

LaB₆ for Electron Microscopes and Electron Lithography Systems
ES-423E (90/15, 90/20, 60/6)

FOR USE IN:

- Scanning Electron Microscopes
- Transmission Electron Microscopes
- Electron Lithography Systems
- Electron Probe Microanalysis
- X-ray Micro-Analysis
- Surface Analysis
- Custom Applications

FEATURES / OPTIONS:

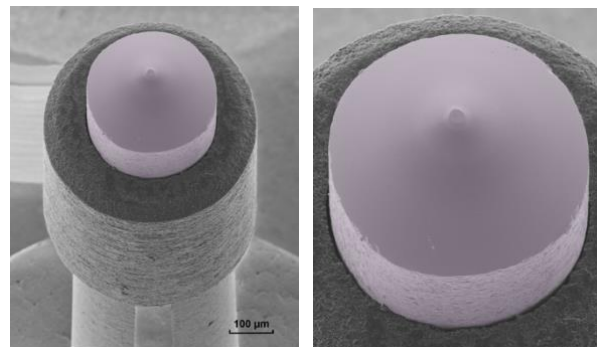
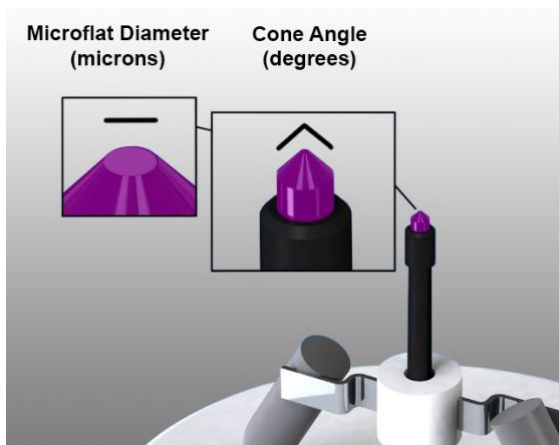
- **Extended Lifetime**
 - Thousands of functional hours in clean vacuum
- **Exceptional Stability**
 - Precision machined carbon mounting
 - High over-temperature tolerance
- **High Brightness / Low Energy Spread**
 - <100> Oriented Single Crystal
 - Best Quality / High Purity Material
- **Accurate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



LaB₆ single crystal cathodes available on high quality bases compatible with numerous commercial systems. Custom bases are available.

The Kimball Physics ES-423E (Extended Life) Lanthanum Hexaboride (LaB₆) 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. With brightness at least an order

of magnitude greater than tungsten, LaB₆ provides superior resolution in a wide range of acceleration voltages to enable clear imaging of the finest details in electron microscopy applications.



SEM of LaB₆ single crystal cathode mounting with heating current path through precision-machined, single-piece carbon rod and <100> oriented LaB₆ crystal with 15 micron microflat at the apex of a truncated 90 degree cone geometry.

LaB₆ has optimal properties for electron beam applications that image and interact at micron and nanometer levels of structure. With a) low work function, b) high melting point with stable emission at temperatures, and c) low vapor pressure to minimize evaporative losses, the LaB₆ cathodes provide an optimized, reliable, and cost-effective solutions.

The Kimball Physics LaB₆ emitters are 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 LaB₆ crystal, and less exposure of LaB₆ 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.

The standard emitter, with a <100> oriented-single LaB₆ crystal, has a 15 μm-diameter microflat at the truncated apex of a 90 degree cone angle and is mounted on the end of a single-piece, stress-free, carbon heater rod, and held in place by a carbon ferrule. Other LaB₆ emitter variations include a 20 μm-diameter microflat at the apex of a 90 degree cone angle, and for higher resolution applications, a 6 μm-diameter microflat at the apex of a 60 degree cone angle is available.

The carbon 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 LaB₆ in the mounting region throughout the entire crystal life. Reduced material loss also means less Wehnelt contamination. Emitter 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 0.5°. 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 essentially eliminated.

The real figure of merit of a thermionic electron emitter is the number of coulombs of electrons which may be emitted ("boiled off") per kilogram of cathode surface evaporated away. LaB₆ is an order of magnitude superior to the refractory metals in this key parameter. Any failure of a cathode mounting structure, before the LaB₆ 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 events. 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 many instrument types for many decades. Kimball Physics invented the “Directly Replaceable Lanthanum Hexaboride Cathode”. Take advantage of the most experience in the business.

Microscope Base Dimensions

Base Type	Dimensions		
	Diameter Ceramic Disc (mm)	Diameter Pins (mm)	Center Distance Pins (mm)
AEI	12.0	1.0	6.45
FEI / PHILIPS	26.0	1.0	5.0
JEOL K-type	28.0	1.2	8.0
HITACHI S-type	9.8	1.2	2.7
ZEISS (DSM & TEM) LEO (1450 & TEM) TESCAN	19.8	1.0	5.0
AMRAY (except 1200)	26.1	1.0	5.0
ISI / ABT / TOPCON 2 pins	23.3	1.2	11.9
ISI / ABT / TOPCON	23.4	1.2	12.0
Notes: -Data Reference: TED PELLA, INC https://www.tedpella.com/apertures-and-filaments.html/Kimball-lab6-cathodes.aspx#Dimensions -Not all bases and options are included in table. Please visit website noted above. 3/4/2024			

CATHODE ES-423E (90/15, 90/20, 60/6)	
CATHODE MATERIAL	Lanthanum Hexaboride (LaB6) single crystal, crystal orientation <100>
CATHODE SHAPE	Cone with 90° or 60° sides and microflat tip
MICROFLAT SIZE	Cone angle 90 degrees(0.015, 0.020, mm dia.) and cone angle 60° (0.006 mm dia.). Custom larger or smaller available.
HEATER	Single piece carbon rod
EMISSION AREA	1.7x10 ⁻⁶ cm ² , 3.14x10 ⁻⁶ cm ² , and 2.8 x 10 ⁻⁷ cm ² for 0.015, 0.020, and 0.006 mm microflats, respectively
HEATING CURRENT	1.7A to 2.1A

CATHODE ES-423E (90/15, 90/20, 60/6)	
CATHODE LOADING	20-30A/cm ² recommended High loadings result in reduced lifetime
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

LaB ₆ Cathode ->	ES-423E-90/15	ES-423E-90/20	ES-423E-60/6
Features	-Extended Lifetime -High Brightness / Low Energy Spread	-Extended Lifetime -High Brightness / Low Energy Spread	-Extended Lifetime -High Brightness / Low Energy Spread -High resolution
Application	SEM, TEM	Analytical SEM, Microprobe	TEM
Material	LaB ₆	LaB ₆	LaB ₆
Cone Angle(degrees)	90	90	60
Microflat (microns)	15	20	6
AEI (Standard)	•	•	•
Company Base			
Amary	•	•	
Cambridge Instruments	•	•	
Cameca	**	**	**
CamScan	•	•	
ETEC / Perkins Elmer	•	•	
Electroscan	•	•	
Hitachi S	•	•	•
Hitachi HU	•		•
ISI, ABT, Topcon (2 pin)	•	•	•
JEOL K	•	•	•
Leica	•	•	
FEI / Philips *	•	•	•
Siemens	•	•	•
Techscan SEM	•	•	•
VG	•	•	•
Zeiss DSM SEM	•	•	
Zeiss LEO TEM	•	•	•
Zeiss EVO	•	•	
Notes: -Table based on data from Ted Pella website (URL noted below) and subject to change. -Table is provided for guidance only and may contain exceptions or errors. • Option available, contact TED Pella or KP Support. * Does not include smaller AEI style on XL30 SEM ** Would require custom mounting on customer base. Call KP support for further discussion and options. -Please visit Ted Pella for most current selections available and prices: https://www.tedpella.com/apertures-and-filaments.html/Kimball-lab6-cathodes.aspx#Dimensions 3/4/2024			

References

For more information on LaB₆ operation in TEM's and SEM's you may download additional detailed technical bulletins (not listed below) from the website cathode support page:

- # LaB₆-01 General Guidelines for Operating LaB₆ Cathodes.
- # LaB₆-02 The Relationship Between LaB₆ and Cathode Life and Gun Vacuum
- # LaB₆-03 Emission Drift—LaB₆ and Gun Stability.
- # LaB₆-04 Oxygen Activation of LaB₆ Cathodes—The Double Saturation Effect
- # LaB₆-05 Kimball Physics ES-423E LaB₆ Cathode Style 60-06 (60° Included Cone Angle, 6µm Diameter Flat)
- # LaB₆-06 Kimball Physics ES-423E LaB₆ Cathode Operating Instructions for LEICA/Cambridge
- # LaB₆-07 Recovery of Emission From ES-423E LaB₆ Cathodes Following a Vacuum Dump

Notes:

1. Specifications and Prices Subject to Change Without Notice.
2. DE Altobelli, DT Taylor 3/4/2024

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