

NATIONAL TRANSPORTATION SAFETY BOARD

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



June 14, 2021

MATERIALS LABORATORY FACTUAL REPORT

Report No. 21-037

1. ACCIDENT INFORMATION

Place : Mount Vernon, Indiana
Date : October 6, 2020
Vehicle : Quicksilver, N2942A
NTSB No. : CEN21LA008
Investigator : Steven Williams, AS-CEN

2. COMPONENTS EXAMINED

Remnants of sectioned support assemblies

3. DETAILS OF THE EXAMINATION

On October 6, 2020, about 0820 central daylight time, an experimental light sport Quicksilver airplane sustained substantial damage when it was involved in an accident near Mount Vernon, IN. The student pilot and private pilot were fatally injured. A witness stated they observed the airplane spiral to the ground after coming out of a loop. The witness did not observe the airplane impact the ground but stated hearing a sound consistent with impact. The airplane impacted a harvested crop field, coming to rest on its right side. The wreckage was found about 100 ft from the initial ground impact marks with debris scattered in between. The wreckage has been retained for further examination.

Several pieces of the structure from the airplane were received by the NTSB Materials Laboratory, as illustrated in Figure 1. These consisted mainly of tubular supports that were bolted together, which had been sectioned prior to receipt. The color, nonmagnetic properties, and relatively low density were consistent with these tubes being composed of anodized aluminum. The blue color exhibited by some of the supports was typical of aluminum anodized with blue dye and seal. The positions shown in Figure 1 do not necessarily correspond with the support positions on the aircraft prior to sectioning.

Figure 2 shows one of the sectioned support assemblies, as received. This assembly remnant consisted of three sectioned tubes joined by two Y-shaped clevis brackets that had been bolted through the supports. A remnant of red and white multilayer polyester fiber cloth was still attached through a bolted connection. The cloth exhibited loose short fiber filaments consistent with having been torn along a seam. All the support sections exhibited reflective, jagged features where sectioned, along with no indications

of macroscopic plastic deformation. These features were consistent with sectioning after the accident rather than having fractured.

Figure 3 shows three of the assembly remnants, positioned as they had been assembled prior to fracture. These consisted of the two-support assembly section from the left in Figure 1 with a bracket, a single sectioned support with a bolted bracket, and a longer metallic-colored support tube with a fractured bolt remnant through a hole in the center.

Figure 4 shows the upper assembly remnant from Figure 3, viewed from the side. This assembly remnant consisted of two anodized support tubes bolted together with a Y-shaped clevis. The bottom support section in the figure also had a U-shaped bracket bolted to its end. This bracket had been attached to the middle support section in Figure 3 with the threaded section of the fractured bolt and a nut (not received).

Of note on this assembly remnant was the bolt hole on the bracket, shown in Figure 5 facing the reader. This bolt hole exhibited plastic deformation along one side of the periphery. Figure 6 shows a microscopic view of the hole deformation. The hole exhibited elongation towards the lower right side of the figure, with material deformed upward and back over the bracket surface. These features were consistent with a mating component (the fractured bolt) having been forced toward the direction of deformation in this bracket.

Figure 7 shows the sectioned anodized support tube from the bottom of Figure 3, viewed with the U-shaped bracket facing the reader. This bracket had been connected to the middle tube in Figure 3 from the fractured bolt. In this case, the black-painted bracket exhibited bare metal and missing material, consistent with having fractured. Moreover, the bracket had fractured along the middle, parallel to the sectioned support. The fracture of the bracket of the left side of the bolt hole in the figure consisted of a straight profile parallel to the support direction. To the right of the bolt hole in the figure, the fracture was angled outward (a V-shape), consistent with the fracture branching, generating a small piece of missing material.

The fractured bracket was removed by disassembling the bolted connection. Figure 8 shows the remaining sectioned support tube, without the bolt or bracket remnants. The surface of the support shows an array of witness marks, consistent with impact against adjacent components. The bolt hole exhibited plastic deformation consistent with elongation parallel to the support direction. This deformation was consistent with the bolt that connected to the bracket being forced along the hole in the direction of the support (towards the right in Figure 8).

Figure 9 shows the fractured support bracket from one of the mating fracture surfaces. The right side of the figure shows the flatter or straight portion of the bracket fracture surface, whereas the left side shows the outward angled portion. Both areas of the fracture surface generally exhibited a rough, fibrous surface with a dull gray luster. There were also sporadic areas that were flatter and reflective—these regions were consistent with smearing and other types of post-fracture damage.

Figure 10 shows a closer view of the flatter area of the fracture surface, adjacent to the bolt hole. The material adjacent to the hole exhibited a curved morphology, oriented upward parallel to the hole surface in the figure. This was consistent with deformation outward of the bracket along the hole. This portion of the fracture surface also exhibited secondary cracks. These cracks were oriented parallel to the rolling or forging direction of the bracket, and were consistent with secondary fracture along the elongated grain boundaries.

Figure 11 shows the mating (opposite) fracture surface of the bracket. In this view, the straighter or flatter fracture surface is on the left, and the angled area of the fracture surface is on the right. In both areas, the surfaces exhibited a rough, fibrous surface texture with a dull gray luster. The areas along both sides of the bolt hole exhibited plastic deformation. This deformation was upward in the figure, which was towards the outward face of the bracket. The outward surface edge on the angled area of the fracture surface (right side in Figure 11) exhibited a stratified angled protrusion.

The bracket fracture surface was cleaned ultrasonically using acetone and then examined using a scanning electron microscope (SEM). Figure 12 shows a typical area of the bracket fracture surface near the bolt hole. The features were relatively uniform, showing a rough layered appearance, consistent with having fractured transverse to the elongated grain direction of the bracket. A closer view of the fracture surface in Figure 13 and Figure 14 revealed dimpled rupture, consistent with overstress fracture. The features illustrated in these figures were typical of the entirety of the bracket fracture surface examined. There were no other features observed consistent with other fracture modes or pre-existing defects such as cracks.

The chemical composition of the fractured bracket was examined using energy dispersive x-ray spectroscopy (EDS). The composition was consistent with a 7000 series aluminum alloy.

Figure 15 shows the middle support tube from Figure 3 with the fractured bolt in the bolt hole. The support tube exhibited inward deformation at the location of the bolt hole, particularly on the side with the head of the fractured bolt. The opposite side of the tube exhibited outward deformation along with periphery of the bolt hole, and nearby inward deformation located towards the right of the hole in Figure 16. These features were consistent with inward buckling from compression of the support around the bolt, and tension on the bolt and surrounding bolt hole walls.

The fractured bolt had been deformed into a C-shape (see Figure 15). The bolt had fractured along the threaded portion of the shaft, as illustrated in Figure 16. This side corresponded with the outward deformation of the adjacent support material around the bolt hole wall.

The fractured bolt was removed from the middle support section. A side view of the fractured portion along the threaded area is displayed in Figure 17. This fracture surface

was positioned so that the shaft of the bolt was horizontal, demonstrating the upward bending deformation in the threaded region. Several of the bolt thread crests exhibited smearing marks in the direction of deformation, and outward-oriented streaks were present along the transition of the shaft to the initial threads. These streaks were consistent with sliding across adjacent metal surfaces. There were two parallel cracks along the thread valleys below the lowest thread that had fractured, visible on the bottom of Figure 17.

Figure 18 shows a planar view of the fracture surface. As also shown in Figure 17, the fracture transited several bolt threads, rather than being oriented solely along the crest of one thread. The fracture surface was oriented at an approximately 45° angle. As shown in Figure 18, the fracture surface exhibited a dull gray luster with a rough, fibrous surface texture. The river patterns and visual features of the bolt fracture surface were consistent with fracture starting on the bottom of Figure 18 and ending at the top of the figure.

The fractured bolt was examined using a SEM. Figure 19 shows the area where the fracture began on the bolt. This region showed flow lines and river patterns emanating from the depressed area near the thread surface. Figure 20 shows a closer view of this area. The fracture surface exhibited rupture consistent with overstress fracture. No other features consistent with other failure modes such as pre-existing cracking were observed.

Figure 21 shows the opposite side of the bolt fracture surface, where the fracture would have terminated. These features were comparable to those at the initial area of the bolt fracture surface. A closer view of this region revealed slanted dimpled rupture, consistent with overstress in a shearing direction.

The chemical composition of the fractured bolt was examined using EDS. The composition was consistent with an alloy steel.

These features were consistent with the bolted joint being pulled under tension with the bolts also being bent towards one direction. When the bolt and brackets could no longer withstand these stresses, the bolt fractured in the threaded region, and the bracket on the opposite side of the middle tube fractured from overstress in tension and shear. This fracture sequence was consistent with the compression deformation observed on the middle tube and elongation of the bolt holes in three of the support sections.

Erik M Mueller
Materials Research Engineer



Figure 1 – The fractured structural support sectioned components, as received.



Figure 2 – Three of the sectioned supports, as received.

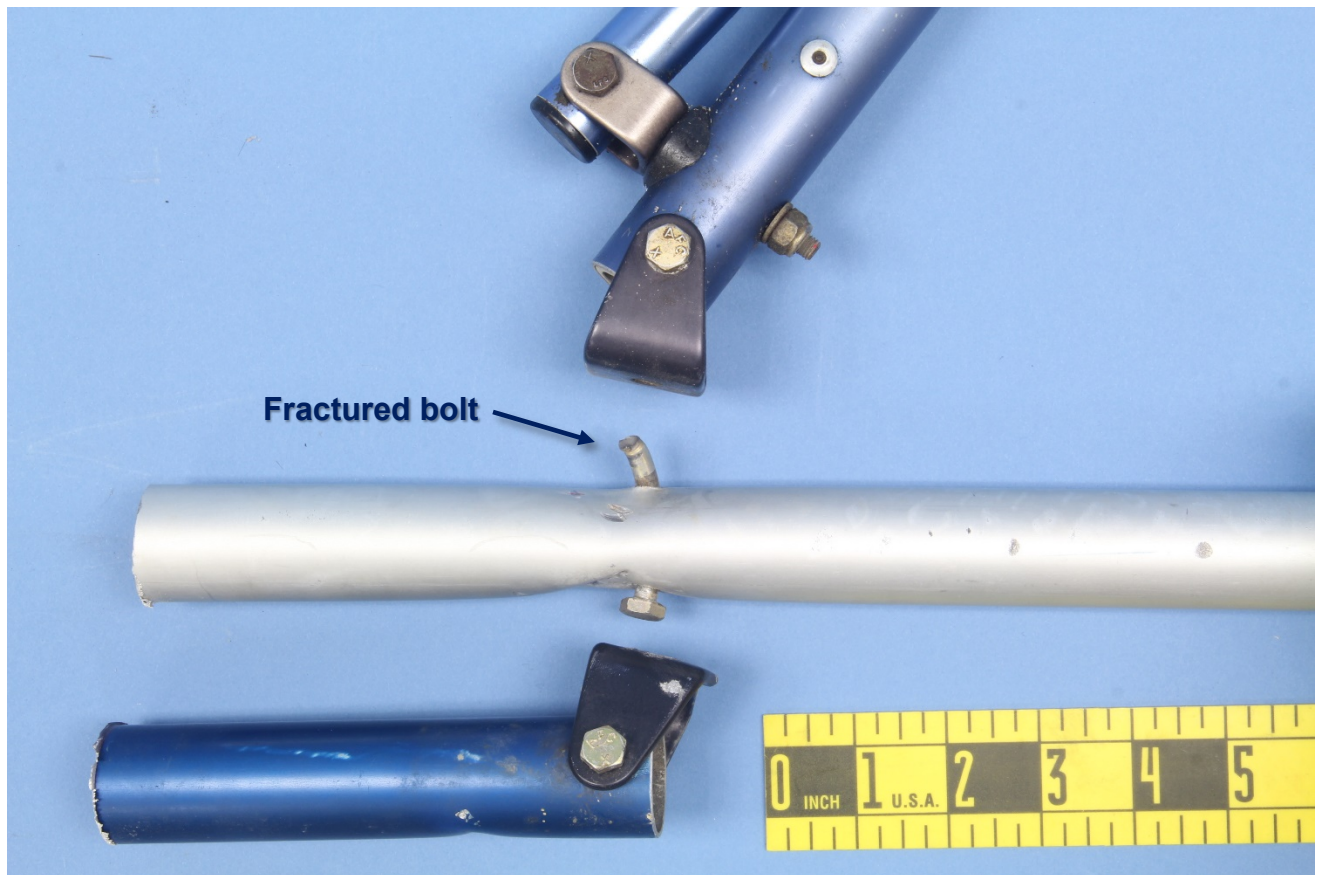


Figure 3 – Several of the sectioned components, repositioned to show the location of a fractured bolt (arrow).



Figure 4 – The sectioned support assembly from Figure 4, viewed from the side.



Figure 5 – View of a second bracket, showing the bolt hole.

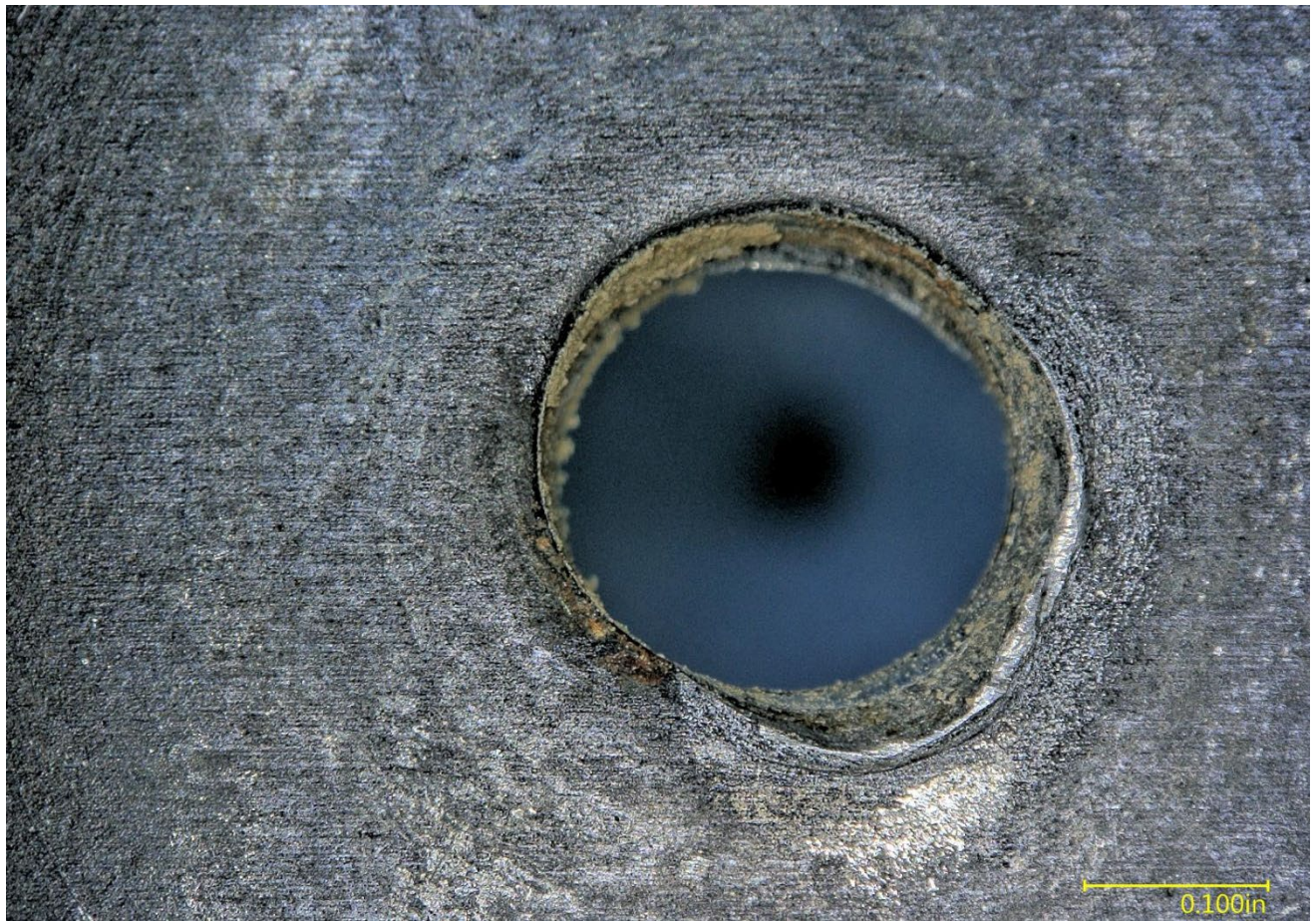


Figure 6 – Closer view of the bolt hole in the bracket in Figure 5, showing outward deformation (towards lower right in figure).

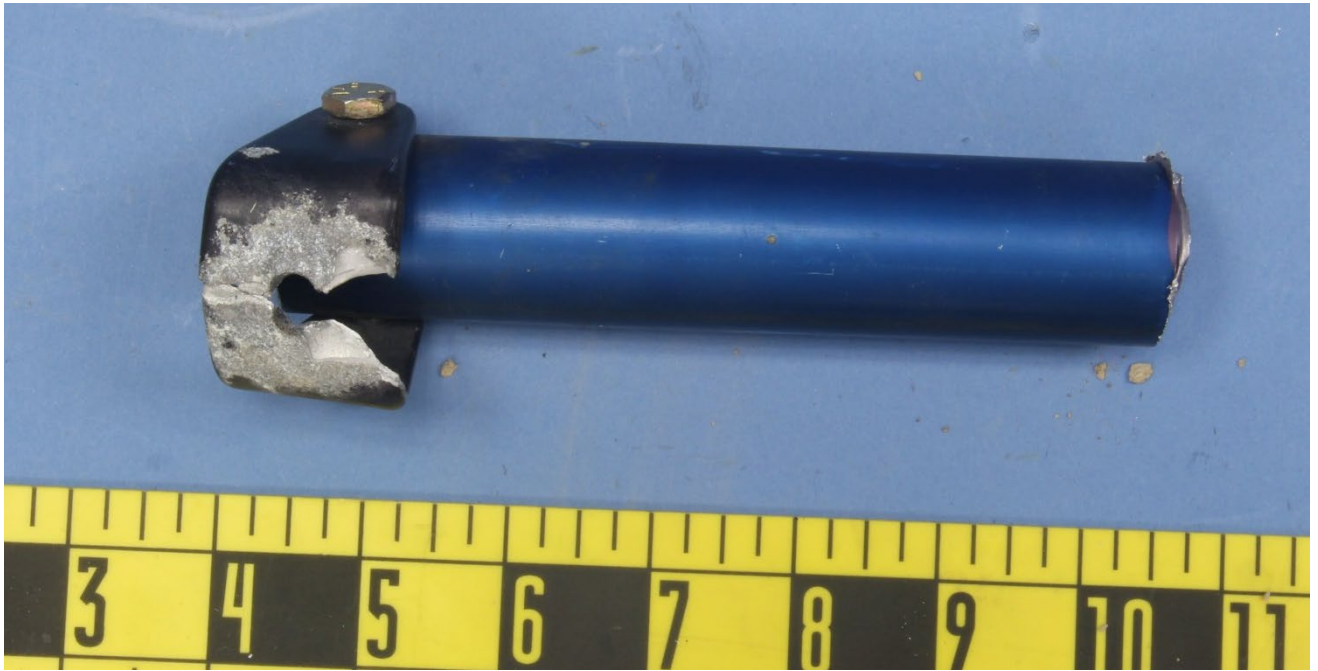


Figure 7 – Planar view of the fractured bracket attached to the sectioned support in Figure 7.

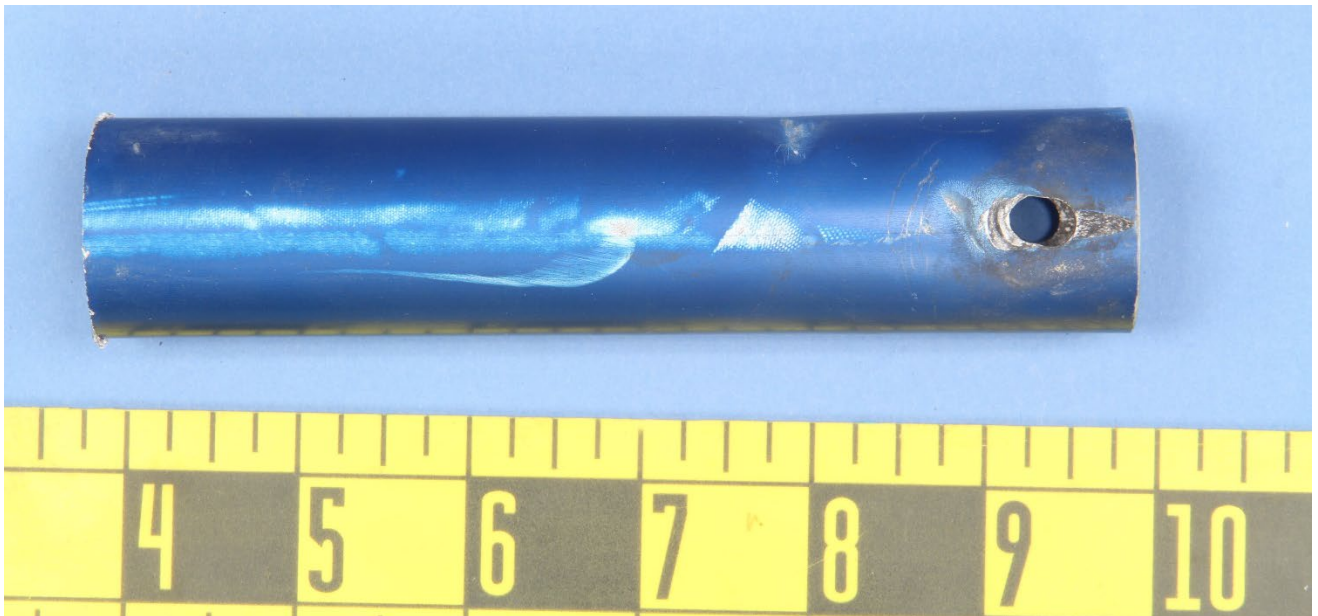


Figure 8 – View of a sectioned support, showing a bolt hole elongated in both directions along the longitudinal direction.



Figure 9 – View of one of the mating faces of the fractured bracket.

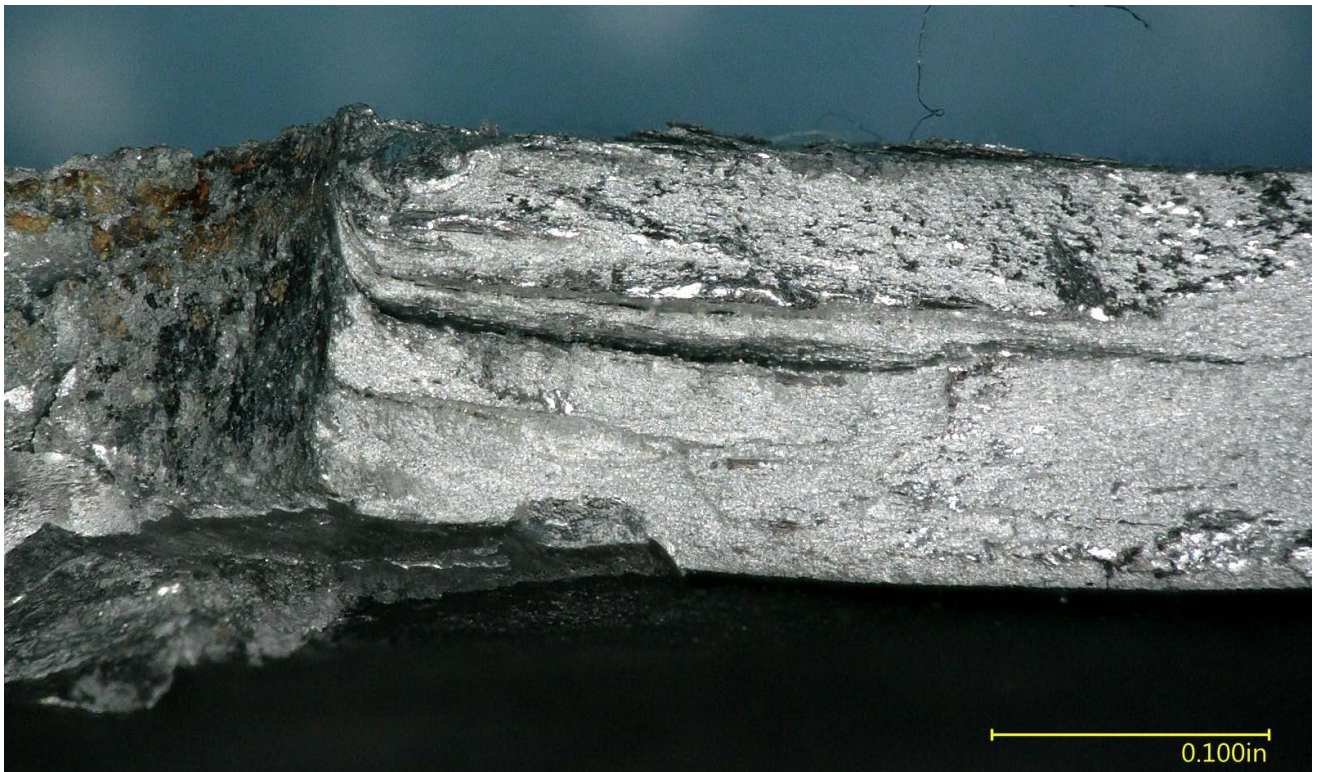


Figure 10 – View of part of the bracket fracture surface near the bolt hole, showing outward deformation.



Figure 11 – View of the mating bracket fracture surface opposite that shown in Figure 9.

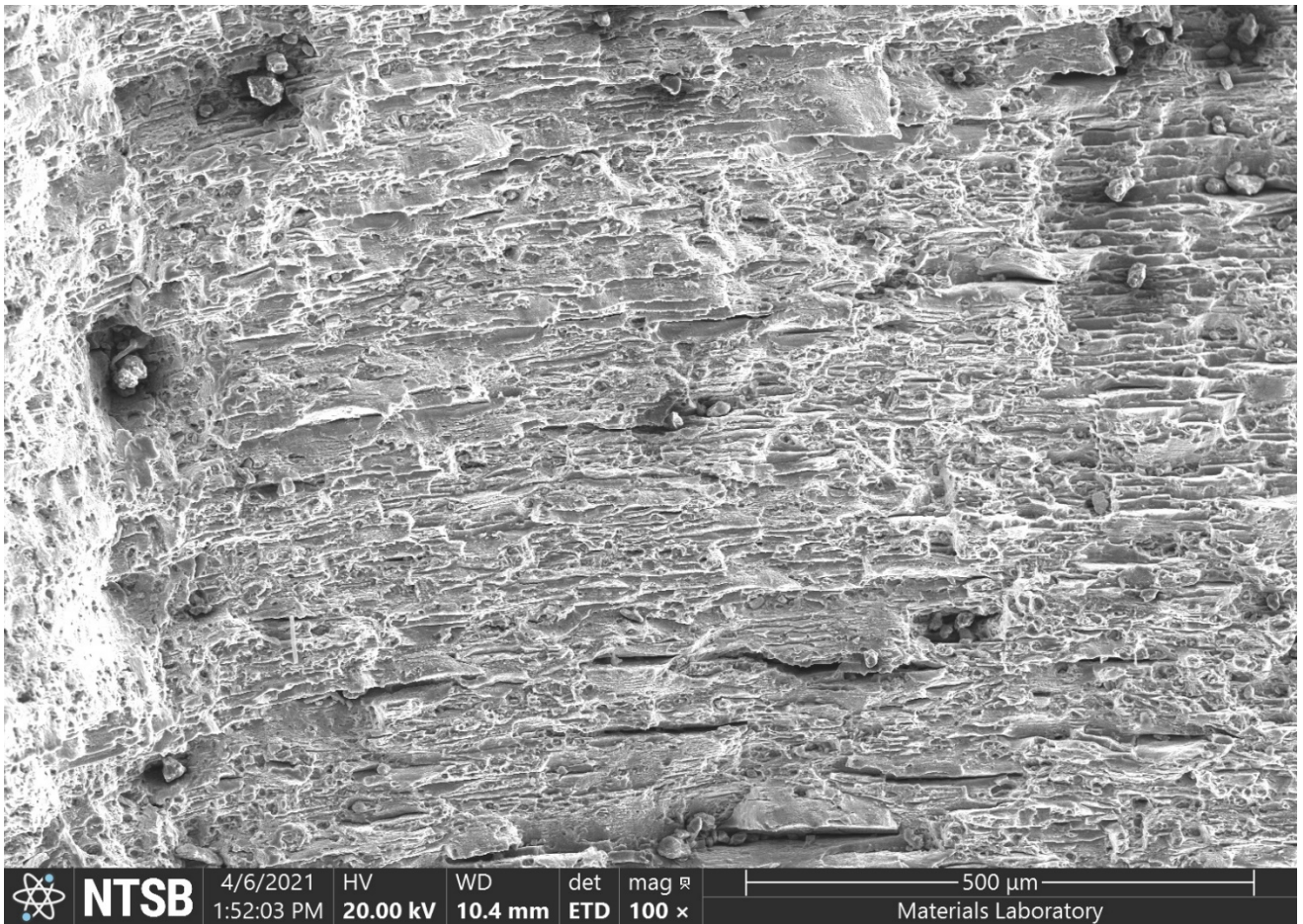


Figure 12 – Secondary electron (SE) micrograph of the bracket fracture surface.

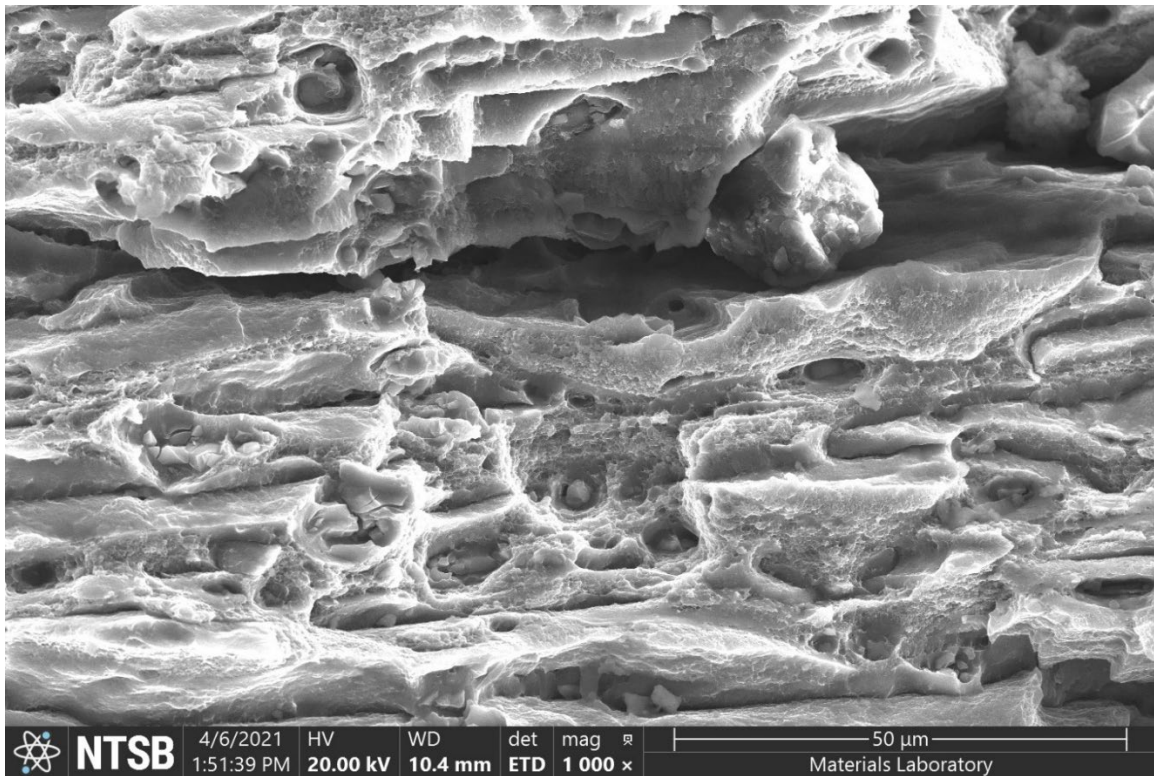


Figure 13 – SE micrograph of a closer view of the fracture surface in Figure 12, showing dimpled rupture.

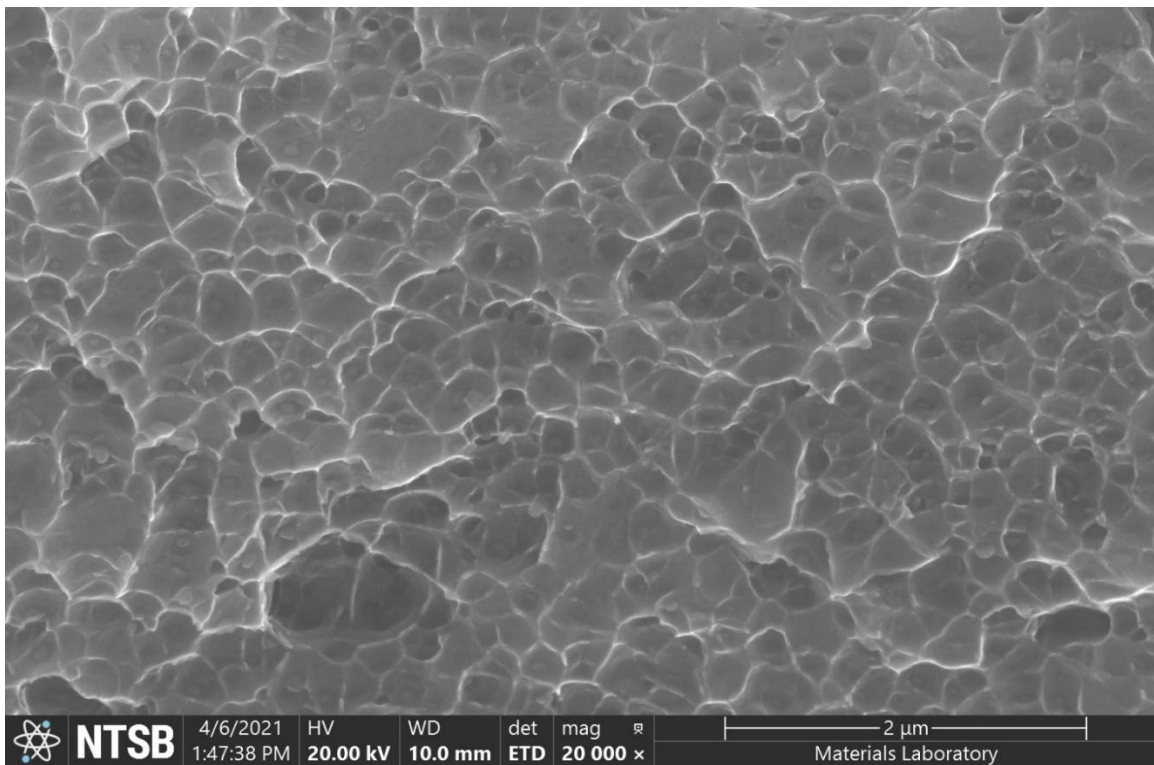


Figure 14 – SE micrograph of dimpled rupture on the fracture surface in Figure 13.



Figure 15 – View of the support section with the fracture bolt.

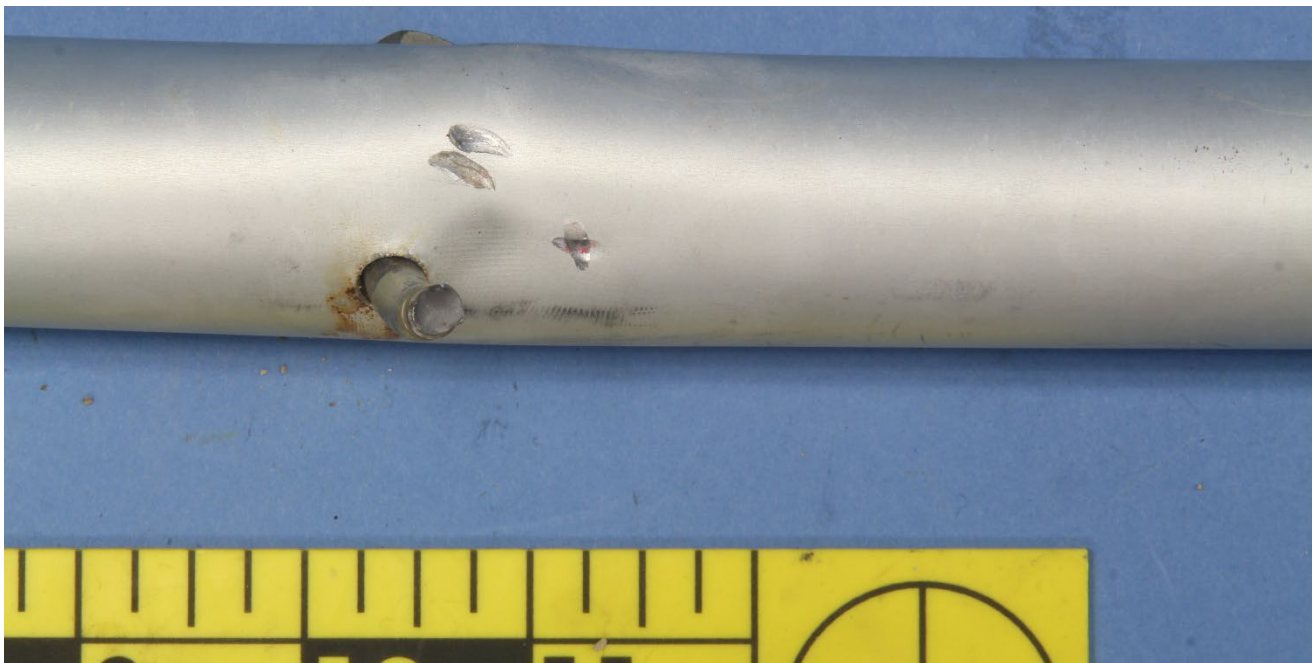


Figure 16 – Closer view of the sectioned support in Figure 15, showing the fracture surface of the bolt, and witness marks on the outer surface of the support.



Figure 17 – View of the fractured bolt, from the side.

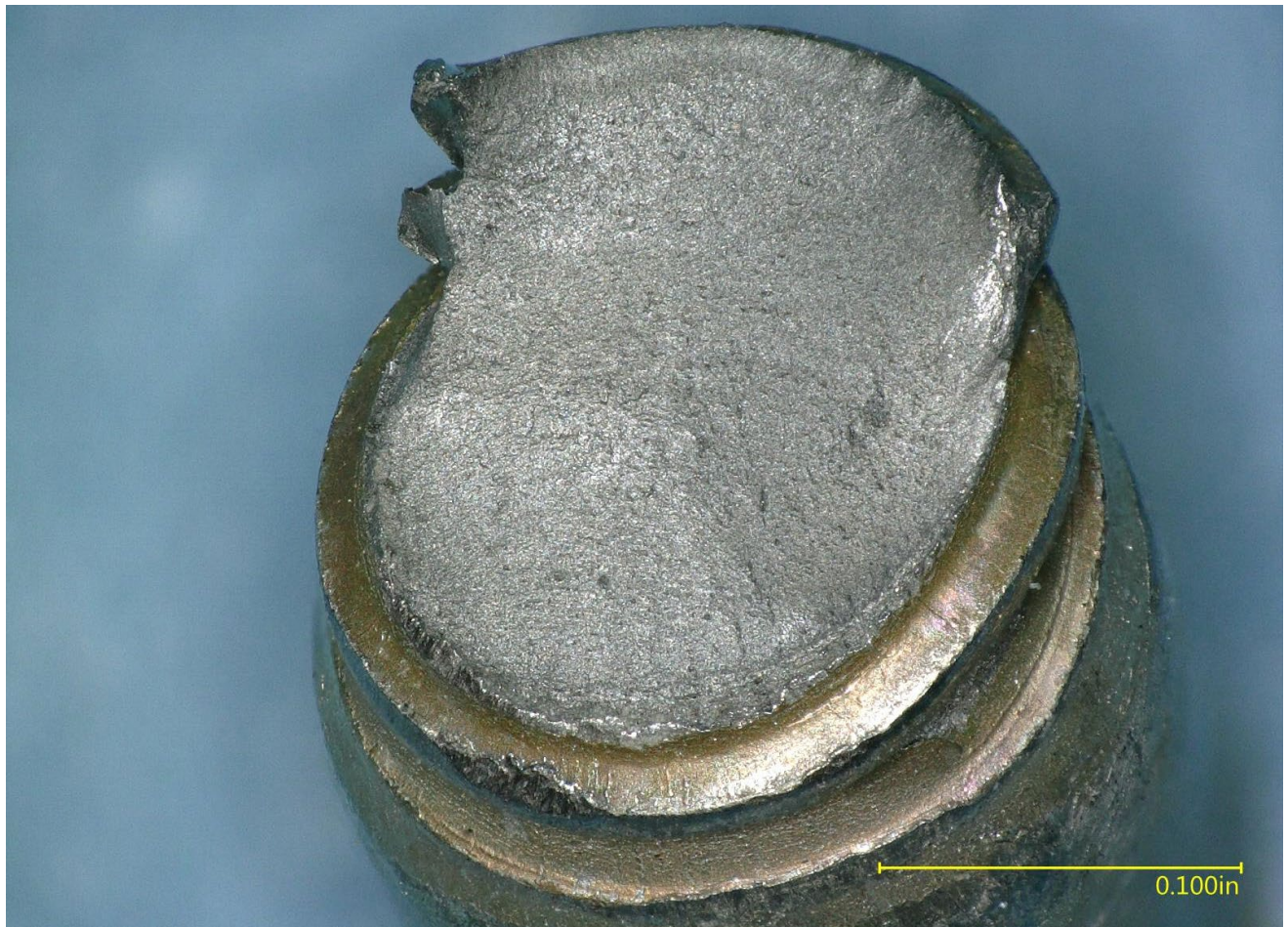


Figure 18 – The bolt fracture surface.

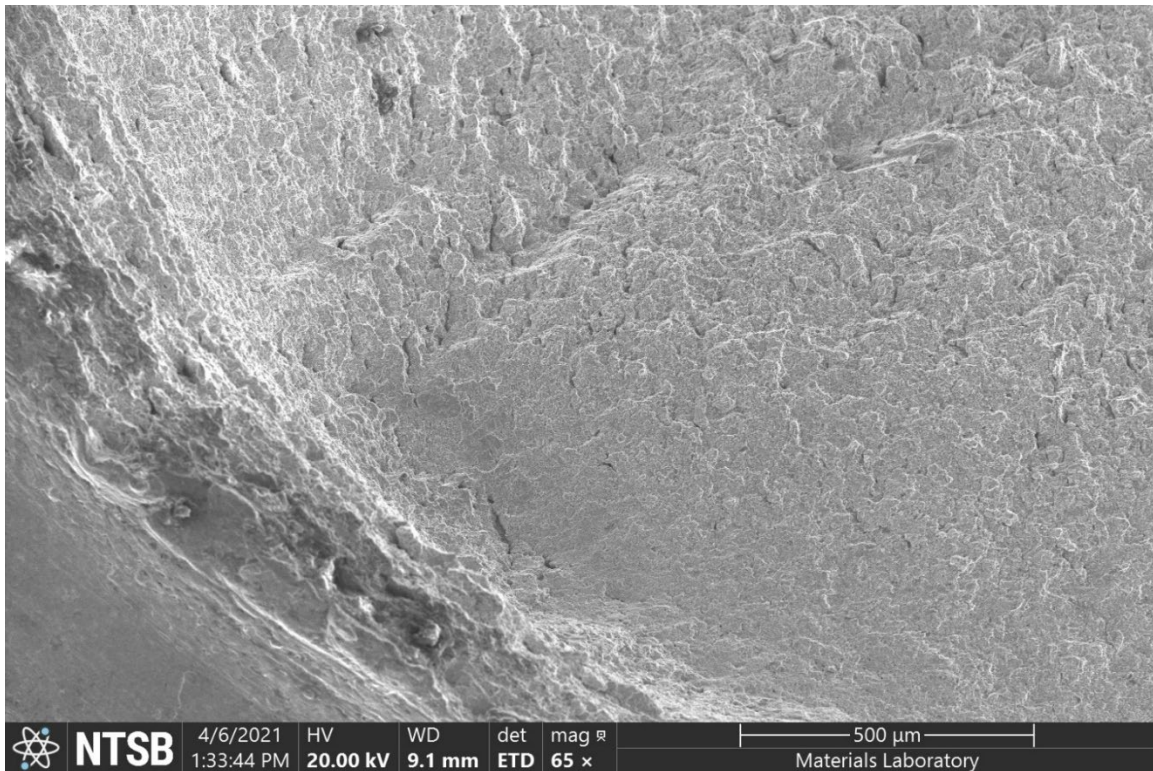


Figure 19 – SE micrograph of the fracture initiation area of the bolt fracture.

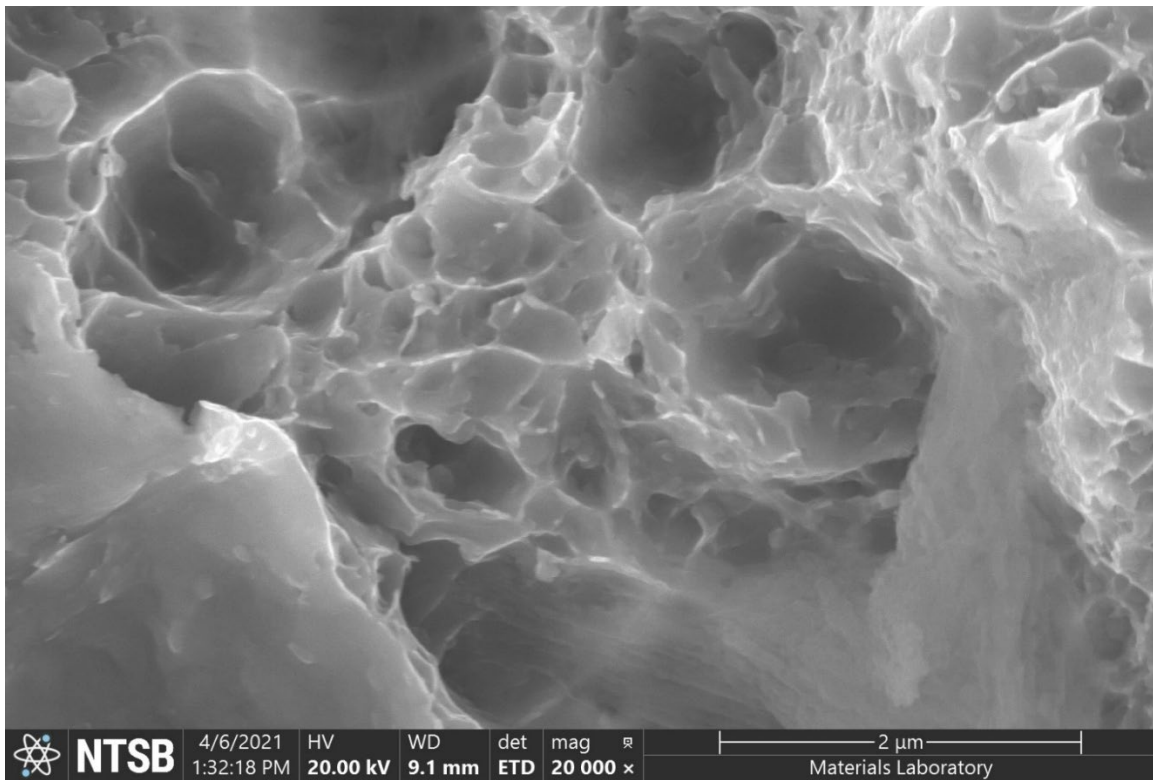


Figure 20 – SE micrograph of dimpled rupture near the initiation area of the bolt fracture.

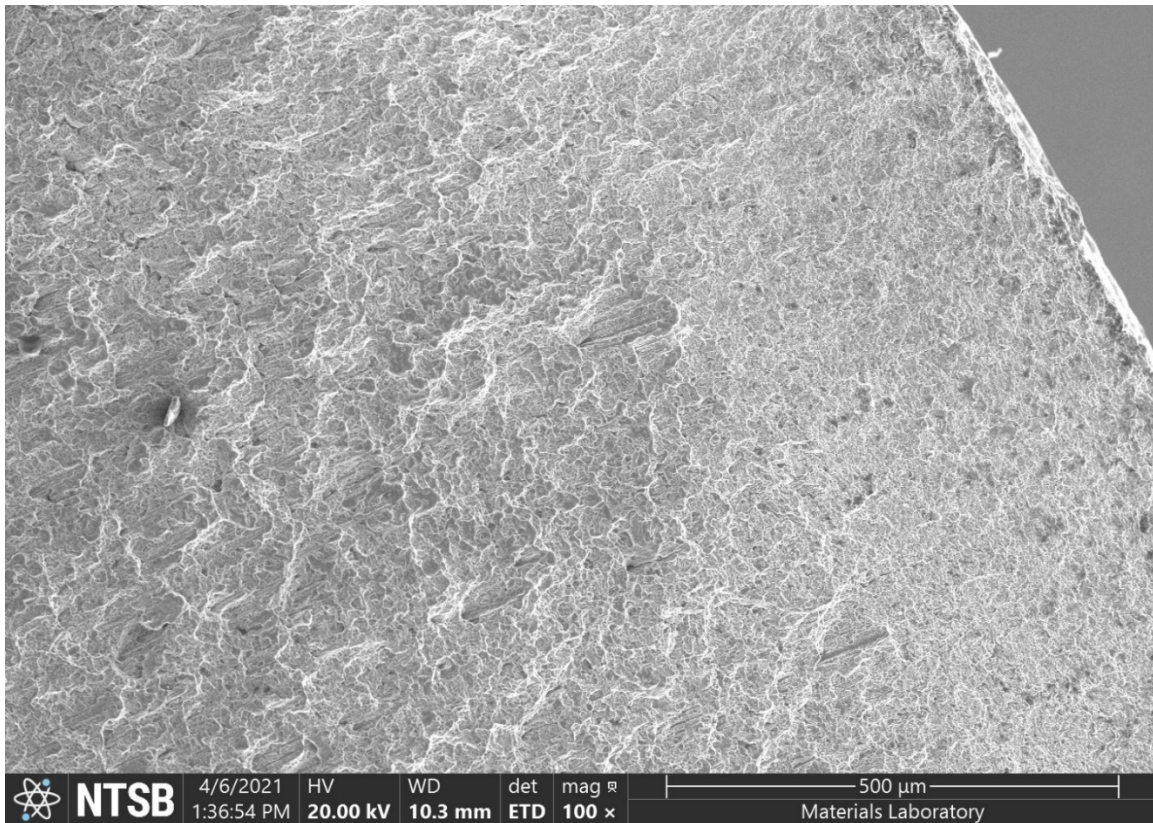


Figure 21 – SE micrograph of the opposite (terminal) side of the bolt fracture.

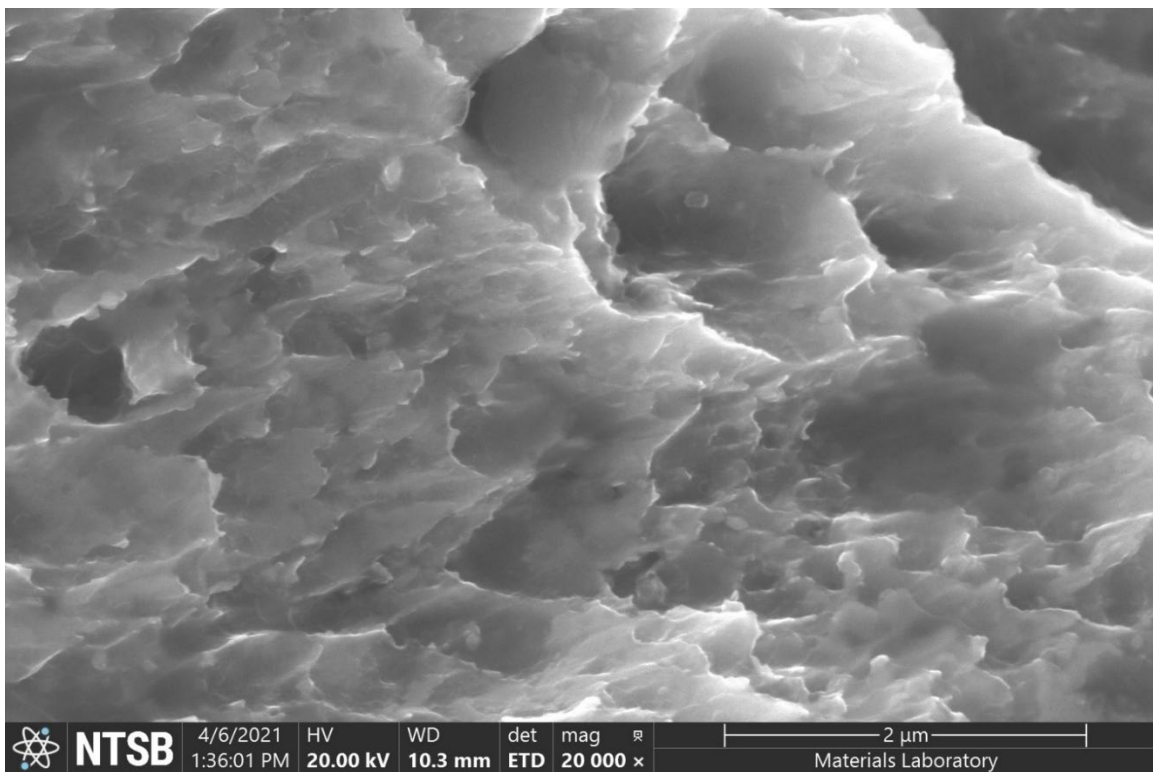


Figure 22 – SE micrograph of shear dimpled rupture from the area in Figure 21.