

NATIONAL TRANSPORTATION SAFETY BOARD

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

May 9, 2019



MATERIALS LABORATORY FACTUAL REPORT

Report No. 19-027

1. ACCIDENT INFORMATION

Place : Passadumkeag, Maine
Date : July 12, 2018
Vehicle : Glasair SH-2, N352GL
NTSB No. : ERA18LA190
Investigator : Heidi Kemner, AS-ERA

2. COMPONENTS EXAMINED

Fractured remnants of a crankshaft

3. DETAILS OF THE EXAMINATION

On July 11, 2018, about 1920 eastern daylight time, an experimental, amateur-built Glasair SH-2 was substantially damaged during a forced landing after a total loss of engine power near Passadumkeag, ME. The commercial pilot was not injured. According to the pilot, during cruise airspeed, the engine started to run "rough" and decreased to half cruise power. The pilot noted no irregularities on the engine gauges, unsuccessfully attempting to regain engine power by turning on the fuel boost pump. The engine, a Lycoming O-320 series, lost total power and the propeller stopped.¹ The pilot performed a forced landing in a bog, and the airplane came to rest in an inverted position with the empennage having separated.

A crankshaft from the accident engine was sent to the NTSB Materials Laboratory, and is shown in Figure 1. According to records supplied to the Materials Laboratory, the engine had undergone a propeller strike in 2013, about 350 flight hours prior to this accident. No engine inspection had been performed after that event.

As shown in Figure 1 and Figure 2, the crankshaft had fractured into two main pieces at the #4 cylinder journal (the aft most cylinder journal). The journal had fractured perpendicular to the crankshaft direction, located along the radius at the web forward of the #4 cylinder journal.

¹ The Lycoming O-320 is a family of air-cooled, four-cylinder, horizontally-opposed, direct-drive engines rated for 150 to 160 horsepower with a displacement of 320 cubic inches, commonly used on light aircraft.

The forward mating fracture surface is shown in Figure 3 and Figure 4. About half of the fracture surface exhibited smearing, consistent with post-fracture damage to the forward surface. The lower half of this fracture surface exhibited crack arrest marks, consistent with progressive crack propagation. As denoted by the arrows in Figure 3, the progressive portion of the fracture surface propagated inward from the journal surface.

Figure 5 and Figure 6 illustrate of the aft fracture surface. This fracture surface was examined more thoroughly as the progressive fracture regions were less damaged than on the forward side. The crack initiation site was located on the journal surface, denoted by the yellow arrow in Figure 6.

This location corresponded with the forward transition radius of the journal as well as a circumferential gouge with a brownish-colored streak. Closer views of the crack initiation area and the brown circumferential streak are shown in Figure 7. The crack initiation area exhibited ratchet marks, consistent with where two smaller cracks joined and coalesced during the propagation stage (see Figure 8).

The aft fracture surface was cleaned using acetone and examined using a scanning electron microscope (SEM). A typical area of the end of the fracture surface is displayed in Figure 9. Much of the microscopic features of the fracture surface had been obliterated by post-fracture contact with the mating forward face, as indicated by the darker-colored, smoother areas in Figure 9. However, undamaged areas were able to be examined, such as the crack arrest marks in Figure 9 and Figure 10.

Closer examination of this region of the fracture surface revealed fatigue striations, consistent with fatigue crack propagation (Figure 11 and Figure 12). These striations were finely spaced and exhibited changing or erratic thicknesses on different areas of the fracture surface (Figure 12). These fatigue features were consistent with propagation through high-cycle fatigue. Outside of the fatigue regions only dimple rupture features were found, consistent with subsequent and final overstress fracture of the crankshaft journal.

Figure 13 through Figure 15 show closer view of the fatigue crack initiation sites. Examination using a SEM found three primary initiation sites, with possible smaller initiation sites collocated in the area. These initiation sites were all located on the fracture surface edge with the journal surface. There were no material features (such as cracks, pores, or voids) located at these initiation sites. However mechanical defects, such as gouges and streaks, were present at the crack initiation sites.

It could not be determined whether the mechanical damage to the journal surface had been entirely present prior to the crankshaft fracture, or if the damage developed after the final fracture of the part.

The chemical composition of the crankshaft was inspected using energy dispersive x-ray spectroscopy (EDS). The composition of the crankshaft was consistent with an alloy

steel. The hardness of the flange was inspected per ASTM E18.² The hardness averaged 43 HRC.

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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.

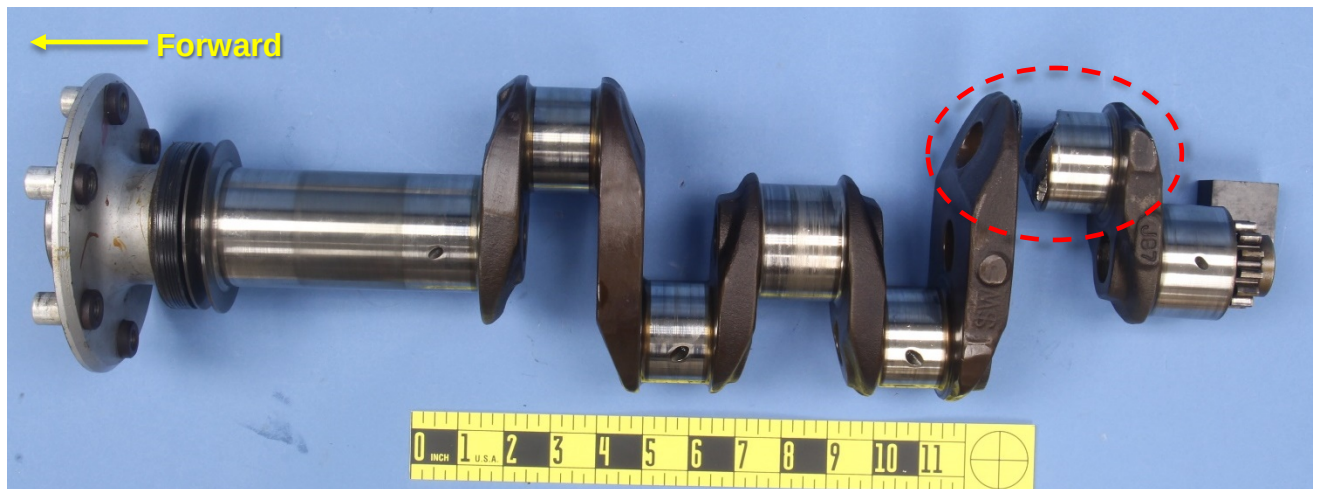


Figure 1 – The fractured pieces of the crankshaft, as received. The fractured #4 cylinder journal is annotated on the figure (red circle).



Figure 2 – The mating halves of the fractured #4 cylinder journal of the received crankshaft.

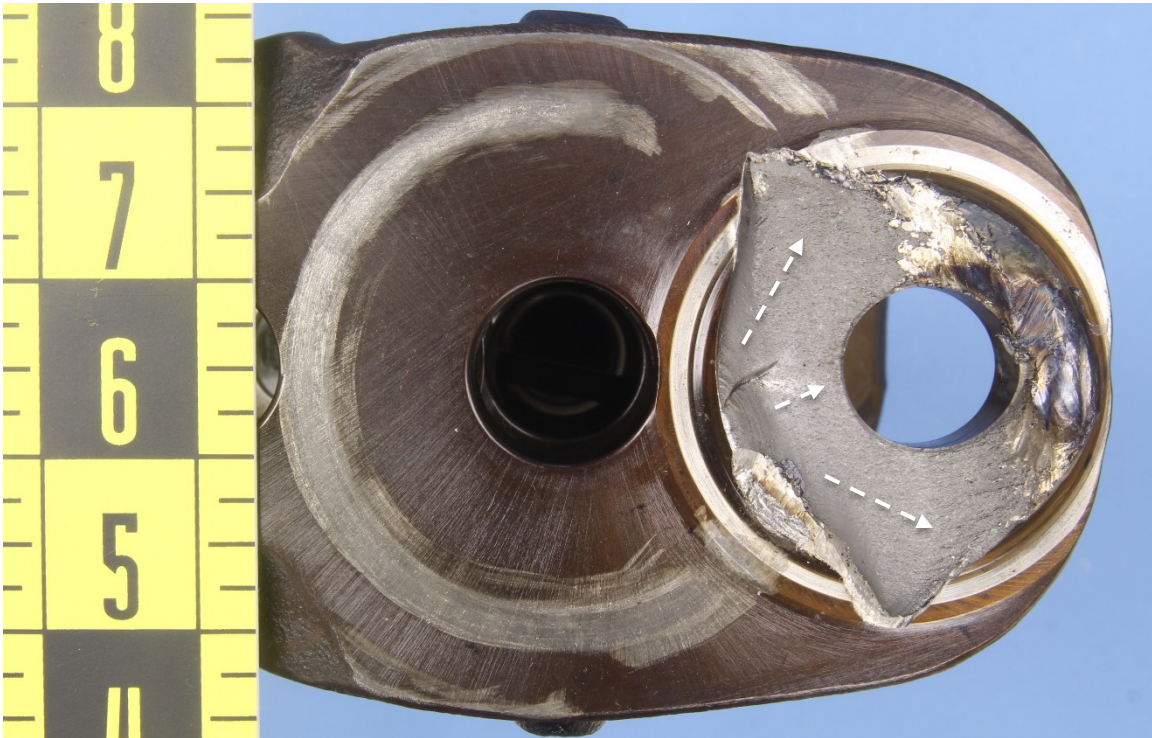


Figure 3 – The forward side fracture surface of the #4 cylinder, as received. The arrows denote the crack growth direction.



Figure 4 – Angled view of the forward fracture surface.

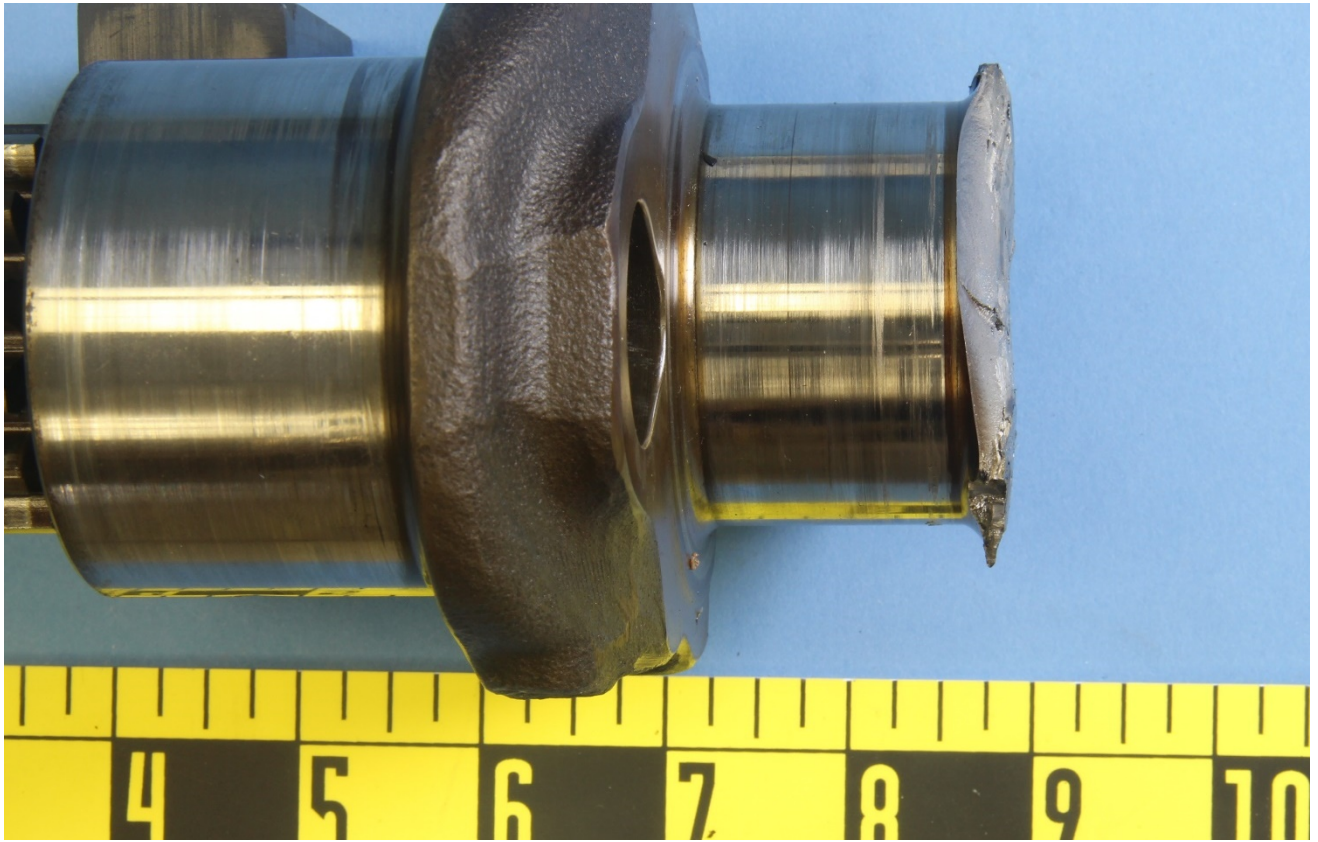


Figure 5 – Normal view of the aft fracture surface from the crack initiation site side.

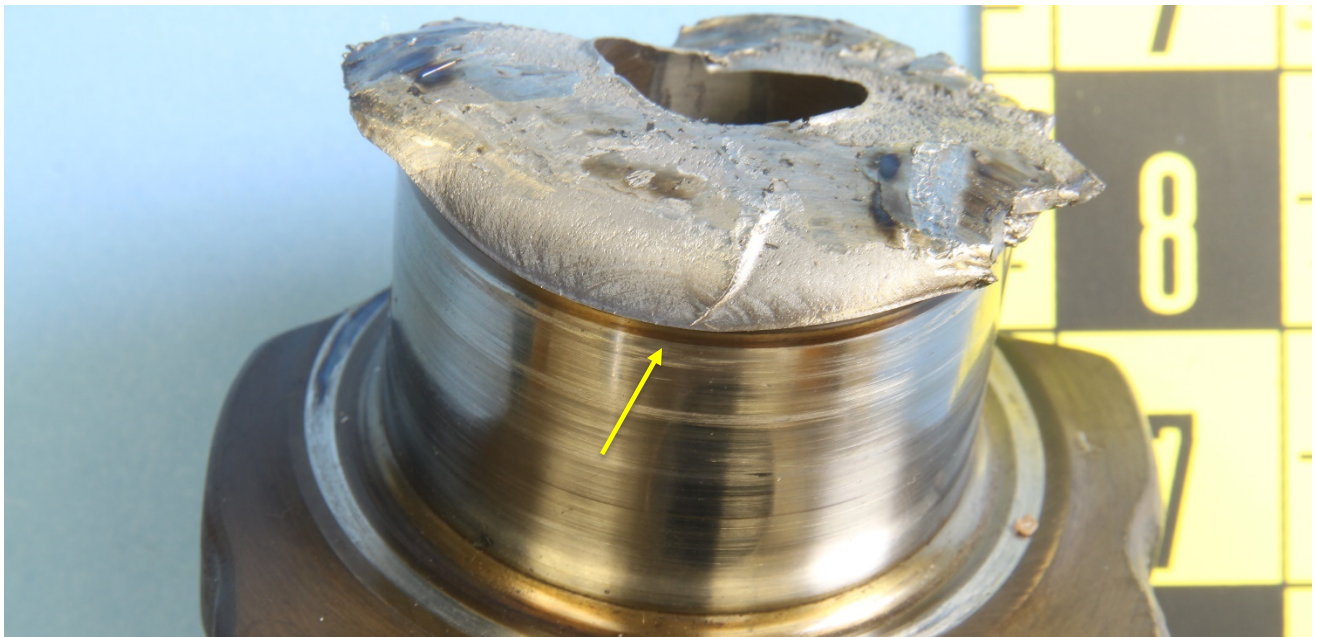


Figure 6 – Angled view of the aft fracture surface, facing the crack initiation area (arrow).

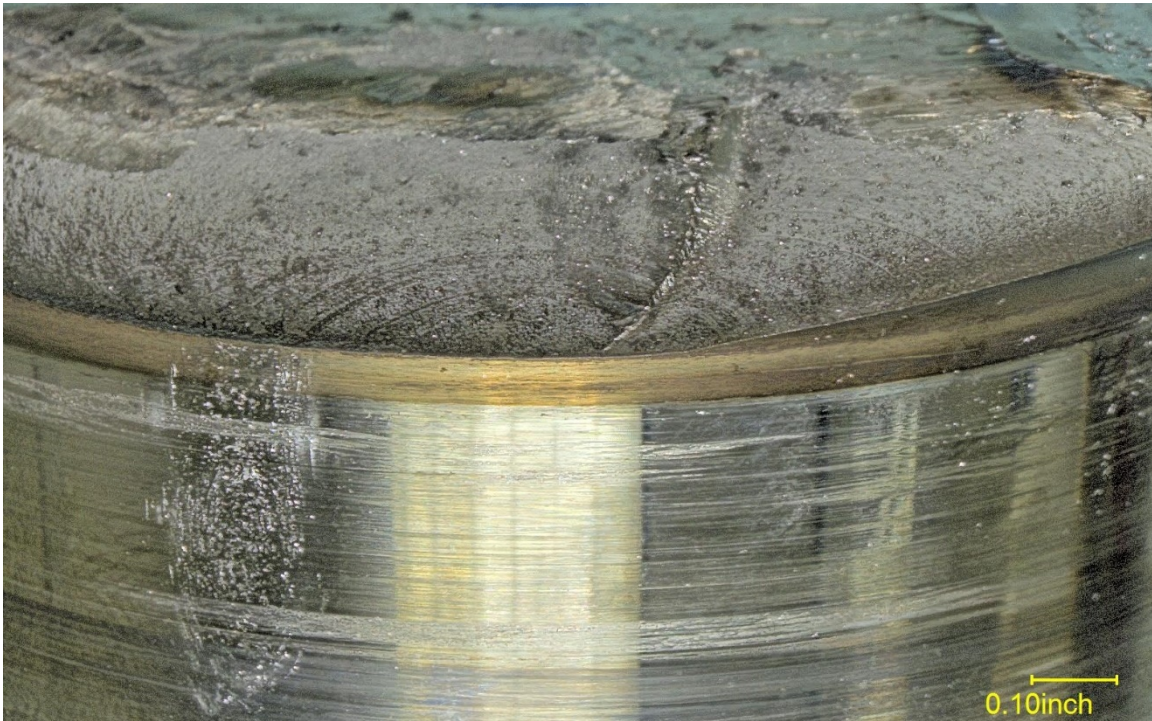


Figure 7 – Closer view of the aft fracture crack initiation site, located at a circumferential streak on the journal.



Figure 8 – Closer view of the aft crack initiation sites, with a prominent ratchet mark present on the right.

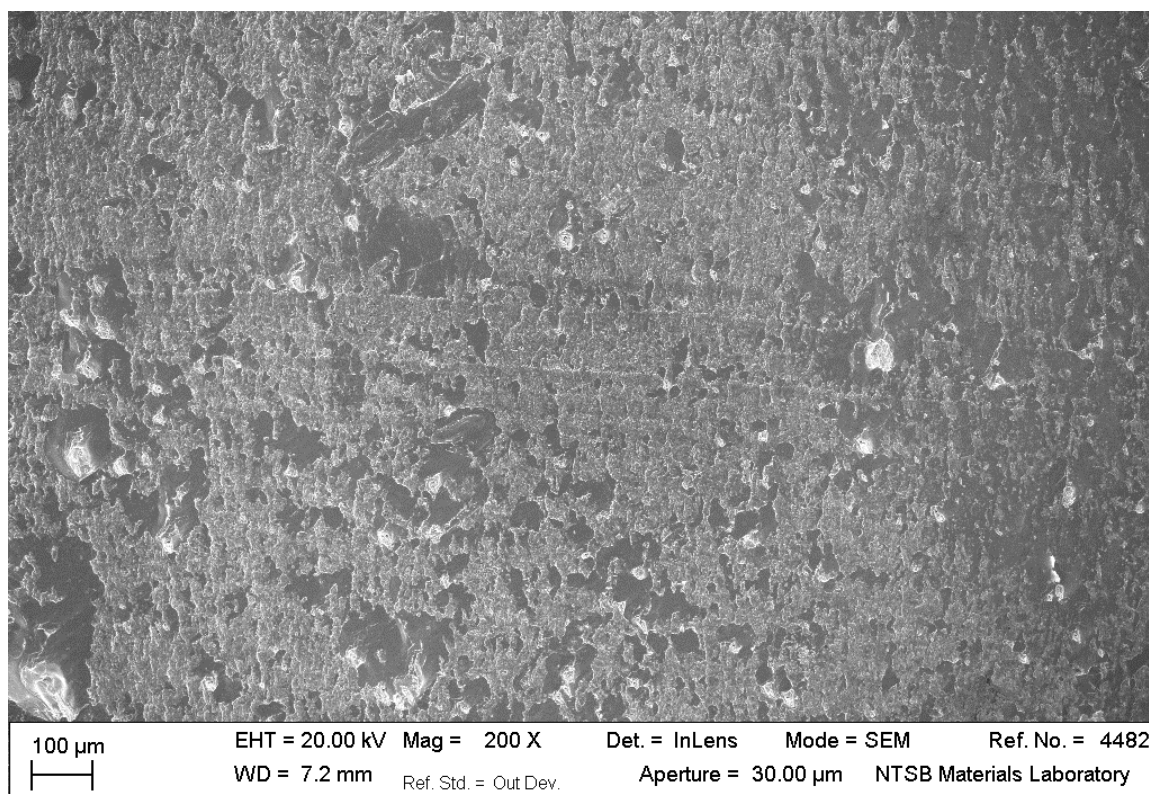


Figure 9 – Secondary electron (SE) micrograph of the end of the aft fracture surface, showing crack arrest marks.

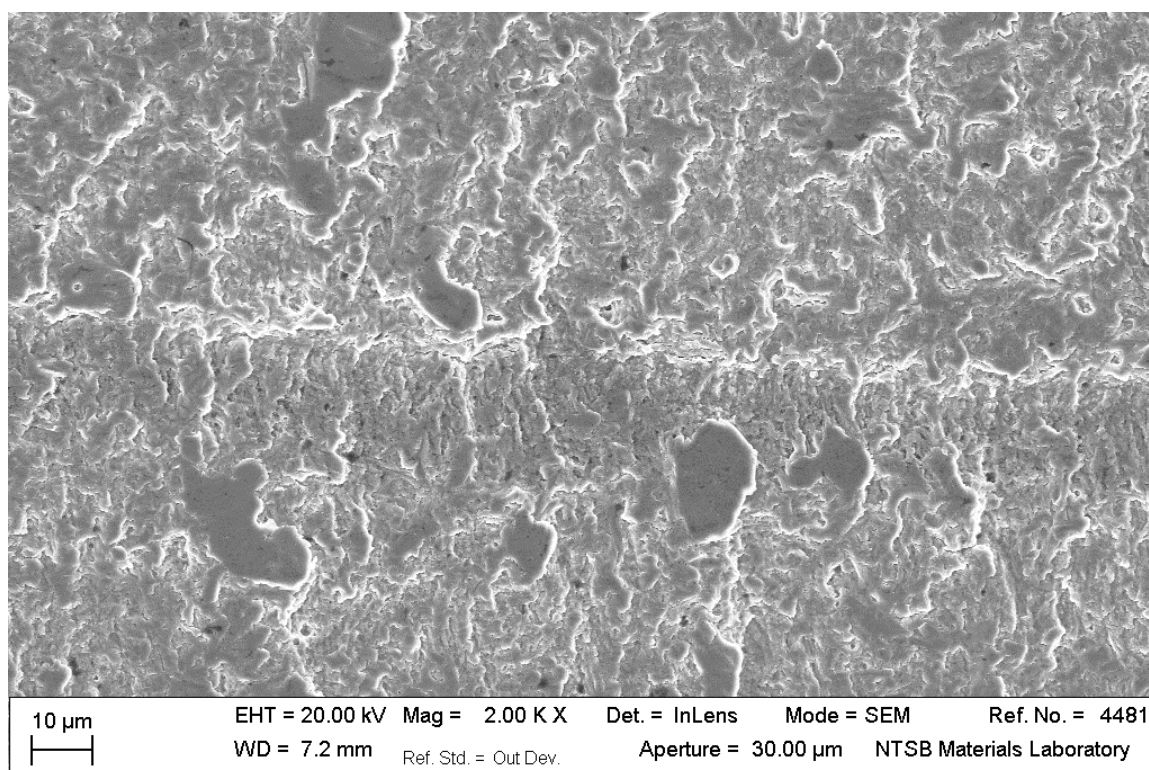


Figure 10 – SE micrograph of one of the crack arrest marks in Figure 9.

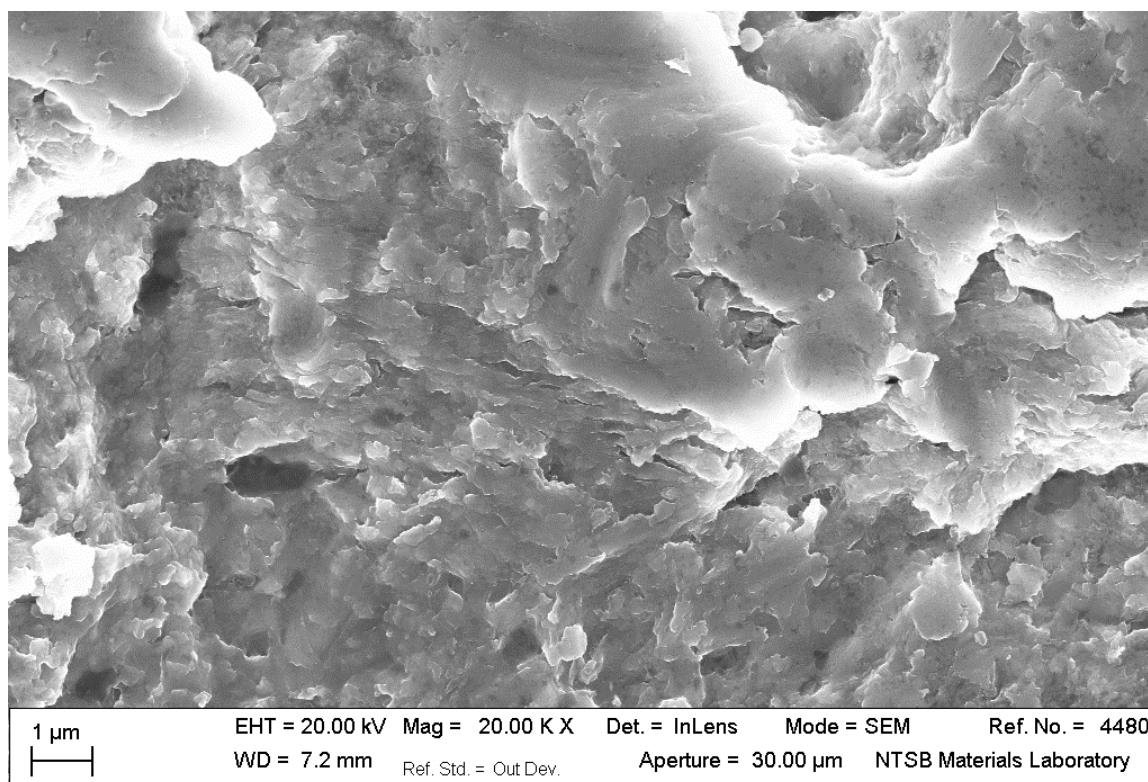


Figure 11 – SE micrograph of fatigue striations from Figure 10.

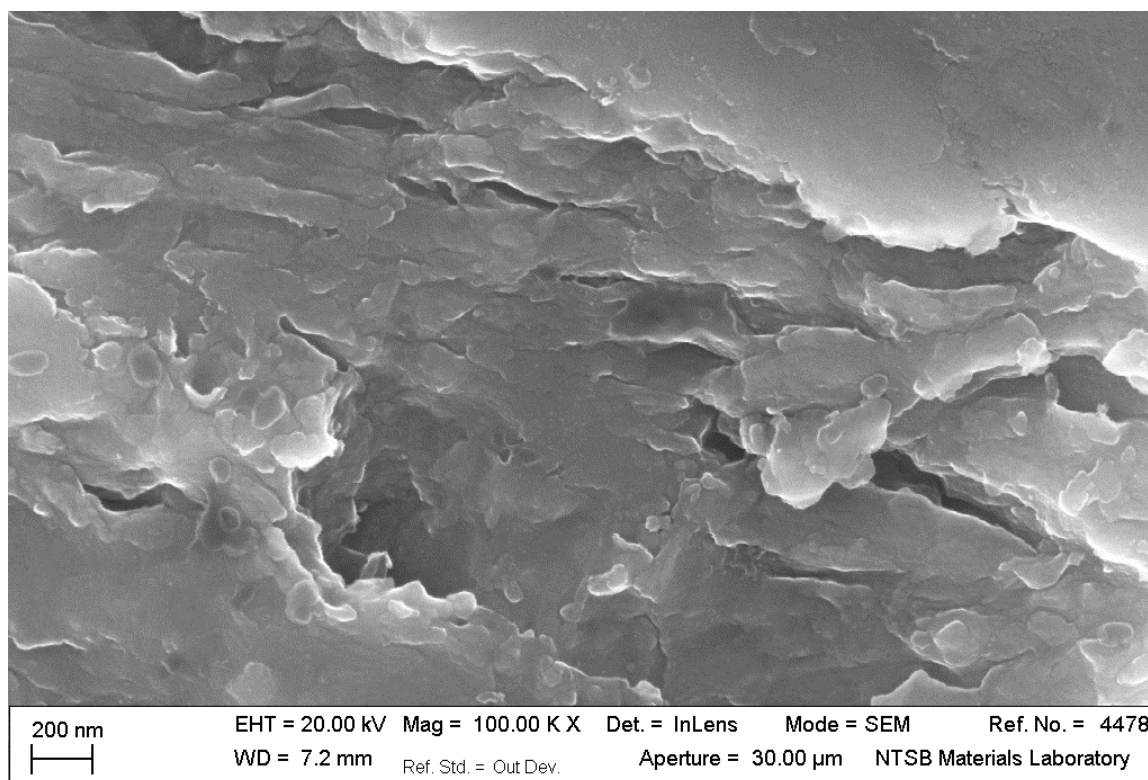


Figure 12 – Closer view of the fatigue striations in Figure 11.

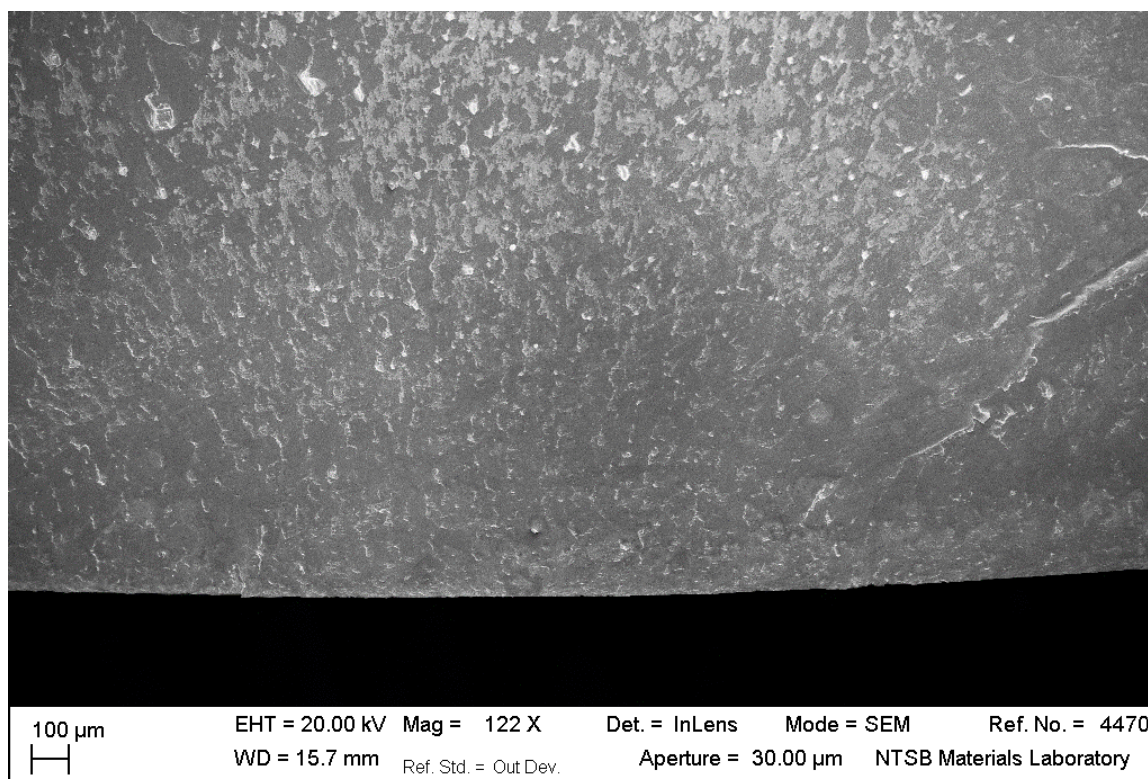


Figure 13 – SE micrograph of the fatigue crack initiation site on the aft fracture.

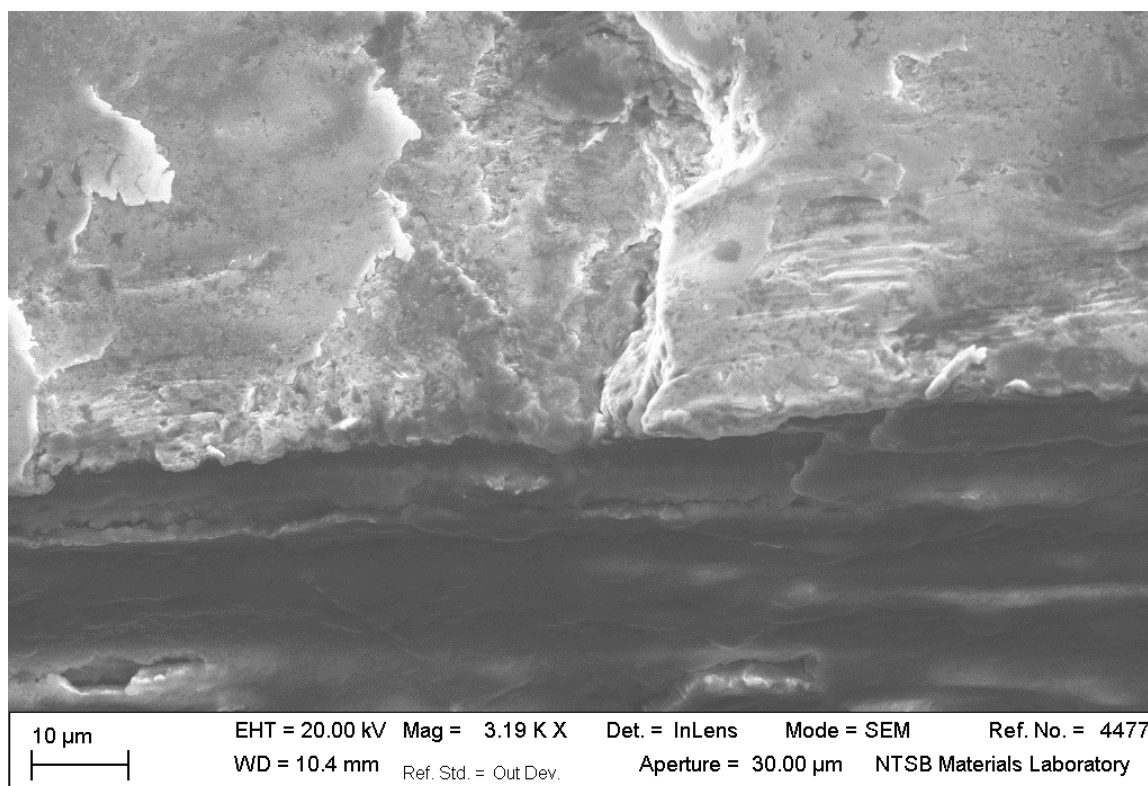


Figure 14 – SE micrograph of the corner of the main crack initiation site in Figure 13.

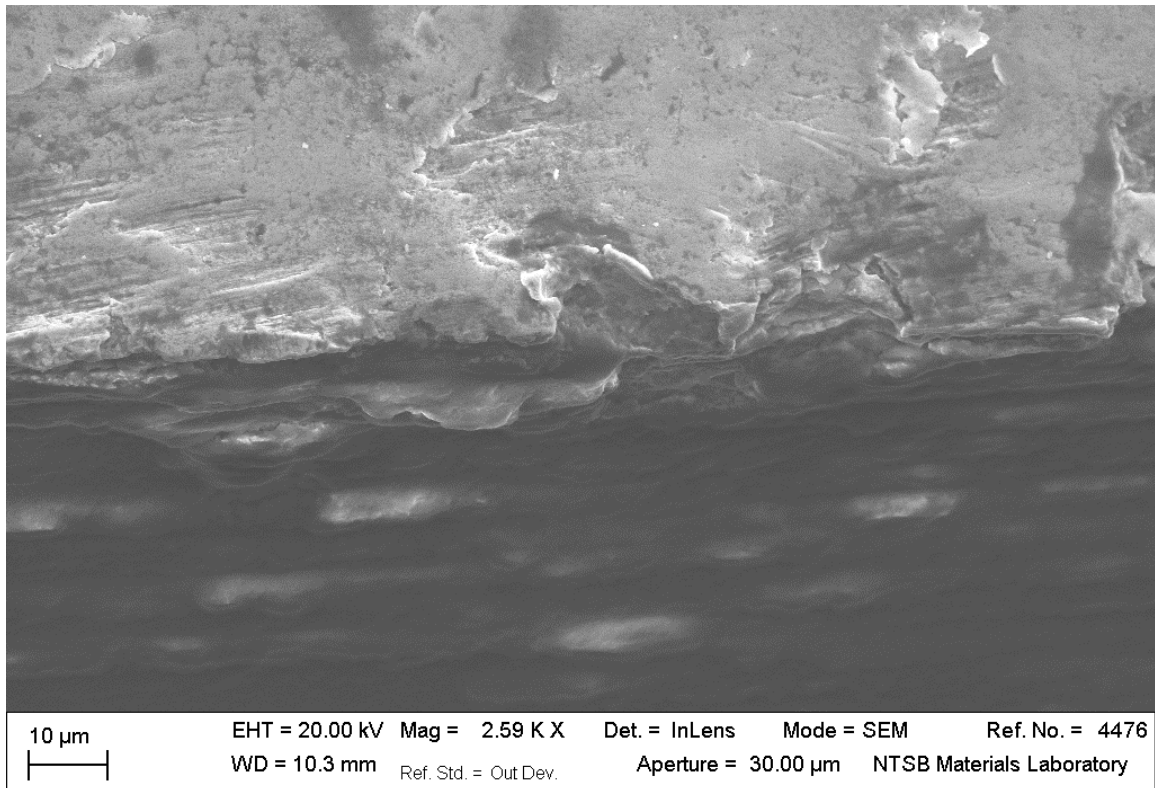


Figure 15 – SE micrograph of a fatigue crack initiation site to the right of the ratchet mark in Figure 8.