

NATIONAL TRANSPORTATION SAFETY BOARD

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



August 15, 2022

MATERIALS LABORATORY FACTUAL REPORT

Report No. 22-055

1. ACCIDENT INFORMATION

Place : Cornelia, Georgia
Date : November 29, 2021
Vehicle : Piper PA-46-500TP, N172MA
NTSB No. : ERA22LA079
Investigator : Robert Gretz, AS-ERA

2. COMPONENTS EXAMINED

Remnants of a nose landing gear trunnion

3. DETAILS OF THE EXAMINATION

On November 29, 2021, about 1447 eastern standard time, a Piper PA-46-500TP was substantially damaged when it was involved in an accident near Cornelia, GA. The airline transport pilot and two passengers sustained minor injuries. The pilot reported that during landing, after the nosewheel touched down, the airplane pulled to the left. The airplane departed the left side of the runway coming to rest upright in a grass area next to the runway. Examination of the wreckage by a Federal Aviation Administration inspector and a representative from the airframe manufacturer revealed that the left wing had separated from the airframe during impact with the ditch. Among other components, fractured sections of the lower nose gear trunnion were retained for further examination.

Figure 1 shows the remnants of the trunnion assembly, as received. The remnants consisted of two pieces of the trunnion cylinder, one of which was the cylindrical trunnion barrel that had fractured on each side, and a remnant of the slotted barrel edge and clamp. As demonstrated in Figure 2, the clamp remnant and slotted portion of the trunnion barrel mated at their respective fracture surfaces. The opposite side of the trunnion barrel also exhibited a fracture surface, as shown in Figure 3.

Figure 4 shows the circumferential portion of the fracture slotted side of the trunnion remnant, which mated to the slotted clamp remnant as demonstrated in Figure 2. The fracture proceeded around approximately half over the circumference of the trunnion barrel, with fractures running parallel to the trunnion barrel on opposite 180° locations. There were also indications of plastic deformation adjacent to several of the fracture

surfaces. The intact, but torn, portions of the trunnion edge had been deformed outward from the center of the part, as illustrated on the top and bottom of Figure 4.

All the fracture surfaces examined from the remnants submitted exhibited similar features. The fracture surfaces were rough in texture, exhibiting a dull luster. Their orientation was generally random, neither entirely parallel nor perpendicular to the longitudinal direction of the trunnion remnant.

Figure 5 shows a closer view of a typical area of the circumferential fracture of the trunnion. The fracture surface was angled overall, with the outer half being oriented closer to 90° or perpendicular to the barrel direction, while the inner portion was angled closer to 45°. In all areas, the surface exhibited a dull gray luster with a rough texture. There were areas that were more reflective, with transverse-oriented parallel streaks—these regions were consistent with post-fracture damage (such as smearing) with adjacent components.

Figures 6 and 7 show the opposite edges of the trunnion fracture surface, viewed from the smaller clamp remnant. Like the circumferential fracture surface, these surfaces exhibited dull lusters and rough textures. The edge fracture surfaces did not exhibit an overall orientation, but they were erratic in elevation and inclination. The areas adjacent to the fracture exhibited localized plastic deformation, distorted out-of-plane from the overall direction of the fractures. These features were consistent with overstress fracture of this portion of the trunnion.

Closer examination of the corners and edges of these fracture surfaces did not reveal any indications of dissimilar fracture modes. There were no features consistent with pre-existing cracks, voids, or deep mechanical wear marks such as gouges.

The opposite fracture surface of the trunnion remnant, shown in Figure 3, was examined closer. Unlike the fracture on the slotted edge, this fracture had proceeded around the entire circumference of the trunnion. As shown on opposite sides in Figures 1 and 2, this fracture was oriented in an angled direction, tapering to a point on one side, and undulating more on another side.

There was a portion of the opposite trunnion fracture surface that exhibited a relatively flatter orientation, as highlighted in Figure 8. This area exhibited river patterns and chevron marks emanating from it, consistent with this region being the start of this fracture surface. There were also a multitude of perpendicular linear ridge features adjacent to the outer edge of the fracture. Figure 9 shows a closer view of these features. The outer trunnion barrel had been partially deformed inward at each of these ridges, as shown in Figure 9 and Figure 10.

The fracture surface in Figure 8 was examined using a scanning electron microscope (SEM). One of the ridges along the outer edge of the fracture surface is shown in Figure 10. As mentioned above, the area of the ridge lip exhibited local plastic deformation inward, with the outer barrel surface machine marks bending inward.

A closer examination of a typical area of the trunnion fracture surface revealed dimpled rupture, consistent with ductile overstress fracture. One of the ridges was also examined, to determine if it exhibited distinct fracture features (see Figure 12). As shown in Figure 13, these areas exhibited dimpled rupture as well. There were no other fracture features observed consistent with other failure modes.

These features were consistent with the trunnion having fractured from overstress in tension and bending. There were no indications of pre-existing cracking or damage in these remnants of the trunnion.

The composition of the trunnion was examined using energy dispersive x-ray spectroscopy (EDS) and x-ray fluorescence (XRF). The chemical composition was consistent with a 2014-series aluminum alloy. The electrical conductivity was inspected per ASTM E1004 and averaged 36.1% IACS.¹ Based on AMS 2658, these data were consistent with a T6 or peak-aged temper for this class of alloys.² This temper is used to impart peak hardness and mechanical properties for this class of aluminum alloys.

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¹ ASTM E1004 – *Standard Test Method for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method*. ASTM International, West Conshohocken, PA

² AMS 2658 – *Hardness and Conductivity Inspection of Wrought Aluminum Alloy Parts*. SAE International, Warrendale, PA.



Figure 1 – View of the fractured remnants of the trunnion, as received.



Figure 2 – Side view of the trunnion remnants, aligned to show the orientation of the mating fracture surfaces on the slotted bore.

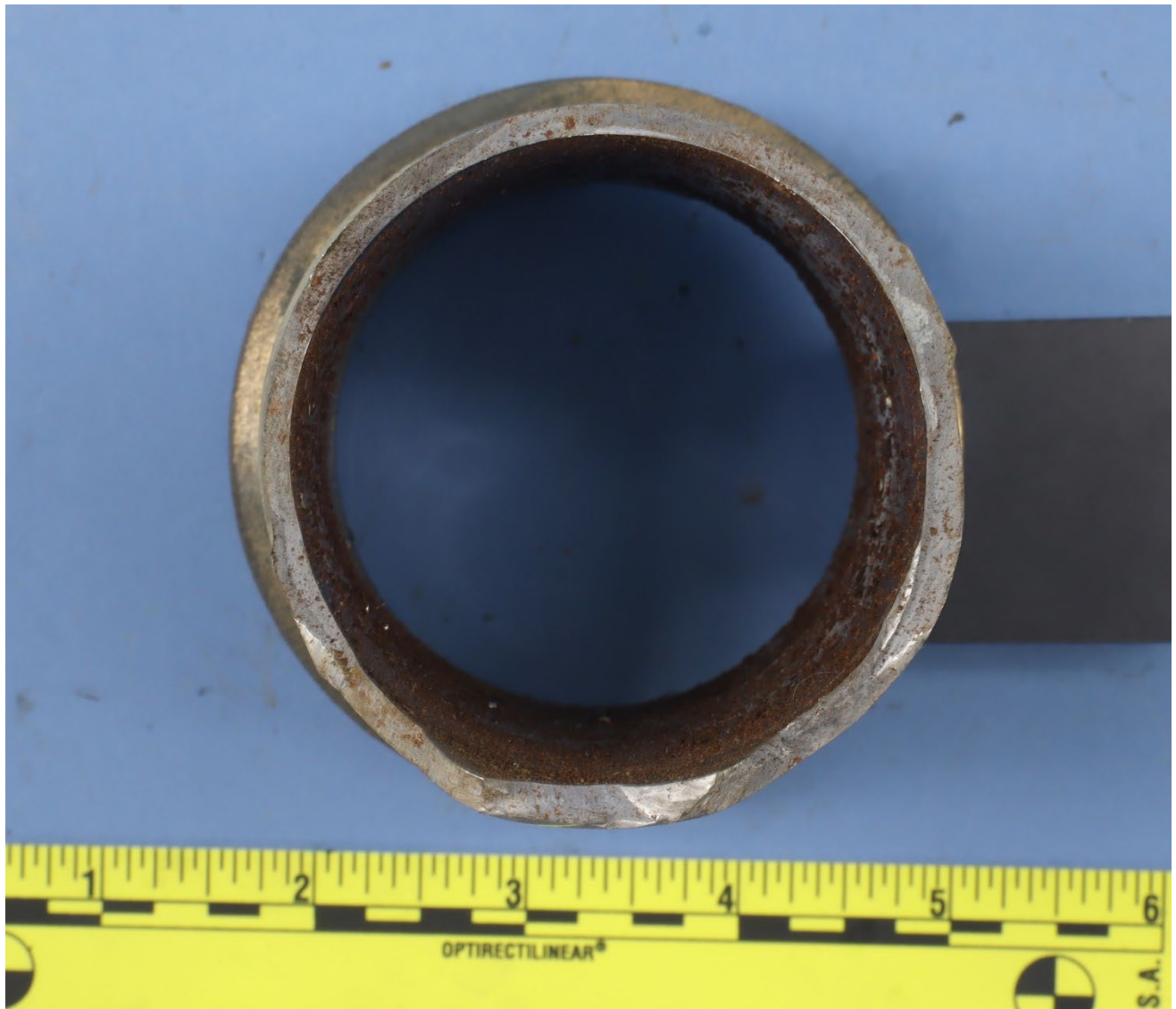


Figure 3 – View of the fracture surface from the trunnion bore, opposite side of the slotted fracture region.



Figure 4 – View of the fractured area along and around the slotted portion of the trunnion.



Figure 5 – Typical area of the trunnion circumferential barrel fracture.



Figure 6 – Montage of the one of the edges of the trunnion fracture surface along the slotted bore, viewed from the interior.



Figure 7 – Montage of the opposite edge of the slotted-side trunnion fracture.



Figure 8 – View of a section of the non-slotted fractured surface of the trunnion cylinder, showing repeating parallel features near the outside edge.

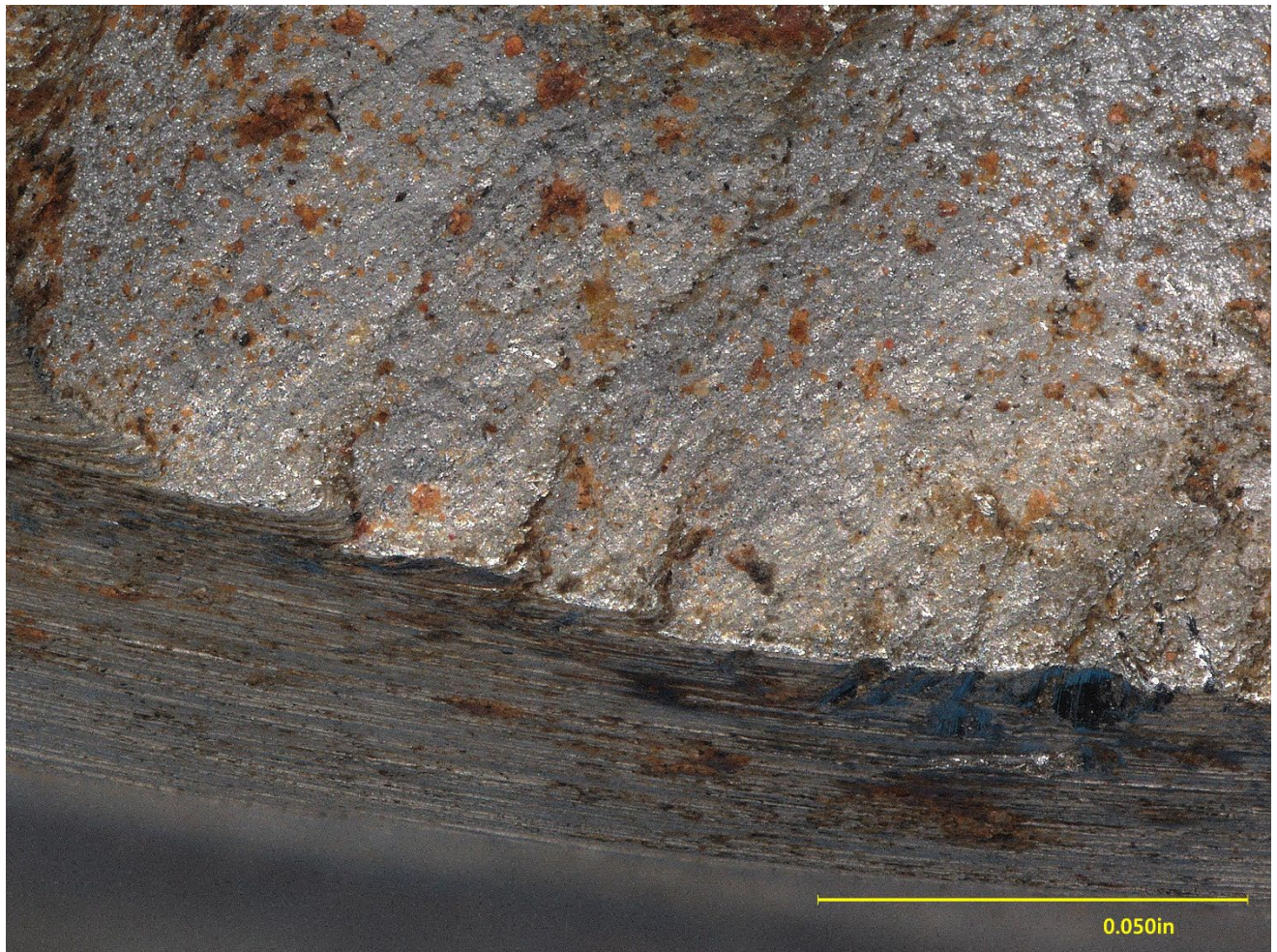


Figure 9 – Closer view of the outside edge in Figure 8, showing the parallel linear features.

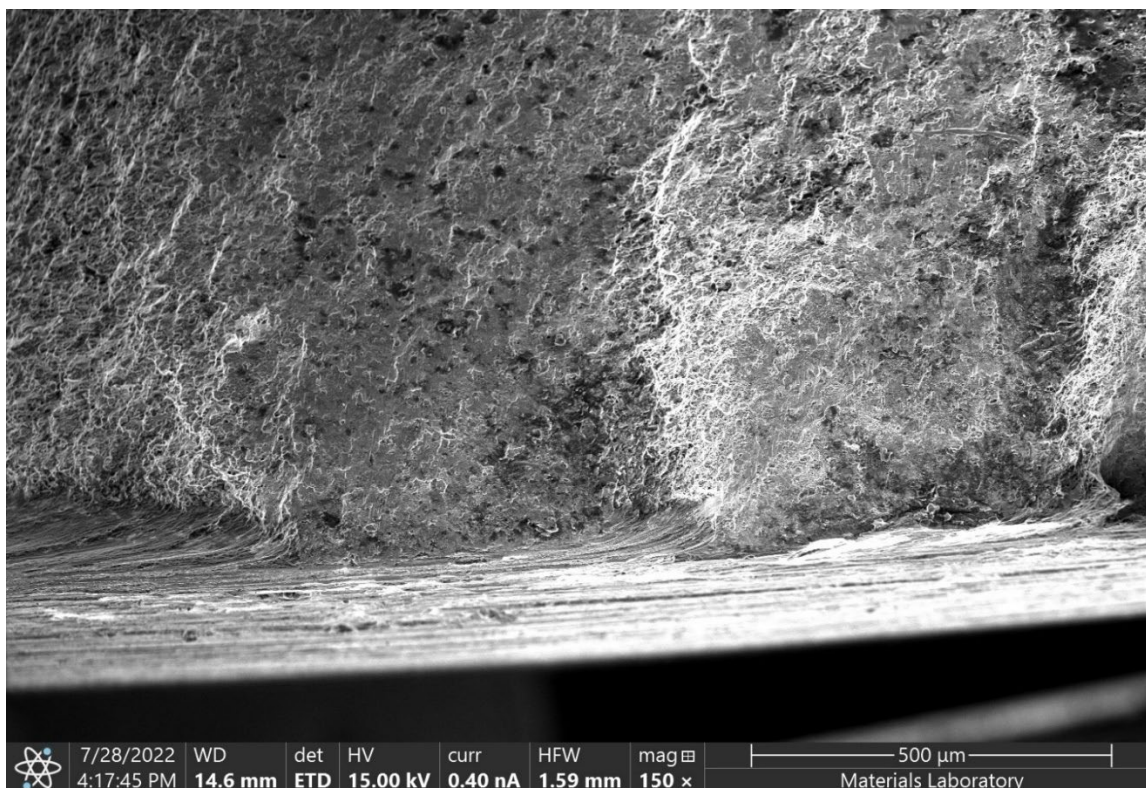


Figure 10 – Secondary electron (SE) micrograph of the outside trunnion edge in Figure 9, showing inward material deformation at the linear ridges.

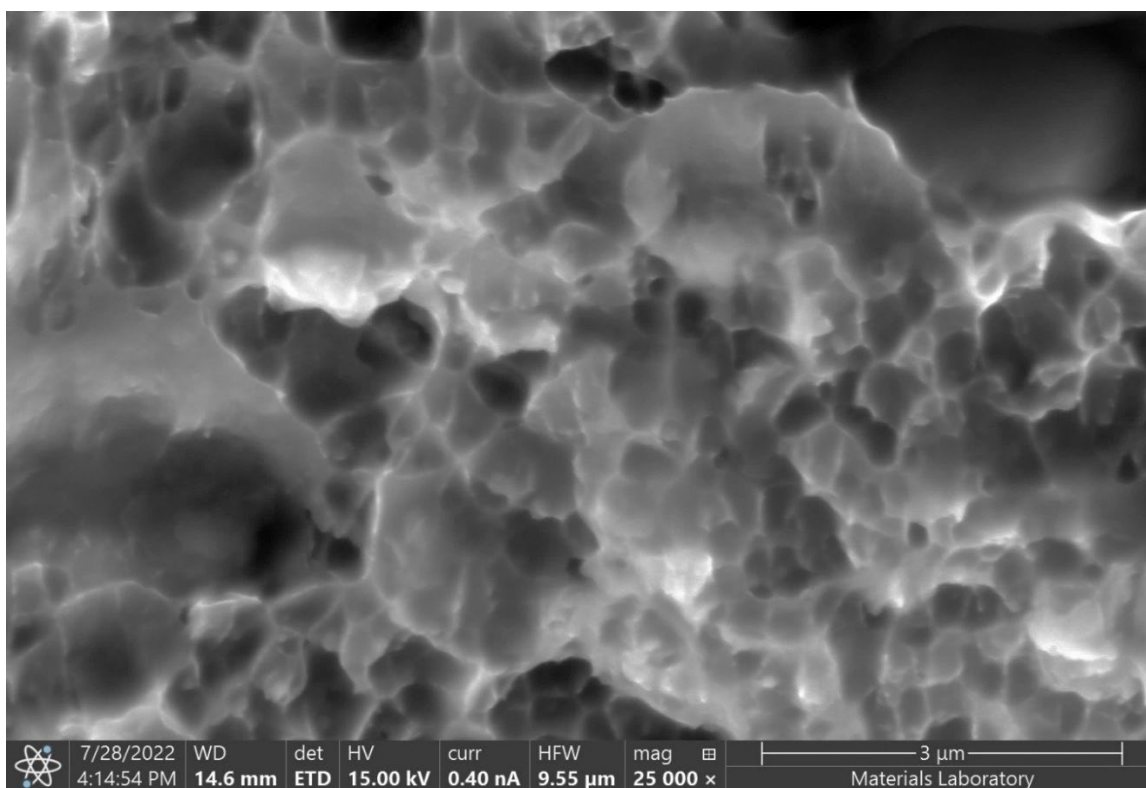


Figure 11 – SE micrograph of dimpled rupture near the edge in Figure 10.

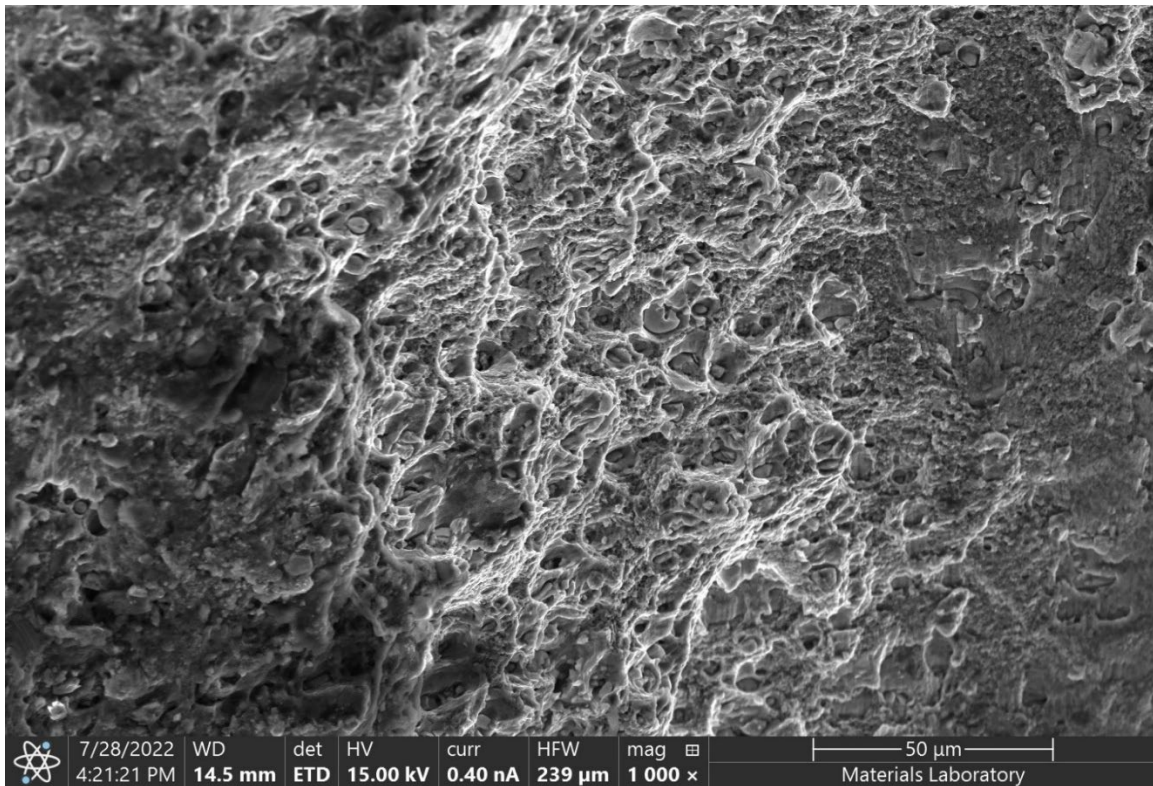


Figure 12 – SE micrograph of showing a closer view of one of the linear perpendicular features in Figure 10.

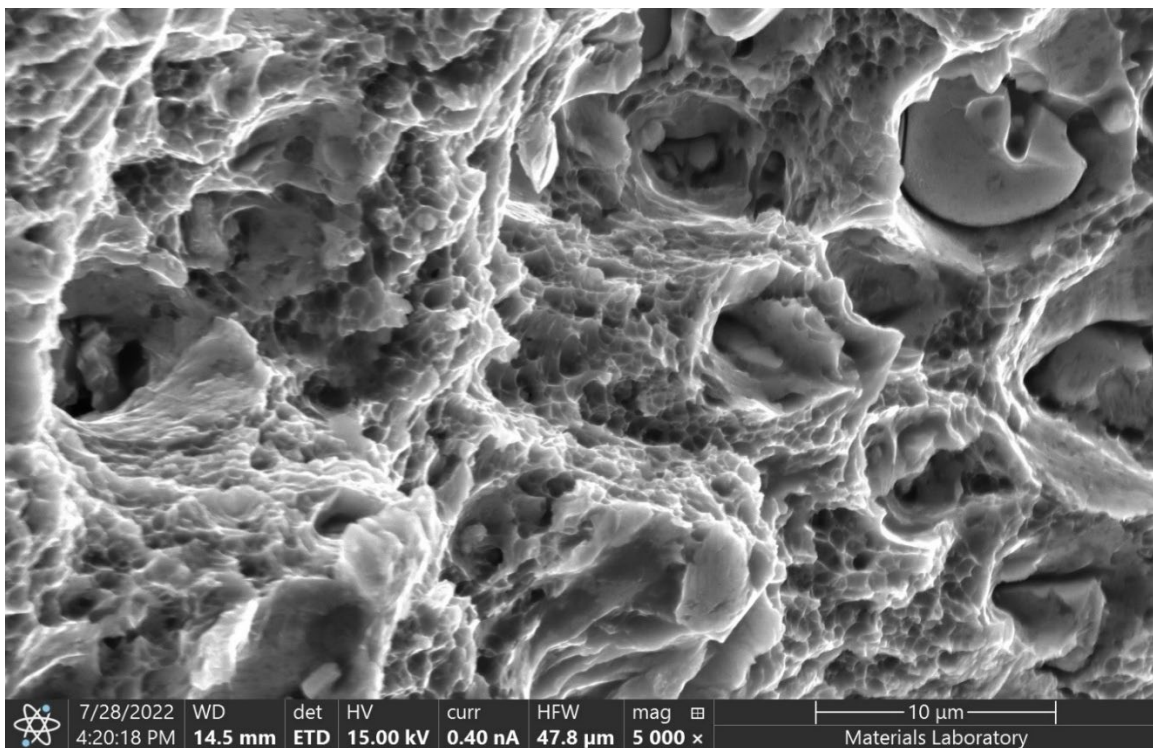


Figure 13 – SE micrograph of a closer view of dimpled rupture on the ridge in Figure 12.

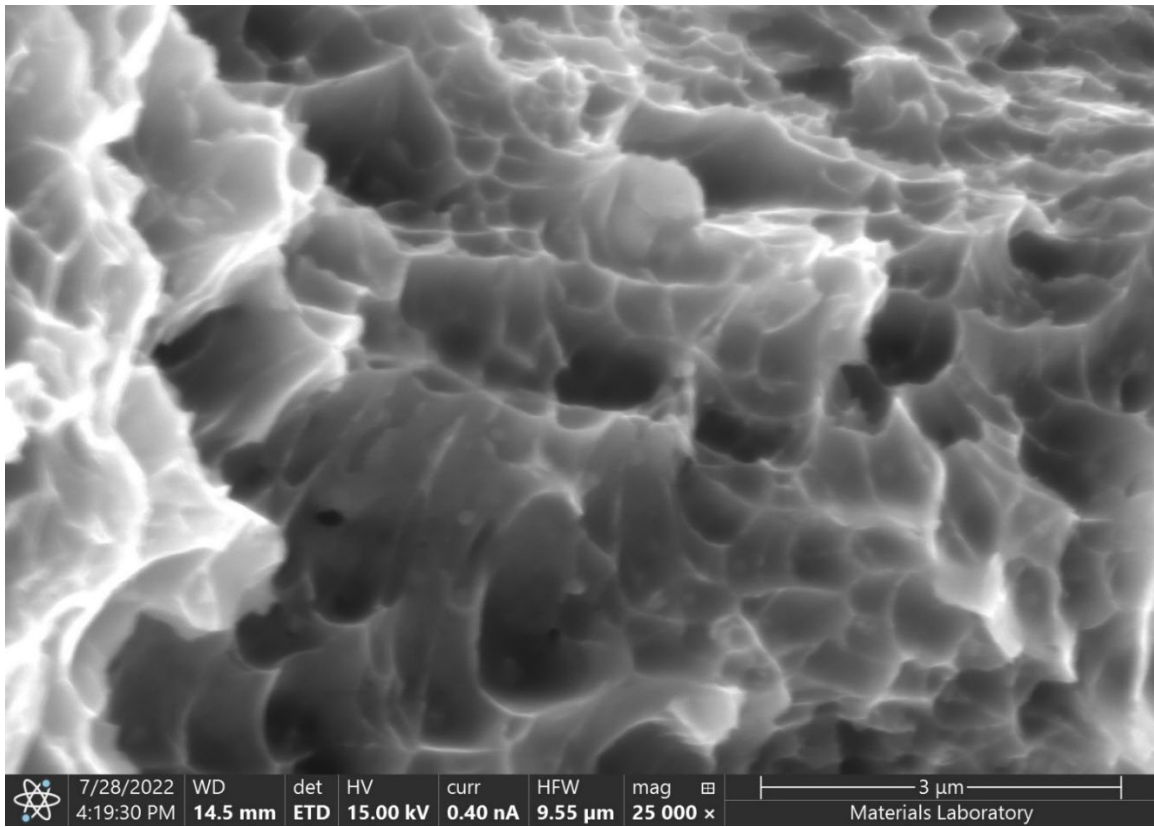


Figure 14 – SE micrograph of a closer view of dimpled rupture in Figure 13.