

KSNPS #1 RPV Skirt Broken Anchor Bolts -Hot Lab Examination Results

Chung-Shing Chang

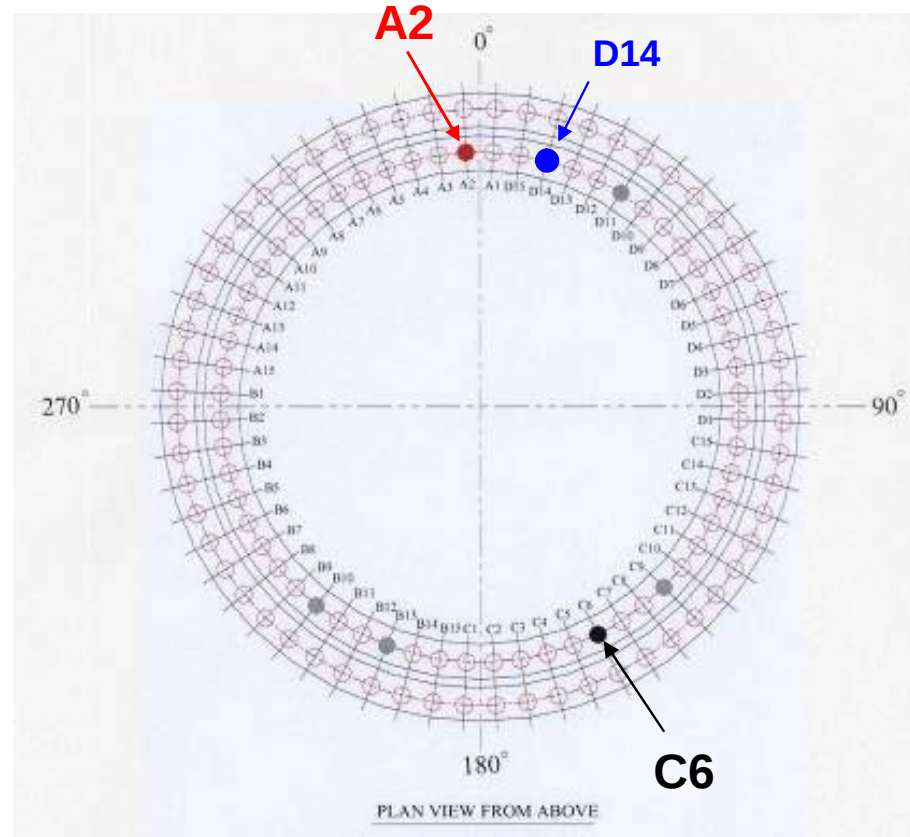
2012/4/25

Failed Anchor Bolts (examined) A2, C6, D14

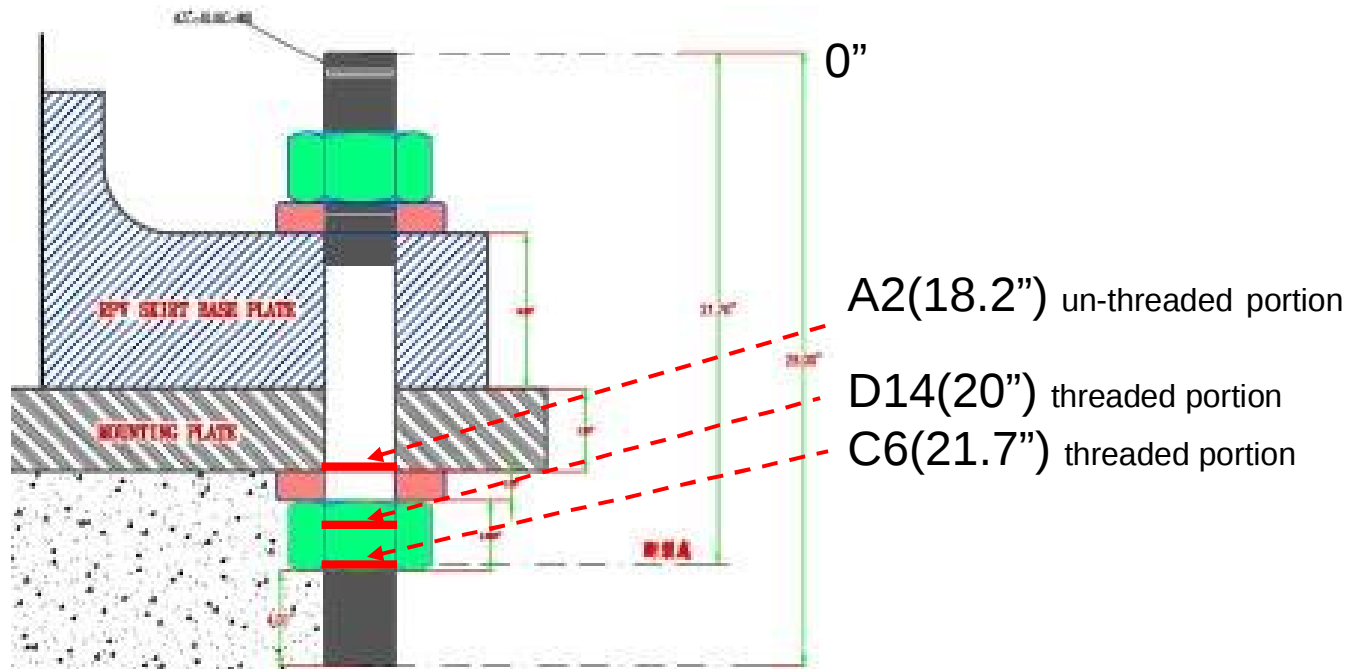
A2 Broken

C6 Broken

D14 Cracked



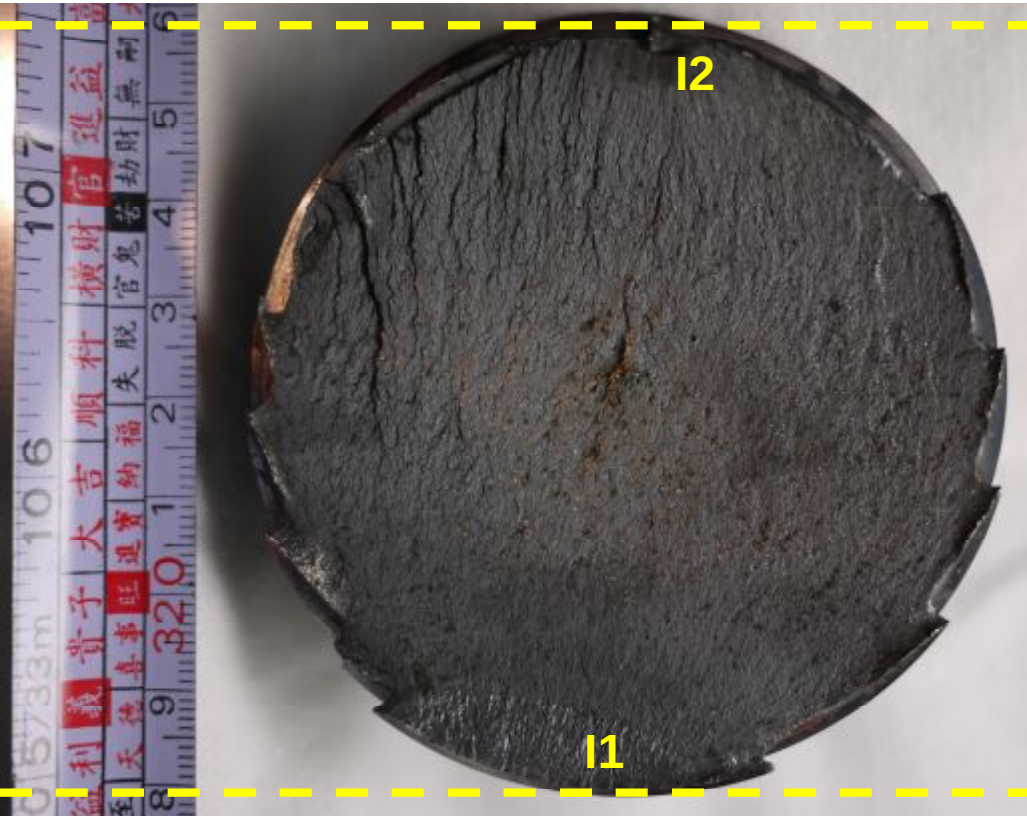
Inner ring



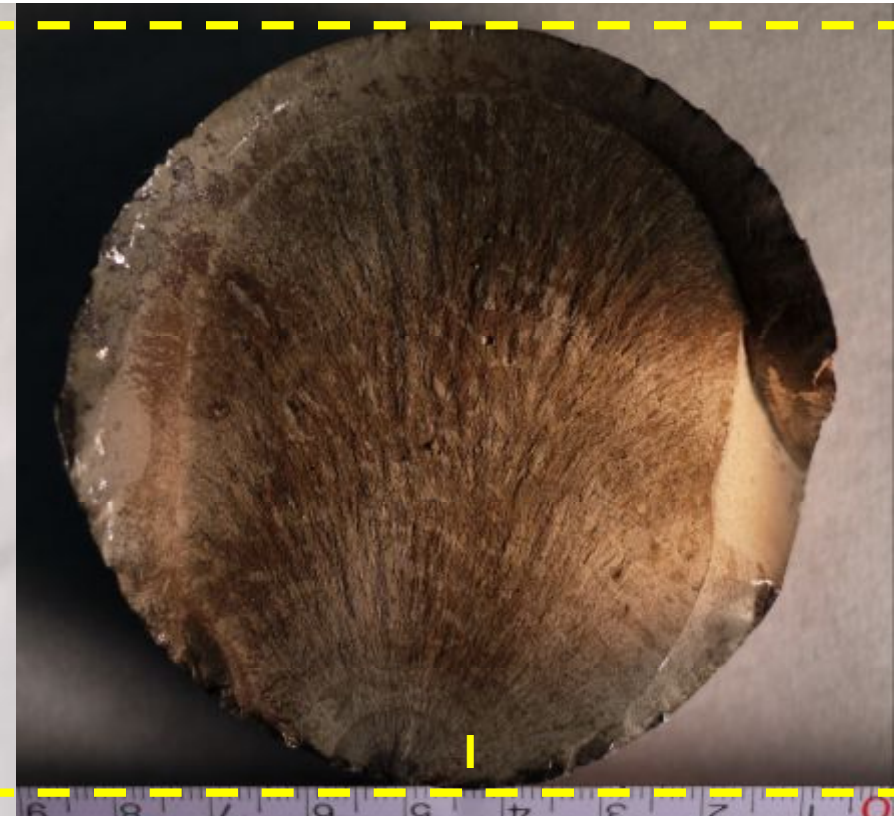
Hot Lab Examinations

- VT
- NDT: MT, UT (Phase Array included)
- Low-mag. Microscope
- Optical Microscope
- SEM & SEM-EDX
- Micro-hardness Test (Vickers)
- Chemical Composition Analysis (ICP&C/S Analyzer)

Broken Anchor Bolts A2 & C6



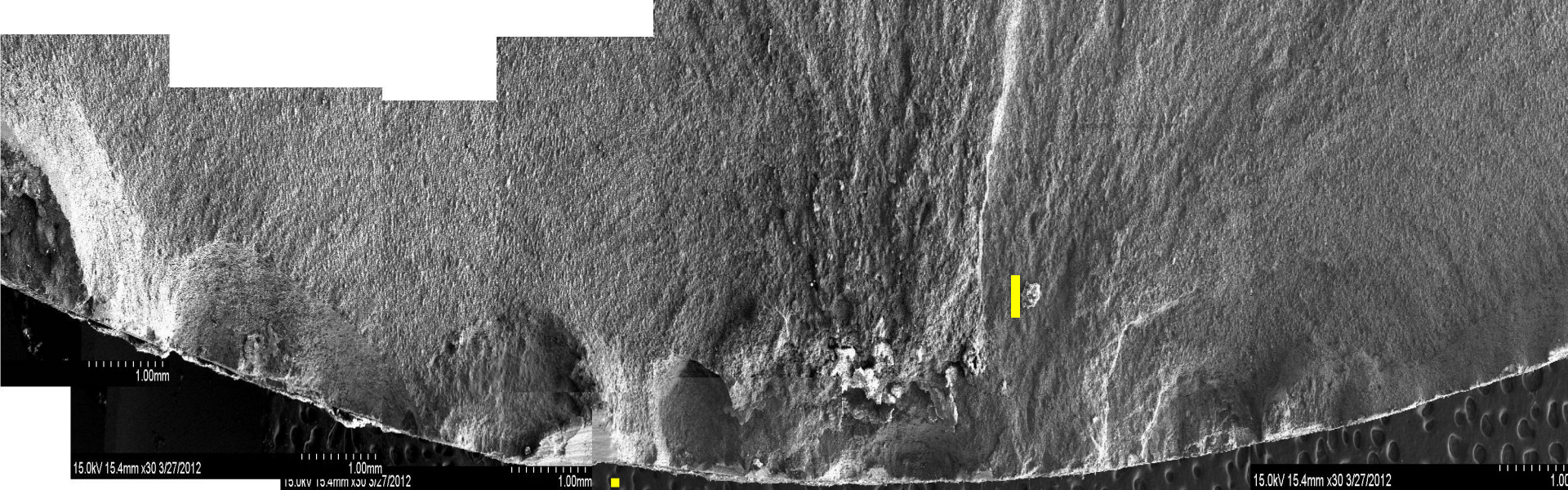
1EOC22 (C6)



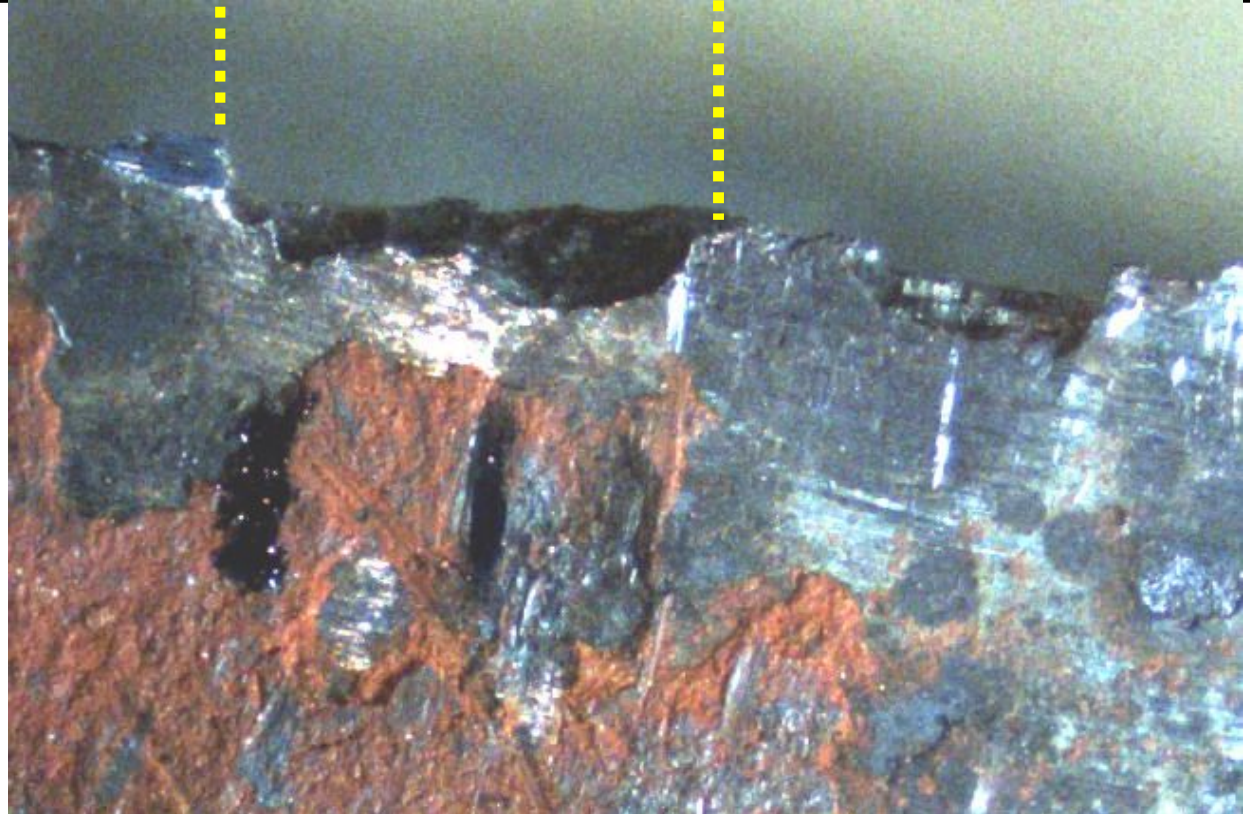
1EOC22 (A2)



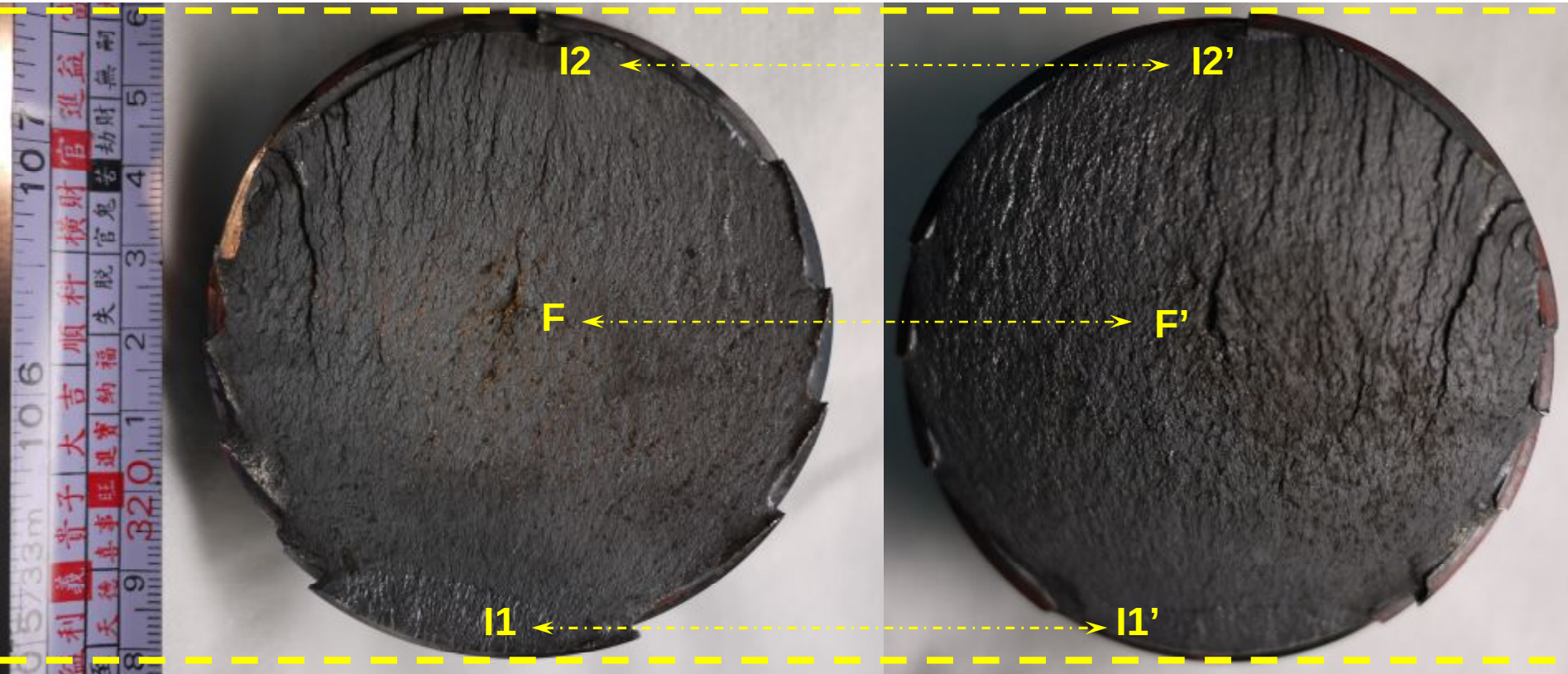
1EOC22 A2



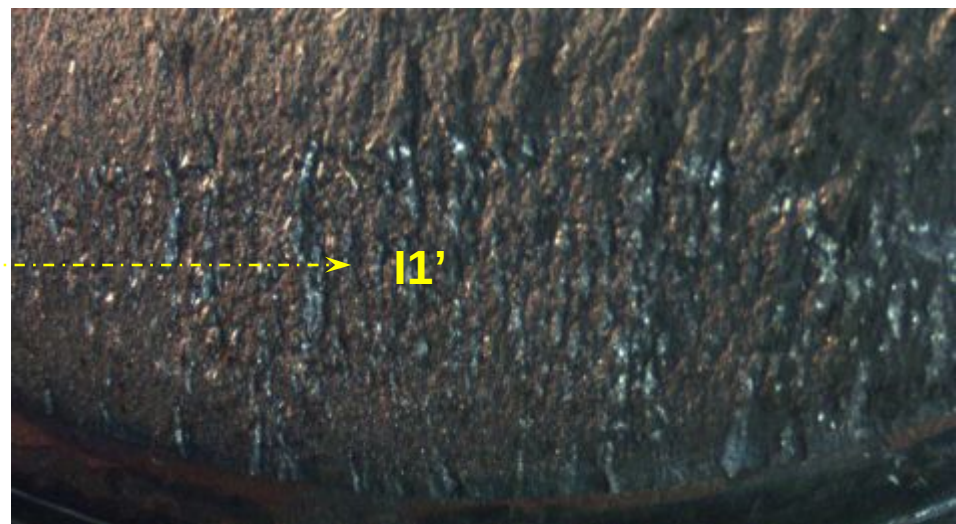
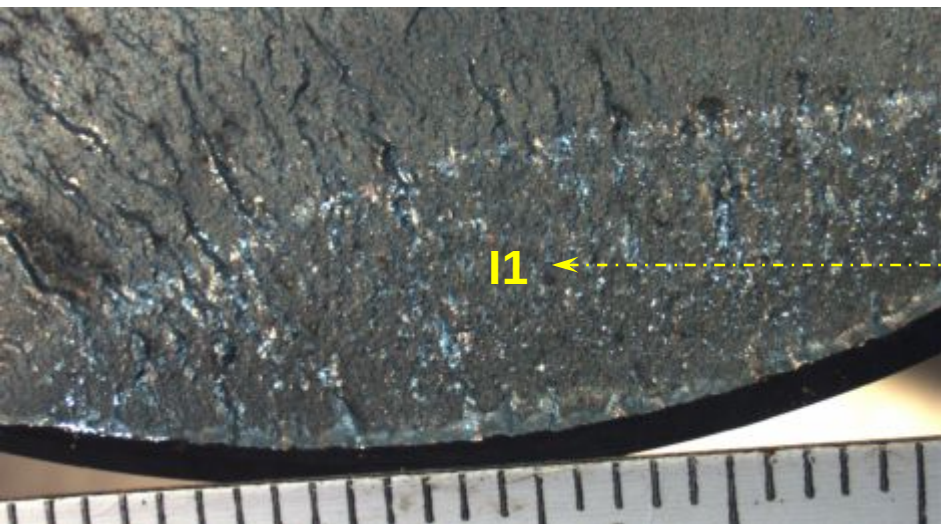
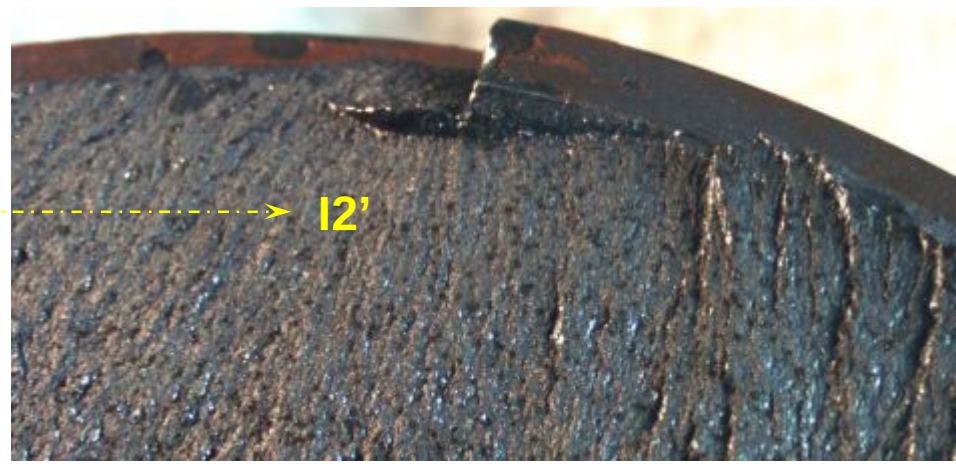
1EOC22 A2



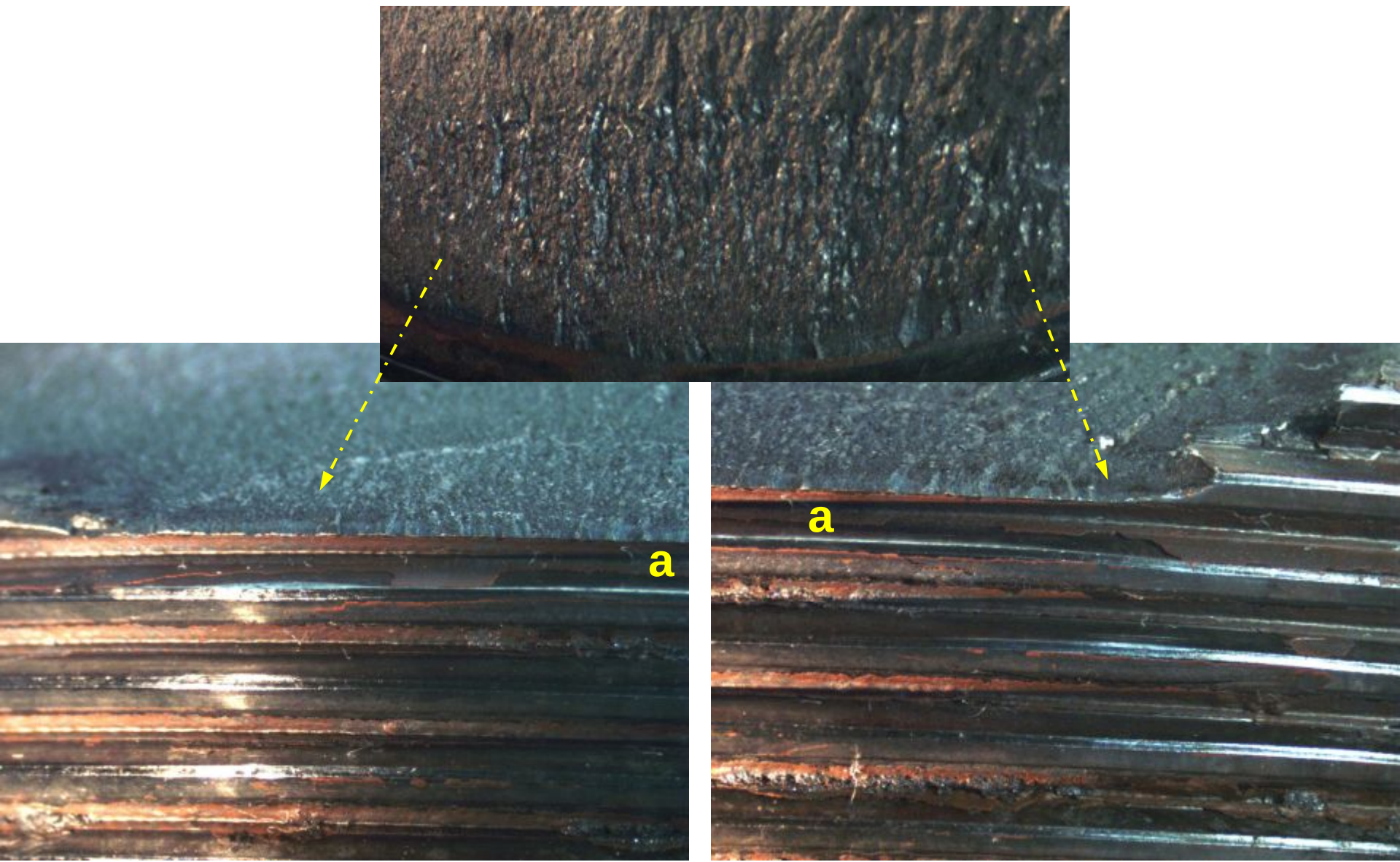
KSNPS #1 RPV Skirt Broken Anchor Bolts



1EOC22 C6 Counterparts



1EOC22 C6 Counterparts



1EOC22 C6

Chemical Compositions Analysis Results

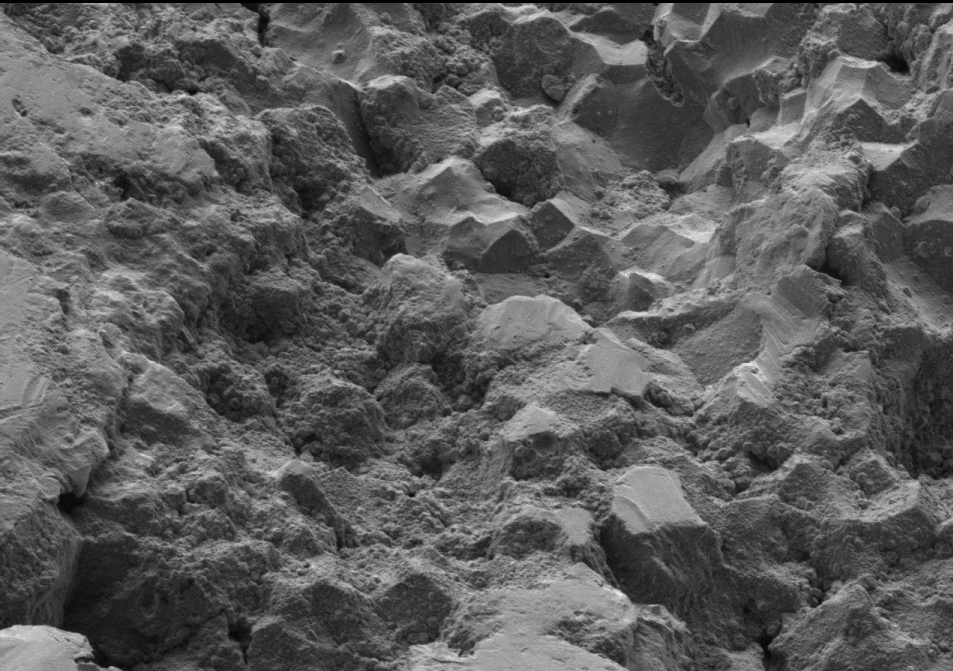
Element	Chemical Requirements (%)							
	A2*B	C6*B	D14*P.Cked	B10*In	B13*In	C9*In	D11*In	B23 (E-4340-H)
C	0.43	0.46	0.385	0.399	0.388	0.379	0.382	0.37-0.44* ¹
Mn	0.74	0.75	0.73	0.68	0.75	0.76	0.74	0.60-0.95
P	0.006	0.01	0.01	0.01	0.01	0.01	0.01	0.025(max)
S	0.013	0.024	0.024	0.0169	0.0228	0.023	0.021	0.025(max)
Si	0.26	0.28	0.29	0.31	0.26	0.26	0.29	0.15-0.35
Cr	0.79	0.78	0.73	0.82	0.76	0.76	0.77	0.65-0.95
Ni	1.77	1.73	1.64	1.82	1.67	1.71	1.7	1.55-2.00
Mo	0.23	0.23	0.2	0.23	0.21	0.21	0.22	0.20-0.30
V	<0.004	<0.004	<0.01	<0.01	<0.01	<0.01	<0.01	

*1: 規範允許誤差為±0.02%

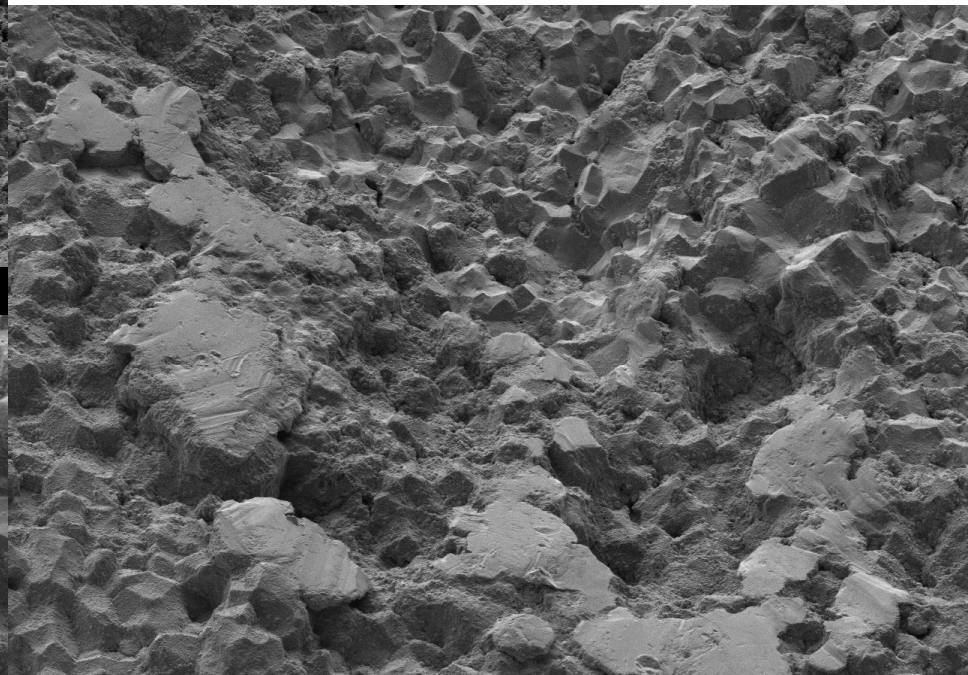
*B: 斷裂(Broken). *P.Cked: 部分龜裂(Partial Cracked). *In: 裂紋指示(Crack Indication)



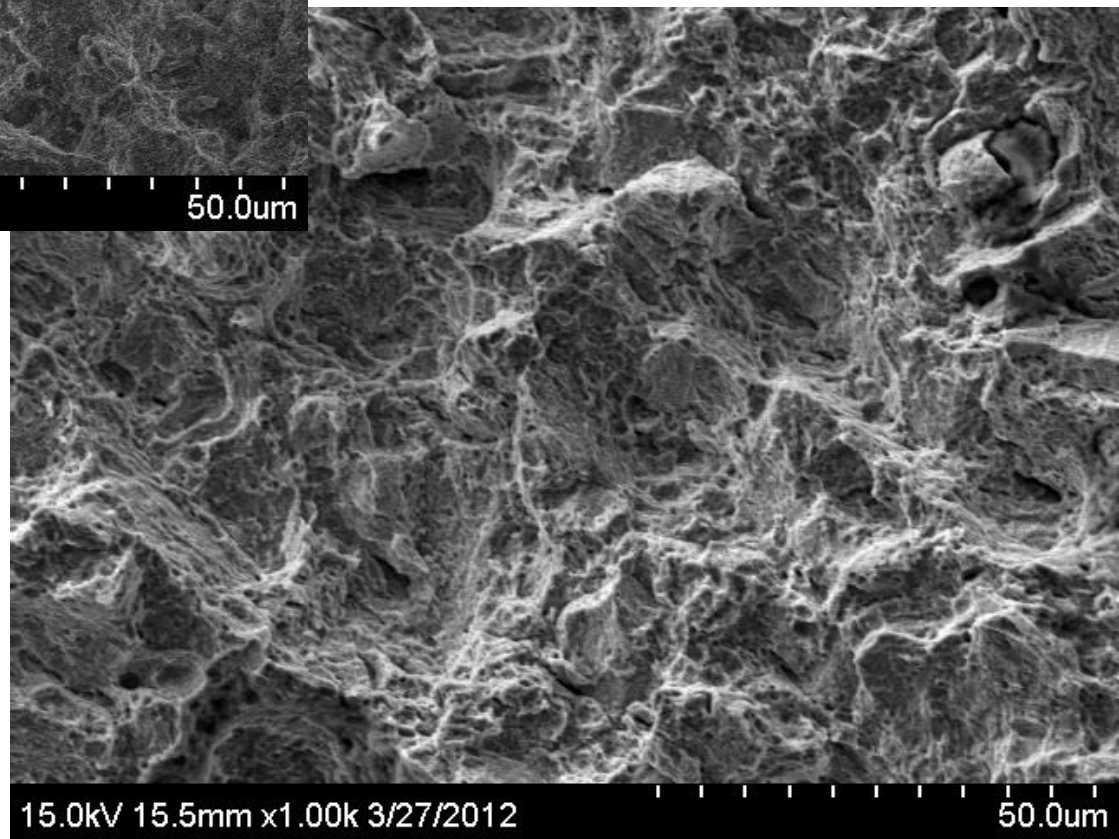
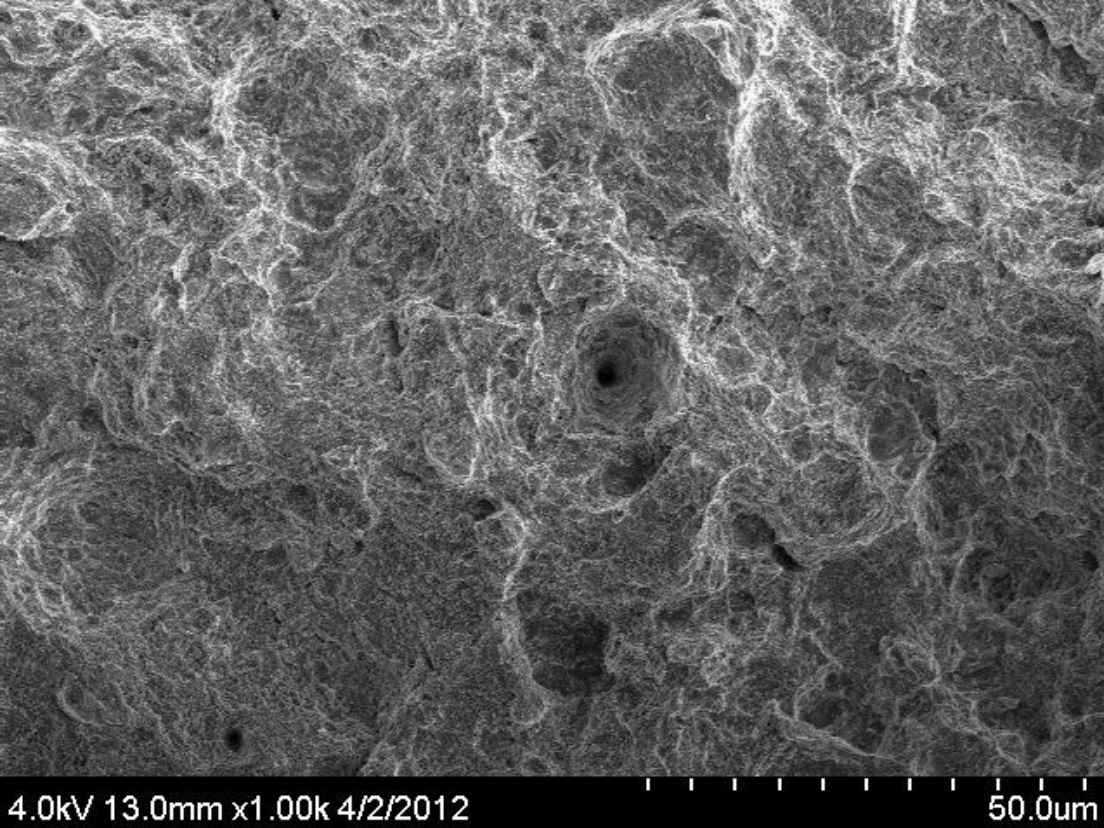
4.0kV 8.0mm x200 4/7/2012 200um

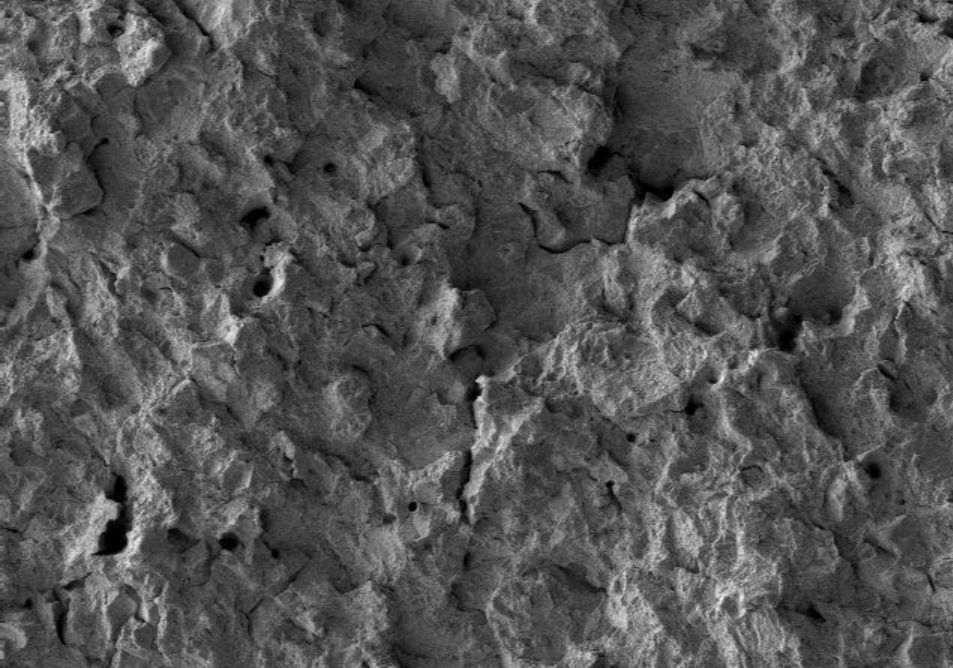


4.0kV 12.0mm x1.00k 4/7/2012 50.0um



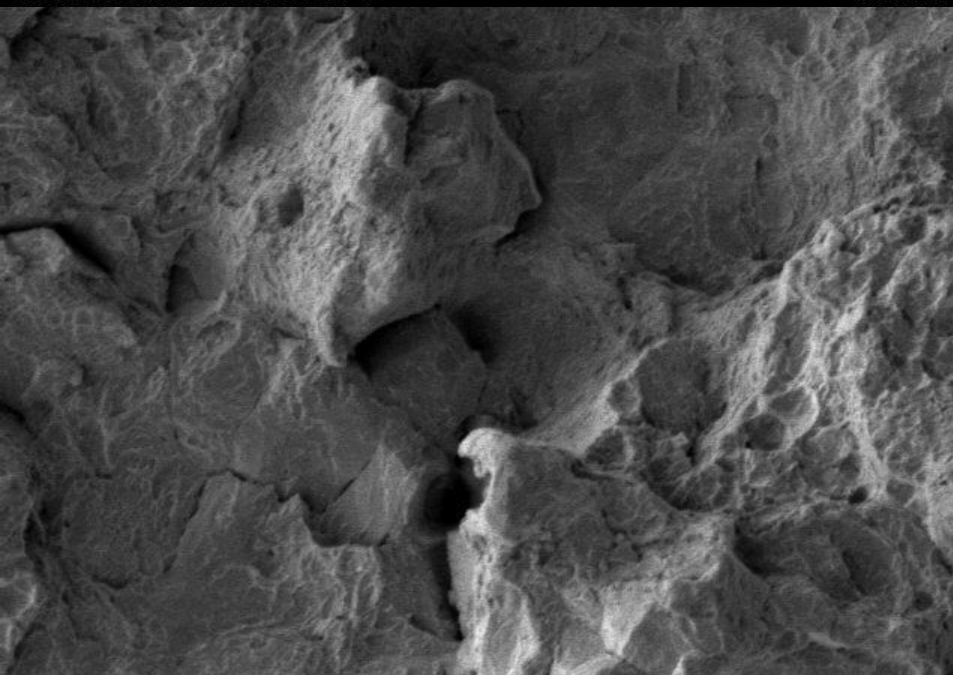
4.0kV 12.0mm x500 4/7/2012 100um





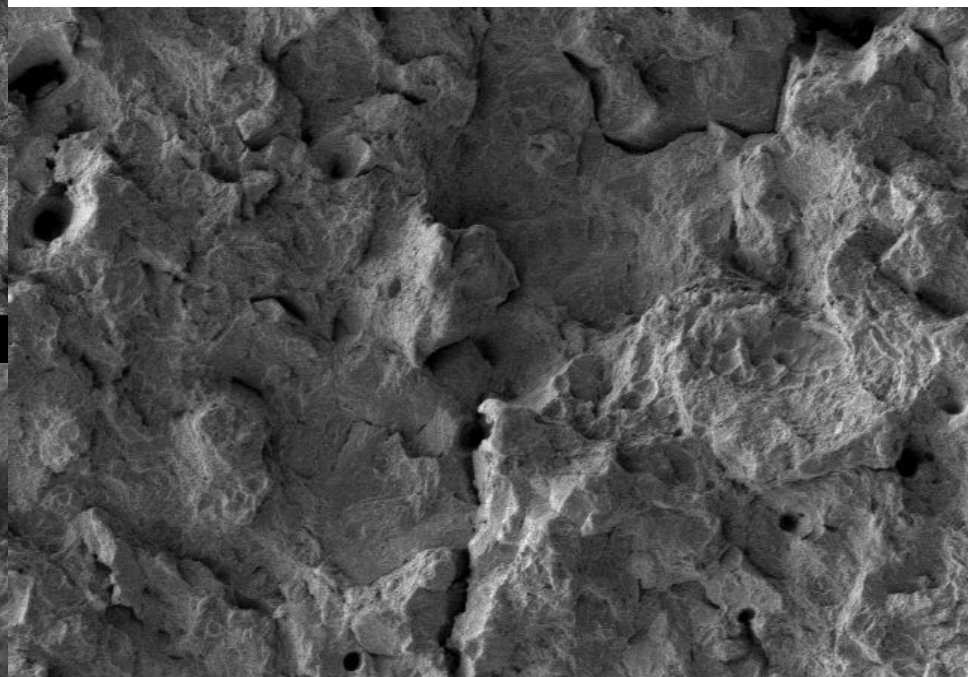
4.0kV 9.2mm x500 3/29/2012

100um



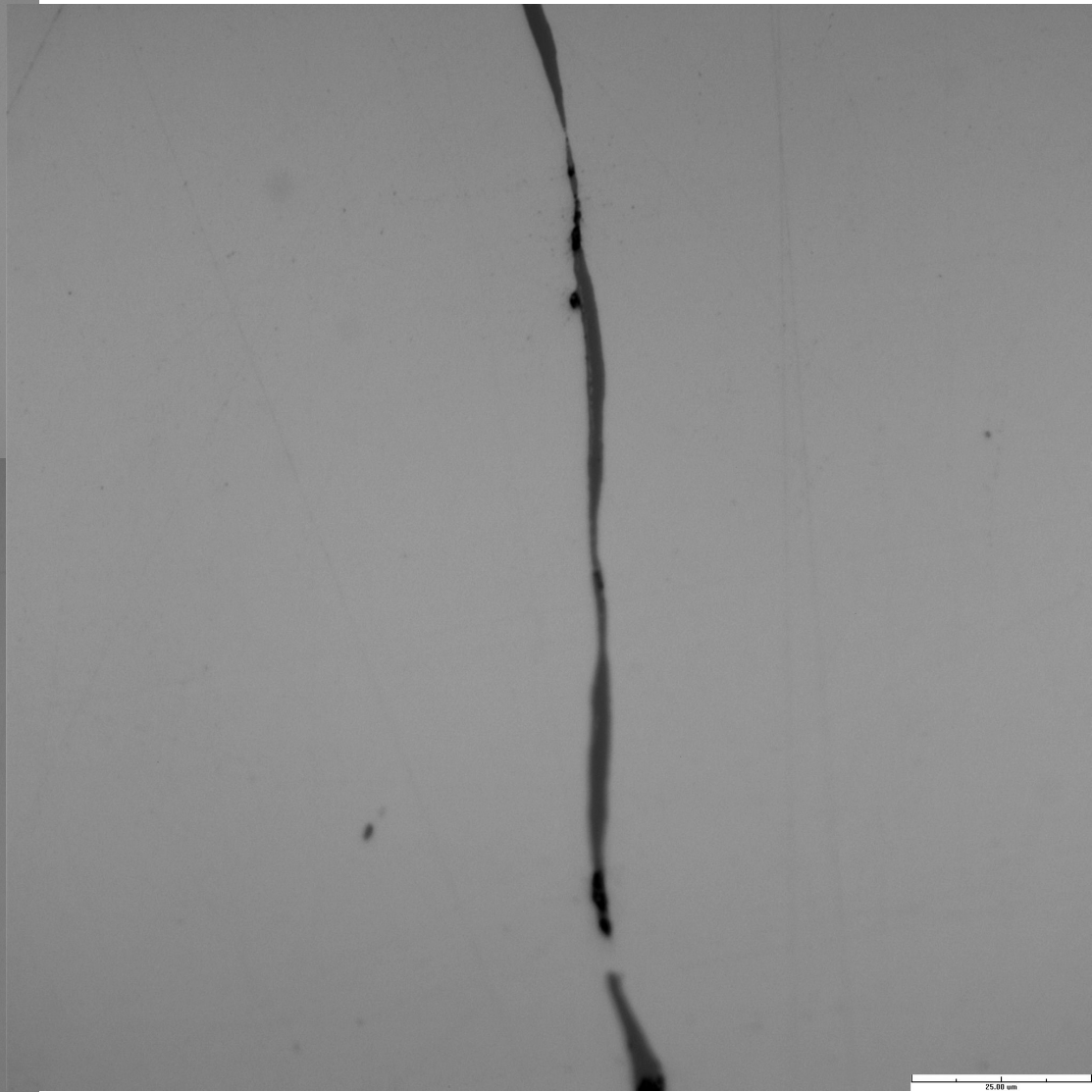
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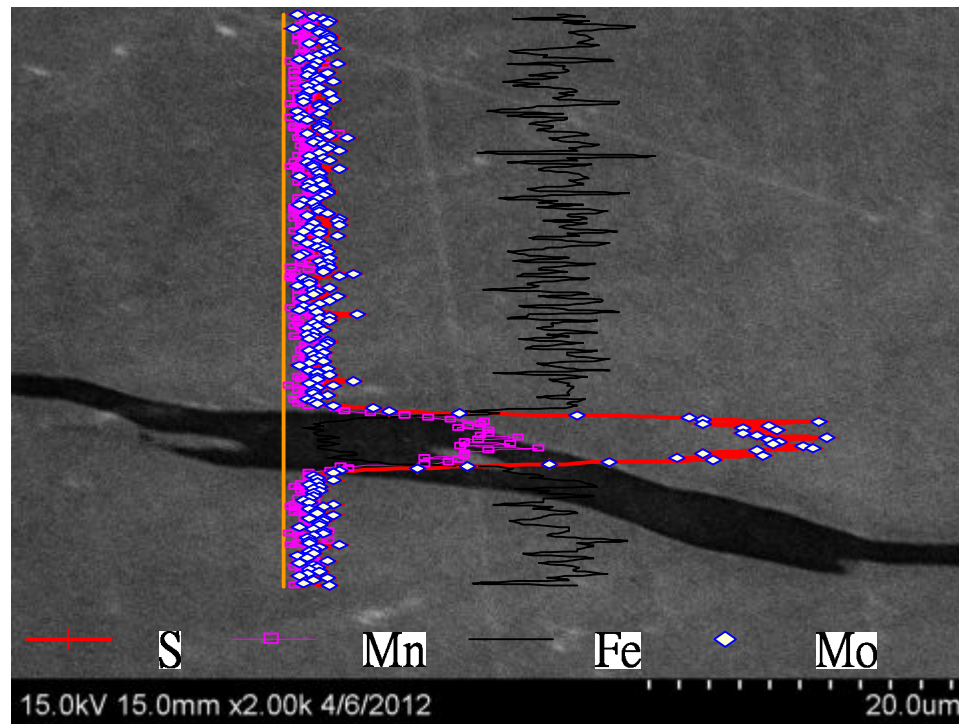
20.0um

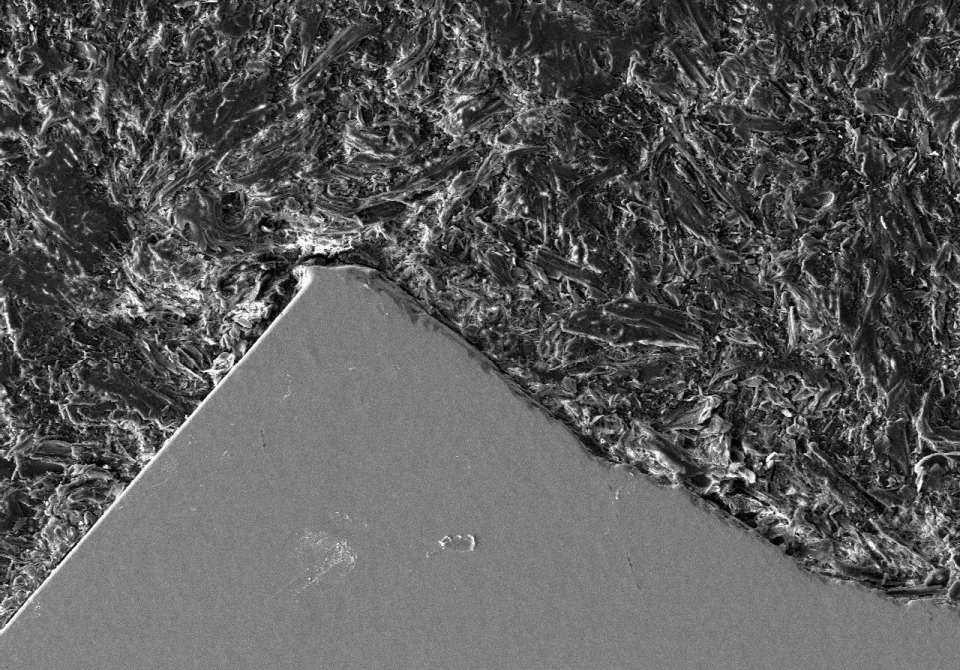


4.0kV 9.2mm x1.00k 3/29/2012

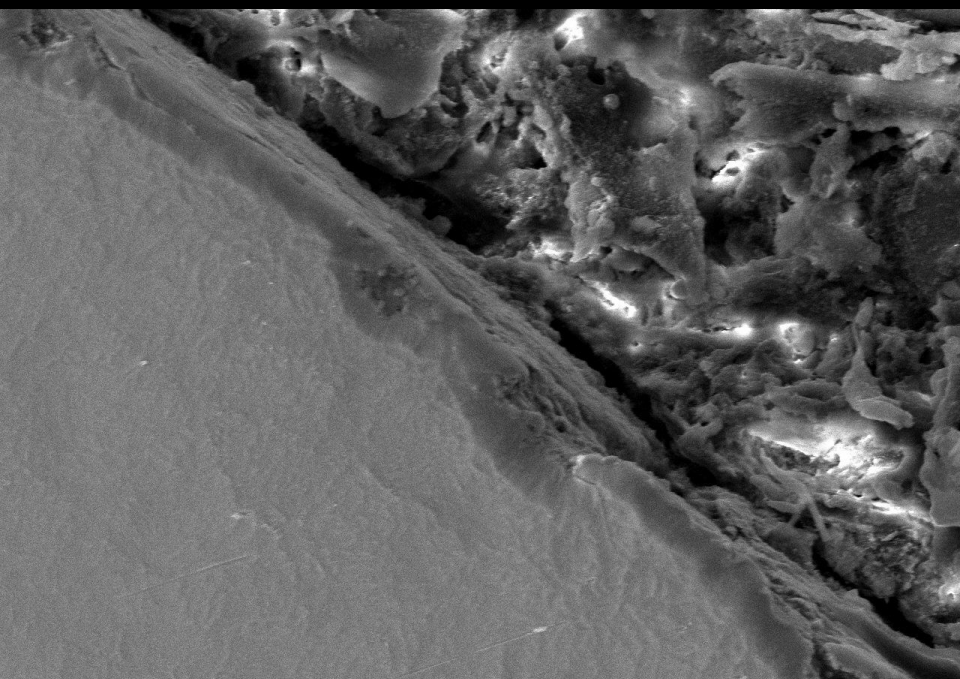
50.0um



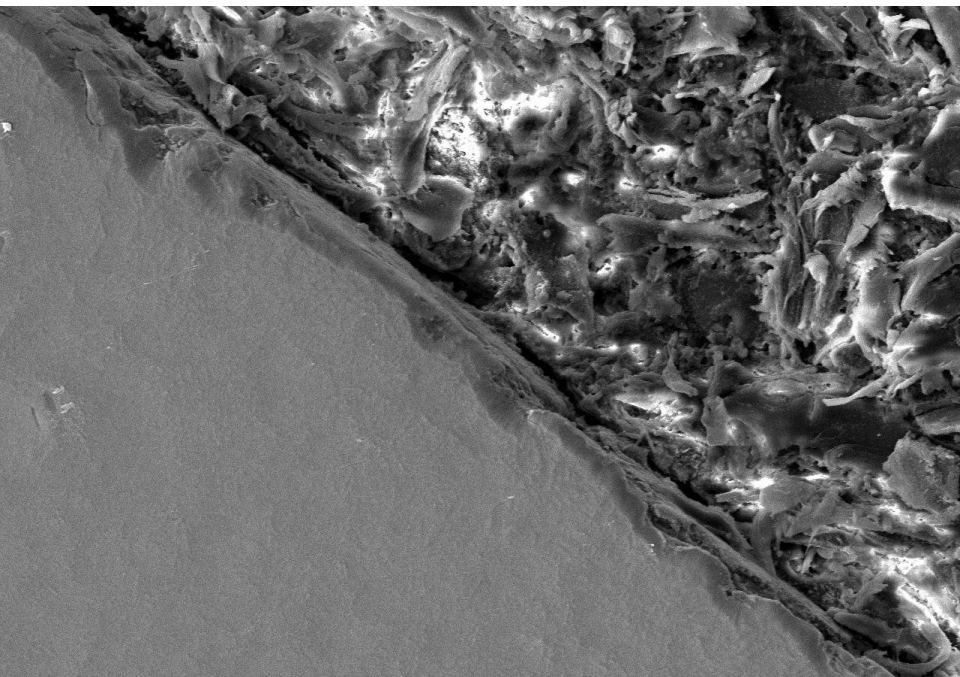




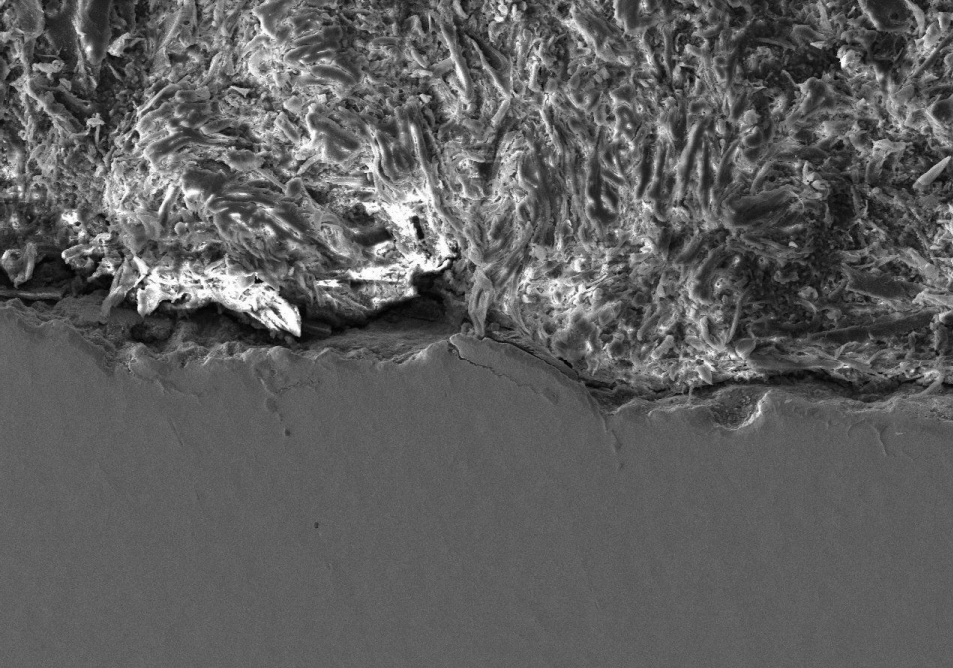
15.0kV 14.0mm x100 4/7/2012 500um



15.0kV 14.0mm x1.00k 4/7/2012 50.0um



15.0kV 14.0mm x500 4/7/2012 100um



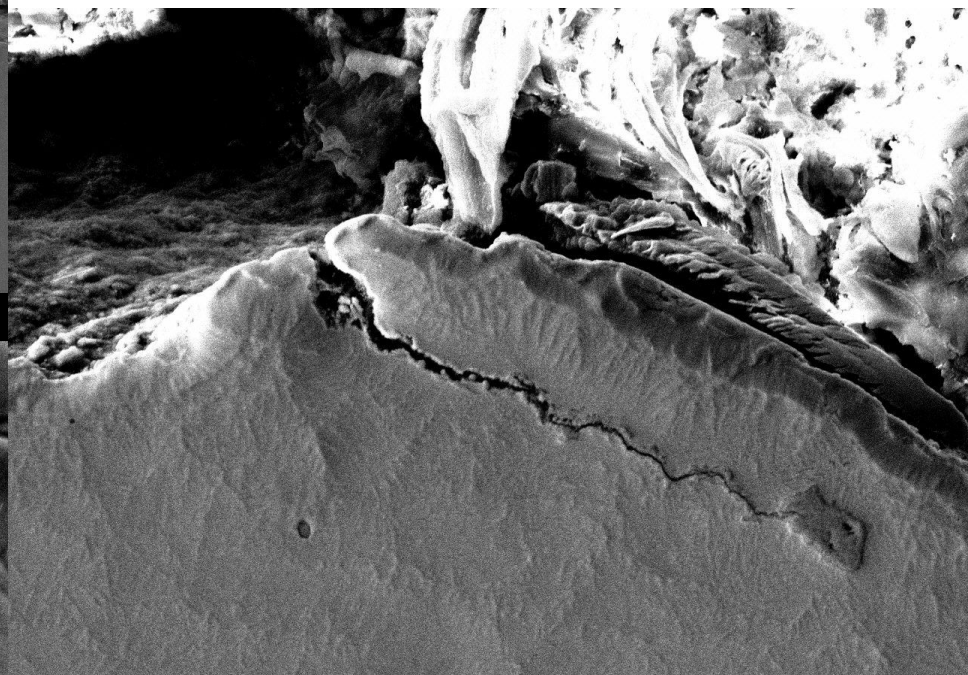
15.0kV 14.0mm x200 4/7/2012

200um



15.0kV 14.0mm x3.00k 4/7/2012

10.0um



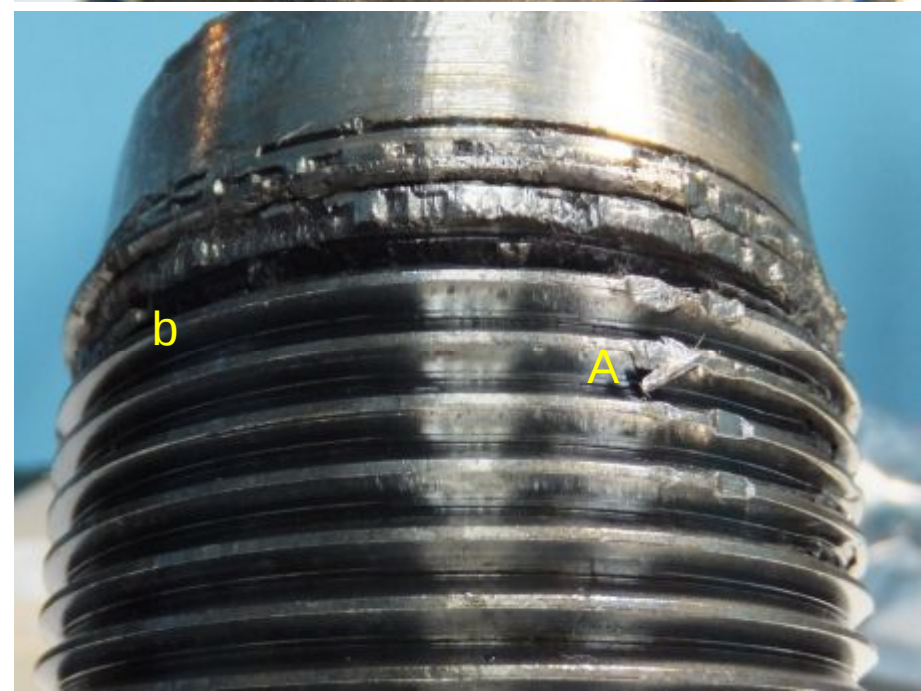
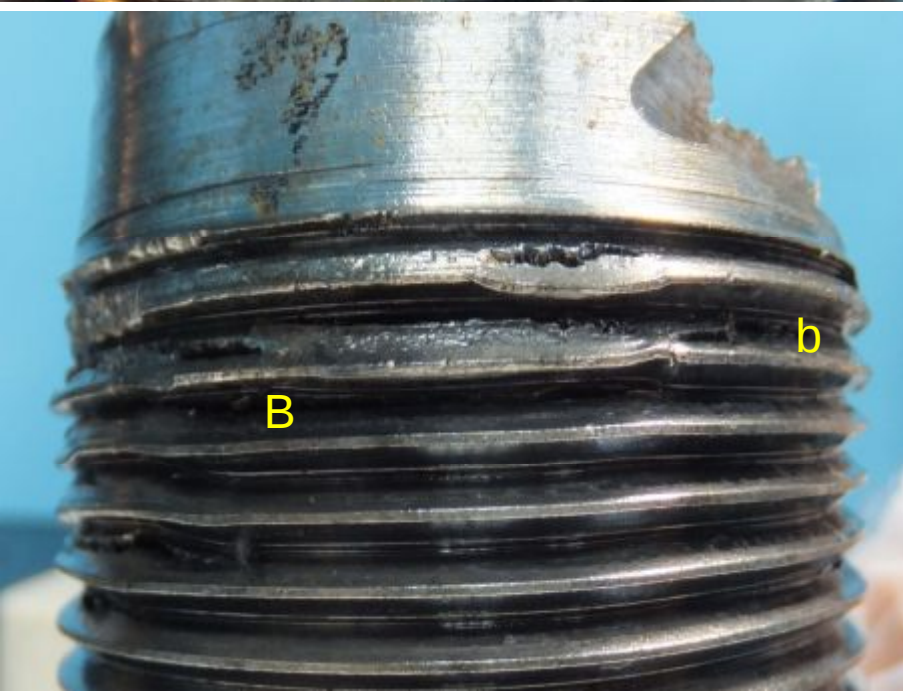
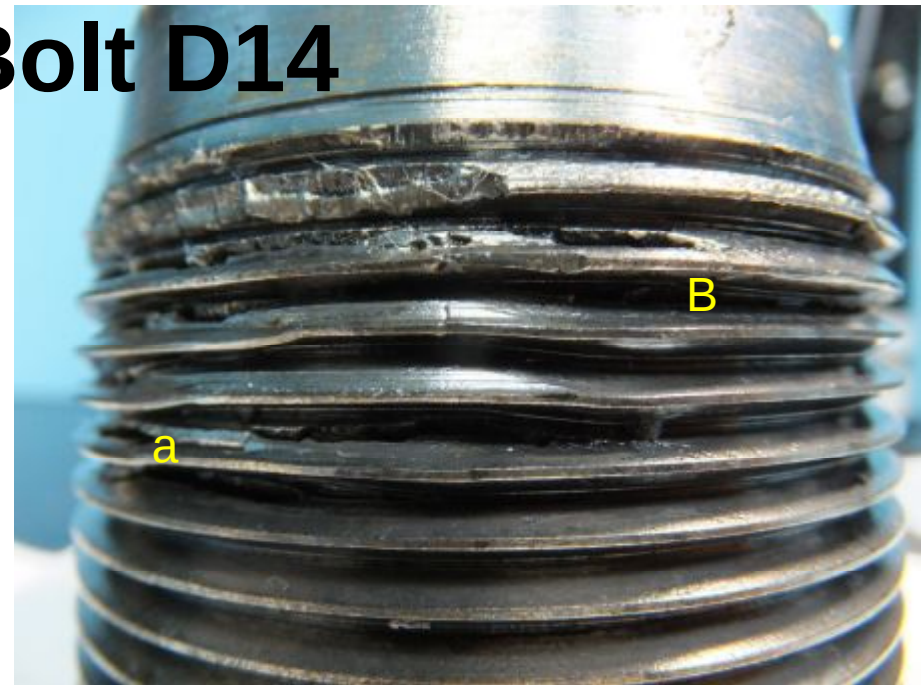
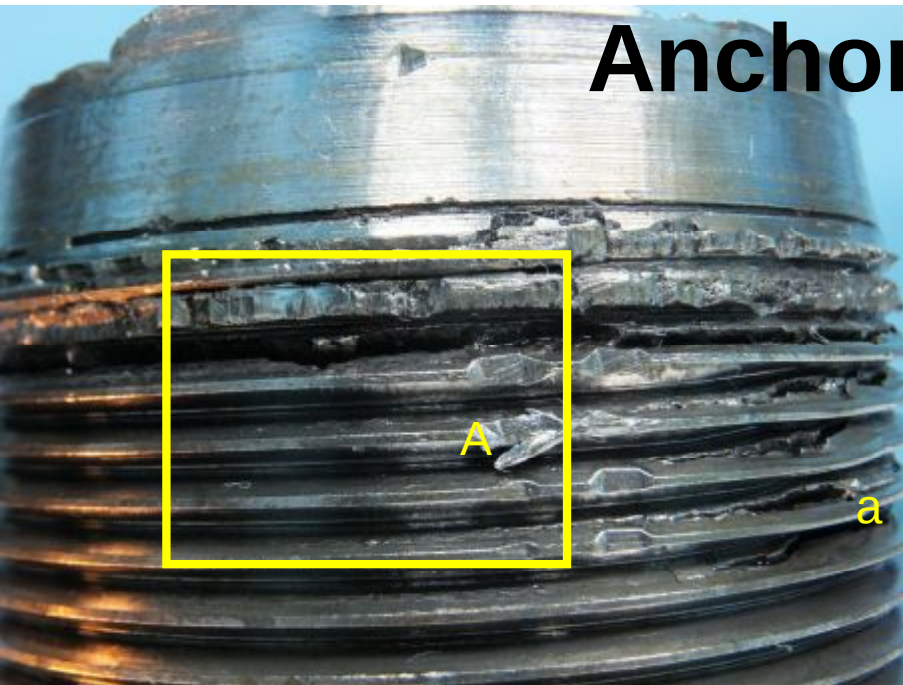
15.0kV 14.0mm x1.00k 4/7/2012

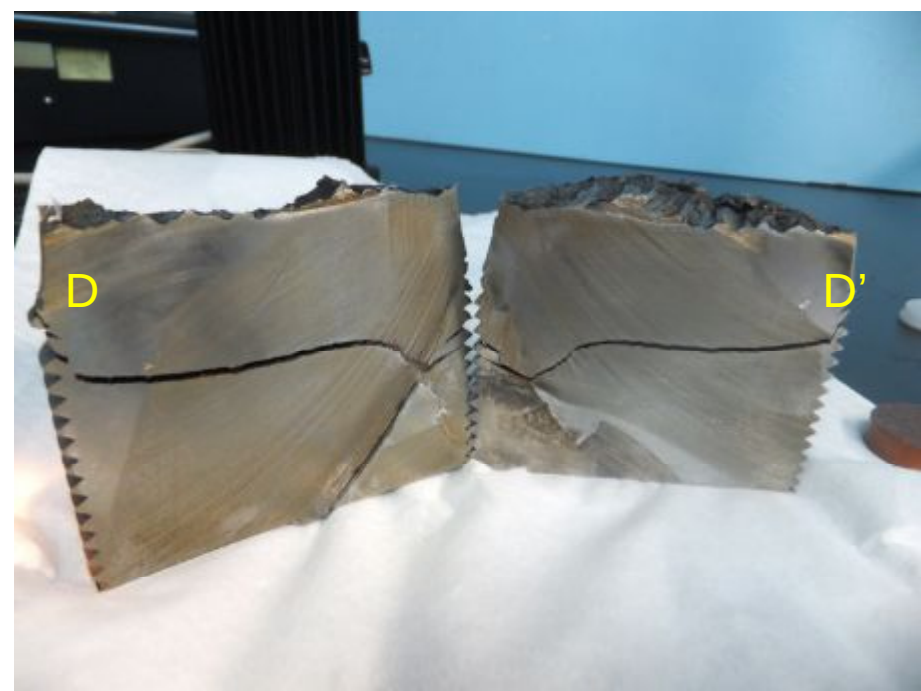
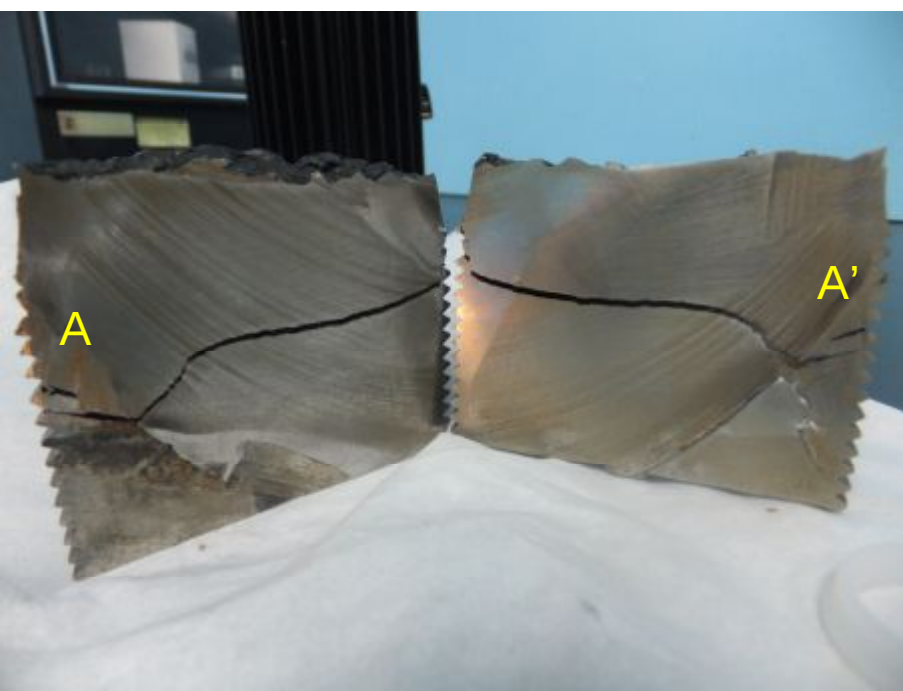
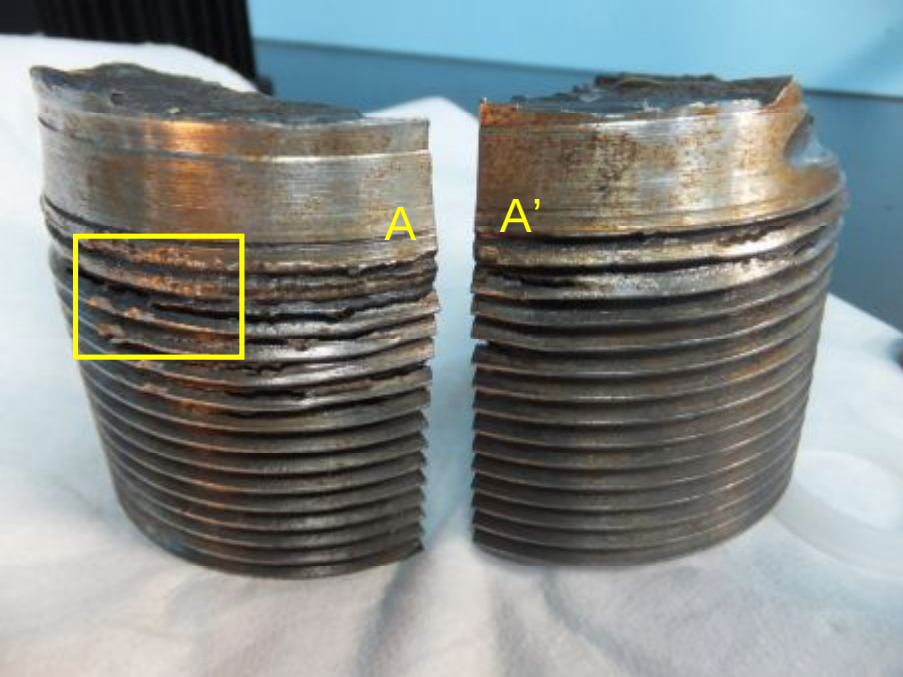
50.0um

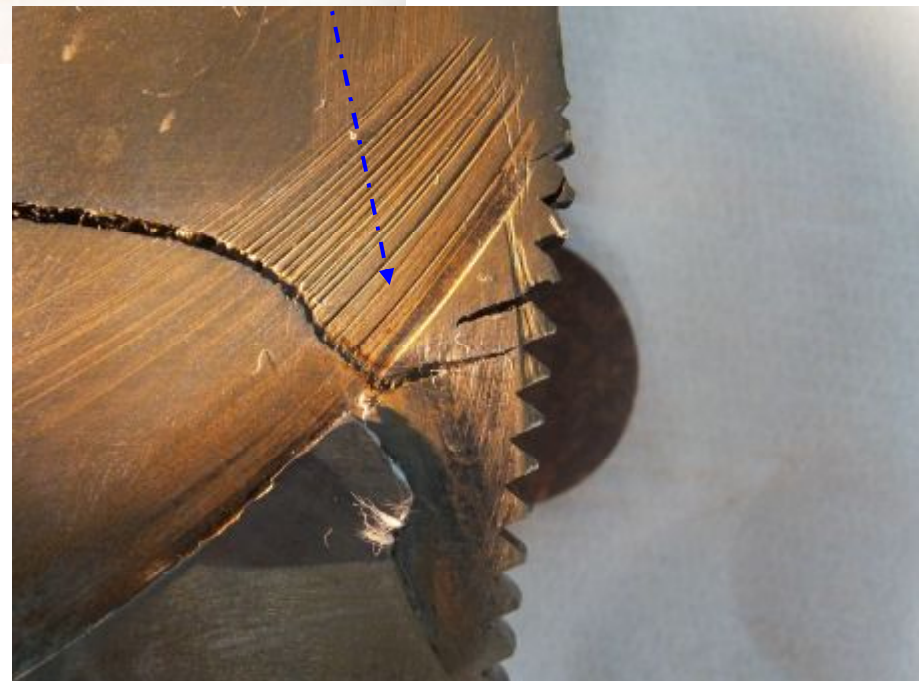
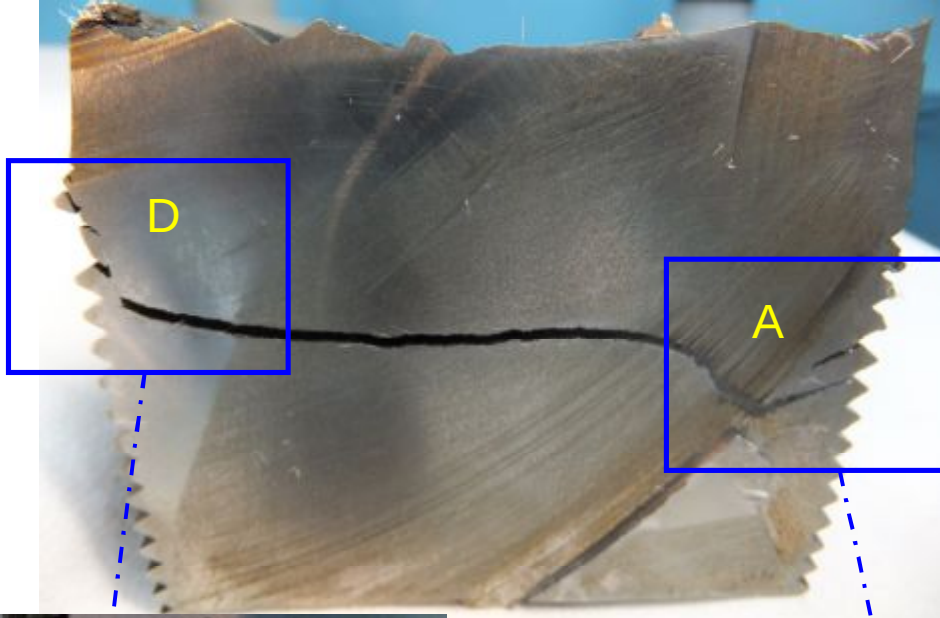
Summaries of the A2&C6 Results

- Fracture location A2: stud w/o thread; C6: thread
- A2: one initiation site on the edge; C6: two initiation sites opposite to each other on the edge
- Macro features of the fracture surface
Plainly flat & radial marks
- Micro features of the fracture surface
Initiation zone: IG (+cleavage+dimples)
Propagation zone: Dimples
- Profile: continuously oxidation product (A2<10 μ m; C6<5 μ m)
- No secondary crack
- Chemical composition, generally, per Code (ASTM A-540 B23)
- Mechanical properties → Class I

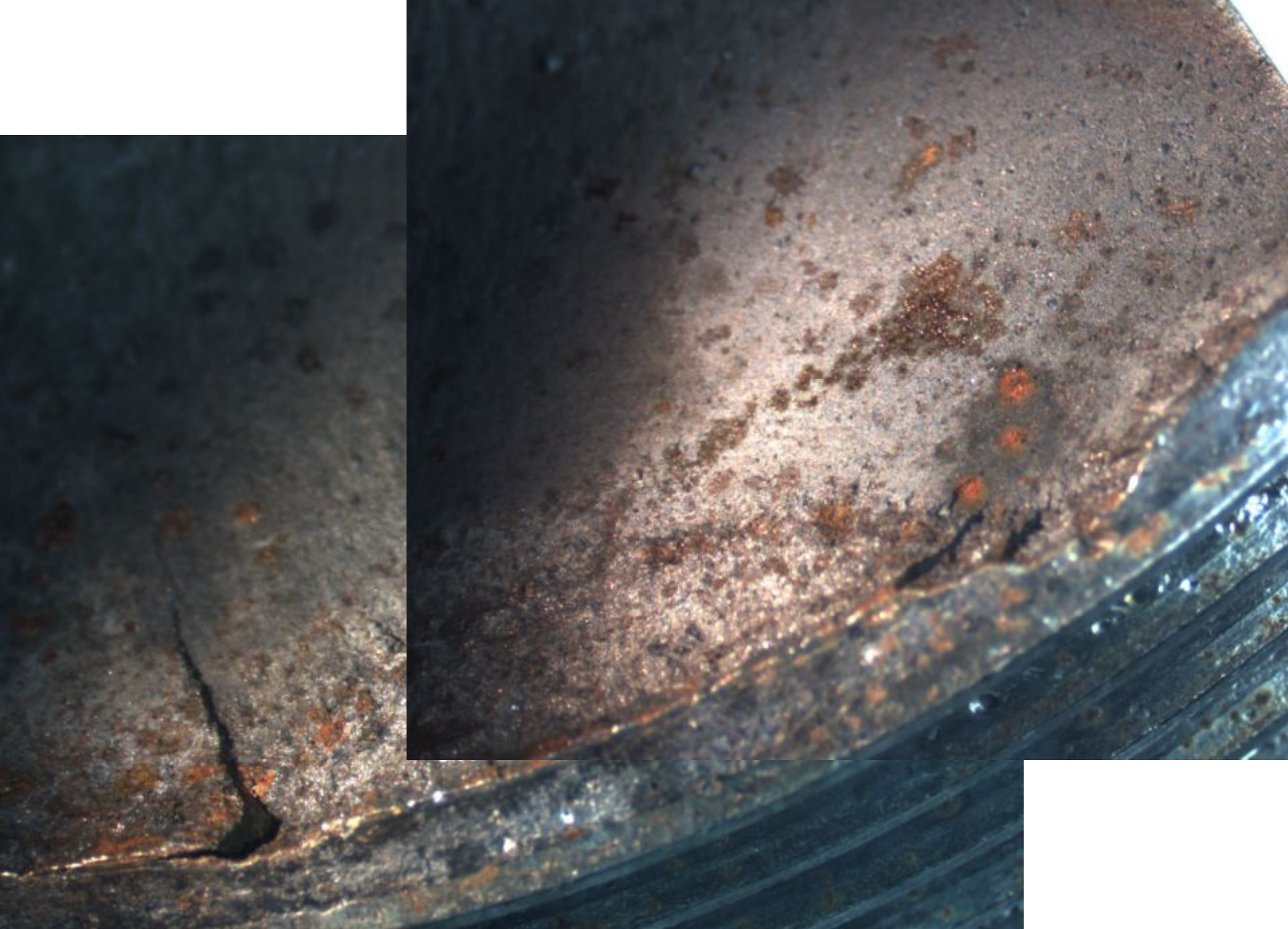
Anchor Bolt D14

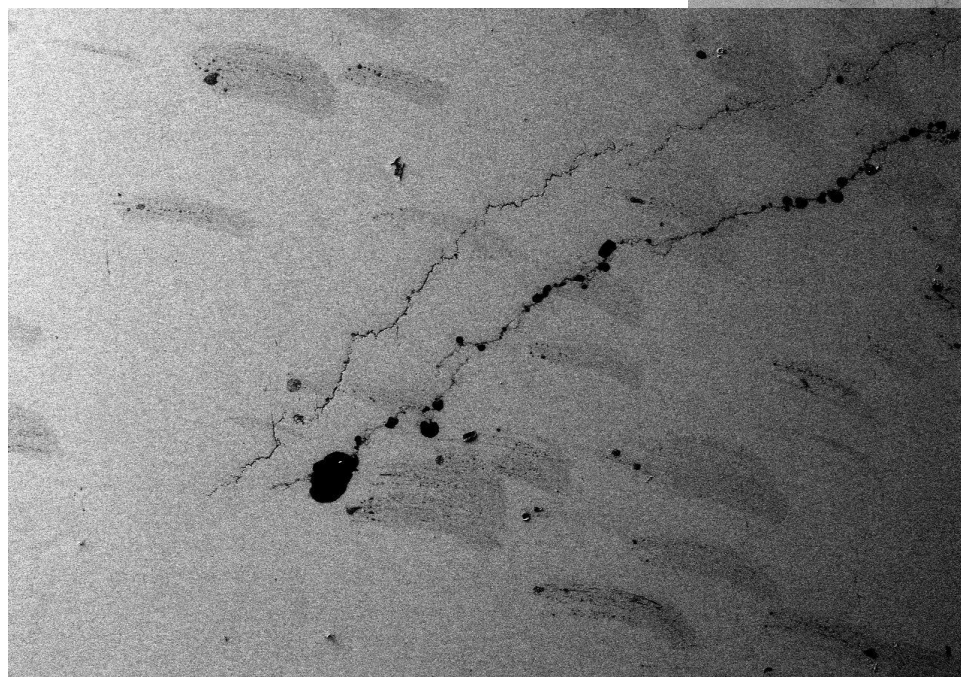
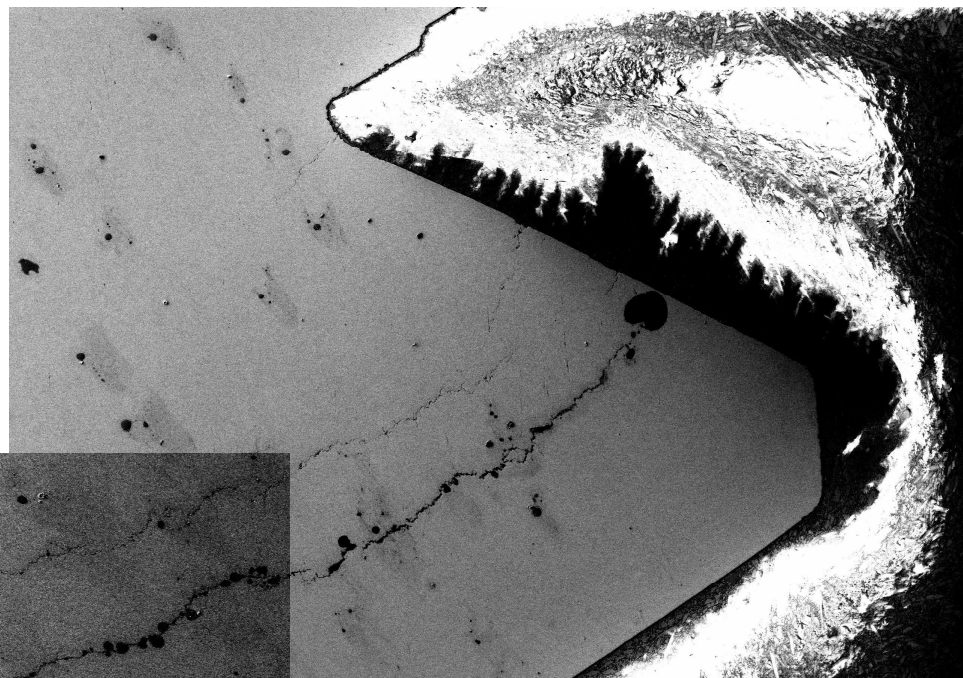






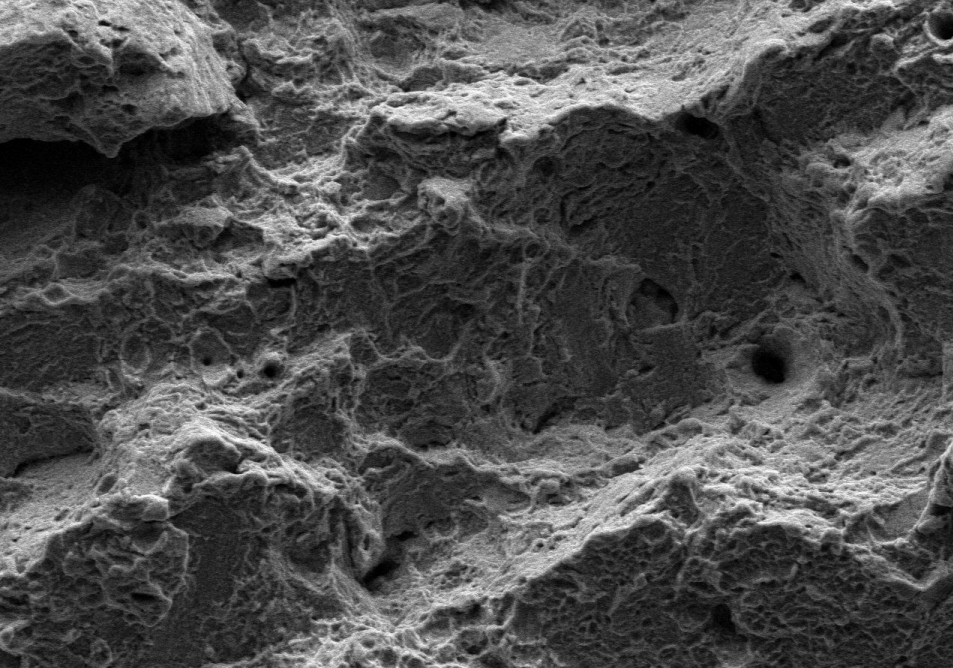




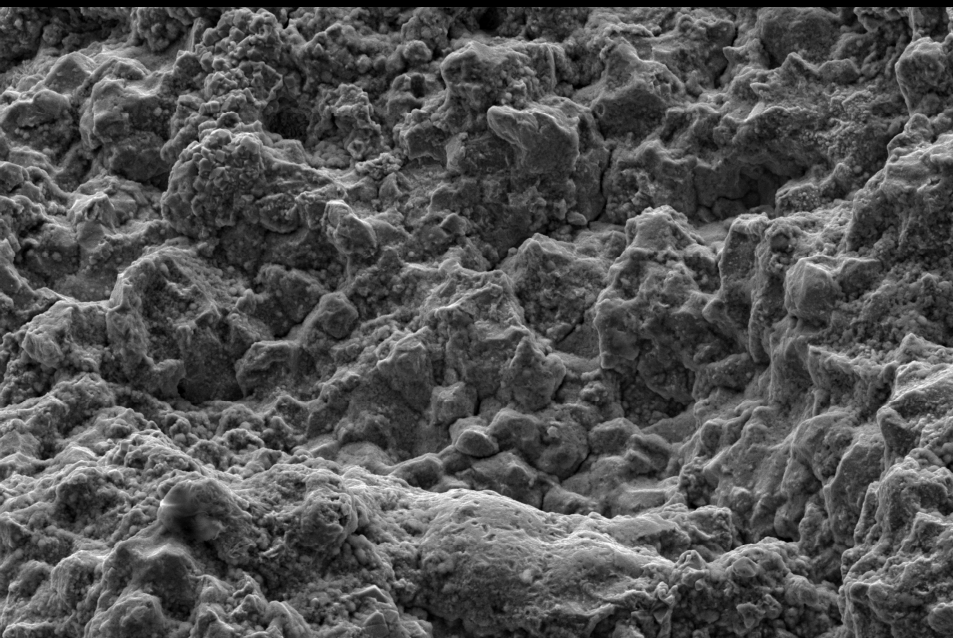
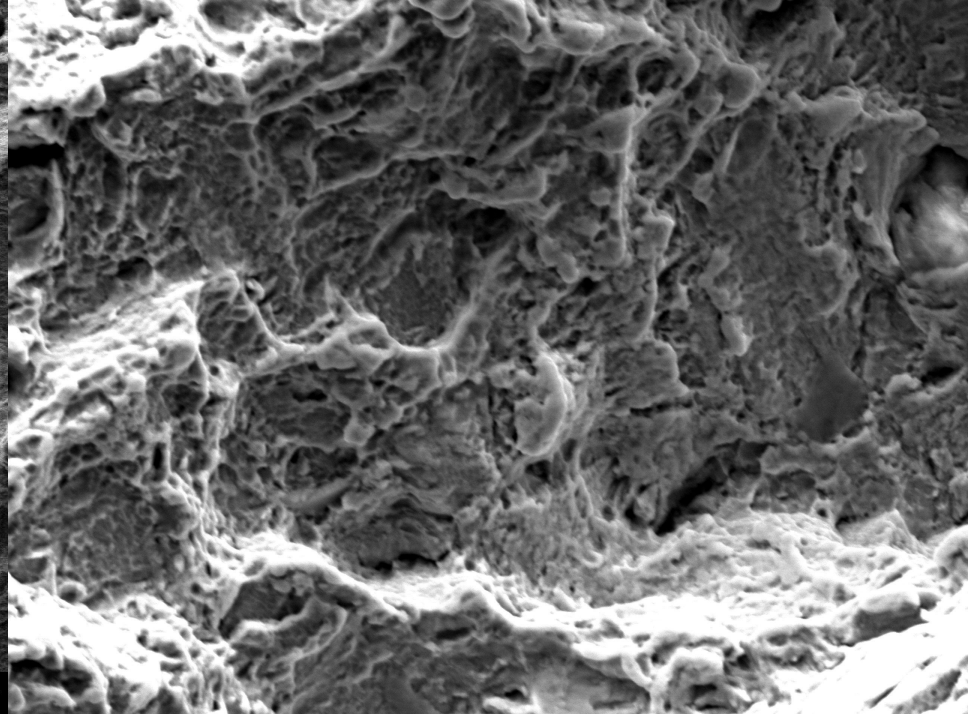


3/2012 1.00mm

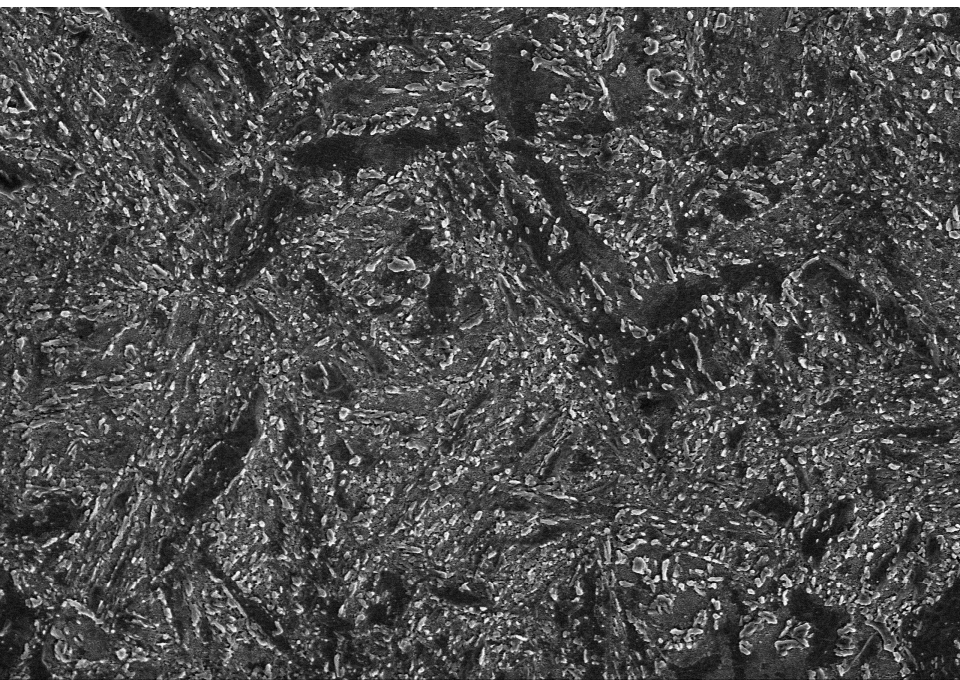
4.0kV 8.6mm x30 4/23/2012 1.00mm



15.0kV 16.1mm x800 4/21/2012 50.0um

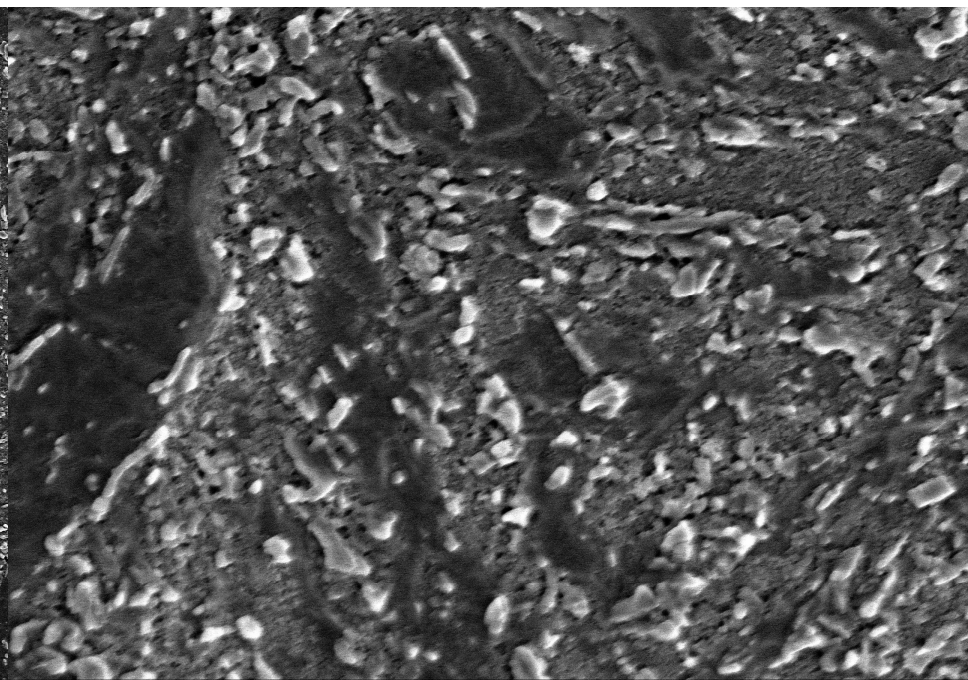


15.0kV 16.1mm x500 4/21/2012 100um



4.0kV 10.2mm x5.00k 4/23/2012

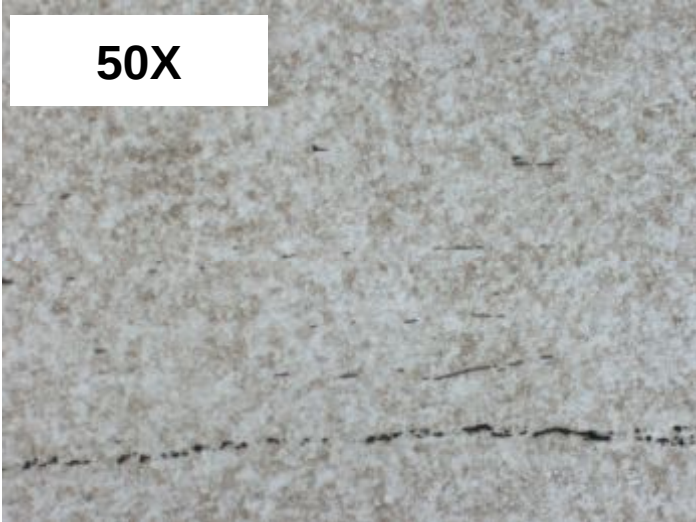
10.0um



4.0kV 10.2mm x20.0k 4/23/2012

2.00um

50X



100X

