NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

December 22, 2020

MATERIALS LABORATORY ADDENDUM REPORT Report No. 20-038B

1. ACCIDENT INFORMATION

Place	:	Big Timber, Montana
Date	:	January 16, 2020
Vehicle	:	Cessna 172Q, N96145
NTSB No.	:	WPR20LA068
Investigator	:	Stephen Stein, AS-WPR

2. COMPONENTS EXAMINED

Spinner
Remnants of attachment bolts and washers

3. DETAILS OF THE EXAMINATION

This report is an addendum to the examination of a Cessna 172Q accident in Big Timber, MT, and details a spinner assembly received separately from the propeller.

Figure 1 and Figure 2 show the spinner and four attachment bolts as received. Two of the attachment bolts were not included in the shipment. The bolt heads and the spaces next to the bolt holes on the spinner had been marked prior to receipt.

Figures 3 and 4 show the spinner after removal of the washers and the attachment bolts, viewed from the forward and aft faces, respectively. The spinner was intact, and exhibited mostly a reflective metallic color, consistent with the absence of the black or dark gray paint over most of the forward face. As shown in Figure 3, circular wear marks, approximately 0.25 inches in thickness, were present around all of the bolt holes. These marks corresponded to and were consistent with the size of the washers removed.

The bolt holes were labeled 1 through 6 for the purposes of this report. Figures 5 through 10 show the shoulders of the bent spinner flange near the holes, viewed from the aft face. Each of these areas exhibited a circular crack, located within the area of the circular marks. The cracks measured between 0.61 and 1.73 inches in chord length, as detailed in Table I.

The crack from hole 2 was backcut and intentionally overstressed (laboratory opened) to examine the crack faces or fracture surfaces. This crack is referred to as Crack

#2 in this report. The other cracks were left intact and are highlighted from the front face of the spinner in Figures 11 through 15. All the cracks illustrated in these figures were located in or along the circular wear marks surrounding the bolt holes on the spinner. This wear exhibited multiple circular marks and small micropits consistent with fretting. This fretting was consistent with contact under vibrational loads between the forward spinner face and the washers under the bolt heads.

Figure 16 shows an area of the opened Crack 2 face (outboard side). The crack surface exhibited protrusions and depressions consistent with ratchet marks. The crack face was examined using a scanning electron microscope (SEM), as typified in Figure 17. Overall, the fracture surface exhibited steps and ridges, along with angled tears. The crack arrest marks were oriented parallel to the surfaces. A closer view shown in Figures 19 and 20 revealed fatigue striations, consistent with fatigue crack propagation. The nature of these striations was consistent with propagation from the forward to aft faces in high-cycle fatigue (see Figure 21). Most of the opened Crack 2 face exhibited features consistent fatigue. The small areas outside the fatigue cracking exhibited dimpled rupture, consistent with the laboratory opening of the crack (see Figure 22). Therefore, these cracks were inconsistent with forming during the accident, having to originate prior to the accident.

The fracture surface exhibited ratchet marks, consistent with multiple fatigue crack initiation sites. One of the initiation sites is highlighted in Figures 22 through 24. The cracking near the initiation site exhibited tear ridges fanning outward and steps parallel to the forward surface. Closer to the initiation site, smoother surface features were observed, displaying fanning river patterns consistent with at least three smaller initiation sites. While there were no material defects present at these sites, the surface exhibited an undulating profile, consistent with the fretting wear on the forward surface. These crack initiation sites were consistent with local areas of the deepest fretting damage.

The chemical composition of the spinner was examined using x-ray fluorescence (XRF) and energy dispersive x-ray spectroscopy (EDS). From the data obtained using these techniques, the spinner was found to be consistent with 2000-series aluminum alloys. The hardness was inspected per ASTM E18.[1] The hardness averaged 62 HRBW.

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

Table I – Lengths of cracks (chordwise) measured on the spinner (in inches), with the adjacent label marking present prior to receipt.

Crack Name	Adjacent Label	Crack Length (in)
Crack 1	370B	0.938
Crack 2	250	1.667
Crack 3	150A	0.606
Crack 4	560	1.363
Crack 5	150B	1.732
Crack 6	370A	0.262

Figure 1 – The spinner and the attachment bolts, as received and viewed from the side.

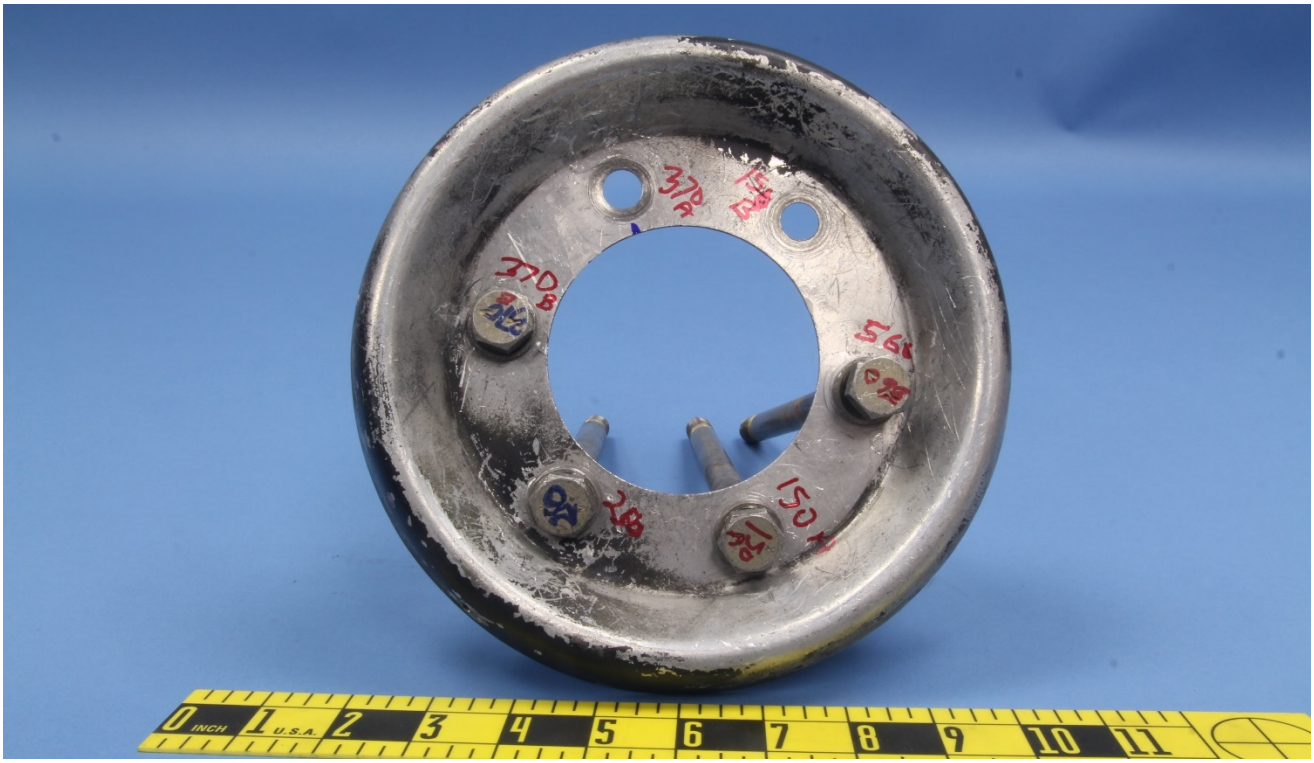

Figure 2 – View of the spinner face with the attachment bolts and labeling, as received.

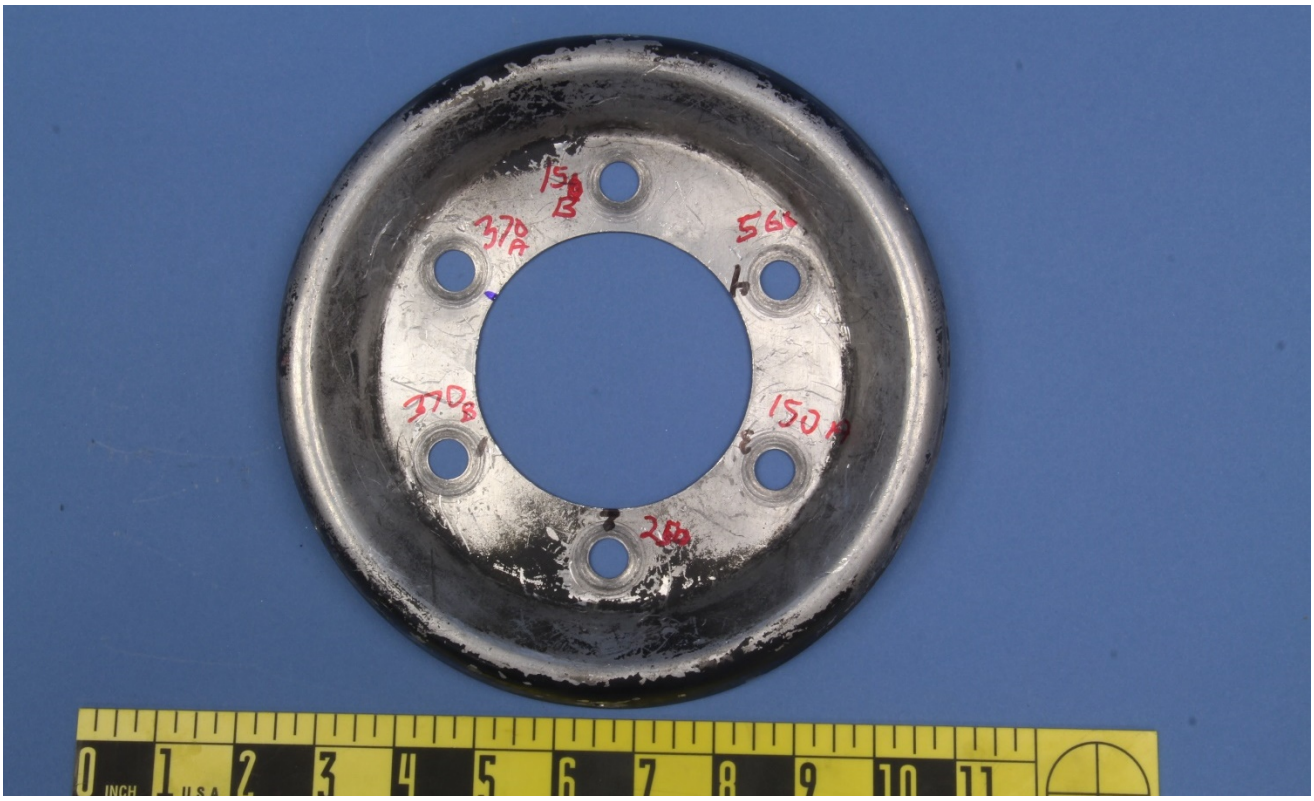

Figure 3 – View of the forward face of the spinner, after removing the bolts.

Figure 4 – View of the aft or opposite face of the spinner shown in Figure 3.

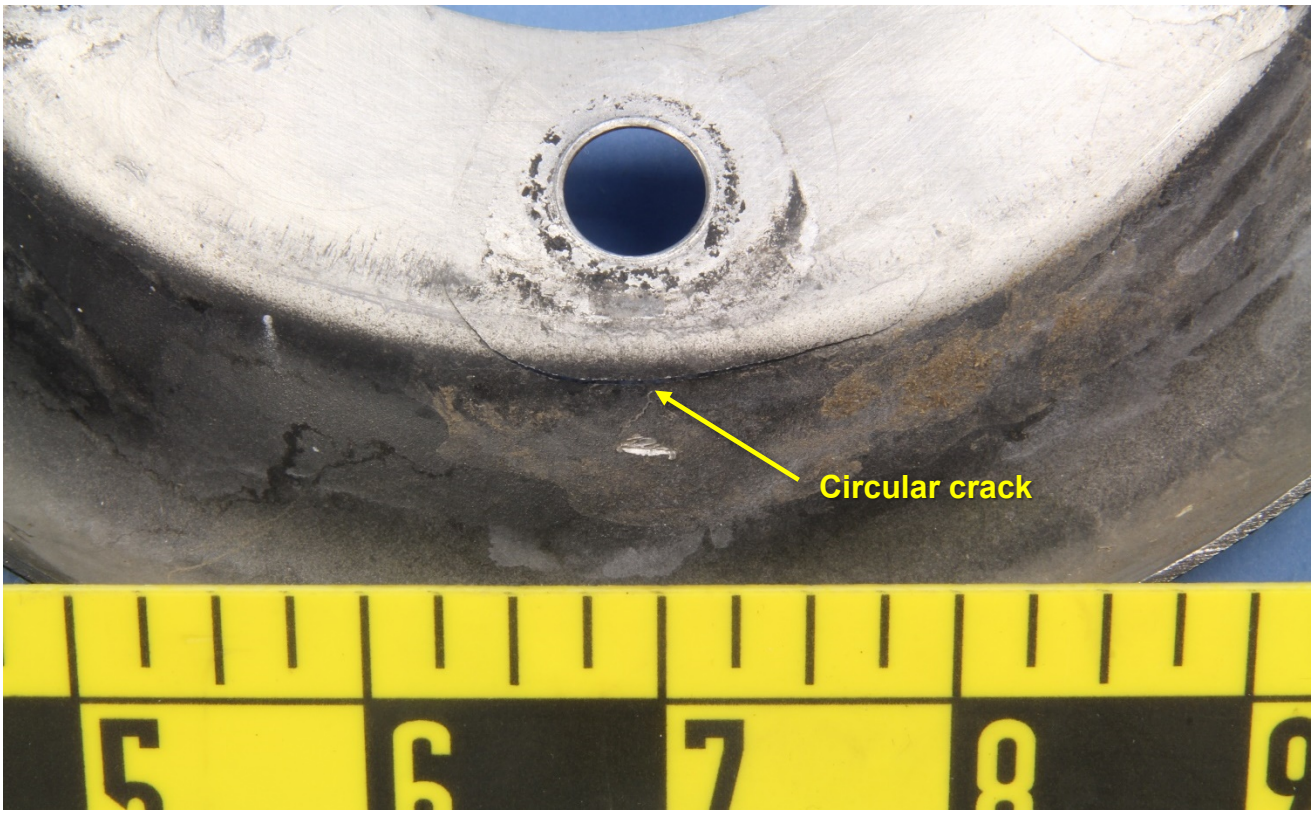

Figure 5 – View of the crack around the bolt hole #2.


Figure 6 – View of the crack around the bolt hole #1.

Figure 7 – View of the crack around the bolt hole #6.

Figure 8 – View of the crack around the bolt hole #5.

Figure 9 – View of the crack around the bolt hole #4.

Figure 10 – View of the crack around the bolt hole #3.

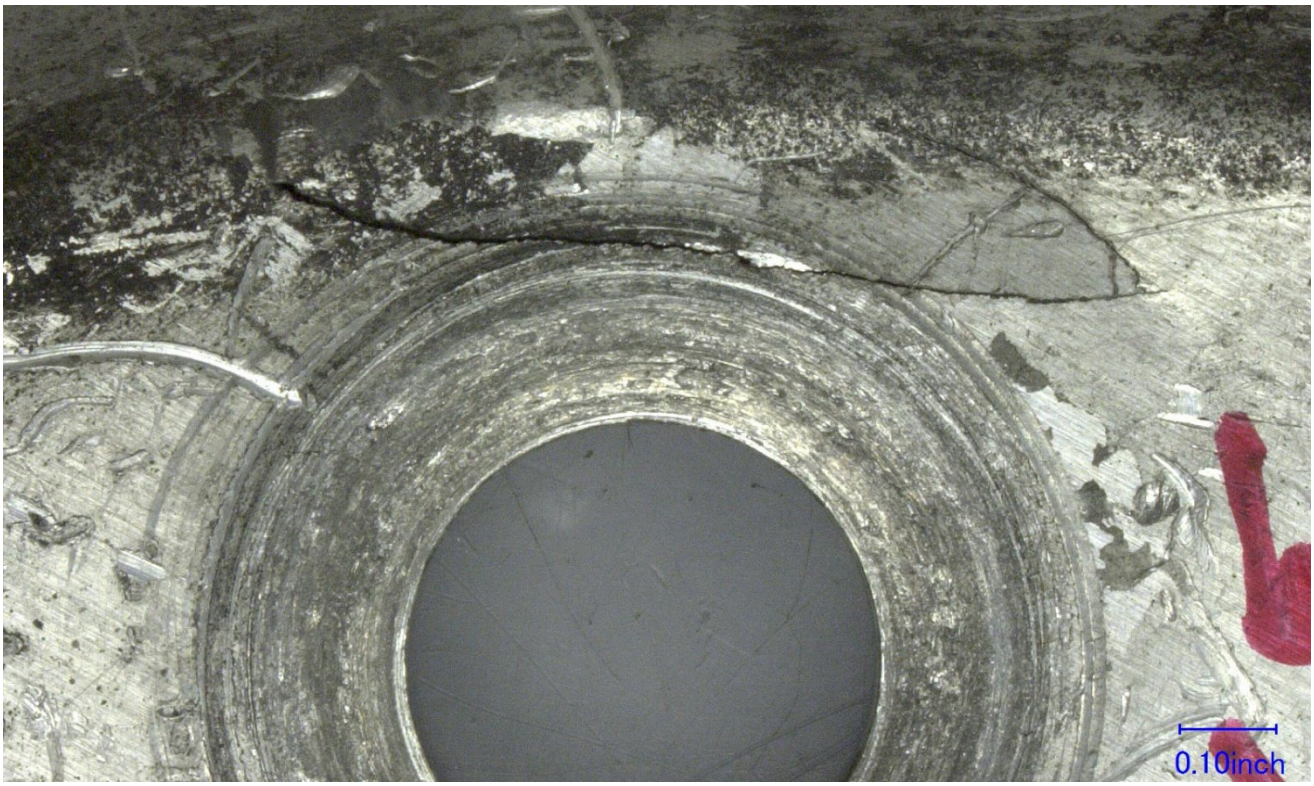

Figure 11 – Closer view of crack #1 on the forward side of the spinner.

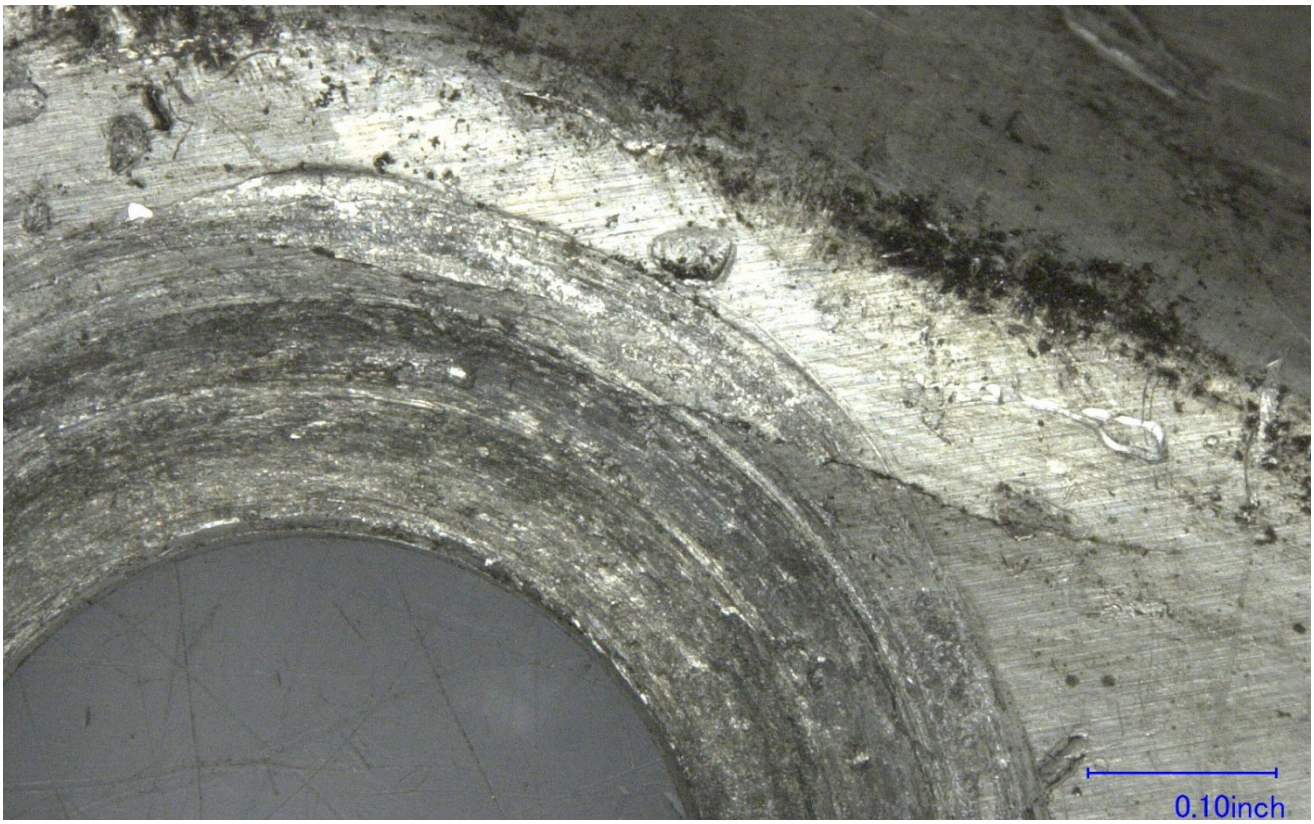

Figure 12 – Closer view of crack #3 around the bolt hole on the forward face.

Figure 13 – Closer view of crack #4 from the forward face.

Figure 14 – Closer view of crack #5 from the forward side.

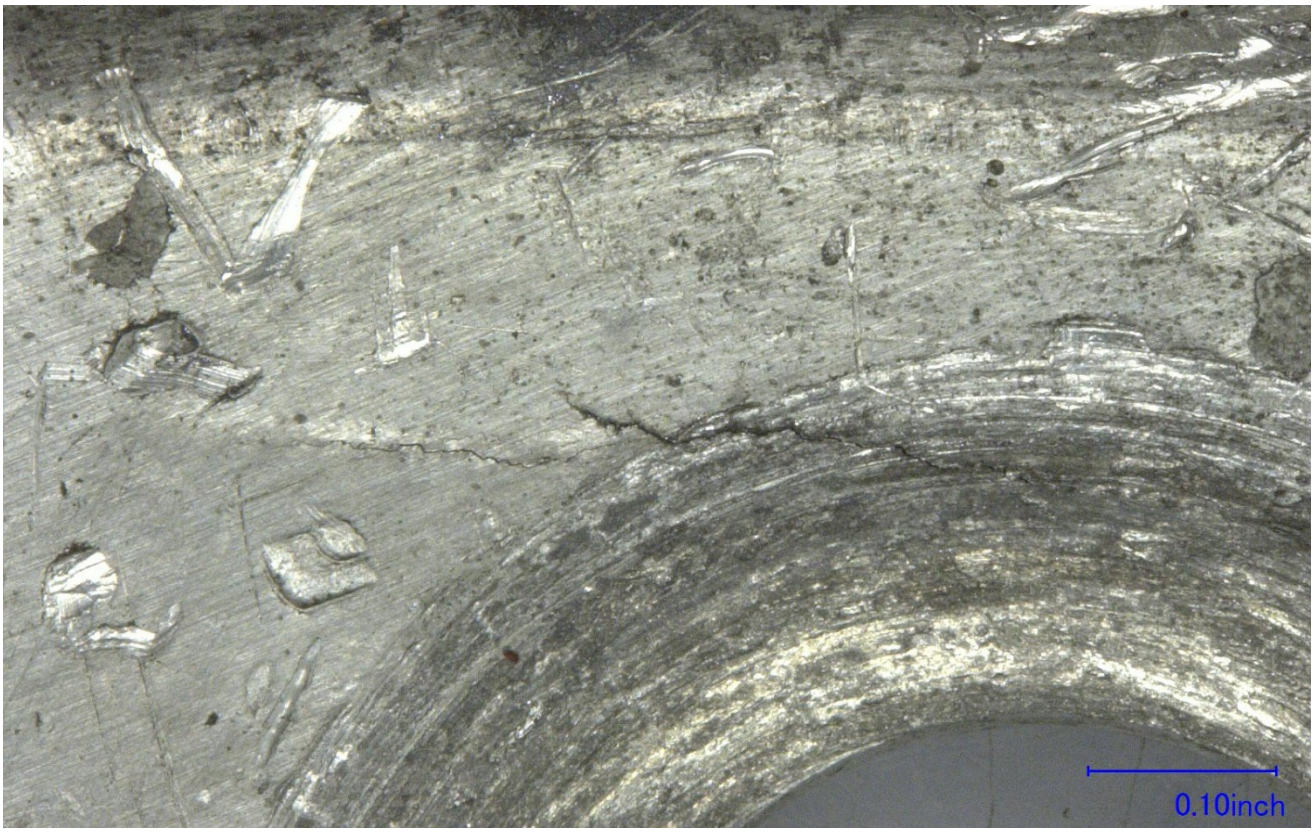

Figure 15 – Closer view of crack #6 from the forward side.

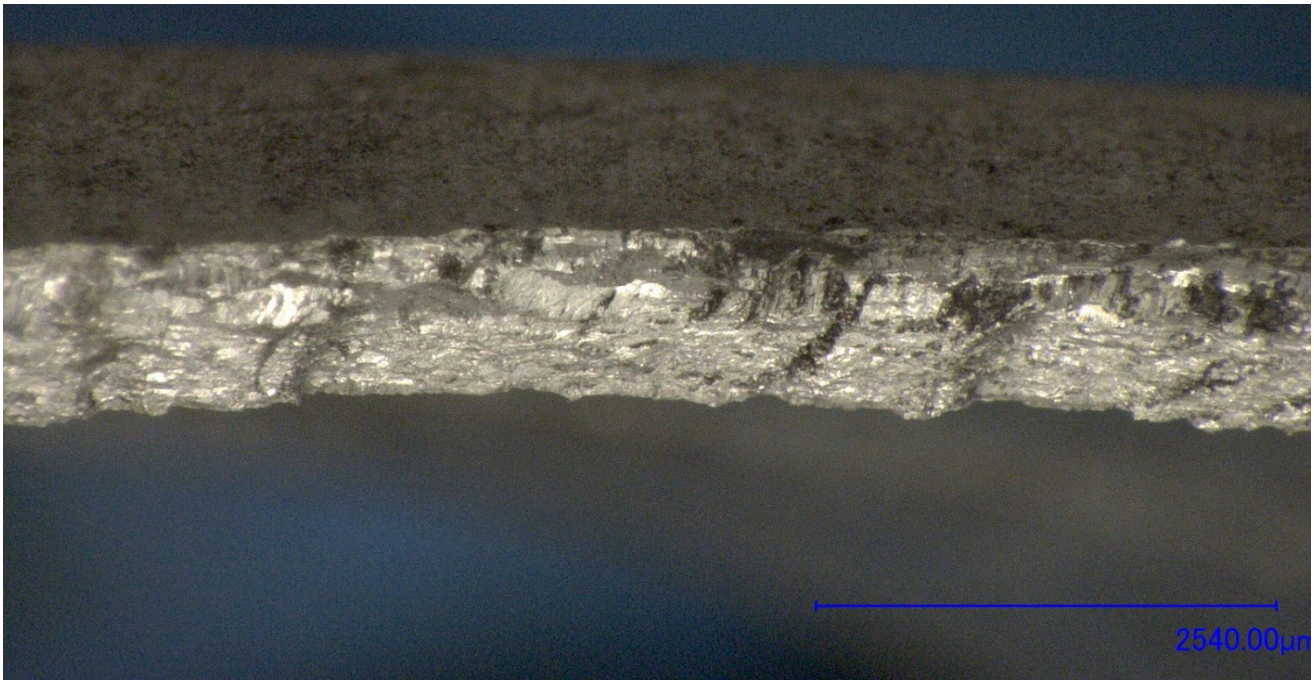

Figure 16 – The outboard crack face of crack #2, after opening.

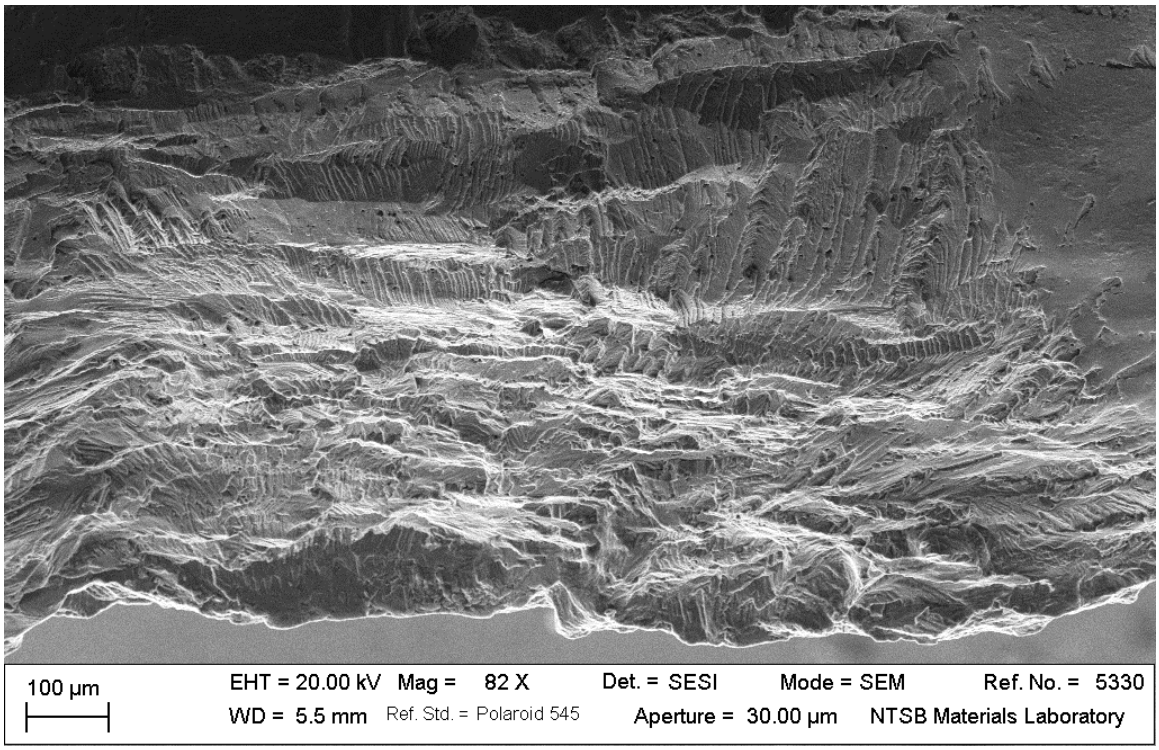

Figure 17 – Secondary electron (SE) micrograph of a typical area of the crack #2 fracture surface.

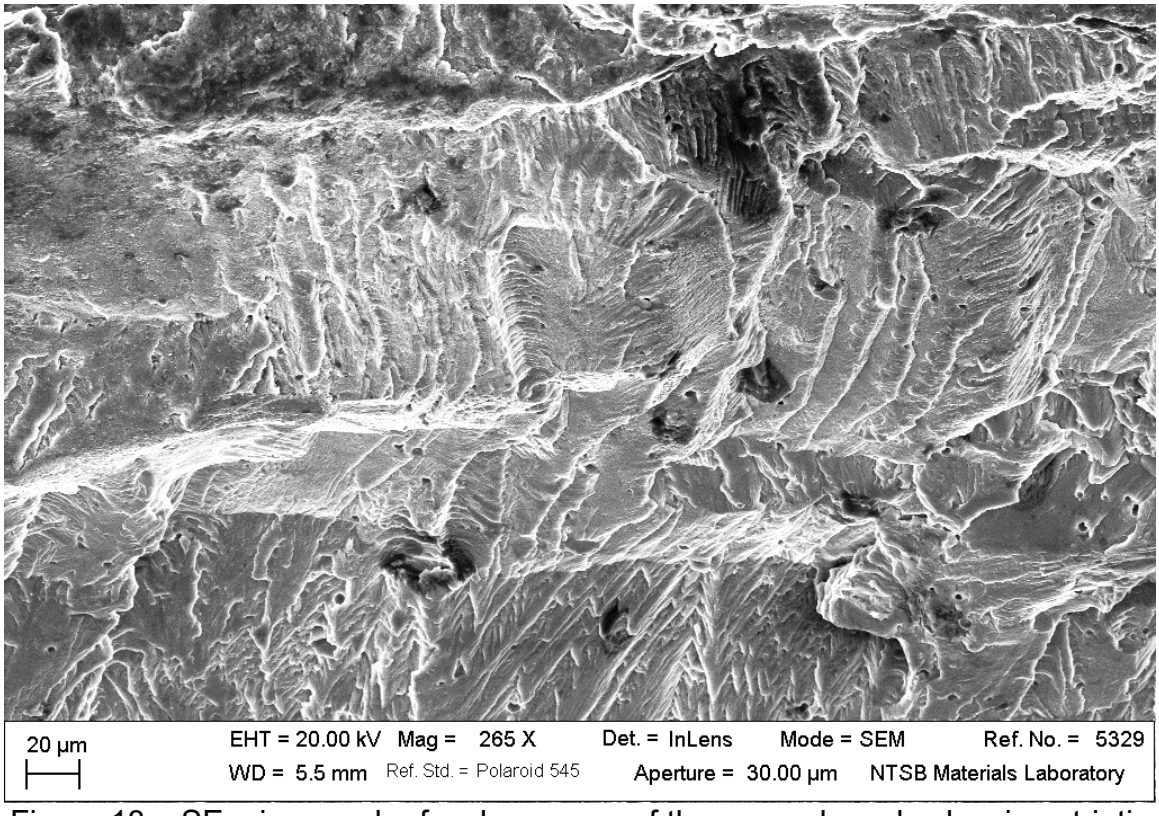

Figure 18 – SE micrograph of a closer area of the opened crack, showing striations.

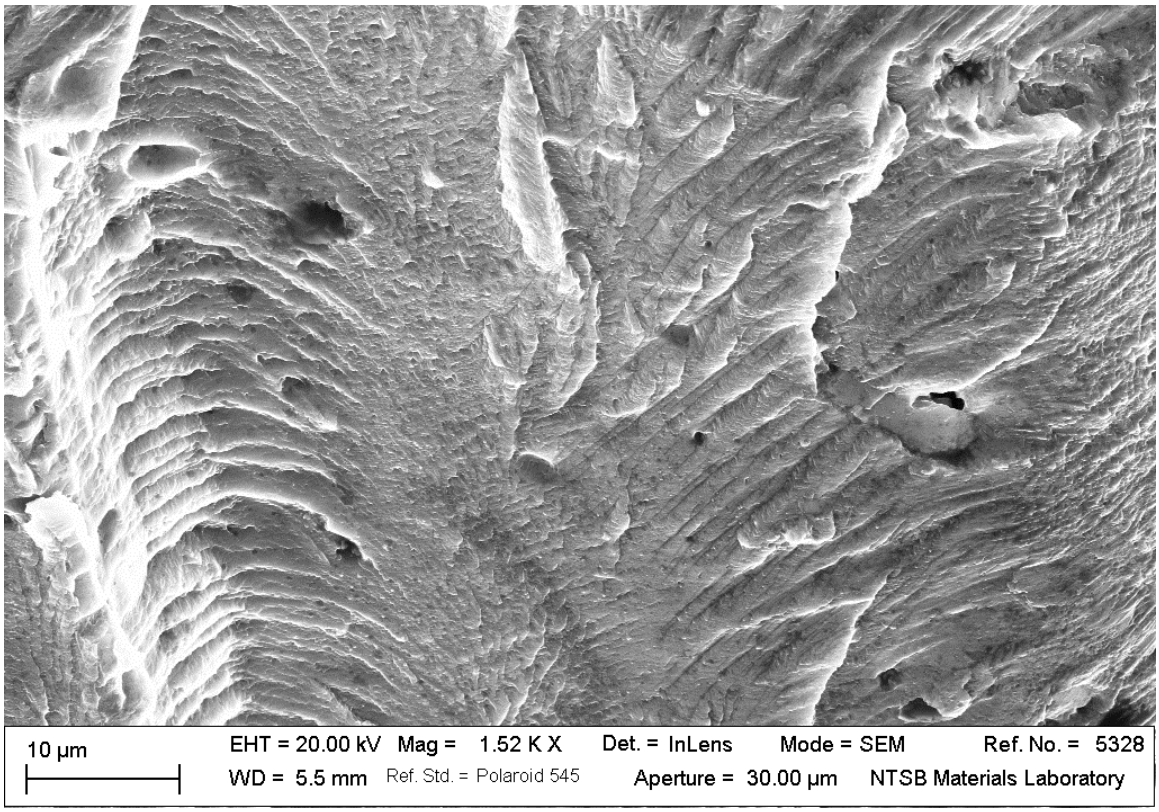

Figure 19 – SE micrograph of a closer view of Figure 18, showing ridges and fatigue striations.

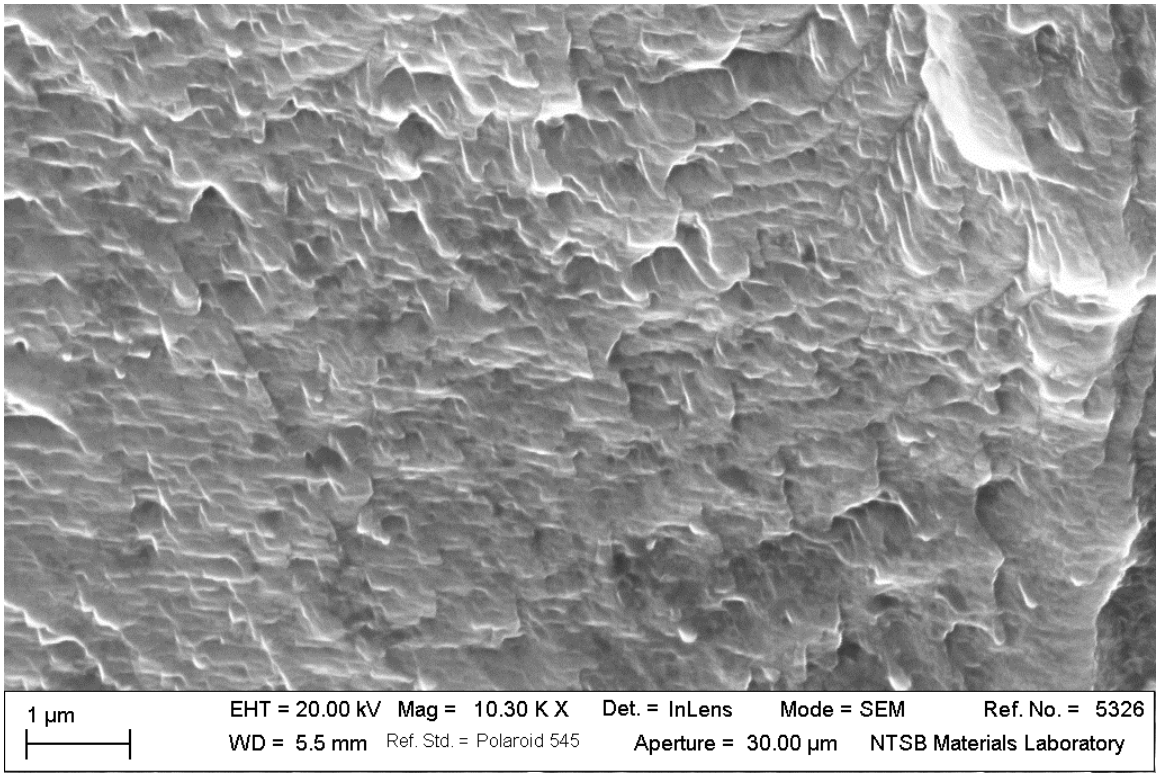

Figure 20 – SE micrograph of a closer view of the fatigue striations in Figure 19.

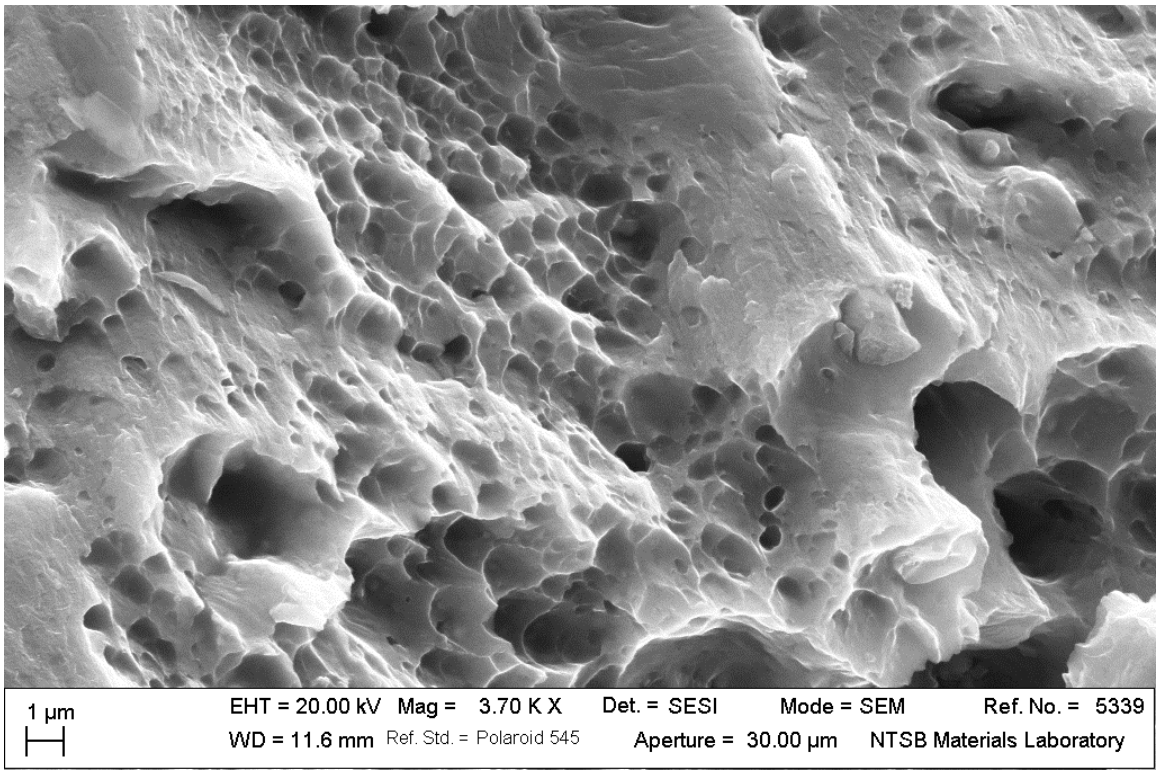

Figure 21 – SE micrograph of dimpled rupture outside the fatigue regions on crack #2.

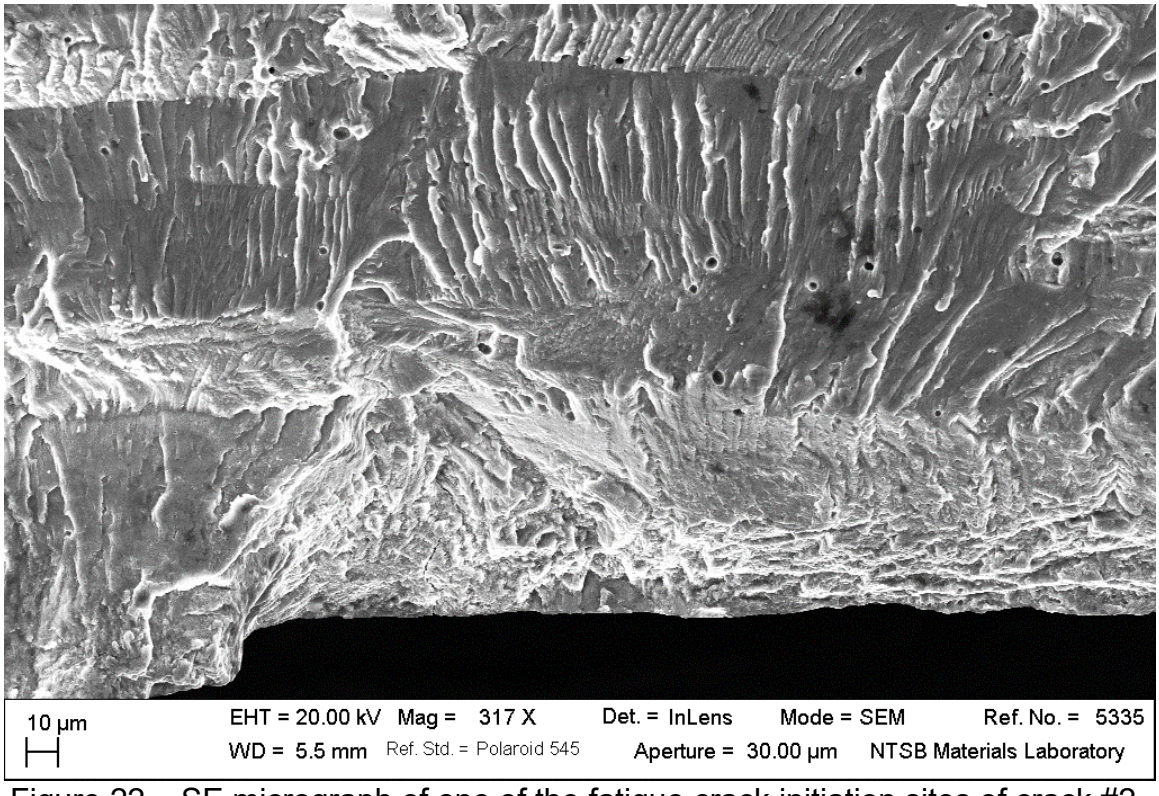

Figure 22 – SE micrograph of one of the fatigue crack initiation sites of crack #2.

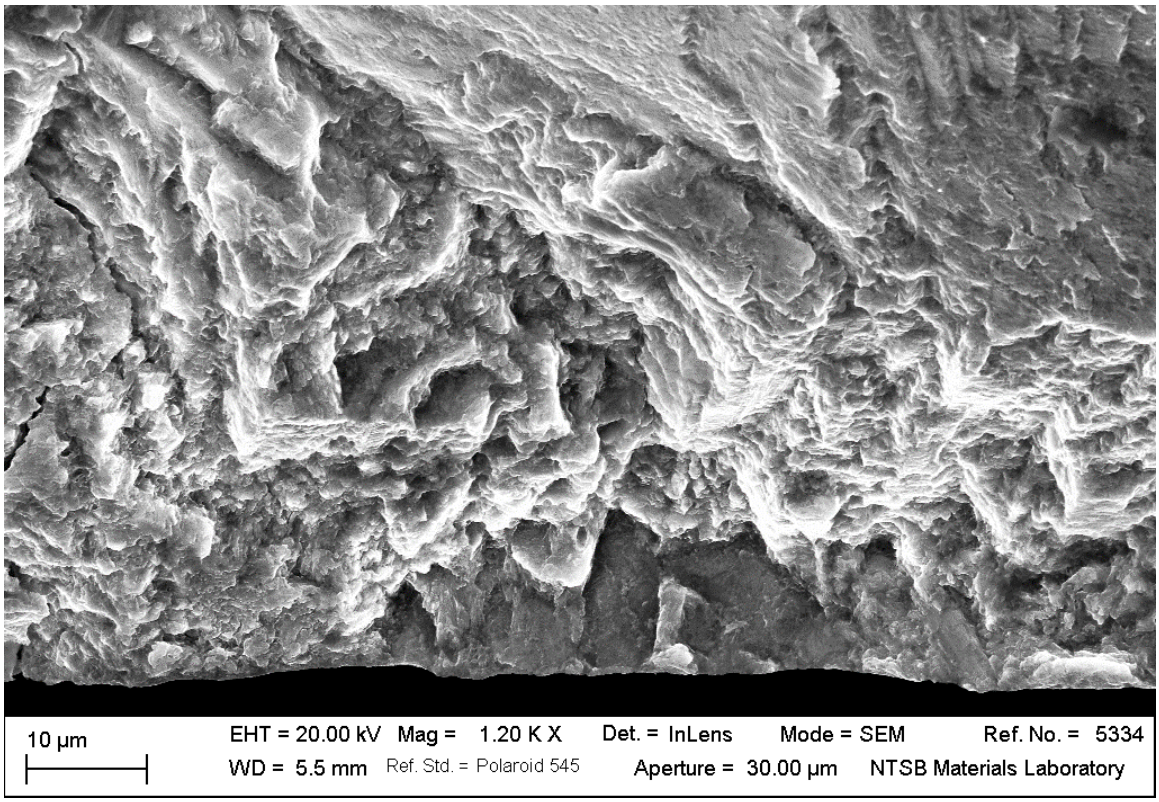

Figure 23 – SE micrograph of showing a closer view of the initiation site in Figure 22.

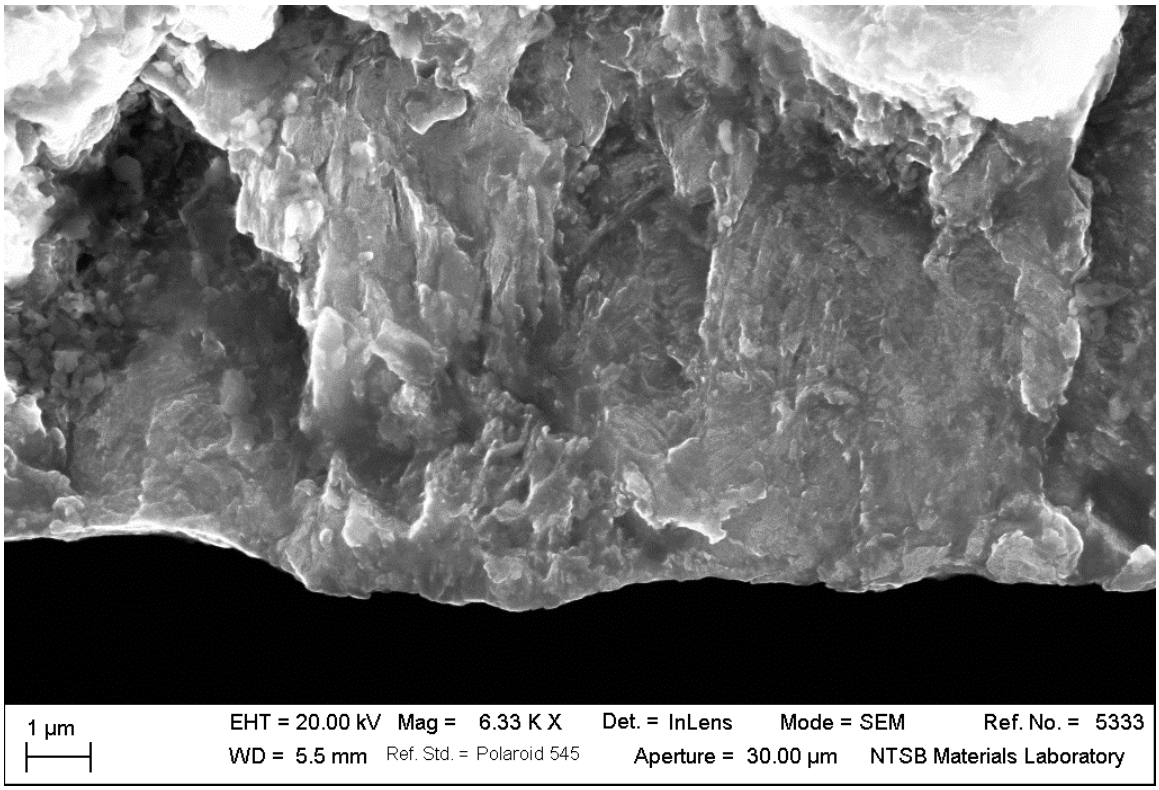

Figure 24 – SE micrograph of the fatigue initiation site in Figure 23.