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Post-Removal Examination of GTF Cathode #2

Robert E. Kirby
Physical Electronics Group
SLAC

This photo-cathode (PC), GTF Cathode #2, was removed from the GTF in October, 2000. It was characterized in September, 1999 by G. Mulhollan and me (Report entitled "A Brief Report on a Brief Examination of the Electropolished GTF Cathode", LCLS-TN-99-10). The cathode conditions and results of that exam were:

- The cathode was conventionally machined and cleaned in the SLAC Plating Shop.
- The machining process left a central defect (400 microns diameter) which was not removed by electropolishing.
- The electropolished surface was "orange-peeled", typical of excessive polishing.
- Secondary electron microscopy (SEM) examination showed numerous 10 micron-diameter etch pits and a small number of copper surface particles.

Operation of this cathode in the GTF exhibited "hollow-beam" behavior, suggesting that the central defect may have been responsible for non-normal emergence of the photo-emitted beam. No laser cleaning of the cathode was done, so all arc features are due to breakdowns.

Post-removal analysis consisted of low-magnification digital camera pictures (taken with glancing-incidence tungsten white light illumination, to emphasize particles/pitting) and SEM. All images are available in digital (TIFF) form. Also available is a Power Point presentation of the results. Contact me for either. These image files are high-resolution and, thus, large in size. A 200K low-resolution contact sheet of a few images is attached to this report. Images are referred to by file name.

Photo1 is a white light image of the cathode surface, showing considerable activity in the central one-third of the plate diameter. The low-magnification SEM version of this, **LCLS1**, shows that the activity is actually present over the entire PC surface, but that most large features are near the center third. Also evident is the central machining defect.

LCLS3 shows the defect at higher mag (the defect is 400 micron diameter) and activity near it (but, interestingly, no arcs on it). Activity on the PC surface was not uniform but clustered in areas, usually with a few large breakdown features (25 microns) accompanied by many smaller (5 micron) arcs (**LCLS6**). A few arcs occurred on grain boundaries, suggesting that sub-surface gas was involved in the plasma formation. But most arcs occur on grain bodies. The larger arcs are clearly multiple "hits"; presumably, plasma heated the surface, releasing more gas and causing a larger channel to form. These observations are consistent with studies done on other high surface field devices. For example, they are identical to activity seen on NLCTA cell irises.

LCLS4 is a closeup, with an x-ray spectrum, of a large arc. Only copper was identified in the crater bottoms and rims. However, randomly distributed around the PC surface was a low density of carbon inclusions or, alternatively, carbon-filled pits (**LCLS5**). Their source is unknown but they may be the locations of the original etch pits observed last year. They are about the same size (10 microns) and surface density.

Summarizing:

- There is no change to the central machining defect, in size or surface structure, as a result of GTF operation.
- There is a number of large arcs in the central third of the plate, having 25 microns or so diameter.
- Pits cluster, rather than being uniformly distributed. A single-hit arc is about 5 micons diameter.
- A uniform low density of carbon inclusions covers the surface.