

SEM Analysis of Cleaned Wire and Un-cleaned Wire

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One un-answered question from the cleaning gas mixture test is if the deposit on the wire surface responsible for the gain drop is silicon. One way resolving this issue is to pull out wire and take SEM images including element analysis.

The last setup of the previous run (Run 9) was to age all wires and clean some of the wires by turning on HV only to the straws to be cleaned during the cleaning process. The test chamber was aged following the usual step using the high vapor pressure silicone oil. The cleaning gas was the 8% mixture (Ar-CO₂-CF₄ (70-22-8)) with ~700 ppm moisture level.

Figures 1 and 2 show the results from this setup. Figure 1 is from one of the wires (#17) went through the cleaning procedure and Figure 2 is from an un-cleaned wire (wire #18). Since the HV to #18 was off during the cleaning process, some of data points are missing. The plots are the gain maps from four out of 26 locations, and these locations were chosen for the SEM analysis. The first location nearest to the gas entrance was chosen because sometimes the gain continued to decrease even during the cleaning process. Location 9 is around the middle of the upstream, location 15 is the downstream right next to the wire-joint and the location 26 is the end of the straw near the gas exit. From each four locations, about 1 cm section of the wire was cut.

When wires were removed, they were inspected with an optical microscope. There is no obvious damage such as color change on the wire surface. However as expected the wire-joints exhibits some damage (frosting) as shown in Figure 3 and 4. The wire-joint from #17 took ~ 0.1 C/cm and #18 took ~ 0.06 C/cm during the four cleaning processes in this run. The degree of frosting is consistent with previous studies. The SEM images of the wire-joints from #17 and #18 are shown in Figure 5 and 6 respectively. As previously observed, the etching is evident and the elementary analysis shows fluorine replacing silicon.

Figure 7 to Figure 18 shows the images and element analyses of the wires at four locations (#1, #9, #15 and #26). In summary:

1. The deposit on the wire surface responsible for the gain drop is made of silicon and oxygen.
2. The wire went through cleaning process (gain is restored) shows very little silicon on the wire surface.

This study shows that the aged wires (with wire-joints) can be safely cleaned with the cleaning mixture (8% for this test) several times without any problem.

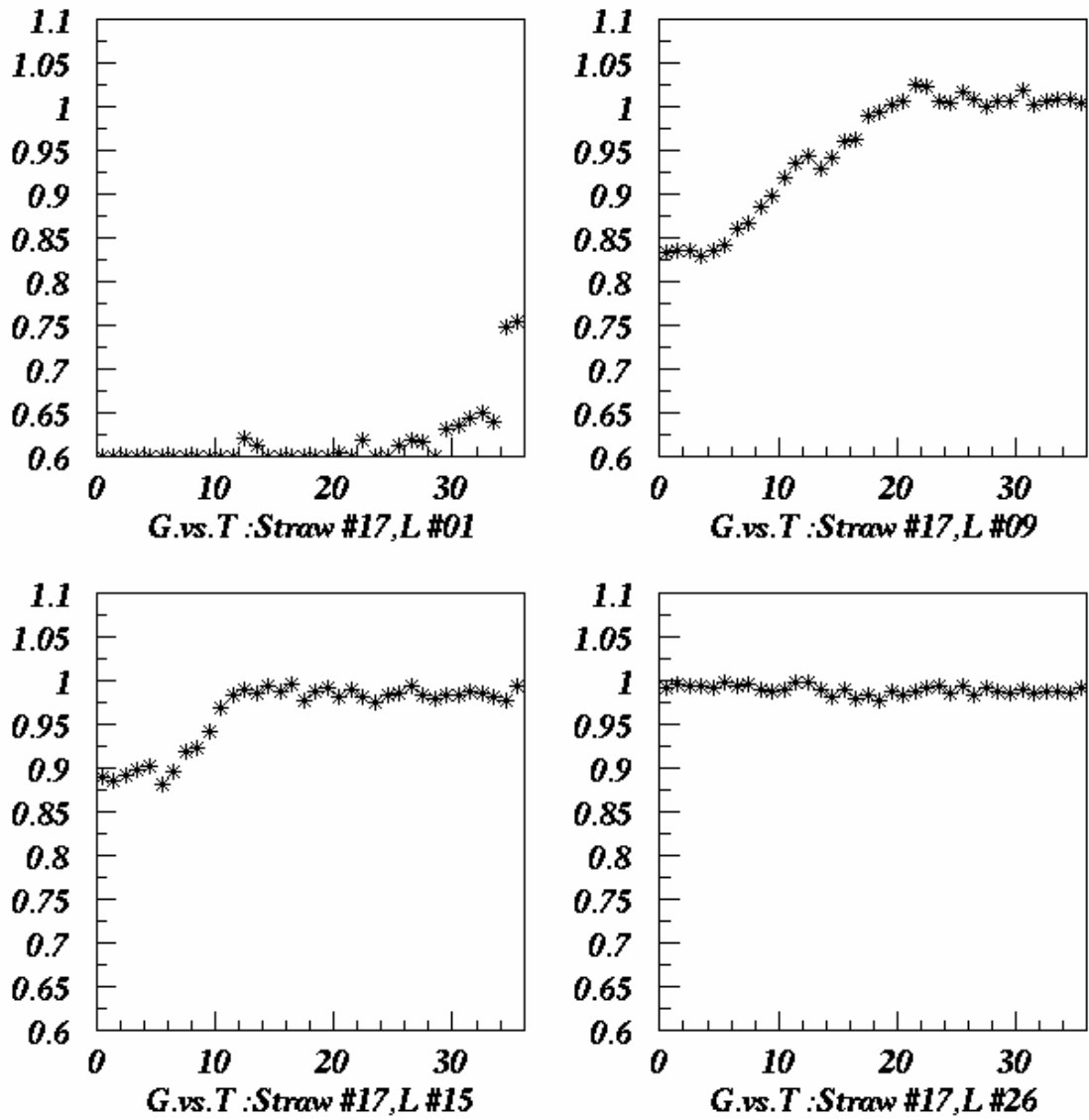


Figure 1. The gain as a function of time for wire #17 (aged and cleaned wire). The x-axis is in hour. After $T=4$ hour, the cleaning gas was introduced. The gain other than location 1 (upper left figure) is completely restored.

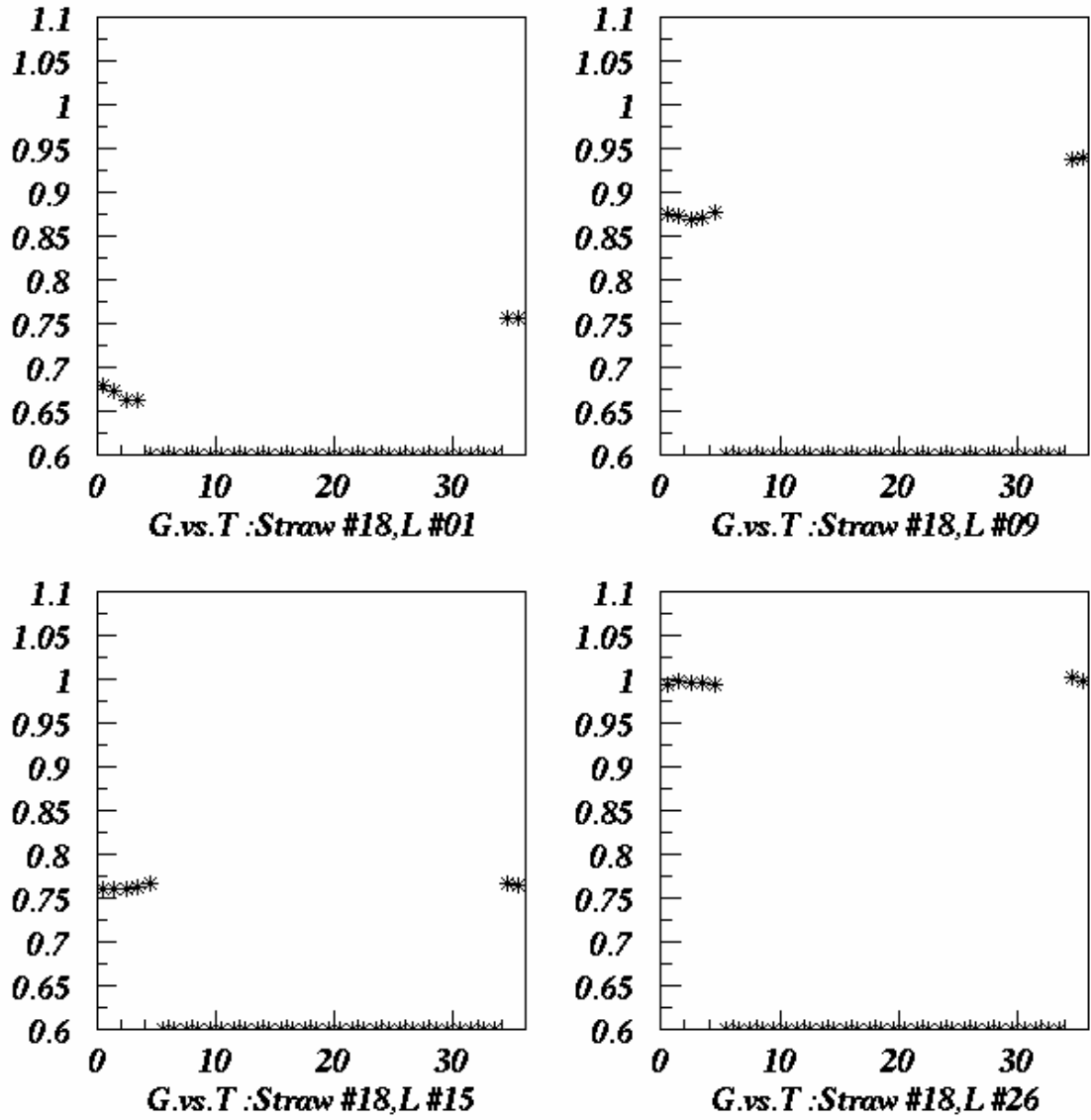


Figure 2. The gain as a function of time for wire #18 (aged but not cleaned). The x-axis is in hour. After T=4 hour, the cleaning gas was introduced. The HV to this straw was turned off during the cleaning process (no data) and turned on after the cleaning process. The last two data points are after the cleaning process was ended.

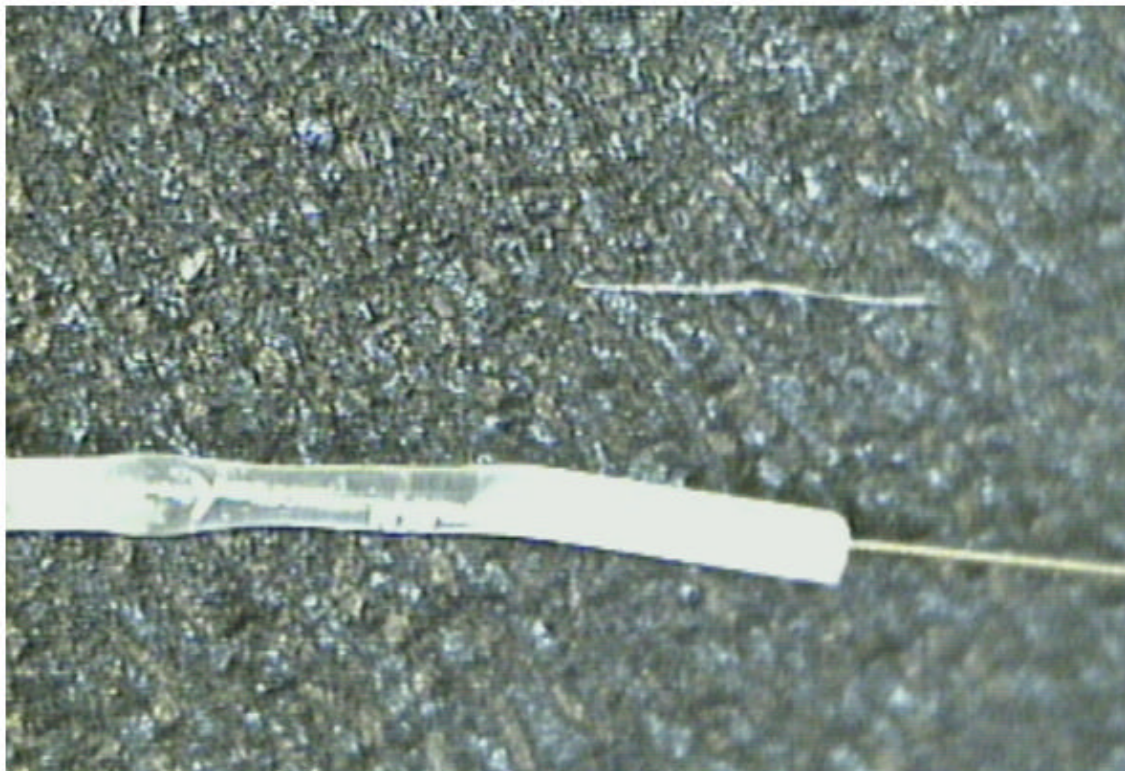


Figure 3. Wire-joint from #17. This took ~ 0.1 C/cm. There is some frosting.

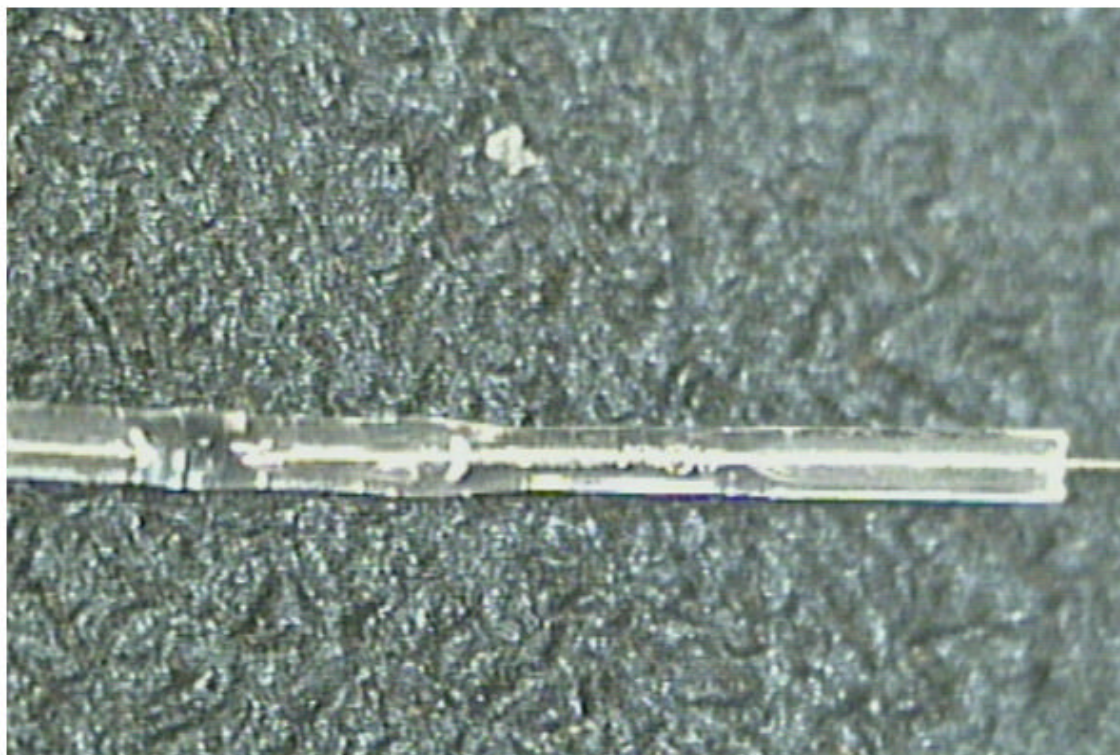


Figure 4. Wire-joint from #18. This took ~ 0.06 C/cm. There is little frosting.

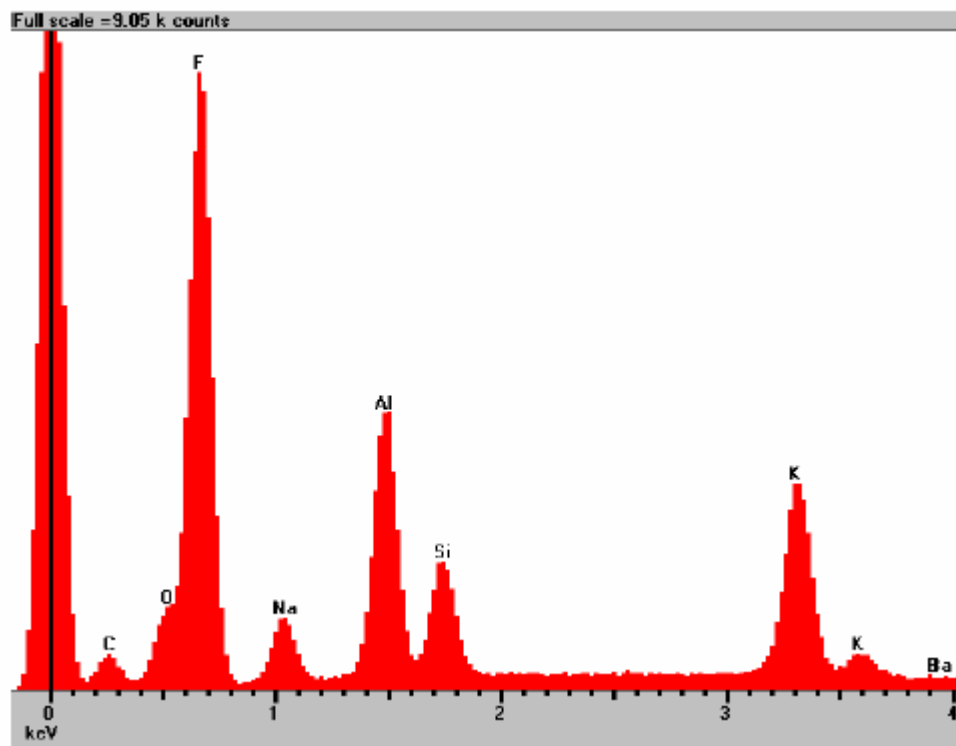
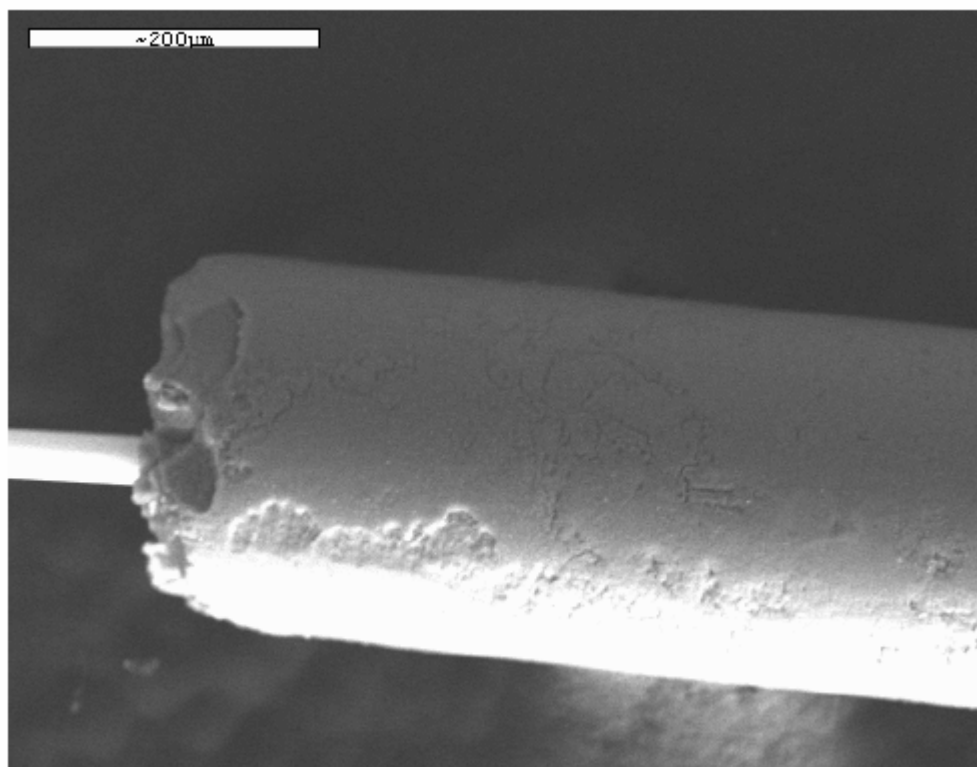


Figure 5. The SEM image of the wire-joint from straw #17, and element analysis. There is a large F peak. This wire-joint took ~ 0.1 C/cm integrated charge.

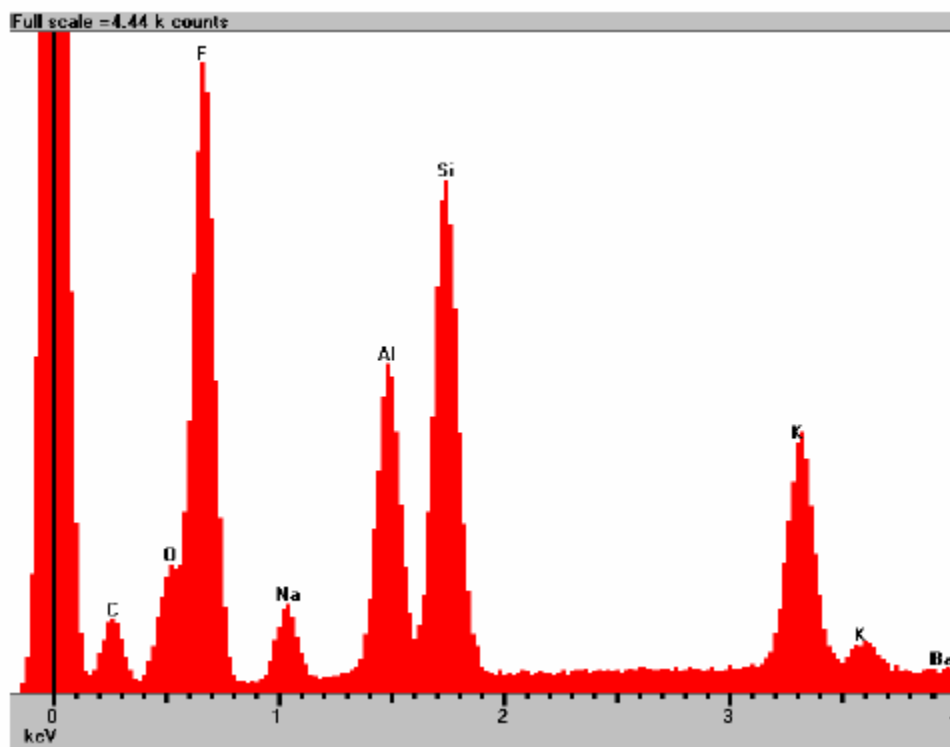
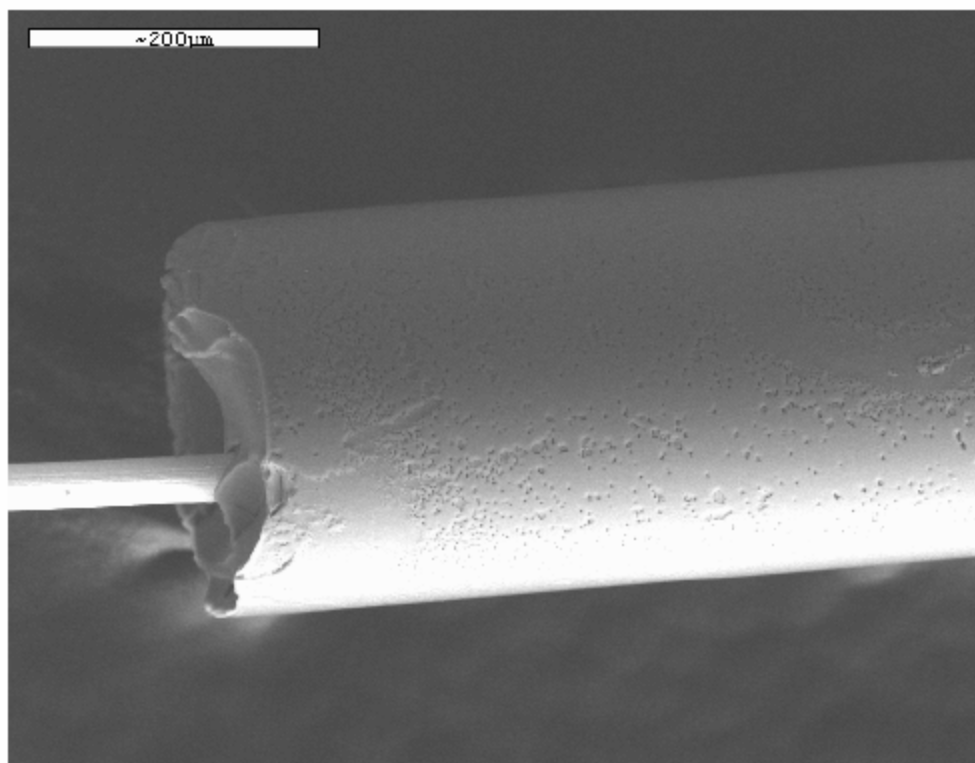


Figure 6. The SEM image of the wire-joint in straw #18, and element analysis. There is a large F peak. This wire-joint took ~ 0.06 C/cm integrated charge.

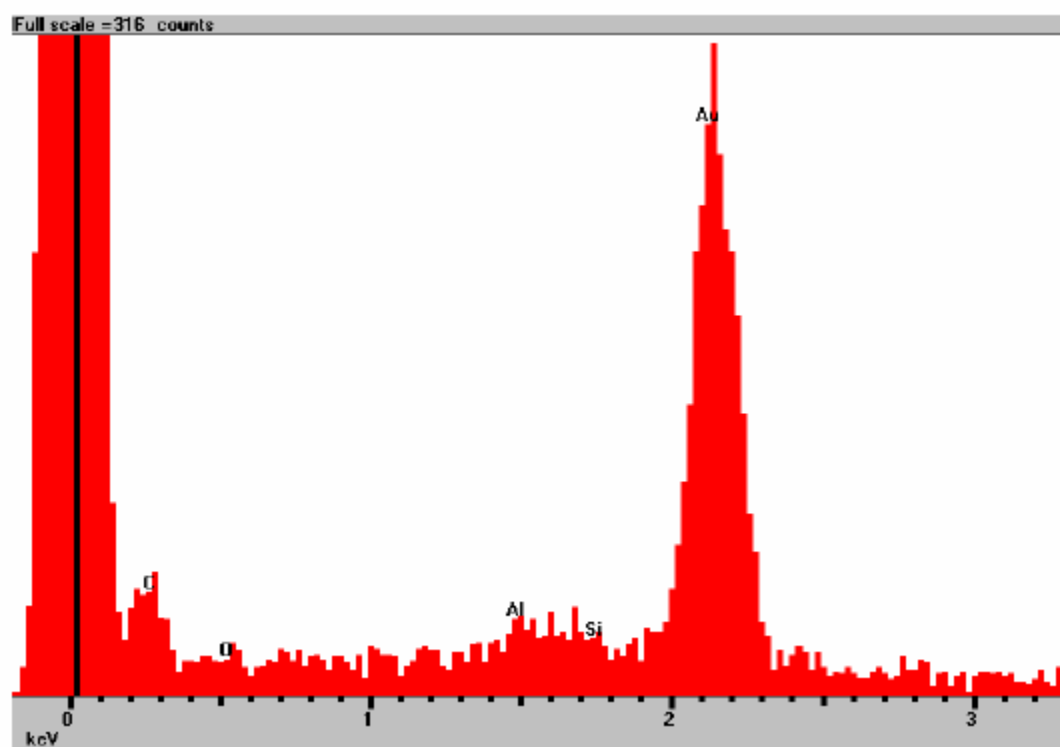
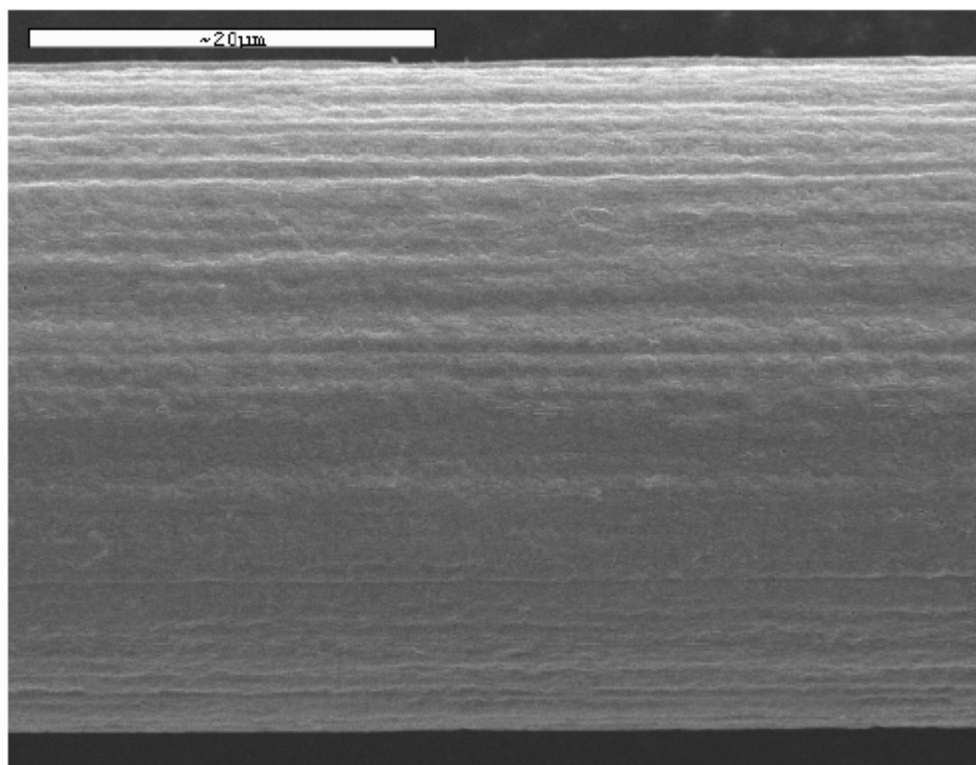


Figure 7. From wire #17, Location #1. Wire surface looks quite good and there is very little silicon.

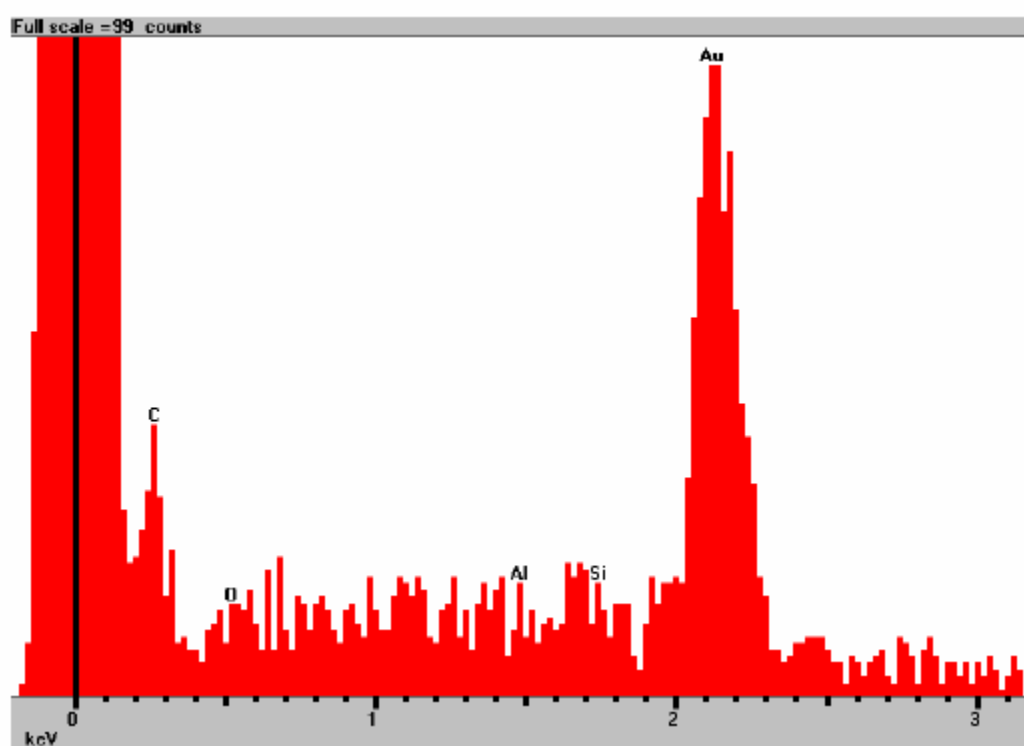
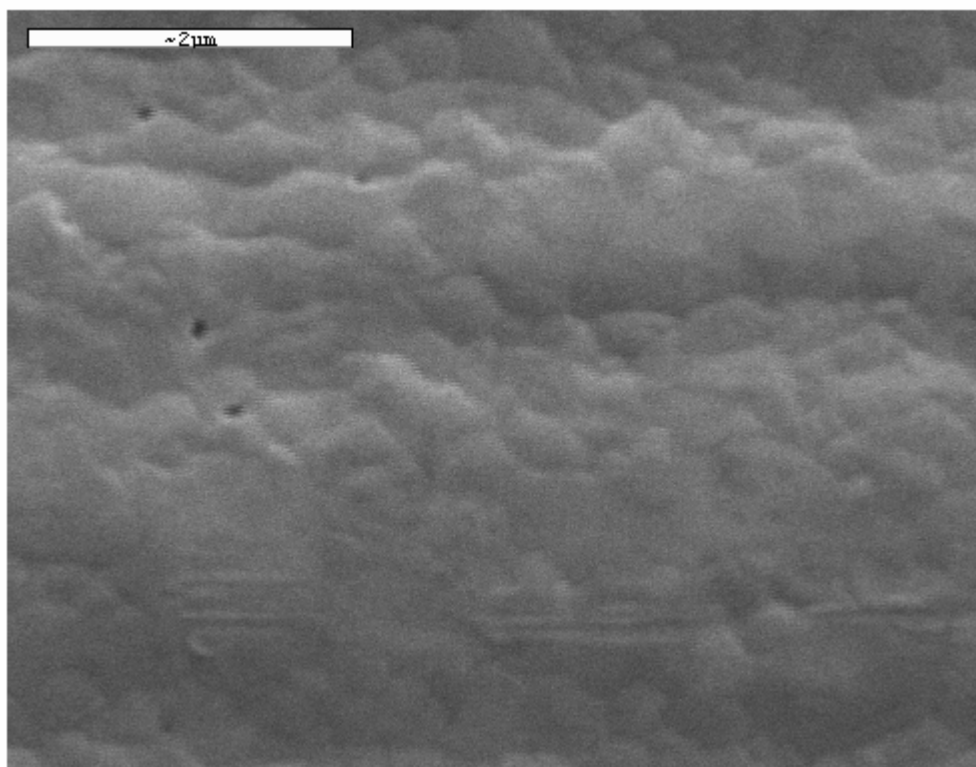


Figure 8. Wire #17, Location 9.

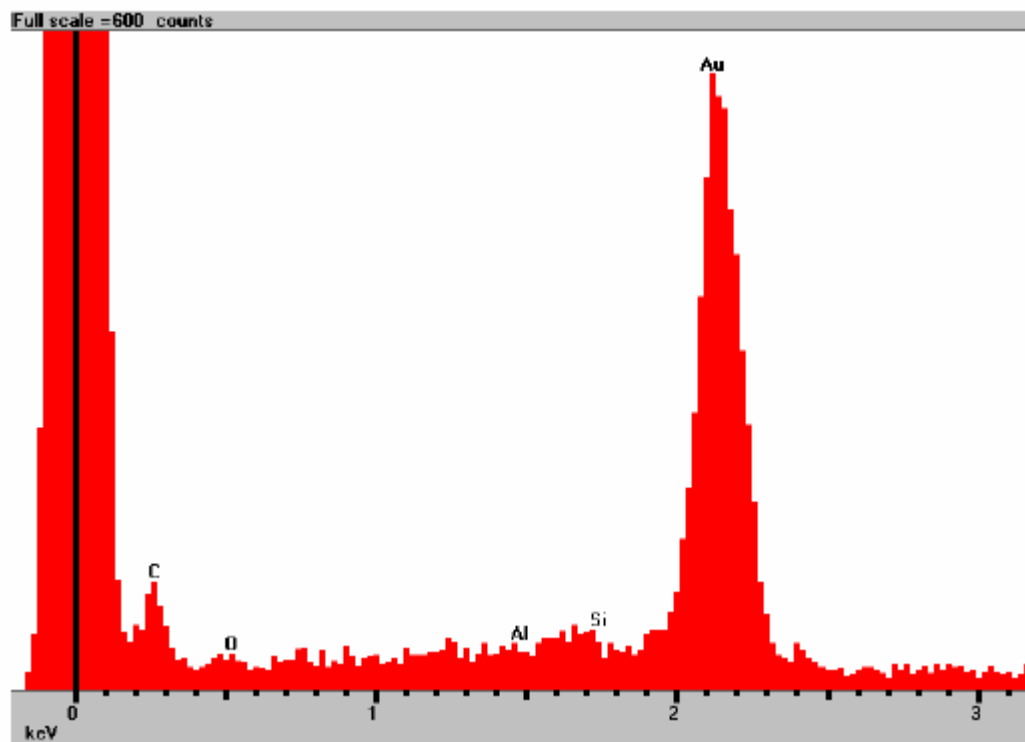
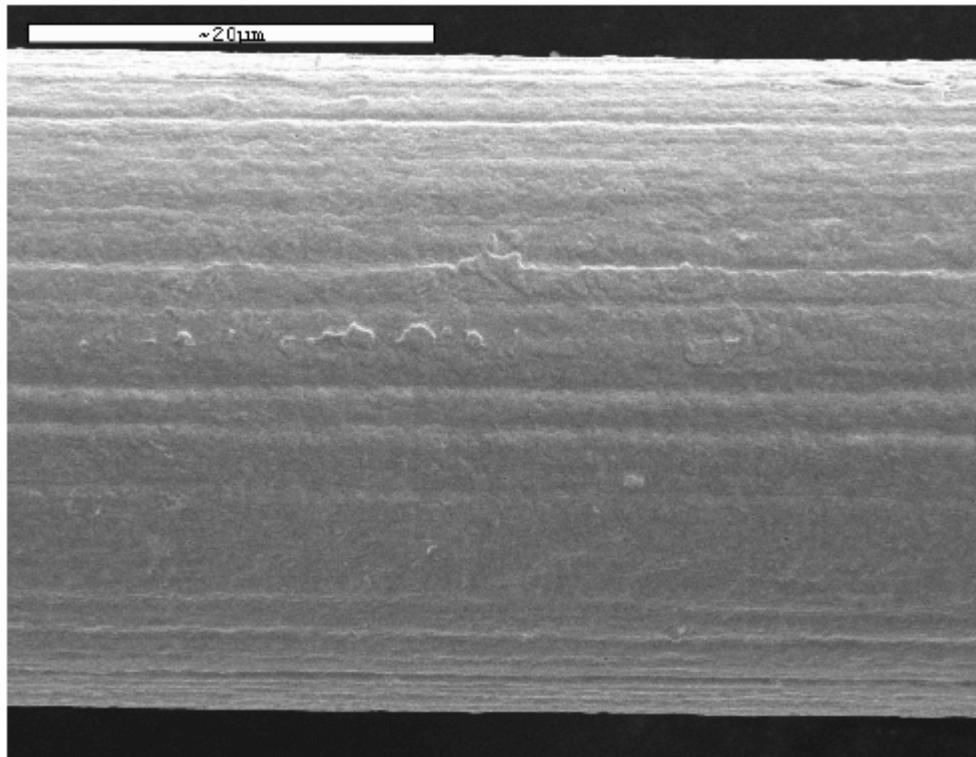


Figure 9 . Wire #17, Location 15. This is just downstream of the wire-joint.

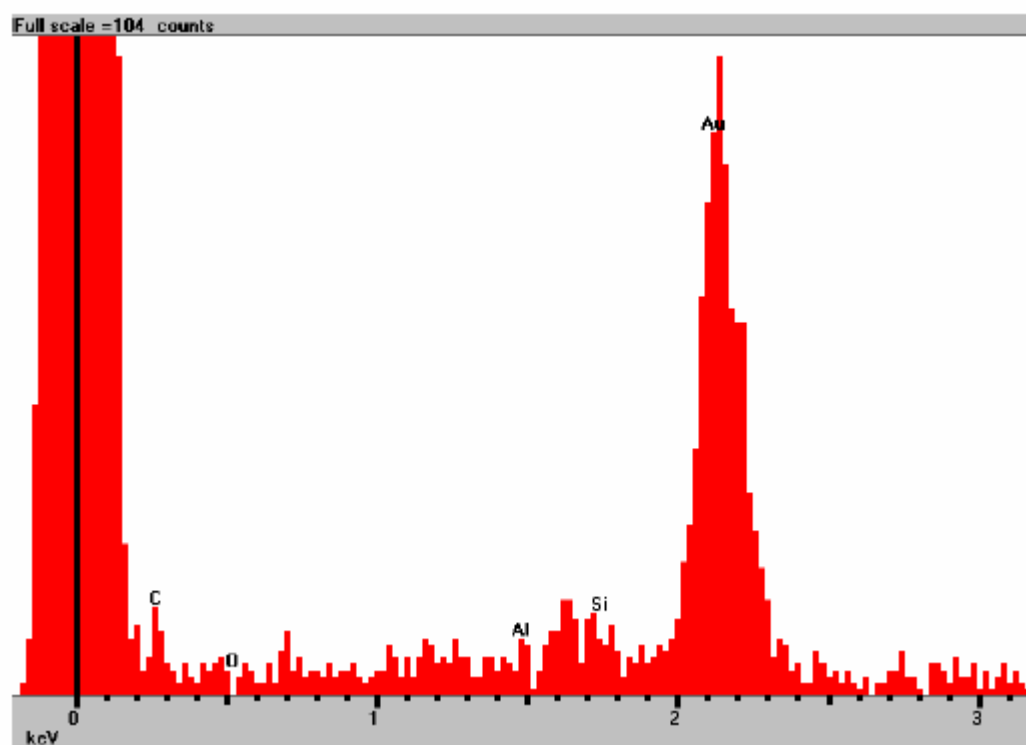
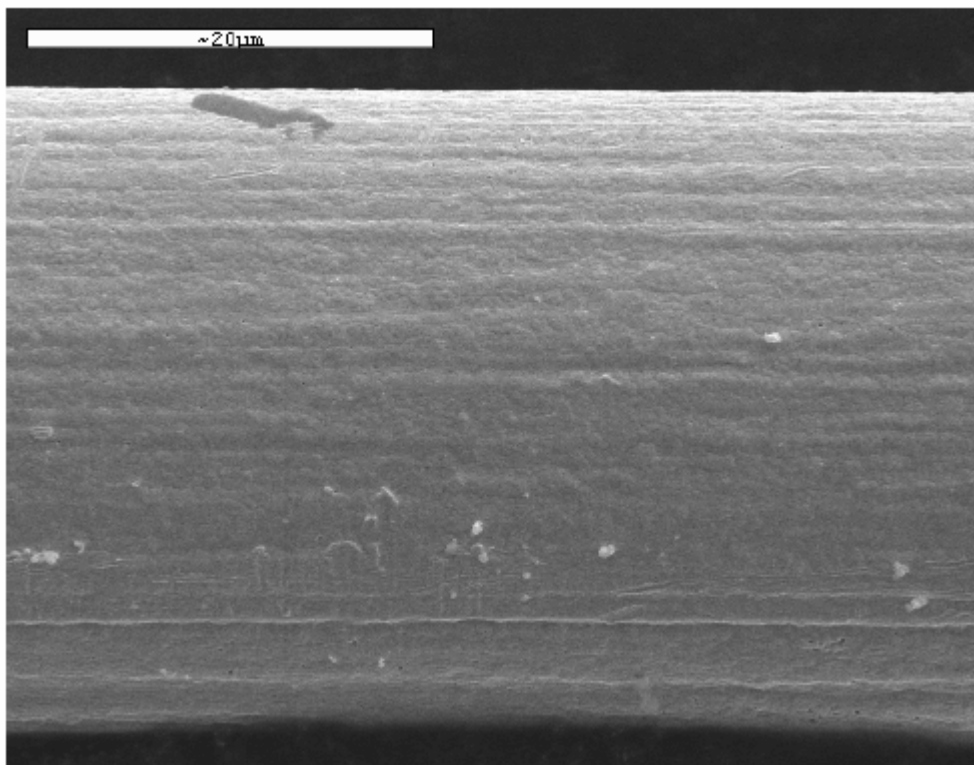


Figure 10. Wire #17, Location 26. This location is near the gas out let.

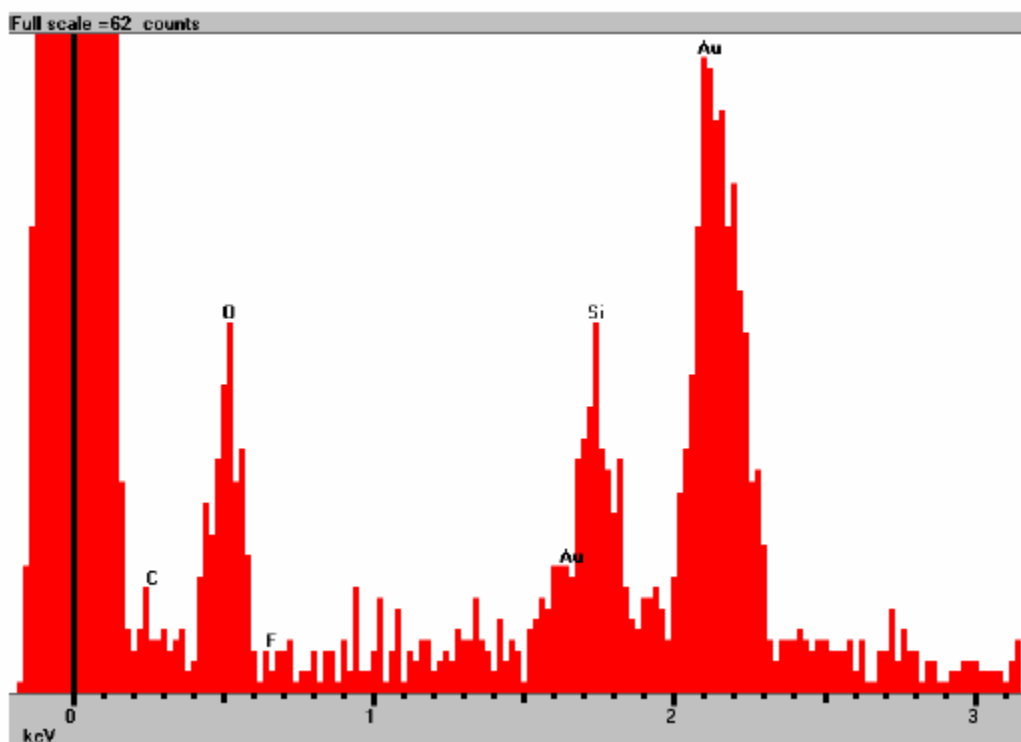
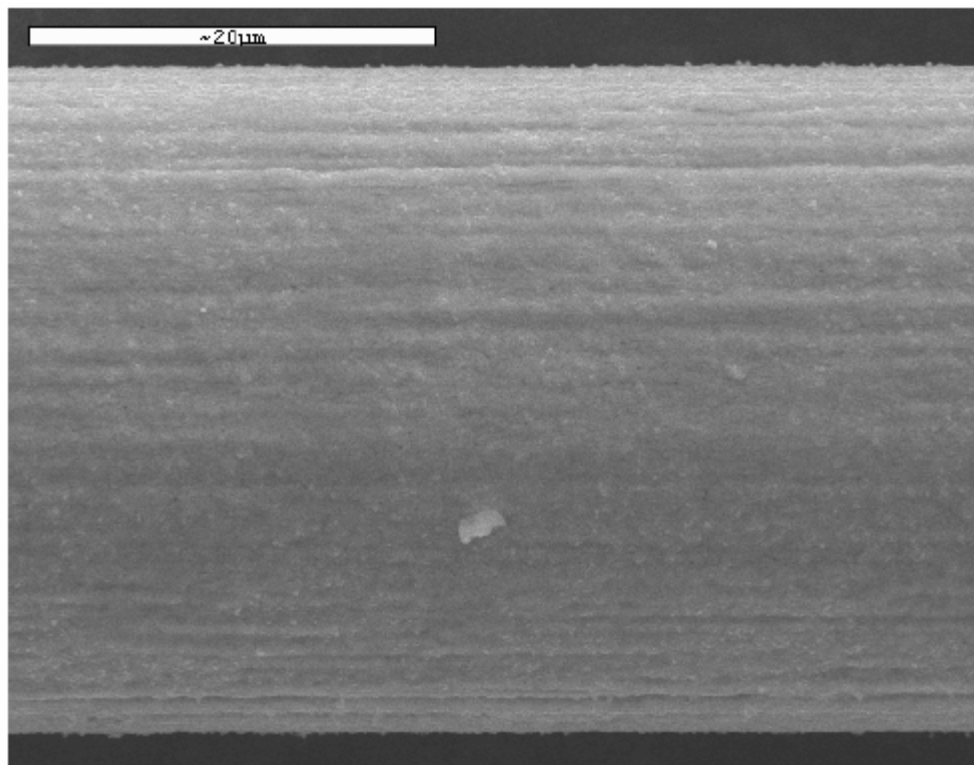


Figure 11. Wire #18 (uncleaned wire). Location #1. There are some deposits on the surface and there is a large silicon peak.

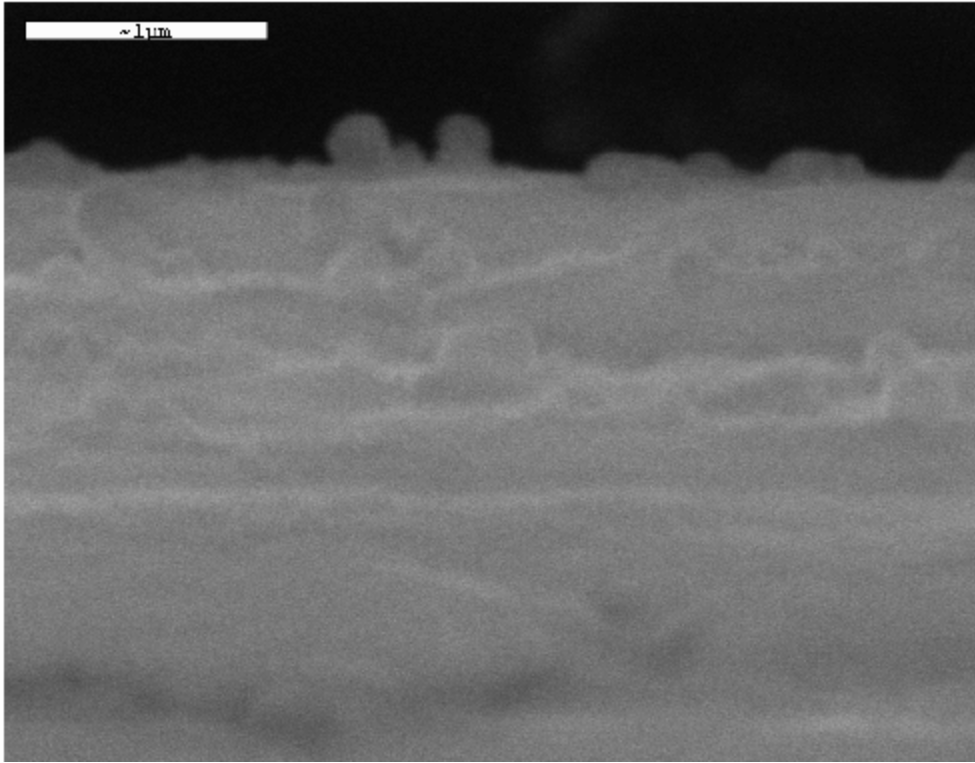


Figure 12. A close-up Figure 11 image.

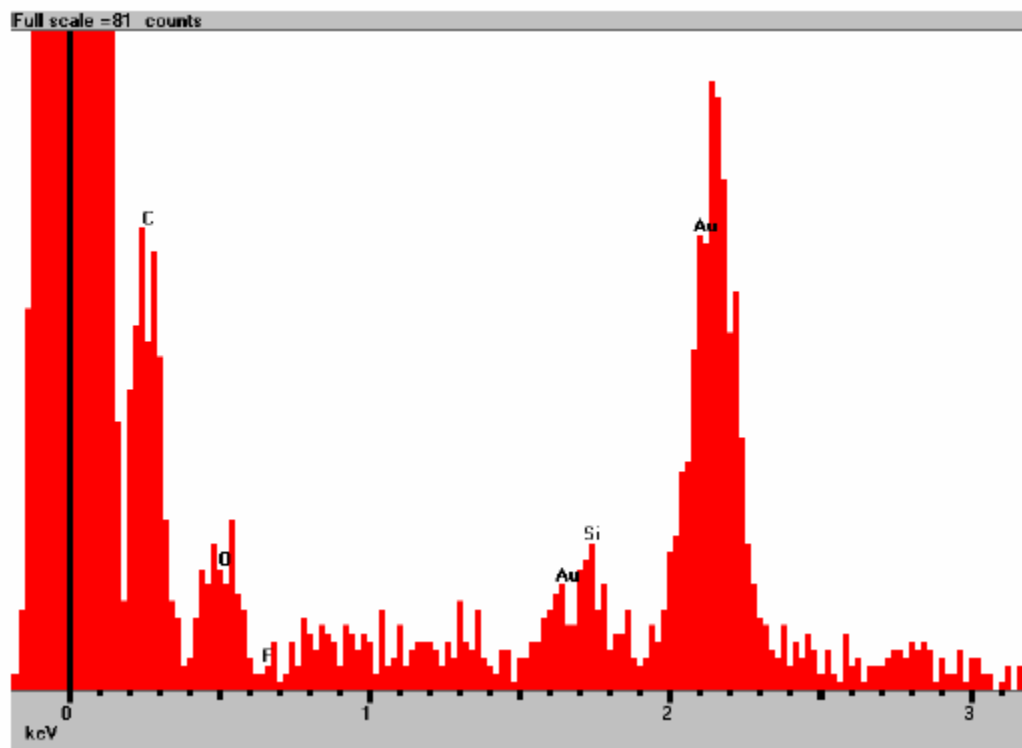
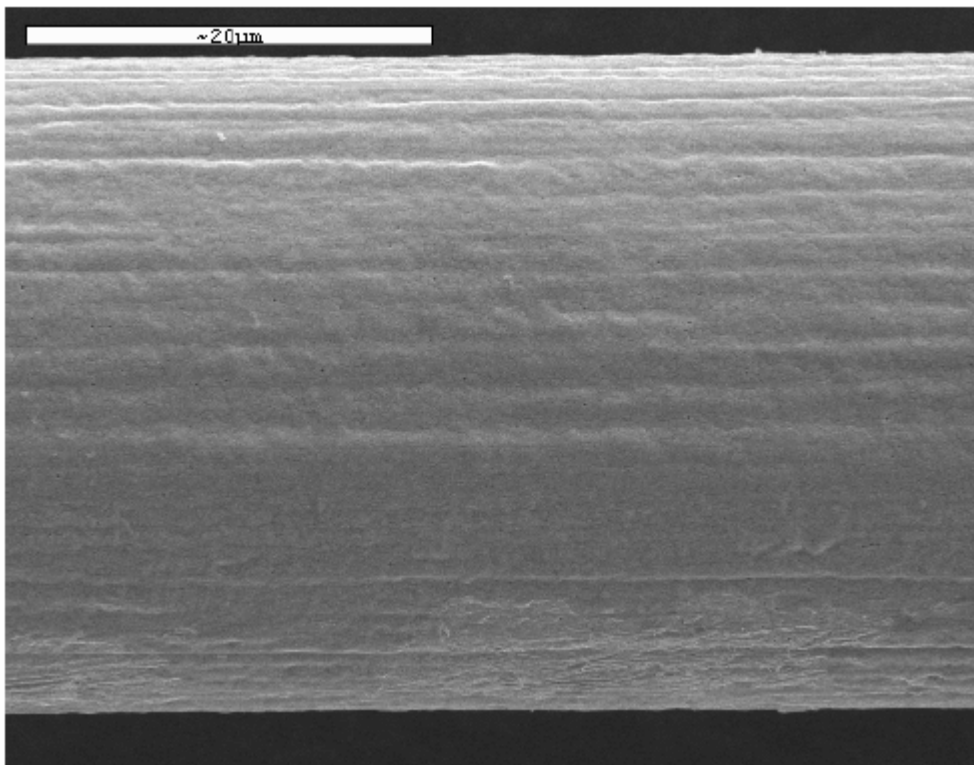


Figure 13. Wire #18, Location 9. There is some silicon.

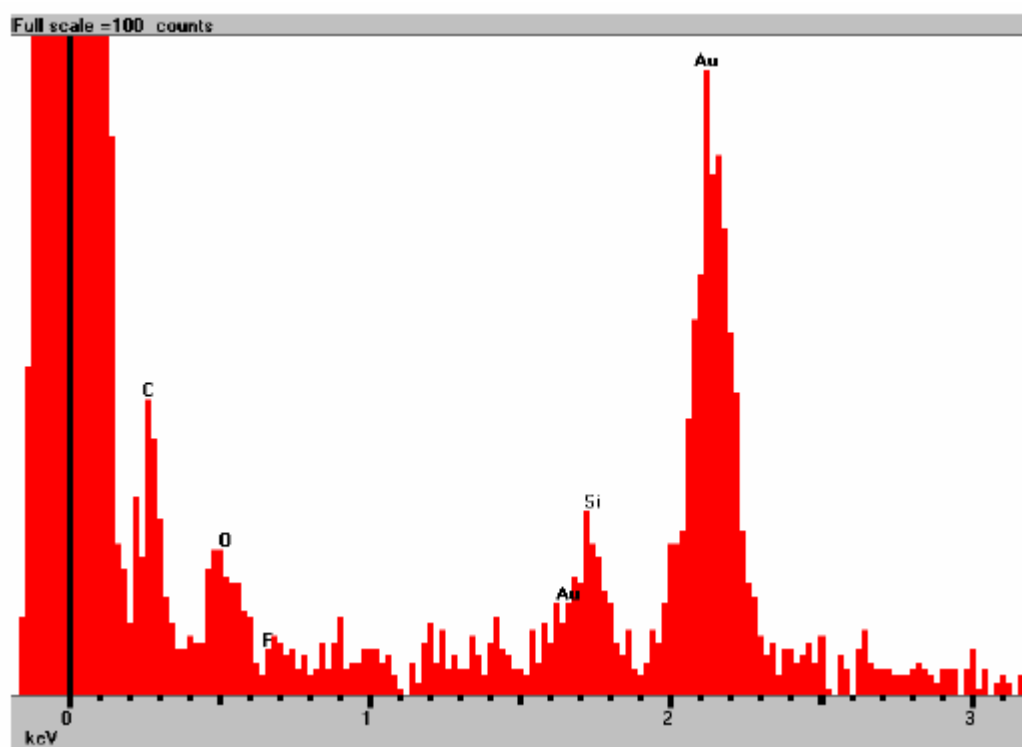
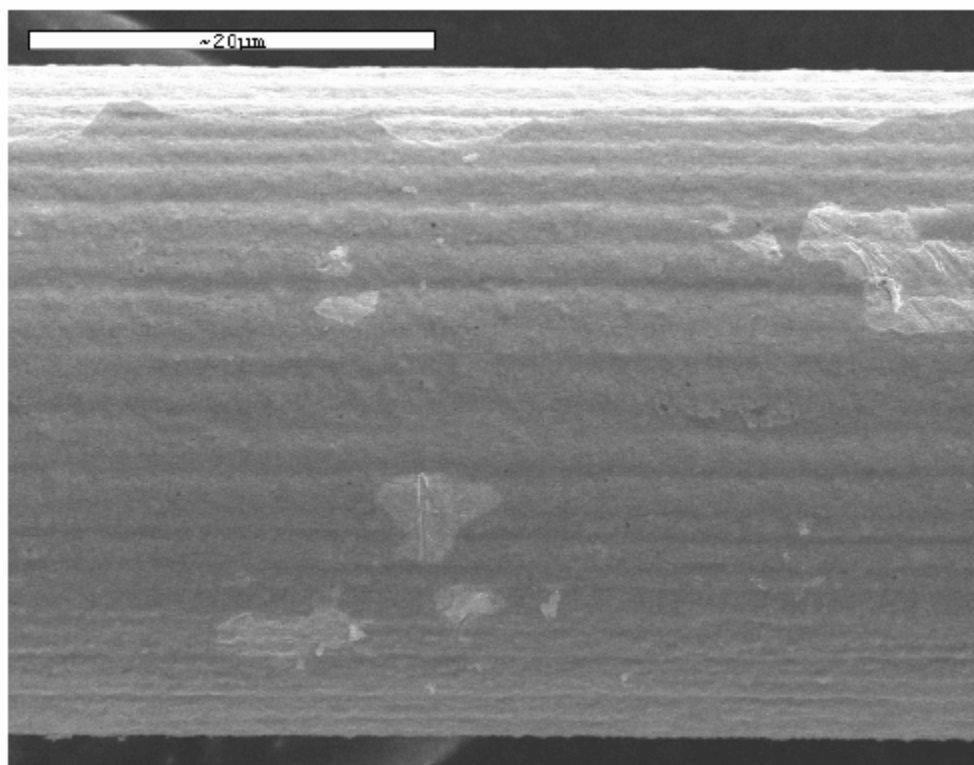


Figure 14. Wire #18, Location 15. This is just downstream of the wire-joint. The wire surface is covered with deposit (dark area). There are good silicon and oxygen peak.

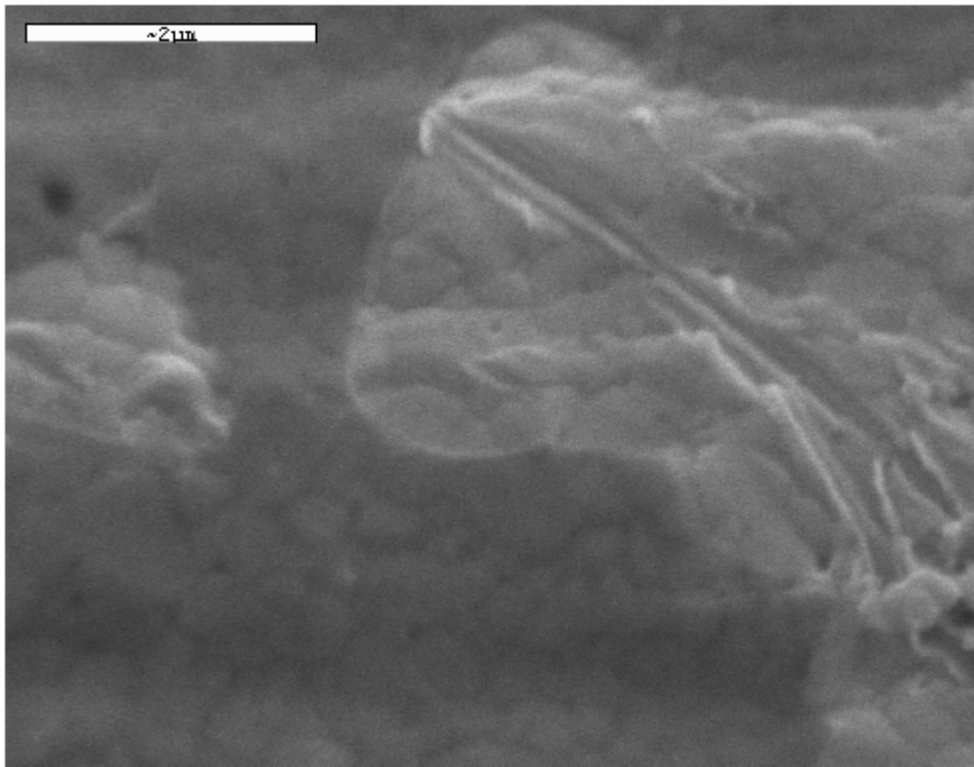


Figure 15. A close up view of the image in Figure 14. The dark area is some type of deposit (silicon).

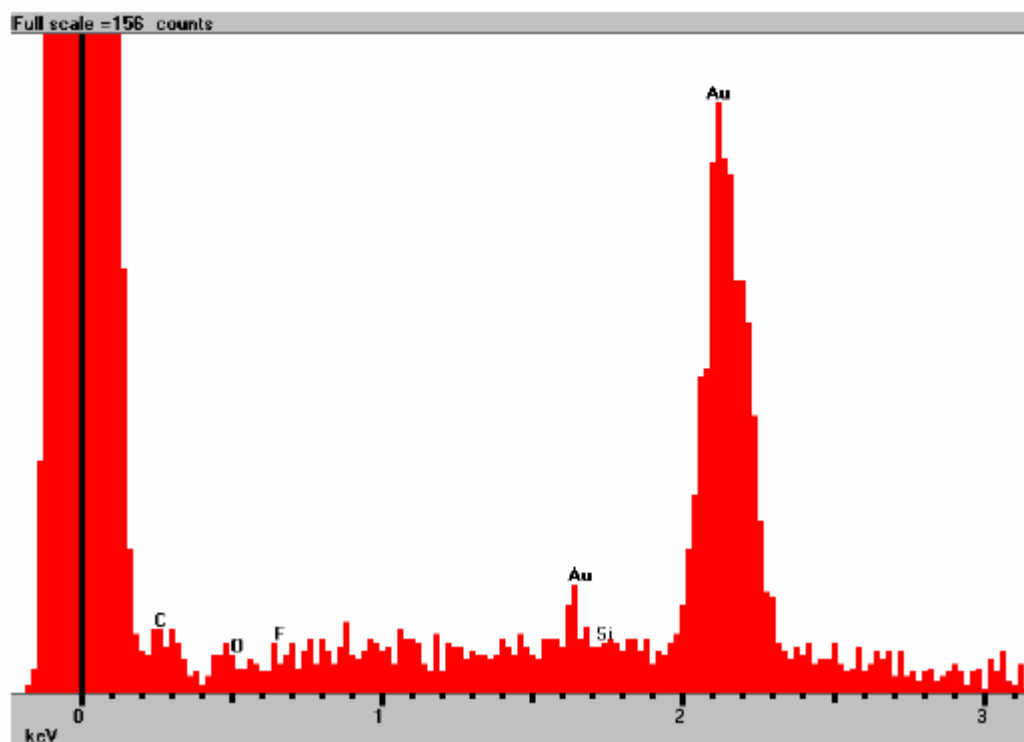


Figure 16a. The element analysis of the bright area in Figure 15. There is no silicon.

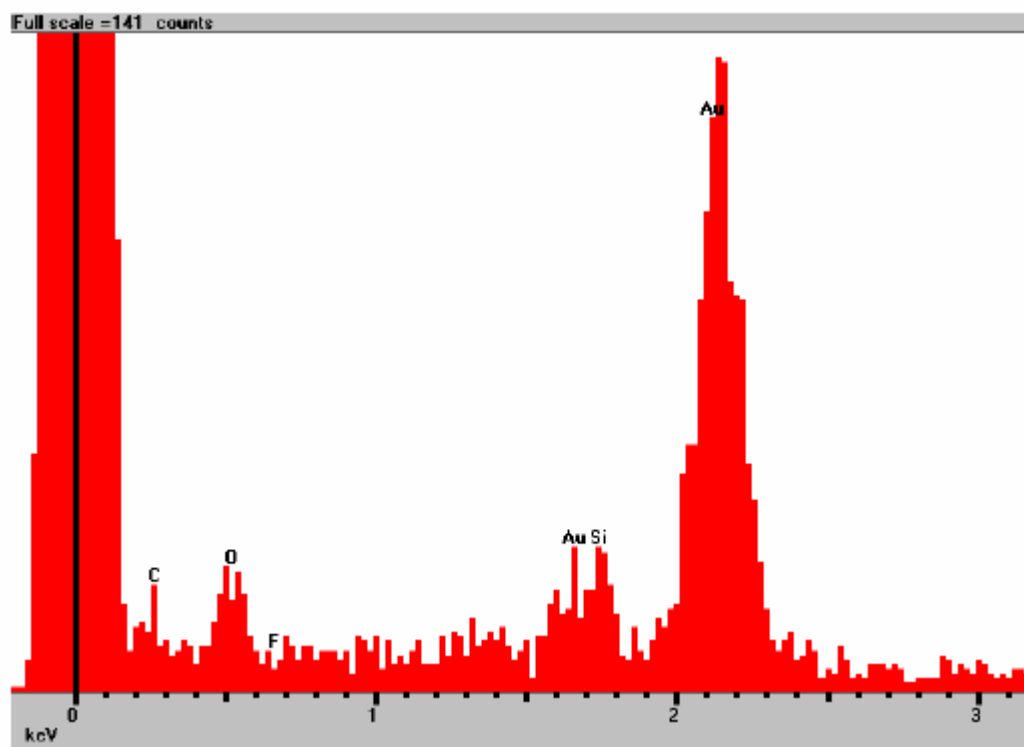


Figure 16b. The element analysis of the dark area in Figure 15. There are a good silicon and oxygen peak.

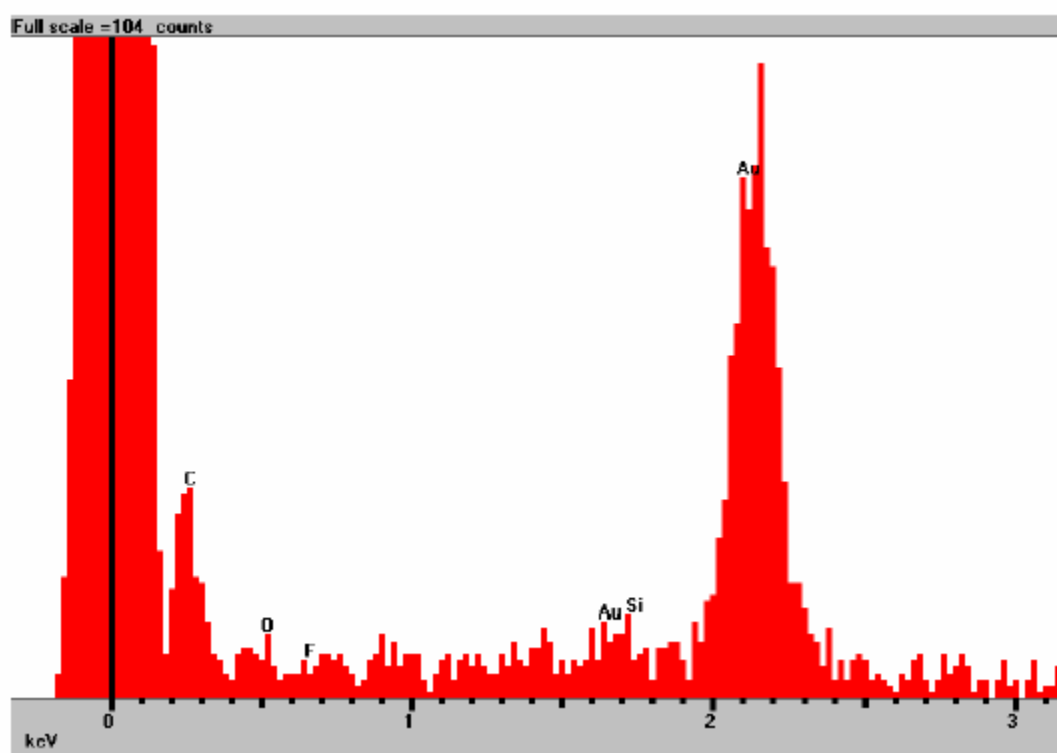
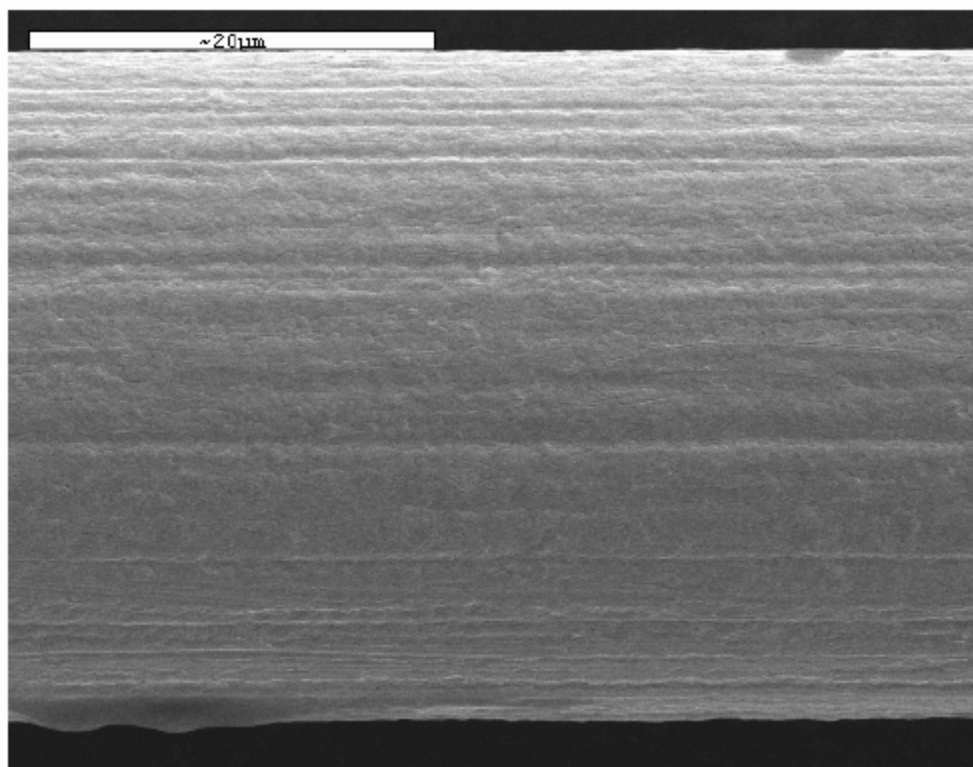


Figure 17. Wire #18, Location #26. This is near the gas exit.