Issues in Cathode Performance
Part 2 - Cathode Mounting Design

Damon Heer, FEI Company, Components Group

Part 1 of this article series covered the performance features of various tip shapes and explained why the <100> crystal orientation is the industry standard. Future articles will deal with material purity, composition, selection, and preparation

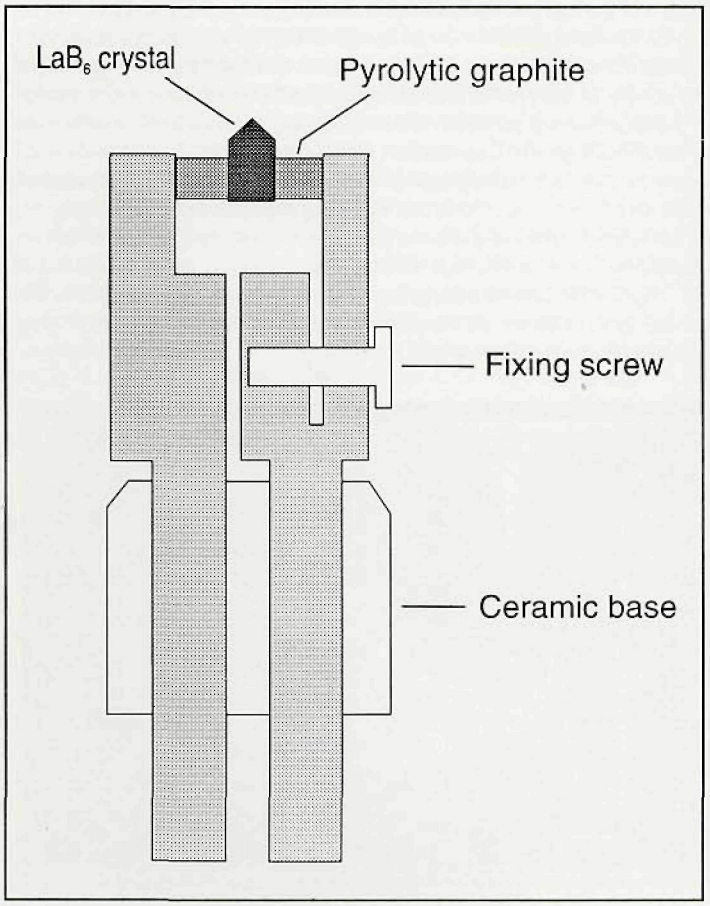
LaB_6 and CeB_6 cathodes are widely used as high-brightness, high-stability, long-lifetime cathodes in a variety of electron beam applications. Two of these factors - stability and lifetime - are critically dependent on proper cathode-mounting design.

Cathode Mount Design History

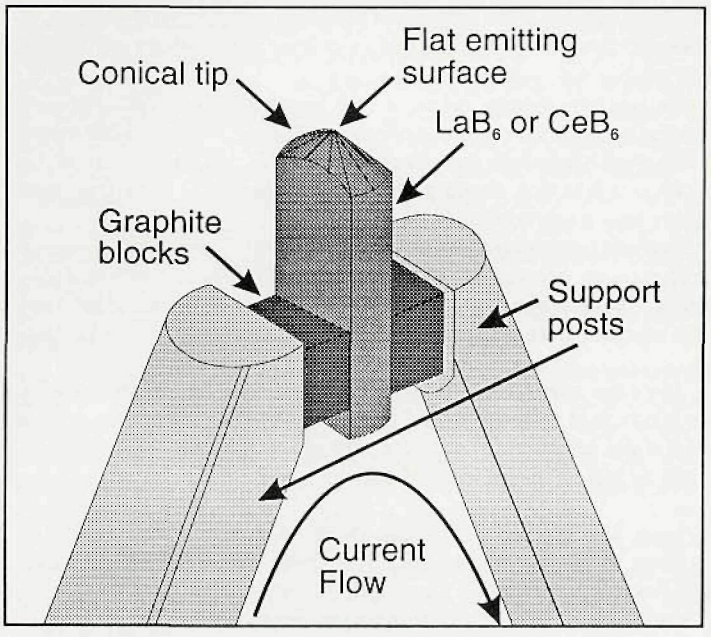
When the benefits of LaB_6 as an emitter material were first investigated, the LaB_6 was indirectly heated by an electron bombardment coil. This design was cumbersome and did not perform well. Wire mounts, such as those used for tungsten emitters, were developed (and are still used today); however, they have many drawbacks. Their stability and lifetime are limited because the thin wire mount moves easily and will eventually break under the changing temperature conditions encountered during operation.

In 1970, Siegfried F. Vogel was granted a patent for the Vogel mount for LaB_6 cathodes. In the Vogel mount, two large posts compressively hold pyrolytic graphite material, which holds the electron-emitting material as shown in the diagram below. The graphite serves as both the mechanical support and the heater for the emitting tip, which is heated by passing an electrical current through the posts and graphite blocks. Due to pyroytic graphite's high ratio of electrical resistivity to heat conductivity, it not only supplies heat to the emitter tip but also isolates the high-temperature area from the supporting posts.

The Vogel mount provided extended life and improved stability over previous mounting styles; however, it is an expensive and complicated structure, and, because of its large size, it is not mechanically compatible with most electron microscopes.



The original Vogel mount design provided significant increases in stability and lifetimes for LaB_6 cathodes, but it was not suitable for most SEM and TEM applications.



The Mini Vogel Mount provides all the advantages of the Vogel mount design to LaB_6 sources for SEM and TEM applications - at a reasonable cost.

The Mini Vogel Mount

In 1988, the LaB_6 Mini Vogel Mount (MVM), pictured above, was introduced to provide the benefits of the Vogel mount to all LaB_6 SEM and TEM users in a compact and less expensive design.

The construction of the MVM is simple. Sturdy camping posts compressively hold the pyrolytic graphite pads and single-crystal emitter in place. The posts are made of a molybdenum-rhenium alloy that maintains a high modulus of elasticity at high temperatures. The clamps will not relax during operation, and the emitter is always held rigidly.

The MVM for Long Lifetimes

The structure of the MVM is very robust. The mounting structure can reasonably sustain impact (for example, accidental bumps while changing cathodes) and not deviate from structural specifications. Other mounting designs are brittle and frail.

Because the graphite pads shield evaporation of the crystal in the direction of the clamping force, the single-crystal emitter can be fully utilized without concern about mount failures.

The MVM for Stability

The large posts maintain a clamping force of approximately 5,000 psi for the life of the cathode. This prevents the emitter from drifting during use. Both position and beam stability tests have been conducted with the following results:

Position stability tests were conducted on an FEI MVM in a modern SEM. With the MVM fully saturated and running at 40 kV accelerating voltage, the gun was switched off and restarted repeatedly. After each restart, the probe current was measured in a Faraday cup. The current varied less than 1 percent.

Beam stability of the MVM exceeds the specifications of the systems in which it runs. In e-beam lithography systems, the MVM has provided less than 0.5 percent instability over a five-day period. In modern SEMs, the MVM has shown less than 1 percent instability over a 63-hour period.

Combining long lifetime, high stability, and universal compatibility, the Mini Vogel Mount is an excellent choice for LaB_6 and CeB_6 cathode mounting. ■