

NATIONAL TRANSPORTATION SAFETY BOARD

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



January 11, 2017

MATERIALS LABORATORY FACTUAL REPORT

Report No. 17-003

1. ACCIDENT

Place : Hollywood, Florida
Date : August 19, 2016
Vehicle : Piper PA-34-200, N16499
NTSB No. : ERA16LA295
Investigator : Doug Brazy, AS-ERA

2. COMPONENTS EXAMINED

Portions of a fractured propeller hub and parts

3. DETAILS OF THE EXAMINATION

On August 19, 2016, at 1130 eastern daylight time, a Piper PA-34-200, N16499, was substantially damaged during a forced landing near Hollywood, Florida. The flight instructor and pilot receiving instruction were uninjured. According to the flight instructor, the pilot under instruction was at the controls when he heard a loud noise and observed something separate from the right engine. The pilot under instruction stated that the right engine had partially separated from its mounts and was angled downward.

Examination of the wreckage at the scene by a Federal Aviation Administration (FAA) inspector revealed that the right engine had separated from its mounts and was found about 75 feet in front of the airplane. One propeller blade was missing and the propeller hub was fractured. Maintenance records revealed that the airplane's most recent 100-hour inspection (which included inspection of both propellers) occurred on May 27, 2016, at which time the propeller installed on the right engine had accrued a total of 7100 hours, with 380 hours since overhaul. The airplane had been flown about 60 hours since that inspection. The fractured propeller hub pieces were sent to the NTSB Materials Laboratory for further examination.

Figure 1 illustrates the portions of the fractured propeller hub, as received, and reconstructed for visual effect. Both halves of the hub had fractured about the circumference of one of the bosses. Figure 2 illustrates a side view of the hub assembly, showing the different depths of the fracture. The forward side hub half contained a deeper fracture location (left in Figure 2).

The majority of both fracture surfaces were generally flat, exhibiting a rough texture and a dull luster. For aluminum alloys, these features are typically consistent with overstress fractures. However, as shown in Figures 3 and 4, a portion of the fracture surface on the

forward hub half exhibited a shinier luster than the rest of the fracture surfaces. This region exhibited a general thumbnail shape, consistent with progressive crack growth, later determined to be fatigue. This crack was located about a grease-fitting hole. The length of this crack was measured as 3.39 inches from the inner surface and 2.78 inches from the outer surface. This discrepancy in crack length was consistent with crack growth from the inner surface outward.

Closer visual inspection of the progressive cracking, as shown in Figures 5 through 7, revealed the presence of crack arrest, or beach, marks. The crack arrest marks emanated from the lower thread root of the fitting bore, as illustrated in Figure 6. Since there were essentially two crack initiation sites on this fracture surface, the right and left sides were labeled 'A' and 'B', respectively, for the purpose of this report. As shown in Figure 7, crack arrest marks were observed propagating from the bottom thread crest.

This fracture surface was examined using a scanning electron microscope (SEM). As illustrated in Figure 8, the crack exhibited fatigue striations, consistent with fatigue crack growth. Outside of the fatigue crack, dimple rupture, consistent with subsequent overstress fracture, was observed (see Figure 9). The erratic spacing of the striations was consistent with spectrum stresses or loads. These features are typical for crack propagation in rotating operations under high cycle fatigue.

Fatigue crack initiation site A was examined using a SEM, as shown in Figures 10 through 12. As displayed in these figures, the fatigue crack initiated at the innermost thread crest on the flat side. Faint fatigue striations were observed adjacent to the surface propagating inward (Figure 12). However, no material defects such as pits, voids, or inclusions, were observed. Likewise, there were no indications of aggressive machining or wear present at this crack initiation site.

Fatigue crack initiation site B was also examined using a SEM, and is highlighted in Figures 13 through 15. The fatigue cracking on this side of the bore initiated at the upper (or outboard) thread face just below the thread crest (Figure 14). Again, faint striations were observed propagating from this site. There were no discernible material or mechanical imperfections found at this crack initiation site.

The hub material was inspected using energy dispersive x-ray spectroscopy (EDS) and x-ray fluorescence (XRF). The cylinder chemical composition was found to be consistent with AA 2014 or 2024 aluminum alloy.

The material hardness was inspected per ASTM E18.¹ The hardness averaged 83 HRBW. The electrical conductivity of the material was inspected per ASTM E1004.² The

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

² ASTM E1004 – *Standard Test Method for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method*. ASTM International, West Conshohocken, PA

conductivity averaged 37.8% IACS. Per ASM 2658, these data were consistent with either a T6 or T8 temper for these aluminum alloys.³

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

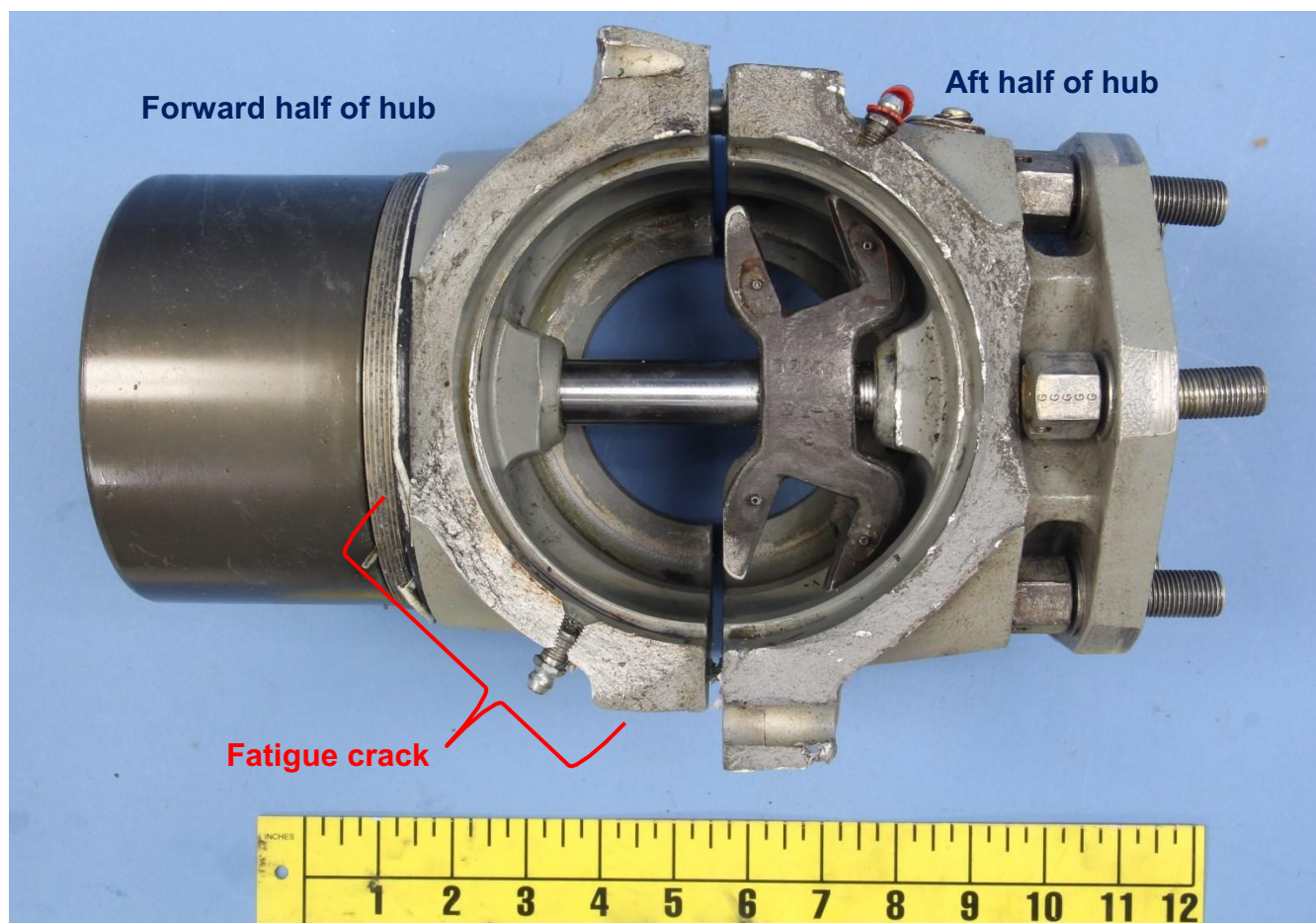


Figure 1 – The fractured halves of the propeller hub as received.

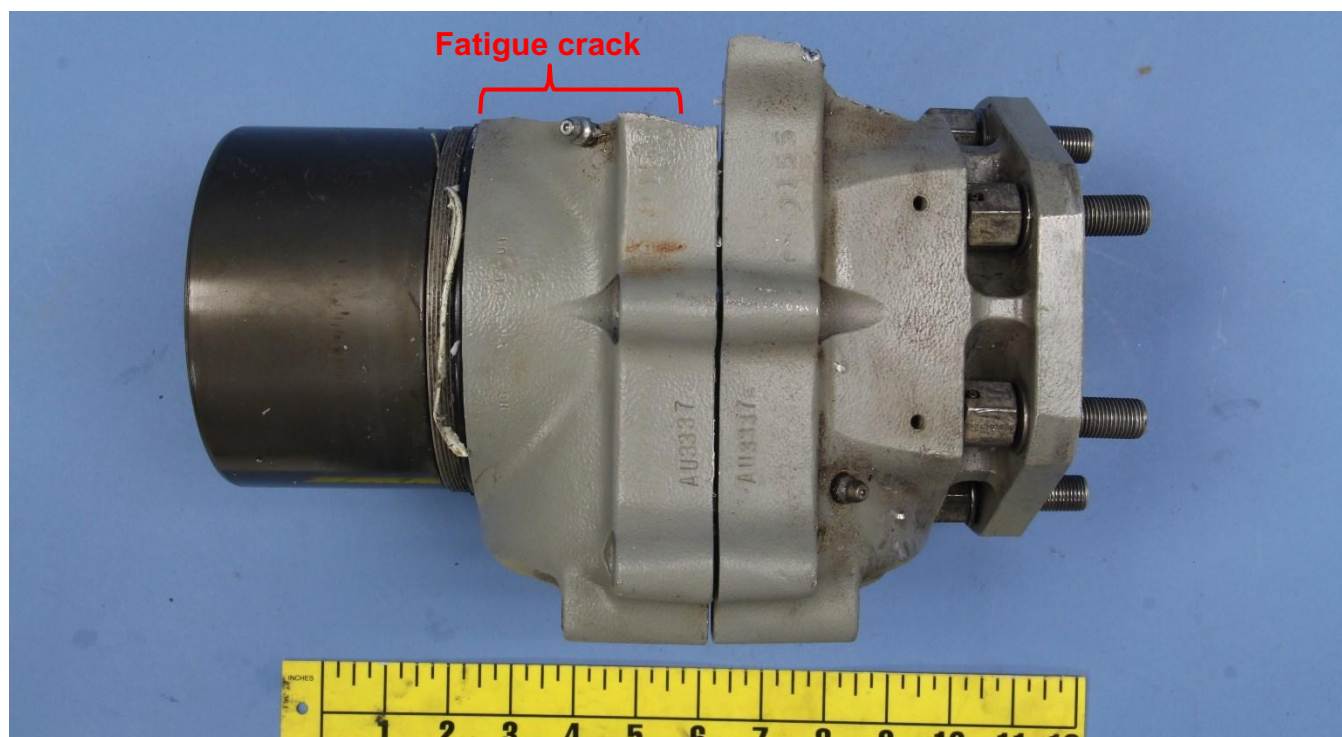


Figure 2 – The propeller hub, rotated 90° from Figure 1. The general location of the fatigue crack is illustrated.



Figure 3 – The forward propeller hub half, as received, showing the fatigue cracking about a grease fitting hole.



Figure 4 – The fracture surface in Figure 3, after sectioning and cleaning. The fatigue crack edges are labeled.

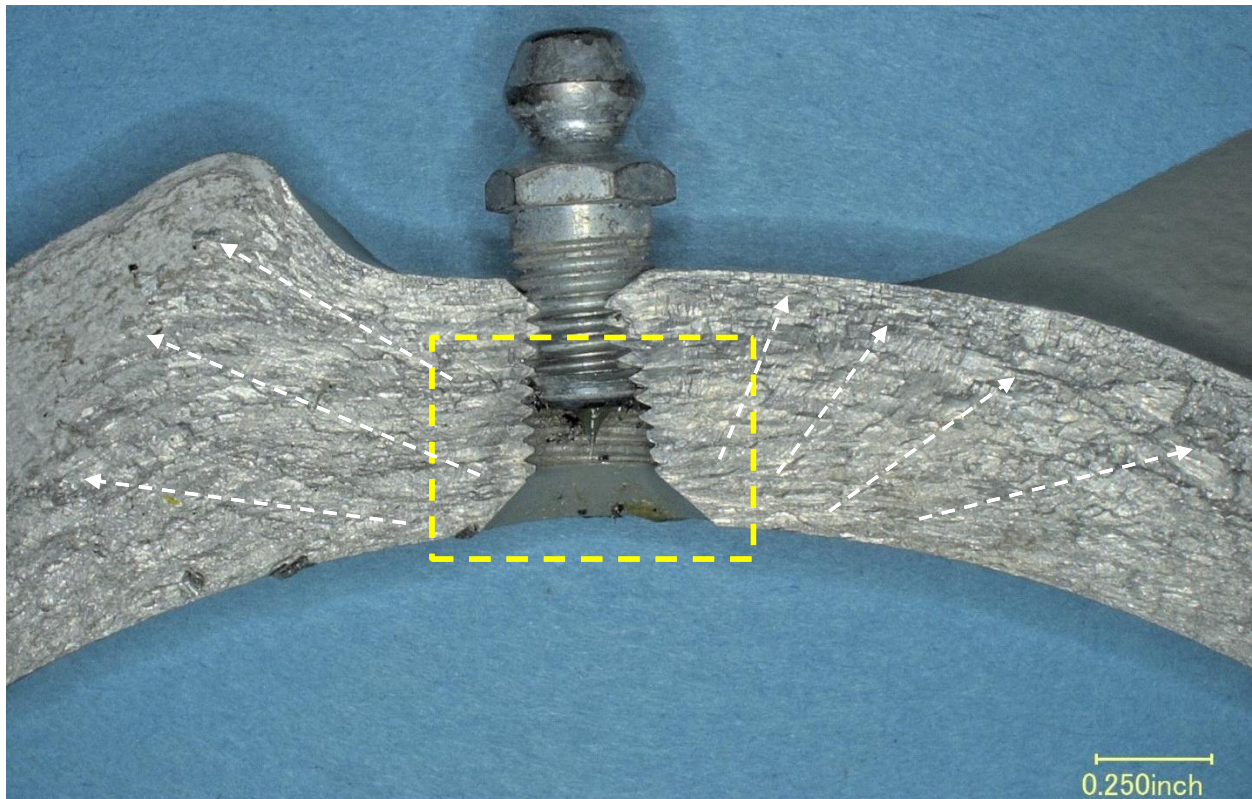


Figure 5 – Closer view of the grease fitting bore in Figure 4, showing crack arrest marks emanating from the bore. The dashed arrows denote crack growth direction, and the boxed area is shown in Figure 6.

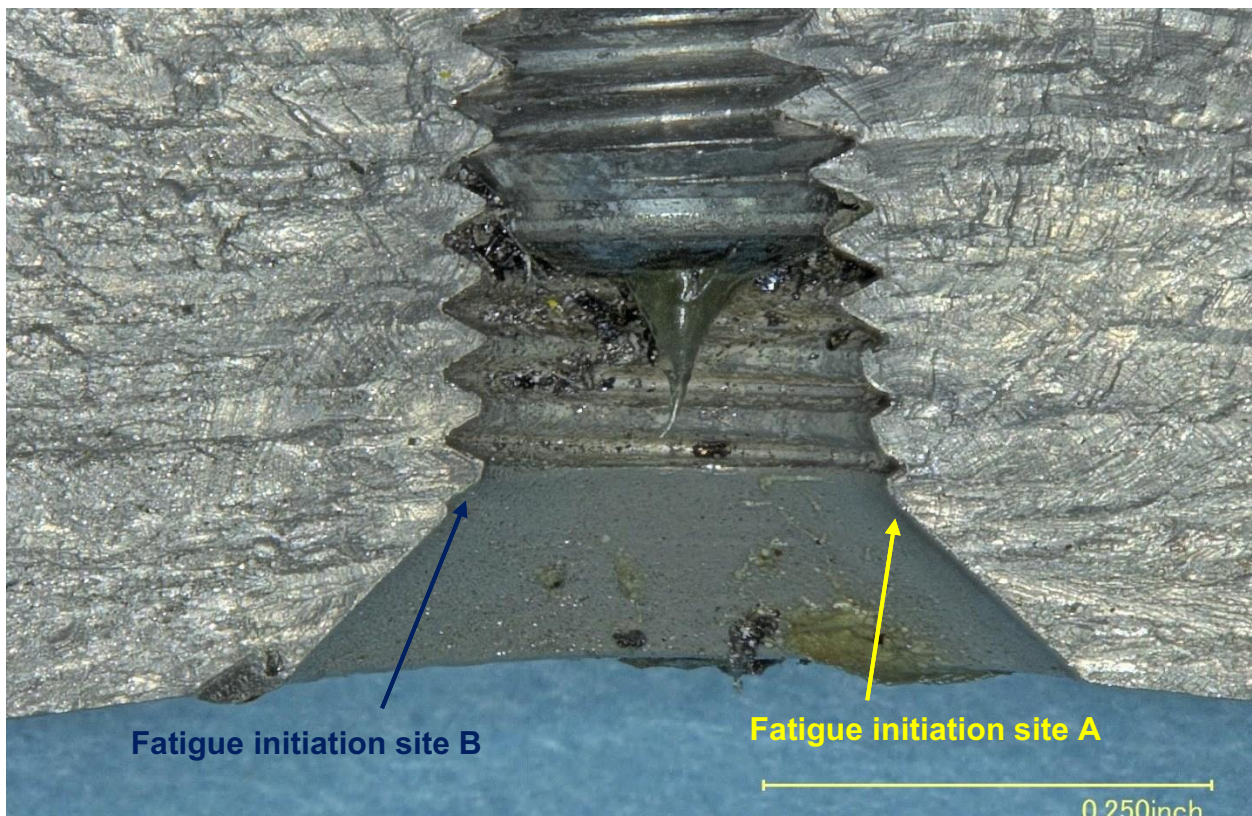


Figure 6 – The boxed area in Figure 5, showing the crack initiation sites at the bore (labeled A and B).



Figure 7 – Closer view of fatigue crack initiation site A (arrow), showing crack arrest marks emanating from a thread crest.

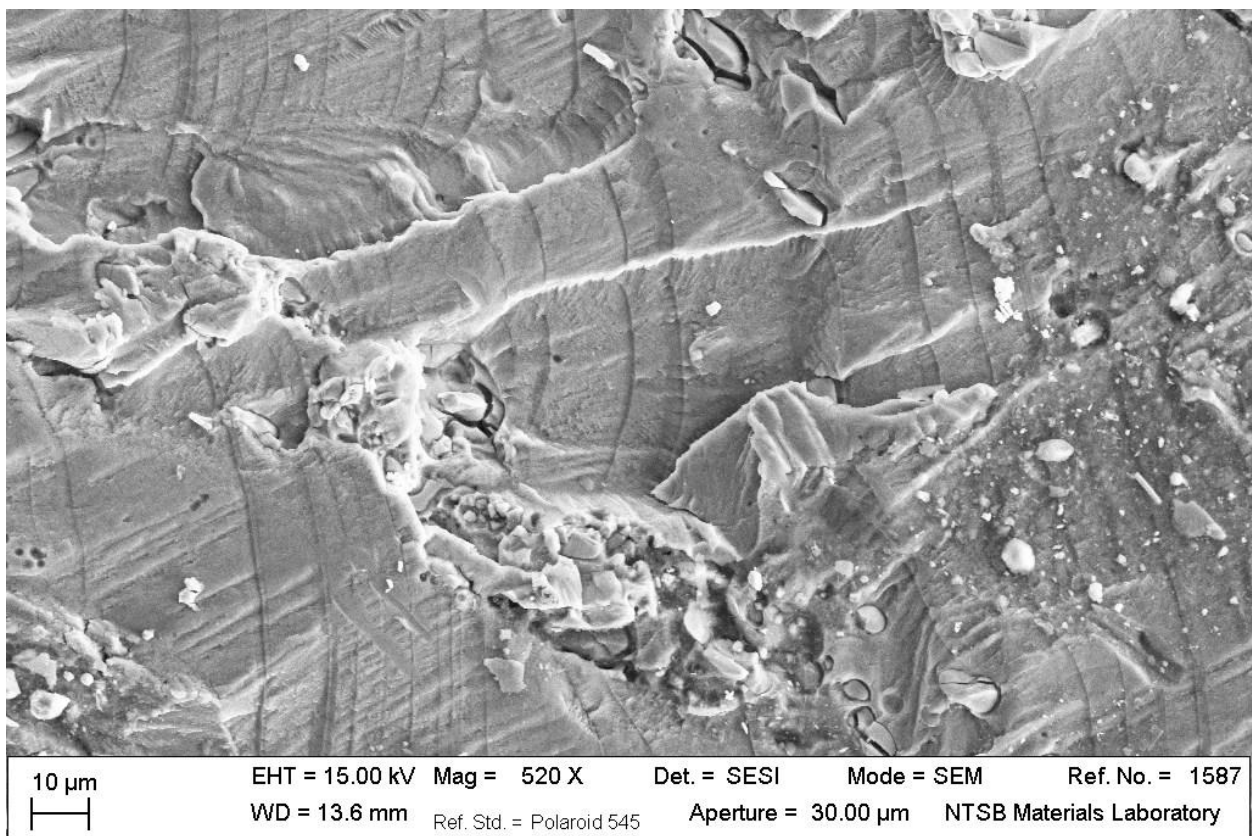


Figure 8 – Secondary electron (SE) micrograph of fatigue striations on the hub fatigue fracture.

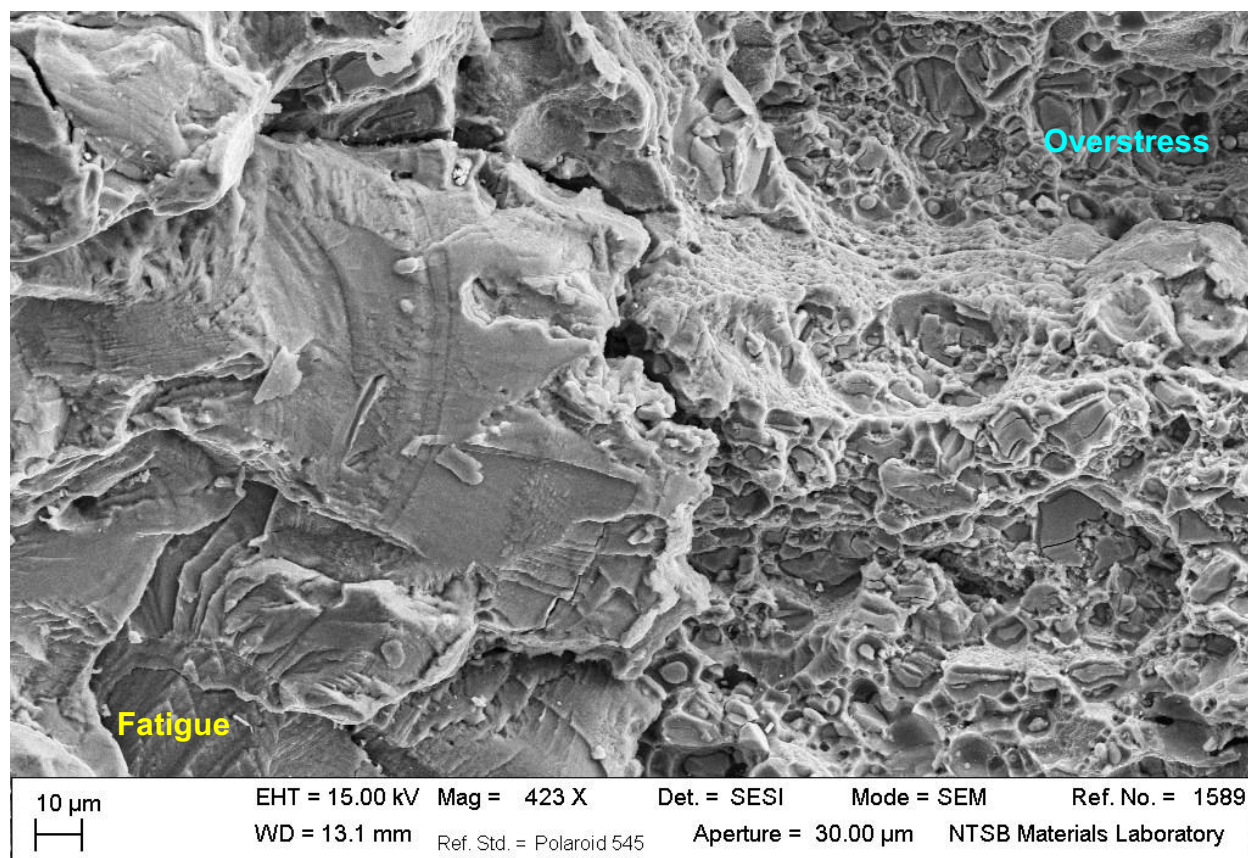


Figure 9 – SE micrograph showing the end of the fatigue crack, transitioning to dimple rupture.

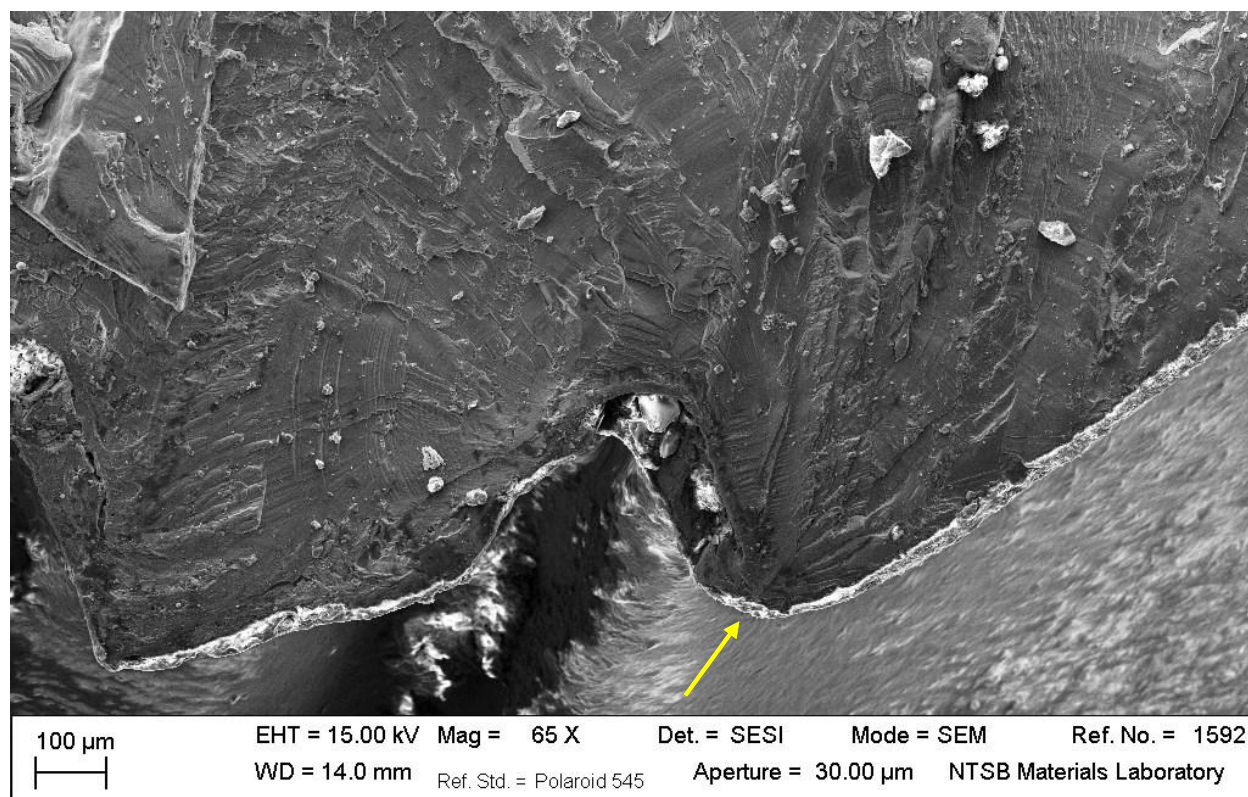


Figure 10 – SE micrograph showing fatigue crack initiation site A (yellow arrow).

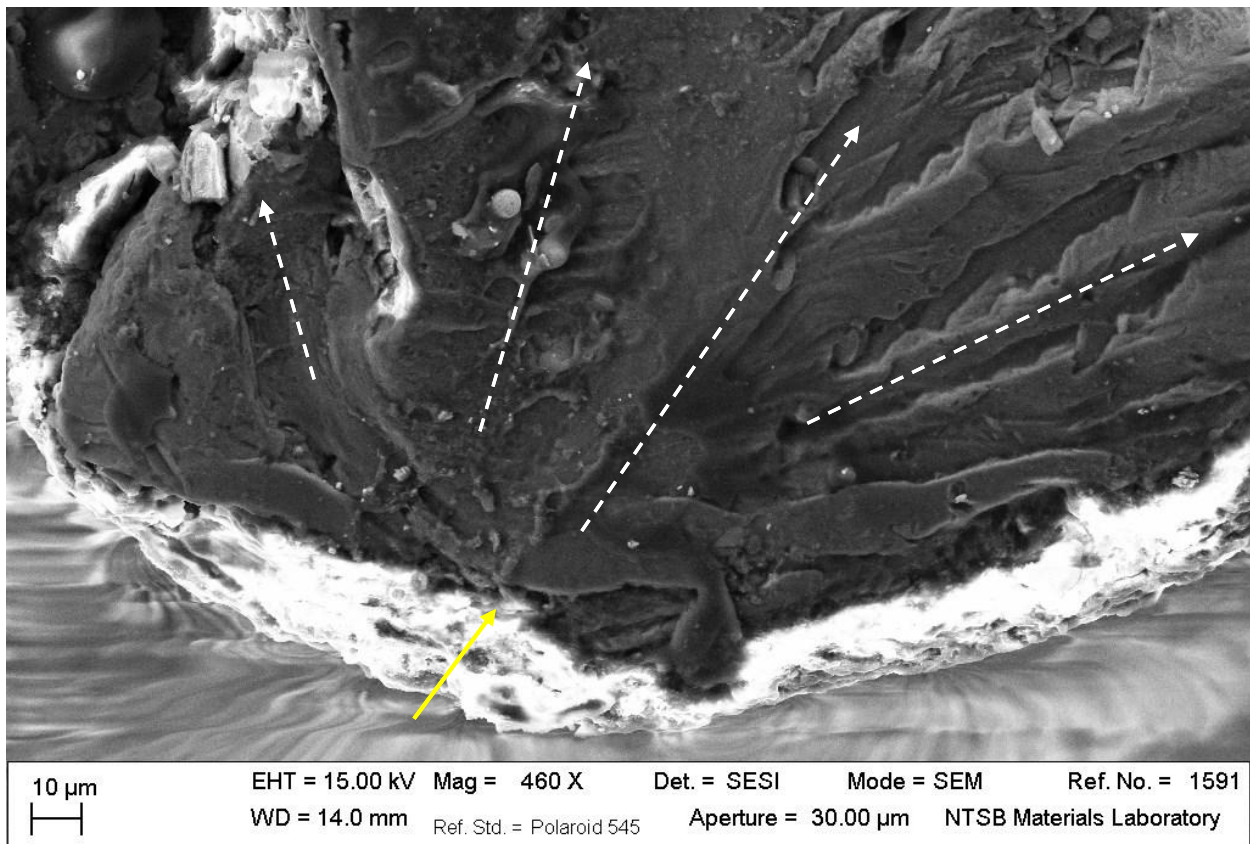


Figure 11 – SE micrograph showing a closeup of initiation site A. The dashed arrows denote crack growth.

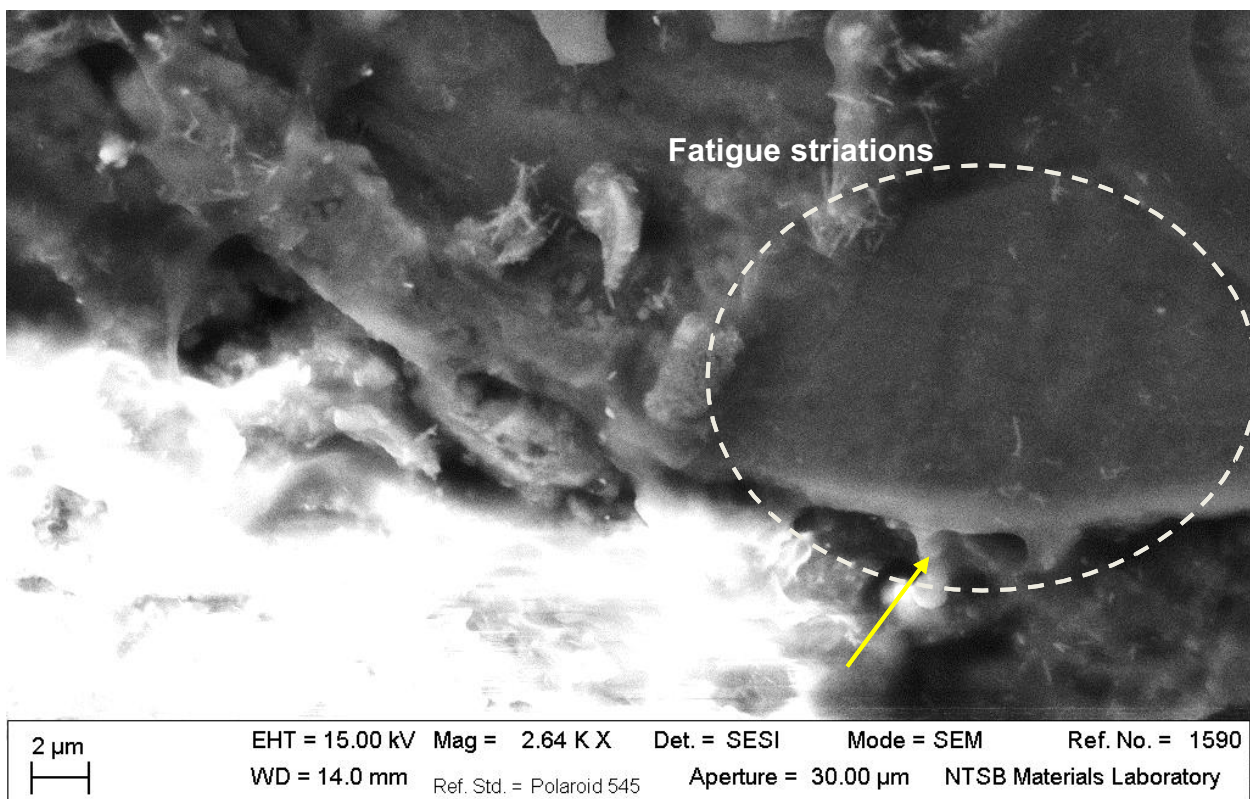


Figure 12 – SE micrograph showing a closer view of the crack initiation site (arrow) in Figure 11.

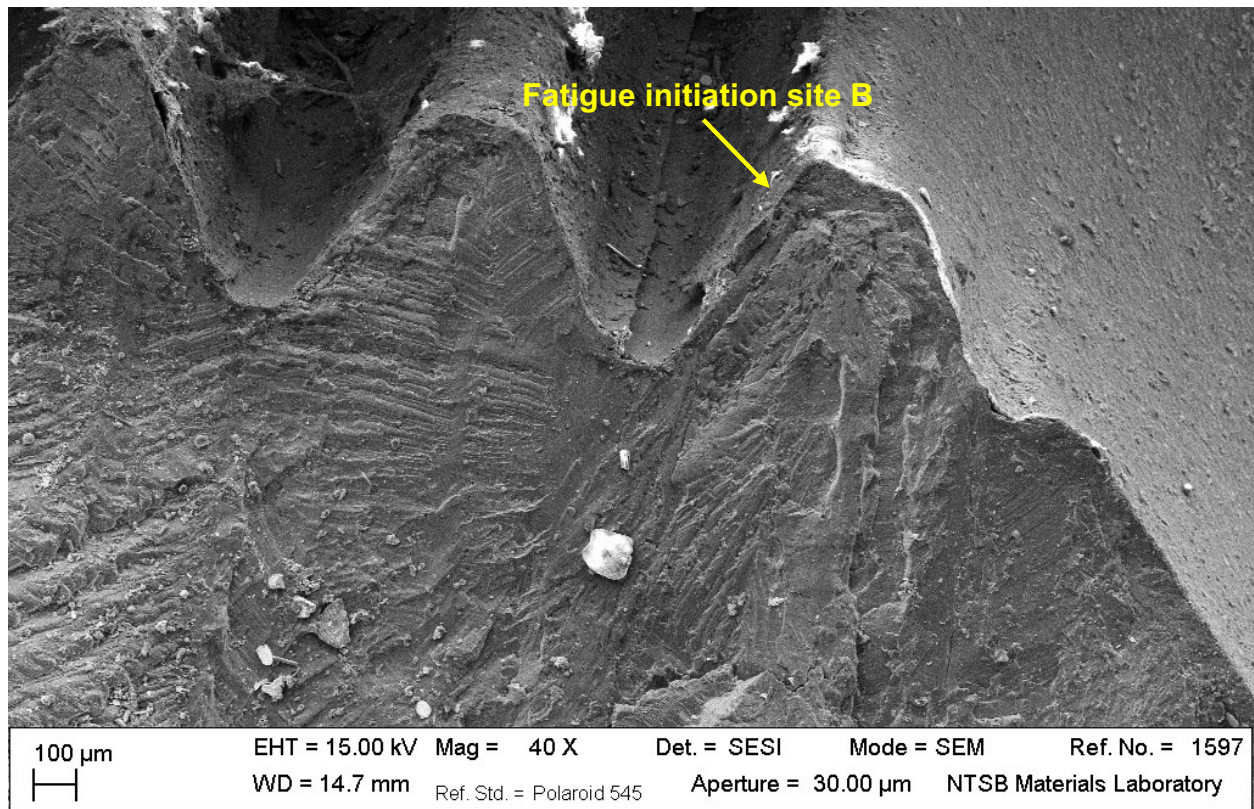


Figure 13 – SE micrograph showing fatigue crack initiation site B (arrow).

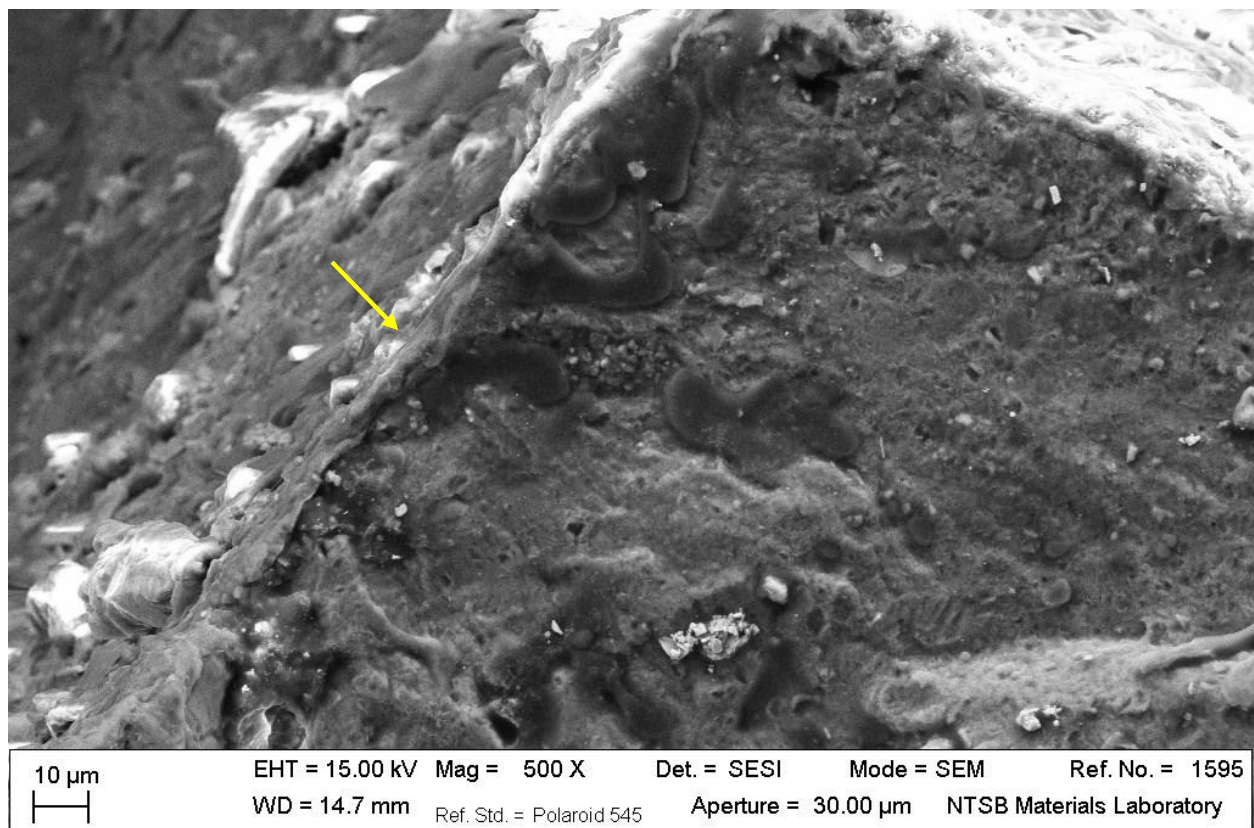


Figure 14 – SE micrograph showing a closer view of crack initiation site B (arrow).

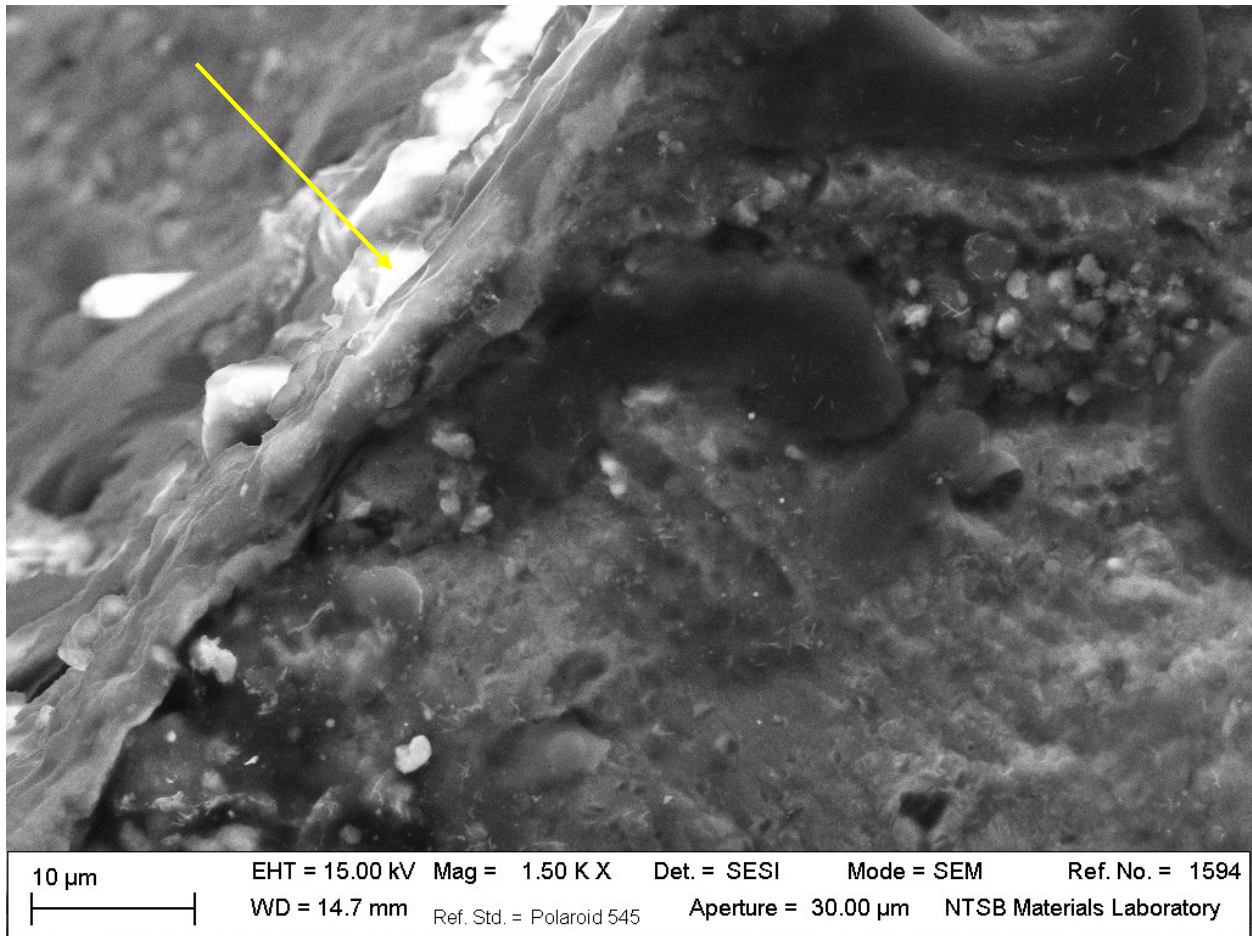


Figure 15 – SE micrograph showing a closer view of the crack initiation site in Figure 14.