KIMBALL PHYSICS
Excellence in Electron and Ion Optics

LaB_6 CATHODES
SINGLE-CRYSTAL LANTHANUM HEXABORIDE

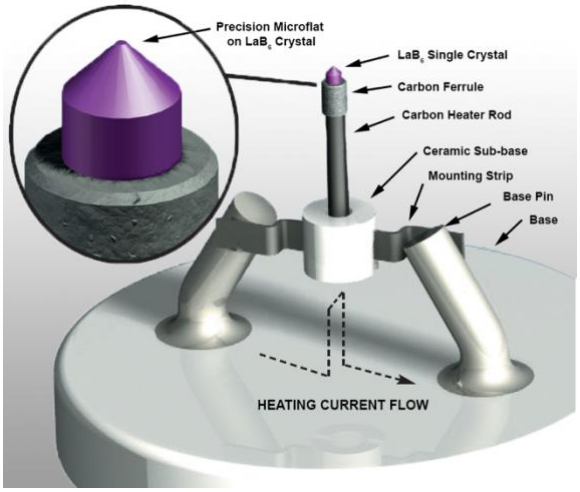
ES-423E (Extended Life) LaB_6 Crystal

FOR USE IN:

- Scanning Electron Microscopes
- Transmission Electron Microscopes
- Electron Lithography Systems
- Electron Accelerators
- X-ray Sources
- Free Electron Lasers
- Custom Applications

FEATURES / OPTIONS:

- **Extended Lifetime**
  - Thousands of functional hours in clean vacuum
  - Guaranteed Against Structural Mounting Failure
- **Exceptional Stability**
  - Precision machined carbon mounting
  - High over-temperature tolerance
- **High Brightness / Low Energy Spread**
  - <100> Oriented Single Crystal
  - Best Quality / High Purity Material
- **Accurate Microflats**
  - Superior Optics, Controlled Source Size
  - Standard Diameters Available

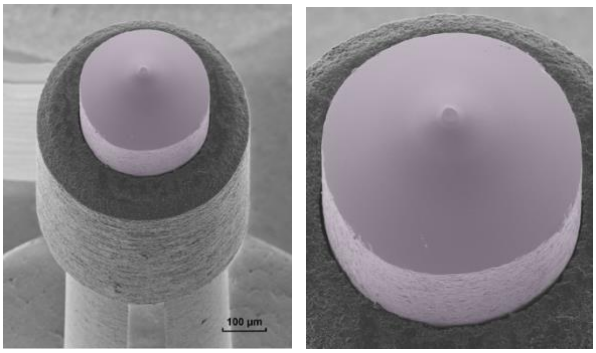


LaB_6 single crystal cathode mounting: Heating current path through precision-machined, slotted single-piece carbon rod and with mounting strips; sub-base provides rigidity and easier mounting.

The Kimball Physics ES-423E (Extended Life) Lanthanum Hexaboride Cathode is a high performance, resistively heated, thermionic electron source. It is currently employed in many brightness-limited electron optical systems: SEM's, TEM's, probes, electron lithography systems, etc.

It is based on a well-proven heater structure, which has recently been further refined with features that include improved reliability of the heater circuit, improved stability of the LaB_6 crystal, and less exposure of LaB_6 to reduce Wehnelt aperture contamination.

Lifetimes in excess of 6 months of continuous operation are regularly achieved in commercial SEM's and TEM's with suitable gun vacuum. Continuous operation at the full operating temperature improves the thermal stability of the gun and hence beam current stability. It is no longer necessary to wait hours for stable beam conditions in order to perform quantitative EEL or EDX measurements.



SEM of LaB_6 single crystal cathode mounting on precision-machined, single-piece carbon rod and 15 micron microflat at the <100> apex of the LaB_6 crystal.

The emitter has a 15 µm-diameter (standard) microflat on a <100> oriented-single crystal, and is mounted on the end of a single-piece, stress-free, carbon heater rod, held in place by a carbon ferrule. The rod has been precision machined with a 100 µm slot cut along the axis, such that the heating current goes up one side and down the other. The small area of the heating current loop keeps the unwanted heater current magnetic field low. Because the carbon rod is one single piece with a unique geometry at the crystal interface, no heating current passes through the crystal; there are no high temperature current-carrying joints.

A high degree of axial symmetry keeps mechanical motions small. The small physical size fits most Wehnelts with ease. In the ES-423E, the crystal can be completely evaporated away without affecting the heating circuit. The very tight tolerances, and the enclosed structure prevent the loss of LaB_6 in the mounting region throughout the entire crystal life. Reduced material loss also means less Wehnelt contamination. Microflat dimensions are machined to a 2 µm tolerance, (standard, 2 µm to 16 µm for microflats up to 320 µm) with a tilt tolerance of 0.5º. Microflat alignment to the instrument base can be provided to a tolerance of 13 µm for x, y and 76 µm for z, the height above the base (less than 70 µm on request). A high angular tolerance is maintained on the perpendicularity of the oriented single-crystal emission plane to the electron optical axis. All cathodes receive a stabilizing run-up prior to shipment.

With electron-gun oxidizing-gas partial pressures kept below 10^{-7} torr, many instruments can achieve thousands of hours of stable cathode operation. In SEM type instruments, lifetimes up to 3000 to 4000 hours may be achieved at operating temperatures of 1850 K (corresponding to material surface loss rates in the 0.025 micron/hour range), with full brightness and excellent stability. With somewhat reduced brightness, as required by typical TEM instruments, lifetimes can be even longer. The ES-423E mounting structure will last more than 10,000 hours. Moreover, neither the electrical heating circuit drive impedance nor the thermal properties will drift perceptibly over that period. Chemical reactivity and mechanical drift problems have been eliminated.

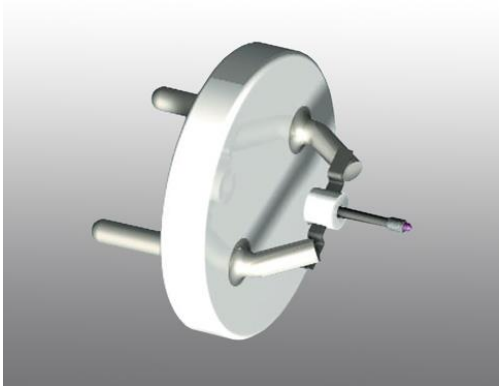
Features of Kimball Physics LaB_6 Cathodes

The real figure of merit of a thermionic electron emitter is the number of coulombs of electrons which may be "boiled off" per kilogram of cathode surface evaporated away. LaB_6 is an order of magnitude superior to the refractory metals in this key parameter. Any failure of a cathode mounting structure, before the LaB_6 cathode itself has been used up, represents a waste of cathode life.

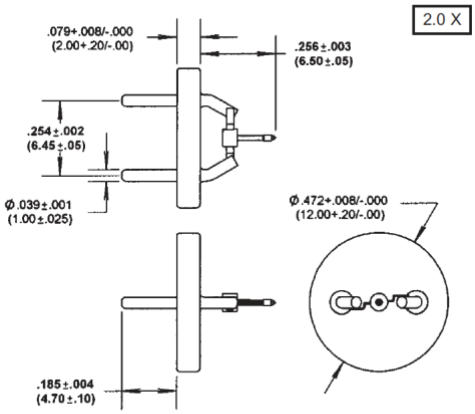
The ES-423E single-piece stress-free ultra-stable carbon mount is unique. Unlike other designs which operate near the temperatures where chemical instabilities will set in, the ES-423E carbon mount is almost impossible to destroy by accidental over-temperature. The melting point of Lanthanum Hexaboride itself is somewhat over 2800 K; there have been examples of crystals being melted (extreme over-temperature), in which the ES-423E carbon mount survived. The Kimball Physics mount is guaranteed.

The ability to run over-temperature may also be utilized to clean a contaminated crystal, and reduces the risks associated with less experienced operating personnel.

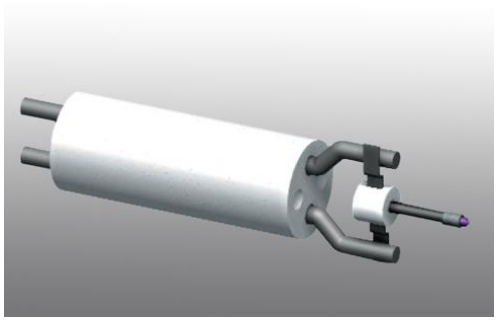
This small source size fits most Wehnelts with ease. In excellent vacuum with low material loss rates, the size of the cathode does not limit lifetimes. The Kimball Physics ES-423E Long Life Lanthanum Hexaboride Cathode is the most recent improved version of the IR 100 Award Winning design which has been used in several instruments types for many years. Take advantage of our industry-leading designs.



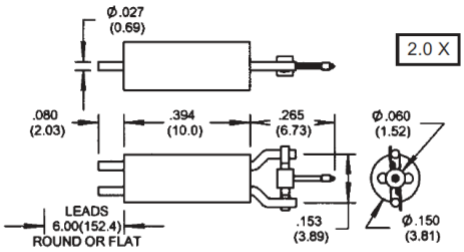
ES-432 LaB_6 (single cone-shaped crystal with microflat emitting surface) mounted on a Kimball Physics AEI ceramic base.



ES-423E Single cone-shaped crystal LaB6 cathode mounted on an AEI Base



ES-432 LaB_6 (single cone-shaped crystal with microflat emitting surface) mounted on a Kimball Physics CB-104 ceramic base.

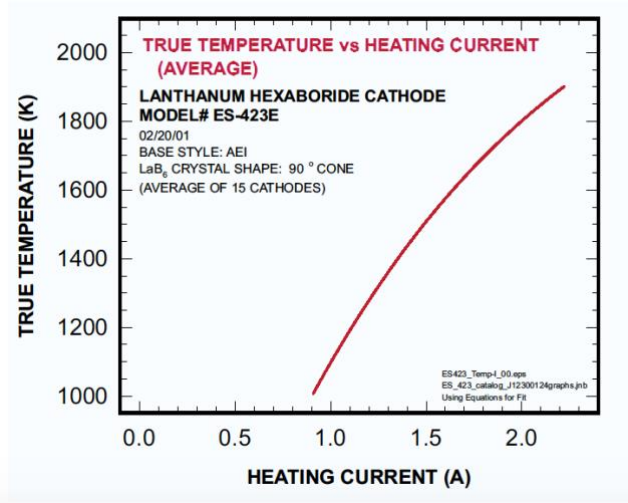


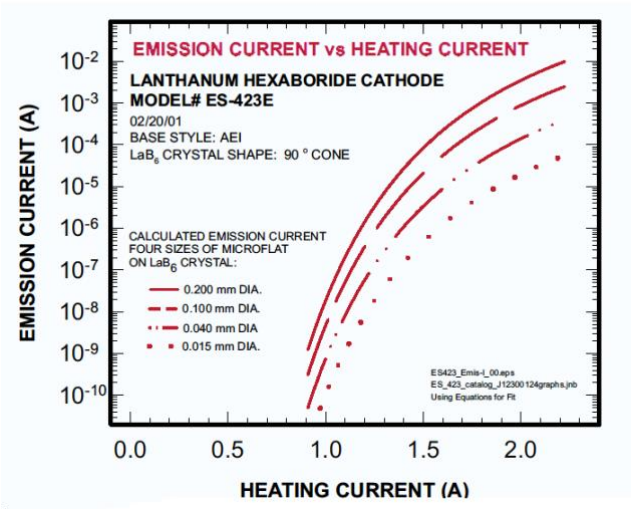
ES-423E Single cone-shaped crystal LaB6 cathode mounted on a CB-104 ceramic base

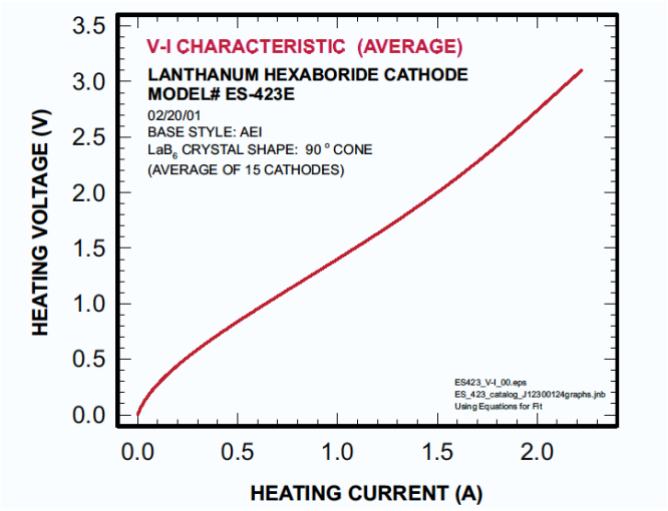
-ALL DIMENSIONS ARE IN INCHES. (MILLIMETERS IN PARENTHESES)
- MAGNIFICATIONS ARE APPROXIMATE (TO PROVIDE SIZE ESTIMATE)

⚠ CAUTION

Kimball Physics recommends that the LaB_6 cathode be operated only in a vacuum of **10^{-7} torr** or better and at currents less than **2.2 A**.
Poor vacuum or excessive current will reduce cathode lifetime.







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CATHODE ES-423E	
CATHODE MATERIAL	Lanthanum Hexaboride (LaB6) single crystal
CATHODE SHAPE	Cone with 60 or 90° sides and microflat tip
MICROFLAT SIZE	Standard: 0.015 mm dia., larger or smaller diameters available
HEATER	Single piece carbon rod
EMISSION AREA	$1.7x10^{-6}$ cm^2 standard microflat, excluding sides
EMISSION CURRENT	0.051 mA (standard microflat)
HEATING CURRENT	1.7A to 2.1A
CATHODE LOADING	20-30A/cm^2 recommended High loadings result in reduced lifetime
BRIGHTNESS	$>10^6$ A/cm^2/sr

CATHODE ES-423E	
WORK FUNCTION	2.69 eV
OPERATING TEMP	Approx. 1700-1900K
ENERGY SPREAD	Approx. 0.4 eV
LIFETIME	Thousand plus hours with medium currents, good vacuum
VACUUM LEVEL	10^{-7} torr or better recommended
POWER SUPPLY CAPABILITY	Voltage regulated power supply recommended, 4V, 3A
BASES	AEI, CB-104, electron microscope bases, and other custom bases available

References

For more information on LaB_6 operations, you may download additional detailed technical bulletins from the website cathode resource page:

LaB_6-01 General Guidelines for Operating LaB6 Cathodes.
LaB_6-02 The Relationship Between LaB_6 and Cathode Life and Gun Vacuum
LaB_6-03 Emission Drift—LaB_6 and 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
LaB_6-07 Recovery of Emission From ES-423E LaB_6 Cathodes Following a Vacuum Dump

LaB_6 ES423-E

LaB6 Cathode (ES-423E) - Cathodes / Emitters- Extended Life LaB6 Cathode- Description and Specifications

LaB6 Cathode (ES-423E) - Cathodes / Emitters- Extended Life LaB6 Cathode- User Information.

Notes:
1. Charts /graphs show typical performance, data is for guidance only
2. It is not necessarily possible to achieve all maximum specifications simultaneously.
3. Specifications Subject to Change Without Notice.
4. DE Altobelli, DT Taylor 1/12/2023

Document: LaB6_ES423-E _2023_0112