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An Examination of the Laser Cleaned GTF Cathode

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The cathode for the GTF RF gun (#1), which had been in use until the end of September, was examined for defects and contamination. The examination included both a visual inspection and a microscopic survey.

History

This cathode was prepared by machining followed by chemical cleaning, diamond polishing and brazing of the tuning nut. It was subsequently coated on its outer rim with titanium nitride as a preventative measure against sticking to the gun assembly. It was then baked to 450°C in a vacuum oven and installed into the gun where it received a final bake to 200°C. During the course of operation the plate was laser cleaned by rastering a finely focused beam across its surface with an applied RF field. The cleaning was used to increase the cathode yield.

Visual Inspection

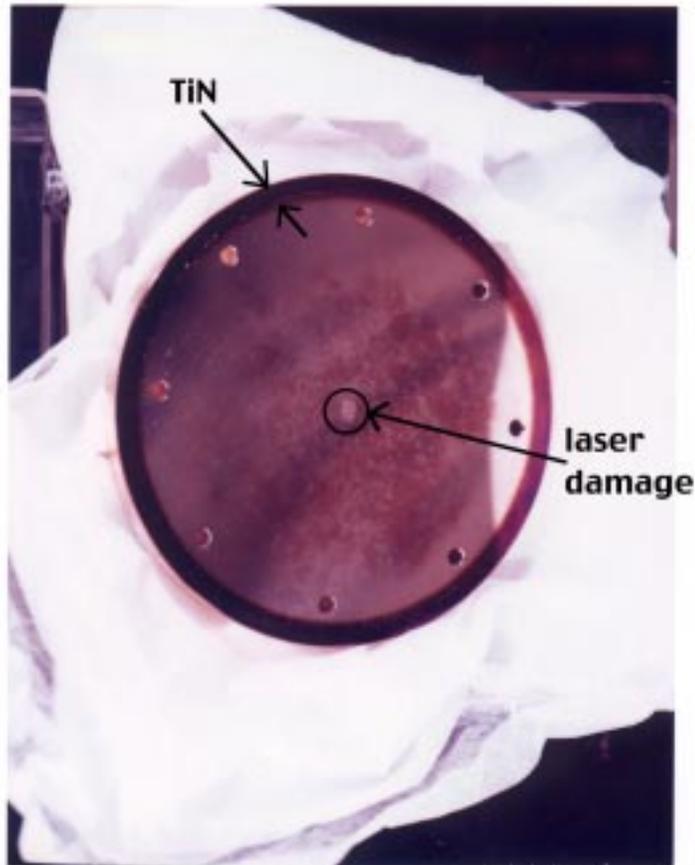


Figure 1. Macroscopic view of cathode plate.

The front of the cathode plate had four clearly discernible types of surface quality.

The first was the dark ring of the TiN coating, the second was the union of all light colored areas which covered ~ 45% of the surface, the third the union of all darker colored areas which also covered ~ 45% of the plate and the last region was a small area in the center of the cathode where the laser cleaning had

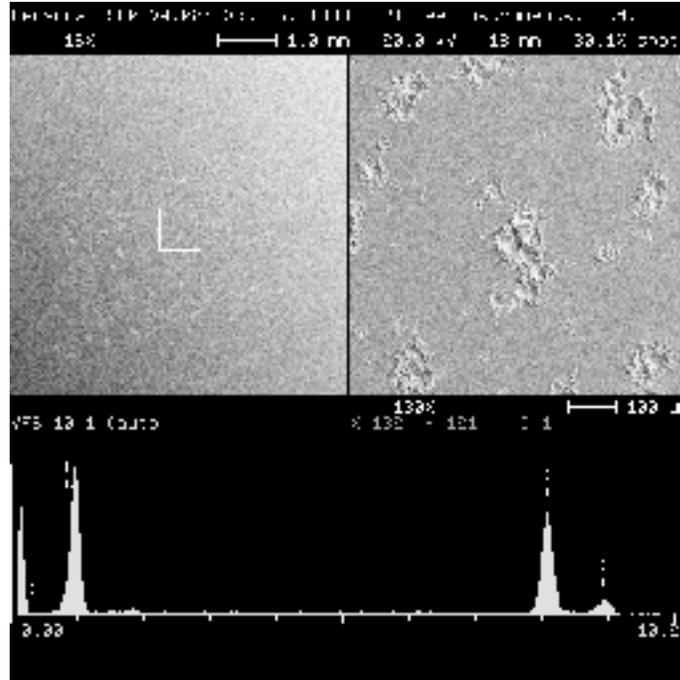


Figure 2. 130x view of center area. The chemical composition of this area was exclusively copper. From this sample, we can estimate the damage to cover about 20-25% of the cleaned area.

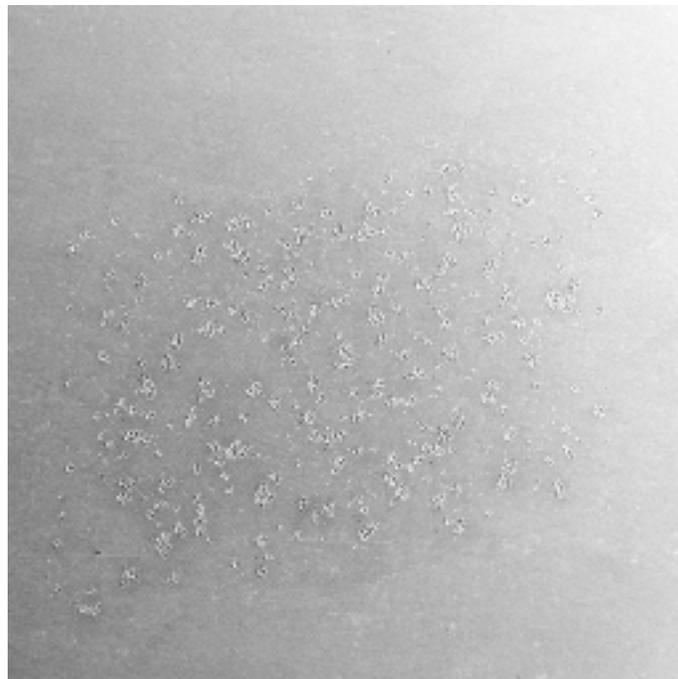


Figure 3. View of laser cleaned area. Size is ~1 mm.

occurred.

Microscopic examination

The cathode plate examination was focused on the obviously damaged area in the center, although a general survey of a larger portion of the surface was conducted.

Overall, the cathode surface appeared to be of good quality with grain boundaries visible though there was some evidence of occasional grain pullout. As seen in fig. 2, there was no sign of any gross chemical contamination with the x-ray spectrum showing only copper. Damage to the surface was mostly confined to the center region although a few areas away from center were also spotted. The dark regions were likely due to light oxidation.

The arrangement of damage from the laser cleaning is shown in fig. 3. There was no obvious pattern even though the laser was rastered over this region. This suggests either inexact rastering or the presence of an occasional hot spot in the laser beam.

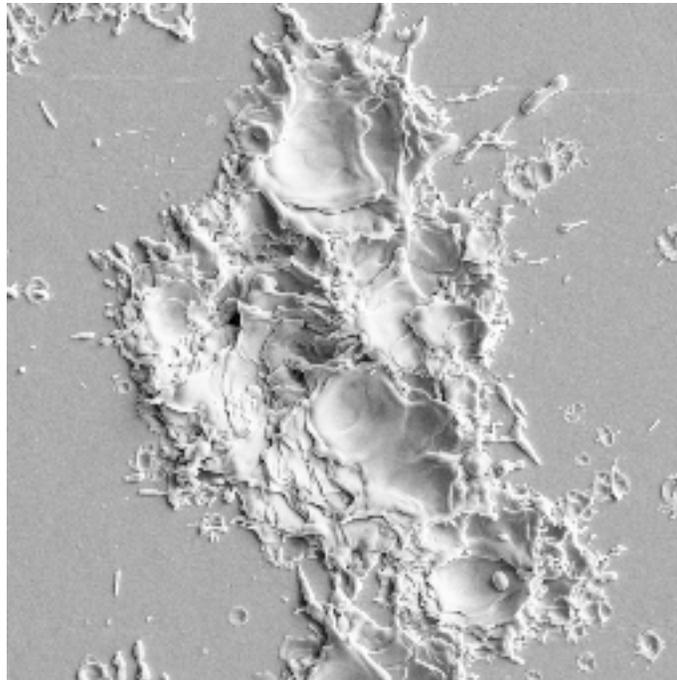


Figure 4. Closeup of a crater caused by laser cleaning.

A closeup view of one of the laser cleaning induced craters appears above in fig. 4. It is clear that this region had experienced several pulses with at least 5 independent craters visible. There was a lot of material splatter as a result of the explosive nature of the creation of the craters. The roughened surface of the crater together with the splatter led to an effective enhancement of the surface area which may account for some fraction of the increased quantum yield.

One interesting feature was discovered well away from the region of laser cleaning. This feature was also a crater, but a particularly well smoothed one

which suggested that a lower intensity or longer duration beam may have been the cause.



Figure 5. Closeup view of a crater caused by laser cleaning with a pulse duration long enough to permit local melting and smoothing.

Conclusions

With the exception of some of the defects located far off-center and the laser cleaned area, the cathode plate showed good quality. The plate could be reused if the surface were remachined to remove the damage.