Materials Characterization

Date In	1/10/03
Date Out	1/25/03
Images	SEM
Chemistry	EDX
Other	

Job ID **965**

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Analyst R. Kirby

Submission

Material: Copper GTF and Orion cathode plates with friction-welded Mg plugs.

History: Both plates as-poly diamond-machined, and then one cathode subsequently MgO-polished.

Purpose of: Analysis Characterize surface condition.

Sample/Mount

Spectrum

All full-resolution images are located on V:\PEL\Public. A few are used in this report.

Details of Analysis

This work encompasses two cathode plates. The Orion plate was poly-diamond machined (at SLAC?) with ethanol, analyzed by PEL, then MgO-polished with 1 micron powder (Buehler MagoMet) and DI water by J. Francis, then analyzed again. The GTF plate was poly-diamond machined at SLAC with ethanol, analyzed, re-machined, analyzed. The GTF plate was allowed to dry during and after machining the first time, but kept continuously wet the second time until just before installation into the SEM, at which point it was withdrawn from the ethanol and rinsed copiously with sub-micron filtered ethanol and blown dry with 0.1 micron filtered dry nitrogen.

Results of Analysis

The attached figures show the characteristics of the surfaces. All Mg cathodes examined in the SEM, to date, show some common properties:

1) The Mg plugs are apparently made by powder metallurgy, with cavitites strewn throughout their bulk. Almost always, a few of these are exposed by the machining;
2) The boundary of the Mg and Cu weld always looks tight, but the stress of the weld near the boundary area is relieved by breakouts of the Mg material nearby;
3) The Mg surface, after machining, is several microns below that of the Cu surface. The cutting tool pressure will be different on the two metals, according to C. Pearson. He thinks the Cu, which is softer (more elastic) actual rebounds after tool passage. The practical result is that there is a rather abrupt inside corner on the Mg, which traps cutting and polishing debris. It is important therefore to not let the surface dry of ethanol at any stage, so that debris is “glued” down by drying.
4) The surface finish produced by the machining depends on cutting tool quality, feedrates, workpiece resonances, and lathe-gearing clearance asymmetries.

Other observations are noted on the figures.

Comments

Job ID 965

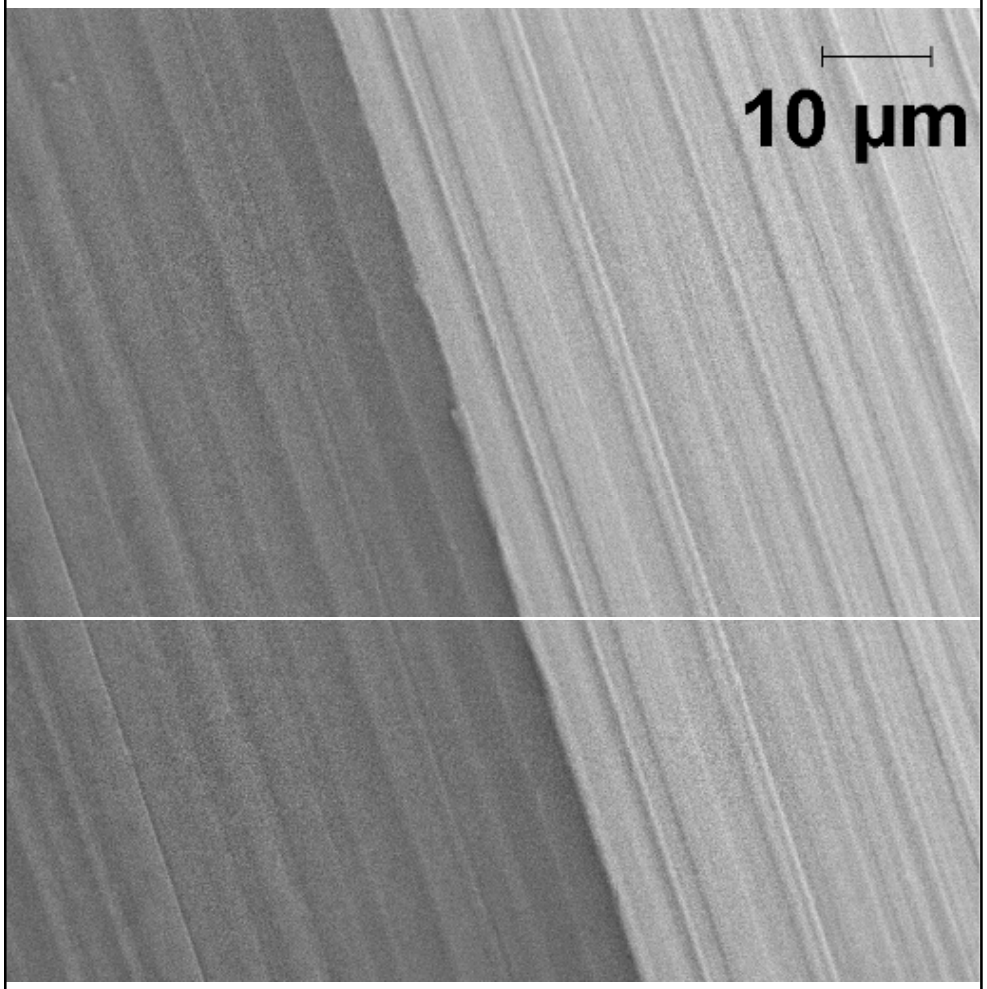

Figure 1: Orion cathode, as-machined. Mg (left)/ Cu (right) boundary. The weld-line is tight around the full 360 degrees.

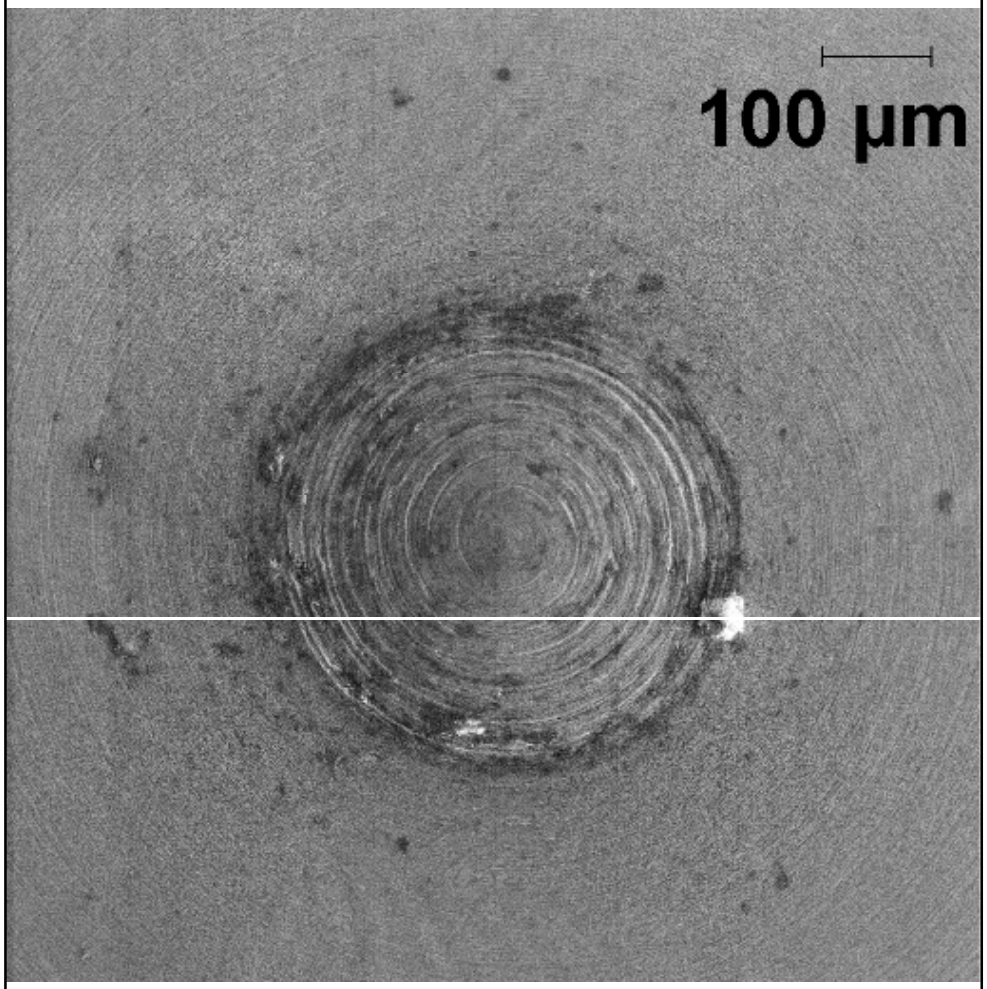

Figure 2: Orion cathode, as-machined. Machining tit, located at center of circular cathode plate. The particle debris is Mg.

Job ID 965

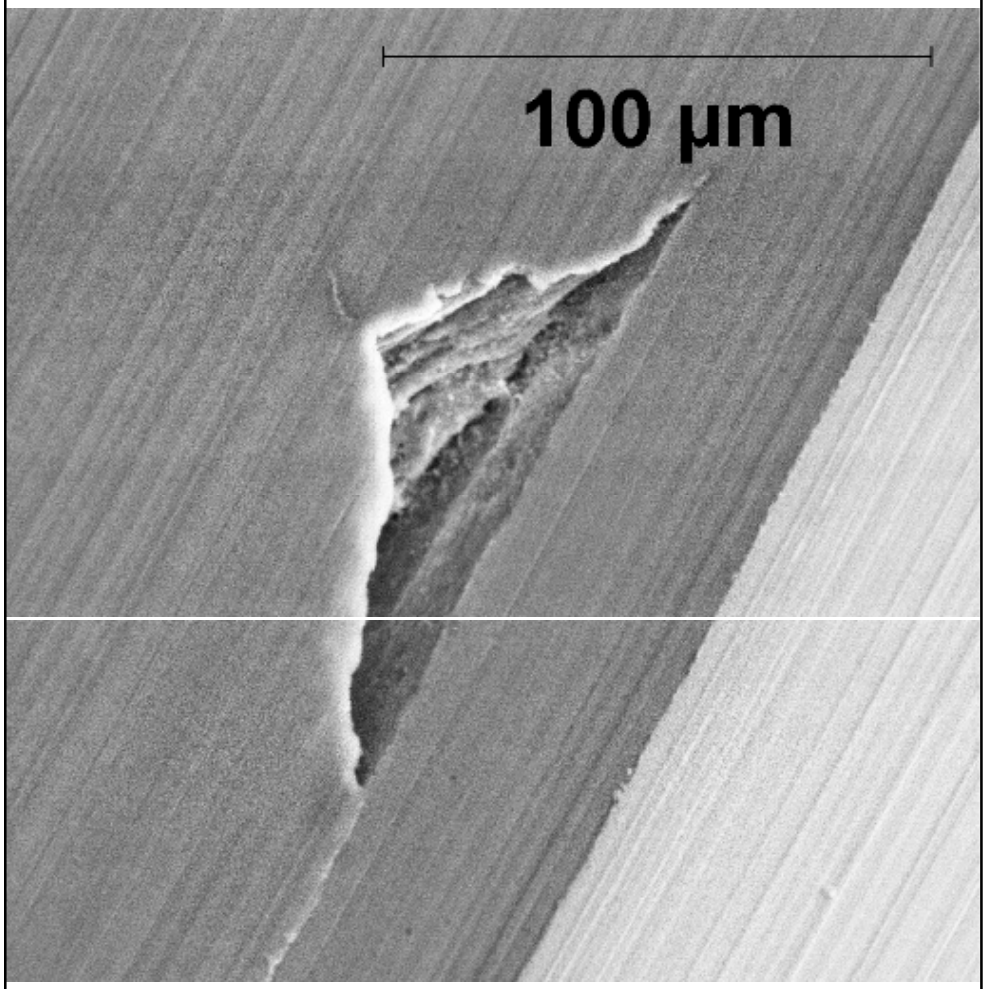

Figure 3: Orion cathode, as-machined. The Mg cavity is caused by material fallout. Such features are common as a way of relieving the stress from the nearby Mg/Cu weld boundary.

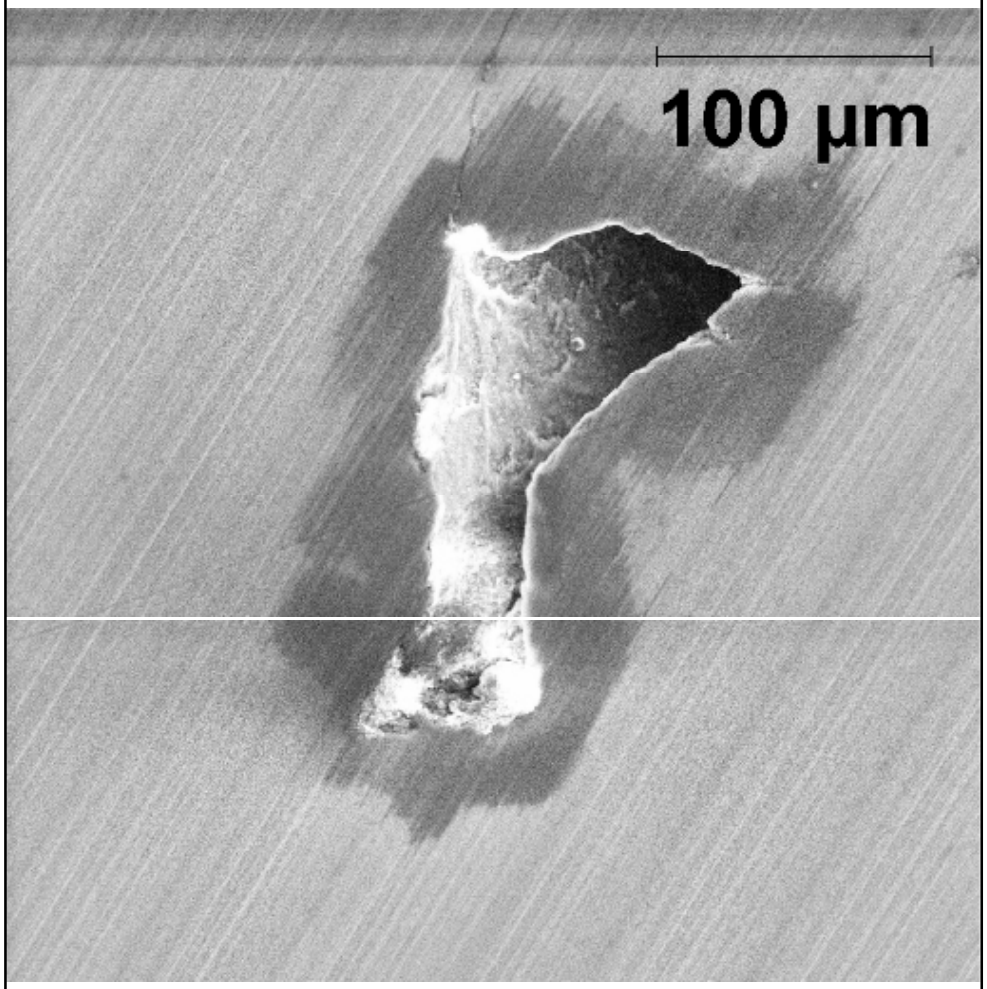

Figure 4: Orion cathode, as-machined. This cavity was revealed on the Mg surface, well away from the weld boundary. The cause of the darkening is possibly due to wicking out of alcohol and contaminants from the cavity interior onto the surrounding surface during drying, giving a low secondary electron yield at the rim.

Job ID 965

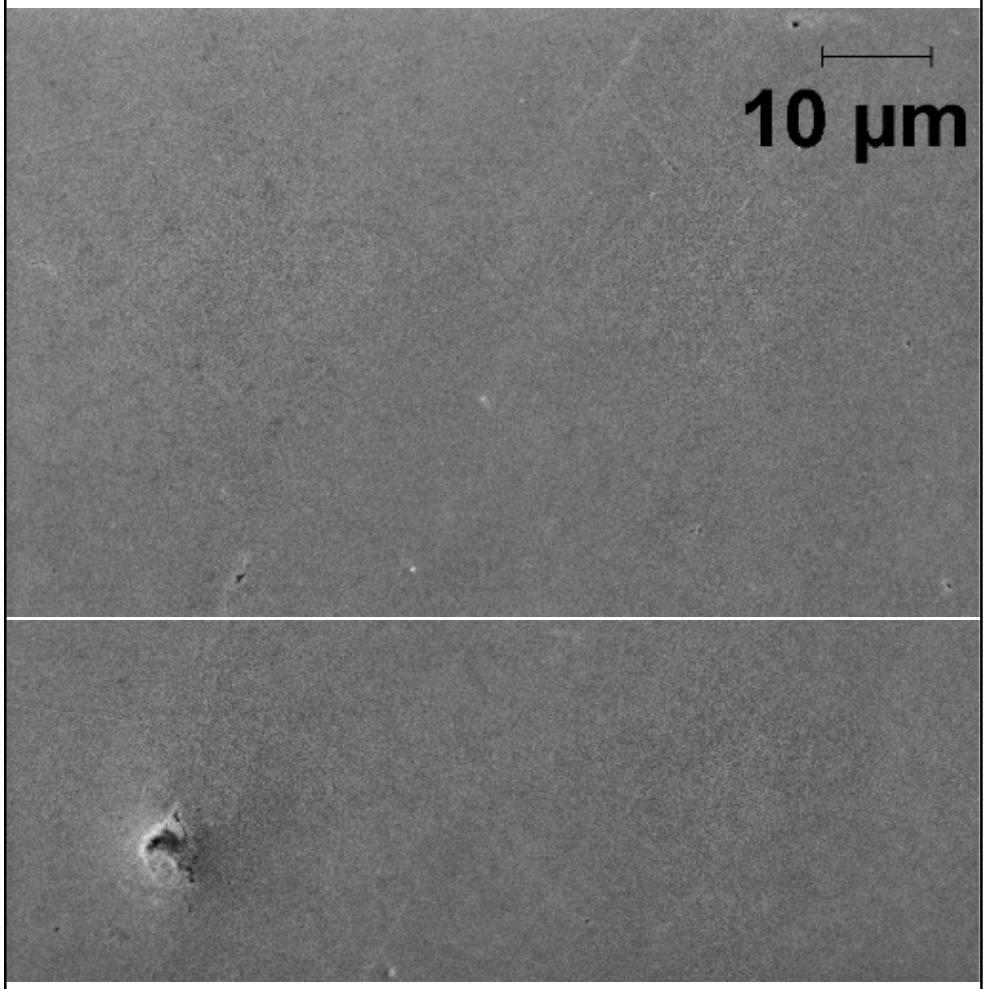

Figure 5: Orion cathode of Figures 1-4, after polishing with one micron MgO and DI water. Surface finish on Cu.

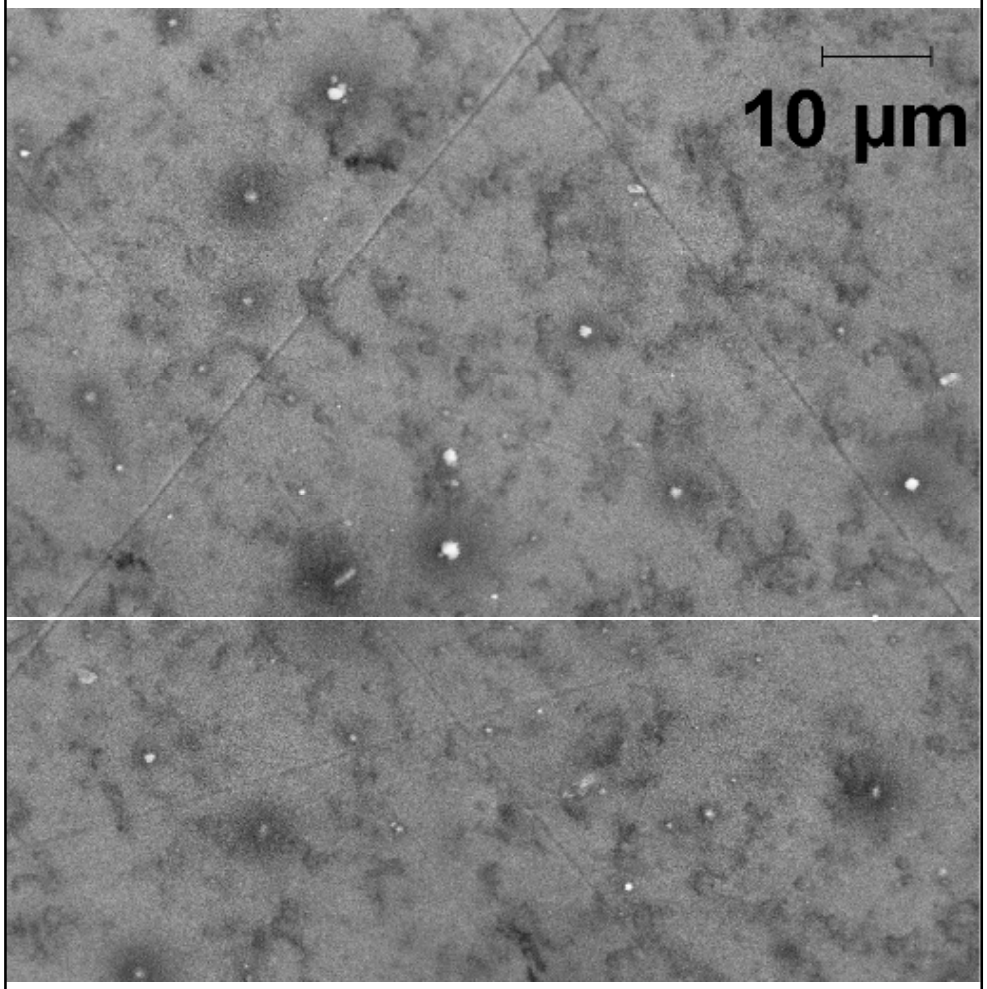

Figure 6: Orion cathode of Figures 1-4, after polishing with one micron MgO and DI water. Surface finish on Mg. White particles are MgO.

Job ID 965

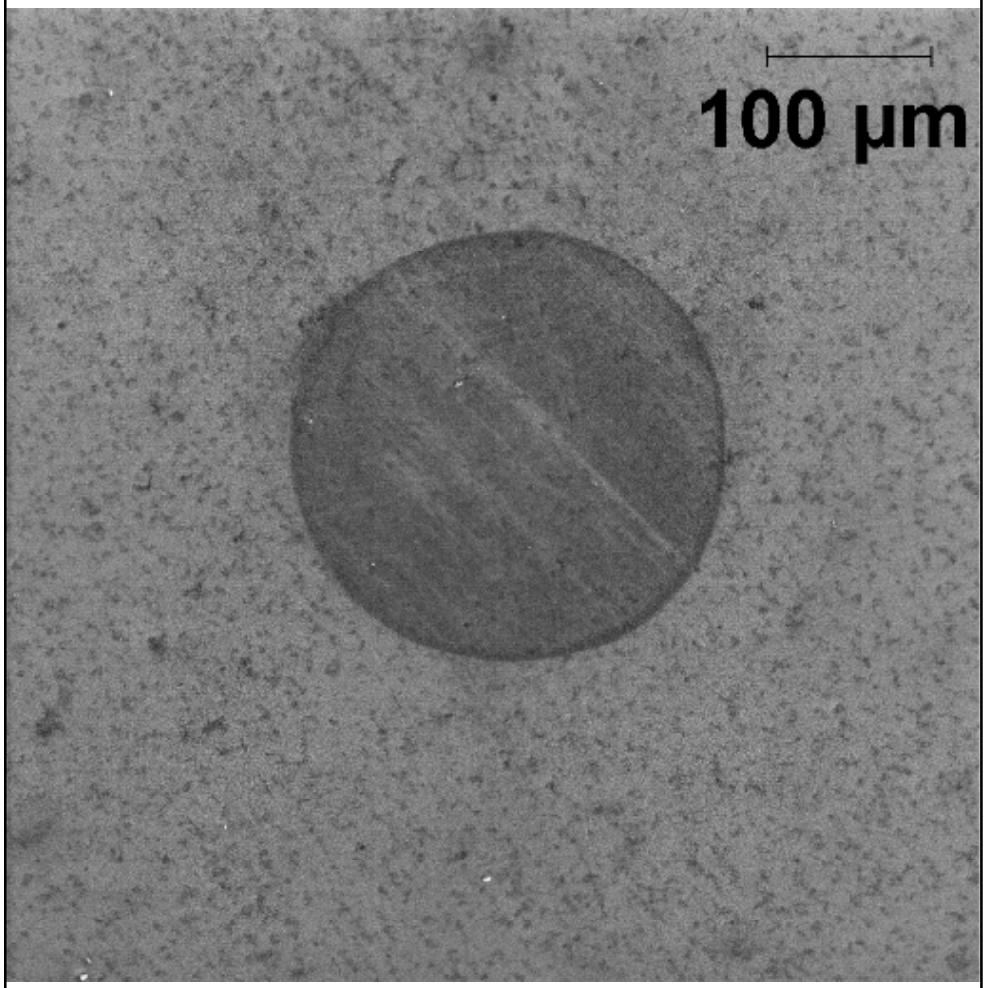

Figure 7: Orion cathode of Figures 1-4, after polishing with one micron MgO and DI water. Shown are the remains of the center machining "tit".

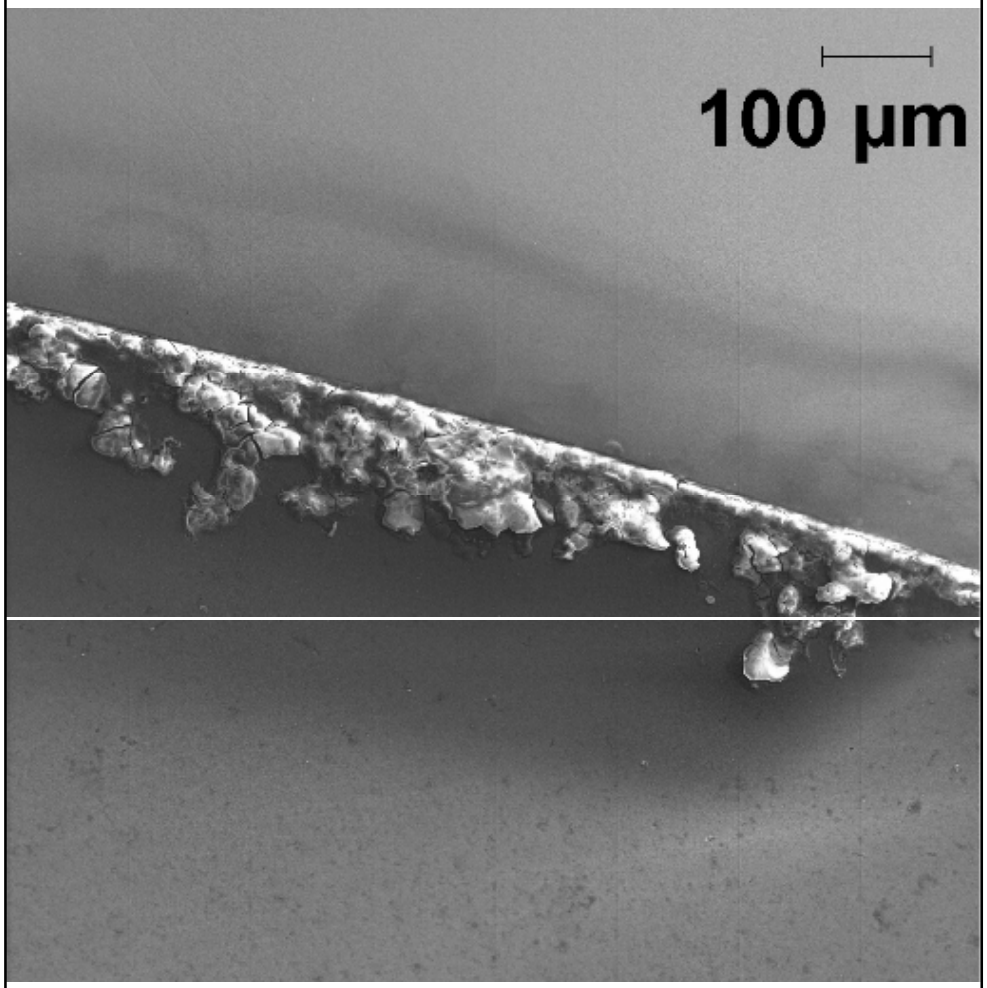

Figure 8: Orion cathode of Figures 1-4, after polishing with one micron MgO and DI water. Polishing debris accumulates at the inside corner of the Mg/Cu weld boundary (Mg plug is lower half of the image).

Job ID 965

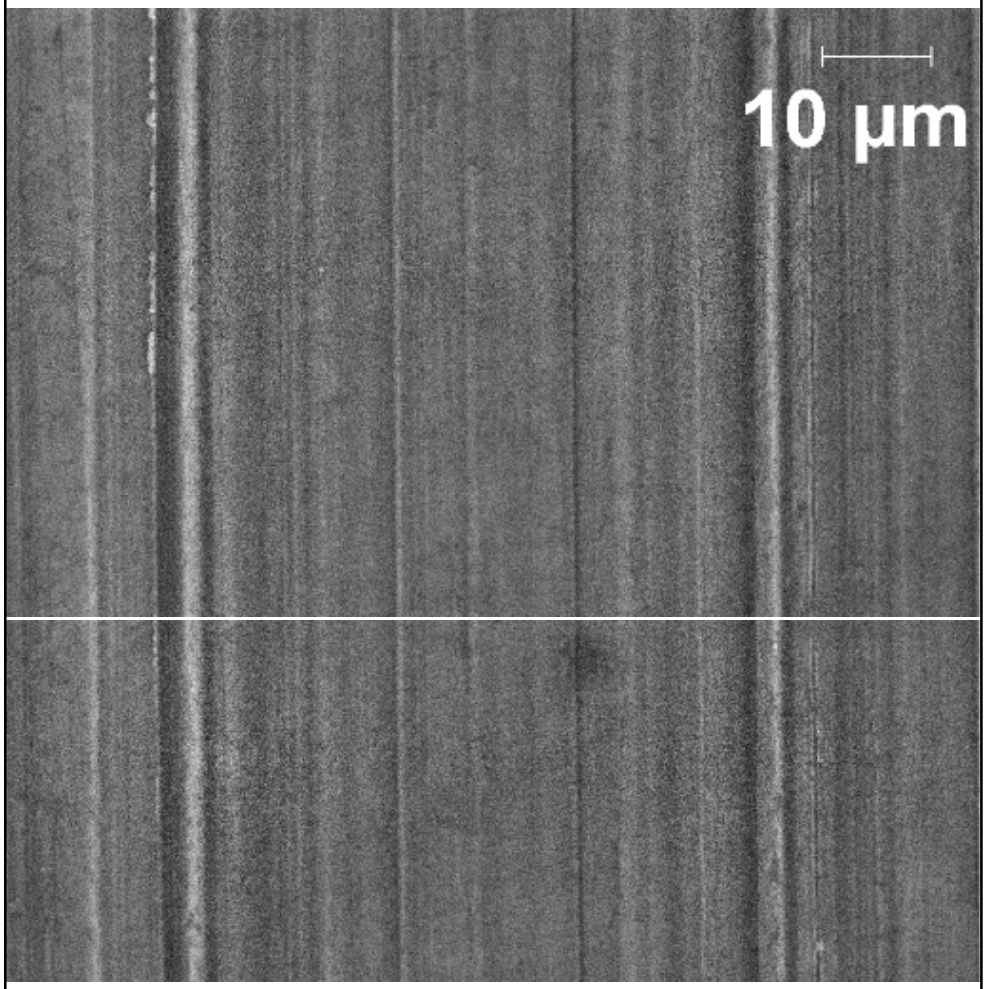

Figure 9: GTF cathode center, after first re-machining off-axis. Shown are prominent tool/lathe cutting marks (two vertical ridges).

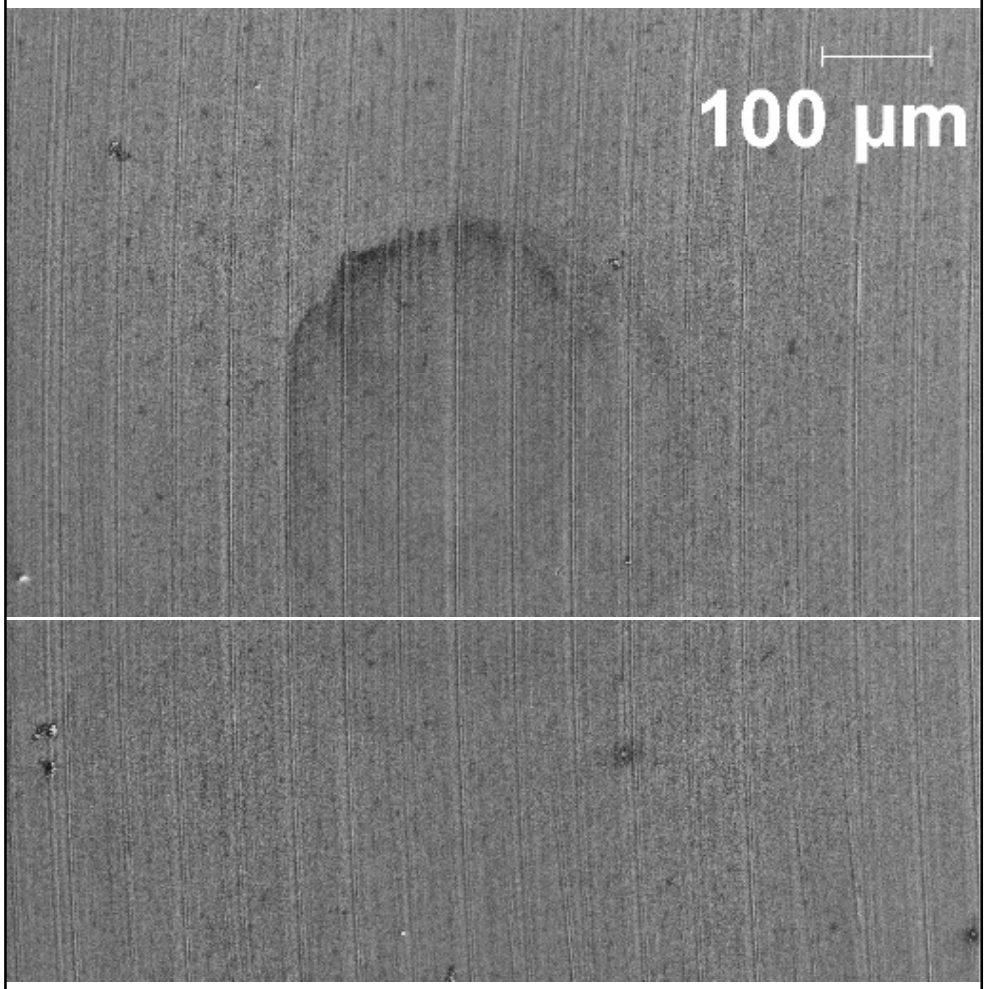

Figure 10: GTF cathode center, after first re-machining off-axis. The "stain" is are the remains of the original on-axis machining tit.

Job ID 965

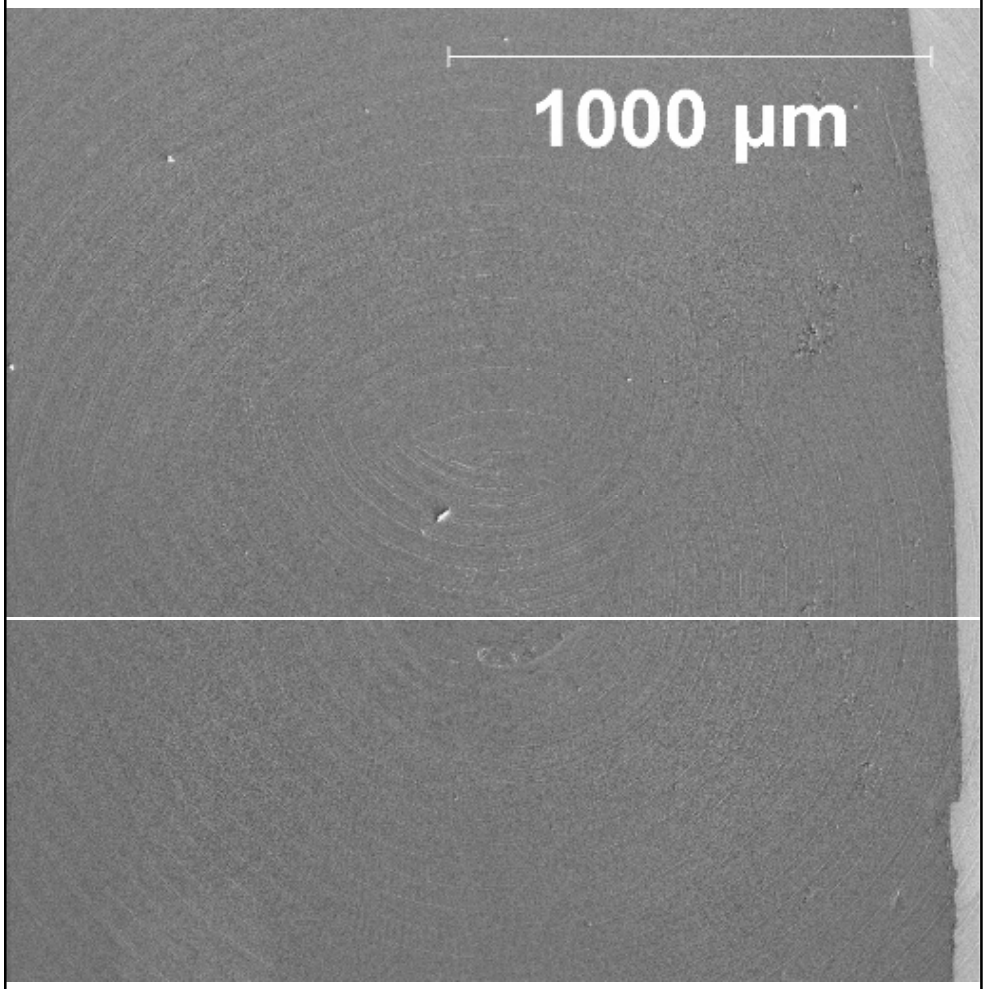

Figure 11: GTF cathode, after first re-machining off-axis. Shown are the off-axis machining "centers".

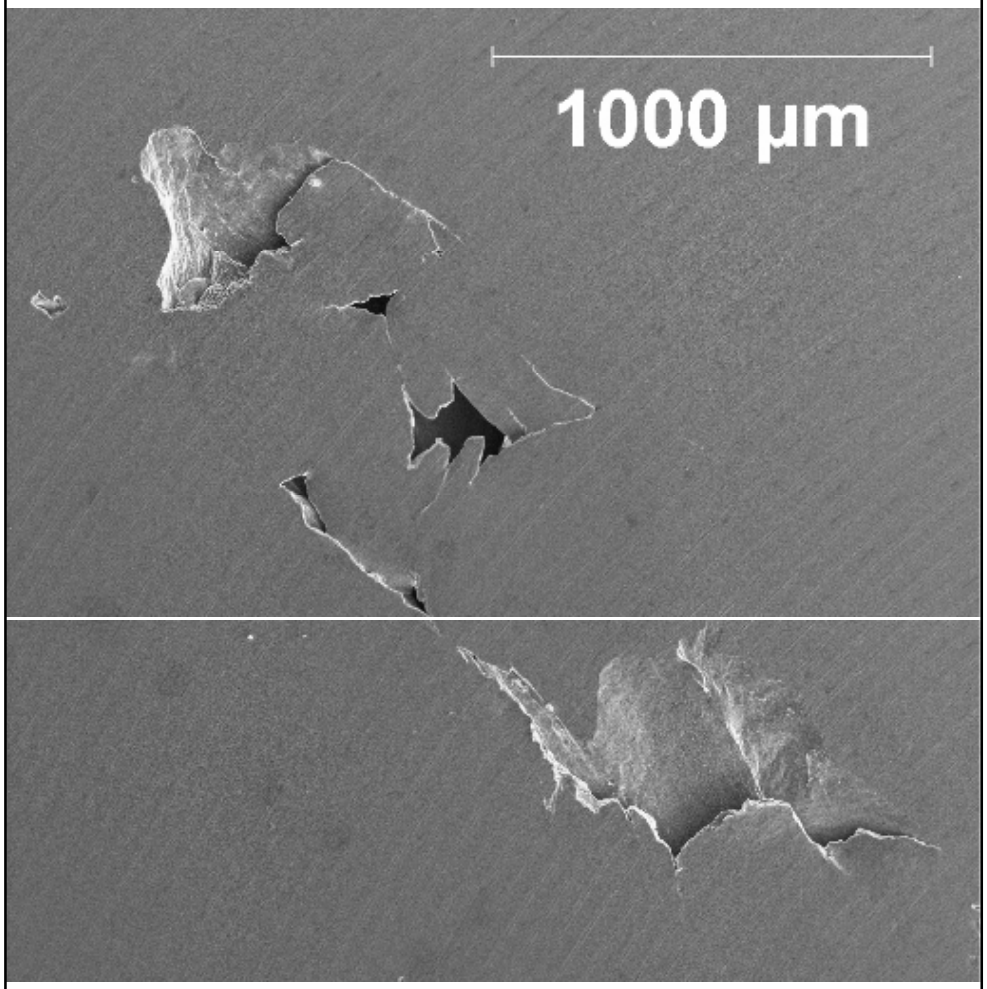

Figure 12: GTF cathode, after first re-machining off-axis. Large cavity on the Mg plug.

Job ID 965

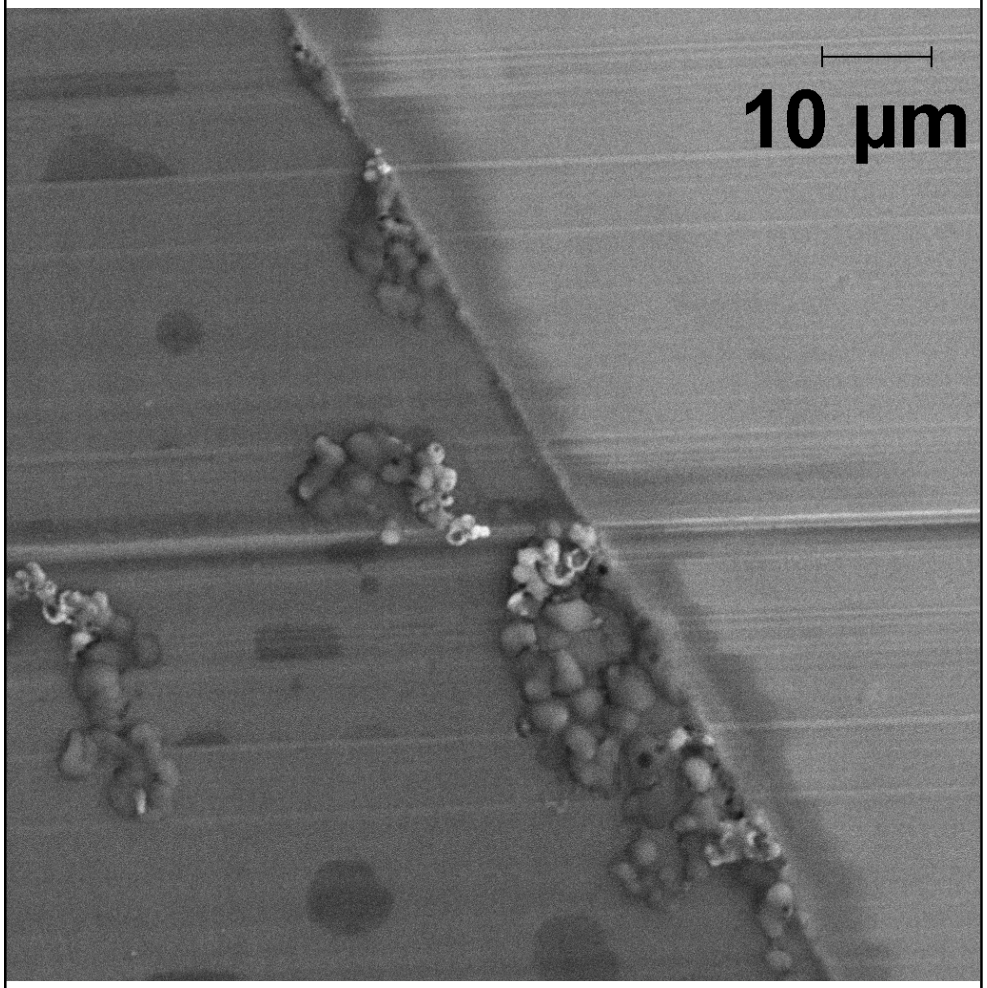

Figure 13: GTF cathode, after first re-machining off-axis. Mg (left)/ Cu (right) boundary, showing accumulation of machining debris at boundary. The surface was allowed to dry prior to final cleaning and this debris (Mg) was not removed in final cleaning, even with low-power ultra-sonic agitation.

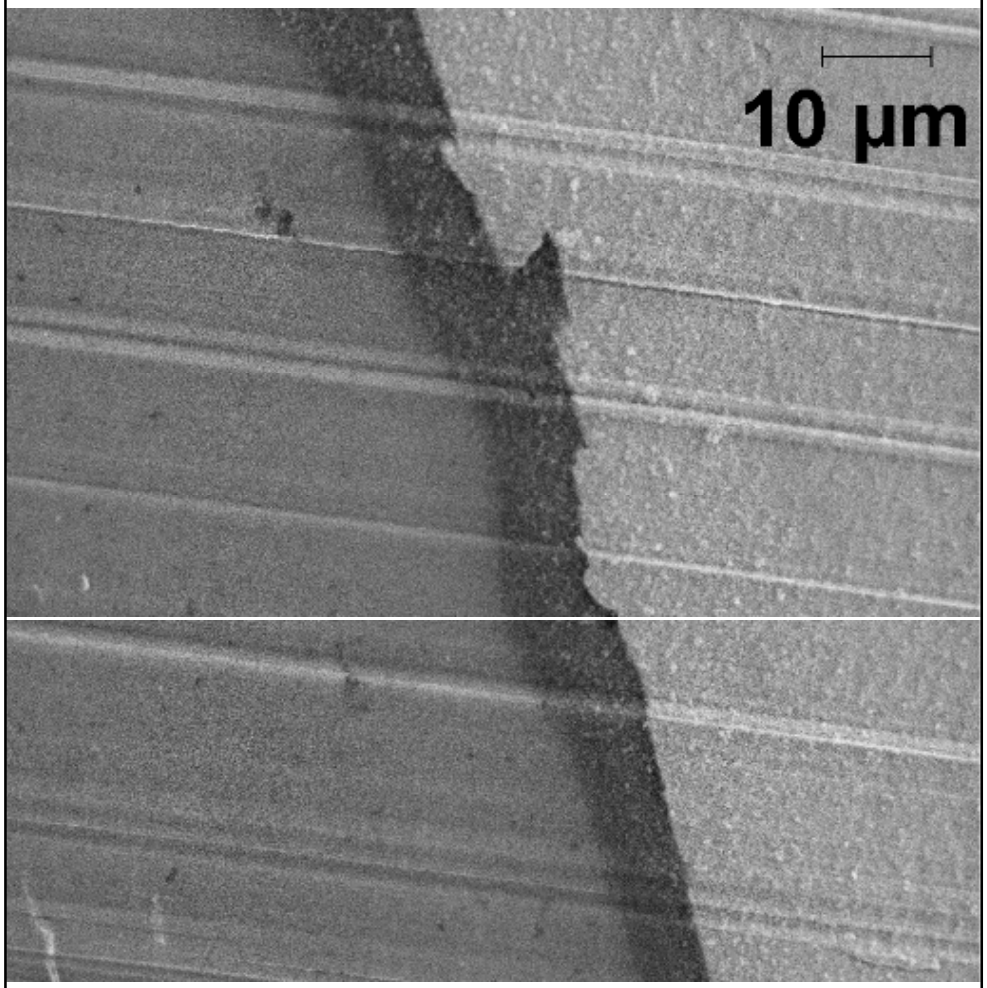

Figure 14: GTF cathode, after second re-machining off-axis. Mg (left)/ Cu (right) boundary shows a vertical displacement of several microns, present on all Mg/Cu plates, and possibly due to elastic rebound of Cu after tool passage.

Job ID 965

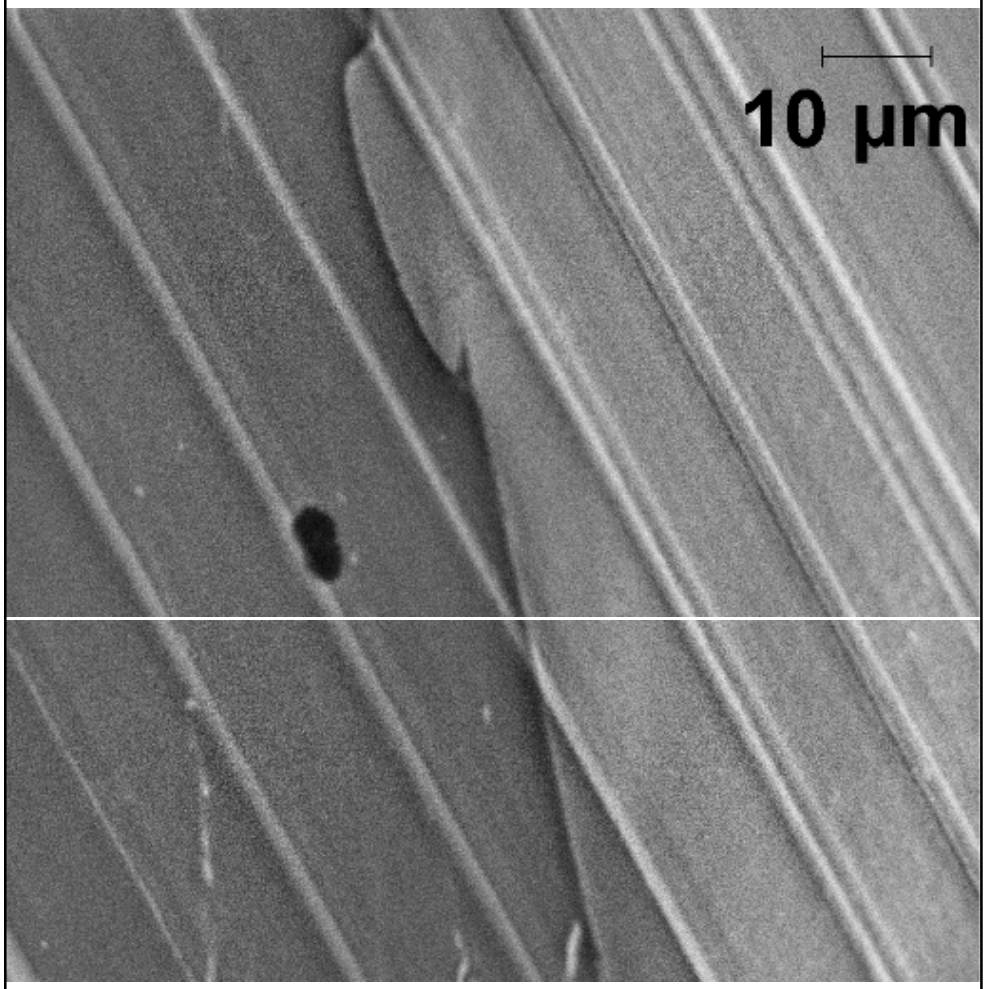

Figure 15: GTF cathode , after second re-machining off-axis. Change of cutting angle to weld boundary appears to affect the vertical offset.

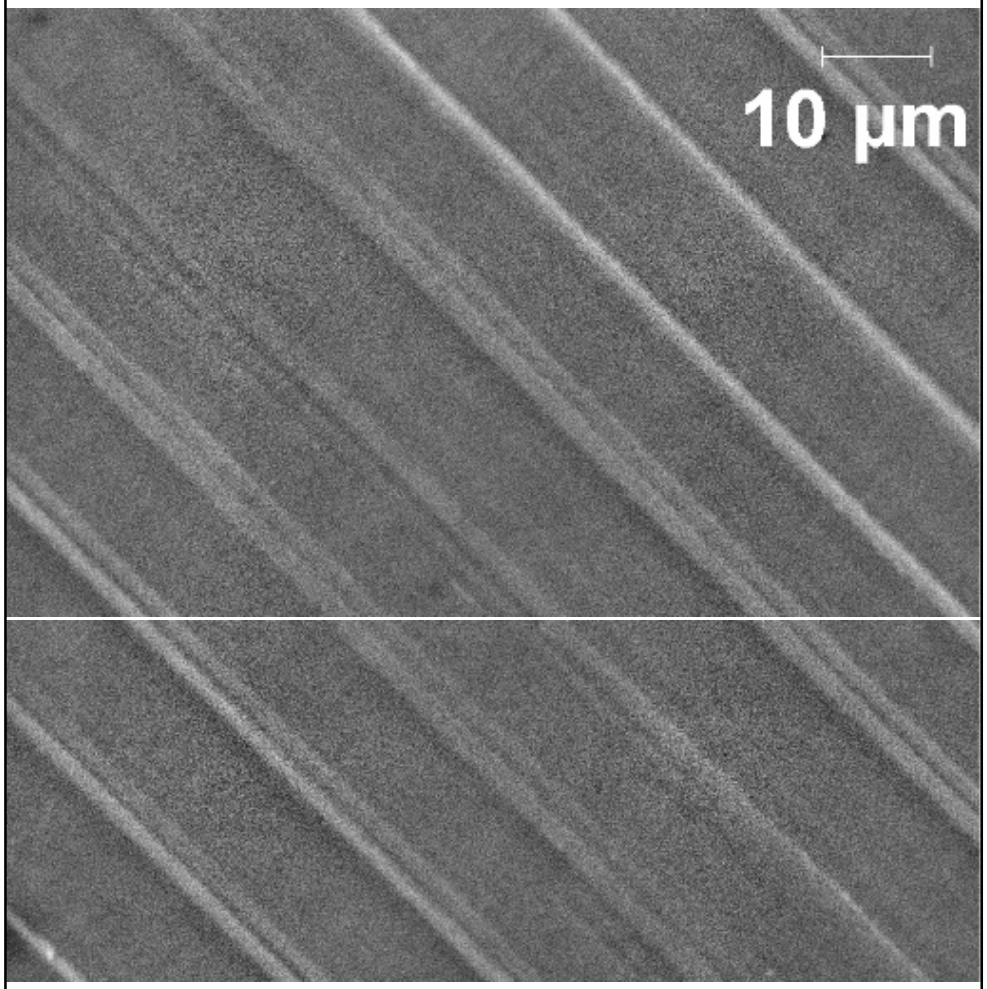

Figure 16: GTF cathode center, after second re-machining off-axis. Machining ridges are now more uniform. The surface was kept flooded with ethanol during and after machining, then rinsed with filtered ethanol and blown dry with filtered dry nitrogen, just prior to insertion into the SEM.

Job ID 965

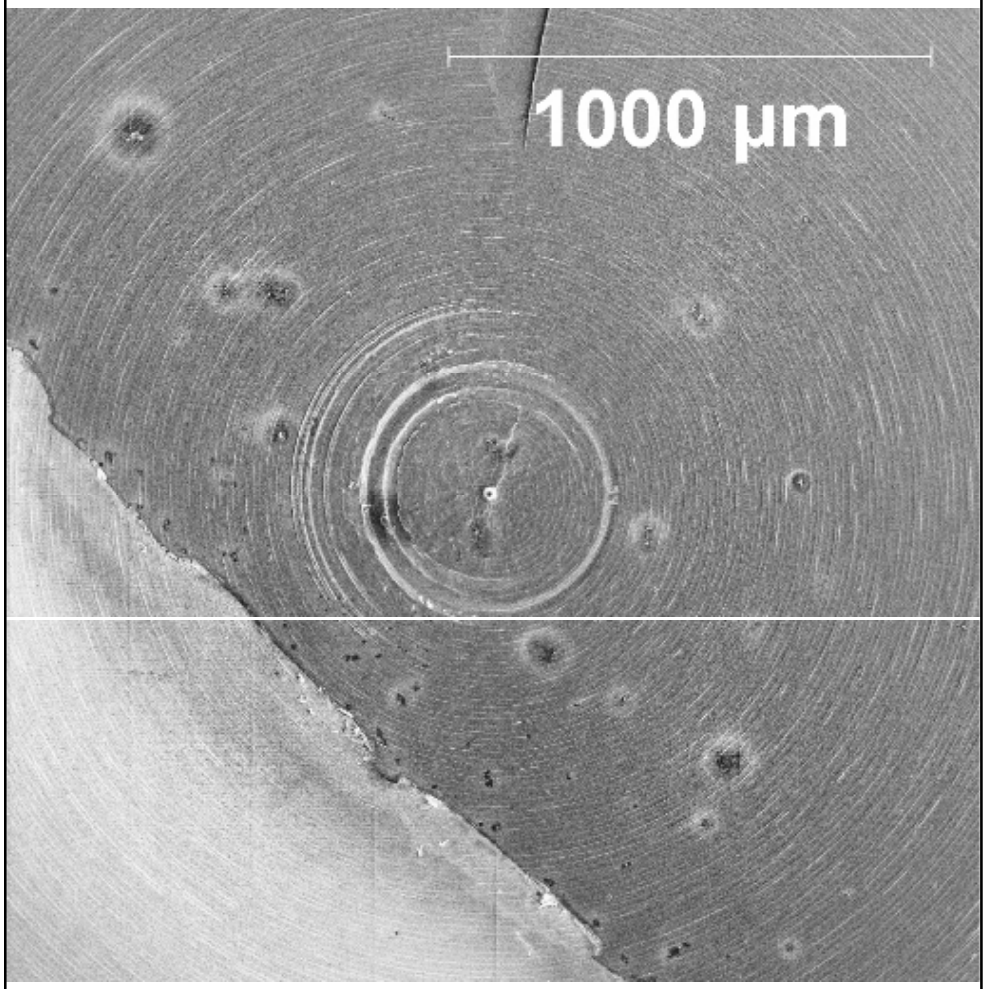

Figure 17: GTF cathode, after second re-machining off-axis. Imaged is the off-axis machining center, on the Mg, near the Cu boundary.

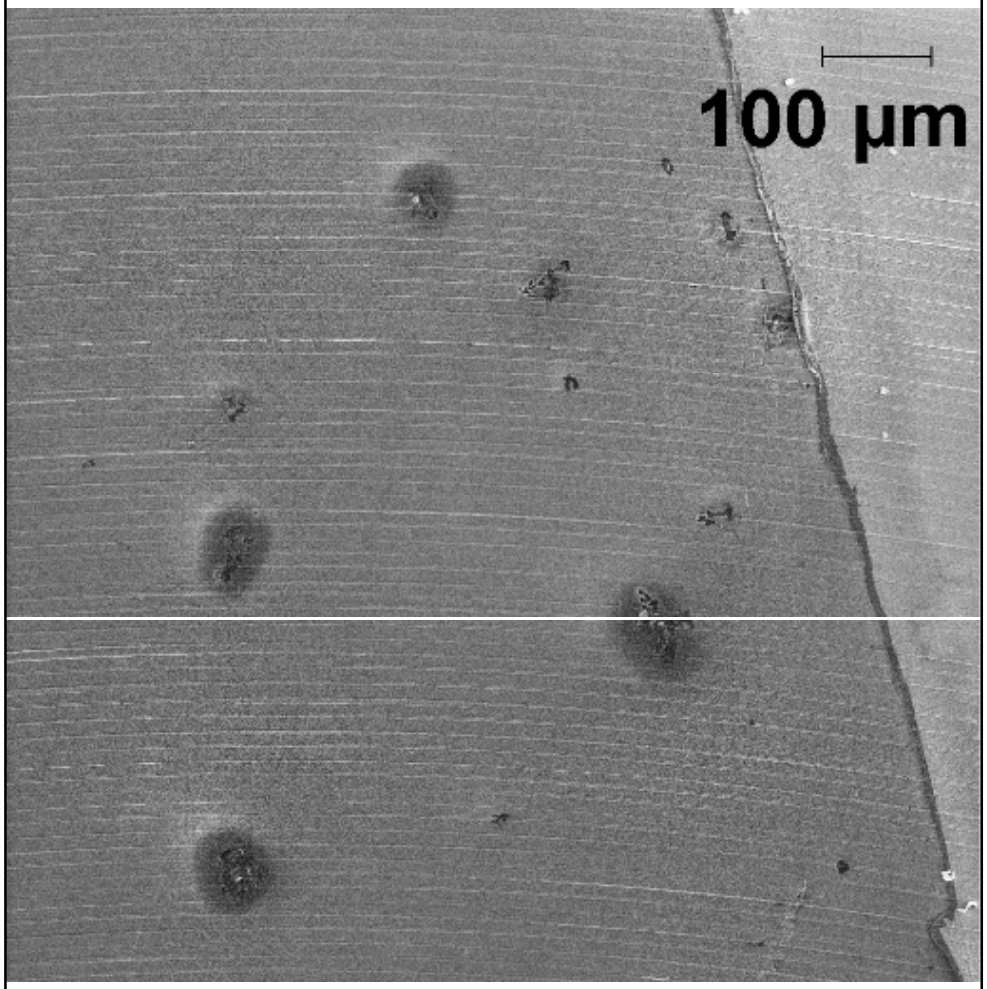

Figure 18: GTF cathode, after second re-machining off-axis. A few of these small voids were found on the Mg, near the Cu boundary. They are at or below surface level and appear to be stress-relief features.