

NATIONAL TRANSPORTATION SAFETY BOARD

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



August 6, 2021

MATERIALS LABORATORY FACTUAL REPORT

Report No. 21-055

1. ACCIDENT INFORMATION

Place : Langley, Washington
Date : November 11, 2020
Vehicle : Cessna 177B, N34633
NTSB No. : WPR21FA145
Investigator : Samantha Link, AS-WPR

2. COMPONENTS EXAMINED

Remnants of a throttle cable

3. DETAILS OF THE EXAMINATION

On November 11, 2020, at 1144 Pacific standard time, a Cessna 177B airplane was substantially damaged when it was involved in an accident near Whidbey Air Park in Langley, Washington. The private pilot and flight instructor were fatally injured. According to radar data, during climb the airplane's ground speed decreased, and the airplane started to descend. The pilot then declared an emergency to air traffic control, later stating they had lost engine power. The airplane impacted the ground nose low amongst trees. The airplane was recovered to a secure location for further examination.

Figure 1 shows the throttle cable remnant submitted to the NTSB Materials Laboratory, as received. The cable consisted of six internal strands wrapped around a seventh internal strand, surrounded by an external thicker coiled wire acting as a sheath. The cable had fractured at one distinct location, illustrated in Figure 2. This was located approximately 7.75 inches from the end of the rubber boot shown in Figure 1.

Figure 3 shows a closer view of the side of the cable near the fracture location. The outer surfaces of the coiled sheath showed flattening of the cylindrical wire, consistent with plastic deformation in a primarily longitudinal direction. The fracture of the outer coil sheath was generally perpendicular to the cable direction, but at an angle to the sheath. The inner strand had fractured at the same location as the outer coil sheath. Figure 4 shows the fracture surface of the strands and outer sheath in a planar view.

The end of the cable was sectioned near the fracture surface, then cleaned in an ultrasonic bath using acetone. The fracture surface was examined using a scanning

electron microscope (SEM). Figure 5 shows the fractured cable strands, which were numbered 1 through 6 for the purposes of this report. The center strand was labeled as 7.

Figure 6 and Figure 7 show the overall fracture surface of Strand 1. The backscattered micrograph in Figure 7 more readily displays the areas of post fracture damage, which appear lighter in contrast.¹ As such, most of this strand fracture surface was relatively undamaged. The overall shape of the strand at the fracture surface was ovoid, as opposed to circular. The lower area of the figures showed the length of the strand surface, with the upper areas absent the strand, consistent with bending deformation, oriented towards the reader in the figures.

Figure 8 shows a closer view of the strand fracture surface, which exhibited a rough, fibrous morphology. A closer view of the fracture surface in Figure 9 revealed dimple rupture, consistent with overstress fracture. No other features indicative of other fracture modes were found on this strand.

Figures 10 and 11 show the fracture surface of Strand 2. This fracture was generally ovoid in shape, with two major steps comprising the fracture. The step closest to the reader had been obliterated by post-fracture damage, consistent with outward smearing (upward in Figure 11). In addition, several outside areas exhibited smeared material towards the fracture surface, consistent with post-fracture smearing damage.

Figure 12 shows a closer view of the strand fracture surface, which exhibited a rough, fibrous morphology, albeit flatter than Strand 1. A closer view of the fracture surface in Figure 13 revealed dimple rupture, consistent with overstress fracture. No other features indicative of other fracture modes were found on this strand.

Figure 14 and Figure 15 shows the fracture surface of Strand 3. This fracture surface exhibited a slanted or angled orientation, with a small protrusion that had folded over itself (upper part of the figures). These streaks and the deformation were consistent with post-fracture damage. As such, no discernible fracture features were present on this strand's surface.

In contrast, the fracture surface of Strand 4, pictured in Figures 16 and 17, exhibited a rough, fibrous surface morphology. In addition, the ovoid-shaped fracture surface was smaller than the cross section of the wire strand. This was consistent with localized plastic deformation, or necking, adjacent to the fracture surface. A closer view of a typical area of the fracture surface is shown in Figure 18. The surface exhibited dimpled rupture, consistent with fracture in tensile overstress. No other features consistent with other fracture modes were observed on Strand 4.

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.

The fracture surface of Strand 5 is illustrated in Figures 19 and 20. Like Strand 3, this fracture surface was slanted in orientation, with unidirectional parallel streaks. These features were consistent with extensive post-fracture damage to the fracture features, which had been obliterated. No features consistent with a known fracture mode were present on the Strand 5 fracture surface.

Likewise, the Strand 6 fracture surface also exhibited a slanted orientation (Figure 21 and 22). While most of the surface had been obliterated from smearing, a small area was found undamaged, and is highlighted in Figure 23. As shown in Figure 24, these features were found to be dimpled rupture, consistent with overstress fracture.

The central Strand 7 fracture surface was also found to have large streaks consistent with post-fracture smearing damage. No discernible fracture features were found on this fracture.

Figure 25 shows an angled view of the outer sheath coil, showing parallel areas of wear or rubbing damage on the outer surface parallel to the fracture surface. The fracture surface exhibited a slanted area toward the fractured internal strands, and an outer facing flatter area, shown facing the reader in Figure 25. The slanted area was primarily consistent with post-fracture damage—no discernible fracture features were observed in this area. The flatter area did exhibit fracture features, as typified in Figure 26. These features were consistent with dimpled rupture, consistent with overstress fracture.

One area near the tip of the sheath fracture surface exhibited a feature near the interior edge, which contain radiating marks appearing to emanate from the surface (shown in Figures 28 and 29). These features were found protruding out of a quasi-linear impression near the inner edge, as shown in Figure 29. A closer view of these radiating streaks found them to be mostly featureless. However, some areas between the streaks exhibited dimpled rupture, as illustrated in Figure 30. These features were consistent with an overstress fracture that had been damaged after the fracture sequence began.

Figure 31 shows an edge area below that seen in Figures 28 and 29. This area exhibited a series of parallel lines. The features of these lines continued along other separated areas of the fracture surface (on the left of Figure 31, opposite the vertical gap). Figure 32 shows a closer view of this area, highlighting some of the parallel streaks. These streaks exhibited similar characteristics as those features often observed in fractures with propagating cracks. However, a closer view of the areas on the streaks found dimpled rupture, as typified in Figure 33. These features were consistent with post-fracture smearing following overstress fracture.

Figure 34 shows the wear and impact damage on a sheath coil below the fractured sheath coil (shown in the upper area of Figure 25). Figure 34 shows erratically oriented streaks on the sheath surface, and a lower area of material deformed outward, manifest as a ridge. A closer view of this region is shown in Figures 35 and 36. These regions exhibited intersecting or crossing streaks, oriented in random directions. These features

were consistent with an impact with an adjacent component, as well as rubbing against another component.

Overall, the fracture features of the sheath and strands of the throttle cable were consistent with overstress fracture. No other features consistent with other fracture modes were observed. All the other features detailed were consistent with post-fracture damage.

The chemical compositions of the outer sheath and the internal wire strands were examined using energy dispersive x-ray spectroscopy (EDS). Both subcomponents exhibited mostly iron, with major indications of zinc. These data were consistent with a galvanized carbon steel for both components.

Erik M Mueller
Materials Research Engineer

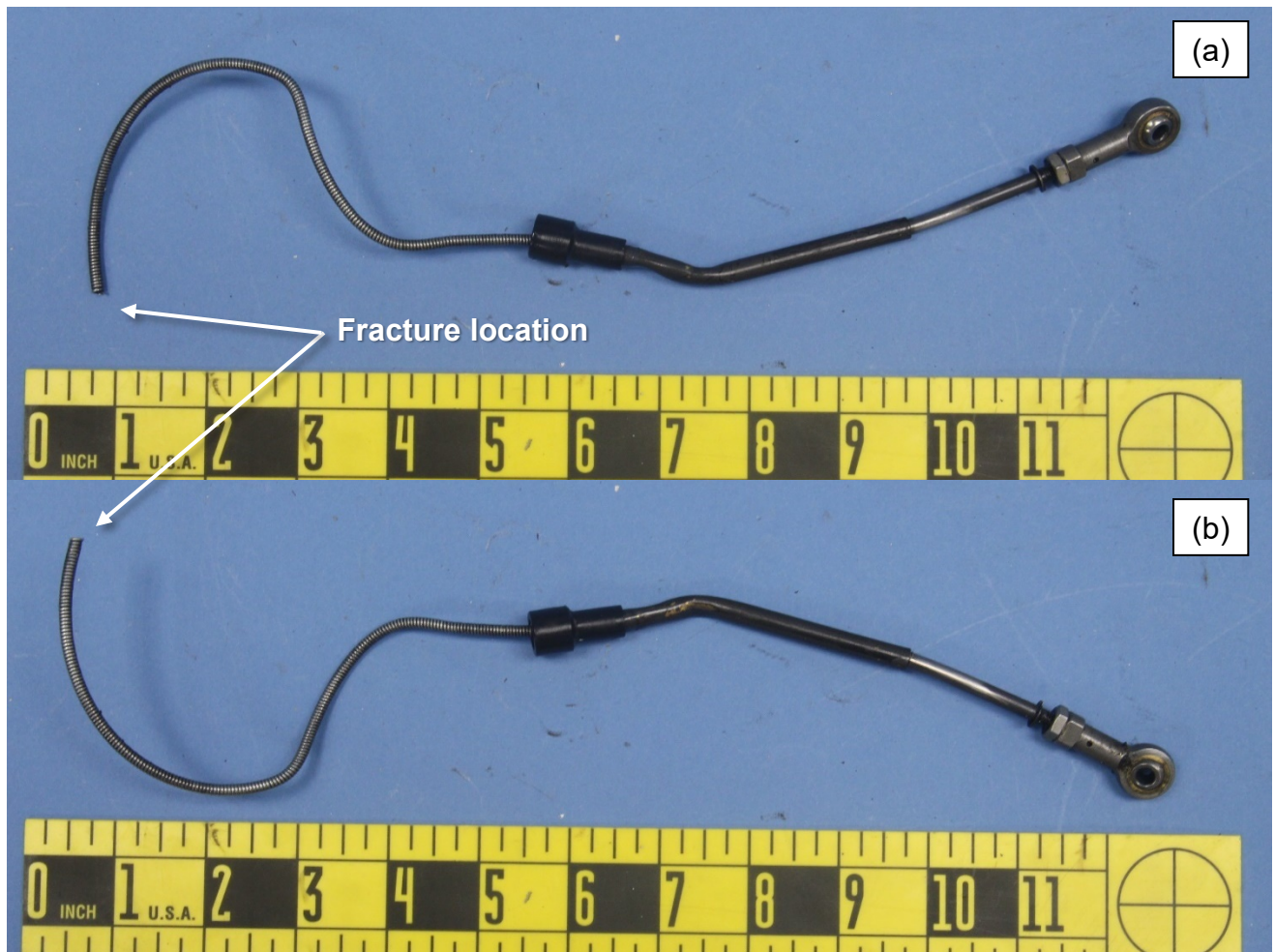


Figure 1 – The throttle cable remnant, as received, viewed from opposite 180° sides (a), (b).

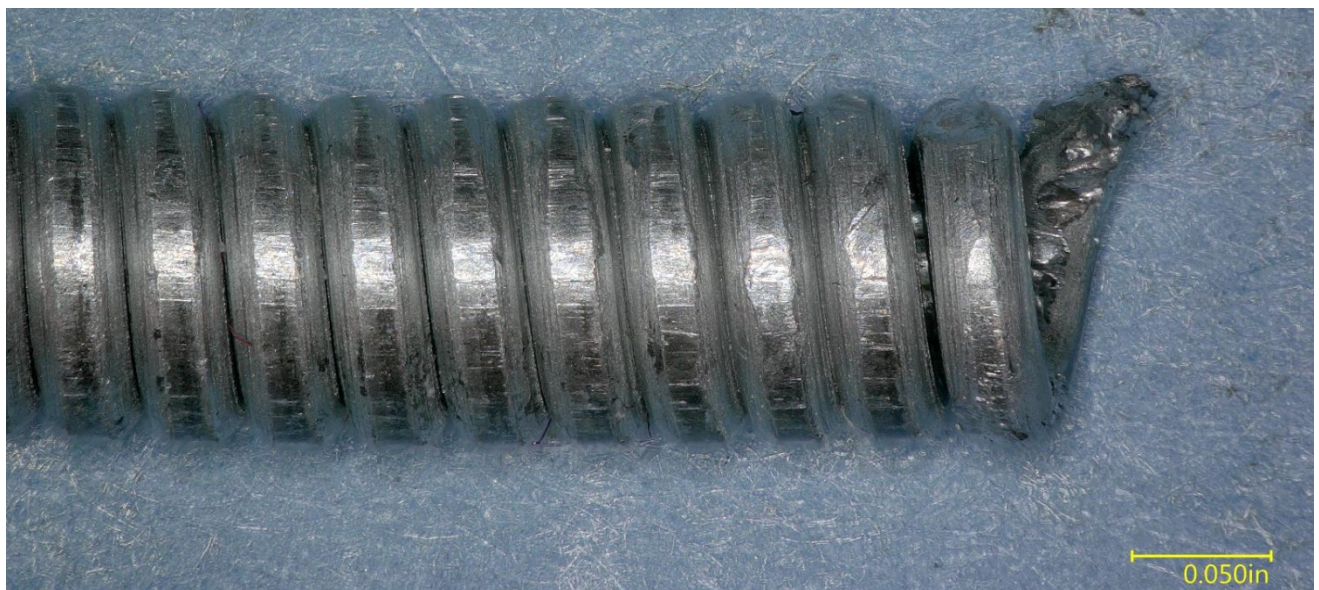


Figure 2 – Side view of the throttle cable remnant, showing the fracture surface.

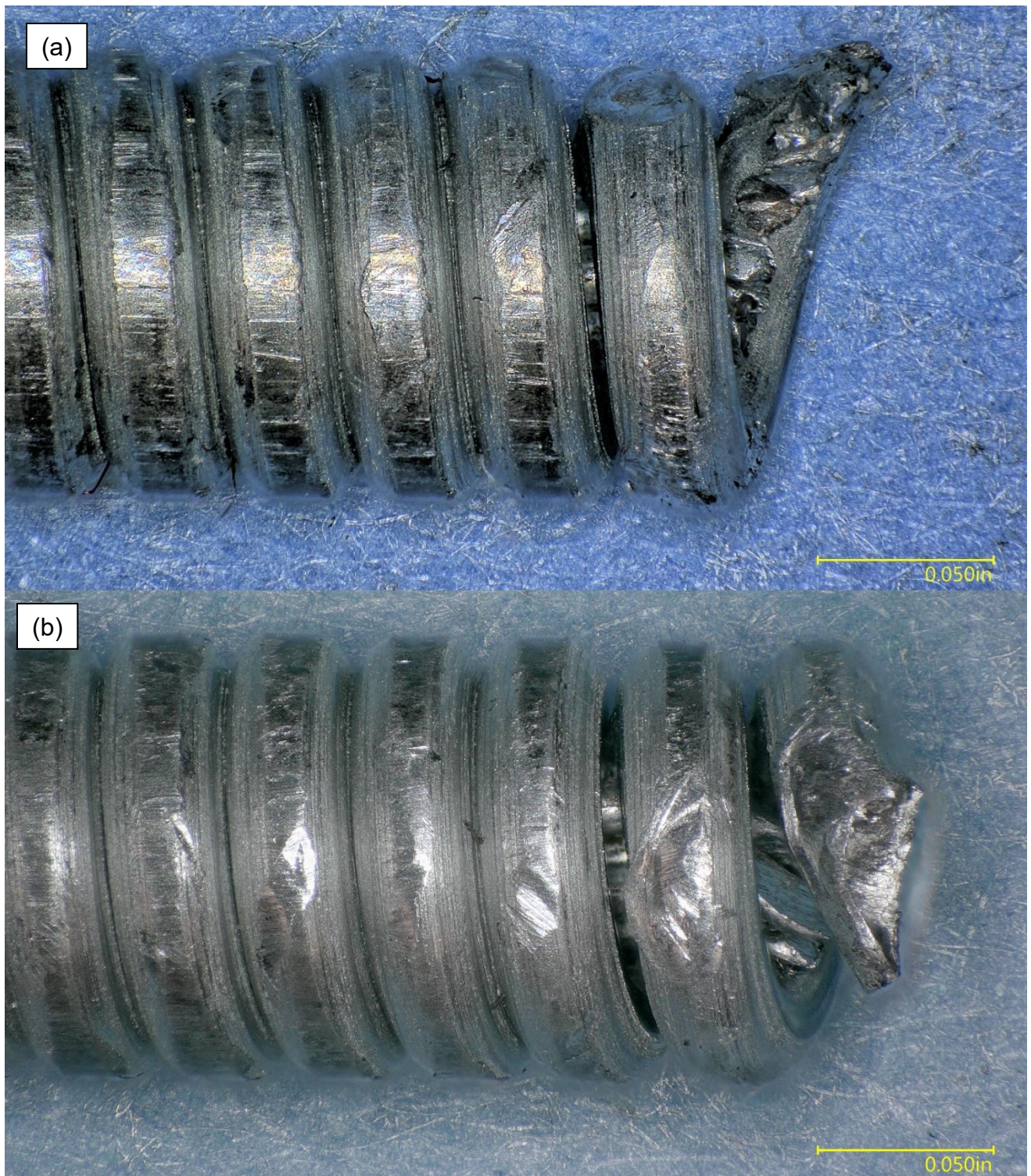


Figure 3 – Closer view of the fractured end of the cable, viewed from 180° opposite views (a), (b).

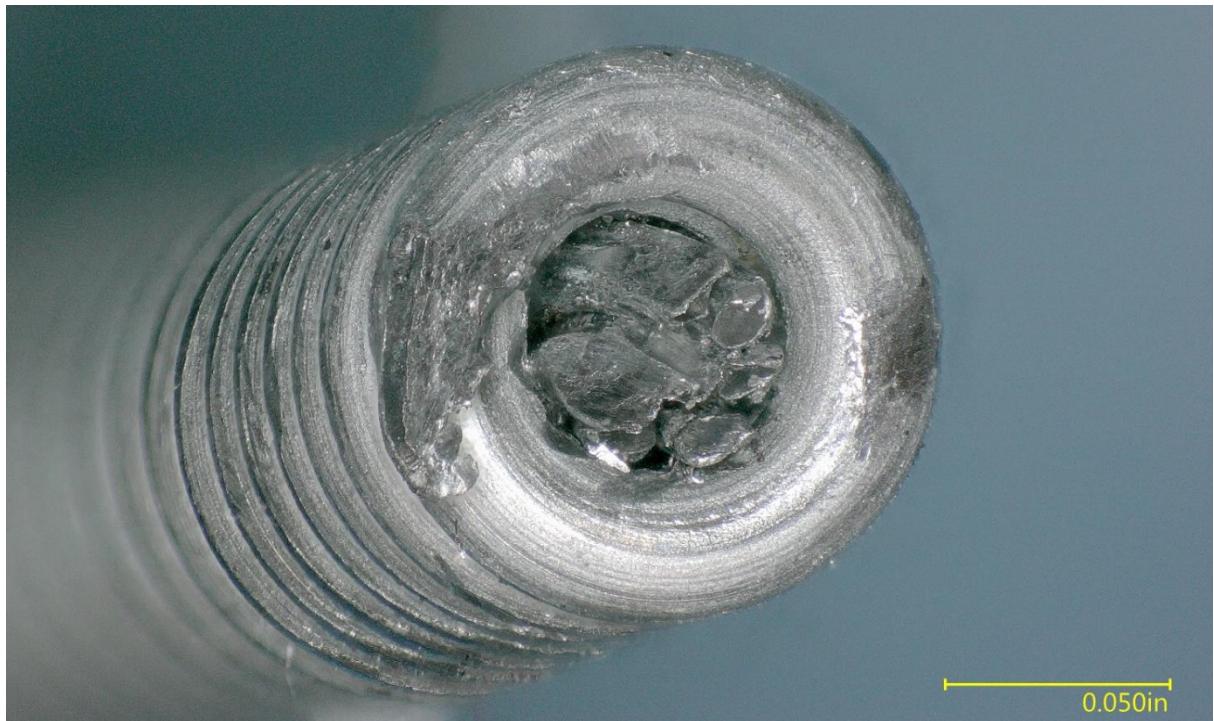


Figure 4 – Optical view of the throttle cable fracture surface.

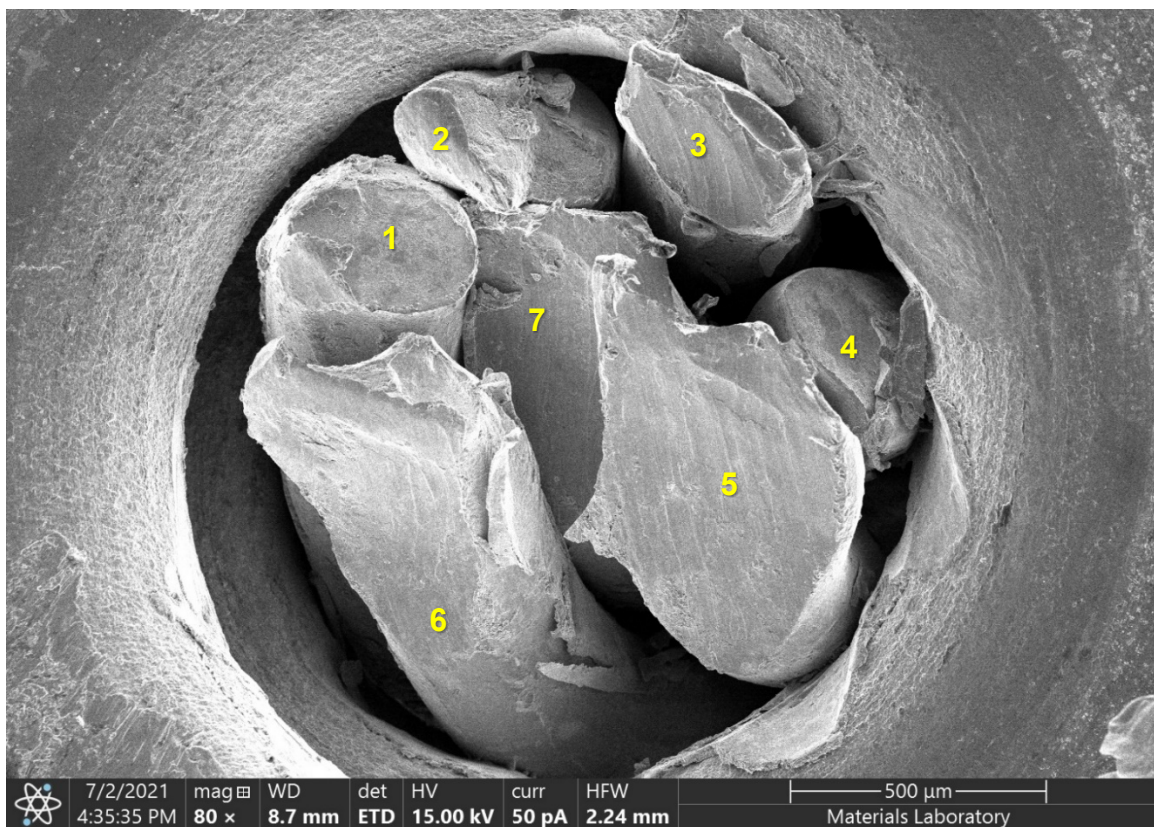


Figure 5 – Secondary electron (SE) micrograph of the fractured cable strands of the throttle cable, numbered for the purposes of this report.

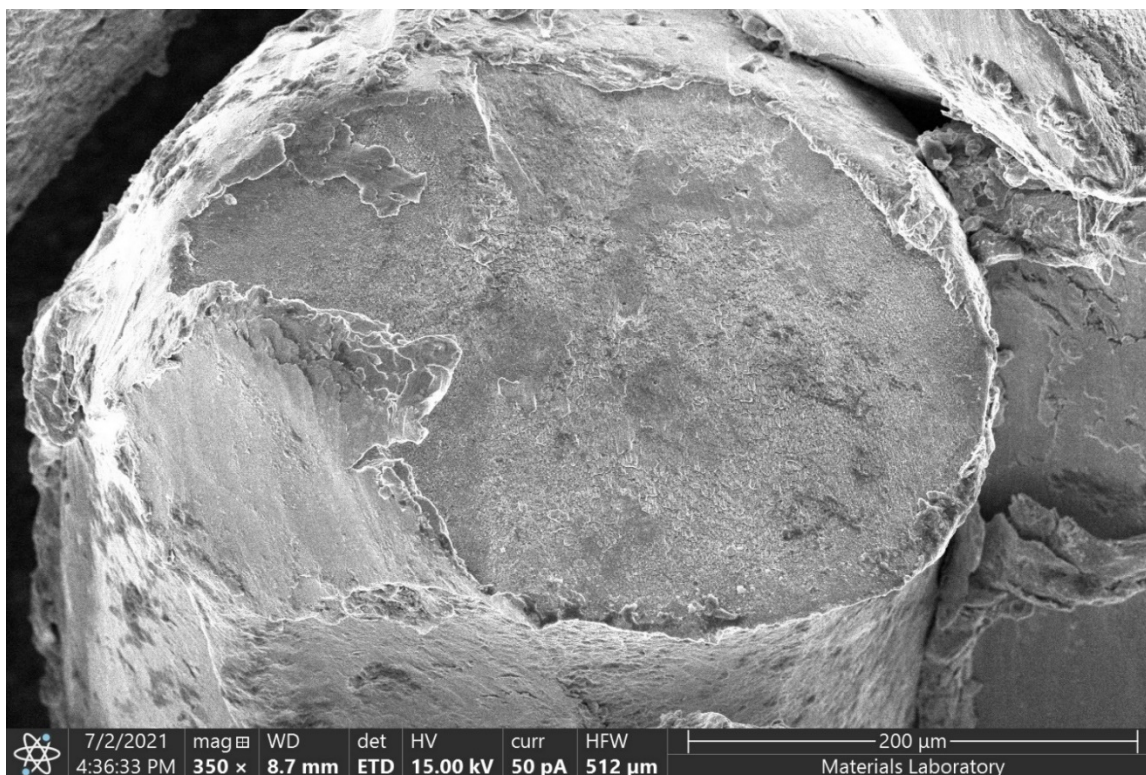


Figure 6 – SE micrograph of the Strand 1 fracture surface.



Figure 7 – Backscattered electron (BE) micrograph of the Strand 1 fracture surface.

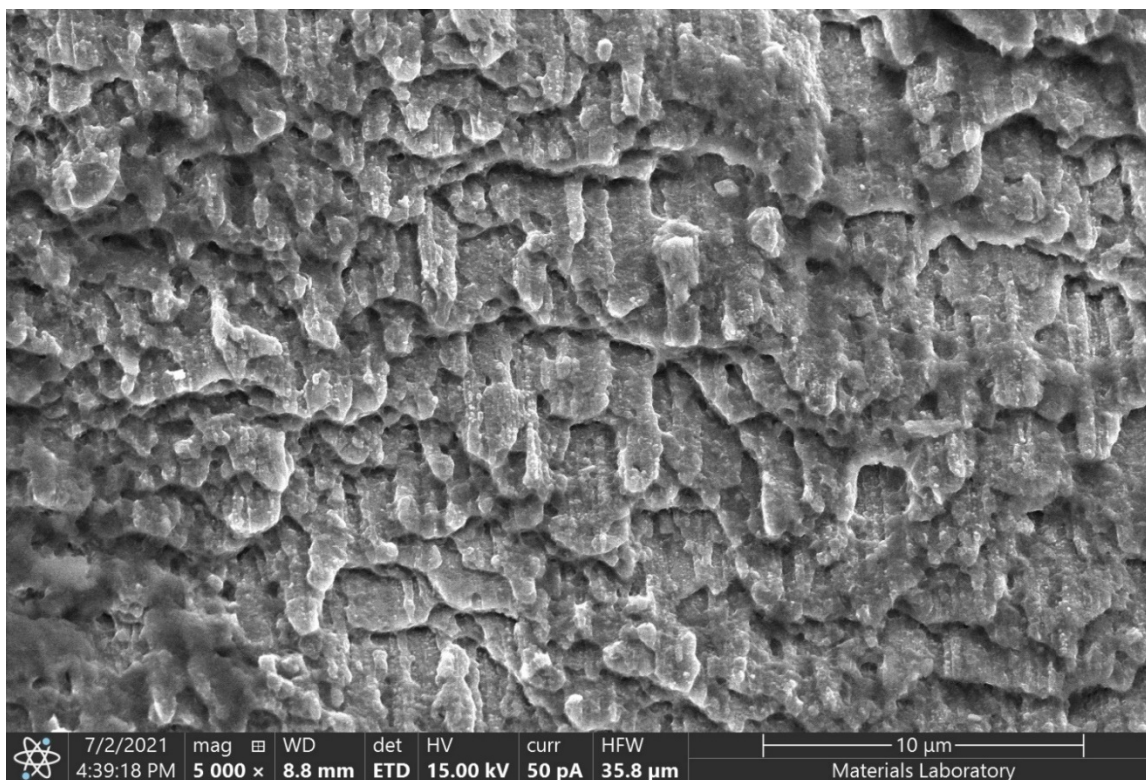


Figure 8 – SE micrograph of a typical undamaged area of the Strand 1 fracture.

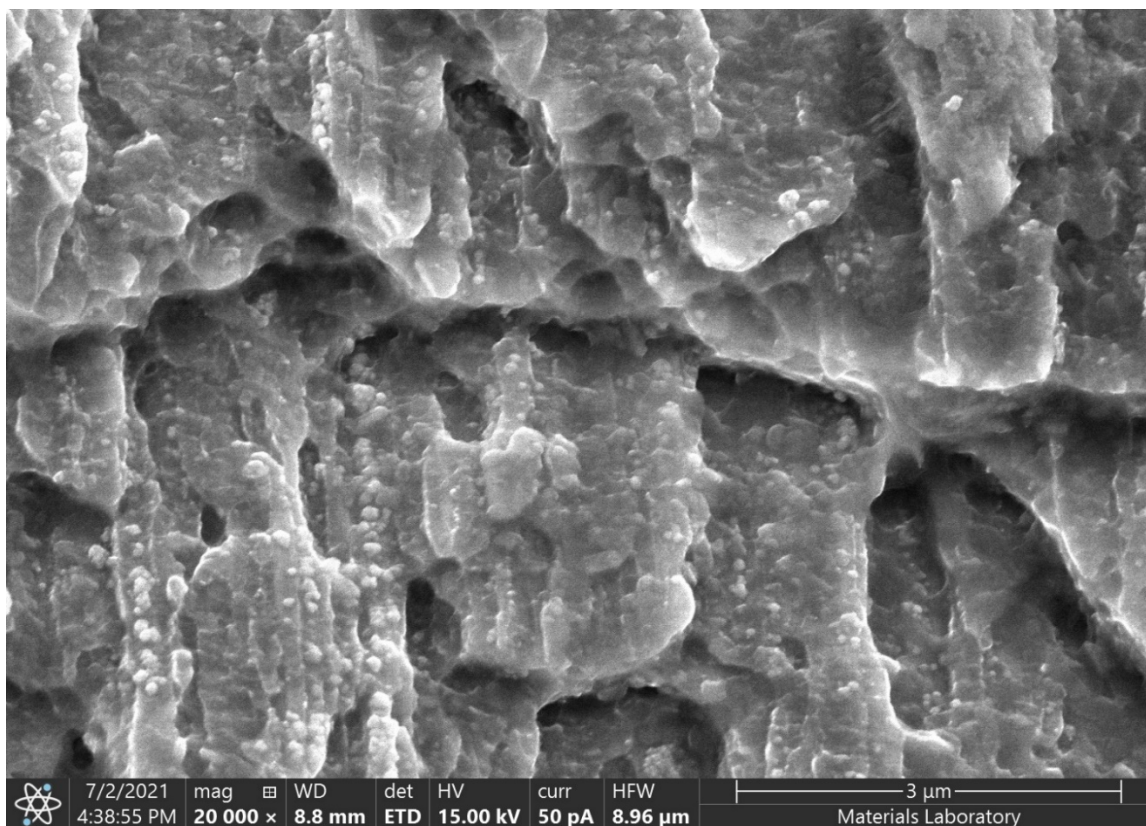


Figure 9 – SE micrograph of a closer view of Figure 8, showing dimpled rupture.

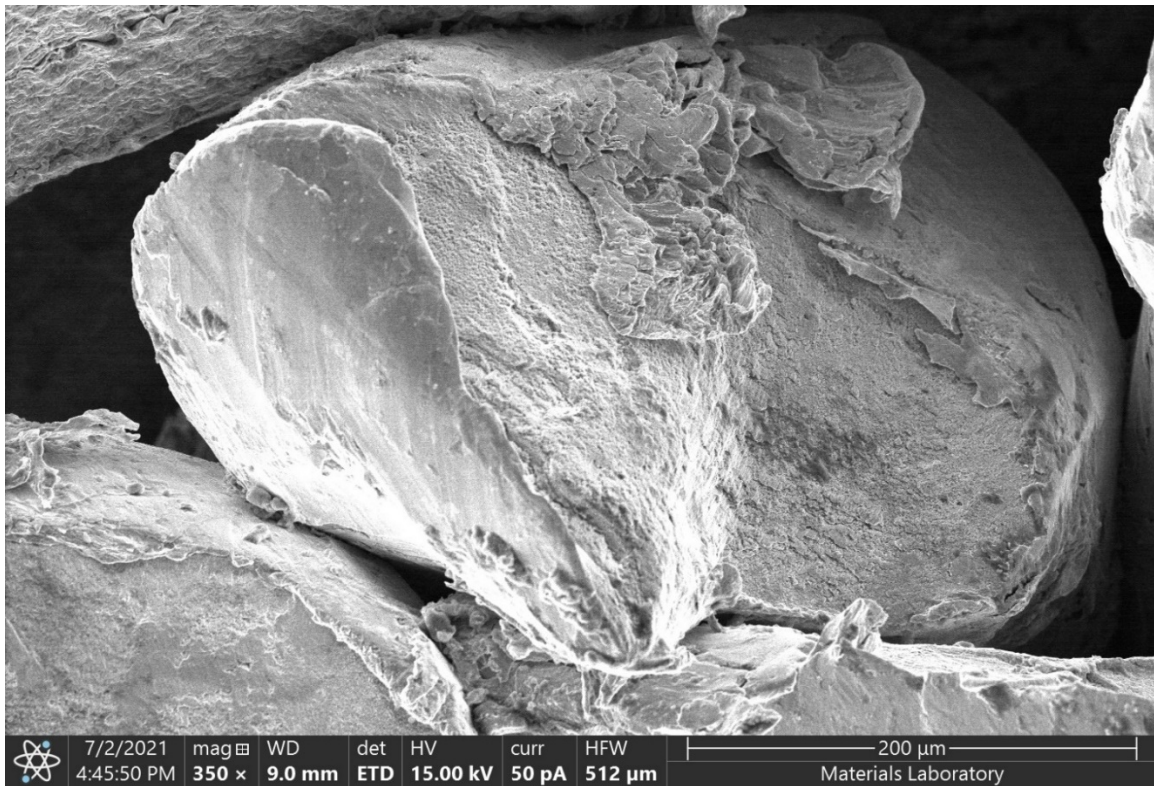


Figure 10 – SE micrograph of the Strand 2 fracture surface.



Figure 11 – BE micrograph of the Strand 2 fracture surface.

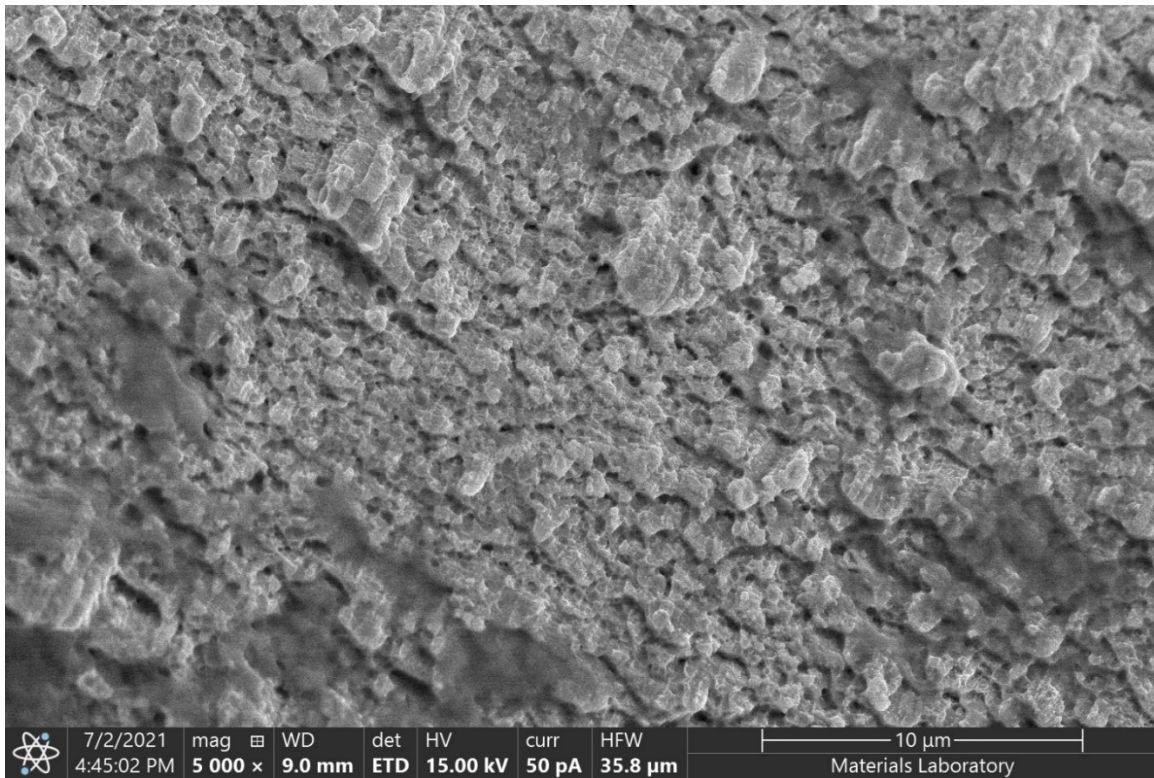


Figure 12 – SE micrograph of a typical undamaged area of the Strand 2 fracture.

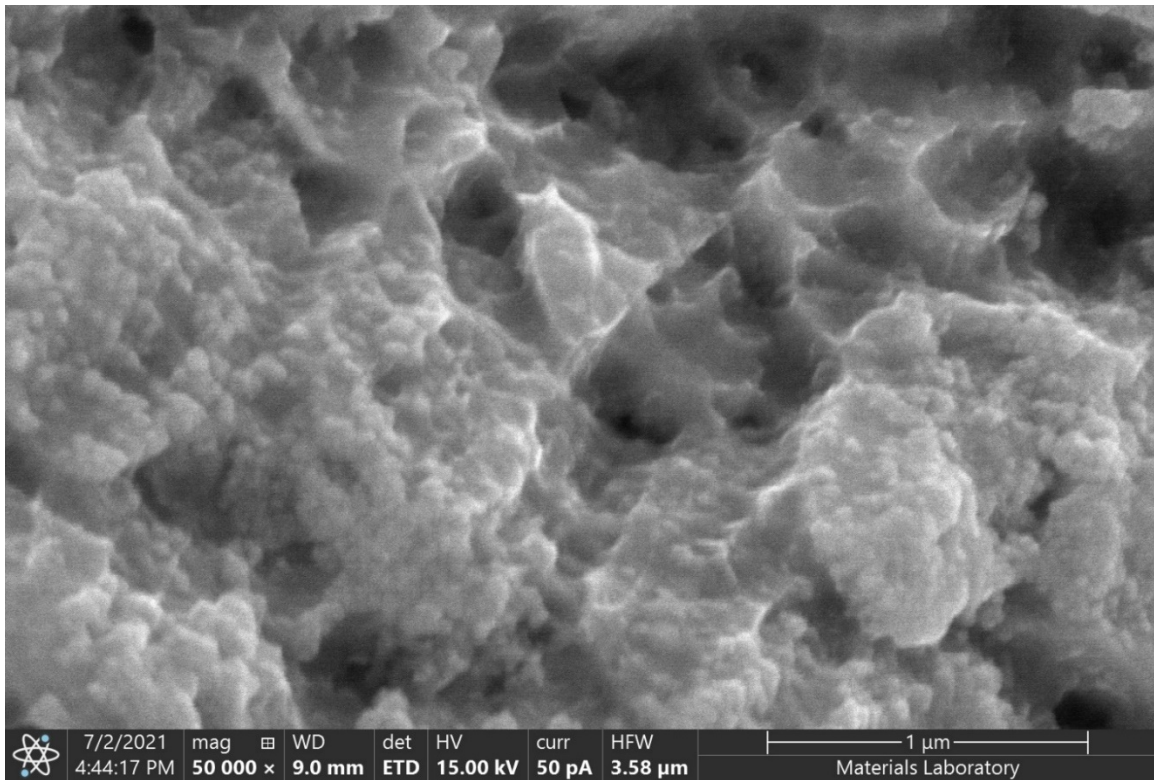


Figure 13 – SE micrograph of a closer view of Figure 12, showing dimpled rupture.

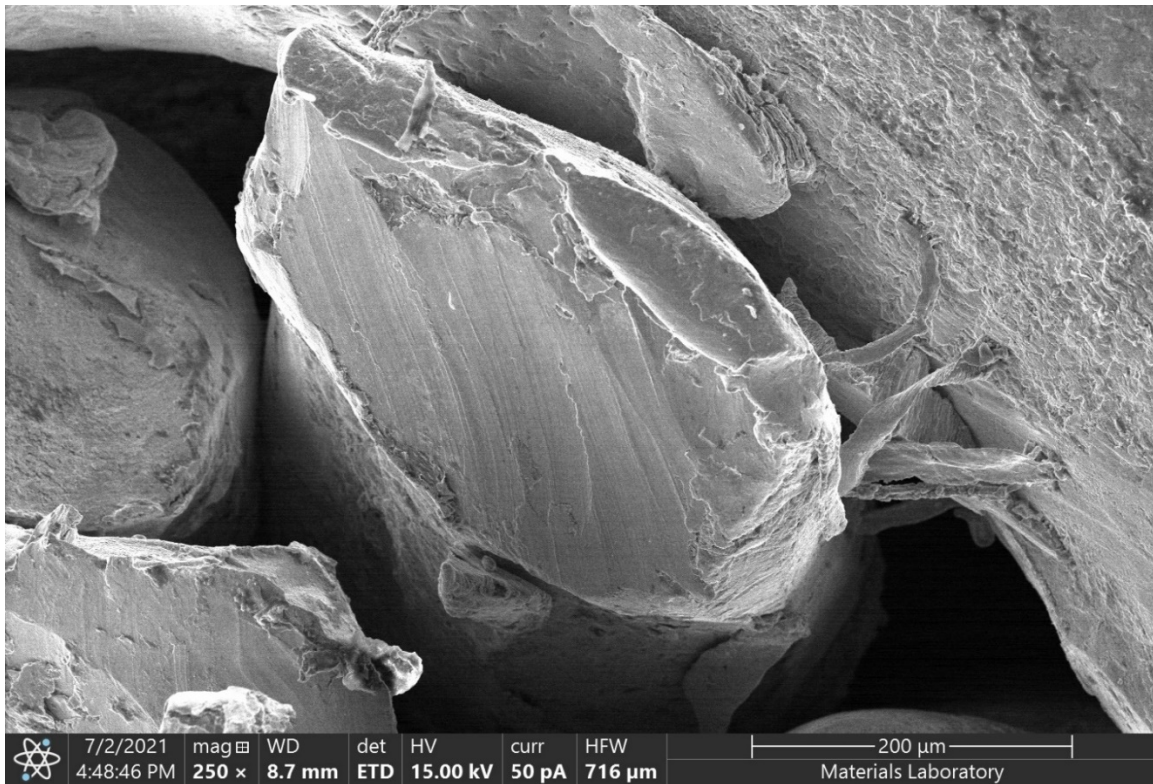


Figure 14 – SE micrograph of the Strand 3 fracture surface.



Figure 15 – BE micrograph of the Strand 3 fracture surface.

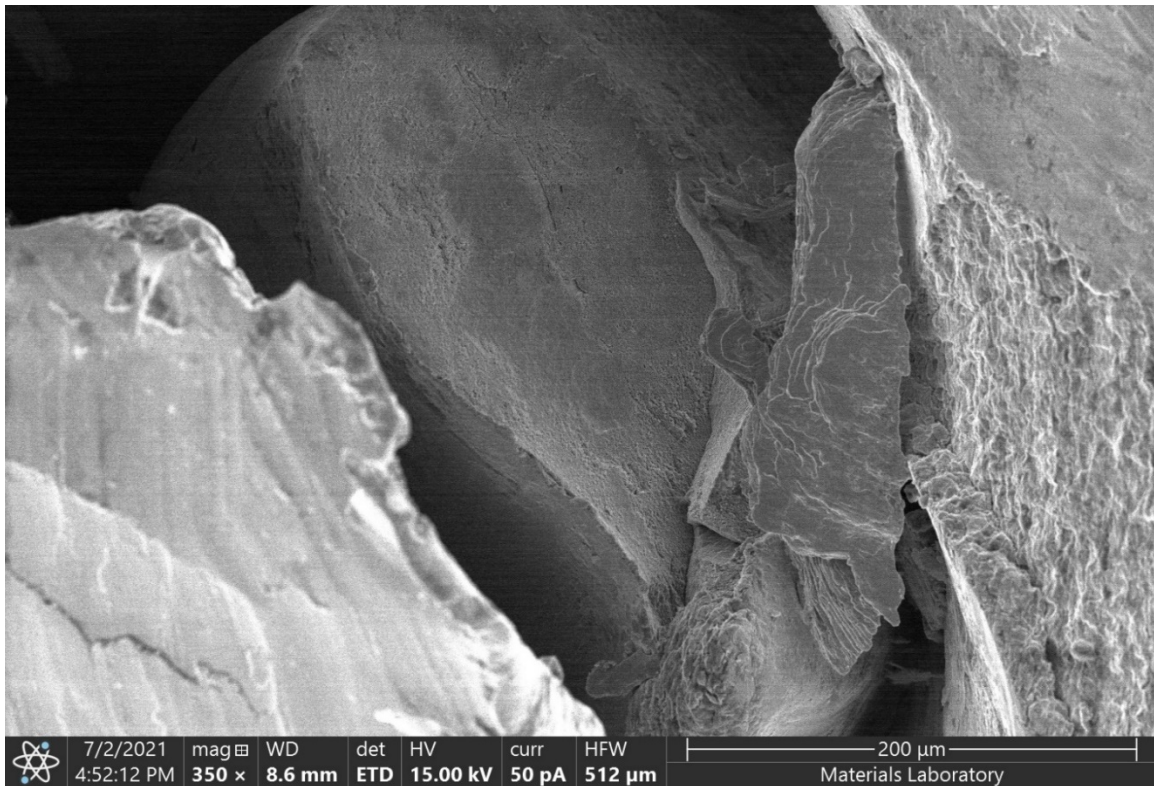


Figure 16 – SE micrograph of the Strand 4 fracture surface.

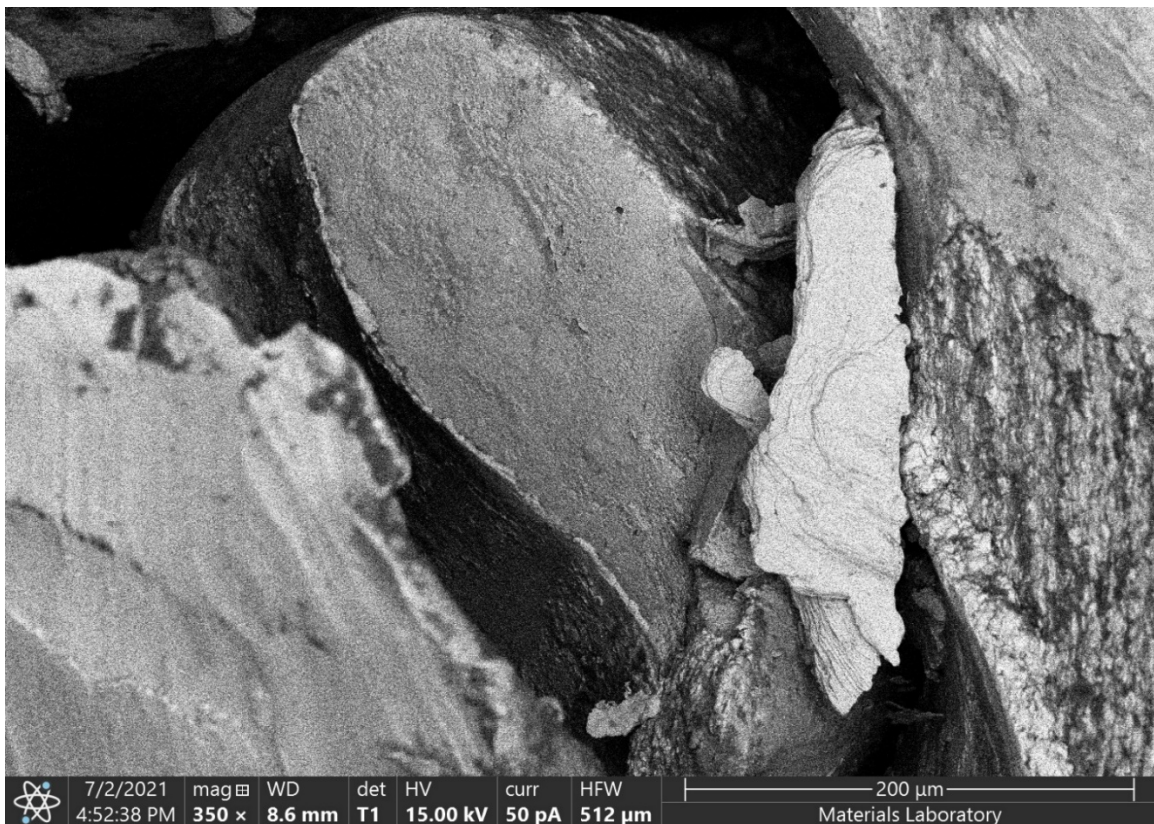


Figure 17 – BE micrograph of the Strand 4 fracture surface.

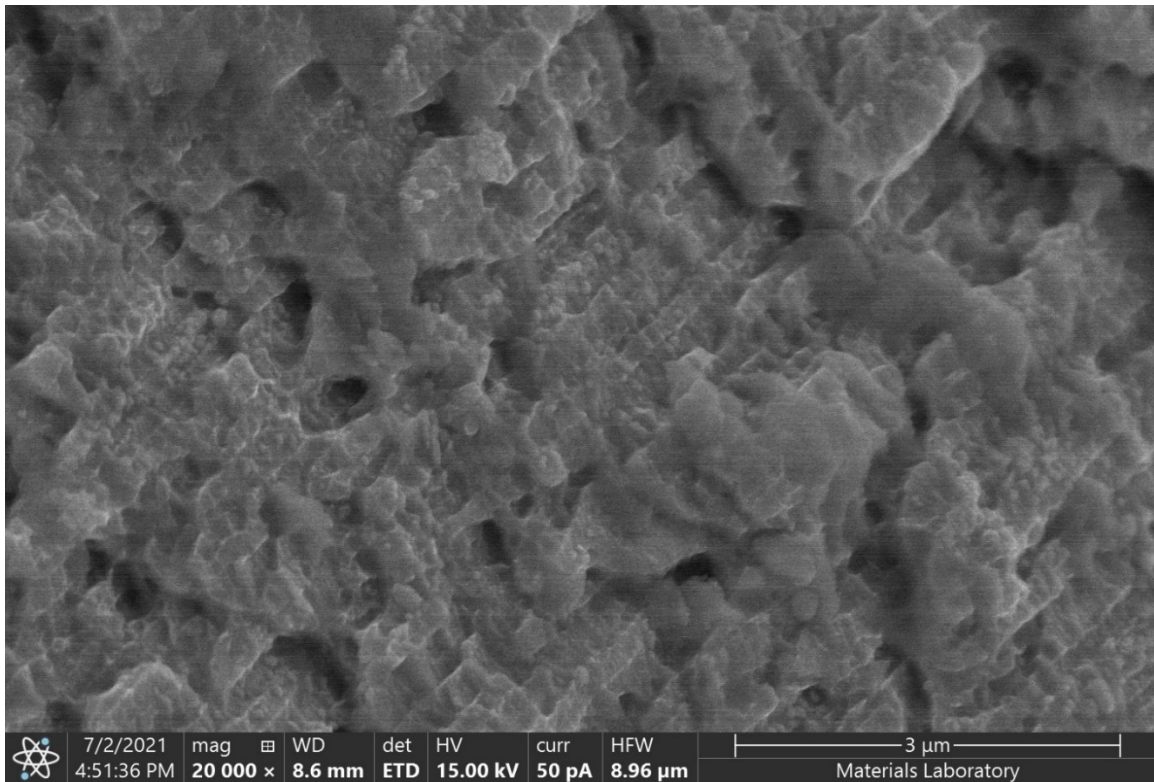


Figure 18 – SE micrograph of a typical dimpled rupture of the Strand 4 fracture.

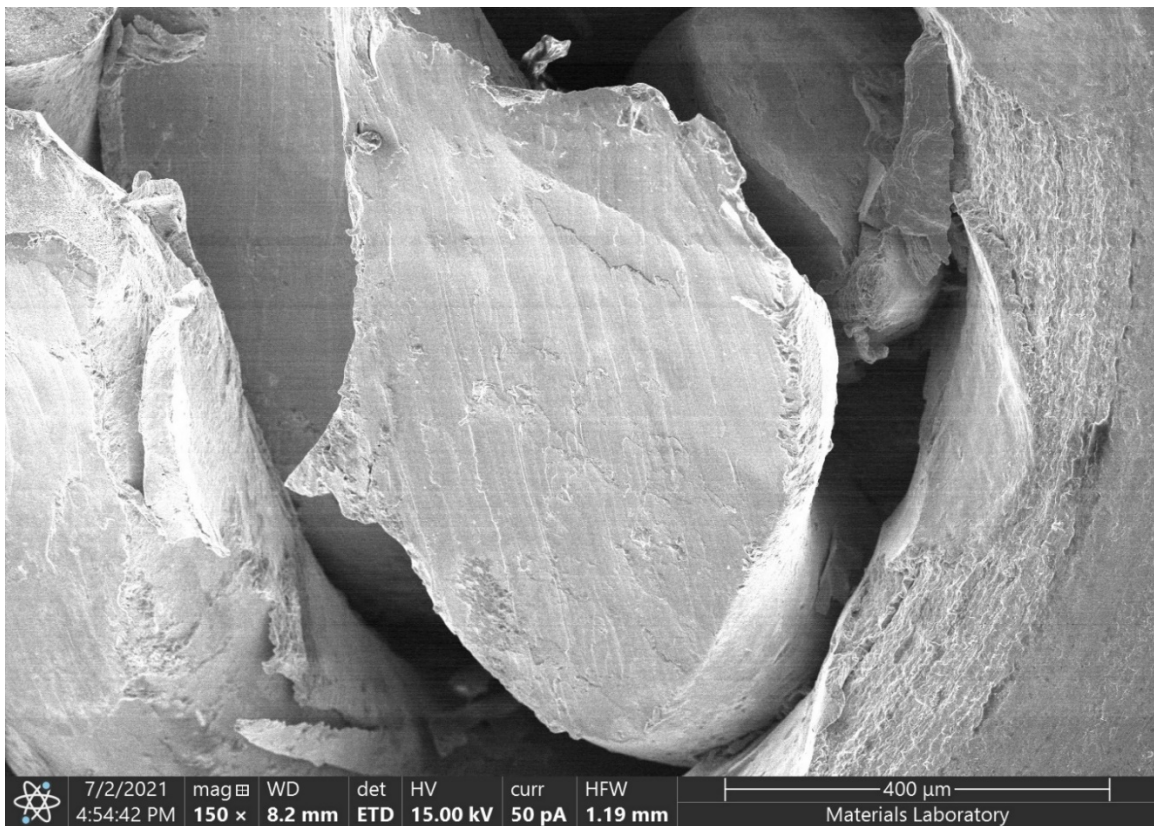


Figure 19 – SE micrograph of the Strand 5 fracture surface.

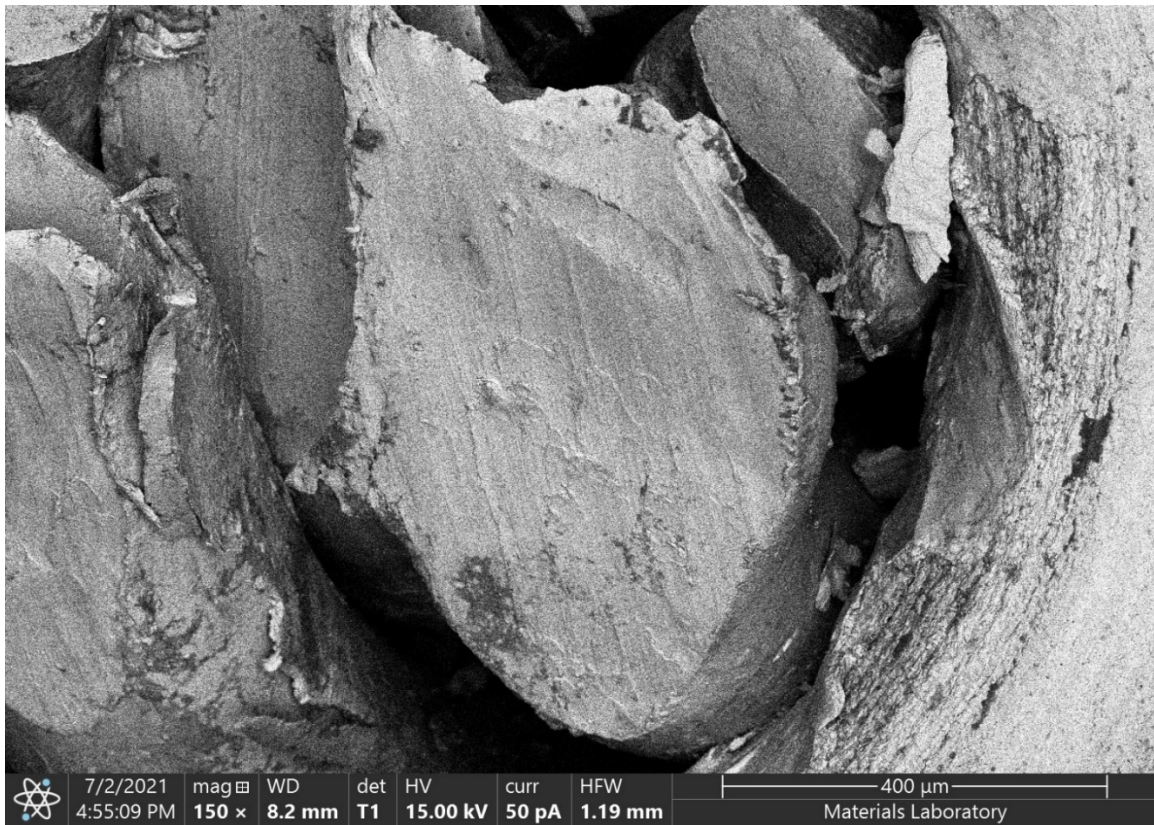


Figure 20 – BE micrograph of the Strand 5 fracture surface.

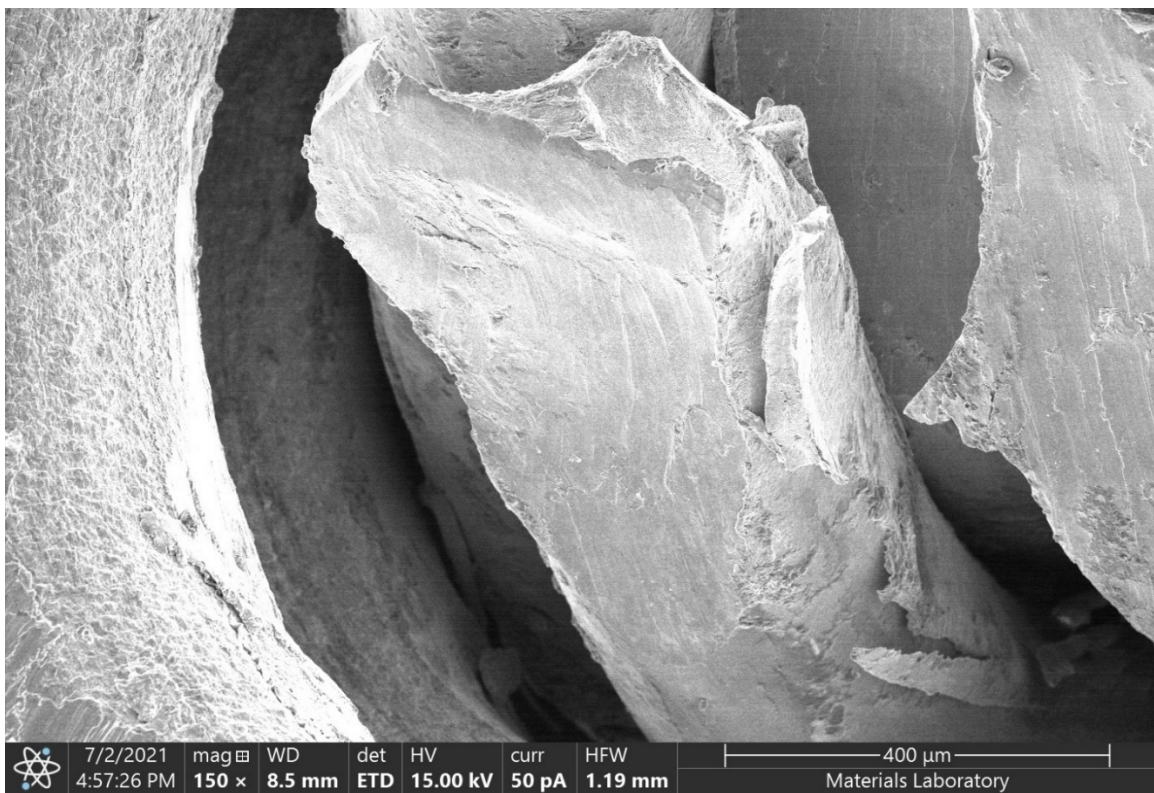


Figure 21 – SE micrograph of the Strand 6 fracture surface.

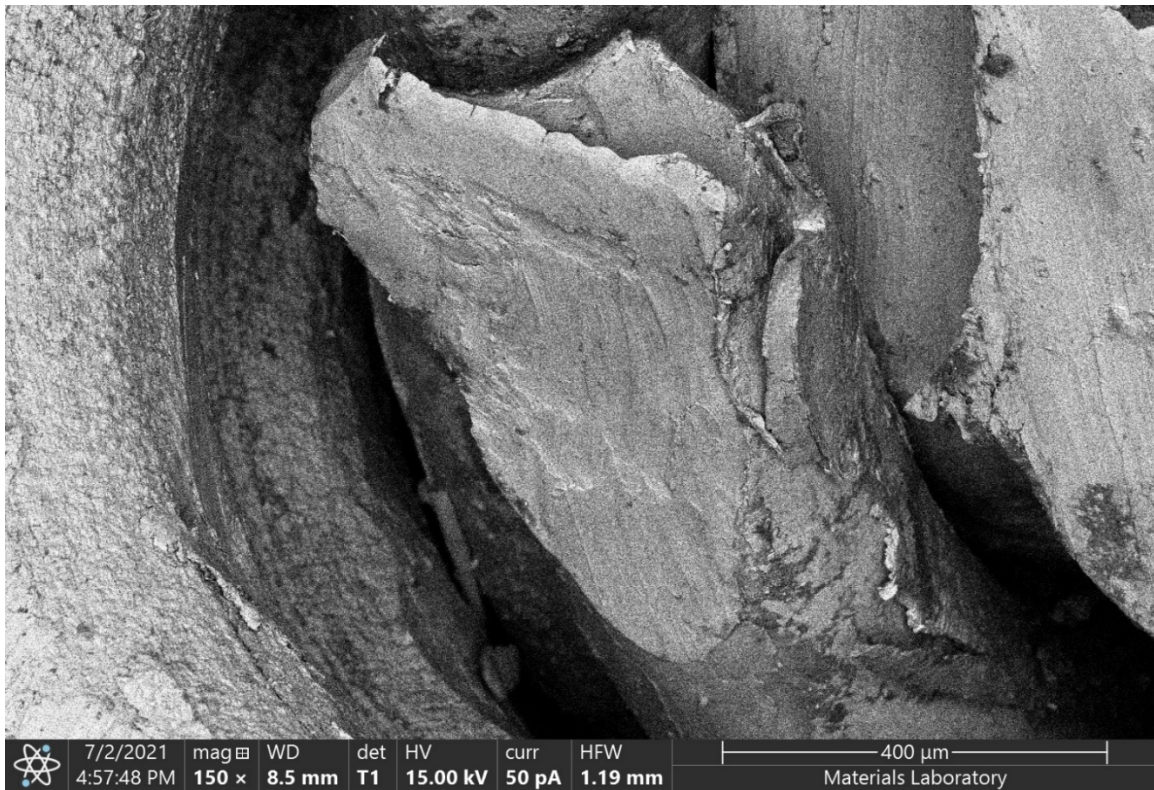


Figure 22 – BE micrograph of the Strand 6 fracture surface.

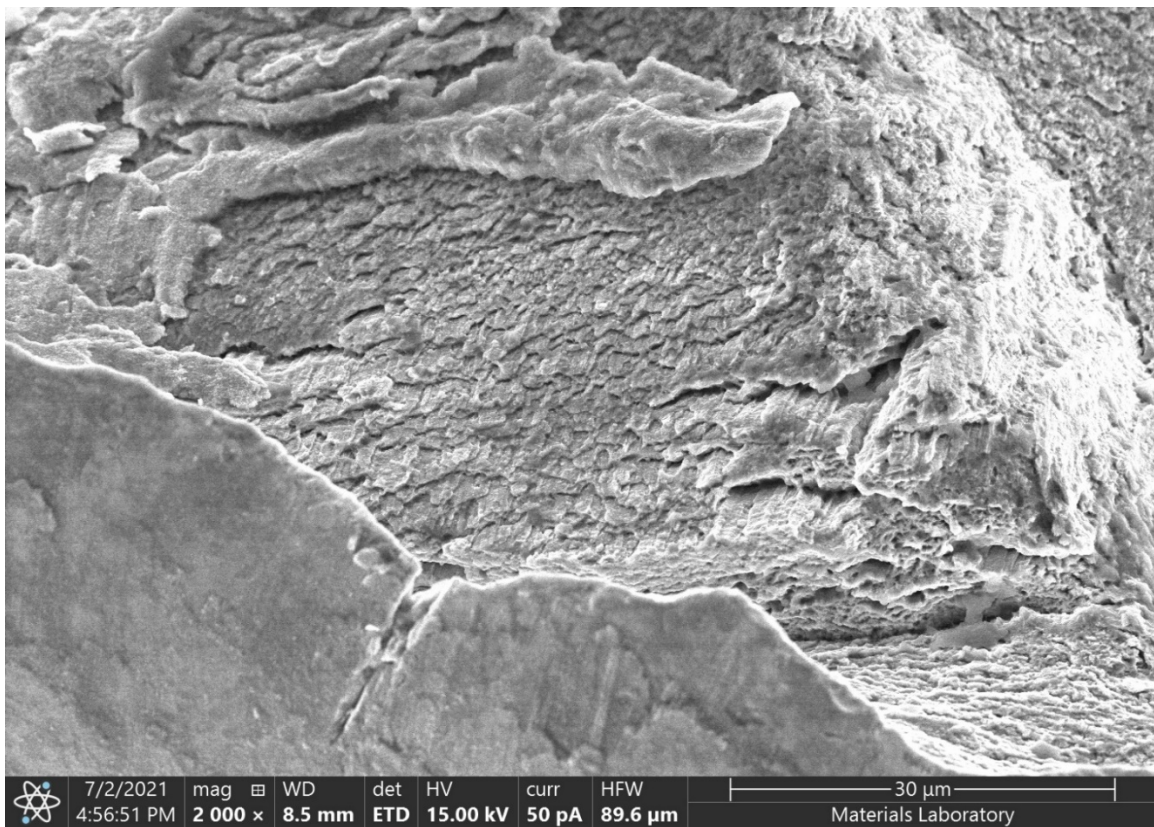


Figure 23 – SE micrograph of a typical undamaged area of the Strand 6 fracture.

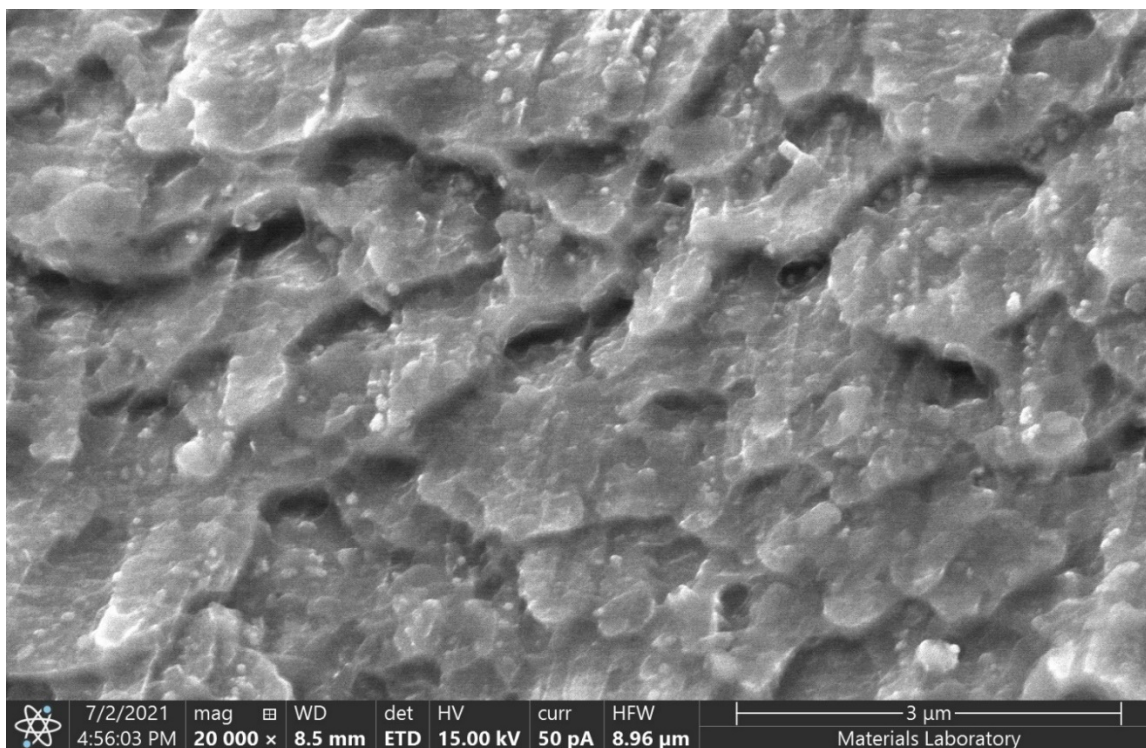


Figure 24 – SE micrograph of a closer view of Figure 23, showing dimpled rupture.



Figure 25 – SE micrograph of an angled view of the outer sheath coil fracture surface and wear damage along adjacent coils.

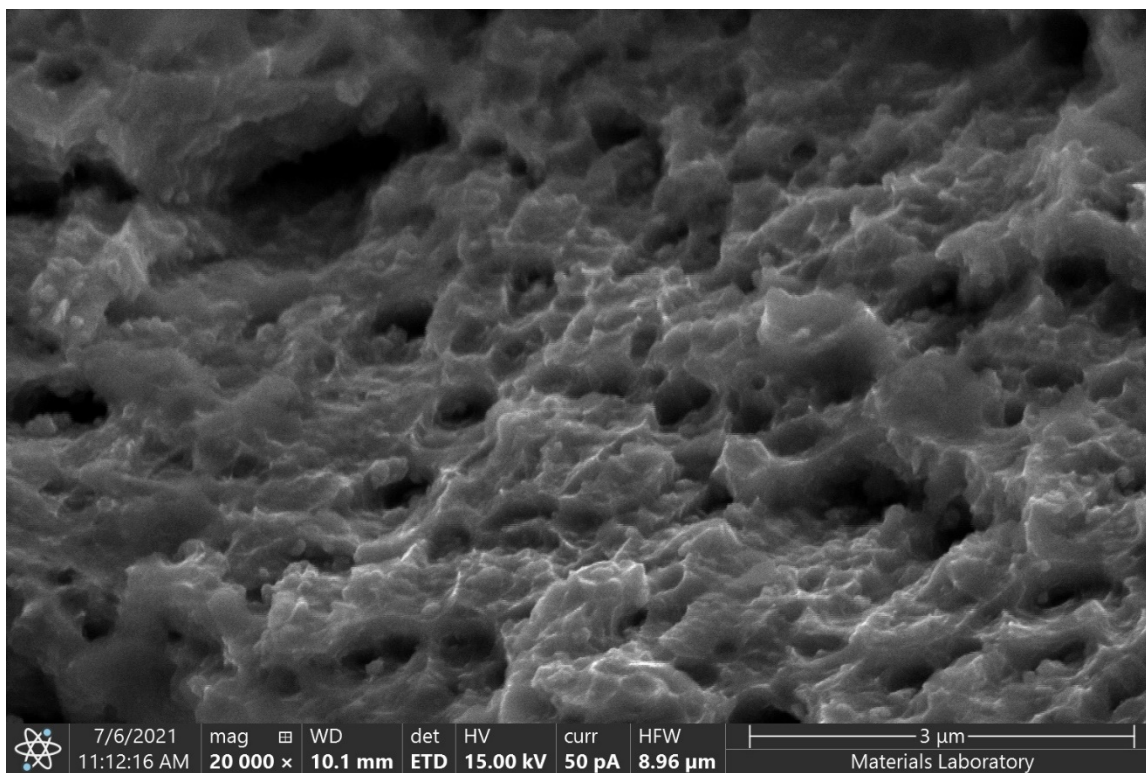


Figure 26 – SE micrograph of a typical area of dimpled rupture on the sheath fracture.

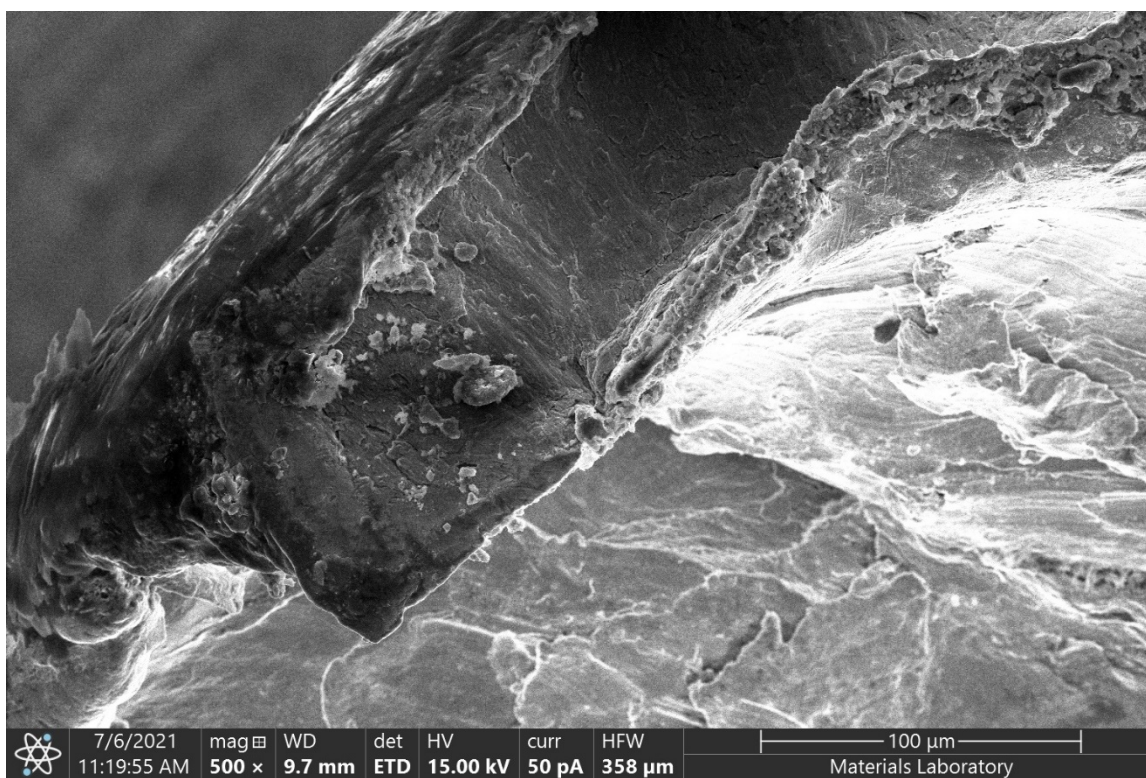


Figure 27 – SE micrograph of an area with radiating marks on the outer sheath fracture.

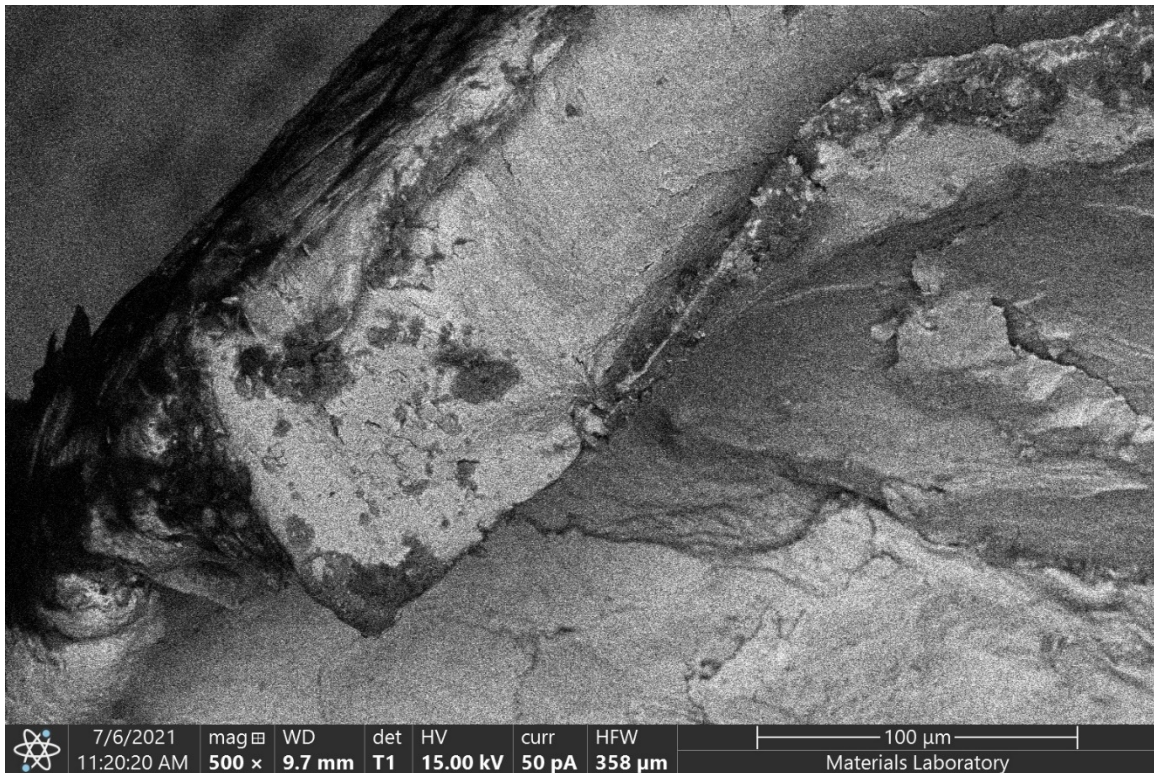


Figure 28 – SE micrograph of an area with radiating marks on the outer sheath fracture.

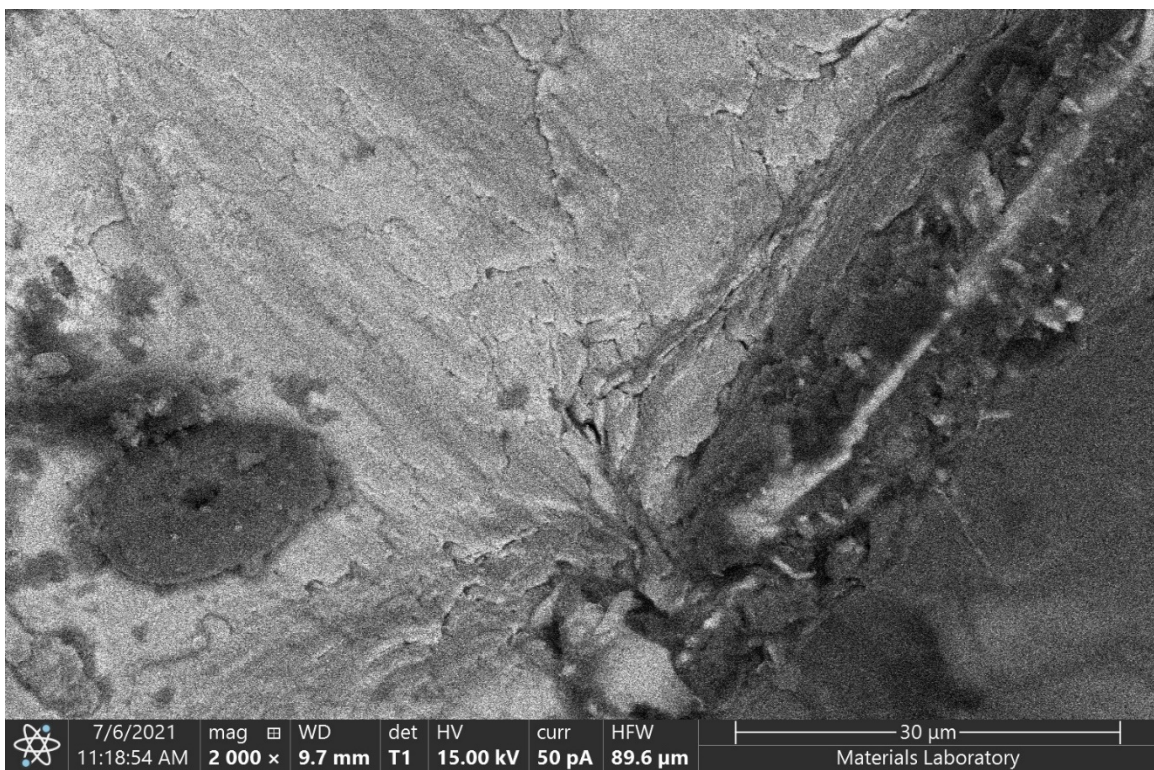


Figure 29 – BE micrograph of a closer view of the radiating marks in Figure 28.

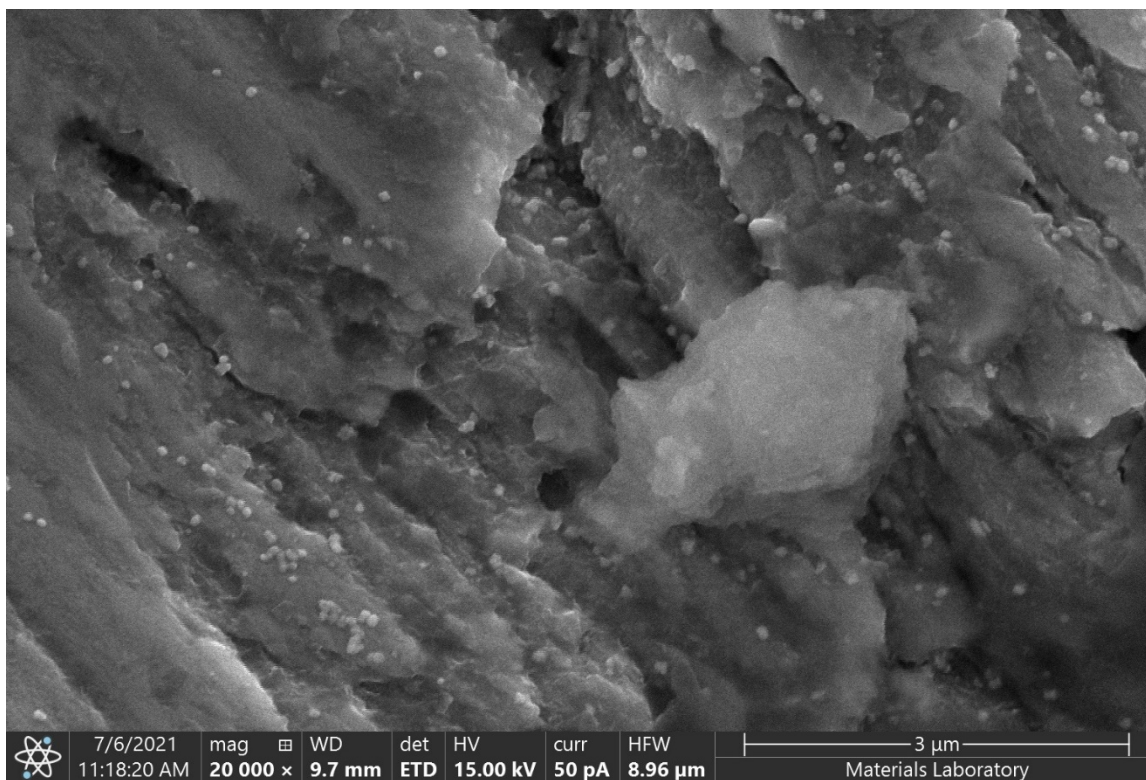


Figure 30 – SE micrograph of dimpled rupture between streaks in Figure 29.

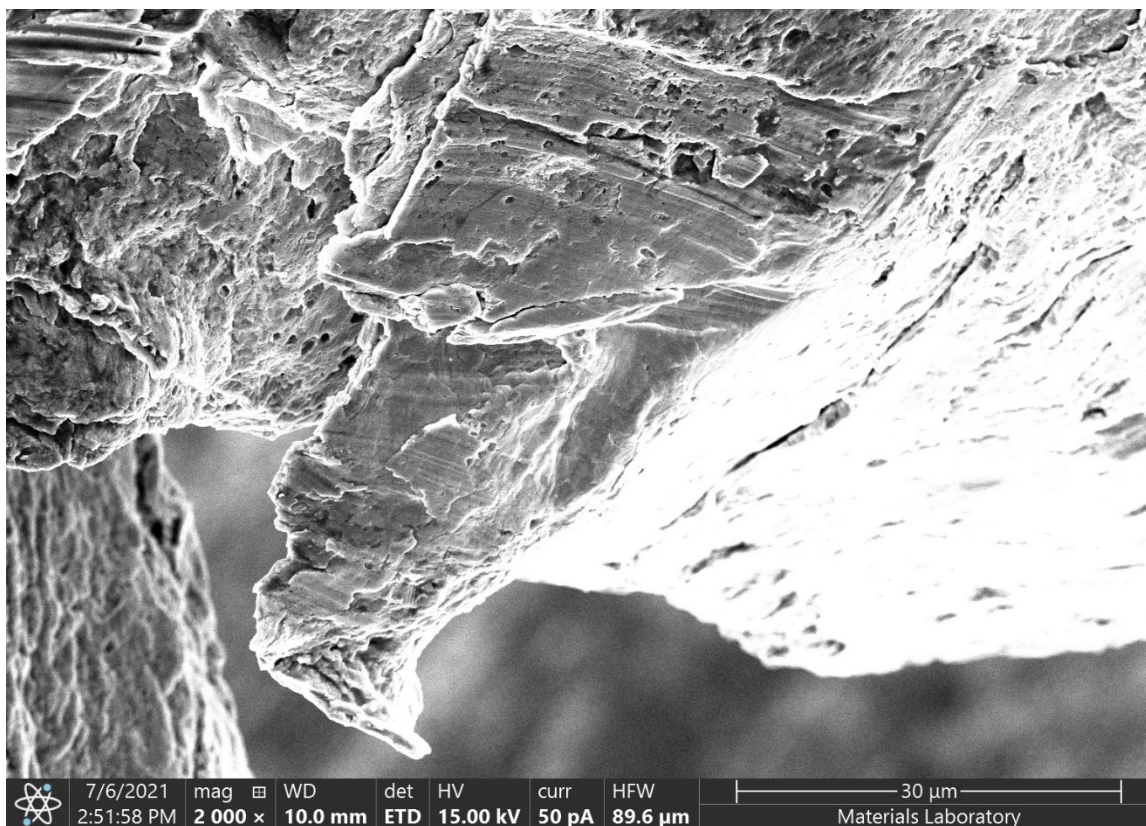


Figure 31 – SE micrograph of parallel marks on the sheath coil fracture surface.

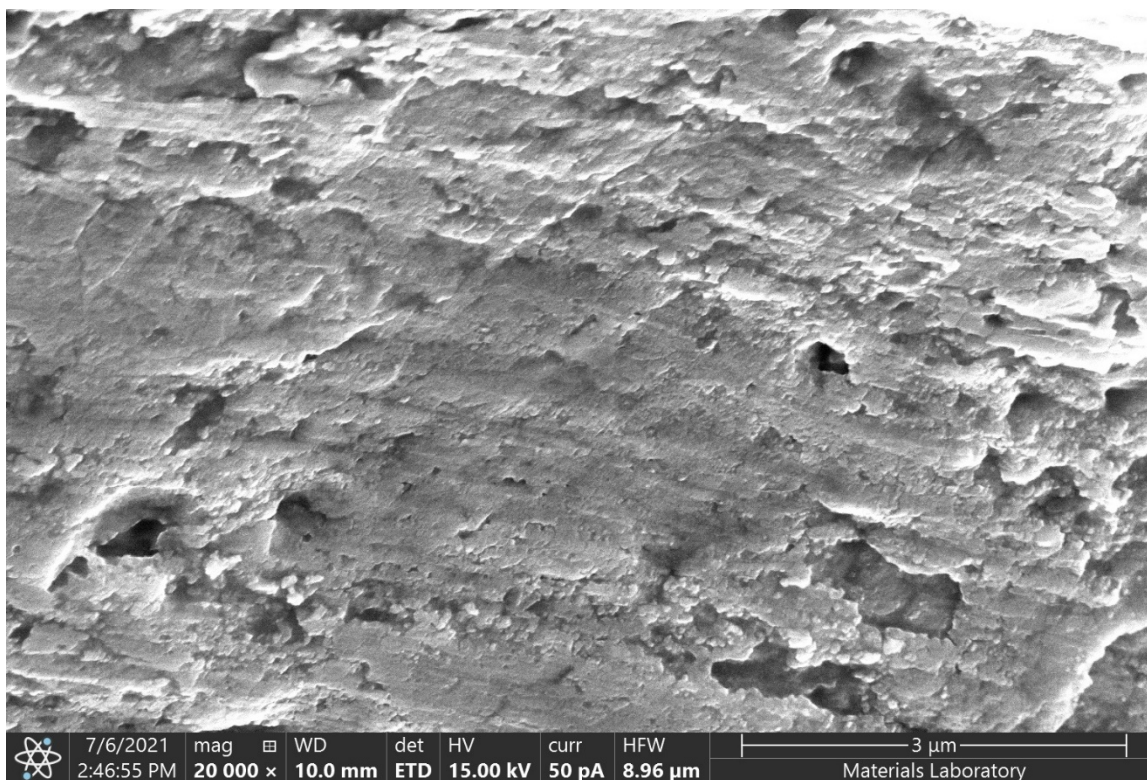


Figure 32 – SE micrograph of a closer view of the marks in Figure 31.

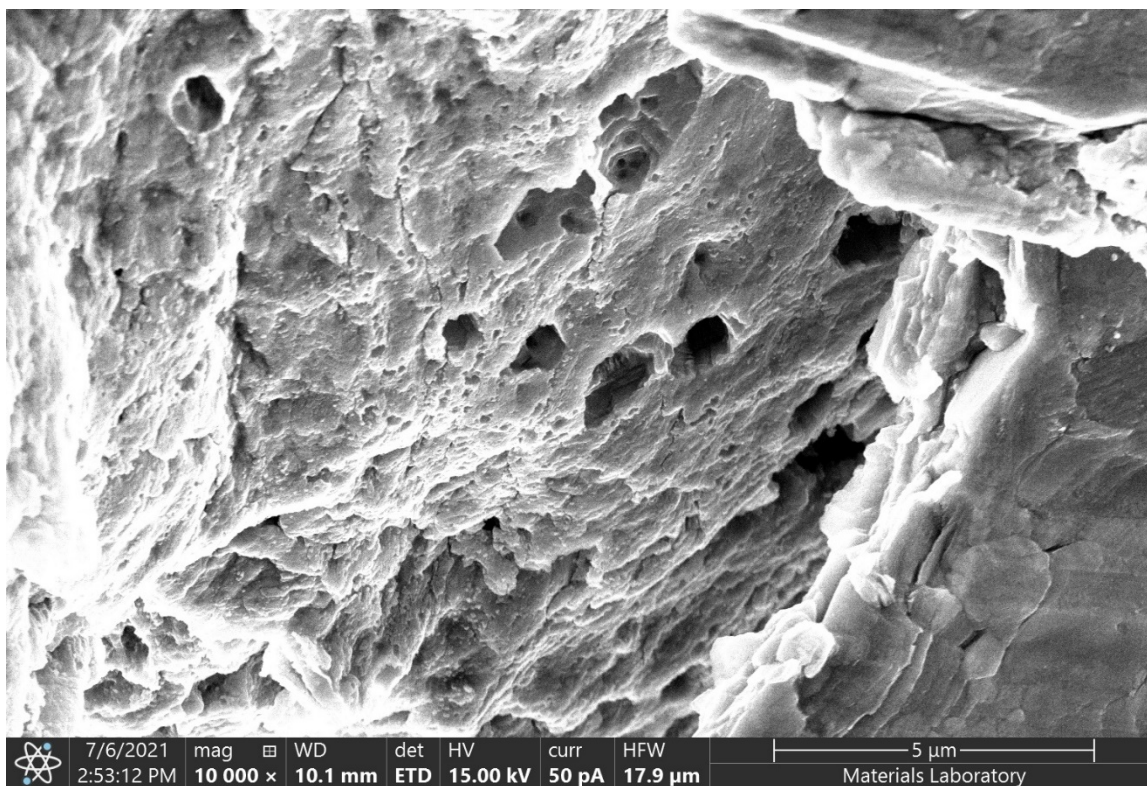


Figure 33 – SE micrograph of dimpled rupture amongst the parallel marks in Figure 31 through Figure 32.

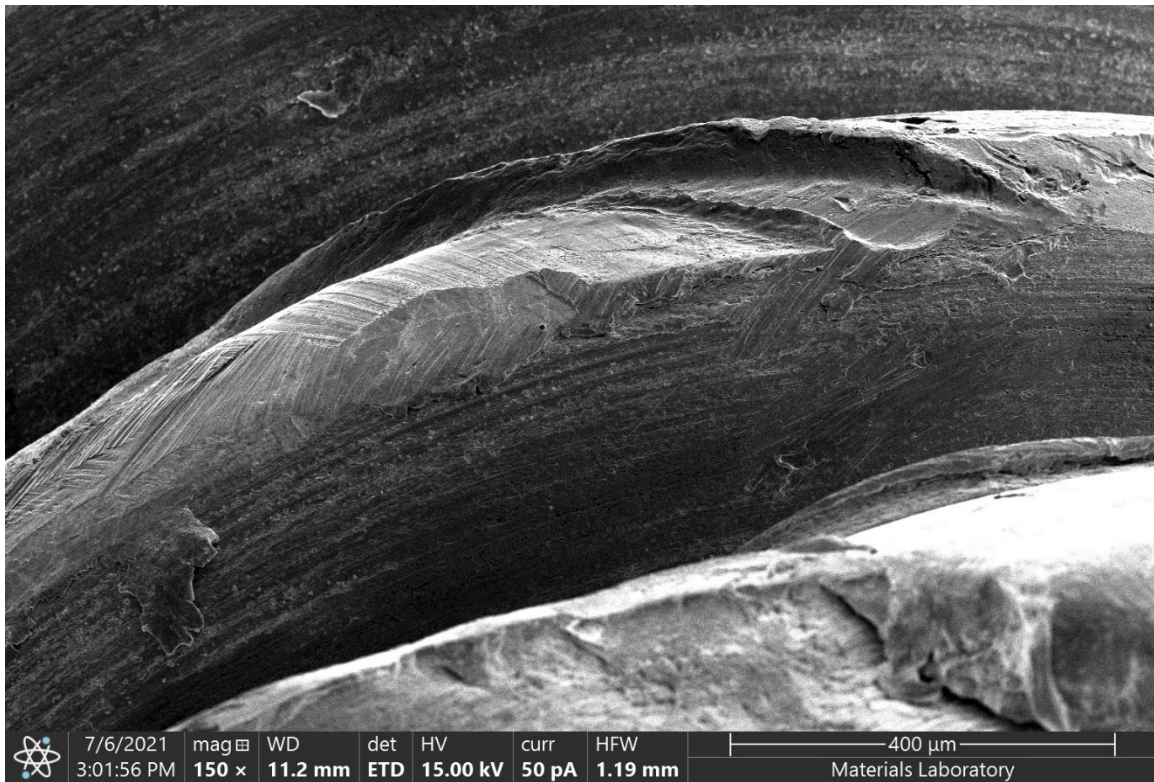


Figure 34 – SE micrograph of the secondary wear marks on the adjacent coil near the sheath fracture surface.



Figure 35 – SE micrograph of a closer view of the wear damage in Figure 34.

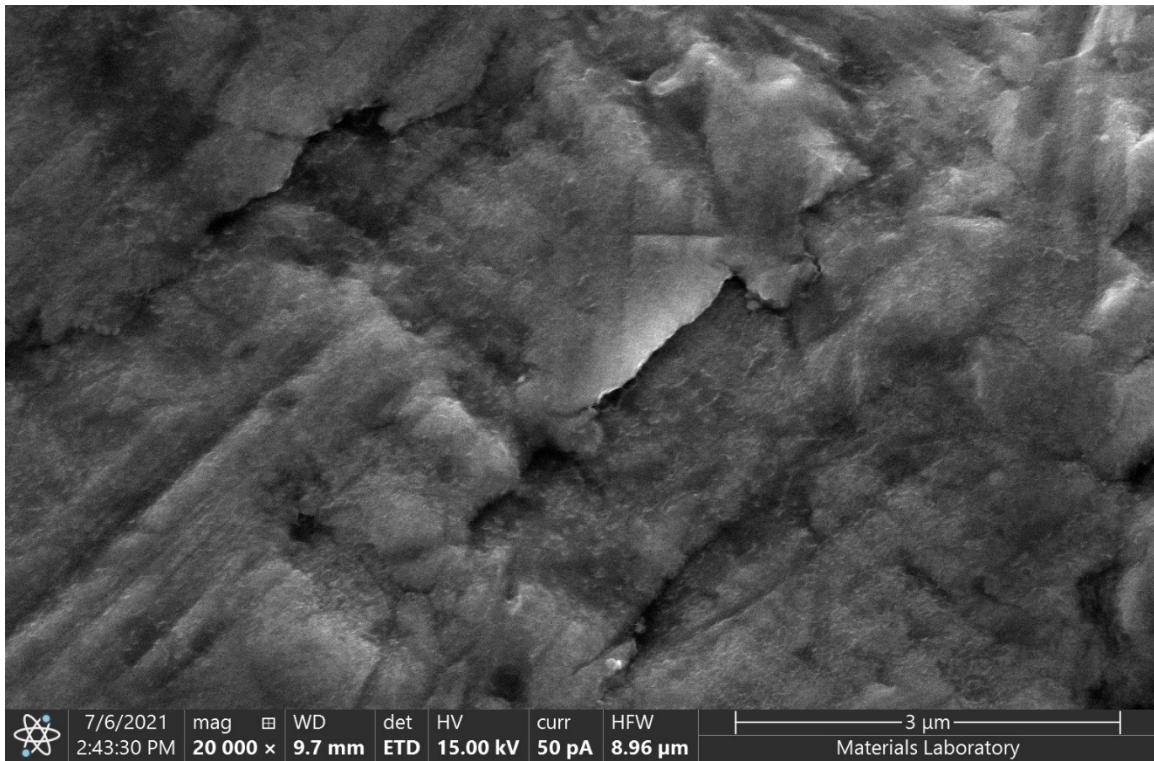


Figure 36 – SE micrograph of the marks in Figure 35, showing intersecting linear features.