

NATIONAL TRANSPORTATION SAFETY BOARD

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



September 1, 2020

MATERIALS LABORATORY FACTUAL REPORT

Report No. 20-041

1. ACCIDENT INFORMATION

Place : Ambler, Alaska
Date : May 31, 2020
Vehicle : Zenith STOL CH-701, N324WS
NTSB No. : ANC20LA053
Investigator : Noreen Price, AS-ANC

2. COMPONENTS EXAMINED

Pieces of a nose wheel fork

3. DETAILS OF THE EXAMINATION

On May 31, 2020, about 1233 Alaska daylight time, an amateur-built Zenith CH-701 airplane was substantially damaged when it was involved in an accident near Ambler, AK. The sport pilot and passenger were not injured. According to the pilot, during takeoff the airplane hit a bump and "leaped into the air." The airplane then descended, and once the nose gear touched down, it collapsed. After the accident, the pilot observed that the nose wheel fork had separated from the nose strut at fractures on both sides of the nose strut attachment. There was no damage evident on the strut or the firewall. The nose wheel fork was removed and sent to the NTSB Materials Laboratory for examination.

Figure 1 through Figure 3 show the pieces of the fractured nose wheel fork, as received. The component had fractured into three fragments at two fracture locations. The fracture locations were located at or near the four attachment bolt holes. The fractures were both oriented perpendicular to the longitudinal rolling, or forging, direction of the fork.

The interior, or concave, surfaces exhibited some circular wear marks, located on both tangs (see Figure 1 and Figure 3). These marks contained alternating dark streaks, consistent with rubber residue from the adjacent tire, and reflective metallic marks, consistent with gouges in the concave surfaces of the fork. These features were consistent with heavy contact from the adjacent wheel.

Figure 2 and Figure 4 demonstrate the relative positions of the fractured fork pieces at the time of fracture. The fracture surfaces were located just outside the darker square area seen in Figure 4. This area was consistent with residue from environmental exposure

(i.e. entrapped water) where the mating attachment fitting would have been fastened. No indications of macroscopic wear damage were observed adjacent to this darker region.

The mating fracture surfaces from the left side of Figure 1 are shown in Figure 5 (a and b), and the mating fracture surfaces from the right fracture in Figure 1 are shown in Figure 6 (a and b). Both mating fracture surfaces exhibited high surface roughness, with visible peaks and valleys present on both sides. The fractures were generally dull in luster, with a fibrous morphology. There was evidence of secondary cracking, oriented perpendicular to the main fracture surfaces, but parallel to the expected rolling direction of the fork. The right fracture exhibited a slanted orientation, whereas the left fracture showed a cup-shaped orientation on one side (Figure 5b) and a cone-shaped orientation on the other (Figure 5a).

The outer surfaces adjacent to the fracture surfaces in Figure 4 exhibited material exuding outward, with some outward lip-like deformation features. In contrast, the material adjacent to the fracture surfaces on the inside concave surface in Figure 3 did not exhibit any outward deformed material. Instead, some smaller cracks were observed next to the fracture surface, oriented parallel to the fractures. These features were consistent with upward bending of the two tangs of the downward-facing wheel fork.

Figure 7 shows a closer view of the fracture surface located through one of the bolt holes. The fracture surface contrasted duller in luster against the reflective machined bolt hole bore. The dull, fibrous fracture surface features were consistent along the surface examined, including the fracture surface regions adjacent to the bolt hole in Figure 7. There were no indications of pre-existing cracks, wear marks, or corrosion along the fracture surface edge at the bolt hole.

This fracture surface was cleaned using acetone and examined using optical and scanning electron microscopes (SEM). Figure 8 shows a typical area of the fracture surface, showing a rough surface with dull, fibrous features. Although not obvious in Figure 8, when examined using a SEM, much of the fracture surface was rounded and smoothed, consistent with post-fracture damage. Figure 9 shows a typical area of the undamaged portions of the fracture surface. This figure demonstrates dimpled rupture, consistent with overstress fracture. Full examination of the fracture surface in Figure 6a found no other features consistent with other fracture modes.

All these combined fracture features were consistent with overstress fracture in upward bending of the nose wheel fork.

The chemical composition of the middle fork fragment was examined using x-ray fluorescence (XRF) and energy dispersive x-ray spectroscopy (EDS). From the data obtained using these techniques, the fork was found to be consistent with AA 6061 aluminum alloy. The electrical conductivity was examined per ASTM E1004.¹ The

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

conductivity averaged 46.3 %IACS. The hardness was inspected per ASTM E18.² The hardness averaged 50 HRBW. Per AMS 2658, these data were consistent with an AA 6061 alloy in a T6 temper.^{3,4}

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² ASTM E18 – *Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*. ASTM International, West Conshohocken, PA.

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

⁴ AA 6061 is a common aluminum alloy strengthened by precipitation hardening from Mg and Si alloying elements. The T6 temper is the heat treatment prescribed for solutioning and then peak aging.

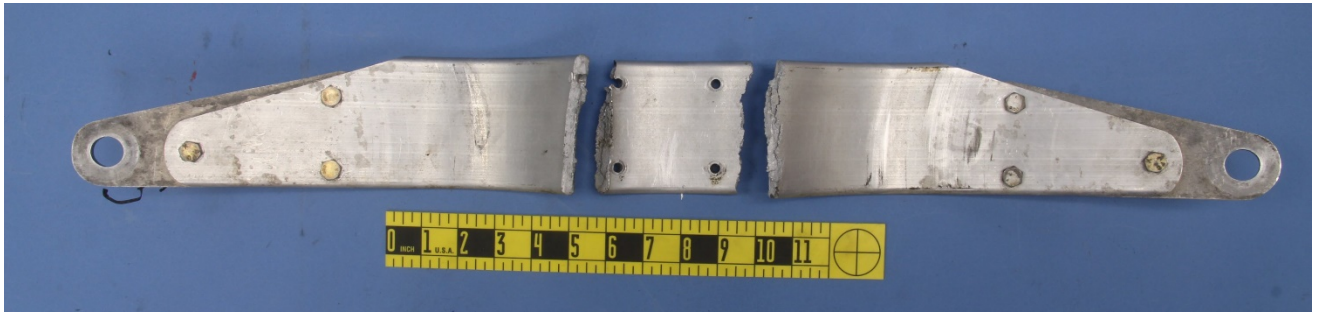


Figure 1 – The three fork pieces, as received, viewed from the bottom surface upward, laid flat.



Figure 2 – The three fractured fork pieces, positioned in their locations at fracture, viewed from the side.

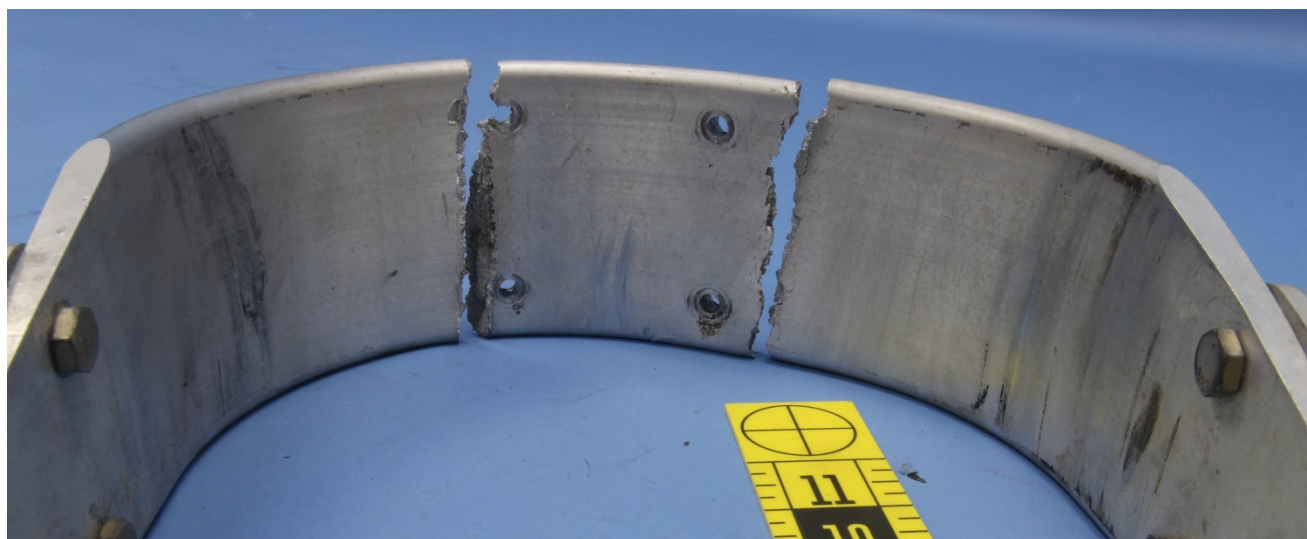


Figure 3 – Closer view of the two fractures of the fork pieces, viewed from the inner (concave) surface.

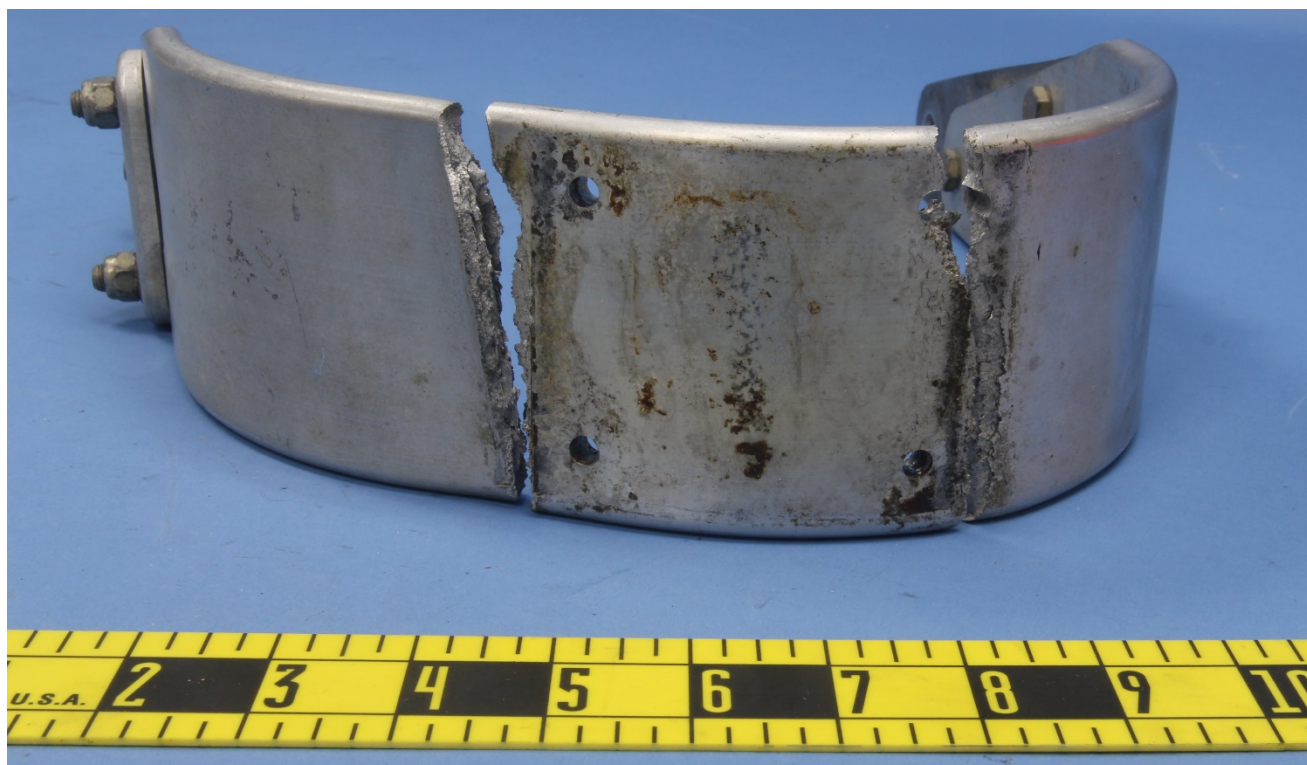


Figure 4 – Closer view of the two fractures of the fork pieces, viewed from the outer (convex) surface.

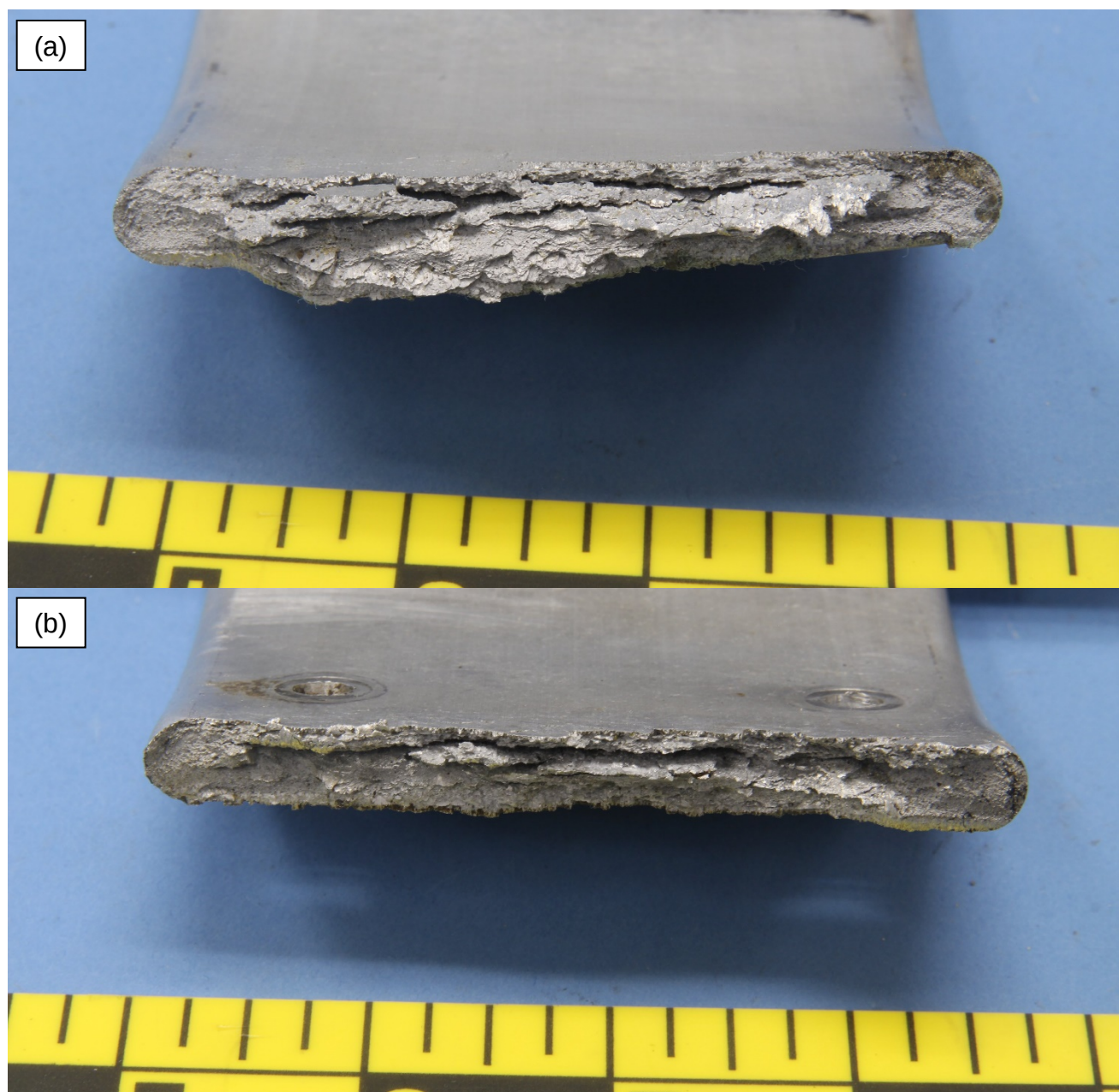


Figure 5 – The mating right side fractures from Figure 1 through 3, showing the (a) outer right piece fracture surface and (b) the right fracture surface of the middle piece.



Figure 6 – The mating left side fractures from Figure 1 through 3, showing the (a) the left fracture surface of the middle piece and (b) outer left piece fracture surface.



Figure 7 – A closer view of the fracture surface features around the bolt hole in Figure 6a.

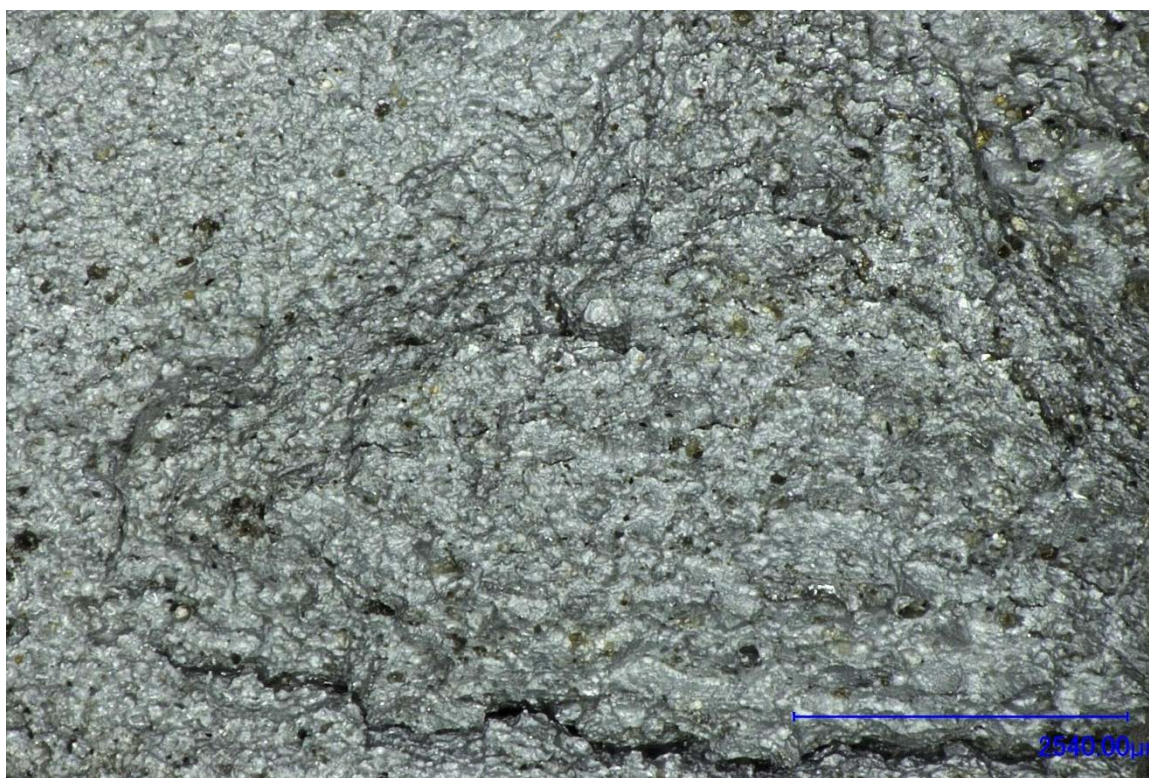


Figure 8 – Closer view of the fracture surface in Figure 7.

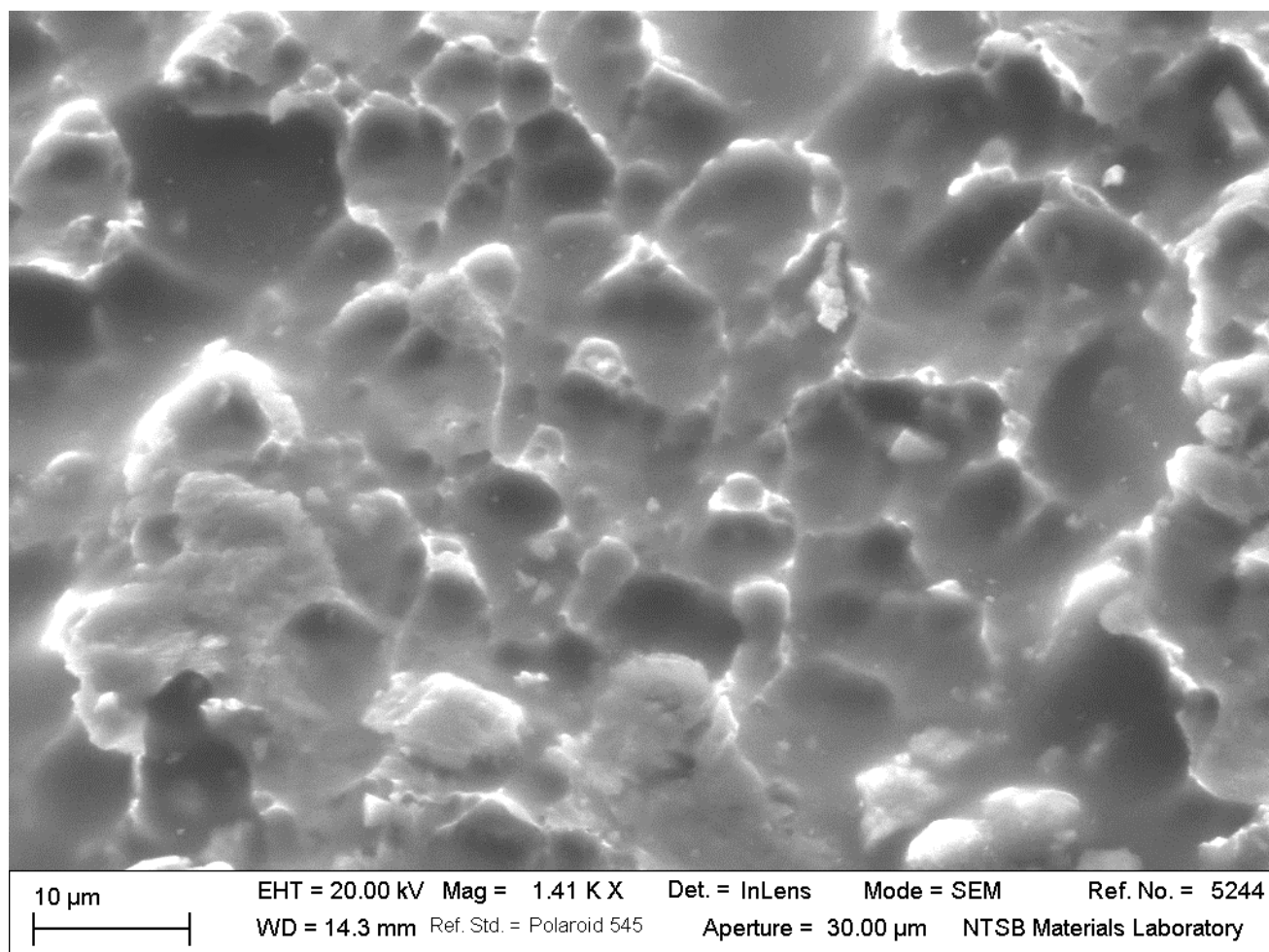


Figure 9 – Secondary electron micrograph of a typical area of the fracture surface in Figure 8, showing dimpled rupture.