NATIONAL TRANSPORTATION SAFETY BOARD

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

October 22, 2021

MATERIALS LABORATORY FACTUAL REPORT Report No. 21-077

A. ACCIDENT INFORMATION

Place	:	Camp Dwyer, Afghanistan
Date	:	April 20, 2020
Vehicle	:	Sikorsky S-61N, N908CH
NTSB No.	:	DCA20LA100
Investigator	:	Dan Bower, AS-10

B. COMPONENTS EXAMINED

Filter with debris from the auxiliary servo cylinder (yaw channel) of the accident vehicle

C. DETAILS OF THE EXAMINATION

On April 20, 2020, at approximately 0800 local time, a Sikorsky S-61N, N908CH, experienced a loss of control in flight and rolled on its side during an emergency landing at Camp Dwyer, Afghanistan. The three crew members onboard were seriously injured, and the helicopter sustained substantial damage. The flight was operating under the provisions of 14 CFR Part 135 as a cargo flight under contract to the Department of Defense. In accordance with ICAO Annex 13, the NTSB accepted delegation of the investigation from the Afghanistan Civil Aviation Authority.

The auxiliary hydraulic servo cylinder was disassembled and examined at Sikorsky Aircraft Corporation (Trumbull, Connecticut).[1] A filter component was extracted from the auxiliary hydraulic servo cylinder and a cluster of debris was observed retained in the filter media. The filter component, shown as received, was sent to the NTSB Materials Laboratory for additional examination.

The filter component was received at the NTSB Materials Laboratory in a sealed plastic bag labeled “DCA20LA100 Yaw servovalve filter”. An oily substance with a red-pink hue was present on the surface of the filter. The filter component consisted of a gray cylindrical head section with reduced diameter sections, flanges, and chamfered sections. At approximately mid-span of the filter head, a diametric through hole intersected an axial central slot extending to the side closer to the filter media. There were darker gray streaks observed on the outer surface of the filter head emanating from the through hole. Two O-rings, one of larger diameter and one of smaller diameter were fitted around two corresponding reduced sections which sandwiched the through hole. The smaller O-ring interfaced with a plastic backup ring. A tapered cylindrical, porous, yellow-orange, lustrous

[1] Results were documented in Sikorsky Aircraft Corporation Materials Engineering Report MER-JO2105251 dated July 8, 2021.

filter element was affixed to the smaller base of the filter head. A debris cluster was observed locally on the filter element as shown in figure 1.

Figure 2 shows a closer view of the interface between the smaller O-ring and the backup ring. The red dashed line indicates a diagonally oriented split location consistent with the backup ring design. The lower side of the split, as oriented in this view, exhibited plastic flow deformation consistent with compression loading. The mating surface of the O-ring was deformed and exhibited a profile which correlated with the backup ring deformation, as highlighted by yellow dashed lines connected by light gray arrows. The comparable deformation profiles were consistent with the O-ring material extruding into the backup ring split location under pressure loading.

The debris cluster was examined with the aid of a 4X – 80X zoom stereomicroscope and was comprised of multi-colored particles of various shapes and sizes, tangled strands of translucent fibers of various lengths and diameters, black-colored deposits, and shiny, metallic looking particles. A digital microscope image of the debris cluster is shown in figure 3 with the visible metallic-looking particles arbitrarily identified 1 through 5 and outlined by yellow dashed shapes. These particles and the debris cluster were further examined using a scanning electron microscope (SEM) equipped with an energy dispersive x-ray spectrometer (EDS), results of which are discussed later in this report.

The filter component was placed in ambient atmosphere for several days in a partially ajar petri dish to allow volatiles from the oily residue to flash off prior to viewing in a scanning electron microscope. A vacuum chamber was also used following the ambient dwell to help drive out additional volatiles and set the debris cluster prior to SEM examination.

A FEI Apreo 2S scanning electron microscope was used to examine the debris cluster more closely. The SEM examination was supplemented with energy dispersive x-ray spectroscopy (EDS) for compositional analysis of selected debris particles. Carbon and oxygen were present throughout the debris cluster and on average approximately 31% carbon and 25% oxygen by weight was detected in each spectrum acquired. This amount of carbon and oxygen was consistent with the presence of organic and sand/soil constituents throughout the debris cluster.

Figure 4 shows a backscattered electron[2] (BSE) image containing a portion of particle 1 and particle 2 labeled and outlined by yellow dashed lines. The smooth, white, approximately-equiaxed circular areas in the background correspond to the filter media. Particle 1 exhibited a darker gray appearance and a shape consistent with a metal flake with some apparent smearing and deformation. The major visible surface exhibited a faint dimpled appearance. Particle 2 appeared whiter in color with a faint dimpled appearance on the visible surface. Radially oriented cracks emanated from the central region of particle 2.

Figure 5 shows the EDS spectrum acquired on particle 1 which showed a strong aluminum peak and minor peaks of copper, zinc, and silicon which were consistent with

[2] 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.

common alloying elements found in aluminum alloys. Other elements detected in lesser amounts were consistent with common elements found in sand/soil and other aircraft alloys.

Figure 6 shows the EDS spectrum acquired on particle 2 which showed strong copper peaks and a minor aluminum peak with lesser amounts of lead, iron, tin, silver, and sulfur identified which were consistent with common elements found in copper, copper alloys, aluminum alloys, and steels.

Figure 7 shows a BSE image with particle 3 outlined by a yellow dashed line. Particle 3 appeared white in this image and had a red-orange metallic luster in visible light, as viewed in figure 3, which was distinct from the baseline filter media. Two dark gray particles, labeled "A" and "B" with yellow arrows, were observed in the BSE image. EDS spectra were acquired on these particles and are shown in subsequent figures. Black fibers, which exhibited strong carbon peaks from EDS were observed tangled throughout this view. These fibers appeared translucent in visible light as viewed in figure 3.

Figure 8 shows the EDS spectrum acquired on particle 3 which shows strong copper peaks with minor peaks of silver, aluminum, and iron. Figure 9 shows the EDS spectrum acquired for particle "A" identified in figure 7 and shows major peaks of carbon, oxygen, copper, and tin that were detected with smaller amounts of other elements detected which are common in aircraft alloys and sand/soil. Figure 10 shows the EDS spectrum acquired for particle "B" identified in figure 7 and shows major peaks of carbon, oxygen, silicon, potassium, and aluminum, and small amounts of other elements common in minerals of sand/soil.

Figure 11 shows a BSE image containing a portion of particle 4 labeled and highlighted within yellow dashed lines. Particle 4 exhibited a light gray appearance and a shape consistent with a twisted and deformed metal shaving.

Figure 12 shows the EDS spectrum acquired on particle 4 which shows major iron peaks with smaller peaks of elements consistent with typical alloying elements found in steel as well as constituents found in sand/soil minerals.

Figure 13 shows a BSE image containing particle 5 labeled and highlighted within yellow dashed lines.

Figure 14 shows the EDS spectrum acquired on particle 5 which shows major iron peaks with smaller peaks of elements consistent with typical alloying elements found in steel as well as constituents found in sand/soil minerals.

Figure 15 shows a secondary electron image of an area of the filter media used to acquire EDS spectra for baseline compositional analysis of the filter media. The orange and blue circular areas correspond to locations where spectra were obtained. The white areas observed between the dark circular filter media regions correspond to non-conductive filtered material charging when exposed to the electron beam.

Figure 16 shows a representative spectrum of the baseline filter media which contains primarily copper with small amounts of tin, consistent with a sintered bronze porous filter element which are common in fuel, pneumatic, and hydraulic applications.

Michael Meadows
Materials Engineer

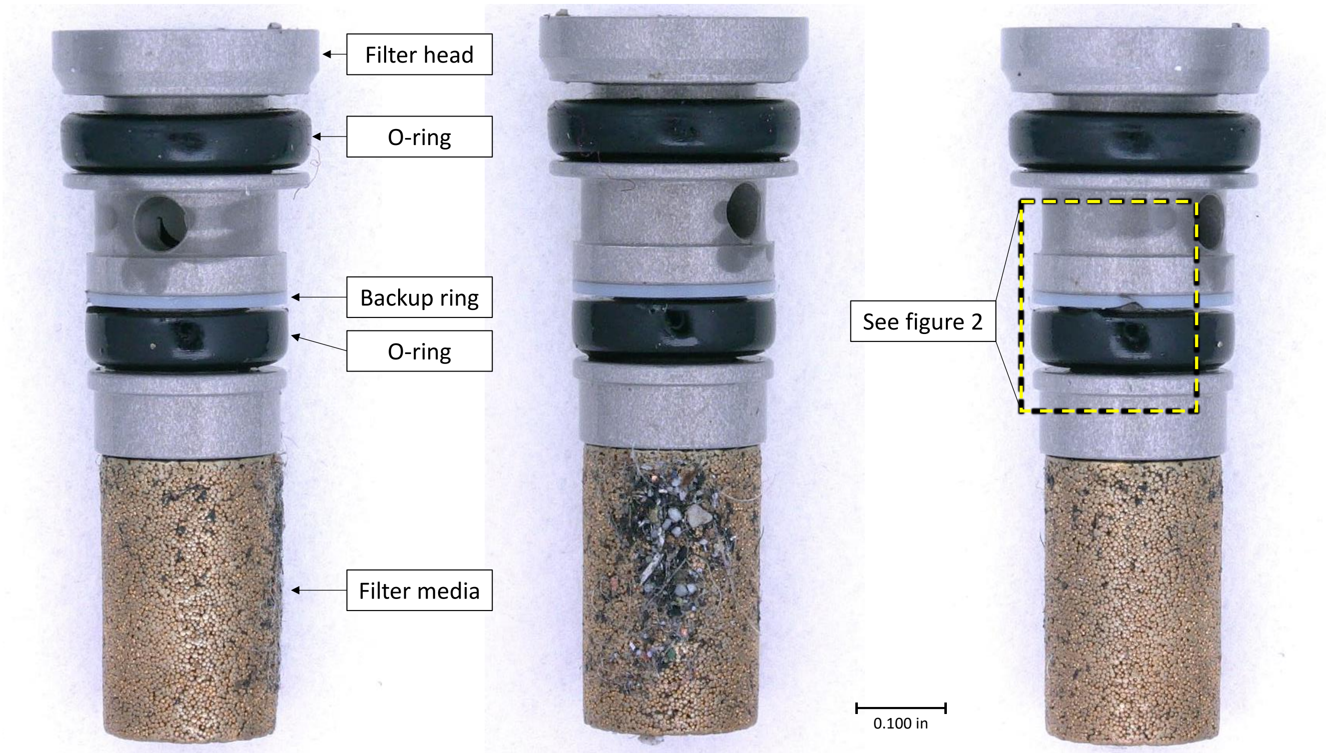

Figure 1: Digital microscope images of the as-received filter component. Each view shows a different segment around the filter component. The middle view shows the debris cluster on the filter media, a closer view is shown in a subsequent figure. A closer view of the area in the right image within the dashed yellow box is shown in a subsequent figure.

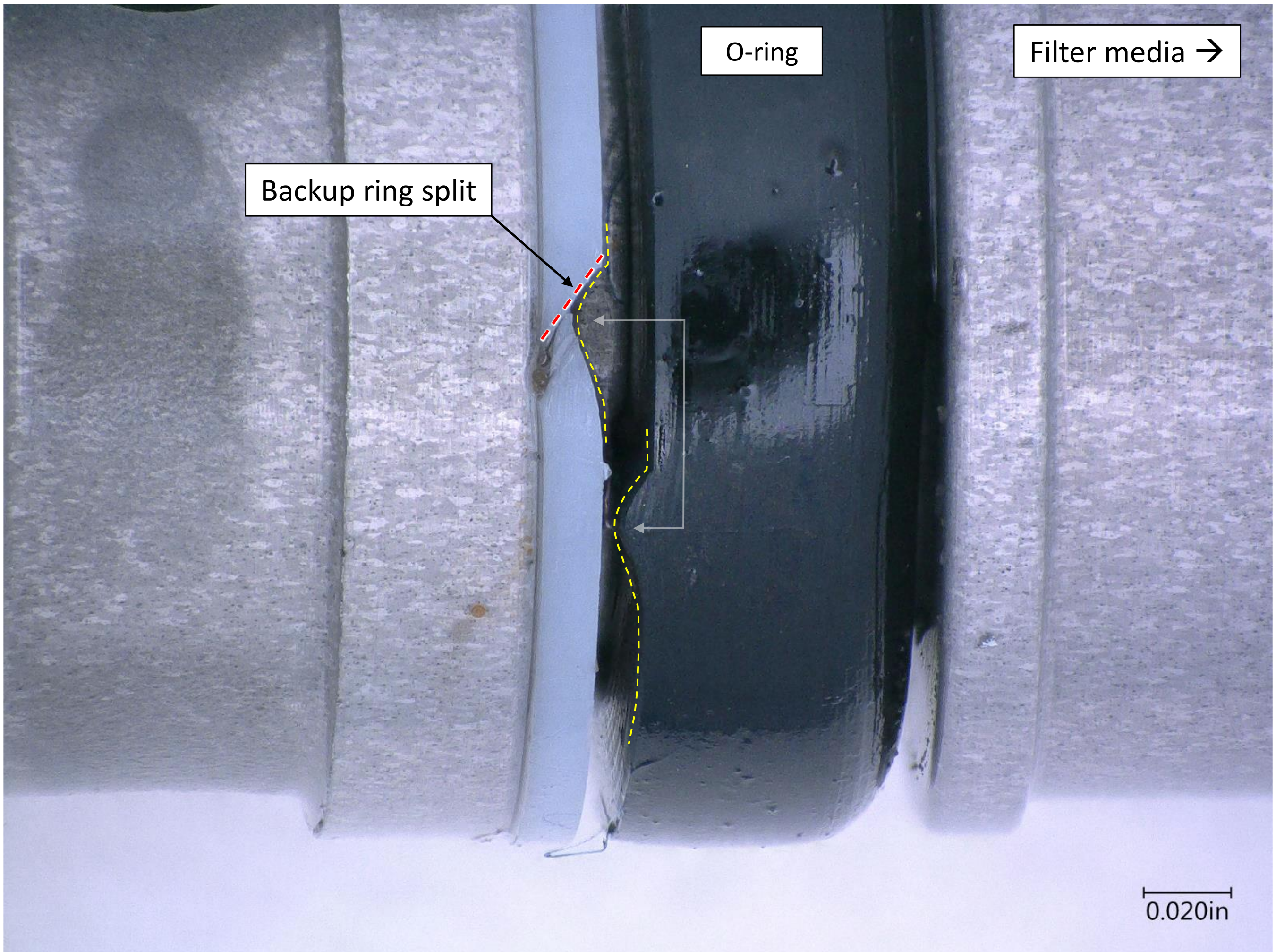

Figure 2: A higher magnification digital microscope image of the area highlighted by the yellow box in figure 1, rotated 90 degrees to the left. The backup ring split location is highlighted by the red dashed line. The lower side of this split location, as oriented in the image, exhibited plastic flow deformation which correlated with O-ring deformation as highlighted by yellow dashed lines.

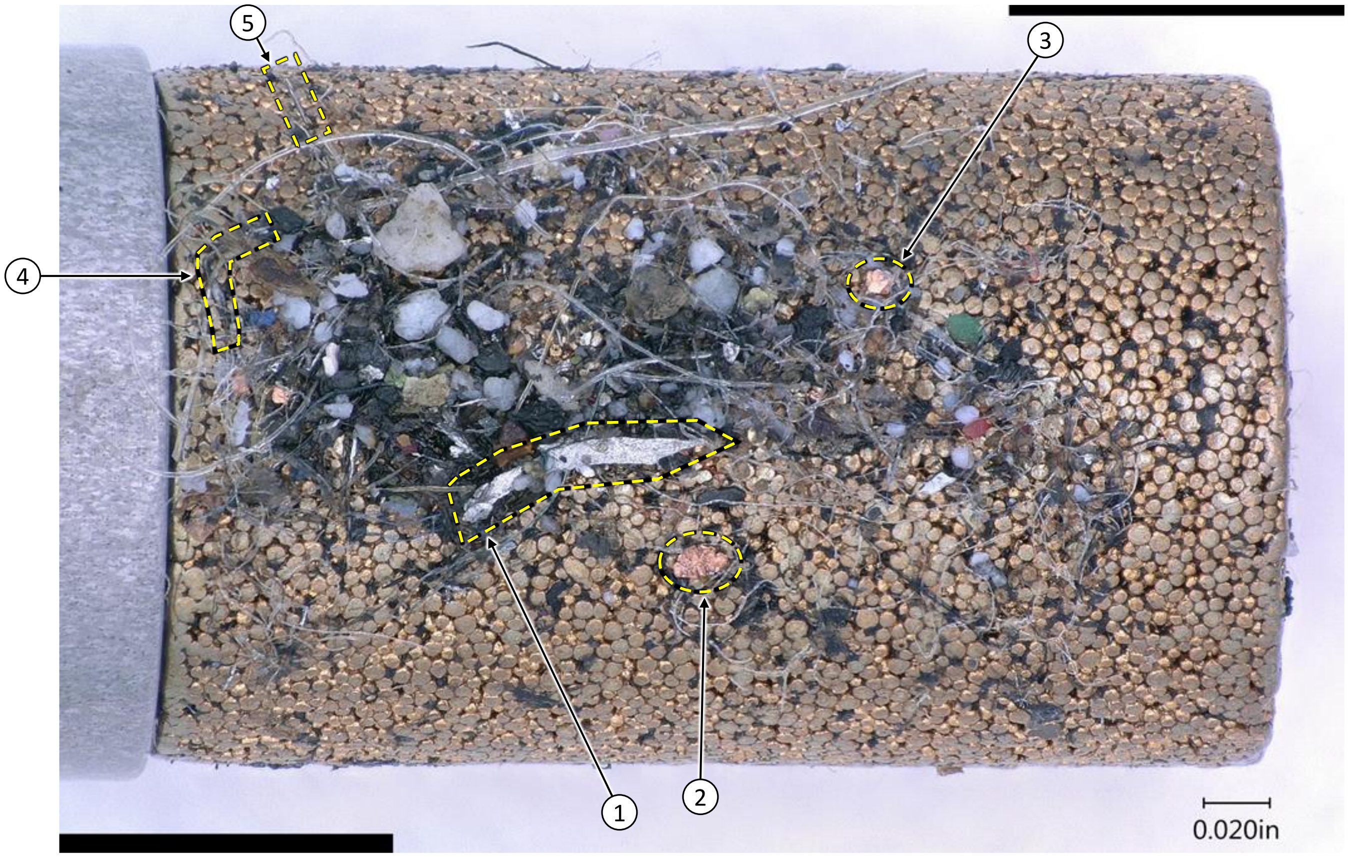

Figure 3: A digital microscope stitched image showing a closer view of the debris cluster on the filter media. The numbered areas highlighted by yellow dashed boxes correspond to particles that were visually observed to exhibit a shiny metallic appearance. These locations were examined further using a scanning electron microscope equipped with an energy dispersive x-ray spectrometer.

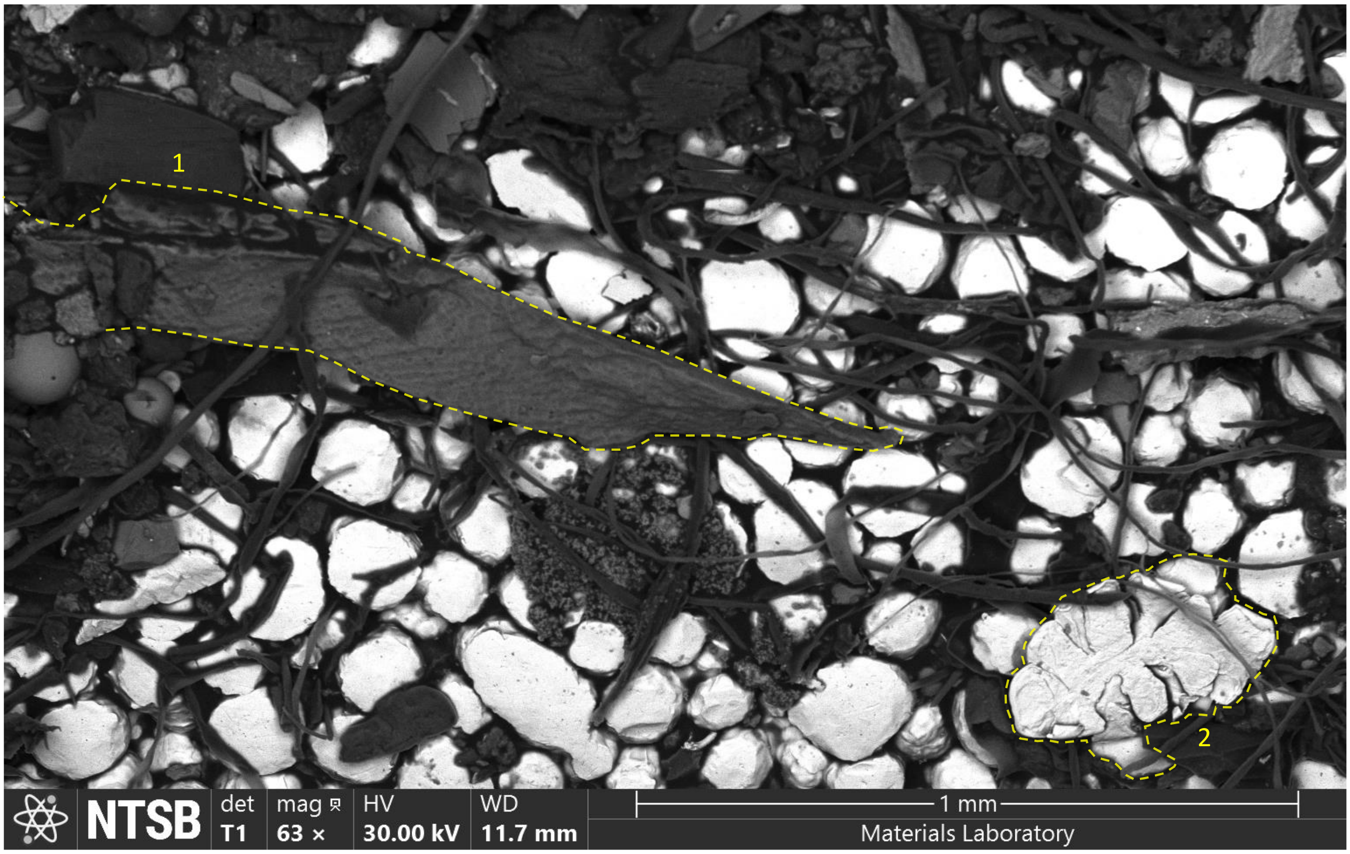

Figure 4: A backscattered electron micrograph showing a closer view near particles 1 and 2 as identified in figure 3. The particles of interest are labeled and outlined by a yellow dashed line.

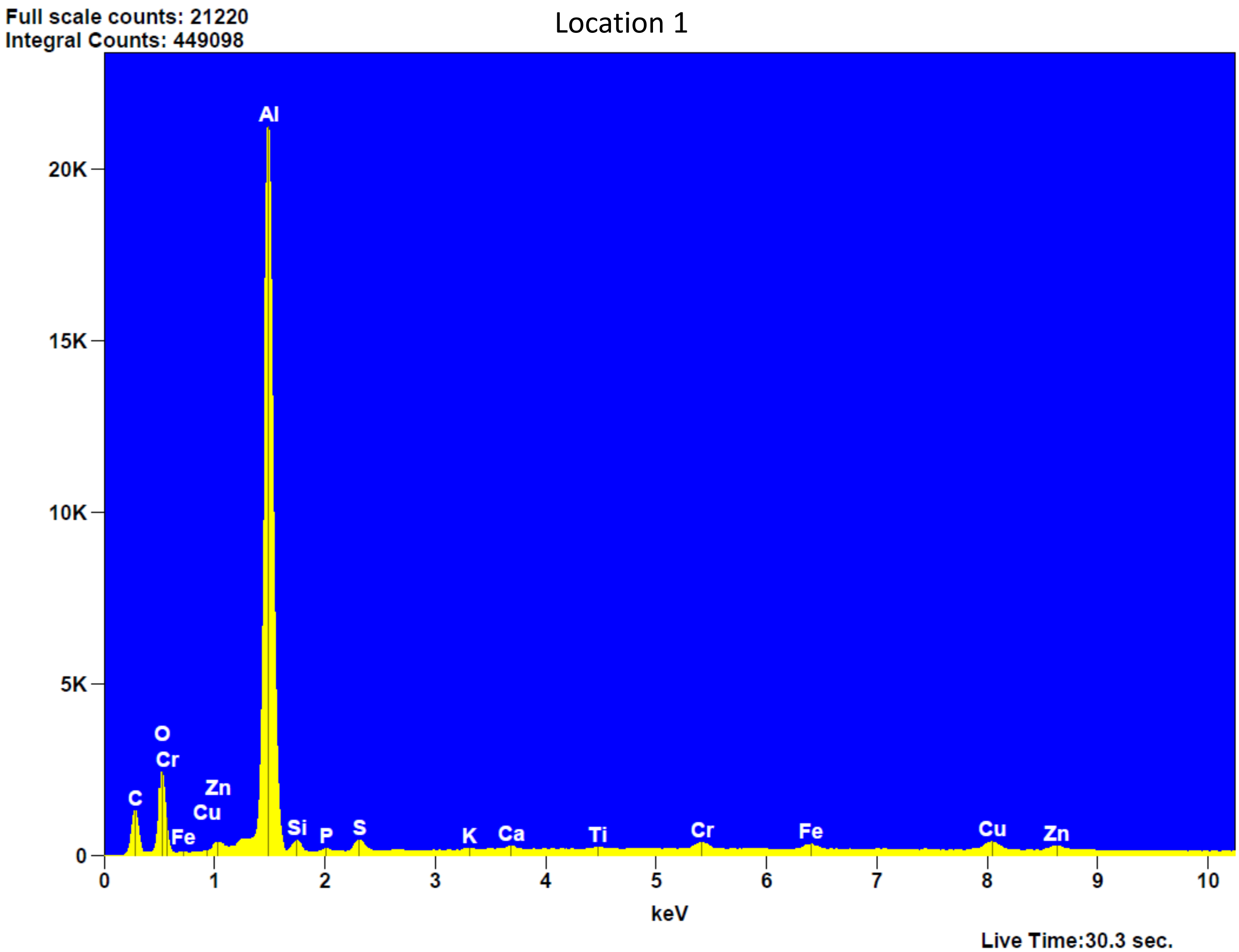

Figure 5: EDS spectrum acquired from the particle identified as location 1.

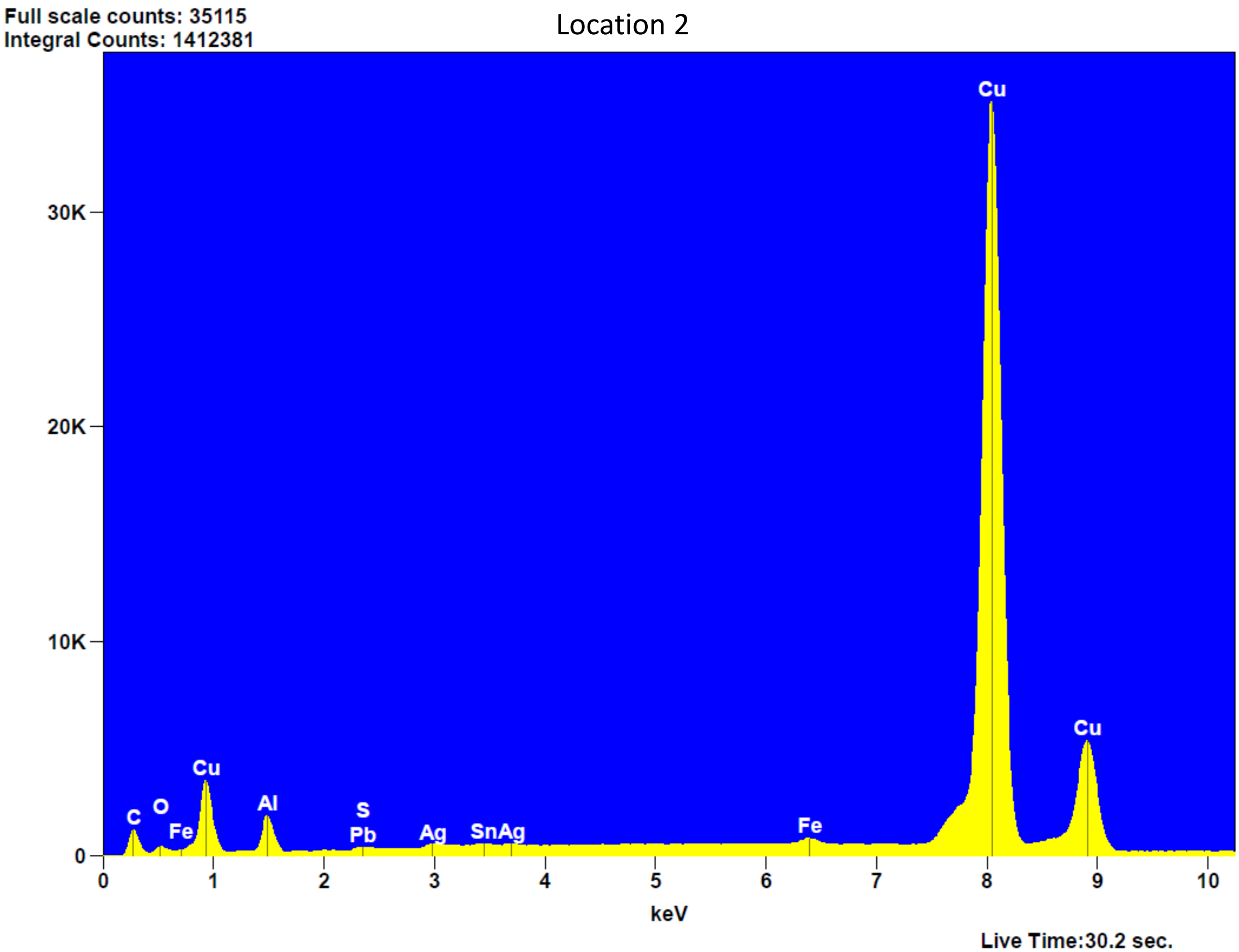

Figure 6: EDS spectrum acquired from the particle identified as location 2.

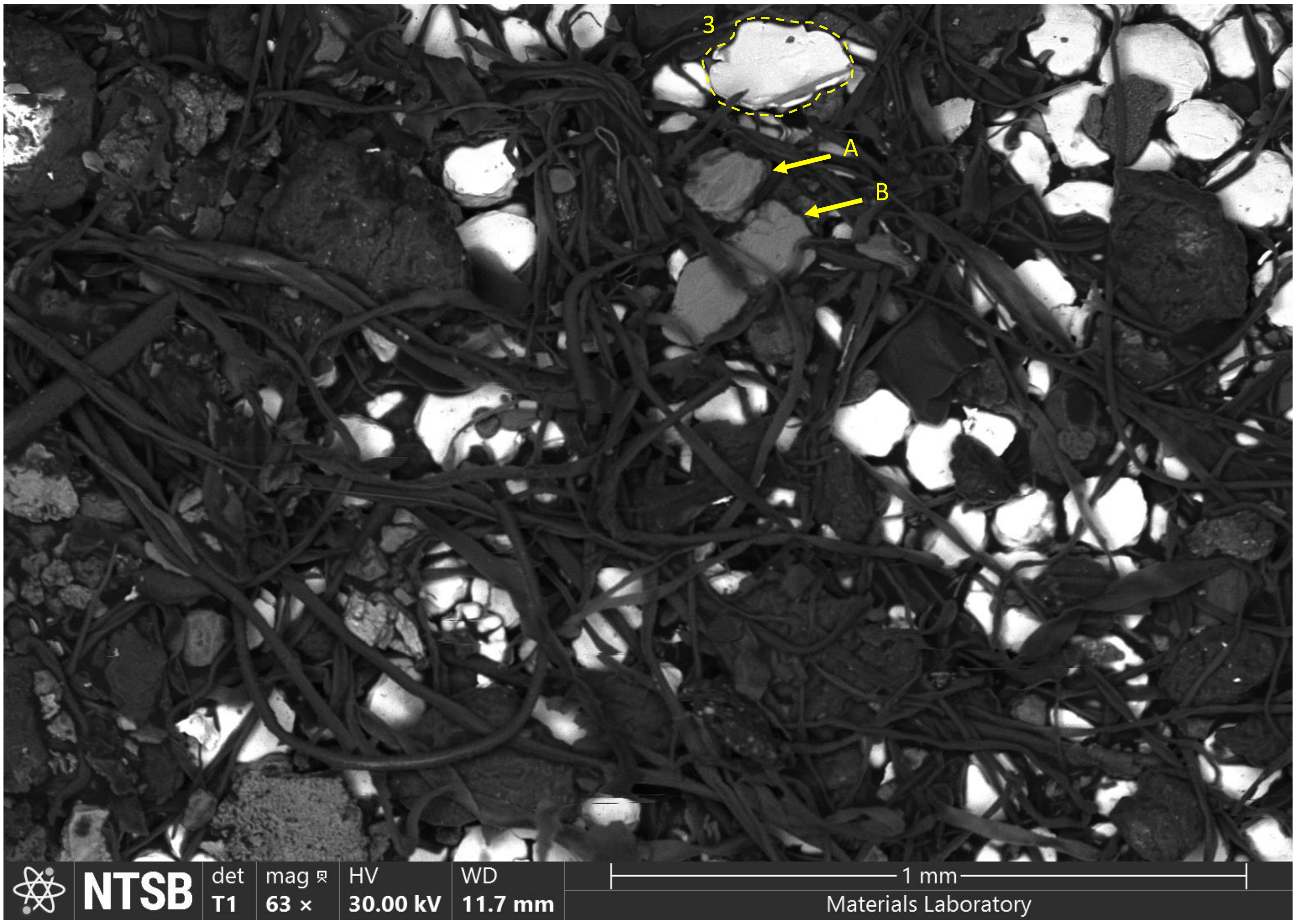

Figure 7: A backscattered electron micrograph showing a closer view near particle 3 as identified in figure 3. Particle 3 is labeled and outlined by a yellow dashed line. Two additional particles of interest were identified and labeled with yellow arrows. EDS spectra of the particles of interest are shown in subsequent figures.

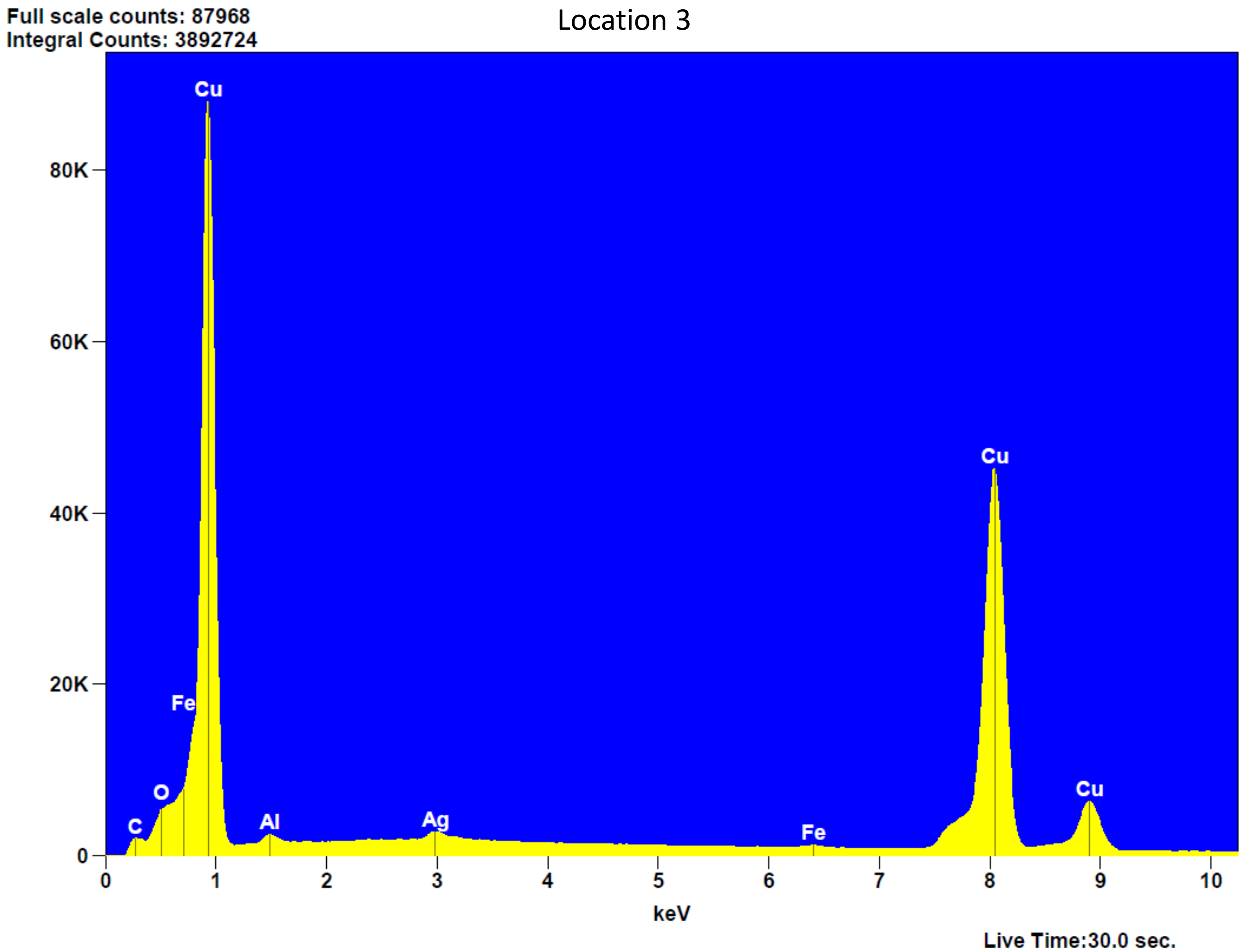

Figure 8: EDS spectrum acquired from the particle identified as location 3.

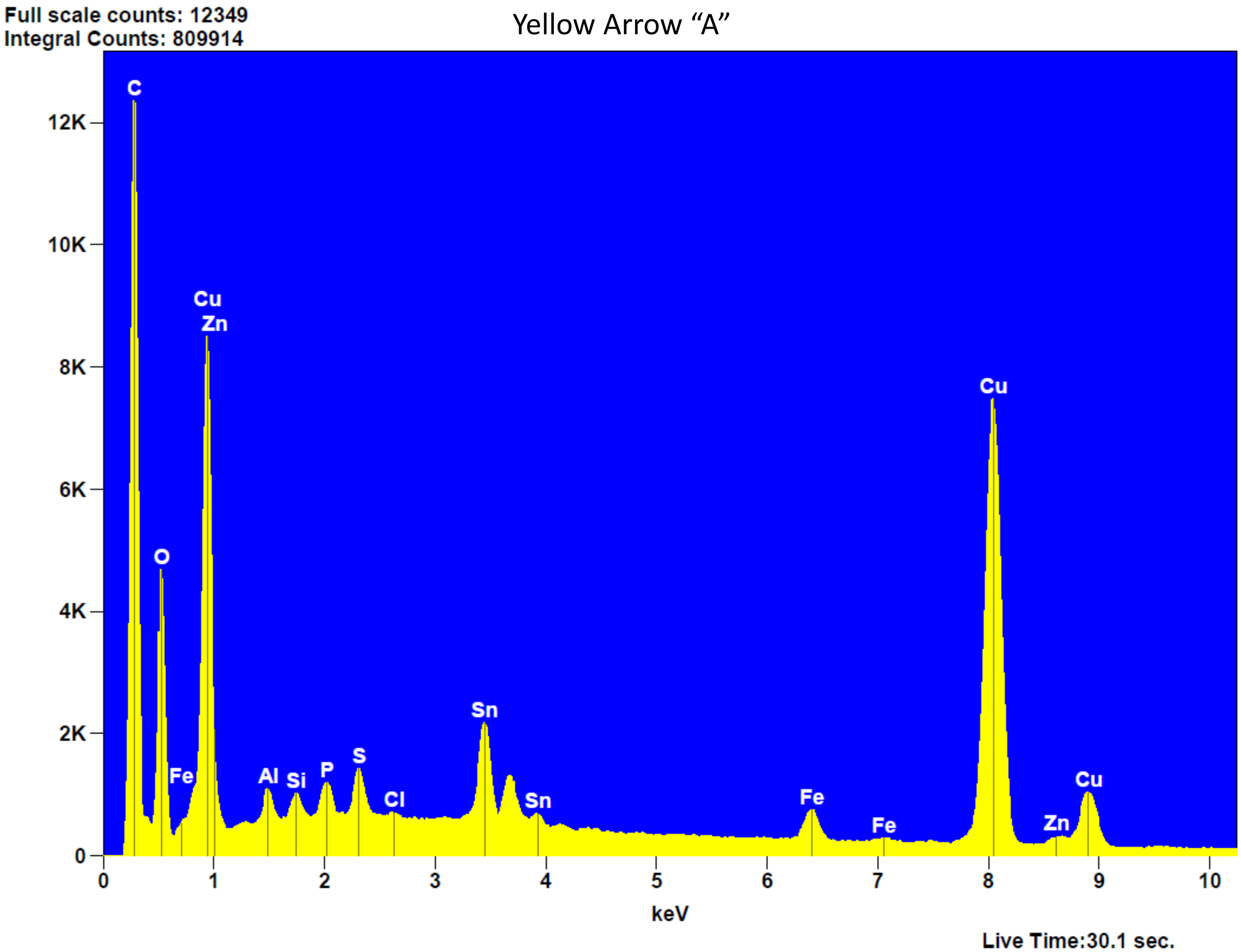

Figure 9: EDS spectrum acquired from the particle identified by yellow arrow labeled "A" in figure 7.

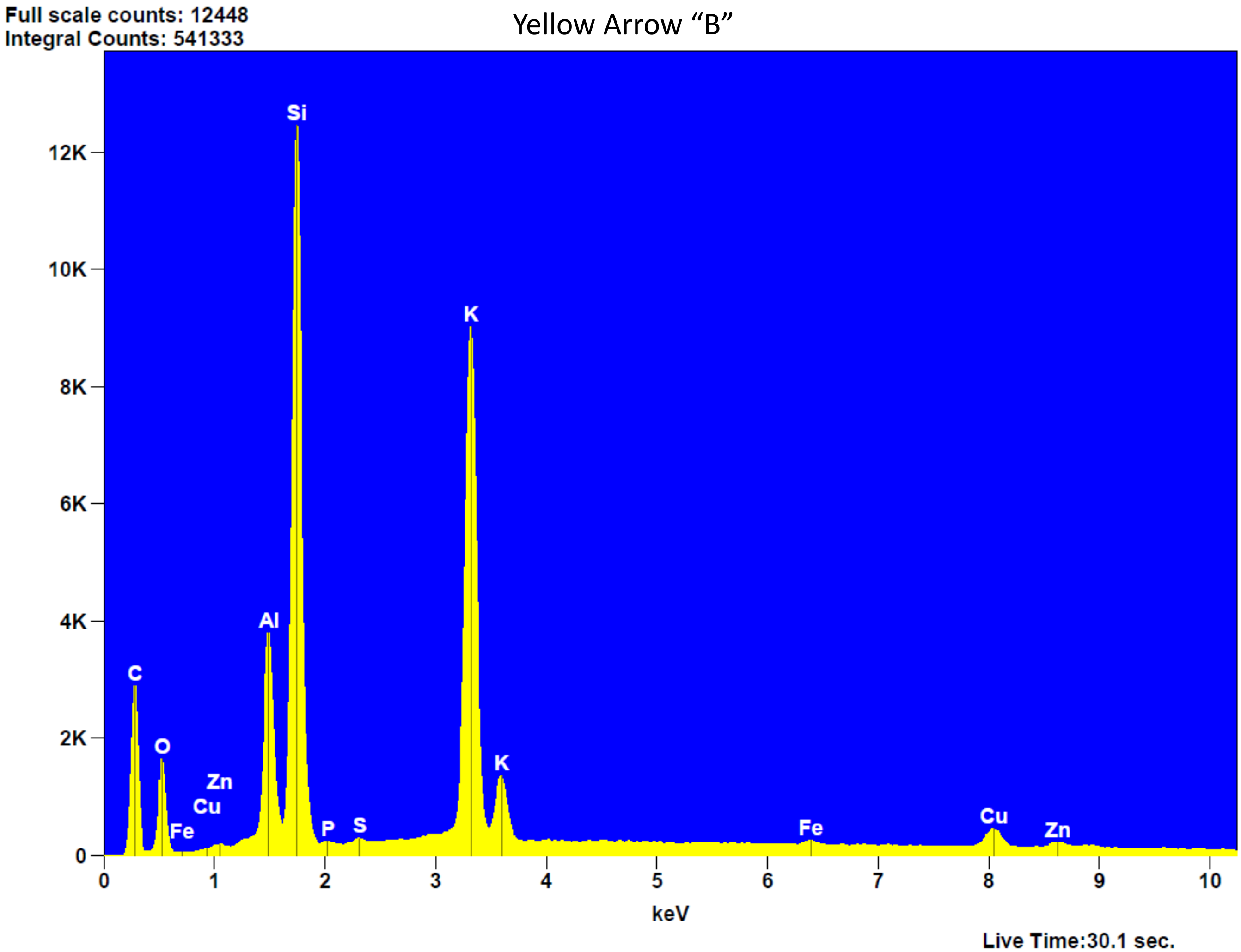

Figure 10: EDS spectrum acquired from the particle identified by yellow arrow labeled “B” in figure 7.

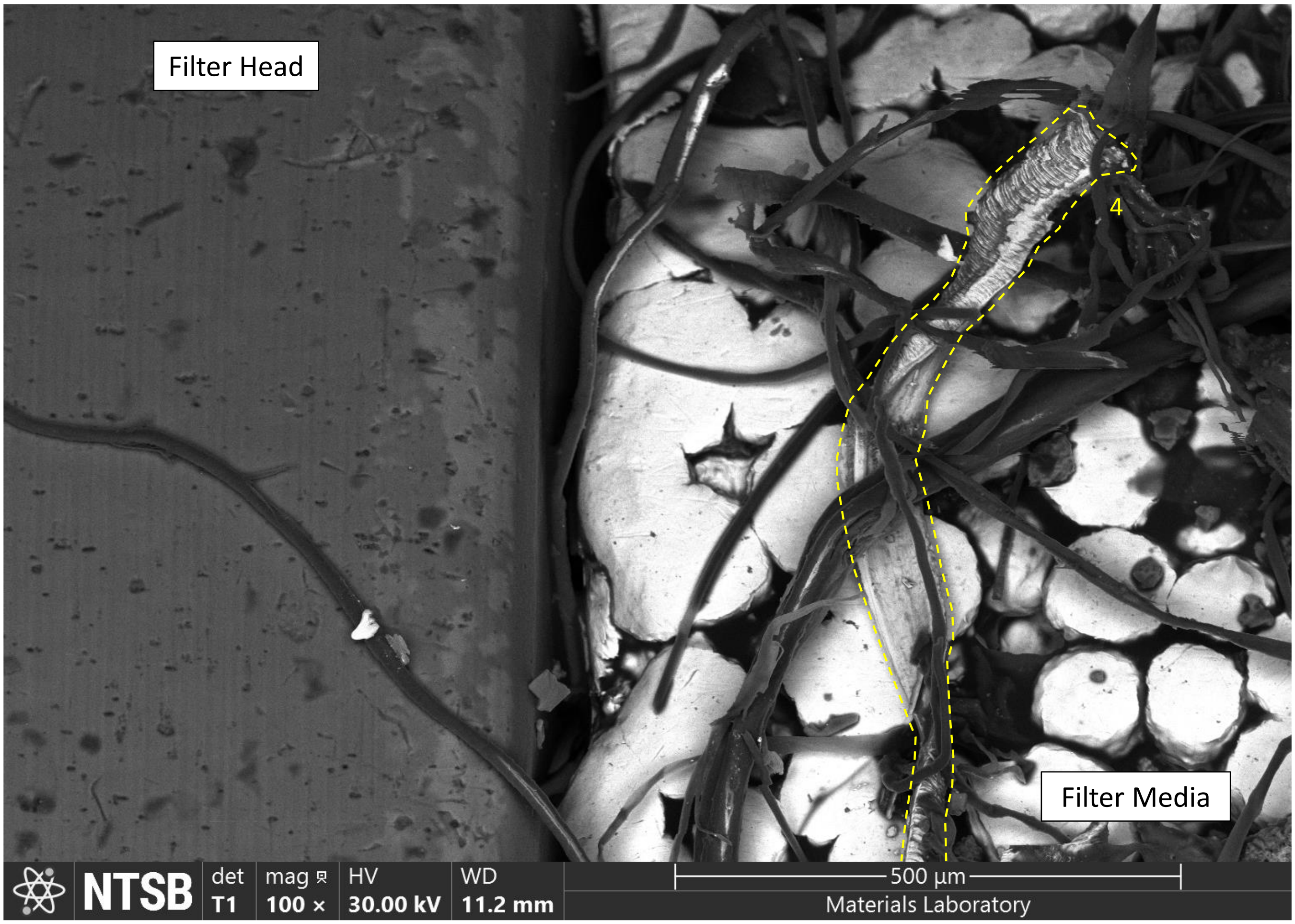

Figure 11: A backscattered electron micrograph showing a closer view near particle 4 as identified in figure 3. The gray filter head is visible on the left side of the image.

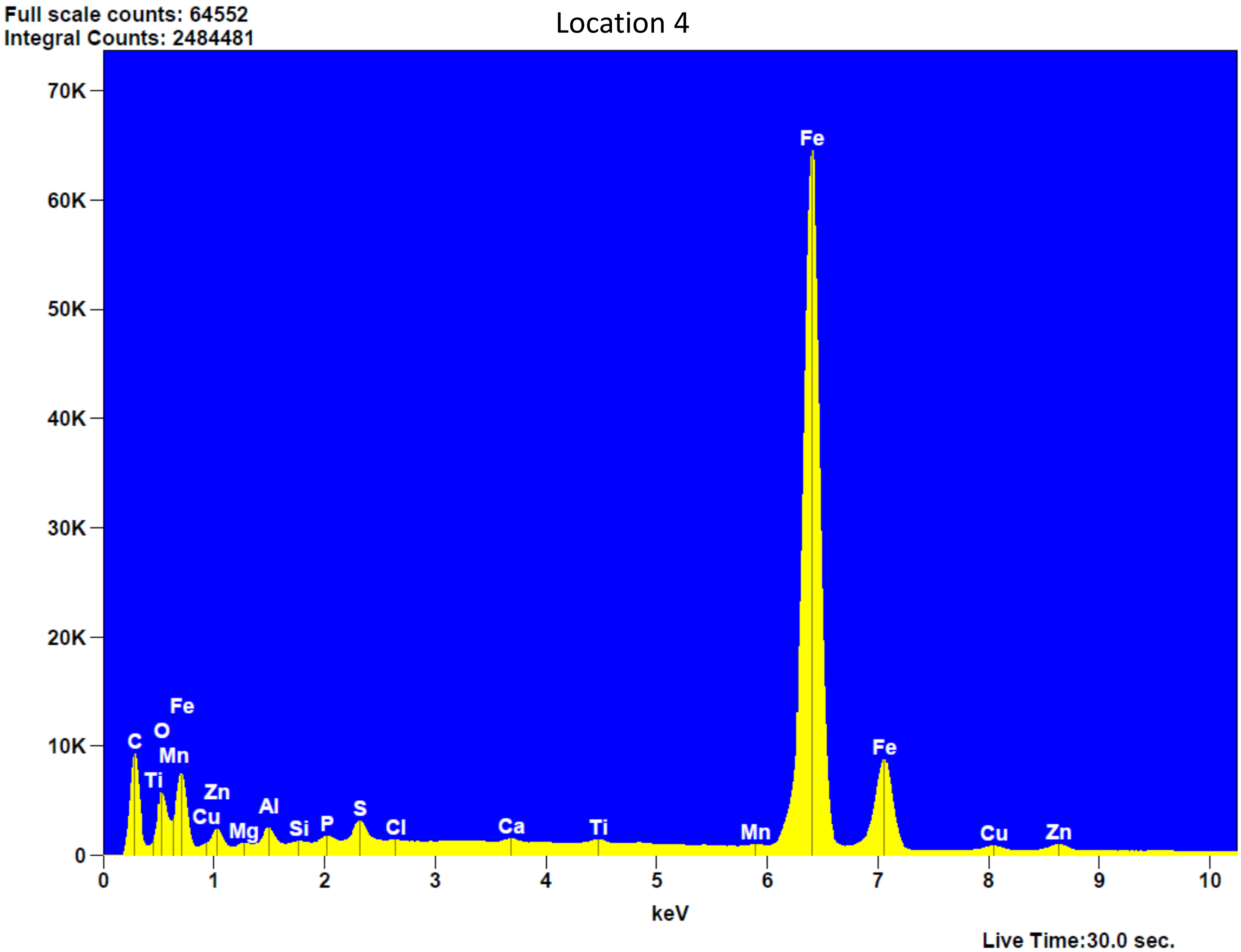

Figure 12: EDS spectrum acquired from the particle identified as location 4.

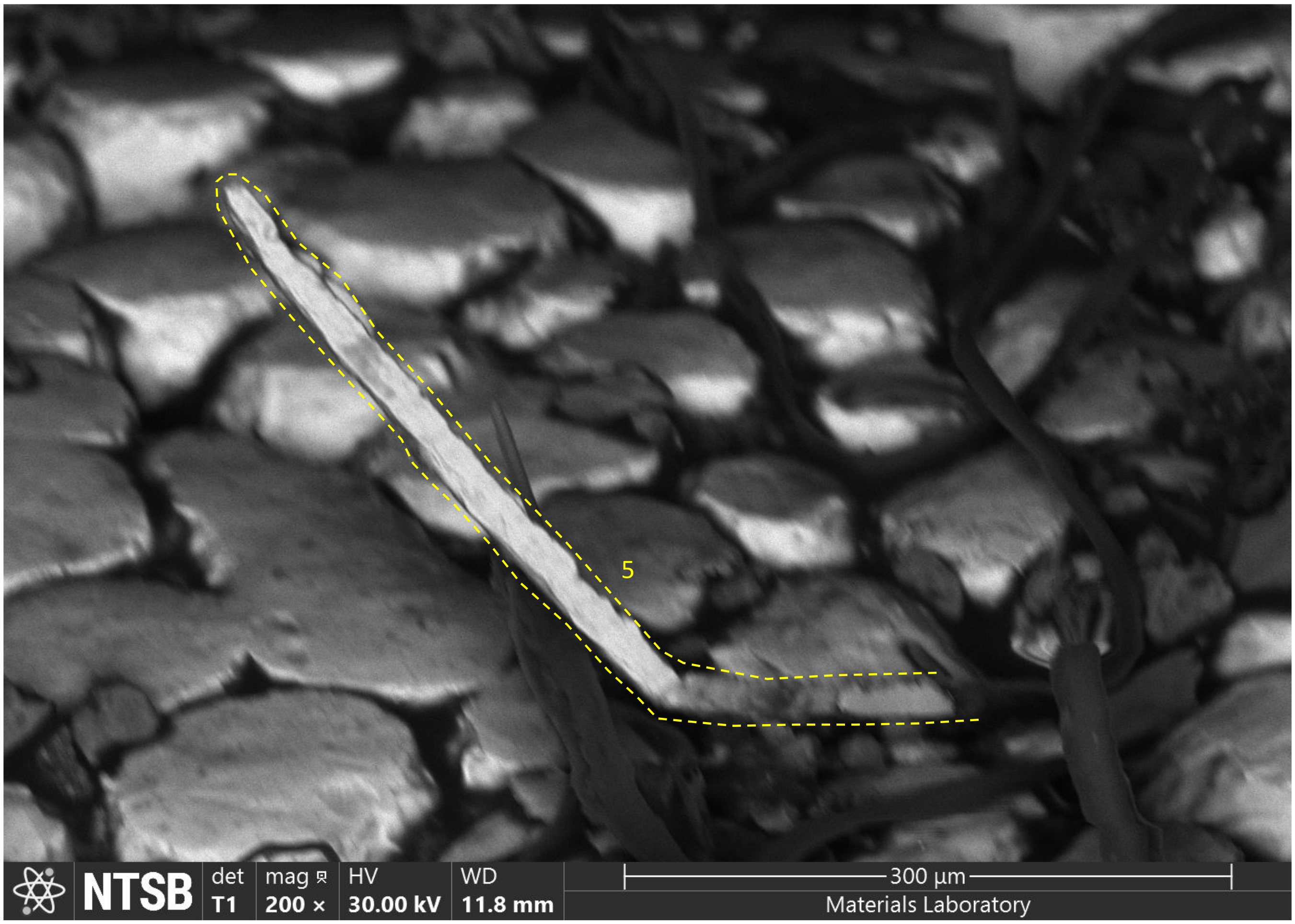

Figure 13: A backscattered electron micrograph showing a closer view near particle 5 as identified in figure 3.

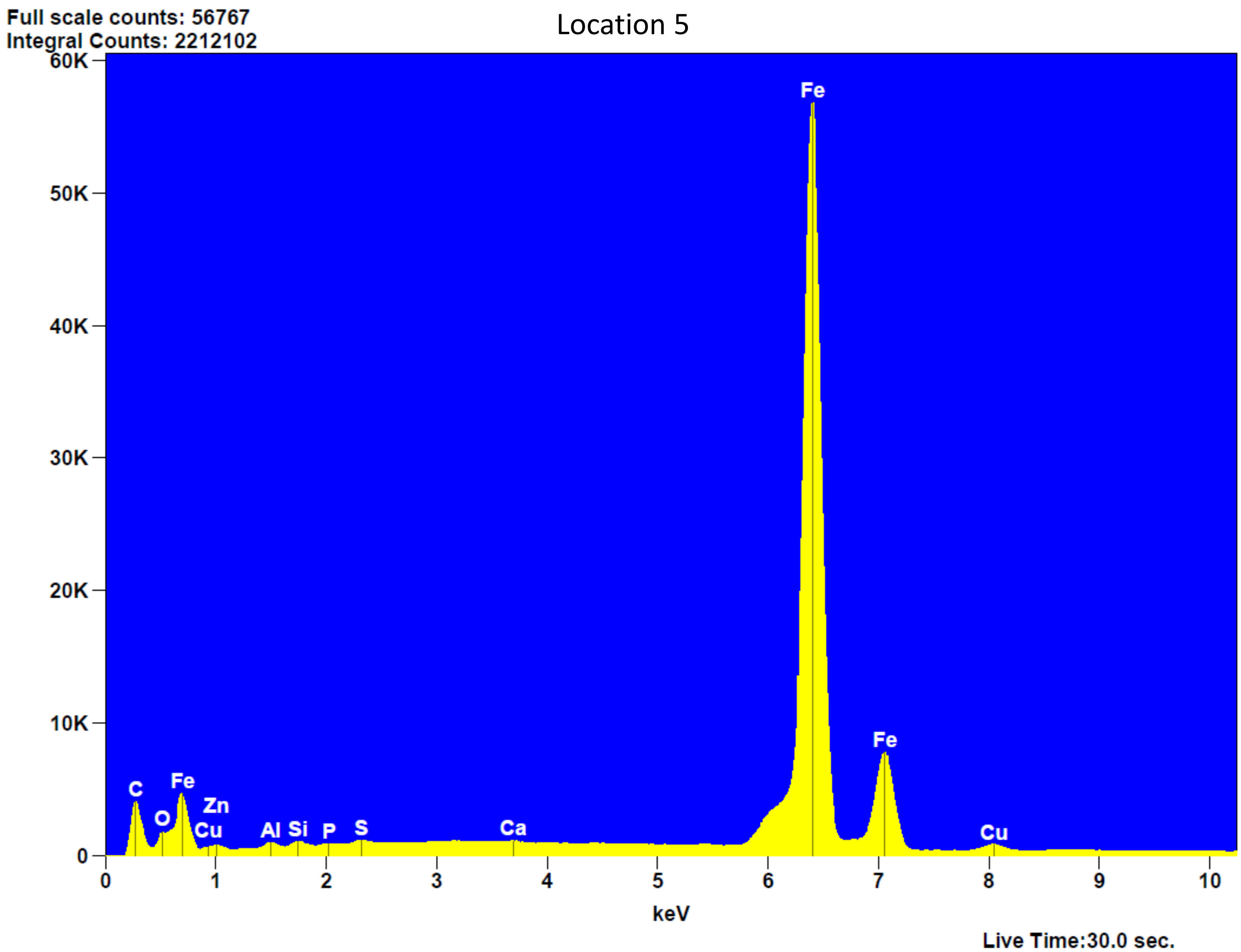

Figure 14: EDS spectrum acquired from the particle identified by location 5.

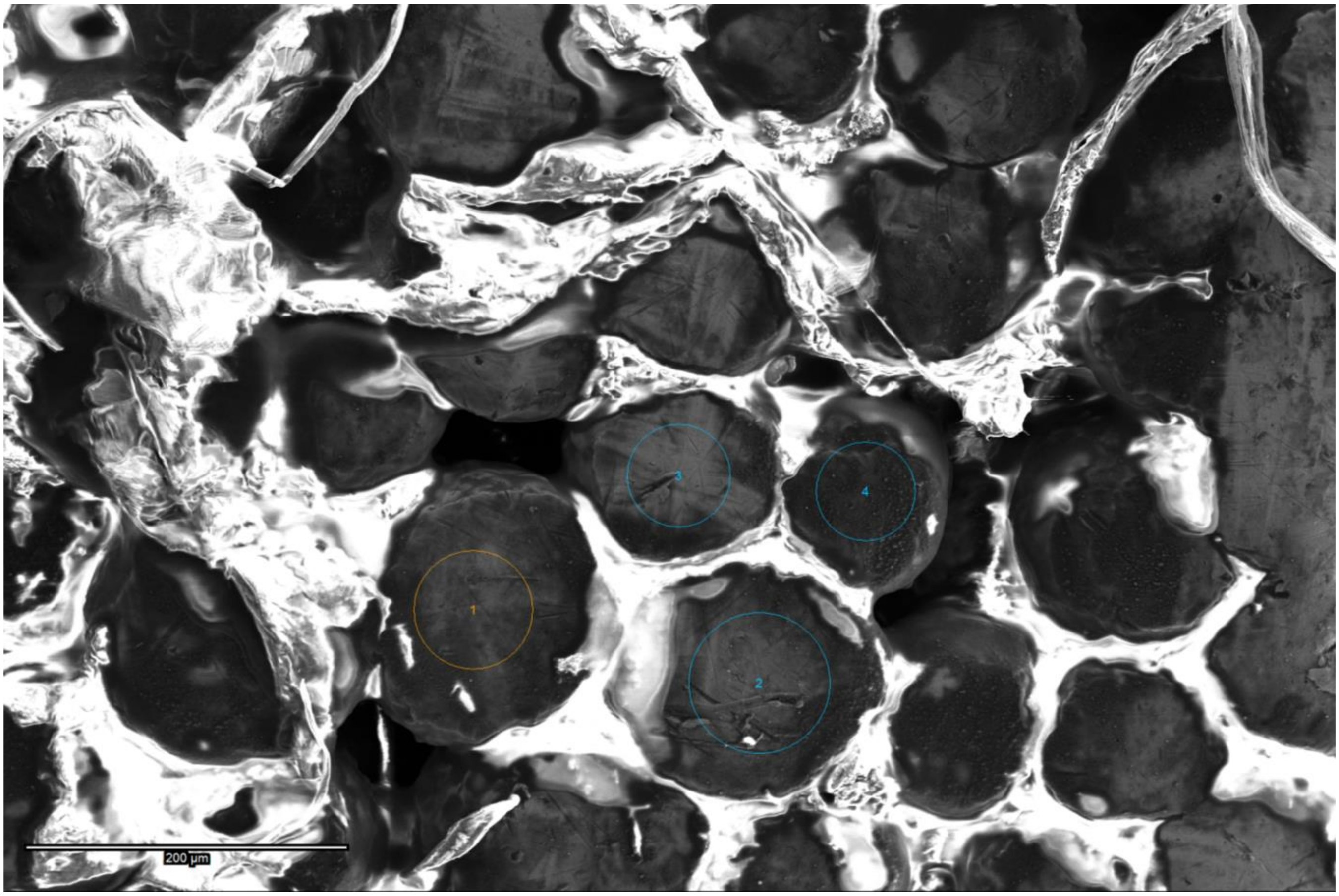

Figure 15: Secondary electron micrograph of the filter media acquired for EDS analysis. The orange and blue circular annotations numbered 1 through 4 indicate where spectra were acquired.

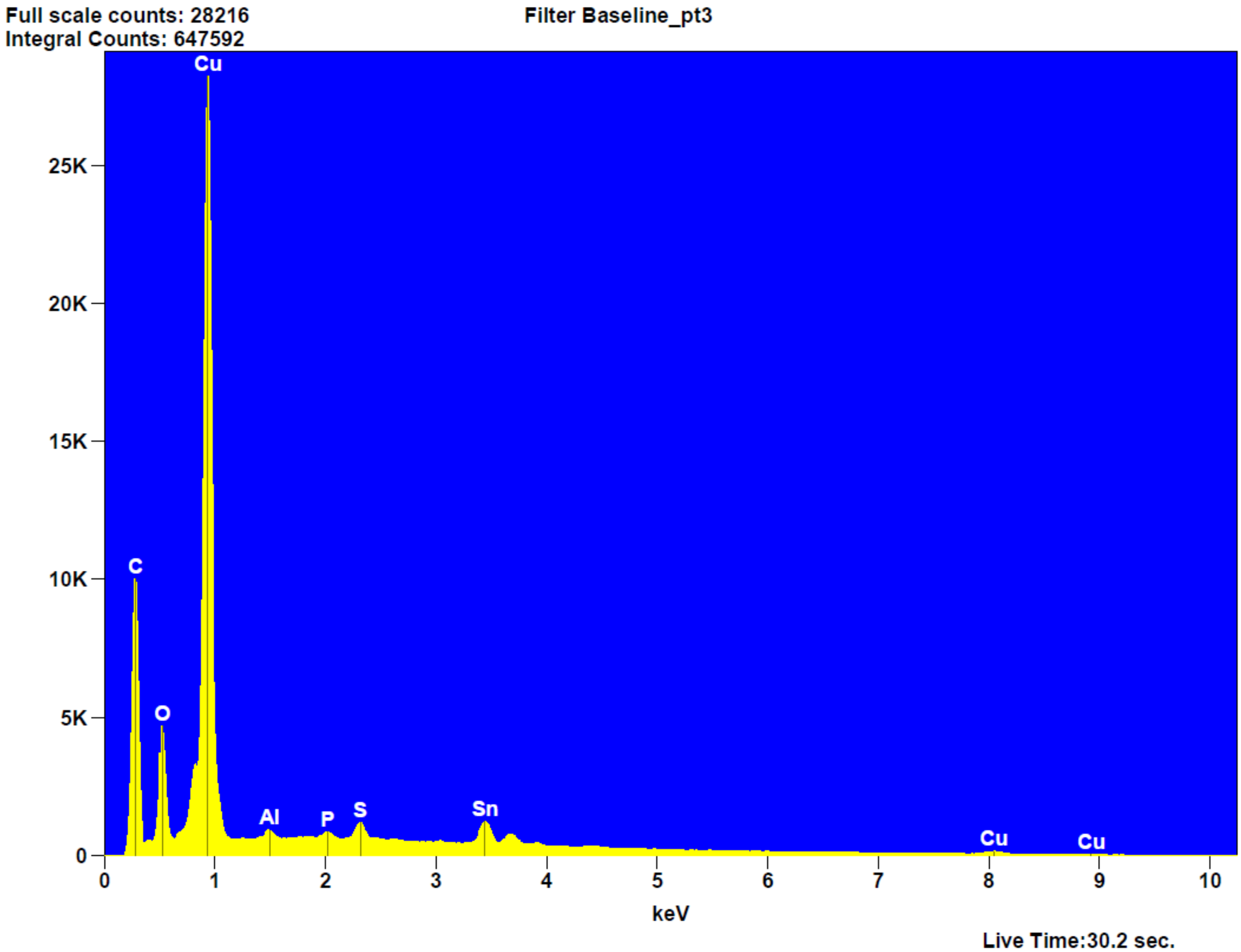

Figure 16: Typical EDS spectra acquired from the filter media locations identified in figure 15.