

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594



June 5, 2014

MATERIALS LABORATORY FACTUAL REPORT

Report No. 14-033

A. ACCIDENT INFORMATION

Place : Fresno, California
Date : February 28, 2014
Vehicle : Grumman G-164A Ag Cat, N72ES
NTSB No. : WPR14LA130
Investigator : Michael Huhn, AS-WPR

B. COMPONENTS EXAMINED

Right Main Landing Gear

C. DETAILS OF THE EXAMINATION

The received inboard half of the fractured right main landing gear spring is displayed in the upper view of figure 1. The spring gear was saw cut about 2 $\frac{3}{4}$ inch inboard of the fracture prior to receipt in the Materials Laboratory. As shown in the lower view of figure 1, the fracture was generally smooth and flat and covered by a speckled pattern of rust products except at the lower forward corner where a semi-elliptical region was nearly rust free.

Visual and magnified examination of the fracture surface revealed fracture traces and marking indicating that the overall fracture initiated in the clean region in the lower forward corner of the gear. Closer optical inspection within the clean area revealed a small (approximate 0.084 Inch wide by 0.040 inch tall) darkly oxidized semi-elliptical region adjacent to the lower gear surface at the forward corner. The oxidized region was then surrounded by a cleaner region measuring about 0.4 inch wide by 0.25 inch high (extent denoted by a red dashed line). One crack arrest band was also apparent in the clean region as indicated by the yellow dashed line. Shear lips (denoted in lower view of figure 1) were evident at the edge of the fracture except adjacent to the oxidized region and at most of the clean area.

Optical examination of the surface of the spring adjacent to the oxidized region revealed chipped yellow paint with a rough and rusted underlying surface as shown in figure 2. Removal of more paint uncovered the eroded and globular surface shown in figure 3. The features of the surface are consistent with localized melting and resolidification indicative of localized electrical arcing. The damage area measured about 0.15 inch wide by 0.6 inch tall, as shown. X-ray energy dispersive spectroscopy (EDS) of the surface revealed only elements consistent with a plain carbon steel.

The piece of landing gear was abrasively cut on a parallel plane below the fracture such that a metallographic sample could be prepared through the globular region at the approximate location of the blue line in the left view of figure 3. Etching with 2% Nital¹ reagent revealed the microstructure shown in figure 4. The etched specimen showed a white (lighter etching) zone adjacent to the lower surface corresponding to the location of the oxidized region on the fracture face. At this location the white zone was about 0.012 inch wide and had a maximum thickness of about 0.008 inch. Microhardness measurements determined that the average white zone hardness was HRC² 61.5. In comparison, the underlying material had an average hardness of HRC 50. The increased hardness and lighter etching characteristics are consistent with a localized rehardened zone.

Closer optical and scanning electron microscope examinations in the dark oxidized area revealed additional details as shown in the two views of figure 5. A thin flat lenticular zone was apparent between the surface of the spring and the oxidized region. Fine fracture traces in the oxidized region indicated initiation at the lenticular zone. The lenticular zone had approximately the same shape and size as the white zone.

Higher magnification SEM examinations found the surface of the lenticular zone to be relatively smooth and heavily oxidized with no recognizable fracture features. The surface of the adjacent oxidized region also showed heavy oxidations but intergranular fracture features were very apparent, as shown in figure 7. The oxidized region was then surrounded by a 0.010 to 0.015 inch wide band of smoother predominately transgranular features (see figure 8). The remainder of the clean fracture region was again intergranular fracture (see figure 9).

In addition to the arc damage adjacent to the fracture initiation on the lower surface of the gear, two small regions of arc damage were found on the upper forward corner of the gear as shown in figure 11. No cracks were visually apparent at these locations. Similar to the lower surface arc damage, corrosion pitting was apparent to the surfaces surrounding the arc damage.

Joe Epperson
Senior Metallurgist

¹ 2% concentrated nitric acid in alcohol.

² Hardness Rockwell C scale converted from Vickers (HV).

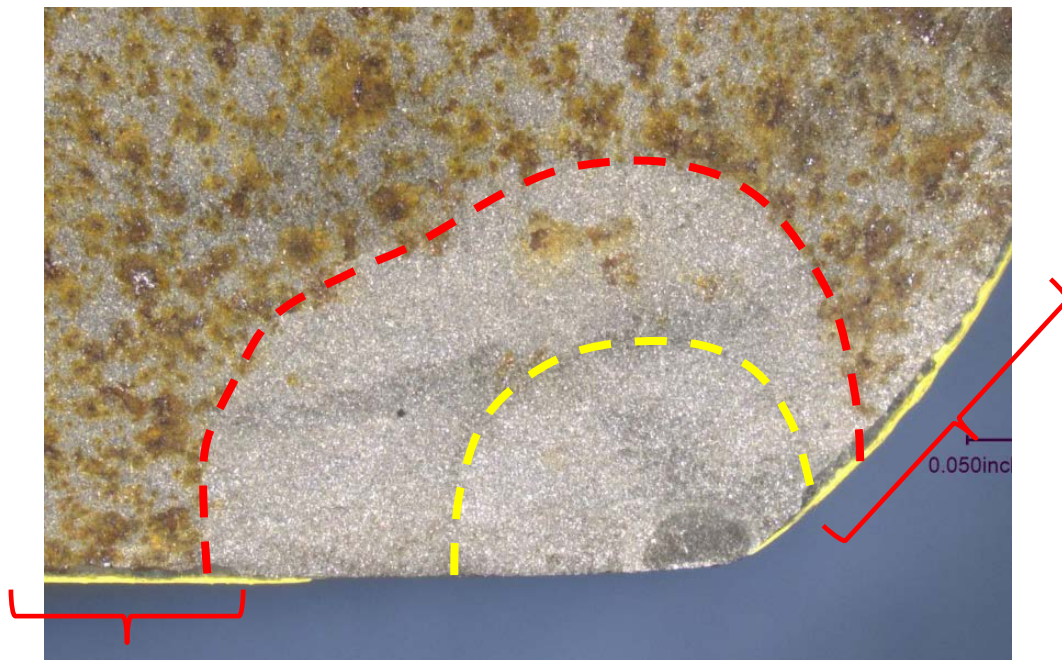
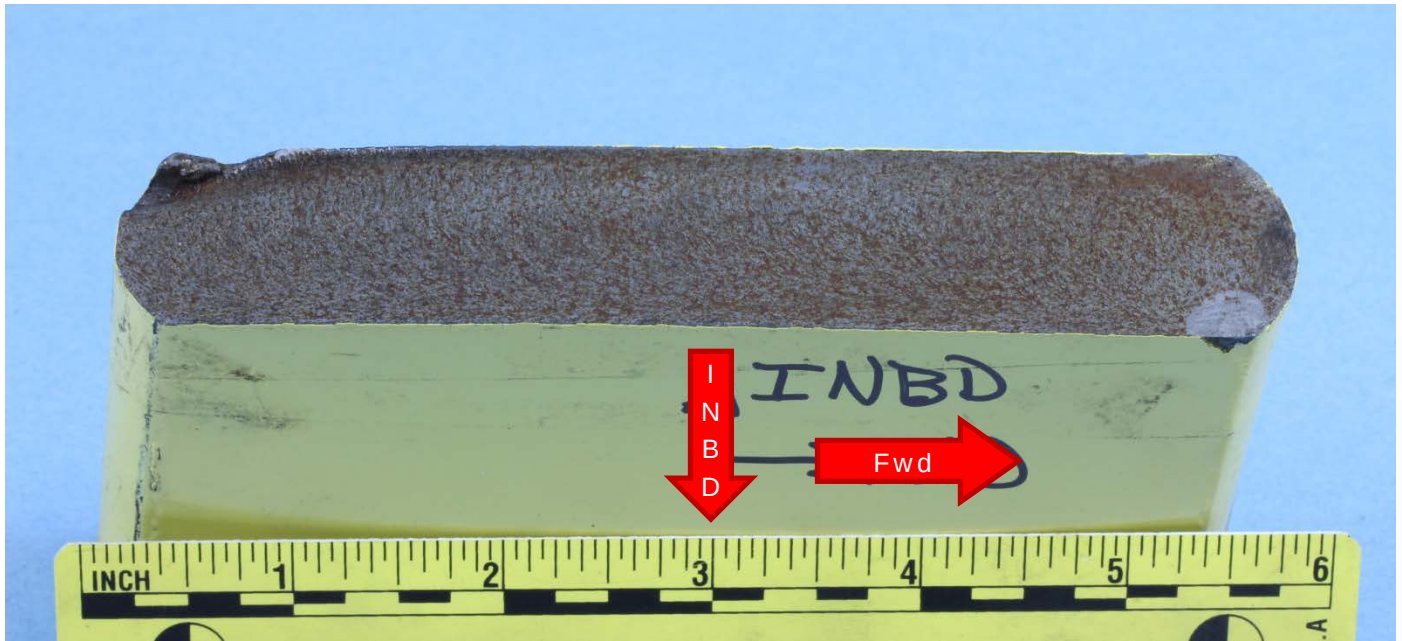


Figure 1. Upper view shows the overall fracture of the landing gear spring looking generally inboard. The lower view shows the clean area (dashed red line) with the darker region at the lower forward corner of the gear. Dashed yellow line denotes an arrest line. Bracket indicate shear lips.

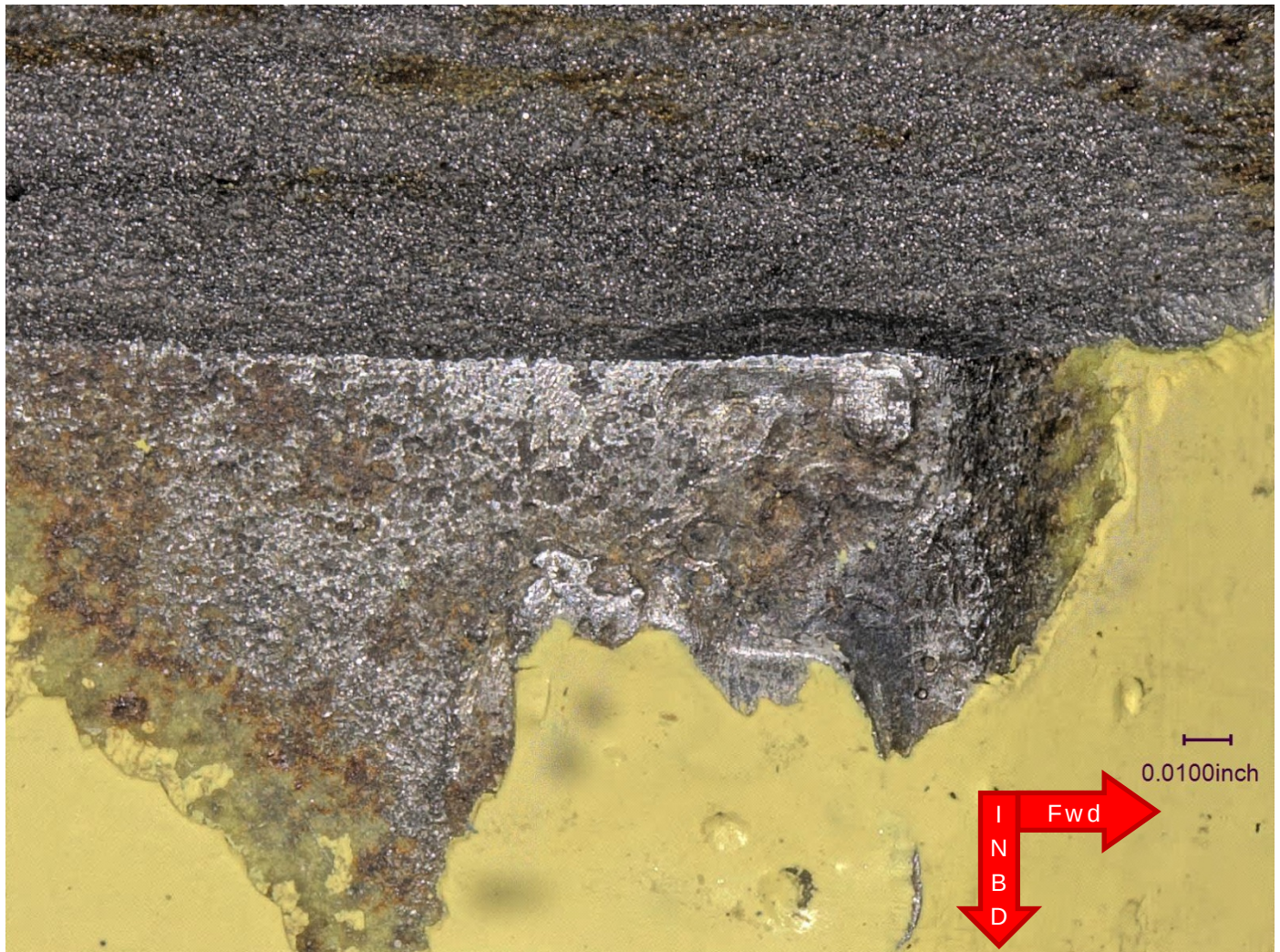


Figure 2. As-received oblique view showing the chipped paint and rough corroded surface at the location of the oxidized region on the fracture face (top).

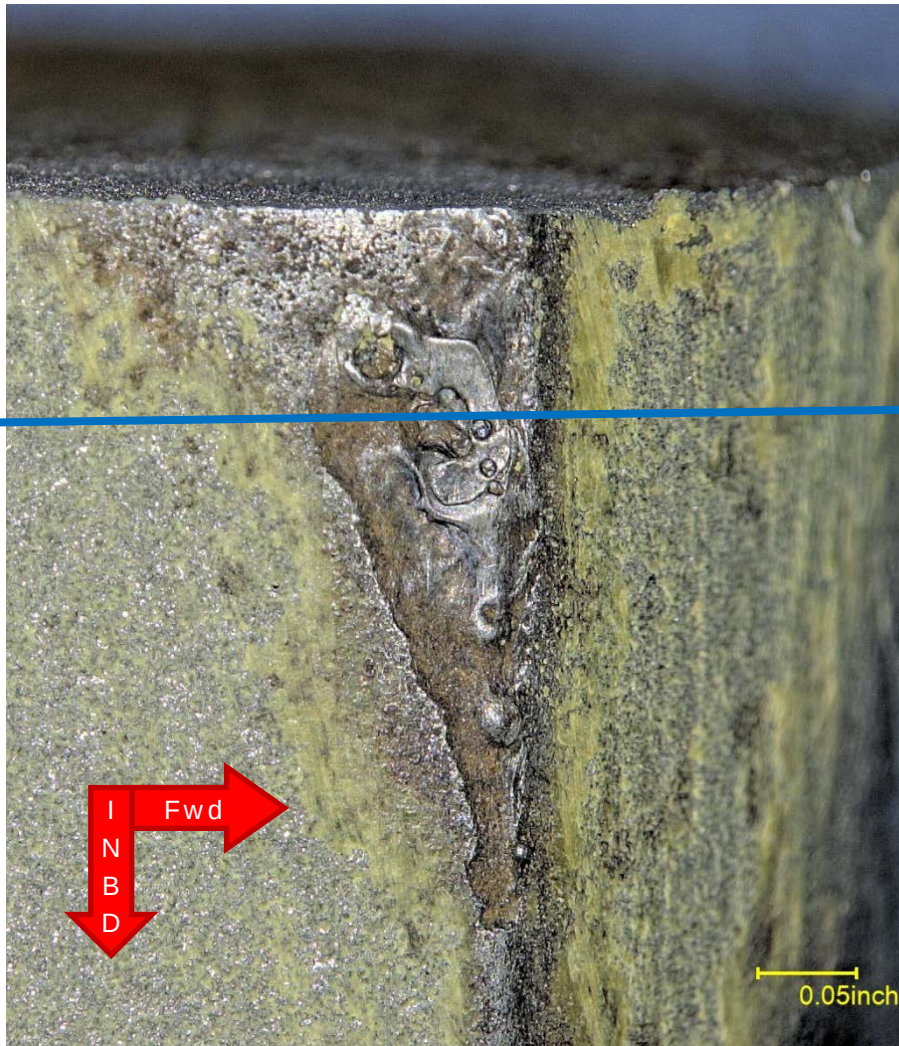


Figure 3. With paint partially removed the resolidified region is apparent in optical (left) and scanning electron (right) images. The blue line indicates the approximate location of the metallographic section.

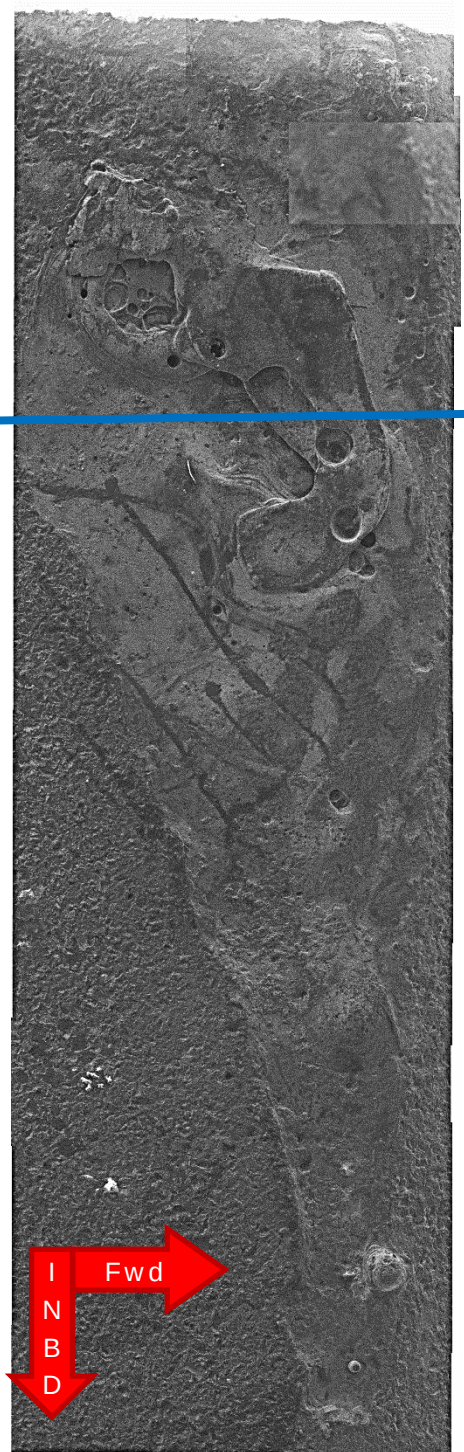




Figure 4. Nital etched metallographic section showing the white zone corresponding to the resolidified region and the fracture initiation area.

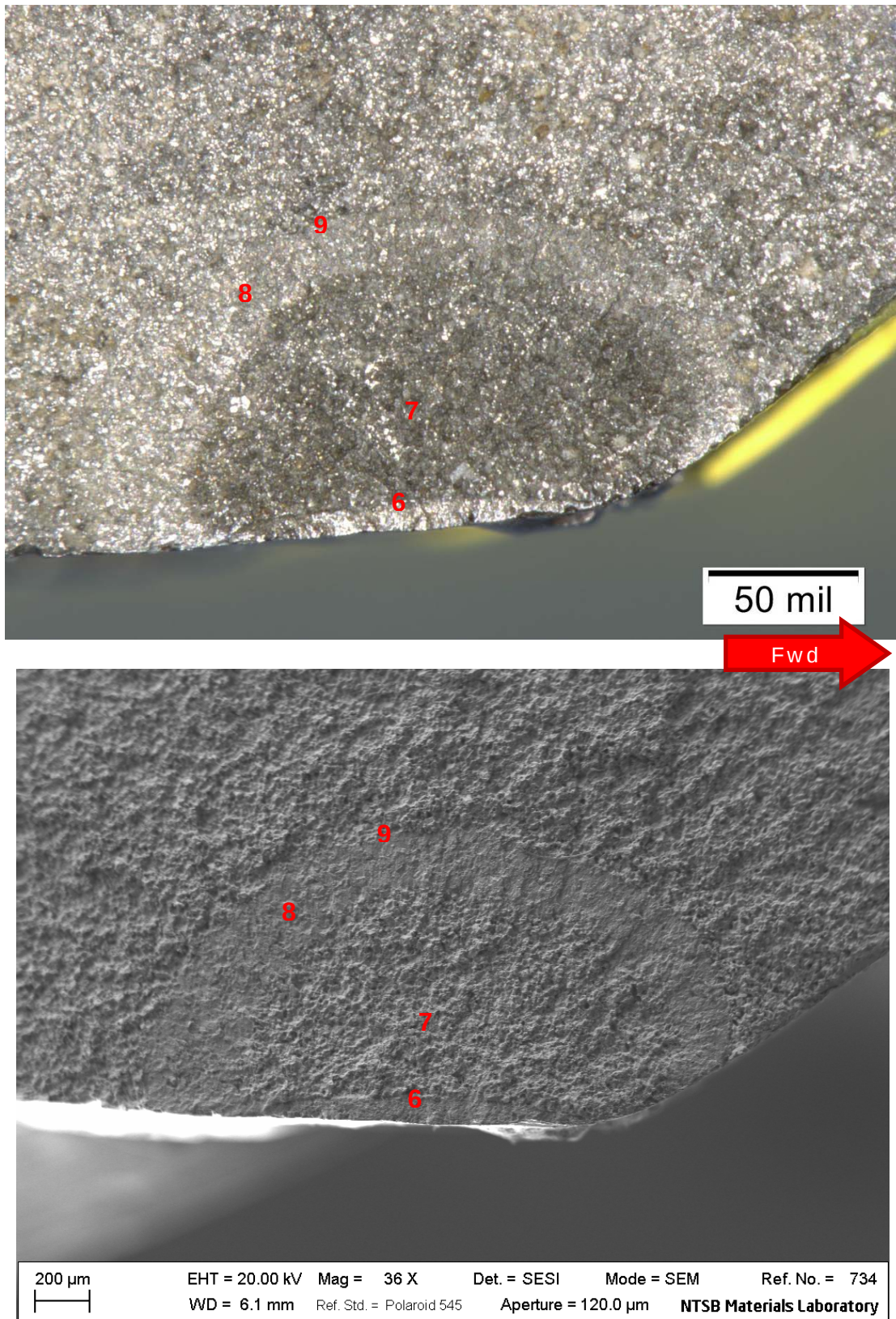


Figure 5. Optical, top, and scanning electron, below, images of the oxidized and surrounding regions of the fracture. Numbers indicate approximate location of following figures.

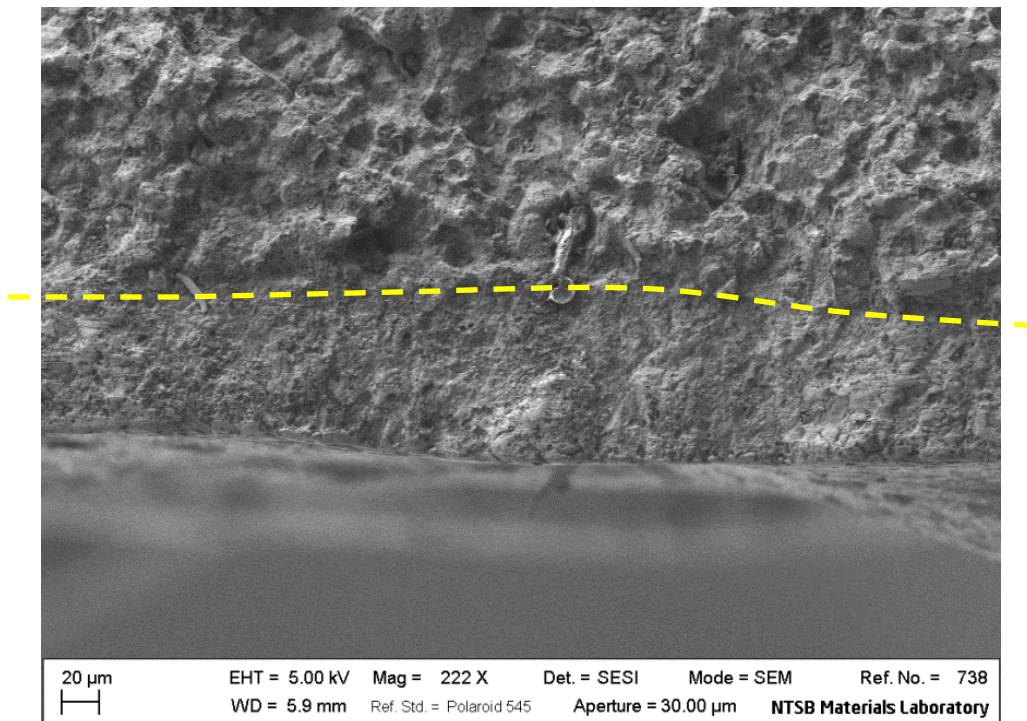


Figure 6. SEM view of the lenticular zone (up to the yellow dashed line) at the initiation of the fracture.

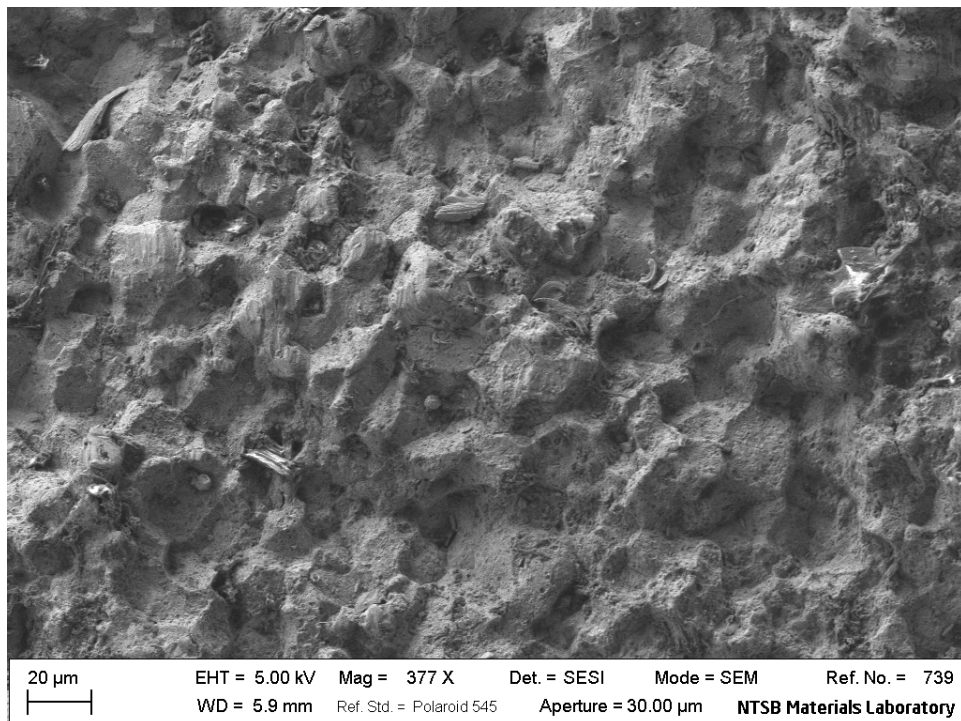


Figure 7. SEM view of the intergranular features in the oxidized region.

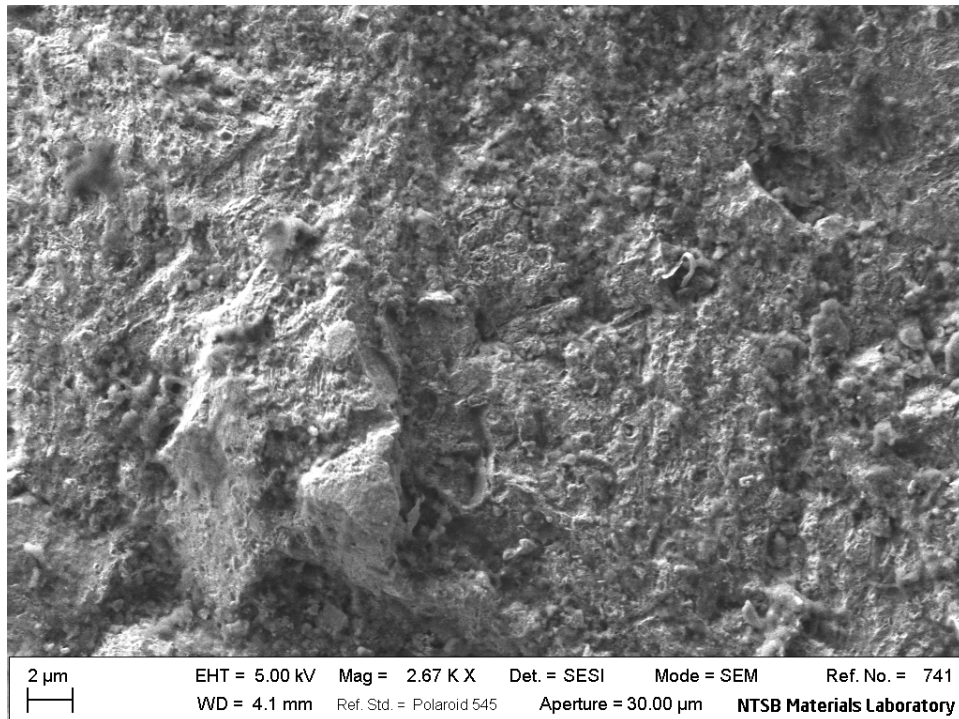


Figure 8. SEM view of the transgranular band between the oxidized region and the clean intergranular region.

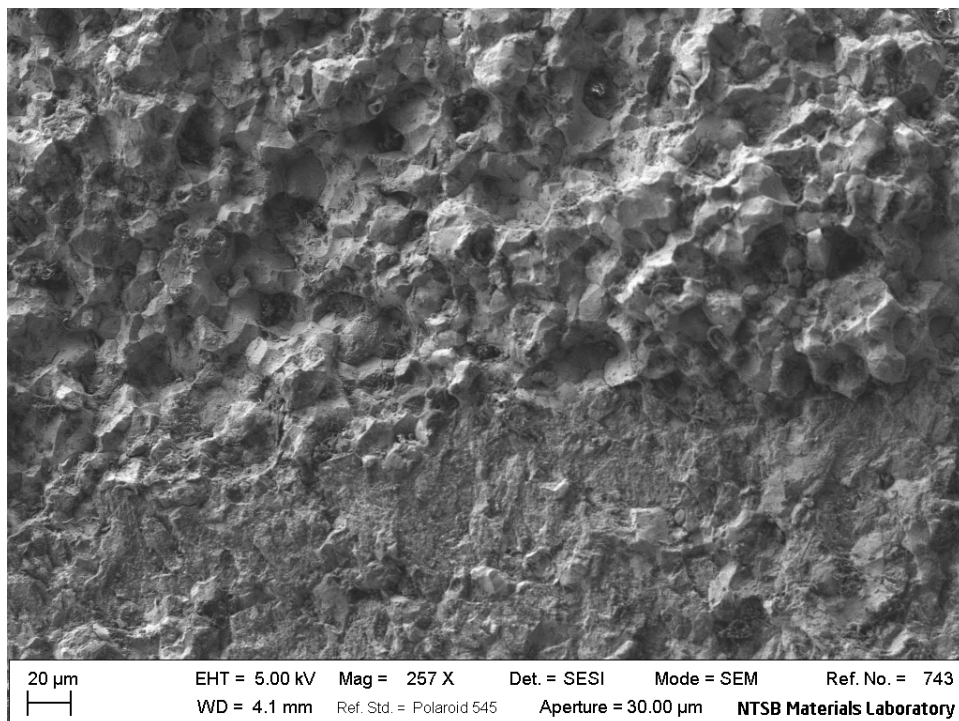


Fig 9

Figure 9. SEM view of the transition from the intergranular band the clean intergranular area.

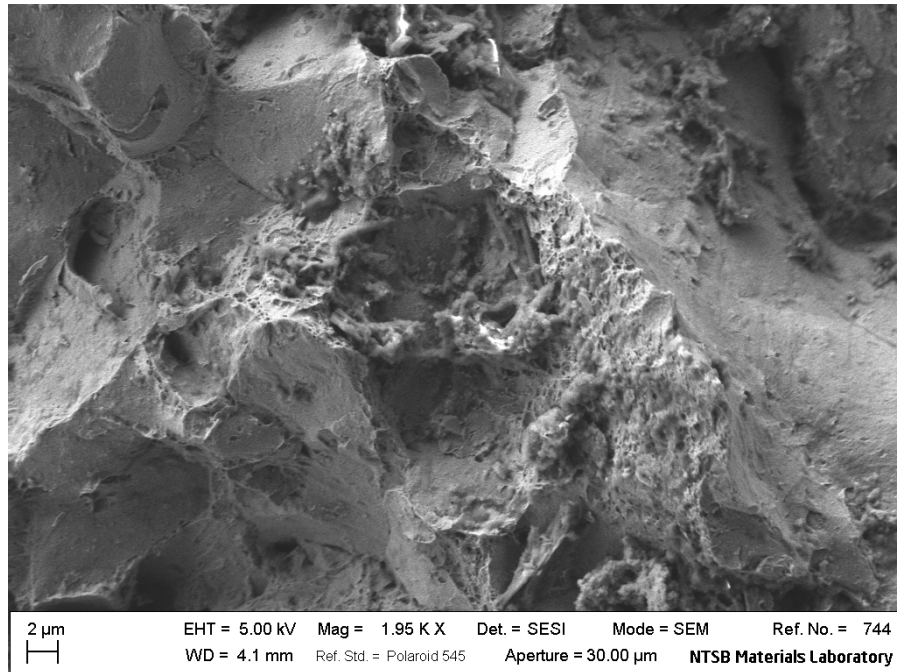


Figure 10. SEM view of the mixed intergranular and ductile dimple features outside of the clean region.

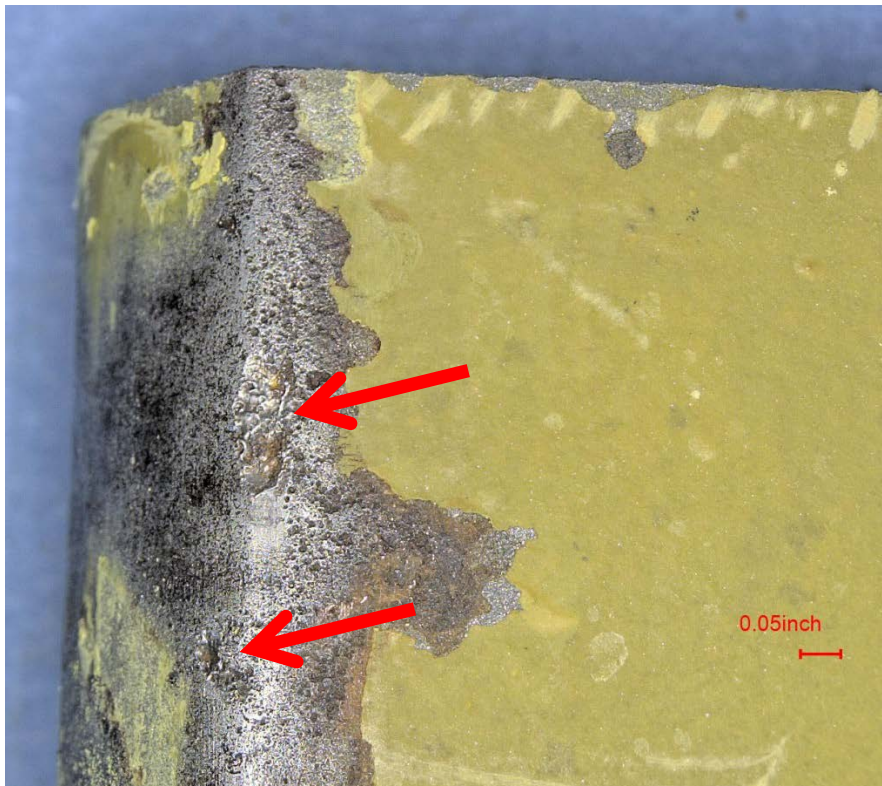


Figure 11. Arc damage (arrows) on the upper forward corner of the gear.