

# NATIONAL TRANSPORTATION SAFETY BOARD

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



May 17, 2016

## MATERIALS LABORATORY FACTUAL REPORT

Report No. 16-046

### 1. ACCIDENT

Place : Bulverde, Texas  
Date : January 31, 2016  
Vehicle : Aeronca O-58B, N47185  
NTSB No. : CEN16LA101  
Investigator : Andrew Todd Fox, AS-CEN

### 2. COMPONENTS EXAMINED

Left main landing gear wheel components

### 3. DETAILS OF THE EXAMINATION

On January 31, 2016, about 1100 central standard time, an Aeronca O-58B airplane was substantially damaged while landing at Bulverde Airpark in Bulverde, Texas. The commercial pilot and passenger were not injured. The pilot reported that following a normal landing, the airplane suddenly veered to the left. The pilot corrected by applying the right rudder and brake; subsequently, the airplane swerved right. The pilot stated that, in order to avoid a runway excursion, he lowered the left wing and intentionally ground-looped the airplane to the right.

A post-accident inspection revealed left main landing gear wheel had fractured. The wheel fracture was located along the inner bearing race flange, which resulted in the bearing being exposed. The left tire tread did not exhibit any abnormal wear or scuffing. The fractured wheel was sent to the NTSB Materials Laboratory for additional examination. The wheel had been cast in 1942, and the owner reported that the airplane had accumulated 3520 hours since new, with 10 hours since the last inspection.

Figure 1 shows the wheel, including the tire and the hub casting, as received. The tire was disassembled, initially by removing the bolts connecting the sides of the wheel hub (see Figure 2a and Figure 2b). The tire and stem were then removed. Figure 2 shows the wheel hub and the brake drum riveted to the hub. This figure also shows the fracture surface of the inner bearing surface flange.

The mating fractured flange piece is illustrated in Figure 3, as received. The flange had separated from the rest of the wheel hub circumferentially. The circumferential fracture exhibited a bright luster, with a generally rough, tortuous surface. These fracture features were consistent with failure from overstress. In addition, the separated flange exhibited two

additional fractures oriented in radial directions. Both of these fractures exhibited features consistent with multiple fracture modes.

Figure 4 shows a closer view of one of the radial fracture surfaces. As denoted in Figure 4, the fracture surface exhibited features consistent with three different regions. The areas highlighted with the yellow dashed lines were progressive fracture regions, later determined to be fatigue (see Figure 5 and Figure 6). The fatigue regions tended to be banded intermittently with overstress regions. The initial fatigue cracks were adjacent to a gold-colored, lenticular, and rough-textured region. The crack arrest marks in these fatigue regions were consistent with the fatigue cracks propagating from the initial region.

Figure 5 shows the most interior (or final) fatigue band on the radial fracture surface, as examined using a scanning electron microscope. Figure 6 shows a closer view of the fatigue band, revealing fatigue striations. The regions adjacent to the fatigue band exhibited dimple rupture consistent with overstress (Figure 7). This alternating banding of fatigue and overstress was consistent with the wheel hub flange having undergone high-cycle cyclic loading, with intermittent high stress events exceeding the local yield strength occurring during crack propagation.

Figure 8 shows a closer view of the lenticular region near the crack initiation site. This region exhibited small folds with non-metallic material (Figure 9). Between this region and the initial fatigue regions, an area of globular non-conductive material was observed (see Figure 10). This material was examined using energy dispersive x-ray spectroscopy (EDS), and found to be consistent with oxides containing iron, calcium, zinc, sulfur, and sodium. When compared with the overstress regions on the radial fracture surface, EDS probes of the lenticular region contained higher weight percentages of iron and oxygen. These features were consistent with the thin oxide “skin” that forms on molten aluminum during the casting process in air.

The other radial fracture surface is pictured in Figure 11. Similar to Figure 4, this fracture surface exhibited a casting oxide region, with small adjacent fatigue thumbnail cracks. The features in these fatigue cracks were consistent with having propagated from the oxide “skin.”

As shown in Figure 12, a crack was found adjacent to the second radial fracture surface. This crack was oriented parallel to the second radial fracture surface, having propagated in the same direction as the fracture surface fatigue cracks. The crack was intentionally backcut and overstressed (laboratory opened) to reveal the crack faces. Figure 13 shows one of the opened crack faces. Similar to Figure 12, the crack exhibited features consistent with a lenticular casting oxide and a thin fatigue region, which had propagated inward.

Observations from examination of the two radial fracture surfaces and the opened crack were consistent with surface casting aluminum oxide “skins” that became incorporated inside the hub flange surface. These oxides would have been present since the part was cast at original manufacture. The alternating fatigue and overstress features would be consistent with spectrum loading, typical of those seen by a landing gear wheel.

The chemical composition of the material was inspected using EDS and x-ray fluorescence (XRF). The composition was consistent with an aluminum casting alloy. The hardness was inspected per ASTM E18.<sup>1</sup> The hardness of the section averaged 30 HRBW. The electrical conductivity of the part was inspected per ASTM E1004.<sup>2</sup> The conductivity averaged 36.1% IACS.

Erik Mueller  
Materials Research Engineer

---

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

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



Figure 1 – The left main wheel hub and tire, as received.

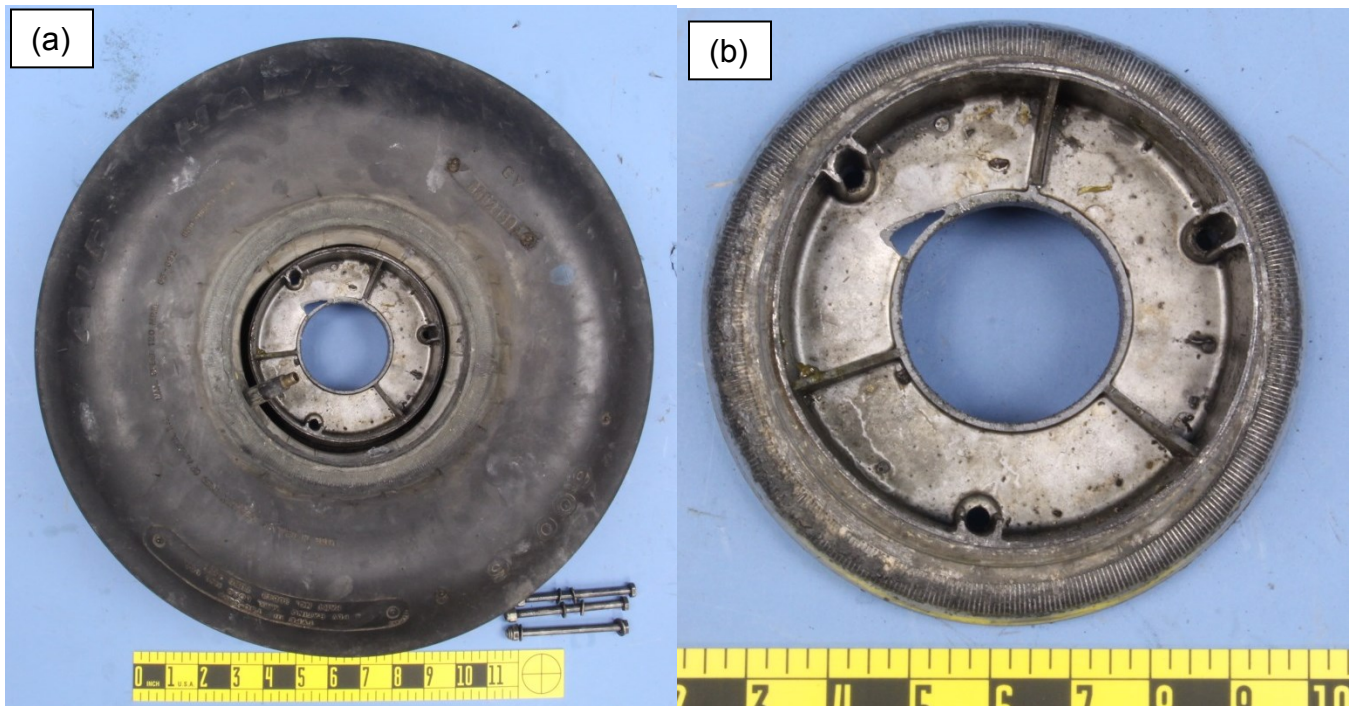


Figure 2 – The wheel hub after removal of (a) the outer half and (b) the rubber tire.

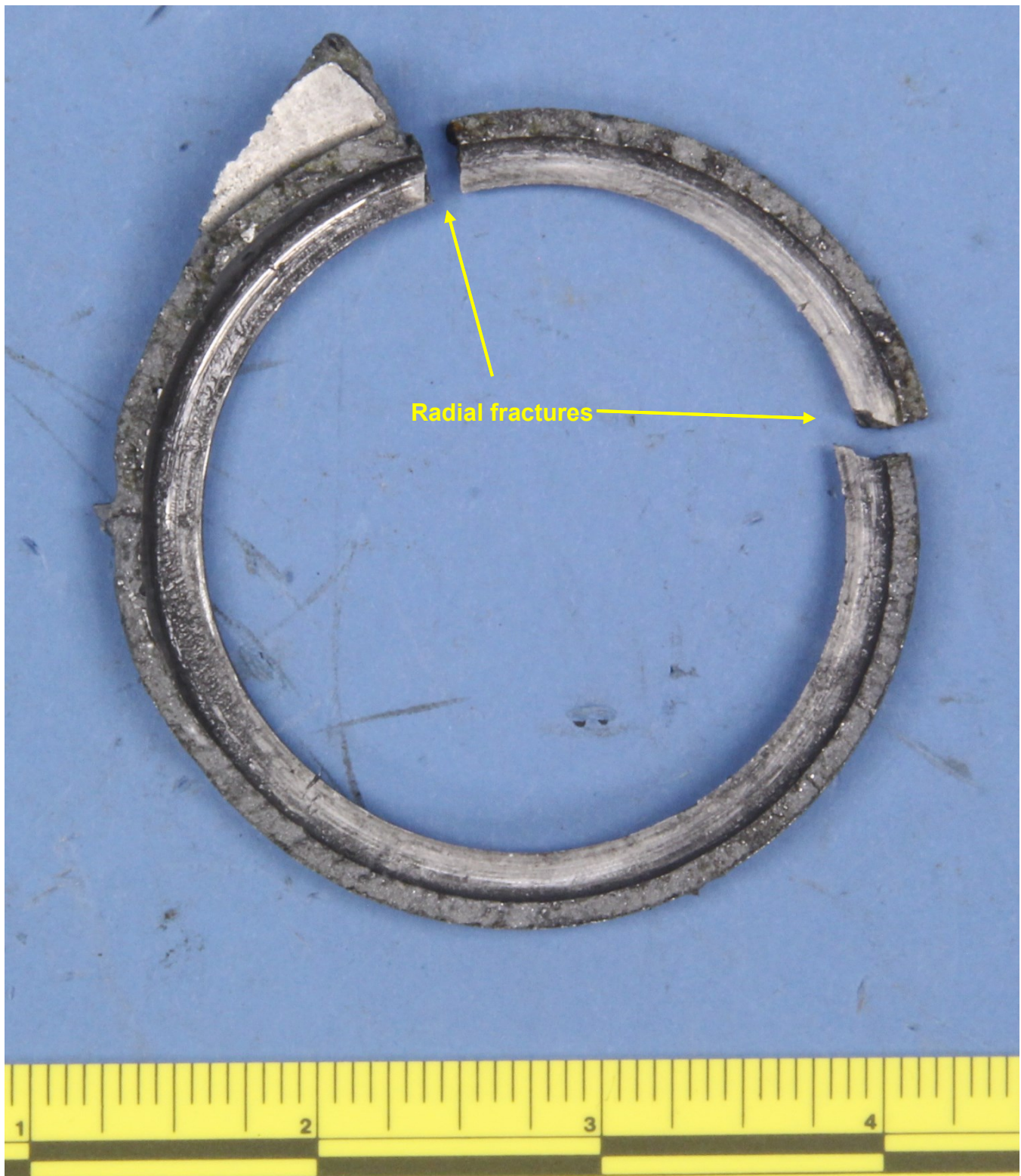


Figure 3 – The mating fractured inner bearing race flange, as received. The race flange had fractured circumferentially, as well as radially in two places. One of the radial fractures is shown in Figure 4.

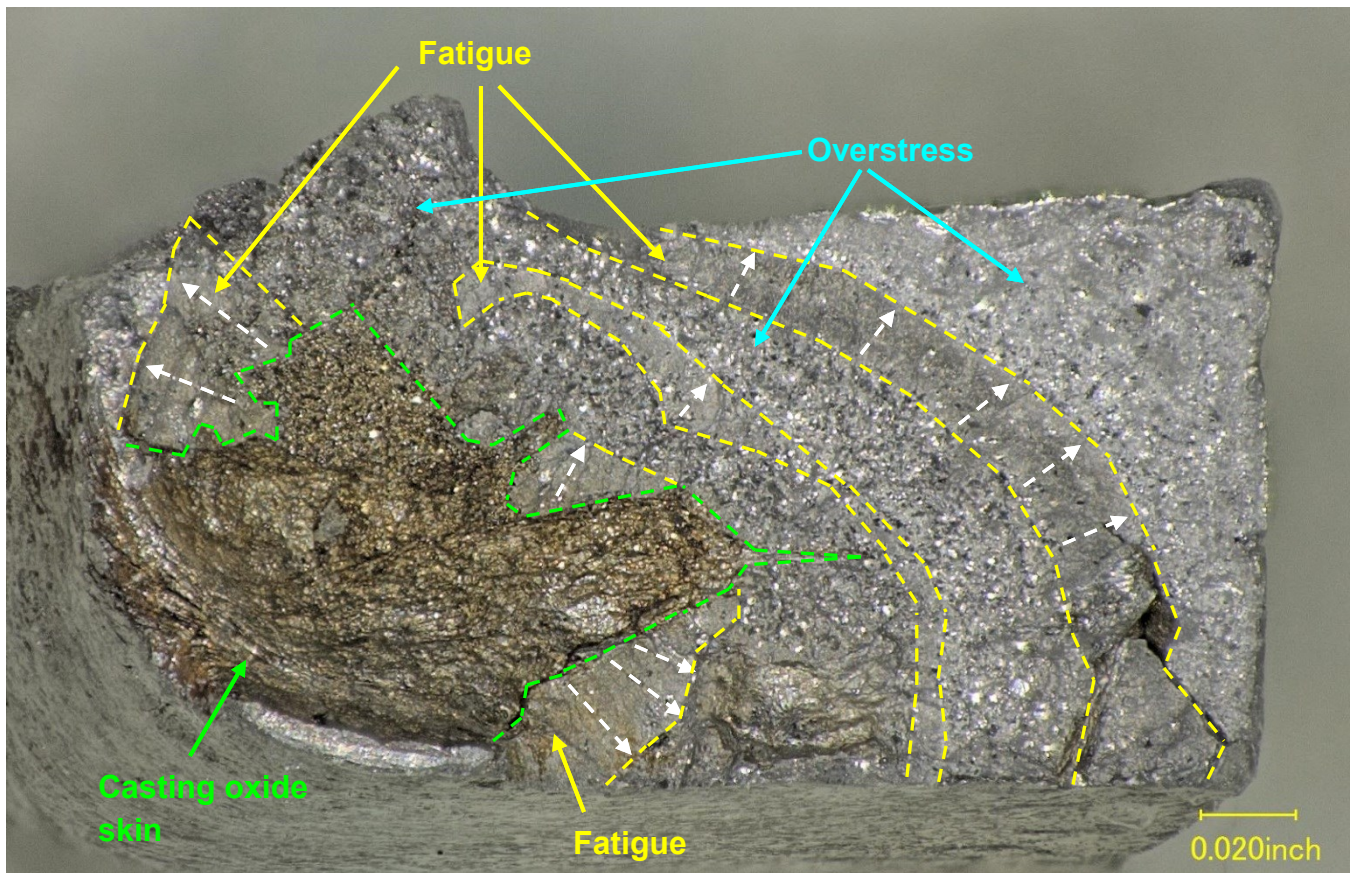


Figure 4 – Closer view of the radial fracture surface on the wheel hub race flange, shown in Figure 3. The different fracture mechanism regions are highlighted, with the crack direction denoted by the arrows.

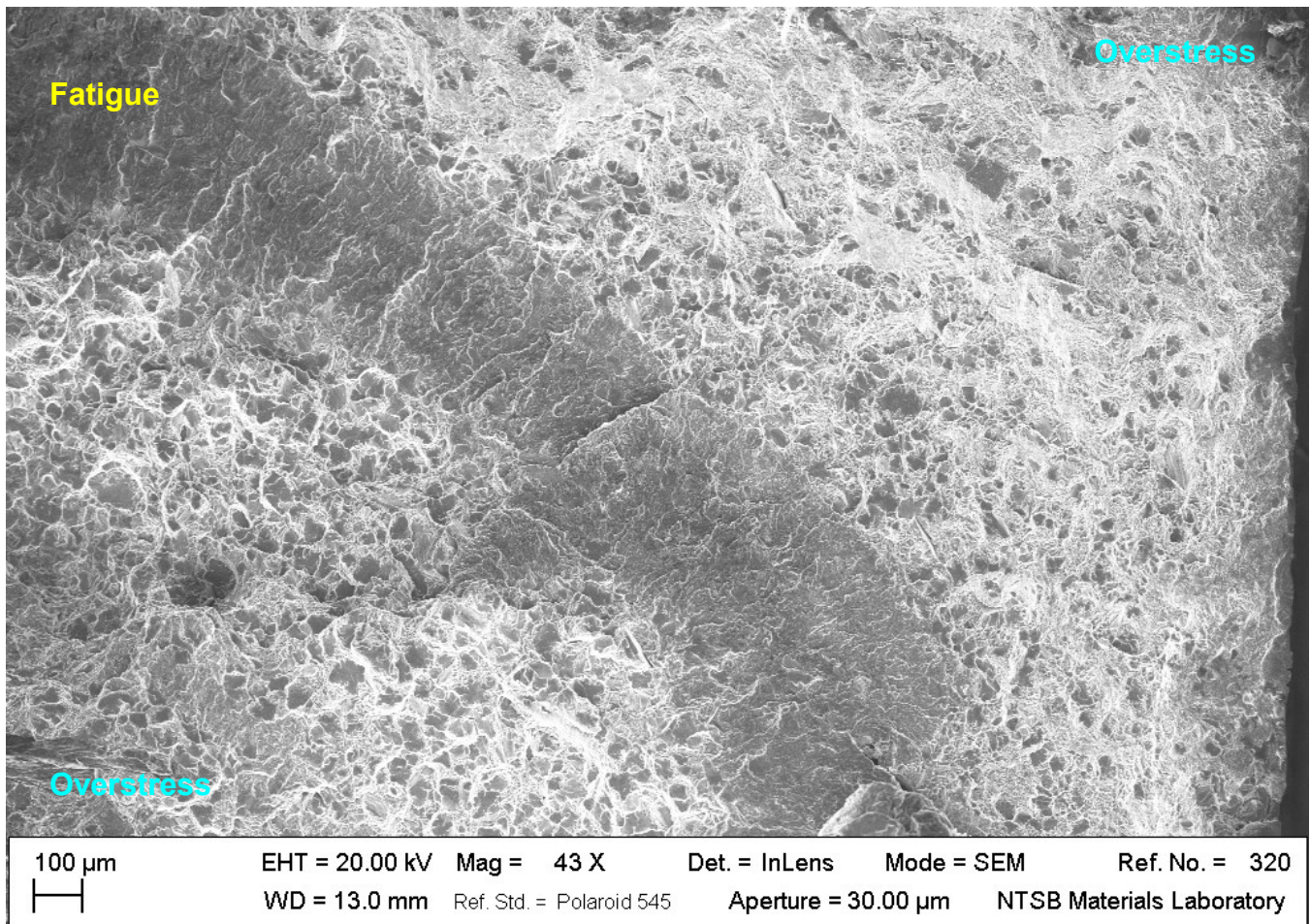


Figure 5 – Secondary electron (SE) micrograph of the final fatigue band, shown between two overstress regions, on the radial fracture surface from Figure 4.

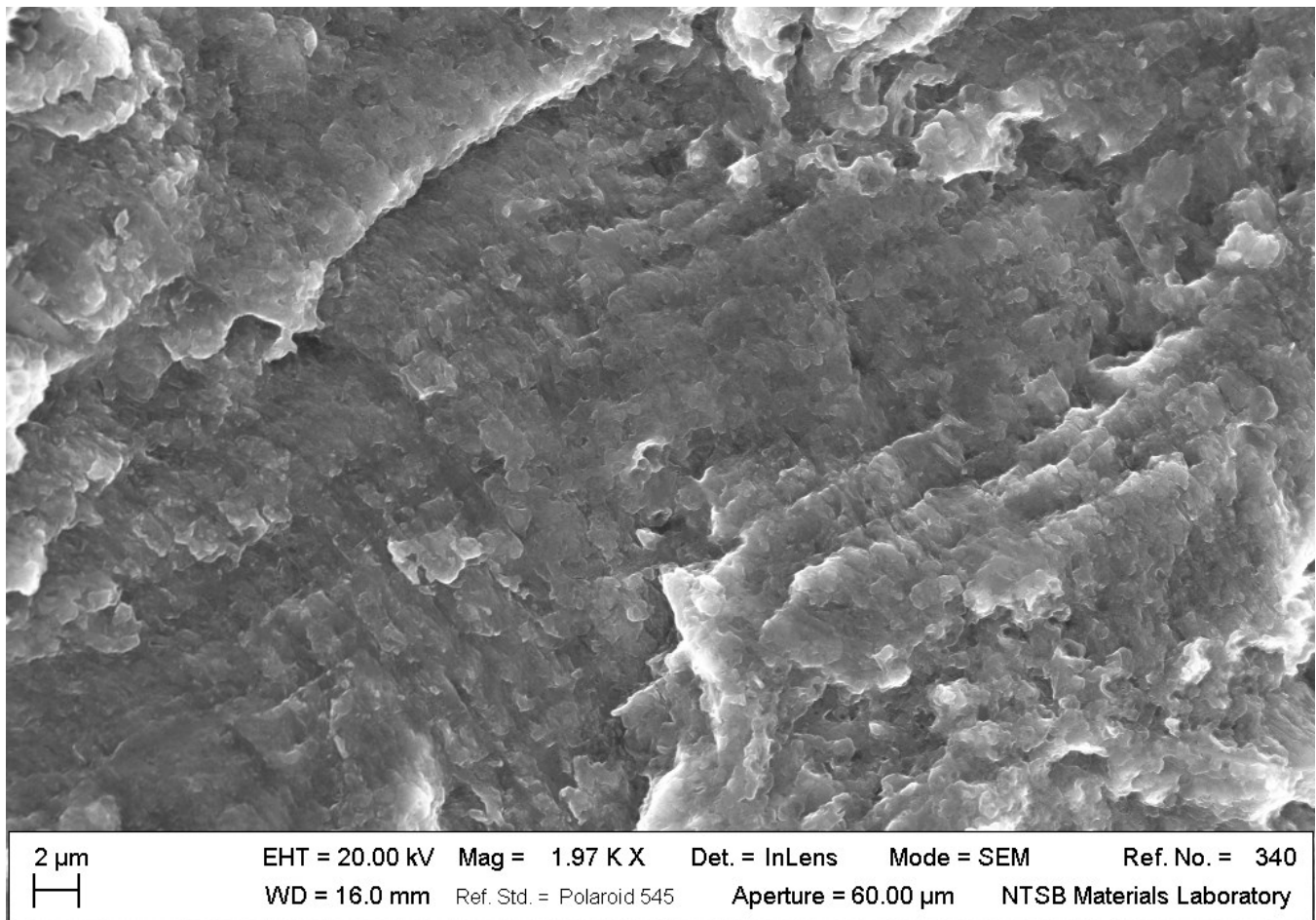


Figure 6 – SE micrograph showing striations in the final fatigue region of the radial fracture surface.

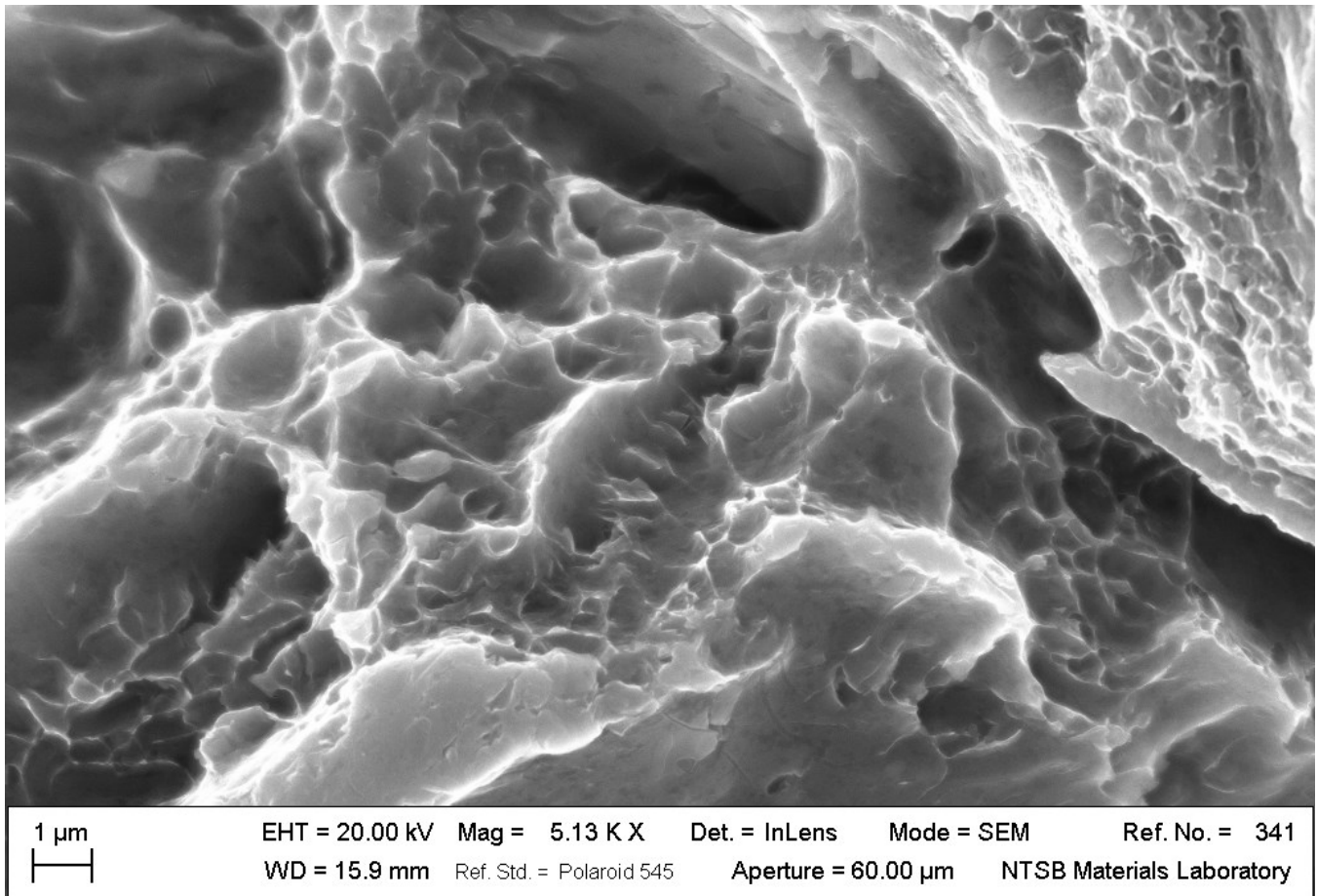


Figure 7 – SE micrograph showing dimple rupture in an intermediate overstress region on the radial fracture surface.

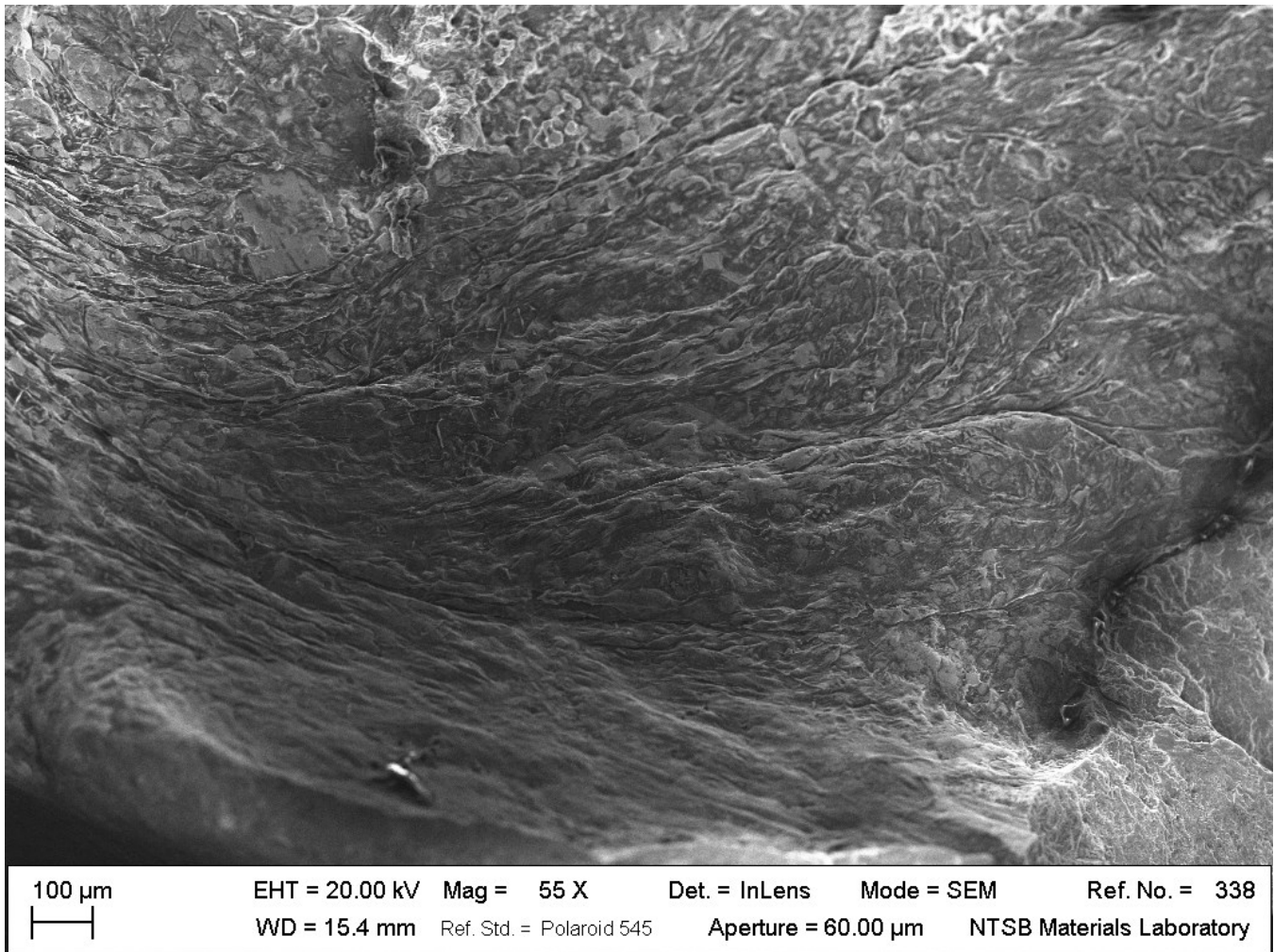


Figure 8 – SE micrograph showing the oxide skin at crack initiation site on the radial fracture surface.

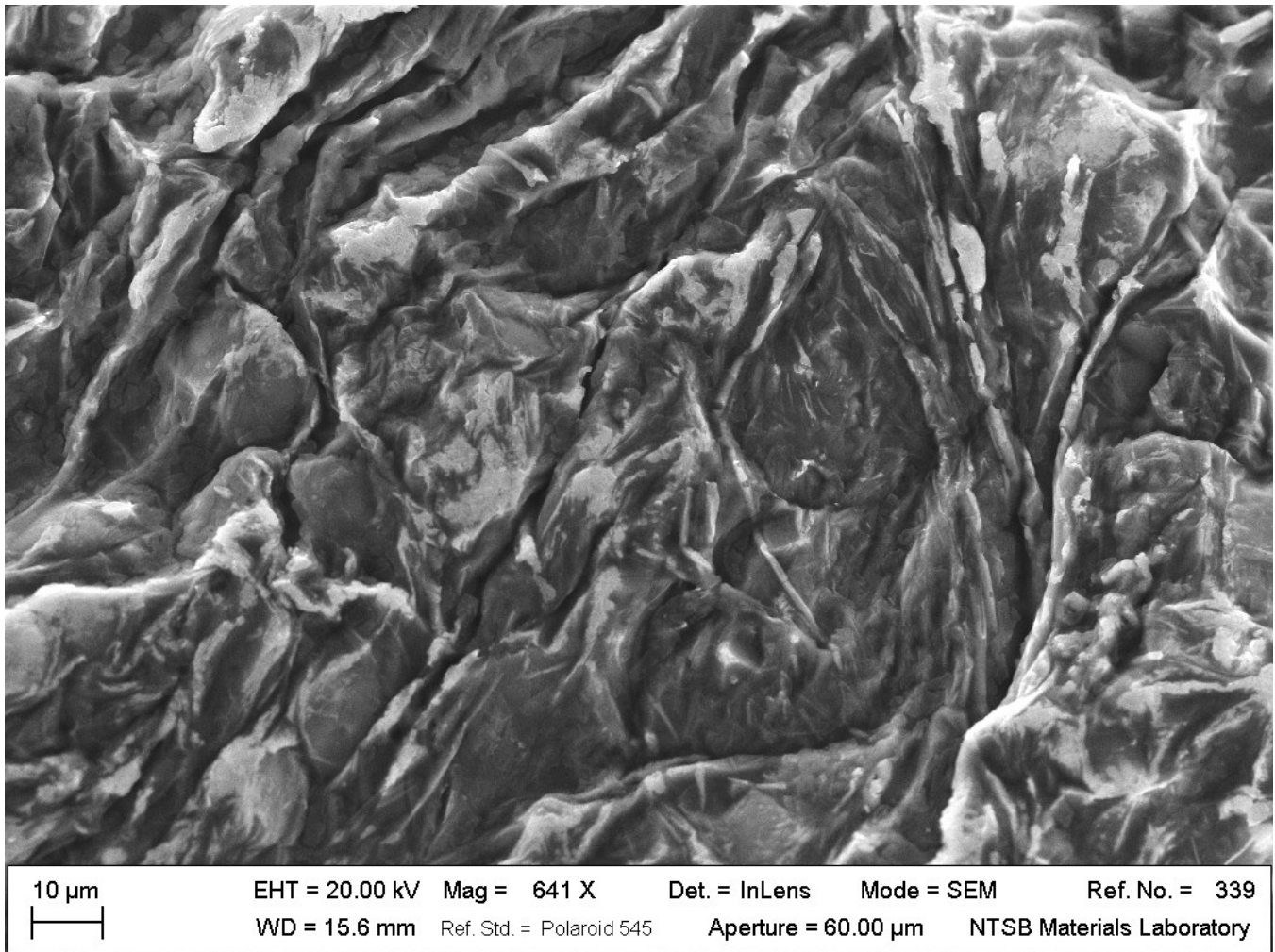


Figure 9 – SE micrograph showing a closer view of the lenticular oxide on the radial fracture surface near the initiation site.

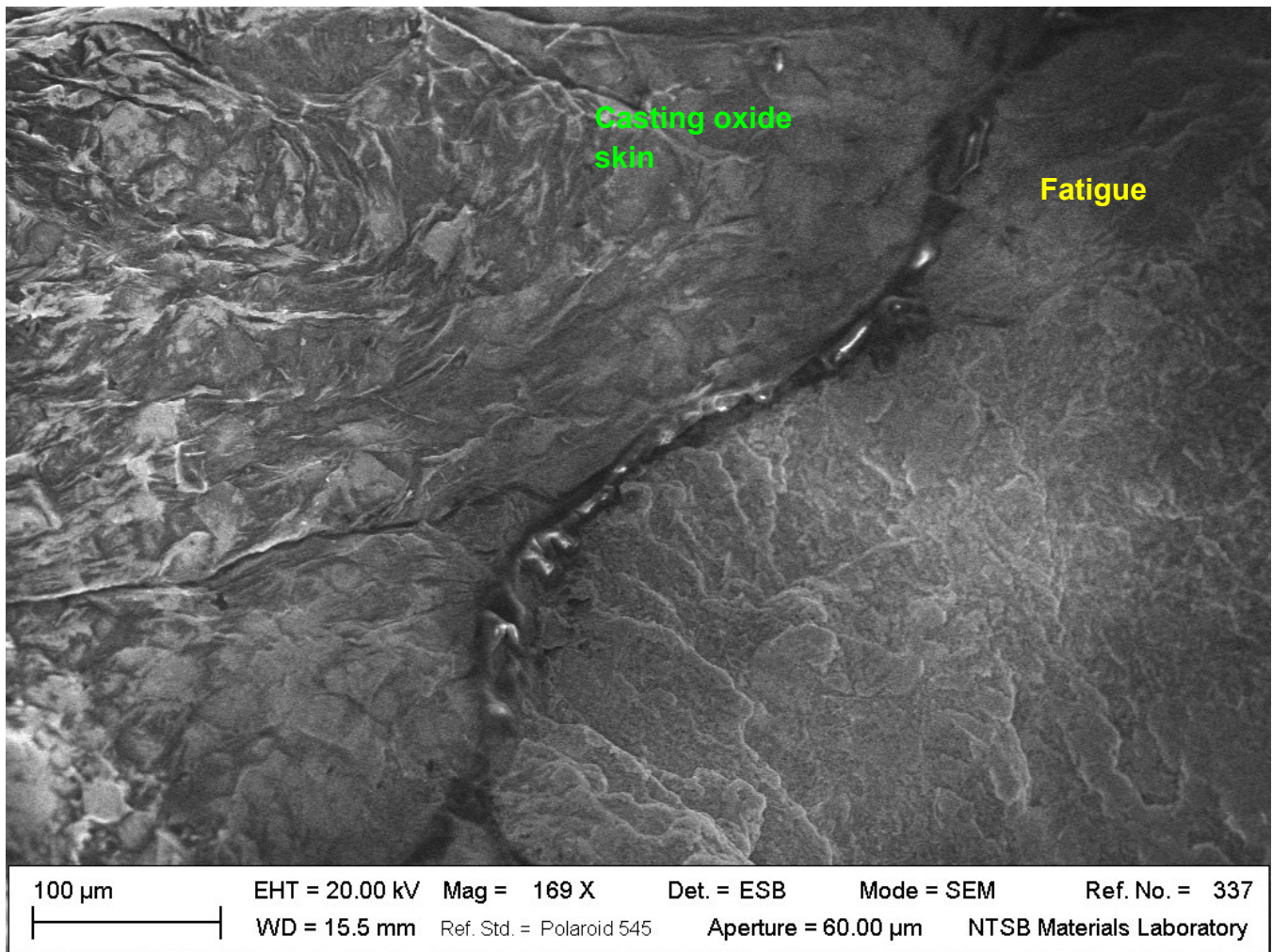


Figure 10 – Backscattered electron (BE) micrograph showing the contamination layer between the oxide skin and the fatigue region on the radial fracture surface.

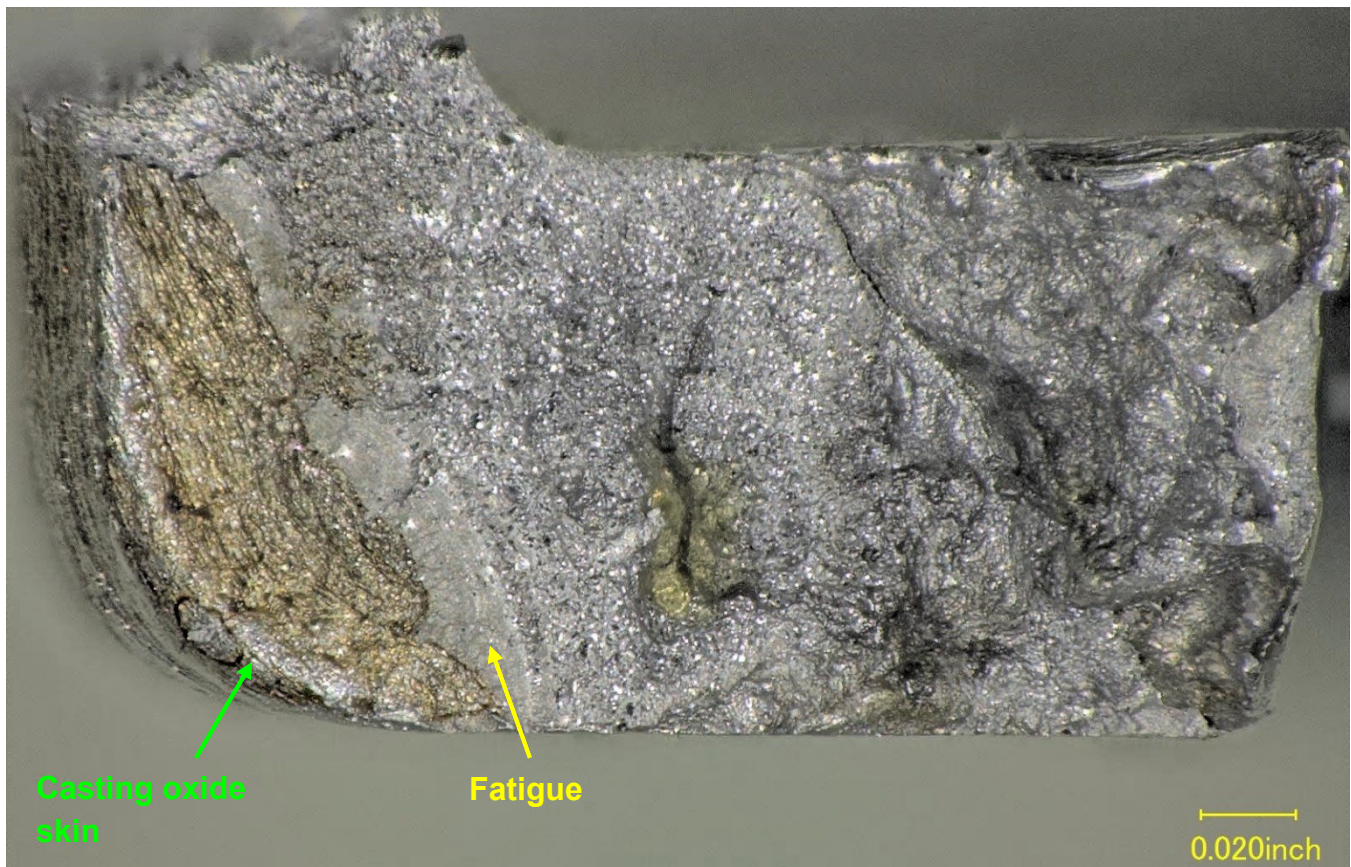


Figure 11 – Closer view of the second radial fracture surface, showing the oxide skin layer and a small fatigue region interior to the casting defect.

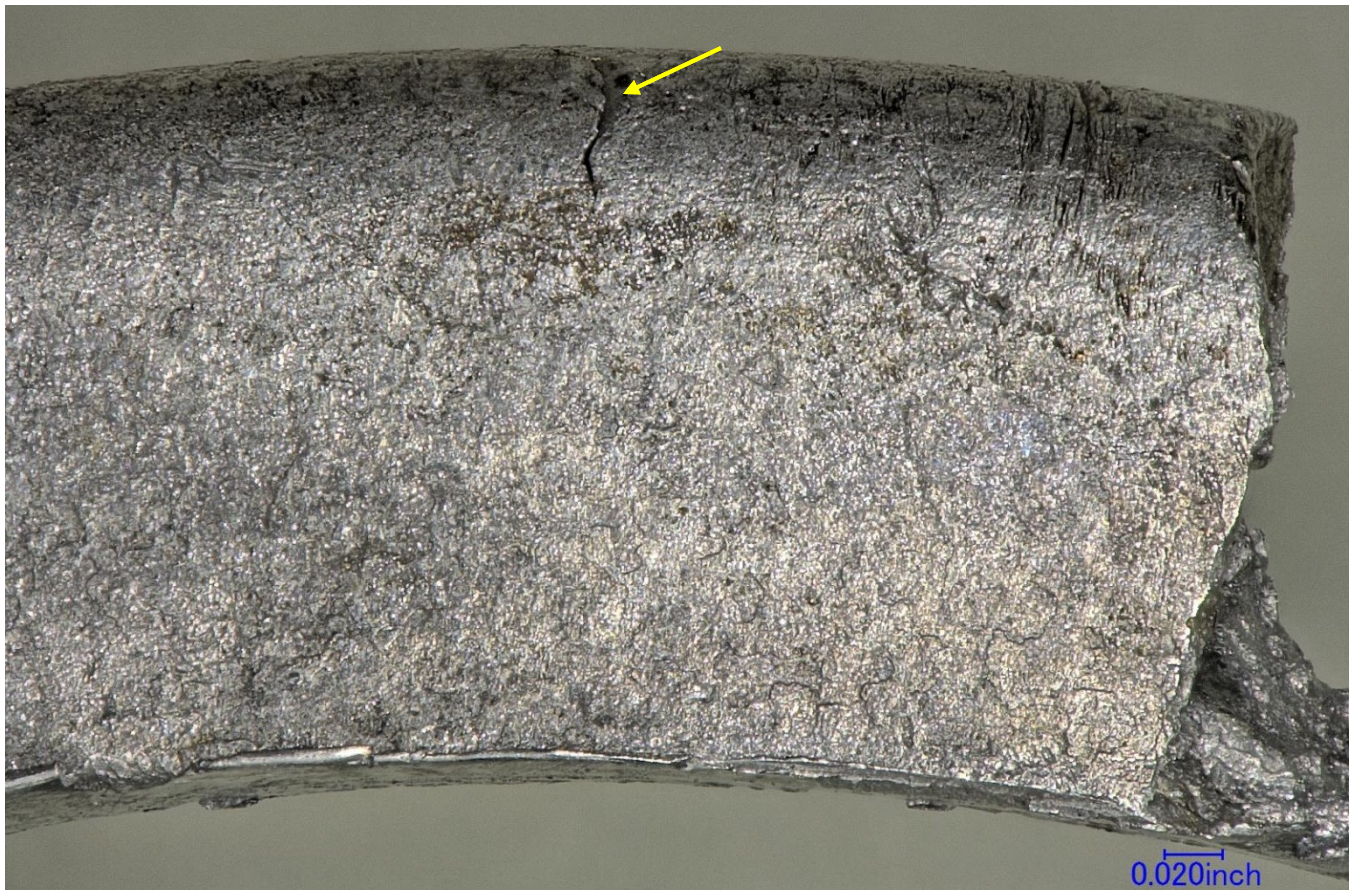


Figure 12 – A second crack (arrow) on the flange fragment near the radial fracture surface on the right (shown in Figure 11).

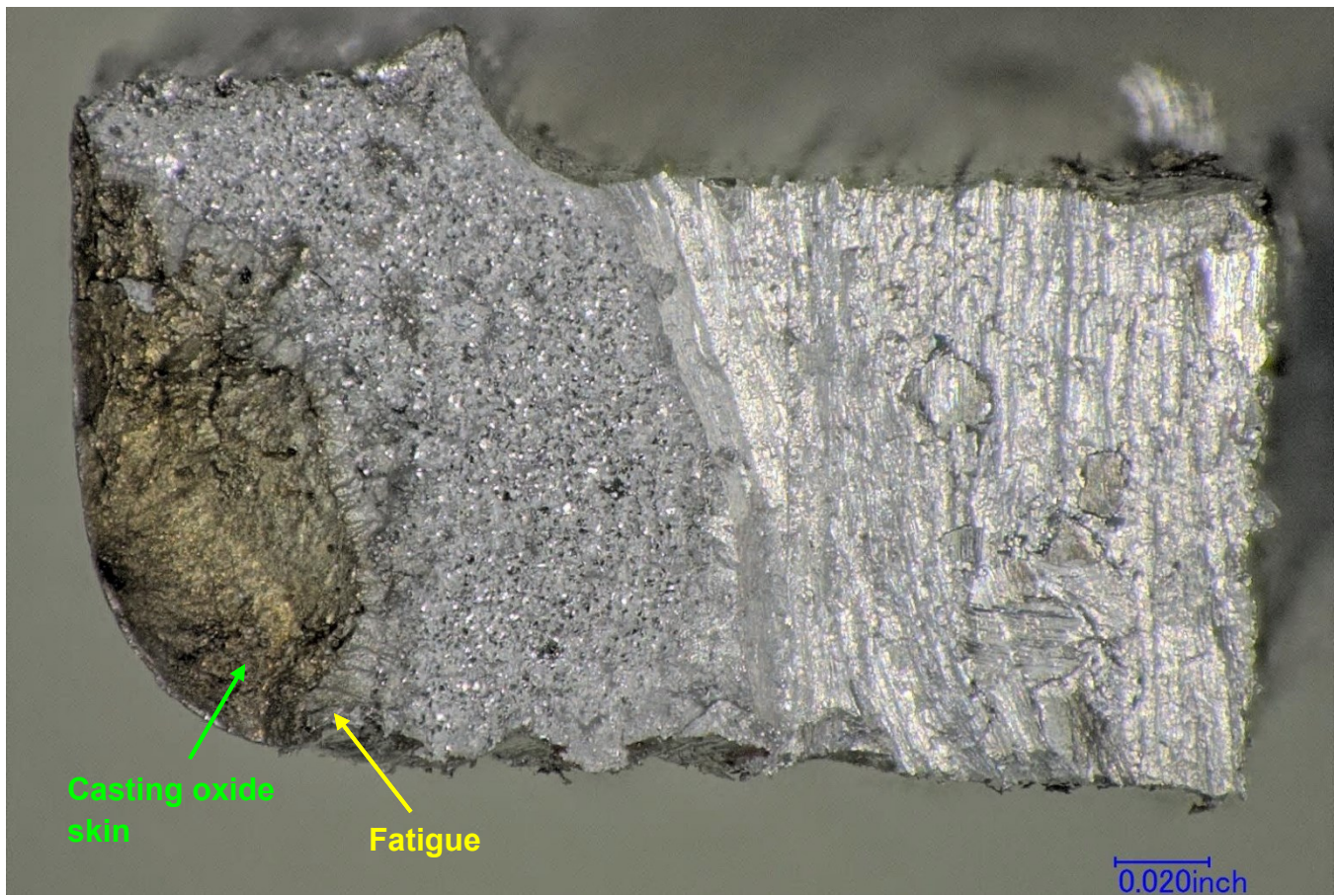


Figure 13 – The radial crack, shown in Figure 12, after laboratory opening, revealing a casting oxide fold and small fatigue region.