

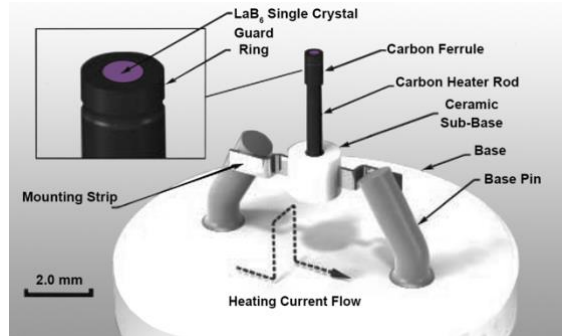
## ES-423GR (Guard Ring) LaB<sub>6</sub> Crystal

### FOR USE IN:

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

### FEATURES / OPTIONS:

- **Guard Ring Design** with optimized emission from microflat surface
- **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



*ES-423GR Guard Ring LaB<sub>6</sub> single crystal cathode mounted on AEI base. Heating current path through precision-machined, slotted single-piece carbon rod and mounting strips; sub-base provides rigidity and easier mounting.*

The Kimball Physics ES-423GR Guard Ring Lanthanum Hexaboride LaB<sub>6</sub> Cathode is a high performance, resistively heated, thermionic electron source. It is currently employed in electron sources such as SEMs, electron lithography systems, x-ray systems, etc. The exposed emitter surface can range from 10 μm to 250 μm diameter (user specified). The single crystal LaB<sub>6</sub>, <100> orientation, is mounted on the end of a single-piece, stress-free carbon heater rod, and is held in place by a carbon ferrule. The additional guard ring aperture structure controls the exposure of the LaB<sub>6</sub> surface.

The model ES-423GR is available with the LaB<sub>6</sub> crystal cut at a cone angle of 60° or 90° and a microflat size range from 10 μm to 250 μm. These dimensions are included in the part number, e.g. the ES-423GR style 90-50, having a 90° cone with a 50 μm microflat. The LaB<sub>6</sub> cathode is available mounted on a standard AEI base, a Kimball Physics CB-104 ceramic base,

or on a variety of custom bases for particular systems.

The design of the crystal geometry is similar to the conical shape with a microflat tip found in the LaB<sub>6</sub> ES-423E design. However, this advanced design optimizes emission from the microflat region and suppresses emission from the inclined conical surface by utilizing the additional guard ring structure without requiring elevated electric fields from the Wehnelt / grid.

The LaB<sub>6</sub> crystal 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. The crystal could theoretically be completely evaporated away without affecting the heating circuit.

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.

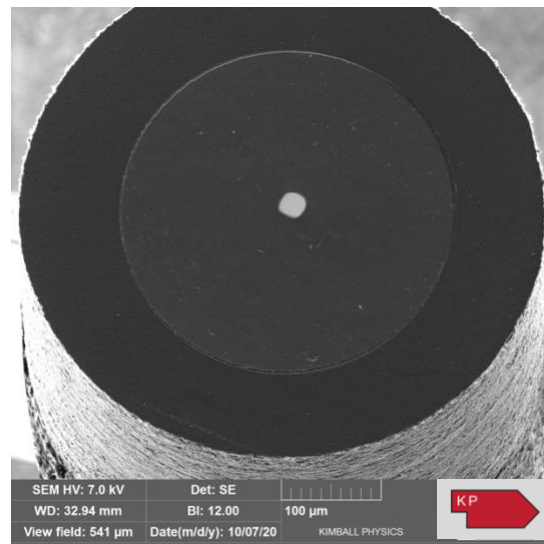
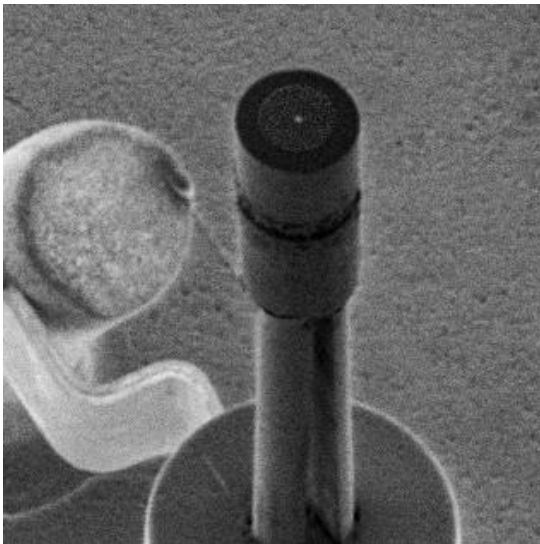
A high degree of axial symmetry keeps mechanical motions small. The small physical size fits most Wehnelts with ease. The very tight tolerances, and the enclosed structure prevent the loss of  $\text{LaB}_6$  in the mounting region throughout the entire crystal life. Reduced material loss also means less Wehnelt contamination.

A high angular tolerance is maintained on the perpendicularity of the oriented single-crystal emission plane to the electron optical axis. All

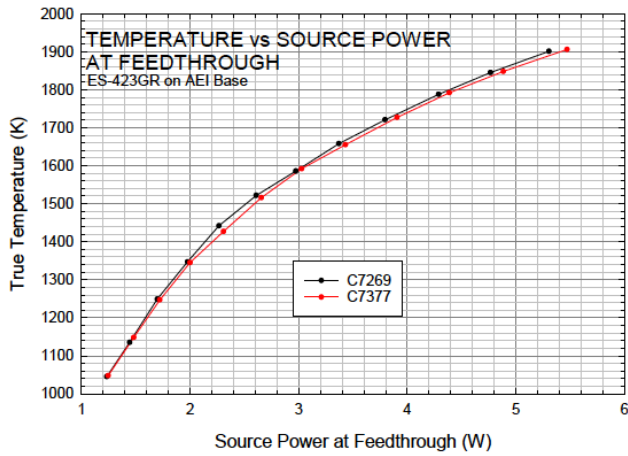
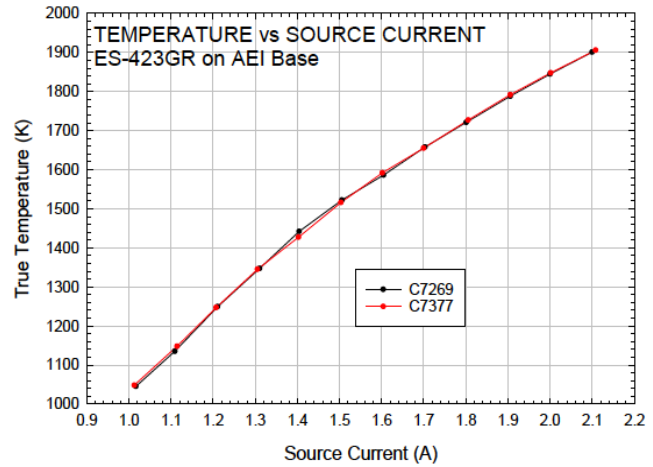
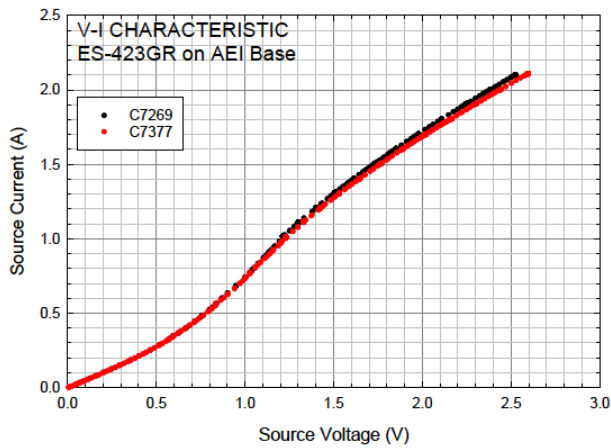
cathodes receive a stabilizing run-up prior to shipment.

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-423GR 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.



*SEM images of ES-423GR Guard Ring  $\text{LaB}_6$  single crystal cathode mounting showing precision-machined, single-piece carbon rod, Guard Ring, and 25 micron  $\text{LaB}_6$  microflat (lighter region cathode surface center).*



**CAUTION**

Kimball Physics recommends that the LaB<sub>6</sub> cathode be operated only in a vacuum of 10<sup>-7</sup> torr or better and at currents less than 2.2 A. Poor vacuum or excessive current will reduce cathode lifetime.

CATHODE ES-423GR		CATHODE ES-423GR	
CATHODE MATERIAL	Lanthanum Hexaboride (LaB <sub>6</sub> ) single crystal	BRIGHTNESS	>10 <sup>6</sup> A/cm <sup>2</sup> /sr
CATHODE SHAPE	Cone available with 60° or 90° sides and variable microflat tip diameter. Guard Ring configuration.	WORK FUNCTION	2.69 eV
MICROFLAT SIZE	Range: 0.010 to 0.250 mm dia (10 – 250 microns)	OPERATING TEMP	Approx. 1700-1900K
HEATER	Single piece carbon rod	ENERGY SPREAD	Approx. 0.4 eV
EMISSION AREA	Range: 7.8 x10 <sup>-7</sup> cm <sup>2</sup> to 4.9 x10 <sup>-4</sup> cm <sup>2</sup>	LIFETIME	Thousand plus hours with medium currents, good vacuum
EMISSION CURRENT DENSITY	Up to 30 A/cm <sup>2</sup>	VACUUM LEVEL	10 <sup>-7</sup> torr or better recommended
HEATING CURRENT	1.7A to 2.1A	POWER SUPPLY CAPABILITY	Voltage regulated power supply recommended, 4V, 3A
CATHODE LOADING	20-30 A/cm <sup>2</sup> recommended High loadings result in reduced lifetime	BASE	AEI, CB-104 or on a variety of custom bases for particular systems.

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## Features of Kimball Physics LaB<sub>6</sub> 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<sub>6</sub> is an order of magnitude superior to the refractory metals in this key parameter. Any failure of a cathode mounting structure, before the LaB<sub>6</sub> cathode itself has been used up, represents a waste of cathode life.*

*The ES-423GR single-piece stress-free ultra-stable carbon mount, based on the IR 100 award winning design from our ES-423E cathode, is unique with beneficial features.*

*Unlike other designs which operate near the temperatures where chemical instabilities will set in,*

*the ES-423GR 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 carbon mount has 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. Take advantage of our industry-leading design.*

## References

For more information on LaB<sub>6</sub> operations, you may download additional detailed technical bulletins (not listed below) from the website cathode support page:

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

### LaB<sub>6</sub> ES423-GR

LaB<sub>6</sub> Cathode (ES-423GR) - Cathodes / Emitters- Extended Life LaB<sub>6</sub> Cathode- Description and Specifications-  
LaB<sub>6</sub> Cathode (ES-423GR) Guard Ring 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 1/12/2022

Document: LaB<sub>6</sub>\_ES423GR\_2023\_0112  
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