

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



ERA22LA282

MATERIALS LABORATORY

Factual Report 22-094

December 14, 2022

(This page intentionally left blank)

A. ACCIDENT INFORMATION

Location: Jasper, Georgia
Date: June 18, 2022
Time: 17:30 eastern daylight time
21:30 coordinated universal time
Vehicle: Cessna 414, N414HF
Investigator: Ralph Hicks, AS-ERA

B. COMPONENTS EXAMINED

Remnants of a torque tube assembly

C. EXAMINATION PARTICIPANTS

Specialist Erik Mueller, Ph.D., P.E.
Office of Research and Engineering, NTSB
Washington, DC

D. DETAILS OF THE EXAMINATION

On June 18, 2022, a Cessna 414 was substantially damaged when it was involved in an accident near Jasper, GA. The commercial pilot was not injured. The pilot reported after touchdown that the left main landing gear collapsed. A Federal Aviation Administration (FAA) inspector examined the wreckage and found substantial damage to the lower structure of the left wing—the landing gear had collapsed, and the left main gear torque tube was fractured. The fractured torque tube was forwarded to the NTSB Materials Laboratory for further examination.

Figure 1 and Figure 2 show the torque tube as received. Of note was the crack or fracture along the right one-third of the figure, which exhibited longitudinal, circumferential, and angled alignments. The circumferential area of the crack was located near the flange welded to the tube, illustrated primarily in Figure 1. The circumferential crack portion measured 5.5 inches long. The longitudinal part of the crack was 1.63 inches long, with the angled portion that had advanced to the welded end measuring 2 inches (shown in Figure 2).

Examination of most crack faces (or fracture surfaces) revealed a slanted orientation with a rough fibrous texture and dull luster. These areas often exhibited chevron, or V-shaped, marks. These marks emanated from an area of the crack located in Figure 3. This figure shows a closer view of the longitudinal cracking around the weld with the boss arm. This area was generally flatter than the rest of the crack faces on the torque tube.

The tube was sectioned strategically to open and examine the crack faces. Figure 4 shows one of the sections and its location relative to the flat area of the tube crack. Figure 5 shows these sectioned fragments separated to reveal the interiors of the tube. The area of interest was the flat-oriented but highly tortuous fracture, as annotated in Figure 5 and highlighted in Figure 6. This portion of the fracture surface was located along the circumferential weld between the tube and the boss.

Figure 7 shows a closer view of this area, revealing at least ten thumbnail-shaped cracks along the edge of the crack. The length of the fracture surface with these thumbnail cracks was measured as 0.527 inches long. These cracks exhibited a different maroon color from the remaining metallic fracture surface. The thumbnails also exhibited radiating river patterns with concentric crack arrest marks. The upper thumbnail crack in Figure 8 exhibited vertically-oriented ratchet marks, consistent with smaller cracks having initiated and coalesced during propagation.

This fracture surface area was excised and examined using a field emission scanning electron microscope (SEM). Figure 10 shows the largest thumbnail crack, annotated to show its outline against the fracture edge and the rest of the surface. A closer view of the thumbnail revealed parallel, concentric features, typically underneath an undulating layer of dissimilar surface compounds. These features were consistent with fatigue striations from fatigue crack propagation.

Figure 12 shows more thumbnail-shaped fatigue cracks on the tube fracture surface. These features exhibited a darker contrast in backscattered mode, consistent with more surface oxidation, as illustrated in Figure 11.¹ Examination of the lighter areas of the fracture using energy dispersive x-ray spectroscopy (EDS) found the material to be consistent with alloy steel. The fatigue crack exhibited higher amounts of oxygen, sulfur, and elements typical of salt compounds, consistent with prolonged exposure to the atmosphere during crack propagation. EDS examination of the cracks also detected cadmium, indicating the part had been coated with cadmium.

The fatigue cracks in Figure 12 exhibited striations, as typified in Figure 13. The edges of the fatigue cracks were examined to assess the nature of the initiation sites. Figure 15 shows a typical area of crack initiation site along the fracture edge. The undulations in the surface oxide were consistent with underlying fatigue striations. Though oxidized, the initiation site itself did not exhibit any geometric anomalies such as pits, scratches, or wear marks.

These features were consistent with fatigue cracking of the weld at multiple crack initiation sites. The presence of opposite-facing fatigue cracks having propagated

¹ Backscattered electrons - SEM micrographs produced using backscattered electrons display contrast that is associated with the atomic numbers of the elements in the micrograph. Materials containing elements with higher atomic numbers visually appear lighter relative to other materials containing elements with lower atomic numbers.

inward from the outer and inner surface was consistent with reverse bending at this location.

Submitted by:

Erik M. Mueller
Materials Research Engineer

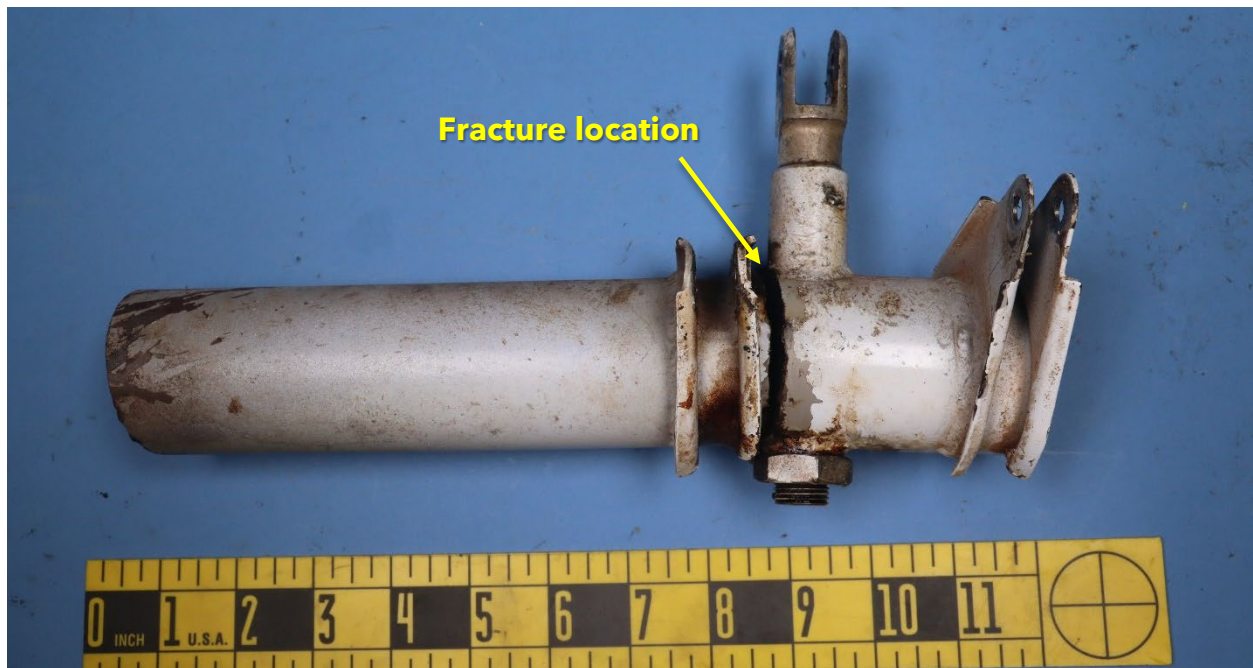


Figure 1. The torque tube, as received. The fracture location on the tube is annotated.



Figure 2. View of the torque tube, rotated 180° from Figure 1.



Figure 3. Closer view of the fracture near the weld along the boss of the torque tube.



Figure 4. View of the torque tube after sectioning to reveal the crack faces. The location of the thumbnail cracks and sections are annotated in the figure.



Figure 5. The sectioned portions of the torque tube, with the different sections separated to expose the tube interior.



Figure 6. Closer view of the circled area in Figure 5, showing small thumbnail cracks.



Figure 7. Closer view of the thumbnail cracks on the torque tube fracture location circled in Figure 6.



Figure 8. Closer view of some of the thumbnail cracks in the middle of the fracture in Figure 7.



Figure 9. View of the largest thumbnail crack from the left side of Figure 7.

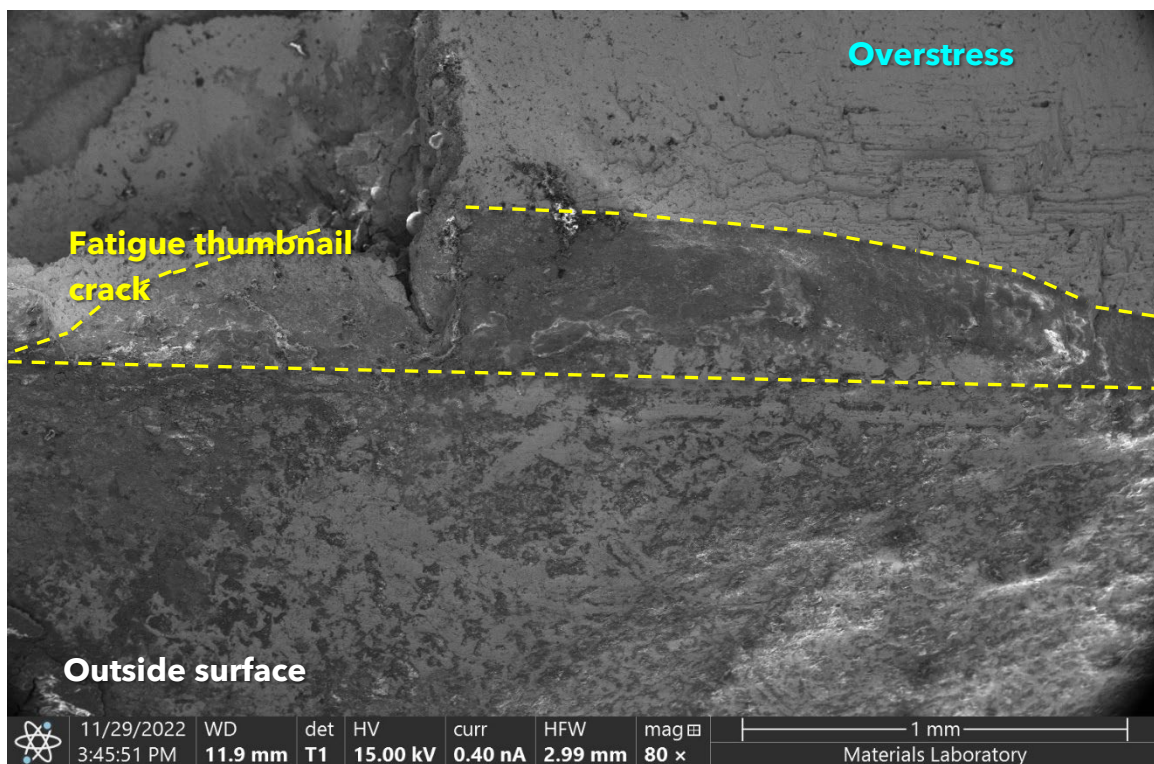


Figure 10. Backscattered electron (BE) micrograph of the crack in Figure 9.

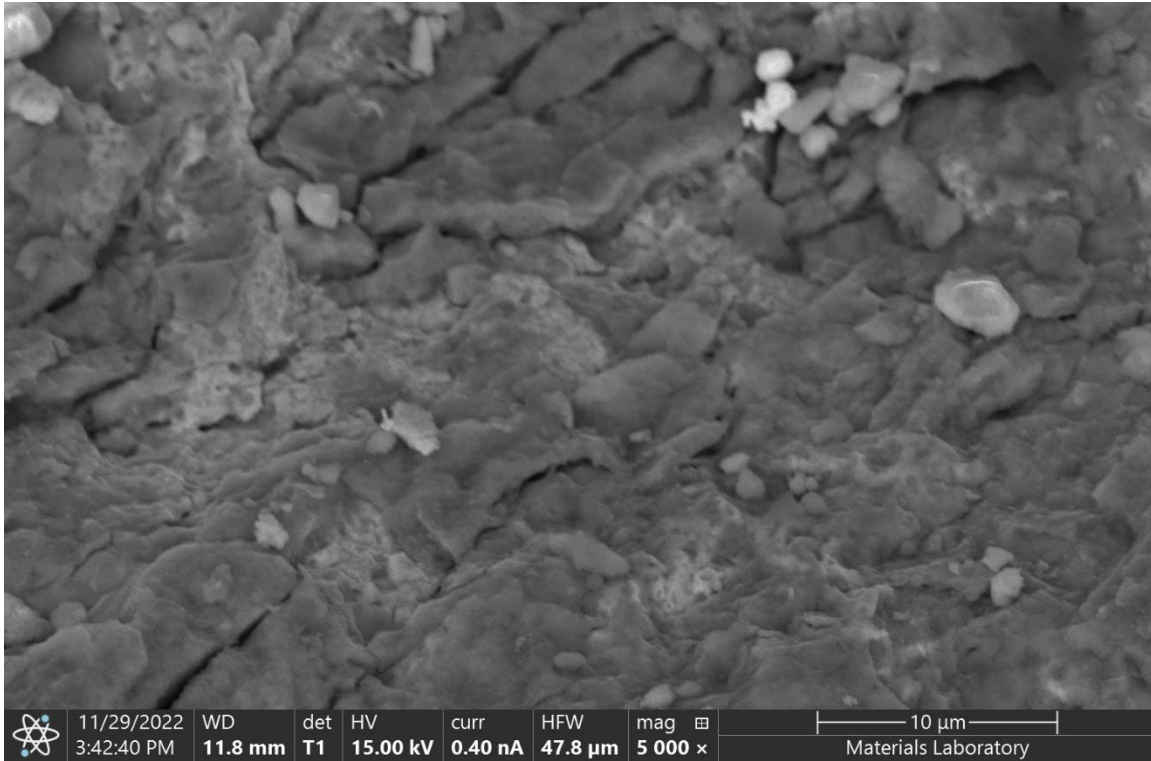


Figure 11. BE micrograph of the end of the fatigue crack in Figure 10.

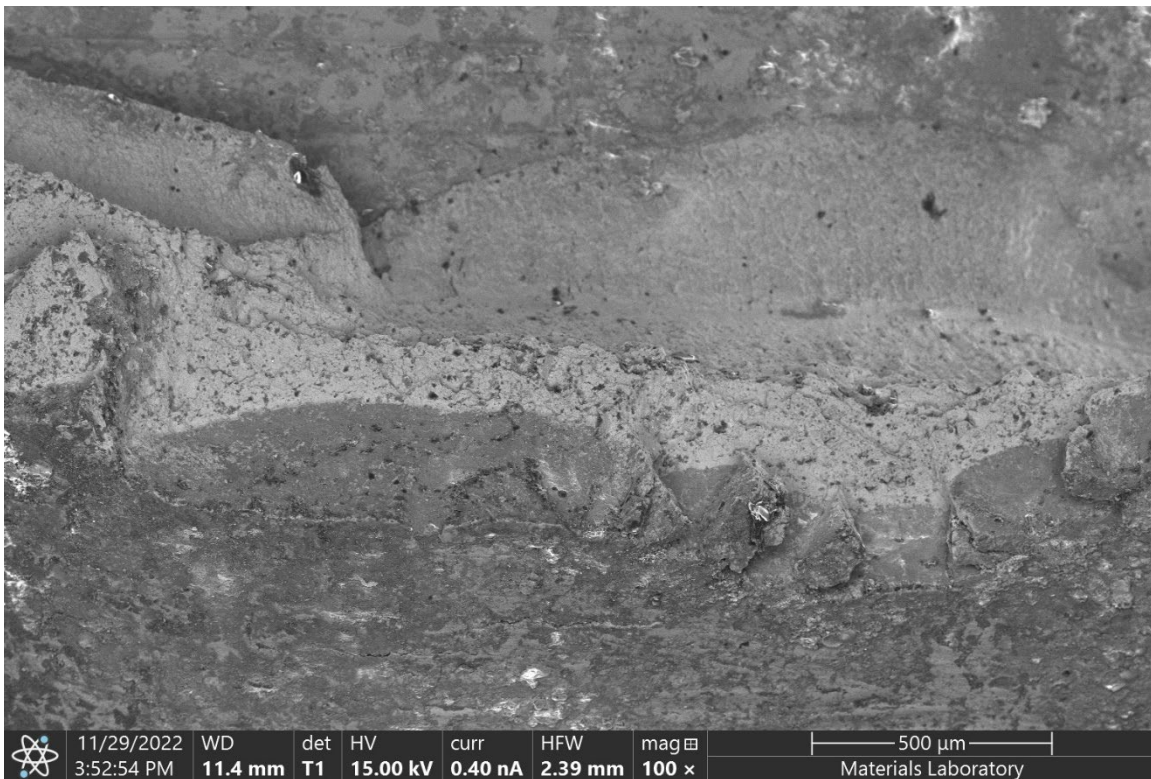


Figure 12. BE micrograph of more thumbnail cracks on the tube.

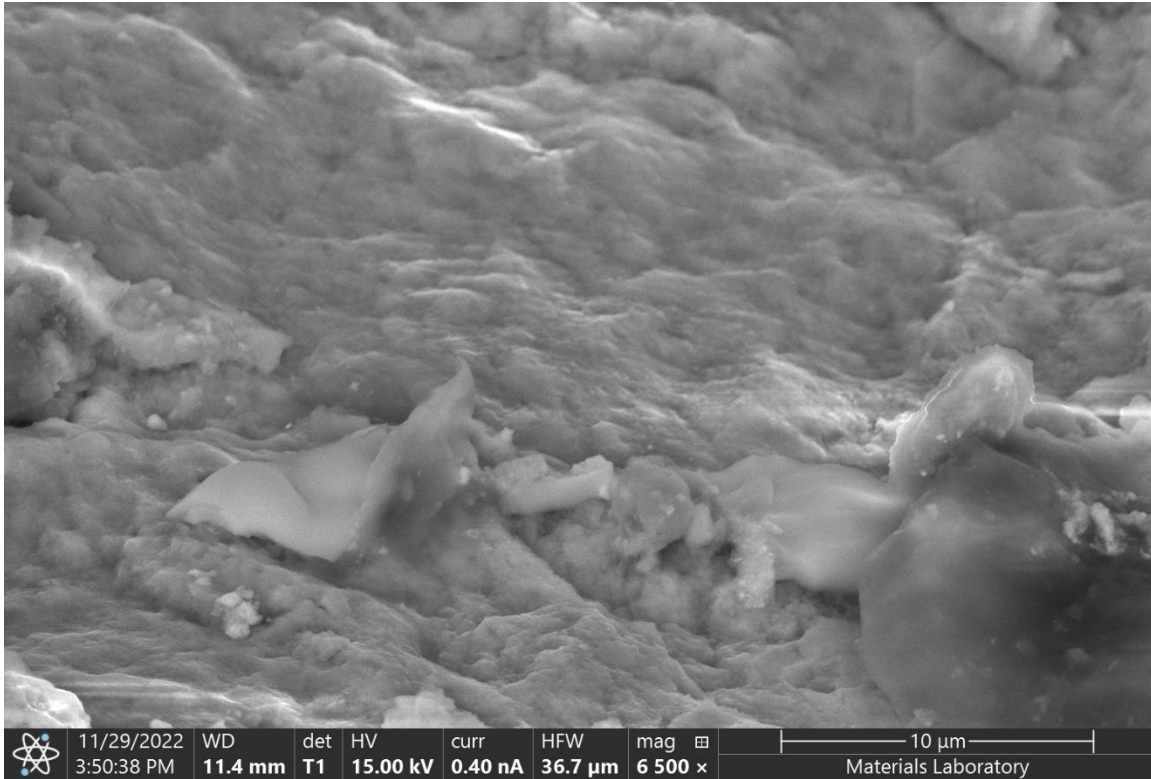


Figure 13. BE micrograph of fatigue striations in the fatigue crack in Figure 12.

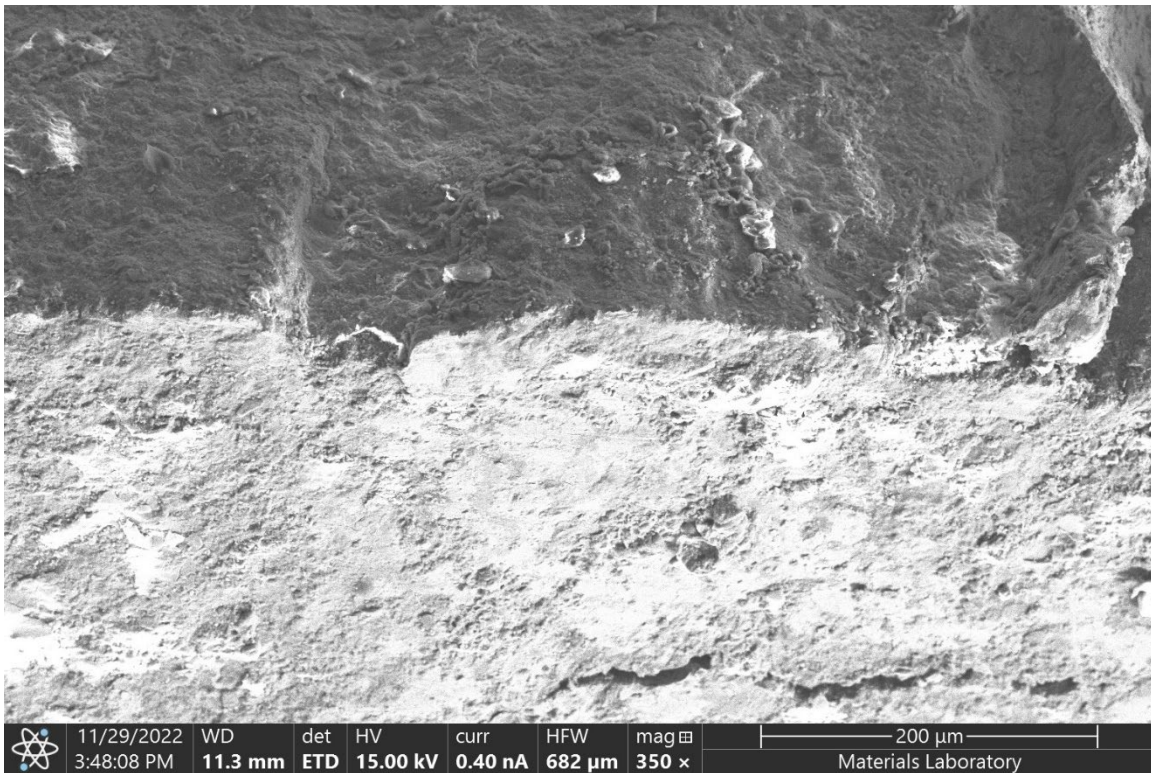


Figure 14. Secondary electron (SE) micrograph of the outer edge of one of the fatigue thumbnail cracks.



Figure 15. BE micrograph of a closer view of the edge of the crack in Figure 4, with the edge annotated and the fatigue crack initiation site labeled.

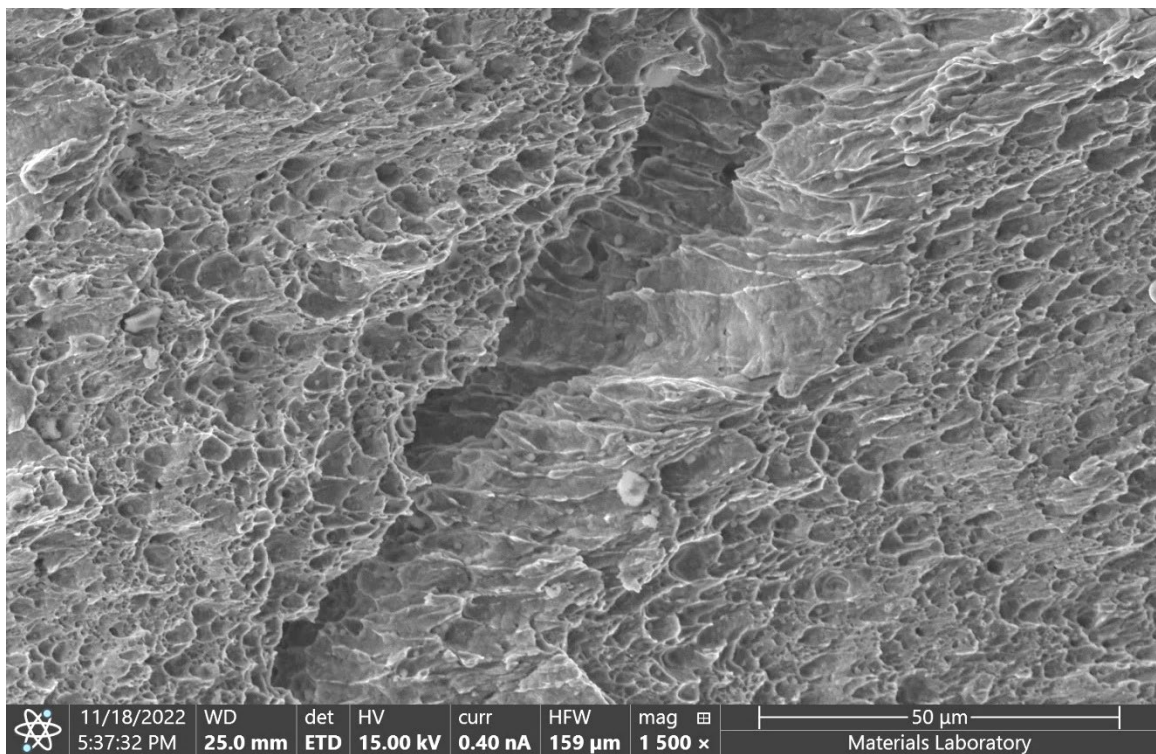


Figure 16. SE micrograph of dimpled rupture and tearing outside the fatigue cracks.