

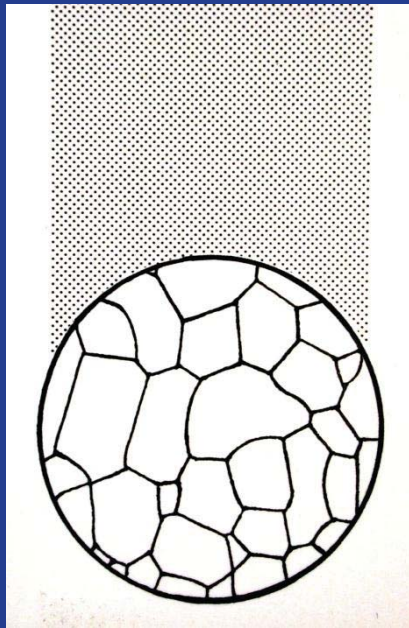


**Orange Coast
Los Angeles
San Fernando**

Symposium on Material & Design Challenges in Aerospace Fasteners

**November 5th, 2012
Irvine, California**

Challenges in the Interpretation of Fastener Microstructures



Frauke Hogue

Hogue Metallography

frauke@hoguemet.com

- Metallography is one of the tools to evaluate quality of fasteners
- Pre-requisites for proper evaluation are:
 - Proper preparation
 - Knowledge of microstructures
 - Knowledge of effects of etchants

Topics of Discussion

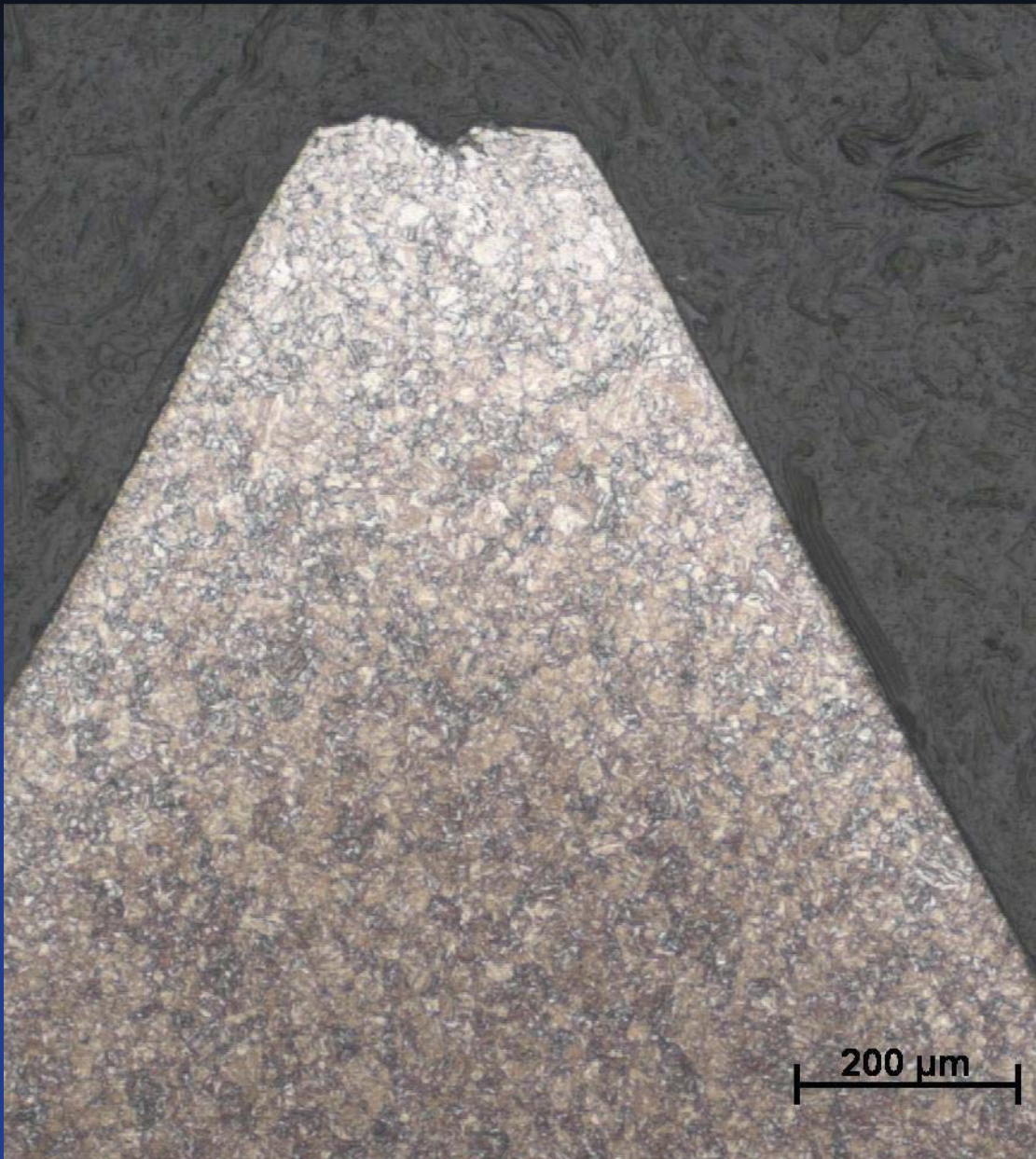
- Decarburization / Cd plated parts
- Ti 6Al-4V
 - structure
 - laps, root bursts, shear planes
 - alpha case
 - grinding burns
- Contaminants on Ti 3Al-2.5V
- Sectioning of Cd plated titanium
- Structures of A286 and Inconel 718

Decarburization of Alloy Steels

- takes place during austenitizing
- caused by poorly controlled furnace atmosphere
- results in lower hardness = lower strength in decarburized layer
- can be detected by metallography – etching with Nital
- exact depth and severity has to be determined by micro hardness traverse

Decarburization Partial

- crest of the thread etches lighter
- indicating lower C content



100x

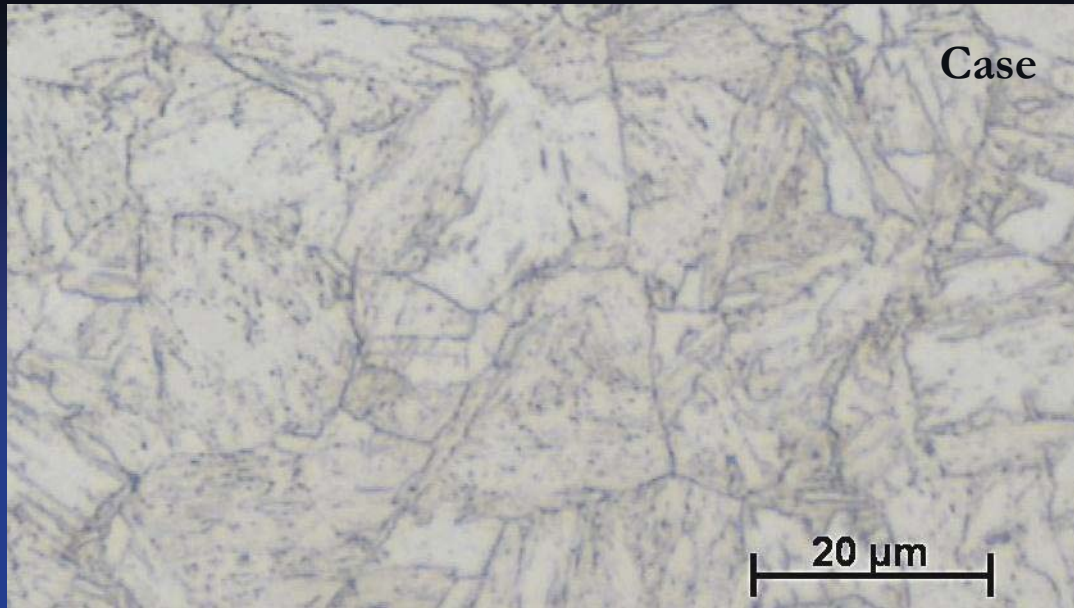
Frauke Hogue

Fe 26

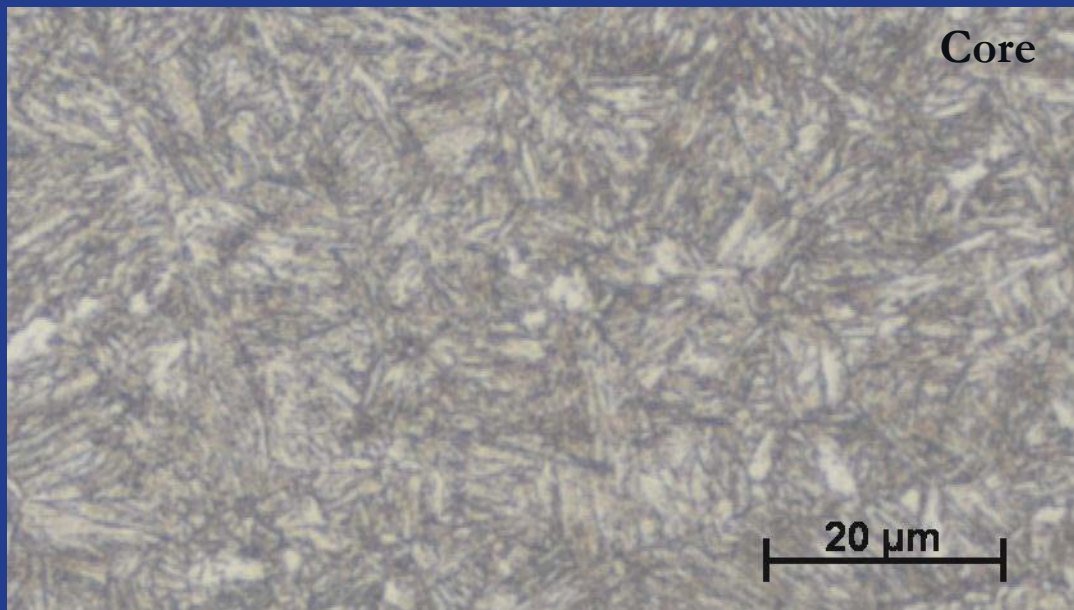
Decarburization

Partial

- case: light etching, low carbon martensite
- HRB 92 = 93 ksi



1000x



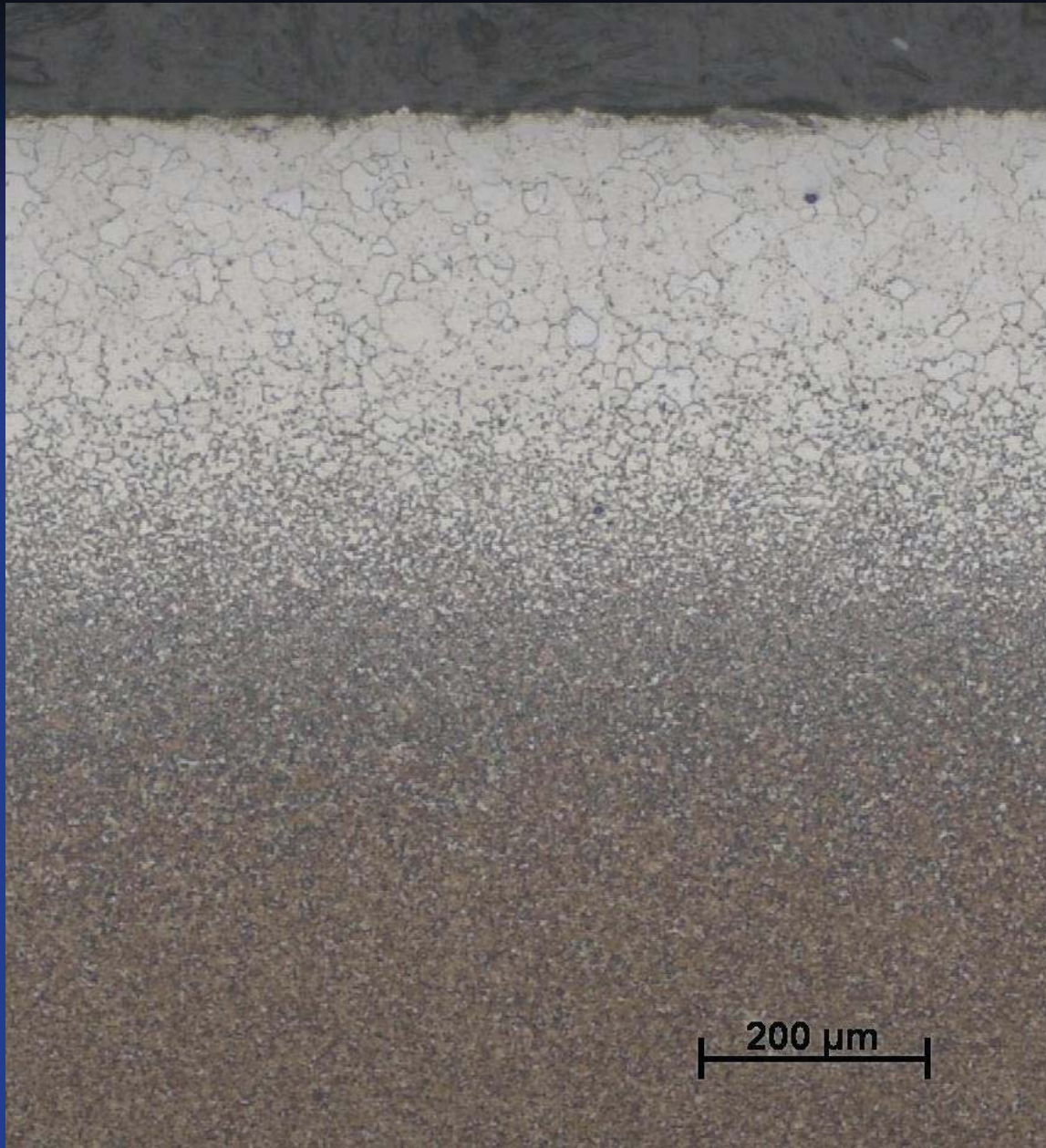
1000x

Frauke Hogue

Fe 26

Decarburization Q & T

- 8650 steel
- decarburized area etches lighter
- C is removed from surface
- less C = less strength
- surface is softer
- core HRC 56
- surface HRB 78

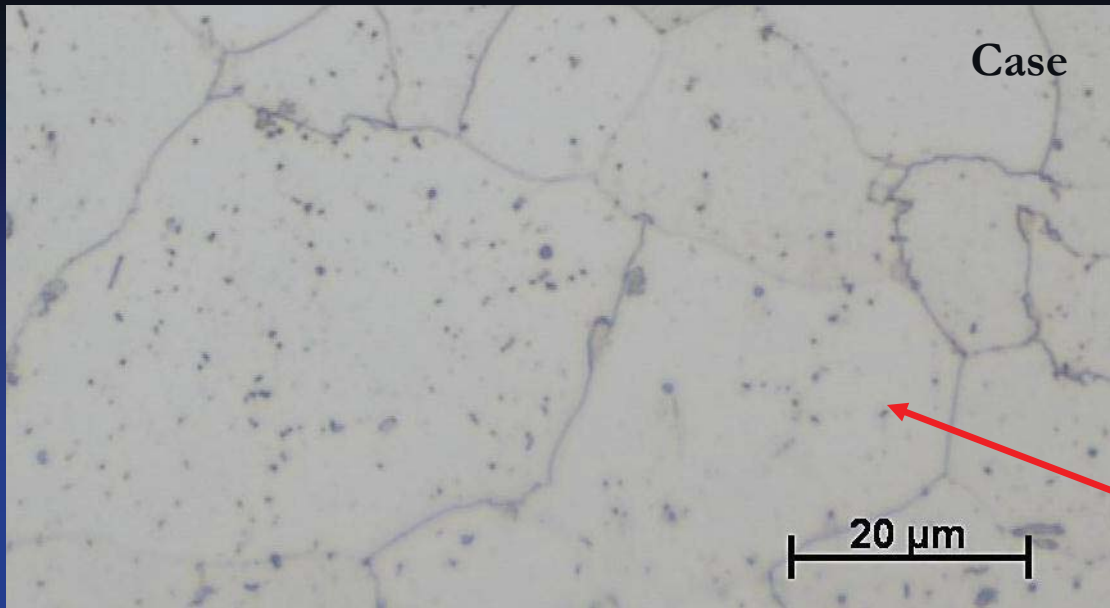


100x

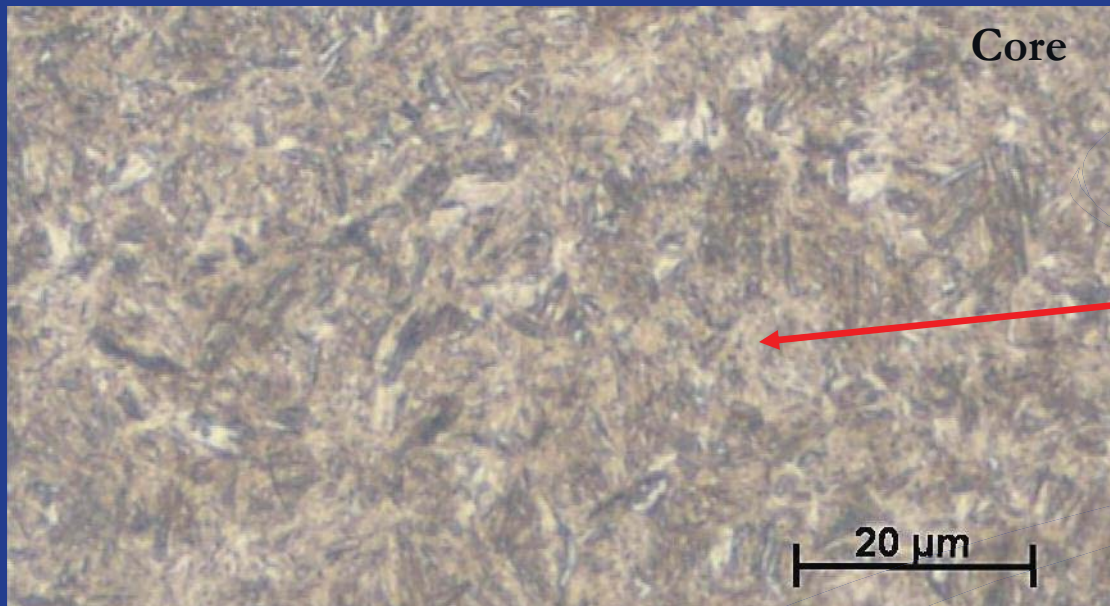
Decarburization Q & T

- 8650 steel
- complete decarburization
- case: ferrite only
HRB 78 = 70 ksi

- core: tempered, high carbon martensite
HRC 56 = 284 ksi



1000x

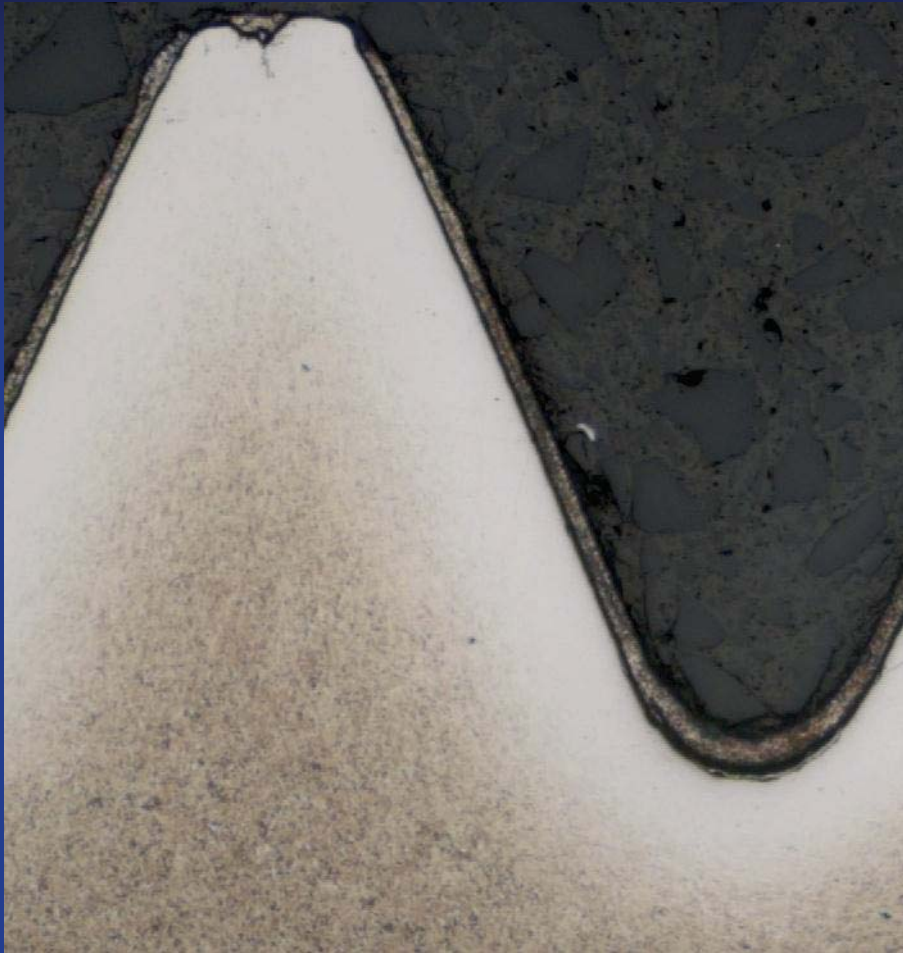


1000x

Frauke Hogue

Fe 25

Cd Plating / Zn Plating

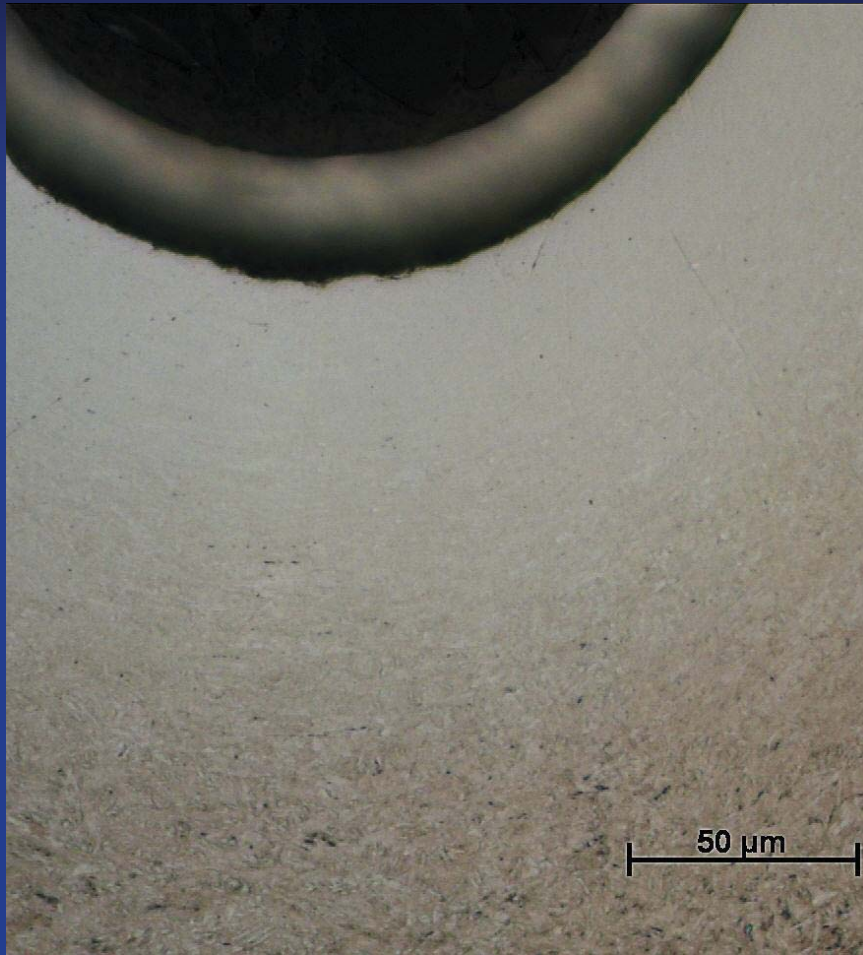


prepared with Zn/Cd
looks like decarburization

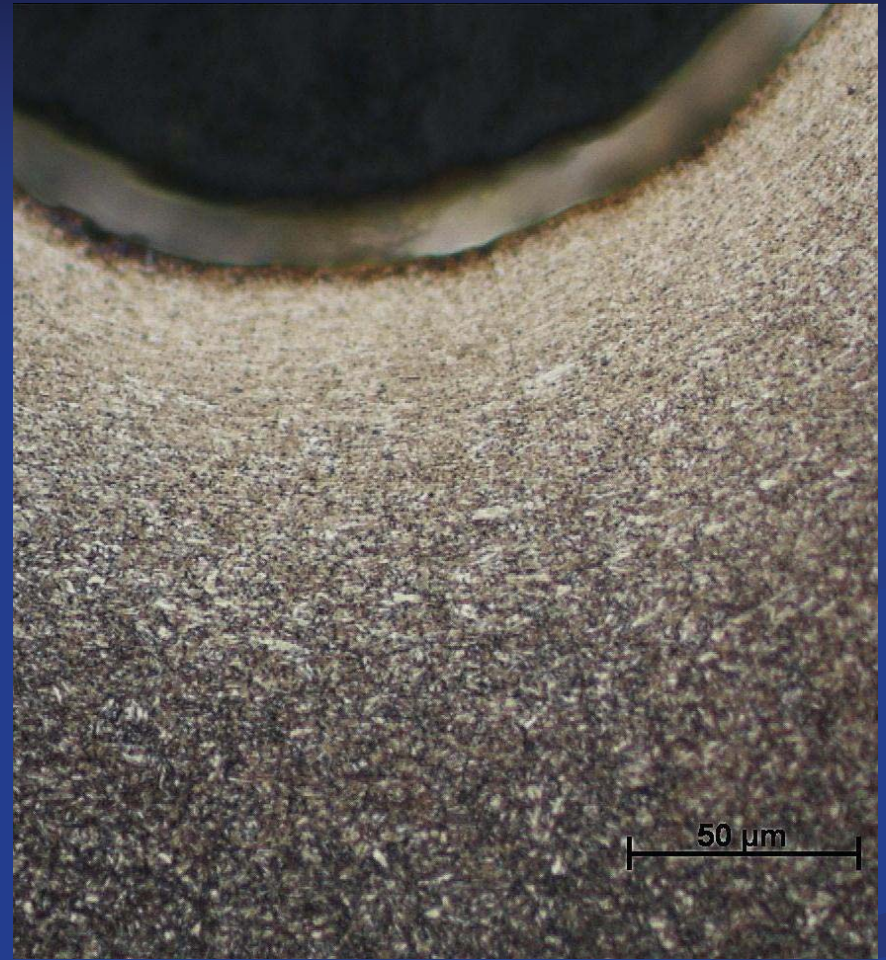


same part
Zn/Cd removed before mounting

Cd Plating / Zn Plating

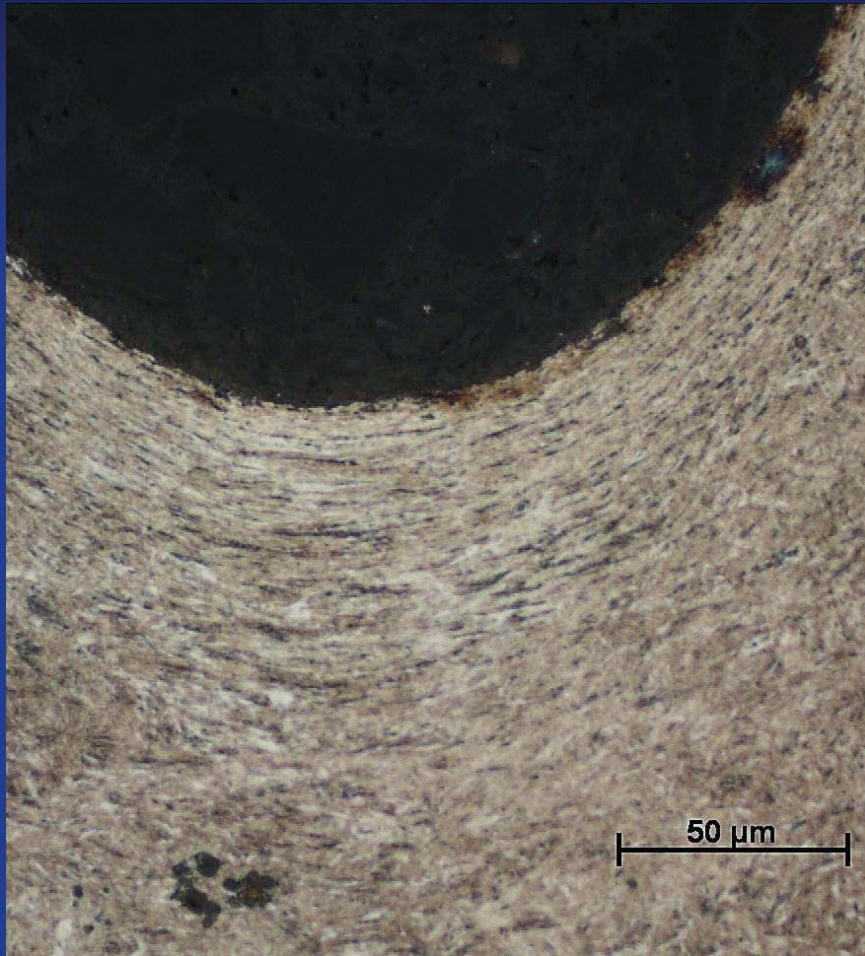


prepared with Zn/Cd
looks like decarburization

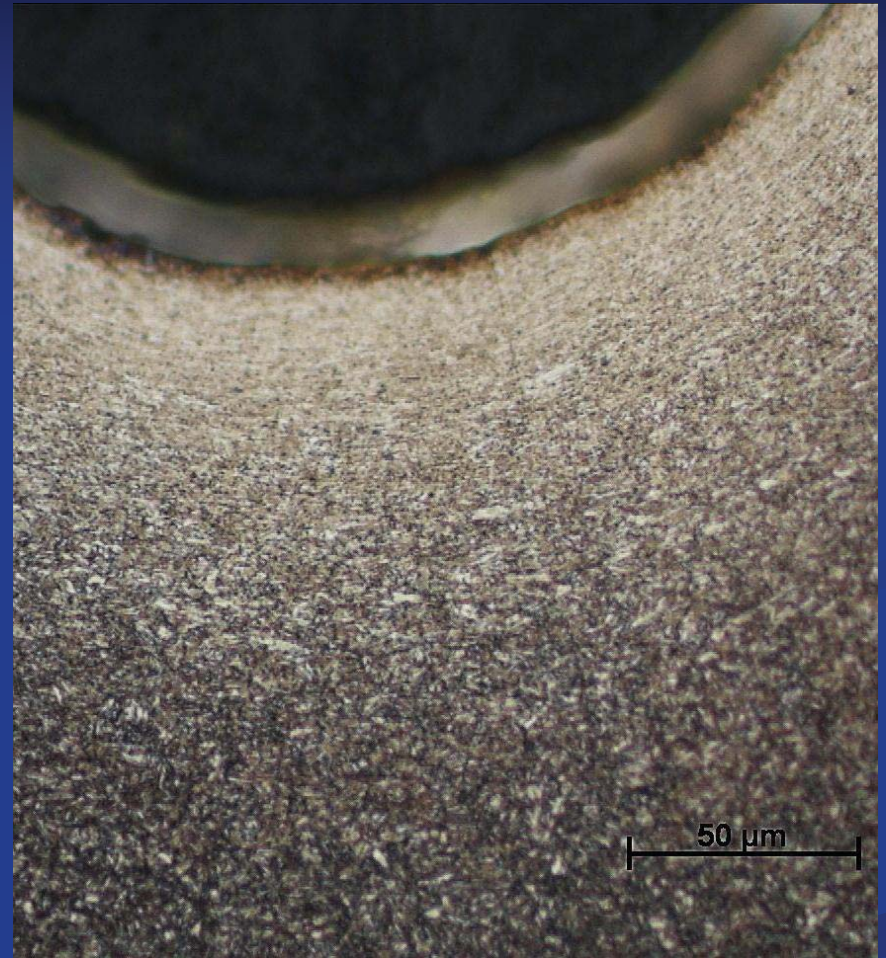


same part – deeper Nital etch
structure very similar to core

Cd Plating / Zn Plating



Cd removed before mounting



Cd not removed – deeper Nital
etch structure very similar to core

Results

- Because of the galvanic protection, surfaces in contact with cadmium or zinc plating will not etch (corrode) properly
- For the untrained eye this might look like decarburization
- Microstructures have to be visible in order to interpret the structure

Ti 6Al – 4V

- Fasteners have to be examined for
 - oxygen contamination caused by heat treating
 - structure – not overheated
 - grinding burns
 - folds & laps
 - shear planes / bursts
- Metallographic analysis performed in process or as final inspection
- Which etchant will show indication best?

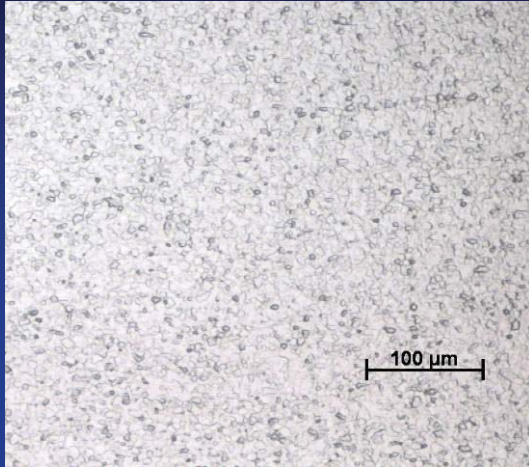
Ti 6Al – 4V

- Most common etchant for structure : Kroll's (ASTM# 192)
- Alternate is ASTM # 186, very strong
- Other etchants show alpha case better
- Some customers require re-polishing if using two etchants
- Can this etchant be applied without re-polishing?
- Which method is better? Drop or swab etching?

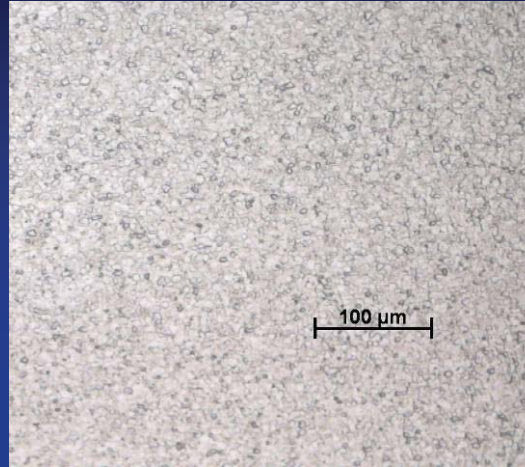
Etchants Used

- Kroll's – ASTM # 192
 - 1-3 ml HF, 2-6 ml HNO₃, 100 ml H₂O
- HF – ASTM # 11
 - 2 ml HF, 100 ml H₂O
- Titanium – ASTM # 186
 - 10 ml HF, 5 ml HNO₃, 85 ml H₂O
- Oxalic
 - 2 ml HF, 98 ml cold sat oxalic acid
- Boeing – Ammonium Bifluoride
 - 1 g ammonium bifluoride, 99 ml H₂O
- Titanium & Oxalic
 - Titanium Etch followed by Oxalic

Ti 6Al – 4V STA 200x



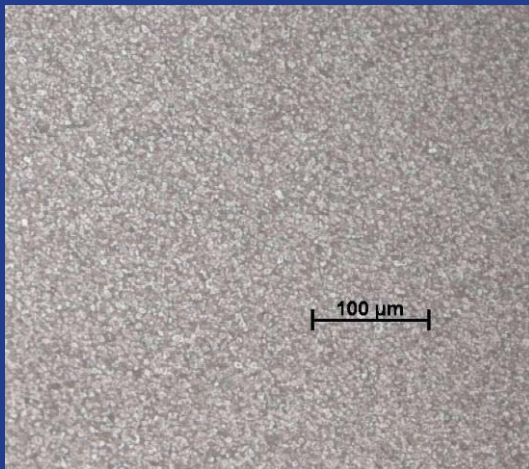
Kroll's



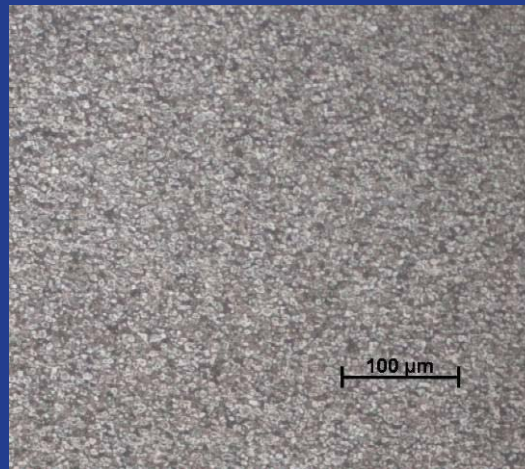
Ti



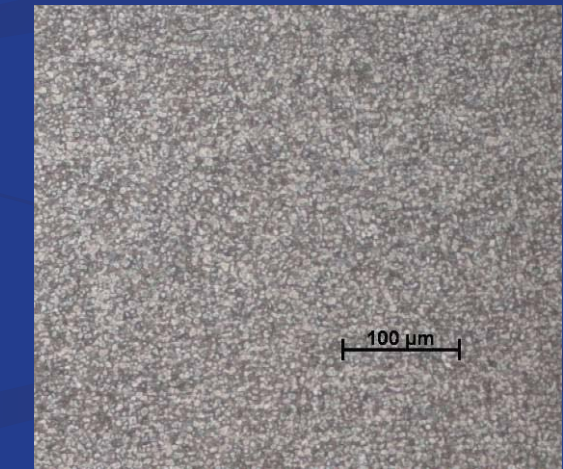
Boeing



2% HF

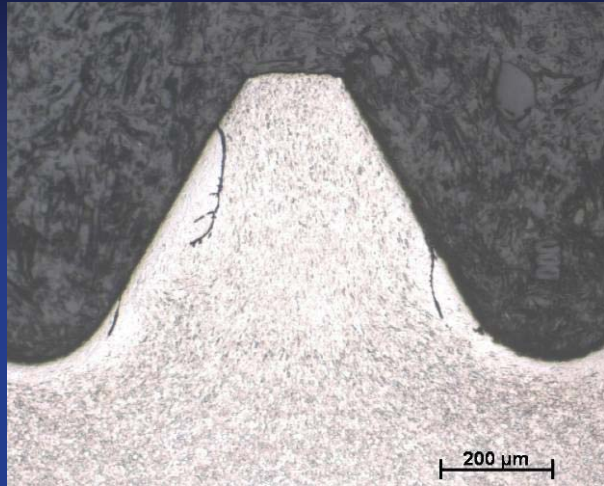


Oxalic

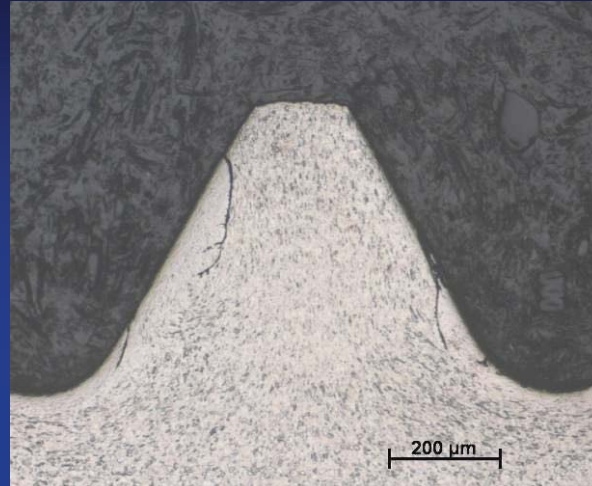


Ti & Oxalic

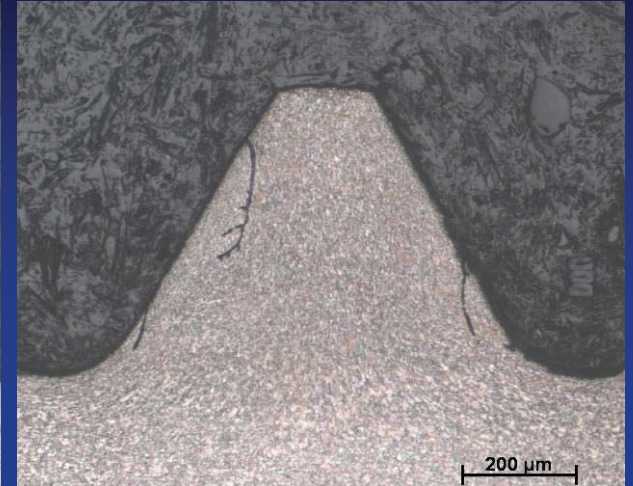
Ti 6Al – 4V Thread Laps 100x



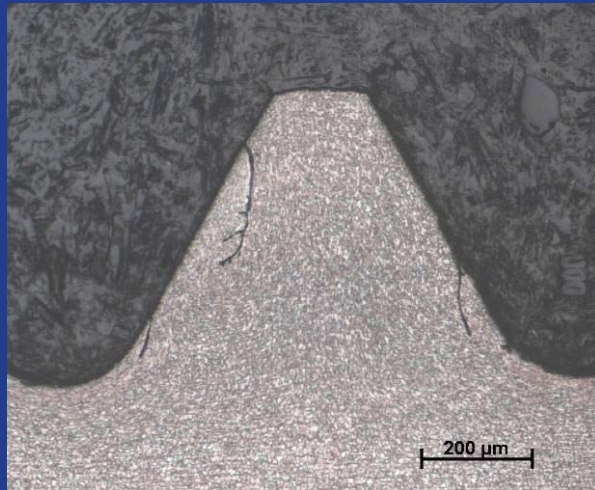
Kroll's



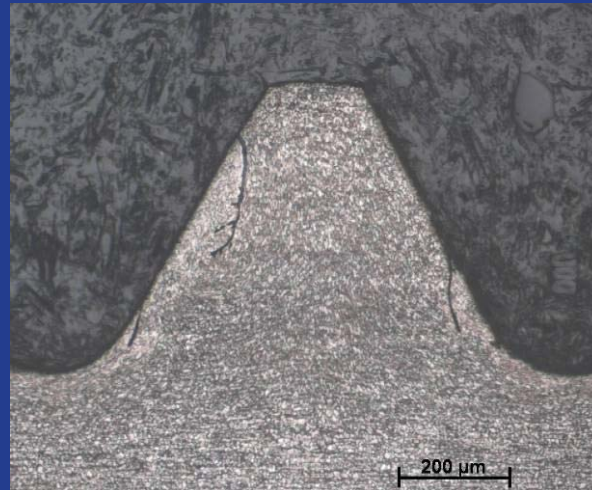
Ti



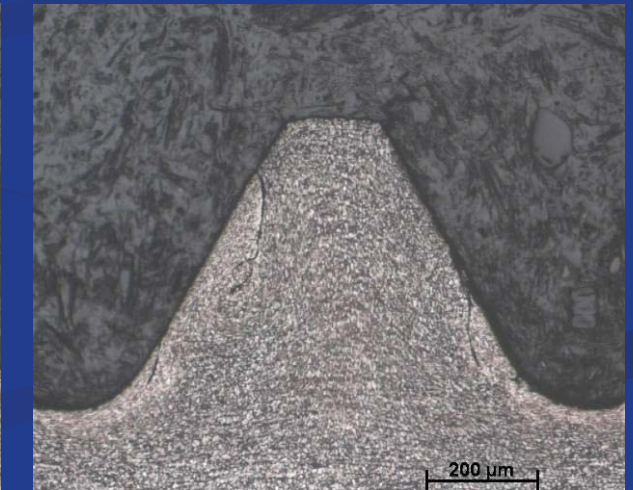
Boeing



2% HF



Oxalic
Frauke Hogue



Ti & Oxalic

Results

- STA structures best revealed with Kroll's (ASTM # 192) or Ti Etch (ASTM # 186)
- Other etchants are too dark
- Laps are visible with all etchants, but easier seen with light etchants

Alpha Case – Ti 6Al – 4V Forging – Fold 200x



Kroll's



Ti



Boeing



Oxalic