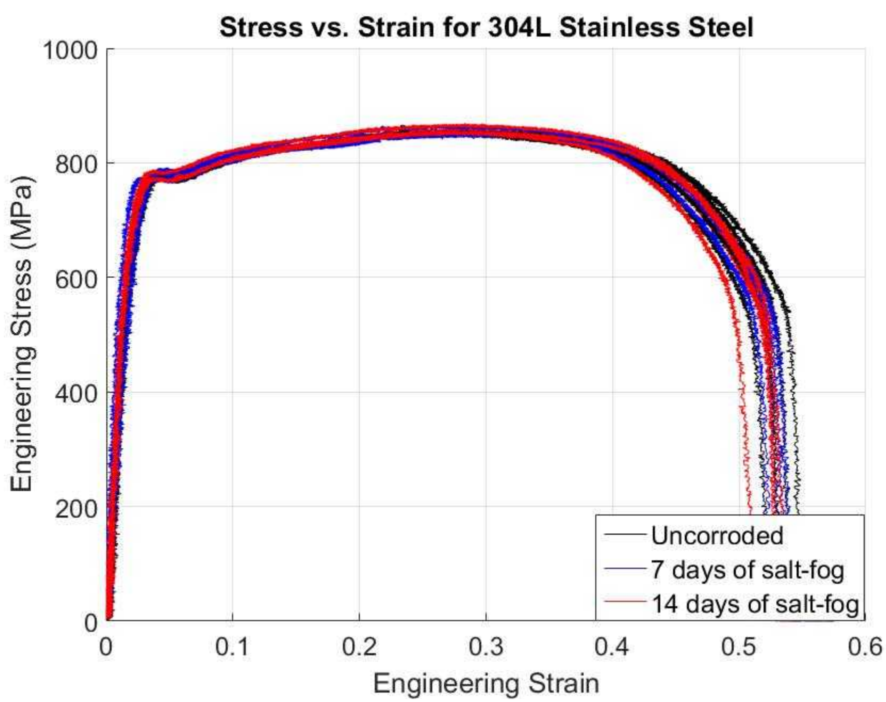


Results



- Mass loss not as consistent
- Same trend as flat samples

- Failure Strength = 1300 MPa
- Failure Strain = 40 – 45 %



Conclusion & Future Work

- Flat samples were the wrong samples
  - Possibly 4140H
  - Same tensile failure, strain and hardness.
- No change in tensile failure strength for cylindrical samples
- Next study will have intervals of 2,3 and 4 weeks in salt-fog