

NATIONAL TRANSPORTATION SAFETY BOARD

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



April 14, 2021

MATERIALS LABORATORY FACTUAL REPORT

Report No. 21-016

1. ACCIDENT INFORMATION

Place : Welsh, Louisiana
Date : July 2, 2020
Vehicle : Robinson R44, N7511D
NTSB No. : CEN20LA286
Investigator : Courtney Liedler, AS-CEN

2. COMPONENTS EXAMINED

Remnant of an oil suction screen
Mixed debris
Oil filter remnants

3. DETAILS OF THE EXAMINATION

On July 2, 2020, about 1000 central daylight time, a Robinson R44 helicopter was substantially damaged when it was involved in an accident in Welsh, LA. The pilot was not injured. According to the pilot, the helicopter had about 9 hours of flight time since the last exam on June 1, 2020. During the flight, the helicopter began to lose power. The pilot made the decision to land the helicopter, but it impacted the ground and came to rest on its left side, sustaining substantial damage to the tail rotor drive shaft and tail boom. Several components from the accident aircraft were sent the NTSB Materials Laboratory for examination.

This report concerns a filter, debris, and an oil suction filter recovered from the aircraft. A separate Materials Laboratory examination was performed on the camshaft and tappet bodies, detailed in *Materials Laboratory Factual Report 20-011*.

Figure 1 and Figure 2 show the accordion-style oil filter, as received. The filter was in two separate remnants, one approximately 8 inches long, and the other approximately 14 inches long when resting without stretching, as depicted in the figures. Both remnants were still saturated with oil. The ends of the remnants exhibited tears or fractures, as illustrated in Figure 2.

Figure 3 shows some of the particles of debris submitted in a separate paper filter. These particles exhibited an oily appearance as received, and they were cleaned in

acetone using an ultrasonic bath. After cleaning, there were two general categories of particles—those that appeared dark visually, as shown in Figure 3, and those that appeared light in appearance.

These cleaned particles were examined using a scanning electron microscope (SEM) with an energy dispersive x-ray spectroscopy (EDS) detector. Figure 4 shows a SEM micrograph of a typical area of the particles that exhibited the dark visual appearance. For the most part, these particles exhibited charging electron effects consistent with non-conductive (i.e., nonmetallic) materials. The particles exhibited sharp, jagged facets, and were relatively uniform in backscattered contrast.¹

Examination of these particles using EDS found them to contain mostly carbon and oxygen, consistent with either organic compounds or combustion products. These particles did exhibit minor amounts of lead, bromine, and sulfur, consistent with combustion products from avgas containing tetraethyllead additives.

Figure 5 shows a typical backscattered image of the visually lighter particles. These particles contrasted in the backscattered view, consistent with different chemical compositions. These particles were often of different sizes, with rounded edges.

The lightest contrast particles were found to be consistent with tetraethyllead combustion products, exhibiting high levels of lead and bromine when examined using EDS. The flat, darker particles exhibited high levels of aluminum, with minor amounts of magnesium, iron, and chromium. This was consistent with commercial aluminum alloys. The larger, lighter gray particles were mostly copper, with minor amounts of aluminum, manganese, and iron. This was consistent with a copper alloy.

Figure 6 shows the oil suction screen, as received. This screen was cleaned using acetone in an ultrasonic bath to remove the oil residues on the surface. The screen consisted of a perforated cylindrical tube, with small concave webs of interconnected material. As can be seen in Figure 7 and Figure 8, the clusters of webs had fractured 0.5 inches from both ends. There were also areas with missing material, as exemplified in Figure 8.

Figure 8 shows some of the fractured webs, as well as a series of intact ones. Some of the fractured webs exhibited areas of localized deformation or necking adjacent to their fractures. Others, though, exhibited a flatter or jagged fracture appearance. As shown in this figure and highlighted in Figure 10, many of the webs and material near the circular holes exhibited areas of thinning consistent with eroded material.

The screen was examined using a SEM. As typified in Figure 11, many of the intact webs of the screen exhibited a concave morphology in their width, and they were relatively

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.

uniform in thickness. Common on this surface and all the exposed surfaces of the screen material was a faceted crystal grain-like or etched appearance, showing a surface texture consistent with those typical of equiaxed grains.

Figure 12 shows one of the fractured screen webs. This figure shows an area that had thinned, both in thickness and width, with the fractured surfaces rolling upward and backward. A closer view shown in Figure 14, illustrates that this web remnant had thinned to just a few micrometers. The grain-like surface appearance was visible on both faces of the screen material.

Figure 13 demonstrates the extent of the thinning at one of the fractured webs. Whereas the thickest regions were 50 to 70 μm , the thinnest area adjacent to the fracture surface was just a few micrometers in dimension.

Similarly, Figure 15 shows a cracked, but not completely fractured, web of the suction screen. Here, the web had also thinned to just a few micrometers, and was cracked or fractured over 75% of the width. A closer view in Figure 16 and Figure 17 show the fractured surfaces of this region. As can be seen in the closest view, this surface exhibited striations oriented parallel to the web fragment width. These features were consistent with fatigue crack propagation of this segment (which had not completely propagated through or fractured). The orientation of these fatigue striations was consistent with bending or flexure of this web.

Figure 18 shows another fractured web, exhibiting a thicker cross section along the fracture surface. The area of the web adjacent to the fracture surface exhibited parallel, secondary cracking, which undertook an intergranular morphology along the grain-like features of the surface. A closer view of the fracture surface revealed similarly oriented fatigue striations to those seen on the cracked web in Figure 17.

Figure 19 shows a thinned but still intact web segment. This web exhibited initial plastic deformation in the form of localized necking on the right side of the figure. The grain like features exhibited rows of parallel bands near the necked area. These features were consistent with areas of high mechanical strain in individual grains, indicating that the equiaxed surface morphology was consistent with the actual grains of the material.

The chemical composition of the suction screen was examined using EDS. From the data obtained using these techniques, the screen was found to be consistent with an alpha brass alloy (~29 wt.% Zn).

A portion of the oil suction screen was mounted, ground, and polished for metallographic examination. Due to the geometry of the screen remnants, much of the specimen surfaces exhibited artifacts consistent with specimen preparation. However, using optical and scanning electron microscopy, various features were able to be conclusively discerned.

Figure 20 shows the locally thinned portion of the neck of a web. This part exhibited pit-like features of missing material. The surface cross sections of these areas exhibited darker surface material, along with features consistent with penetrating cracks. A similar pit-like feature was observed on another web as shown in Figure 21. This pit exhibited intergranular cracking or penetration.

Figure 22 shows a backscattered electron micrograph of another pit-like feature. As demonstrated in the figure, the material in the pit was dissimilar from the copper-rich brass alloy of the screen. In addition, there was branching and parallel cracking features, consistent with intergranular corrosive attack along grain and subgrain boundaries. All these features were consistent with a chemical attack of the screen material.

The surface and pit regions were examined using EDS. This material was consistent with oxides of copper and zinc, consistent with byproducts from the corrosion of brass. However, these regions also exhibited high levels of lead, bromine, and phosphorus.

Figure 23 shows a partial cross section through a corroded web surface (the area on the left was polished through, whereas the area on the right was not, which displays the exterior web surface). This figure demonstrates the faceted morphology along the surface grains, revealing an underlying corrosion compound. This compound was consistent with those previously observed—copper/zinc oxides with high levels of lead, bromine, and phosphorus. This material also contained elevated levels of sulfur.

In addition to these oxides on the surface and underneath, the some of the webs also exhibited small cracks. While some of these cracks exhibited an intergranular quality, such as shown in Figure 18, some were consistent with a transgranular morphology, as shown in Figure 24.

Erik M Mueller
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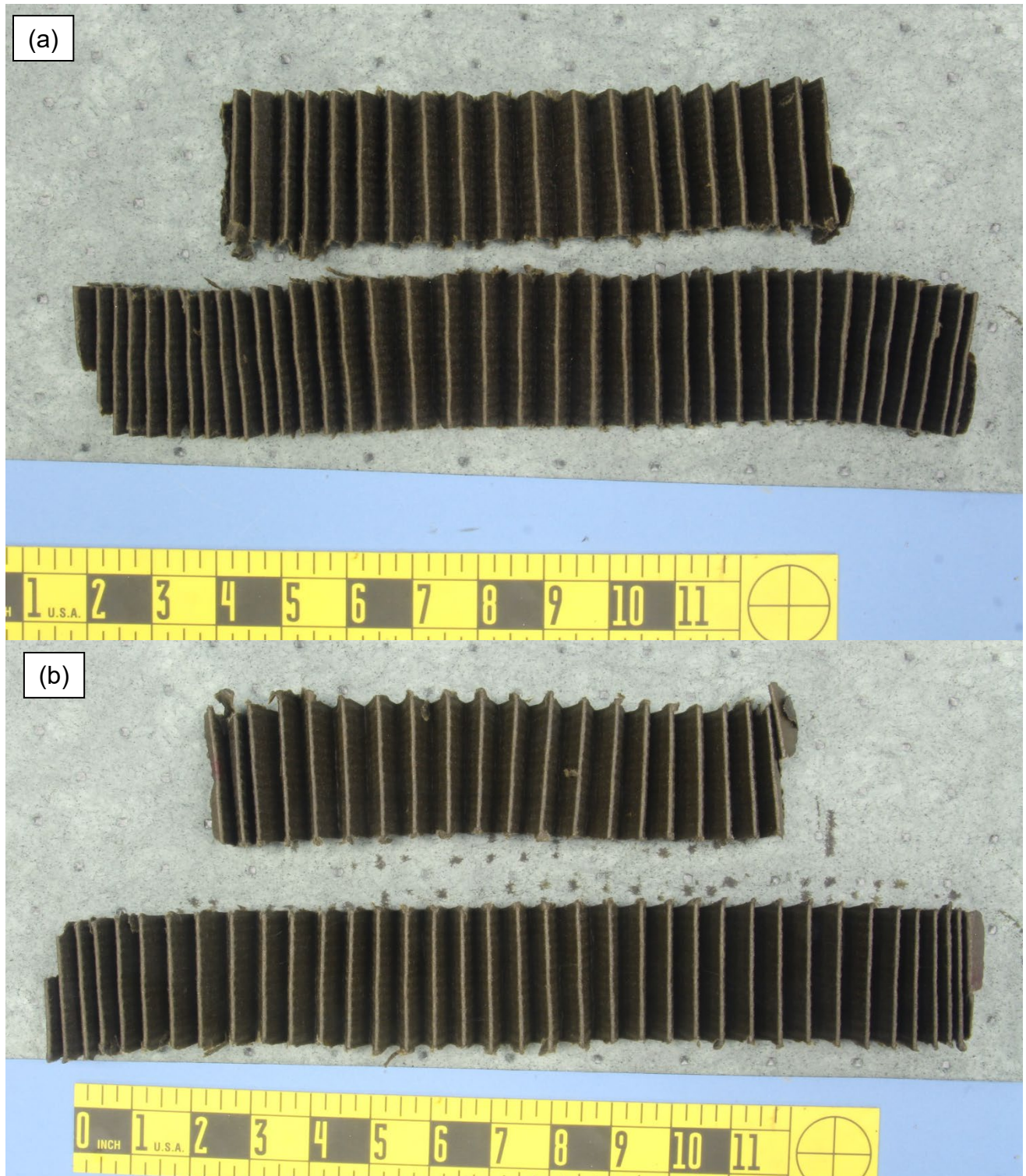


Figure 1 – View of the accordion oil filter, as received from (a) (b) each side.



Figure 2 – View of two of the fractured ends of the filter.



Figure 3 – View of the debris sent in a filter, showing most of the dark-colors particles.

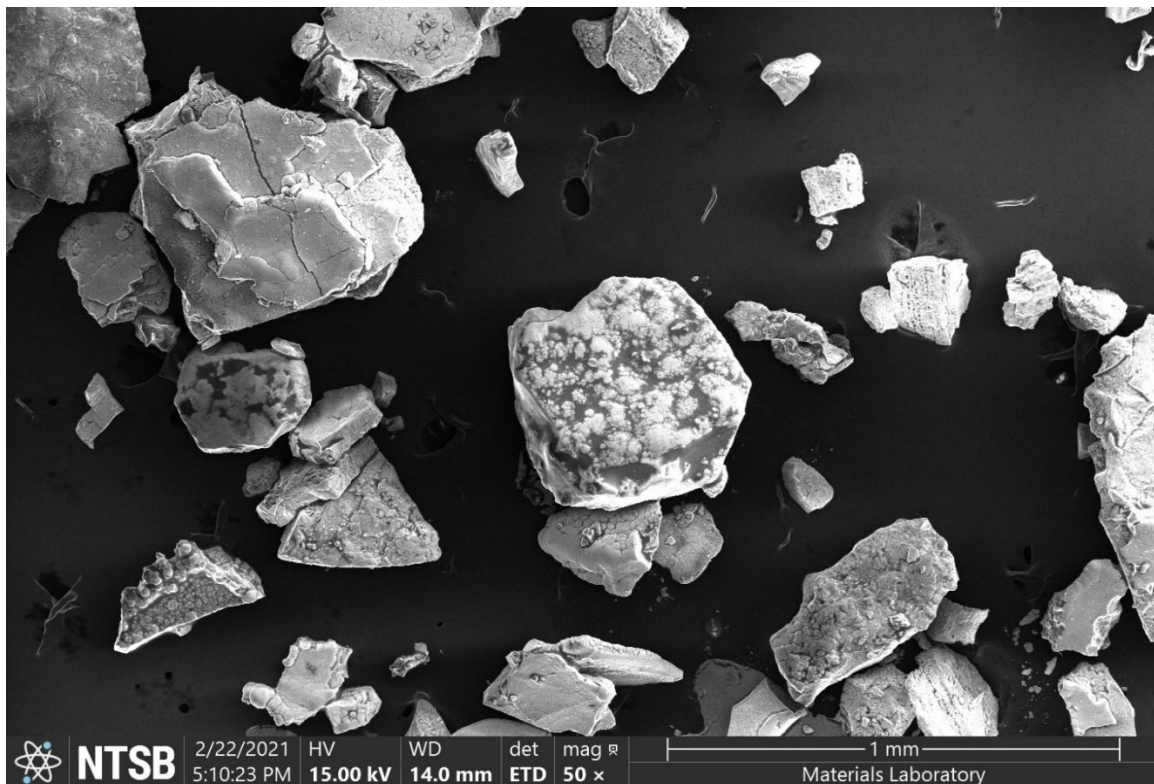


Figure 4 – Secondary electron (SE) micrograph of the dark-colored debris.

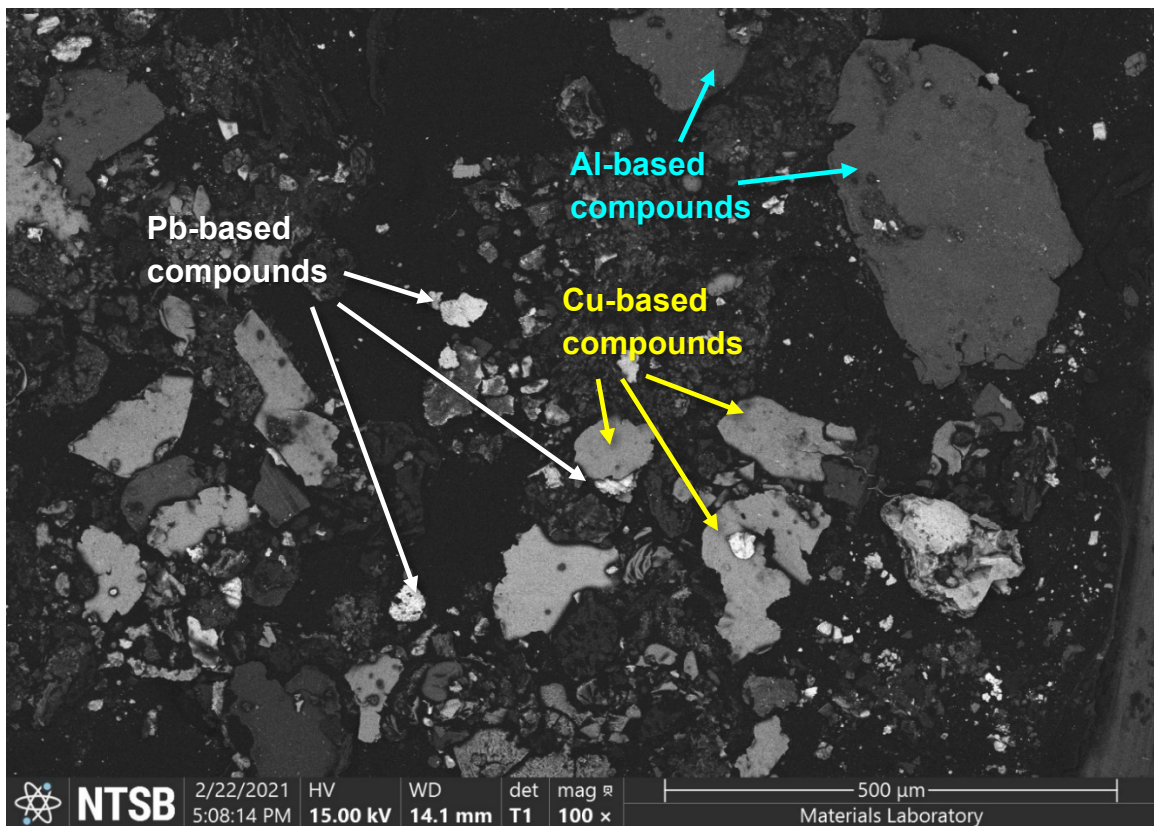


Figure 5 – Backscattered electron (BE) micrograph of the lighter colored debris.

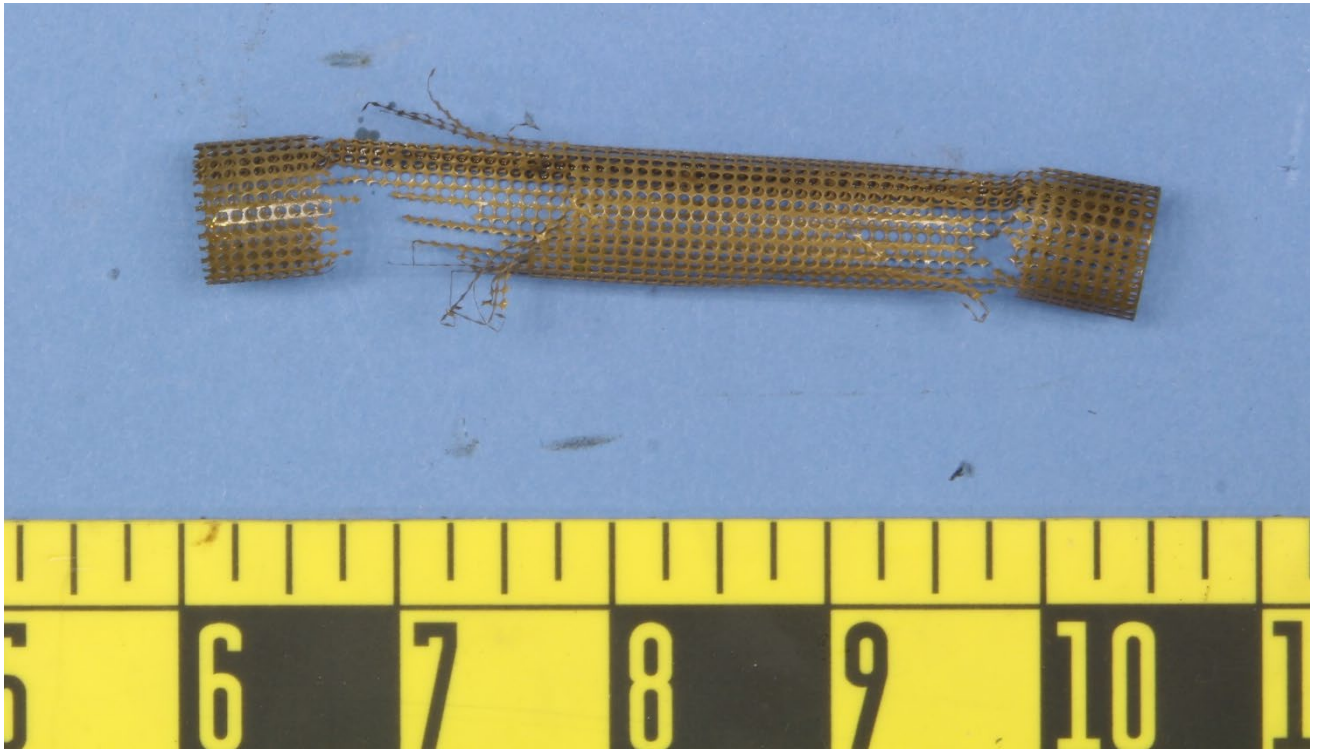


Figure 6 – View of the oil suction screen, as received.

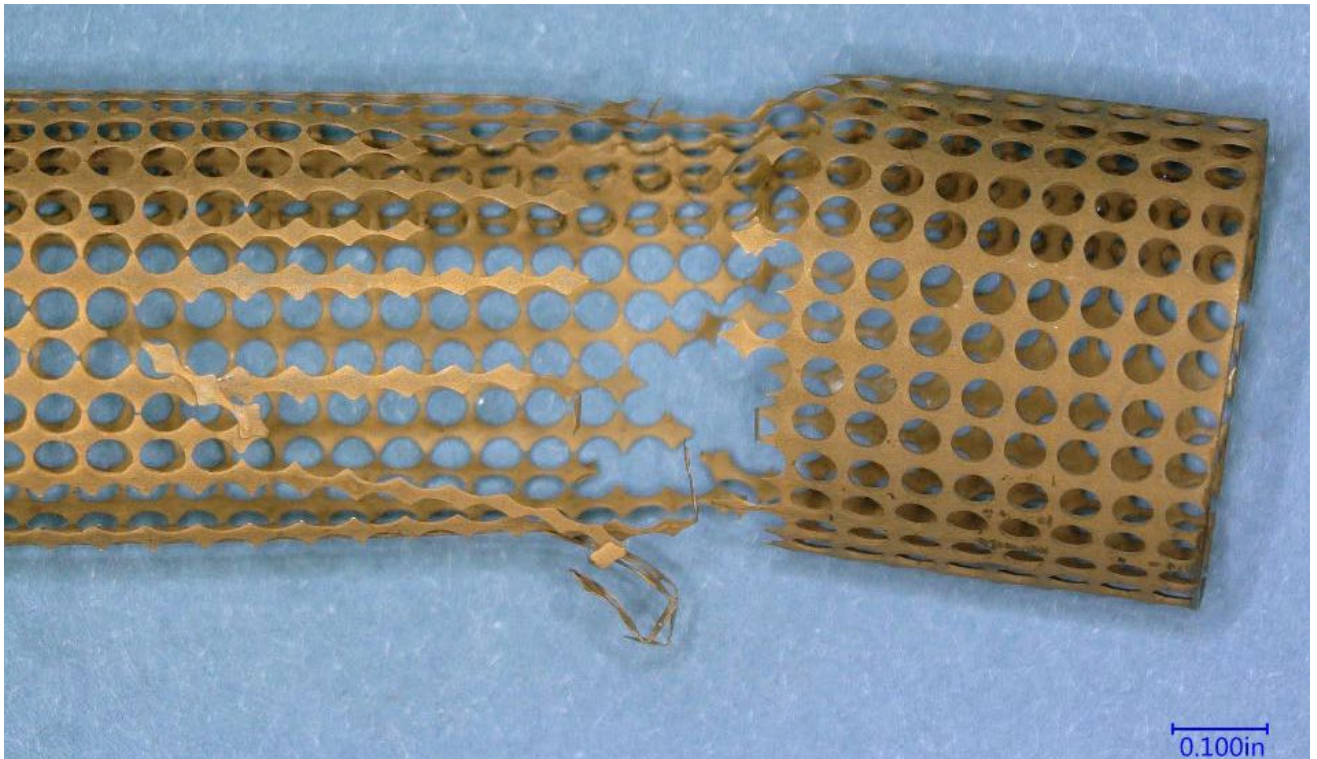


Figure 7 – The right area of fractured webs on the screen in Figure 6, after cleaning with acetone.

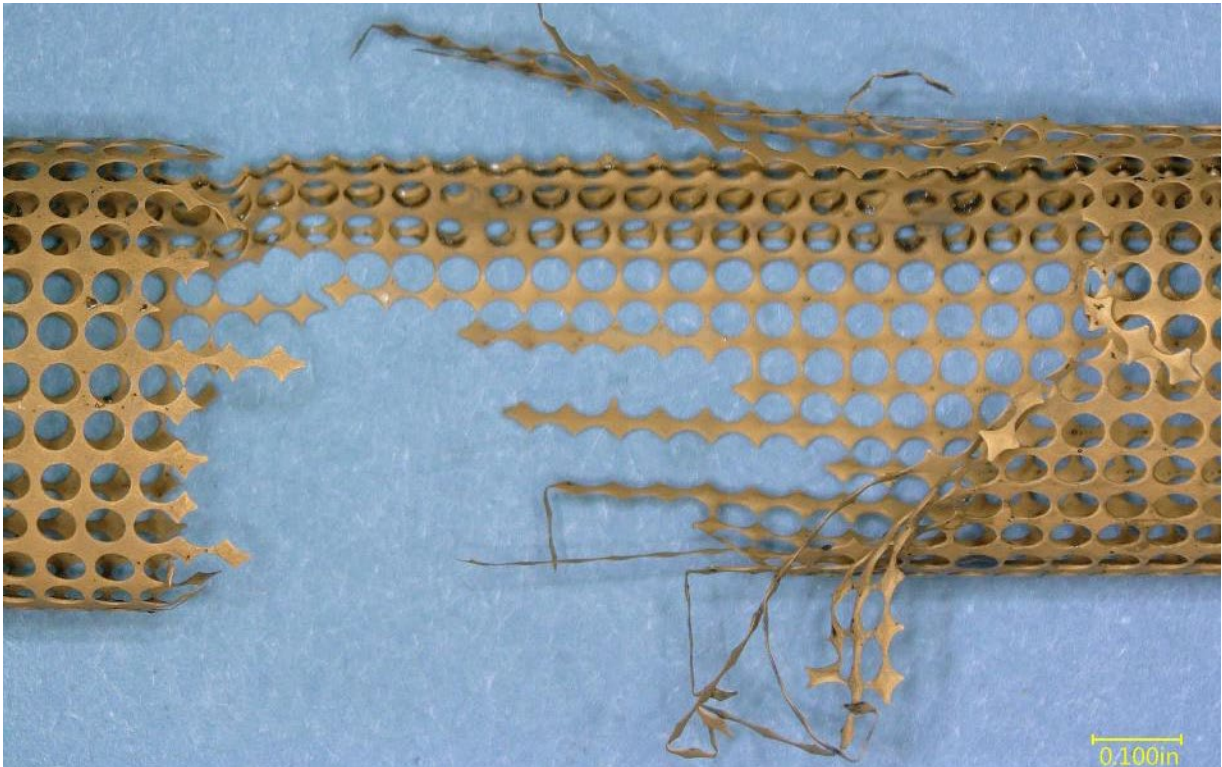


Figure 8 – The left area of fractured webs on the screen in Figure 6, after cleaning with acetone.

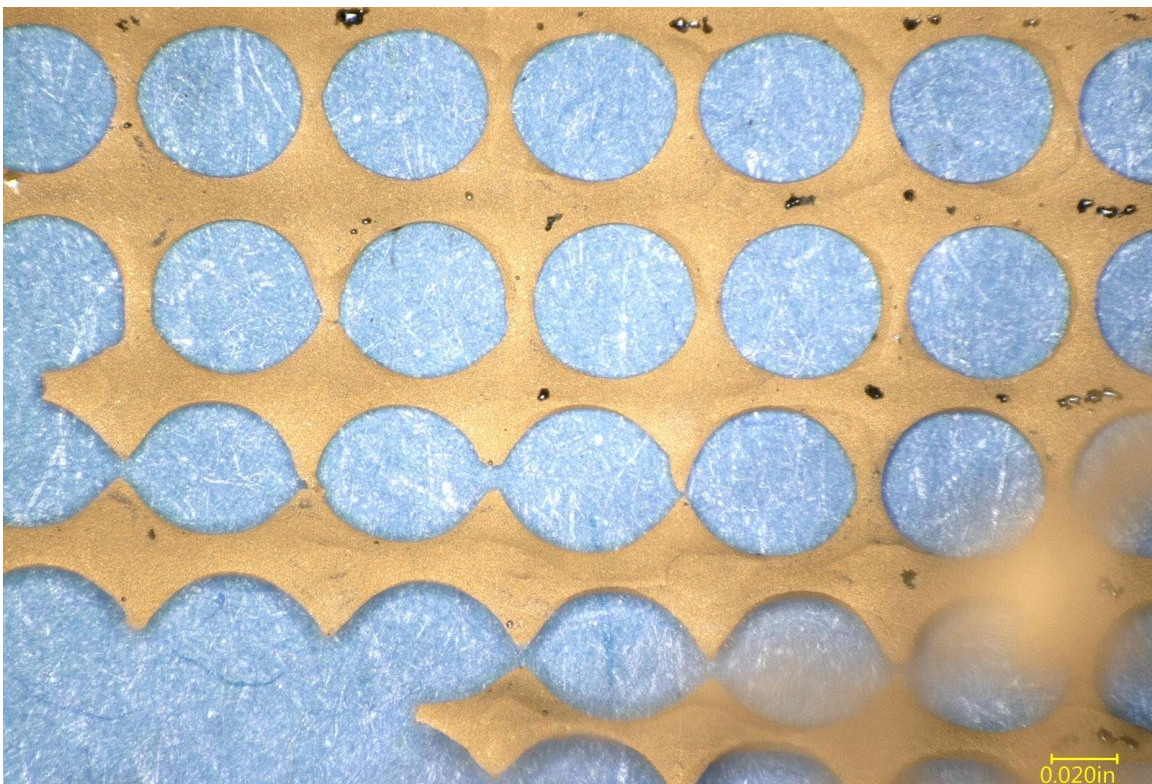


Figure 9 – View of a series of fractured webs in the oil suction screen.

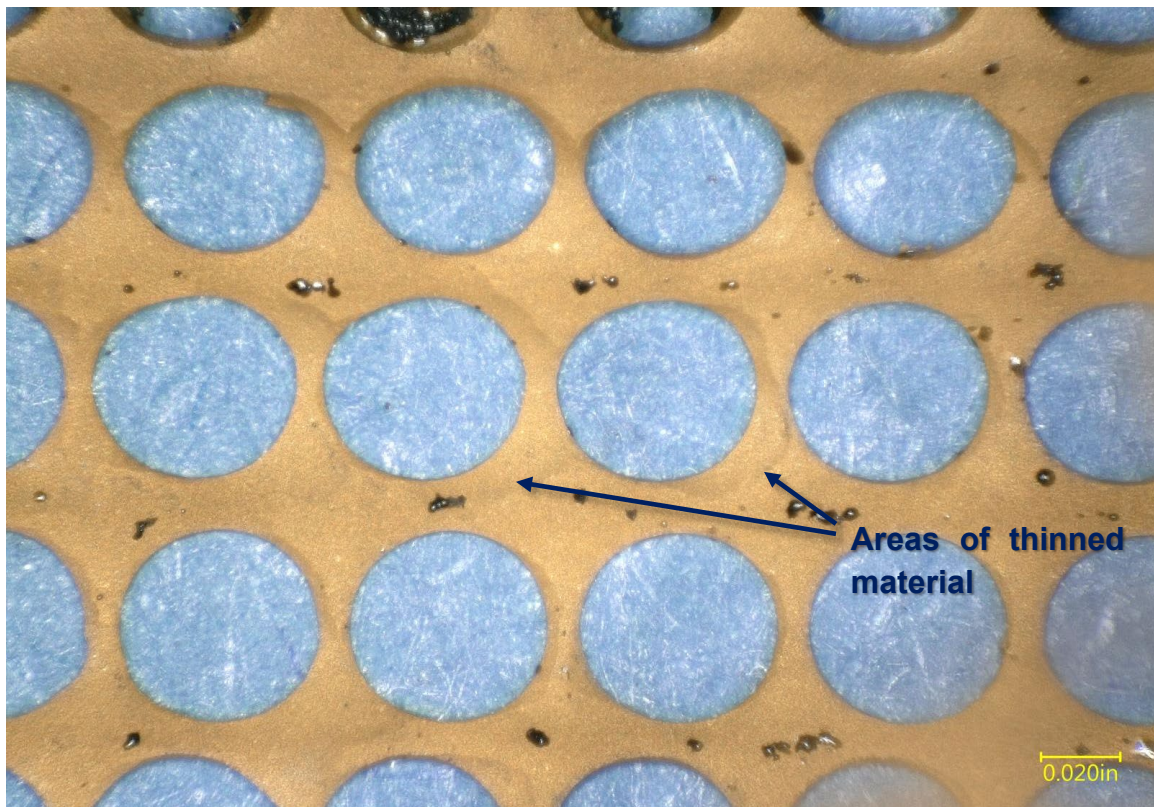


Figure 10 – Closer view of some of the thinned but intact webs of the screen.

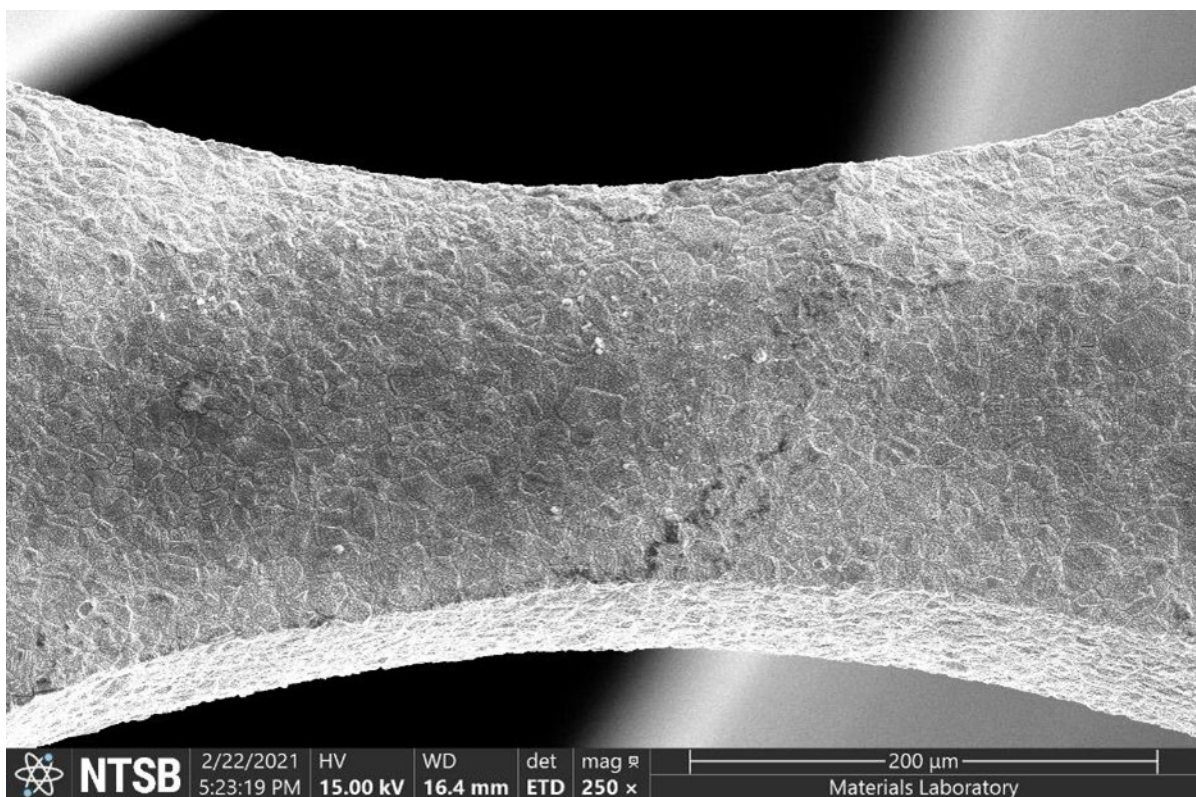


Figure 11 – SE micrograph of on intact web of the oil suction screen.

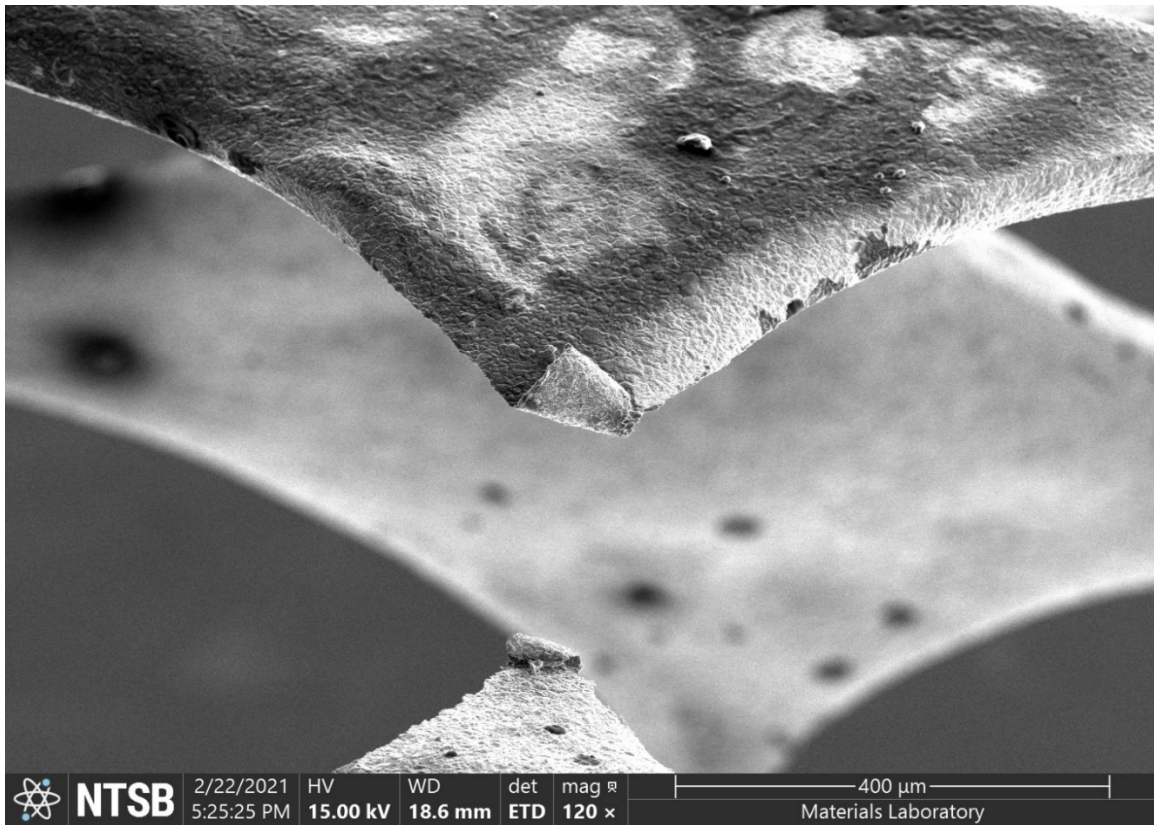


Figure 12 – SE micrograph of one of the fractured webs from Figure 9.

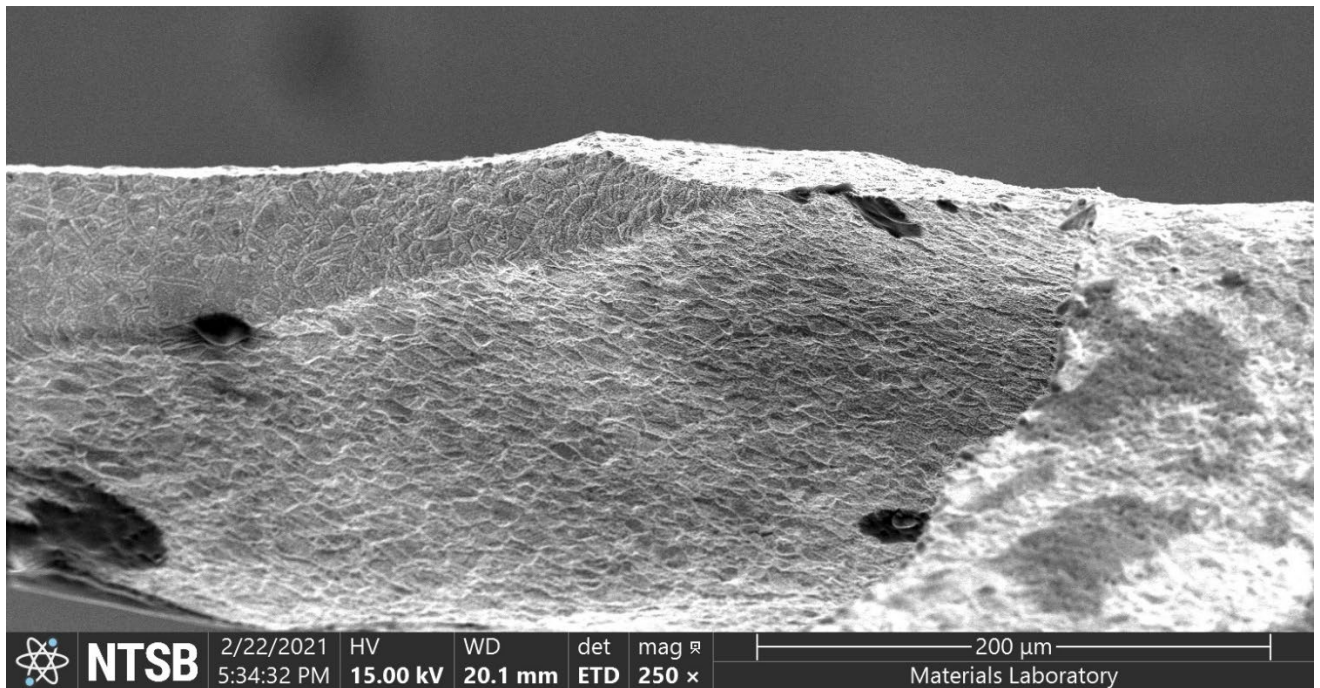


Figure 13 – SE micrograph of a thinned and separated web portion of the screen.

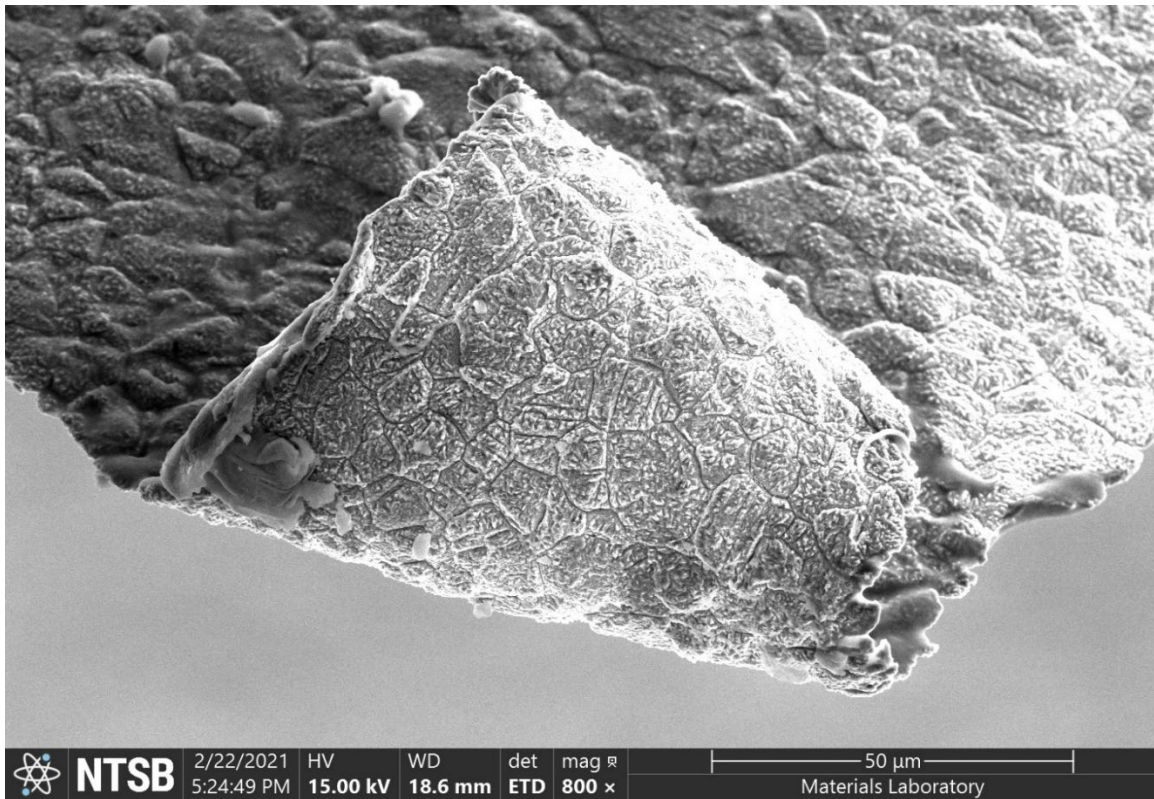


Figure 14 – SE micrograph of a closer view of the thinned web fracture in Figure 12.

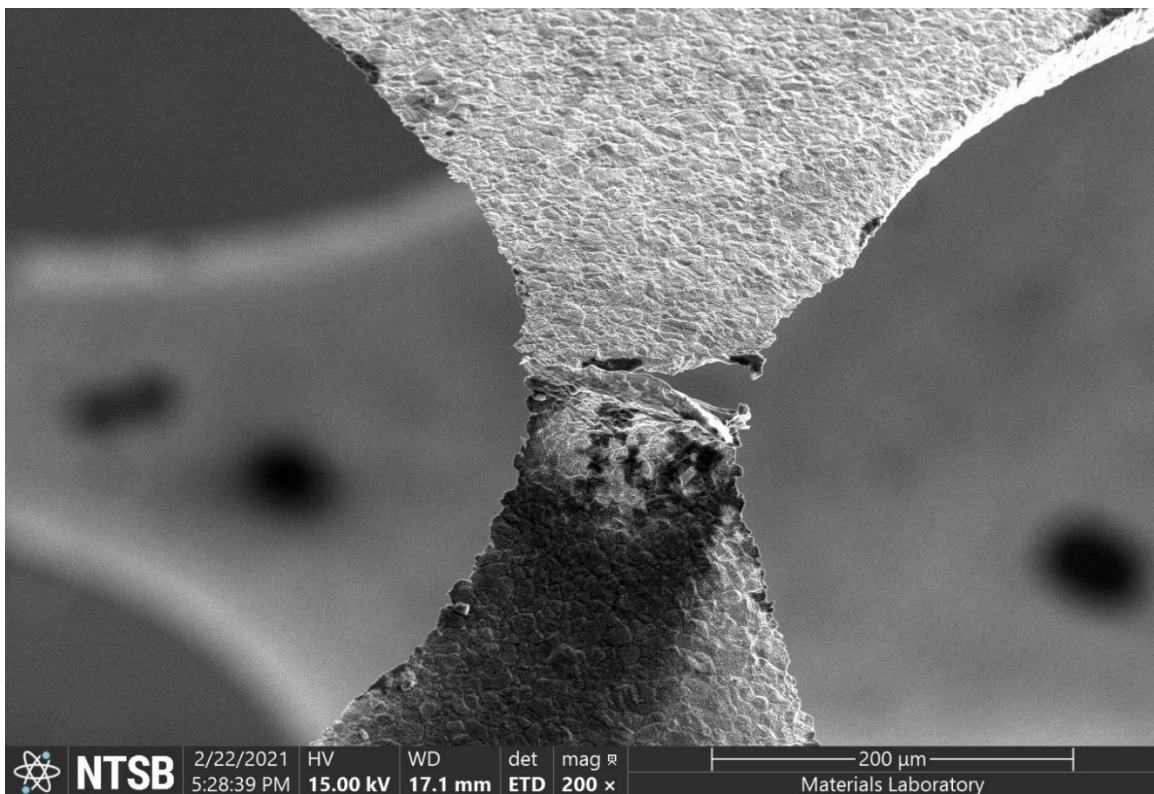


Figure 15 – SE micrograph of a partially fractured web.

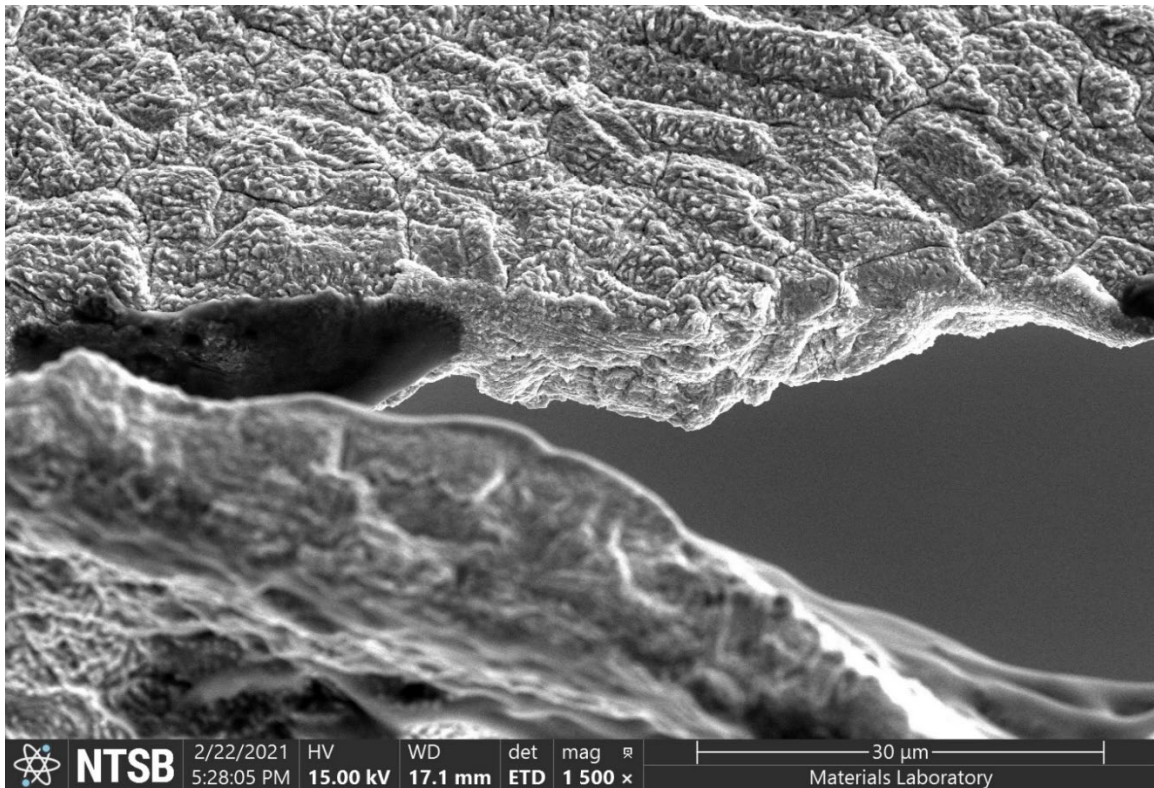


Figure 16 – SE micrograph of a closer view of the fractured part of the web in Figure 15.

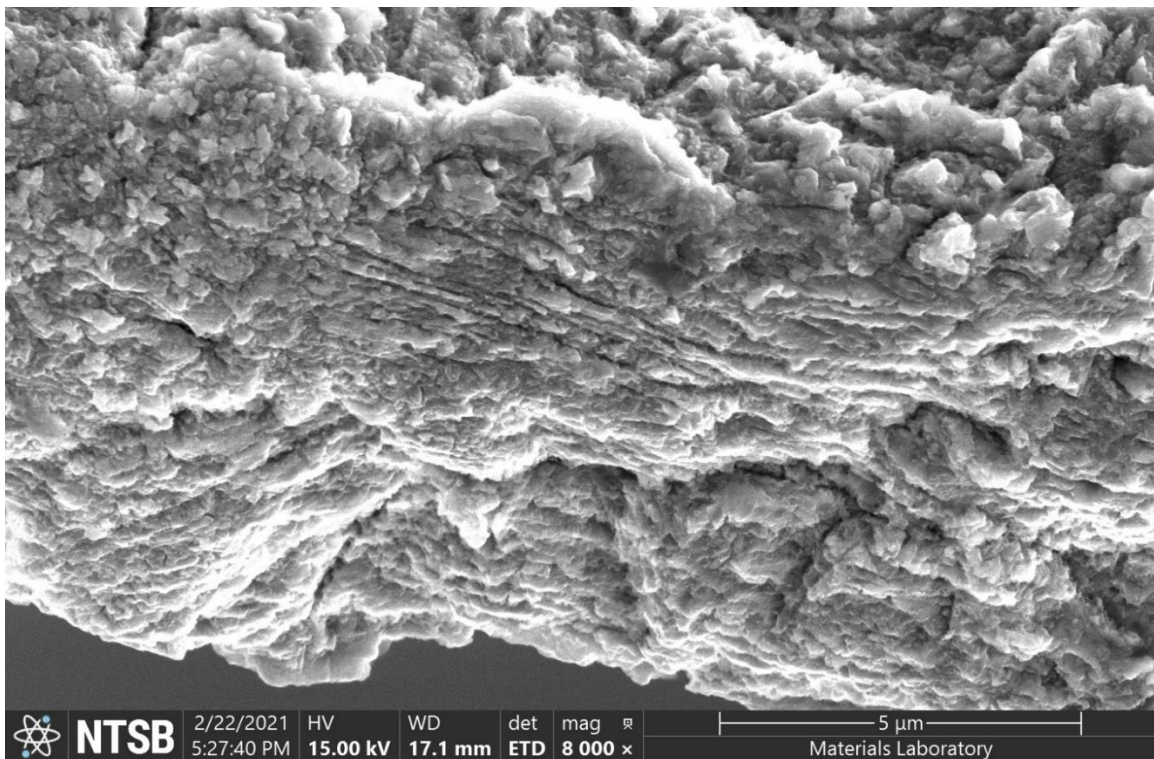


Figure 17 – SE micrograph of the fractured surface in Figure 16, showing fatigue striations.

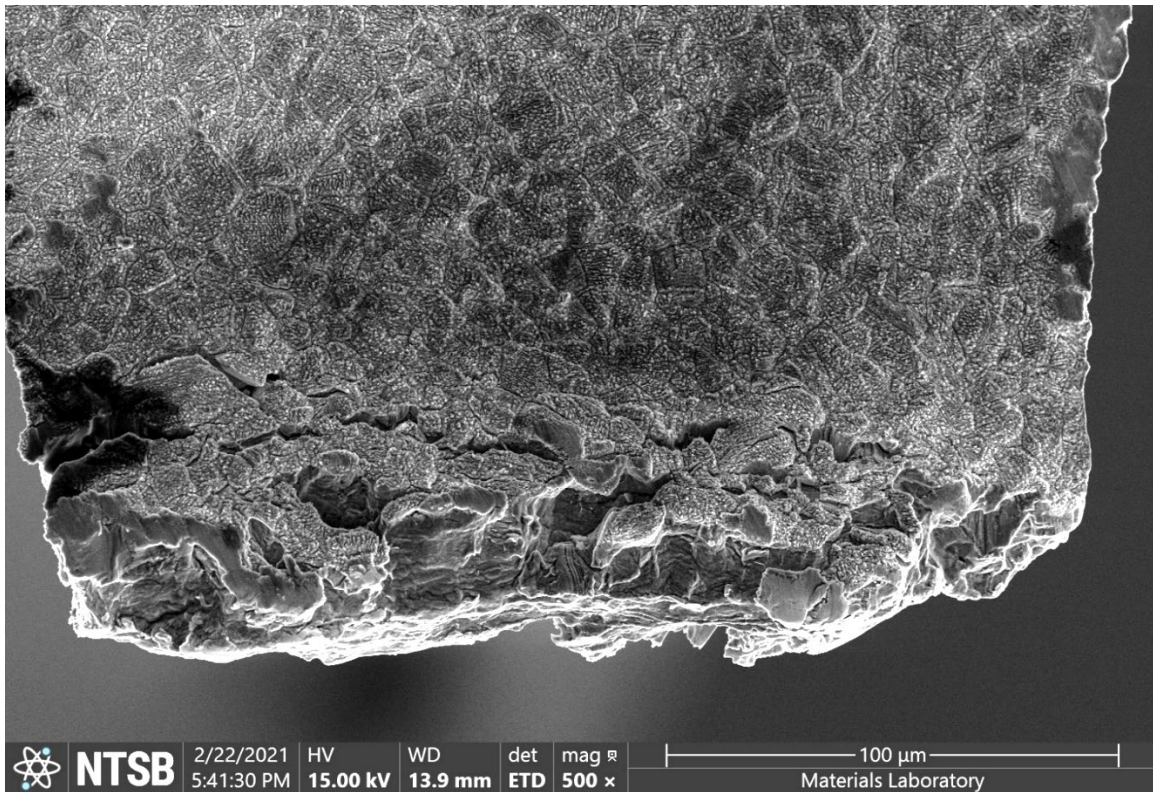


Figure 18 – SE micrograph of a web fracture surface, showing intergranular separation.

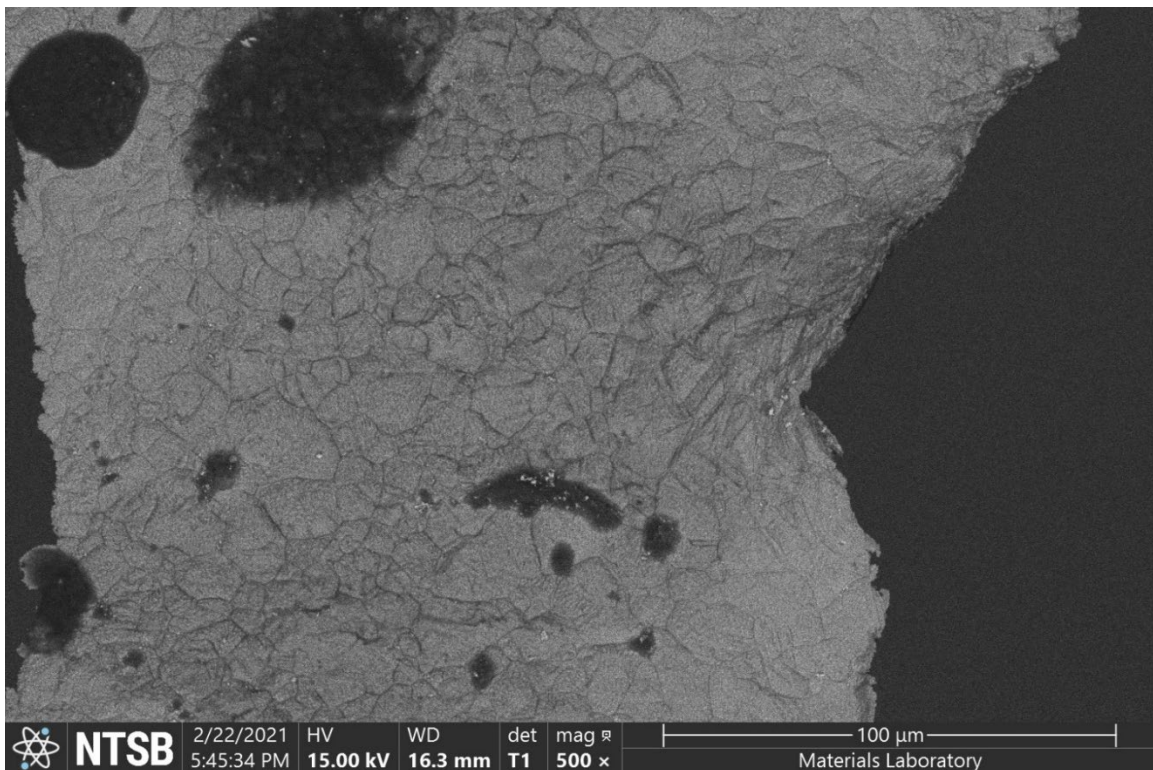


Figure 19 – BE micrograph of an intact but necked suction web.



Figure 20 – Bright-field (BF) optical micrograph of an eroded area of a still intact web cross-section (~200X, as-polished).

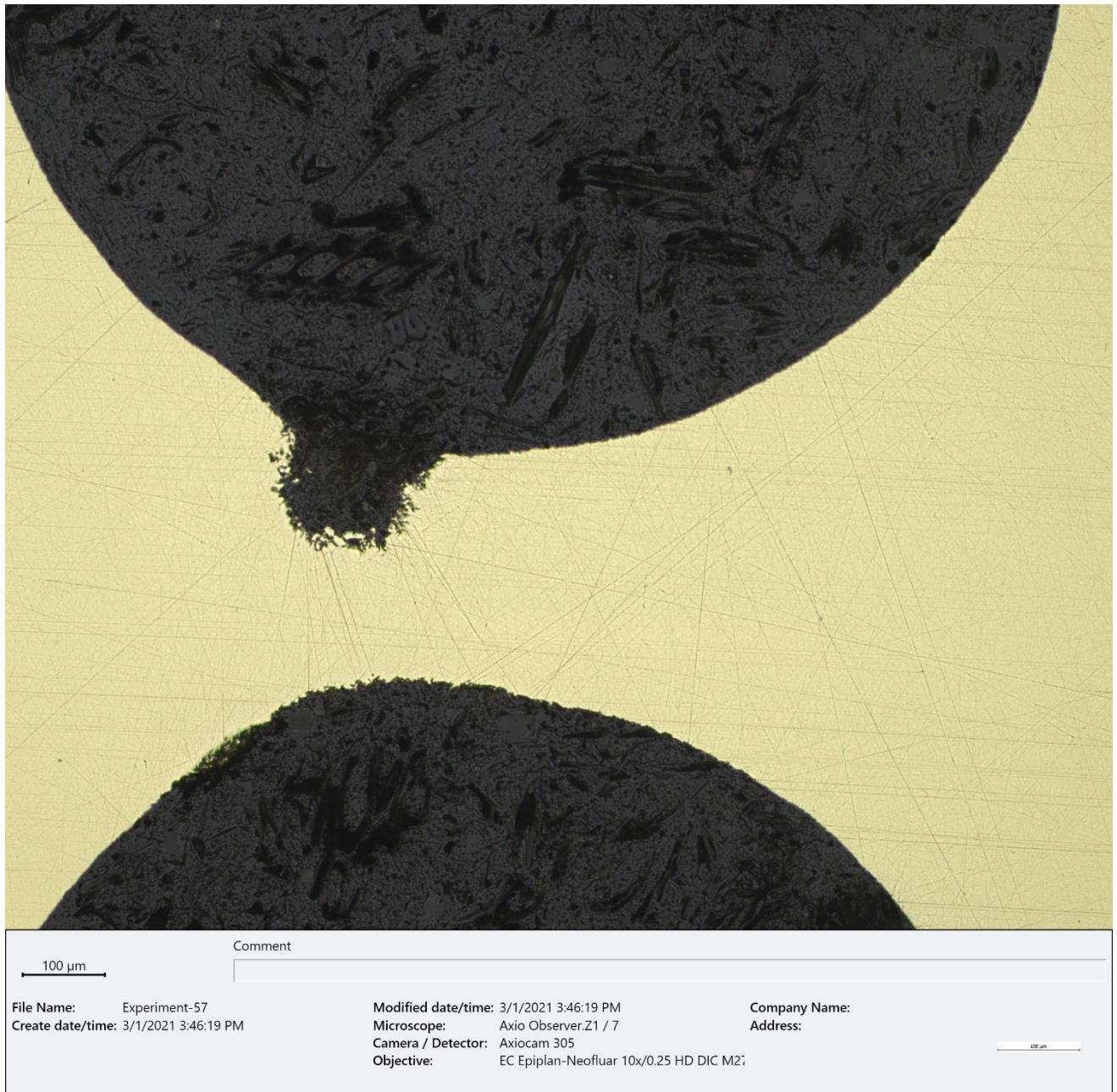


Figure 21 – BF optical micrograph of an eroded area of a web (~200X, as-polished).

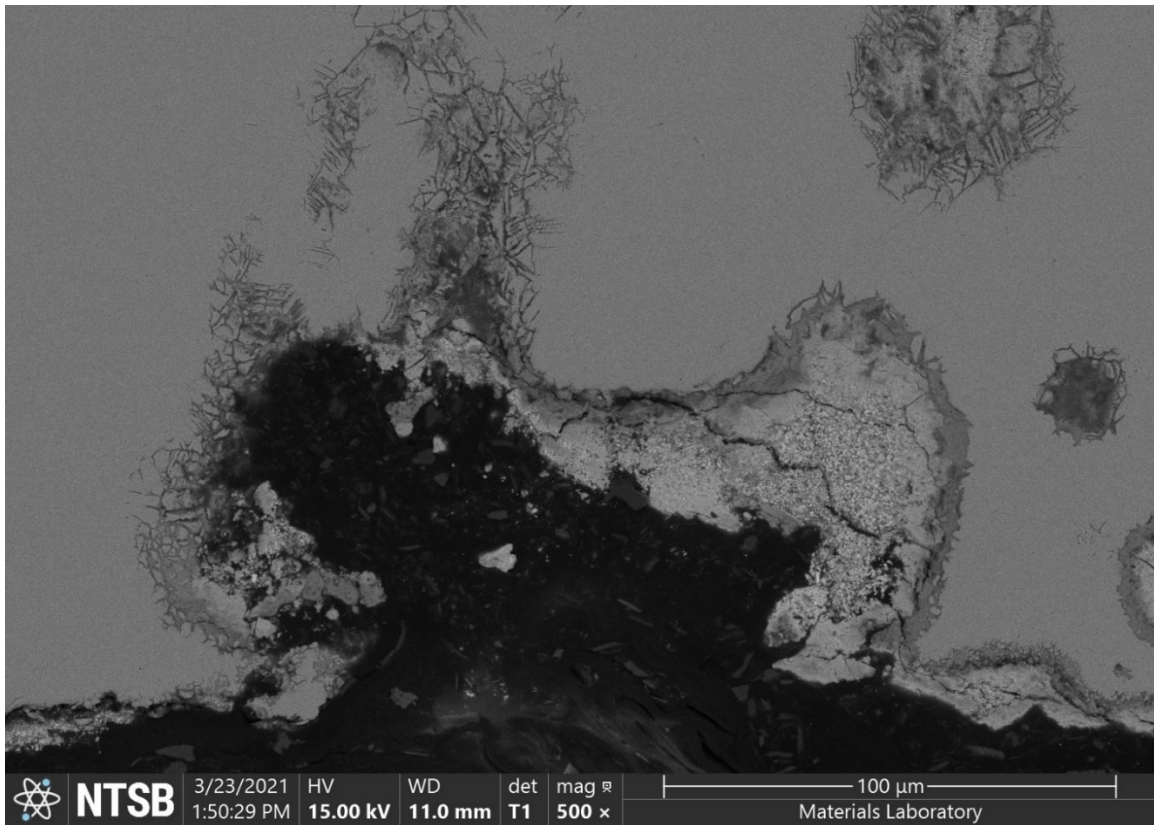


Figure 22 – BE micrograph of an area of a cross-sectioned web, showing localized corrosion products.

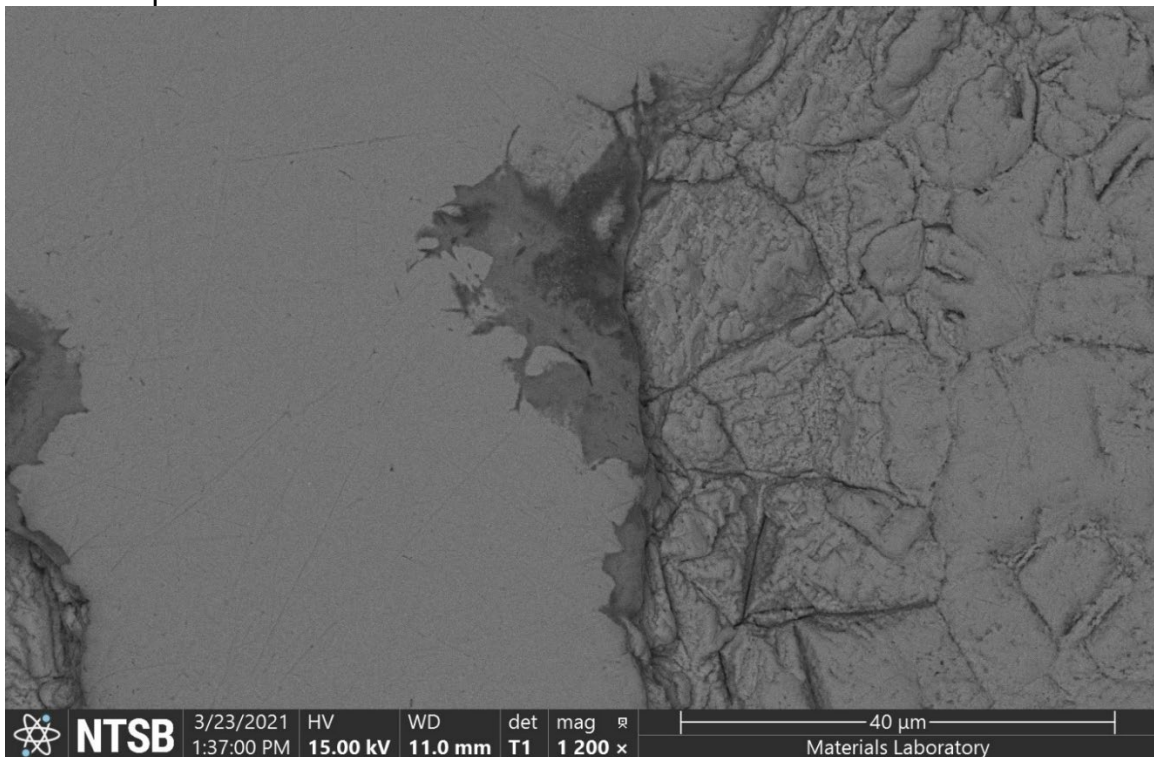


Figure 23 – BE micrograph of an area of partially-cross sectioned screen web, showing intergranular attack and penetrating corrosion product.

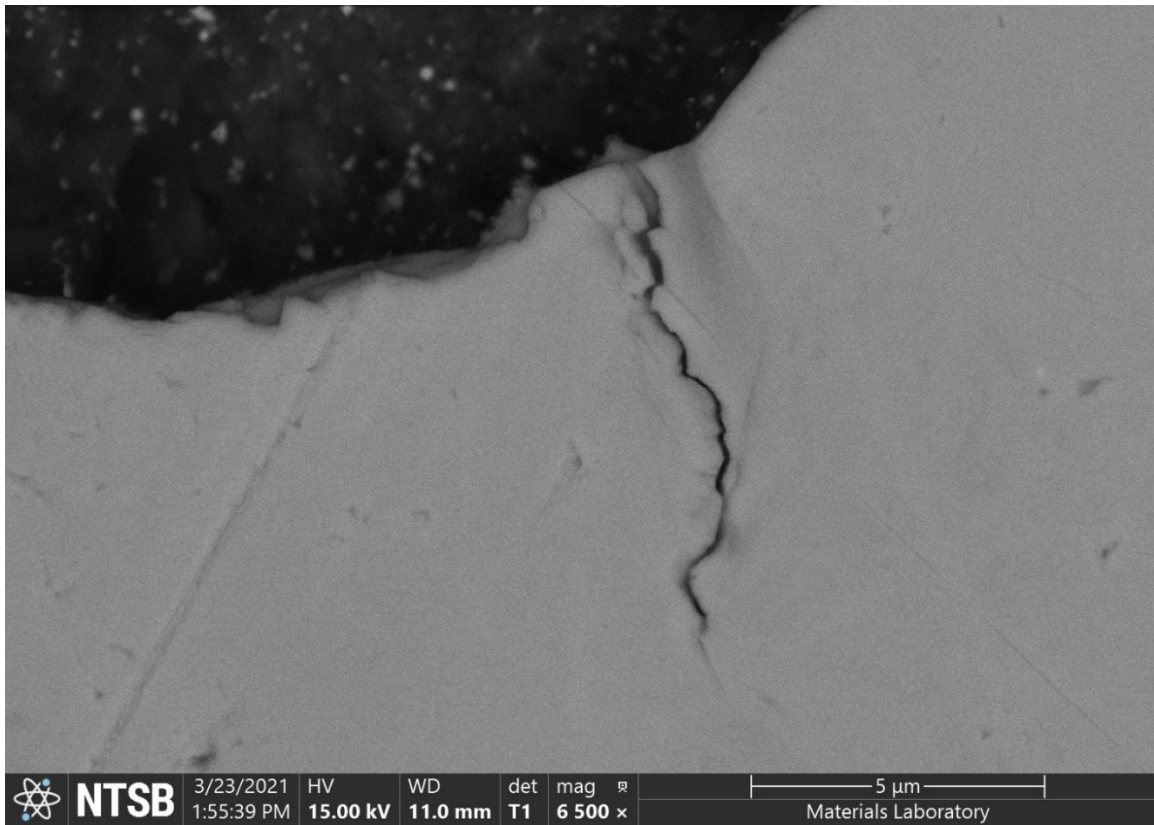


Figure 24 – BE micrograph of a crack in a web cross-section absent corrosion.