# THROUGH CARBURIZED FATIGUE

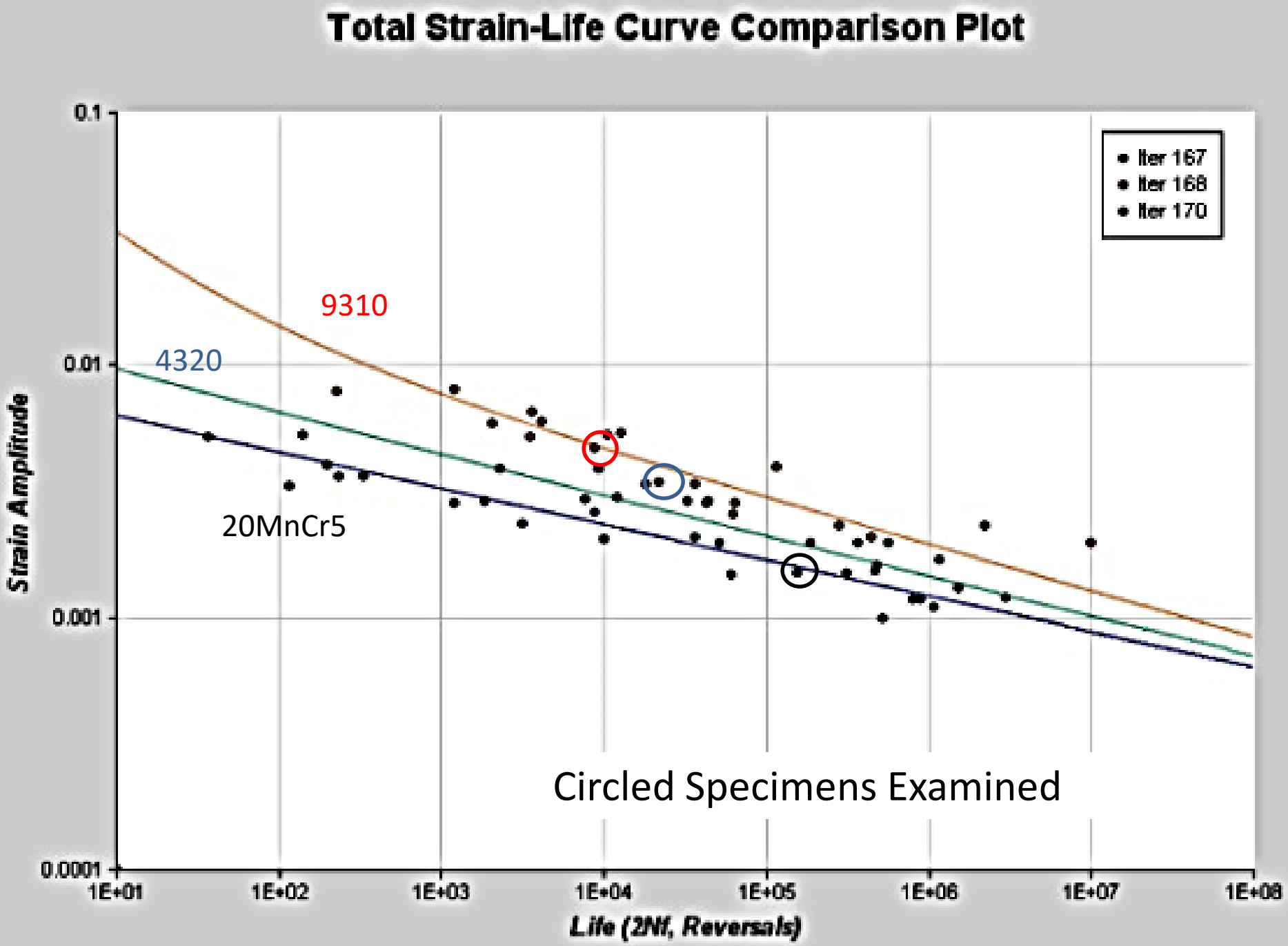
EFFECT OF Ni CONTENT

Iterations 167, 168, and 170

Bob Cryderman, May 25, 2017

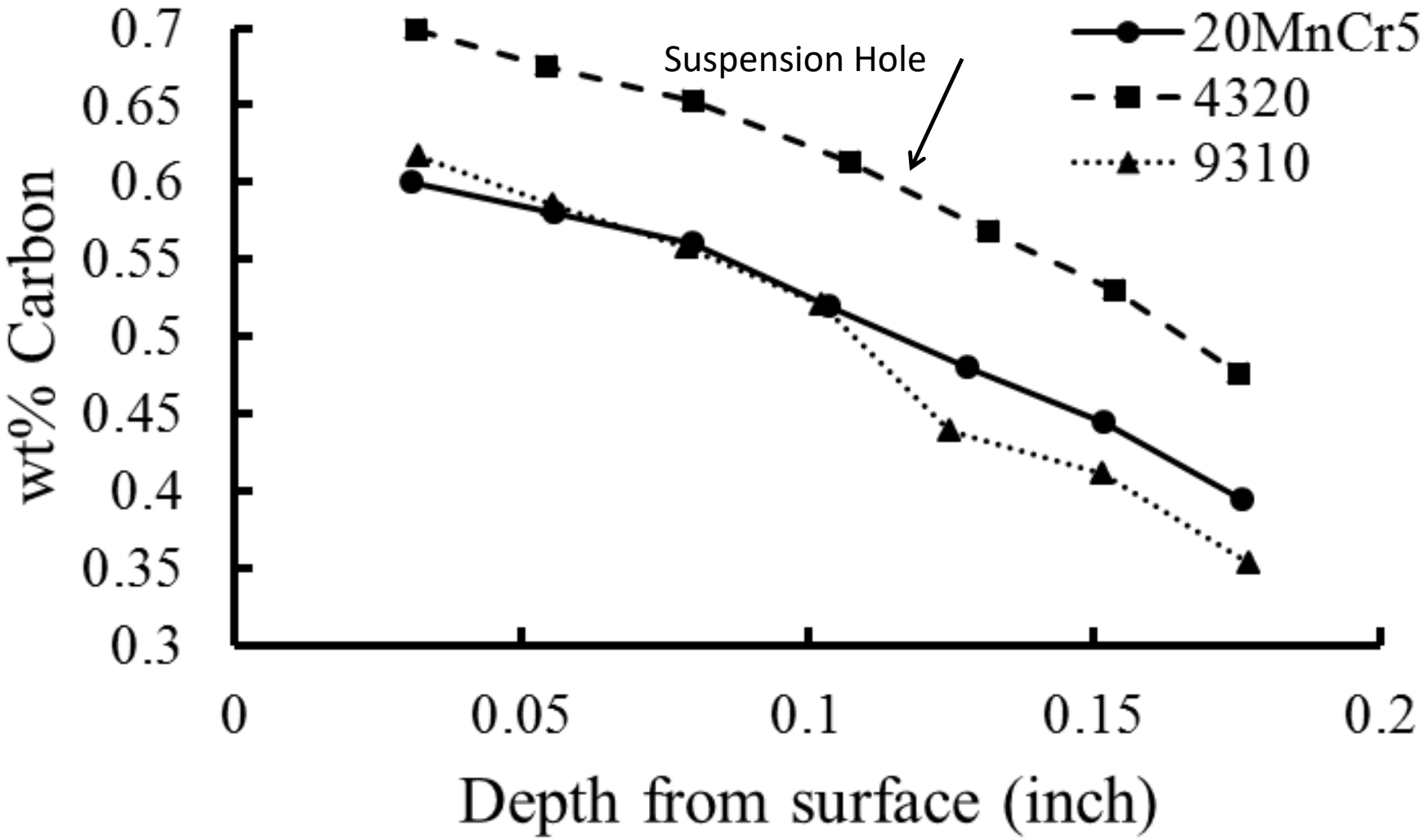
# Chemical Compositions

| wt% | 20MnCr5 | 4320 | 9310 |
|---|---|---|---|
| Carbon | 0.18 | 0.18 | 0.12 |
| Nickel | 0.16 | 1.75 | 3.12 |
| Chromium | 1.11 | 0.5 | 1.11 |
| Manganese | 1.2 | 0.63 | 0.62 |
| Silicon | 0.21 | 0.21 | 0.19 |
| Molybdenum | 0.04 | 0.25 | 0.09 |
| Copper | 0.21 | 0.22 | 0.16 |
| Aluminum | 0.034 | 0.026 | 0.022 |
| Sulfur | 0.03 | 0.025 | 0.014 |
| Phosphorous | 0.01 | 0.013 | 0.007 |
| Other | 0.0204 | 0.0176 | 0.0124 |
| Oxygen (ppm) | 8 | | |
| Nitrogen (ppm) | 97 | 82 | 66 |

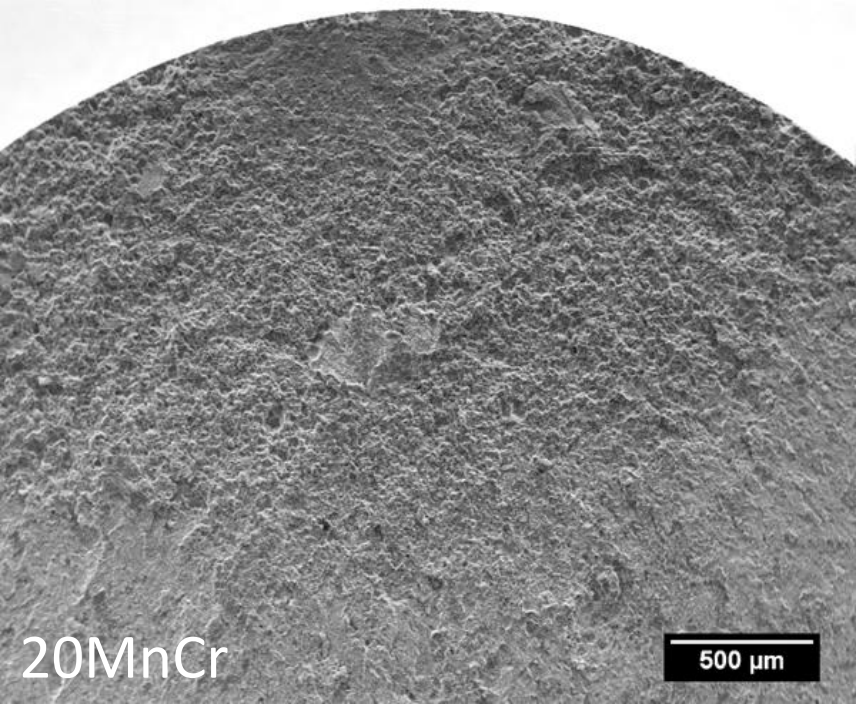

Total Strain-Life Curve Comparison Plot
Iter 167
Iter 168
Iter 170
9310
4320
20MnCr5
Circled Specimens Examined
Strain Amplitude
0.1
0.01
0.001
0.0001
1E+01
1E+02
1E+03
1E+04
1E+05
1E+06
1E+07
1E+08
Life (2Nf, Reversals)

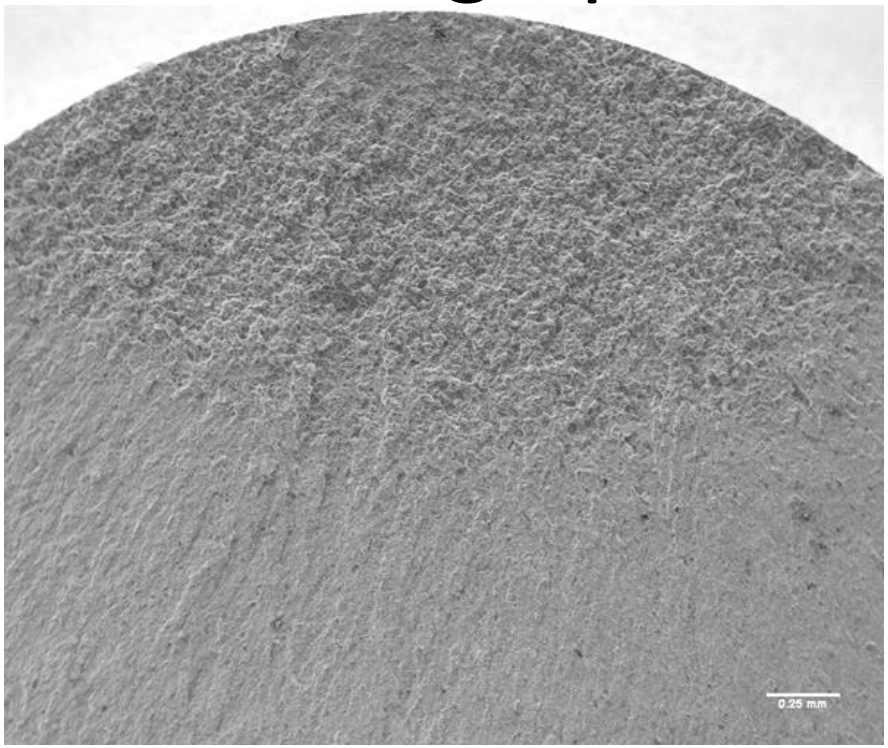
# Specimens Received

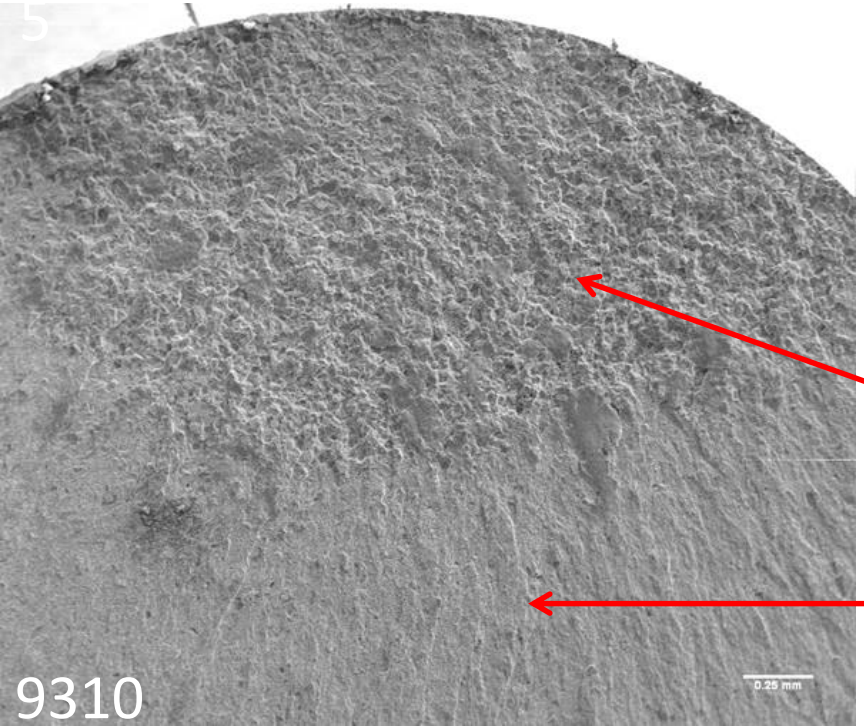
# Carbon Profiles - Grip Ends



# SEM Fractographs



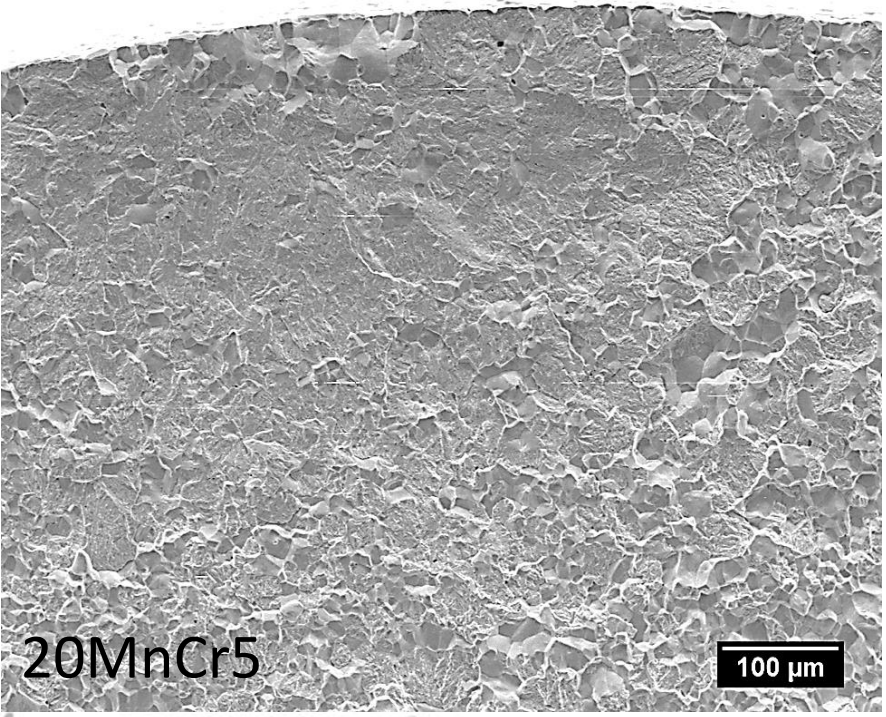



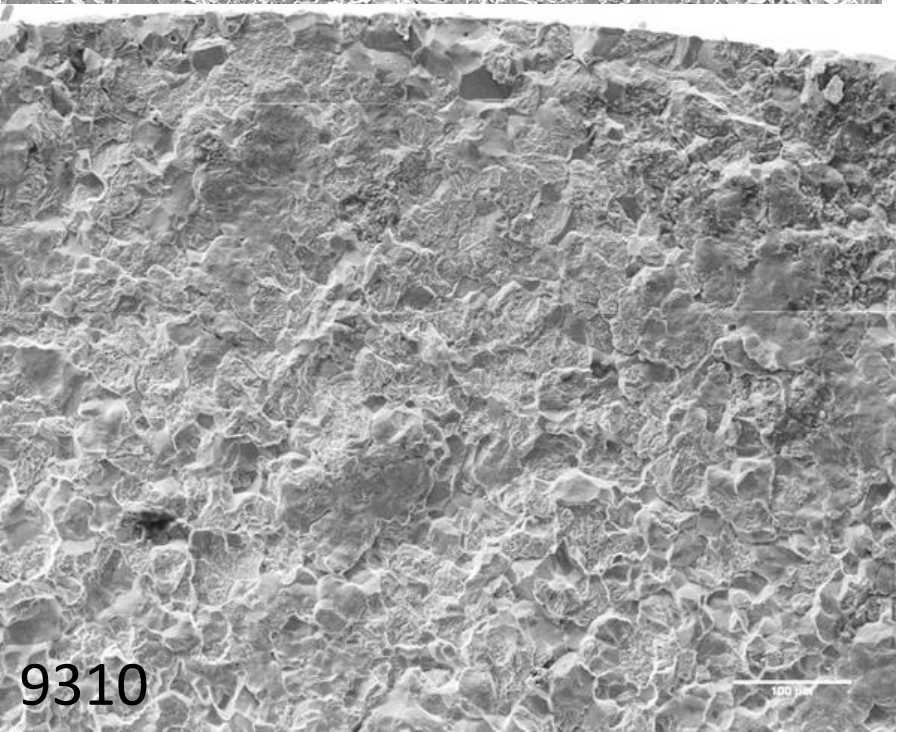



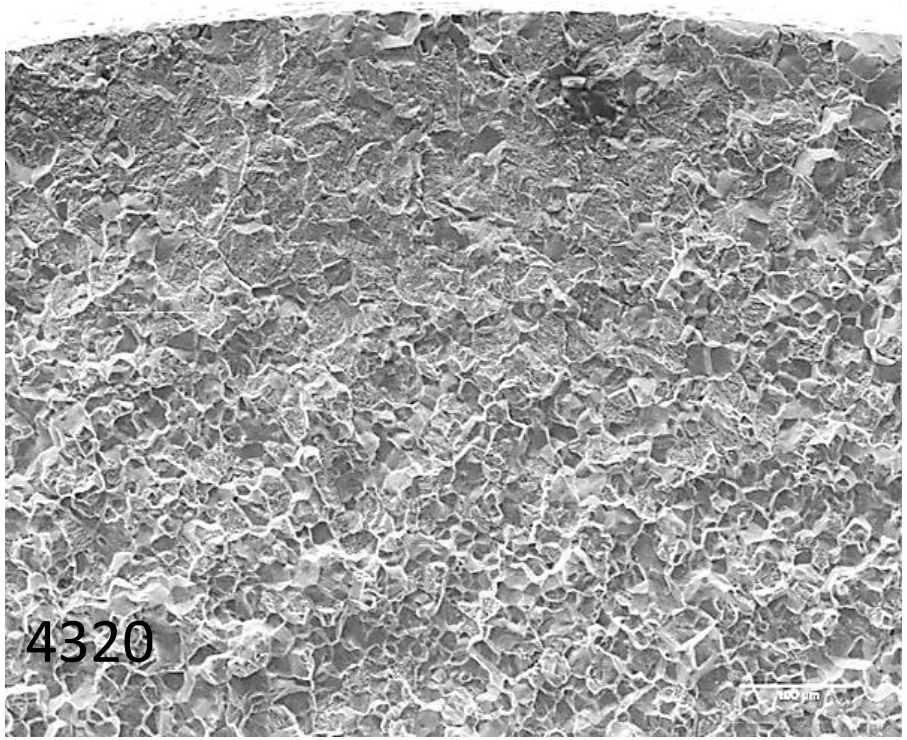

Fatigue

Overload

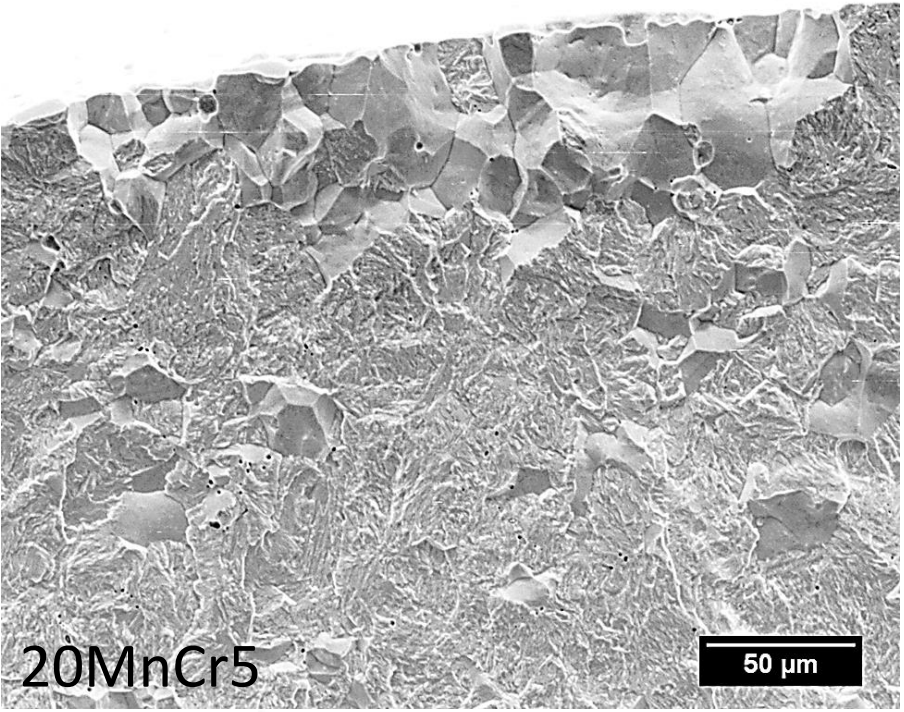
# SEM Fracture Zone

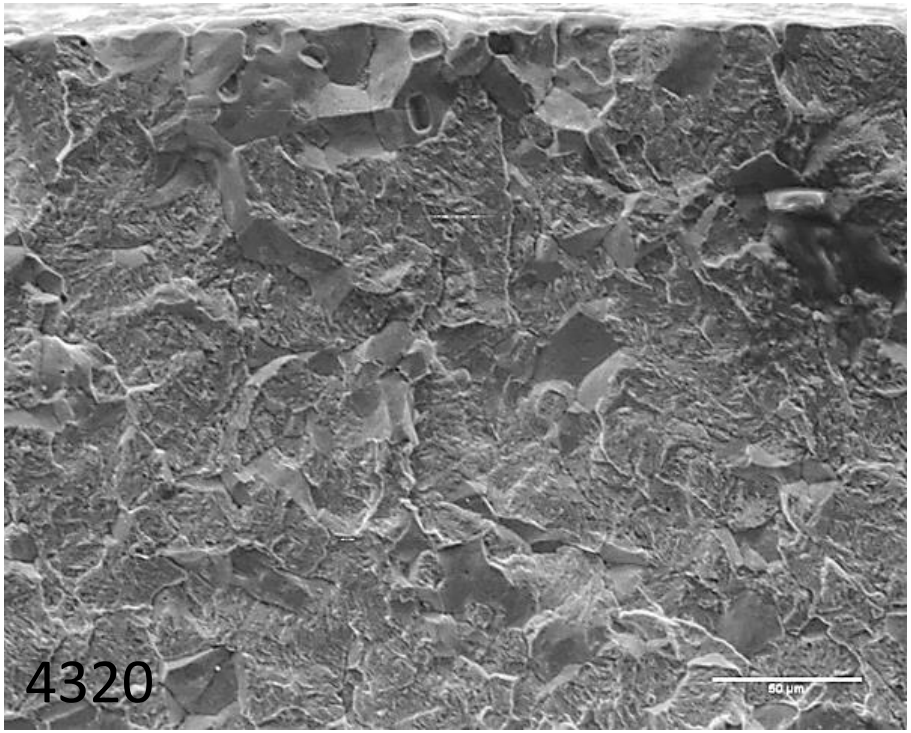


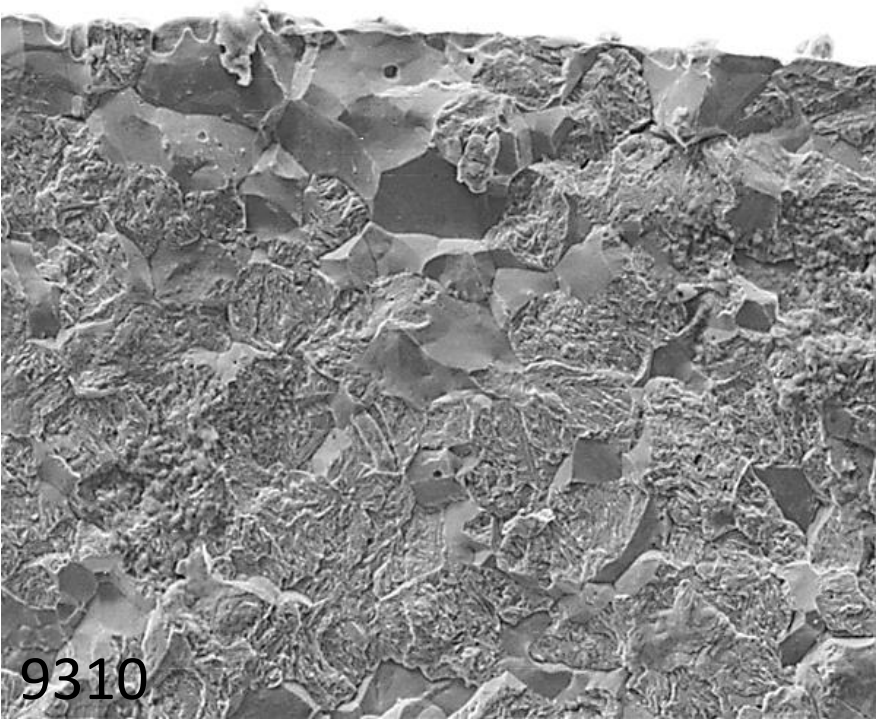



# SEM
# Fracture Origins

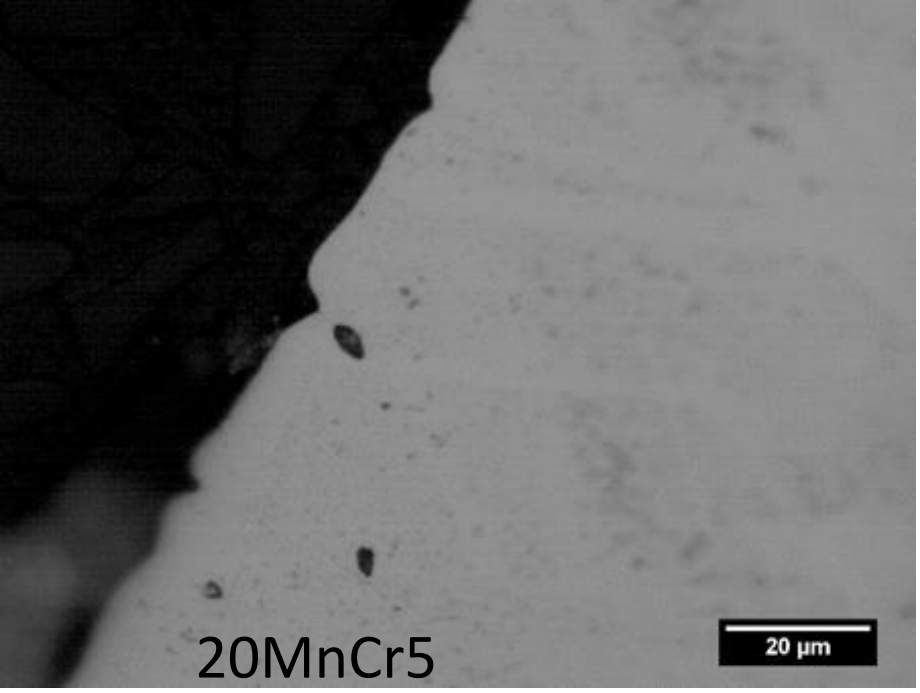


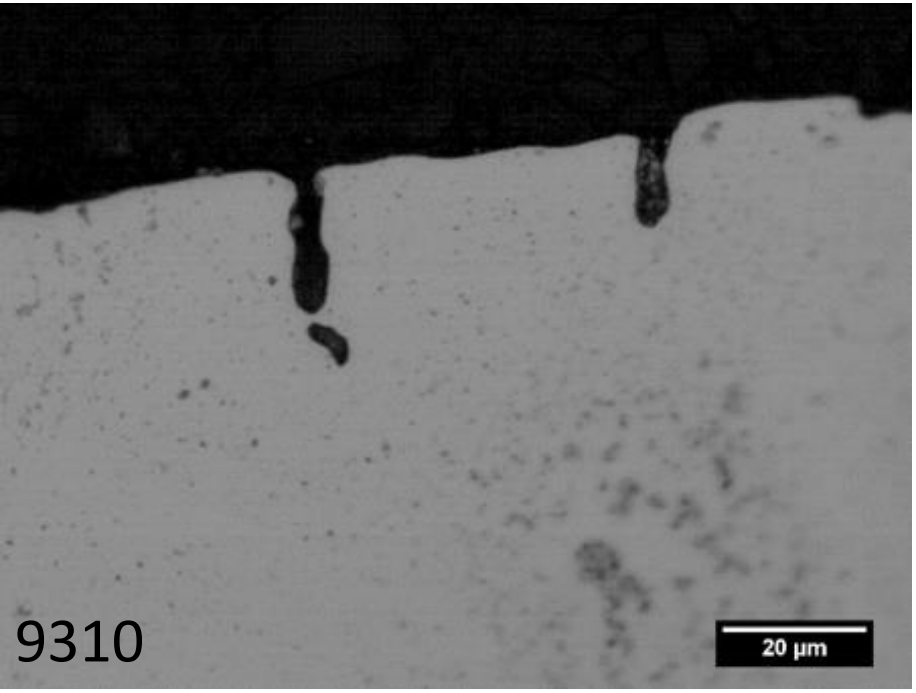



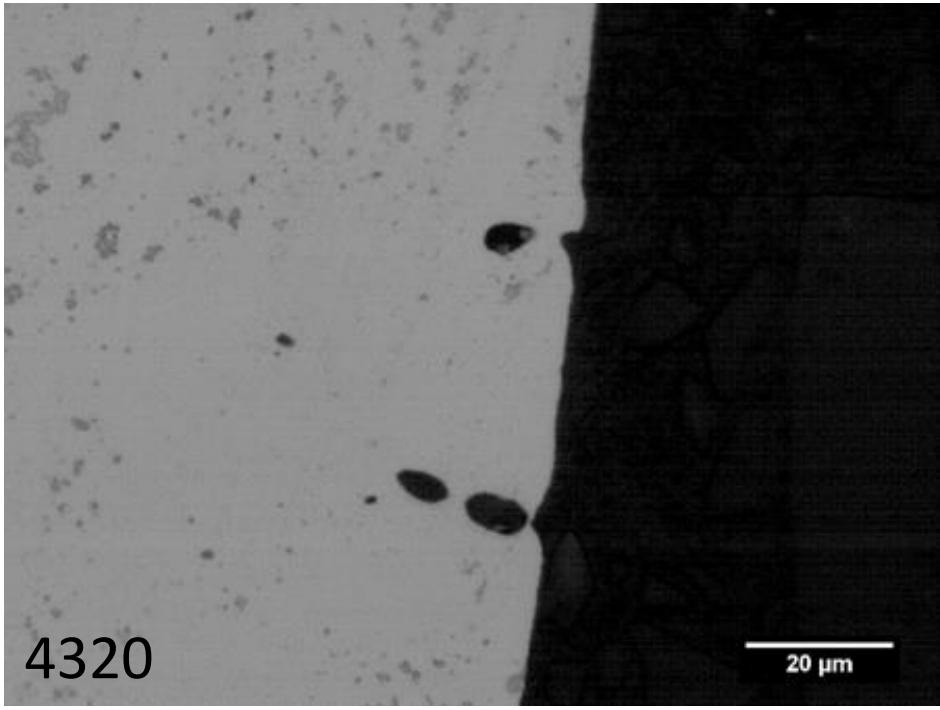




Intergranular Fracture
approximately 50 µm Deep

# LOM
# Surface Voids



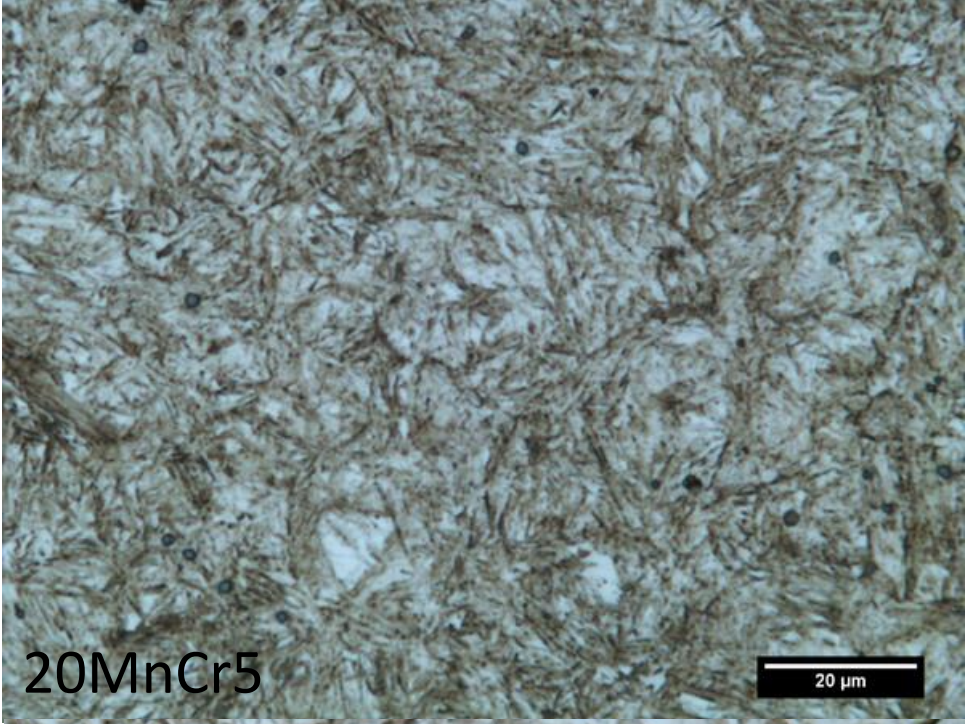



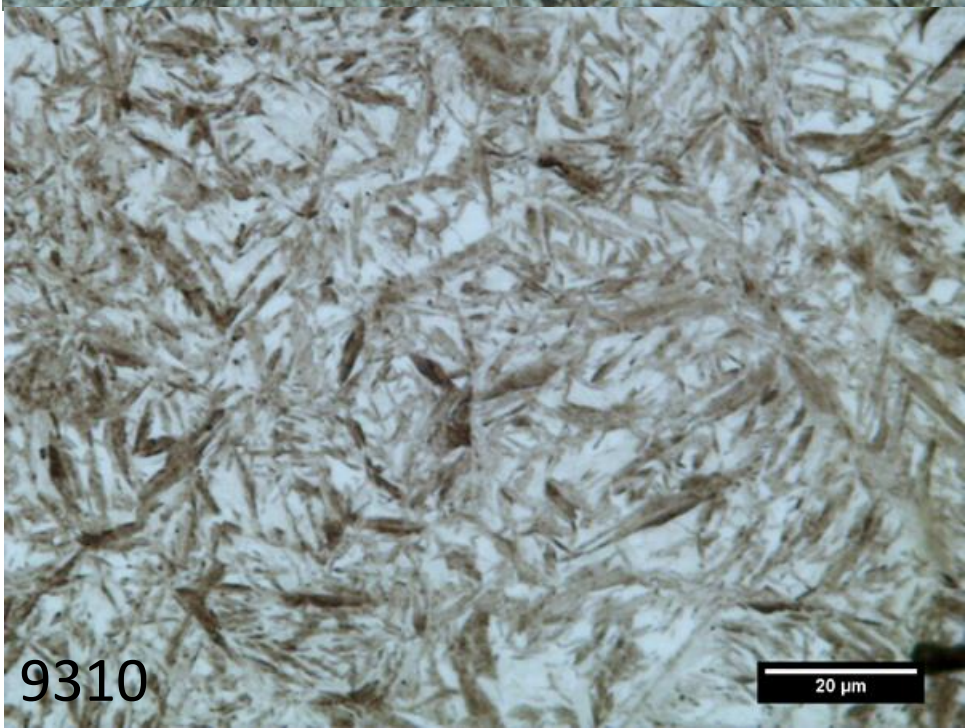

Thermal Grooving
15 – 20 µm Deep

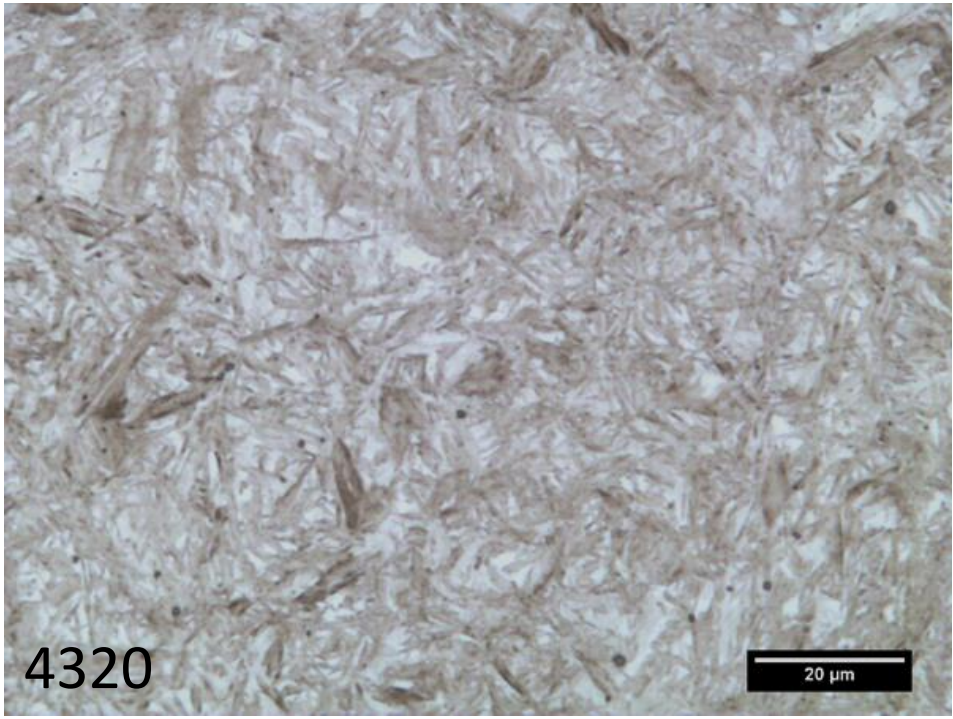
# Austenite Grain Size

| | Average grain size, µm | Standard deviation |
|---|---|---|
| **20MnCr5** | 16.0 | 1.6 |
| **4320** | 16.4 | 1.1 |
| **9310** | 20.6 | 1.5 |

# LOM
# 2% Nital



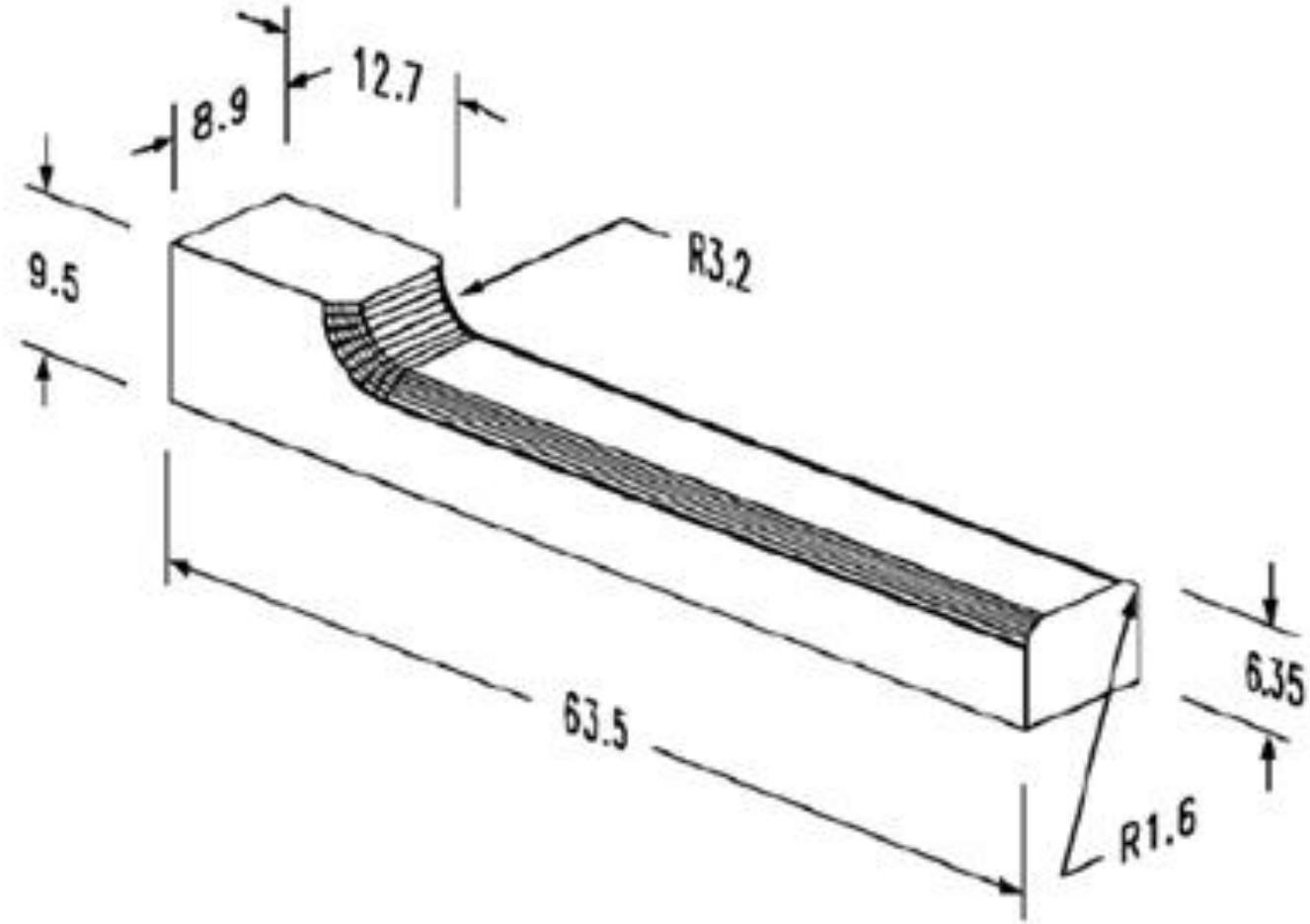
# Retained Austenite

| | Retained Austenite, % | Std Deviation, % |
|---|---|---|
| 20MnCr5 | 13.6 | 1.4 |
| 4320 | 20.1 | 3.6 |
| 9310 | 23.4 | 3.3 |

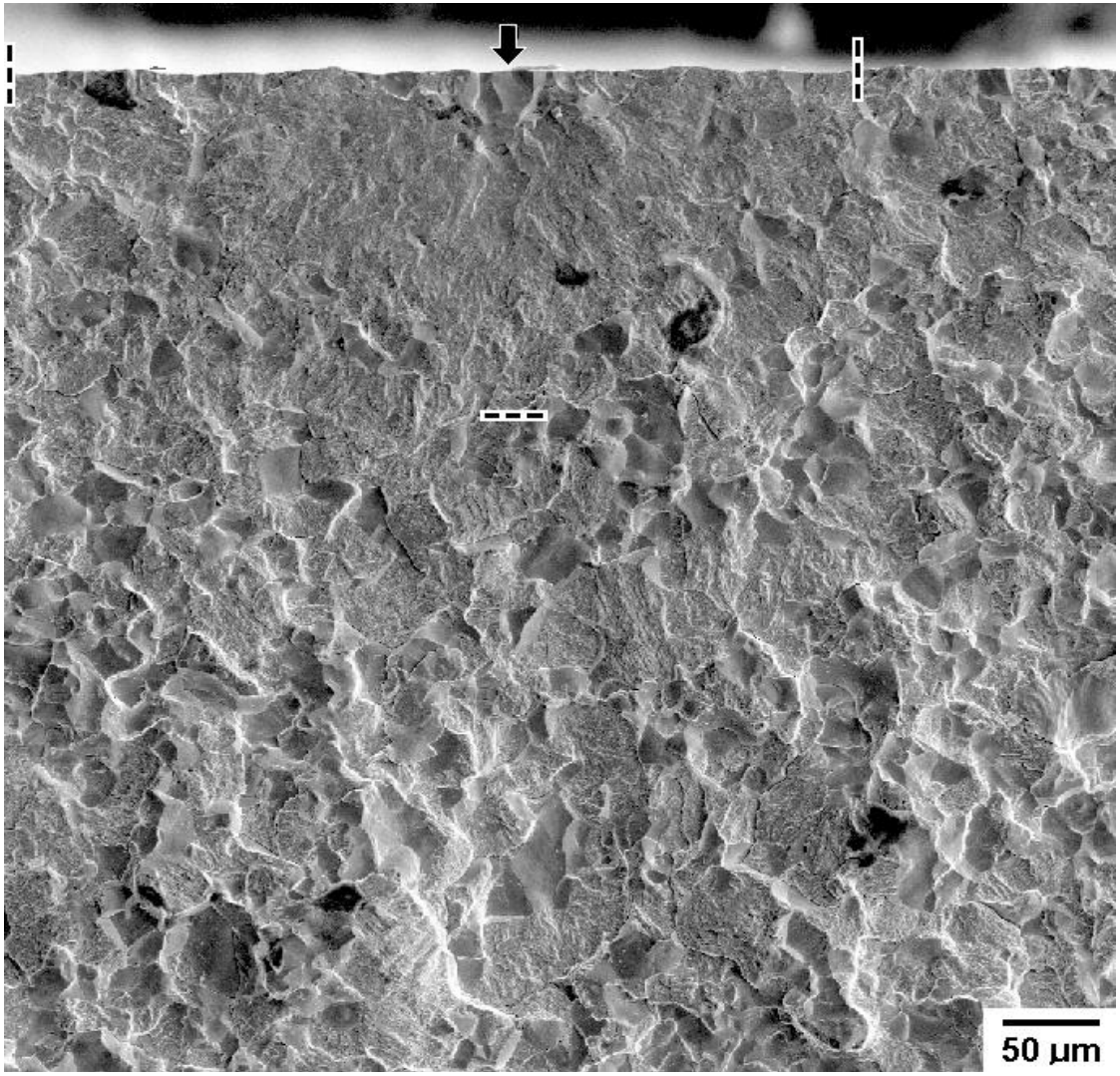
# Summary

- AGS 16 -20 µm
- Failures Initiated as Intergranular Cracks on the order of 50 µm Deep at The Surface
- Role of Surface Grooving not Clear
- Fatigue Crack Grows Until Overload Failure
- Not Clear If Life Related to Integranular Crack Nucleation or Crack Growth Rate Till Overload
- Increased Ni Increased Retained Austenite and Delayed Crack Nucleation or Growth Rate

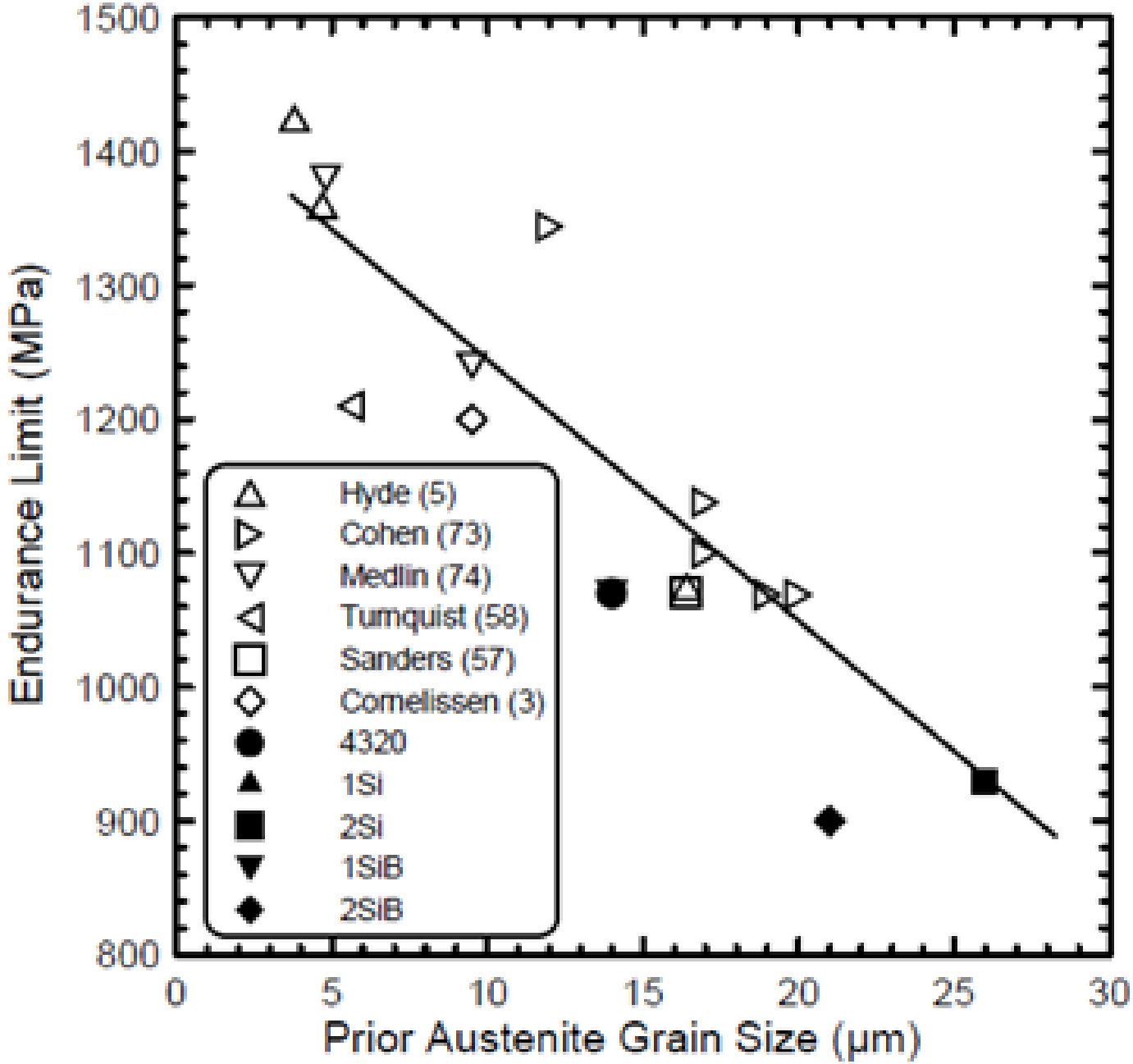
# Modified Brugger Specimen



# Bend Test Fatigue Fracture on Vacuum Carburized Carburized 4320




Jason Spice PHd Thesis, Specimens  Chemically Polished Before Carburizing




Jason Spice PHd Thesis 2006