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RECOVERY OF EMISSION FROM ES-423E LaB_6 CATHODES FOLLOWING A VACUUM DUMP

Accidents can always happen. One unfortunate accident that can occur with electron optical instruments using LaB_6 cathodes is accidental venting to air of the gun region while the gun is operating. Most systems have vacuum interlocks that instantly remove the high voltage and cathode power supply.

Unfortunately, the thermal inertia of the cathode and its surrounding region results in a slow cooling of the cathode in the increased pressure. While this cooling period is only measured in seconds it is sufficient to cause the growth of a thin oxide film on the surface of the cathode.

On inspecting a cathode after a vacuum dump, the surface of the LaB_6 crystal will be found to be a greenish-blue or a blue-silver color rather than the rich purple of clean LaB_6. The color results from the presence of an oxide film and the modification of the lanthanum/boron ratio in the outer surface of the crystal.

A clean LaB_6 surface can generally be re-established by evaporating away the oxidized and/or modified surface layers of the crystal.

If the cathode has been removed from the instrument, check the continuity of cathode resistance. The room temperature resistance should be about 2 to 2.2 ohms. If it is significantly higher that this, then the heater circuit has suffered damage from the vacuum-dump and the cathode cannot be recovered.

If the cathode has been left in the gun, a clean-up procedure can be tried. Increase the bias resistor value to its maximum value (minimum emission) to limit the cathode emission as the cathode activates. With the high voltage on, watch for electron emission as the cathode temperature is increased. It is possible that the cathode will emit immediately when the oxide evaporates as the temperature is raised. The emission, as observed via a cross-over image or an electron emission pattern, may be very patchy. Continue to increase the temperature of the cathode slowly, and watch for improvements in the quality of the emission. It is quite possible that the cathode will recover to normal emission quite rapidly.

However, if no emission is seen at the normal setting of the cathode, leave it at this temperature for 5 to 10 minutes. The emission may recover. If not, increase the temperature of the cathode. If a current meter is available, increase the current to 2.0 A or 2.1 A for about 10 minutes.

After some 10 minutes at 2.0 A the cathode can be returned to its normal value at about 1.8 - 1.9 A and the bias re-adjusted for normal emission. The cathode should have recovered from the effects of the vacuum dump. If not, repeat this sequence. If the cathode will not activate after two such attempts, it is probable that some other damage has occurred as a result of the vacuum-dump. Gas discharges in the gun can contaminate the tip of the cathode with metals which are extremely difficult to remove by short term heating due to reactions with the surface of the LaB_6 and modification to the work function.

Do not panic after a vacuum dump. If everything else is in order in your instrument and normal vacuum is recovered, then try the above procedures before going to the trouble of replacing the cathode. You may be lucky and find a complete recovery to normal operation. The heater circuit of a Kimball Physics ES-423E cathode is quite robust and can survive vacuum dumps.

Further Information

Additional details are available in the following Kimball Physics Technical Bulletins:

- LaB_6-01: General Guidelines for Operating ES-423E LaB_6 Cathodes
- LaB_6-02: The Relationship Between LaB_6 and Gun Vacuum
- LaB_6-03: Emission Drift - LaB_6 Gun Stability
- LaB_6-04: Oxygen Activation of LaB_6 Cathodes - The Double Saturation Effect
- LaB_6-05: Kimball Physics ES-423E LaB_6 Cathode Style 60-06 (60° Included Cone Angle, 6μm Diameter Flat)
- LaB_6-06: Kimball Physics ES-423E LaB_6 Cathode Operating Instructions for Leica/Cambridge Stereoscan Series SEM's