

NATIONAL TRANSPORTATION SAFETY BOARD

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



July 23, 2018

MATERIALS LABORATORY FACTUAL REPORT

Report No. 18-052

1. ACCIDENT INFORMATION

Place : Juneau, Alaska
Date : January 14, 2018
Vehicle : Cessna 210C, N3607Y
NTSB No. : ANC18LA019
Investigator : Noreen Price, AS-ANC

2. COMPONENTS EXAMINED

Right landing gear actuator assembly

3. DETAILS OF THE EXAMINATION

On January 14, 2018 about 1445 Alaska standard time, a retractable landing gear-equipped Cessna 210 sustained substantial damage during a landing at Juneau Airport in Juneau, AK. The pilot and passenger sustained no injuries.

During an interview with the NTSB investigator in charge, the pilot stated that while on approach, the left and right landing gear only partially extended, and the landing gear position light failed to illuminate. He stated that he attempted to manually extend the landing gear with the emergency hand pump, but felt a loss of pressure during this procedure, failing to fully extend the gear. At the end of the landing, both main gear collapsed, causing the right wing tip and horizontal stabilizer to contact the runway. The hydraulic actuator for the landing gear was found cracked and was submitted to the NTSB Materials Laboratory for further examination.

The cracked hydraulic actuator is illustrated in Figure 1, as received. The part was cracked about the barrel section adjacent the endcap with a circumferential and a longitudinal component, as shown in Figure 2 and Figure 3, respectively. The stencil markings on the barrel stated:

*ASSEM 3Q62
CURE 1Q62
J002135*

The metallic placard affixed to the barrel had been partially destroyed. The remnant stated:

EA1614
275

The actuator was partially disassembled, and the endcap and retaining screws were removed. Once the endcap was removed, a crescent fragment of the actuator barrel with the circumferential crack separated from the structure. Figure 5 illustrates the barrel of the actuator and the fragment and retaining ring, after partial disassembly. The fracture surface of the actuator circumferential crack is shown in Figure 6, and the mating fracture surface (from the crescent fragment) is shown in Figure 7.

This fracture surface exhibited one thumbnail-shaped crack. The thumbnail portions of this fracture surface exhibited crack arrest marks, consistent with progressive cracking, later determined to be fatigue. The fatigue cracks originated from the retaining ring groove, progressing through half of the actuator barrel thickness at the largest portion (see Figure 8). The thumbnail crack initiated at a corner in the retainer clip groove. Figure 9 shows the mating fracture surface on the actuator barrel, illustrating the location of the retainer clip groove, and the location of the corners.

The actuator fracture surface was examined using a scanning electron microscope (SEM). Figure 10 shows a typical area of the thumbnail region, displaying striations consistent with fatigue crack propagation. Portions of the fracture surface outside of the fatigue crack revealed dimple rupture, consistent with subsequent overstress fracture (Figure 11).

The thumbnail-shaped fatigue cracks exhibited ratchet marks, consistent with multiple fatigue crack initiation (see Figure 12). Examination of these initiation sites revealed small pit-like features. Examination of the surface of the retaining ring groove revealed multiple corrosion pits, as exemplified in Figure 13.

The actuator barrel was sectioned in order to expose the longitudinal crack. The sectioned housing and mating fracture faces are shown in Figure 14. The longitudinal crack face is illustrated in Figure 15. As revealed from examination of this crack face using a SEM, the fracture features exhibited dimple rupture, consistent with tensile overstress fracture.

A portion of the actuator housing was cross-sectioned through the retaining ring for metallographic examination. Figure 17 shows this cross-section after mounting and polishing. Overall, the microstructure exhibited grain flow consistent with wrought material processing (perpendicular to that shown in Figure 17 and Figure 18). As shown in Figure 17, an additional horizontal crack was present across the groove. Figure 18 shows a closer view of one of these cracks, showing features inconsistent with this section of the crack being at or near its initiation site. Also observed were corrosion pits present along the surface of the retaining ring groove (see Figure 19).

The mounted and polished cross section was examined using energy dispersive x-ray spectroscopy and x-ray fluorescence to verify the chemical composition of the actuator housing. The composition was consistent with AA 7075 aluminum alloy.

The mounted cross section was hardness tested per ASTM E18.¹ The hardness averaged 88 HRBW. The electrical conductivity of a portion of the actuator housing was tested per ASTM E1004 after removal of surface paint and primer.² The conductivity averaged 33.9 %IACS. Per AMS 2658, the conductivity and hardness were consistent with a T6 temper for a 7075 aluminum alloy.³ The prescribed material and temper for the actuator housing was AA 7075-T6 aluminum alloy.

Erik M Mueller
Materials Research Engineer

¹ ASTM E18 – *Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*. ASTM International, West Conshohocken, PA. The Rockwell B (HRBW) scale is an indentation method of determining the hardness of soft metals and uses a 1/16-inch diameter tungsten ball indenter at a load of 100 kilograms.

² ASTM E1004 – *Standard Test Method for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method*. ASTM International, West Conshohocken, PA

³ AMS 2658 – *Hardness and Conductivity Inspection of Wrought Aluminum Alloy Parts*. SAE International, Warrendale, PA.

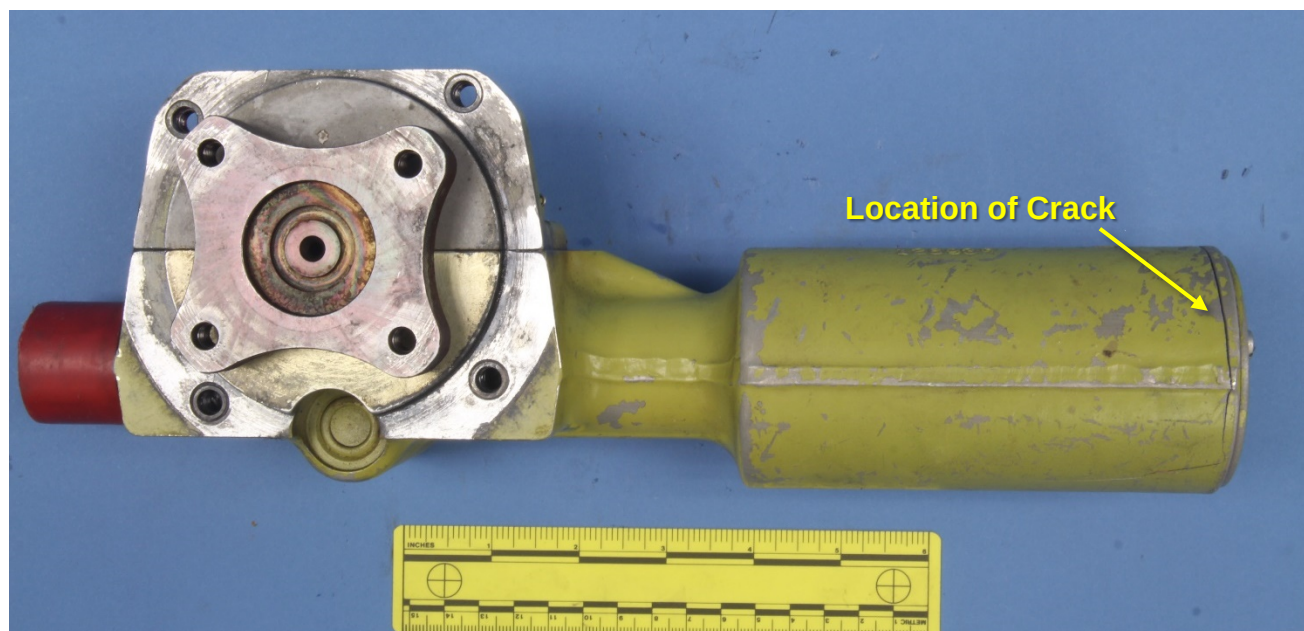


Figure 1 – The cracked hydraulic actuator, as received.

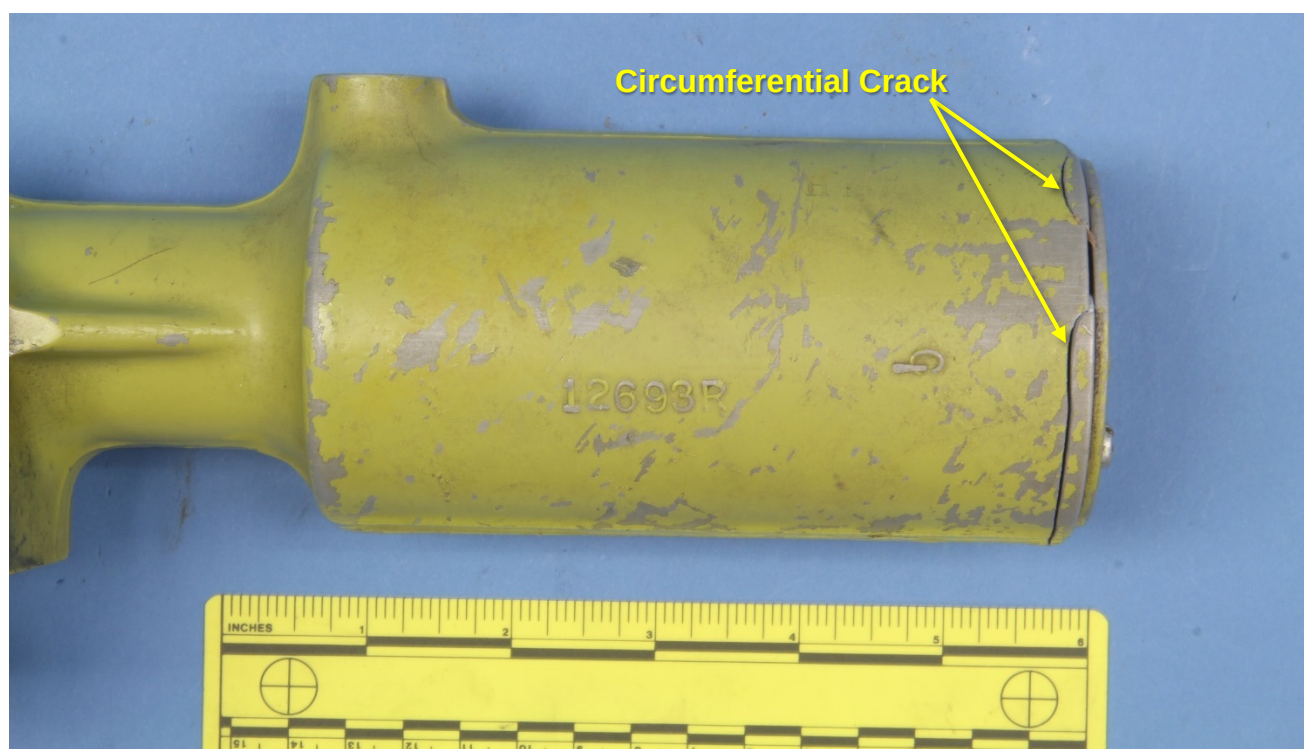


Figure 2 – The cracked portion of the actuator, showing the circumferential and longitudinal cracks.



Figure 3 – The end of the hydraulic actuator, showing the circumferential portion of the crack.

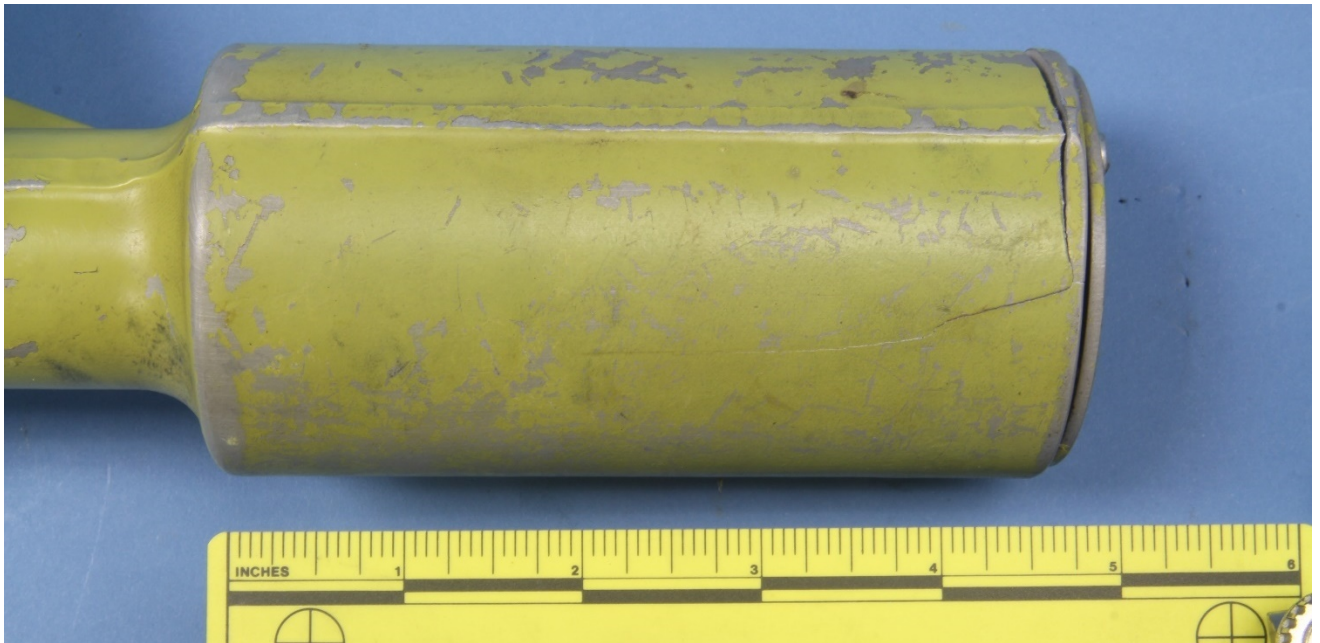


Figure 4 – The longitudinal crack on the actuator housing.



Figure 5 – The cracked end of the actuator pictured in Figure 3, after removal of the screws and the end cap.



Figure 6 – The fractured end of the actuator, after disassembly. The retaining ring was still in place in the groove.



Figure 7 – Montage of magnified images of the crack face of the circumferential crack, showing indications of progressive cracking.

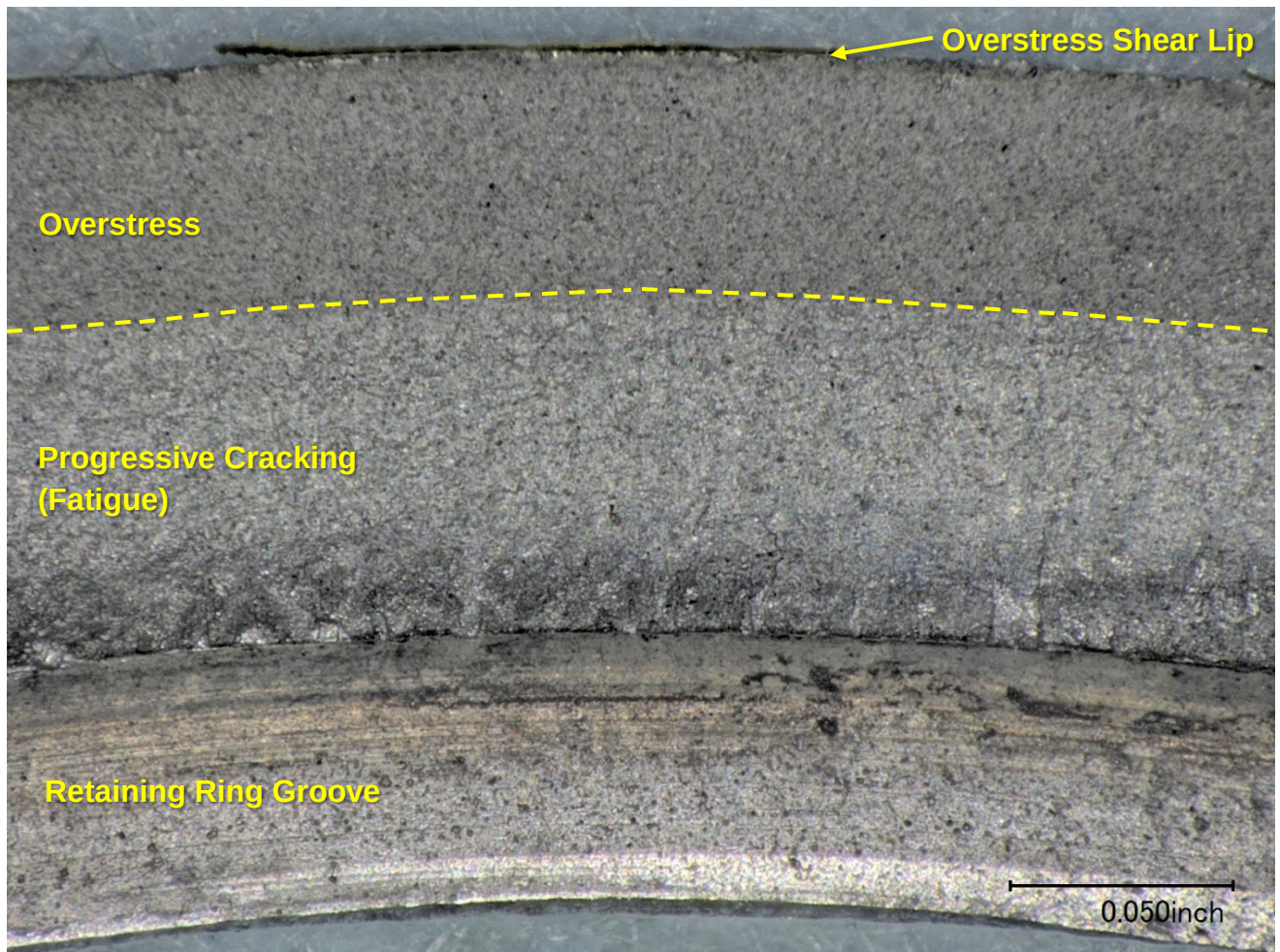


Figure 8 – The progressive crack in Figure 6, tilted to showing the retaining ring groove.

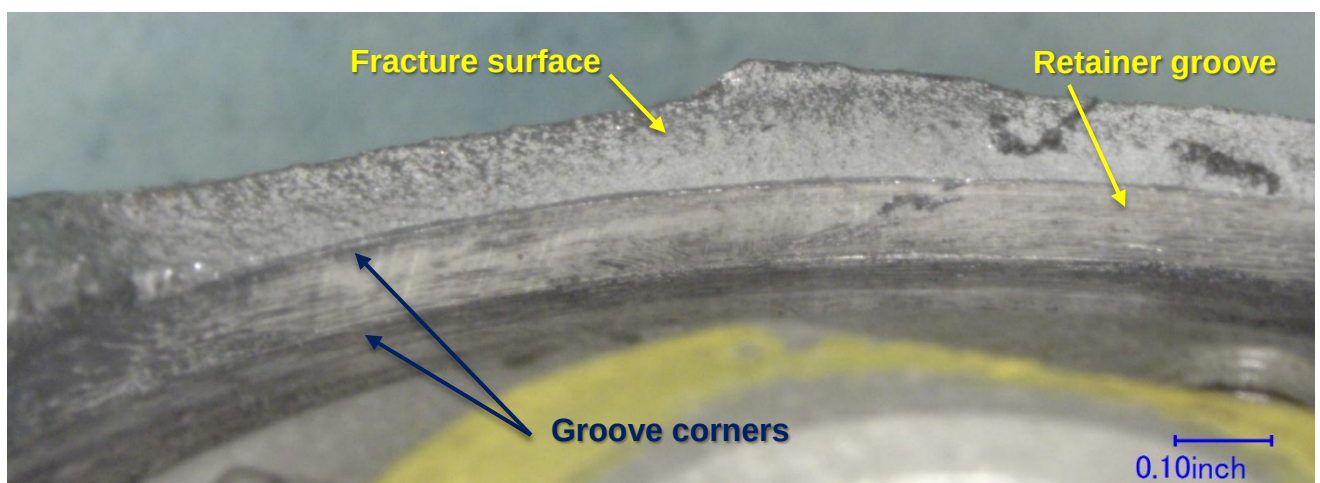


Figure 9 – The mating fracture surface on the actuator barrel, showing the location of the thumbnail crack in relation to the retainer groove (retainer clip removed).

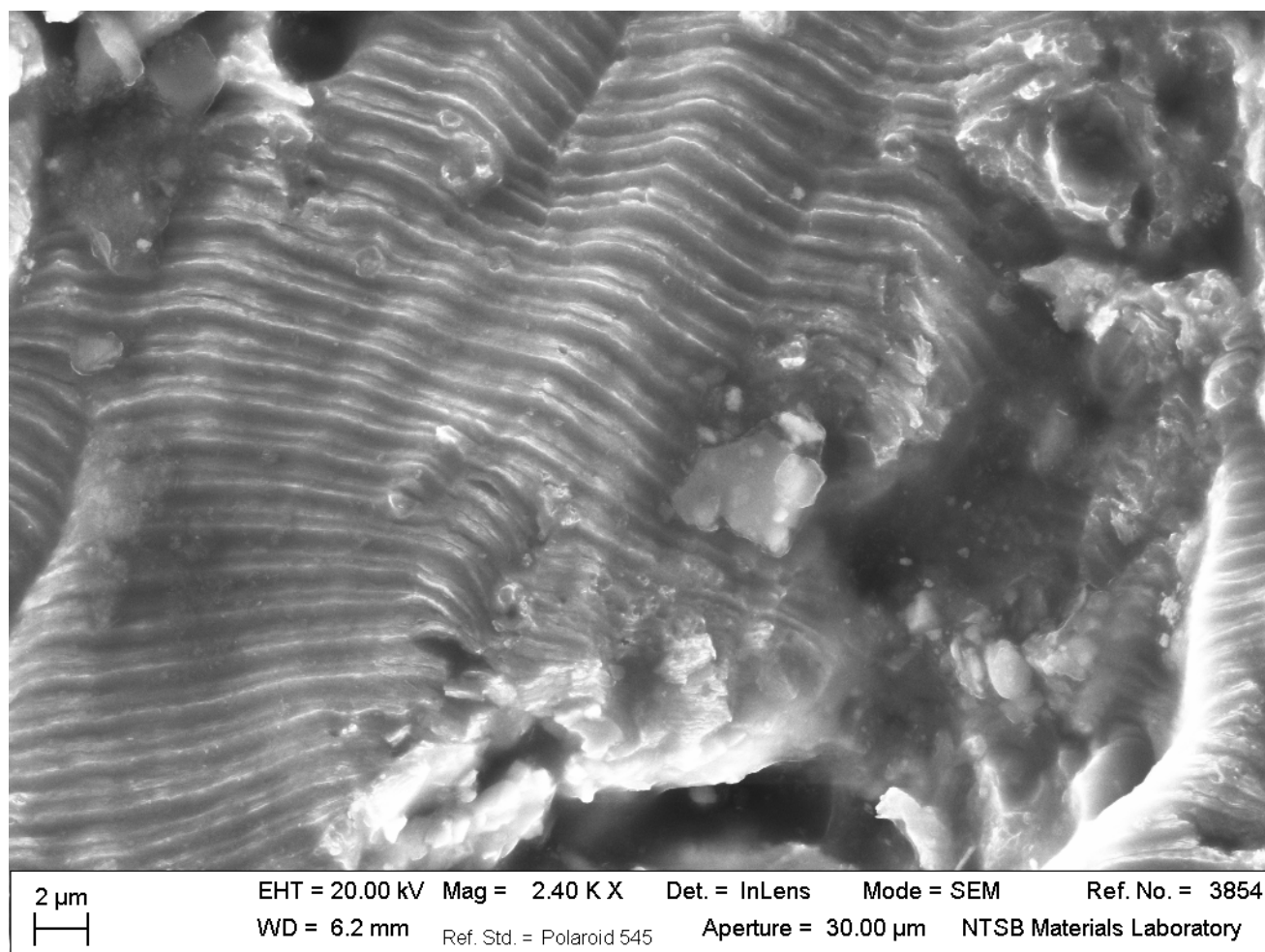


Figure 10 – Secondary electron (SE) micrograph showing fatigue striations in the progressive cracking portion of the fracture surface.

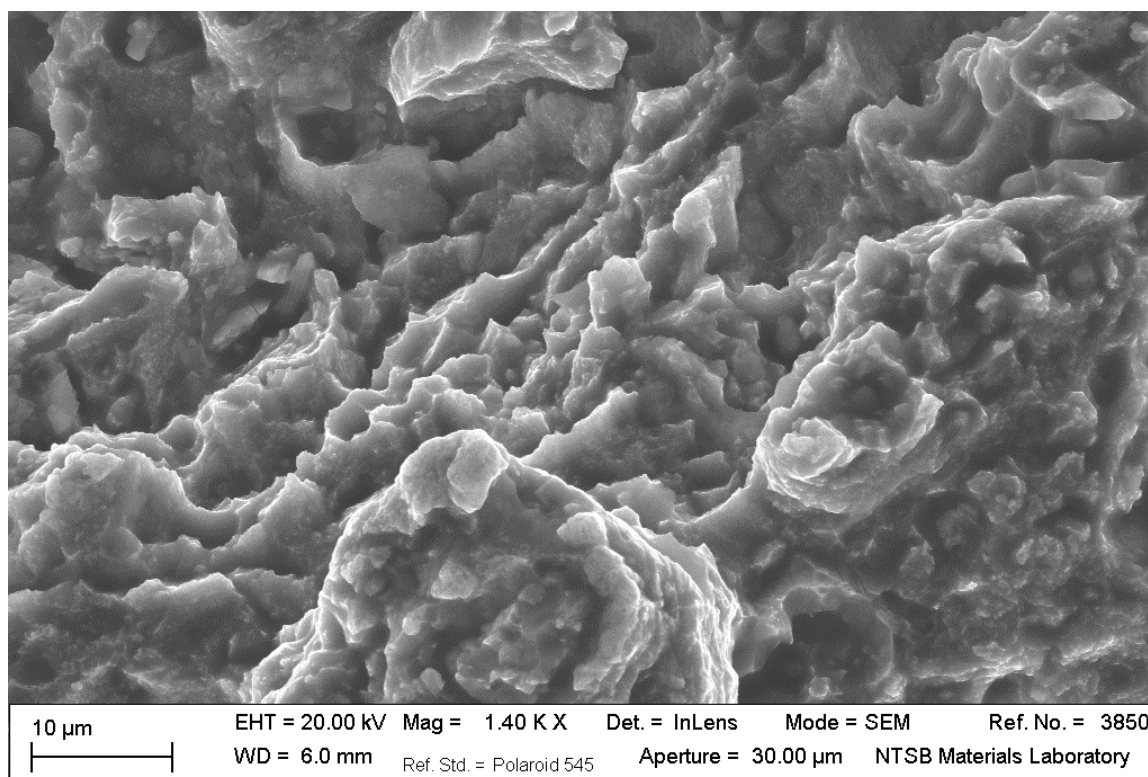


Figure 11 – SE micrograph showing dimple rupture, indicative of overstress, in the fracture surface regions outside the fatigue region.

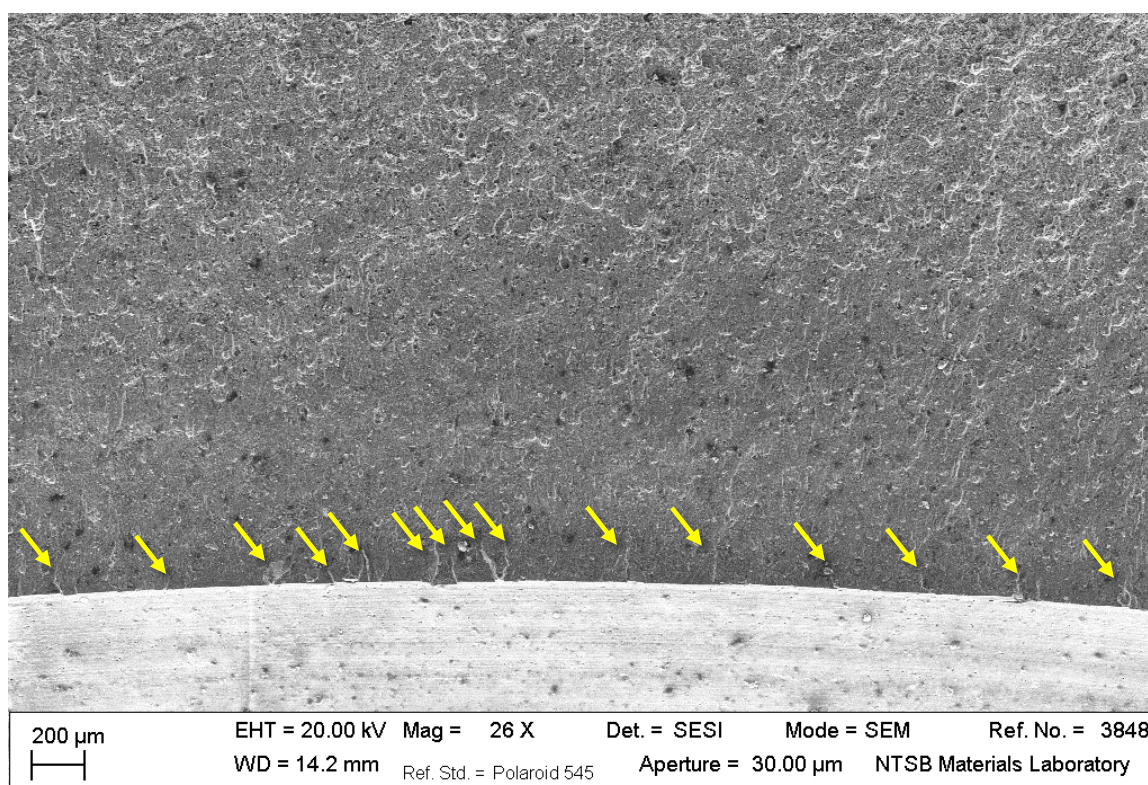


Figure 12 – SE micrograph of the thumbnail crack, showing ratchet marks (arrows).

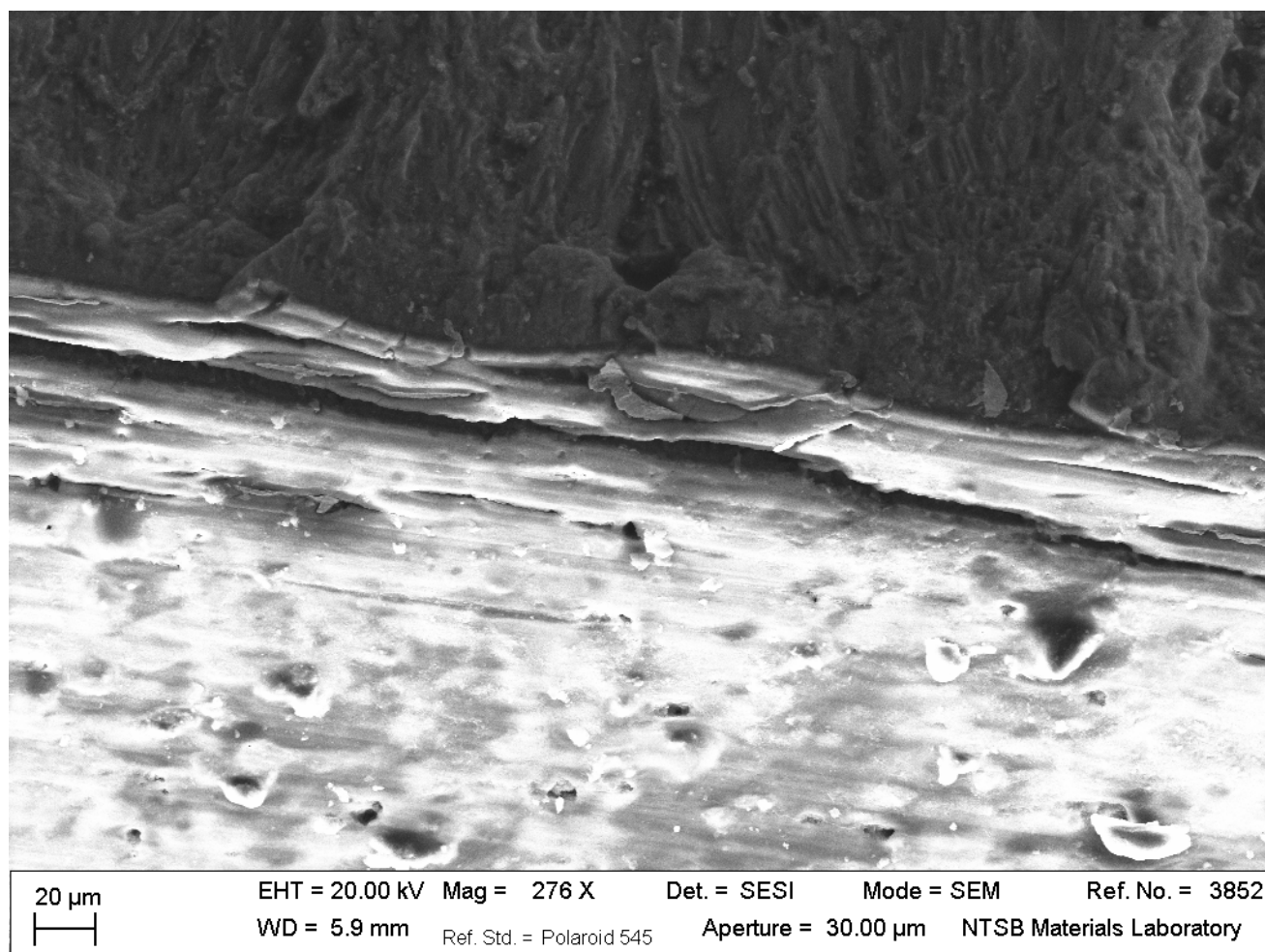


Figure 13 – Backscattered electron (BE) micrograph showing pits on the actuator retaining ring groove.

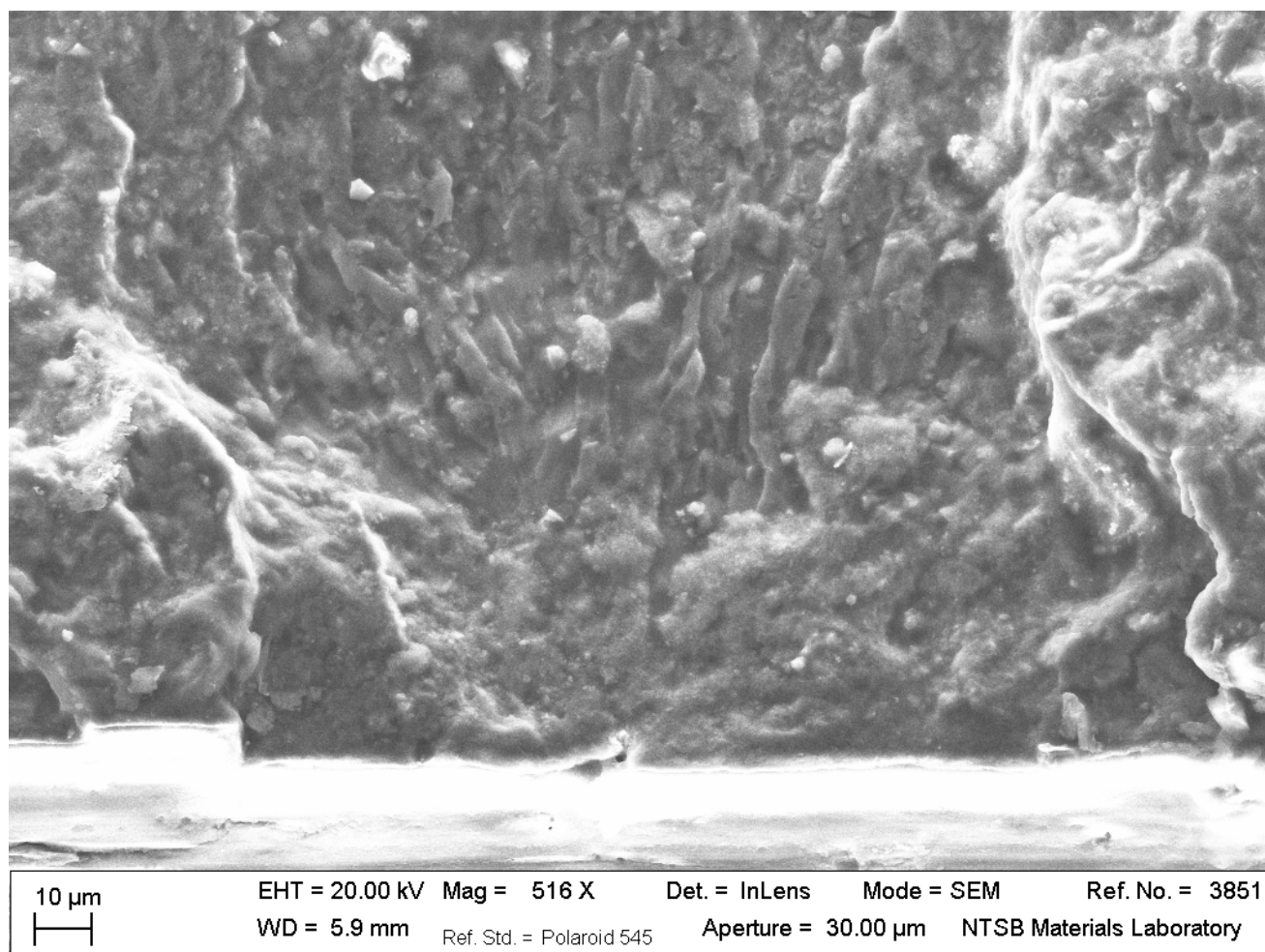


Figure 14 – SE micrograph of one of the fatigue crack initiation sites on the cylinder groove.

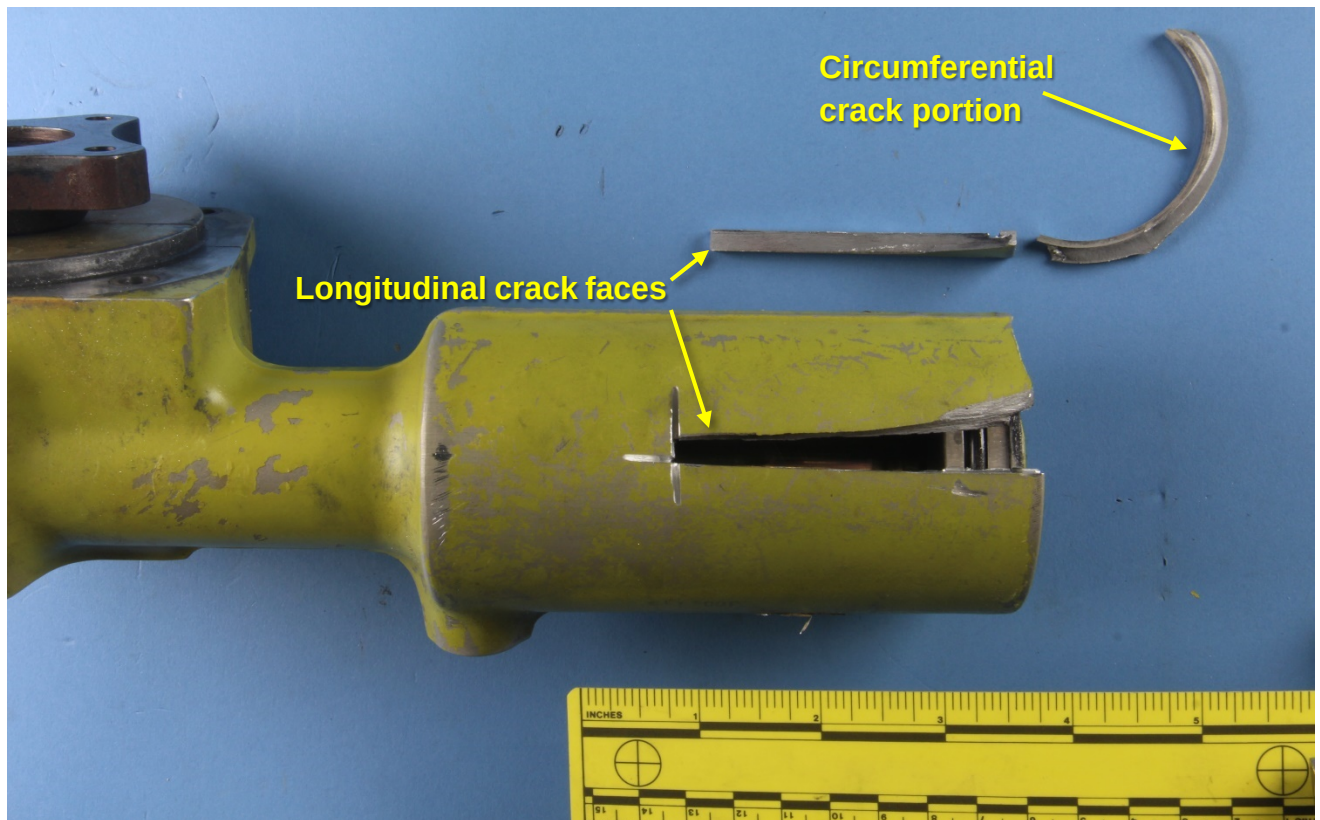


Figure 15 – The cracked portion of the actuator housing, after sectioning to expose the longitudinal portion of the crack.



Figure 16 – The fracture surfaces of the circumferential fatigue and overstress fracture and the longitudinal fracture, after disassembly, sectioning, and cleaning.

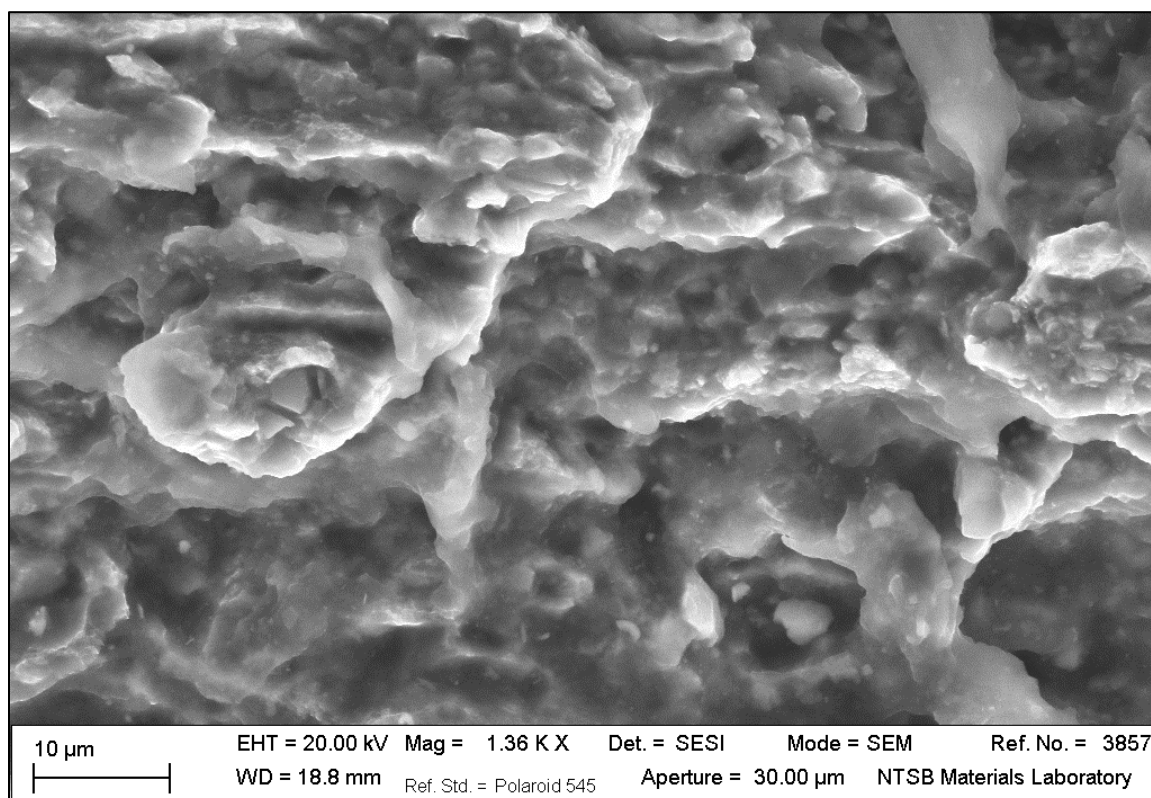


Figure 17 – SE micrograph of the fracture surface of the longitudinal crack, revealing dimple rupture consistent with overstress.



Figure 18 – Bright-field (BF) optical metallograph cross-section of the actuator retaining ring showing a horizontal crack through the groove (~25X, as polished).



Figure 19 – BF optical metallograph showing a closer view of the right crack from Figure 16 (~100X, as polished).

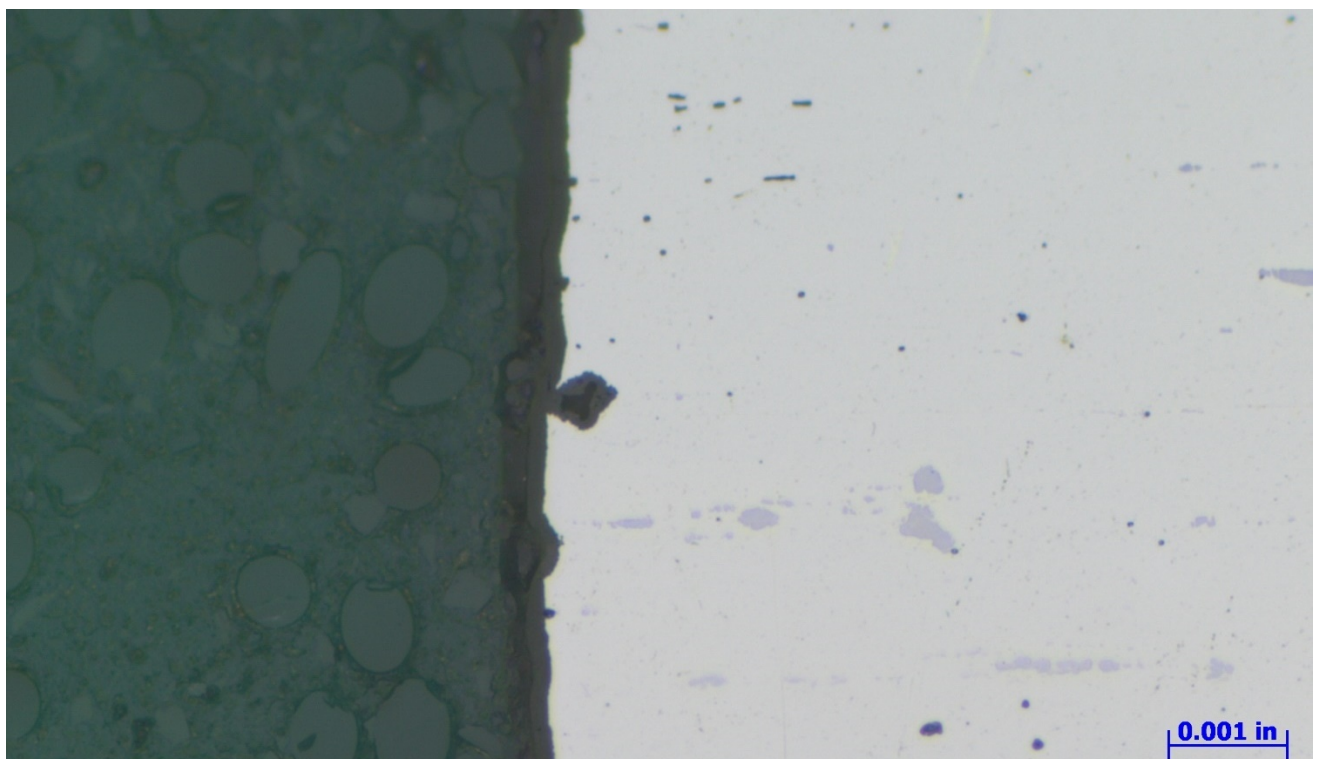


Figure 20 – BF optical metallograph of the actuator retaining ring surface, showing a small surface pit (~500X, as polished).