ABSTRACT FOR IVESC
Miniature Reservoir Cathode – an update

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We report on recent work to produce a small low power, low cost reservoir cathode capable of long life (more than 100,000 hours) at high loading (> 5 A/cm²). Our objective is a highly manufacturable, commercial device costing less than $30. Small highly loaded cathodes are needed, especially for millimeter wave tubes, where focusing becomes difficult when area convergence ratios are too high. We currently have 3 models ranging from .060-inch diameter to .125-inch diameter.

Reservoir type barium dispenser cathodes have a demonstrated capability for simultaneous high emission density and long life. Seven reservoir cathodes continue to operate on the cathode life test facility at NSWC, Crane, Indiana at 2 and 4 amps/cm². They have accumulated nearly 100,000 hours with practically no change in emission levels or knee temperature.

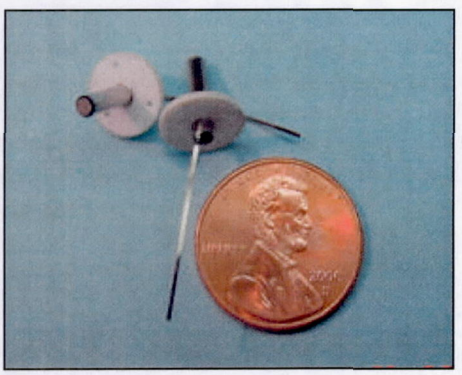

Figure 1

Production of a practical reservoir cathode is contingent on reducing its mechanical complexity. Figure 1 is a photo of two cathodes. Figure 2A is a diagram of the cathode assembly. The number of assembly steps has been significantly reduced. Furthermore every assembly step can be implemented in automated production. No brazes and no batch processes remain in the assembly shown in Figure 2A.

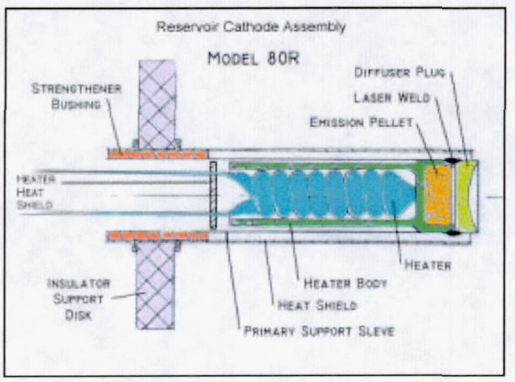

Figure 2A

Reservoir cathodes may be less costly than M cathodes because there is no impregnation step with subsequent laborious clean up of impregnant. Emission pellets for reservoir cathodes can be mass produced on pill pressing machines and loaded into reservoirs just before welding of the diffuser plug to reservoir body. No barium appears at the cathode surface until cathode is turned on. This allows use of a sealant to prevent moisture from reaching the emission pellet before use.

Apart from manufacturability considerations success is contingent on several other factors:

1. Developing emission materials that don't over-dispense or under-dispense barium and are reasonably stable in air. Also how quickly after turn-on barium appears at the cathode surface is important. We will discuss barium and barium oxide desorption rates for several formulations as determined by residual gas analysis (RGA). The best material continues to be barium oxide and tungsten, pressed together in a matrix. Tungsten concentration and grain size are

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important as well as over-all processing in predicting barium yield.

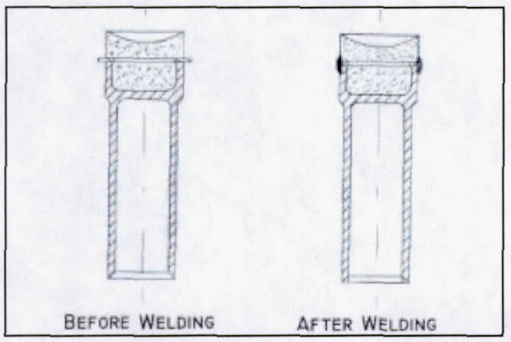

Figure 2B

2. Developing a weld technology that joins the reservoir body to diffuser plug. Weld must be hermetic and must not fail after long periods at elevated temperatures or after many temperature cycles. The basic weld process is shown in Figure 2B and a cross-section is shown in Figure 2C. A key element is the weld washer which is interposed between reservoir body and diffuser plug. This provides weld filler at the porous matrix. We have experimented with about 50 different weld washer materials and geometries to determine which produces the strongest, most ductile welds. We will discuss our testing program for evaluating the weld process.

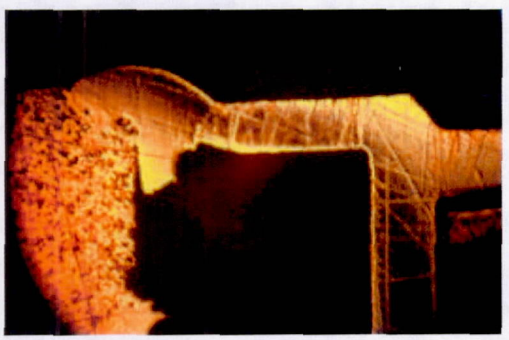

Figure 2C

3. Developing diffuser plugs that have the right combination of porosity, density and strength to avoid fractures while at the same time metering accurately the required amount of barium to its surface. We discuss our efforts in this regard.

4. Developing the lowest cathode work functions, about 1.85 electron volts, similar to that of osmium coated cathodes. Also the metallurgical properties must not change i.e. osmium concentration of cathode surface must remain at about 40%. This limits life on M cathodes, as will be shown in the review of the Crane data and also our own tests. We have taken two approaches: a) Develop low work function mixed matrix cathodes. They are not subject to the inter-diffusion phenomenon. Osmium-tungsten mixtures have yielded the best results to date. b) Use coated cathodes but develop diffusion barriers that stabilize the surface concentration of osmium. Results are inconclusive, but our best result has come from combining the mixed matrix approach with an osmium-tungsten coating. We have reduced the bulk osmium content to a level that allows good machinability while still preventing inter-diffusion of osmium surface layer. Details will be discussed.

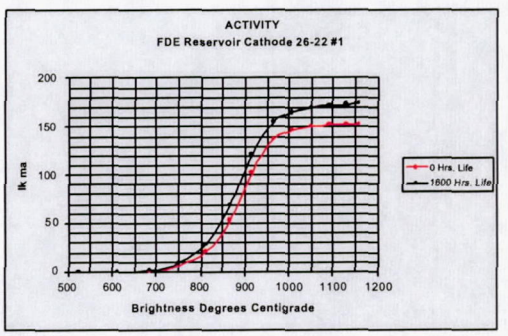

Figure 3A

Figure 3A shows the evolution of cathode activity for one or our mixed matrix diffusion plugs and compares favorably with the commercially procured M cathode shown in Figure 3B. Knee temperature is about the same but the M cathode is flatter above the knee at zero hours – indicating greater surface homogeneity. The reservoir cathode in Figure 3A shows no change in knee position, sharpness or slope above the knee after 1600 hours of operation at 5 Amps/cm^2. The curves are offset for clarity. M cathodes consistently show sharper knees at 0 hours. However, the knee transition point inevitably drops very early in cathode

life, and the slope above the knee tips up. This is shown in figure 3B after only 1600 hours of operation. After 18,000 hours at 5 amps/cm² (1010° CB) this cathode has failed. We consistently saw this behavior when M cathodes are pushed to loadings between 5-8 A/cm². We have identified osmium diffusion as the main reason for this problem

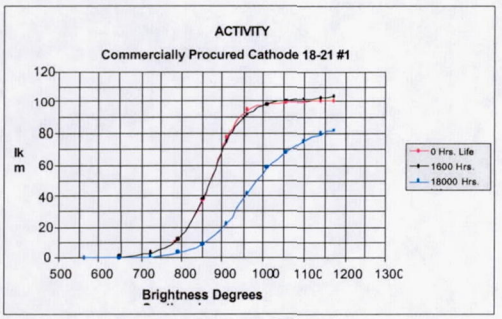

Figure 3B

5. We will present residual gas data from our reservoir cathodes at various stages of activation and temperature and compare it to similar data for commercially procured M cathodes. The technique involves placing a quadrupole mass spectrometer in line with the front of the cathode surface and measuring barium and barium oxide desorption rates. Not surprisingly the barium to barium-oxide ratios are higher for the reservoir cathode.

Figure 4 shows the barium to barium-oxide ratios vs. temperature for our reservoir cathode and for an M cathode.

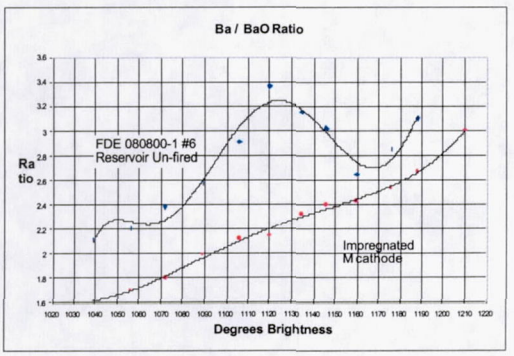

Figure 4

We also present results of auger surface studies for our reservoir cathodes compared to M cathodes. Again the cathodes are operated at various temperatures and activation states.

Figure 5 shows the evolution of elemental surface compositions for a commercially available M cathode.

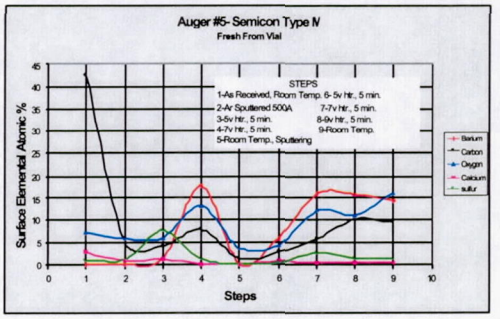

Figure 5

Figure 6 shows similar data for one of our reservoir cathodes. Again the barium to oxygen ratio is far higher for the reservoir cathode. Also carbon concentration is lower on the surface of the reservoir cathode.

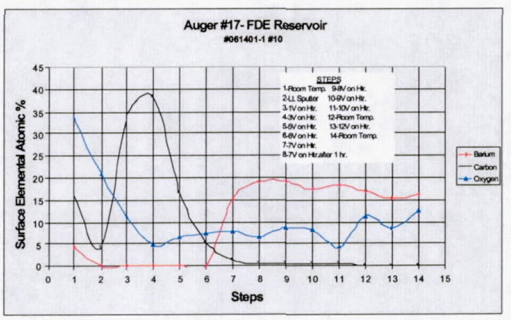

Figure 6